U.S. Department
of Transportation
Federal Highway
Administration
Federal Transit
Administration
Maritime
Administration

1995 Status of the Nation's Surface Transportation System:

Condition and Performance

Report to Congress

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

October 27, 1995

The Honorable Newt Gingrich
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

I am pleased to transmit for your consideration the 1995 Status of the Nation's Surface Transportation System: Conditions and Performance Report. This report combines condition, performance and investment information on the Nation's highway, bridge, and transit systems. Also included, to complement this material, is information on maritime infrastructure.

The report highlights the need to maintain our commitment to infrastructure investment to keep our highway and transit systems functioning effectively. Recognizing the close relationship between an efficient transportation system and economic productivity, the Clinton Administration has dramatically increased funding for transportation infrastructure over the past several years. And in the light of the Nation's growing transportation needs, the Department has moved aggressively to find ways to stretch the Federal dollar. These include streamlining Federal programs, using innovative financing techniques to attract private investment to transportation, and adopting new technologies.

The Department has submitted highway reports, since 1968, on an odd year basis in accordance with Title 23, U.S.C., Section 307(h). Transit reports have been submitted, since 1982, in even years in accordance with Title 49, U.S.C., Section 308(e). In 1993, the highway and transit reports were combined. To further the intermodal perspective of the report series, maritime information is included in the current 1995 report. However, a maritime report is not statutorily required.

In keeping with the principles established by the Intermodal Surface Transportation Efficiency Act of 1991 (Public Law 102-240), this report is further evidence of the Department's commitment to a truly intermodal perspective of the Nation's transportation system. Combining information about our highways, bridges, transit, and maritime systems provides decisionmakers with a valuable intermodal perspective as we seek to make the best use of each mode in satisfying our Nation's growing transport requirements. We look forward to continuing the expansion of modal coverage in this report series so that the Department can provide the breadth of information needed by decisionmakers to deal with our ever increasing and complex transport requirements.

An identical letter has been sent to the President of the Senate, the Chairman and Ranking Minority Member of the Senate Committee on Environment and Public Works, and the Chairman and Ranking Minority Member of the House Committee on Transportation and Infrastructure.

Sincerely,

Federico Peña

2 Enclosures

1995 Status of the Nation's Surface Transportation System:

Condition and Performance

Table of Contents

List of Acronyms I

Introduction and Executive Summary V

INTRODUCTION VII

EXECUTIVE SUMMARY XII

The Dimensions of Personal Travel XII
The Dimensions of Travel XII
Travel Behavior: Demographic Trends XIII
Travel Behavior: Economic Trends XIV
Travel Behavior: Population Movements and Land Use Patterns XV
Implications for Future System Requirements XV

Highway, Bridge and Transit System and Usage Characteristics XVII
System Classification XVII
System Extent and Capacity XVIII
System Usage XVIII

Highway, Bridge and Transit Finance XIX
Public Sector Financing XIX
Total Expenditures XX
Capital Expenditures XXI
Noncapital Expenditures XXII

Highway, Bridge and Transit System Condition and Performance XXV
Conditions XXV
Performance XXVII
Highway Safety XXVIII
Selected Highway Environmental Indicators XXIX

Highway, Bridge and Transit Investment Requirements XXX
Investment Requirements, 1994-2013 XXX
Comparison of 1994 Investment Requirements with 1993 Capital Expenditures XXXI
Significant Analytical Advancements and Issues XXXIII

Waterborne Transportation System XXXIV
Waterborne Transportation System Characteristics XXXIV
System Performance XXXVI
Federal Role XXXVIII
Demand for Water Transportation and Shipping Capacity XXXIX
System Investment Requirements XXXIX

Chapter 1: The Dimensions of Personal Travel 3

INTRODUCTION 5

THE DIMENSIONS OF TRAVEL 8

Introduction 8

Population Growth 11

Employment Growth 12

Household Growth 12

Growth in Driver's Licensing and Vehicle Ownership 12

Income 14

Travel Implications 19

DEMOGRAPHIC TRENDS 20

Introduction 20

Minorities 20
- Hispanics 21
- African Americans 22
- Travel Implications 23

The Elderly 23
- Elderly People and Private Vehicles 24
- Residential Patterns 25
- Ethnic and Racial Diversity Among the Elderly 25
- Elderly People and Poverty 26
- Problems in Providing Services to Older People 27
- The Travel Implications of an Aging Society 27

Women 28
- Women in the Labor Force 29
- Married Women 30
- Trip Linking 30
- Single Mothers 31
- Women and Poverty 32
- Travel Implications 33

Economic Trends 34

Introduction 34

The Changing Nature of the Labor Force 34

The Growth of a Service Economy 35
The Flexible Labor Force 36
Working at Home and in the Car 37

The Impact of Economic Trends on Travel 39

Population Movements and Land Use Patterns 40

Inter-Regional Population Patterns 40
Internal Migration 41
External Migration 41

Intra-Regional Population Patterns 42
Overall Trends in Population Growth 42
Concentration of Central City Populations 43

The Character of Neighborhoods 44

Transportation Impact of Population Movements 45

The Implications 47

Chapter 2: Highway, Bridge and Transit System and Usage Characteristics 51

Introduction 53

System Classification 53

Highway Functional Classification System 53
Arterial System 54
Collector System 56
Local Roads and Streets 56

Highway Functional Systems and Tripmaking 56

Highway Classification by Jurisdiction 57

The Proposed National Highway System 58

Transit Functional Services 59
Low-Cost Mobility 59
Congestion Management 59
Livable Metropolitan Areas 60
Transit's Public Policy Functions and Mobility 60

Transit Services and Jurisdiction 61

SYSTEM EXTENT AND CAPACITY 62

Extent 62
Highway 62
Transit 64

Capacity 65

SYSTEM USAGE: TRAVEL TRENDS 68

Highway 68

Transit 72

Chapter 3: Highway, Bridge and Transit Finance 73

INTRODUCTION 75

PUBLIC SECTOR FINANCING 76

Funding by Level of Government 76
Highway 76
Transit 78

Sources of Public Sector Financing 79
Highway 79
Transit 80

CAPITAL AND NONCAPITAL EXPENDITURES 82

Summary of Expenditures 82
Highway 82
Transit 83

Definitions 83

Capital Expenditures 85
Highway 85
Transit 93

Noncapital Expenditures 94
Highway 94
Transit 95

PRIVATE SECTOR FINANCING 98

Highway 98

Transit 98

Chapter 4: Highway, Bridge and Transit System Conditions and Performance 99

INTRODUCTION 101

HIGHWAY AND TRANSIT PERFORMANCE 104

Highway Performance 104
Measuring Highway Performance 104
Urban and Rural Operating Characteristics 106
Peak-Hour Travel 109
Highway Performance in the 33 Most Populous Urbanized Areas 113

Transit Performance 116
User Travel Speed 116
Transfers and Waiting Times 117
Available Seats 118
Travel Times 119

HIGHWAY, BRIDGE AND TRANSIT CONDITIONS 120

Highway Conditions 120
Pavement Condition 120
Highway Alignment and Lane Width 129

Bridge Conditions 132

Transit Conditions 136
Bus and Paratransit Conditions 136
Rail Conditions 142

HIGHWAY SAFETY 146

HIGHWAY ENVIRONMENTAL INDICATORS 148

Transportation Impacts 148

Indicators 148

Performance Data 148
Air Quality 149
Water Quality 150
Wetlands 150
Energy 151
Highway Project Noise Mitigation 152
Land Use/Open Space 153
Threatened and Endangered Species 153
Community Impacts 153

Chapter 5: Highway, Bridge and Transit Future Investment Requirements 155

INTRODUCTION 157

Highway Investment Scenarios 158
Cost to Maintain Conditions and Performance 158
Economic Efficiency 158

Bridge Investment Scenarios 158
Cost to Maintain Conditions 158
Cost to Improve Conditions 159

Transit Investment Scenarios 159
The Cost to Maintain Conditions and Performance 159
The Cost to Improve Conditions and Performance 159

Summary: Highway, Bridge and Transit Investment Scenarios 159

Significant Analytical Advancements and Issues 161

Background 161

Travel Forecasts 162
Highway Performance Monitoring System Travel Forecast Adjustment 163
Implications 163
Strategies to Reduce Highway Vehicle Miles of Travel 167

Highway Economic Requirements System 169

Highway Investment Requirements 172

Analytical Overview 172
Model Input and Output Adjustments 172
Report Coverage: Additional Investment Requirements 173

Investment Scenarios 174
Cost to Maintain Conditions and Performance 174
Economic Efficiency 177

Economic Analysis Issues 180

Bridge Investment Requirements 181

Cost to Maintain Conditions 181

Cost to Improve Conditions 182

Transit Investment Requirements 184

Cost to Maintain Conditions and Performance 184

Cost to Improve Conditions and Performance 186

Comparison of 1994 Investment Requirements with Related 1993 Capital Expenditures 190

Economic Analysis Issues 191

Inclusion of Relevant Benefits and Costs 191
Productivity Improvements 192
Externalities 192

Inefficient Pricing of Facilities 194

Inelastic Demand 194

Value of Travel Time 195

Chapter 6: Waterborne Transportation 197

INTRODUCTION 199

WATERBORNE TRANSPORTATION SYSTEM CHARACTERISTICS 202

World and U.S. Fleets and Their Characteristics 202
Tanker Fleet 203
Dry Bulk Fleet 208
Intermodal Vessels 209
Cruise/Passenger Fleet 212

The U.S. Domestic Fleet and Its Characteristics 213
Dry Cargo Barge Fleet 214
Tank Barge Fleet 215
Towboat/Tugboat Fleet 217
Great Lakes Fleet 217
Ferries 218

Port Infrastructure 218
Deep-Draft Seaport and Great Lakes Port Facilities 218
Inland River and Intracoastal Waterways Port Facilities 220
Port Capital Investment 222

Intermodal Transportation Systems 224

U.S. Shipbuilding and Repair Base and Its Characteristics 225

SYSTEM PERFORMANCE 228

World Oceanborne Trade 228

U.S. Oceanborne Foreign Trade 229
Liner Trades 229
Non-Liner Trades 232
Tanker Trades 233
U.S.-Flag Shares 234
World Fleet 235

U.S. Domestic Trade 236
Great Lakes 237
Inland Waterways 238
Domestic Ocean 239

Port Traffic 239

World Shipyard Production 244

U.S. Shipyard Activity 244

Accomplishments and Innovations 247
Intermodal Services 247
Research and Development 247
Domestic Trade 248
Sealift Support 248

Regulation, Environment and Port Access 249

FEDERAL ROLE 253

Federal Assistance Programs 253
Shipyard Revitalization 253
Financing Programs 254
Operating Assistance 254
Cargo Preference 255
Ports and Domestic Shipping 255
Market Promotion 256
Research and Development 257
Training 257
Economic and National Security Role 258

DEMAND FOR WATER TRANSPORTATION AND SHIPPING CAPACITY 260

World Oceanborne Trade 260

U.S. Oceanborne Trade 261

Demand for Ocean Shipping Capacity 262

SYSTEM INVESTMENT REQUIREMENTS 264

Appendix A: Highway Data 271

INTRODUCTION 273

HIGHWAY PERFORMANCE MONITORING SYSTEM 273

Overview 273
Areawide Data 273
Universe Data 274
Sample Section Data 274

System Description 275
Sampling 275
Stratification 276
Confidence Level 276

Data Use 278
Support For Interstate Maintenance Program Apportionments 278
Statistics 278
Support for Analytical Modeling 278

Data Changes 278

NATIONAL BRIDGE INVENTORY 279

Overview 279

Data Uses 279

Data Contents 280

Future Data Changes 280

Appendix B: Highway Methodology 281

INTRODUCTION 283

HPMS Database 283

Travel Forecasts 284

Cost-to-Maintain 1993 Conditions and Performance Scenario 285

Scenario Objective 285

Model-Based Results 285
Overview: Analytical Process Logic 285
Future Conditions and Performance 285
Deficiency Identification 286
Potential Improvement Identification 288
Potential Improvement Selection 289
Cost Calculations 289

Simulation Procedure Adjustments 290
Peak Spreading Procedure 290
Revisions to the Highway Capacity Manual 290
Transportation System Management 290
Transportation Demand Management 291

Model-Based Requirements: Investment and Capacity 292

Additional Investment Requirements 294
Metropolitan Expansion Requirements 294
Local Roads 295
Defense Highways 295

Final Investment Requirements 296

Economic Efficiency Scenario 298

Scenario Objective 298

Model-Based Results 298
Overview: HERS Logic 298
Simulation Procedure Adjustments 301
Model-Based Investment Requirements 302

Additional Investment Requirements 304

Final Investment Requirements 304

Comparison of 1994 Investments with Related 1993 Capital Expenditures 306

Appendix C: Bridge Methodology 309

Purpose and Scope of the Bridge Needs and Investment Process 311

Investment Requirements Analysis 312

Deficiency Analysis 312
Structurally Deficient 312
Functionally Deficient 312
Functionally Adequate 313

Improvement Selection 313
Structurally Deficient 316
Functionally Deficient 316
Functionally Adequate 316

Look-Ahead Feature 317

Improvement Simulation 318
Replacement 320
Widening 320
Rehabilitation 321
Deterioration Relationships 321
Cost Estimation 322
Replacement 322
Widening 323
Rehabilitation 323

Investment Analysis 324

Analysis Results 325

Conclusion 326

Appendix D: Transit Mehodology 327

Introduction 329

Cost to Maintain 1993 Conditions 330

Bus and Other Non-Rail Services 330
Urban Vehicle Replacement 330

Urban Vehicle Midlife Rebuilds ... 332
Urban Facility Recapitalization ... 332
Rural Vehicle Replacement ... 334
Rural Transit Facilities ... 334
Specialized Service Vehicles ... 335
Specialized Service Facilities ... 336
Costs of Compliance with the Americans with Disabilities Act ... 336
Clean Air Act Amendment/National Energy Policy Act Costs ... 337

Rail Systems ... 342
Rail System Infrastructure Recapitalization ... 342
Rail Vehicle Replacement ... 343
Rail Vehicle Midlife Rebuilds ... 343
Americans with Disabilities Act Costs ... 344

COST TO MAINTAIN PERFORMANCE 345

Amount of Additional Transit Service Required ... 345

Cost of Expanded Existing Rail Services ... 348

Cost to Provide New Fixed Guideway Services ... 348

Cost of Expanded Bus and Paratransit Service ... 349

COST TO IMPROVE CONDITIONS 350

Bus and Other Non-Rail Service ... 350
Urban Vehicle Replacement ... 350
Urban Facility Recapitalization ... 350
Rural Vehicle Replacements ... 351
Rural Transit Facilities ... 352
Specialized Service Vehicle Replacements ... 352
Specialized Service Facilities ... 352

Rail Systems ... 353
Rail System Infrastructure Improvement ... 353
Rail Vehicle Replacements ... 353
Rail Vehicle Midlife Rebuilds ... 354

Cost to Improve Performance (User Costs) 355

Dimensions of Transit Performance to be Improved 355

Increasing Transit Speed 355

Cost to Improve Comfort, Convenience and Door-to-Door Travel Time 357

Cost to Improve Coverage in Rural Areas 358

Development of Improved Information on Transit Capital Requirements 359

List of Exhibits

Introduction and Executive Summary

Exhibit 1
Summary of Highway and Bridge Expenditures XX

Exhibit 2
Summary of Transit Expenditures XX

Exhibit 3
Summary of Highway and Bridge Capital Outlay XXI

Exhibit 4
Summary of Transit Capital Outlay XXII

Exhibit 5
Summary of Highway and Bridge Noncapital Outlay XXIII

Exhibit 6
Summary of Transit Noncapital Outlay XXIV

Exhibit 7
Facilities in Poor Condition, Mileage and Travel, 1993 XXV

Exhibit 8
Daily Vehicle Miles of Travel Per Lane Mile, 1983 and 1993 XXVII

Exhibit 9
Highway Fatality Rates, 1983 and 1993 XXVIII

Exhibit 10
1994 Investment Required for Highways, Bridges, and Transit Systems versus 1993 Capital Outlay XXXII

Chapter 1: The Dimensions of Personal Travel

Exhibit 1-1
Factors Affecting U.S. Travel Patterns 6

Exhibit 1-2
Percent Increase in Various Factors Linked to Travel, 1969-1990 8

Exhibit 1-3
Percent Increase in Person Trips, 1983-1990 9

Exhibit 1-4
Percent Increase in Person Miles, 1983-1990 10

Exhibit 1-5
Licensing Rates Among Men and Women by Age, 1990 13

Exhibit 1-6
Daily Person Trips in Urban Areas, 1990 15

Exhibit 1-7
Urban Daily Person Miles in Urban Areas, 1990 16

Exhibit 1-8
Average Work Trip Length in Urban Areas, 1990 17

Exhibit 1-9
Average Work Trip Length in Rural Areas, 1990 18

Exhibit 1-10
Daily Parameters of Urban Travel, 1990 21

Exhibit 1-11
Average Annual Miles Driven by Driver Age, 1969-1990 24

Exhibit 1-12
Urban Travel Mode for All Trips, 1990 26

Exhibit 1-13
Indicators of Travel by Sex, Income, and Work Status, 1990 29

Exhibit 1-14
Percent of Parents of Children Under Age 6 Who Link Trips Home from Work, 1990 30

Exhibit 1-15
Differences in Urban Average Daily Person Trips by Sex and Selected Lifestyles, 1990 32

Exhibit 1-16
Average Distance Traveled per Trip in Central City, Suburban, and Rural Areas, 1990 43

Exhibit 1-17
Summary of the Impact of Societal Trends on the Amount and Type of Travel 48

Chapter 2: Highway, Bridge and Transit System and Usage Characteristics

Exhibit 2-1
Highway Functional Classification Hierarchy 53

Exhibit 2-2
Percent Highway Miles, Lane-Miles, and Vehicle-Miles Traveled by Functional System, 1993 54

Exhibit 2-3
Highway Mileage by Jurisdiction, 1983-1993 57

Exhibit 2-4
Bridges by Jurisdiction, 1994 58

Exhibit 2-5
Highway and Transit Route Miles by Functional System, 1983-1993 62

Exhibit 2-6
Bridges by Functional System, 1994 63

Exhibit 2-7
Mass Transit Fleet and Infrastructure, 1993 64

Exhibit 2-8
Highway Lane-Miles and Transit System Equivalent Lane-Miles by Functional System, 1983-1993 66

Exhibit 2-9
Highway Vehicle and Passenger Miles of Travel, 1983-1993 68

Exhibit 2-10
Daily Vehicle Miles Traveled per Lane-Mile by Functional System, 1983-1993 69

Exhibit 2-11
Highway Travel by System and Vehicle Type, 1985-1993 71

Exhibit 2-12
Transit Passenger Miles of Travel, 1983-1993 72

Chapter 3: Highway, Bridge and Transit Finance

Exhibit 3-1
Funding for Highways by Government Jurisdiction, 1956-1993 77

Exhibit 3-2
Funding for Transit by Government Jurisdiction, 1956-1993 78

Exhibit 3-3
Revenue Sources for Public Sector Financing of Highways, 1993 79

Exhibit 3-4
Revenue Sources for Public Sector Financing of Transit, 1993 81

Exhibit 3-5
Expenditures for Highways by Function, All Units of Government, 1956-1993 82

Exhibit 3-6
Mass Transit Capital and Operating Expenditures, 1956-1993 84

Exhibit 3-7
Source of Funds for Capital Outlay, 1956-1993 86

Exhibit 3-8
Highway Capital Outlay by Functional System, 1993 87

Exhibit 3-9
Distribution of Capital Outlay on Interstate System by Improvement Type, 1993 88

Exhibit 3-10
Distribution of Capital Outlay on Arterials Other Than Interstate
by Improvement Type, 1993 89

Exhibit 3-11
Distribution of Capital Outlay on Collectors by Improvement Type, 1993 90

Exhibit 3-12
Spending by Major Categories on Nonlocal Roads, 1993 91

Exhibit 3-13
Capital Outlay Related to Condition and Performance
on Nonlocal Roads and Bridges, 1993 92

Exhibit 3-14
Sources of Transit Capital Funds, 1988-1993 93

Exhibit 3-15
Transit Capital Expenditures by Type of Expenditure, Fiscal Year 1993 94

Exhibit 3-16
Mass Transit Operating Expenses by Mode, 1983-1993 96

Exhibit 3-17
Disbursements for Mass Transit Operations by Mode and Function, 1993 97

Chapter 4: Highway, Bridge and Transit System Conditions and Performance

Exhibit 4-1
Levels of Service 105

Exhibit 4-2
Daily Vehicle Miles of Travel per Lane Mile - Rural, 1983-1993 107

Exhibit 4-3
Daily Vehicle Miles of Travel per Lane Mile - Urban, 1983-1993 108

Exhibit 4-4
Percent Highway Mileage by Functional System with Volume to Service Flow Ratio of 0.80 or Greater, 1983-1993 109

Exhibit 4-5
Percent Peak-Hour Travel by Functional System with Volume to Service Flow Ratio of 0.80 or Greater, 1983-1993 110

Exhibit 4-6
Percent Congested and Highly Congested Peak Urban Travel by Functional System, 1993 111

Exhibit 4-7
Percent Interstate Peak-Hour Travel by Volume/Service Flow Range, 1993 112

Exhibit 4-8
Urbanized Areas with Populations Over 1 Million, 1993 113

Exhibit 4-9
Congested Peak-Hour Travel in the 33 Most Populous Urbanized Areas by Functional System, 1993 114

Exhibit 4-10
Selected Summaries by Functional System, All Urban Areas versus 33 Most Populous Urbanized Areas, 1993 115

Exhibit 4-11
Passenger-Mile Weighted Average Speed by Transit Mode, 1984-1993 116

Exhibit 4-12
Percentage of Transit Riders Waiting Less than 5 or 10 Minutes, by Transit Function, 1993 117

Exhibit 4-13
Percentage of Transit Riders Who Must Transfer, by Transit Function, 1993 117

Exhibit 4-14
Percentage of Transit Riders with Available Seat by Transit Function, 1990 118

Exhibit 4-15
Percentage of Transit Riders by Trip Time and Transit Function, 1990 119

Exhibit 4-16
Present Serviceability Rating 121

Exhibit 4-17
Pavement Condition and Roughness Definitions 122

Exhibit 4-18
Percent Mileage by Functional System and Pavement Condition Category, 1993 123

Exhibit 4-19
Percent Travel by Functional System and Pavement Condition Category, 1993 124

Exhibit 4-20
Miles by Pavement Condition, 1993 125

Exhibit 4-21
Percent Highway Mileage by Pavement Condition, Functional System, and Year, 1993 126

Exhibit 4-22
Distribution of Pavement Roughness for Principal Arterial System, 1993 128

Exhibit 4-23
Percent Rural Highway Mileage by Alignment Adequacy and Functional System, 1993 130

Exhibit 4-24
Percent Rural Mileage and Travel by Lane Width and Functional System, 1993 131

Exhibit 4-25
Percent Urban Mileage and Travel by Lane Width and Functional System, 1993 131

Exhibit 4-26
Interstate Bridge Deficiencies, 1990-1994 132

Exhibit 4-27
Other Arterial Bridge Deficiencies, 1990-1994 133

Exhibit 4-28
Collector Bridge Deficiencies, 1990-1994 134

Exhibit 4-29
Average Overall Bridge Conditions, 1994 135

Exhibit 4-30
Number of Overage Vehicles and Average Vehicle Age in Urban Transit, 1985-1993 137

Exhibit 4-31
Number of Overage Vehicles and Average Fleet Age in Rural and Special Service, 1994 ... 138

Exhibit 4-32
Definitions of Urban Bus Maintenance Facility Conditions 139

Exhibit 4-33
Condition of Urban Bus Maintenance Facilities, 1992 140

Exhibit 4-34
Age of Bus Maintenance Facilities, 1992 140

Exhibit 4-35
Condition of Rural Bus Maintenance Facilities, 1992 141

Exhibit 4-36
Rail Condition Criteria and Definitions 142

Exhibit 4-37
Physical Condition of U.S. Transit Rail Systems, 1984 and 1992 143

Exhibit 4-38
Rail Transit Overage Vehicles and Average Fleet Age, 1985-1993 144

Exhibit 4-39
Rural Highway Fatality Rates, 1983-1993 146

Exhibit 4-40
Urban Highway Fatality Rates, 1983-1993 147

Exhibit 4-41
Percent Improvement in Emissions Reductions, 1984-1993 149

Exhibit 4-42
Changes in Highway Gasoline Usage, 1970-1993 151

Chapter 5: Highway, Bridge and Transit Future Investment Requirements

Exhibit 5-1
Summary of Highway, Bridge, and Transit Annual Investment Requirements, 1994-2013 .. 160

Exhibit 5-2
Estimated Highway Travel Growth Rates, 1994-2013 164

Exhibit 5-3
33 Most Populous Urbanized Areas, Daily Vehicle Miles of Highway Travel, Actual versus Projected, 1980-2013 165

Exhibit 5-4
33 Most Populous Urbanized Areas, Annual Transit Passenger Miles of Travel, Actual versus Projected, 1984-2013 166

Exhibit 5-5
33 Most Populous Urbanized Areas, Growth in Vehicle Miles of Travel, Assuming Gradual Reduction in Travel 167

Exhibit 5-6
Economics-Based Approach to Highway Investments, Schematic 170

Exhibit 5-7
Application of Model Adjustments, AP-Based Cost to Maintain, Urban Lane-Mile Requirements 173

Exhibit 5-8
Cost to Maintain 1993 Highway Conditions and Performance, Investment Requirements, 1994-2013 175

Exhibit 5-9
Cost to Maintain 1993 Highway Conditions and Performance Scenario, Lane-Mile Requirements, 1994-2013 176

Exhibit 5-10
Economic Efficiency Scenario, Investment Requirements, 1994-2013 178

Exhibit 5-11
Economic Efficiency Scenario, Lane-Mile Requirements, 1994-2013 179

Exhibit 5-12
Cost to Maintain Bridge Conditions, 1994-2013 181

Exhibit 5-13
Cost to Improve Bridge Conditions, 1994-2013 183

Exhibit 5-14
Cost to Maintain Transit Conditions and Performance, Annual Average, 1994-2013 185

Exhibit 5-15
Cost to Maintain Conditions and Performance by Transit Function, 1994-2013 186

Exhibit 5-16
Cost to Improve Transit Conditions and Performance, 1994-2013 187

Exhibit 5-17
Cost to Improve Transit Conditions and Performance by Function, 1994-2013 188

Exhibit 5-18
Urban Transit Fleet Requirements, Cost to Maintain and
Cost to Improve Scenarios, 1994-2013 189

Exhibit 5-19
1994 Investment Required for Highways, Bridges, and Transit Systems
versus 1993 Capital Outlay 190

Chapter 6: Waterborne Transportation

Exhibit 6-1
Merchant Fleets of the World, Top 20 Flags by Ship Type, 1995 202

Exhibit 6-2
Age Distribution of World Tanker Fleet by Size, 1995 204

Exhibit 6-3
Age Distribution of U.S.-Flag Tanker Fleet by Size, 1995 205

Exhibit 6-4
World Tanker Fleet Phase-Out Due to the Oil Pollution Act of 1990 and
International Maritime Organization Double Hull Requirements, 1995-2005 206

Exhibit 6-5
Jones Act Tanker Fleet Phase-Out Due to the Oil Pollution Act of 1990
and International Maritime Organization Double Hull Requirements, 1995-2015 207

Exhibit 6-6
Age Distribution of World Dry Bulk Fleet by Size, 1995 208

Exhibit 6-7
Age Distribution of U.S.-Flag Dry Bulk Fleet by Size, 1995 208

Exhibit 6-8
Age Distribution of U.S.-Flag Containership Fleet by Size, 1995 209

Exhibit 6-9
Size Distribution of Containerships in East-West and Other Trades, 1995 210

Exhibit 6-10
Age Distribution of World Containership Fleet by Size, 1995 211

Exhibit 6-11
Age Distribution of World Roll-on/Roll-off Fleet by Size, 1995 211

Exhibit 6-12
Age Distribution of U.S.-Flag Roll-on/Roll-off Fleet by Size, 1995 212

Exhibit 6-13
Age Distribution of World Cruise/Passenger Fleet by Size, 1995 212

Exhibit 6-14
Domestic Fleet by Area of Deployment and Selected Vessel Type, 1993 213

Exhibit 6-15
Age Distribution of Domestic Dry Cargo Barge Fleet by Area of Deployment, 1993 214

Exhibit 6-16
Age Distribution of Domestic Tank Barge Fleet by Area of Deployment, 1993 215

Exhibit 6-17
Domestic Tank Barge Fleet Phase-Out Due to the Oil Pollution Act of 1990, 1993 216

Exhibit 6-18
Age Distribution of Domestic Tug/Towboat Fleet by Area of Deployment, 1993............ 217

Exhibit 6-19
Age Distribution of Great Lakes Self-Propelled Fleet, 1993 217

Exhibit 6-20
Age Distribution of Domestic Ferry Fleet by Area of Deployment, 1993 218

Exhibit 6-21
U.S. Seaport Terminals by Berth Type and Coastal Region, 1993 219

Exhibit 6-22
U.S. Inland Waterway/Riverport Terminal Facilities by State, 1993 220

Exhibit 6-23
U.S. Port Capital Expenditures, 1990-1993 222

Exhibit 6-24
U.S. Port Capital Expenditures by Type of Facility, 1993 223

Exhibit 6-25
Major U.S. Shipbuilding and Repair Bases, 1994 225

Exhibit 6-26
Location of Major Shipbuilding and Repair Facilities in the United States, 1994 226

Exhibit 6-27
Private Shipyard Drydocking Facilities, 1994 227

Exhibit 6-28
World Oceanborne Trade, 1985-1994 228

Exhibit 6-29
U.S. Oceanborne Foreign Trade by Type Service, 1994 229

Exhibit 6-30
U.S. Liner Trade by Major Route, 1988-1994 230

Exhibit 6-31
U.S. Containerized Liner Trade by Route, 1994 231

Exhibit 6-32
U.S.-Far East Liner Trade by Coast, 1970-1994 232

Exhibit 6-33
U.S. Non-Liner Trade by Major Route, 1988-1994 233

Exhibit 6-34
U.S. Tanker Trade by Major Route, 1988-1994 234

Exhibit 6-35
U.S.-Flag Shares of U.S. Oceanborne Trade, 1970-1994 235

Exhibit 6-36
World Merchant Fleet that Called at U.S. Ports, 1994 236

Exhibit 6-37
Domestic Waterborne Commerce of the United States, 1987-1993 236

Exhibit 6-38
Domestic Waterborne Commerce of the United States, Great Lakes, 1987-1993 237

Exhibit 6-39
Domestic Waterborne Commerce of the United States, Inland Waterways, 1987-1993 238

Exhibit 6-40
Waterborne Commerce of the United States, Domestic Ocean, 1987-1993 239

Exhibit 6-41
Top 50 U.S. Ports, Waterborne Commerce of the United States, 1993 240

Exhibit 6-42
Top 25 U.S. Container Ports, 1993 and 1994 242

Exhibit 6-43
Top 20 U.S. Ports, Port Calls by Vessel Type, 1994 243

Exhibit 6-44
Shipbuilding Orderbook by Country of Build, 1995 244

Exhibit 6-45
U.S. Merchant Shipbuilding Orderbook,
Ships of 1,000 Gross Tons and Over, 1976-1995 245

Exhibit 6-46
Second-Tier Shipyards, New Construction Acitivity, Number of Vessels, 1984-1993 246

Exhibit 6-47
World Oceanborne Trade, 1985-2005 260

Exhibit 6-48
U.S. Oceanborne Trade, 1985-2005 261

Exhibit 6-49
World Fleet Forecast by Vessel Type, 1985-2000 263

Exhibit 6-50
Capital Investments, U.S. Shipbuilding and Repair Industry, 1985-1995 265

Exhibit 6-51
Newbuilding Demand, 1995-2000 266

Exhibit 6-52
Newbuilding Orderbook by Type, 1995 267

Exhibit 6-53
U.S. Port Capital Expenditures by Type of Facility, 1994-1998 268

Exhibit 6-54
Expenditures for Operations and Maintenance Dredging, Fiscal Years 1993-1998............ 270

Appendix A: Highway Data

Exhibit A-1
Highway Performance Monitoring System Database,
Confidence Levels for Each Volume Strata 277

Appendix B: Highway Methodology

Exhibit B-1
Highway Performance Monitoring System Analytical Process,
Cost to Maintain 1993 Conditions and Performance,
Rural Minimum Conditions Standards 286

Exhibit B-2
Highway Performance Monitoring System Analytical Process,
Cost to Maintain 1993 Conditions and Performance,
Urban Minimum Conditions Standards 288

Exhibit B-3
Cost to Maintain 1993 Highway Conditions and Performance Scenario;
Investment Requirements; HPMS Results—Does Not Include Metropolitan Expansion,
Local Road, or Incremental Defense Requirements, 1994-2013 292

Exhibit B-4
Cost to Maintain Highway Conditions and Performance Scenario; Lane-Mile Requirements;
HPMS Results—Does Not Include Metropolitan Expansion, Local Road,
or Incremental Defense Requirements; 1994-2013 293

Exhibit B-5
Metropolitan Expansion Lane-Mile Requirements, 1994-2013 294

Exhibit B-6
Cost to Maintain 1993 Conditions and Performance; Investment Requirements;
Includes Metropolitan Expansion, Local Road, and
Incremental Defense Requirements, 1994-2013 296

Exhibit B-7
Cost to Maintain 1993 Highway Conditions and Performance Scenario;
Lane-Mile Requirements; Includes Metropolitan Expansion, Local Road, and
Incremental Defense Requirements, 1994-2013 297

Exhibit B-8
Highway Economic Requirements System, Economic Efficiency Scenario,
Rural Minimum Conditions Standards 298

Exhibit B-9
Highway Economic Requirements System, Economic Efficiency Scenario, Urban Minimum Conditions Standards 300

Exhibit B-10
Economic Efficiency Scenario; Investment Requirements; HERS Results—Does Not Include Metropolitan Expansion, Local Road, or Incremental Defense Requirements; 1994-2013 302

Exhibit B-11
Economic Efficiency Scenario; Lane Mile Requirements; HERS Results—Does Not Include Metropolitan Expansion, Local Road, or Incremental Defense Requirements; 1994-2013 30

Exhibit B-12
Economic Efficiency Scenario; Investment Requirements; Includes Metropolitan Expansion, Local Road, and Incremental Defense Requirements; 1994-2013 304

Exhibit B-13
Economic Efficiency Scenario; Lane-Mile Requirements; Includes Metropolitan Expansion, Local Road, and Incremental Defense Requirements; 1994-2013 305

Exhibit B-14
1994 Investment Required for Highways (All Systems, Including Local) versus 1993 Capital Outlay 306

Exhibit B-15
Annual Cost to Maintain Conditions and Performance (All Systems), 1994-2013 307

Exhibit B-16
Annual Economic Efficiency Investment Requirements (All Systems), 1994-2013 308

Appendix C: Bridge Methodology

Exhibit C-1
Criteria for Structurally Deficient Bridges 313

Exhibit C-2
Bridge Width: Minimum Tolerable Conditions 314

Exhibit C-3
Vertical Clearance: Minimum Tolerable Condition 315

Exhibit C-4
Condition Deficiencies for Functionally Adequate Structures 315

Exhibit C-5
Design Standards: Bridge Load Capacity, Rural and Urban 318

Exhibit C-6
Design Standards: Bridge Width Default Values 319

Exhibit C-7
Design Standards: Vertical Clearance 320

Exhibit C-8
Bridge Deterioration Equation 321

Appendix D: Transit Methodology

Exhibit D-1
Number of Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle; Cost to Maintain Conditions and Performance; 1994-2013 331

Exhibit D-2
Number of Rural Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle; Cost to Maintain Conditions and Performance Scenario; 1994-2013 335

Exhibit D-3
Number of Specialized Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle Cost to Maintain Conditions and Performance Scenario; 1994-2013 335

Exhibit D-4
Conversion to Alternative Fuels, Average Annual Incremental Costs, 1994-2013 339

Exhibit D-5
Incremental Estimates per Vehicle and Facility 341

Exhibit D-6
Number of Rail Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle; Cost to Maintain Conditions and Performance Scenario; 1994-2013 343

Exhibit D-7
Number of Long-Range Plans and Transportation Improvement Programs Reviewed to Develop Transit Travel Demand Forecasts 345

Exhibit D-8
Transit Travel Growth Estimates from Analysis of Metropolitan Planning Organization Long-Range Plans and Transportation Improvement Programs Compared to Actual Experience, 1983-2013 346

Exhibit D-9
Type of Transit Service Assumed by Urbanized Area Size and Type and Location within Urbanized Areas; Cost to Maintain Conditions and Performance Scenario; 1994-2013 ... 347

Exhibit D-10
Average Annual Increase in Transit Travel Demand by Service Type; Cost to Maintain Conditions and Performance Scenario; 1994-2013 347

Exhibit D-11
Type of Transit Service Assumed by Urbanized Area Size and Type and Location within Urbanized Areas; Cost to Improve Conditions and Performance Scenario; 1994-2013 356

Exhibit D-12
Average Annual Increase in Transit Travel Demand by Service Type; Cost to Maintain Conditions and Performance Scenario; 1994-2013 356

List of Acronyms and Abbreviations

3R	Restoration, Rehabilitation and Resurfacing
AADT	Average Annual Daily Traffic
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
AP	Analytical Process
APTA	American Public Transit Association
BCA	Benefit/Cost Analysis
BNIP	Bridge Needs and Investment Process
C&P Report	Status of the Nation's Surface Transportation System: Conditions and Performance Report to Congress
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CCF	Capital Construction Fund
CNG	Compressed Natural Gas
COFR	Certificate of Financial Responsibility
CTAA	Community Transportation Association of America
DOD	Department of Defense
DOT	Department of Transportation
DVMT	Daily Vehicle Miles of Travel
DWT	Deadweight Tonnage
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FY	Fiscal Year
GMIS	Grants Management Information System

List of Acronyms

GRT	Gross Registered Tons
HCM	Highway Capacity Manual
HERS	Highway Economic Requirements System
HPMS	Highway Performance Monitoring System
IMO	International Maritime Organization
IRI	International Roughness Index
ISO	International Standards Organization
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
IWTF	Inland Waterway Trust Fund
JIT	Just-In-Time
LNG	Liquefied Natural Gas
LOS	Level of Service
LRTP	Long Range Transportation Plan
MARAD	Maritime Administration
MCS	Minimum Condition Standard
MPO	Metropolitan Planning Organization
MPRSA	Marine Protection Research and Sanctuaries Act
MSA	Maritime System of the Americas
MSP	Maritime Security Program
MTC	Minimum Tolerable Condition
NAAQS	National Ambient Air Quality Standards
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NEPA	National Environmental Policy Act
NHS	National Highway System

List of Acronyms

NOx	Nitrogen Oxides
NPTS	Nationwide Personal Transportation Survey
NSI	National Shipbuilding Initiative
ODS	Operating-Differential Subsidy
OECD	Organization for Economic Cooperation and Development
OPA-90	Oil Pollution Act of 1990
PM-10	Particulate Matter
PSR	Pavement Serviceability Rating
PTMS	Public Transportation Facilities and Equipment Management Systems
RO/RO	Roll-On/Roll-Off
RRF	Ready Reserve Fleet
RTW	Round-the-World
SBT	Segregated Ballast Tanks
SOLAS	Safety of Life at Sea Convention
STRAHNET	Strategic Highway Network
TDM	Transportation Demand Management
TEU	Twenty-Foot Equivalent Units
TIP	Transportation Improvement Program
TSM	Transportation Supply Management
U.S.	United States
UZA	Urbanized Area
VMT	Vehicle Miles Traveled
VLCC	Very Large Crude Carriers
V/SF	Volume to Service Flow

Introduction and Executive Summary

INTRODUCTION

THIS IS THE SECOND IN A SERIES of combined documents satisfying statutory requirements for reports by the Department of Transportation to Congress on the condition, performance, and capital investment requirements of the Nation's highway and transit systems. This report also includes detailed information on the maritime industry. Since 1968, highway reports have been submitted in alternate years in accordance with Section 307(h) of Title 23 United States Code (U.S.C.). Beginning in 1984, transit reports have been submitted every other year in accordance with Section 308(e) of Title 49 U.S.C. Maritime reports are not statutorily required.

Beginning in 1993, the Department presented its first combined highway/transit condition and performance report. As with previous single mode reports, the combined 1993 version provided detailed information on system usage characteristics, finance, condition and performance, and future investment requirements, for all of the Nation's highways, bridges, and transit systems. The current 1995 version of the report series continues that tradition, and expands the discussion to include the Nation's maritime system.

In this spirit of multimodal analysis and in recognition of the complementary nature of the modes and the rapid growth in intermodalism, the Department will produce specifications for a fully integrated condition and performance report in 1996 and will develop integrated system performance measures that can be tracked and reported over time. Such a report will provide a strategic overview of system performance, but it will not preclude the need for more detailed, mode specific reports, such as the one you are currently reading. The Department will continue submitting individual or combined modal reports to provide more modal specificity than can be provided in a broader, fully integrated transportation report.

To supplement this broader departmental effort, the Federal Highway Administration (FHWA) and Federal Transit Administration have begun development of an integrated framework for considering highway/transit investment options. This integrated framework anticipates conducting future analyses with a single set of analytical tools. It is expected that the 1997 version of this report will include a detailed discussion of various integrated methodologies for investment analysis, and that such a methodology will be used as the basis for combined highway/transit investment analyses in future reports.

Previous versions of this report have relied on engineering-based estimates for future investment requirements. In the case of highway analysis, the State transportation agencies provided future travel forecasts. Those forecasts were analyzed using a computer simulation of the impact of traffic on pavement and capacity deterioration. Using a set of minimum standards that reflect established engineering practices of cost effectiveness and safety, the future demand was translated into pavement and capacity deficiencies. Associated with each deficiency or combination of deficiencies was a preferred improvement to rectify the deficiency, again based on good engineering judgment.

Previous reports identified the "cost to maintain" conditions and the "cost to improve" conditions. The first was an estimated annual cost to keep the system functioning at its current level and the second, the estimated annual cost to bring the system up to a specified level of condition and performance. The specified levels of condition and performance were measured as changes in a composite index, a scale that considers a combined index of physical conditions, safety, and operating characteristics. Both transit and bridge analysis were conducted using similar principles of asset replacement and improvement to meet a level of future demand at specified levels of condition and performance, always in keeping with accepted engineering practice or asset replacement practice as specified by the appropriate State or Federal agency. Economic analysis was not applied in the development of such infrastructure estimates.

This philosophy of infrastructure assessment places emphasis on the impact users have on the system, that is, the cost imposed on transportation agencies of satisfying user service demands. This approach to infrastructure analysis provides useful benchmarks for achieving definable levels of condition and performance, and treats infrastructure as a depreciating asset that requires periodic investment to maintain or improve serviceability.

This philosophy, however, fails to provide another critical dimension of transportation programs; that is, to provide service to users while minimizing overall cost. The Congress noted the need for this perspective in a letter to the Department acknowledging receipt of the 1989 version of this report by urging the Department to "...accelerate its efforts to examine the costs, benefits and national economic implications associated with a broad array of investment options."

In January 1994, the President issued Executive Order 12893, Principles for Federal Infrastructure Investments, which directed each executive department and agency with infrastructure responsibilities to base investments on "...systematic analysis of expected benefits and costs, including both quantitative and qualitative measures...."

In anticipation of these concerns, the FHWA began developing a new simulation procedure in 1988, the Highway Economic Requirements System (HERS), that uses marginal benefit/cost analysis to optimize highway investment. This new procedure is described in great detail in Chapter 5 and Appendix B. HERS addresses highway deficiencies by quantifying the agency and user costs of various types and combinations of improvements, each subjected to a rigorous benefit/cost analysis that considers vehicle operating, travel time, and safety costs. The HERS minimizes the combination of capital investment and user costs to achieve different levels of highway performance.

The HERS extends the traditional engineering-based means of considering infrastructure investment strategies by evaluating the impact of highway condition and performance on highway users, as well as the impact of users on highway performance. However, the current version of HERS has a number of significant limitations, including the failure to consider external costs. Also, the HERS results do not replicate the actual investment decisions that would be made by individual States and local agencies in establishing their highway programs. Each State and local government applies a variety of factors in determining highway investment priorities. The actual resulting investment levels, patterns, and effects, when aggregated over the entire Nation, will differ from those calculated by HERS. The HERS results, however, provide a useful benchmark measure of highway investment estimates.

The bridge analysis continues to use engineering asset replacement techniques, although benefit/cost procedures are being developed and will be introduced in the 1997 version of this report. The transit analysis also continues to use engineering asset replacement techniques, although benefit/cost procedures were used to validate some aspects of the investment scenarios and establish certain unit costs. More complete benefit/cost procedures are being developed and will also be implemented in the 1997 report.

The introduction of the HERS methodology for highway analysis is one of two significant changes in this version of the report. The other major change concerns assumptions regarding future travel demand in major metropolitan areas.

In past reports, the investment requirements have been estimated based on the cost of accommodating State supplied forecasts of travel demand. Estimates of new capacity requirements were made to satisfy the demand forecast, while maintaining or improving the quality of service provided. Although the concepts of demand and system management were introduced in the 1991 and 1993 versions, the basic travel demand forecasts were accepted as given.

Historically, the major influence on travel demand has been the strength of the economy, with higher economic growth mirrored in higher travel demand. However, although such estimates provided useful information to decisionmakers on investment strategies and performance implications, they do not directly consider the impact of changes in the policy environment, other than economic growth, which could affect future demand. For example, the Clean Air Act Amendments of 1990 call for substantial efforts to ensure environmental quality, some of which could result in slower growth in automobile travel levels, compared to historic levels.

Other national policies (for example, efforts to reduce greenhouse gas emissions) could affect future demand through measures such as the proposal to require employers to offer cash as an alternative to employer-provided parking. Similarly, in some urbanized areas there is evidence of changing patterns of demographics and life styles which would result in different travel demand patterns than in the past. All of these factors lead to a degree of uncertainty about the future direction for travel demand, particularly in larger urbanized areas.

In the face of this challenging environment, decisionmakers are seeking tools to maintain national mobility by managing travel demand. Some of these tools are already in place. For example, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) permits unprecedented flexibility by local decisionmakers in the use of Federal surface transportation assistance. ISTEA goes further than just providing funding flexibility by fostering a new intermodal way of looking at transportation problems.

Through enhanced requirements for Statewide and metropolitan transportation planning, State and local decisionmakers are being asked to manage the existing transportation infrastructure more efficiently, as well as to look at transportation from an intermodal standpoint, rather than on a mode-by-mode basis.

In keeping with the ISTEA mandate to consider these expanded perspectives, this report relies on travel forecasts for metropolitan areas that reflect the current and expected policies adopted locally to manage and satisfy future travel demand. The travel forecasts used in developing investment estimates in this report are a combination of forecasts made available through both the State transportation agencies, as well as the Metropolitan Planning Organizations (MPOs), urbanized area planning entities that assume a considerable degree of transportation planning and programming authority under provisions of the ISTEA.

These travel forecasts consider a broad range of transportation options to address demand. Some mobility and connectivity needs can best be met by highway investments, particularly in rural areas, for intercity connections and international connections. This is also true in parts of metropolitan areas where additional highway capacity is needed to respond to travel demand increases due to changing lifestyles and roles within households which may result in multiple trips currently accessible only by auto travel (e.g., "trip chaining"). Further, suburban expansion, a continuing trend in many urbanized areas, will require additional basic highway infrastructure, as lower densities and deconcentrated employment and shopping opportunities demand an auto oriented system.

Others may be best satisfied by new investments in conventional transit or other means of increasing transport system productivity through the use, for example, of ridesharing, paratransit, specialized service to the elderly and to those with disabilities, intermodal freight, and a host of options tailored to meet the particular demands of individual communities. The promise of ISTEA is the move toward true intermodality and away from the traditional "either/or" approach of highway and transit investment. The strength of intermodality is the ability of States and local governments to choose the best solutions for the appropriate situation from an array of transportation options.

The demand forecasts used in this report for the urbanized areas of greater than 1 million population, and the investment requirements derived from them, address how such measures and effects could influence the transport requirements over the next twenty years. Chapter 1 provides a highly detailed examination of travel characteristics from a personal, rather than a systemic, perspective. It clearly indicates that demographic and employment factors are continually changing to meet the demands of a changing society. This increasing degree of uncertainty about our future significantly impacts our ability to plan for the Nation's transport service requirements.

The development of accurate travel forecasts, particularly in a changing environment, is a complicated process and the results could vary upward or downward by a considerable amount. For example, recent trends in certain factors could indicate lower transit travel than projected in this report. Such trends include increases in autos per household, the percent of adults with driver's licenses, and workers using single occupant vehicles for their commute trips, and decreases in transit share among the young, the old, the poor, and women, which in the past have been major sources of transit use.

On the other hand, the assumed transit share is likely to be affected by urban travelers' reactions to increased highway congestion, the availability, cost and quality of the transit service provided, and initiatives that may be taken to influence travel demand. These may include such items as changes in the tax treatment of employer-provided parking and local efforts to comply with the Clean Air Act Amendments. In fact, the MPO travel forecasts and the resulting investment estimates presume that some of these demand-shaping measures will be in place. The resulting investment requirement estimates suggest what could be done to provide the transit capacity needed to accommodate demand that would be shaped by these measures.

The resulting estimates of highway and transit investment requirements represent benchmarks as in past reports, but of a different kind, more appropriate to the philosophy inherent in ISTEA. They provide a first estimate of the costs of accommodating the overall demand for mobility, but at the same time assume that demand will be managed to ensure that the transportation system is sensitive to other important national and regional priorities.

THE DIMENSIONS OF PERSONAL TRAVEL

This section examines the dimensions of personal travel, identifies important economic and demographic trends and links them to changes in travel behavior. The potential impact of these trends, should they persist, on future highway, bridge and transit system requirements is explored.

The Dimensions of Travel

Substantial increases in population have caused the aggregate number of trips made and miles traveled to increase. However, from 1969 through 1990 the total number of trips taken by all Americans grew at a rate three times as fast as the growth in population. Almost every segment of society increased its trips and mileage between 1983 and 1990; the largest increases in both miles and trips were by women and older people. While much of the change in travel has been due to the substantial increase in population, other factors, such as those listed below, have had a significant impact on travel growth.

Employment Growth

Since 1960, the United States has experienced a 1.8 percent yearly increase in jobs. As people gain jobs they increase the number of trips they take and the miles they cover.

Smaller Households

Between 1969 and 1990 the number of American households grew 49 percent while the population grew only 21 percent. The largest share of the increase was accounted for by single-person and single-parent households. The growth in the number of households is significant because a baseline amount of trips and travel is required to maintain a household unit.

Growth in Driver's Licensing and Vehicle Ownership

Between 1969 and 1990, the number of licensed drivers went up almost 60 percent and people drove further and more often than people in the past. During the same period the number of household vehicles increased 128 percent and the average number of vehicles per household rose from 1.16 to 1.77.

Travel Behavior: Demographic Trends

Minorities

Large and growing numbers of the U.S. population are from diverse cultural, racial, or ethnic backgrounds. Not all of these groups have the same employment opportunities, skill levels, or educational attainment—and these differences are reflected in income and labor force participation rates, which in turn impacts the amount and type of travel.

Hispanics. Since 1980, the number of Hispanic workers has increased 65 percent—four times the rate of non-Hispanic workers—and a substantial expansion is expected as the Hispanic population continues to grow. Hispanics have experienced high unemployment, are overrepresented in low-paying jobs, and have high poverty rates; each of which impacts their access to and use of transportation.

African Americans. Between 1990 and 2000, African American employment is expected to grow between 10 percent and 20 percent so that these workers will comprise as much as 20 percent of the entire U.S. labor force. African Americans have had higher rates of unemployment and have remained unemployed longer than other workers. Further, the ratio of African American to White income has fallen from 61 percent of White income in 1969 to 56 percent at the present.

The Elderly

The elderly are the fastest growing age component of the U.S. population. They take more and longer trips, are largely dependent on the private car, and may face serious mobility losses when they can no longer drive.

Elderly People and Private Vehicles. Most older people today are drivers; between 1983 and 1990, the increase in licensing among older men and women was substantial.

Residential Patterns. The travel patterns of older people are strongly influenced by residential patterns. Most older people age in the places they lived while working; increasingly these are low density suburban or rural communities.

Elderly People and Poverty. In 1990, two out of every five households living in poverty were headed by an older person. Many poor elderly are single women, often minorities, living alone.

Ethnic and Racial Diversity Among the Elderly. The diversity of America is increasingly being reflected in the makeup of the elderly. The travel patterns of American elders varies by ethnic and racial background. For example, in 1990, Whites and Hispanics were much more dependent on the private car and much less dependent on walking or public transit than African Americans or older people from other ethnic backgrounds.

Women

Today women account for close to half of those in paid employment. The ways in which salaried women balance their household and employment responsibilities create substantially greater and different impacts on the modes they choose, the hours they travel, the routes they take, and how they organize and combine their out-of-home activities. Working women generally make more trips than comparable men, even though men usually travel more miles than women, except at low incomes.

Trip Linking. Because they retain multiple responsibilities when they enter the paid labor force, women often "link" trips together, dropping children at daycare on the way to work or going grocery shopping on the way home. As a result of trip linking, women may take longer to make a shorter home-to-work trip, and may be more dependent on the car to do so.

Women and Poverty. It appears that women, particularly low-income women who head households, may be disproportionately impacted by the growing suburbanization of jobs. Many reside in more central locations but must commute out to the suburbs for employment. These women have longer commutes than their incomes would indicate and are more often forced to make those trips in a car. As a result many low-income women drive, spending a considerable and disproportionate part of their incomes to maintain a car.

Travel Behavior: Economic Trends

The Growth of a Service Economy

In the U.S. the total number of service sector jobs grew 73 percent from 1970 to 1990 while those in manufacturing grew only 2 percent and jobs in agriculture fell 6 percent. Retail trade will soon replace manufacturing as the second largest source of total U.S. employment. The growth of the service sector economy may impact travel patterns and the demands on our transportation systems by changing the schedules that employees work, the destinations to which they travel, the routes they take, or their income and other resources they own.

The Changing Nature of the Labor Force

In 1992 there were 20 million more people employed than there had been a decade earlier. And in the next 10 years, projections show that 26 million new jobs will be added to the U.S. economy. Most of the job growth will be in service rather than production industries. In addition, the composition of the labor force is changing in important ways. Minorities of all kinds are increasing their share of the labor force, changing the racial and ethnic composition of the entire labor force. And, women continue to enter in unprecedented numbers.

The Flexible Labor Force

A key component of the service sector is the flexible labor force, which contains as much as one-fourth of all American workers. The flexible labor force consists of those in temporary employment, those working variable schedules, those having multiple employers (including contract workers), and those who work less than 35 hours to 40 hours per week. With an expanding flexible workforce comes an expanding variety of work schedules and trip patterns.

Working at Home

Two related employment trends within the flexible workforce have strong transportation implications: people who run businesses at home and people who telecommute to work. Both trends create patterns that differ from traditional commutes. Most of those who work at home will change the nature, routing and timing of their trips, in ways that are difficult to predict. They may reduce their total number of trips or the miles they cover—or, they may make longer non-work trips or move much further from their workplace, "using up" any mileage saved on the days they don't report to an external job site.

Travel Behavior: Population Movements and Land Use Patterns

There have been significant changes in the distribution of the U.S. population across the country, within regions, and within metropolitan areas. The internal migration of the population (to the west and south), combined with concentration of immigrants from abroad in a limited number of States, combined with the rapid suburbanization of homes and jobs, have been linked to major growth in suburb-to-suburb and reverse commutes as well as increased distances between home and all trip purposes.

Implications for Future System Requirements

The major societal trends discussed above appear to have affected certain groups in society differently. Women of all ages have different travel patterns than men of the same age group, the elderly have different travel patterns than younger people, while immigrants and those from racial and ethnic minorities appear to have different travel patterns than the majority culture.

Some of these differences are the result of historical trends and patterns which may not continue. However, some of the differences may be deeply rooted in the way families organize themselves, assign responsibilities to various members, and view their neighborhoods. If so, such differences may strengthen in the future.

Those differences that result from income or occupational disparities are equally important—if the underlying conditions are likely to persist. If a substantial subset of older women continue to be poor, or immigrants to have low-paying jobs, or minority women to be single parents, the resulting travel differences will continue to affect our highways and transit systems.

Future travel behavior will also be impacted by a host of governmental policies, from transport policies which affect parking rates and gasoline taxes to local land use regulations which require the separation of residential and commercial properties. Many of the factors that contributed to the rapid increase in automobile travel in the recent past may level off or even decline in the next decade, leading to a possible reduction in the rate of growth of travel.

Overall, the trends identified have created longer worktrip commutes, dispersed and generally lower density workplaces, new and decentralized employment locations, and different and variable employment schedules.

Because certain groups are disproportionately affected by the trends just discussed; they are likely to make more trips, make longer trips, make trips only to chauffeur children, and link trips together. This is particularly true in the case of working women with children and those living in the central city.

These changes in travel patterns, if they persist, will potentially have significant impacts on the Nation's highway and transit systems by lengthening the peak periods, causing greater dispersion of travel demand, increasing the destinations to which people travel, creating congestion in new time periods or along different routes, and creating patterns difficult to serve with transit or other alternatives to driving alone.

HIGHWAY, BRIDGE AND TRANSIT SYSTEM AND USAGE CHARACTERISTICS

This section contains information regarding system and usage characteristics for highways, bridges, and transit. Descriptive information on the highway and transit functional classification system is provided. In addition, highway and transit extent, capacity, and travel trends are examined.

System Classification

Highway

All public roads and streets in the United States are functionally classified by type and use. There are three major functional systems: arterials, collectors, and local roads. These major systems are further subdivided into both rural and urban areas.

Functional classification is not necessarily an indication of highway ownership. Nationwide, States have jurisdictional responsibility for 20 percent of total public road and street mileage. The Federal government has responsibility for 5 percent, primarily in national parks, forests, and Indian reservations. Local governments retain control of, and responsibility for, the remaining 75 percent.

Transit

All public transit services in the United States may be functionally classified by the public policy purposes served by individual trips: low-cost mobility, congestion management and livable metropolitan areas.

In the last quarter century, public transit services in the United States have been transformed from private companies under local public regulation to virtually universal local public ownership and operations. Still, considerable transit services are provided by private companies under franchise and contract arrangements, most notably express bus services in the largest metropolitan areas and specialized demand responsive services in many metropolitan areas.

System Extent and Capacity

Highway

In 1993, total National public road and street center-line mileage reached 3.9 million miles. Seventy-nine percent of this mileage was in rural areas.

The extent of rural mileage declined between 1983 and 1993 due to (1) the expansion of Federal-aid urban and urbanized area boundaries based on the periodic census and (2) reclassification of certain U.S. Forest Service roads to non-public roadways.

Mileage on rural principal arterials increased as a result of States functionally reclassifying their roads and streets in order to establish an updated principal arterial system.

In 1994, there were more than 576,000 bridges on our Nation's highways.

In 1993, there were 8.1 million lane-miles of highways in the Nation.

Transit

In 1993, 508 local public transit operators provided transit services in 316 urbanized areas. An additional 5,010 local and regional organizations provided publicly accessible transit services in rural and small urban areas. In 1993, there were 129,317 total transit vehicles, 7,439 miles of rail track, 2,271 rail stations and 1,172 maintenance facilities.

In 1993, rail transit systems provided 1,564 million bus-equivalent vehicle miles, while bus transit systems provided 1,659 million bus-equivalent vehicle miles.

System Usage

In 1993, total highway vehicle miles traveled reached 2.3 trillion vehicle miles, up at an annual rate of 2.2 percent since 1989.

In 1993, total highway passenger miles reached 3.9 trillion, up at an annual rate of 2.3 percent since 1989. On rail, transit patronage was 17.9 billion passenger miles in 1993, down 2.5 percent per year since 1989 (since 1983, rail transit patronage has increased at an annual rate of 0.7 percent). On bus systems, transit patronage was 18.4 billion passenger miles in 1993, down by one-tenth of 1 percent per year since 1989.

Truck travel is an important factor affecting highway investment requirements. Combination trucks are used primarily for intercity freight transportation, and their travel is concentrated on rural arterial highways. In 1993, combination trucks accounted for 16 percent of total travel on rural Interstate highways and 5 percent of travel on urban Interstate highways.

HIGHWAY, BRIDGE AND TRANSIT FINANCE

This section addresses the sources and uses of funds expended for highways and transit. Funding by level of government and source of revenue is provided. Expenditures are summarized as to capital and noncapital and are examined in terms of where funds are invested and for what purpose.

Sources of Public Sector Financing

Highway

In 1993, all levels of government provided $88.5 billion for highway programs. The Federal government funded $18.2 billion, the States $46.9 billion, and counties, cities and other local government entities funded the remaining $23.4 billion.

Public sector financing of highways comes from a number of sources: highway-user charges, property taxes and assessments, general funds, investment income, other taxes, miscellaneous fees, and bond issues.

At the Federal and State levels, motor-fuel and motor-vehicle taxes are the primary source of funds for highways. These highway-user revenues provide 87 percent of Federal funds and 72 percent of State funds.

Transit

Public funding for transit in 1993 was $15.5 billion. The Federal share of this support was $3.3 billion, the State and local share was $12.1 billion. Fares and other system-generated revenue accounted for $7.1 billion. Total transit revenue, from all sources, was $22.6 billion in 1993.

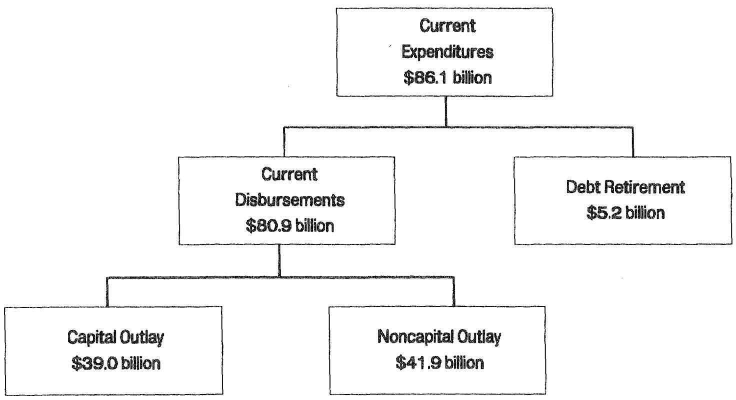
Sources of transit support at the State and local level in 1993 included direct system taxing authority, property taxes, motor-fuel taxes, income taxes and other, unspecified tax sources. Federal support for transit included motor-fuel taxes and general fund appropriations.

All levels of General Funds Appropriations combined to provide the largest revenue source (57 percent) followed by State and local sales taxes (20 percent) and fuel taxes (15 percent).

Total Expenditures

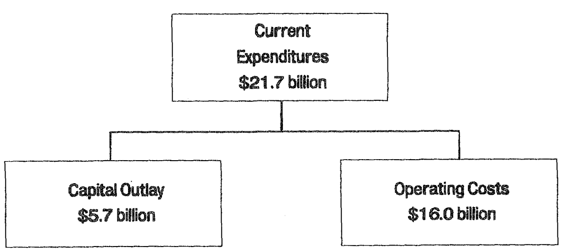
Of the $88.5 billion in funding provided for highways in 1993, $86.1 billion was expended for highway programs and $2.4 billion was placed in reserve. Total expenditures for highways are separated into current expenditures and debt retirement. In 1993, $80.9 billion went for current expenditures and $5.2 billion was used for debt retirement. Current expenditures include capital investment and spending for noncapital purposes (see Exhibit 1).

Exhibit 1
Summary of Highway and Bridge Expenditures
All Roads
1993



In 1993, of the $22.6 billion in funding provided for transit, $21.7 billion was expended for capital investment and operating requirements (see Exhibit 2).

Exhibit 2
Summary of Transit Expenditures
1993



Capital Expenditures

Highway

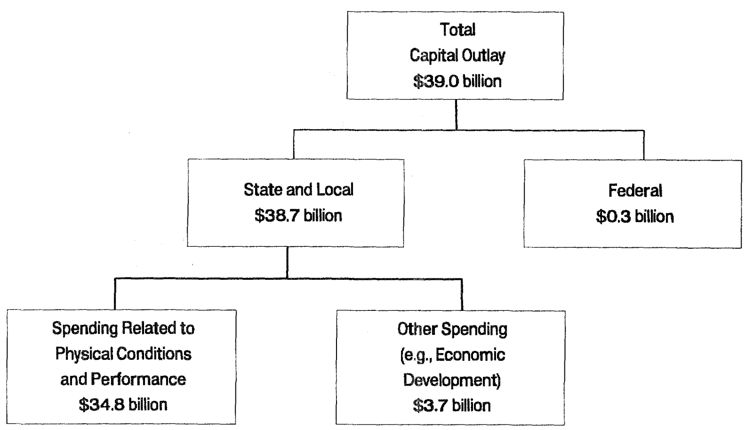
Highway capital expenditures are those outlays associated with physical highway improvements such as new construction, reconstruction, resurfacing, rehabilitation, and restoration. Highway capital expenditures include items such as land acquisition and other right-of-way costs, preliminary and construction engineering, and construction.

All levels of government spent over $39.0 billion on highway capital improvements in 1993 compared to $6.3 billion in 1960. In constant dollars, highway capital outlay has increased 28.1 percent since 1960. Of total expenditures, capital outlay represented 61.9 percent in 1960 and 48.2 percent in 1993.

State and local governments spent $38.7 billion of the $39.0 billion spent by all levels of government. This included $17.1 billion in Federal funds. The 1993 Federal share of highway capital outlay, 44 percent, is down from a high of 56 percent in 1980.

Of the $38.7 billion spent by State and local governments on capital improvements in 1993, $31.6 billion was spent on non-local roads and $7.1 billion was spent on local roads. Of the $31.6 billion spent on non-local roads, $27.7 billion was spent on system preservation and capacity improvements to correct deficient conditions. This $27.7 billion is comparable to the future investment requirement estimates provided in this report. The remaining $3.7 billion includes capital outlays for purposes other than the condition and performance of roads and bridges such as environmental improvements and investments related to economic development. Exhibit 3 presents a summary of highway and bridge capital outlay on all roads, including local. Local spending is assumed to be related to the improvement of system condition and/or performance.

Exhibit 3
Summary of Highway and Bridge Capital Outlay
All Roads (Including Local)
1993



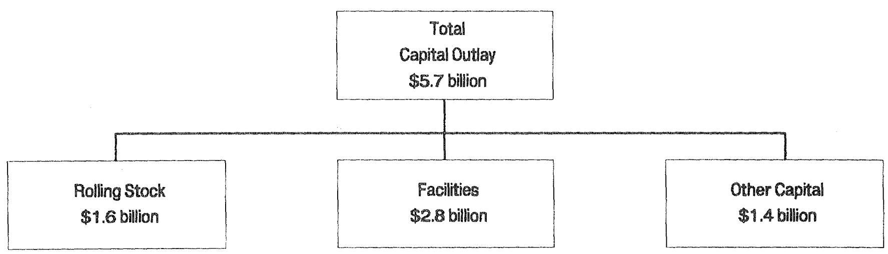
In 1993, system preservation improvements accounted for 42.2 percent of spending on nonlocal roads, capacity improvements accounted for 52.0 percent, and other improvements accounted for 5.8 percent.

Transit

Transit capital expenditures totaled $5.7 billion in 1993 and included those sums expended for the design, engineering construction and reconstruction of fixed transit assets as well as rolling stock. Fixed assets may include bus garages, rail facilities, tracks and rights-of-way, etc. The largest single component of transit capital expenditures in 1993 was rail facilities, at $2.2 billion. Rolling stock accounts for 27 percent of transit capital expenditures (see Exhibit 4).

While Federal capital assistance has remained relatively stable between 1988 and 1993, the level of State and local contribution to transit capital assistance has grown. Investment in transit capital assets, both for existing and new systems increased from $4.1 billion in 1988 to $5.7 billion in 1993. Federal capital assistance levels in fiscal years 1994 and 1995 were substantially higher than in past years.

Exhibit 4
Summary of Transit Capital Outlay
1993

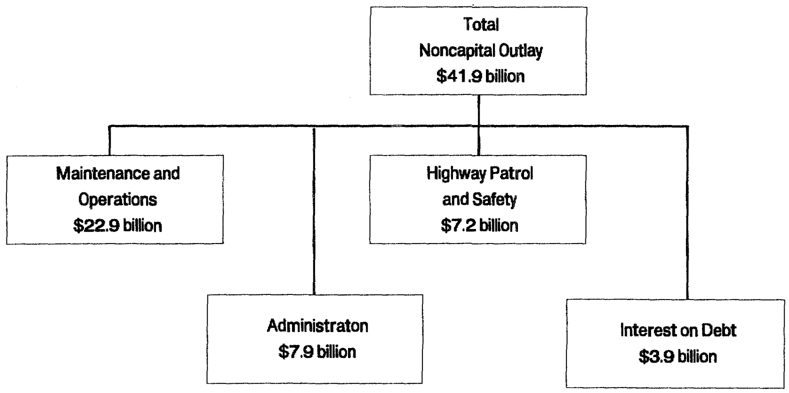


Noncapital Expenditures

Highway

Noncapital highway expenditures include items such as maintenance, operations, administration, highway law enforcement and safety, and interest on highway debt (see Exhibit 5). The noncapital share of expenditures for highways was $41.9 billion in 1993, or 52 percent of highway expenditures. In 1960, it was $3.9 billion, or 38 percent of all highway expenditures. Constant dollar growth from 1960 through 1993 for the noncapital category of expenditures was 122 percent compared to a 60 percent growth in total highway expenditures.

Exhibit 5
Summary of Highway and Bridge Noncapital Outlay
All Roads
1993



Spending for roadway maintenance and traffic services is the largest single component of noncapital highway expenditures. Maintenance costs include routine and regular expenditures required to keep highways in usable condition, such as patching, minor repairs, bridge painting, and so on. A total of $22.9 billion was spent by State and local governments in 1993 to keep all highways, roads and streets in serviceable condition. The maintenance and traffic services share of total expenditures was 26 percent in 1960 and 28 percent in 1993.

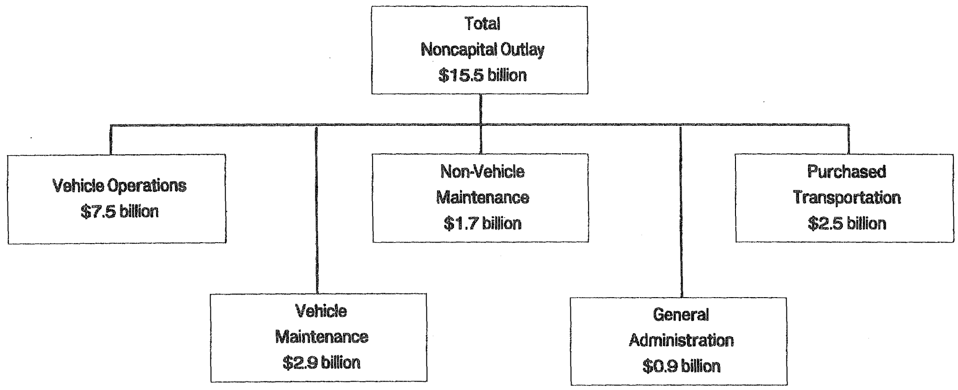
Other noncapital highway expenditures include administration, highway law enforcement and safety, and interest on highway debt. The relative share of these other noncapital expenditures to total expenditures has increased from 12 percent in 1960 to 24 percent in 1993.

Transit

Transit operating (noncapital) expenditures include spending for wages, salaries, fuel, spare parts, support services and leases used in providing public transit service (see Exhibit 6). These expenditures increased significantly between 1983 and 1993 from $8.4 billion to $16.0 billion. The increase is due, in large part, to significant increases in service supplied. Between 1983 and 1993, Light Rail service supplied, as measured in vehicle revenue miles, increased by over 65 percent. Demand responsive service increased by over 457 percent in the same period.

The $16.0 billion provided for transit operating expenditures in 1993 came primarily from State and local funding sources. These included State general revenues, dedicated State and local taxes, and farebox revenues. Overall, Federal funds contributed only 5.7 percent to transit operating costs, while contributing just under 42 percent of transit capital expenditures in 1993. Fare and other operating revenue contributed 44 percent in 1993.

Exhibit 6
Summary of Transit Noncapital Outlay
1993



HIGHWAY, BRIDGE AND TRANSIT SYSTEM CONDITION AND PERFORMANCE

This section addresses the condition and performance of arterial and collector highways, transit rolling stock and infrastructure, and aspects of the environment influenced by transportation construction and operation.

Conditions

Highway

Pavement. The percentage of pavement mileage in poor condition and the percentage of travel on facilities in poor condition is as follows:

Exhibit 7
Facilities in Poor Condition
Mileage and Travel
1993

	Percent Mileage in Poor Condition	Percent Vehicle Miles Travelled on Poor Roads
Rural		
Interstate	6.9	5.6
Other Principal Arterial	9.3	6.6
Minor Arterial	11.0	8.4
Major Collector	6.8	5.7
Urban		
Interstate	9.5	8.9
Other Freeway & Expressway	9.9	9.6
Other Principal Arterial	15.0	15.8
Minor Arterial	7.9	7.6
Collector	10.6	8.9

Alignment. Alignment adequacy affects the speed at which vehicles can safely travel. Alignment is rarely a significant problem in urban areas. Less than 2 percent of rural Interstate miles have alignment deficiencies. In contrast, over 25 percent of rural major collectors have alignment deficiencies.

Special Notes:

Note 1: The 1993 pavement condition statistics are based on a combination of Present Serviceability Rating (PSR) and International Roughness Index (IRI). The States are in transition from the PSR pavement evaluation system to the IRI approach. Subsequent editions of this report series will provide pavement condition information based solely on the IRI. Because there is no exact correspondence between the PSR and IRI values, a comparison of 1993 data with past years may be misleading.

Note 2: The urban area boundaries changed for the 1993 data set to incorporate formerly rural or suburban highways that were urban in character. This change affects the overall average values of any highway condition indicator.

Lane Width. Lane width is related to both capacity and safety. Substandard lane widths tend to reduce the capacity of a highway, and may affect the safety of the facility as well. Essentially all Interstate mileage has a lane width of 12 feet or more, which is the standard lane width for high-type facilities. In rural areas, 86 percent of other principal arterials, 66 percent of minor arterials and 34 percent of major collectors have lane width deficiencies. There has been a slow but steady improvement in the mileage with adequate lane widths each year, as reconstruction and widening of substandard highways occur.

Bridge

Bridges in need of repair may be categorized as either structurally or functionally deficient. A structurally deficient bridge is in need of significant maintenance attention, rehabilitation, or replacement. Some of these bridges are load-posted so that heavier trucks will be required to take an alternate, longer route. Functionally deficient bridges are those that do not have the lane widths, shoulder widths, or vertical clearances adequate to serve the traffic demand.

In general, the higher functional systems have fewer deficient bridges than the lower systems. The total percent of deficient bridges decreased in each of the functional system categories from 1990 to 1994. In 1994, 24 percent of the Interstate bridges were classified as being deficient compared to 29 percent in 1990. On all other arterial systems 28 percent of all bridges were deficient in 1994 compared to 32 percent in 1990. On the collector system 28 percent of all bridges were deficient in 1994 compared to 35 percent in 1990.

Transit

Bus and Paratransit Conditions. Vehicle age is used as a surrogate for condition and is therefore used as the basis for evaluating bus and paratransit fleet conditions. The average fleet age for all classes of bus and paratransit vehicles is greater than the minimum useful life guidelines. As a result, there is a backlog of overage vehicles of each type in need of replacement.

Rail Conditions. Between 1984 and 1992, maintenance yards went from only 17 percent in good or better condition to 64 percent in good or better condition, and maintenance buildings went from 28 percent in good or better condition to 52 percent in good or better condition. Stations improved significantly from 29 percent in good or better condition to 66 percent in good or better condition, and bridges from 33 percent in good or better condition to 61 percent in good or better condition. As of 1992, 76 percent of rail cars were in good or better condition.

Performance

Highway

The perception of congestion varies with geographic location and may be measured according to three dimensions: severity, extent and duration. Severity refers to how bad congestion is during the peak-hour of travel. The extent of congestion is defined by the geographic area impacted. The duration of congestion is defined by the length of time that highway facilities are congested. As the volume of traffic increases and congestion occurs, the traffic flow breaks down, and queues form that do not dissipate until the traffic demand is reduced after the peak period. Thus the duration of congestion increases rapidly once breakdown in the traffic flow occurs.

Exhibit 8 shows that travel per lane-mile has increased on the higher urban systems since 1983. This is an indication that travel has increased at a faster rate than the capacity of the highway system to accommodate this travel. An increase in the duration of congestion is a result of this trend.

Special Note:

The urban area boundaries changed for the 1993 data set to incorporate formerly rural or suburban highways that were urban in character. This change affects the overall average values of any highway performance indicator.

Exhibit 8
Daily Vehicle Miles of Travel (DVMT) Per Lane-Mile, Urban Areas
1983 and 1993

	Year	DVMT Per Lane-Mile
Interstate	1983	9,810
	1993	12,650
Other Freeway & Expressway	1983	7,720
	1993	10,000
Other Principal Arterial	1983	4,640
	1993	5,380

Note:
These values of travel per lane-mile are average values. While there is no recognized value of "daily capacity" to which these values can be compared, a value of 13,000 vehicles per lane-mile per day has been used as a threshold value of congested freeway travel.

Transit

The perception of quality among customers and potential customers is an important determinant of transit use, often more important than the fare levels.

User Travel Speed. One of the most important dimensions of performance is the speed of transit service, as perceived by the user. Since 1984, the passenger-mile weighted average speed improved by about 10 percent.

Transfers and Waiting Times. The majority of transit users do not spend much time waiting for service. Well over half of all riders reported wait times of 5 minutes or less. About 80 percent of riders wait no longer than 10 minutes. Fifty-one percent of transit trips involve one or more transfers.

Available Seats. Passengers often consider a vehicle to be crowded when it is operating with a load factor above seated capacity, but still significantly below full capacity. Twenty-nine percent of transit trips involve standing for at least part of the trip.

Travel Times. About 25 percent of all transit users report trip times of 10 minutes or less, and nearly 76 percent of transit trips were reported to take less than half an hour.

Highway Safety

An overall improvement in highway safety occurred over the 10-year period 1983 through 1993. The fatality rate decreased for each functional system. Accident and fatality rates are affected by many factors other than highway condition and performance, including weather conditions, occupant protection use, number of intoxicated drivers, extent of police exposure, law enforcement, vehicle speed variations, and driver performance. A comparison of highway fatality rates between 1983 and 1993 is presented in Exhibit 9.

Exhibit 9
Highway Fatality Rates
1983 and 1993

		Fatalities Per 100 Million Vehicle Miles Travelled	
		Rural	Urban
Interstate	1983	1.50	1.01
	1993	1.25	0.61
Other Arterial	1983	3.79	2.21
	1993	2.55	1.28
Collector	1983	4.03	2.11
	1993	3.42	1.02

Selected Highway Environmental Indicators

Air Quality

There has been significant progress in reducing the overall levels of four major (carbon monoxide, lead, nitrogen dioxide and ozone) transportation related air pollutants over the last decade. As a result of Federal limits on gasoline volatility; the replacement of older cars with newer, less polluting ones; and the increased usage of unleaded gasoline, transportation sources were responsible for most of the emission reductions during the decade.

Energy

Although indicators related to highway energy use, the number of automobiles, and amount of travel have all increased since 1970, the rate of fuel usage per registered automobile, per mile of travel, and per licensed driver have declined. There have been significant increases in the fuel economy of automobiles since 1974. In fact, the fuel efficiency of new cars has increased from 14 miles-per-gallon to almost 28 miles-per-gallon.

Other Environment Performance Indicators

Other environmental indicators related to highway construction and usage, in addition to those highlighted above, include water quality, wetlands, noise, land/open space, threatened and endangered species and community impacts.

HIGHWAY, BRIDGE AND TRANSIT INVESTMENT REQUIREMENTS

This section provides general investment benchmarks as a basis for the development and evaluation of transportation policy and program options. Estimates of total capital investment required from all sources to achieve specified levels of overall condition and performance for the Nation's highway, bridge and transit systems are presented.

Investment Requirements, 1994-2013

Special Notes:

All investment estimates are in 1993 dollars and do not reflect inflation.

The "annual average investment requirement" is the 20 year total divided by 20 years.

The highway and transit investment estimates are based on travel growth estimates which differ significantly from historical experience and assume wide-spread demand shaping policies.

Highway

The average annual **Cost to Maintain** overall 1993 conditions and performance on arterial, collector and local systems is estimated at **$49.7 billion**. Under this investment strategy, existing and accruing system deficiencies would be selectively corrected; some highway sections would improve, some would deteriorate, but overall the system would remain the same.

Improving the highway system according to **Economic Efficiency** objectives would require an average annual investment of **$65.1 billion**. Under this scenario, system condition and performance would be improved by systematically correcting existing and accruing system deficiencies through the year 2013, provided that the improvements generate direct user and agency benefits in excess of initial improvement costs.

Bridge

The average annual **Cost to Maintain** overall 1994 bridge conditions is estimated at **$5.1 billion**. Existing and accruing deficiencies would be selectively corrected; the total number of deficient bridges would remain the same.

The average annual **Cost to Improve** 1994 bridge conditions is estimated at **$8.9 billion**. At these investment levels, all existing bridge deficiencies would be eliminated through bridge replacement, rehabilitation or major widening. All accruing requirements would be met through the year 2013.

Transit

The average annual **Cost to Maintain** 1993 transit conditions and performance levels through the year 2013, is estimated at **$7.9 billion**. Under this scenario, which assumes a significant increase in passenger miles traveled, transit vehicles would be replaced at about the current rate and transit operators would meet the requirements of the Americans with Disabilities Act and the Clean Air Act Amendments.

The average annual **Cost to Improve** conditions and performance on the Nation's transit systems is estimated at **$12.9 billion** through the year 2013. This investment level includes (1) the cost of maintaining 1993 conditions and performance, (2) the cost to eliminate the backlog and (3) the cost of improving transit service levels in terms of system speed, comfort and convenience.

Comparison of 1994 Investment Requirements with 1993 Capital Expenditures

Investment estimates in this chapter are reported on a 20-year basis. To provide linkage between these 20-year investment estimates and the consideration of actual current year budget options, this section offers a comparison of investment requirements and actual recent capital outlays by all units of government for highway, bridge, and transit capital improvements.

Because of projected increases in highway and transit travel over the 20-year analysis period, the investment requirement estimate for any given year (except the midpoint) will be different than the average annual investment requirement reported above. Investment required for capacity expansion to maintain or improve system performance is assumed to grow at a rate equal to the rate of travel growth. Therefore, the investment required for each year during the first 10 years of the analysis period will be lower than the average annual and the investment required for each year during the second half of the analysis period will be higher than the average annual.

In Exhibit 10, the investment required in 1994 to maintain or improve highway, bridge and transit conditions is compared to the comparable 1993 capital outlays. Readers will note that the highway and transit investment required in 1994 is indeed lower than the average annual. Bridge investment is directed at system preservation and is therefore relatively insensitive to travel growth estimates.

Exhibit 10
1994 Investment Required for Highway, Bridge, and Transit Systems versus 1993 Capital Outlay*
All Systems (Includes Local)
Billions of Dollars

	1994 Cost to Maintain Conditions and Performance	1994 Economic Efficiency	1993 Capital Outlay*
Highway			
Capacity Expansion	$20.2	$24.6	
System Preservation	$24.6	$34.7	
Total	**$44.8**	**$59.3**	**$28.8**

	1994 Cost to Maintain Conditions	1994 Cost to Improve Conditions	1993 Capital Outlay*
Bridge			
Capacity Expansion	–	–	
System Preservation	$5.1	$8.9	
Total	**$5.1**	**$8.9**	**$6.0**

	1994 Cost to Maintain Conditions and Performance	1994 Cost to Improve Conditions and Performance	1993 Capital Outlay*
Transit			
Capacity Expansion	$2.2	$4.7	
System Preservation	$5.1	$7.1	
Total	**$7.3**	**$11.8**	$5.7

*Capital outlay related to capital investment requirements.

Significant Analytical Advancements and Issues

Travel Forecasts

The highway and transit travel forecasts used in this report reflect the Metropolitan Planning Organizations' (MPOs) Transportation Improvement Plans and Long Range Transportation Plans. The 1994 through 2013 investment requirements are based on lower 20-year forecasts of highway travel (2.15 percent compound annual) than indicated by past experience and a corresponding increase in travel by transit (2.40 percent compound annual).

Without significant demand-shaping policies (to include wide-spread congestion pricing and/or regulatory measures), it is not likely that the MPO forecast will be achieved. To the extent that actual future experience exceeds the highway travel forecasts, the resulting investment requirement estimates may be understated. Analogously, the degree to which the transit travel forecasts are not realized, the estimates of future transit investment requirements may be overstated.

Highway Economic Requirements System (HERS)

The HERS approach, upon which analysis of the Economic Efficiency scenario is based, relies on benefit/cost analysis to evaluate the attractiveness of potential highway improvements for each deficient prototype section in the HPMS database. The model will implement only those projects for which direct user and agency benefits exceed the initial cost of the improvement.

HERS is responsive to the requirement that increasingly constrained national investment resources be efficiently allocated. With HERS, the focus is on the service that the highway system provides to the users, rather than on the condition and performance of the highway infrastructure. However, the current version of HERS has a number of significant limitations, including the failure to consider external costs. Also, the HERS results do not replicate the actual investment decisions that would be made by individual States and local agencies in establishing their highway programs. Each State and local government applies a variety of factors in determining highway investment priorities. The actual resulting investment levels, patterns, and effects, when aggregated over the entire Nation, will differ from those calculated by HERS. The HERS results, however, provide a useful benchmark measure of highway investment estimates.

WATERBORNE TRANSPORTATION SYSTEM

This section provides a brief overview of the U.S. waterborne transportation system, its characteristics and performance, and the Federal role and interest in the system.

Waterborne Transportation System Characteristics

World and U.S. Fleets and Their Characteristics

As of January 1, 1995, the world merchant fleet of oceangoing vessels 1,000 gross tons and over amounted to just over 25,000 vessels with a capacity, or deadweight tonnage (DWT) of 686 million. Only 15 nations have more than 10 million DWT of vessels registered under their flags, and together these 15 account for 75 percent of the world total. The U.S. ranks tenth in capacity with a total of 20 million DWT.

Tanker Fleet. Tanker vessels make up the largest part of the world fleet, accounting for 5,994 vessels and 297 million DWT. More than two-thirds of the tonnage are the larger ships which are mostly crude oil carriers; over half were built during the 1970's. The smaller ships tend to be mostly product carriers, and over half of these were built in the 1980's. The U.S.-flag tanker fleet consists of 187 vessels and is considerably older than the world fleet.

Dry Bulk Fleet. Dry bulk carriers comprise the second largest segment in the world fleet, with 5,291 vessels. Nearly two-thirds of the tonnage was built during the 1980's.

Intermodal Vessels. The U.S. pioneered the container shipping concept, and currently the U.S.-flag containership fleet ranks third in the world with a 7 percent share of the 39 million DWT world capacity; its average age is older than the world fleet as a whole.

Cruise/Passenger Fleet. The cruise industry is a large and growing segment of the waterborne transportation system, with 231 active vessels. However, there is no U.S.-flag participation in this business except in the domestic trades.

The U.S. Domestic Fleet and Its Characteristics

The inland waterway, Great Lakes and ocean components of the domestic fleet include nearly 40,000 vessels with a cargo capacity of more than 67 million short tons.

Dry Cargo Barge Fleet. The predominant vessel in the domestic fleet is the dry cargo barge, 87 percent of which operate on the inland waterways. Total capacity of this fleet is 39 million short tons. About half of the barges were built during the 1975 through 1984 period, and about 11 percent were built in the last 5 years.

Tank Barge Fleet. In 1993, 82 percent of the tank barges operated on the inland waterways, but were considerably smaller than those operating in the coastal trades. Seventy-five percent of this fleet is more than 15 years old; just over 8 percent has been built in the last 5 years.

Towboat/Tugboat Fleet. The domestic towboat/tugboat fleet included 5,224 vessels in 1993, with 62 percent of them operating on the inland waterways. About 44 percent of this fleet is more than 25 years old; less than 2 percent having been built in the last five years.

Great Lakes Fleet. The self-propelled U.S.-flag Great Lakes fleet consists almost exclusively of dry bulk vessels, most of which carry ores. More than 40 percent of the fleet is over 20 years old, and while approximately one-third was built during the 1975 through 1979 period, very few vessels have been built in the last 10 years.

Port Infrastructure

The U.S. port system is the interface between water and surface transportation modes, and includes both publicly and privately owned marine terminal facilities located at deep-draft seaports, Great Lake ports and on the inland water system.

Deep-Draft Seaport and Great Lakes Port Facilities. There are 1,917 major U.S. seaport terminals comprising 3,173 berths. East coast ports have the largest share of berths at 34 percent, followed by the gulf and west coasts with identical 25 percent shares and the Great Lakes with a 16 percent share.

Inland River and Intercoastal Waterways Port Facilities. There are 1,789 river terminal facilities located in 21 states on the 25,000 mile U.S. inland waterway system. The inland facilities are less concentrated geographically and provide almost limitless access points to the waterways. Terminal siting on the waterways is less constrained than coastal ports, providing greater flexibility to the users in determining the location of plants requiring water access.

Port Capital Investment. Overall total public sector port capital expenditures have remained relatively stable in recent years, annually ranging between $654 million and $682 million during the period 1990 through 1993.

U.S. Shipbuilding and Repair Base

The Major U.S. Shipbuilding and Repair Base is comprised of 101 private shipbuilding and repair shipyards having the capability to construct, drydock, and/or topside repair vessels.

System Performance

World Oceanborne Trade

In 1994, world oceanborne trade (imports) amounted to about 3.1 billion long tons, with the U.S., Japan and Europe accounting for approximately 66 percent. The United States alone accounted for 18 percent of world oceanborne imports in 1994.

U.S. Oceanborne Foreign Trade

Total oceanborne U.S. foreign trade (exports and imports) in 1994 amounted to 898 million long tons with a value of $566 billion. Liner cargoes tend to have a much higher value per long ton than non-liner and tanker cargoes. Consequently, while liner cargoes accounted for 13 percent of the total tonnage, they accounted for nearly three-fourths of the value. Similarly, tanker traffic, consisting primarily of oil imports, accounted for nearly half of the tonnage but only 10 percent of the value.

<u>Liner Trades</u>. Liner vessels are operated between scheduled, advertised ports of loading and discharge on a regular basis. U.S. liner trade expanded at an annual rate of 6.8 percent between 1985 and 1994; the major U.S. liner trades have all been growing steadily. Approximately 78 percent of all U.S. liner cargoes in 1994 were containerized, as highly specialized line haul/feeder services, joint services and vessel sharing agreements have expanded.

<u>Non-Liner Trades</u>. In contrast to liner vessels, non-liner dry cargo vessels do not operate on fixed schedules or itineraries. They generally transport cargoes based on a charter. Non-liner shipments declined at an annual rate of 1.1 percent between 1985 and 1994.

<u>Tanker Trades</u>. Tankers carry liquid cargoes in bulk, including crude oil, refined products, liquid gas, vegetable oils and wine. The U.S. tanker trade grew at an average annual rate of 7 percent between 1985 and 1994. A sharp increase in the U.S. tanker trade from 1988 to 1994 was due largely to rising U.S. petroleum imports (occasioned in part by declining domestic crude oil production).

<u>U.S.-Flag Shares</u>. U.S.-flag vessels carried approximately 3.9 percent of U.S. waterborne foreign trade in 1994, down from 5.3 percent in 1970. However, the quantity carried on U.S.-flag vessels has increased steadily from 25.1 million long tons in 1970 to 35.2 million long tons in 1994, a 40 percent increase. This absolute increase in cargo carried on U.S.-flag vessels reflects the deployment of larger, more productive U.S.-flag vessels in the 1970s and 1980s.

World Fleet. In 1994, 7,206 vessels, or 29 percent of the world merchant fleet, called at U.S. ports. In terms of capacity, these ships represented 44 percent of the DWT in the world fleet. Of the 231 cruise vessels in the international fleet, 98 regularly served the U.S.

U.S. Domestic Trade

Total domestic trade (inland waterways, Great Lakes, and domestic ocean services) amounted to approximately 1.1 billion short tons annually during the 1987 through 1992 period. Preliminary data for 1993 indicated a 2.4 percent decline in total traffic, reflecting the impact of the great floods of that year which restricted the flow of traffic on the inland waterways.

Great Lakes. The Great Lakes domestic trade includes shipments among U.S. Great Lakes ports and connecting waterways. The major commodities moved on the lakes are iron ore, coal, and limestone. The total volume of cargo has been quite stable over the last several years, and amounted to nearly 110 million tons in 1993.

Inland Waterways. The inland waterways trade includes shipments on the navigable internal waterways of the Atlantic, Gulf, and Pacific coasts, and the Mississippi River system. The primary commodities moved on this system include farm products, chemicals, petroleum, and coal. Total traffic on the system peaked at 709 million tons in 1990. In the flood year 1993, approximately 682 million tons of cargo were carried on the system.

Domestic Ocean. The major segments of the domestic ocean trade are the noncontiguous trades between the mainland and Alaska, Hawaii, Puerto Rico, Guam, Wake and Midway Islands; and the coastwise trades along the Atlantic, Gulf, and Pacific coasts. The major products moving in domestic ocean trade are crude petroleum, refined petroleum products, residual fuel, and coal. Total cargo moving in the domestic ocean trades has been declining steadily in recent years, reflecting the decline in Alaska North Slope crude oil shipments.

Port Traffic

There were a total of 343 ports that handled waterborne trade during 1993. The tonnage handled by the 50 leading coastal and inland ports amounted to 89 percent of the total waterborne trade in that year. In 1994, the 25 leading container ports accounted for 98 percent of total container traffic moving in foreign trade. In terms of port calls, the top 20 ports accounted for approximately 75 percent of the vessel calls to all U.S. ports in 1994.

World Shipyard Production

As of January 1, 1995, the world orderbook for merchant vessels 1,000 Gross Registered Tons and over, consisted of 1,527 vessels totaling 67 million DWT. Construction in Japan and Korea account for 64 percent of the total. The average size of vessel on order is 60 percent larger than the average of the existing world fleet.

U.S. Shipyard Activity

As a result of the suspension of Federal construction assistance, the U.S. shipbuilding industry's commercial orderbook fell from 77 vessels in the mid-1970s to zero by 1988, its lowest level since pre-World War II, and currently ranks 26th in terms of its orderbook. However, since enactment of the National Shipbuilding and Shipyard Conversion Act of 1993, U.S. shipyards have been aggressively competing for reentry into commercial shipbuilding markets.

Accomplishments and Innovations

The U.S. maritime industry has consistently been a leader in innovation and technology development in the quest for lower transportation costs to improve competitiveness and service to shippers.

Intermodal Services. U.S.-flag shipping companies have developed a fast-paced, well-supported commercial waterborne transportation infrastructure through containerization, intermodalism, satellite communication, cargo tracking, and related advanced technology systems.

Sealift Support. This country's changing defense posture and the closing of overseas bases increases our dependence upon timely sealift support. For example, the industry's ability to respond in a national emergency was clearly demonstrated during Operations DESERT SHIELD/DESERT STORM, when 79 percent of the equipment and supplies moved on the U.S.-flag fleet.

Domestic Trade. In the domestic trades, both the inland waterways and the shallow-draft vessels which operate on them have been improved over time. Barge sizes and towboat horsepower have increased, and more significantly, tow sizes have grown. Waterway channels have been improved and lock sizes enlarged. These developments allow greater cargo throughput and much more intensive use of the waterway system.

Regulation, Environment and Port Access

The performance of the system is affected by a number of regulatory, environmental and port access constraints that may significantly increase the cost of building and operating vessels.

Federal Role

There are a wide variety of Federal programs—including shipyard revitalization, ship financing programs, operating assistance and market promotion—designed to support a viable water transportation system that provides a National defense transport capability and serves the needs of U.S. domestic and international commerce.

Demand for Water Transportation and Shipping Capacity

World oceanborne trade is expected to grow at rates significantly higher than those for world gross domestic product (3 percent per year) due to reduction in trade barriers, privatization, and advances in transportation and communications. U.S. oceanborne trade is expected to grow at an average annual rate of 4.5 percent between 1994 and 2005. Because the demand for shipping capacity is largely a function of the volume of international oceanborne trade, the demand for shipping services is expected to increase.

System Investment Requirements

Investment in the waterborne transportation system is a blend of public (Federal, state and local) and private money. The industry is, for the most part, privately capitalized. It is anticipated that future investment will be required to replace aging tonnage, expand and upgrade shipyard facilities, and to advance technology, equipment and training programs.

1995 Status of the Nation's Surface Transportation System:

CONDITION AND PERFORMANCE

Report to Congress

Chapter 1

The Dimensions of Personal Travel

Chapter 1

Introduction

Americans as a group travel substantially more than the citizens of any other developed country in the world and the gap is widening. Over the last two decades Americans have substantially increased the number, frequency, and length of their trips--travel made possible by the extensive American network of highway and transit facilities. The Nationwide Personal Transportation Survey (NPTS) shows that in 1990 Americans made 250 billion person trips, travelling 2.3 trillion miles--in a car or truck, or by bus, train, subway or airplane, or by walking, biking, or riding a motorcycle. The largest share of those miles--almost 1.6 trillion--were made in a personal vehicle. As large as these numbers are, they represent substantial growth since 1969; in 1990 Americans made 72 percent more person trips and travelled 65 percent more person miles than they had in 1969. As a result, each American took an average of 1,042 trips in 1990, or 2.85 trips per day[1].

[1] This chapter deals almost exclusively with household-based travel; it does not include commercial driving such as that done by bus or commercial truck drivers, freight deliverers, police on patrol, etc.

The sheer volume and length of these trips creates significant problems for our Nation's highways, bridges, and transit systems. Many transportation facilities are currently carrying far more passengers and vehicles than they were ever designed for; this has created tremendous demands for new facilities and substantially increased the need to maintain and reconstruct existing facilities.

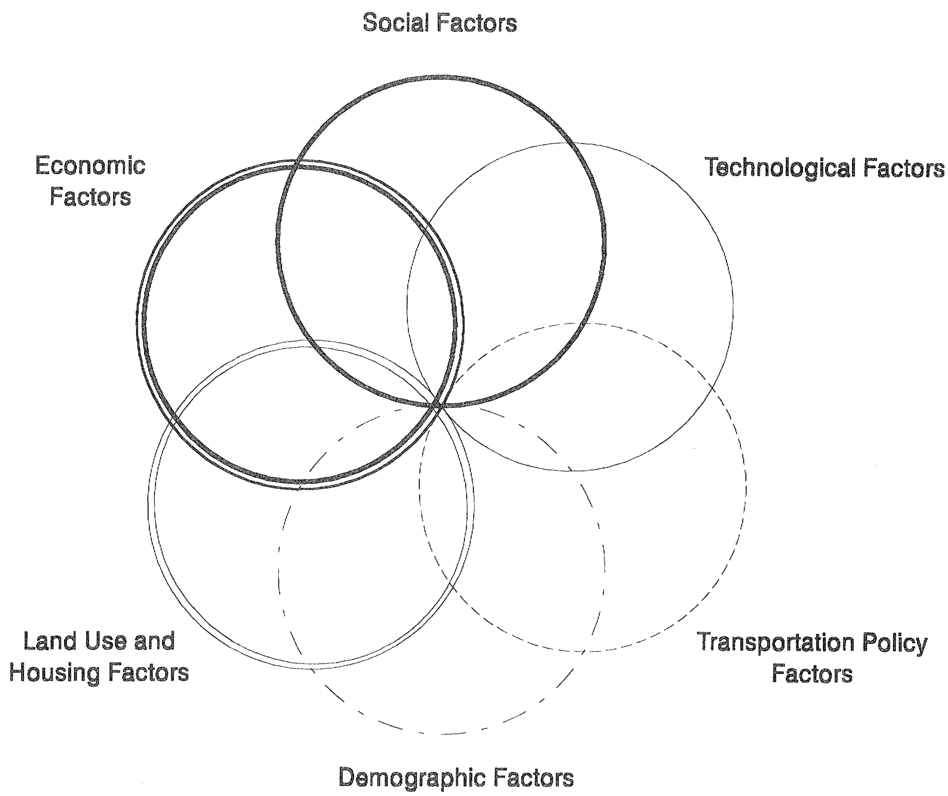
But Americans today are not only travelling more, they are travelling differently--at different hours, along different routes, and on different days in the week than comparable people two decades earlier. Because current transportation networks were often designed to serve trips located in narrowly defined corridors or occurring in sharply defined peaks, the growing variation in the patterns of American travellers will create new challenges for the Nation's highway and transit systems.

In the last two decades perhaps the most changed trip is the work commute--commuter trips are now spread over a much longer day, with a sizable minority of travelers having variable work schedules, working late at night, or starting early in the morning. In addition, a significant percentage of all trips have both suburban origins and destinations, which reduces the number of workers travelling to any one destination while simultaneously increasing the number of destinations to which people travel.

These major changes in American travel patterns over the last three decades arise from the interaction of many complex forces, as illustrated in Exhibit 1-1. Growth in the population has combined with changes in family structure, residential and employment location, industrial reorganization, demographic forces, and income trends to create a variety of travel patterns.

Moreover, while almost all indicators of travel are up, there is substantial diversity within aggregate travel trends; there are important differences in the travel patterns of men and women, the young and the old, those in urban and rural areas, and among those of different racial and ethnic backgrounds. Many of these differences result directly from a combination of societal trends. Finally, travel choices are impacted by a host of governmental policies, from transport policies which affect parking rates and gasoline taxes to local land use regulations which require the separation of residential and commercial properties. The combined effect, insofar as future travel trends are concerned, is very difficult to predict. Many of the factors that contributed to the rapid increase in automobile travel in the recent past may level off or even decline in the next decade, leading to a possible reduction in the rate of growth of travel.

Exhibit 1-1
Factors Affecting U. S. Travel Patterns



Especially notable are changes in transportation policy which are intended to ensure compliance with the Clean Air Act Amendments. The Metropolitan Planning Organizations estimate dramatic reductions in future highway travel growth rates, relative to past experience. Equally dramatic increases in transit travel are projected. For the most part, policies required to effect these changes in travel trends have yet to be implemented. This chapter focuses on prior and emerging societal trends which will undoubtedly impact the scope and form of any future demand shaping policies.

The changes in our travel patterns in the last two decades are the result of the interaction of complex societal forces that constrain and shape how American households organize all aspects of their lives. In order to recognize the demands which will be made on the Nation's transportation systems in the future, we must recognize how American households respond to the pressures created by these linked forces, and how their responses lead to wide variations in individual and aggregate travel patterns. This chapter will examine important economic and demographic trends, linking them to changes in travel behavior and ultimately to changing demands on the Nation's highways, bridges, and transit systems.

This Chapter describes the changes in travel seen in the last few decades; subsequent sections explain how major societal factors expand and constrict the range of choices facing American households, suggesting how these translate into different or variable transportation patterns which may create new or increased demands on the Nation's highways, bridges, and transit systems.

Overall these analyses show that the trends described here have created:

longer worktrip commutes,

dispersed and generally lower density workplaces,

new and variable employment locations, and

different and variable employment schedules.

Certain groups, particularly working women with children and those living in the central city, are disproportionately affected by the trends just discussed; as a result they are likely to:

make more trips,

make longer trips,

make trips only to chauffeur children, and

link trips together.

These changes in travel patterns together have significant impacts on the Nation's highway and transit systems by:

lengthening peak periods,

causing greater dispersion of travel demand,

increasing the destinations to which people travel,

creating congestion in new time periods or along different routes, and

creating patterns difficult to serve with transit or other alternatives to driving alone.

The following sections describe the major trends which have led to these new and different demands on our transportation networks.

THE DIMENSIONS OF TRAVEL

Introduction

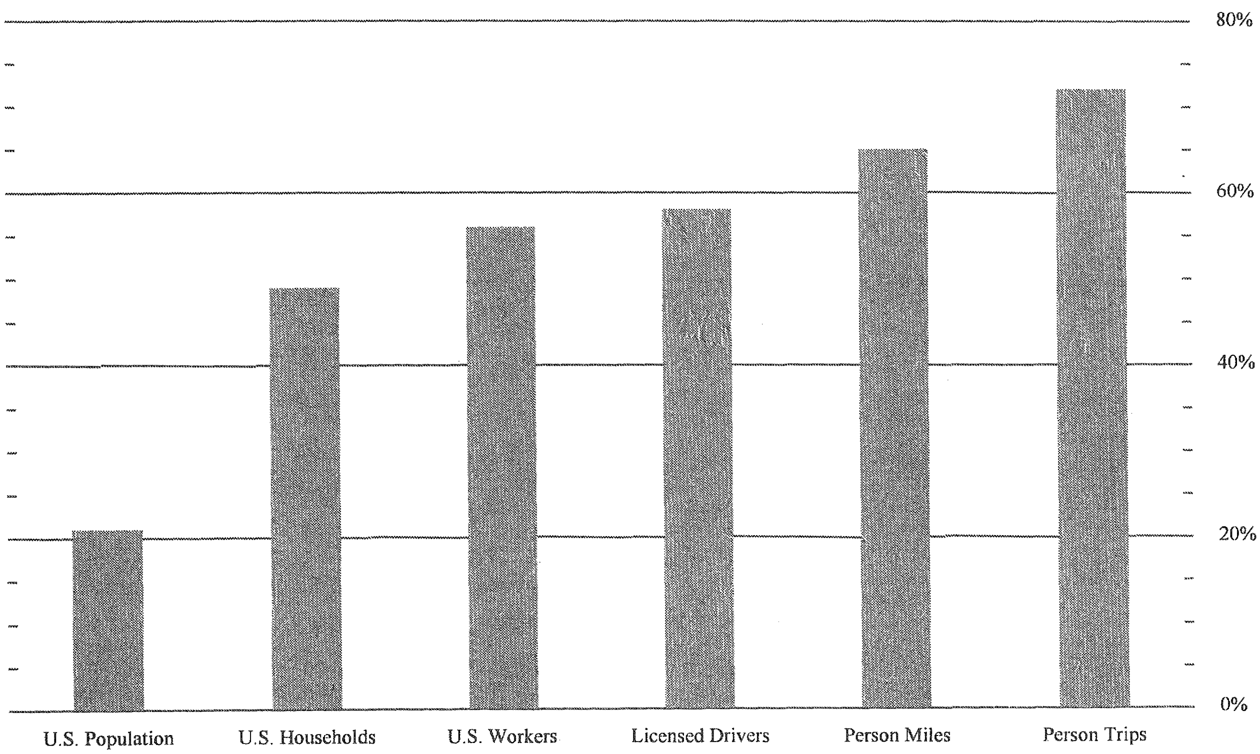
The remarkable growth in travel in various dimensions of travel has two major components:

aggregate travel growth, and

per capita growth.

Aggregate travel growth is related to total growth in the U.S. population; as the population increases the aggregate number of trips made and miles travelled increases, even if no one person takes more trips or travels further than ever before. But, as Exhibit 1-2 shows, from 1969 through 1990 the total number of trips taken by all Americans increased over three times as fast as the population; the number of people grew 21 percent but the total number of person trips grew almost 72 percent. Other factors must account for much of the increase in total trips.

Exhibit 1-2
Percent Increase in Various Factors Linked to Travel
1969-1990

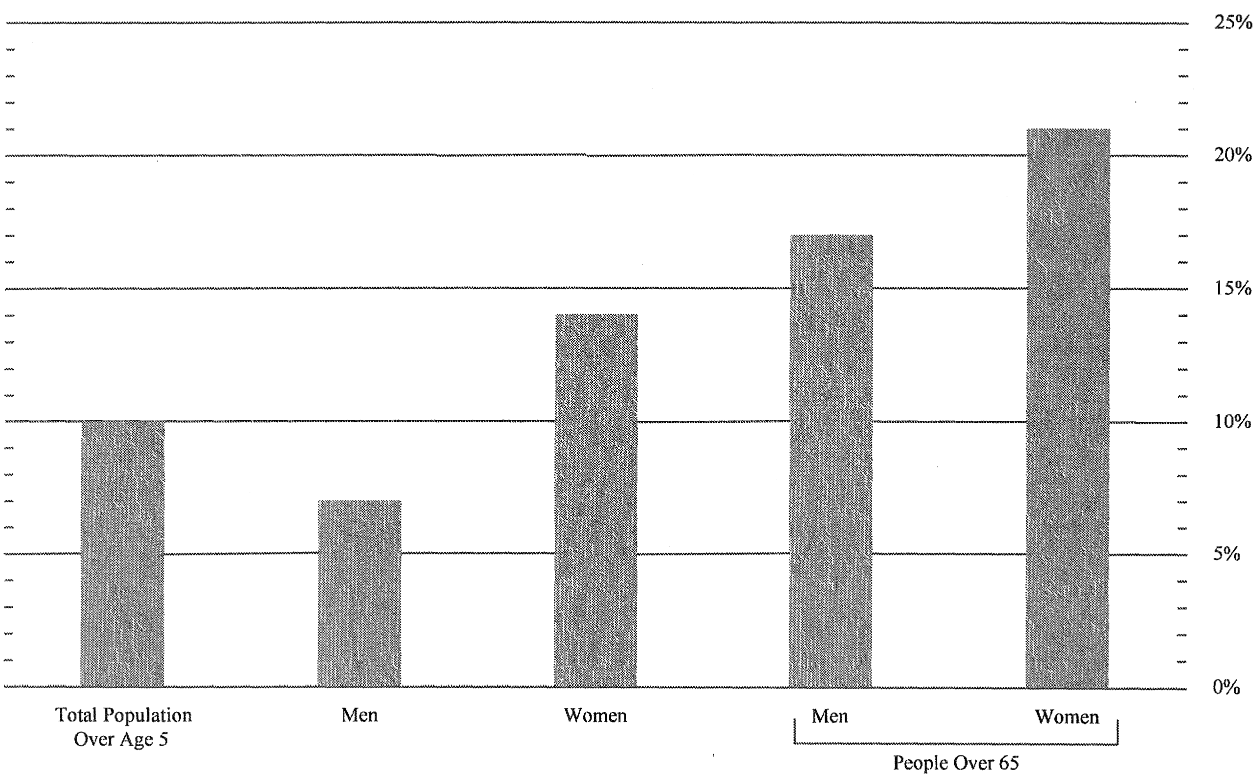


Source: <u>1990 Nationwide Personal Transportation Survey Databook</u>, Vol. I, Tables 3-1 and 3-4

It is clear that over the last two decades **per capita travel growth** has also occurred; that is, a number of people individually took more trips and travelled more miles than they, or comparable people, had before. In 1990 the average trip for all purposes was 9.45 miles compared to 8.68 miles in 1983 while the average commute increased to 10.7 miles from 8.5 miles, or a 26 percent increase.

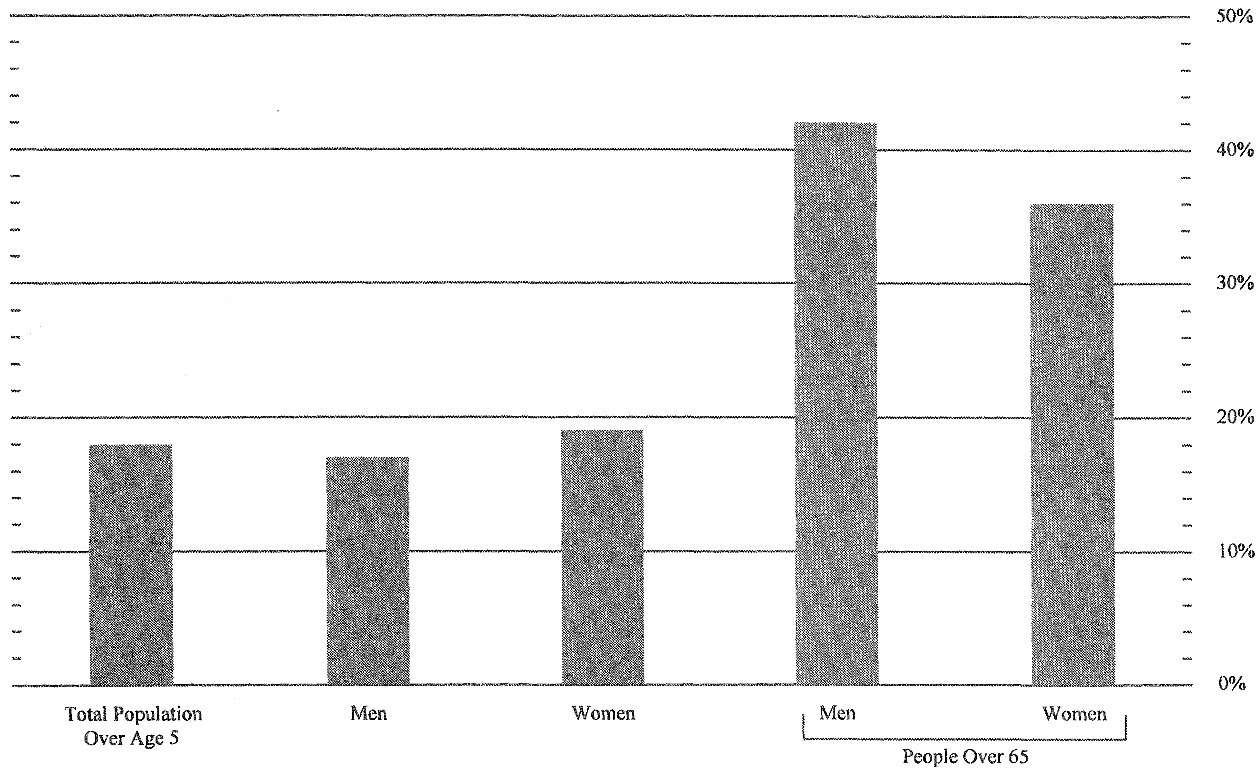
Exhibits 1-3 and 1-4 show that almost every segment of society increased their trips and mileage between 1983 and 1990, although at different rates; the largest increase in both parameters of travel were among women and among older people. Women over age 65 increased their trips by almost 21 percent and their mileage by almost 36 percent while men over age 65 increased trips by roughly 17 percent and mileage by almost 43 percent.

Exhibit 1-3
Percent Increase in Person Trips
1983-1990



Source: <u>1990 Nationwide Personal Transportation Survey Databook</u>, Vol. I, Table 4-4

Exhibit 1-4
Percent Increase in Person Miles
1983-1990



Source: 1990 Nationwide Personal Transportation Survey Databook, Vol. I, Table 4-4

In addition to travelling more, people have become more likely to do their travel in a personal vehicle rather than walking, biking, or using mass transit. In 1990 Americans took over 91 percent of work trips and over 87 percent of all trips in a car or truck or other personal vehicle and only 2 percent to 4 percent of all trips in a bus, subway, or train; although the transit share is much higher in urban areas, particularly the largest.

The next sections describe the major demographic changes that are affecting both aggregate and per capita travel.

Population Growth

In 1993 there were 258 million people in the country, the result of a 1 percent average annual growth rate since 1980. The growth in the population reflected:

a rise in the frequency of childbearing,

a decrease in death rates, and,

most significantly, a sustained flow of immigrants from abroad.

There has been a substantial increase in the number of births in the U.S. The number of annual births rose, for the first time in a quarter of a century, to 4.2 million in 1990. Yet just a decade ago demographers predicted a drop in fertility due in large measure to their estimate that up to 25 percent of all women born during the so-called Baby Boom would remain childless. In fact, the rates of childlessness among this group are running only 17 percent, largely because so many of these women simply shifted childbearing to older ages. Most demographers feel that much of the natural increase in the entire population in the last decade was "catch-up" childbearing among "babyboomer" women in their thirties.

Immigration is one of the largest causes of this country's population growth. Latin America has been the major source of legal immigration to the U.S.; since 1969, the primary country of birth being Mexico. Over 43 percent of the current foreign born population came from Latin American countries; the bulk of the remainder of legal immigrants has shifted from those of European origin to those from Asia. Today those born in Asia account for 25 percent of the foreign-born compared to 21 percent from European countries. In the last half of the 1980s, the total number of Asian immigrants outnumbered those from Latin America--1.32 million Asian immigrants arrived in the U.S. compared to 1.02 million Latin Americans.

Most analysts believe that the growth of the Hispanic-origin population will be the major element in total population growth; a recent Census report predicted that the Hispanic population will contribute 32 percent of the Nation's growth to the end of the century, and almost 40 percent to the year 2010. By the year 2000 there will be 31 million Hispanics; by the year 2015 the Hispanic population will be double what it was in 1990. In fact, much of the growth predicted for the west and south will come from the 8 million Hispanics that will be added to the population before the end of the century. Almost 81 percent of that number will reside in those two regions, over half in just Texas and California. This trend explains why Texas in 1994 replaced New York as the Nation's second most populous state.

Employment Growth

Since 1960, employment growth in the U.S. has led the world; we have experienced a 1.8 percent yearly increase in jobs, compared to 1.2 percent in Japan and just .03 percent in the combined European Community countries. The most significant change has been increasing labor force participation among women, particularly those with young children. As people gain jobs they may significantly increase both the number of trips and the miles they cover.

Data from the 1990 NPTS show that in urban areas working women aged 16 through 64 took 31 percent more trips than women not employed; employed men made 25 percent more trips than men not employed. In addition, those who were employed travelled substantially longer than those who were not employed; in urban areas, employed women aged 16 through 64 travelled 45 percent more and employed men travelled 65 percent more daily miles than their non-working counterparts. Clearly the changes in labor force participation have had substantial impacts on individual travel patterns.

Household Growth

Between 1969 and 1990 the number of American households grew 49 percent while the population grew only 21 percent. The largest share of the growth was created by single-person and single-parent households. For example, between 1969 and 1990 the number of one-person households grew almost 109 percent while in roughly the same period (1969 through 1988) the number of families with children headed by a woman grew 117 percent. During the same period, the number of more "traditional" families with children (headed by a married couple) actually declined by 3 percent. The substantial growth in new, smaller, family units is linked to divorce, children born to never married parents, and young people leaving their parents' home to be on their own. The growing number of smaller households has important transportation effects, as each household unit has a baseline amount of trips and travel required to maintain the household.

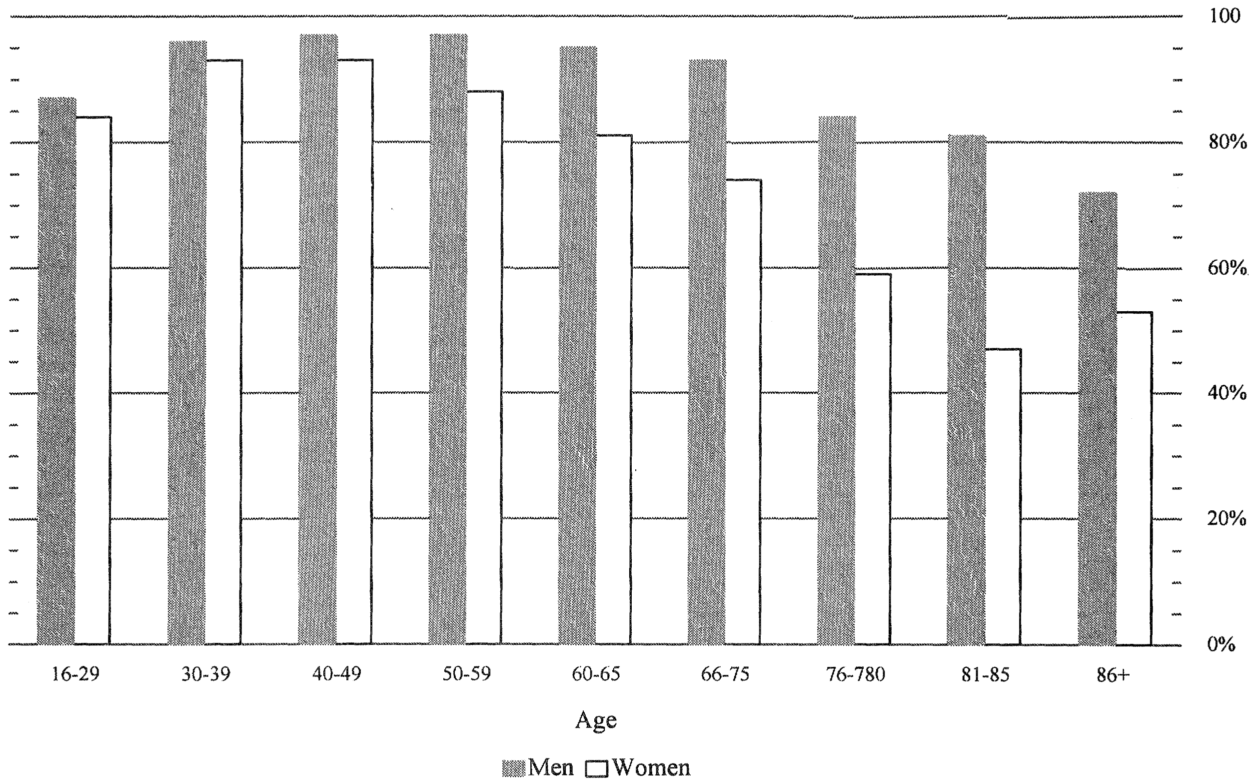
Growth in Driver's Licensing and Vehicle Ownership

The growth in licensed drivers is also related to growth in all aspects of travel; more people can drive and these people drive further and more often. Between 1969 and 1990 the number of licensed drivers went up almost 60 percent. Even relatively low-income people had licenses; 1990 NPTS data show that over 73 percent of all people age 16 and older with household incomes below $10,000 had licenses, and over 90 percent of people age 16 and older, at incomes of $25,000 or more, had driver's licenses.

Today, licensing is almost universal among younger drivers of both sexes. Exhibit 1-5 shows licensing rates by sex in 1990; note that among those aged 30 through 49, over 96 percent of the men and roughly 93 percent of the women are licensed. This suggests that within 20 years we will no longer see any significant difference in the licensing rates of men and women under age 70, and most older drivers will be licensed, compared to less than 70 percent of all women over age 65 in 1990.

However, as strong a factor as licensing is in explaining why people travel more, it cannot account for all of the growth in travel. In 1990, for example, men with licenses travelled 46 percent more miles in 1990 while licensed women travelled 76 percent more miles than both had in 1969. The largest jump in miles travelled was among younger people; for example, licensed female drivers aged 20 through 34 travelled 103 percent more miles than comparable women in 1969.

Exhibit 1-5
Licensing Rates Among Men and Women by Age
1990



Source: Unpublished data from the <u>1990 Nationwide Personal Transportation Survey</u>

Vehicle ownership is also clearly linked to the large jumps in trips per capita, miles travelled, and growing dependence on the private car. Between 1969 and 1990 the number of household vehicles increased 128 percent and the average number of vehicles per household rose from 1.16 to 1.77. Households having two vehicles jumped 117 percent while the percent of those without a car fell by a third. As a result, in 1990 only 9.2 percent of U.S. households did not have a car, while almost one in five households had three or more cars.

Of course, households without cars are not distributed evenly through the population. Households headed by older adults are the most likely to be without cars; over 23 percent of all households without a car were headed by a person over 75 years of age, although they constitute only 6 percent of all U.S. households. Over one-fifth of one adult households didn't own a car in 1990 (compared to well over half in 1969); African American households, those headed by immigrants, and those without children were also more likely to be without cars.

Both licensing and vehicle ownership are linked to the major changes seen in American travel patterns in the last three decades. At the same time, differences in licensing and vehicle ownership are also linked to the variations in travel patterns seen among various groups in society. Both the ever-expanding number of car drivers and the declining but still large group of those without other options pose serious challenges to the development and maintenance of an effective and responsive transportation system.

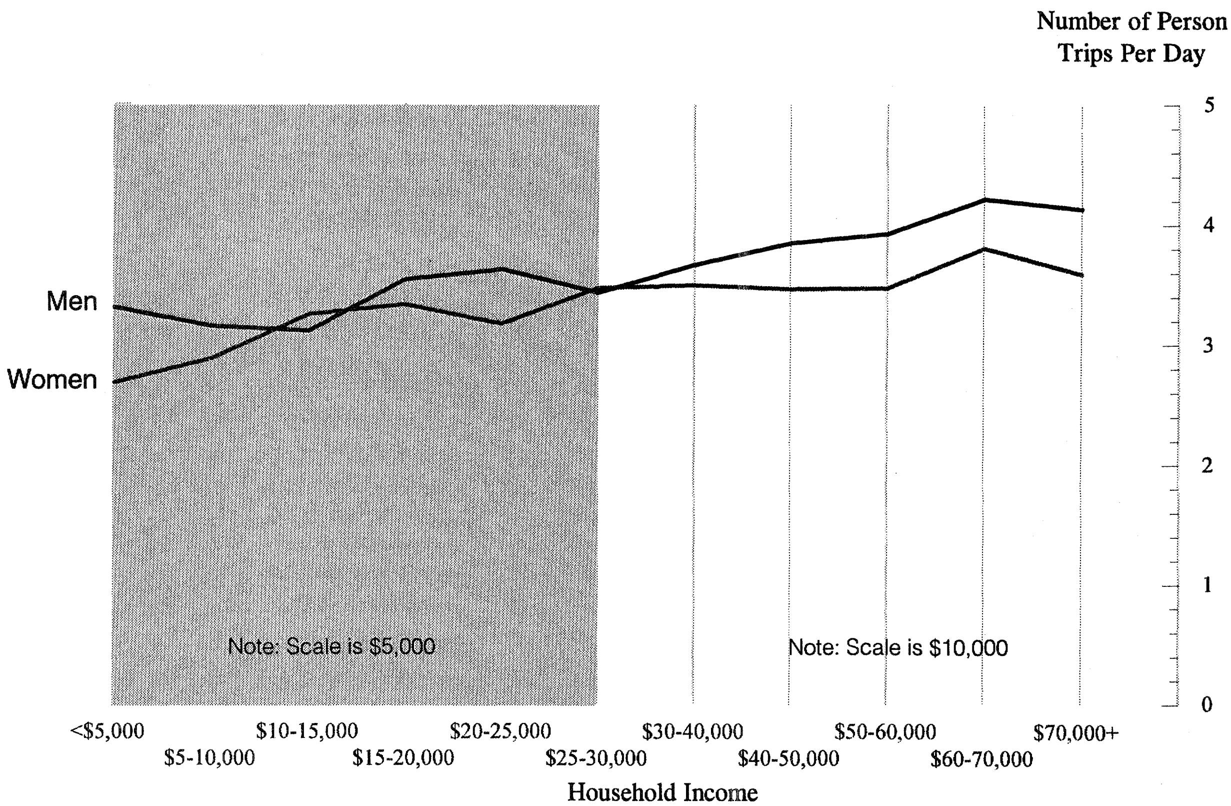
Income

Income is a major factor in travel decisions, both directly and indirectly. Income is related to employment, vehicle ownership, and the propensity to travel more. All aspects of travel increase with income--trips, miles, and use of the car. Exhibits 1-6 and 1-7 show how both total **person trips** and **person miles** rise with increasing household income; at very low incomes people average around 20 person miles and 3.0 person trips per day while at very high incomes people may travel over 50 miles, making over 4.0 person trips per day.

Real per capita income had been increasing steadily in the U.S. since 1969; in that year the average person made about $9,000. In 1979 per capita income had climbed to roughly $12,600. Between 1979 and 1982 real income dropped; from 1982 to 1989 it increased steadily. Income then declined 5.3 percent in real terms between 1989 and 1991, or 2.5 percent between 1990 and 1991--to $14,617.

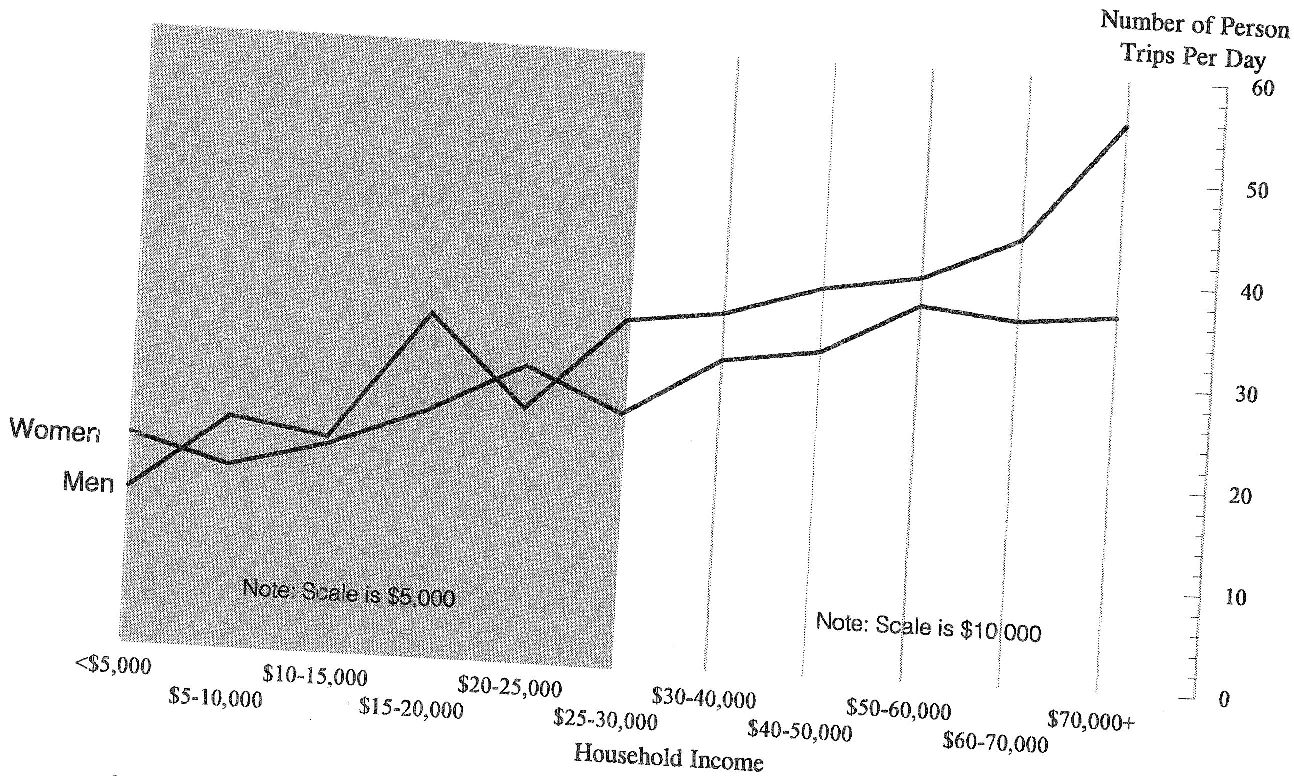
Even when the U.S. was experiencing real gains in per capita income, those gains were not equally distributed. These income disparities have important transportation implications. Certain overlapping sub-sets of Americans tend to have very low incomes which constrain their travel as well as housing and other related choices: the elderly living alone, women heading households, those from racial and ethnic minorities. The next section of this chapter contains a discussion of these groups and their transportation issues.

Exhibit 1-6
Daily Person Trips in Urban Areas
People Aged 16 through 64 by Sex and Household Income
1990



Source: Unpublished data from the <u>1990 Nationwide Personal Transportation Survey</u>

Exhibit 1-7
Urban Daily Person Miles in Urban Areas
People Aged 16 through 64 by Sex and Household Income
1990



Source: Unpublished data from the __1990 Nationwide Personal Transportation Survey__

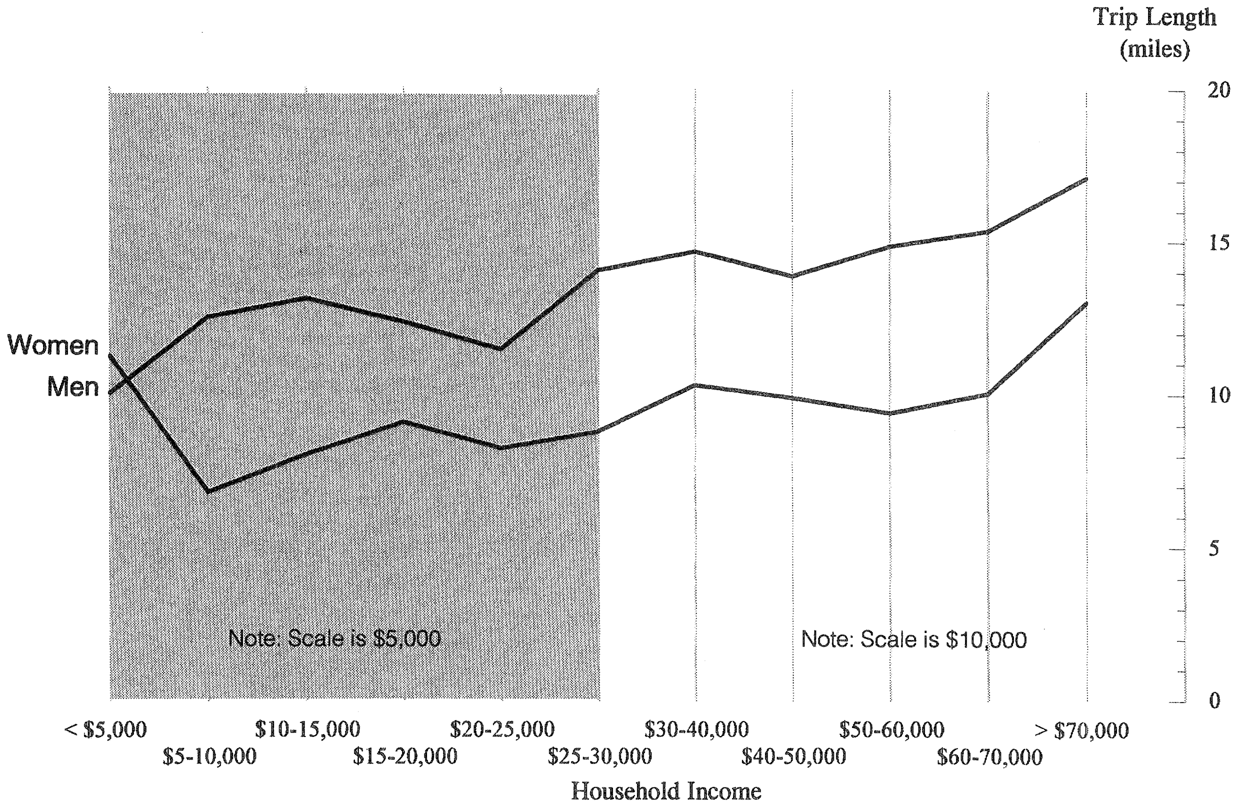
Exhibits 1-8 and 1-9 show that income also affects average work trip lengths, regardless of the mode chosen, in both rural (non-metropolitan) and urban areas, although there are also important differences between the sexes and among low income workers. Urban men with household incomes between $15,000 and $25,000 commute under nine miles a day while those making more than $50,000 travel over 13 miles to work. Household income also affects the length of the commute for both urban and rural women, although the trip length does not increase as fast or go as high. Most striking is the fact that low income people commute so much further than those with considerably higher household incomes; for example, men making between $5,000 and $10,000 travel 18 percent farther to work than men with incomes of $30,000 through $40,000.

It appears that people with low incomes have different transportation patterns, both than those with higher incomes and than we might have expected. Income disparities interact with a range of economic factors to create special transportation patterns, and problems, for affected groups. As such, they may make different demands on our highways and transit systems.

Exhibit 1-8
Average Work Trip Length in Urban Areas
People Aged 16 through 64 by Sex and Household Income
1990

Source: Unpublished data from the 1990 Nationwide Personal Transportation Survey

Exhibit 1-9
Average Work Trip Length in Rural Areas
People Aged 16 through 64 by Sex and Household Income
1990



Source: Unpublished data from the <u>1990 Nationwide Personal Transportation Survey</u>

Travel Implications

Over the last two decades, much of the change in travel has been due to the synergetic combination of substantial increases in population, income, employment, driver's licensing, vehicle ownership, and the number of smaller households. Due to these factors we have seen growth in:

aggregate trip-making and distance travelled,

per capita trip-making and distance travelled, and

use of private vehicles.

Still, as powerful as these factors are, they do not explain all of the substantial growth in travel experienced in the last 20 years nor do they explain differences in the travel patterns of otherwise comparable people. Moreover, growing income disparities themselves pose important questions for those concerned with the development and maintenance of the Nation's transportation facilities and services.

The next major section describes and evaluates some of the factors which have created disparities and differences in the travel patterns of men and women, of the young and the old, and among those from different ethnic and racial backgrounds. The section following that describes and discusses a host of economic trends which also directly or indirectly affect traditional and evolving travel patterns.

Demographic Trends

Introduction

The major societal trends discussed in this chapter appear to have affected certain groups in society differentially. Women of all ages have different travel patterns than comparable men, the elderly have different travel patterns than younger people, while immigrants and those from racial and ethnic minorities appear to have different travel patterns than the majority culture. These groupings interact as well; elderly women have different travel patterns than elderly men, while women from some ethnic groups have different travel patterns than comparable men and than women from the majority culture.

Some of these differences are the result of historical trends and patterns which may not continue; for example, a substantial number of older women and recent immigrants from some countries have never learned to drive. But we already know that most women approaching retirement in 1995 are drivers; it is possible that immigrants will learn to drive as they assimilate. However, some of the differences seen between men and women, or between members of different racial and ethnic groups, may be deeply rooted in the way families organize themselves, assign responsibilities to various family members, and view their neighborhoods. If so, such differences may only strengthen in the future. Both the differences themselves, and the possibility that they will continue, have profound implications for the magnitude and direction of the demands made on our Nation's transportation system, both now and in the future.

At the same time, those differences which result from income or occupational disparities are equally important--if the underlying conditions are likely to persist. If a substantial sub-set of older women continue to be poor, or immigrants to have low paying jobs, or minority women to be single parents, the resulting travel differences will continue to affect our highways and transit systems.

Minorities

Large and growing numbers of the U.S. population are from different cultural, racial, or ethnic backgrounds. In 1993, approximately 15 percent of the population was African American, 11 percent Hispanic (of any race), 4 percent Asian and Pacific Islander, and just under 1 percent were American Indian, Eskimos, or Aleuts. By the year 2050, Hispanics may compose 23 percent of the population, while the White proportion will drop to just over 70 percent.

Data suggest that African Americans and Hispanics have different travel patterns than other workers. Exhibit 1-10, for example, shows that Hispanics made fewer person trips than all other categories of travelers, even though they travelled for longer distances than African American or Other workers. The distances travelled may reflect the fact that more such workers are located in the inherently lower density metropolitan areas of the south and west which require longer suburban to suburban or reverse commutes. However the differential trip rates suggest different norms about travel and tripmaking; for example, only among Hispanics do women take fewer daily trips than men.

We do not know how much these patterns reflect differences in employment location, access to cars, family size, or income, or how much they reflect cultural differences. Therefore, we don't know how long such differences will persist. For the near future, however, these differences in the travel patterns of diverse travellers create important and different demands on the highway and transit network. These trends have significant implications for specific groups in society, particularly Hispanics and African Americans.

Exhibit 1-10
Daily Parameters of Urban Travel
People Aged 16 through 64 by Sex, Race, and Ethnicity
1990

	Travel Parameters			
Race and Sex	**Person Trips**	**Person Miles**	**Vehicle Trips**	**Vehicle Miles**
Hispanic				
Men	2.8	29.5	2.0	18.9
Women	2.7	17.4	1.4	9.0
White				
Men	3.4	38.9	2.8	27.9
Women	3.7	31.1	2.6	17.8
African American				
Men	3.0	24.1	2.0	16.1
Women	3.1	19.7	1.8	11.0
Other				
Men	2.8	23.5	1.9	16.9
Women	2.8	16.8	1.5	9.1

Source: Travel by Women, Sandra Rosenbloom, pg. 2-41

Hispanics

Since 1980, the number of Hispanic workers has increased 65 percent--four times the rate of non-Hispanics and a substantial expansion is expected as the Hispanic population continues to grow. Hispanics have experienced high unemployment, are overrepresented in low-paying jobs, and have high poverty rates; each of which impacts their access to and use of transportation. In 1992 an average of 11.5 percent of Hispanic workers were unemployed--compared to 7.1 percent of non-Hispanics. In 1987, median family income for Hispanics was $20,300, two-thirds of the median income of non-Hispanic families. Even when employed in the same occupational category, Hispanics made less; for example Hispanic men in managerial and professional jobs made 87 percent of the salary earned by non-Hispanics. In real dollars the income gap between Hispanics and non-Hispanics grew between 1978 and 1987. Poverty rates for Hispanics increased in those ten years as well; in 1987, 26 percent of all Hispanic families had incomes below the poverty level--compared to 10 percent of non-Hispanic families.

The Hispanic workforce has several subgroups. For example, Mexican Americans, who are concentrated in the south and west, account for 63 percent of the Hispanic labor force, while Cubans, two out of three who live in Florida, account for six percent of the Hispanic labor force. Not all of these subgroups have the same employment opportunities, skill levels, or educational attainment--and these differences are reflected in income and labor force participation rates, which in turn impact the amount and type of travel done by Hispanics.

African Americans

Between 1990 and 2000, African American employment is expected to grow between 10 percent and 20 percent so that these workers will comprise as much as 20 percent of the entire U.S. labor force. African American women and men have long participated in the labor force in equal numbers; in the 1950s over one-half of African American women were in the paid labor force compared to less than one-third of White women. However, while African American women's rates have continued to increase, reaching 58 percent in 1990, rates among men have been dropping; in 1990 only 70 percent of African American men over age 16 were in the labor force compared to 77 percent of White men. Often, employment issues for African Americans are exacerbated by the lack of transportation options for the community.

African Americans also have significant problems in the labor force. African Americans have higher rates of unemployment and remain unemployed longer than other workers. In addition, underemployment--working fewer hours than desired--is thought to be more common among African Americans. Even controlling for differences in age and education, African Americans have a harder time finding a job; for example among men with five or more years of college, African Americans are more likely to be unemployed and to work fewer hours than Whites. In 1990, White men were twice as likely as African American men to hold jobs in administration, management, or a profession; conversely African American men were one and one-half times more likely to have semi-skilled jobs. For example over 33 percent of African American men but only 19 percent of White men were unskilled workers.

In 1987, the median annual income of African American families was $20,200--compared to $31,600 for White families. The ratio of African American to White income had actually fallen to 56 percent since 1969, when African American family earnings were 61 percent of that of White families. The poverty rate for married African American couples was almost twice that of White couples, and higher in 1990 than it had been in 1978.

A recent study of African Americans noted,

> *Many policy observers are concerned that the American economy will evolve into a two-tiered system of high- and low-wage jobs, and that African Americans who lack the educational training required for upward job mobility will become disproportionately clustered in the bottom tier...this two-tiered occupational structure will divide African Americans along educational and socioeconomic lines, creating a class of persistently poor African Americans*[2].

[2] William P. O'Hare, Kelvin M. Pollard, Taynia Mann, and Mary K. Kent, "African Americans in the 1990's," Population Bulletin, vol. 46, no. 1, 1991, p. 26.

Travel Implications

Clearly these employment trends may lead to massive unemployment among some workers while widening the wage gap for others, while those with lower incomes tend to travel shorter distances and depend more on public transit. Service workers with low or falling incomes may not be able to continue to travel shorter distances and use transit because of dispersed suburban jobs without transit access. As a result the growing number of low paid service workers may be forced to spend proportionately more--in time and money--for their home to work commute.

The Elderly

American society is rapidly aging. In 1990 more than one-fourth of the entire population was over age 60. Indeed, the elderly are the fastest growing component of the U.S. population; the number of those over age 65 grew more than 20 percent between 1980 and 1990. Moreover, in 1990 there were 6.2 million Americans over age 85, a number the Census Bureau expects to increase over 400 percent by 2050. By the first decade of the next century almost half of all elderly people will be over age 75, and almost 5 percent of the entire U.S. population will be over age 80. Among the elderly, women outnumber men by three to two and are overrepresented among the very old. The Census Bureau predicts that by 2010 more than half of all women but only 41 percent of all men will be over age 75. Partially because of the age gap between men and women, older women are substantially more likely to be unmarried or to live alone.

The aging of the population has transportation implications because the elderly have different travel patterns than younger members of society, because those elderly today have different travel patterns from those over age 65 two decades ago, and because a large and growing number of elderly need help in transporting themselves--or in obtaining services that substitute for travel.

The travel patterns of the elderly have been changing with the rest of society; many aspects of the travel patterns of those over age 65 mirror those seen in the younger population. The elderly as a group are taking more and longer trips, traveling to new and different destinations. The elderly do take fewer trips than younger people, but largely because they've stopped going to work. For at least a decade after retirement the only real difference between younger and older travellers is the absence of work-related travel.

People between the ages of 65 and 75 make as many or more trips than slightly younger workers for shopping, and personal business and recreation, travelling as many miles. This strongly suggests that those who retire retain all their "usual" travel patterns except the work trip for as long as they can; that they shop at the same stores and travel to the same doctors and visit the same friends, largely because they stay in the same neighborhood where they lived while members of the labor force, and they continue to drive to meet their needs.

Several major factors relating to the aging of society have profound implications for our Nation's highways, bridges, and transit systems:

large numbers of elderly drivers,

low density and rural concentrations of elderly people, and

requirement for services and facilities to elderly needing assistance.

Elderly People and Private Vehicles

Today most older people are drivers; between 1983 and 1990 the increase in licensing among both older men and women was substantial—not, of course, because older people learned to drive but because younger drivers were aging. In 1992 almost 90 percent of men and 50 percent of women over age 70 were licensed drivers; more importantly, almost 100 percent of men and 90 percent of women who will be over age 70 in 2012 are currently licensed drivers. As a result the elderly are driving far more than they did just two decades ago. Exhibit 1-11 shows how the elderly have increased the annual miles they have driven since 1969; in 1990 those over age 70 drove almost 32 percent more miles than comparable elders in 1969.

Exhibit 1-11
Average Annual Miles Driven by Driver Age
1969-1990

	Year			
	1969	**1977**	**1983**	**1990**
All Ages	8,685	10,006	10,588	13,181
60-64	8,112	8,002	8,568	10,314
65-69	5,850	6,277	6,804	8,347
70+	4,644	4,828	4,348	6,138

Source: Travel by the Elderly, Sandra Rosenbloom, p. 3-19

The dependence of the elderly on the car creates major safety concerns; growth in the elderly population threatens to increase accident rates. The NPTS, coupled with accident data, shows that those over age 65—who account for roughly 13 percent of the population and of licensed drivers—account for only 8 percent of all accidents. But when the accident rate of the elderly is calculated by exposure, that is, by miles driven, the result is the well-known U-shaped curve; older and very young drivers have more accidents per mile driven than those in the middle. Moreover the rate of accidents per exposure increases rapidly with increasing age after age 60. In reality, older drivers have fewer accidents simply because they drive less.

Whether we will see per capita increases in accident rates among the elderly will depend on whether the newer generation of older drivers continue to drive less as they age. It is possible that people used to driving will keep doing so without the reduction seen with previous generations. However, even if all older drivers either reduced their driving as they aged, or newer generations of older people had better driving records per mile driven, it makes sense to explore ways to make driving safer and easier for people as they age, and develop alternative travel options for those unable or unwilling to continue driving. The transit options available to replace the mobility lost with their car are often limited. Thus the elderly have no incentive to stop driving, as their loss of mobility will be substantial.

Residential Patterns

The travel patterns of older people are strongly influenced by residential patterns. Like most Americans, in 1990, over three quarters of all those over age 65 lived in metropolitan areas, with almost two thirds in the **suburbs** of those areas. Those elderly people who do live in the central cities of metropolitan areas are more likely to be members of ethnic or racial minorities; they are also more likely to be women living alone and to be poor.

At the same time, over 8 million lived in non-metropolitan, or rural, regions in 1990; because younger people have been moving out of nonmetropolitan counties, the actual **concentration** of rural elders has been increasing substantially.

In short, most older people age in the places they lived while working; increasingly these are low density or rural communities where it is difficult to access services or facilities without a car, and where it is difficult to provide transit services.

Ethnic and Racial Diversity Among the Elderly

The diversity of America is increasingly being reflected in the makeup of the elderly. In 1990 roughly 8 percent of those over age 65 were African American while 5 percent were of Hispanic origin. However, the Census Bureau predicts that by the middle of the next century 20 percent of older Americans will be African American, 19 percent will be of races other than African American or White, and over 15 percent will be of Hispanic origin.

The ethnic and racial makeup of the older population may have travel implications as well. Several major studies have found that cultural and ethnic preferences have important transportation implications; there is a growing body of literature which shows that cultural or ethnic differences may well create variations in the kind and amount of ride-giving either requested by or provided to older relatives as well as older people's attitudes about transit safety and security. For example, elderly Mexican-American women were significantly less likely to have a driver's license but more likely to make trips in autos than comparably situated Anglos or other minority women--generally traveling with relatives and family members.

Exhibit 1-12 shows that there are indeed differences in the travel of American elders by ethnic and racial background; in 1990, Whites and Hispanics were much more dependent on the private car and much less dependent on walking or public transit than African American or Other older people. We do not as yet know why people from different backgrounds have different travel patterns and whether these differences reflect the need for additional services or just variations in life style or personal and family norms about travel.

Exhibit 1-12
Urban Travel Mode for All Trips
People Over Age 65 by Sex, Race, and Ethnicity
1990

	Hispanic		White		African American		Other	
Mode	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
Private Vehicle	85.6%	74.2%	91.6%	88.4%	71.0%	69.7%	70.7%	70.0%
Transit	3.6%	4.6%	1.4%	1.7%	13.7%	13.5%	12.1%	16.3%
Walk	9.0%	15.2%	6.2%	8.7%	13.7%	15.4%	14.1%	12.5%
Taxi	-	1.5%	0.2%	0.5%	-	1.4%	-	1.2%
All Others	1.8%	4.6%	0.6%	0.7%	1.6%	-	3.1%	-

Source: Travel by the Elderly, Sandra Rosenbloom, pg. 3-34

Elderly People and Poverty

In 1990, two out of every five households living in poverty were headed by an older person. Over 3.4 million elderly people had incomes below the poverty level in 1989—or roughly one in ten, although that rate was well below the overall poverty rate of the Nation or of the elderly in the past. Many poor elderly are single women, often minorities, living alone. In general, those living alone have the lowest median incomes. In 1990, the majority of those over age 75 who lived alone had incomes below $10,000 and were 50 percent more likely to have poverty level incomes than married couples. At the same time, older women living alone were more likely to be poor than comparable men; 40 percent of women over age 85 but only 27 percent of comparable men living alone had poverty level incomes.

Problems in Providing Services to Older People

One of the major implications of the aging of society is that there will be fewer and fewer younger workers available to pay for, or to directly provide, services for the rapidly growing number of seniors who increasingly require assistance—including transportation or services which take the place of transportation. Those living alone may be particularly needy—and far less likely to receive assistance from non-governmental sources. This has both a societal and personal dimension. The personal dimension may be strongly affected by ethnic and family norms about the aid given to older relatives while the societal dimensions may be governed by financial and political concerns.

With the babyboom generation currently in their prime working age, the ratio of persons over age 65 to workers will decline in the next 15 years. But as babyboomers age, the ratio of persons over age 65 to workers will increase dramatically, and by 2030 the forecast is for 83 dependent people to every 100 working age adults—about 50 percent higher than in 1990.

The overall level of care required by our rapidly aging population is much more physically and psychologically demanding than that needed four decades ago, in part because of the increased number of cognitive diseases among the growing number of people older than age 80. The problem of providing care to an aging population also has very personal dimensions which may in turn have transportation implications. A 1990 study found that almost one in five men and one in three women older than age 75 required assistance to conduct some of their daily activities, such as bathing, dressing, or eating. Between 80 percent and 90 percent of this kind of personal care, as well as help with household tasks—including transportation—are provided to the elderly by family members, usually daughters and daughters-in law. With the high levels of women's labor force participation, these demands are stressful and may result in women leaving the work force to provide care for older relatives.

At a minimum, the needs of their elderly parents will constrain the schedules and travel choices of many women relatives, particularly those in paid employment; at the worst, middle-aged women may actually leave the work force to care for frail older relatives.

The Travel Implications of an Aging Society

All of the demographic changes described above will create an elderly population that will differ notably from previous generations in many important ways: while wealthier and better educated as a group, a major subset of the elderly will be poor—generally older women living alone—requiring substantial assistance. In addition, most elderly people today are drivers, substantially dependent on the car for their transportation needs.

It is clear that:

most older people are or will be licensed drivers,

the majority of elderly live in low density suburban and rural areas,

there are central city concentrations of older people with special needs, and

there are fewer younger people to provide or pay for transportation assistance.

As a result of these trends, we have seen that the elderly:

take more and longer trips,

are currently dependent on the private car, and

may face serious mobility losses when they can no longer drive.

Since over three-fourths of the elderly live in low density suburban or non-metropolitan places—places where the private car is the only viable travel option—it is difficult to imagine how society can urge older drivers to curtail their driving if they have physical difficulties in doing so, or replace the mobility lost when driving is no longer possible. The high concentration of elderly in the rural areas poses even more intractable problems, since elders there face severe isolation if they lack transportation options.

We have little way to gauge the extent to which current differences among the elderly are a function of choice and to what extent necessity. Are variations in the life style and ultimately transportation choices among the elderly (by age or sex or racial and ethnic background) likely to continue because they reflect important cultural norms and expectations held by younger cohorts of the population? Or will they change as new generations of Americans age?

Women

While societal trends have increased both aggregate and per capita trip rates among women as they have among men, women seem disproportionately impacted by the suburbanization of so many jobs, the growth of service sector employment, and other demographic trends. The ways in which salaried women balance their domestic and employment responsibilities given these trends create substantially greater and different impacts on the modes they choose, the hours they travel, the routes they take, and how they organize and combine their out-of-home activities. For example, Exhibit 1-13 shows that at most income categories, high or low, working women always make more trips than comparable men, even though men travel more miles than women except at low incomes.

Other aspects of women's travel patterns are different. How and where working women take care of, or arrange care for, their children while they work have important transportation implications. In 1988 less than 28 percent of all young children with salaried mothers were cared for in their own homes. As women increasingly find care options outside their own homes, they create the need to transport their children as part of their home to work commute.

Exhibit 1-13
Indicators of Travel by Sex, Income, and Work Status
1990

Household Income	Travel Parameters Daily Person Trips	 Daily Person Miles
Income under $5,000		
Women Workers	4.4	28.1
Men Workers	2.4	15.0
Income $25-30,000		
Women Workers	3.8	28.1
Men Workers	3.6	31.9
Income over $70,000		
Women Workers	4.1	36.6
Men Workers	3.7	55.9

Source: Travel by Women, Sandra Rosenbloom, pg. 2-29

Women in the Labor Force

Today women account for close to half of those in paid employment; in 1992 women comprised 46 percent of the total civilian work force--compared to 38 percent in 1970. Participation rates are different among various sub-groups of the population. African American women and men have long participated in the labor force in equal numbers; in the 1950s over one half of African American women were in the paid labor force compared to less than one third of White women. African American women's rates have continued to increase, reaching 58 percent in 1990. Hispanic women are less likely to be in the labor force than non-Hispanics; in 1992, 53 percent of Hispanic women were employed compared to 58 percent of non-Hispanics.

The substantial increase in women in the labor force has been associated with the:

increased participation of married women, particularly with small children,

need to link work trips with daycare or school trips, and

need to balance employment and household responsibilities.

Married Women

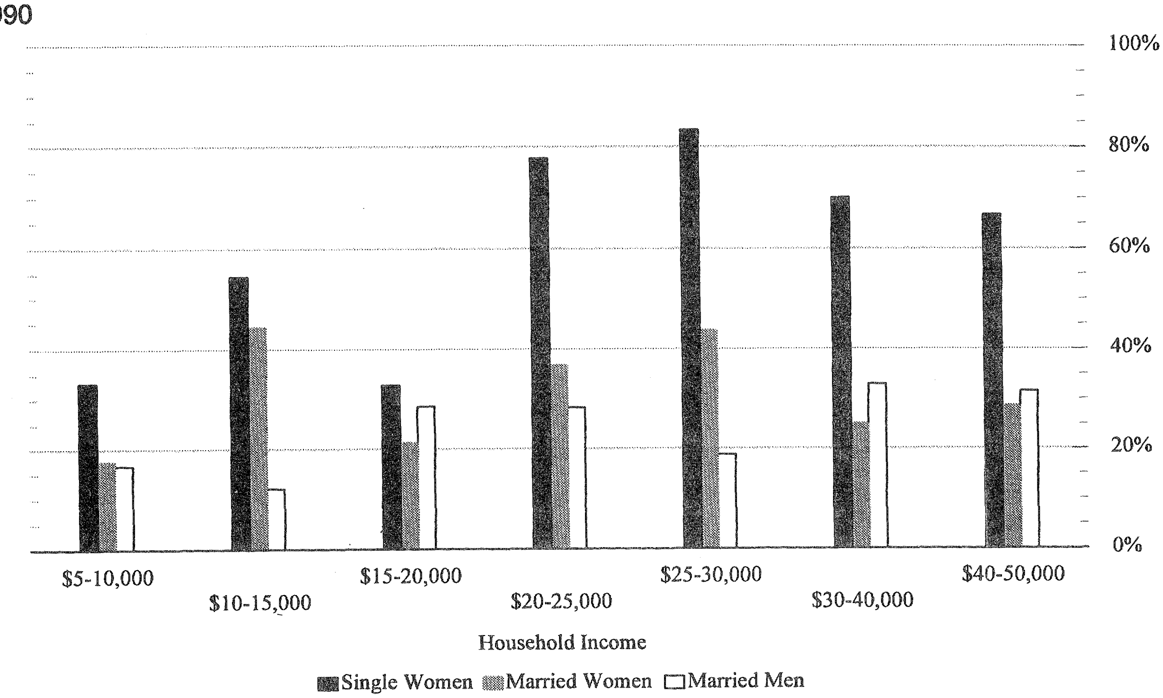
A more striking trend than the increasing number of employed women, is the growth in number of **married** women who work outside the home. In 1990, almost 60 percent of all married women were employed, in contrast to 1960 when less than one-third of married women were in the paid labor force. The aggregate figures also hide the dramatic increase in the labor force participation of **women with children**. Today almost 60 percent of married women with children under age six have salaried employment, while almost 75 percent of married women with children from age six to seventeen are in the paid work force.

Aggregate data also obscure the even more substantial increase in the labor force involvement of married women with **very young** children. In 1990, almost half of all mothers of babies under 6 months were in the paid labor force--one in twelve employed women had an infant. A 1990 Department of Labor study found that over 44 percent of all women return to work before their babies are 6 months of age, over two-thirds of those on a full-time basis.

Trip Linking

Because they retain multiple responsibilities when they enter the paid labor force, women often "link" trips together, dropping children at daycare on the way to work or going grocery shopping on the way home. Exhibit 1-14 shows that women workers are substantially more likely to link trips home from work; they are also more likely to link multiple trips when they do. But the mothers of small children, particularly single mothers, are much more likely to link trips than comparable male parents.

Exhibit 1-14
Percent of Parents of Children Under Age 6 Who Link Trips Home from Work
Urban Areas
1990



Source: Unpublished data from the 1990 Nationwide Personal Transportation Survey

As a result of trip linking, women may take longer to make a shorter home to work trip, and may be more dependent on the car to do so. Studies show that the more children a woman had, and the younger those children, the more likely she was to drive to work while the number and age of children has no impact on men's mode choice. Data from the 1990 NPTS show that women in households earning under $30,000 took a higher percentage of all trips in a car than comparable men. The differences were the greatest at the lowest income levels: women in households making under $5,000 annually made 74 percent of all trips in a car compared to 61 percent of the trips of comparable men. And at all household income levels under $25,000 women were more likely to go to work in a car than comparable men.

Women with children often have to make trips solely to meet the needs of their children; therefore they may be less able to use alternative modes which rarely allow for chauffeuring small children on the way to or from work. Many workers report that their inability to stop driving alone is due to their need for their car immediately before and after work, to their child care needs, and to their concern that they might be faced with a family emergency during the middle of the work day.

Single Mothers

Women in the labor force appear to have travel patterns that differ from those of comparable men. But some women, particularly those who are poor or who head families on their own, also face additional constraints which affect their travel patterns and the demands they make on the Nation's transportation systems.

Exhibit 1-15 shows how much the presence of children in a household affects the travel patterns of women, particularly single mothers. Women in two adult households with children aged 6 to 15 make 21 percent more person trips than comparable men; those with children under age 6 make over 9 percent more trips than comparable men. Single mothers almost always make more trips than either comparable women or men, probably because they have no one to share the obligations that require travel.

Over the last three decades, the number of families headed by a woman alone has increased substantially. In 1970, just 11 percent of all families were maintained by a woman alone; that grew to 15 percent in 1980, 16 percent in 1985 and almost 20 percent in 1990. This is a result of a steady drop in the rate of first-marriage coupled with a steady increase in the divorce rate.

Families headed by a woman alone have considerably higher poverty rates than any other type of households--over one third are living below the poverty level. Even employment didn't help much; over 24 percent of families with children headed by employed women were living below the poverty level.

Exhibit 1-15
Differences in Urban Average Daily Person Trips
by Sex and Selected Lifestyles
1990

Gender and Presence of Children	Adults in Household Two	Adults in Household One
Children 0-5		
Men	3.2	3.1
Women	3.5	3.6
Difference	9.4%	16.1%
Children 6-15		
Men	3.3	3.7
Women	4.0	4.1
Difference	21.2%	10.8%
Children 16-21		
Men	3.3	3.8
Women	3.4	3.6
Difference	3.0%	-5.2%
No Children		
Men	3.3	3.6
Women	3.4	3.7
Difference	3.0%	2.8%

Source: Travel by Women, Sandra Rosenbloom, pg. 2-32

Women and Poverty

It appears that women, particularly low income women who head households, may be disproportionately impacted by the growing suburbanization of jobs since many reside in more central locations but must commute out to the suburbs for employment. Thus, these women have longer commutes than their incomes would indicate and are more often forced to make those trips in a car. The need to make reverse commutes or suburb to suburb commutes only strengthens the need to have a car. As a result even low income women drive, spending a considerable and disproportionate part of their incomes to maintain a car.

The 1990 NPTS data also suggest that low income women may be paying a serious transportation penalty for living in the inner city. Exhibits 1-8 and 1-9 showed that women in households making $5,000 to $10,000 travelled over 8.5 miles to work in 1990; no other income group of women travelled that far until they have incomes in excess of $25,000. In addition, in 1990 at incomes of $5,000 to $10,000, urban women were more likely use a car for their work trip than comparable men; in fact women in households with incomes of $10,000 to $15,000 were more likely to travel to work in a car than men in households making $10,000 more.

Travel Implications

Clearly many women—even those with low incomes—have responded to their complex domestic and employment activities with substantial increases in all aspects of travel. Moreover the dimensions of their travel—mode, time, routes, destinations—are often very different than otherwise comparable men because they work in different places, or on different schedules, or have different concerns about safety, or because they must combine domestic, childcare, and employment travel together to optimize their time. These complicated patterns have profound implications for their use of the Nation's transportation systems and services.

ECONOMIC TRENDS

Introduction

American society is experiencing a complicated set of economic changes. These trends help to create a variety of individual and aggregate travel patterns which have serious implications for our Nation's highways, bridges, and transit systems. These trends have interacted to produce:

new and variable employment locations,

lower density employment concentrations, and

different and variable employment schedules.

These trends are linked with important differences in the travel patterns of workers who may have:

longer worktrip commutes,

dispersed and generally lower density workplaces, and

new and variable employment locations.

Each of the major economic trends, and its ultimate impact on the Nation's transportation system, are discussed below.

The Changing Nature of the Labor Force

From 1970 to 1990, while the population of the U.S. grew 1 percent annually, employment grew 2 percent per year. As a result, in 1992 there were 20 million more people employed than there had been just ten years earlier. And in the next decade, projections show that 26 million new jobs will be added to the U.S. economy. With this growth has come important changes in the composition of the labor force.

First, industries and jobs have changed significantly. In the next decade most of the job growth will be in service rather than production industries. That is, more people will be employed in jobs in retail sales, or public administration, or communications and fewer people will have jobs in factories or mines, or on the farm. Nonfarm wage and salary jobs in service industries are expected to account for 94 percent of all new jobs in the next decade.

Second, the racial and ethnic composition of the entire labor force has been changing. In 1980 minorities of all kinds comprised 18 percent of the U.S. civilian labor force; in 1992 that had grown to 22 percent. African Americans increased their share of the labor force by 1 percent annually in those years--roughly the same rate seen during the previous decade--but Asians and others doubled their share of the labor force. The growth in both Asian and Hispanic employment is tied to immigration and, among Hispanics, also to a higher birth rate.

Third, women have entered in unprecedented numbers; between 1970 and 1990 the participation rate of women increased over 14 percent--while dropping almost 4 percent for men. The rate of growth has been most rapid among women aged 35 to 44; today almost 75 percent are in the paid labor force. All three of these trends complement one another and each contributes to significant changes in the travel patterns of affected workers and their families.

The Growth of a Service Economy

One of the most striking economic factors of the last three decades has been the significant change in the **sectoral composition** of the labor force—that is, changes in the industries and occupations in which most workers are employed. In the United States the total number of service sector jobs grew 73 percent from 1970 to 1990 while those in manufacturing grew only 2 percent—as jobs in agriculture actually fell 6 percent. As a result, in 1990, there were almost 85 million jobs in the service sector in the U.S.—or 72 percent of total civilian employment.

The growth of the service sector economy may create a widening gap between the wages of low- and high-skill workers; this will change the resources and options available to many workers, ultimately affecting their transportation choices. The U.S. has seen substantial widening of wage differentials; real wages fell 1.28 percent for low skilled workers between 1980 and 1990. The U.S. Bureau of Labor Statistics has predicted that the trend toward income disparity will increase between 1992 and 2005.

At the same time, the absolute number of jobs in the goods-producing sector will continue to grow in the next decade—even though that sector's proportion of all nonfarm jobs will drop to 13 percent (from 17 percent in 1992). In 1992, employment in manufacturing accounted for only 17 percent of the labor force—compared to 34 percent in 1950—but it had almost 3 million more jobs than in 1950. Even within the goods producing sector there will be winners and losers; manufacturing and mining will show absolute job losses while construction industries will gain just over a quarter of a million new jobs by 2005.

Retail trade will soon replace manufacturing as the second largest source of total U.S. employment; it is expected to generate over 5 million jobs by 2005. This industry is dominated by part-time, low-skill, "demand little" jobs which offer little chance for advancement. Unfortunately, women have traditionally been the dominant participants in this division accounting for 52 percent of the jobs in 1990 and holding 68 percent of the part-time jobs.

All of these changes impact travel patterns, and the demands on our transportation systems by changing the schedules which employees work, or the destinations to which they travel, or the routes they take, or their income and other resources they own.

The Flexible Labor Force

A key component of the service sector is the **flexible labor force**, which contains as much as one-fourth of all American workers. The term commonly refers to:

people with variable work schedules with a given employer,

those who work at different locations in a given time period,

those who consistently work for multiple employers in a given year or month,

people who are not always employed full-time, although they might wish to be, and

the growing number of contract workers--people who do not join one company for a lengthy period but instead sell their services for fixed periods of time to different employers, often without receiving traditional benefits.

Associated with the growth of the flexible labor force are:

people working multiple jobs,

people working variable schedules, and

people working at widely dispersed job locations in short periods of time.

It is difficult to estimate the number of people who actually make up the flexible labor force, but it is clear that these trends are strongly related to the growth of the service economy discussed above, and have very important transportation implications which translate into very different demands on the Nation's transportation systems. Today, perhaps 34 million people comprise the flexible work force, "contingency workers" who are available to respond to different employers' needs. Estimates are that by the turn of the century, almost half of the work force will be contingency workers.

One component of the flexible labor force is those in temporary employment. Estimates are that between 1982 and 1993 temporary employment increased almost 250 percent while total employment grew only 20 percent. Temporary employment services place 1.5 million temporary workers each day--three times as many as they did just a decade ago.

Another component of the flexible work force is those working variable work schedules; in 1991 over 15 percent of the U.S. work force had flexible schedules which either allowed or required them to vary the hours they started or stopped work; the comparable 1985 figure was 12 percent.

A third component is workers with multiple employers, including so-called contract workers. In 1991 roughly 6 percent of the U.S. population had more than one job, including contracts with more than one employer.

Finally, a key component of the flexible work force is those who work less than 35 hours to 40 hours per week. The expansion of the service sector has been coupled with the rapid growth of part-time jobs; the rate of growth of part-time jobs has outpaced that of full-time jobs in almost all developed countries in the last two decades. For example, between 1973 and 1990 the annual rate of growth of part-time jobs in the U.S. was 2.4 percent compared to 1.8 percent for full-time jobs. A recent Census study estimated that as many as 90 percent of the new jobs created each month are "involuntary" part-time jobs. With an expanding part-time work force comes an expanding variety of work schedules and trip patterns, which in turn decrease opportunities to use public transit or to carpool.

The growth of both the flexible labor force and service sector employment itself have work schedule implications; they involve a variety of work schedules which change the nature of the traditional home to work commute. For example, recent Census data show that almost 40 percent of all women workers—who are disproportionately represented in service sector employment—do not have a day shift job (defined as a work schedule where at least one-half of the hours fall between 8:00 AM and 4:00 PM). Twenty-three percent of all full-time working mothers and almost 60 percent of those working part-time not only don't work the classic "9-to-5" day, they don't even work most of their hours during that traditional period.

The transportation implications of the growing flexible labor force are clear. The nature of the work commute will be profoundly altered as the dimensions of the daily home-to-work trip change rapidly and frequently. Variable schedules and jobs will have tremendous impact on the transportation options open to workers, the safety problems which various modes may entail, and the home-to-work routes which they take. Workers will see little point in choosing a home with some relationship to their job since their work location will change so frequently; they may be less likely to walk or to try to find transit services and they will find it difficult to join carpools. It will be equally difficult for transit systems to provide convenient service to all the destinations to which workers could be sent--and for the variety of schedules they might be working. On the other hand, these changes could reduce the peaking of transit travel, which would have a favorable impact on transit costs.

Working at Home and in the Car

Two related employment trends within the flexible work force have strong transportation implications: people who run businesses at home and people who telecommute to work. It is not always easy to differentiate these two trends and analysts have not always been clear as to the distinction. Telecommuting usually involves working at different locations over the course of a work week or month—perhaps at home a few days, perhaps at the office other days. Running a business at home, however, generally means having only one work location, although the proprietor may travel to visit clients; running home based businesses often requires changes in zoning and building codes. Both trends create patterns that differ from traditional commutes.

The Bureau of Labor Statistics found that in 1991, of 20 million people who reported engaging in some (nonfarm) work at home as part of their primary job, only two million were actually paid for working at home while 5.6 million were self-employed. The remaining 12 million nonfarm workers working at home were just "taking some work home from the office" and were not paid specifically for that work.

Overall a greater percentage of women performed job-related work at home, although in numbers more men work at home. That is, 3.5 percent of all women at work, or 1.8 million, work at home, while 3.2 percent of male workers, or 1.9 million, work at home.

The propensity to work at home varies substantially with race--Whites were three times more likely to work at home than African Americans, and went up with age. Salesworkers were the most likely to work at home; managers and professionals also had a high rate of work at home, about 3 percent. Those who worked at least 35 hours a week at home were more likely to be in service occupations, generally hairdressers and childcare workers.

Those people who work for pay at home are generally the focus of "telecommuting" discussions. A 1993 survey found that there were 7.6 million telecommuters--those working part of their paid week at home; approximately 75 percent were people working in information industries such as programming, accounting, data processing, marketing, planning, and engineering. These are clearly professions that lend themselves more readily to work at home than do production jobs; given the fact that these industries have growing numbers of employees, there is a strong possibility that telecommuting may have substantial impact on transportation patterns in the future.

At the same, there have been reports of the growing number of sales and other employees who no longer have an office and use their cars as offices as they travel from one site to another. A recent Wall Street Journal article estimated that over 6 million U.S. workers used their cars each day in lieu of offices--a number which some experts think will increase 25 percent by the end of this decade.

We do not yet know the full impact of these trends on the commute patterns of workers and the demands on the Nation's highway and transit systems. Most of those who work at home will change the nature, routing, and timing of their work trips. They may reduce their total number of trips or the miles they cover--or, they may make longer non-work trips or move much further from their workplace "using up" any mileage saved on the days they don't report to an external job site. All of these patterns will create work trip "commutes" that defy the traditional definition of the term--and place new and different demands on the transportation network.

The Impact of Economic Trends on Travel

All of the economic changes just described create different and, in many cases, new travel patterns. With the change to a service industry has come a deconcentration of employment sites--industries do not need to be near one another or in a central area. Moreover average firm size is smaller and firms are less likely to locate along heavily travelled corridors--so there are a wide variety of dispersed work destinations.

The changing economic base of America has substantially altered the commute trip patterns of many workers; they are travelling at different hours, along different routes, and on different days in the week than comparable people two decades earlier. Commuter trips are now spread over a much longer day, with a sizable minority of travelers having variable work schedules or working late at night or early in the morning.

Therefore, the vast number of work trips, and indeed all trips, have both suburban origins and destinations, which reduces the number of people travelling to any one employment or commercial destination while simultaneously increasing the number of destinations to which people travel. These patterns also place new demands on the Nation's transit systems which often were designed to serve commutes occurring in more narrowly defined peak periods, in corridors of high density demand.

Population Movements and Land Use Patterns

There have been significant changes in the distribution of the U.S. population across the country, within regions, and within metropolitan areas, changes which interact strongly with the demographic and economic trends previously addressed. Over the last three decades, the U.S. has experienced strong shifts in employment and population which have resulted in:

suburbanization of the population,

suburbanization of employment,

development of suburban employment clusters, and

concentrations of poverty in urban cores.

At the same time, local land use regulations have interacted with these factors to continue to increase the expansion of single purpose neighborhoods and low density communities.

These patterns all have strong implications for how, where, and how often people travel. Over the last three decades, both population and employment growth have been greatest in the lowest density parts of the country; the majority of Americans today live and work in metropolitan areas with low density land use and housing patterns. These patterns condition their commute to work and other trips, their mode choices, and even the routes along which they travel. In general, the lower the density of a community the fewer concentrated origins and destinations and the fewer corridors of high density demand. These kinds of patterns require decentralized transportation facilities and services.

Inter-Regional Population Patterns

Most population growth since 1970 has gone to the south and west. The largest component of the U.S. population (34 percent) lives in the south while the northeast region has the smallest share of the population (under 20 percent). However the fastest growth in population has been in the western region where many States showed double-digit population increases since 1980; Nevada grew almost 40 percent in the last decade while Alaska and Arizona also grew over 30 percent. In contrast two of the States in the southern region actually declined in population (West Virginia and the District of Columbia) while most of the other southern States grew less than 7 percent since 1980.

Internal Migration

Many of these differences in population growth are due to **internal** migration, that is, people already living in the U.S., moving from one part of the country to another.

> *High mobility underlies many fundamental institutions of American society; business, the military, higher education, and more frequently the family. Young adults in the United States are highly mobile because they tend to leave home and live independently before marriage. In addition, Americans' older ages at marriage, low fertility, and high rates of divorce and separation, along with the growth in single-parent households, are consistent with elevated levels of residential mobility*[3].

[3] Patricia Gober, "Americans on the Move," Population Bulletin, vol. 48, no. 3, November 1993, p. 4.

Most internal migration in the past decade has been from the northeast and midwest to the south. So, in spite of disproportionate western growth, some analysts believe that the westward movement of the U.S. population may be coming to an end as internal migration slows; for example, net internal migration to the west was almost zero in 1988. The most conspicuous indicator is that California, the principal recipient of westward migration in the last forty years, has seen a marked downward trend in migration.

Not surprising, the south and the west, housing half of the country's population, recorded 61 percent of U.S. employment growth between 1960 and 1980. In themselves these patterns have transportation implications; in general people have been moving from higher density industrial cities to lower density service-oriented cities. Even the goods-producing firms in the south and west have been able to locate in suburban areas to take advantage of cheaper land costs. As a result, the worktrip patterns of internal migrants may change remarkably—even if they keep the same occupation in the same kind of firm.

External Migration

The patterns created first by internal migration have been strengthened by migration from abroad. Almost 40 percent of all **external** migrants—that is, those from countries other than the U.S.—live in the west: 43 percent of those from Latin America and almost 50 percent of those from Asia. In fact 4 of every 10 foreign born persons from Latin America lived in California in 1988. However more of those born in Latin America and Asia lived in the northeast (27 percent) than the south (24 percent).

Thus not only are the south and the west the fastest growing and now the largest areas of the country, they are also the home of large concentrations of recent immigrants to the U.S.—people who tend to have poor education and low skill levels and who may be limited to the poorly paid service sector jobs, and thus have special transportation issues.

Intra-Regional Population Patterns

Within regions, most population growth has gone to metropolitan areas. Between 1910 and 1988, while the national population grew 167 percent, the metropolitan population grew by 449 percent—or over 600 percent in areas over 1 million. Metropolitan growth in the last decade has been almost 4 times that of nonmetropolitan or rural areas. Moreover the annual rate of metropolitan growth has been increasing over the last two decades—it was 1.0 percent in the 1970s and 1.2 percent from 1984. This was a sharp reversal from the 1960 to 1970 decade when non-metropolitan areas grew faster. As a result, today almost 80 percent of the total U.S. population live in metropolitan areas.

Conversely, a significant number of non-metropolitan areas lost population; between 1980 and 1988, 18 states, mostly in the mid-west, had one or more non-metropolitan counties which lost population. Nationally non-metropolitan growth overall fell to 0.3 percent annually but there was wide variation in growth rates. Almost 60 percent of counties in the midwest and over one-third of those in the northeast lost population in the 1980s. However, those non-metropolitan counties which were closely linked to metropolitan areas (for example, having a high level of commuting) generally had much higher growth rates and this pattern was uniform across regions of the country.

Overall Trends in Population Growth

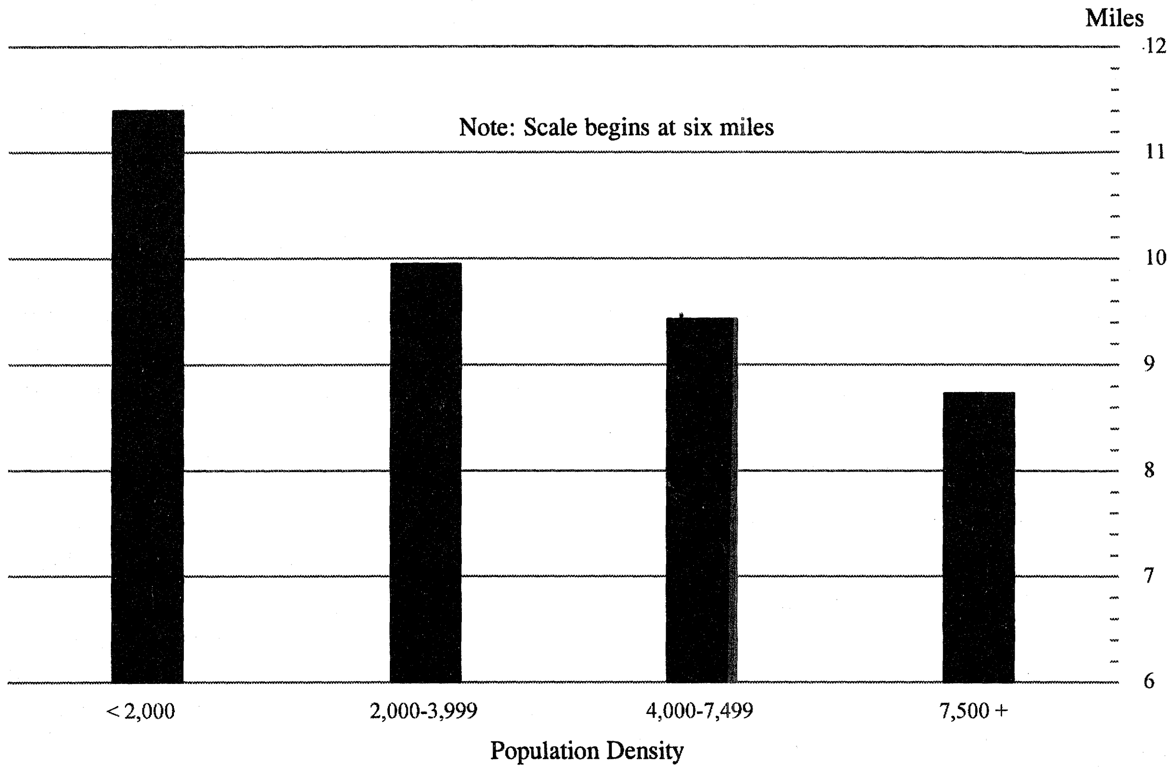
Within metropolitan regions, the majority of population growth in the last three decades has been in the suburbs. The dimensions of this suburban population growth are staggering: while U.S. population rose 56 percent in the forty years since World War II, central cities only grew 50 percent. In contrast the suburban population grew almost 200 percent in the same years. In short most of the increase in metropolitan population was actually in the suburbs; 86 percent of total U.S. population growth since 1970 has gone to suburban areas.

Since 1950 about one-third of the total U.S. population has lived in the central city, but the suburban portions of metropolitan areas have increased from 23 percent of total U.S. population in 1950 to 46 percent in 1988. While central cities grew faster after 1980 than they had after 1970, their growth rate was less than half that of the suburbs. In fact the suburbs absorbed almost 76 percent of metropolitan growth in the decade of the 1980's. Thus overall central cities have grown but at not nearly the rate as their suburbs.

Not all central cities experienced growth; 43 percent of the central cities of recognized Metropolitan Statistical Areas lost population in the last half of the 1980s. The incidence of loss was highest in the northeast region of the country where over 70 percent of the central cities lost population and where over half of the central cities had been declining in population since 1950. Conversely fewer than one in five central cities in the west experienced absolute losses.

Given the low densities in many suburban areas it is not surprising that travel patterns are affected by the relative changes in central cities and suburbs. Exhibit 1-16 shows that, in 1990 those living in areas of less than 2,000 persons per square mile commuted 11.4 miles, while those in the highest density areas, 7,500 or more persons per square mile, travelled 8.7 miles to work.

Exhibit 1-16
Average Distance Traveled per Trip in Central City, Suburban, and Rural Areas
1990



Source: 1990 Nationwide Personal Transportation Survey Databook

Concentration of Central City Populations

The reverse side of the suburbanization trend is the profound changes occurring in central cities. The mass movement of American families and business to the suburbs has helped to create central cities which differ sharply from those of fifty years ago--in terms of both the kind of economic activity and the kinds of families which live there.

Today almost all of U.S. neighborhoods characterized by extreme poverty are located in the Nation's 100 largest central cities. Moreover, the percentage of the population in central city census tracts living at "extreme poverty" more than doubled between 1970 and 1990, from 5.2 percent to 10.7 percent of the central city population. As the sheer numbers of the poor increase, they are being more concentrated not only within the central city but within small areas of the central city; the total percentage of the 100 largest central cities' poor populations living in extreme poverty tracts increased from 16.5 percent to 28.2 percent.

Thus, central cities are often the home of both large numbers and large concentrations of very poor people. In 1980, 2.4 million poor people lived in concentrated central city areas—or 9 percent of all poor people in the U.S. In 1991 the poverty rate of all families was 17 percent in central cities and 7 percent in the suburbs. Over 26 percent of central city families with children were considered poverty households compared to 11.9 percent of those in the suburbs—the ratio of poverty households to total households was 2.5 times as large in the central cities as in the suburbs.

The concentration of the poor has two major impacts on an urban economy: low-income households increase the per capita cost of public service provision and the pressure to provide these services creates substantial budgetary pressures on local governments which have a disproportionate share of the responsibility for service provision. Thus they are forced to raise taxes, which in turn accelerates the flight of higher income households and employment to suburban jurisdictions.

At the same time, the nature of the employment base in central cities frustrates attempts to decrease poverty by matching central city residents to central city jobs. Most central cities experienced **absolute** job growth but those new jobs are primarily high skill information processing and professional jobs. Thus low skilled inner-city workers are disadvantaged by both the nature of the jobs left in (or coming to) the central city and by the movement of other jobs to the suburbs. As a result they are forced to seek the suburban jobs still matched to their skills and become reverse commuters; generally incurring more expensive and longer commutes in both time and distance—with fewer and poorer transit options.

Nationally, reverse commute trips increased almost 9 percent between 1970 and 1980. There are indications that this trend grew even more during the 1980s, but data to track it is confounded by changes in the definition of central city between 1980 and 1990. However, a 1991 study in the Washington D.C. Metropolitan area found that reverse commuting from the core increased 45 percent between 1980 and 1988, to account for one in five trips in the region in 1988.

The Character of Neighborhoods

Most neighborhoods are largely or entirely residential in character, particularly those in suburbs and in rapidly growing parts of the country. But, there has been a growing movement among urban designers to re-create the way in which European, or older mixed use American, neighborhoods work by replicating features from those communities in new suburban developments. These so-called neo-traditional design advocates promise a reduction in auto use from the return to higher density, mixed land use neighborhoods. In such neighborhoods, transit and walking would be viable options and required drives would be shorter.

Whether or not it is possible to substantially remake American neighborhoods, it is clear that the low-density, single-purpose neighborhoods so characteristic of many American areas have substantial impact on the travel patterns of the residents. Because few services are located within walking or biking distance of the home, people must leave the neighborhood, often by car, to meet their needs--this increases both the mileage they cover and the trips they take.

For example, older people living in the suburbs or rural areas travel farther and more often in a car than their central city counterparts. In 1990 suburban women over age 65 drove 6 percent more than central city women while suburban men drove 14 percent more than comparable central city men. The patterns are even sharper when the elderly are grouped by cohort; for example, suburban men aged 75 to 79 drove 20 percent more than their central city counterparts.

These same pressures are at work for most Americans. Between 1983 and 1990 a remarkable array of trips taken for different purposes grew longer; every single non-work trip purpose except shopping grew in length. The average car driver or passenger in 1990 went almost 12 miles to visit friends, 11 miles to the doctor or dentist, and over 7 miles to conduct personal business. Indeed, the average car traveller increased his or her mileage to school or church by over 25 percent, travelling almost 7.5 miles to conduct activities we are used to thinking of as "neighborhood."

These longer trips imply that the car has given people the ability to conduct activities anywhere they wish within their community, choosing among many potential doctors, or banks, or churches. On the other hand, the current structure of neighborhoods has denied these same travellers the choice of shopping, or visiting medical services, or conducting social activities very close to home. And for those unable or unwilling to drive, few of these trips could easily be replaced by another mode, given the time costs of transit and walking.

Transportation Impact of Population Movements

The internal migration of the population, combined with migration from abroad, combined with the rapid suburbanization of homes and jobs, have been linked to:

substantial population and employment growth in the west and south,

concentrations of migrants from abroad in a limited number of States,

major growth in suburb-to-suburb commutes,

major growth in reverse commutes, and

increased distances between home and all trip purposes.

These patterns have profound implications for the Nation's highways, bridges, and transit systems. Employees who both work and live in low density places create scattered travel patterns--they do not travel along highly concentrated corridors and they have few options to the private car when they travel. Employees who live in the core of metropolitan areas but work in the suburbs also create non-traditional commutes and may have limited travel options. Overall, these population and land use trends accelerate the travel patterns linked to the growth of the service based economy. They lead to:

longer work trips,

longer nonwork trips,

more scattered origins and destinations, and

greater dependence on the car.

The Implications

Changing household structures, the labor force participation of women with children, immigration, the aging of society, and evolving family relationships interact with land use and housing patterns and major changes in the ways industries and firms do business to have profound social and ultimately transportation implications. All of these trends together have remarkably changed the nature of both work and non-work travel. Exhibit 1-17 summarizes the key transportation impacts which could be experienced if these major trends persist in the future. Clearly all the entries in this Exhibit are open to debate.

The Nations's transportation system and its various components must respond to the complex and difficult situations and responsibilities that structure the daily activities of a number of travelers. Because of the economic and demographic changes occurring in our country—and around the world—people are travelling more than ever before--they make more trips, those trips are longer, and they are often made in a personal vehicle. At the same time, there is wide variability in most people's travel patterns; they are travelling along different routes, at different times of the day, to different destinations--and all these choices can change frequently and even daily. It is becoming ever more difficult for our current transportation systems to respond to these growing, yet rapidly changing, demands.

In addition, different groups of travellers have other demands of the transportation system. Most travelers require safety, security, convenience, and reliability at cost-effective prices; some travellers, however, may value some system attributes more than do others (security, for example), may have disproportionate requirements for other attributes (reliability or convenience, for example), or make different assessments of the cost effectiveness of transportation improvements. Those with low incomes may view the cost of travel as a significant issue since it may constitute a greater percentage of their disposable income; well paid service workers may be more concerned with reliability. Older people may be very concerned with safety while workers are concerned with speed; those with children may be concerned with flexibility, as well as cost and safety. Each of these needs poses special problems for the Nation's highways, bridges, and transit systems.

The Nation's transportation system is already a powerful force in the lives of most American families; it can be an even more potent instrument to increase the mobility and independence of many segments of society if it is planned, developed, and maintained with special concern for the varied and different needs of American travellers. However, it remains speculative at this time to predict whether or not some or all of the trends that have accounted for the rapid growth in automobile travel will continue in the future. Some may level off, or even decline, resulting in a lower rate of travel growth.

Exhibit 1-17
Summary of the Impact of Societal Trends on the Amount and Type of Travel

	Aggregate Travel		Per Capita Travel		Trip Patterns Affected		
	Trips	Mileage	Trips	Mileage	Scheduling	Location	Type
Population							
Total Growth	+	+					
Immigration	+	+				o	
Aging	-	-			o	o	o
Employment							
Total Increase in Jobs	+	+	+	+			
Service Sector Growth				+	o	o	o
Women's Participation Rate	+	+	+	+	o	o	o
Work-at-Home	-	-*	-	-*		o	
Land Use and Housing Patterns							
Suburbanization of Homes and Jobs		+		+		o	
Low Density Single-Use Neighborhoods		+		+		o	o
Declining Regional Densities		+		+		o	o
Employment Nodes		-		-	o	o	
Rural Retirement Concentrations		+	-	+		o	o
Household							
Total Increase in Number	+	+					
Single Adult Households	+	+	+	+			
Single Parent Households	+	+	+	+	o	o	o
Driver's Licensing							
Total	+	+	+	+		o	
Women	+	+	+	+		o	o
Elderly	+	+	+	+		o	
Policy Factors							
TDM/TCM Incentives	-	-	-	-	o		
TDM/TCM Sanctions	-	-	-	-	o	o	o
Congestion Pricing	-	-	-	-	o	o	
Land Use and Zoning	+**	-	+**	-		o	o

* If people substitute 2 to 3 very long daily work trips for five shorter ones, they could increase mileage.

** Data indicate those living at high density may make more short trips.

Note:

Much of the information about the travel of Americans comes from a series of reports on the Nationwide Personal Transportation Survey or NPTS; national surveys were undertaken in 1969, 1977, 1983, and 1990. The NPTS reports most used in this Chapter are:

Demographic Special Reports, Feb. 1995
Special Reports on Trip and Vehicle Attributes, February 1995
Travel Mode Special Reports, December 1994
Urban Travel Patterns, June 1994
1990 NPTS Databook, Vols. I, November 1993, and II, Oct. 1994
Travel Behavior Issues in the 90's, July 1992
Summary of Travel Trends, March 1992

All of these reports are available from the Office of Highway Information Management, Federal Highway Administration, Washington, DC.

Chapter 2

Highway, Bridge and Transit System and Usage Characteristics

Chapter 2

Introduction

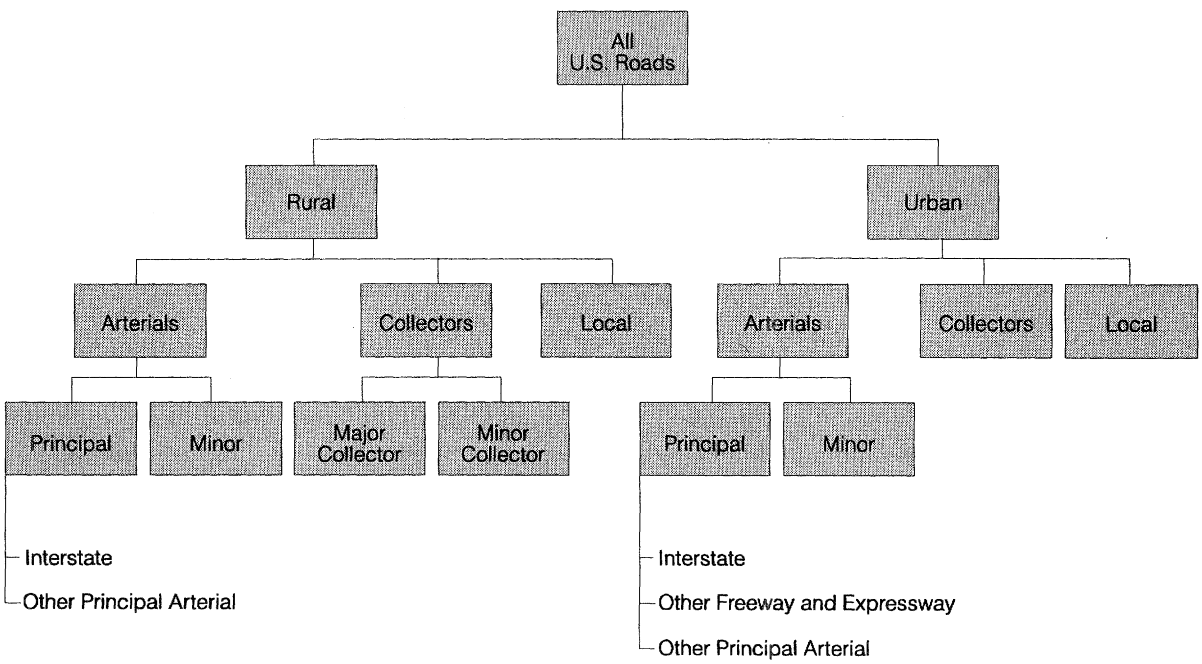
This chapter contains a description of system and usage characteristics for highways, bridges, and transit. The first section, System Classification, contains descriptive information on the highway and transit functional classification systems and the proposed National Highway System (NHS). The second section examines trends in surface transportation extent and capacity. Finally, the System Usage section contains highway and transit travel trends.

System Classification

Highway Functional Classification System

All public roads and streets in the United States (U.S.) are functionally classified by type and use. There are three major functional systems: arterials, collectors, and local roads. These major systems are further subdivided into both rural and urban areas, as is illustrated in Exhibit 2-1. Exhibit 2-2 summarizes the distribution of mileage and use of the system by functional classification.

Exhibit 2-1
Highway Functional Classification Hierarchy



Source: <u>Highway Functional Classification Manual: Concepts, Criteria and Procedures</u>, March 1989

Exhibit 2-2
Percent Highway Miles, Lane-Miles, and Vehicle-Miles Traveled by Functional System
1993

Functional System	Miles	Lane-Miles	Vehicle-Miles Traveled
Rural Highways			
Interstate	0.8	1.6	9.1
Other Principal Arterial	2.5	2.9	8.8
Minor Arterial	3.5	3.5	6.4
Major Collector	11.1	10.7	7.8
Minor Collector	7.2	6.9	2.1
Local	54.3	52.2	4.5
Subtotal	79.4	77.9	38.6
Urban Highways			
Interstate	0.3	0.9	13.8
Other Freeway & Expressway	0.2	0.5	6.2
Other Principal Arterial	1.4	2.2	15.5
Minor Arterial	2.2	2.7	12.0
Collector	2.2	2.2	5.3
Local	14.3	13.7	8.6
All Urban	20.6	22.1	61.4
Total Highway	100.0	100.0	100.0

Source: Highway Statistics, 1993

Arterial System

Rural Areas. In rural areas, the arterial system is broken down into principal and minor arterials. The rural principal arterial system is stratified into two subsystems: Interstate and other principal arterials. The rural principal arterial system consists of a connected rural network of continuous routes and has the following characteristics:

serves corridor movements having trip length and travel density characteristics indicative of substantial statewide or interstate travel;

serves all, or virtually all, urban areas with populations greater than 50,000 and a large majority of those with populations greater than 25,000; and

provides an integrated network without stub connections except where unusual geographic or traffic flow conditions dictate otherwise (e.g., connections to international borders, coastal cities, airports, and waterports).

In 1993, the rural principal arterial system accounted for about 4.2 percent of rural mileage and about 3.3 percent of total mileage. This small portion of highways carried 46.1 percent of rural travel and 17.8 percent of total travel in the Nation.

The rural minor arterial system is made up of routes whose design should be expected to provide for relatively high overall travel speeds, with minimum interference to through-movement. The rural minor arterial system, in conjunction with the principal arterial system, forms a rural network having the following characteristics:

links cities and larger towns (and other traffic generators, such as major resort areas, that are capable of attracting travel over similarly long distances) and forms an integrated network providing interstate and intercounty service;

is spaced at such intervals, consistent with population density, so that all developed areas of a given state are within a reasonable distance of an arterial highway; and

provides service to corridors with trip lengths and travel density greater than those predominantly served by rural collector or local systems.

In 1993, the rural minor arterial system accounted for about 4.4 percent of rural mileage and about 3.5 percent of total mileage. It carried 16.6 percent of rural travel and 6.4 percent of total travel.

Urban Areas. In urban areas, the arterial system is also broken down into principal and minor arterials. The urban principal arterial system is stratified into three subsystems: Interstate, other freeways and expressways, and other principal arterials. The urban principal arterial system serves the major centers of activity of a metropolitan area, the highest traffic volume corridors, and the longest trip lengths. It carries the major portion of trips entering and leaving the urban area, as well as the majority of through-movements and provides continuity for all rural arterials that intercept the urban boundary.

In 1993, the urban principal arterial system accounted for 9.3 percent of urban mileage and 1.9 percent of total mileage. This mileage carried 57.8 percent of urban travel and 35.1 percent of total travel.

The urban minor arterial system interconnects with and augments the urban principal arterial system and provides service to trips of moderate length at a somewhat lower level of travel mobility. It provides connection to rural collector roads where such connections have not been classified as urban principal arterials.

The urban minor arterial system accounted for 10.7 percent of urban mileage and 2.2 percent of total mileage in 1993. It carried 20.0 percent of urban travel and 12.0 percent of total travel.

Collector System

Rural Areas. The rural collector system is stratified into two subsystems: major and minor collectors. Major collector routes provide service to any county seat not on an arterial route, to the larger towns not directly served by the higher order systems, and to other traffic generators of equivalent intracounty importance, such as important mining and agricultural areas. Major collector routes link these places to nearby larger towns, cities, or routes of higher classification, and they serve the more important intracounty travel corridors.

Rural minor collector routes are spaced at intervals, consistent with population density, to collect traffic from local roads and bring all developed areas within a reasonable distance of a collector road. They also provide service to the remaining smaller communities.

The rural major collector system accounted for 13.9 percent of rural mileage and 11.1 percent of total mileage in 1993. It carried 20.1 percent of rural and 7.8 percent of total travel. The rural minor collector system accounted for 9.1 percent of rural mileage and 7.2 percent of total mileage. It carried 5.6 percent of rural and 2.2 percent of total travel.

Urban Areas. The urban collector system provides both land access service and traffic circulation within residential neighborhoods and commercial and industrial areas. It differs from the arterial system in that facilities on the collector system may penetrate residential neighborhoods, distributing trips from the arterials through the area to the ultimate destination. The collector system also collects traffic from the local streets and channels it into the arterial system.

The urban collector system accounted for 10.6 percent of urban mileage and 2.2 percent of total mileage in 1993. It carried 8.6 percent of urban travel and 5.3 percent of total travel.

Local Roads and Streets

In both rural and urban areas, all public road mileage below the collector system is classified as local. In 1993, rural local roads accounted for 68.4 percent of rural mileage and 54.3 percent of total mileage. These roads carried 11.6 percent of rural travel and 4.4 percent of total travel. Urban local roads accounted for 69.4 percent of urban mileage and 14.3 percent of total mileage. These roads carried 14.1 percent of urban travel and 8.6 percent of total travel.

Highway Functional Systems and Tripmaking

The functional systems described above work together to provide efficient vehicle movement. A typical highway trip begins on either a collector or a local road, then moves onto an arterial route for the line-haul portion of the trip. This allows the vehicle to take advantage of the arterial's higher speeds and more direct connections between towns and cities or, in the case of a purely urban trip, between areas of the city. Because of the higher design characteristics of arterials, particularly the control of access, the travel time, accident rate, and vehicle operating cost per mile are usually lower for the portion of the trip made on the arterial than for the portion made on the collector or local road.

Incomplete networks, poor physical conditions, or serious congestion on higher level systems lead to greater use of lower level systems and often result in longer, slower, and more expensive trips. These factors may also generate incompatibilities between the transportation system and adjacent land uses; for example, when commuters or trucks use collectors and/or local residential streets to avoid a highway facility that is congested.

Highway Classification by Jurisdiction

Functional classification is not necessarily an indication of highway ownership. Nationwide, States have jurisdictional responsibility for 20 percent of total public road and street mileage. The Federal government has responsibility for 5 percent, primarily in national parks, forests, and Indian reservations. Local governments retain control of, and responsibility for, the remaining 75 percent, although State/local agreements may authorize States to construct and maintain locally controlled roads under a cooperative reimbursement agreement. There is no consistent relationship between functional systems and jurisdictional responsibility, although, as a general rule, States control the higher functional systems and local governments control lower systems. Exhibit 2-3 displays changes in highway mileage by jurisdiction since 1983.

Exhibit 2-4 contains a list of bridges by jurisdiction. The majority of these bridges, nearly 299,000, are under local jurisdictions. Slightly over 270,000 are under State jurisdiction, while approximately 3,600 are under Federal jurisdiction. Private entities own 2,800 bridges.

Exhibit 2-3
Highway Mileage by Jurisdiction
Selected Years, 1983-1993

Jurisdiction	1983	1985	1987	1989	1991	1993
Rural						
Federal	262,122	225,122	211,511	178,189	182,143	179,567
State	817,206	773,249	703,554	706,506	702,637	692,403
Local	2,137,960	2,172,616	2,248,773	2,238,029	2,254,655	2,229,673
Subtotal	3,217,288	3,170,987	3,163,838	3,122,724	3,139,435	3,101,643
Urban						
Federal	893	1,035	1,045	1,026	1,030	1,311
State	99,627	111,496	95,442	96,901	95,848	107,317
Local	561,830	578,416	613,701	655,850	652,986	694,450
Subtotal	662,350	690,947	710,188	753,777	749,864	803,078
Total	3,879,638	3,861,934	3,874,026	3,876,501	3,889,299	3,904,721

Source: Highway Statistics, 1983-1993

Exhibit 2-4
Bridges by Jurisdiction
1994

Jurisdiction	Number of Bridges
Federal	3,622
State	270,691
Local	298,295
Private	2,800
Unknown/Unclassified	1,052
Total	576,460

Source: National Bridge Inventory, June 30, 1994

The Proposed National Highway System

Previous editions of this report included material on the various Federal-aid systems: Interstate, primary, urban, and secondary. Roads included in these systems were eligible for Federal funding. Upon passage of the Intermodal Surface Transpiration Efficiency Act of 1991 (ISTEA), these systems, except the Interstate, were replaced. A National Highway System (NHS), which will incorporate the Interstate and much of the other principal arterial system, will be the system of highest Federal interest. The Surface Transportation Program will provide funds for all functional systems not in the NHS and higher than the local functional system and the rural minor collector.

The proposed NHS, developed through a collaborative effort with State and local partners, was announced on December 9, 1993, and is before the Congress for consideration. The ISTEA requires Congress to officially designate an NHS by September 30, 1995. The proposed NHS consists of 159,000 miles of the most important roads in the U.S. but represents only 4 percent of the 4 million miles of roadways in the country. The NHS is expected to carry 40 percent of our Nation's highway traffic and 75 percent of heavy truck traffic.

States designated the majority of the NHS, but approximately 67,000 miles—the Interstate system, the Strategic Highway Corridor Network (STRAHNET), major STRAHNET connectors, and ISTEA-specified high priority corridors—were mandated by the ISTEA. The remaining "flexible" mileage is regional in character and was selected by the States in cooperation with the Metropolitan Planning Organizations.

The purpose of the NHS is to provide an interconnected system of principal arterial routes which will serve major population centers, international border crossings, ports, airports, public transportation facilities, and other intermodal transportation facilities and other major travel destinations; meet national defense requirements; and serve interstate and interregional travel. By focusing Federal resources on these most important roads, we will improve the efficiency of our strategic investment in transportation.

Transit Functional Services

All public transit services in the United States may be functionally classified by the public policy purposes served by individual trips. There are three major public policy functions performed by transit: low-cost mobility, congestion management, and supporting livable metropolitan areas. Since the services performing these functions overlap (e.g., congestion management by transit includes trips which also represent low-cost mobility), their sum exceeds 100 percent. The Federal Transit Administration (FTA) intends to develop the data necessary to examine these functions more closely than is possible with presently available data. The following discussion is based on approximations of the data needed to describe transit in terms of these functions.

Low-Cost Mobility

All transit systems in the United States devote a portion of their services to provide low-cost mobility for people who, for reasons of low income, youth, old age, or disability, do not or cannot operate personal motorized transportation. The most important characteristic of such services is the provision of regular access to as many destinations in the service area as possible for a fare that passengers from low-income households can afford.

All types of transit routes provide a degree of low-cost mobility.

Bus services in smaller urban and rural areas and the lower density portions of larger systems tend to be predominantly low-cost mobility services; transit planners call them "policy headway" services.

The hallmark of transit service for low-cost mobility is an emphasis on the extent of service (coverage) rather than its intensity (frequency).

In 1990, an estimated two-fifths of transit trips in the United States were in the low-cost mobility category. For the analytical purposes in this report, the "low-cost mobility" group of trips consists of all trips made by people with household incomes below the poverty level plus nonwork trips in bus-only transit systems.

Congestion Management

Transit services that are competitive with the automobile most effectively serve the congestion mitigation function. The most distinctive characteristic of these transit services is consistently rapid door-to-door travel speeds so that a large proportion of people who own automobiles choose transit to avoid the unreliability and delays of congested highways.

A separate right-of-way for transit services is the key to providing congestion management.

Rapid rail, commuter rail, light rail, and buses operating on busways or in high occupancy vehicle lanes are the most effective congestion mitigation services.

The mark of a service providing this function is highly concentrated, high frequency service in a few primary heavily traveled corridors, rather than service within walking distance of as many people as possible.

In 1990, an estimated one-half of transit trips involved congestion management. Three-quarters of these transit trips were in urban areas served by commuter, rapid, or light rail systems. For the analytical purposes in this report, all worktrips were classified as congestion management-related.

Livable Metropolitan Areas

Transit services that provide motorized access to and from pedestrian oriented and multiple purpose central business districts and communities serve the function of supporting livable metropolitan areas. The most distinctive characteristic of these services is design for pedestrian access rather than access by automobile. Transit's role in supporting a livable metropolitan area is strongest where pedestrian access to transit and to other services via transit enable households and businesses to function with reduced use of automotive transport.

> *An immediate physical environment that is pedestrian-oriented rather than automobile-oriented, assuming transit service is dense enough to justify such design choices, enables transit to best support livable metropolitan areas.*
>
> *Most transit trips in the United States support this function because most transit trips originate or end in central cities, central business districts, and urban neighborhoods designed around pedestrian access to transit.*
>
> *In metropolitan areas where transit works best to support a livable community, automobile vehicle miles per capita are significantly lower than in other metropolitan areas.*
>
> *Residents of areas where transit works best to support a livable community can often operate a household without owning an automobile or owning fewer automobiles than if they lived in an auto-oriented area.*

For the analytical purposes in this report, livable metropolitan areas are defined as urbanized areas with more than 55 annual transit trips per capita or significant transit rail services. In 1990, approximately 70 percent of transit trips were taken by people residing in such areas. Approximately one-half of those trips were journeys to work. Although most such areas are very large cities, communities with very large college campuses exhibit similar characteristics.

Transit's Public Policy Functions and Mobility

It is uncertain to what extent the number of people needing low-cost mobility will grow in the future, with new workforce entrants, immigration, and an aging population balanced by increasing access to automobiles by elderly and low-income persons. Independent of the number of people needing low-cost mobility, the increasing dispersal of regional activities by itself will require increased mobility services. Travel demand management, including provision of transit services, is being viewed as an important tool in managing highway traffic congestion in our major metropolitan areas. The concept of livable metropolitan areas, with its emphasis on building on existing metropolitan infrastructure and resisting urban sprawl, offers great promise for fostering strong economic growth in our metropolitan areas without creating unacceptable infrastructure costs and degradation of the quality of life.

In the environment of constrained transit resources, local public policy makers have been compelled to choose among these functions in the design of transit services. After decades of intermittent neglect, all three functions ultimately have deteriorated, bringing with them loss of mobility for the people who can least afford economic isolation, increasing traffic congestion where economic growth is the strongest, and increasing urban sprawl and the concomitant degradation of still powerful downtowns and still attractive urban neighborhoods.

Transit Services and Jurisdiction

In the last quarter century, public transit services in the United States have been transformed from private companies under local public regulation to virtually universal local public ownership and operations. Still, considerable transit services are provided by private companies under franchise and contract arrangements, most notably express bus services in the largest metropolitan areas and specialized demand responsive services in many metropolitan areas.

In addition to coming under public sector control, largely with the influx of Federal financial assistance, transit operations have increasingly become the subject of State initiatives in the form of financial support, performance oversight, and outright ownership and operation of services.

Five states own and operate transit services as state functions: Maryland, Delaware, New Jersey, Connecticut, and Rhode Island. Other States assert a very strong role in many facets of transit, manifested in the creation of strong institutional foundations for transit: New York, Massachusetts, Pennsylvania, California, Illinois, Minnesota, Texas, and Washington. The trend toward State involvement is likely to increase under the planning provisions mandated by the Clean Air Act Amendments of 1990 (CAAA) and the ISTEA.

Despite the influence of Federal and State support, however, transit remains essentially a localized public service. Since transit services transcend local jurisdictions, however, transit institutional and financial matters often elude the control of a single local government, and are often in the center of regional decisionmaking and institution building.

Insofar as transit plays an increasingly important part in regional job access, congestion mitigation, and making communities more livable, the institutional evolution for transit is expected to accelerate. The newest dimension of change on the horizon is "multimodalism," which will be driven by planning requirements, flexible Federal funding and the corresponding flexibility of State and local financial support. It seems likely that this will strengthen Metropolitan Planning Organizations (MPOs) and regional transit authorities.

System Extent and Capacity

Extent

Highway

In 1993, total National public road and street center-line mileage reached 3.9 million miles. Exhibit 2-5 contains a comparison of this mileage by functional classification for the alternate years 1983 to 1993. The share of total miles in rural areas decreased slightly, from 83 to 79 percent.

In addition the extent of rural mileage declined between 1983 and 1993. This decrease is attributed to the expansion of Federal-aid urban and urbanized area boundaries based on the periodic census and the reclassification of certain U.S. Forest Service roads to non-public roadways.

Exhibit 2-5
Highway and Transit Route Miles by Functional System
Selected Years, 1983-1993

Functional System	1983	1985	1987	1989	1991	1993
Rural Highway Miles						
Interstate	32,788	32,761	33,111	33,378	33,677	32,652
Other Principal Arterial	81,234	80,719	80,719	80,951	85,729	96,201
Minor Arterial	147,536	146,583	147,254	147,327	142,866	137,928
Major Collector	434,166	432,753	435,413	436,184	436,737	432,675
Minor Collector	300,172	296,636	294,799	294,424	293,500	282,361
Local	2,221,392	2,181,535	2,172,542	2,130,460	2,146,926	2,119,826
Subtotal	3,217,288	3,170,987	3,163,838	3,122,724	3,139,435	3,101,643
Urban Highway Miles						
Interstate	10,240	10,832	11,217	11,471	11,603	12,878
Other Freeway & Expressway	7,024	7,170	7,390	7,582	7,714	8,857
Other Principal Arterial	47,330	49,895	50,483	51,489	52,349	52,835
Minor Arterial	69,108	72,177	74,984	74,746	74,979	85,822
Collector	72,513	75,370	76,860	78,474	77,097	85,378
Local	456,135	475,503	489,254	530,015	526,122	557,308
Subtotal	662,350	690,947	710,188	753,777	749,864	803,078
Total Highway Miles	3,879,638	3,861,934	3,874,026	3,876,501	3,889,299	3,904,721
Transit Route Miles						
Rail	6,341	5,761	5,966	6,754	7,003	7,334
Non-Rail	130,755	138,973	141,915	146,589	149,332	158,779
Total Transit	137,096	144,734	147,881	153,343	156,335	166,113

Source: Highway Statistics, 1983-1993; Federal Transit Administration Section 15 report, years 1983-1993

Most recently, the Federal-aid urban area boundaries changed as a result of the 1990 census, with most of the boundary changes reflected in the 1993 data. This resulted in the reclassification of a notable number of suburban facilities from rural to urban.

As a prelude to NHS designation, the States functionally reclassified their roads and streets in order to establish an updated principal arterial system. Consequently, rural principal arterial mileage (excluding the Interstate system) increased 12 percent between 1991 and 1993. This contrasts with mileage on the other rural functional systems, which has decreased slightly over the past decade.

Over the past 10 years, mileage increased slightly (less than 2.5 percent) on each of the urban functional systems. It is noteworthy, however, that with the exception of "other principal arterials" and "local" roads, urban mileage increased from 6 percent to 15 percent on each functional system in the last two year period. This increase is due to the functional reclassification noted in the preceding paragraph.

In 1994 there were more than 576,000 bridges on our Nation's highways. Exhibit 2-6 contains a listing of these bridges by functional system.

Exhibit 2-6
Bridges by Functional System
1994

Functional System	Number of Bridges
Rural Bridge	
Interstate	28,865
Other Principal Arterial	35,031
Minor Arterial	37,422
Major Collector	98,196
Minor Collector	49,416
Local	206,389
Subtotal Rural	455,319
Urban Bridge	
Interstate	25,861
Other Freeway & Expressway	13,746
Other Principal Arterial	23,408
Minor Arterial	19,858
Collector	14,702
Local	23,566
Subtotal Urban	121,141
Unknown/Unclassified	0
Total	576,460

Source: National Bridge Inventory, June 3, 1994

Transit

In 1993, 508 local public transit operators provided transit services in 316 urbanized areas. An additional 5,010 local and regional organizations provided publicly accessible transit services in rural and small urban areas. The inventory of transit infrastructure is provided in Exhibit 2-7. In 1993, there were 129,317 total transit vehicles, 7,439 miles of rail track, 2,317 rail stations and 1,172 maintenance facilities.

Exhibit 2-7
Mass Transit Fleet and Infrastructure
1993

	Areas > 1 million	Areas < 1 million	Total
Vehicles			
Buses	40,601	16,756	57,357
Rapid Rail	10,074	0	10,074
Light Rail	908	35	943
Self-Propelled Commuter Rail	2,526	0	2,526
Commuter Rail Trailers	2,382	20	2,402
Commuter Rail Locomotives	551	5	556
Vans	8,025	5,309	13,334
Other (including ferryboats)	293	51	344
Rural Service Vehicles	0	12,450	12,450
Special Service Vehicles	4,400	24,931	29,331
Total Active Vehicles	69,760	59,557	129,317
Infrastructure - Track			
Rapid Rail	2,007	0	2,007
Light Rail	646	14	660
Commuter Rail	4,753	0	4,753
Other Rail	17	2	19
Total Miles of Track	7,423	16	7,439

Transit route miles are defined as the extent of service, meaning the number of miles on the route map, ignoring how many transit vehicle runs occur on that map. However, in cases where two different bus routes travel on the same road for a mile, that mile represents two bus miles. The combined route miles of transit rapid rail, commuter rail, and light rail (or streetcar) services in 1993 reached 7,334 miles. Exhibit 2-5 compares this total with comparable data since 1983. Route miles of transit rail grew 15.7 percent from 1983 to 1993, or 1.5 percent per year. Nonrail transit includes buses, ferry boats, vans, and other conveyances, which in 1993 reached 158,799 route miles, an annual increase of 2.0 percent since 1983.

Capacity

Surface transportation capacity comparisons are found in Exhibit 2-8. In 1993, there were 8.1 million lane-miles of highways in the Nation. Over the 10-year period from 1983 to 1993, lane-mileage has increased at an annual rate of 0.2 percent. For the same period, lane-mileage increased on all functional systems except rural minor arterials, minor collectors, and local roads.

	Areas > 1 million	Areas < 1 million	Total
Infrastructure - Stations			
Rapid Rail	984	0	984
Light Rail	373	14	387
Commuter Rail	915	0	915
Other Rail	24	7	31
Total Transit Rail Stations	2,296	21	2,317
Infrastructure - Maintenance			
Rapid Rail	53	0	53
Light Rail	19	3	22
Commuter Rail	44	0	44
Ferry Boat	3	2	5
Bus	280	243	523
Demand Response	21	44	65
Other	6	4	10
Rural Transit Maintenance Facilities	0	450	450
Total Maintenance Facilities	426	746	1,172

Exhibit 2-8
Highway Lane-Miles and Transit System Equivalent Lane-Miles by Functional System
Selected Years, 1983-1993

Functional System	1983	1985	1987	1989	1991	1993
Rural Highway Lane-Miles						
Interstate	131,976	131,808	133,521	134,969	136,477	132,239
Other Principal Arterial	201,414	202,398	203,526	205,818	218,491	238,035
Minor Arterial	309,034	307,434	309,031	308,266	299,474	286,586
Major Collector	867,549	873,187	878,203	880,650	881,532	870,689
Minor Collector	574,554	592,124	587,686	586,998	584,371	564,722
Local	4,442,784	4,363,070	4,345,084	4,260,920	4,293,852	4,239,652
Subtotal Rural	6,527,311	6,470,021	6,457,051	6,377,621	6,414,197	6,331,923
Urban Highway Lane-Miles						
Interstate	53,386	57,327	59,831	61,854	62,936	69,135
Other Freeway & Expressway	30,817	31,598	32,569	33,739	34,635	39,915
Other Principal Arterial	150,892	159,264	166,461	170,977	176,027	176,325
Minor Arterial	172,395	180,940	190,751	188,218	190,414	216,233
Collector	153,118	162,203	164,395	167,699	164,752	181,035
Local	912,270	951,006	978,508	1,060,030	1,052,244	1,114,616
Subtotal Urban	1,472,878	1,542,338	1,592,515	1,682,517	1,681,008	1,797,259
Total Highway Lane-Miles	8,000,189	8,012,359	8,049,566	8,060,138	8,095,205	8,129,182
Transit Capacity Equivalent Miles (thousands)						
Rail	1,256,316	1,330,595	1,405,685	1,538,710	1,558,489	1,564,354
Non-Rail	1,423,827	1,503,958	1,467,618	1,561,618	1,619,021	1,658,679
Total Transit Equivalent Miles	2,680,143	2,834,553	2,873,303	3,100,328	3,177,510	3,223,033

Note 1: For local roads, the number of lanes is assumed to be 2.

Note 2: Transit Capacity Equivalent Miles are based on vehicle revenue miles by mode weighted by a factor comparing comfortable carrying capacity of a vehicle to the seated capacity of a full-sized transit bus (e.g., Commuter Rail, 2.2; Rapid Rail, 2.1; Light Rail, 2.0; Demand Response, 0.2)

Source: Highway Statistics, 1983-1993, Federal Transit Administration Section 15 Report, 1983-1993

Lane-mileage trends mirror those of center-line mileage, with a rural decrease and an urban increase between 1983 and 1989 and a rural increase and an urban decrease between 1989 and 1991. Between 1991 and 1993, rural lane-miles decreased while urban lane-miles increased. Annually, urban lane-mileage increased at a rate of 2.0 percent and rural lane-mileage decreased at a rate of 0.3 percent. For both rural and urban areas, the largest increases occurred on the higher functional systems.

Urban freeways and expressways (including Interstate highways) experienced the largest increase, 2.6 percent per year. Other urban principal arterials and local roads also experienced significant growth, over 2.0 percent per year. Lane-mileage on rural Interstate highways remained relatively constant while lane-mileage on other principal arterials grew at an annualized rate of 1.68 percent. The largest decrease in lane-mileage, 0.8 percent per year, occurred on rural minor arterials.

Transit rail and bus capacity is defined as the average number of miles traveled by each transit vehicle multiplied by the number of vehicles, expressed as standardized "bus equivalent vehicles." For example, in terms of seated passengers, a self-propelled rapid rail car is the capacity equivalent of 2.2 standard 40-foot buses (43 seated passengers). In 1993, transit rail capacity consisted of 15,945 rail passenger vehicles providing 1,564 million equivalent vehicle miles, after an annual increase of 2.2 percent since 1983. Transit bus capacity was 1,659 million vehicle miles in 1993, after an annual increase of 1.5 percent since 1983.

Highway

Highway Vehicle Miles Traveled (VMT) comparisons are found in Exhibit 2-9. In 1993, total highway VMT travel reached 2.3 trillion vehicle-miles. For the 10-year period from 1983 to 1993, total travel increased at an annual rate of 3.4 percent. For the same period, VMT increased across all functional systems. Travel growth in urban areas appears to outpace rural areas. However, as noted earlier, part of this growth is because of expanding urban boundaries, i.e., rural travel becoming urban travel. Urban travel increased 4.0 percent per year while rural travel increased 2.4 percent per year. On a functional system basis, the largest annual increase, 5.2 percent, occurred on urban Interstate highways. Rural minor collectors experienced the smallest annual growth, 1.1 percent.

Exhibit 2-9
Highway Vehicle and Passenger Miles of Travel
Millions of Miles
Selected Years, 1983-1993

Functional System	1983	1985	1987	1989	1991	1993
Rural Highway Vehicle Miles						
Interstate	144,733	154,148	171,866	191,120	205,011	208,021
Other Principal Arterial	139,962	145,903	155,446	165,993	177,425	201,031
Minor Arterial	133,421	136,854	146,528	156,626	157,424	147,723
Major Collector	156,786	163,197	174,176	187,182	194,006	178,149
Minor Collector	43,806	43,345	44,488	48,085	51,601	48,846
Local	81,825	86,868	89,243	99,877	98,154	103,176
Subtotal Rural	700,533	730,315	781,747	848,883	883,621	886,946
Urban Highway Vehicle Miles						
Interstate	191,149	216,441	245,339	270,652	285,325	315,837
Other Freeway & Expressway	86,790	97,351	109,900	122,055	128,242	142,322
Other Principal Arterial	255,327	279,025	304,673	326,897	338,987	356,315
Minor Arterial	188,467	201,738	224,107	234,863	240,402	275,665
Collector	86,593	89,531	95,964	101,259	107,272	121,214
Local	140,247	160,361	162,597	202,431	188,365	198,286
Subtotal Urban	948,573	1,044,447	1,142,580	1,258,157	1,288,593	1,409,639
Total Highway Vehicle Miles	1,649,106	1,774,762	1,924,327	2,107,040	2,172,214	2,296,585
Total Highway Passenger Vehicle Miles	n/a	n/a	n/a	3,543,011	3,670,765	3,881,229

Source: Highway Statistics, 1983-1993

Exhibit 2-10 presents daily vehicle-miles traveled per lane-mile for each functional system. Daily travel per lane-mile is equivalent to annual average daily traffic (AADT) per lane. In both urban and rural areas, the higher functional systems carry the most daily travel per lane-mile. On a per-lane-mile basis, urban Interstate highways carried the most travel in 1993, 12,520 AADT. Other urban freeways and expressways and other urban principal arterials carried 9,770 AADT and 5,540 AADT, respectively. Rural Interstate highways and rural other principal arterials carried 4,310 AADT and 2,310 AADT, respectively.

Exhibit 2-10
Daily Vehicle Miles Traveled (DVMT) per Lane-Mile by Functional System
Thousands of DVMT
Selected Years, 1983-1993

Functional System	1983	1985	1987	1989	1991	1993
Rural						
Interstate	3.00	3.20	3.53	3.88	4.12	4.31
Other Principal Arterial	1.90	1.97	2.09	2.21	2.22	2.31
Minor Arterial	1.18	1.22	1.30	1.39	1.44	1.41
Major Collector	0.50	0.51	0.54	0.58	0.60	0.56
Minor Collector	0.21	0.20	0.21	0.22	0.24	0.24
Local	0.05	0.05	0.06	0.06	0.06	0.07
All Rural	0.29	0.31	0.33	0.36	0.38	0.38
Urban						
Interstate	9.81	10.34	11.23	11.99	12.42	12.52
Other Freeway & Expressway	7.72	8.44	9.24	9.91	10.14	9.77
Other Principal Arterial	4.64	4.80	5.01	5.24	5.28	5.54
Minor Arterial	3.00	3.05	3.22	3.42	3.46	3.49
Collector	1.55	1.51	1.60	1.65	1.78	1.83
Local	0.42	0.46	0.46	0.52	0.49	0.49
All Urban	1.76	1.86	1.97	2.05	2.10	2.15
Total	0.56	0.61	0.65	0.72	0.74	0.77

Source: Highway Statistics, 1983-1993

AADT per lane-mile is a measure of average traffic density. As shown in Exhibit 2-10, there is much more travel per lane-mile in urban areas than in rural areas. Overall, AADT per lane-mile is 5.6 times greater in urban areas than in rural areas. However, annual growth in AADT per lane-mile in rural areas has outpaced that of urban areas. The rural Interstate system showed the largest annual growth in vehicle miles traveled on a per-lane-mile basis. Between 1983 and 1993, vehicle miles traveled per lane-mile on rural Interstate highways increased by 3.67 percent per year, compared to 2.47 percent per year for urban Interstate highways. Overall, rural travel per lane-mile increased by 2.70 percent per year while urban vehicle miles traveled per lane-mile increased by only 1.99 percent per year.

Truck travel is an important factor affecting highway investment requirements on the various functional systems. Exhibit 2-11 contains a breakdown of travel by vehicle type and road type for the years 1985, 1987, 1989, 1991, and 1993 (complete data for truck travel in 1983 is not available).

Combination trucks are used primarily for intercity freight transportation, and their travel is concentrated on rural arterial highways. In 1993, combination trucks accounted for 16 percent of total travel on rural Interstate highways, but only 5 percent of travel on urban Interstate highways.

Single-unit trucks are used primarily for local transportation. Whereas half of all combination-truck travel is on Interstate highways, less than 23 percent of travel by single unit trucks is on the Interstate system.

Combination-truck travel grew at an annual rate of 3.3 percent between 1985 and 1993. This was somewhat less than the 3.4 percent annual growth for passenger vehicles. For the same period, travel by single-unit trucks decreased at an annual rate of 1.7 percent.

Exhibit 2-11
Highway Travel by System and Vehicle Type
Millions of Vehicle-Miles of Travel
Selected Years, 1985-1993

Functional System		**1985**	**1987**	**1989**	**1991**	**1993**
Rural						
Interstate	PV	127,433	139,054	155,538	168,283	169,473
	SU	5,388	5,299	5,825	6,040	5,942
	Combo	21,327	27,513	29,757	30,688	32,606
Other Arterials	PV	253,042	272,328	291,521	302,967	313,924
	SU	12,099	10,304	10,879	11,015	11,287
	Combo	17,616	19,342	20,219	20,867	23,543
Other Rural	PV	268,961	287,000	311,988	320,236	305,630
	SU	15,339	11,567	12,564	12,653	12,556
	Combo	9,110	9,340	10,592	10,872	11,985
Subtotal	PV	649,436	698,382	759,047	791,486	789,027
	SU	32,826	27,170	29,268	29,708	29,785
	Combo	48,053	56,195	60,568	62,427	68,134
Urban						
Interstate	PV	197,357	225,234	247,259	261,948	293,253
	SU	6,609	5,681	6,227	6,331	6,461
	Combo	12,475	14,784	17,166	17,046	16,103
Other Urban	PV	783,481	865,124	951,977	968,040	1,054,903
	SU	25,651	16,762	17,695	17,752	20,427
	Combo	18,874	15,355	17,833	17,476	18,472
Subtotal	PV	980,838	1,090,358	1,199,236	1,229,988	1,348,156
	SU	32,260	22,443	23,922	24,083	26,888
	Combo	31,349	30,139	34,999	34,522	34,575
Total						
	PV	1,630,274	1,788,740	1,958,283	2,021,474	2,137,183
	SU	65,086	49,613	53,190	53,791	56,673
	Combo	79,402	86,334	95,567	96,949	102,709

Note 1: PV = Passenger Vehicles (including buses and 2-axle, 4-tire vehicles) SU = Single Unit Trucks (6 tires or more), Combo = Combination Trucks (trailers and semi-trailers).

Note 2: Complete data for 1983 not available.

Transit

Transit travel, in passenger miles, is defined as the average trip length times the number of passengers. On rail, transit patronage was 17.9 billion passenger miles in 1993, up at an annual rate of 0.7 percent from 1983. On bus systems, transit patronage was 18.4 million in 1993, down by one-half of one percent per year since 1983.

Exhibit 2-12
Transit Passenger Miles of Travel
Millions of Miles
Selected Years, 1983-1993

Transit Passenger Miles	**1983**	**1985**	**1987**	**1989**	**1991**	**1993**
Rail	16,597	17,334	18,131	19,766	18,551	17,867
Non-Rail	19,216	20,455	18,241	18,455	18,921	18,353
Total Transit Passenger Miles	35,814	37,789	36,372	38,221	37,473	36,220

Federal Transit Administration Section 15 report, 1983-1993

Another measure of system usage is the ratio of transit passenger miles to transit capacity equivalent miles. This ratio reveals that the transit service utilization rate declined by 16 percent from 1983 to 1993, with a greater decline (18 percent) in the use of non-rail service than in rail service (14 percent). A large part of this decline can be explained by the increase in real transit fares of 41 percent between 1983 and 1993.

Chapter 3

Highway, Bridge and Transit Finance

Chapter 3

INTRODUCTION

This chapter addresses the sources and uses of funds expended for highways and transit. It examines the public sector role in funding highway and transit capital and noncapital needs. The chapter begins with a comparison of highway and transit funding by level of government, then continues with a summary of sources of funds for highways and transit overall. Expenditures for highways and transit are summarized as to capital and noncapital, as well as by type of expenditure. Finally, capital and noncapital expenditures are examined in terms of where funds are invested and for what purpose.

Financing for highways, roads and streets comes from both the public and private sectors. All levels of government provide funding for highways and expend funds to construct and maintain highways. The private sector invests in roads to provide access to new development, to mitigate development impact, and for profit. A discussion of both public and private sector financing is included.

The highway sections begin with a discussion of public funding and expenditures by level of government and source of funds. Expenditures for highways are then disaggregated into capital and noncapital outlays. The section on capital outlay includes analysis of trends, and information on source of funds for capital outlay by level of government, spending by improvement type, spending by functional system, and spending on highways and bridges for which investment needs are estimated. Data on public sector financing is provided by State and local governments to the Federal Highway Administration (FHWA).

The transit sections of this chapter include a review of transit operating revenues, sources of Federal funding for transit, capital expenditures by type of expenditure and some of the innovative financing techniques available to support transit investment. As with highways, all levels of government provide funding for transit. However, the organizational structure through which expenditures are made varies by locality. In some cases, funding is provided to an operator of public transit services which functions as an independent municipal entity. In some States, such entities may even have their own taxing authority. In other cases, the transit operator is a functional component of the city or county government and, as such, has no independent funding or expenditure authority. There is very little private funding in transit, except to the extent that transit operators are able to benefit from joint development activities. These may include the sale or leasing of development rights, air rights and joint participation in commercial ventures.

PUBLIC SECTOR FINANCING

Funding by Level of Government

Funding for highways by all levels of government in 1993 totalled $88.5 billion; funding for transit was $15.4 billion.

Public sector financing of highways and transit includes all funding from governmental sources at the Federal, State and local levels. Because of the intergovernmental transfer of funds, the level of government providing highway and transit funding is not necessarily the same as the level of government that expends the funds. Therefore, unless specified, the analysis in this chapter will focus on the revenue source of funds used for highways and transit and not on the level of government that expended the funds.

Highway

In 1993, all levels of government provided $88.5 billion for highway programs (Exhibit 3-1). The Federal Government funded $18.2 billion, the States $46.9 billion, and counties, cities, and other local government entities funded the remaining $23.4 billion. Federal funds accounted for 20.6 percent of the total funding for highways in 1993, a decrease from the 21.5 percent share in 1991. The Federal share of funding for highways increased dramatically between 1956 and 1960 following the passage of the Federal-Aid Highway Act of 1956 and the establishment of the Highway Trust Fund. However, since 1960 there has been a gradual trend downward in the Federal share of funding.

State funds accounted for 53 percent of funding in 1993, an increase of 9 percent since 1991. The State share of funding declined during the 1980s, but since 1990 has been over 52 percent, a level comparable to the 1960s. Local governments provided 26.4 percent of the funding for highways in 1993. In general, the local government share of funding has steadily increased since the early 1970s.

As stated previously, funding can also be viewed in terms of which level of government actually made the expenditure. While the Federal Government provided 20.6 percent of the funding for highways in 1993, its share of total expenditures for highways was only $0.9 billion, less than 1 percent. This is because almost all of the funds that the Federal Government provides for highways are returned to the States under the Federal-Aid Highway Program for State and local governments to expend.

Exhibit 3-1
Funding for Highways by Government Jurisdiction
Millions of Dollars
Selected Years, 1956-1993

Year	Federal	State	Local	Total
1956	$1,048	$5,453	$1,943	$8,444
	12.4%	64.6%	23.0%	100%
1960	$3,063	$6,055	$2,367	$11,485
	26.7%	52.7%	20.6%	100.0%
1964	$3,907	$7,192	$2,594	$13,693
	28.5%	52.5%	18.9%	100.0%
1968	$5,064	$10,036	$3,534	$18,634
	27.2%	53.9%	19.0%	100.0%
1972	$6,286	$13,551	$4,646	$24,483
	25.7%	55.3%	19.0%	100.0%
1976	$8,038	$16,126	$6,667	$30,831
	26.1%	52.3%	21.6%	100.0%
1980	$9,830	$19,666	$10,219	$39,715
	24.8%	49.5%	25.7%	100.0%
1981	$10,338	$21,044	$11,311	$42,693
	24.2%	49.3%	26.5%	100.0%
1982	$10,110	$22,078	$11,867	$44,055
	22.9%	50.1%	26.9%	100.0%
1983	$11,684	$23,918	$12,471	$48,073
	24.3%	49.8%	25.9%	100.0%
1984	$14,698	$26,550	$13,388	$54,636
	26.9%	48.6%	24.5%	100.0%
1985	$14,749	$30,543	$15,933	$61,225
	24.1%	49.9%	26.0%	100.0%
1986	$14,986	$32,493	$18,302	$65,781
	22.8%	49.4%	27.8%	100.0%
1987	$14,466	$32,788	$18,280	$65,534
	22.1%	50.0%	27.9%	100.0%
1988	$15,552	$34,288	$19,112	$68,952
	22.6%	49.7%	27.7%	100.0%
1989	$15,946	$37,274	$19,501	$72,721
	21.9%	51.3%	26.8%	100.0%
1990	$14,426	$40,026	$20,842	$75,294
	19.2%	53.2%	27.7%	100.0%
1991	$17,695	$42,948	$21,736	$82,379
	21.5%	52.1%	26.4%	100.0%
1992	$17,865	$46,127	$22,711	$86,703
	20.6%	53.2%	26.2%	100%
1993	$18,204	$46,890	$23,389	$88,483
	20.6%	53.0%	26.4%	100.0%

Note: Some 1993 data are preliminary and may be adjusted.

Source: Bulletin -- Highway Funding, Table HF-10B, Various Years;
Bulletin -- Receipts and Disbursements for Highways, Table HF-11, Various Years

Transit

Public funding for transit in 1993 was $15.4 billion. The Federal share of this support was $3.3 billion, remaining at about the same level in current dollar terms since 1985. The State and local share was $12.1 billion in 1993. The State and local share of transit assistance has climbed steadily since reaching a low of 45.1 percent in 1980.

At the same time, while the dollar level of Federal assistance has fluctuated between $3.3 and $3.9 billion since 1981, the Federal share of transit assistance has declined. This is due in part to a reduction in Federal operating assistance in the 1980s, an increase in State and local assistance over the same period, as well as to a continued increase in transit service provided. Exhibit 3-2 shows the trend in funding for transit for selected years since 1956.

Exhibit 3-2
Funding for Transit by Government Jurisdiction
Millions of Dollars
Selected Years, 1956-1993

Year	Federal	State and Local	Total
1956	$0	$580	$580
	0.0%	100.0%	100%
1961	$0	$688	$688
	0.0%	100.0%	100%
1966	$21	$1,008	$1,029
	2.0%	98.0%	100%
1971	$212	$1,680	$1,892
	11.2%	88.8%	100%
1976	$1,831	$3,787	$5,618
	32.6%	67.4%	100%
1978	$2,177	$3,441	$5,618
	38.8%	61.2%	100%
1980	$3,060	$2,514	$5,574
	54.9%	45.1%	100%
1982	$3,495	$3,811	$7,306
	47.8%	52.2%	100%
1983	$3,670	$5,038	$8,708
	42.1%	57.9%	100%
1984	$4,016	$5,469	$9,486
	42.3%	57.7%	100%
1985	$3,302	$6,469	$9,771
	33.8%	66.2%	100%
1986	$3,589	$6,737	$10,326
	34.7%	65.2%	100%
1987	$3,438	$7,643	$11,082
	31.0%	69.0%	100%
1988	$3,228	$8,220	$11,448
	28.2%	71.8%	100%
1989	$3,491	$8,713	$12,204
	28.6%	71.4%	100%
1990	$3,458	$9,823	$13,281
	26.0%	74.0%	100%
1991	$3,395	$11,116	$14,511
	23.4%	76.6%	100%
1992	$3,448	$11,195	$14,643
	23.6%	76.4%	100%
1993	$3,295	$12,125	$15,420
	21.4%	78.6%	100%

Source: Congressional Budget Office, CBO Papers, 1956-1989; and Federal Transit Administration Section 15 data, 1990-1993

Sources of Public Sector Financing

Highway

Public sector financing of highways reflects the revenue sources available to each level of government. The $88.5 billion provided for highway programs in 1993 came from a number of sources including highway-user charges, property taxes and assessments, general funds, investment income, other taxes, miscellaneous fees, and bond issues (Exhibit 3-3). Public sector financing of highways also includes revenues from exactions, development fees, and special district assessments.

Exhibit 3-3 includes only the revenues from these sources that were used to finance highway activities in 1993, not the total of all revenues that were raised from the listed sources. The exhibit excludes revenues from the same sources that were used to finance transit and other nonhighway activities. For example, State highway-user revenues from motor-fuel taxes, motor-vehicle fees and tolls actually generated $47.1 billion in revenues in 1993 with only $36.7 billion used to fund highways. Although local governments raised $2.4 billion from highway-user taxation, only $1.7 billion was expended for roads and streets. The difference in highway-user revenues went for a variety of nonhighway purposes.

Exhibit 3-3
Revenue Sources for Public Sector Financing of Highways
Billions of Dollars
1993

	Federal	State	Local	Total	Percent
User Charges					
Motor-Fuel Taxes	$13.8	$22.9	$0.7	$37.4	42.2
Motor-Vehicle Taxes	$2.1	$10.7	$0.4	$13.2	14.9
Tolls	$0.0	$3.1	$0.6	$3.7	4.2
Subtotal	$15.9	$36.7	$1.7	$54.3	61.3
Other					
Property Taxes and Assessments	$0.0	$0.0	$4.3	$4.3	4.8
General Fund Appropriations	$1.3	$2.1	$8.5	$11.9	13.4
Other Taxes and Fees	$0.2	$1.9	$1.4	$3.5	4.0
Investment Income and Other Receipts	$0.8	$2.2	$3.9	$6.9	7.8
Bond Issue Proceeds	$0.0	$4.0	$3.7	$7.7	8.7
Subtotal	$2.3	$10.2	$21.8	$34.3	38.7
Total	$18.2	$46.9	$23.5	$88.5	100.0

Source: Bulletin—Highway Funding, Table HF-10B, 1992-1995; Highway Statistics—1993, Tables FE-9, MF-3, MV-3 and unpublished data from States

The $15.9 billion of Federal highway-user revenues from motor-fuel and motor-vehicle taxes includes only the amount credited to the Highway Account of the Highway Trust Fund, less the amounts transferred and expended for territories ($95.0 million) and mass transit ($58.0 million) from the Highway Account. An additional $5.3 billion of Federal highway-user revenues was credited to: the Transit Account of the Highway Trust Fund, the General Fund for deficit reduction, and the Leaking Underground Storage Tank Trust Fund.

At the Federal level, motor-fuel and motor-vehicle taxes are the primary source of funds for highways. These highway-user revenues provide 87.4 percent of Federal funds for highways. General fund appropriations, investment income, and other taxes and fees provide the remaining 12.6 percent of Federal funding for highways.

Motor-fuel and motor-vehicle taxes also provide the largest share, 71.6 percent, of highway funds at the State level. Although not used at the Federal level, tolls imposed on highway-users represent 6.6 percent of State highway funding. Bond issue proceeds are another significant source of funds, 8.5 percent, at the State level. The remaining 13.2 percent of State funds are from general fund appropriations, investment income and miscellaneous receipts, and other State taxes and fees.

Local governments derive some 4.7 percent of their road and street funding from motor-fuel and motor-vehicle taxes. Local governments rely heavily on property taxes and assessments to fund their highway programs. Property taxes and assessments are a funding source that is not used at either the Federal or State levels. Local governments derive 18.5 percent of their highway funding directly from property taxes and assessments. The largest source of funds at the local level is general fund appropriations which provide 36.3 percent of local highway funds.

Transit

Sources of transit support at the State and local level in 1993 included direct system taxing authority, property taxes, motor-fuel taxes, income taxes and other, unspecified tax sources. Federal support for transit included motor fuel taxes (from the Transit account of the Highway Trust Fund) and general fund appropriations. All levels of General Funds Appropriations combined to provide the largest revenue source (57.1 percent) followed by State and local sales taxes (19.8 percent) and fuel taxes (15.0 percent).

Federal expenditures for transit came from two sources: the Mass Transit Account of the Highway Trust Fund, and the General Fund. From 1983 to 1990, the Transit Account received one cent per gallon of the Federal motor fuel tax receipts. From December 1, 1990 to September 30, 1995, the distribution to the transit account is 1.5 cents per gallon. On October 1, 1995, the distribution will increase to 2.0 cents per gallon.

Exhibit 3-4
Revenue Sources for Public Sector Financing of Transit
Billions of Dollars
1993

Tax Revenue	Federal	State	Local	Total	Percent
Motor Fuel Taxes	$1.9	$0.3	$0.0	$2.3	14.9
General Fund Appropriations	$1.4	$2.1	$2.5	$6.0	38.9
Other Dedicated Taxes					
Income	$0.0	$0.5	$0.0	$0.5	3.0
Sales	$0.0	$0.5	$2.8	$3.3	21.6
Property	$0.0	$0.1	$0.4	$0.5	3.0
Other	$0.0	$1.3	$1.6	$2.9	18.6
Subtotal	$0.0	$2.4	$4.8	$7.1	46.2
Total Tax Revenue	$3.3	$4.8	$7.3	$15.5	100.0
Fares and Other System-Generated Revenue				$7.1	
Total All Sources				$22.6	

Source: Federal Transit Administration Section 15 data

State and local expenditures other than General Fund appropriations were made possible by two primary sources: sales taxes and motor fuel taxes. The local revenue source includes indirect taxing support of the transit system, such as a set-aside of tax revenues each year, as well as direct taxing authority. Thus, in 1993, transit systems raised just under $1.5 billion in direct tax revenues. These may include proceeds from the establishment of a special benefit assessment district or other, land-related taxes.

Capital and Noncapital Expenditures

Summary of Expenditures

Total highway and transit expenditures in 1993 were $107.4 billion, of which highway expenditures comprised $86.1 billion and transit expenditures represented $21.3 billion.

Highway

Data in this section when converted to constant 1987 dollars are based on the FHWA Highway Construction Index for capital outlay and the Consumer Price Index for all other expenditures.

Of the $88.5 billion in funding provided for highways in 1993, $86.1 billion was expended for highway programs (Exhibit 3-5) and $2.4 billion was placed in reserve.

Exhibit 3-5
Expenditures for Highways by Function, All Units of Government
Millions of Dollars
Selected Years, 1956-1993

	Capital Outlay	Maint and Ops	Admin, etc.	Hwy Patrol & Safety	Interest on Debt	Subtotal Current Disbursements	Debt Retirement	Total
1956	$5,015	$2,089	$312	$210	$312	$7,938	$416	$8,354
1960	$6,290	$2,640	$483	$327	$420	$10,160	$601	$10,761
1964	$8,252	$3,060	$684	$474	$515	$12,985	$752	$13,737
1968	$10,346	$4,003	$1,017	$940	$606	$16,912	$1,071	$17,983
1972	$12,275	$5,443	$1,600	$1,671	$950	$21,939	$1,270	$23,209
1974	$13,102	$6,573	$1,857	$2,061	$1,079	$24,672	$1,445	$26,117
1976	$13,927	$7,735	$2,209	$2,633	$1,234	$27,738	$1,567	$29,305
1978	$14,938	$9,785	$2,590	$3,160	$1,368	$31,841	$1,593	$33,434
1980	$20,337	$11,445	$3,022	$3,824	$1,456	$40,084	$1,711	$41,795
1981	$19,734	$12,165	$3,439	$3,884	$1,202	$40,424	$2,464	$42,888
1982	$19,052	$13,319	$3,152	$4,068	$1,690	$41,281	$2,046	$43,327
1983	$20,224	$14,240	$3,347	$4,309	$1,872	$43,992	$2,172	$46,164
1984	$23,123	$15,008	$3,604	$4,937	$1,641	$48,313	$2,411	$50,724
1985	$26,647	$16,589	$4,174	$5,241	$2,148	$54,799	$2,737	$57,536
1986	$29,232	$17,643	$4,677	$5,549	$2,505	$59,606	$2,794	$62,400
1987	$30,740	$18,152	$4,973	$5,962	$2,788	$62,615	$2,685	$65,300
1988	$32,956	$19,109	$4,961	$6,108	$2,682	$65,816	$2,824	$68,640
1989	$33,144	$18,952	$5,683	$6,647	$2,825	$67,251	$3,612	$70,863
1990	$35,153	$20,364	$6,424	$7,235	$3,205	$72,381	$2,951	$75,332
1991	$36,154	$20,420	$6,876	$7,756	$3,282	$74,488	$3,772	$78,260
1992	$38,309	$22,223	$7,718	$7,088	$3,621	$78,959	$4,589	$83,548
1993	$39,004	$22,907	$7,923	$7,222	$3,862	$80,918	$5,199	$86,117

Note: Some 1993 data are preliminary and may be adjusted.

Source: Bulletin—Highway Funding, Table HF-10B, various years; Bulletin—Receipts and Disbursements for Highways, Table HF-12, various years

Total expenditures for highways are separated into current expenditures and debt retirement. In 1993, $80.9 billion went for current expenditures and $5.2 billion was used for debt retirement. Throughout the highway section of this chapter, the term "expenditure" refers to current expenditures without debt redemption.

Current dollar expenditures for highways in 1993 were almost eight times the 1960 level of $10.2 billion. The increase in constant dollars was 40.5 percent. However, while current dollar expenditures increased at a fairly steady rate, constant dollar expenditures fluctuated due to the increased cost of highway construction in the 1970s. Constant dollar expenditures reached a peak in the early 1970s which was not reached again until 1987.

In constant dollars per unit of travel, expenditures have dropped 50 percent from $59.78 per 1,000 vehicle miles of travel (VMT) in 1960 to $30.03 per 1,000 VMT in 1993. However, in constant dollars per mile of public road, expenditures have increased 45.7 percent from $12,120 per mile in 1960 to $17,662 per mile in 1993.

Transit

Of the $21.7 billion expended for transit in 1993, $5.7 billion was expended for capital and $16.0 billion was for operating costs. Exhibit 3-6 shows the trend in transit expenditures for selected years since 1956.

Definitions

Highway expenditures can be divided into two broad categories: capital and noncapital. Highway capital expenditures are those outlays associated with physical highway improvements such as: new construction, reconstruction, resurfacing, rehabilitation, and restoration costs of roadways and structures; and installation of traffic service facilities such as guard rails, fencing, signs, and signals. Highway capital expenditures include items such as: land acquisition and other right-of-way costs, preliminary and construction engineering, and construction. Noncapital highway expenditures include items such as: maintenance, operations, administration, highway law enforcement and safety, and interest on highway debt.

Prior to the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), Federal spending was generally restricted to projects involving capital outlay with the exception of highway planning and research, and some highway law enforcement and safety related activities. ISTEA has greatly expanded the type of projects and activities that are now eligible under the basic capital programs. Some of the types of projects and activities now eligible include: transit capital improvements, participation in wetland mitigation programs, start-up costs for traffic management and control systems, improvements necessary to accommodate other transportation modes, transportation enhancements, and capital improvements to toll facilities, including initial construction and other physical improvements, as well as preliminary studies to determine the feasibility of the above work.

Transit expenditures can also be divided into two broad categories: capital and operating. Transit capital expenditures are those sums expended for the design, engineering construction and reconstruction of fixed transit assets as well as rolling stock. Fixed assets may include bus garages, rail facilities, tracks and rights-of-way, ferryboat terminals, and park-and-ride lots for rail or bus services. Rolling stock would include all types of buses, vans, railcars, and ferryboats to be used in providing public transit service. These assets have estimated useful lives of as little as four years in the case of vans, to as much as 30 years in the case of some rail and bus facilities.

Transit operating expenditures are those sums expended for wages, salaries, fuel, spare parts, support services and leases used in providing public transit service. These differ considerably from comparable highway non-capital expenditures in that they represent a substantially greater proportion of overall expenditures.

Exhibit 3-6
Mass Transit Capital and Operating Expenditures
Millions of Dollars
Selected Years, 1956-1993

Year	Capital	Operating	Total
1956	$109	$471	$580
	18.8%	81.2%	100%
1961	$120	$568	$688
	17.4%	82.6%	100%
1966	$216	$813	$1,029
	21.0%	79.0%	100%
1971	$446	$1,446	$1,892
	23.6%	76.4%	100%
1976	$1,759	$3,858	$5,617
	31.3%	68.7%	100%
1978	$1,460	$4,158	$5,618
	26.0%	74.0%	100%
1980	$2,095	$6,084	$8,179
	25.6%	74.4%	100%
1982	$3,208	$7,066	$10,274
	31.2%	68.8%	100%
1983	$3,679	$9,080	$12,759
	28.8%	71.2%	100%
1984	$3,863	$9,383	$13,246
	29.2%	70.8%	100%
1985	$3,830	$11,038	$14,868
	25.8%	74.2%	100%
1986	$3,904	$11,698	$15,602
	25.0%	75.0%	100%
1987	$4,095	$12,319	$16,414
	24.9%	75.1%	100%
1988	$4,106	$12,998	$17,104
	24.0%	76.0%	100%
1989	$4,683	$13,869	$18,552
	25.2%	74.8%	100%
1990	$4,535	$14,711	$19,246
	23.6%	76.4%	100%
1991	$5,097	$15,404	$20,501
	24.9%	75.1%	100%
1992	$5,283	$15,498	$20,781
	25.4%	74.6%	100%
1993	$5,733	$15,970	$21,703
	26.4%	73.6%	100%

Source: Congressional Budget Office, CBO Papers; and Federal Transit Administration Section 15 data

Capital Expenditures

Highways

All levels of government spent over $39.0 billion on capital improvements in 1993 compared to $6.3 billion in 1960. In constant dollars, highway capital outlay has increased 28.1 percent since 1960. Of total expenditures, capital outlay represented 61.9 percent in 1960 and 48.2 percent in 1993.

Highway capital outlay increased at a steady pace from 1956 to 1993 with brief downturns in 1976 and 1977, and in 1981 and 1982. In constant dollars, capital outlay reached a peak of $36.0 billion in 1968 before gradually declining to a low of $20.6 billion in 1979. Since 1979, capital outlay in constant dollars has increased to a new peak of $36.5 billion in 1992. Constant dollar spending was $36.0 billion in 1993.

In constant dollars per unit of travel, capital outlay has dropped from $39.12 per 1,000 VMT in 1960 to $15.68 per 1,000 VMT in 1993, a 59.9 percent decline. However, capital outlay per mile of public road in constant dollars has increased 16.3 percent from $7,930 per mile in 1960 to $9,223 per mile in 1993.

All highways that are not functionally classified as local or rural minor collectors are eligible for Federal aid (see Chapter 2). Those highways are collectively referred to as Federal-aid highways. Total capital outlay by State and local governments on Federal-aid highways is estimated at $30.1 billion (77 percent) of the $39.0 billion expended for capital outlay in 1993.

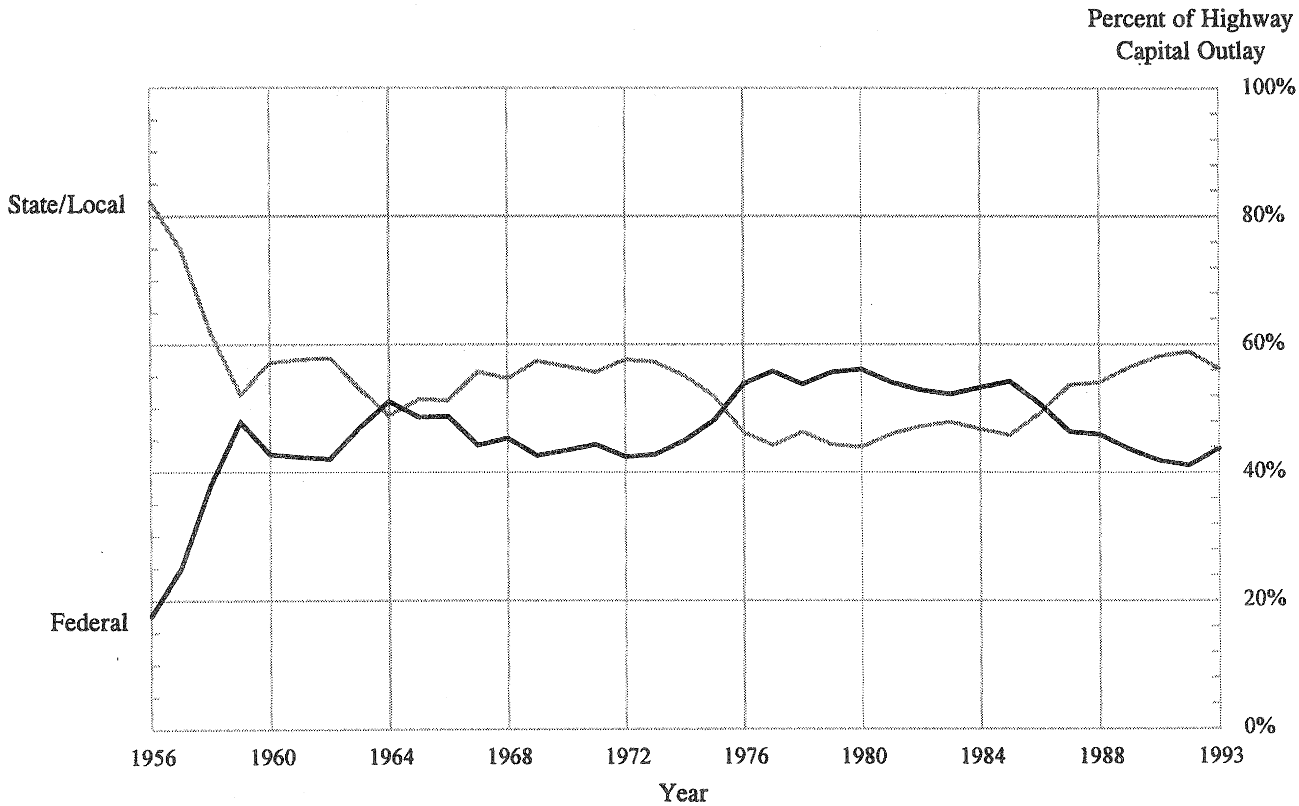
<u>Source of Funds for Capital Outlay by Level of Government</u>. Until the passage of ISTEA, Federal-aid program funds were restricted to capital improvements only. The analysis in this section assumes: (1) that all Federal funds are spent on capital outlay and (2) that the balance of the funding for capital outlay comes from State and local revenues.

Total capital outlay for 1993 was $39.0 billion. State and local governments spent $38.7 billion including $17.1 billion in Federal funds. Federal direct expenditures were $0.3 billion.

The $17.1 billion in Federal funds account for 43.8 percent of the total highway capital outlay of $39.0 billion in 1993. The Federal share of highway capital outlay in 1993 is down from a high of 56.1 percent in 1980. As can be seen in Exhibit 3-7, the Federal share of highway capital outlay increased significantly after the Highway Trust Fund was established by the Highway Revenue Act of 1956 to 42.8 percent in 1960. It has been in a range between 40 percent and 56 percent since then.

State and local governments supplied 55.4 percent of all funds for highway capital improvements in 1993. With the exception of the period from 1976 to 1986, the State and local government share has been consistently more than 50 percent.

Exhibit 3-7
Source of Funds for Capital Outlay
1956-1993



Source: Bulletin—Highway Funding, Table HF10-B, various years
Bulletin—Receipts and Disbursements for Highways, Table HF-11, various years

<u>Capital Expenditures by Functional System</u>. This section considers State and local spending for capital improvements by functional system and on the Interstate system which continues to be a separately identified component of the arterial functional system. Spending estimates include funding from all public sources including Federal funds provided to State and local governments.

Capital outlay on the Interstate system was $9.5 billion in 1993. As shown in Exhibit 3-8, expenditures on the rural Interstate were $3.1 billion or $14.76 per 1,000 VMT. Expenditures on the urban Interstate were $6.4 billion or $20.10 per 1,000 VMT.

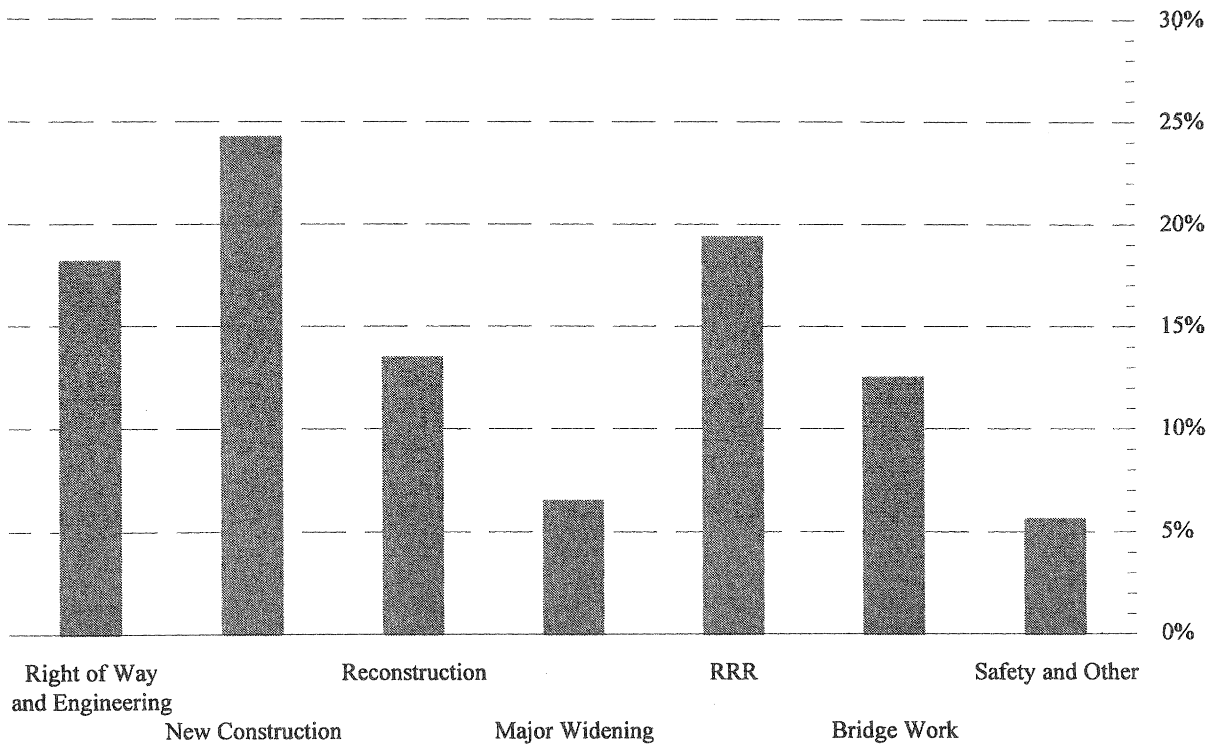
Exhibit 3-8
Highway Capital Outlay by Functional System
1993

Functional System	Capital Outlay (billions of dollars)	Expenditures per 1000 VMT
Interstate - Rural	$3.1	$14.76
Interstate - Urban	$6.4	$20.10
Other Arterials - Rural	$7.7	$22.18
Other Arterials - Urban	$9.9	$12.79
Collectors - Rural	$3.3	$14.70
Collectors - Urban	$1.2	$9.85
Local Roads	$7.1	$23.54
Total (All Systems)	$38.7	$16.84

Source: Bulletin—Highway Funding, 1992-1995, Table HF10B; <u>Highway Statistics</u>, 1993, Tables SF-2, SF-12, LGF-12, LGF-21, and VM-2. Direct expenditures by the Federal Government are not included.

Capital outlay on the Interstate system was mainly for capacity improvements. Capacity improvements include right-of-way, new construction, most reconstruction, major widening, and relocation. New construction (Exhibit 3-9), which is the improvement type that adds the most additional capacity, represented 24.3 percent of capital outlay on the Interstate class. Safety and other improvements accounted for only 5.6 percent of total Interstate expenditures.

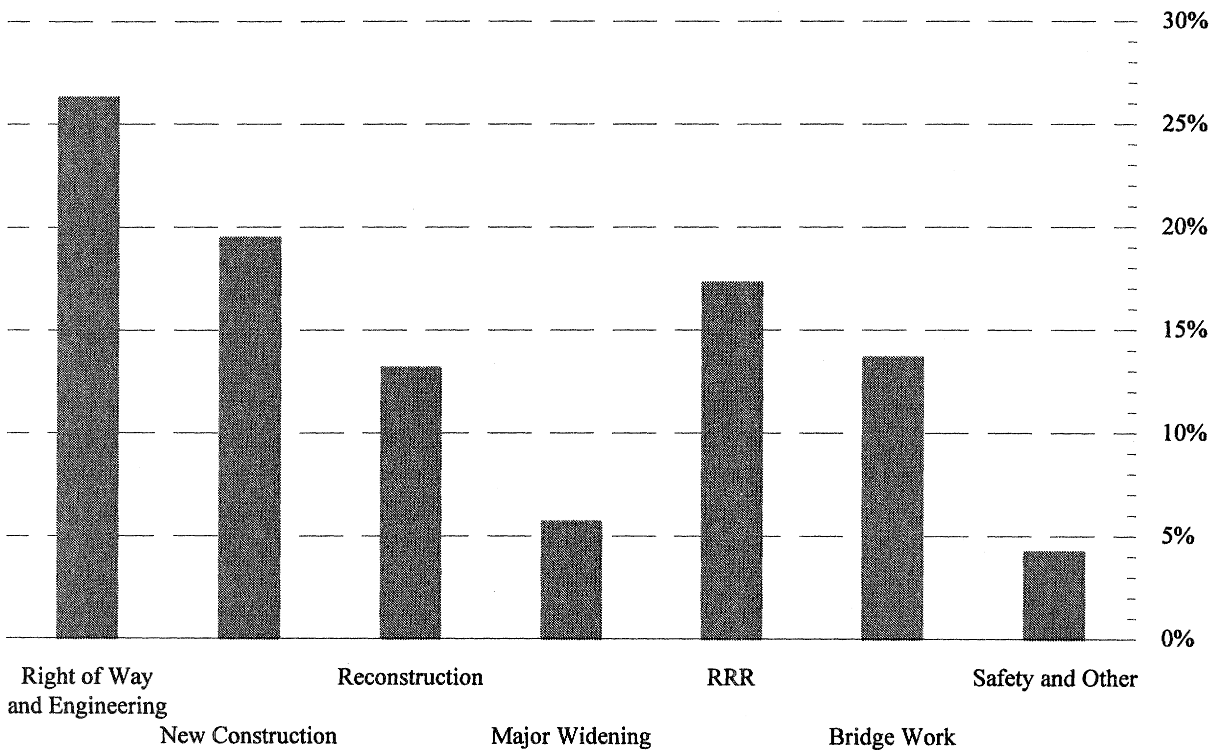
Exhibit 3-9
Distribution of Capital Outlay on Interstate System by Improvement Type
1993



Source: Highway Statistics, Table SF-12A,1993

Capital outlay on arterials other than the Interstate system were $17.6 billion in 1993. On rural arterials, 1993 expenditures were $7.7 billion or $22.18 per 1,000 VMT; on urban arterials, expenditures were $9.9 billion or $12.79 per 1,000 VMT (Exhibit 3-8). As on the Interstate system, capital outlay was mainly for capacity improvements with new construction accounting for approximately 19.5 percent of expenditures. Spending for safety and other improvements were 4.3 percent of the total for these arterials which was less than the same category for Interstate capital outlay (Exhibit 3-10).

Exhibit 3-10
Distribution of Capital Outlay on Arterials Other Than Interstate by Improvement Type
1993

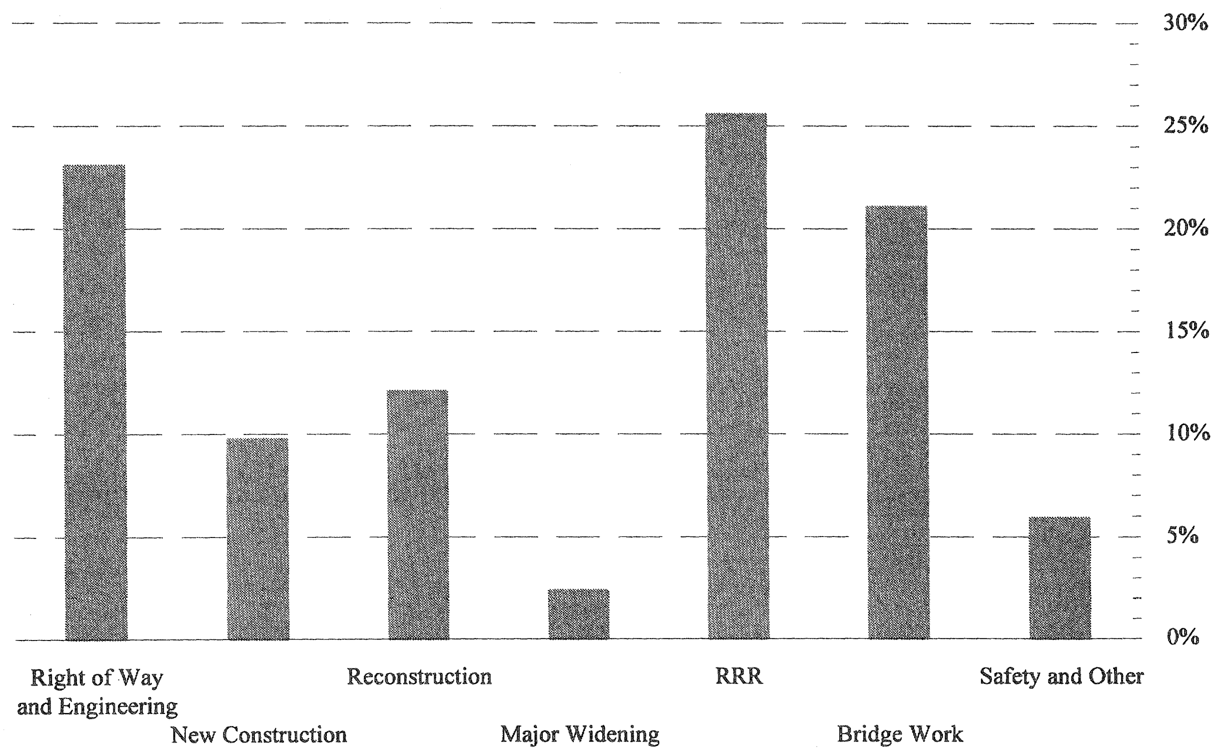


Source: Highway Statistics, Table SF12A, 1993

Capital outlay on collectors was $4.5 billion in 1993. On rural collectors, 1993 expenditures were $3.3 billion or $14.70 per 1,000 VMT; on urban collectors, expenditures were $1.2 billion or $9.85 per 1,000 VMT (Exhibit 3-8). Improvements on collectors were mainly for system preservation. System preservation includes restoration, rehabilitation, and resurfacing (3R); a portion of reconstruction; minor widening; and bridge improvements. The 3R improvements account for 25.6 percent of capital outlay on collectors. New construction accounted for only 9.8 percent of total expenditures on collectors, significantly less than expenditures for these types of improvements on the Interstate and other arterials. Spending for safety and other improvements accounted for 5.9 percent. System preservation type improvements on collectors represent 50.7 percent of total capital outlay (Exhibit 3-11).

Capital outlay on all local roads was $7.1 billion in 1993 or $23.54 per 1,000 VMT. Local roads have the highest level of spending per unit of travel of all of the functional systems. Improvement type data, however, are not available for this functional class.

Exhibit 3-11
Distribution of Capital Outlay on Collectors by Improvement Type
1993



Source: Highway Statistics, Table SF12A, 1993

Capital Expenditures by Type of Improvement. Capital spending on highways can be categorized as follows:

> *System Preservation improvements on existing roads and bridges include minor widening, 3R, bridge replacement, bridge rehabilitation, and reconstruction that does not add additional lanes of capacity. This category also includes improvements to the physical condition of a road or a bridge to improve safety, e.g., the elimination of unsafe highway curves and grades, or narrow width lanes. Spending for these improvements is related to investment required to maintain or improve the pavement structure, and repair or replace bridges.*
>
> *Capacity Improvements add capacity either by adding lane-miles to existing facilities, or by the construction of new roads and bridges. Spending for this category of improvements is related to investments required to add capacity.*
>
> *Other Improvements are not coincidental to the capital improvements described above (and are not included in their costs). "Other improvements" include features or devices to enhance safety, improve traffic operations or reduce vehicle use. Also included is spending for environmentally-related improvements such as noise barriers. Spending for this category of improvements is not directly related to the highway investment requirements in this report.*

As shown in Exhibit 3-12, system preservation improvements in 1993 accounted for 42.2 percent of spending on nonlocal roads, capacity improvements accounted for 52.0 percent, and other improvements accounted for 5.8 percent. Spending on local roads cannot be disaggregated by improvement type.

Exhibit 3-12
Spending by Major Categories on Nonlocal Roads
Billions of Dollars
1993

	Estimated Capital Expenditures	Percent
System Preservation		
Road	$8.7	27.4
Bridge	$4.7	14.8
Subtotal	$13.4	42.2
Capacity Improvements		
Capacity Additions to Roads and Bridges	$10.2	32.4
New Roads and Bridges	$6.2	19.6
Subtotal	$16.4	52.0
Other Improvements	$1.8	5.8
Total Capital Spending on Nonlocal Roads	$31.6	100.0

Source: Highway Statistics Table SF12A, 1993;
Unpublished data from States. Direct expenditures by Federal Government not included.

<u>Capital Outlay Related to Physical Condition and Performance</u>. A total of $38.7 billion was spent by State and local governments on capital improvements in 1993. Of that $38.7 billion, $31.6 was spent on arterials and collectors, including Interstate, and $7.1 billion was spent on local roads. The $31.6 billion spent on arterials and collectors can be disaggregated into two categories (Exhibit 3-13): capital outlay for system preservation and capacity improvements related to the physical condition and performance of roads and bridges ($27.7 billion) and capital outlay for other purposes ($3.7 billion).

Capital outlay for other purposes not related to the condition and performance of roads and bridges includes expenditures for other improvements ($1.8 billion) and expenditures for economic development ($1.9 billion). Economic development represents a portion of new construction that is not directly related to the conditions and performance discussed in this report.

Exhibit 3-13
Capital Outlay Related to Condition and Performance on All Roads and Bridges
Billions of Dollars
1993

Functional Class	Total Capital Outlay	Condition and Performance Related Capital Outlay
Rural		
Interstate	$3.1	$2.7
Other Principle Arterial	$4.7	$4.2
Minor Arterial	$3.0	$2.7
Major Collector	$2.7	$2.5
Minor Collector	$0.6	$0.6
Subtotal	$14.1	$12.6
Urban		
Interstate	$6.3	$5.4
Other Freeway & Expressway	$2.7	$2.3
Other Principle Arterial	$4.4	$3.9
Minor Arterial	$2.8	$2.4
Collector	$1.2	$1.0
Subtotal	$17.4	$15.0
Subtotal, Rural and Urban	$31.6	$27.7
Rural and Urban Local	$7.1	$7.1
Total, All Systems	$38.7	$34.8

Source:
Bulletin—Highway Funding, 1992-1995, Table HF-10B, 1992; 1993 <u>Highway Statistics</u>, Tables SF-12, SF-12A, VM-2; 1992 <u>Highway Statistics</u>, Tables LGF-12, and LGF-21
Direct expenditures by Federal Government not included.

The $7.1 billion spent on roads and bridges in the local functional class cannot be disaggregated by improvement type with the data available. It is likely that most of the $7.1 billion is related to the conditions and performance of local roads and streets as discussed in Chapter 5. Adding the $7.1 billion to capital outlay related to the conditions and performance on arterial and collector highways would raise the total from $27.7 billion to $34.8 billion.

Transit

As shown in Exhibit 3-14, while Federal capital assistance has remained relatively stable between 1988 and 1993, the level of State and local contribution to transit capital assistance has grown. Thus, investment in transit capital assets, both for existing and new systems has increased from $4.11 billion in 1988 to $5.73 billion in 1993. Federal capital assistance levels in fiscal years (FYs) 1994 and 1995 were substantially higher than in past years.

Exhibit 3-14
Sources of Transit Capital Funds
Millions of Dollars
1988-1993

	1988	1989	1990	1991	1992	1993
Federal	$2,395	$2,667	$2,636	$2,545	$2,599	$2,383
(Federal percent)	58%	57%	58%	50%	49%	42%
State	$671	$790	$645	$638	$778	$1,317
Local	$1,041	$1,226	$1,255	$1,914	$1,906	$2,033
Total	$4,106	$4,683	$4,536	$5,097	$5,283	$5,733

Source: Congressional Budget Office (1988-89); Federal Transit Administration Section 15 data (1990-93)

Exhibit 3-15 shows transit capital expenditures by mode and type. As shown in the exhibits, the largest single component of transit capital expenditures in 1993 was rail facilities, at $2.17 billion. This reflects a general preponderance in capital investment for facilities. Rolling stock accounts for just 27 percent of transit capital expenditures. A significant difference is revealed between transit modes. While facilities account for more than 53 percent of rail capital expenditures, they account for only 36 percent of bus capital expenditures. This is due, primarily, to the greater investment required for rail facilities, which include the rights-of-way, track and structure over which the service operates. Bus facilities, while far more numerous, can be much simpler and require less substantial investment.

Exhibit 3-15
Transit Capital Expenditures by Type of Expenditure
Millions of Dollars
Fiscal Year 1993

	Total Expenditure	Rolling Stock	Facilities	Other Capital
Rail	$4,015	$722	$2,168	$1,126
Bus	$1,570	$791	$564	$215
Other	$146	$42	$72	$32
Total	$5,731	$1,555	$2,804	$1,373

Note: "Other" includes Automated Guideway, Ferryboat, and Inclined Plane.

Source: Federal Transit Administration Section 15 data

All of the transit capital investment reported here was spent on improvements whose cost is included in the estimates of future transit investment requirements presented in Chapter 5. However, this investment does not include an estimate of rural or specialized transit capital expenditures. These capital expenses are not captured by the Section 15 data reporting requirement, although they are supported with Federal grant funds to States, State grants, and other funding sources.

Noncapital Expenditures

Highway

A brief overview of noncapital highway expenditures from 1956 through 1993 is included to provide some perspective on changes in the share of total expenditures that is being spent on this category of activities. In both current and constant dollars, spending for this category has increased. The noncapital share of expenditures for highways was $41.9 billion for 1993, or 51.8 percent of highway expenditures. In 1960, it was $3.9 billion, or 38.1 percent of all highway expenditures. Constant dollar growth from 1960 through 1993 for the noncapital category of expenditures was 121.8 percent compared to a 60.5 percent growth in total expenditures for both the capital and noncapital categories.

On an expenditure for unit of travel basis, noncapital spending in current dollars has increased 238.6 percent from $5.39 per 1,000 VMT in 1960 to $18.25 per 1,000 VMT in 1993 while constant dollar spending has declined 30.6 percent from $20.67 per 1,000 VMT to $14.35 per 1,000 VMT in 1993. On the basis of public road mileage, constant dollar spending has increased 101.5 percent from $4,190 per mile in 1960 to $8,439 per mile in 1993.

Maintenance and Traffic Services Expenditures. Spending for roadway maintenance and traffic services expenditures is the largest single component of noncapital highway expenditures. Maintenance costs include routine and regular expenditures required to keep highways in usable condition, such as patching repairs, bridge painting, and other maintenance of condition costs. Traffic service costs include most operational costs such as snow and ice removal, pavement markings, signs, signals, litter cleaning, and toll collection expenses. Some of these activities, including bridge painting, are now eligible for Federal aid.

A total of $22.9 billion was spent by State and local governments in 1993 to keep all highways, roads and streets in serviceable condition. The maintenance and traffic services share of total expenditures was 26.0 percent in 1960 and 28.3 percent in 1993. In constant dollars, 1993 maintenance and traffic services expenditures were 77.8 percent higher than in 1960.

Other Noncapital Expenditures. Other noncapital highway expenditures include administration, highway law enforcement and safety, and interest on highway debt. The relative share of these other noncapital expenditures to total expenditures has increased from 12.1 percent to 23.5 percent. In constant dollars, this category of spending has increased dramatically (216.3 percent) since 1960.

Transit

As shown in Exhibit 3-16, operating (noncapital) expenditures increased significantly between 1983 and 1992, from $8.4 billion to $16.0 billion. Most of the percentage increase took place between 1983 and 1986. From 1987 to 1993, the annual increase in operating expenses, in current dollars, was less than 4.4 percent; in real terms, the annual increase was less than 1 percent. The earlier increases result, in large part, from more complete reporting of costs, particularly in the rail transit sector, as well as from significant increases in service supplied. Between 1983 and 1993, Light Rail service supplied, as measured in Vehicle Revenue Miles, increased by over 65 percent. Demand Response service increased by over 457 percent in the same period. This rate of increase is expected to continue over the next two years for the demand response sector of transit as more systems begin to reach full implementation of plans to meet the requirements of the Americans with Disabilities Act of 1990 (ADA).

Although real operating costs per unit of service have remained relatively stable in recent years, expenditures per unit of travel have increased due to a decline in the rate of service utilization, as noted in Chapter 2. Specifically, real operating costs per passenger mile have increased 31 percent from 1983 to 1993, an average annual increase of 3 percent. As noted in Chapter 2, the decline in service utilization rates can largely be explained by the increase in real fares of 41 percent during this period, an annual rate of 3.5 percent.

The $16.0 billion provided for transit operating expenditures in 1993 came primarily from State and local funding sources. These included State general revenues, dedicated State and local taxes, and farebox revenues. Overall, Federal funds contributed only 5.7 percent to transit operating costs ($911 million), while contributing just under 42 percent to transit capital expenditures ($2.4 billion) in 1993. Fare and other operating revenue contributed $7.1 billion (44 percent) in 1993.

Exhibit 3-16
Mass Transit Operating Expenses by Mode
Millions of **Current** Dollars
1983-1993

	Bus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other	Total
1983	$5,243	$2,242	$411	$120	$126	$288	$8,429
1984	$5,653	$2,594	$566	$127	$127	$279	$9,346
1985	$6,017	$2,848	$732	$140	$154	$306	$10,197
1986	$6,336	$3,102	$1,640	$158	$176	$309	$11,721
1987	$6,737	$3,235	$1,748	$172	$211	$254	$12,357
1988	$6,995	$3,524	$1,889	$197	$252	$261	$13,118
1989	$7,295	$3,704	$2,068	$209	$323	$284	$13,883
1990	$7,779	$3,825	$2,157	$236	$386	$323	$14,705
1991	$8,330	$3,841	$2,175	$290	$443	$325	$15,404
1992	$8,625	$3,555	$2,170	$307	$500	$342	$15,499
1993	$8,866	$3,669	$2,203	$314	$561	$358	$15,970

Source: Federal Transit Administration Section 15 data

Exhibit 3-17 reflects the dominance of bus services, which accounted for nearly 56 percent of 1993's total operating expenses. Heavy rail consumed 23 percent and commuter rail consumed another 14 percent of total operating cost. Demand response and light rail, while increasing in the amount of service supplied and in operating expenses, represented only 3.5 percent and 2.0 percent, respectively. This exhibit shows that rail modes show a higher need for facilities and wayside maintenance than other modes.

The exhibit also shows that demand response service had a higher percentage of operating expense resulting from general administration (41 percent) than did other modes. This is due to two factors: a significant amount of service that is operated under contract, and substantial expenses resulting from data processing, customer service and scheduling costs. Rail modes show a higher need for facilities and wayside maintenance than other modes.

Exhibit 3-17
Disbursements for Mass Transit Operations, All Sectors, by Mode and Function
Millions of Dollars
1993

Mode	Vehicle Operations	Vehicle Maintenance	Non-Vehicle Maintenance	General Administration	Purchased Transportation	Total
Bus	$4,702	$1,756	$366	$340	$1,476	$8,641
	63%	61%	22%	39%	58%	56%
Heavy Rail	$1,620	$552	$887	$0	$610	$3,669
	22%	19%	52%	0%	24%	24%
Commuter Rail	$785	$453	$365	$140	$338	$2,080
	10%	16%	21%	16%	13%	13%
Light Rail	$134	$69	$60	$0	$51	$314
	2%	2%	4%	0%	2%	2%
Demand Response	$109	$27	$3	$369	$31	$539
	1%	1%	0%	43%	1%	3%
Other	$136	$31	$17	$19	$23	$226
	2%	1%	1%	2%	1%	1%
Total	$7,485	$2,888	$1,698	$868	$2,529	$15,468
	100%	100%	100%	100%	100%	100%

Source: Federal Transit Administration Section 15 data

Private Sector Financing

Highway

As mentioned in the Introduction, financing for roads and highways comes from both the public and private sectors. The term "private sector financing" as used in this report means financing for highway projects that are primarily developed and constructed by private companies and individuals through nongovernmental revenue sources. Projects financed by the private sector include construction of local roads in new developments, improvements to existing collector or arterial roads that provide access to new developments, improvements to existing facilities or the construction of new facilities to provide for the additional traffic generated by a new development or by a change in the way land is used, and toll facilities built as an investment.

There is no distinction made based on whether the project is required by the government as a condition for changes in land use or is done at the initiative of the developer to make property more attractive to potential buyers.

Unlike public sector financing, private sector financing generally is restricted to capital outlay since facilities are usually turned over to the appropriate governmental organization to maintain and operate after construction is completed. However, this would not be the case if a toll road were privately owned and operated; financing of maintenance and operation would then be the responsibility of the owner.

The ISTEA allows the use of Federal-aid funds on privately-owned facilities and is expected to increase the attractiveness of toll road development as an investment option. The private entities emerging as developers are consortiums of investors, and construction, management, and technology companies. Under franchise or public utility-type contracts, these entities may design, finance, construct, and operate highway facilities. The financing package for these projects may include combinations of grants or loans of Federal, State, or local highway funds, and private investor equity or debt supported by tolls.

Transit

FTA has supported a wide variety of locally-initiated innovative financing mechanisms to help cover the cost of rolling stock and infrastructure, many of which involve a larger role for private sector financing. These have included cross-border leases, bond refinancing, benefit assessment districts, Certificates of Participation, joint development and negotiated investment ventures. These techniques are not equally applicable to all transit operators and they do not, even in the aggregate, contribute a major share of any single transit project. However, they have been used very effectively to assist transit operators in attracting private capital and contributing to the local matching share of transit projects. For example, between June 1990 and December 1994, over $950 million in cross-border leases were effected, which generated over $33 million in net benefits to transit operators. The benefits resulted from the transit operator being able to engage in a cross-border sale-leaseback transaction that capitalized depreciation benefits from rolling stock that could not be sold or leased back within the United States under current tax laws.

Chapter 4

Highway, Bridge and Transit System Condition and Performance

Chapter 4

Introduction

This chapter addresses the conditions and performance of the arterial and collector highway systems, transit rolling stock and infrastructure, and aspects of the environment influenced by transportation construction and operation. Those features of the arterial and collector highways that affect condition and performance are examined. Condition refers to the physical condition of the pavement, and performance refers to the level of service (LOS) provided to the highway user. Information is included about the highway systems in terms of LOS, pavement condition, bridge condition, and accidents.

Similarly, the analysis of transit conditions refers to the physical condition of capital assets including the condition of buses, paratransit vehicles, and rail cars, as well as the condition of track, maintenance yards, and other facilities. Mass transit performance refers to the quality of service provided to the public.

Achieving the objectives of transportation policy without compromising the nation's environmental goals will require both Congress and the Department of Transportation (DOT) to have up-to-date measures of the environmental consequences of transportation policies and projects. The section on environment lays the foundation for appraisal of an ongoing program of monitoring environmental conditions and performance in the surface transportation sector, just as pavement, bridge and transit conditions and performance have been monitored for many years. The inclusion of this section in the report series is an attempt to address the performance of the highway system in environmental terms.

Conditions and performance information contained in this chapter is provided generally by functional highway system and by transit mode and is presented in three major sections, which are:

> ***Performance** — highway and transit level of service;*
>
> ***Physical Conditions** — pavement conditions, roadway alignment, lane width, bridge deficiencies and conditions and transit conditions; and*
>
> ***Safety** — highway crash fatality rates.*

The highway information contained in this chapter has been developed primarily from data supplied by the State highway agencies via the Highway Performance Monitoring System (HPMS) and the National Bridge Inventory (NBI). The HPMS data, updated annually by the States, provides the Federal Highway Administration (FHWA) with information about highway physical condition and usage. Data about pavement, roadway cross-section, alignment, and usage is collected for more than 110,000 sample sections of arterial and collector highways nationwide. The samples represent all functional highway systems except rural minor collectors and local roads and streets. The NBI data on bridges contains records on each of approximately 575,000 bridges.

The HPMS database is the primary source of information for the Federal government about the Nation's highway infrastructure. The HPMS includes statistical estimates of pavement condition and system performance. The data presented on highway physical conditions was collected in 1993 and represents average conditions that existed during that year. Much information from the HPMS is contained in the annual Highway Statistics. Readers should note that rural minor collectors are no longer included in the HPMS sample section database. These are generally low-volume roads that are ineligible for Federal-aid funding.

The second source of data, the NBI, is updated continuously and includes detailed information about all highway bridges in the country, on all functional systems. This information is used in the monitoring and managing of the Highway Bridge Replacement and Rehabilitation Program, as well as to provide the condition information presented in this report.

The bridges included in this report are all bridges and culverts with a length along the centerline of the roadway of 20 feet or greater. The bridge data is updated for each bridge, usually on a 2-year cycle. The bridge information presented in this chapter is based on the data on file June 30, 1994, which includes the updates for each bridge, primarily from 1992 and 1993.

The HPMS and NBI databases are discussed in more detail in Appendix A.

Highway condition and performance measures are shown for alternate years from 1983 to 1993. However, comparison of previous year data with 1993 data should be approached with caution. The HPMS redesign and the shift in emphasis in pavement condition reporting from Present Serviceability Rating (PSR) to International Roughness Index (IRI) invalidates direct comparison of 1993 pavement conditions with previous years' conditions. Also, the urban area boundaries enlarged as a result of the 1990 census, and a significant portion of miles and travel shifted from rural to urban. Finally, a functional system reclassification in the 1992 to 1993 timeframe resulted in some mileage changing systems. This must be kept in mind when looking at data prior to 1993.

It should also be noted that the Volume to Service Flow Ratios (V/SFs) reported as a measure of congestion are based on the 1985 Highway Capacity Manual (HCM), Special Report 209 of the Transportation Research Board. The recently-released 1994 HCM update had not been incorporated into the 1993 HPMS data reporting procedures. The implications of this are that lower percentages of highway mileage and travel will fall into the poor LOS categories.

Information is stratified by the rural and urban functional classification systems. Results of these analyses are contained in the subsections that follow. The conditions and performance of rural minor collectors and local roads and streets are not included because data for these systems are not collected in the HPMS submittal.

The information on transit conditions and performance is taken from several sources. The most important is the data reported to the Federal Transit Administration (FTA) under the requirements of Section 15 of the Federal Transit Act. Data is reported by all transit operators receiving or benefiting from Federal capital or operating assistance. The data used in this report includes local fiscal years ending during calendar year 1993.

Trends are examined for transit condition and performance measures for the period 1983 through 1993, where data are available. Data are stratified by transit mode and by area size (urbanized areas over 1 million, urbanized areas under 1 million, and rural areas).

Other sources include the Nationwide Personal Transportation Survey (NPTS), 1990 and earlier; the Rail Modernization Study, 1987; and Modernization of the Nation's Rail Transit Systems: A Status Report, 1992; data from the Community Transportation Association of America (CTAA), 1994; and a report on bus maintenance facility conditions conducted for FTA by ATE Management and Service Company, 1991.

The information on the effects of transportation on the environment include the Environmental Protection Agency (EPA) National Air Quality and Emissions Trend Report, 1991, and Highway Statistics, 1993 and earlier.

The material in the following sections is presented to characterize the relative differences among functional highway systems and types of transit service and changes that are occurring on those systems and services over time at the national level. The annual FHWA publication titled Highway Statistics contains information about the physical condition and usage of highways at the individual State level.

Highway and Transit Performance

Highway Performance

Highway operating performance, on a given facility or system, is determined by the level of service provided. Congestion, which occurs at poor levels of service, results from the inability of an individual highway section or highway system to accommodate adequately the volume of traffic that attempts to use the section or system. The results of congestion are interruptions in the traffic flow, delay, increased travel time, increased fuel consumption, increased vehicle emissions and reduced air quality, increased user costs, increased cost of goods transport with resultant increased costs to the consumer, increased aggravation to the driver, and other effects.

There are substantial costs to the economy of the Nation as a result of congestion. A report by the Texas Transportation Institute, Roadway Congestion Estimates and Trends - 1990, March 1993, states that in 1990, the total cost of congestion for the 50 urban areas studied was approximately $43.2 billion. Delay accounted for approximately 85 percent of this amount, while excess fuel consumption accounted for 15 percent. Eight of the top ten urban areas had total congestion costs exceeding $1 billion.

The Nation experienced a decline in urban highway operating performance, measured in terms of the severity of peak-hour congestion, between 1983 and 1989. However, this trend has moderated since 1989.

Measuring Highway Performance

A description of highway performance is an appraisal of the quality of traffic flow over the highway systems. Congestion is a term often used to describe poor highway performance. However, there is no widely accepted specific definition of congestion.

The perception of what constitutes congestion varies from place to place. What may be perceived as congestion in a city of 300,000 population may not be considered congestion in a city of 3 million. For that reason, this report does not attempt to specifically define congestion. Instead, it looks at the peak-hour volume of traffic relative to the calculated capacity.

Congestion can be appraised from a variety of viewpoints. The **severity** of congestion refers to the magnitude of the problem, as measured by the average overall travel speed, travel time delay, the number and magnitude of acceleration and deceleration cycles, or the maximum length of a queue behind a bottleneck. The **extent** of congestion is defined by the geographic area, the portion of the population or the portion of total travel affected. The **duration** of congestion is the length of time that the traffic flow is congested, often referred to as the "peak period" of traffic flow.

This report uses the V/SF, formerly called the volume/capacity ratio, as a measure of severity. The V/SF is the ratio between the volume of traffic actually using a highway facility during the peak hour and the theoretical capacity of that facility to accommodate the traffic.

Congestion reported in this chapter is based on a threshold V/SF ratio of 0.80, representing LOS D. This volume of traffic is 80 percent of the maximum that can be accommodated on a highway facility, but freedom to maneuver is noticeably limited and incidents result in significant delays. Higher V/SF ratios represent increasing congestion through LOS E until LOS F is reached and a breakdown in traffic flow occurs. Exhibit 4-1 contains definitions of the levels of service.

Exhibit 4-1
Levels of Service (LOS)

LOS	DESCRIPTION
A	LOS A describes primarily free-flow operations. Average operating speeds at the free-flow speed generally prevail. Vehicles are almost completely unimpeded in their ability to maneuver within the traffic stream. The effects of incidents are easily absorbed.
B	LOS B also represents reasonably free flow, and speeds at the free-flow speed are generally maintained. The ability to maneuver within the traffic stream is only slightly restricted, and the general level of physical and psychological comfort provided to drivers is still high. The effects of minor incidents are still easily absorbed, though local deterioration in service may be more severe than for LOS A.
C	LOS C provides for flow with speeds still at or near the free-flow speed of the freeway. Freedom to maneuver within the traffic stream is noticeably restricted at LOS C. Minor incidents may still be absorbed, but the local deterioration in service will be substantial. The driver experiences a noticeable increase in tension.
D	LOS D is the level at which speeds begin to decline slightly with increasing flows. Freedom to maneuver within the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort levels. Even minor incidents can be expected to create queuing.
E	LOS E describes operation at or near capacity. Operations are volatile, because there are virtually no usable gaps in the traffic stream. Any disruption can cause the following vehicles to give way, which can establish a disruption wave that propagates throughout the upstream traffic flow. The traffic stream has no ability to dissipate even the most minor disruptions, and any incident can be expected to produce a serious breakdown with extensive queuing. The level of physical and psychological comfort afforded the driver is extremely poor.
F	LOS F describes breakdowns in vehicular flow. Such conditions generally exist with queues forming behind breakdown points. Such breakdowns occur because of traffic incidents, recurring points of congestion, or peak hour flow demand exceeding the capacity of the location.

Source: Abstracted from the Highway Capacity Manual, 1994

Current research shows that more traffic can move through a freeway lane per hour than ever before because drivers have become willing to travel at closer headways (less than 2-second intervals) and at higher speeds at higher rates of flow than previously. This is documented in the 1994 release of the HCM.

The 1994 HCM has been revised to reflect the increased volumes of traffic that are now being accommodated by freeways and, to a lesser extent, by other roads. The new capacity procedures indicate that the capacity of a freeway lane under ideal conditions, before adjustment for trucks and other conditions, is 2,200 passenger cars per hour per lane for 4-lane freeways and 2,300 passenger cars per hour per lane for freeways with 6 or more lanes. This value from the 1985 HCM was 2,000 passenger cars per hour per lane. Thus the new HCM suggests a capacity increase of 10 percent to 15 percent and means that less highway mileage and travel occurs under poor LOS conditions than is reported using the old procedure.

The saturation flow rate of a signalized intersection was changed from 1,800 passenger cars per hour per lane to 1,900 passenger cars per hour of green signal per lane. There are many adjustments that are required to determine the actual capacity of a signalized intersection, and many of those have changed as well. However, the increase in saturation flow rate is an indication that the capacity of a signalized intersection did increase in many cases.

There were no changes in the capacity procedures for 2-lane rural highways.

When the HPMS data has incorporated the results of the 1994 HCM, the results will be reported. It is anticipated that the 1995 HPMS data furnished by the States and reported in the 1997 Status of the Nation's Surface Transportation System: Conditions and Performance Report to Congress (C&P Report) will reflect the new capacity calculation procedures. This change in calculated capacity is likely to result in reductions in the severity of congestion as measured by peak-hour V/SF.

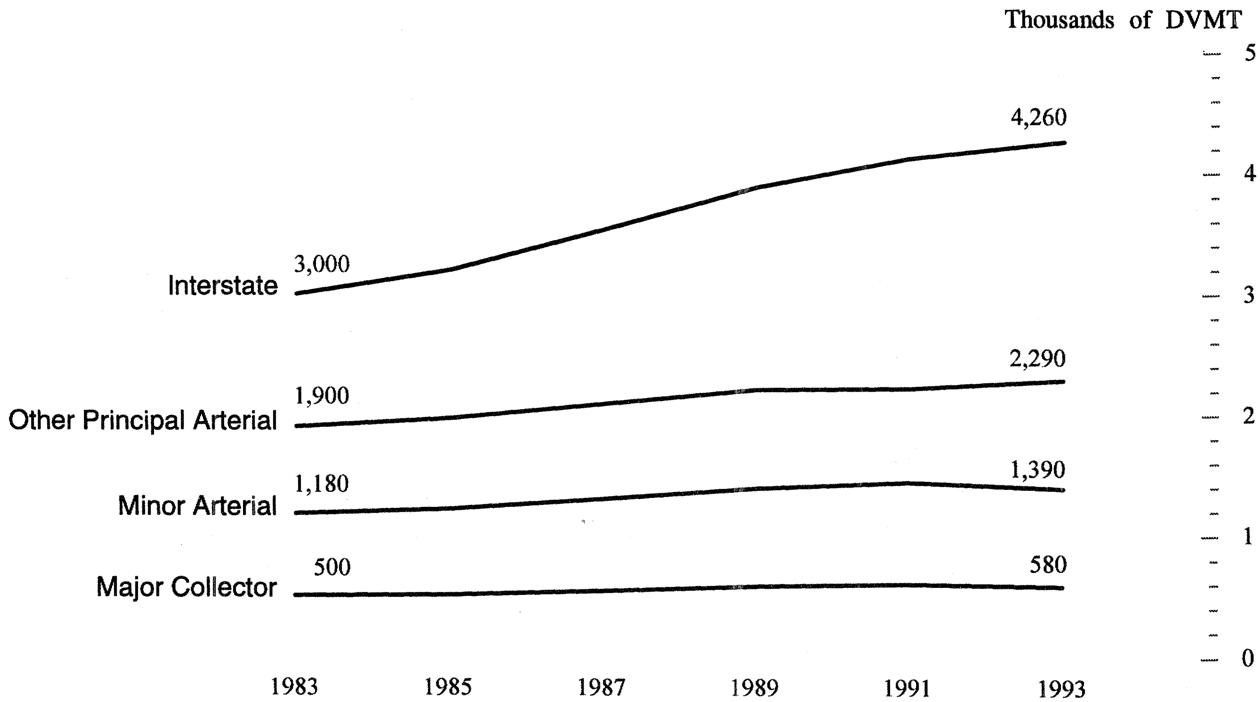
Urban and Rural Operating Characteristics

Congestion, as expected, is concentrated in the urban areas, and on the higher functional systems. Travel on Interstates and other freeways and expressways experiences the highest levels of congestion. Congestion on other principal arterials and minor arterials is also significant. It should be noted that a congested freeway may still have an overall travel speed higher than that on a lower type facility with traffic control signals, depending on the severity of the congestion and other factors.

Because of changes in the Federal-aid urban area boundaries as a result of the 1990 census, most of which changes were implemented since the 1993 C&P Report, the severity of congestion reported in 1993 should not be compared to that in prior years. Changing the classification of roadways in many suburban areas from rural to urban affected the percentage of congested miles and travel in the urban category by diluting the miles of highly congested central urban roadways with additional suburban roadways. These roadways with generally lower levels of congestion reduce the percentage of congested roadways shown in this report.

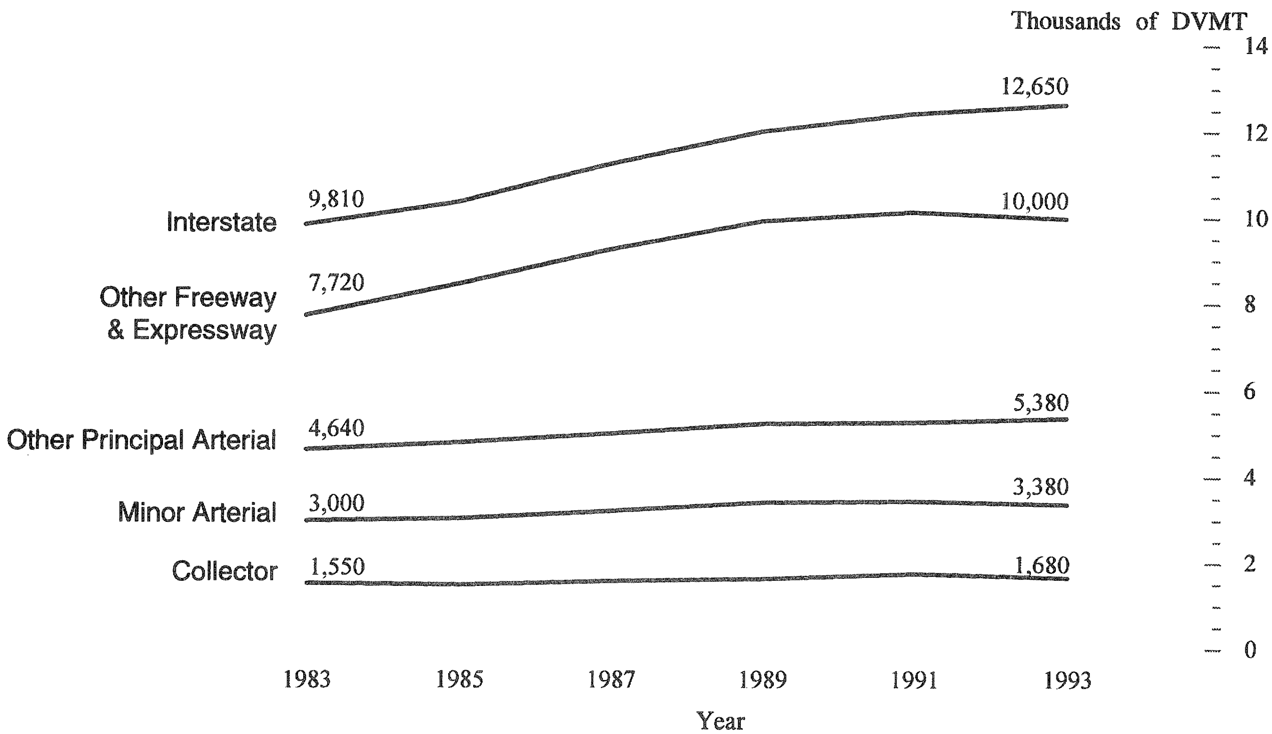
There has been a consistent increase in travel relative to the capacity of the highway system to accommodate this travel. Exhibits 4-2 and 4-3 illustrate the daily vehicle miles of travel (DVMT) per lane-mile for each functional system for the study period, for rural and urban systems respectively. DVMT per lane-mile is the average annual daily traffic (AADT) per lane.

Exhibit 4-2
Daily Vehicle Miles of Travel (DVMT) per Lane Mile - Rural
1983-1993



Source: Highway Performance Monitoring System Master datasets, various years

Exhibit 4-3
Daily Vehicle Miles of Travel (DVMT) per Lane Mile - Urban
1983-1993



Source: Highway Performance Monitoring System Master datasets, various years

These exhibits demonstrate the continuing increase in travel density on the higher functional systems, particularly the Interstate, both urban and rural, and urban other freeways and expressways. DVMT per lane-mile on the rural Interstates increased from 3,000 vehicles per day in 1983 to 4,260 vehicles per day in 1993, an average 3.6 percent annual increase. On the urban Interstates, travel per lane-mile increased from nearly 10,000 to 12,650, a 2.6 percent annual increase.

Note that these values of travel per lane-mile are average values. While there is no recognized value of "daily capacity" to which these values can be compared, a value of 13,000 vehicles per lane-mile per day has been used as a threshold value of congested freeway travel.

The increase in DVMT per lane-mile stabilized or increased only slightly from 1989 to 1993 on the lower functional systems. Whether this begins a trend of lower travel growth, as has been predicted, remains to be seen. It may reflect the economic condition of the country during this period. For 1993, expanded urban areas are reflected in these values.

This increase in travel relative to the slower increase in supply of highway capacity points to increasing congestion of the higher functional systems in the urbanized areas. The increase in rural travel has not yet saturated the facilities to the degree that has occurred in the large urbanized areas. The greatest extent of congestion on highways in the rural category often occurs on those highways adjacent to urban areas or on facilities with heavy recreational travel.

Peak-Hour Travel

Exhibit 4-4 contains the percent of **mileage** on which peak-hour travel occurred with V/SF ratios greater than or equal to 0.80, for 1983 to 1993, by functional system. These data indicate that for the past 10 years an increasing portion of the urban Interstate and other freeway and expressway mileage has accommodated high rates of flow. While congested mileage on rural Interstates has increased, the extent of congestion is still far less than in the urban areas.

Exhibit 4-4
Percent Highway Mileage by Functional System with
Volume to Service Flow (V/SF) Ratio of 0.80 or Greater
Selected Years, 1983-1993

	Year					
Functional System	**1983**	**1985**	**1987**	**1989**	**1991**	**1993**
Rural						
Interstate	3.0	3.5	7.7	9.8	8.8	8.8
Other Principal Arterial	2.7	3.2	2.1	2.2	2.1	2.1
Minor Arterial	2.0	2.4	1.2	1.3	1.4	1.2
Major Collector	0.5	0.6	0.3	0.3	0.3	0.2
Urban						
Interstate	30.6	38.1	42.0	45.6	47.2	45.3
Other Freeway & Expressway	22.8	28.0	31.3	33.4	34.7	31.5
Other Principal Arterial	28.5	30.2	30.0	30.8	28.7	25.8
Minor Arterial	17.1	18.2	18.3	19.0	17.2	13.5
Collector	6.0	6.7	6.0	6.9	7.5	5.4

Note 1: The change in Federal-aid urban area boundaries resulted in reclassification of roadways in many suburban areas from rural to urban. This affected the percentage of congested miles and travel in the urban category by diluting the miles of highly congested central urban roadways with additional suburban roadways. Therefore, these roadways, with generally lower levels of congestion, reduced the percentage of congested roadways.

Note 2: The V/SF ratios and Level of Service (LOS) values are based on the 1985 Highway Capacity Manual (HCM). The 1994 HCM would probably indicate a lower percentage of travel at the highest V/SF ratios and a lower percentage of travel at the poorer LOS.

Source: Highway Statistics, various years

The changes in urban area boundaries following the 1990 Census, which occurred primarily between 1991 and 1993, affect the values shown. The transfer of mileage and travel from rural to urban status must be considered when these values are compared. The vertical line in Exhibits 4-4 and 4-5 between the 1991 and 1993 values is intended to emphasize this change.

Exhibit 4-5 contains the percent of peak-hour travel that occurred with V/SF ratios greater than or equal to 0.80, by functional system. The percent of peak-hour travel on rural Interstates operating under such conditions has increased at an annual rate of 10 percent from 1983 to 1993.

Exhibit 4-5
Percent Peak-Hour Travel by Functional System with
Volume to Service Flow (V/SF) Ratio of 0.80 or Greater
Selected Years, 1983-1993

	Year					
Functional System	**1983**	**1985**	**1987**	**1989**	**1991**	**1993**
Rural						
Interstate	8.5	9.4	18.9	22.9	21.5	22.9
Other Principal Arterial	8.8	9.5	7.8	8.2	8.0	7.0
Minor Arterial	8.8	10.0	5.6	6.3	6.2	5.1
Major Collector	5.3	6.4	3.2	3.9	3.4	2.3
Urban						
Interstate	55.4	62.7	67.0	69.6	70.2	69.4
Other Freeway & Expressway	49.3	54.4	57.0	59.9	61.4	58.8
Other Principal Arterial	40.3	42.4	43.3	45.0	41.4	38.5
Minor Arterial	31.7	33.5	34.2	34.5	31.2	26.0
Collector	19.5	20.0	18.0	19.5	20.5	14.9

Note 1: The change in Federal-aid urban area boundaries resulted in reclassification of roadways in many suburban areas from rural to urban. This affected the percentage of congested miles and travel in the urban category by diluting the miles of highly congested central urban roadways with additional suburban roadways. Therefore, these roadways, with generally lower levels of congestion, reduced the percentage of congested roadways.

Note 2: The V/SF ratios and Level of Service (LOS) values are based on the 1985 Highway Capacity Manual (HCM). The 1994 HCM would probably indicate a lower percentage of travel at the highest V/SF ratios and a lower percentage of travel at the poorer LOS.

Source: Highway Performance Monitoring System datasets, various years

The portion of rural travel with high V/SF ratios on the other functional systems has actually declined over the same period of time. On rural Interstates, the percent of congested peak-hour travel has remained relatively stable since 1989. Again, the reclassification of some highway sections from rural to urban affected this trend.

The percent of peak-hour travel on urban Interstates with V/SF ratios greater than 0.80 increased from about 55 percent to about 70 percent from 1983 to 1989, and has remained relatively constant since that time. This is an average annual growth rate in congested peak-hour travel of 2.3 percent. On the non-freeway arterial and collector systems, the portion of peak-hour travel with V/SF ratios greater than 0.80 actually declined slightly during this 10-year period. This says nothing about the duration or extent of congestion.

Exhibit 4-6 contains the portions of urban peak-hour travel in 1993 that occur with LOS D, E and F. For the purpose of this Exhibit, LOS D is defined as having a V/SF ratio of between 0.80 and 0.95 and LOS E and F are defined as having a V/SF of greater than 0.95. At these levels of service vehicle flow approaches instability and stop-and-go travel is likely of occur, resulting in LOS F. It is noteworthy that of the peak-hour travel on Interstates and other freeways and expressways that is occurring at LOS D or worse, 77 percent is occurring at LOS E or F.

Exhibit 4-6
Percent Congested and Highly Congested Peak Urban Travel by Functional System
1993

	Level of Service (LOS)		
Functional System	"D"	"E" & "F"	"D-F"
Interstate	15.9	53.5	69.4
Other Freeway & Expressway	12.9	45.9	58.8
Other Principal Arterial	16.7	21.8	38.5
Minor Arterial	10.5	18.4	28.9
Collector	7.0	8.0	15.0
Total	13.9	29.9	43.8

Note 1: LOS D has a Volume/Service Flow (V/SF) ratio between 0.80 and 0.95. LOS E and F have a V/SF greater than 0.95.

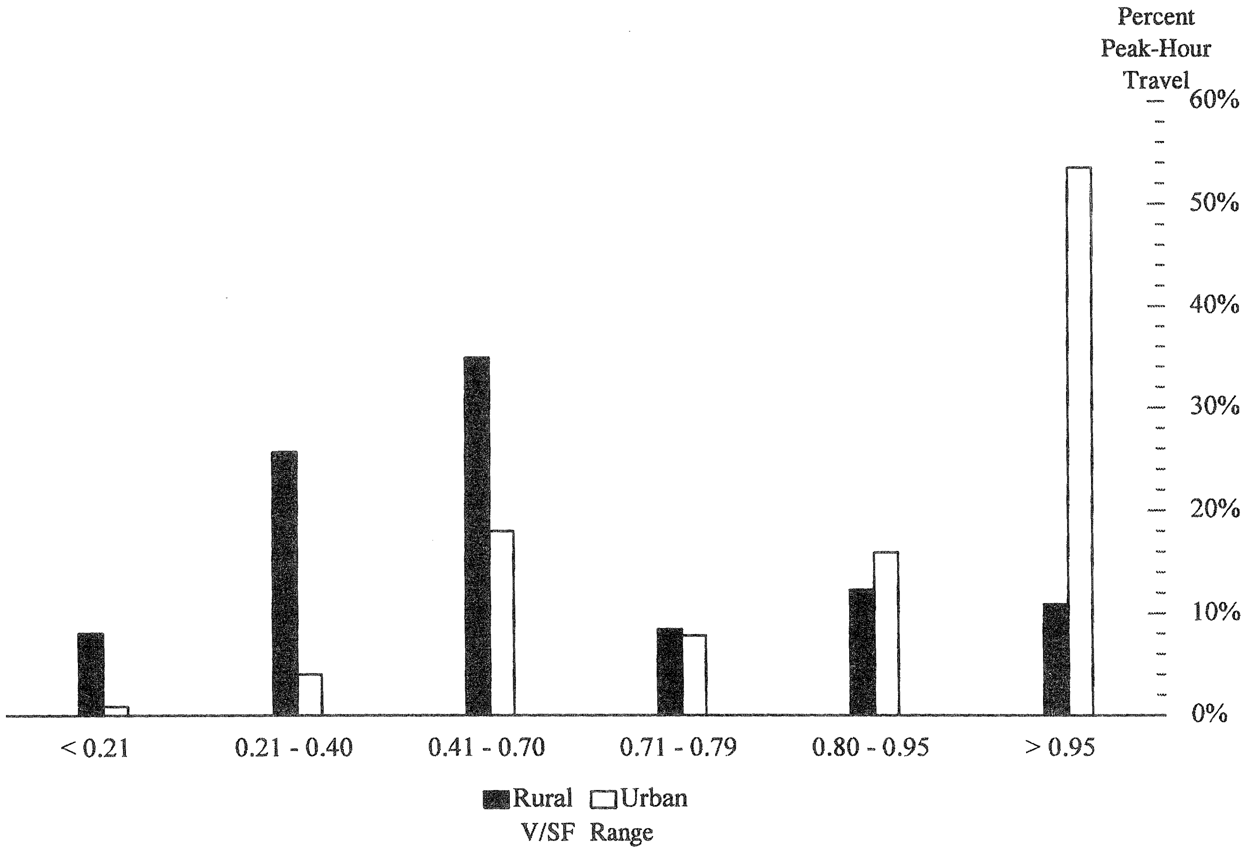
Note 2: The V/SF ratios and Level of Service (LOS) values are based on the 1985 Highway Capacity Manual (HCM). The 1994 HCM would probably indicate a lower percentage of travel at the highest V/SF ratios and a lower percentage of travel at the poorer LOS.

Source: Highway Performance Monitoring System master dataset, 1993

A significant problem that occurs when traffic flow is high is that any incident will cause breakdown in the traffic flow and result in LOS F. When traffic flow results in LOS C, an incident may result in little or no delay to the traffic stream. However, as the traffic flow and density increases, any perturbation in the flow is increasingly likely to cause disruption to the smooth flow and result in a stop-and-go situation, which on a freeway is generally classified as LOS F. This results in a lower throughput than occurs under LOS D or E.

Exhibit 4-7 shows 1993 travel on the Interstate systems, rural and urban, within specified V/SF categories. Increasing V/SF levels indicate increasing traffic density and decreasing LOS. Exhibit 4-1 contains LOS definitions. V/SF ratios up to about 0.70 indicate levels of service from A to C, which are free-flow at LOS A to moderately restrictive flow at LOS C. Above a V/SF of approximately 0.80 (the actual value varies with the type and characteristics of the facility), the LOS moves from D to E indicating increasing congestion. Finally, at LOS F, breakdown in the traffic flow occurs and fewer vehicles per hour are able to traverse the facility.

Exhibit 4-7
Percent Interstate Peak-Hour Travel by Volume/Service Flow (V/SF) Range
1993



Note: The V/SF ratios and Level of Service (LOS) values are based on the 1985 Highway Capacity Manual (HCM). The 1994 HCM would probably indicate a lower percentage of travel at the highest V/SF ratios and a lower percentage of travel at the poorer LOS.

Source: Highway Statistics, 1993

Highway Performance in the 33 Most Populous Urbanized Areas

Most of the peak-hour congestion in the United States occurs in the 33 urbanized areas with populations exceeding 1 million. Exhibit 4-8 contains a list of these areas and their population.

Exhibit 4-8
Urbanized Areas with Populations Over 1 Million
1993

Rank	Name	States	Estimated Population (thousands)
1	New York - NE NJ	NY, NJ	16,112
2	Los Angeles	CA	11,954
3	Chicago - NW IN	IL, IN	7,702
4	Philadelphia	PA, NJ	4,524
5	Detroit	MI	3,947
6	San Francisco - Oakland	CA	3,832
7	Washington	DC, MD, VA	3,320
8	Dallas - Fort Worth	TX	3,198
9	Houston	TX	2,902
10	Boston	MA	2,843
11	San Diego	CA	2,531
12	Atlanta	GA	2,322
13	Minneapolis - St Paul	MN	2,112
14	Baltimore	MD	2,107
15	Phoenix	AZ	2,073
16	St Louis	MO, IL	1,966
17	Miami-Hialeah	FL	1,928
18	Seattle	WA	1,879
19	Pittsburgh	PA	1,768
20	Tampa - St Petersburg	FL	1,756
21	Cleveland	OH	1,677
22	Denver	CO	1,594
23	San Jose	CA	1,526
24	Riverside - San Bernadino	CA	1,323
25	Kansas City	MO, KS	1,315
26	For Lauderdale - Hollywood - Pompano Beach	FL	1,299
27	Portland - Vancouver	OR, WA	1,277
28	Milwaukee	WI	1,226
29	Cincinnati	OH, KY	1,223
30	Sacramento	CA	1,204
31	San Antonio	TX	1,129
32	Buffalo	NY	1,069
33	New Orleans	LA	1,040

Source: Highway Statistics, 1993

Exhibit 4-9 contains the percentages of peak-hour travel in these areas that occurs under conditions of LOS D and LOS E and F. This Exhibit shows that for the urban Interstate peak-hour, more than 56 percent of the LOS D travel and more than 70 percent of the LOS E and F travel occurs in these 33 urbanized areas. On each functional system, more than half of peak-hour travel of LOS D or higher occurs in the top 33 urbanized areas.

Exhibit 4-9
Congested Peak-Hour Travel in the 33 Most Populous Urbanized Areas by Functional System
1993

Functional System	Proportion Top 33 of all Urban
Level of Service (LOS) D	
Interstate	56.3%
Other Freeway & Expressway	67.1%
Other Principal Arterial	65.3%
Minor Arterial	61.8%
Collector	67.1%
Total	62.2%
Level of Service E & F	
Interstate	70.5%
Other Freeway & Expressway	75.5%
Other Principal Arterial	53.8%
Minor Arterial	55.8%
Collector	52.2%
Total	65.4%
Level of Service D-F	
Interstate	67.3%
Other Freeway & Expressway	73.8%
Other Principal Arterial	58.5%
Minor Arterial	58.2%
Collector	58.9%
Total	64.5%

Note: The Volume to Service Flow (V/SF) ratios and LOS values are based on the 1985 Highway Capacity Manual (HCM). The 1994 HCM would probably indicate a lower traffic volume at the highest V/SF ratios and less travel at the poorer LOS.

Source: Highway Performance Monitoring System master dataset, 1993

Exhibit 4-10 contains comparisons of the 1993 mileage, lane-mileage, overall travel, and daily travel per lane-mile in the 33 most populous urbanized areas and in all other urban areas of the country. Approximately 37 percent of the mileage, 40 percent of the lane-miles, and more than 51 percent of the travel on non-local urban roads occurs in the 33 most populous urbanized areas.

Exhibit 4-10
Selected Summaries by Functional System
All Urban Areas versus 33 Most Populous Urbanized Areas
1993

	Urbanized Areas			Proportion
Functional System	**Top 33**	**Other Urban**	**Total**	**Top 33 of All Urban**
Mileage				
Interstate	5,223	7,655	12,878	40.6%
Other Freeway & Expressway	3,884	4,973	8,857	43.9%
Other Principal Arterial	19,635	33,200	52,835	37.2%
Minor Arterial	32,096	53,726	85,822	37.4%
Collector	30,453	54,925	85,378	35.7%
Total	91,291	154,479	245,770	37.1%
Lane Mileage				
Interstate	31,670	37,465	69,135	45.8%
Other Freeway & Expressway	19,000	20,915	39,915	47.6%
Other Principal Arterial	71,572	104,753	176,325	40.6%
Minor Arterial	86,831	129,402	216,233	40.2%
Collector	65,409	115,626	181,035	36.1%
Total	274,482	408,161	682,643	40.2%
Annual Vehicle Miles Traveled (millions)				
Interstate	187,216	128,621	315,837	59.3%
Other Freeway & Expressway	90,440	51,882	142,322	63.5%
Other Principal Arterial	166,402	189,913	356,315	46.7%
Minor Arterial	124,532	151,133	275,665	45.2%
Collector	50,279	70,935	121,214	41.5%
Total	618,869	592,484	1,211,353	51.1%
Daily Vehicle Miles Traveled/Lane-mile (thousands)				
Interstate	16,195	10,696	12,647	
Other Freeway & Expressway	13,026	7,912	9,998	
Other Principal Arterial	6,369	5,377	5,385	
Minor Arterial	3,929	3,448	3,382	
Collector	2,106	1,793	1,679	
Total	6,176	4,368	4,747	

Source: Highway Performance Monitoring System dataset, 1993

This compares with 65 percent of the overall peak-hour congested urban travel that occurs in these 33 most populous urbanized areas. Peak-hour travel in these areas has a higher degree of congestion than urban areas in general. The volume of travel per lane-mile is also greater in the 33 most populous urbanized areas than in the average of all urbanized areas.

Transit Performance

The 1992 edition of the report by the FTA, Public Transportation in the United States: Performance and Conditions, began to examine issues related to the quality of mass transit service. The perception of quality among customers and potential customers is an important determinant of transit use, often more important than the fare levels. This report continues the development of transit service level concepts as a way of assessing transit performance.

User Travel Speed

One of the most important dimensions of performance is the speed of transit service, as perceived by the user. Detailed data is not available on the average speed of a passenger's trip. However, Section 15 data does include information on the average speed of transit service. By weighting the system level data on service speed by passenger miles, it is possible to create an indicator of how transit system speeds have changed. Exhibit 4-11 displays the trend in the value of this indicator between 1984 and 1993.

Exhibit 4-11
Passenger-Mile Weighted Average Speed by Transit Mode
1984-1993

	Year										10 Year
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Change
Rail	24.8	24.4	24.4	23.7	24.4	24.3	24.8	27.6	27.0	26.3	6.0%
Bus	12.9	13.5	13.1	13.2	13.8	13.5	13.4	13.4	13.5	13.7	6.2%
Total	18.1	18.5	18.8	19.3	19.1	19.1	19.2	20.4	20.3	19.9	9.9%

Source: Federal Transit Administration Section 15 data

It shows that passenger-mile weighted system speeds are much higher on rail transit systems. This is largely due to the availability of separated guideways for rail systems and longer distances between stations or stops. More disaggregated bus data would be likely to show similarly higher speeds on bus services provided on separated rights-of-way. The overall weighted average increased faster than for either mode because of a general shift in the balance of transit use from bus to rail, which is the faster mode.

Transfers and Waiting Times

According to the 1990 NPTS data, the majority of transit users do not spend much time waiting for service. Well over half of all riders (59 percent) reported wait times of 5 minutes or less. About 80 percent of riders wait no longer than 10 minutes.

The amount of time spent waiting is related to the function that transit is performing. Exhibit 4-12 shows the percentage of transit trips made with waiting times less than 5 and 10 minutes, to achieve "livable metropolitan areas," "congestion management," and "low-cost basic mobility" functions, as described in Chapter 2.

Exhibit 4-12
Percentage of Transit Riders Waiting Less than 5 or 10 Minutes, by Transit Function
1993

	Minutes	
	< 5	< 10
Livable Metropolitan Areas	59	80
Low-Cost Basic Mobility	57	77
Congestion Management	61	83
Total	59	80

Source: 1990 Nationwide Personal Transportation Survey

Congestion management trips, typically work trips, have the least waiting time, reflecting the higher levels of service in peak periods, and the lower tolerance by work trip travelers for waiting.

In addition to waiting times, the need to transfer between transit vehicles en route to one's travel destination influences transit patronage. As shown in Exhibit 4-13, 51 percent of transit trips involve one or more transfers. In addition, approximately 17 percent of transit trips involve a transfer from a private vehicle, e.g., park-and-ride situations.

Exhibit 4-13
Percentage of Transit Riders Who Must Transfer, by Transit Function
1993

Livable Metropolitan Areas	57
Low-Cost Basic Mobility	39
Congestion Management	62
Total	51

Source: 1990 Nationwide Personal Transportation Survey

Again, the quality of transit service varies by the function represented by the trip. Exhibit 4-13 shows the percentage of transit trips which require a transfer, by the functions specified in Chapter 2. Those trips which serve the Low-Cost Basic Mobility function involve substantially fewer transfers than those serving the Livable Metropolitan Area and Congestion Management functions.

Available Seats

The capacity of a transit vehicle is generally measured in three ways: seated capacity, full capacity, and peak capacity. Seated capacity is defined by the number of seats on a particular vehicle. Full capacity includes seated capacity plus one standee for every 5.5 square feet of open floor space. Peak capacity is the absolute maximum passenger load that a vehicle can accommodate, seated and standing. Industry definitions do not necessarily correspond to passenger perceptions, however.

The presence of standees, even one or two, tends to convey a sense of crowding. This is especially true from the perspective of those who must stand. Passengers often consider a vehicle to be crowded when it is operating with a load factor above seated capacity but still significantly below full capacity. As shown in Exhibit 4-14, 29 percent of transit trips involve standing for at least part of the trip.

Exhibit 4-14
Percentage of Transit Riders with Available Seat by Transit Function
1990

	Seat Availability		
	Entire Trip	**Part of Trip**	**Not Available**
Livable Metropolitan Areas	67	8	23
Low-Cost Basic Mobility	78	7	13
Congestion Management	67	9	23
Total	71	9	20

Source: 1990 Nationwide Personal Transportation Survey

As in the other dimensions of performance, the quality of transit service varies by the function represented by the trip. Exhibit 4-14 provides the percentage of transit trips where a seat is available for the entire trip, where all of the trip was without a seat, and where a seat was available for part of the trip, by the functions specified in Chapter 2. Those trips which serve the Low-Cost Basic Mobility function involve substantially fewer transfers than those serving the Livable Metropolitan Areas and Congestion Management functions, since Low-Cost Basic Mobility trips tend to be taken in off-peak periods.

Travel Times

Travel time and speed are somewhat difficult to measure and quantify. Many individuals do not know how far they actually travel (especially transit users) much less their average speed, and their sense of time spent en route is likely to be distorted. According to data from the 1990 NPTS, about 25 percent of all transit users reported trip times of 10 minutes or less, and nearly 76 percent of transit trips were reported to take less than half an hour.

The function for which the transit trip is taken has a great deal of impact on the travel time involved in the trip. Exhibit 4-15 shows the amount of time reported for each transit trip segment, based on the function for which the trip was taken. Trips for Low-Cost Basic Mobility purposes are generally shorter than those serving other functions. Likewise, the work trips included in the Congestion Management function tend to be the longest.

Exhibit 4-15
Percentage of Transit Riders by Trip Time and Transit Function
1990

	Minutes		
	<10	<20	<30
Livable Metropolitan Areas	24	54	74
Low-Cost Basic Mobility	29	64	81
Congestion Management	20	51	71
Total	25	57	76

Source: 1990 Nationwide Personal Transportation Survey

Highway, Bridge and Transit Conditions

Assessments of pavement, roadway alignment, lane width, bridge and transit conditions are included in this section. Pavement condition ratings are used to evaluate current pavement surface conditions, to estimate pavement life, and to determine what rehabilitation actions will be required within the planning horizon. Roadway horizontal and vertical alignment measures and lane width measures are used to evaluate the service and safety that the highway facilities provide. The bridge conditions are used to evaluate the current conditions of highway bridges and to estimate the future requirements for rehabilitation and replacement of highway bridges. Transit conditions are used to evaluate the current conditions of transit vehicles and facilities and to estimate the future requirements for rehabilitation and replacement of transit vehicles and facilities.

Highway Conditions

Pavement Condition

Pavement condition evaluations have in the past been based on the PSR system. Exhibit 4-16 contains a description of this rating system. However, a transition is being made to ratings based on the IRI. Exhibit 4-17 contains a comparison of PSR and IRI values and their relationship to the verbal descriptions used in this report. The IRI values are based on objective measurements of pavement roughness, and are used to obtain more consistent ratings than were possible using PSR.

The pavement condition information reported in this chapter for the higher functional systems is, for most States, based on the IRI system. IRI is an objective measure of pavement roughness developed by the World Bank, and is accepted as a standard in the pavement evaluation community. It has been adopted as the measurement of pavement condition by FHWA for the HPMS database because 1) it uses a standard procedure and can be replicated, 2) it provides a consistent measure across jurisdictional lines and diverse functional systems, 3) it is an objective measurement, and 4) it is consistent with accepted worldwide pavement roughness measurement procedures. Most of the rural arterial and all urban principal arterial pavement condition data reported in this chapter are based on IRI.

The measure PSR is more subjective, and its application varied among jurisdictions and over time in the same jurisdiction, so that it was difficult to compare accurately the trends in pavement condition. The adoption of IRI will make valid trend comparisons possible.

However, the change from PSR to IRI does invalidate any comparison of 1993 pavement condition data in this report with that of preceding years. While specific values are shown for both PSR and IRI for each pavement condition category, it should be noted that an exact correspondence does not exist between PSR and IRI. That is, a given Interstate pavement section could have a PSR rating of 2.5 and an IRI rating of 165. This pavement would be considered "poor" by the estimated PSR rating and "mediocre" by the measured IRI rating. Thus, the mileage of any given pavement condition category may differ depending on the rating methodology. Therefore, the exhibits containing data for 1993 and prior years should be used with caution.

Exhibit 4-16
Present Serviceability Rating (PSR)

PSR	CONDITION	DESCRIPTION
5	Very Good	Only new (or nearly new) pavements are likely to be smooth enough and sufficiently free of cracks and patches to qualify for this category. All pavements that have been recently constructed or resurfaced should be rated in this category.
4	Good	Pavements in this category, although not quite as smooth as those described above, give a first-class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling.
3	Fair	The riding qualities of pavements in this category are noticeably inferior to those of new pavements and may be barely tolerable for high-speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and extensive patching. Rigid pavements in this group may have a few joint fractures, faulting and cracking, and some pumping.
2	Poor	Pavements have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavements may have large potholes and deep cracks. Distress includes raveling, cracking, and rutting and occurs over 50 percent or more of the surface. Rigid pavement distress includes joint spalling, faulting, patching, cracking, and scaling and may include pumping and faulting.
1	Very Poor	Pavements are in extremely deteriorated conditions. The facility is passable only at reduced speeds and considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.
0		

Source: Highway Performance Monitoring System Field Manual, 1993

Exhibit 4-17
Pavement Condition and Roughness Definitions*

Very Good	**New or almost new pavement, will not require improvement for some time.**		
	PSR*	Interstate	>= 4.0
		Other	>= 4.0
	IRI**	Interstate	< 60
		Other	< 60
Good	**In decent condition; will not require improvement in the near future.**		
	PSR	Interstate	3.5 - 3.9
		Other	3.5 - 3.9
	IRI	Interstate	60 - 94
		Other	60 - 94
Fair	**Will likely need improvement in the near future, but depends on traffic use.**		
	PSR	Interstate	3.1 - 3.4
		Other	2.6 - 3.4
	IRI	Interstate	95 - 119
		Other	95 - 170
Mediocre	**Needs improvement in the near future to preserve usability.**		
	PSR	Interstate	2.6 - 3.0
		Other	2.1 - 2.5
	IRI	Interstate	120 - 170
		Other	171 - 220
Poor	**Needs immediate improvement to restore serviceability.**		
	PSR	Interstate	<= 2.5
		Other	<= 2.0
	IRI	Interstate	> 170
		Other	> 220

Note: In many of the exhibits in this report the categories "Good" and "Very Good" are combined under the term "Good," as the pavement in both categories will not require improvement in the near future.

* PSR = Present Serviceability Rating
** IRI = International Roughness Index

While the actual PSR or IRI value to identify a need for a specific improvement varies by functional system, travel, and other factors, the values in Exhibit 4-17 provide a general definition of pavement in poor, mediocre, fair, and good condition. The pavement in poor condition requires immediate improvement. The mediocre pavement has been separated from the fair to show the mileage that is expected to need improvement in the near future, generally within the next five years, depending on the pavement design, environmental factors, and the traffic loading. The pavement in fair condition will likely need improvement in the 5- to 10-year horizon. The pavement in good condition will not likely need improvement for 10 years to 15 years or more.

Exhibit 4-18 contains the mileage distribution for 1993 by five categories of pavement roughness, and the percentage of unpaved mileage. Note that the values for poor, mediocre, and fair categories are different for Interstate than for the other functional systems. This is because the Interstate system is expected to maintain a higher standard of condition than the lower systems, commensurate with higher travel volumes and higher speeds. There is very little unpaved mileage on the higher functional systems; however, unpaved mileage is a significant portion of rural major collector mileage.

Exhibit 4-18
Percent Mileage by Functional System and Pavement Condition Category
1993

	Pavement Condition					
Functional System	**Poor**	**Mediocre**	**Fair**	**Good**	**Very Good**	**Unpaved**
Rural						
Interstate	6.9	24.0	18.4	34.4	16.3	0.0
Other Principal Arterial	9.3	26.5	23.8	26.0	14.3	0.0
Minor Arterial	11.0	22.0	29.1	23.0	14.9	0.0
Major Collector	6.8	12.4	37.7	16.3	15.9	10.9
Urban						
Interstate	9.5	24.9	20.3	27.0	18.3	0.0
Other Freeway & Expressway	9.9	30.2	21.9	22.1	15.8	0.0
Other Principal Arterial	15.0	26.4	23.5	19.9	15.3	0.0
Minor Arterial	7.9	13.8	40.2	18.4	19.4	0.4
Collector	10.6	16.8	40.0	16.1	15.5	1.0

Note: See Exhibits 4-16 and 4-17 for definition of pavement condition and roughness categories

Source: Highway Statistics, Table HM-63, 1993, Revised June 1995

Exhibit 4-19 contains the distribution of travel by pavement condition category. This shows that in general the pavements in better condition are carrying somewhat more travel than the pavements in poor condition.

Exhibit 4-19
Percent Travel by Functional System and Pavement Condition Category
1993

Functional System	Pavement Condition					
	Poor	Mediocre	Fair	Good	Very Good	Unpaved
Rural						
Interstate	5.6	20.2	17.6	36.0	20.6	0.0
Other Principal Arterial	6.6	22.8	23.7	29.2	17.6	0.0
Minor Arterial	8.4	19.6	31.6	23.3	17.2	0.0
Major Collector	5.7	11.8	38.4	21.2	21.8	1.1
Urban						
Interstate	8.9	24.7	20.5	25.0	20.8	0.0
Other Freeway & Expressway	9.6	27.1	24.8	22.7	15.9	0.0
Other Principal Arterial	15.8	24.0	22.4	22.5	15.3	0.0
Minor Arterial	7.6	12.9	40.7	18.4	20.3	0.1
Collector	8.9	16.0	39.7	18.3	16.8	0.3

Note: See Exhibits 4-16 and 4-17 for definition of pavement condition and roughness categories.

Source: Highway Performance Monitoring System master dataset, 1993

Exhibit 4-20 contains an aggregation from Exhibit 4-18, showing the percent of miles by five pavement condition categories plus unpaved mileage for the Interstate, all other arterials, and all collectors, as well as the overall national total.

Exhibit 4-20
Miles by Pavement Condition
1993

	Pavement Condition						
	Poor	Mediocre	Fair	Good	Very Good	Unpaved	Total
Interstate	3,231	10,342	8,082	13,825	7,176	0	42,656
(% system)	8	24	19	32	17	0	100
Other Arterials	37,268	79,028	107,440	80,683	57,449	311	362,179
(% system)	10	22	30	22	16	0	100
Collectors	38,365	67,987	196,995	84,241	81,699	47,831	517,118
(% system)	7	13	38	16	16	9	100
Total	78,864	157,357	312,517	178,749	146,324	48,142	921,953
(% system)	9	17	34	19	16	5	100

Note: See Exhibits 4-16 and 4-17 for definition of pavement condition categories. "Collectors" do not include rural minor collectors.

Source: Highway Statistics, 1993, Revised June 1995

Exhibit 4-21 contains the percent of mileage by pavement condition category for alternate years from 1983 to 1991, and by pavement roughness category for 1993. The functional systems are combined into three categories each for rural and urban: Interstate, other arterial, and collectors. The percent of mileage in poor condition declined from 1983 to 1991. From 1991 to 1993, the percent of poor mileage appears to increase on several system categories (urban Interstate, rural other arterial, and urban other arterials). However, it must be remembered that the change from PSR (condition) to a combination of PSR and IRI (roughness) may affect this apparent change. Several years of measurements using the IRI procedure are needed to define a trend.

Using the IRI criteria, the percent of pavement in the mediocre category appears to have increased sharply for all arterials between 1991 and 1993. The portion of mediocre pavement on collectors, still largely using the PSR rating procedures, changed little. This fact points toward the change in procedure as a significant cause of the apparent change, confirming the need for caution for following trends until the IRI procedure has been in use for several years.

Exhibit 4-21
Percent Highway Mileage by Pavement Condition, Functional System, and Year
1993

	Year					
	1983	*1985*	*1987*	*1989*	*1991*	**1993**
Functional System	*PSR Measurement*					**PSR and/or IRI Measurement**
Rural Interstate						
Poor	*13.3*	*10.8*	*11.6*	*9.1*	*7.6*	6.9
Mediocre	*13.8*	*14.1*	*15.5*	*15.4*	*15.6*	24.0
Fair	*14.3*	*15.4*	*14.4*	*17.1*	*15.9*	18.4
Good	*58.6*	*59.7*	*58.4*	*58.4*	*60.8*	50.7
Unpaved	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0
Urban Interstate						
Poor	*16.8*	*11.1*	*11.1*	*9.6*	*7.7*	9.5
Mediocre	*16.1*	*19.5*	*18.5*	*16.1*	*15.6*	24.9
Fair	*13.7*	*13.5*	*15.0*	*16.7*	*16.6*	20.3
Good	*53.4*	*56.0*	*55.4*	*57.6*	*60.1*	45.3
Unpaved	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0
Rural Other Arterials						
Poor	*11.1*	*8.3*	*6.6*	*4.8*	*3.9*	10.4
Mediocre	*11.8*	*10.0*	*11.0*	*9.9*	*8.0*	23.8
Fair	*35.3*	*36.7*	*37.3*	*37.4*	*38.3*	27.1
Good	*41.8*	*44.9*	*45.0*	*47.8*	*49.8*	38.7
Unpaved	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*	0.0

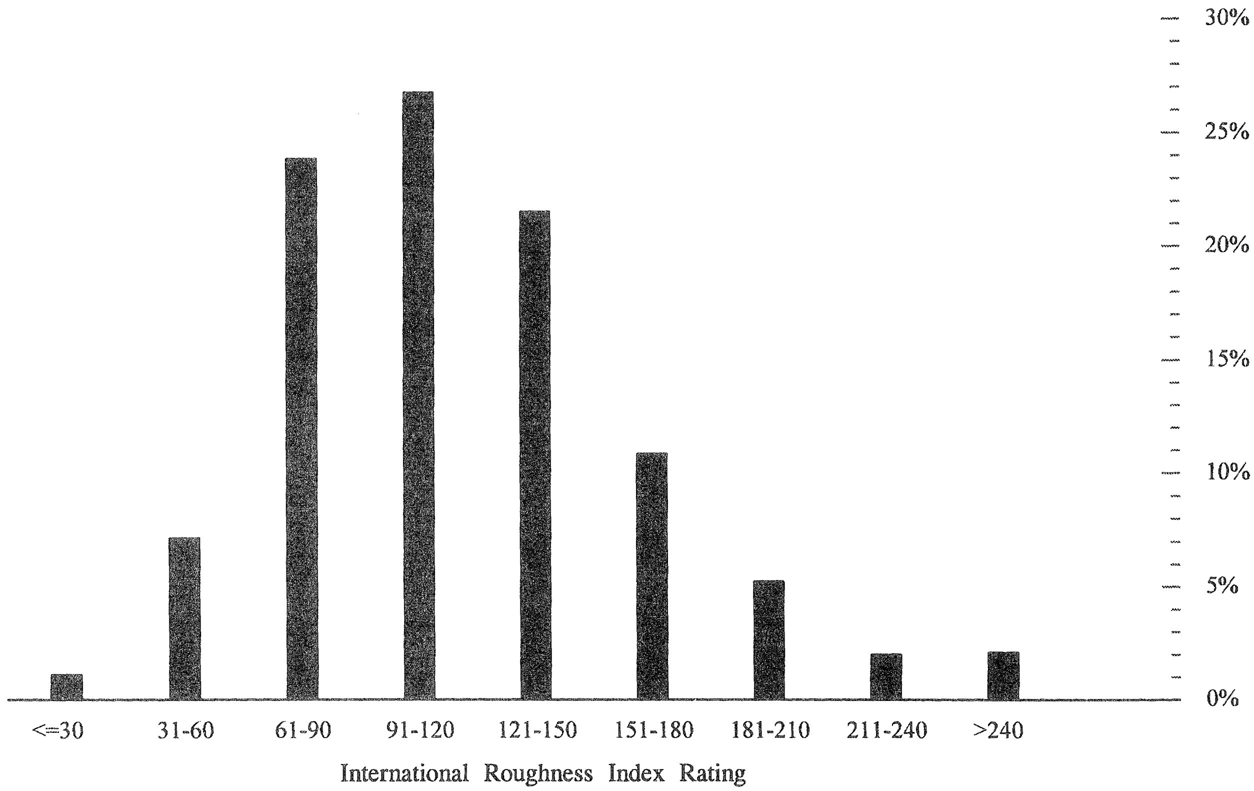
Note: See Exhibit 4-17 for definitions of pavement condition categories. Years 1983 to 1991 are based on PSR; 1993 is based primarily on IRI and should not be compared to previous years. Also, 1993 rural collectors do not include minor collector mileage.

Functional System	1983	1985	1987	1989	1991	1993
	PSR Measurement					PSR and/or IRI Measurement
Urban Other Arterials						
Poor	*10.0*	*9.0*	*8.7*	*7.7*	*6.8*	10.6
Mediocre	*13.6*	*13.9*	*14.0*	*13.4*	*13.2*	19.7
Fair	*34.1*	*34.7*	*35.2*	*36.5*	*36.0*	34.2
Good	*41.7*	*42.0*	*41.7*	*42.1*	*43.6*	35.4
Unpaved	*0.6*	*0.5*	*0.4*	*0.3*	*0.4*	0.2
Rural Collectors						
Poor	*15.0*	*12.8*	*12.0*	*10.5*	*8.2*	6.8
Mediocre	*12.1*	*13.4*	*13.0*	*12.7*	*12.0*	12.4
Fair	*25.5*	*27.2*	*26.9*	*27.9*	*29.8*	37.7
Good	*24.7*	*24.2*	*26.5*	*28.6*	*30.1*	32.2
Unpaved	*22.8*	*22.3*	*21.7*	*20.3*	*19.9*	10.9
Urban Collectors						
Poor	*14.9*	*13.1*	*13.6*	*17.6*	*11.3*	10.6
Mediocre	*15.5*	*17.4*	*17.4*	*16.5*	*17.4*	16.8
Fair	*34.2*	*35.3*	*36.6*	*33.3*	*36.0*	40.0
Good	*33.3*	*32.5*	*31.1*	*31.3*	*34.2*	31.6
Unpaved	*2.0*	*1.7*	*1.3*	*1.4*	*1.1*	1.0

Source: Highway Statistics, various years

Exhibit 4-22 contains the distribution of pavement roughness based on IRI for all principal arterials, including Interstate. This shows that only about 8 percent of the arterial mileage is in the very good category, which means that the pavement is in new or nearly new condition. However, more than 60 percent of the mileage is between 91 and 180, which is largely in the mediocre and fair range. This mileage will require some type of rehabilitation in the near future.

Exhibit 4-22
Distribution of Pavement Roughness for Principal Arterial System
(Includes the Interstate System)
1993



Source: Highway Performance Monitoring System summary tables, 1993

The reader will note that pavement condition values for each State are not included in this report as in the past. With the transition from PSR to IRI, no comparison is possible with previous years. Also, with the States in various stages of transition from PSR to IRI, comparisons between States are not valid. For indications of which measure predominates in each State, see <u>Highway Statistics</u>, Table HM-63.

Highway Alignment and Lane Width

There are other physical highway characteristics in addition to pavement condition that have a major effect on highway performance. Among these are alignment adequacy and lane width, both of which contribute to the level of service and safety of a highway. Horizontal alignment affects the speed and sight distance. Vertical alignment affects principally the sight distance, a safety consideration.

The alignment of a highway affects the speed at which vehicles can safely travel. The rating scheme used in this report contains values from 1 to 4, where 1 and 2 represent reasonably good horizontal and vertical alignment, and 3 and 4 represent increasingly poor alignment. The alignment of arterials is considered more important than that of collectors, because higher travel speed is more important on highways where longer trips are made, which are the arterials.

A summary of both horizontal and vertical alignment adequacy on rural highway mileage for 1993 is contained in Exhibit 4-23. Alignment is rarely a significant problem in urban areas, and, therefore, is not shown. The rating system used for alignment adequacy is found at the bottom of this table. Less than 2 percent of rural Interstate miles are given the lowest ratings for horizontal alignment adequacy (codes 3 or 4, which are significantly below design standards for new highways). In contrast, over 25 percent of rural major collector miles are given the low ratings of 3 or 4. Similar distributions are found in the vertical alignment adequacy ratings. There has been a slow, steady improvement in highway alignment over the years, as sections with poor alignment are reconstructed.

The lane width of highways is related to both capacity and safety. Substandard lane widths tend to reduce the capacity of a highway, and may affect the safety of the facility as well. Again, lane widths are considered more important on the higher functional systems.

Exhibits 4-24 and 4-25 contain information for the distributions of rural and urban lane widths, respectively. Essentially all of the Interstate mileage has a lane width of 12 feet or more, which is the standard lane width for high-type facilities. These percentages for rural highways dropped to 86 percent for other principal arterials, 66 percent for minor arterials, and 34 percent for major collectors. Once again, the higher service functional systems with the higher travel densities generally have the better physical characteristics. For example, 3 percent of urban collector mileage has lane widths of less than nine feet, while the higher systems have virtually none. Again, there has been a slow but steady improvement in the mileage with adequate lane widths each year, as reconstruction and widening of substandard highways occur.

Exhibit 4-23
Percent Rural Highway Mileage by Alignment Adequacy and Functional System
1993

	Horizontal Alignment Adequacy Rating			
Functional system	**Code 1**	**Code 2**	**Code 3**	**Code 4**
Interstate	95.4	2.8	0.7	1.1
Other Principal Arterial	77.8	14.4	3.5	4.3
Minor arterial	70.3	11.4	7.6	10.7
Major Collector	54.5	19.1	14.7	11.7
Total	63.4	15.9	10.8	9.9

	Vertical Alignment Adequacy Rating			
Functional system	**Code 1**	**Code 2**	**Code 3**	**Code 4**
Interstate	92.3	6.9	0.4	0.4
Other Principal Arterial	71.9	22.4	2.5	3.2
Minor arterial	58.6	30.5	5.4	5.5
Major Collector	51.7	29.6	12.3	6.4
Total	58.2	27.6	8.8	5.4

Code 1:	All grades and curves meet appropriate design standards.
Code 2:	Some grades/curves are below design standards for new construction, but curves can be negotiated safely at prevailing speed limits. Truck speed is not substantially affected.
Code 3:	Infrequent curves or grades impair sight distance or affect truck speed. Infrequent curves may have reduced speed limits for safety purposes.
Code 4:	Frequent grades occur that impair sight distance or severely affect truck speeds. Generally curves are unsafe or uncomfortable at prevailing speed limit, or the speed limit is severely restricted due to the design speeds of the curves.

Note: Paved mileage only. Sections for which no alignment were supplied are treated as code 2.

Source: Highway Performance Monitoring System summary tables, 1993

Exhibit 4-24
Percent Rural Mileage and Travel by Lane Width and Functional System
1993

	Lane Width (feet)				
	<9	9	10	11	12+
Mileage (percent)					
Interstate	0.0	0.0	0.1	0.4	99.5
Other Principal Arterial	0.1	0.6	2.7	10.7	85.9
Minor Arterial	0.1	2.0	12.7	19.5	65.7
Major Collector	2.4	9.2	30.6	24.0	33.8
Total	1.4	5.9	21.0	19.9	51.8
Travel (percent)					
Interstate	0.0	0.0	0.0	0.1	99.9
Other Principal Arterial	0.1	0.3	2.4	9.2	88.0
Minor Arterial	0.1	1.5	10.9	19.1	68.4
Major Collector	1.0	7.6	26.0	23.1	42.3
Total	0.3	2.3	9.2	12.0	76.2

Source: Highway Performance Monitoring System summary tables, 1993

Exhibit 4-25
Percent Urban Mileage and Travel by Lane Width and Functional System
1993

	Lane Width (feet)				
	<9	9	10	11	12+
Mileage (percent)					
Interstate	0.0	0.0	0.0	0.6	99.4
Other Freeway & Expressway	0.0	0.1	0.9	3.9	95.1
Other Principal Arterial	0.1	0.7	8.2	13.9	77.1
Minor Arterial	0.5	3.3	16.5	18.0	61.7
Collector	3.2	8.9	22.7	15.3	49.9
Total	1.3	4.4	15.4	14.8	64.1
Travel (percent)					
Interstate	0.0	0.0	0.0	1.7	98.3
Other Freeway & Expressway	0.0	0.1	0.5	4.2	95.2
Other Principal Arterial	0.1	0.5	8.5	14.5	76.4
Minor Arterial	0.3	2.0	14.2	18.5	65.0
Collector	1.7	5.5	19.0	17.2	56.6
Total	0.3	1.1	7.5	11.0	80.1

Source: Highway Performance Monitoring System summary tables, 1993

Bridge Conditions

The proportions of bridges that are classified as being structurally or functionally deficient are found in Exhibits 4-26 through 4-28, for Interstate, other arterials, and collectors, respectively. Changes in the Bridge Coding Guide in 1988 made a comparison of the number of deficient bridges before and after that date invalid. Therefore, only bridge deficiencies after 1988 are contained in Exhibits 4-26 through 4-28.

Exhibit 4-26
Interstate Bridge Deficiencies
Selected Years, 1990-1994

	Year					
	1990		1992		1994	
	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	29,171		29,148		28,865	
Deficient Bridges	6,811	23.3	5,659	19.4	5,342	18.5
Structurally Deficient	1,521	5.2	1,330	4.6	1,162	4.0
Functionally Deficient	5,290	18.1	4,329	14.9	4,180	14.5
Urban Bridges	24,012		25,013		25,861	
Deficient Bridges	8,397	35.0	8,066	32.2	7,920	30.6
Structurally Deficient	2,327	9.7	2,367	9.5	2,141	8.3
Functionally Deficient	6,070	25.3	5,699	22.8	5,779	22.3
All Bridges	53,183		54,161		54,726	
Deficient Bridges	15,208	28.6	13,725	25.3	13,262	24.2
Structurally Deficient	3,848	7.2	3,697	6.8	3,303	6.0
Functionally Deficient	11,360	21.4	10,028	18.5	9,959	18.2

Source: National Bridge Inventory database, 1990—1994

A structurally deficient bridge is not necessarily unsafe or one that requires special posting for speed or weight limitations. It is a bridge which is designated as needing significant maintenance attention, rehabilitation, or sometimes replacement. Some of these bridges are load-posted so that heavier trucks will be required to take an alternate, longer route. Functionally deficient bridges are those that do not have the lane widths, shoulder widths, or vertical clearances adequate to serve the traffic demand; or the waterway of the bridge may be inadequate and, therefore, allow occasional flooding of the roadway.

Bridge conditions are based on three sets of criteria: (1) the load capacity, (2) the physical measurements of lane width, shoulder width, vertical clearances, and horizontal clearances, and (3) the condition rating of the major bridge elements. Load capacity indicates the structural adequacy of the bridge to accommodate the loads expected for the particular highway of which the bridge is a part. A structurally deficient bridge cannot carry these loads. The clearances and other physical measures indicate the capability of the bridge to accommodate the required number and size of vehicles safely. This affects the functional capability of the bridge. A functionally obsolescent bridge is deficient in this respect. The condition rating of the deck, superstructure, and substructure elements of a bridge indicate the expected remaining life of the bridge and when rehabilitation or replacement may be required.

Exhibit 4-27
Other Arterial Bridge Deficiencies
Selected Years, 1990-1994

	Year					
	1990		1992		1994	
	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	72,997		78,123		72,453	
Deficient Bridges	18,639	25.5	19,884	25.5	15,693	21.7
Structurally Deficient	8,430	11.5	9,965	12.8	6,914	9.5
Functionally Deficient	10,209	14.0	9,919	12.7	8,779	12.1
Urban Bridges	51,618		54,589		57,012	
Deficient Bridges	20,852	40.4	20,481	37.5	20,506	36.0
Structurally Deficient	7,559	14.6	7,544	13.8	7,247	12.7
Functionally Deficient	13,293	25.8	12,937	23.7	13,259	23.3
All Bridges	124,615		132,712		129,465	
Deficient Bridges	39,491	31.7	40,365	30.4	36,199	28.0
Structurally Deficient	15,989	12.8	17,509	13.2	14,161	10.9
Functionally Deficient	23,502	18.9	22,856	17.2	22,038	17.0

Source: National Bridge Inventory database, 1990—1994

In general, the higher functional systems have fewer deficient bridges (i.e., structurally deficient plus functionally obsolete bridges) than the lower systems. The total percent of deficient bridges decreased on each of the functional system categories from 1990 to 1994. In 1994, 24 percent of the Interstate bridges were classified as being deficient compared to 29 percent in 1990. On all other arterial systems there were 28 percent deficient bridges in 1994 compared to 32 percent in 1990. On the collector systems there were 28 percent deficient bridges in 1994 compared to 35 percent in 1990.

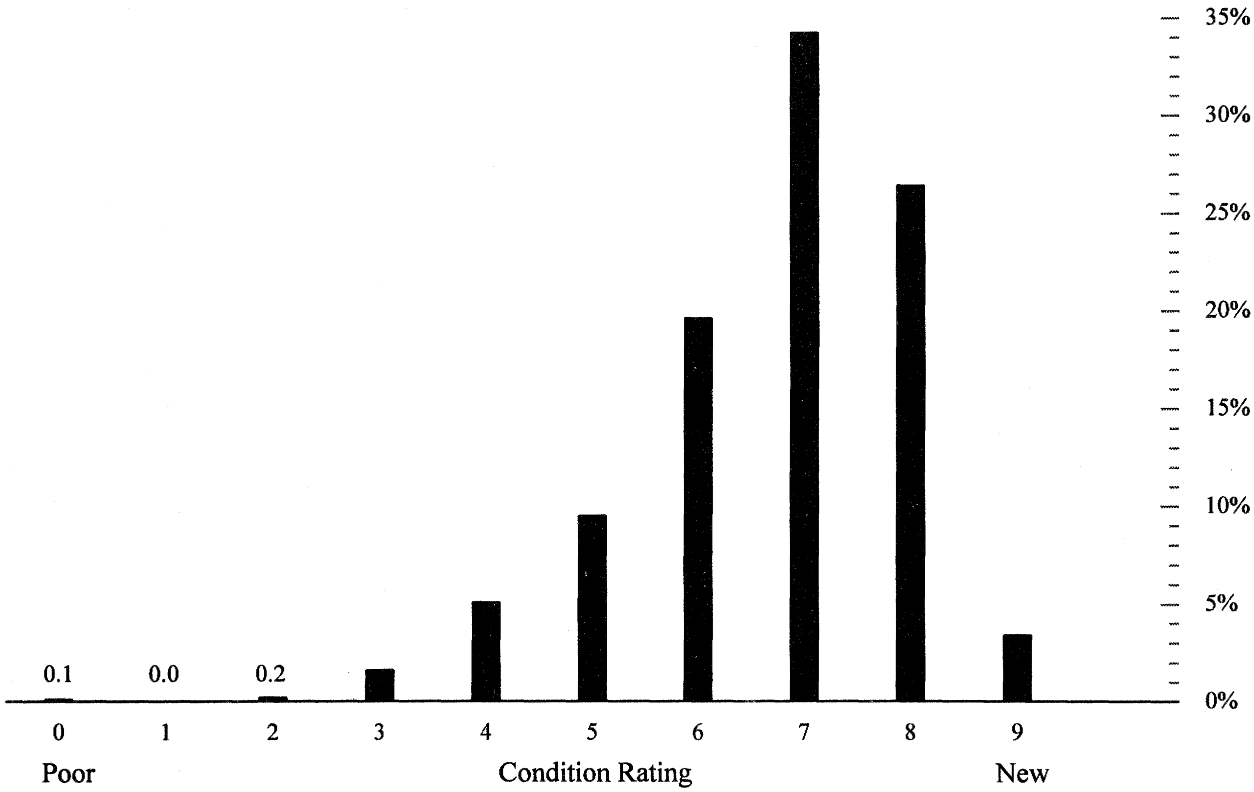
Exhibit 4-28
Collector Bridge Deficiencies
Selected Years, 1990-1994

	Year					
	1990		1992		1994	
	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	152,435		147,148		147,612	
Deficient Bridges	51,145	33.6	42,270	28.7	39,398	26.7
Structurally Deficient	30,703	20.1	25,933	17.6	23,645	16.0
Functionally Deficient	20,442	13.4	16,337	11.1	15,753	10.7
Urban Bridges	11,865		13,647		14,702	
Deficient Bridges	5,477	46.2	5,847	42.8	5,932	40.3
Structurally Deficient	2,353	19.8	2,440	17.9	2,415	16.4
Functionally Deficient	3,124	26.3	3,407	25.0	3,517	23.9
All Bridges	164,300		160,795		162,314	
Deficient Bridges	56,622	34.5	48,117	29.9	45,330	27.9
Structurally Deficient	33,056	20.1	28,373	17.6	26,060	16.1
Functionally Deficient	23,566	14.3	19,744	12.3	19,270	11.9

Source: National Bridge Inventory database, 1990—1994

Exhibit 4-29 contains the distribution of average overall bridge conditions. The rating scale is from 9 to 0, with 9 being new condition and 0 being so poor as to be unusable. Bridges that are rated 7 to 9 are in good to excellent condition. Bridges with a condition rating of 5 or 6 have some deficiencies, and are considered fair or satisfactory. Bridges rated 4 or less are in poor to critical condition. The values displayed in the figure are an average of deck, superstructure, and substructure condition ratings. The largest segment is rated as 7, which is good condition. However, there are a significant number of bridges in poor to very poor condition.

Exhibit 4-29
Average Overall Bridge Conditions
1994



Source: National Bridge Inventory database, 1994

Transit Conditions

Estimation of the long-term capital investment needs of mass transit in the United States in Chapter 5 is based in part on information on the current condition of the capital assets used by transit providers. The following section describes the conditions of the assets used to provide bus and paratransit service, urban rail service (light, rapid, and commuter rail).

Bus and Paratransit Conditions

The most accurate way of gauging the condition of the bus fleet would be to have information on the results of inspections, using standardized definitions of condition, of a sample of the vehicles. However, such information is not available. Good data is available, however, on the actual age of the entire bus and paratransit fleet. Since the actual condition of a vehicle of a given age would be affected by such factors as usage, maintenance practices, and climate, the age of a vehicle is not necessarily directly correlated to condition. However, on an overall basis, vehicle age is a good surrogate for condition and, thus, will be used as the basis for evaluating bus and paratransit fleet conditions.

For the purposes of managing the Federal investment in transit, FTA has established minimum requirements for the period of time an asset must remain in mass transit service before it will be considered eligible for funding of a replacement. These guidelines are based on such factors as industry practices, manufacturer recommendations, and studies of the tradeoff between capital investments and operating costs. On this basis, the following are the minimum useful life guidelines for vehicles used in bus and paratransit service:

Standard Full Size Transit Bus:	*12 years*
Medium Duty Transit Bus:	*10 years*
Small Transit Bus:	*7 years*
Urban Paratransit Van:	*4 years*

It should be noted, however, that there is no recent information on whether these guidelines represent optimal vehicle replacement ages, or at what point reduced maintenance costs justify increased replacement costs. If it were possible for transit agencies to replace vehicles on this schedule, the average age of type of vehicle would be one-half the useful life guideline.

Exhibit 4-30 displays the trend in bus and paratransit vehicle conditions, in terms of the number of vehicles in excess of the FTA guideline age, and the average age of the fleet, for each type of vehicle.

The average fleet age for all classes of bus and paratransit vehicle is greater than the minimum useful life guideline. As a result, there is a backlog of overage vehicles of each type in need of replacement.

Exhibit 4-30
Number of Overage Vehicles and Average Vehicle Age in Urban Transit
1985-1993

	Year								
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Articulated Buses									
Total Fleet	1,423	1,694	1,712	1,751	1,730	1,717	1,764	1,698	1,807
Number of Overage Vehicles	0	0	0	0	0	0	230	312	295
Average Age	3.36	4.02	4.85	5.91	6.67	7.56	8.15	9.11	9.53
Full-Size Buses									
Total Fleet	46,138	46,945	46,231	46,164	45,446	46,553	46,660	46,757	46,824
Number of Overage Vehicles	9,277	9,509	9,592	10,389	10,372	9,016	8,047	8,188	9,362
Average Age	8.13	8.32	8.24	8.22	8.35	8.20	8.01	8.29	8.46
Mid-Size Buses									
Total Fleet	2,569	2,654	2,821	3,002	2,928	3,106	3,268	3,204	3,598
Number of Overage Vehicles	237	244	275	431	402	553	748	846	865
Average Age	5.63	5.98	5.92	6.53	6.53	6.64	6.68	6.79	6.42
Small Buses									
Total Fleet	1,685	1,811	2,127	2,116	2,428	2,684	3,415	3,716	4,064
Number of Overage Vehicles	280	269	236	305	375	304	490	530	513
Average Age	4.76	4.44	3.91	4.16	4.06	3.86	4.02	4.12	3.95
Vans									
Total Fleet	1,733	2,610	3,241	3,243	3,288	3,778	6,261	7,028	8,353
Number of Overage Vehicles	790	982	964	950	690	830	1,400	1,074	1,804
Average Age	3.75	3.46	3.14	3.63	2.89	2.84	2.95	3.08	3.09

Source: Federal Transit Administration Section 15 data

Since 1985, the total bus fleet size has not noticeably changed, and the number of vehicles replaced for several years was near that required to maintain the average fleet age at the current average age. Thus, the number of overage vehicles has stayed about the same. In contrast, the number of vans in the urban paratransit fleet has increased significantly. The number of overage vans has increased slightly and the average age has fallen slightly. However, since 1990, the number of vehicles replaced has fallen below that required to maintain current average age. Therefore, the number of overage vehicles has increased and the average age has worsened.

In general, vehicle conditions were worse in areas under 1 million than in the urbanized areas over 1 million. The average age of standard size buses in areas under 1 million was 8.99 years in 1993, compared with 8.27 years in areas of over 1 million. Similarly, the average age of medium size buses was 6.87 years in smaller areas compared with 5.60 years in the larger areas; for vans the averages were 3.56 years and 2.70 years for small and large areas respectively. Only small buses were younger in the areas under 1 million (3.80 years versus 4.14 years).

Detailed information is also available for the first time on the fleet used to provide service to rural areas (FTA Section 18 operators) and to persons with special transportation needs (FTA Section 16 operators). This data was collected by the CTAA. Exhibit 4-31 displays this data and shows that there is a significant number of overage vehicles of all types in the Section 16 and 18 fleets. The Section 16 fleet includes all vehicles owned by the private nonprofit human service agencies which are recipients of Section 16 funds, not just those acquired with FTA funds.

Exhibit 4-31
Number of Overage Vehicles and Average Fleet Age in Rural and Special Service
1994

	Section 18 Operators	Section 16 Operators
Medium-Size Buses		
Total Fleet	740	310
Number of Overage Vehicles	380	60
Average Age	10.39	8.37
Small Buses		
Total Fleet	3,660	5,250
Number of Overage Vehicles	890	970
Average Age	4.88	4.47
Vans and Other		
Total Fleet	8,050	23,770
Number of Overage Vehicles	3,510	10,190
Average Age	4.45	4.36

Source: Community Transportation Association of America

Detailed information is available on the condition of the Nation's bus maintenance facilities from the FTA report, Bus Support Facilities: Conditions and Needs, published in January 1993. This is the first time FTA has conducted a specific review of facilities. FTA intends to continue working with the industry and the States to ensure that the estimates contained in this report accurately represent bus maintenance facility conditions, through the Public Transportation Management Systems required by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and its implementing regulations.

The study of facilities assessed the current condition and five-year capital needs, fiscal years (FYs) 1993 to 1997, for transit operator bus support facilities. In order to determine the condition of the facilities, transit operators were asked to rate each of their facilities relative to how well it sustained the bus maintenance support function, and provide information on the age of each. The data was gathered in calendar year 1992. The rating for each facility was along a spectrum of excellent, good, adequate, substandard or poor. Exhibit 4-32 provides definitions of these condition levels.

Exhibit 4-32
Definitions of Urban Bus Maintenance Facility Conditions

CONDITION	DESCRIPTION
Poor	The facility has significant shortcomings in its ability to support a transit bus maintenance program.
Substandard	The facility has shortcomings in its ability to support a transit bus maintenance program, and these shortcomings are deemed by the operator to be below industry standards. The deficiencies impact the efficiency and/or effectiveness of the operation.
Adequate	The facility has shortcomings in its ability to support a transit bus maintenance program. While these shortcomings hinder the department's effectiveness or efficiency, they are not deemed to significantly impact performance.
Good	The facility meets most reasonable requirements of a transit bus maintenance program but may have some less than optimum characteristics.
Excellent	The facility meets or exceeds most reasonable requirements of a transit bus maintenance program.

According to the transit operators, more than half (57 percent) of the transit industry's bus support facilities are in "good" or better condition for their current mission. The remaining facilities are categorized as "adequate" (18 percent), "substandard" (14 percent), and "poor" (10 percent). Exhibit 4-33 displays the conditions of bus maintenance facilities in more detail.

Exhibit 4-33
Condition of Urban Bus Maintenance Facilities
1992

Condition	Percent
Poor	18.0
Substandard	14.0
Adequate	10.0
Good	32.0
Excellent	25.0

Source: Bus Support Facilities: Conditions and Needs

Two-thirds of the bus maintenance facilities are less than twenty years old. The remainder range in age from 21 years to 99 years, with the age range of 21 years to 30 years representing the next highest percent (7 percent). Exhibit 4-34 provides more detail on the age of bus maintenance facilities.

Exhibit 4-34
Age of Bus Maintenance Facilities
1992

Age (years)	Number	Percent
0-10	177	42
11-20	107	25
21-30	30	7
31-40	22	5
41-50	22	5
51-60	14	3
61-70	11	3
71-80	6	1
81-90	22	5
91-99	15	4
Total	426	100

Source: Bus Support Facilities: Conditions and Needs

Data is also available for the first time on the facilities owned and/or used by Section 18 rural operators from the CTAA. Thirty percent (about 350) Section 18 rural transit operators own maintenance facilities, and an additional 9 percent (about 100) rent or lease a facility. The remainder send their vehicles elsewhere for maintenance. Of those facilities owned by rural operators, 74 percent are reported to be of adequate size and 68 percent adequately equipped. Of leased facilities, 61 percent are reported to be of adequate size and 55 percent adequately equipped. The overall ratings of the owned or leased rural transit facilities are shown in Exhibit 4-35.

Exhibit 4-35
Condition of Rural Bus Maintenance Facilities
1992

Condition	Percent
Very Poor	4
Poor	14
Good	52
Excellent	30

Source: Community Transportation Association of America

Rail Conditions

Detailed information is available on the condition of the Nation's rail system from the FTA Report, Modernization of the Nation's Rail Transit Systems: A Status Report, published in August 1992. This study developed an updated assessment of the physical condition of the rail systems, using the original Rail Modernization Study, published in April 1987, as a starting point. On-site inspections were not conducted as in the earlier study, which relied on such inspections conducted during 1983 and 1984. Rather, the transit authorities were requested to comment on the original conditions obtained from the earlier on-site inspections and provide updated estimates of the condition and levels of improvement still required to bring these transit systems up to "good" condition. This analysis was conducted in 1992 and provided a benchmark on the progress the major urban transit authorities have made in rail modernization since 1984.

In both of the Rail Modernization Studies, each system element was evaluated to determine its condition at that time (as well as to establish the improvements needed and the associated capital costs). Specific definitions were developed for each of five condition levels ("excellent," "good," "fair," "poor," and "bad."). Rail system conditions range from poor to excellent, with good defined as the desirable level over the long term. Exhibit 4-36 displays the definitions of these condition levels.

Exhibit 4-36
Rail Condition Criteria and Definitions

Rating	Condition	Description
1	Bad	In sufficiently poor condition that continued use presents potential problems.
2	Poor	Requires frequent major repairs (less than 6 months between major repairs).
3	Fair	Requires frequent minor repairs (less than 6 months between repairs) or infrequent major repairs (more than 6 months between repairs).
4	Good	Elements are in good working order, requiring only nominal or infrequent minor repairs (greater than 6 months between minor repairs).
5	Excellent	Brand new, no major problems exist, only routine preventative maintenance.

Exhibit 4-37 displays the results of Rail Modernization Study assessment of the physical condition of the Nation's rail systems in 1984 and 1992. The areas reported to be in most need of improvement in the 1984 Report have improved significantly. Maintenance yards went from only 17 percent in good or better condition to 64 percent, and maintenance buildings went from only 28 percent to 52 percent. Also, stations improved significantly from 29 percent to 66 percent, and bridges from 33 percent to 61 percent.

Exhibit 4-37
Physical Condition of U.S. Transit Rail Systems
1984 and 1992

	Condition									
	Bad		Poor		Fair		Good		Excellent	
	1984	1992	1984	1992	1984	1992	1984	1992	1984	1992
Track	0	0	7	5	49	32	31	49	12	14
Rail Cars		2		8		14		49		27
Self-Propelled	23	n/a	24	n/a	18	n/a	28	n/a	7	n/a
Unpowered	3	n/a	13	n/a	35	n/a	49	n/a	0	n/a
Locomotives	3	n/a	10	n/a	32	n/a	43	n/a	12	n/a
Power Systems										
Substations	6	2	23	19	5	17	43	56	23	6
Overhead	20	0	12	33	27	10	36	52	5	5
Third Rail	13	0	26	21	19	20	36	53	6	6
Stations	0	0	15	5	56	29	23	63	6	3
Structures										
Bridges	1	0	16	11	51	28	28	54	4	7
Elevated	0	0	1	1	80	72	3	15	16	12
Tunnels	0	0	5	5	49	34	35	51	11	10
Maintenance										
Facilities	4	2	54	34	14	12	24	35	4	17
Yards	4	2	53	7	26	26	16	55	1	9

Source: Rail Modernization Study

A substantial portion of rail infrastructure is still in need of investment to return it to good condition. Most significantly, over 73 percent of elevated structures need major investments. In addition, overhead (43 percent), third rail (41 percent), and maintenance facilities (48 percent) also have significant shares in less than good condition, requiring major investments.

Additional information on the condition of the Nation's rail transit fleet may be obtained by assessing the average age of the fleet and the number of rail vehicles which have exceeded useful life guidelines. For the period 1985 through 1993, for each type of vehicle, Exhibit 4-38 shows the total number of vehicles of that type, the number which exceed FTA's minimum useful life standards (25 years for all types of rail vehicles) and the average age of the fleet.

Exhibit 4-38
Rail Transit Overage Vehicles and Average Fleet Age
1985-1993

	Year								
	1985	1986	1987	1988	1989	1990	1991	1992	1993
Locomotives									
Total Fleet	364	463	491	564	451	472	467	479	556
Number of Overage Vehicles	129	127	149	131	87	94	81	81	97
Average Age	16.3	15.1	16.9	14.9	14.6	15.7	15.3	15.8	15.6
Rapid Rail Cars									
Total Fleet	9,326	8,963	10,344	10,419	10,246	10,325	10,170	10,161	10,074
Number of Overage Vehicles	1,587	1,796	1,539	2,012	1,785	2,912	2,925	3,031	2,763
Average Age	17.1	16.5	15.2	15.2	15.4	16.2	16.9	17.7	17.8
Unpowered Commuter Rail Cars									
Total Fleet	1,587	1,918	2,137	2,266	2,138	2,154	2,226	2,240	2,402
Number of Overage Vehicles	540	624	883	724	687	619	644	794	700
Average Age	19.1	18.3	19.6	17.3	18.0	17.6	17.3	19.3	18.6
Powered Commuter Rail Cars									
Total Fleet	2,205	2,407	2,563	2,552	2,421	2,492	2,529	2,541	2,526
Number of Overage Vehicles	49	47	41	106	128	126	114	126	154
Average Age	12.3	12.5	13.3	14.3	15.0	15.9	16.5	17.6	18.2
Light Rail Vehicles									
Total Fleet	797	668	879	890	917	903	954	977	943
Number of Overage Vehicles	335	191	238	263	186	159	184	182	99
Average Age	20.6	16.9	17.2	18.9	15.6	15.2	16.6	17.0	14.9

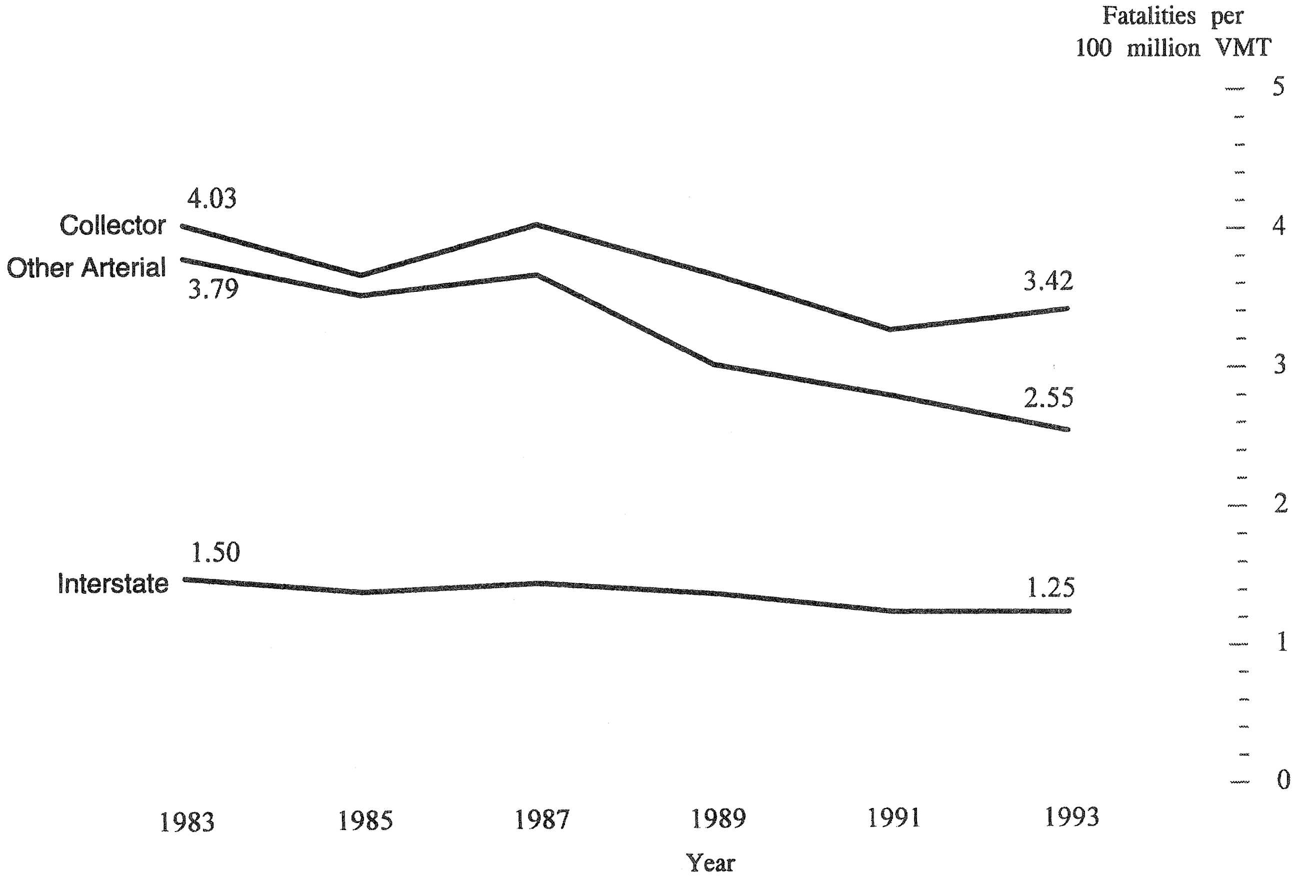
Source: Federal Transit Administration Section 15 data

The trend in average fleet age is similar for all vehicle types except self-propelled commuter rail cars. All improved somewhat between 1986 and 1989, when the trend reversed. Since that time, the average age has increased, to 15.8 years for locomotives, 19.3 for unpowered commuter rail cars, 17.7 for rapid rail cars, and 17.0 for light rail vehicles. The average age of self-propelled commuter rail cars deteriorated steadily, to 17.6 years. The average age of all vehicle types was well in excess of the desired level of 12.5 years in 1993.

Highway Safety

Exhibits 4-39 and 4-40 display rates of highway fatalities resulting from vehicle crashes for the years 1983 through 1993, for rural and urban highways, respectively. The fatality rates are the number of persons fatally injured per 100 million vehicle miles traveled (VMT). An overall improvement in highway safety has occurred during this 10-year period. The fatality rate has decreased for each of the functional system categories shown. Accident and fatality rates are affected by many factors other than highway condition and performance, including weather conditions, occupant protection use, number of intoxicated drivers, extent of police exposure, law enforcement, vehicle speed variations, and driver performance.

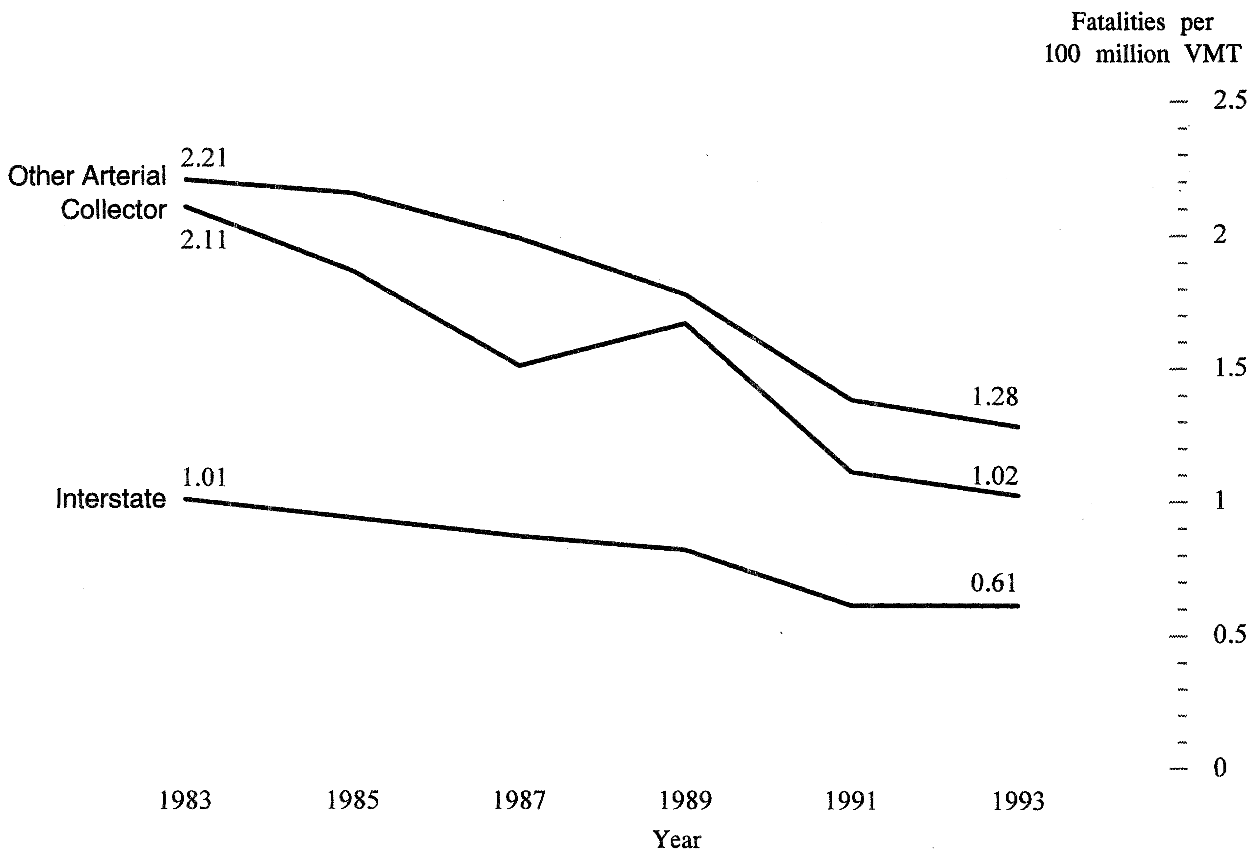
Exhibit 4-39
Rural Highway Fatality Rates
1983-1993



Source: Highway Statistics, various years

While there is some year-to-year variation, for the 10-year period shown the fatality rates have generally decreased on all of the urban and rural functional system categories. In 1993 fatality rates ranged from a low of 0.61 fatalities per 100 million VMT on the urban Interstate system to a high of 3.42 fatalities per 100 million VMT on the rural collector system. The overall fatality rates are 2.62 per 100 million VMT for rural highways and 1.20 fatalities per 100 million VMT for urban highways. The overall average has declined from 2.58 fatalities per 100 million VMT to 1.75 fatalities per 100 million VMT since 1983. While any fatalities resulting from highway crashes are tragic, the decline in the highway fatality rate is a continuing trend in the direction of increasingly safe highway travel in this country.

Exhibit 4-40
Urban Highway Fatality Rates
1983-1993



Source: Highway Statistics, various years

Highway Environmental Indicators

Transportation Impacts

The environmental consequences of transportation arise from construction as well as usage. An initial set of categories for the purpose of reporting on the consequences and efforts to prevent or mitigate these impacts have been identified:

Air Quality	*Noise*
Water Quality	*Land/ Open Space*
Wetlands	*Threatened and endangered species*
Energy	*Community impacts*

Indicators

Indices or indicators of performance pose both conceptual and practical challenges. First, an indicator could measure the direct result of an activity, such as the quantity of air pollutants emitted by vehicles, or it may attempt to measure the significance of such a quantity, such as an activity's share of the total quantity of a given pollutant emitted by all sources, or the change in the level of health risk posed by the results of the activity.

There are also many questions about measuring effort and accomplishments in protecting and enhancing environmental quality. Indicators may be based on inputs, outputs, or effectiveness. While indicators of effectiveness are preferred, measures of the effectiveness of efforts to protect and enhance the environment are often difficult to define, and the data required to describe effectiveness often do not exist or are not available.

Alternatively, the direct change caused by application of the inputs, such as miles of sound walls constructed, may be used as a surrogate descriptor. Input-based indicators are usually least satisfactory because they are most weakly coupled to the effectiveness of efforts. However, they can be combined with either of the other two types of indicators to derive indicators of efficiency, such as cost-effectiveness.

Performance Data

This section presents selected data and other information describing the environmental consequences of transportation, using readily available information. Future reports will be more comprehensive in capturing environmental impacts and resulting costs to society. While these impacts are significant, and include important economic and social benefits, they may be difficult to measure.

Air Quality

There has been significant progress in reducing the overall levels of four major transportation-related air pollutants over the last decade, as reported in the EPA's National Air Quality and Emissions Trend Report, 1993, issued in October 1994. Exhibit 4-41 contains the national air quality improvements and emission reductions that have occurred during the time period 1984 through 1993.

Exhibit 4-41
Percent Improvement in Emissions Reductions
1984-1993

	Carbon Monoxide	Lead	Nitrogen Dioxide	Ozone (smog)
Air Quality	37	89	12	12
Emission Reductions				Hydrocarbons
All Sources	15	88	-1	9
Highways	24	96	11	35

Source: Environmental Protection Agency, National Air Quality and Emissions Trend Reports, 1993

The analysis shows that transportation sources were responsible for most of the emission reductions during the decade. Of equal importance, the emissions reductions were accomplished even though travel during the period increased by 33 percent. The major reasons for the improvements in air quality include Federal limits on gasoline volatility; the replacement of older cars with newer, less polluting ones; and the increased usage of unleaded gasoline.

The EPA air quality data shows that 48 of the 91 nonattainment areas for ground level ozone (smog) under the Clean Air Act Amendments (CAAA) of 1990 are no longer recording violations of the standard. Similarly, 28 of the 38 carbon monoxide areas have not measured violations of the standard. Once other air quality planning and implementation requirements are completed, and assuming new violations do not occur, these areas will qualify for attainment status under the CAAA.

While substantial progress has been made, whether air quality will continue to improve depends on many factors, including trends in VMT. As demonstrated elsewhere in this report, VMT continues to increase. Some projections of future VMT show that mobile source emissions may begin to increase slowly sometime after the year 2000, unless additional technological advances are made or more stringent transportation control measures are implemented.

As part of an overall effort to insure that mobile source emissions do not increase, several new requirements and programs have been initiated under the CAAA and the ISTEA. For example, in areas that do not meet the national ambient air quality standards ("nonattainment areas"), new transportation plans, projects, and programs cannot be approved unless they "conform" to the intent and purpose of State plans to improve air quality. These conformity requirements provide strong impetus toward achievement of the standards in nonattainment areas.

New sources of funds have also been initiated to improve air quality. The Congestion Mitigation and Air Quality Program was created under ISTEA and makes $6 billion available over 6 years to reduce emissions through transportation projects and programs. One billion, eight hundred million dollars were obligated during the Program's first three years. While the results indicate only modest emissions reductions, a wide variety of strategies are being implemented.

Water Quality

In the early 1970s, a growing awareness of the potential threat to water resources by transportation construction and operation emphasized a need to identify and quantify water quality impacts. With the passage of the National Environmental Policy Act (NEPA) and the Clean Water Act of 1972, as amended, Federal decisionmakers were to be accountable for activities having the potential to impact features of the natural environment, in particular water quality.

The planning for and implementation of highway systems can interact with the Nation's water resources in numerous ways. Since most highways lie within or traverse watersheds, all phases of project development have the potential for impacting both surface and underground water resources. Highway project planning, location, and design activities can influence future uses of water resources in localities by influencing patterns of growth, development, and water supply distribution. Construction and maintenance activities have direct impacts to both supply and water quality characteristics of the project area. Impacts range from the erosion of disturbed soils to the chemical pollutants associated with highway maintenance practices. Finally, the operation of highways contributes other potential pollution sources present in roadway storm water runoff.

Research sponsored by the FHWA, and the collective experience of the State highway agencies, identifies and measures these pollution sources and develops techniques to lessen their impact on water resources. The ISTEA provides Transportation Enhancement funding for mitigation measures addressing the water quality impacts of highway storm water runoff.

Wetlands

Wetlands are a diminishing habitat resource that may require special conservation efforts during the implementation of Federal programs. A study conducted by the U.S. Fish and Wildlife Service in 1991 investigated wetland status and trends from the 1970s to the 1980s. The lower 48 States have lost an estimated 53 percent of their original wetlands since the 1780s. The results document a continuing loss of wetland acreage. An estimated 1.1 percent of estuarine wetlands and 2.5 percent of inland wetlands were lost from the lower 48 States during the 9-year study period. Agricultural land uses accounted for 54 percent of the conversions from wetland to upland. Urban expansion accounts for 5 percent of the conversion, with other land uses making up the balance of the losses.

There is an extensive program to avoid and mitigate wetland impacts. The primary objective of the program is to avoid wetland impacts during the development of highway and transportation improvements. However, in some situations, wetlands are unavoidable and mitigation must be applied. Mitigation banking and other measures to offset impacts to wetland resources are eligible for Federal-aid funding under the Surface Transportation Program and National Highway System funding under the ISTEA. Twenty-six States currently have operating banks or the necessary agreements in place to have them operating soon.

Energy

Highway transportation consumes significant amounts of energy (49 percent of total U.S. petroleum use) and generates large amounts of carbon dioxide (25 percent of CO_2 emissions in the United States). Exhibit 4-42 shows the trend in highway use of fuel in the United States based on U.S. Departments of Transportation and Commerce data for the period 1970 through 1990. The data indicates that highway energy use, the number of automobiles, the amount of travel, and the number of drivers have increased.

However, the rates of fuel usage per registered automobile, per mile of travel, and per licensed driver have declined. There have been significant increases in the fuel economy of automobiles since 1974. The fuel efficiency of new cars has increased from 14 miles per gallon to almost 28 miles per gallon. As older cars are replaced by newer cars, the fleet average fuel economy will continue to improve. Trends for transit are not available for this report, but may be included in future editions.

Exhibit 4-42
Changes in Highway Gasoline Usage
1970-1993

	Overall Change	**Average Annual Change**
Highway Use of Gasoline (gallons)	37.1%	1.38%
Registered Automobiles	81.0%	2.61%
Number of Licensed Drivers	55.2%	1.93%
Average Miles Per Vehicle	14.0%	0.57%
Annual Gasoline Consumption		
Per Registered Automobile	-24.3%	-1.20%
Per Licensed Driver	-11.6%	-0.53%

Source: Highway Statistics, Tables VM-1 and DL-1, 1970-1993

Highway Project Noise Mitigation

Highway noise is being attacked with a three-part strategy: motor vehicle control, land use control, and highway planning and design. The responsibilities for implementing these strategies must be shared by all levels of government: Federal, State, and local. The first part of the strategy goes right to the source of traffic noise: the vehicles. Quieter vehicles would bring about a substantial reduction in traffic noise along those roads and streets where no other corrective measures are possible. The EPA has issued regulations placing a limit on the noise that new trucks can make. In addition, many local and State governments have passed ordinances or laws requiring existing vehicles to be properly maintained and operated.

The second part of the strategy calls for the control of future development. Prudent land use control can help to prevent many future traffic noise problems in these areas. Such controls need not prohibit development, but rather can require reasonable distances between buildings and roads as well as "soundproofing" or other abatement measures to lessen noise disturbances. Many local governments are working on land use control.

The third part of the highway noise reduction strategy is highway planning and design. Early in the planning stages of most highway improvements, highway agencies do a study to determine if the project will create any noise problems. If the predicted noise levels are above Federal noise criteria, the noise study must consider measures that can be taken to lessen these adverse noise impacts.

Some noise reduction measures that are possible on existing roads or on roads that are being rebuilt include creating buffer zones, constructing barriers, planting vegetation, installing noise insulation in buildings, and managing traffic.

The construction of traffic noise barriers is the most commonly used noise abatement measure found in highway programs. From the early 1970s through the end of 1989, 39 State highway agencies and the Commonwealth of Puerto Rico had constructed over 720 linear miles of barriers at a cost of $555 million. It is estimated that an additional 285 miles of barriers were constructed during the period 1990 through 1992 at a cost of $300 million. Significant trends in barrier construction during the last 15 years include:

A dramatic increase in the amount of highway traffic noise barrier construction occurred in the two most recent years of reporting, 1988 and 1989.

Approximately three-fourths of Federal-aid barriers have been on new construction, reconstruction, or major widening of highways (Type I barriers). Noise barrier construction built along existing highways (Type II barriers) has decreased.

Barriers have been made from materials that include concrete, masonry block, wood, metal, earth, brick, and combinations of these materials.

Land Use/Open Space

The appropriate use of land and the conservation of open spaces are becoming increasingly important issues, particularly in urban areas. Future reports may document monitoring and data collection efforts to determine the effects of highway improvements on developed lands and open space. Probable data sets could include items such as the amount of land devoted to transportation purposes, open space (including park land and wildlife habitat), conservation efforts supported by the highway program, information on access control, and other land-use issues. The indirect impacts of highways on open space and land use, through development activity, are also a concern, but may be impossible to measure.

Threatened and Endangered Species

During the period FY 1990 to 1994, over $20 million of Federal-aid highway funds were expended for the conservation of threatened and endangered species pursuant to the Endangered Species Act of 1973. The yearly expenditures were as follows (in thousands): 1990 - $13,747; 1991 - $5,442; 1992 - $1,614; 1993 - $1,320; 1994 - $11,931.

Measures were taken for the conservation of 74 threatened and endangered species. California continues to lead all States in average annual costs for endangered species conservation, spending nearly $5 million in FY 1994. As States incorporate more avoidance and mitigation features in projects, and as the number of endangered species increases, costs are expected to increase in the near term. Not reflected in these costs are the numerous cases where the State highway agencies have avoided the habitats of protected species through project modifications and other actions.

Community Impacts

The DOT is required to evaluate physical and social environmental effects of federally funded surface transportation projects to comply with the President's Council on Environmental Quality's Regulations for Implementing the NEPA. Potential socioeconomic effects and methods to avoid or mitigate those effects are analyzed in environmental documents (Environmental Impact Statements and Environmental Assessments) prepared for major Federal projects and distributed to concerned Federal, State, and local agencies and the public. While there are many positive impacts on communities from the increased mobility provided by highways, there are three broad categories of possible adverse community effects which may arise: (a) dislocation of businesses and residences within the proposed transportation corridor; (b) division and separation of formerly cohesive communities; and (c) inducement of growth in undeveloped or sparsely developed areas, which, in the absence of growth management and land use policies, can foster urban sprawl and decline of central business districts.

The NEPA environmental review process is used to identify possible effects and to develop measures to minimize or eliminate those effects. To minimize dislocation of businesses and residents, alternative routes are analyzed and affected individuals are offered relocation assistance, including monetary aid. To prevent segregation of communities and urban sprawl, local and State governments are required to integrate transportation planning into the long-term urban planning and rural development efforts. The NEPA review process ensures that local governments and citizens have extensive opportunities for input into the design of transportation networks at an early stage.

The ISTEA provides for several programs that are intended to promote access to and enhancement of the scenic or recreational aspects of the environment. These include the Federal Lands Program, the Scenic Byways Program, and the National Recreational Trails Program.

Chapter 5

Highway, Bridge and Transit Future Investment Requirements

Chapter 5

INTRODUCTION

This chapter provides general investment benchmarks as a basis for the development and evaluation of transportation policy and program options. Total capital investment required from **all sources** to achieve certain specified levels of overall condition and performance for the Nation's highway, bridge and transit systems is estimated.

The investment requirement estimates are intended to serve as benchmarks for policy development. The (bridge and transit) **Cost to Improve** conditions and performance and the (highway) **Economic Efficiency** scenarios suggest the upper limit of appropriate national investment, based on either engineering or economic criteria. Alternatively, the **Cost to Maintain** conditions and performance investment estimates provide a sense of the lowest reasonable level of investment; investment at levels less than the **Cost to Maintain** benchmark will result in system deterioration. The reader should note that the investment estimates reported for the various scenarios reflect certain assumptions which may be uncertain. For example, the travel growth forecasts assume the implementation of aggressive demand shaping policies which have yet to be implemented in any American city. Further, the highway **Economic Efficiency** scenario relies on assumptions regarding a number of critical parameters, such as the value of travel time, which have not achieved widespread consensus.

The investment scenarios do not represent comprehensive alternative national investment policies. No policy priorities have been assumed regarding either the strategic importance of individual facilities, classes of facilities, or mode of transportation. In actual practice, however, State and local transportation agencies do target selected facilities for improvement.

The investment requirement estimates cover the period 1994 through 2013 and include the cost to selectively:

Repair pavement, bridge and transit deficiencies,

Eliminate unsafe conditions, and

Add capacity.

Independent analytical techniques, assumptions and objectives are used to develop each set of modal estimates. The techniques used to develop the **Cost to Maintain**, **Economic Efficiency** and **Cost to Improve** estimates are outlined in the remainder of this chapter; a somewhat more detailed presentation may be found in the appendices.

In the case of the highway analysis, the Highway Performance Monitoring System (HPMS) database and associated simulation models provide the foundation for the estimates of future highway investment requirements. The HPMS provides current conditions and performance information as well as state-supplied estimates of anticipated highway travel growth. The modeling procedures simulate future conditions and performance, evaluate the system for deficiencies and identify potential improvements to correct the deficiencies. If funds are limited, improvements are selected from an order-of-merit list.

The Analytical Process (AP), an engineering-based model, supports the analysis of the **Cost to Maintain** scenario. The newly developed Highway Economic Requirements System (HERS) is used to evaluate the **Economic Efficiency** scenario. For each scenario, the model results are augmented with other estimation techniques.

Bridge investment requirements for both the **Cost to Improve** and **Cost to Maintain** scenarios have been estimated using an engineering-based procedure, the Bridge Needs and Investment Process, analogous to the HPMS AP. The bridge investment requirements do not reflect explicit benefit-cost considerations.

The transit analysis is based on current infrastructure extent and conditions and an estimate of the costs of system preservation and added transit capacity required to satisfy the objectives of each scenario. Explicit benefit-cost procedures are used to validate service level assumptions and certain unit costs.

Highway Investment Scenarios

Cost to Maintain Conditions and Performance

The average annual **Cost to Maintain** overall 1993 highway conditions and performance on arterial, collector and local systems through 2013 is estimated at $49.7 billion. Under this investment strategy, existing and accruing system deficiencies would be selectively corrected; some highway sections would improve, some would deteriorate, but overall the system would remain the same.

Economic Efficiency

Improving the highway system according to **Economic Efficiency** objectives, would require an average annual investment of $65.1 billion. Under the **Economic Efficiency** scenario, system conditions and performance would be improved by systematically correcting existing and accruing system deficiencies through the year 2013, provided that the improvements generate direct user and agency benefits in excess of initial improvement costs.

Bridge Investment Scenarios

Cost to Maintain Conditions

The average annual **Cost to Maintain** overall 1994 bridge conditions is estimated at $5.1 billion through 2013. Existing and accruing deficiencies would be selectively corrected; the total number of structurally deficient and functionally obsolete bridges would remain the same.

Cost to Improve Conditions

The average annual **Cost to Improve** 1994 bridge conditions over the 20-year analysis period, is estimated at $8.9 billion. At these investment levels, all existing bridge deficiencies would be eliminated through bridge replacement, rehabilitation, or major widening. All accruing requirements would be met through the year 2013.

Transit Investment Scenarios

The Cost to Maintain Conditions and Performance

The average annual **Cost to Maintain** 1993 transit conditions and performance levels through 2013, is estimated at $7.9 billion. This level of investment, which assumes a significant increase in passenger miles traveled, is required to maintain transit facilities and equipment in their current state of repair. Under this scenario, transit vehicles would be replaced at about the current rate and transit operators would meet the requirements of the Americans with Disabilities Act (ADA) and the Clean Air Act Amendments (CAAA).

The Cost to Improve Conditions and Performance

The average annual **Cost to Improve** conditions and performance on the Nation's transit systems is estimated at about $12.9 billion over the 20 year analysis period. This investment level includes (1) the **Cost to Maintain** 1993 conditions and performance; (2) the cost to eliminate the backlog and (3) the cost of improving transit service levels in terms of system speed, comfort and convenience.

Summary: Highway, Bridge and Transit Investment Scenarios

Exhibit 5-1 provides a summary of the highway, bridge and transit investment scenarios. The reader is cautioned that the investment scenario objectives and underlying analytical procedures differ significantly between the modes. Further any comparisons with investment requirements in prior reports are complicated by:

changes in urbanized area boundaries,

expanded report series coverage,

reclassification of functional systems,

revised capacity calculations,

enhanced simulation procedures, and

alternative assumptions, especially regarding highway and transit future travel growth estimates.

The summary is found at Exhibit 5-1.

Exhibit 5-1
Summary of Highway, Bridge, and Transit Average Annual Investment Requirements
Billions of 1994 Dollars
1994-2013

	All Systems (Includes Local)					
	Cost to Maintain			Economic Efficiency		
Highway (2.2% Compound Annual Travel Growth)	Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total
	$25.1	$24.6	$49.7	$30.4	$34.7	$65.1
	Cost to Maintain			Cost to Improve		
Bridge	Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total
	-	$5.1	$5.1	-	$8.9	$8.9
	Cost to Maintain			Cost to Improve		
Transit (2.4% Compound Annual Travel Growth)	Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total
	$2.8	$5.1	$7.9	$5.8	$7.1	$12.9

Significant Analytical Advancements and Issues

Background

The methods and assumptions used to estimate future highway, bridge and transit investment requirements are continuously evolving. Since the beginning of the report series, in 1968, innovations in analytical techniques, new empirical evidence and changes in transportation planning objectives have combined to encourage the development of improved data and analytical techniques.

Estimates of future highway investment requirements, as reported in the 1968 Status of the Nation's Highways: Conditions and Performance Report to Congress, began as a "wish list" of state highway "needs." Early in the 1970s the focus changed from system expansion to management of the existing system. National engineering standards were defined and applied in the identification of system deficiencies and by the end of the decade a comprehensive database, the HPMS, had been developed to monitor system conditions and performance.

By the early 1980s a sophisticated simulation model, the AP, was available to evaluate the impact of alternative investment strategies on system conditions and performance. This procedure is founded on engineering principles: engineering standards define which system attributes are considered deficient and the improvement option "packages" assigned to potentially correct given deficiencies are based on standard engineering practice.

The current 1995 Status of the Nation's Highways: Conditions and Performance Report to Congress (C&P Report) marks the beginning of a significant transition from engineering- to economic-based estimates. The introduction of economics into the investment analysis process, with the highway **Economic Efficiency** scenario, is responsive not only to a special Congressional request that the report provide more advanced economic analysis of highway investment options but also to the more general requirement that increasingly constrained national investment resources be efficiently allocated.

In addition to fiscal constraints, potential highway improvement strategies are shaped by environmental and social concerns. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) reflects these new challenges and permits unprecedented flexibility by local decision-makers in the use of Federal surface transportation assistance. Through enhanced requirements for statewide and metropolitan transportation planning, State and local decisionmakers are being asked to manage the existing transportation infrastructure more efficiently, as well as to look at transportation from an intermodal standpoint rather than on a mode-by-mode basis.

Recognizing the importance of a multimodal orientation in transportation planning, the C&P Report series combined highway and transit material under one cover in 1993. However, the individual modal investment analyses did not reflect consistent assumptions. In fact, the 1993 report merely merged the highway analysis with information contained in the 1992 biennial Public Transportation in the United States: Performance and Condition Report to Congress.

The current 1995 C&P Report improves the integration of highway and transit investment requirements. Although rigorous analytical procedures have not yet been developed to support a fully integrated approach, the investment scenarios now share a common conceptual framework that is consistent with the Metropolitan Planning Organization (MPO) transportation planning objectives and assumptions.

Subsequent editions of the report series will address modal tradeoffs more fully. The Federal Transit Administration (FTA) is now developing a transit investment/performance analytic capability which will use benefit-cost procedures as a basis for estimating investment requirements.

The 1997 C&P Report will provide economic-based investment estimates using the Bridge Investment Analysis System, a process similar in technique to the HERS approach. At that point, the bridge analysis will also include an **Economic Efficiency** scenario.

Introduction of these new analytical approaches brings different challenges, some of which may influence the scope and reasonableness of the analysis conclusions. These issues are discussed in the following sections. Two of the more important issues relate to travel forecasts and the new **Economic Efficiency** scenario.

Travel Forecasts

The MPO highway and travel forecasts are made in the context of development of the area's Transportation Improvement Program (TIP) and Long Range Transportation Plan (LRTP). In accordance with ISTEA planning requirements, their plans and programs must be in conformance with Clean Air Act requirements and must be consistent with the fiscal capability of the area to implement the proposed transportation investments.

For the current 1995 C&P Report, the travel forecasts underlying the investment requirements for the 33 most populous urbanized areas (UZAs) are derived from the MPO planning process. The travel forecast for highway sections in these areas represent a synthesis of MPO and State forecasts. The transit forecasts are taken directly from the MPOs. As a result, the 1994 through 2013 investment requirements are based on lower 20-year forecasts of highway travel than assumed in previous reports and a corresponding increase in travel by transit.

Previous editions of the report series relied exclusively on forecasts of future highway vehicle miles of travel (VMT) as supplied in the HPMS State submittal. Ad hoc procedures were developed to estimate the impact of aggressive Transportation System Management (TSM) and Transportation Demand Management (TDM) strategies, expressed as lane-miles of capacity not required. The transit investment requirement estimate was based on that increment of (HPMS-based) highway demand that would be eliminated through application of TDM strategies.

The ad hoc adjustments to the HPMS-based highway investment requirements were necessary because of significant uncertainty as to what extent the HPMS travel forecasts reflected the potential transportation and land-use policy changes necessary to respond to current and anticipated constraints on capacity increases, especially in the 33 most populous UZAs. For example, policies designed to conform with the CAAA could result in slower growth in automobile travel levels compared to historic levels.

Social, fiscal and environmental concerns are most pronounced in these 33 areas and transportation modal alternatives are more prevalent as well. For example, approximately 90 percent of transit ridership occurs in the 33 most populous UZAs. Therefore, multimodal investment tradeoffs are most probable in these areas.

HPMS Travel Forecast Adjustment

The HPMS travel forecasts were adjusted as follows: On HPMS highway sections in the 33 most populous UZAs, a factor was applied to each coded target year travel forecast. The factor expressed the relationship between the aggregate 20-year MPO travel forecast, for the transportation planning areas associated with these cities, and the aggregate 20-year HPMS section forecasts in the corresponding Federal-aid UZAs.

In this manner, the average compound annual travel forecast for the year 2013, for all HPMS sections in the 33 most populous Federal-aid UZAs, is the same as the average compound annual travel growth rate projected by the MPOs for highways in the transportation planning areas. The section specificity characteristic of the HPMS database was thus retained. No adjustments were made to HPMS data coded for sections outside the 33 most populous UZAs.

It should be noted that the geographic area represented by an MPO transportation planning area is typically 2 to 3 times larger than the HPMS Federal-aid UZA. Further, the forecasting techniques used to produce the MPO forecasts differ from those used by the States to develop the HPMS forecasts. In the case of both the MPO and HPMS forecasts, the underlying assumptions regarding specific strategies which are planned to achieve the forecast travel levels are not made explicit.

Implications

Exhibit 5-2 provides a comparison of the unadjusted HPMS forecasts and the MPO-consistent forecasts. The investment requirements in this report assume that the rate of growth in highway travel beyond 1993 will average 2.15 percent per year. Both the unadjusted and adjusted forecasts are well below historic levels. For the period 1966 to 1993, the rate of growth in highway travel averaged 3.5 percent annually.

Exhibit 5-2
Estimated Highway Travel Growth Rates
1994-2013

Location	HPMS Forecast Compound Annual Growth Rates	HPMS Forecast Total Growth 1994-2013	MPO Consistent Forecast Compound Annual Growth Rates	MPO Consistent Forecast Total Growth 1994-2013
Rural Areas	2.45%	62.2%	2.45%	62.2%
Small Urban Areas	2.37%	59.6%	2.37%	59.6%
All Urbanized Areas	2.32%	58.1%	1.91%	46.0%
Most Populous Urbanized Areas	2.23%	55.4%	1.50%	34.7%
Total	2.37%	59.8%	2.15%	53.1%

Exhibits 5-3 and 5-4 illustrate the divergence from historical patterns implied by the travel growth adjustments. As indicated in Exhibit 5-3, highway travel will increase at a dampened rate relative to past experience. (Of course, the growth rate will naturally decline in the future as the VMT base grows; however, the MPO forecast implies a sudden shift to a lower rate.) Alternatively, as shown in Exhibit 5-4, transit travel growth trends are assumed to shift from a continually constant level of travel to one in which travel will grow at a compound annual rate of 2.4 percent. These trends are consistent with MPO plans that seek to reduce highway travel through TDM/TSM measures that encourage higher transit use.

Exhibit 5-3
33 Most Populous Urbanized Areas
Daily Vehicle Miles of Travel (DVMT)
Actual versus Projected

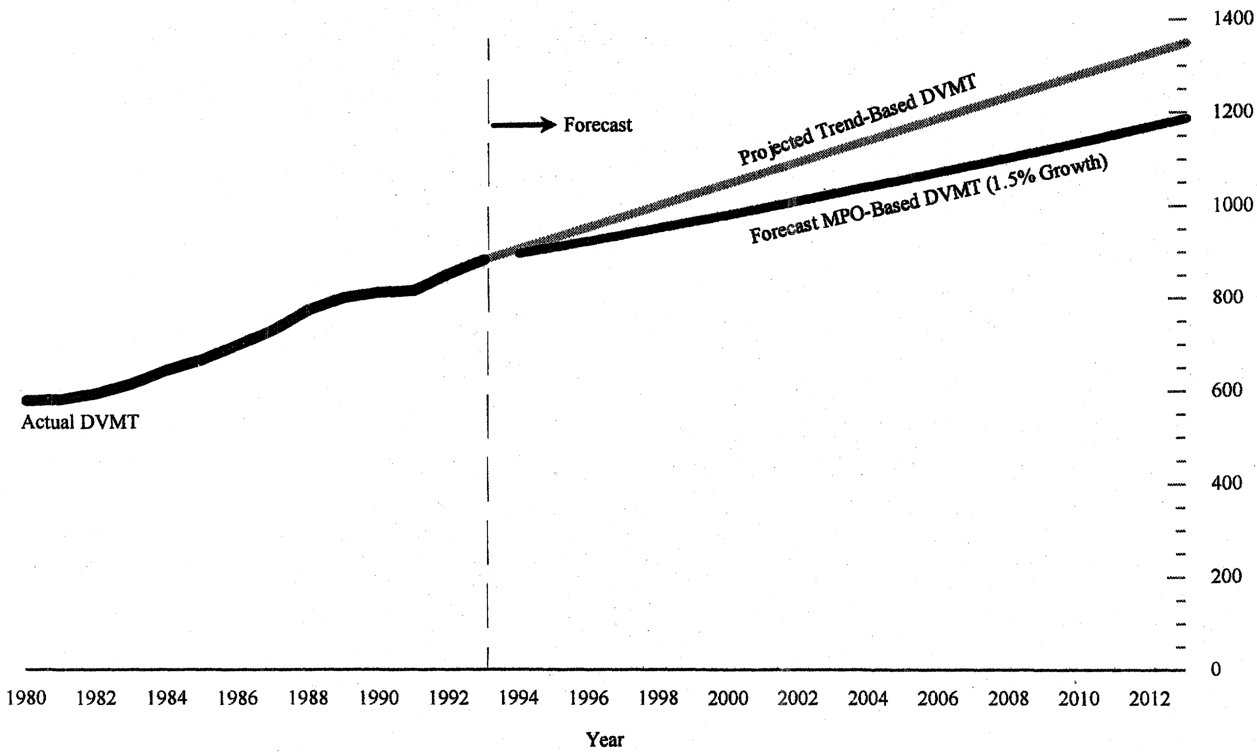
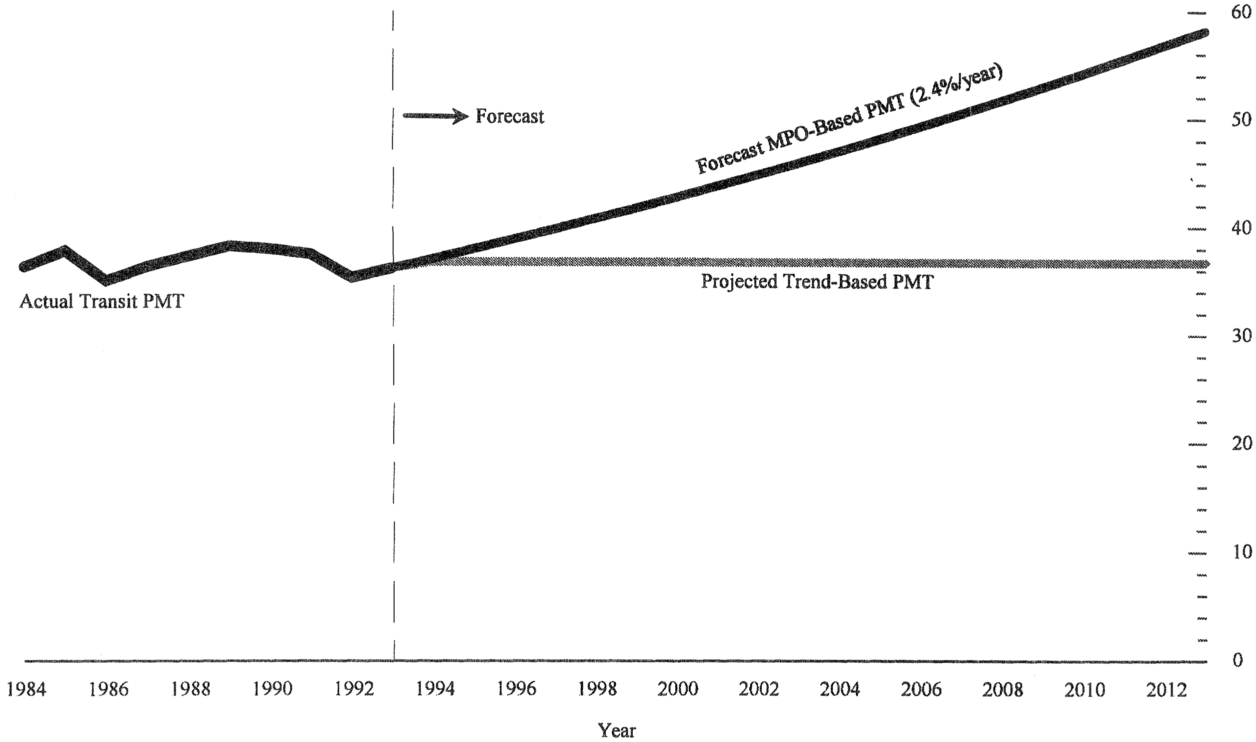


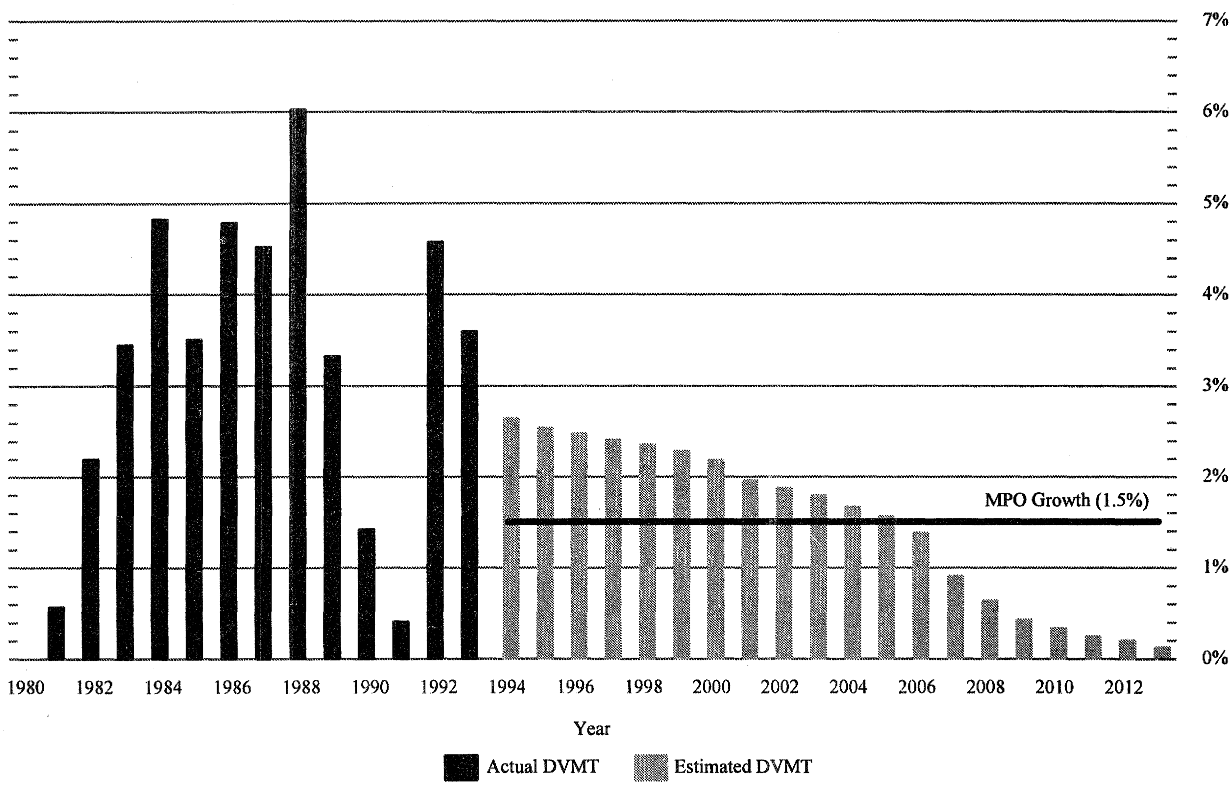
Exhibit 5-4
33 Most Populous Urbanized Areas
Annual Transit Passenger Miles of Travel (PMT)
Actual versus Projected



Without significant and wide-spread demand shaping policies, it is not likely that the MPO forecasts will be achieved. This statement is underscored by the trends outlined in chapter 1 as well as the observation that, if future rates of growth in travel decline gradually from current growth rates, the longer that demand reductions (e.g., from current to MPO forecast levels) are postponed, the lower the rate of growth would have to be in future years to achieve the overall forecast growth rate.

As illustrated in Exhibit 5-5 if the current rate of growth remains stable for several years before the projected reduction takes effect, the impact on future growth would be more dramatic if the overall 2.15 percent growth rate is to be realized. In fact, if the reductions are realized gradually from actual current levels of highway usage, future rates of highway travel growth in the 33 most populous UZAs could drop to approximately 0.5 percent annually if the 2.15 percent average is to be realized.

Exhibit 5-5
33 Most Populous Urbanized Areas
Growth in Vehicle Miles of Travel Assuming Gradual Reduction in Travel



To the extent that actual future experience exceeds the highway travel forecasts, the resulting investment requirement estimates may be understated. Analogously, to the degree which the transit travel forecasts are not realized, the estimates of future transit investment requirements may be overstated.

Strategies to Reduce Highway Vehicle Miles of Travel

As indicated earlier, the strategies planned to achieve the reduced rate of growth in highway travel are not made explicit by the MPOs in their TIPs or LRTPs. However, an examination of the demand reduction options available, indicates that aggressive pricing and/or regulatory initiatives would have to be a significant part of any transportation management plan intended to realize the reductions in highway VMT inherent in the MPO forecasts.

Demand reduction strategies include subsidy, regulation and pricing. Subsidies and regulations--such as restricted drive days, employee commute option mandates, transit fare reductions, and land use regulations--have only small impacts on reducing highway VMT. Although it is difficult to generalize about the impact of such actions, they tend to have relatively narrow targets, have small impacts on the target group and stimulate the most resistance when impacts would be the greatest (e.g., mandatory reductions in single occupancy vehicles).

Pricing strategies--such as congestion pricing, parking pricing, weight-distance truck fees and higher annual registration fees--promise greater reductions in highway VMT. In general, pricing policy actions increase the cost of driving and typically have significant response rates. For price increases in the range of $0.05 to $0.15 per VMT, overall demand price elasticity may be as much as -1.0 for peak period pricing on congested travel. This means that, an action that increased the cost per mile of highway use by 10 percent could reduce VMT by 10 percent.

For example, if the price (in 1992) of congested peak period travel on urban Interstates had been increased by $0.05 per vehicle mile, approximately 28 billion VMT (or 9 percent of total urban Interstate VMT) per year would not have occurred. This estimate assumes that:

> *46 percent of the 302 billion VMT of 1992 urban Interstate travel occurred under congested conditions (therefore the target VMT was 139 billion);*
>
> *the base price for the congested travel was $0.25 per VMT (therefore a $0.05 per VMT increase represented a change of 20 percent); and*
>
> *the upper limit elasticity of -1.0 was realized (therefore the target VMT of 139 billion was reduced by 20 percent).*

Expanding a similar strategy to all congested VMT might result in reductions in the 35 billion to 50 billion range.

Parking pricing has a similar elasticity and can be analyzed using the same framework. A rough estimate for all types of parking nationwide might yield a VMT reduction impact of up to 50 billion VMT.

Although limited in implementation, parking pricing has proved very effective in recent experience. However, even widespread parking pricing policies would have to be combined with congestion pricing in order for the travel forecasts assumed in this report to be realized.

Urban areas have been reluctant to implement pricing strategies, especially congestion pricing. The expected time frame for achieving any of the pricing actions is unknown, but implementation is certainly not imminent.

Highway Economic Requirements System

In 1988, the FHWA embarked on a long-term research, development, testing and critical review effort to produce an alternative, economic-based, HPMS simulation procedure. The HERS selects the "best" set of highway improvements to satisfy economically sound highway performance objectives. The model supports program and budget development by reporting the cost to achieve and maintain, at the national level, a highway system that is economically efficient.

When funding is not available to achieve "optimal" spending levels, HERS will prioritize economically worthwhile potential improvement options according to relative merit (that is, net contribution to social welfare) and select the "best" set of projects. Given funding constraints or user-specified performance objectives, the system minimizes the expenditure of public funds while simultaneously maximizing highway user benefits.

The HERS approach, upon which analysis of the **Economic Efficiency** scenario is based, relies on Benefit/Cost Analysis (BCA) to evaluate the attractiveness of potential highway improvements for each deficient prototype section in the HPMS database. The model will implement only those projects for which direct user and agency benefits exceed the initial cost of the improvement.

In the current version of HERS, highway user benefits are defined as reductions in travel time costs, accidents and vehicle operating costs. Agency benefits include reduced maintenance costs and the residual value of a project (the amount by which the cost of the section's next improvement will be reduced). "Cost" includes expenditures associated with implementing the improvement such as project design, right-of-way acquisition and construction.

For each alternative, a time stream of constant-dollar costs and benefits is estimated for the lifetime of the project. Future benefits are measured relative to the base, or "do nothing" alternative, and discounted to allow for the opportunity value of resources with respect to time.

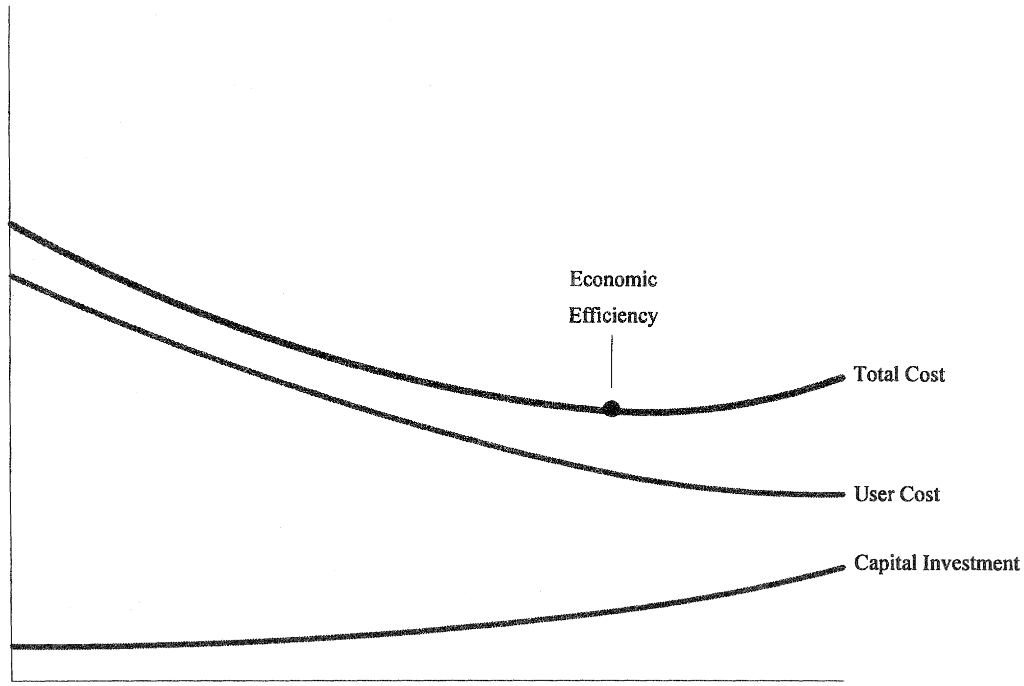
The current 1995 C&P Report introduces a HERS-based investment strategy, the **Economic Efficiency** scenario. It is similar in concept to the traditional engineering-based, **Cost to Improve** strategy, provided in prior reports, in that it identifies existing and accruing system deficiencies and corresponding improvements to correct these deficiencies based on standard engineering judgement and practice. However, where the AP analysis will systematically implement all appropriate improvement options identified, regardless of economic merit, HERS evaluates each potential improvement to assure that direct user and agency benefits generated by the project will exceed the initial cost of the improvement.

With HERS the focus is on the service that the highway system provides to the users; rather than on the condition and performance of the highway infrastructure.

Subsequent reports will include expanded HERS-based analysis. The model will be used to develop an investment/performance curve that relates highway investment to user and agency benefits. All assumptions held equal, investment beyond that indicated by the **Economic Efficiency** scenario would include projects having negative net benefits. Investment short of this point is a "second best" alternative because constraints are imposed (e.g., funding) to exclude some projects having benefits greater than costs.

Another way to conceptualize the HERS goal is presented in Exhibit 5-6. The lines marked "user cost" and "investment" indicate (not to scale) that as highway investment increases, user costs will decline. However, at some point the additional increment of investment will fail to result in user cost reductions sufficient to warrant the additional investment. This point is indicated on the "total cost" line as **Economic Efficiency**.

Exhibit 5-6
Economics-Based Approach to Highway Investments
Schematic



In 1994, the HERS was subjected to an intense critical review process in which subject matter experts from the transportation community and related disciplines participated. The reviewers indicated that the model was fundamentally sound but could be improved by consideration of a number of issues. Some of the most significant are as follows:

inelastic demand (e.g., induced travel is not considered),

inefficient pricing of facilities (e.g., congestion pricing is not included in the model framework),

network interactions are not reflected (e.g., the database consists of discrete highway sections), *incomplete accounting of benefits and costs (e.g., the model considers only direct user and highway agency benefits and the initial direct cost of the improvement; externalities and potential productivity impacts are not included), and*

uncertain value of travel time (e.g., there is a lack of consensus regarding the "correct" values to be placed on travel time savings, especially non-commercial time).

Despite the incompleteness of the model, HERS is recognized as an important advancement in integrating economic considerations into transportation investment decisions. The HERS will provide useful information regarding the economically optimal mix of improvements under a constrained budget. Further, while HERS was not designed to provide definitive program allocation answers, it is a potentially powerful analytical device that will provide decisionmakers with important investment/performance benchmarks. The model will provide analytical support in determining the increment of national resources that can be efficiently allocated to highway programs.

The issues highlighted above, as well as others, are applicable not only to the current HERS analysis, but will be relevant to BCA procedures used to evaluate improvement options within the other transportation modes as well as to assess multimodal tradeoffs.

Despite the difficulties, BCA remains an important and viable evaluation technique, especially when the alternative is to exclude economic considerations from transportation investment decisions.

The initial version of HERS provides a "core capability" and is intended as a first step in the application of economic analysis to transportation investment evaluation. The system can be modified to integrate additional benefits and costs or to improve the procedures that quantify and/or monetize the direct benefits and costs now included. The Federal Highway Administration has a long-term research agenda designed to advance such efforts.

However, because broad agreement on the underlying BCA assumptions is presently unavailable and is unlikely in the future, HERS was designed to facilitate extensive sensitivity analysis. Investment/performance scenarios may be evaluated with a range of values assigned to a number of critical but uncertain assumptions (e.g., the discount rate and the value of time). The HERS analysis presented in future reports will include the results of such sensitivity testing. One of the goals of BCA is to make the analysis as transparent as possible and to provide decisionmakers with fully informed recommendations.

Highway Investment Requirements

Analytical Overview

The centerpiece of the highway investment/performance analysis process is the coordinated HPMS database and simulation models, the AP and HERS. These models use information describing the current state of the highway system, as provided in the HPMS data, to simulate investment decisions and predict system performance.

The database, as well as the associated models, are under continuous review. Procedures are routinely developed, external to the models, to keep the investment requirement findings consistent with current information. Efforts to incorporate the external procedures, implemented in the current 1995 C&P Report, into the model structures are underway but may take several years to complete.

Appendix B provides more detail on the methodology used to develop the highway investment requirements.

Model Input and Output Adjustments

This section outlines the external revisions to the model inputs and outputs which were implemented the current 1995 C&P Report. The net impact of these ad hoc adjustments was to reduce the requirement for highway capacity expansion.

Travel Forecasts. The first major adjustment made to both the HPMS AP and HERS analyses was to reduce the amount of travel projected by the States over the 20-year period, 1994 through 2013. This was explained, in detail, in the Significant Analytical Advancements and Issues section above.

Peak Spreading. As highway travel increases faster than capacity, congestion in the morning and afternoon peak periods extends for longer periods of time and in more locations. As a result, high traffic volumes occur over more hours of the day and congestion spreads from major facilities to a larger number of parallel facilities that can serve the same trips. These changes in travel behavior make more intensive and efficient use of available highway capacity.

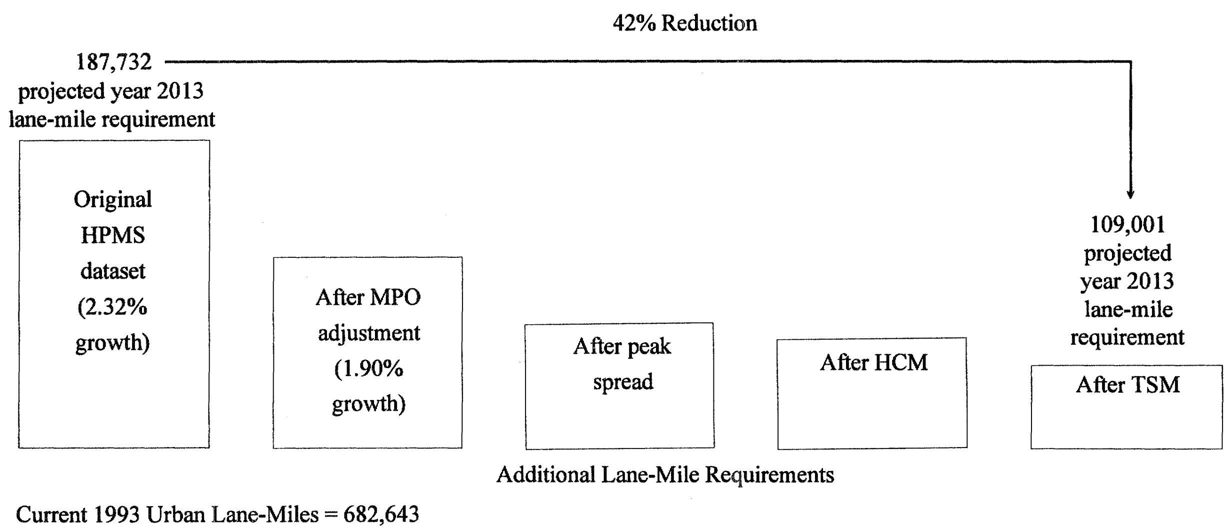
To reflect this phenomenon and reduce the tendency of the simulation procedures to overestimate investment requirements, a spreading of the peak is simulated through the reduction in the percent of future daily travel that is expected to occur during the peak periods.

Revised Highway Capacity Calculations. The model-based results were adjusted to reflect the latest edition of the Highway Capacity Manual (HCM). The revised HCM includes new procedures to calculate capacity for several types of highways, especially freeways and other multilane highways. The new procedures are based on research indicating that a larger number of vehicles per lane per hour are now being accommodated than in the past. In other words, drivers are accepting shorter headways between vehicles at higher speeds than was formerly the case.

Transportation System Management. Where appropriate, capacity enhancements other than constructing additional lanes are simulated. Freeway surveillance and control, High Occupancy Vehicle facilities, ramp metering, incident management, signalization improvements, traffic channelization, and restriping the existing pavement are the major features chosen to represent capacity enhancement. The impact of implementing an aggressive TSM program was estimated and translated into lane-miles not required.

Conclusions. The application and impact of these adjustments is presented in Exhibit 5-7. Without the above adjustments, almost 188,000 new lane miles would have been required to satisfy anticipated travel growth under the **Cost to Maintain** scenario. **After reducing travel growth, simulating peak spreading, applying the new capacity calculations, and accounting for TSM, the number of lane-miles required decreased by slightly over 40 percent. A similar percentage reduction was observed after these adjustments were made to the HERS-based Economic Efficiency analysis.**

Exhibit 5-7
Application of Model Adjustments
AP-Based Cost to Maintain Urban Lane-Mile Requirements



Report Coverage: Additional Investment Requirements

In recent years, supplementary procedures have been developed to augment the model results, thereby expanding the report coverage. These investment requirements are estimated using supplemental analysis procedures and other sources of data. The HPMS database supports analysis on the **existing** arterial and most of the collector systems.

Metropolitan Expansion Requirements. To incorporate the basic infrastructure requirements in expanding suburban areas, a procedure was developed to translate the expected population growth in and around urbanized areas into basic network infrastructure, separate from estimates for increased demand on existing facilities. Incremental metropolitan expansion requirements are estimated at $8.5 billion per year.

Local Roads. The HPMS database does not contain condition and performance information for the approximately 2.7 million miles of roads functionally classified as local. However, the results of additional analysis to estimate future local road capital requirements for **existing** local roads are added to the model-based investment requirements. New local road and subdivision road construction is included under the Metropolitan Expansion Requirements above. Local road investment requirements are estimated at $1.0 billion per year.

Defense Highways. The military relies on the highway system for peacetime movement of military shipments, as well as for wartime or emergency mobilization and deployment of military units. For these purposes, a subset of Interstate and other principal arterial systems has been accorded certain design specifications in order to accommodate large and heavy military vehicles. Capital requirements necessary to achieve these specifications, above and beyond what would normally be required to accommodate nonmilitary traffic, are estimated at $30 million annually.

Rural Minor Collectors. In their HPMS submittal, the States are no longer required to provide information on rural minor collectors. In the case of the AP-based **Cost to Maintain** investment requirement estimates, the corresponding 1992 through 2011 investment requirements were factored for inflation by applying the FHWA Bid Price Index and added to the model results.

The HERS-based **Economic Efficiency** analysis used rural minor collector data from the 1992 HPMS database. In other words, the HERS input data included rural minor collector data from the 1992 submittal and all other functional classes (except local) from the 1993 submittal.

Future potential infrastructure requirements that might reflect major new Federal or State program initiatives, such as intercity high speed rail, or new highway and bridges needed to support continental demands associated with enhanced Canadian/U.S./Mexican economic interaction, have not been considered.

Investment Scenarios

Cost to Maintain Conditions Performance

The average annual **Cost to Maintain** overall 1993 highway conditions and performance on existing arterial, collector and local systems through 2013 is estimated at $49.7 billion.

Under this strategy, the conditions and performance of some roads would improve and some would deteriorate. In general, however, the system would stay about the same. The overall backlog of highway deficiencies would remain essentially constant over the 20-year analysis period. Some backlog deficiencies would be remedied depending on how cost-effective the repairs would be compared to other accruing problems.

Exhibit 5-8 shows investment required under this scenario for each functional system of highway. The exhibit shows total 20-year investment requirements categorized as system preservation and capacity improvements, and gives annualized totals. The annualized total is the 20-year total divided equally.

Exhibit 5-8
Cost to Maintain 1993 Highway Conditions and Performance
Investment Requirements
2.15% Compound Annual Growth
Billions of 1993 Dollars
1994-2013

Functional System	Total 20-Year Investment Requirement: Capacity	System Preservation	Total Capacity and System Preservation	Annualized Total
Rural				
Interstate	$21.6	$34.2	$55.8	**$2.8**
Other Principal Arterial	$14.0	$36.9	$50.9	**$2.5**
Minor Arterial	$11.1	$40.3	$51.4	**$2.6**
Major Collector	$8.4	$83.6	$92.0	**$4.6**
Minor Collector	$1.2	$38.9	$40.1	**$2.0**
Local	$0.0	$10.0	$10.0	**$0.5**
Subtotal	$56.3	$243.9	$300.2	**$15.0**
Urban				
Interstate	$97.9	$48.9	$146.8	**$7.3**
Other Freeway and Expressway	$41.7	$20.9	$62.6	**$3.1**
Other Principal Arterial	$98.0	$63.0	$161.0	**$8.1**
Minor Arterial	$86.9	$58.7	$145.6	**$7.3**
Collector	$44.0	$47.1	$91.1	**$4.6**
Local	$76.8	$10.3	$87.1	**$4.4**
Subtotal	$445.3	$248.9	$694.2	**$34.7**
Total Rural and Urban	$501.6	$492.8	$994.4	**$49.7**

Under this scenario, over two-thirds of total investment would occur in urban areas. Capacity improvements would account for 67 percent of urban investment and about half of total investment. Over two-thirds of the total **Cost to Maintain** investment would be directed to the arterial system. Somewhat over half of the $33.7 billion annual arterial requirement is intended to correct capacity deficiencies.

Exhibit 5-9 shows current and future lane-miles of highway facilities by functional system in both rural and urban areas. The added lane-mile values are shown in two columns: lane-mile requirements for normal-cost capacity expansion and lane-mile requirements for higher-cost capacity. Thirteen percent of urban lane-mile additions are at high cost.

Exhibit 5-9
Cost to Maintain 1993 Highway Conditions and Performance Scenario
Lane-Mile Requirements
1994-2013

Functional System	1993 Current Lane-Miles	Additional Capacity Lane-Miles: Standard Cost	High Cost	Total	Total Lane-Miles Required
Rural					
Interstate	132,239	42,600		42,600	174,839
Other Principal Arterial	238,035	17,381		17,381	255,416
Minor Arterial	286,586	15,741		15,741	302,327
Major Collector	870,689	17,564		17,564	888,253
Minor Collector	564,722	3,806		3,806	568,528
Local	4,239,652				4,239,652
Subtotal	6,331,923	97,092		97,092	6,429,015
Urban					
Interstate	69,135	20,932	8,298	29,230	98,365
Other Freeway and Expressway	39,915	8,712	4,380	13,092	53,007
Other Principal Arterial	176,325	25,134	20,247	45,381	221,706
Minor Arterial	216,233	30,665	18,434	49,099	265,332
Collector	181,035	14,534	10,847	25,381	206,416
Local	1,114,616	300,000		300,000	1,414,616
Subtotal	1,797,259	399,977	62,206	462,183	2,259,442
Total Rural and Urban	8,129,182	497,069	62,206	559,275	8,688,457

The high cost lane-mile additions reflect the fact that growth in travel is rapidly overwhelming available highway capacity. To accommodate capacity demands, States may employ strategies beyond the simple addition of lanes to existing facilities within existing rights-of-ways. They may construct highways on new, often parallel alignments, within corridors and/or enhance capacity on existing roads through grade-separation structures (elevated or depressed sections) or via acquisition of more costly rights-of-way.

High cost additions increase costs up to 40 percent above the normal costs, adding an average increment of $1 million to the $1.4 million to $3.7 million per lane-mile range for "average" facility expansion.

Under this scenario, the total number of rural and urban lane-miles would increase by about 7 percent, almost 28,000 lane-miles per year. Urban capacity would increase by one-quarter. Part of this increase is the result of the recent reclassification of generally congested facilities from rural to urban. The largest contribution of the projected increase (63 percent) is the requirement for facilities to support metropolitan expansion, which is mostly local lane-miles.

Lane-miles on the urban and rural arterial system would increase by 18 percent, or 10,626 lane-miles added per year. Sixty-four percent of this increase would take place on urban systems. Interstate capacity would expand by 36 percent, or 3,600 lane-miles annually.

Under the **Cost to Maintain** scenario, the miles of roadway in poor or mediocre condition would remain essentially unchanged over the 20-year analysis period. System performance would be maintained at its current level on most rural and many urban miles. This means that about 70 percent of peak-hour travel on the urban Interstate system would continue to experience Level of Service (LOS) D or worse. See Chapter 4 for an explanation of the "LOS" concept.

Economic Efficiency

Similar to the traditional, AP-based **Cost to Improve** scenario, the **Economic Efficiency** strategy assumes the availability of sufficient funding necessary to implement all worthwhile projects. It represents—given the assumptions underlying the analysis—the upper limit of worthwhile highway spending.

Under this scenario, any investment which creates positive net benefits is considered worthwhile. (Alternative uses of the funds in the rest of the economy were considered in selecting the discount rate.) This scenario resulted in an average BCR of greater than 2.6. Some improvements resulted in BCRs significantly higher than 2.6 and some were lower; no improvement was implemented that had a BCR of less than 1.0. However, the reader should remember that the model has a number of limitations, including not reflecting external costs, which were discussed earlier.

Exhibit 5-10 shows highway investment requirements associated with the **Economic Efficiency** scenario, for the period 1994 through 2013. The Exhibit shows total 20-year investment requirements categorized as pavement and capacity improvements, and gives annualized totals. The annualized total is the 20-year total divided equally.

Exhibit 5-10
Economic Efficiency Scenario
Investment Requirements
2.15% Compound Annual Growth
Billions of 1993 Dollars
1994-2013

	Total 20-Year Investment Requirement			
Functional System	**Capacity**	**System Preservation**	**Total Capacity and System Preservation**	**Annualized Total**
Rural				
Interstate	$26.8	$34.9	$61.7	**$3.1**
Other Principal Arterial	$22.2	$60.7	$82.9	**$4.1**
Minor Arterial	$15.1	$61.1	$76.2	**$3.8**
Major Collector	$7.0	$123.5	$130.5	**$6.5**
Minor Collector	$0.0	$56.5	$56.5	**$2.8**
Local	$0.0	$14.3	$14.3	**$0.7**
Subtotal	$71.1	$351.0	$422.1	**$21.1**
Urban				
Interstate	$129.9	$58.7	$188.6	**$9.4**
Other Freeway and Expressway	$62.8	$29.5	$92.3	**$4.6**
Other Principal Arterial	$131.2	$82.9	$214.1	**$10.7**
Minor Arterial	$97.6	$91.6	$189.2	**$9.5**
Collector	$37.8	$70.5	$108.3	**$5.4**
Local	$76.8	$10.3	$87.1	**$4.4**
Subtotal	$536.1	$343.5	$879.6	**$44.0**
Total Rural and Urban	$607.2	$694.5	$1,301.7	**$65.1**

Under this scenario, approximately 67 percent of total investment would occur in urban areas. Capacity improvements would account for over 60 percent of urban investment, and almost half of total investment. Seventy percent of the total **Economic Efficiency** investment would be focused on the arterial system. Over half the $45.2 billion annual arterial requirement would correct capacity deficiencies; however, less than one-third of rural requirements would be for capacity improvements.

Exhibit 5-11 shows the current and future number of lane-miles of highway facilities by functional system in both rural and urban areas under this investment scenario. The added lane-mile values are shown in two columns: lane-mile requirements for normal-cost capacity expansion and lane-mile requirements for higher cost capacity. Eleven percent of the added lane-miles in urban areas would be at high cost.

Exhibit 5-11
Economic Efficiency Scenario
Lane-Mile Requirements
1994-2013

Functional System	1993 Current Lane-Miles	Additional Capacity Lane-Miles: Standard Cost	High Cost	Total	Total Lane-Miles Required
Rural					
Interstate	132,239	47,294		47,294	179,533
Other Principal Arterial	238,035	34,255		34,255	272,290
Minor Arterial	286,586	21,321		21,321	307,907
Major Collector	870,689	13,173		13,173	883,862
Minor Collector	564,722	1,847		1,847	566,569
Local	4,239,652				4,239,652
Subtotal	6,331,923	117,890		117,890	6,449,813
Urban					
Interstate	69,135	30,521	8,752	39,273	108,408
Other Freeway and Expressway	39,915	14,220	5,081	19,301	59,216
Other Principal Arterial	176,325	44,294	18,947	63,241	239,566
Minor Arterial	216,233	37,579	15,973	53,552	269,785
Collector	181,035	14,655	7,033	21,688	202,723
Local	1,114,616	300,000		300,000	1,414,616
Subtotal	1,797,259	441,269	55,786	497,055	2,294,314
Total Rural and Urban	8,129,182	559,159	55,786	614,945	8,744,127

Lane-miles on the urban and rural arterial system would increase by 24 percent, or almost 14,000 lane-miles annually. Sixty-three percent of this increase would take place on urban systems. Interstate capacity would expand by 42 percent, or 4,330 lane-miles per year. Because of social and environmental concerns, these capacity increases may not be feasible.

If the **Economic Efficiency** scenario were implemented, most highly congested conditions could be eliminated. However, this scenario does not imply system perfection. Conditions and performance would be superior to today's, but pavements would not be "like new" nor would traffic be free flowing on all systems. In fact, some lower volume roads would experience disinvestment.

Economic Analysis Issues

The introduction of economics into investment analysis brings a unique set of analytical challenges. As noted earlier, a number of important issues regarding the HERS procedure need to be considered when interpreting the **Economic Efficiency** scenario results as well as addressed in future research initiatives. Some of the more critical issues are discussed in the final section of this chapter.

BRIDGE INVESTMENT REQUIREMENTS

Cost to Maintain Conditions

The average annual **Cost to Maintain** overall 1994 bridge conditions is estimated at $5.1 billion through 2013. This investment level would maintain the current total number of structurally deficient and functionally obsolete bridges. Exhibit 5-12 summarizes the **Cost to Maintain** bridge conditions investment requirements. All bridges 20 feet in length or greater, including those on local roads, are considered.

The bridge investment/performance procedure does not, at this time, incorporate explicit economic considerations into the analytical framework. Appendix C provides more detail on the methodology used to develop the investment levels required to maintain or improve bridge conditions.

Exhibit 5-12
Cost to Maintain Bridge Conditions
Billions of 1993 Dollars
1994-2013

Functional System	Number of Repaired or Replaced Bridges	1994 - 2013 Investment Required	Annualized Requirements
Rural			
Interstate	11,035	$9.0	**$0.4**
Other Principal Arterial	8,102	$5.4	**$0.3**
Minor Arterial	2,569	$1.8	**$0.1**
Major Collector	2,310	$0.8	**$0.0**
Minor Collector	24,972	$3.2	**$0.2**
Local	95,515	$9.1	**$0.5**
Subtotal	144,503	$29.3	**$1.5**
Urban			
Interstate	28,063	$40.0	**$2.0**
Other Freeway and Expressway	8,098	$10.8	**$0.5**
Other Principal Arterial	10,248	$13.7	**$0.7**
Minor Arterial	3,829	$3.7	**$0.2**
Collector	962	$0.7	**$0.0**
Local	8,091	$2.9	**$0.1**
Subtotal	59,291	$71.8	**$3.6**
Total Rural and Urban	203,794	$101.1	**$5.1**

Cost to Improve Conditions

The **Cost to Improve** bridge conditions scenario supports improved conditions for both urban and rural bridges across all functional systems on a uniform basis nationwide. This scenario provides cost estimates for achieving and maintaining predefined Minimum Condition Standards (MCSs) for physical conditions on bridges that are currently deficient or expected to become deficient at some point during the 1994 through 2013 analysis period. Since all deficiencies present at the beginning of the analysis period would be eliminated, this scenario represents a significant improvement in nationwide bridge conditions.

As indicated earlier, the modelling procedure used to develop the investment estimates for this scenario does not employ economic considerations in the evaluation of potential improvements.

Exhibit 5-13 summarizes 1994 through 2013 investment requirements to eliminate all backlog and accruing bridge deficiencies for all bridges 20 feet or greater in length, including those on local roads. The **Cost to Improve** bridge conditions for the period 1994 through 2013 is $8.9 billion annually.

Between 25 percent (Interstate) and 70 percent (local) of bridge deficiencies are attributable to structural deficiencies. If bridge structural deficiencies are not identified and repaired in timely fashion, further deterioration could require major rehabilitation or bridge replacement. These actions cost significantly more than highway repair on a unit-cost basis. In addition, deferred investment on deficient bridges may impose public safety hazards more dangerous than the risks of deferred highway improvement.

Exhibit 5-13
Cost to Improve Bridge Conditions
Billions of 1993 Dollars
1994-2013

Functional System	Number of Repaired or Replaced Bridges	1994 - 2013 Investment Required	Annualized Requirements
Rural			
Interstate	29,511	$18.2	**$0.9**
Other Principal Arterial	23,977	$11.9	**$0.6**
Minor Arterial	24,641	$8.3	**$0.4**
Major Collector	58,156	$9.7	**$0.5**
Minor Collector	33,648	$3.4	**$0.2**
Local	147,553	$11.0	**$0.6**
Subtotal	317,486	$62.5	**$3.1**
Urban			
Interstate	47,908	$56.4	**$2.8**
Other Freeway and Expressway	20,987	$19.0	**$0.9**
Other Principal Arterial	24,674	$22.9	**$1.1**
Minor Arterial	17,133	$9.7	**$0.5**
Collector	11,818	$4.0	**$0.2**
Local	15,819	$4.5	**$0.2**
Subtotal	138,339	$116.5	**$5.8**
Total Rural and Urban	455,825	$179.0	**$8.9**

Transit Investment Requirements

This section provides estimates of the **Cost to Maintain** transit 1993 conditions and performance as well as the **Cost to Improve** transit conditions and performance. A detailed discussion of the methodology used to produce these estimates may be found at Appendix D.

Cost to Maintain Conditions and Performance

The average annual **Cost to Maintain** current transit conditions and performance is estimated at $7.9 billion. This is the investment required to maintain facilities and equipment in their current state of repair and includes the cost of expanding transit service to meet the transit travel demand increase forecasted by the MPOs. At this level of investment, the amount of transit service provided would increase at an annual rate of 2.4 percent per year. In 20 years, this would result in a capacity increase of 60 percent, raising the total amount of transit service from the present 175 million revenue-vehicle-hours to about 280 million revenue-vehicle hours. This increase in capacity would accommodate an increase in passenger-miles carried from the present 36 billion to about 58 billion.

At this level of investment, transit vehicles would be replaced at about the current rate, which is slightly slower than what is generally regarded as optimal. Existing rail systems would be maintained in about their current condition, with no major improvements. Investments on existing rail systems would occur at about the rate required to ensure that equipment and facilities are replaced as they wear out. Transit operators would meet the requirements of the ADA and the CAAAs.

Exhibit 5-14 provides detailed estimates of investment required to maintain transit condition and performance for each of the major types of service provided.

Exhibit 5-14
Cost to Maintain Transit Conditions and Performance, Annual Average
Millions of 1993 Dollars
1994-2013

Mode and Type of Facility	Cost to Maintain Current Conditions	Cost to Maintain Performance	Total
Areas Over 1 Million			
Bus			
Vehicles (Replacement and Rehabilitation)	$789		
Maintenance and Other Facilities	$649		
Americans with Disabilities Act (ADA) Costs	$70		
Clean Air Act Costs	$125		
Section 16 Vehicles and Facilities	$48		
Subtotal Bus	$1,681	$775	$2,457
Rail			
Vehicles (Replacement and Rehabilitation)	$1,405	$168	$1,574
Maintenance and Other Facilities	$846		$846
ADA Costs	$100		$100
New Rail	$0	$1,624	$1,624
Subtotal Rail	$2,351	$1,793	$4,144
Total Areas Over 1 Million	$4,032	$2,568	$6,601
Areas Under 1 Million			
Bus			
Vehicles (Replacement and Rehabilitation)	$316		
Maintenance and Other Facilities	$264		
ADA Costs	$42		
Clean Air Act Costs			
Section 16 Vehicles and Facilities	$271		
Section 18 Vehicles and Facilities	$159		
Subtotal Bus	$1,052	$174	$1,226
Rail			
Vehicles (Replacement and Rehabilitation)	$6		
Maintenance and Other Facilities	$0		
New Rail	$0	$53	
Total Rail	$6	$53	$59
Total Areas Over 1 Million	$1,058	$227	$1,285
Total	$5,091	$2,795	$7,886

Chapter 2 describes the multiple functions performed by transit services. While the estimates of investment requirements made in this report were developed using a method that focuses on the transit facilities and equipment, rather than services, it is possible to estimate investment requirements on the basis of the three transit functions described in Chapter 2.

Exhibit 5-15 presents these requirements which are based on the estimates made earlier on the basis of mode and location. Note that because the transit functions overlap, the total of the estimates made for each function sum to more than the overall estimate reported above.

Exhibit 5-15
Cost to Maintain Conditions and Performance by Transit Function
Millions of 1993 Dollars
1994-2013

	Livable Metropolitan Areas	**Low-Cost Basic Mobility**	**Congestion Management**
Maintain Conditions	$3,298	$1,706	$2,212
Maintain Performance	$1,560	$658	$1,363
Total to Maintain Conditions and Performance	$4,859	$2,364	$3,575

Cost to Improve Conditions and Performance

The **Cost to Improve** transit conditions and performance is estimated at $257 billion for the period 1994 through 2013. This would require an annual investment of $12.9 billion and would eliminate the backlog of investment over the 20-year analysis period. Of these amounts, $7.9 billion represents the **Cost to Maintain** current conditions and performance, $2.0 billion to retire the backlog, and $3.0 billion to improve transit service levels in terms of system speed and comfort and convenience. These estimates reflect investment requirements imposed by the CAAA and the ADA. Exhibit 5-16 summarizes the transit **Cost to Improve** conditions and performance.

Exhibit 5-16
Cost to Improve Transit Conditions and Performance, Annual Average
2.4% Compound Annual Travel Growth
Millions of 1993 Dollars
1994-2013

Mode and Type of Facility	Cost to Maintain Conditions and Performance	Incremental Cost to Improve Conditions	Incremental Cost to Improve Performance	Total
Areas Over 1 Million				
Bus				
Vehicle Replacement and Rehabilitation		$260		
Maintenance and Other Facilities		$363		
Section 16 Vehicles and Facilities		$12		
Subtotal Bus	$2,457	$635	$61	$3,154
Rail				
Facilities		$308		
Vehicles		$696	$534	
New Rail			$2,137	
Subtotal Rail	$4,144	$1,004	$2,671	$7,818
Total Areas Over 1 Million	$6,600	$1,639	$2,733	$10,973
Areas Under 1 Million				
Bus				
Vehicles Replacement and Rehabilitation		$102		
Maintenance and Other Facilities		$151		
Section 16 Vehicles and Facilities		$70		
Section 18 Vehicles and Facilities		$40	$26	
Subtotal Bus	$1,226	$363	$152	$1,742
Rail				
Facilities				
Vehicles		$2		
New Rail			$90	
Subtotal Rail	$59	$2	$90	$151
Total Areas Under 1 Million	$1,285	$366	$242	$1,892
Total Bus All Areas	$3,683	$999	$214	$4,895
Total Rail All Areas	$4,203	$1,006	$2,761	$7,970
Total All Areas	$7,886	$2,005	$2,975	$12,865

At this investment level, transit services will increase over a 20-year period to about 364 million revenue-vehicle-hours per year, still providing capacity to accommodate about 58 billion passenger miles per year, compared with 36 billion passenger-miles today, but at a substantially higher level of service than under the **Cost to Maintain** scenario. Sufficient capacity would be available to provide transit patrons with seats for all but those trips occurring at the peak of rush hours. In addition, wait times and the need to transfer would be reduced. Finally, the backlog of deferred rail and bus modernization and rehabilitation requirements would be eliminated, restoring those systems to good condition and bringing them up to modern transit standards.

Exhibit 5-17 provides the **Cost to Improve** investment requirements on the basis of the three transit functions described in Chapter 2, compared with the estimates made earlier on the basis of mode and location. Again, note that because the transit functions overlap, the total of the estimates made for each function add to more than the overall estimate reported above.

Exhibit 5-17
Cost to Improve Transit Conditions and Performance by Function
Millions of 1993 Dollars
1994-2013

	Livable Metropolitan Areas	**Low-Cost Basic Mobility**	**Congestion Management**
Total to Maintain Conditions and Performance	$4,858	$2,364	$3,575
Incremental Cost to Improve Conditions	$1,338	$1,408	$1,372
Incremental Cost to Improve Performance	$1,810	$708	$1,443
Total to Improve Conditions and Performance	$8,006	$4,480	$6,390

The implications for the size of the transit fleet are displayed in Exhibit 5-18.

Exhibit 5-18
Urban Transit Fleet Requirements
Cost to Maintain and Cost to Improve Scenarios
Millions of 1993 Dollars
1994-2013

	1993 Current Fleet	Cost to Maintain Fleet	Cost to Improve Fleet
Areas Over 1 Million			
Rail	16,520	22,672	36,493
Bus	48,760	90,933	94,301
Areas Under 1 Million			
Rail	66	210	467
Bus	22,099	33,169	41,224

As transit service levels would increase 107 percent under this scenario, the cost to operate transit would also increase. It is estimated that total operating costs would increase from the present $16 billion per year to $30 billion per year by 2013 under the **Cost to Improve** scenario.

COMPARISON OF 1994 INVESTMENT REQUIREMENTS WITH 1993 CAPITAL EXPENDITURES

Investment estimates in this chapter are reported on a 20-year basis. To provide linkage between these 20-year investment estimates and the consideration of actual current year budget options, this section offers a comparison of investment requirements and actual recent capital outlays by all units of government for highways, bridges, and transit capital improvements.

Because of projected increases in highway and transit travel over the 20-year analysis period, the investment requirement estimate for any given year (except the midpoint) will be different than the average annual investment requirement. Investment required for capacity expansion to maintain or improve system performance is assumed to grow at a rate equal to the rate of travel growth. Therefore, the investment required each year during the first 10 years of the analysis period will be lower than the average annual and the investment required for each year during the second half of the analysis period will be higher than the average annual. Indeed the 1994 investment requirement estimates reported below are lower than the average annual investment required provided earlier in this chapter (see Exhibits 5-8, 5-10, 5-14, and 5-16).

Certain types of economic development improvements made by States are not simulated in this report, and have been removed to simplify comparison. This adjustment is presented in further detail on pages 92 and 93. The 1993 capital outlay estimates presented below represent outlay comparable to the investment requirements provided in this report.

Exhibit 5-19 shows 1994 investment requirements with actual 1993 capital outlay. All units of government are assumed to provide the current capital outlay referenced as well as to potentially provide the projected investment requirements. In 1993, the Federal government provided 44 percent of highway and bridge capital outlay and 42 percent of funds used for transit capital investment.

Exhibit 5-19
1994 Investment Required for Highways, Bridges, and Transit Systems versus 1993 Capital Outlay*
Millions of Dollars

All Systems (Includes Local)

Highway	1994 Cost to Maintain			1994 Economic Efficiency			1993 Capital Outlay*
	Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total	
	$20.2	$24.6	$44.8	$24.6	$34.7	$59.3	$28.8

Bridge	1994 Cost to Maintain			1994 Cost to Improve			1993 Capital Outlay*
	Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total	
	-	$5.1	$5.1	-	$8.9	$8.9	$6.0

Transit	1994 Cost to Maintain			1994 Cost to Improve			1993 Capital Outlay*
	Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total	
	$2.2	$5.1	$7.3	$4.7	$7.1	$11.8	$5.7

*Capital outlay related to capital investment requirements.

ECONOMIC ANALYSIS ISSUES

The objective of BCA, as applied to highway investment programming decisions, is to assure that the improvements implemented will result in a net gain in social welfare. However, the straightforward BCA decision rule--invest only when benefits exceed costs--is difficult to operationalize.

Individuals and firms assess the benefits of highway travel and determine if they are willing to pay the "price." Because all budgets are finite, purchasing highway travel means foregoing another good or service. The value of any given travel benefit is equal to the value of the other benefits foregone by the user. This concept, "willingness to pay," is central to measuring benefits and costs in BCA.

The integrity of the BCA evaluation, then, depends on:

all the relevant benefits and costs being considered, but not double counted;

the magnitude of the benefits and costs being accurately quantified; and

the benefits and costs being correctly monetized or valued.

The following discussion outlines some of the more significant technical issues involved in applying BCA in the context of the HERS analysis.

Inclusion of Relevant Benefits and Costs

Identifying the relevant benefits and costs and assuring that their impacts are counted once, but not double counted is difficult to accomplish. This difficulty relates to the multi-dimensional nature of highway travel. The demand for highway transportation is derived: individuals and firms do not generally buy transportation as an end in itself. Rather, transportation is purchased to accomplish a business or personal objective.

Improvements in system condition may bring immediate, and direct, savings to private and commercial highway users in the form of reduced travel time requirements, lower energy consumption (fuel and oil), longer vehicle lives, fewer injuries and fatalities and reduced inventory costs.

As individuals and firms adjust to the direct savings, **indirect or long-term**, impacts will accrue. For example, some of the direct savings will be translated into improved productivity as firms restructure their operations to take advantage of system reliability, lower land rents, expanded markets and so on.

Another major class of impacts (generally disbenefits) are externalities. Examples include: noise, air quality, water pollution, excess runoff, aesthetics, danger to pedestrians and loss of wetlands. These represent real social gains or losses and should be considered in BCA.

The HERS model considers the major direct user and agency benefits associated with highway improvements. In the HERS, "cost" refers to the initial capital expenditure required to implement the improvement.

While the benefits and costs included in the current version of HERS constitute the major impacts of highway improvements, the HERS accounting is not comprehensive. In addition to other, most probably lesser impacts (such as reduced driving stress derived from improved conditions and performance), two potentially very significant categories are not considered: externalities and productivity improvements arising from industrial restructuring.

Productivity Improvements

Many beneficial **indirect economic impacts** resulting from the reduction in highway user costs may be observed throughout the economy. Highway improvements reduce the transportation component of production costs, allow retailers to expand their markets, and provide individuals greater choice in determining where they live, work, shop and vacation. Indirect impacts may also include changes in land values. Some land will become more attractive; some will be less.

In general, these indirect benefits/disbenefits result from a **transfer** of the direct highway user benefits to other parties. As such, they cannot be counted as additional benefits. For example, firms may choose to use their savings in direct highway user costs to invest in manufacturing improvements. Of course, the direct benefits are far easier to capture and therefore are of more use in BCA.

Traditional economic thinking indicates that indirect benefits are equal to the direct benefits. However, recent work by a number of researchers seems to indicate that the complex indirect effects may not be captured in the conventional demand forecasts. For example, some firms may expand their output as they restructure their logistical operations because of lower transportation costs and/or improved system predictability.

If "real" (as opposed to pecuniary) benefits can be demonstrated they should be included as benefits; in the case of industrial restructuring, such benefits would be long-term. Much research is needed in this area.

Externalities

The construction of highways and the consumption of VMT may unintentionally impact third parties that did not participate in the decision to use the road or build the highway. These costs, referred to as "externalities," are generally negative and include environmental and social impacts.

To ensure that the willingness-to-pay decision is properly considered, the cost of externalities should be internalized; the decisions which potentially create the externalities would weigh the cost of the impacts. The issue of costs being internalized is important because the price that a road user is willing to pay is not necessarily the same as the cost. If all costs were internalized, the price would increase, and the parameters of the willingness to pay decision would change. The result would be a decrease in demand.

For investment analysis, estimates of the cost of negative externalities can be included by subtracting them from benefits, or regulatory constraints can be imposed to restrict or eliminate the externalities. In fact, the requirement that there be no net loss of wetlands or parklands means that wetland mitigation should be included in the initial cost of the improvement.

Because of the great interest in the impact of changes in emissions on the HERS analysis, FHWA commissioned an informal study to estimate the probable outcome of including emissions impacts in the model framework. Specifically, the study evaluated the economic costs of pollution that might result from a selected group of highway capacity expansion projects. The analysis included the costs associated with emissions of NOx and VOCs, but not other air pollutants. NOx and VOCs account for a significant share of total pollution costs.

When the emissions impacts were factored into the average HERS BCR for the capacity improvements of interest, the average BCR changed by less than plus or minus 10 percent, depending on assumptions regarding the magnitude of increased travel. The incremental pollution costs analyzed in this study were found to be very small when compared with the other costs and benefits estimated by the HERS model.

A major consideration in calculating the air pollution impact of a given highway improvement is the magnitude of induced travel (see following discussion on Inelastic Demand) resulting from the improvement. The analysis was conducted under two alternative assumptions: 1) VMT would increase by 17 percent and 2) VMT would increase 50 percent.

Under the 17 percent VMT increase assumption, highway widening allows for substantially higher speeds, increasing NOx emissions per mile slightly, but significantly reducing VOC emissions per mile. Therefore, pollution costs decreased as a result of implementing the projects analyzed. Although traffic increased, pollution costs per mile fell, and the net result was a reduction in pollution cost. Recalculating the average BCR to include emissions impacts generated from the capacity improvements caused benefits to increase slightly. When VMT increased 50 percent, the average BCR declined.

The analysis was conservative in that, while induced travel was estimated, the emissions impact was calculated for the additional increment of estimated VMT resulting from the improvements but the benefits accruing from these "new trips" were not factored into the revised BCR.

A significant source of uncertainty characterizing the analysis relates to the fact that emission effects vary widely with region and time of year. As a result, any nationwide or even regional analysis will not be particularly accurate, unless it is based on site-specific analyses.

There are a number of social costs, in addition to vehicle emissions, that are associated with increased highway investment and increased VMT. These costs, such as neighborhood disruption, highway noise, delays and detouring of traffic during highway construction, etc., may represent significant added costs that in combination can create formidable opposition to new highway construction or capacity expansion. If these additional social costs could be measured and monetized they would reduce the BCR of many of the investments estimated by the HERS analysis and the overall level of economically efficient highway improvements.

Inefficient Pricing of Facilities

Because highways (and transportation in general) are not efficiently priced, highway users do not consider the marginal costs--increased travel times--they impose on all other drivers using the facility. Congestion may be viewed as an externality. As with other externalities, the goal is to internalize the cost so that willingness to pay decisions will reflect the true price.

As noted earlier, to achieve the reduction in travel growth rates implied by the MPO forecasts, significant demand shaping policies will need to be implemented. It is unlikely that travel trends will be reversed without widespread congestion pricing.

Therefore, although congestion pricing is not assumed to be applied to specific sections as would be ideal (e.g., sections with Volume/Service Flow ratios exceeding 0.95), the reduced travel growth rates underlying the analysis of the highway requirements could be assumed to reflect a nationwide congestion pricing strategy. The fundamental impact of increasing the price to users is a reduction in VMT.

It is important to note that congestion pricing will reduce (or postpone) the requirement for expanded capacity, but will not eliminate the need for additional capacity.

Inelastic Demand

The volume of travel on a facility is one of the most important factors in quantifying the improvement impacts of interest. The relationship between price, facility characteristics, and demand is dynamic: For any given highway segment, as price is reduced (e.g., conditions and performance are improved), the quantity consumed (e.g., VMT) will increase. Trips will be diverted from other highway facilities, or modes, and previous users will make more trips. Induced travel brings additional benefits; it occurs because consumers perceive a benefit they are willing to pay for (the improved travel characteristics). However, the increased VMT will reduce the benefits that would have accrued to the base users in the absence of the increase in VMT.

As indicated earlier, the HERS model uses travel forecasts as coded for each section in the HPMS database. Changes in VMT are invariant with respect to changes in the cost of travel. Therefore, HERS is not able to measure the additional effects resulting from induced travel.

Value of Travel Time

One of the most significant benefits associated with many highway improvements is travel time savings. Although much research has been conducted in this area, there is still disagreement on the proper values that should be applied to the various types of travel: commercial, commuting to work and personal. In the case of travel time, as well as other benefits/ disbenefits (such as externalities), monetizing the benefits and costs is complicated by the fact that not all costs and benefits are traded in normal markets.

Limited sensitivity analysis of the model results to critical assumptions such as the value of travel time has been completed. In HERS, travel time benefits typically account for roughly 50 percent of total benefits. As a result, model conclusions could be significantly influenced, especially in the case of a constrained funding scenario where BCRs are ranked and improvements are selected accordingly.

However, in the case of the **Economic Efficiency** scenario, where all improvements with BCRs greater than 1 are selected, changes in assumptions regarding the value of travel time have a relatively small impact on total investment requirements indicated. The **average** BCR for the **Economic Efficiency** scenario exceeds 2.6. Even when personal travel time is valued at zero, the total investment level indicated under this scenario is only 13 percent lower than that reported, and the average BCR is reduced to 2.2. The impact is not as dramatic as might be expected because many capacity improvements are postponed but not eliminated. In other words, an improvement that would have been implemented during the first 5-year period will now be selected for implementation in, say, year 14 of the analysis.

Chapter 6

Waterborne Transportation

Chapter 6

INTRODUCTION

The material contained in this chapter is intended to provide a brief overview of the United States (U.S.) waterborne transportation system, its characteristics and performance, and the Federal role and interest in the system. The first section presents a description of the components of the system. Subsequent sections describe: the asset base and how it is being used; regulation, environment and port access; and the Federal role in terms of the relevant assistance programs and economic and national security aspects. The final section offers a sense of the magnitude of public and private investment in the maritime industry by providing compendium of the available industry investment figures and estimates of the amount of shipbuilding activity required to replace aging vessels and provide for trade growth.

The U.S. waterborne transportation system serves the needs of both international and domestic commerce. Much of the world merchant fleet is attracted to our shores because of the immense trading opportunities and cargo flows generated by the U.S. economy. The principal ship types employed in the system are tanker, dry bulk, containership, roll-on/roll-off (RO/RO) and cruise/passenger. In operational terms the international segments may be divided into three service types—liner (scheduled), non-liner (unscheduled dry cargo) and tanker.

The domestic trade portion of the waterborne system, known also as the "Jones Act" trade, is made up of inland waterways, Great Lakes and domestic ocean segments. The commercially navigable inland waterways extend 25,777 miles, some 11,000 of which are generally considered to be significant for domestic commerce. The principal components of the inland waterways are the Mississippi River and its tributaries, which include the Ohio, Illinois, Missouri, and Arkansas Rivers; the Gulf Intracoastal Waterway, and the Columbia-Snake River System. The Army Corps of Engineers owns or operates 273 lock chambers at 228 locations in support of the waterways. Operations on the waterways are primarily towboat and barge systems. The Great Lakes domestic segment includes shipments among U.S. Great Lakes ports and connecting waterways. The domestic ocean segment is comprised of the noncontiguous trades between the mainland and Alaska, Hawaii, Puerto Rico, Guam, Wake, and Midway Islands, and the coastwise trades along the Atlantic, Gulf, and Pacific coasts.

Ports are also a key component of the waterborne transportation network, serving as transfer points between surface and water transportation. Coastal and Great Lakes ports handle both domestic and foreign trade. Shallow-draft or inland waterway ports serve principally the domestic trades, although a significant volume of some foreign trade commodities does move between shallow-draft and coastal ports. Compared to the coastal port system, inland waterway ports are less concentrated geographically and provide almost limitless access points to the waterways.

The intermodal transportation system, that is the transport infrastructure required for the efficient movement of goods from origin to ultimate destination, involves the seamless movement of cargo among the modes using sophisticated vessels, terminals, inland delivery systems and information technology to meet shipper needs.

The U.S. shipbuilding industry, with its long history of commercial ship construction, is an integral part of the waterborne transportation system. This industry includes those shipyards which have been identified as the Major Shipbuilding and Repair Base for national defense purposes as being able to build, drydock and repair large vessels, as well as a multitude of second-tier shipyards which can build and repair small vessels.

Shipboard, shipyard and longshore labor support the various segments already described and are essential to ensure safety and efficiency in the movement of U.S. waterborne commerce. The labor segment also includes students in the officer training programs at the U.S. Merchant Marine Academy and the six state maritime academies, as well as those in the industry sponsored mariner training programs, which ensure that mariners have the necessary skills to operate today's high technology vessels and shipboard cargo handling equipment.

The nature of the federal interest in the waterborne merchant fleet is captured in the Declaration of Policy in the Merchant Marine Act, 1936, which states:

> *" ...the United States shall have a merchant marine (a) sufficient to carry its domestic waterborne commerce and a substantial portion of the waterborne export and import commerce of the United States and to provide shipping service essential to maintaining the flow of such domestic and foreign waterborne commerce at all times, (b) capable of serving as a naval and military auxiliary in time of war or national emergency, (c) owned and operated under the U.S. flag by citizens of the U.S. insofar as possible, (d) composed of the best equipped, safest and most suitable types of vessels, constructed in the U.S. and manned with trained, efficient citizen personnel, and (e) supplemented by efficient facilities for shipbuilding and ship repair."*

Section 8 of the Merchant Marine Act of 1920 clearly states the federal interest in "...developing port and transportation facilities in connection with water commerce."

The U.S. maritime industry plays an important role in both the global and domestic economy; it plays a critical role in meeting our national security requirements and contributing to economic growth. The industry has provided leadership and innovations which have improved the total transportation system and contributed to the international competitiveness of American industry. Creation and maintenance of a seamless global intermodal network provides significant economic benefit to producers and consumers alike.

As required by law, the Maritime Administration (MARAD) administers programs to aid in the development, promotion, and operation of a water transportation system to serve U.S. domestic and international trade and to provide a national defense transport capability. Financial assistance programs are administered to support the provision of essential services by U.S.-flag carriers and the construction of ships in U.S. shipyards. MARAD helps industry generate cargo for U.S. ships and conducts programs to promote development of efficient port facilities and intermodal transport systems, and promotes domestic shipping. MARAD is also charged with maintaining the National Defense Reserve Fleet and its component Ready Reserve Force (RRF), and with organizing and directing commercial marine transport operations in support of sealift during times of national emergencies.

Within the Federal Government, the Maritime Administration shares responsibility for waterborne transportation. The Coast Guard is primarily responsible for the safety and pollution prevention aspects of marine operations, which leads to technical system specifications, manning and operating standards and the maintenance of aids to navigation. The Army Corps of Engineers performs activities related to the design, planning, construction, operation and maintenance of river, harbor and waterway channels, locks and dams. The Saint Lawrence Seaway Development Corporation is responsible for the operation and promotion of that important link between the Great Lakes and the Atlantic Ocean; and the Federal Maritime Commission is generally responsible for the regulation of liner competition in the offshore domestic and U.S. international maritime sectors.

World and U.S. Fleets and Their Characteristics

The world merchant fleet of oceangoing vessels 1,000 gross tons and over, as of January 1, 1995, amounted to just over 25,000 vessels with a capacity, or deadweight tonnage (DWT) of 686 million. Only 15 nations have more than 10 million DWT of vessels registered under their flags, and together these 15 account for 75 percent of the world total. The 5 largest registry flags are Panama, Liberia, Greece, Cyprus and the Bahamas, accounting for 46 percent of the total world fleet. Of these, all but Greece are considered "open registries" in that there need not be a genuine link between the registry country and the nationality of the vessel owner. The United States ranks tenth in capacity with a total of 20 million DWT.

Exhibit 6-1 shows the twenty largest national merchant fleets in the world by major ship type: tankers, dry bulk, containerships, RO/RO and cruise/passenger ships.

Exhibit 6-1
Merchant Fleets of the World
Top 20 Flags by Ship Type
January 1, 1995

	Containerships		Dry Bulk		Tanker	
	Number	Deadweight Tonnage (thousands)	Number	Deadweight Tonnage (thousands)	Number	Deadweight Tonnage (thousands)
Panama	248	6,171	803	38,269	789	37,961
Liberia	128	3,551	450	28,224	651	59,523
Greece	33	705	470	23,444	272	27,361
Cyprus	81	1,274	561	22,336	155	9,576
Bahamas	41	906	132	7,492	240	20,569
Norway (NIS)	7	134	147	8,455	287	19,735
Japan	41	1,287	206	12,129	316	12,198
Malta	21	450	290	10,906	225	11,123
China	83	1,653	318	10,067	203	3,749
U.S	88	2,853	18	880	187	11,476
Singapore	70	1,495	97	5,550	241	9,221
Philipines	14	173	238	11,386	57	796
Hong Kong	28	695	120	10,717	23	1,339
Russia	37	476	85	2,854	196	3,439
India	5	102	118	4,644	81	4,453
S. Korea	53	1,368	118	6,458	85	1,170
Taiwan	81	2,482	54	4,621	18	1,634
Turkey	1	12	135	5,696	64	1,760
Brazil	12	237	65	3,910	87	4,031
Italy	15	432	39	2,833	224	4,355
Top 20	1,087	26,455	4,464	220,870	4,401	245,469
All Flags	1,591	38,868	5,291	250,472	5,994	297,141

Source: Lloyd's Register of Ships, January 1, 1995

Tanker Fleet

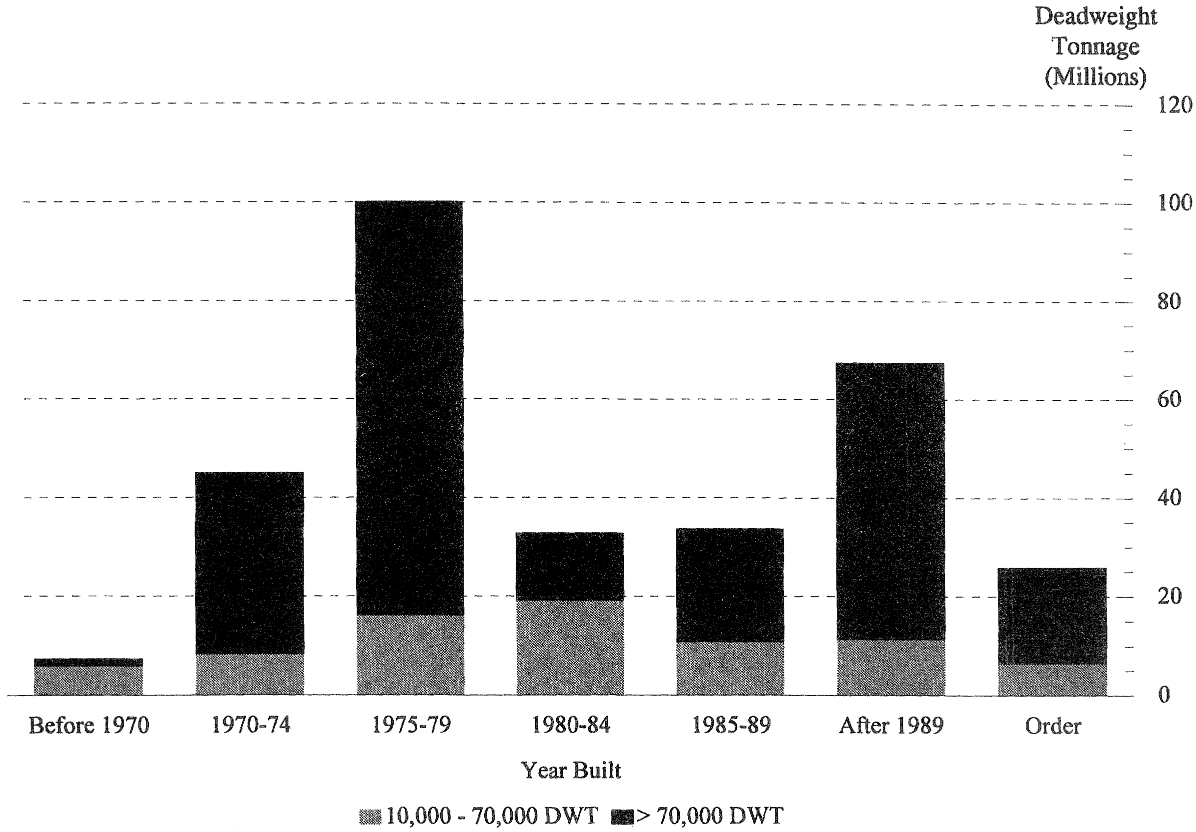
Tanker vessels make up the largest part of the world fleet, accounting for 5,994 vessels and 297 million DWT. Liberia, Panama, Greece, Bahamas and Norway have the largest fleets, accounting for 55 percent of the world total in terms of DWT, although if only the number of ships is considered, the positions of Liberia and Panama are reversed and Japan (sixth in DWT terms) actually has the third largest fleet.

Exhibit 6-2 illustrates the size and age distribution of the world tanker fleet. More than two-thirds of the tonnage are the larger ships which are mostly crude oil carriers. More than half of those were built during the 1970s, with another building surge underway in the 1990s. The smaller ships, between 10,000 and 70,000 DWT, tend to be mostly product carriers, and the largest segment of these were built in the early 1980s. (For all of the principal vessel types, ships built in the 1980s and 1990s are generally more fuel efficient and have smaller crews than older ships.)

Roll-on/Roll-off		Cruise/Passenger		Other*		Total	
Number	Deadweight Tonnage (thousands)	Number	Deadweight Tonnage (thousands)	Number	Deadweight Tonnage (thousands)	Number	Deadweight Tonnage (thousands)
189	1,861	24	91	1,435	11,246	3,488	95,600
58	714	34	170	213	3,195	1,534	95,376
16	127	22	68	168	1,928	981	53,633
26	182	6	21	607	6,302	1,436	39,692
45	397	51	251	401	5,435	910	35,049
73	984	13	50	151	2,169	678	31,527
113	720	8	23	128	593	812	26,951
28	144	2	2	359	3,477	925	26,102
17	147	2	-	764	6,652	1,387	22,267
50	1,008	8	74	192	3,643	543	19,934
28	337	-	-	139	1,499	575	18,102
37	318	-	-	190	1,639	536	14,312
3	43	-	-	41	682	215	13,475
26	276	7	8	1,228	6,160	1,579	13,213
-	-	-	-	80	873	284	10,072
8	134	-	-	143	697	407	9,826
-	-	-	-	41	231	194	8,967
9	96	2	2	205	1,169	416	8,735
9	152	-	-	38	310	211	8,640
45	464	4	11	68	309	395	8,403
780	8,104	183	770	6,591	58,208	17,506	559,875
1,222	11,597	231	906	10,763	86,772	25,092	685,756

* Breakbulk ships, partial containerships, refrigerated cargo ships, barge carriers, and specialized cargo ships.

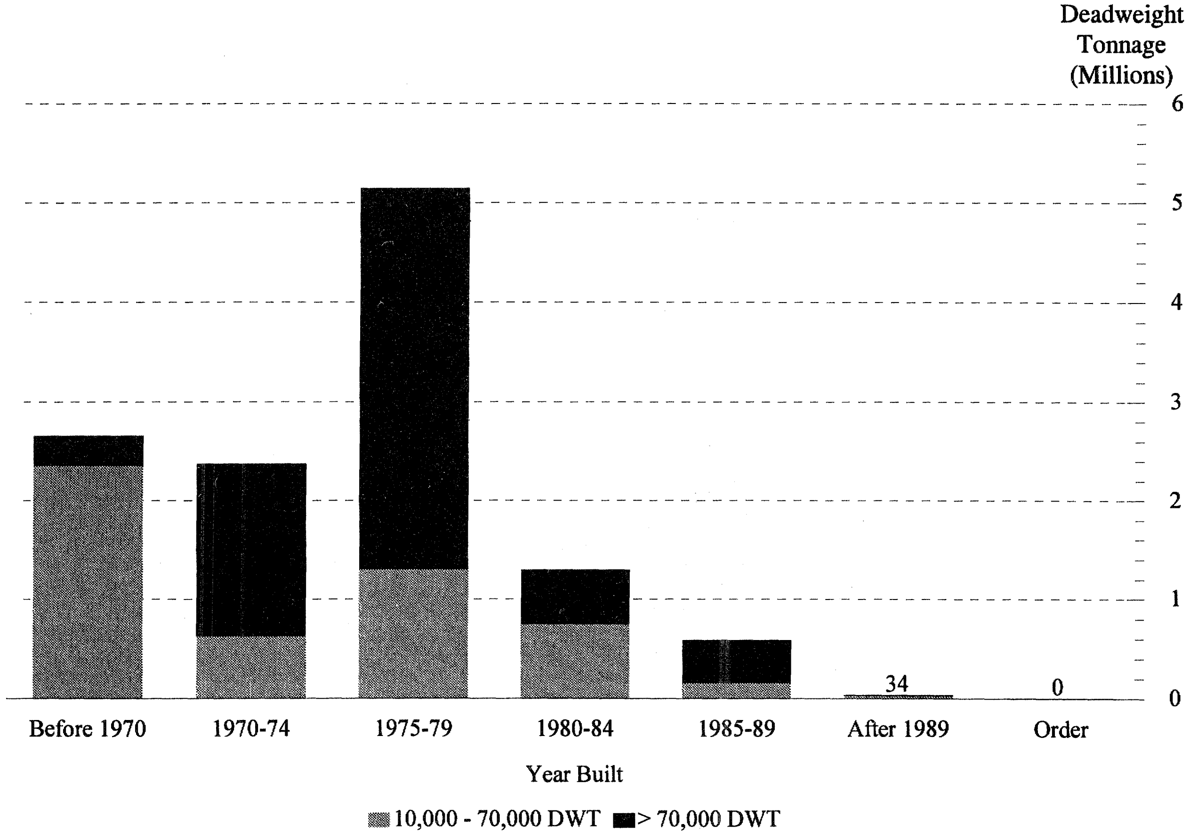
Exhibit 6-2
Age Distribution of World Tanker Fleet by Size
January 1, 1995



Source: Lloyd's Register of Ships

In comparison, the U.S.-flag tanker fleet is considerably older than the world fleet. There was a surge in building during the 1970s, reflecting the eligibility of bulk vessels for government assistance under the 1970 Merchant Marine Act and the enormous private sector investment for the transportation of Alaskan oil (Exhibit 6-3). While there were no new U.S.-flag tankers on order as of January 1, 1995, orders have since been placed for four product tankers and there are an additional eleven subject to the approval of Title XI financing. Several new tankers will be ordered for the U.S. domestic (Jones Act) product trades due to the aging of the existing fleet and the double-hull requirements of the Oil Pollution Act of 1990 (OPA-90).

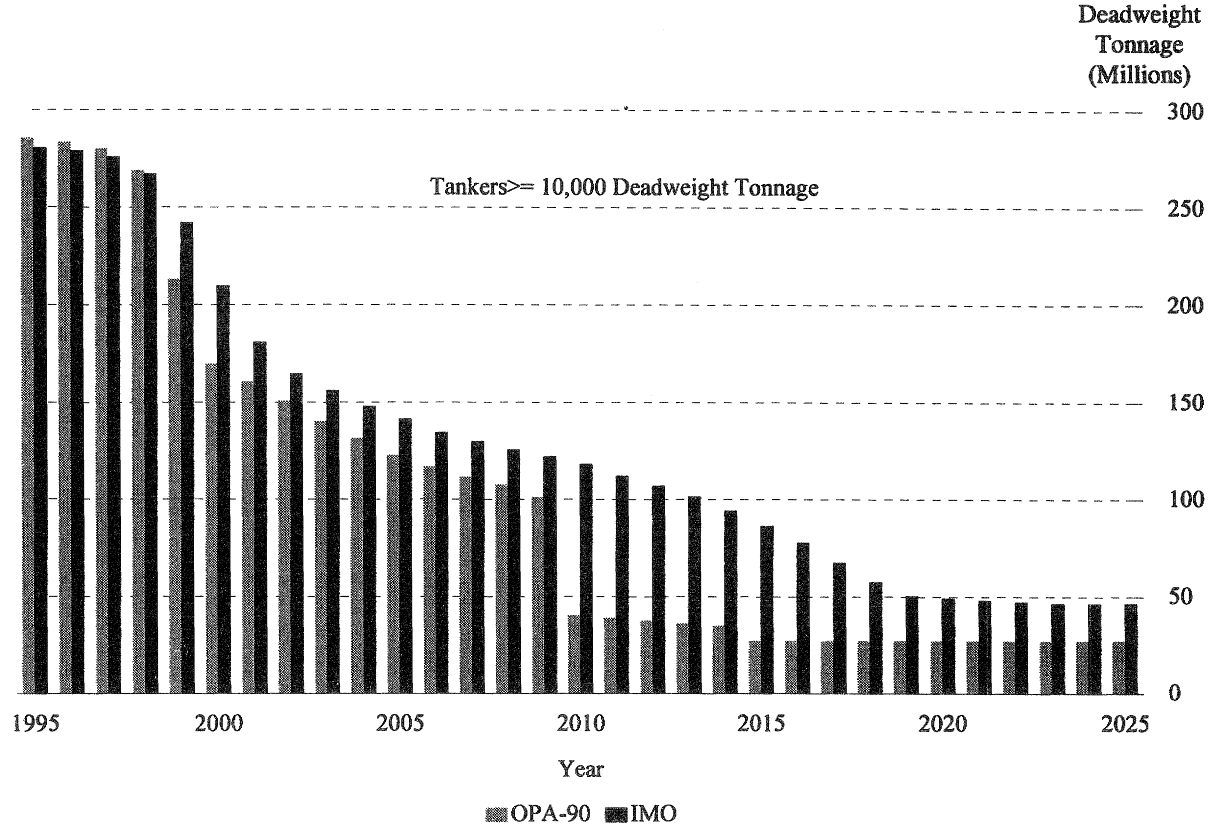
Exhibit 6-3
Age Distribution of U.S.-Flag Tanker Fleet by Size
January 1, 1995



Source: Lloyd's Register of Ships

As of January 1, 1995, only 9.6 percent of the world and 6.6 percent of the U.S.-flag tanker fleet had double hulls. Exhibits 6-4 and 6-5 show the required phase-out of the current world and U.S. non-double-hull tanker fleets as a result of the OPA-90 and less stringent International Maritime Organization (IMO) requirements.

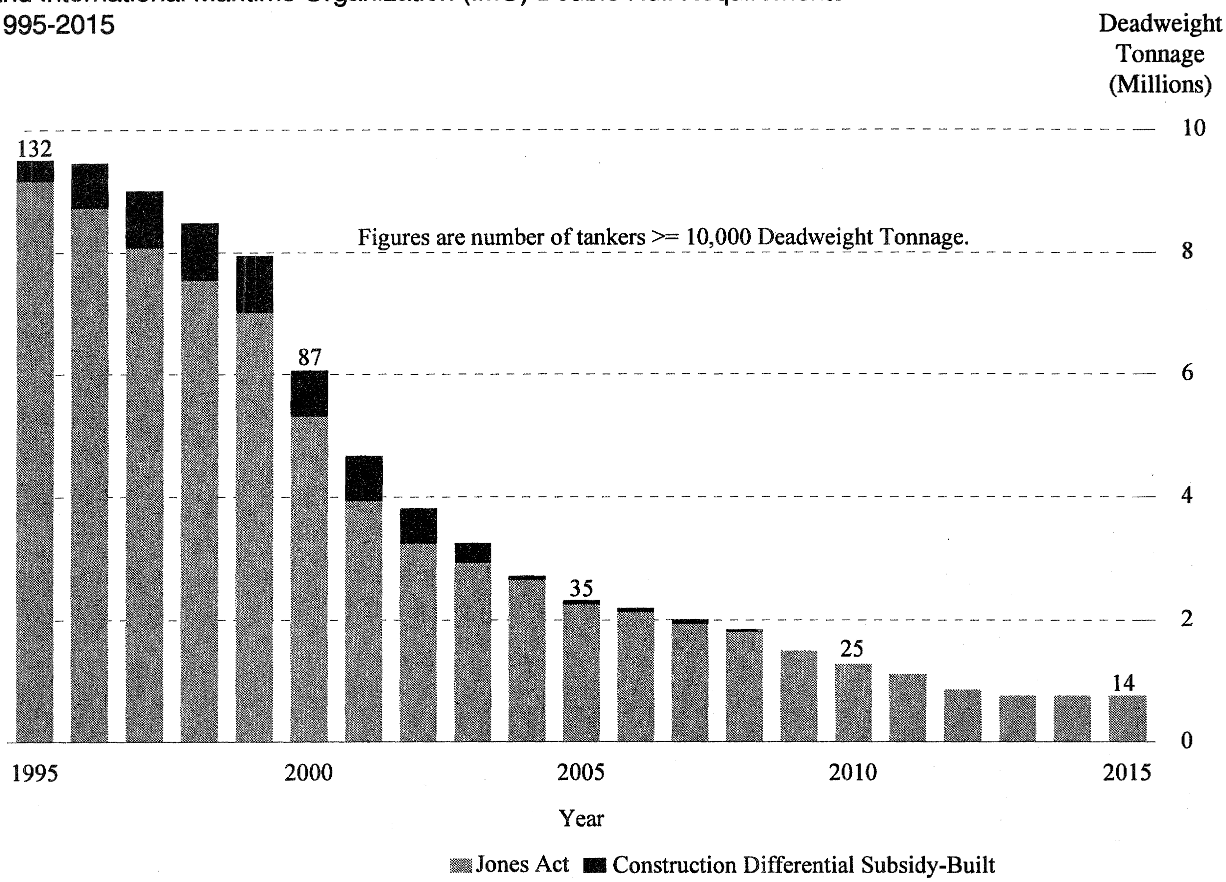
Exhibit 6-4
World Tanker Fleet Phase-Out Due to the Oil Pollution Act of 1990 (OPA-90)
and International Maritime Organization (IMO) Double Hull Requirements
1995-2025



Source: Lloyd's Register of Ships, January 1, 1995

OPA-90 mandates a phase-out of all non-double-hull tankers serving U.S. ports, in stages (based on age and size) beginning in 1995. By 2010, no single-hull tanker will be allowed to call at U.S. ports. By 2015, no double-bottom or double-sided tanker will be allowed to call at U.S. ports. For non-U.S. trades, IMO's 1992 amendments to the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) affect crude oil and product tankers that are in excess of 20,000 DWT and 30,000 DWT, respectively. Tankers that are 25 years old or older, not constructed with protectively located segregated ballast tanks (SBTs), will have to be fitted with double-hulls. On reaching 30 years of age tankers built with SBTs will have to be fitted with double-hulls.

Exhibit 6-5
Jones Act Tanker Fleet Phase-Out Due to the Oil Pollution Act of 1990 (OPA-90) and International Maritime Organization (IMO) Double Hull Requirements
1995-2015



Source: Lloyd's Register of Ships, January 1, 1995

Dry Bulk Fleet

Dry bulk carriers comprise the second largest segment in the world fleet, with 5,291 vessels in this category. Panama, Liberia, Greece and Cyprus are the principal registries, each having more than 20 million DWT. Together these countries account for 45 percent of the world total of dry bulk ships. Exhibit 6-6 displays the age distribution of the world dry bulk fleet in three size categories, and indicates a fairly normal distribution and an order book of about one-eighth of the existing fleet.

The U.S.-flag dry bulk fleet consists of only 18 vessels. Nearly two-thirds of the tonnage was built during the 1980s, and no new vessels have been constructed during the 1990s (Exhibit 6-7).

Exhibit 6-6
Age Distribution of World Dry Bulk Fleet by Size
January 1, 1995

	Deadweight Tonnage (millions)		
Year Built	**10,000 - 50,000**	**50,001 - 80,000**	**> 80,000**
Before 1970	6	2	1
1970 - 1974	18	9	17
1975 - 1979	24	12	15
1980 - 1984	25	19	15
1985 - 1989	17	9	18
After 1989	9	11	23
On Order	9	7	13

Source: Lloyd's Register of Ships

Exhibit 6-7
Age Distribution of U.S.-Flag Dry Bulk Fleet by Size
January 1, 1995

	Deadweight Tonnage (millions)		
Year Built	**10,000 - 50,000**	**50,001 - 80,000**	**> 80,000**
Before 1970	24	53	0
1970 - 1974	30	0	167
1975 - 1979	51	0	0
1980 - 1984	237	127	0
1985 - 1989	0	191	0
After 1989	0	0	0
On Order	-	-	-

Source: Lloyd's Register of Ships

Intermodal Vessels

There are two major groupings of intermodal vessels—containerships and RO/ROs.

The United States pioneered the container shipping concept, and currently the U.S.-flag containership fleet ranks third in the world with a 7 percent share of DWT although its average age is older than the world fleet as a whole (Exhibit 6-8).

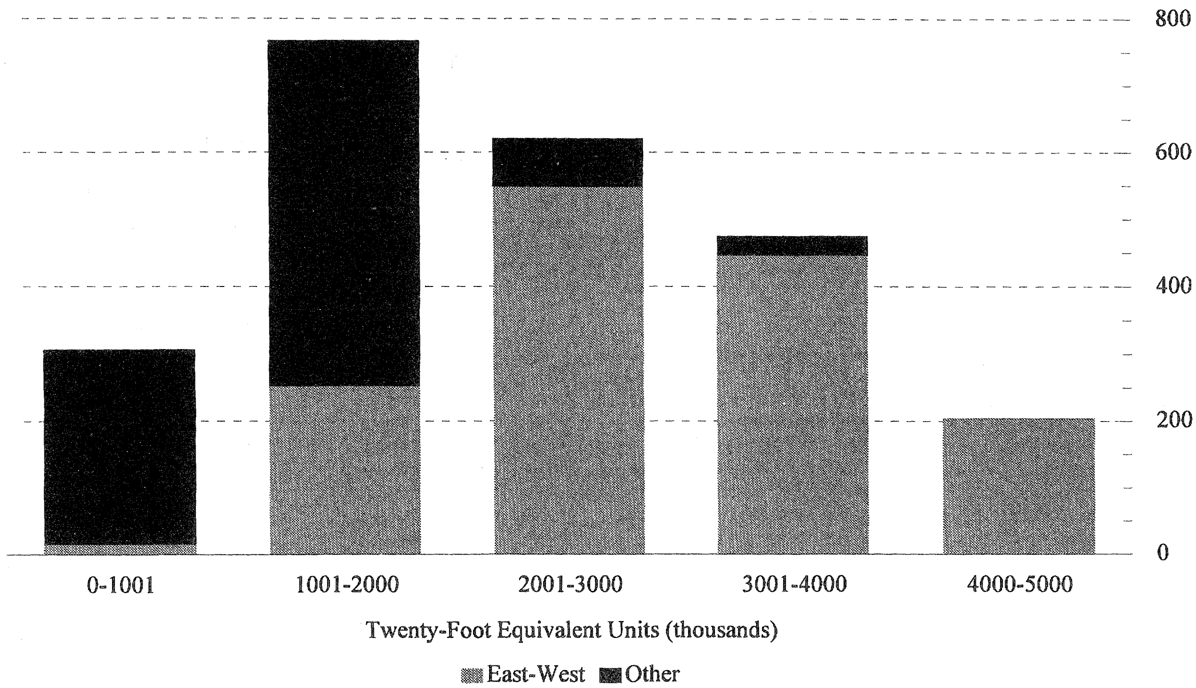
Exhibit 6-8
Age Distribution of U.S.-Flag Containership Fleet by Size
January 1, 1995

	Twenty-Foot Equivalent Units (thousands)					
Year Built	**< 1,001**	**1,001 - 2,000**	**2,001 - 3,000**	**3,001 - 4,000**	**4,001 - 5,000**	**5,001 - 6,000**
Before 1970	2,919	10,898	0	0	0	0
1970 - 1974	944	15,716	10,662	0	0	0
1975 - 1979	0	1,070	2,139	0	0	0
1980 - 1984	0	4,886	48,547	0	21,290	0
1985 - 1989	0	8,034	4,822	12,104	51,506	0
After 1989	0	1,930	0	0	0	0
On Order	0	0	9,920	12,000	0	0

Source: Lloyd's Register of Ships

The size and age distribution of the world containership fleet shown in Exhibits 6-9 and 6-10 illustrate the development of this segment since the early 1970s, and also the evolution of larger containerships that operate on the principal East/West routes.

Exhibit 6-9
Size Distribution of Containerships in East-West* and Other Trades
February 1, 1995



* United States (U.S.)/Europe, U.S./Far East, and Europe/Far East

Source: MDS/Transmodal Containership Databank on Disk

Exhibit 6-10
Age Distribution of World Containership Fleet by Size
January 1, 1995

	Twenty-Foot Equivalent Units					
Year Built	< 1,001	1,001 - 2,000	2,001 - 3,000	3,001 - 4,000	4,001 - 5,000	5,001 - 6,000
Before 1970	9,522	32,265	0	0	0	0
1970 - 1974	48,787	97,964	67,515	18,244	0	0
1975 - 1979	86,095	101,024	83,230	3,344	0	0
1980 - 1984	65,825	173,500	135,039	18,125	21,290	0
1985 - 1989	46,219	89,908	164,448	178,563	63,654	0
After 1989	63,333	256,992	166,947	218,268	149,255	0
On Order	61,990	102,231	68,410	123,384	194,709	46,658

Source: Lloyd's Register of Ships

Among the full containerships built in the 1990s and currently on order, the largest tend to have a capacity of 4,000 to 5,000 containers, expressed as twenty-foot equivalent units (TEUs), with another large group in the 3,000 TEU to 4,000 TEU range. The smaller ships tend to operate in feeder services and the north/south trades in which containerization is still developing. While there are nearly 1,600 full containerships in the world fleet, there are another 4,072 ships capable of carrying at least 100 containers.

The world fleet of RO/RO vessels, which is of particular interest for national security purposes because of the versatility of the vessels, tends to be relatively small in size (Exhibits 6-11 and 6-12). The largest groups were built between 1975 and 1984 and there are not very many currently under construction. More than half of the U.S. fleet of RO/RO vessels is government-owned, and none have been delivered in the 1990s.

Exhibit 6-11
Age Distribution of World Roll On-Roll Off Fleet by Size
January 1, 1995

	Deadweight Tonnage (millions)		
Year Built	10,000 - 20,000	20,001 - 30,000	> 30,000
Before 1970	40	0	0
1970 - 1974	70	200	0
1975 - 1979	1,100	600	500
1980 - 1984	1,600	500	600
1985 - 1989	1,400	400	90
After 1989	500	900	60
On Order	300	40	40

Source: Lloyd's Register of Ships

Exhibit 6-12
Age Distribution of U.S.-Flag Roll-on/Roll-off Fleet by Size
January 1, 1995

	Deadweight Tonnage (millions)		
Year Built	**10,000 - 20,000**	**20,001 - 30,000**	**> 30,000**
Before 1970	41	0	0
1970 - 1974	44	204	0
1975 - 1979	169	108	97
1980 - 1984	0	105	65
1985 - 1989	56	99	0
After 1989	0	0	0
On Order	0	0	0

Source: Lloyd's Register of Ships

Cruise/Passenger Fleet

While the cruise industry is a large and growing segment of the waterborne transportation system (Exhibit 6-13), there is no U.S.-flag participation in this business except in the domestic trades.

Exhibit 6-13
Age Distribution of World Cruise/Passenger Fleet by Size
January 1, 1995

	Gross Registered Tons (Thousands)		
Year Built	**< 20,000**	**20,001 - 30,000**	**> 40,000**
Before 1970	690	717	194
1970 - 1974	129	196	0
1975 - 1979	152	0	0
1980 - 1984	54	239	90
1985 - 1989	66	116	373
After 1989	154	208	1,033
On Order	38	38	1,569

Source: Lloyd's Register of Ships

The U.S. Domestic Fleet and Its Characteristics

The inland waterway, Great Lakes and ocean components of the domestic fleet include nearly 40,000 vessels with a cargo capacity of more than 67 million short tons (Exhibit 6-14).

Exhibit 6-14
Domestic Fleet by Area of Deployment and Selected Vessel Type
December 1993

Region/Type	Vessels	Capacity* Short Tons	Horse-Power	Passengers	Average Capacity
Great Lakes					
Dry Cargo Vessel	212	2,126,057	-	-	10,029
Tanker	5	29,634	-	-	5,927
Dry Cargo Barge	243	409,882	-	-	1,687
Tank Barge	25	45,417	-	-	1,817
Tug/Towboat	188	-	203,580	-	1,095
Ferry	18	-	-	3,361	187
Mississippi River System and Gulf Coats Intracoastal Waterway					
Dry Cargo Barge	23,424	33,601,202	-	-	1,434
Tank Barge	3,173	6,911,513	-	-	2,178
Tug/Towboat	3,291	-	5,558,105	-	1,689
Ferry	7	-	-	2,840	406
Atalantic, Gulf and Pacific Coasts					
Dry Cargo Barge	3,286	4,971,469	-	-	1,513
Tank Barge	664	3,762,173	-	-	5,666
Tug/Towboat	1,745	-	3,237,577	-	1,855
Ferry	125	-	-	80,839	647
Total Domestic					
Dry Cargo Barge	26,953	38,982,553	-	-	1,446
Tank Barge	3,862	10,719,103	-	-	2,775
Tug/Towboat	5,224	-	8,999,262	-	1,723
Ferry	150	-	-	87,040	580

* Dry cargo vessels and tankers deployed in coastal trades are included in the international section.

Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

The larger self-propelled oceangoing vessels that operate in the coastwise and non-contiguous trades were included in the previous discussion of the international fleet, because they can be operated in the international trades, and they will not be discussed again in this section. Instead, this section will focus on the non-self-propelled dry cargo barges, tank barges and the towboats that move them, as well as the Great Lakes fleet and the ferries that operate between domestic points.

Dry Cargo Barge Fleet

The predominant vessel in the domestic fleet is the dry cargo barge, 87 percent of which operate on the inland waterways. Total capacity of the dry cargo barge fleet is 39 million short tons. They tend to be about 1,500 tons each, or the equivalent of 15 rail cars or 60 highway trailers. About half of the barges were built during the 1975 through 1984 period, and about 11 percent were built in the last 5 years (Exhibit 6-15).

Exhibit 6-15
Age Distribution of Domestic Dry Cargo Barge Fleet by Area of Deployment
December 1993

	Capacity (Thousands of Short Tons)		
	Coastwise	Inland	Great Lakes
Before 1970	1,774	3,763	133
1970 - 1974	908	5,887	78
1975 - 1979	919	8,887	66
1980 - 1984	807	9,245	35
1985 - 1989	341	1,776	31
After 1989	223	4,044	68

Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

Tank Barge Fleet

In 1993, 82 percent of the tank barges operated on the inland waterways, but were considerably smaller (2200 ton average) than those operating in the coastal trades (5700 ton average).

As shown in Exhibit 6-16, 75 percent of the tank barge fleet (70 percent of capacity) is more than 15 years old (57 percent are older than 20 years). Overall, about 45 percent of the tank barge fleet has double hulls. Just over 8 percent of the tank barge fleet has been built in the last 5 years, and 73 percent of those have double hulls.

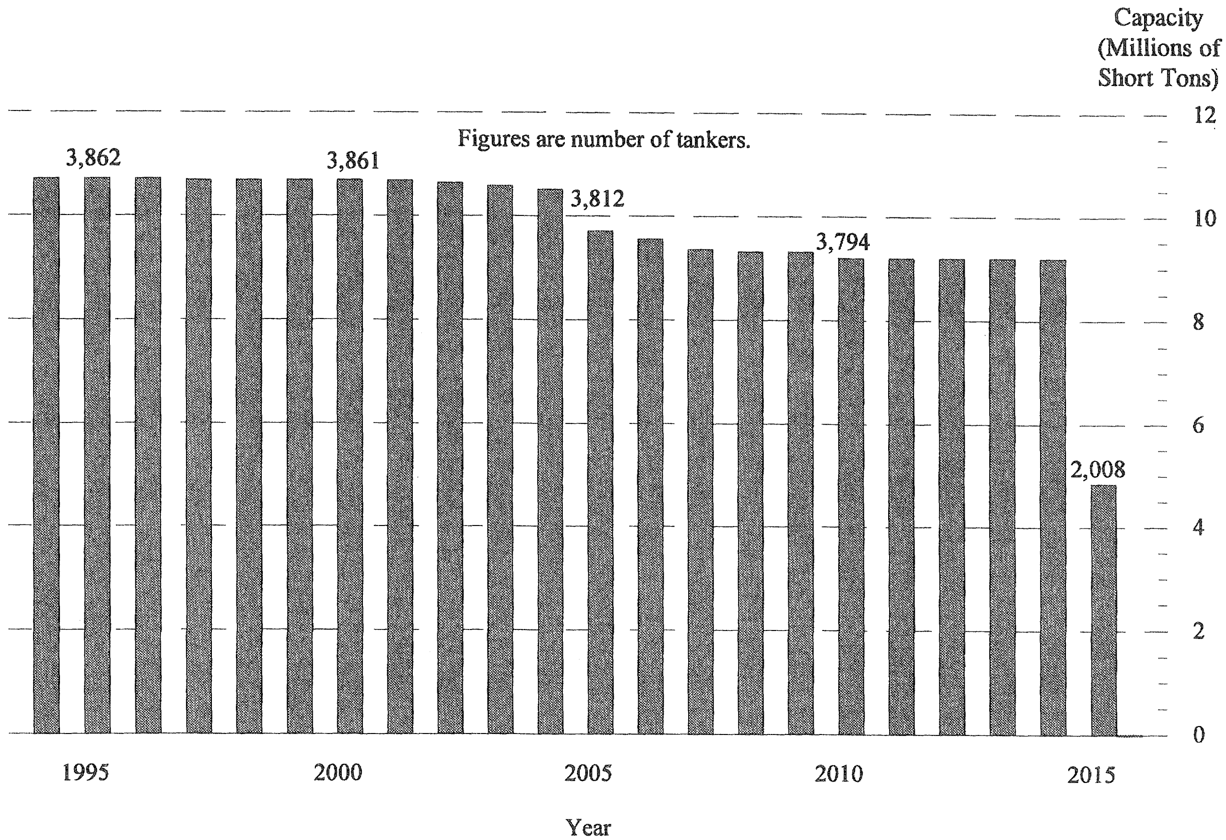
Exhibit 6-16
Age Distribution of Domestic Tank Barge Fleet by Area of Deployment
December 1993

	Capacity (Thousands of Short Tons)		
Year Built	**Coastwise**	**Inland**	**Great Lakes**
Before 1970	1,068	2,267	26
1970 - 1974	649	1,394	4
1975 - 1979	734	1,353	7
1980 - 1984	950	1,102	8
1985 - 1989	210	61	-
After 1989	152	736	-

Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

Exhibit 6-17 shows the phase-out of single skin tank barges required by OPA-90.

Exhibit 6-17
Domestic Tank Barge Fleet Phase-Out Due to the Oil Pollution Act of 1990
December 1993



Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

Towboat/Tugboat Fleet

The domestic towboat/tugboat fleet amounted to 5,224 vessels in 1993, with 62 percent of them operating on the inland waterways. Towboats vary in size from less than 40 feet in length with engines of a few hundred horsepower to over 140 feet long powered by engines of up to 10,000 horsepower. About 44 percent of the towboats and tugboats are more than 25 years old, and less than 2 percent of the fleet has been built in the last five years (Exhibit 6-18).

Exhibit 6-18
Age Distribution of Domestic Tug/Towboat Fleet by Area of Deployment
December 1993

	Engine Horsepower (Thousands)		
Year Built	Coastwise	Inland	Great Lakes
Before 1970	1,155	1,674	125
1970 - 1974	481	1,001	33
1975 - 1979	879	1,350	20
1980 - 1984	536	1,236	20
1985 - 1989	86	161	5
After 1989	100	135	-

Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

Great Lakes Fleet

The self-propelled U.S.-flag Great Lakes fleet consists almost exclusively of dry bulk vessels, most of which carry ores. More than 40 percent of the fleet is more than 20 years old (25 percent older than 25 years), and while approximately one-third of the fleet was built during the 1975 through 1979 period, very few vessels have been built in the last 10 years (Exhibit 6-19).

Exhibit 6-19
Age Distribution of Great Lakes Self-Propelled Fleet
December 1993

	Capacity (Thousands of Short Tons)	
Year Built	Dry Cargo	Tanker
Before 1970	508	9
1970 - 1974	356	9
1975 - 1979	768	13
1980 - 1984	460	-
1985 - 1989	18	-
After 1989	17	-

Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

Ferries

Ferries constitute a small segment of the domestic fleet, 150 in number, with a total passenger capacity of just over 87,000 (580 per vessel average). About one-half of the capacity is more than 25 years old and represents potential for new construction. About 25 percent of capacity was built during the 1980 through 1984 period, but only about 3 percent was built in the past 5 years (Exhibit 6-20).

Exhibit 6-20
Age Distribution of Domestic Ferry Fleet by Area of Deployment
December 1993

Year Built	Capacity (Thousands of Passengers)		
	Coastwise	Inland	Great Lakes
Before 1970	32.7	-	2.8
1970 - 1974	7.1	-	0.1
1975 - 1979	5.4	2.0	-
1980 - 1984	22.5	0.1	0.1
1985 - 1989	10.7	0.2	0.1
After 1989	2.4	0.5	0.1

Source: U.S. Army Corps of Engineers, Transportation Lines of the United States, 1993

Port Infrastructure

The U.S. port system is comprised of deep-draft seaport and Great Lakes port facilities and the inland waterway system. Each of these elements includes both publicly and privately owned marine terminal facilities which are the interface between water and surface transportation modes.

Deep-Draft Seaport and Great Lakes Port Facilities

There is considerable diversity among U.S. ports with respect to facility ownership and operation. The majority (75 percent) of the marine terminals are owned by the private sector and are predominately dry and liquid bulk facilities. Public ownership is heavily concentrated in general cargo and passenger facilities. While some public port authorities manage and operate their marine terminals, the majority lease their facilities to private operators. Privately owned terminal facilities generally are operated by the owner or leased to a private operator.

There are in total 1,917 major U.S. seaport terminals comprising 3,173 berths. The distribution of berths by type and coastal region is shown in Exhibit 6-21. East coast ports have the largest share at 34.4 percent, followed by the gulf and west coasts with identical 24.8 percent shares and the Great Lakes with a 16 percent share. The general cargo class is the predominant berth type in all regions except the Great Lakes where the majority of facilities are for dry bulk cargoes.

Exhibit 6-21
U.S. Seaport Terminals by Berth Type and Coastal Region[1]
1993

	Berth Total		Atlantic[2]		Gulf		Pacific[3]		Great Lakes	
Berth Type	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
General Cargo	1,194	38	472	43	269	34	358	46	95	19
Dry Bulk	715	23	146	13	169	22	124	16	276	54
Liquid Bulk	624	20	246	23	183	23	138	18	57	11
Passenger	81	3	35	3	6	1	31	4	9	2
Other	559	18	194	18	160	20	135	17	70	14
Total	3,173	100	1,093	100	787	100	786	100	507	100

[1] Includes those commercial cargo handling facilities with a minimum depth alongside of 25 feet for coastal ports and 18 feet for Great Lakes ports.
[2] Includes Puerto Rico and the U.S. Virgin Islands.
[3] Includes Hawaii and Alaska.

Source: Maritime Administration

Inland River and Intracoastal Waterways Port Facilities

Exhibit 6-22 provides a profile of the 1,789 river terminal facilities located in 21 states on the 25,000 mile U.S. inland waterway system, categorized by state and terminal type.

Exhibit 6-22
U.S. Inland Waterway/Riverport Terminal Facilities by State
1993

	Number and Type of Facilities					
			Dry Bulk Cargo			
State	Number of Terminals	General Cargo	Grain	Coal	Ore	Other
Mississippi System						
Alabama	137	8	16	21	-	41
Arkansas	72	1	21	-	-	20
Illinois	254	9	60	20	1	49
Indiana	60	2	8	14	1	16
Iowa	81	1	18	6	-	20
Kansas	8	-	4	-	-	1
Kentucky	176	3	13	46	-	50
Louisiana	66	1	8	2	-	12
Minnesota	62	2	13	4	-	16
Mississippi	69	2	16	-	-	13
Missouri	137	2	23	5	-	61
Nebraska	17	1	7	-	-	4
Ohio	132	6	7	21	2	43
Oklahoma	27	3	5	-	-	9
Pennsylvania	145	9	-	41	2	49
Tennessee	124	5	22	7	1	44
West Virginia	149	9	-	47	1	52
Wisconsin	18	-	1	4	-	6
Subtotal	1,734	64	242	238	8	506
Columbia/Snake System						
Idaho	4	1	2	-	-	1
Oregon	17	1	7	-	-	4
Washington	34	7	16	-	-	2
Subtotal	55	9	25	-	-	7
Total	1,789	73	267	238	8	513

Source: Maritime Administration

Number and Type of Facilities			
Liquid Bulk Cargo			Multi-Purpose
Petroleum	LPG	Other	
21	-	15	15
9	-	4	17
42	-	34	39
9	-	2	8
11	-	9	16
-	-	2	1
32	1	15	16
19	1	14	9
12	-	7	8
16	1	6	15
17	-	17	12
-	-	4	1
23	-	19	11
4	-	2	4
18	-	18	8
22	-	11	12
21	1	15	3
2	-	4	1
278	4	198	196
-	-	-	-
-	-	2	3
2	-	3	4
2	-	5	7
280	4	203	203

The U.S. inland waterway ports and terminals possess unique characteristics that distinguish them from the coastal seaports. Aside from shallow water depths of 14 feet or less, the inland system is less concentrated geographically and provides almost limitless access points to the waterways. Terminal siting on the waterways is less constrained than coastal ports providing greater flexibility to the users in determining the location of plants requiring water access. Private ownership is somewhat higher for inland waterway facilities than for coastal facilities (89 versus 75 percent).

Port Capital Investment

Data on the investment in shoreside port facilities is limited to information on the public sector of the deep-draft and Great Lakes ports. There are no public or private sector investment data on the inland waterway system.

Overall total public sector port capital expenditures have remained relatively stable in recent years, annually ranging between $654 million and $682 million during the period 1990 through 1993. Exhibits 6-23 and 6-24 summarize the 1993 investment by coastal region and facility type. Expenditures for new construction accounted for 66.2 percent of the 1993 total.

Exhibit 6-23
U.S. Port Capital Expenditures
1990-1993

	1990		1991		1992		1993	
Coast	Dollars (millions)	Percent	Dollars (millions)	Percent	Dollars (millions)	Percent	Dollars (millions)	Percent
Atlantic	$286	43	$234	34	$235	35	$240	37
Gulf	$98	15	$156	23	$145	22	$130	20
Pacific	$270	40	$291	43	$186	28	$234	36
Great Lakes	$4	1	$1	0	$3	0	$23	4
Non-Contiguous*	$10	2	-	0	$102	15	$28	4
Total	$668	100	$682	100	$672	100	$654	100

* Alaska, Hawaii, Puerto Rico, and Virgin Islands

Source: American Association of Port Authorities

Exhibit 6-24
U.S. Port Capital Expenditures by Type of Facility
Millions of Dollars
1993

	Type of Facility								
Coast	General Cargo	Inter-modal	Dry Bulk	Liquid Bulk	Passenger	Other	Infra-structure	Dredging	Total
Atlantic	$53	$65	-	$4	$19	$8	$42	$49	$240
Gulf	$49	$7	$4	$5	$16	$32	$10	$8	$130
Pacific	$16	$101	$26	$2	$2	$38	$47	$2	$234
Great Lakes	$23	-	-	-	-	-	-	-	$23
Non-Contiguous*	$20	$8	-	-	-	-	$1	-	$28
Total	$160	$180	$30	$11	$36	$78	$100	$59	$654
Percent	24	28	5	2	6	12	15	9	100

* Alaska, Hawaii, Puerto Rico, and Virgin Islands

Source: American Association of Port Authorities

Each of the five cargo type categories includes expenditures for pier or wharf structures, storage facilities, and handling equipment. Infrastructure expenditures cover improvements such as roadways, rail, sewer, lighting, and parking either on or off terminal property. Dredging consists of local port expenditures associated with the dredging of Federal and non-Federal channels and berths as well as the local costs for land, easements, rights-of-way, and disposal areas. The "other" category includes those structures, spaces, and fixtures not directly related to the movement of cargo, such as maintenance and administrative facilities.

Capital expenditures for intermodal facilities at U.S. seaports are shown in Exhibit 6-24. During the period 1988 to 1993, expenditures in this category totalled $1.7 billion.

U.S. public ports utilize a variety of methods to underwrite their capital expenditures, including port revenues, general obligation bonds, revenue bonds, loans, grants, state transportation trust funds, state and local appropriations, taxes (i.e., property and sales), and lease revenue.

Intermodal Transportation Systems

To appreciate the complexity of intermodal services and the capital intensity of both the equipment and facilities, it is useful to understand just how far the system has evolved from traditional breakbulk carriage.

Before containers, "export" packaging had to be substantial to prevent damage and pilferage. Today, container carriers are usually able to accept domestic packaging as adequate for export.

The freight forwarder, or the company traffic manager, was officially responsible to the exporter for the timely arrival at the pier. A breakbulk carrier, having booked cargo for a particular sailing, took an interest in the arrival of the customer's cargo at the marine export terminal. This was a service to the shipper, but it was really self-serving since breakbulk loading operations were highly reliant on having the right mix of cargo available at specified times. The ocean carrier was responsible for unloading the inland conveyance and for all activities that followed through the ocean voyage.

A similar process took place at the destination port. There a custom house broker (hired by the cargo owner) cleared the cargo and arranged--and was responsible for--inland transportation to the final destination. The breakbulk carrier ended his responsibility when the cargo was turned over to the inland carrier. It would have been considered presumptuous and unthinkable for the ocean carrier to take a direct interest in the timely delivery of cargo to the final destination.

Beginning with the introduction of containerization in the late 1950s, U.S.-flag liner carriers have complemented the physical elements of the waterborne transportation system with innovative transportation systems which expanded their traditional services to their shippers. Intermodal transportation uses sophisticated equipment (vessels, terminals, and inland delivery systems) linked through information technology to meet shippers' needs. In addition to container shipping itself, U.S.-flag carriers have pioneered the development of marine container terminals, double stack trains, and cargo and equipment tracking systems to provide the total logistics support required for an efficient transportation network.

Compared to traditional breakbulk services, intermodal transportation provides shippers with lower transportation costs, reduced inventory and warehousing costs, intransit visibility, Just-In-Time (JIT) logistics support, reduced damage and pilferage, and increased market opportunities through lower costs and improved services.

Containerization inevitably extended the role of the marine carrier. With an interest in the box as well as the cargo, the marine carrier was able to offer door-to-door service, providing all of the transportation equipment and services, ocean and inland, under a single bill of lading.

The JIT concept gave logistical responsibilities to the marine container carrier. Under JIT, the carrier manages the transportation and the information chain, and assures the customer of a smooth flow of product.

Shipment patterns, markets, and logistics have been rapidly transformed in the past few years, and in many cases globalized to make JIT deliveries and a wider variety of transportation services available to the shippers. Significant investment continues to be made in intermodal port facilities (See Exhibit 6-25 and related text.). The competitiveness of the marketplace and technological advances have resulted in the development of a sophisticated global system of logistics for freight transportation. Today, the successful delivery of a shipment requires efficient movement on each leg and intermodal connectivity. Each component of the movement must function in partnership to achieve cost-effectiveness, timeliness and reliability.

U.S. Shipbuilding and Repair Base and Its Characteristics

The Major U.S. Shipbuilding and Repair Base is comprised of 101 private shipbuilding and repair shipyards with the capability to construct, drydock, and/or topside repair vessels with a minimum length overall of 122 meters (400 feet) with water depth in the channel to the facility of at least 12 feet (Exhibit 6-25).

Exhibit 6-25
Major U.S. Shipbuilding and Repair Bases
October 1994

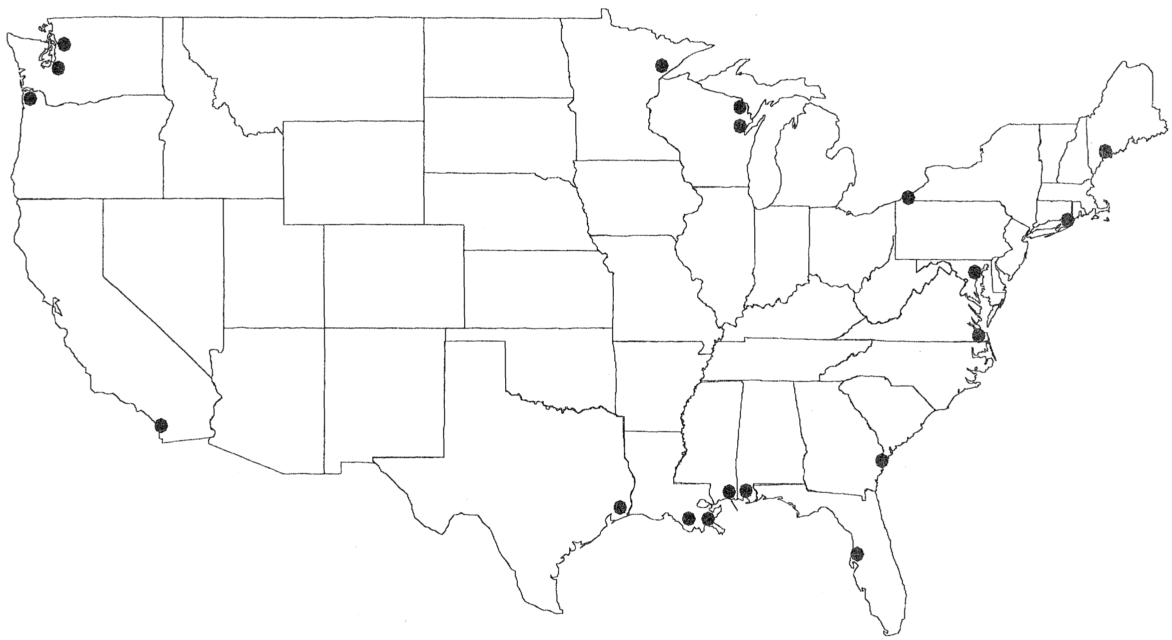
	East Coast	Gulf Coast	West Coast	Great Lakes	Non-Contiguous	Total by Type
Shipbuilding	5	7	5	4	-	21
Repair w/Drydock	12	8	8	2	2	32
Topside Repair	17	18	10	2	1	48
Total by Coast	34	33	23	8	3	101

* Alaska, Hawaii, Puerto Rico, and Virgin Islands

Source: Maritime Administration

The group of 21 shipbuilding yards shown in Exhibit 6-25 are widely dispersed geographically, and their locations are shown in Exhibit 6-26.

Exhibit 6-26
Location of Major Shipbuilding and Repair Facilities in the United States
1994



At the end of 1994, eight of the 21 shipyards were engaged in construction and/or conversion of major combatant and auxiliary ships for the Navy. One shipyard had an order for two 46,500 DWT double hulled petroleum tankers, the first U.S.-built oceangoing commercial ships for export since 1957. Nine of the yards had only repair and overhaul work, smaller Navy vessel orders, and non-ship construction work, and the other four shipyards had no new construction orders.

While over 200 privately-owned firms of varying capabilities are involved in repairing ships in the United States, only 32 yards are classified as major repair yards because of their capability to drydock large vessels. The U.S. shipbuilding and repair industry is currently operating a total of 46 floating drydocks, 30 graving docks, and 3 marine railways.

Major shipyards usually combine repair, overhaul, and conversion with shipbuilding capabilities, and it is difficult to draw a sharp line between shipbuilding yards and ship repair yards. Exhibit 6-27 enumerates the drydocking facilities by geographical area in the 32 major repair shipyards with drydocking capability.

Exhibit 6-27
Private Shipyard Drydocking Facilities
October 1994

	East Coast	Gulf Coast	West Coast	Great Lakes	Non-Contiguous	Total by Type
Graving Docks	17	5	1	6	1	30
Floating Docks	11	16	17	1	1	46
Marine Railways	2	-	1	-	-	3
Total by Coast	30	21	19	7	2	79

* Alaska, Hawaii, Puerto Rico, and Virgin Islands

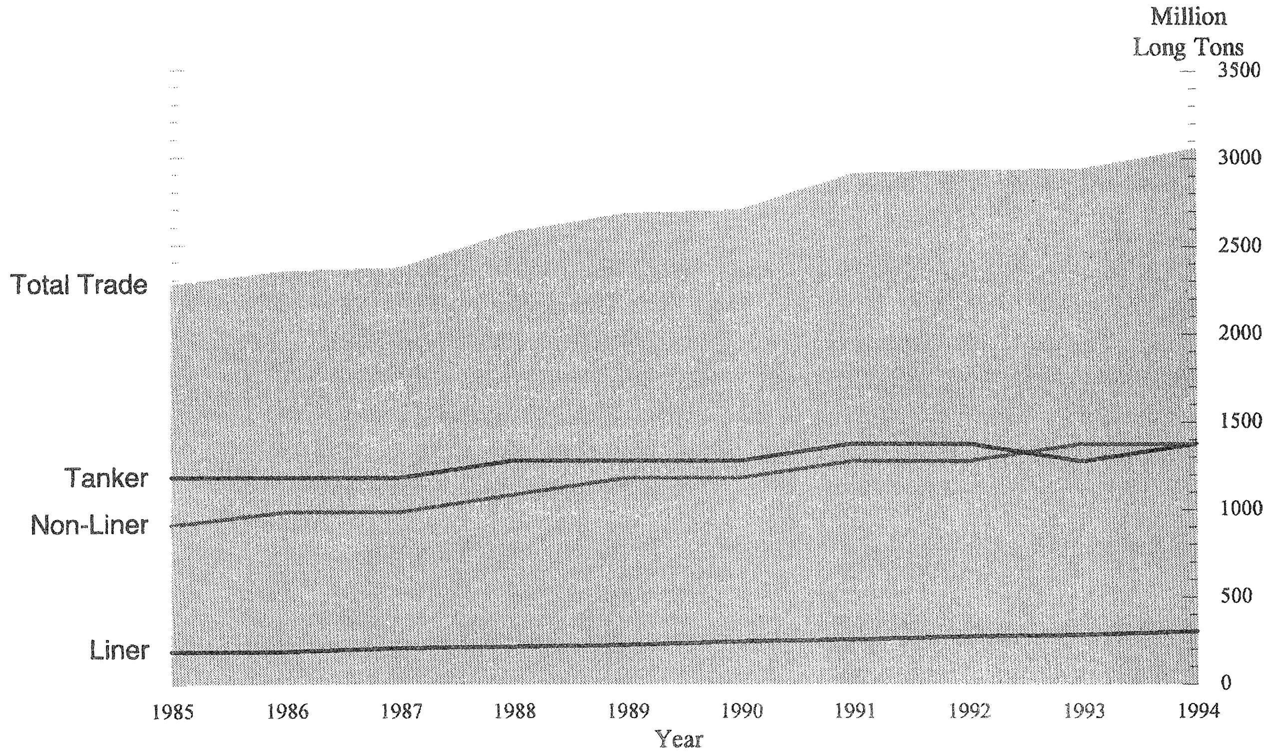
Source: Maritime Administration

There are an additional 48 yards which are capable of performing topside work on large vessels. Services rendered by these firms vary from simple repairs to major topside overhauls, particularly when the work on oceangoing ships can be accomplished without taking the ships out of the water. Reflecting a worldwide trend to keeping ships in operation to maintain schedule integrity, ship repairers are commonly deployed to the ship in lieu of bringing the ship to the shipyard, thus calling for greater mobility of ship repair personnel to meet customer requirements.

World Oceanborne Trade

In 1994, world oceanborne trade (imports) amounted to about 3.1 billion long tons, with the United States, Japan and Europe accounting for approximately 66 percent of world oceanborne imports. The United States alone accounted for approximately 18 percent of world oceanborne imports in 1994 (Exhibit 6-28).

Exhibit 6-28
World Oceanborne Trade
1985-1994



Source: DRI/McGraw-Hill and Mercer Management, World Sea Trade Service, First Quarter 1995

U.S. Oceanborne Foreign Trade

Total oceanborne U.S. foreign trade (exports and imports) in 1994 amounted to 898 million long tons with a value of $566 billion, an increase of 3.2 percent in tonnage and 12.8 percent in value from the previous year.

Oceanborne foreign trade can be divided into the following segments (services): liner (scheduled), non-liner (unscheduled dry cargo) and tanker. Exhibit 6-29 indicates the distribution of cargo among these services by tonnage and value, as well as the U.S.-flag share in each segment.

Exhibit 6-29
U.S. Oceanborne Foreign Trade by Type Service
1994*

	Thousands of Long Tons			Millions of Dollars		
	All Flags	**U.S. Flag**	**Percent U.S. Flag**	**All Flags**	**U.S. Flag**	**Percent U.S. Flag**
Liner	117,847	16,999	14	$419,427	$70,916	17
Tanker	448,250	9,841	2	$57,301	$1,315	2
Non-Liner	331,612	8,394	2	$88,907	$4,786	5
Total	897,709	35,234	4	$565,635	$77,017	14

*Preliminary. Excludes trans-Great Lakes and Department of Defense Cargoes.

Source: U.S. Bureau of the Census

Liner cargoes tend to have a much higher value per long ton than non-liner and tanker cargoes. Consequently, while liner cargoes accounted for 13 percent of the total tonnage, they accounted for nearly three-fourths of the value. Similarly, tanker traffic, consisting primarily of oil imports, accounted for nearly half of the tonnage but only 10 percent of the value of oceanborne foreign trade.

Liner Trades

Liner vessels are operated between scheduled, advertised ports of loading and discharge on a regular basis. The freight rates charged are based on the shipping line's tariff or the Conference tariff if the shipping line is a member of a rate-setting Conference. Shipping lines may carry cargo on their own vessels or on another company's vessel, reflecting slot charter, joint service or other ship sharing arrangements.

U.S. liner trade expanded at an annual rate of 6.8 percent between 1985 and 1994. The major U.S. liner trades are transatlantic (U.S./Europe and Mediterranean), transpacific (U.S./Far East), and U.S./Latin America (Exhibit 6-30), and all have been growing steadily. Hub ports on these routes, e.g. Algeciras, Singapore and Kingston, also serve as transshipment points for U.S. trade with other regions, e.g., Middle East, Australasia, Africa.

Exhibit 6-30
U.S. Liner Trade by Major Route
Millions of Long Tons
1988-1994

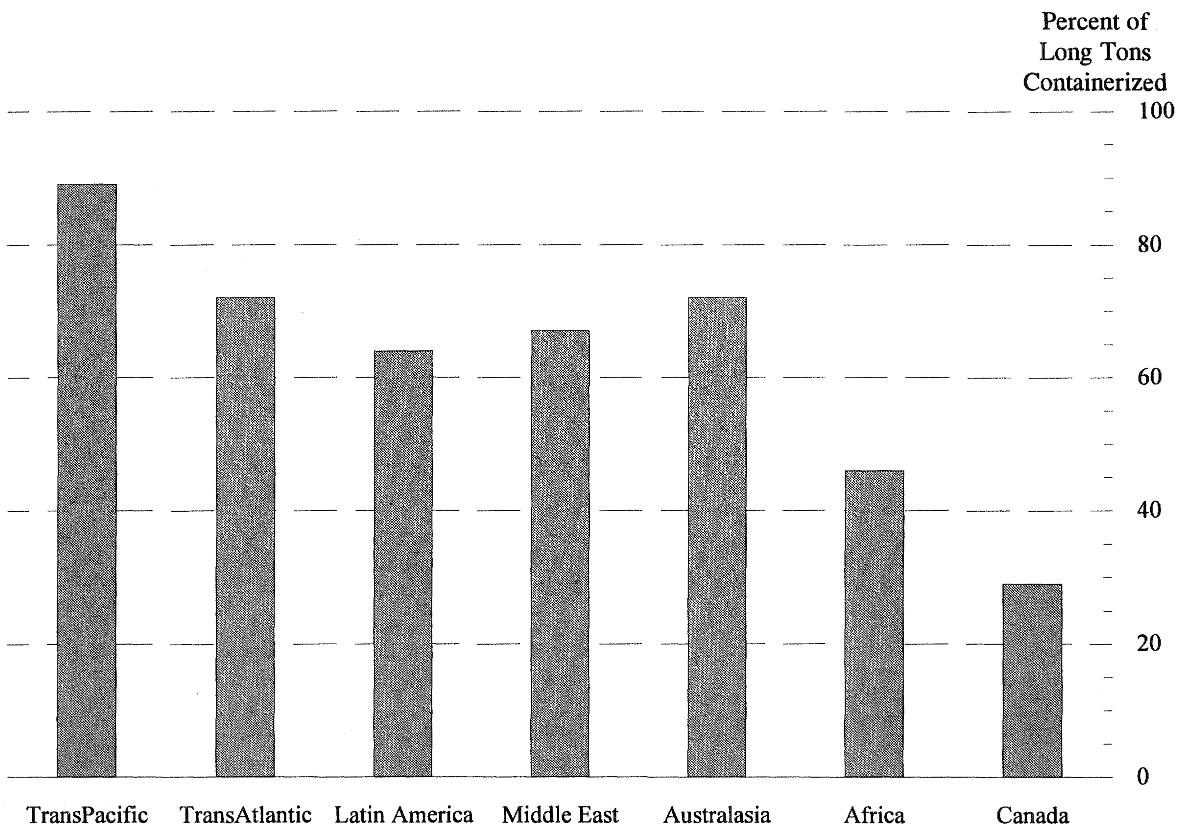
	Year						
	1988	1989	1990	1991	1992	1993	1994*
Transpacific	40	45	46	49	53	54	60
Transatlantic	25	27	29	28	30	30	31
U.S. - Latin America	10	11	13	15	18	18	20
U.S. - Middle East	3	3	3	4	4	4	4
U.S. - Australasia	3	3	3	3	3	4	4
Other	3	3	4	3	3	3	3
Total	84	92	98	102	111	113	122

* Estimate

Source: DRI/McGraw-Hill and Mercer Management, World Sea Trade Service Review, First Quarter 1995

In 1994, approximately 78 percent of all U.S. liner cargoes (long tons) were containerized (Exhibit 6-31). Eighty-nine percent of the transpacific and 72 percent of the transatlantic liner cargoes were containerized. With containerization, different commodities can be treated the same for cargo-handling purposes (liner cargoes include a wide variety of manufactured and semi-manufactured products). As a result, highly specialized line-haul/feeder services, connecting carrier services, vessel-sharing arrangments and intermodal services have been developed and have become the norm in these trades.

Exhibit 6-31
U.S. Containerized Liner Trade by Route
1994



Source: U.S. Bureau of the Census

The expansion and improvement of U.S. intermodal services by mainstream liner operators has contributed to an increase in the percentage of transpacific cargoes moving through West Coast ports (Exhibit 6-32). More frequent rail departures and faster rail transit times have resulted in intermodal services from the East Coast to the Far East through U.S. West Coast ports which are 5 to 10 days faster than all-water routings. In fact, intermodal services have become so sophisticated that a transpacific shipment may have as little as a four hour window in which to meet a stack train heading eastbound across the U.S.

Exhibit 6-32
U.S.-Far East Liner Trade by Coast
Percent of Long Tons
Selected Years, 1970-1994

	Year			
	1970	1980	1990	1994
Atlantic	36	26	22	18
Gulf	23	5	3	4
Pacific	41	69	75	78

Source: U.S. Bureau of the Census

Liner operators have also used vessel-sharing agreements extensively to maintain competitive service frequencies (sailings per year), expand itineraries, and rationalize investment in new vessels. As of November 1, 1994, 51 percent of the liner full and partial containership capacity (DWT) deployed in the U.S. liner trades were involved in vessel sharing agreements in the form of joint services and slot charters.

As a result of vessel sharing agreements, the distinction among carriers with respect to their market shares has tended to blur. Cargo booked with one shipping line may or may not move on that line's vessels, and statistics based upon either the vessel operator or the line booking the cargo do not tell the whole story.

As of November 1, 1994, approximately 25 percent of the vessel capacity (DWT) in U.S. liner trades was deployed in Round-the-World (RTW)/tricontinental services, up from 18 percent in 1990. The average age of the fleet deployed in these services is 8 years, compared to 13 years for vessels deployed in end-to-end services. The growth in RTW/tricontinental services reflects the fact that major shippers prefer shipping lines that operate on a worldwide scale. Shipping lines want to be able to offer a total service package, covering all the major routes, transatlantic, transpacific and Europe-Far East.

Cargo rarely moves in equal volumes in both directions, which causes carriers to engage in a significant amount of repositioning of empty containers. With RTW/tricontinental services, it is generally easier and more economical to move containers from low to high utilization areas. Finally, RTW/tricontinental services generally facilitate more effective utilization of marketing, logistics and intermodal services.

Non-Liner Trades

In contrast to liner vessels, non-liner dry cargo vessels do not operate on fixed schedules or itineraries. They generally transport cargoes based on a charter. Non-liner shipments declined at an annual rate of 1.1 percent between 1985 and 1994. In 1994, the largest U.S. non-liner cargoes were grains (85 million long tons), coal and coke (73 million long tons) and iron ore (22 million long tons).

In 1993, the transpacific was the largest U.S. non-liner trade, followed by the transatlantic and U.S.-Latin America trades (Exhibit 6-33). The Far East and Europe are major buyers of U.S. coal and grains, while Latin America is a major supplier of iron ore and crude minerals to the United States.

Exhibit 6-33
U.S. Non-Liner Trade by Major Route
Millions of Long Tons
1988-1994

	Year						
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994***
Transpacific	119.9	116.5	112.3	106.1	100.1	96.0	104.4
Transatlantic	129.9	133.6	133.5	130.0	117.7	98.1	81.8
U.S. - Latin America	59.1	60.2	61.2	58.4	57.6	61.9	65.3
U.S. - Canada	58.3	57.2	50.0	41.6	47.7	46.9	53.3
Other	35.7	30.1	26.9	23.8	30.2	26.5	23.1
Total	402.9	397.6	383.9	360.0	353.5	329.5	327.9

* Estimate

Source: DRI/McGraw-Hill and Mercer Management, World Sea Trade Service Review, First Quarter 1995

Tanker Trades

Tankers carry liquid cargoes in bulk, including crude oil, refined products, liquid gas, vegetable oils and wine. In 1994, crude oil alone accounted for 66 percent of all U.S. tanker cargoes and petroleum products accounted for another 24 percent.

The U.S. tanker trade grew at an average annual rate of 7 percent between 1985 and 1994. In 1994, Latin America was by far the largest source of tanker cargoes for the U.S., followed by the transatlantic and Middle East trades (Exhibit 6-34). The sharp increase in the U.S. tanker trade from 1988 to 1994 was due largely to rising U.S. petroleum imports (occasioned in part by declining domestic crude oil production).

Exhibit 6-34
U.S. Tanker Trade by Major Route
Millions of Long Tons
1988-1994

	Year						
	1988	1989	1990	1991	1992	1993	1994*
Transatlantic	69.3	67.7	61.9	63.2	69.2	80.7	86.2
U.S. - Latin America	121.5	127.1	134.0	142.0	151.8	167.8	173.8
U.S. - Middle East	56.9	73.6	79.8	71.6	74.3	77.0	73.8
U.S. - Africa	46.9	61.1	53.3	50.8	56.5	60.3	56.3
Other	48.0	49.9	51.5	46.4	48.1	51.6	57.1
Total	342.7	379.4	380.5	374.0	399.9	437.4	447.2

* Estimate

Source: DRI/McGraw-Hill and Mercer Management, World Sea Trade Service Review, First Quarter 1995

U.S.-Flag Shares

As shown in Exhibit 6-35, U.S.-flag vessels carried approximately 3.9 percent of U.S. waterborne foreign trade in 1994, down from 5.3 percent in 1970. However, the quantity (long tons) carried on U.S.-flag vessels has increased steadily from 25.1 million long tons in 1970 to 35.2 million long tons in 1994, a 40 percent increase. Liner cargoes were up 44 percent and non-liner cargoes were up 58 percent over the period. This absolute increase in cargo carried on U.S.-flag vessels reflects the deployment of larger, more productive U.S.-flag vessels in the 1970s and 1980s.

Exhibit 6-35
U.S.-Flag Shares of U.S. Oceanborne Trade
Millions of Long Tons
Selected Years, 1970-1994

	Year			
	1970	**1980**	**1990**	**1994***
Liner				
U.S.-Flag	11.8	16.2	16.8	17.0
Total	50.4	59.3	96.4	117.8
Percent U.S.-Flag	23.5	27.3	17.4	14.4
Non-Liner				
U.S.-Flag	5.3	4.3	7.2	8.4
Total	240.7	356.7	378.4	331.6
Percent U.S.-Flag	2.2	1.2	1.9	2.5
Tanker				
U.S.-Flag	8.0	7.8	10.6	9.8
Total	182.1	356.3	$379.1	448.2
Percent U.S.-Flag	4.4	2.2	2.8	2.2
Total				
U.S.-Flag	25.1	28.3	34.6	35.2
Total	473.2	772.2	853.9	897.7
Percent U.S.-Flag	5.3	3.7	4.1	3.9

* Preliminary

Source: United States Bureau of the Census

World Fleet

In 1994, 7206 vessels, or 29 percent of the world merchant fleet, called at U.S. ports. In terms of capacity, these ships represented 44 percent of the DWT in the world fleet. The importance of the U.S. trades is even more dramatically displayed in Exhibit 6-36 which shows the portion of the world fleet calling at U.S. ports in terms of the principal vessel types. In terms of capacity, about 54 percent of the world dry bulk fleet, 48 percent of the full containership fleet, and 40 percent of the tanker fleet called at U.S. ports in 1994. Of the 231 cruise vessels in the international fleet, 98 regularly served the U.S.

Exhibit 6-36
World Merchant Fleet that Called at U.S. Ports
1994

Type	U.S. Port of Call		Total	
	Vessels	DWT (Thousands)	Vessels	DWT (Thousands)
Container	569	18,559	1,591	38,868
Dry Bulk	2,855	134,608	5,291	250,472
Tanker	1,508	117,663	5,994	297,141
Roll-on/Roll-off	407	6,011	1,222	11,597
Cruise	98	554	231	906
Other	1,769	22,978	10,763	86,772
Total	7,206	300,373	25,092	685,756

Source: Lloyd's Vessel Itineraries

U.S. Domestic Trade

Total domestic trade (inland waterways, Great Lakes, and domestic ocean services) amounted to approximately 1.1 billion short tons annually during the 1987 through 1992 period. Preliminary data for 1993 indicate a 2.4 percent decline in total traffic. However, those numbers reflect the impact of the great floods of that year which restricted the flow of traffic on the inland waterways (Exhibit 6-37).

Exhibit 6-37
Domestic Waterborne Commerce of the United States
Millions of Short Tons
1987-1993

Region	Year						
	1987	1988	1989	1990	1991	1992	1993
Total Domestic Ocean	328.2	330.3	307.2	303.1	299.1	289.3	276.7
Noncontiguous	221.2	206.6	173.8	170.8	171.1	156.2	162.4
Total Inland Waterways	651.7	671.8	686.2	709.0	676.0	697.8	681.7
Mississippi System*	414.2	423.0	431.5	457.5	444.5	466.8	451.7
Gulf Intracoastal	106.1	115.9	111.6	114.7	110.3	111.6	114.1
Columbia	13.2	14.6	17.2	13.0	13.5	12.8	13.8
Total Great Lakes	96.5	109.7	109.1	110.2	103.4	107.4	109.8
Total	1,076.5	1,111.8	1,102.5	1,122.3	1,078.5	1,094.6	1,068.2

* Includes Mississippi, Ohio, Missouri and Illinois Rivers

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States

Great Lakes

The Great Lakes domestic trade includes shipments among U.S. Great Lakes ports and connecting waterways. The major commodities moved on the lakes are iron ore, coal and coke, and limestone. Iron ore, coke and limestone are used in the production of steel, and the coal primarily fuels electric plants. The total volume of cargo carried on the Great Lakes has been quite stable over the last several years (Exhibit 6-38), and amounted to nearly 110 million tons in 1993. More than 90 percent of this traffic moved in dry bulk ships.

Exhibit 6-38
Domestic Waterborne Commerce of the United States
Great Lakes
Millions of Short Tons
1987-1993

	Year						
Vessel Type	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Dry Cargo Ship	91.7	104.4	104.1	102.9	100.0	98.8	100.3
Tank Ship	0.8	0.7	1.0	1.5	0.6	0.6	0.9
Dry Cargo Barge	2.3	2.5	2.0	4.1	1.2	5.5	6.9
Tank Barge	1.7	2.0	2.0	1.7	1.6	1.9	1.7
Other	-	0.1	-	-	-	0.6	-
Total	96.5	109.7	109.1	110.2	103.4	107.4	109.8

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States

Inland Waterways

The inland waterways trade includes shipments on the navigable internal waterways of the Atlantic, Gulf, and Pacific coasts, and the Mississippi River system. The main arteries of the inland waterways network for the mid-continent are the Mississippi River System and Gulf Intracoastal Waterway. The Columbia River System similarly serves the Pacific Northwest. The primary commodities moved on the inland waterways include farm products, chemicals, petroleum, and coal. Total traffic on the inland waterways peaked at 709 million tons in 1990. In the flood year 1993, approximately 682 million tons of cargo were carried in the system, with an estimated value of $115 billion. More than 95 percent of the cargo moves in barges, with about a two to one ratio between dry and liquid cargoes (Exhibit 6-39).

Exhibit 6-39
Domestic Waterborne Commerce of the United States
Inland Waterways
Millions of Short Tons
1987-1993

	Year						
Vessel Type	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Dry Cargo Ship	7.2	8.0	6.7	5.2	6.8	8.4	8.1
Tank Ship	13.5	16.9	23.4	19.0	9.9	11.2	20.2
Dry Cargo Barge	389.4	390.9	404.7	424.8	412.5	436.7	407.2
Tank Barge	237.7	251.0	248.3	251.2	242.6	236.9	239.0
Other	3.9	5.0	3.1	8.8	4.2	4.6	7.2
Total	651.7	671.8	686.2	709.0	676.0	697.8	681.7

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States

One out of every eight tons of goods transported domestically moves via the inland or intracoastal waterway systems, and more than half of the U.S. is tied to a waterway system. The inland river system's contribution to the economic development of waterway dependent regions and the nation is significant.

Domestic Ocean

The major segments of the domestic ocean trade are the noncontiguous trades between the mainland and Alaska, Hawaii, Puerto Rico, Guam, Wake, and Midway Islands; and the coastwise trades along the Atlantic, Gulf, and Pacific coasts. The major products moving in domestic ocean trade are crude petroleum, refined petroleum products, residual fuel, and coal. Traditional liner cargoes, particularly consumer products, move between the contiguous 48 states and Alaska, Hawaii, and Puerto Rico. Passengers cruise the Hawaiian Islands as part of the domestic ocean trade.

Total cargo moving in the domestic ocean trades has been declining steadily for the past several years, reflecting the decline in Alaska North Slope crude oil shipments. The 277 million tons which moved in the domestic ocean trades in 1993 represent an approximate decline of 15 percent since 1987; but in absolute terms this reduction is almost precisely mirrored by the decline in tanker movements, indicating a stability or modest growth in the other segments of the domestic ocean trades (Exhibit 6-40). The growing movement of reformulated gasoline and additives from gulf coast refineries (particularly to the west coast) represents a bright spot on the horizon for product tanker demand.

Exhibit 6-40
Waterborne Commerce of the United States
Domestic Ocean
Millions of Short Tons
1987-1993

	Year						
Vessel Type	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Dry Cargo Ship	13.6	12.8	13.8	14.6	15.7	14.2	13.6
Tank Ship	222.5	216.9	198.6	186.6	186.6	180.1	164.3
Dry Cargo Barge	30.8	33.3	33.9	37.0	37.9	37.8	37.8
Tank Barge	61.3	66.9	60.5	64.9	57.2	56.7	60.7
Other	-	0.4	0.4	-	1.7	0.5	0.3
Total	328.2	330.3	307.2	303.1	299.1	289.3	276.7

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the U.S.

Port Traffic

The movement of domestic and foreign waterborne commerce through the U.S. port system is highly concentrated. There were a total of 343 ports which handled waterborne trade during 1993. The tonnage handled by the 50 leading coastal and inland ports (Exhibit 6-41) amounted to 88.7 percent of the total waterborne trade in that year. Despite the high degree of concentration, there were 145 ports that handled over 1 million short tons of cargo, which demonstrates the broad base on which the U.S. port system is built.

Exhibit 6-41
Top 50 U.S. Ports
Waterborne Commerce of the United States
Short Tons
1993

Rank	Port	Total	Domestic	Foreign
1	South Louisiana, Port of LA	193,796,104	100,062,787	93,733,317
2	Houston, TX	141,476,979	64,329,185	77,147,794
3	New York/New Jersey, NY	116,735,760	74,021,708	42,714,052
4	Valdez, AK	85,722,337	85,711,858	10,479
5	Baton Rouge, LA	85,078,863	44,623,571	40,455,292
6	New Orleans, LA	67,037,285	38,028,470	29,008,815
7	Corpus Christi, TX	59,649,751	23,589,020	36,060,731
8	Long Beach, CA	54,320,932	24,202,970	30,117,962
9	Texas City, TX	53,652,781	17,437,367	36,215,414
10	Plaquemine, Port of, LA	53,110,120	36,213,860	16,896,260
11	Norfolk Harbor, VA	45,543,792	8,350,108	37,193,684
12	Lake Charles, LA	45,436,380	18,692,954	26,743,426
13	Tampa, FL	44,992,777	27,672,005	17,320,772
14	Pittsburgh, PA	44,490,094	44,490,094	-
15	Mobile, AL	43,959,704	22,774,048	21,185,656
16	Los Angeles, CA	43,622,807	19,089,706	24,533,101
17	Philadelphia, PA	42,707,684	15,112,279	27,595,405
18	Port Arthur, TX	38,326,902	5,866,533	32,460,369
19	Duluth-Superior, MN/WI	37,679,398	28,729,550	8,949,848
20	Baltimore, MD	37,170,223	12,392,908	24,777,315
21	Marcus Hook, PA	30,907,303	14,325,567	16,581,736
22	Portland, OR	29,804,208	12,381,837	17,422,371
23	St. Louis, MO/IL	27,551,350	27,551,350	-
24	Pascagoula, MS	27,020,433	10,048,072	16,972,361
25	Beaumont, TX	25,409,757	13,523,388	11,886,369
26	Chicago, IL	25,048,025	21,206,362	3,841,663
27	Richmond, CA	24,570,112	18,842,297	5,727,815
28	Huntington, WV	22,833,285	22,833,285	-
29	Paulsboro, NJ	22,614,762	10,293,290	12,321,472

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States

Rank	Port	Total	Domestic	Foreign
30	Seattle, WA	21,693,410	7,608,714	14,084,696
31	Boston, MA	19,447,857	9,445,237	10,002,620
32	Jacksonville, FL	18,849,849	10,780,031	8,069,818
33	Tacoma, WA	18,651,709	6,337,559	12,314,150
34	Detroit, MI	17,421,533	13,991,379	3,430,154
35	Newport News, VA	16,734,878	3,928,574	12,806,304
36	Port Everglades, FL	16,297,269	10,605,185	5,692,084
37	Indiana Harbor, IN	15,546,403	15,375,637	170,766
38	Savannah, GA	14,962,844	3,280,116	11,682,728
39	New Castle, DE	14,242,529	6,620,221	7,622,308
40	San Juan, PR	14,153,403	8,888,806	5,264,597
41	Cleveland, OH	14,083,014	11,847,085	2,235,929
42	Freeport, TX	14,024,604	5,377,333	8,647,271
43	Lorain, OH	13,676,686	13,649,902	26,784
44	Cincinnati, OH	13,648,255	13,648,255	-
45	Memphis, TN	13,332,165	13,332,165	-
46	Anacortes, WA	13,123,794	11,416,492	1,707,302
47	Oakland, CA	12,733,691	3,892,826	8,840,865
48	Toledo, OH	12,149,760	7,225,259	4,924,501
49	Portland, ME	11,171,097	2,144,768	9,026,329
50	Two Harbors, MN	10,711,059	10,711,059	-
	Total - Top 50 Ports	1,886,925,717	1,052,503,032	834,422,685
	Total - All U.S. Ports	2,128,221,188	1,068,179,971	1,060,041,217
	Top 50 - Percent of Total	88.7	98.5	78.7
	Total - Top 5 Ports	622,810,043	368,749,109	254,060,934
	Total - Top 10 Ports	910,580,912	508,220,796	402,360,116
	Total - Top 20 Ports	1,334,510,673	711,390,981	623,119,692

Container traffic through U.S. ports is also highly concentrated. The 25 leading container ports accounted for 97.5 percent of total container traffic moving in foreign trade in 1994. The top 10 ports accounted for 79 percent of the total with 4 west coast ports among the top 5 U.S. container ports (Exhibit 6-42). Overall, the 1994 container traffic, in terms of TEUs, increased by 11.6 percent over 1993.

Exhibit 6-42
Top 25 U.S. Container Ports
1993 and 1994

	1993		1994	
Rank	**Port**	**Twenty-Foot Equivalent Units**	**Port**	**Twenty-Foot Equivalent Units**
1	Los Angeles, CA	1,626,660	Long Beach, CA	1,938,686
2	Long Beach, CA	1,543,336	Los Angeles, CA	1,786,172
3	New York/New Jersey	1,305,959	New York/New Jersey	1,404,133
4	Seattle, WA	780,491	Seattle, WA	966,875
5	Oakland, CA	772,183	Oakland, CA	878,904
6	Charleston, SC	579,034	Charleston, SC	654,834
7	Tacoma, WA	547,466	Norfolk, VA	569,969
8	Miami, FL	468,750	Tacoma, WA	509,777
9	Savannah, GA	406,183	Miami, FL	497,226
10	Houston, TX	392,526	Houston, TX	418,883
11	Norfolk, VA	519,106	Savannah, GA	418,300
12	Baltimore, MD	291,325	Baltimore, MD	310,036
13	Port Everglades, FL	229,760	Port Everglades, FL	281,100
14	New Orleans, LA	187,790	Portland, OR	233,385
15	Portland, OR	179,042	New Orleans, LA	196,705
16	Boston, MA	56,240	Jacksonville, FL	151,146
17	Jacksonville, FL	141,999	San Juan, PR	112,986
18	Wilmington, DE	99,071	Gulfport, MS	96,926
19	Gulfport, MS	89,862	W. Palm Beach, FL	90,934
20	San Francisco, CA	89,588	Wilmington, DE	82,689
21	W. Palm Beach, FL	88,742	Wilmington, NC	76,846
22	Wilmington, NC	83,083	Philadelphia, PA	75,953
23	San Juan, PR	81,871	Galveston, TX	68,531
24	Philadelphia, PA	81,691	Boston, MA	62,686
25	Galveston, TX	81,353	San Francisco, CA	55,151
	Top 25 Ports	10,723,111		11,938,833
	Total All Ports	10,960,863		12,238,133
	Top 25 Ports Percent of Total	97.8		97.6

Source: Journal of Commerce, Port Import Export Reporting Service

In terms of port calls, the top 20 ports accounted for approximately 75 percent of the vessel calls to all U.S. ports in 1994. The major ports on the Atlantic and Pacific Coasts service the container trades while the major ports on the U.S. Gulf coast ports are involved primarily in tanker and dry bulk trades. For cruise ships, Miami and San Juan were the major U.S. ports of call (Exhibit 6-43).

Exhibit 6-43
Top 20 U.S. Ports
Port Calls by Vessel Type
1994*

Rank	Port	Container	Dry Bulk	Tanker	Roll-on/ Roll-off	Cruise	Other	Total
1	New Orleans, LA	387	2,731	1,593	114	88	1,158	6,071
2	Los Angeles/Long Beach, CA	1,850	863	940	403	373	717	5,146
3	Houston, TX	316	648	2,636	227	-	1,260	5,087
4	New York, NY	1,627	391	1,014	636	222	481	4,371
5	San Francisco/Oakland, CA	1,358	310	998	359	44	346	3,415
6	Miami, FL	718	6	9	775	1,052	835	3,395
7	Philadelphia, PA	337	372	943	151	22	796	2,621
8	Hampton Roads/Norfolk, VA	992	642	223	251	25	370	2,503
9	Baltimore, MD	669	473	195	575	20	319	2,251
10	Columbia River, WA	304	1,071	242	224	4	190	2,035
11	San Juan, PR	530	41	88	334	738	285	2,016
12	Port Everglades, FL	398	70	379	302	314	498	1,961
13	Savannah, GA	522	248	240	161	6	618	1,795
14	Tampa, FL	1	466	333	15	223	528	1,566
15	Charleston, SC	909	91	97	130	13	308	1,548
16	Corpus Christi, TX	-	229	992	3	-	54	1,278
17	Jacksonville, FL	393	125	138	365	1	129	1,151
18	Seattle, WA	686	143	61	71	13	156	1,130
19	Texas City, TX	2	48	1,043	1	-	29	1,123
20	Tacoma, WA	333	235	76	254	1	66	965
	Total Top 20 Ports	12,332	9,203	12,240	5,351	3,159	9,143	51,428
	Total All Ports	13,518	12,528	18,849	6,787	4,387	12,112	68,181
	Top 20 Percent of Total	91.2	73.5	64.9	78.8	72.0	75.5	75.4

* Excludes calls by non-self-propelled vessels and vessels under 1,000 Gross Tons.

Source: Lloyd's Vessel Intineraries

World Shipyard Production

As of January 1, 1995, the world orderbook for merchant vessels 1,000 Gross Registered Tons (GRT) and over, consisted of 1,527 vessels totaling 66.6 million DWT. The average size of vessels on order is 43,596 DWT, which is 60 percent higher than the average of the existing world fleet. The average size of dry bulk carriers on order is 64,326 DWT, compared to an average of 47,339 DWT for the existing fleet. Similarly, tankers on order average 63,945 DWT, compared to an average of 49,573 DWT for the existing fleet.

Japan and South Korea are by far the leading world merchant shipbuilders with a combined 64 percent share (based on DWT) of the January 1, 1995 orderbook. The U.S. ranks twenty-sixth among the world's shipbuilding nations (Exhibit 6-44).

Exhibit 6-44
Shipbuilding Orderbook by Country of Build
January 1, 1995

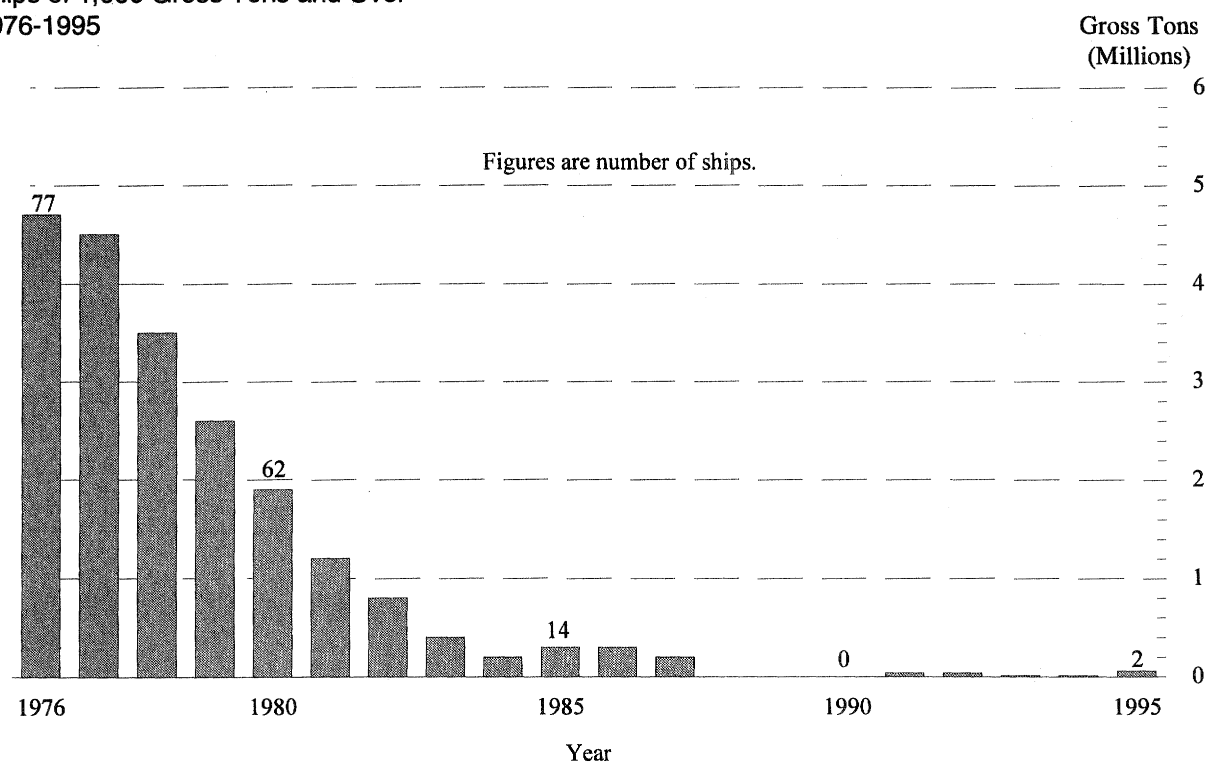
Rank	Country	Deadweight Tonnage (Millions)	Percent
1	Japan	22.4	33.6
2	South Korea	20.1	30.2
3	China (PRC)	3.1	4.7
4	Romania	2.3	3.5
5	Taiwan	1.2	3.1
:			
:			
26	United States	0.1	0.2
	Total	66.6	100.0

Source: Lloyd's Register

U.S. Shipyard Activity

The U.S. shipbuilding industry has a long history of commercial ship construction, building a large variety of oceangoing vessels in recent decades, including freighters, RO/RO cargo vessels, containerships, bulk carriers, very large crude carriers (VLCCs), passenger ships and sophisticated liquified natural gas carriers. However, as a result of the suspension of Federal construction assistance, the U.S. shipbuilding industry's commercial orderbook fell from 77 vessels (approximately 4.7 million GRT) in the mid-1970s to zero by 1988, its lowest level since pre-World War II (Exhibit 6-45).

Exhibit 6-45
U.S. Merchant Shipbuilding Orderbook
Ships of 1,000 Gross Tons and Over
1976-1995



Source: Maritime Administration

Following a huge construction program in the 1980's, the largest in peacetime history, Navy construction programs have been on the decline, with the 1995 through 1999 shipbuilding program proposing an average of less than eight new ships per year, compared with an average of nineteen new ships annually in the 1980s. This severe contraction in Navy work has forced U.S. shipyards to search harder for commercial work in order to survive.

Since the enactment of the National Shipbuilding and Shipyard Conversion Act of 1993, U.S. shipyards have been aggressively competing for re-entry into the domestic and foreign commercial shipbuilding markets. The newly expanded Federal mortgage guarantee program (Title XI) has been a major impetus to the shipyards, and, during 1994, 7 companies received approval for Title XI loan guarantees to construct a total of 52 ships and barges in U.S. shipyards. This included the first order for U.S.-built ocean-going commercial ships for export since 1957 (two 46,000 DWT double-hulled tankers).

The U.S. ship repair industry is very active, competing aggressively in the domestic and foreign markets for ship repair and conversion work to replace diminishing Navy orders. The large number of ships calling at U.S. ports on tight schedules could provide significant employment for U.S. ship repair yards, provided they are able to offer timely service and competitive prices.

The second-tier shipyards, with small or medium size facilities, are currently building a variety of vessels for use on the inland and coastal waterways. Some of this demand emanates from an on-going interest in the use of gaming boats as floating casinos. New orders for ferries will also continue to provide work, as projects such as the North Carolina six vessel fleet expansion, are developed. The ferry industry may also benefit from the $100 million discretionary program created in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and the second-tier shipyards are taking advantage of high demand for excursion/dinner boats, towboats, drug interdiction craft, research vessels, fireboats, petroleum and other types of barges as well as large and small pleasure boats.

Exhibit 6-46 displays new construction activity in second-tier shipyards during the period 1984 through 1993, based on a survey of its members by the American Waterways Shipyard Conference. The reduction in activity in the power driven vessel segment reflects substantial declines in military and offshore oil service vessels. However, this decline was more than offset by fourfold increases in hopper and tank barges in the river barge segment and a huge 1993 increase in the offshore barge segment. The second-tier shipyards also perform a significant volume of repair work which, in terms of the number of vessels repaired, was 40 percent higher in 1993 than in 1984.

Exhibit 6-46
Second-Tier Shipyards
New Construction Activity
Number of Vessels
1984-1993

	Year									
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Power Driven Vessels	350	300	239	348	237	196	90	122	117	147
River Barges	221	277	166	145	278	571	521	604	765	675
Offshore Barges	10	8	5	9	6	29	12	4	16	130
Total	581	585	410	502	521	796	623	730	898	952

Source: American Waterways Shipyard Conference, 1993 Annual Survey

Accomplishments and Innovations

The maritime industry has consistently been a leader in innovation and technology development in the quest for lower transportation costs to improve competitiveness and service to shippers. Since the demand for transportation services is derived from the demand for the goods transported, economic growth is clearly linked to the availability of efficient transportation services.

Intermodal Services

Containerization was invented by U.S. ocean carriers as a means of moving larger cargo units on and off ships to cut handling costs, reduce time in port, and minimize loss and damage to cargo. The U.S. ocean carriers have remained the prime innovators in containerization and intermodal transportation. The containership has evolved from a modified tanker which carried a few containers on deck to today's generation of huge wide-body vessels designed with capacities upwards of 5000 TEU.

The container itself has evolved from the early 17-foot box to large 53-foot high cube units to optimize their use on railways and within highway size and weight limits. Specialized containers are used to carry refrigerated cargoes, and special liners permit the carriage of edible, noxious, humidity controlled and even bulk cargoes without contamination, giving the container incredible versatility as a means of transport. Container cranes and other handling equipment have evolved to service higher and wider stacks of containers on board and shoreside.

U.S.-flag shipping companies have developed a fast-paced, well-supported commercial waterborne transportation infrastructure through containerization, intermodalism, satellite communications, cargo tracking, and related advanced technology systems. With 17 percent of U.S. Gross Domestic Product spent on transportation services, even tiny percentage improvements in transportation efficiency save billions of dollars. It was a U.S.-flag carrier that established the first liner/stack trains to provide faster service at lower cost, and today most of the major liner companies either operate their own stack trains or contract for such service from the railroads. A number of companies have formed integrated transportation companies in order to provide complete door-to-door service.

These innovations have contributed to dramatic productivity improvements and have enabled the carriers to provide U.S. business with lower transportation costs, reduced inventory and warehouse costs, JIT logistics support, in-transit visibility and reduced loss and damage, all of which results in expanded market opportunities for U.S. business.

Research and Development

The industry played a lead role during the late 1980s in the development and application of a standard technology for the automatic identification of containers and other transportation equipment. This technology has become an international standard and been adopted by the American Trucking Associations and the Association of American Railroads, which is requiring all railroads to have the system in use by 1995.

The industry has also been in the forefront in the application of artificial intelligence technology to ship operations. Shipboard installations were produced of an expert diesel engine diagnostic system and a piloting expert system which improves the safety of ship navigation and reduces collisions and groundings.

Domestic Trade

In the domestic trades, both the inland waterways and the shallow-draft vessels that operate on them have been improved over time. Barge sizes and towboat horsepower have increased, and more significantly, tow sizes have grown. Waterway channels have been improved and lock sizes enlarged. These developments allow greater cargo throughput and much more intensive use of the waterway system.

The inland waterway industry tends to be more evolutionary than revolutionary. However, vessel management systems that integrate vessel and shoreside operations, a technology which arose from the need to control fuel costs, have become comprehensive and effective means to coordinate and manage the operation of all waterway equipment.

Sealift Support

This country's changing defense posture and the closing of overseas bases increases our dependence upon timely sealift support. For example, the industry's ability to respond in a national emergency was clearly demonstrated during Operations DESERT SHIELD/DESERT STORM, when 79 percent of the equipment and supplies moved on the U.S.-flag fleet.

Cargo delivery service to the Persian Gulf theater was provided by 62 commercial U.S.-flag ships as part of their ongoing commercial operations under the Military Sealift Command's Special Middle East Sealift Agreement. Many of the companies that provided service during the conflict utilized larger vessels for the longer, line-haul portion of the voyage, and off-loaded the cargo on to smaller vessels that actually went into the Gulf. Many of those vessels were foreign-flag vessels controlled by the U.S.-flag company. This kind of vessel deployment is consistent with the way that many modern commercial operations are structured and also conformed to the desires of the local commanders at the destination points who preferred dealing with smaller vessels to minimize port congestion.

Regulation, Environment and Port Access

Previous sections have described the nature and performance of the waterborne transportation system. However, the performance of that system is affected by a number of regulatory, environmental and port access constraints.

Tanker operations are subject to the IMO International Convention for the Prevention of Pollution from Ships, and the OPA-90 regulations which will significantly increase the cost of building and operating tankers in the mid to late 1990s. IMO regulations apply to tankers trading worldwide, while OPA-90 applies only to tankers trading at U.S. ports.

IMO and OPA-90 regulations mandate a phase-out of single-hull tankers in stages (based on size and age) beginning in 1995. OPA-90 requires that newly built tankers delivered after 1993 be equipped with double hulls, while IMO requires that newbuilding tankers delivered after 1995 be so equipped. According to Lloyd's Shipping Economist, the cost for a newly built double-hull tanker is 15-20 percent greater than that for a single-hull tanker of comparable size. As of January 1, 1995, Lloyd's reported that only 9.6 percent of the world tanker fleet 10,000 DWT and above were equipped with double hulls.

Beginning in 1996, IMO's Safety of Life at Sea Convention (SOLAS) requires enhanced class surveys for tankers. These include supplemental surveys to monitor the performance of corrosion protection, including annual thickness gauging of salt water ballast tanks when corrosion is detected.

Beginning in 1995, OPA-90 requires tanker owners/operators that load/discharge at U.S. ports to establish and maintain evidence by means of a Certificate of Financial Responsibility (COFR) that they are capable of paying for oil spill cleanup operations. Tankers are required to show financial backing of $1,200 per GRT. Financial responsibility can be established with insurance, surety bond guarantee, letter of credit or self-insurance.

The OPA-90 requires that laden single-hull tankers over 5,000 GRT be escorted by tugs in Prince William Sound and Puget Sound. Other U.S. escort areas are under consideration. The law also requires tankers loading/discharging at U.S. terminals to carry spill containment/cleanup equipment and pumps to move cargo between tanks. OPA-90 and IMO require tanker operators to prepare detailed emergency oil spill response plans, and train shipboard and office staff in using the plans.

The combined effect of the regulations will be to accelerate the replacement of tankers in the late 1990s. For example, an operator of a single hull tanker that will not be allowed to trade after the year 2000 (double-hull requirement), and which is due its next quadrennial survey in 1998 would probably choose to scrap the vessel in 1998 rather than pay the higher survey costs for an additional two years of operation.

The loss of the ACHILLE LAURO in 1994 resulted in new IMO regulations, pursuant to the SOLAS convention, addressing enhanced fire protection for new and existing passenger ships (more than 36 passengers). The regulations require that passenger ships be equipped with the following by 1997: fire doors, smoke detectors, alarm systems, sprinkler systems, escape routes marked by photo-luminescent strips, and a central control room for fire doors.

The regulations are expected to shorten the economic life of some older vessels. Cruise Lines International Association, for example, is predicting a 10 percent decline in the cruise fleet serving U.S. ports between 1997 and 1998 after the regulations go into effect.

A number of recent regulatory requirements impact upon port operations and efficiency, particularly those dealing with safety, the environment, dredging and dredged material disposal, and operating conditions that require permits for overweight trucks and restrict local truck and/or rail operations.

Ports are affected by environmental regulations from all levels of government—Federal, State, and local. With the increase in environmental awareness, the number and complexity of the regulations has grown as well as the time required for compliance.

Among the key environmental factors affecting the port industry are: (1) dredging navigation channels and disposing of dredged material in a timely, cost-effective, and environmentally sound manner; (2) managing the wastes generated by facilities and ships in a safe and environmentally sound manner; (3) providing prompt and adequate response to spills of oil and hazardous substances; (4) controlling air polluting emissions from vessels and port operations; (5) preventing water pollution; (6) providing for the safe handling of hazardous cargo; (7) developing old industrial properties that may be contaminated; (8) complying with wetland and endangered species regulations; and (9) dealing with other legal, liability, and financial obligations associated with environmental and safety regulations.

The following list of key federal laws affecting the port industry gives a sense of the breadth and complexity of environmental issues with which the ports must deal.

> *Marine Protection Research and Sanctuaries Act (MPRSA) regulates the disposal of materials at sea, and authorizes the designation of marine sanctuaries. The MPRSA implements U.S. obligations under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention).*
>
> *Clean Water Act is designed to improve and protect surface water quality, with the National Pollutant Discharge Elimination System permit program as the primary regulatory tool and with separate permit programs for wetlands protection and for dredging and dredged material disposal.*
>
> *Comprehensive Environmental Response, Compensation, and Liability Act provides for liability, compensation, clean-up, and emergency response for hazardous substances.*
>
> *Resource Conservation and Recovery Act provides for cradle to grave management of hazardous waste by imposing management requirements on generators and transporters of materials and upon owners and operators of treatment, storage, and disposal facilities.*
>
> *Clean Air Act regulates emissions from stationary and mobile sources and establishes the basic Federal-state regulatory framework.*
>
> *Ports and Waterways Safety Act seeks to enhance navigation and vessel safety, protect the marine environment, and protect life, property, and structures in, on or immediately adjacent to the navigable waters of the United States.*
>
> *Coastal Zone Management Act requires coastal states to formulate a management program for the land and water resources of their coastal zones.*
>
> *Oil Pollution Act of 1990 profoundly changed the way oil is transported in U.S. waters (and has been discussed earlier).*

There is also a crucial need to improve land transportation connections at the ports. Inefficient rail and highway connections can increase bottlenecks on those few miles nearest to marine terminals and reduce the ability of ports to provide vital cargo transfer services from water to land transport mode.

The ISTEA specifically recognizes the importance of access to intermodal facilities, and requires metropolitan planning organizations and State departments of transportation to give consideration to port access in their planning processes and intermodal plans. The recent assessment of ISTEA implementation identified the movement of freight as one of ten key issues not adequately addressed in the legislation, and the action plan resulting from that process calls for the Department of Transportation to increase awareness of the contribution that the movement of freight makes to the national economy and the importance of including representatives of trucking, rail, air cargo, ports, and shipping in the MPO planning process.

More than 90 percent of the Nation's top ports, accounting for more than 90 percent of U.S. foreign trade, require regular maintenance dredging. When delays occur in the maintenance dredging cycle, channels silt in, causing hazardous and restricted navigation conditions and the diversion of cargo and vessels.

It has become increasingly difficult for the Federal government and for deep-draft port facility owners to proceed with essential harbor and berthing area dredging operations and the disposal of dredged material in a timely and cost effective way, consistent with environmental quality controls. The process through which dredging permits are obtained is generally long and arduous. Local sponsors of dredging projects must deal with a variety of Federal and State regulatory agencies with differing missions and mandates, and this division of responsibility may cause delays.

The disposal of dredged material is at the heart of the dredging problem for many ports. The total volume of dredged materials disposed of annually is about 400 million cubic yards. Over 95 percent of the material is classified as uncontaminated, and is often suitable for both unconfined disposal in open water and beneficial use applications, such as beach nourishment and habitat restoration. However, increasing opposition to unconfined aquatic disposal has led to a decrease in the number of approved disposal sites and has escalated pressure on existing sites.

In recent years, the mounting problems with the dredging and disposal process have led to a number of public and private endeavors seeking to improve the process. The MARAD-led Interagency Working Group on the Dredging Process has sought to bring efficiency and predictability to the process and in December 1994 issued a report (The Dredging Process in the United States: An Action Plan for Improvement) which contained a variety of recommendations which are currently being implemented.

FEDERAL ROLE

Federal Assistance Programs

There are a wide variety of Federal programs which support the development of a water transportation system to provide a National defense transport capability and serve the needs of U.S. domestic and international commerce. These public investments in the water transportation system tend to be relatively small and highly leveraged, as the industry overall remains overwhelmingly financed with private capital.

Shipyard Revitalization

American shipyards built more than 5,000 cargo ships during World War II. However, in recent years, Naval ship orders have declined. American shipyards have also been at a competitive disadvantage in the world commercial shipbuilding market for years, largely due to foreign government shipyard subsidies and recent technological improvements in foreign shipyards.

The Administration recognized the plight of U.S. shipyards, and responded with a 5-point revitalization plan. The most important element extended government guarantees to the financing of vessels purchased in U.S. shipyards by foreign owners through the existing Title XI domestic loan guarantee program. Other elements included efforts to ensure fair international competition, improve commercial competitiveness, eliminate unnecessary government regulation, and assist in international marketing. This plan was implemented with the passage of the National Shipbuilding and Shipyard Conversion Act of 1993.

The 1993 Act also funded industry-initiated cooperative research and development projects, under the MARITECH program. The first phase is focused on near-term market penetration with competitive, commercial ship designs for international buyers. Subsequent efforts will focus on longer-term technology development.

Thus far, twenty MARITECH projects, with 147 participants located in 22 states and nine foreign countries, have been approved. These projects involve double hull tankers, passenger vessels, dry and bulk cargo vessels, container ships, high speed ferries, and off-shore service craft.

Additionally, U.S.-led efforts have resulted in an Organization for Economic Cooperation and Development (OECD) agreement to eliminate unfair foreign subsidies to shipbuilders. That agreement is now subject to ratification by the U.S. and other OECD governments.

MARAD works closely with standards-developing organizations, such as the International Standards Organization (ISO), the IMO, and the Coast Guard for the adoption of improved and rationalized international ship construction and quality standards. MARAD has undertaken broad efforts to make U.S. shipyards aware of international quality management standards and to facilitate compliance with and/or certification under such standards, which will assist the shipyards in their marketing efforts.

Financing Programs

The Title XI loan guarantee program allows MARAD to guarantee private sector debt financing for the construction or reconstruction in U.S. shipyards of U.S. flag vessels and export (foreign flag) vessels, and U. S. shipyard modernization and improvement projects. The Government's liability on these loans is limited to defaults. Title XI guarantees enable shipowners and shipyards to borrow funds from the private markets on more favorable terms than may otherwise be available, at a fixed rate, with longer maturities. The maximum percentage of government financing drops from 87 1/2 percent to 80 percent after the OECD Agreement goes into force. The maximum term would decrease from 25 years to 12 years under the OECD Agreement.

Since passage of the Act, MARAD has approved 13 new Title XI applications involving ship construction worth $778 million and guarantees totalling $575 million (including the first export order), and has under review applications involving another $2.1 billion in financing guarantees. MARAD has also approved Title XI guarantees for shipyard modernization projects at two shipyards.

The Capital Construction Fund (CCF) is a tax deferral program designed to encourage owners and operators to construct, reconstruct, or acquire vessels in U.S. shipyards for operation in the foreign, Great Lakes, or non-contiguous domestic trades. Deposits may come from vessel income, depreciation, and net proceeds from vessel disposition. Deferred taxes are recouped by the government through a reduction in the depreciable basis of a vessel corresponding to the amount of CCF funds used for the vessel. If funds are withdrawn for a non-qualified purpose, the withdrawal is taxable. Fundholders deposited $5.8 billion into CCF accounts from the inception of the program in 1971 through 1993, and at the end of that period there were 111 companies party to CCF agreements.

Operating Assistance

Recognizing that the U.S. merchant marine engaged in U.S. foreign commerce was in danger of disappearing, and acknowledging the need for limited assistance to help the industry transition into international competitiveness, the Administration proposed a ten-year Maritime Security Program (MSP). With annual appropriations of $100 million, the MSP would attract the most modern, efficient and militarily useful U.S.-flag vessels at a per vessel cost of up to 50 percent less than the current operating-differential subsidy (ODS) program. The MSP would support up to 50 liner ships operating in the foreign commercial trade of the U.S. with payments of $2.5 million per vessel for the first three years, decreasing to $2 million per vessel per year through the next seven years.

The vessels would be able to operate without restriction in foreign trade, and participating carriers would be required to enroll in an Emergency Preparedness Program established to provide intermodal sealift support in time of war or national emergency. Vessel owners would be required to provide ships, intermodal equipment, terminal facilities, and management services. This partnership with the private sector would provide the government with cost-effective sealift, utilizing commercial assets to complement Department of Defense sealift programs and the RRF.

While the MSP would replace the existing ODS program, obligations under the old program would continue until 1998 for liner vessels and for bulk vessels until 2001. In Fiscal Year (FY) 1996, ODS contract obligations for 35 liner vessels and 19 bulk ships will amount to $162.6 million.

Cargo Preference

Cargo Preference refers to a series of laws reserving certain oceanborne cargo for U.S. registered vessels. Preference cargoes are generally those arising from procurement or shipment by or for the government.

MARAD provides guidance to other Federal agencies regarding cargo preference and monitors their compliance with cargo preference laws, dealing with civilian agencies (e.g. EXIMBANK), military cargoes (including household goods) and agricultural cargoes (USDA/USAID humanitarian aid).

MARAD assures that the freight rates charged for certain preference cargoes are fair and reasonable, and reimburses the Department of Agriculture for the higher cost of carriage on U.S.-flag vessels for certain agricultural cargoes. For FY 1995, MARAD expects to spend less than $25 million for ocean freight differential payments.

Ports and Domestic Shipping

MARAD provides technical assistance in port planning and operations to State and local port authorities, private industry and foreign governments. It also develops contingency plans for the utilization of ports and port facilities to meet defense needs in time of national emergency or war and to provide port security training.

MARAD's technical assistance to the port industry is aimed at enhancing the role of U.S. ports in cargo transfer services, economic development and national defense. This involves the development of various analytical reports, models, methodologies and data systems, seminars and training programs for improving planning, safety, security, productivity, and the general efficiency of marine terminal operations through improved port management. Specifically, these cost-shared efforts are designed to help ports plan for future trade growth, cargo and ship types, and intermodal transportation technology.

To fulfill its emergency planning role with respect to U.S. ports, MARAD administers a Federal Port Controller program to ensure the availability of qualified personnel, allocate port facilities and set priorities during war or national emergency, so that both military and civilian needs are met.

The responsibility for maintaining and improving the coastal navigation channels is divided between the Army Corps of Engineers and the public and private elements of the port industry. The differentiation is between Congressionally designated channel projects and spur or connecting channels leading from them to private or non-Federal installations. The improvement and maintenance of the connecting channels is the responsibility of the terminal owner.

The landmark Water Resources Development Act of 1986 established a new framework for funding Federal navigation channels by establishing cost-sharing provisions which required the non-Federal sponsor to fund a portion of each channel improvement project based on channel depth. The Act also established the Harbor Maintenance Trust Fund, which now fully funds the Corps' operation and maintenance dredging costs. Revenues for the trust fund come from the Harbor Maintenance Tax, which is an ad valorem fee on the cargo loaded or discharged at U.S. ports.

The last authorization bill enacted, the Water Resources Development Act of 1992, provided $1 billion for nine navigation projects, seven deep-draft and two inland waterway. The seven deep-draft projects totalled $381.3 million with the Federal funding totalling 61 percent. The funding for the two inland waterway projects of $624 million is split 50 percent from general Federal funds and 50 percent from the Inland Waterway Trust Fund.

Waterway projects are subject to a rigorous cost-benefit analysis, and practically every water development project has multiple public purposes: the maintenance of channels and the operation of the network of locks and dams essential to flood control; water supply for communities along the river; recreational opportunities, and environmental benefits.

As noted above, inland waterway improvements are jointly funded by the Corps and the users through the Inland Waterway Trust Fund (IWTF), which receives the proceeds from a 20 cent per gallon tax on fuel used in commercial transportation on the inland waterways. Operations and maintenance expenditures are a Federal responsibility. In 1994, IWTF revenues were nearly $100 million, and the fund had a balance of $220 million on February 1, 1995.

Federal inland waterway investment for the period 1989 through 1993 totalled $4.5 billion dollars. Operations and maintenance expense in this same period totalled $2.1 billion, an annual average of $425 million.

Market Promotion

The goals of MARAD's market promotion activities are to stimulate and facilitate communications between the providers of and the users of ocean transportation services; lower or remove trade barriers; neutralize foreign export subsidies; increase participation by private firms in the U.S. export market; and provide information and assistance geared toward raising the volume of U.S. exports and the U.S. market share in the international arena.

In addition, MARAD conducts a global marketing effort for the U.S. shipbuilding industry and seeks to ensure a fair international market. Other activities include aiding U.S. shipyards in the transfer of their skills from military to commercial markets, improving productivity and providing market information.

Research and Development

MARAD administers a small R&D program which emphasizes on-going government-industry cooperative activities to improve the competitiveness of the U.S. merchant marine and revitalize U.S. shipbuilding and repair through focus on intermodal solutions to commercial and national defense transportation requirements.

MARAD research supports six major research themes: industry competitiveness, intermodal development, maritime safety, environmental protection, shipyard revitalization and national security.

One specific example of ongoing intermodal projects is the Maritime System of the Americas (MSA), a government/industry cooperative research program to provide a comprehensive analysis of the potential market for water transportation in the trade between the United States, Canada and Mexico. The already growing trade between the United States and Mexico, and Canada and Mexico, as well as the greater growth projected to follow implementation of NAFTA enhances the opportunity for increased U.S. marine transportation market share in these markets, with resultant increase in maritime employment.

Training

The Maritime Administration supports the training of merchant mariners in order to ensure safety and efficiency in the movement of U.S. waterborne commerce. Graduates of the U.S. Merchant Marine Academy and the six State maritime academies are the foundation of efforts to ensure that the American maritime labor force is the best educated, safest and most responsible in the world. At the same time, the Nation must continually renew the pool of highly qualified entry level officers in the civilian merchant marine, so that commercial vessels and the fleet of government owned and/or operated sealift ships can be crewed quickly in a crisis.

Since 1943, the U.S. Merchant Marine Academy at Kings Point, New York has been preparing young men and women to be leaders in the maritime industry on land and at sea. The Academy has an enrollment of over 900 students from throughout the United States and several foreign countries. For FY 1995, Federal support for the Academy will be approximately $31 million.

The Federal government also provides financial assistance to six State maritime academies in the form of direct payments to the academies, incentive payments to cadets, and maintenance and repair of five ships on loan for use as training ships. FY 1995 appropriations amount to $9.3 million, including about $1.4 million in student stipends and $6.8 million for schoolship maintenance and repair. Although the State maritime academies receive Federal funds, the largest source of money for these institutions is state appropriations and tuition and fees from students.

The Federal Government does not sponsor direct training programs for unlicensed mariners; however, industry-sponsored programs provide the essential basic and advanced skills required to operate the high technology vessels and shipboard cargo handling equipment used in the Nation's waterborne transportation system.

Economic and National Security Role

In the past, the U.S. relied on a huge fleet of relatively small commercial ships to provide sealift support; now, that fleet has been superseded by an infinitely more sophisticated network of interrelated, intermodal equipment and large vessels. Today's "fleet" includes not only ships, but also containers, chassis, computer-based data systems, rail and truck interchanges, warehouses, piers, cranes, terminals, and most importantly, people ashore and at sea. These assets—located throughout the world—are available to support military operations at any time.

This aspect of the importance of the U.S. merchant marine was most clearly demonstrated during the Persian Gulf War. While 79 percent of the total equipment and supplies required for Operations DESERT SHIELD/DESERT STORM moved on private and government-owned U.S.-flag ships, more than 32 percent of the dry cargo sealift was carried on commercial U.S.-flag ships as part of their normal liner operations or under time-charter to the Defense Department. In addition, the 76 ships activated from the RRF were crewed by U.S. citizen seafarers. Operation RESTORE HOPE in Somalia and Operation MAINTAIN DEMOCRACY in Haiti also depended on U.S. citizen seafarers to crew activated RRF ships. Thus, not only does the commercial fleet provide sealift capacity, it also furnishes the skilled labor force upon which we rely to crew our reserve fleet.

Several U.S. companies are currently building, or have plans to begin construction of, new state-of-the-art vessels. The proposed MSP specifically seeks to include vessels which are militarily useful, thus making them available to DOD in time of war or national emergency. Maintaining this fleet would also permit retention of the pool of U.S.-citizen crews, the need for which has been so frequently demonstrated, to support the RRF and DOD organic fleet.

However, several U.S. companies have begun to transfer or register new vessels under foreign flags. Most of the companies involved have indicated their support for enactment of the MSP. However, without a new program that provides adequate support levels, they will not remain under U.S. flag.

The U.S.-flag fleet also makes a significant contribution to the economic security of the Nation. U.S.-flag shipping companies in foreign trade contribute $4 billion annually to the Nation's balance of payments by transporting U.S. exports to foreign markets. Due to the rapid expansion of U.S. trade and increased vessel capacity and efficiency, U.S.-flag vessels are carrying more cargo even though the number of ships in the U.S.-flag fleet has declined.

However, as some carriers reflag to achieve the cost savings available with non-U.S. crews, fewer safety and operational requirements, increased operating flexibility, and more extensive tax benefits, the economic contribution of the U.S. fleet will decline.

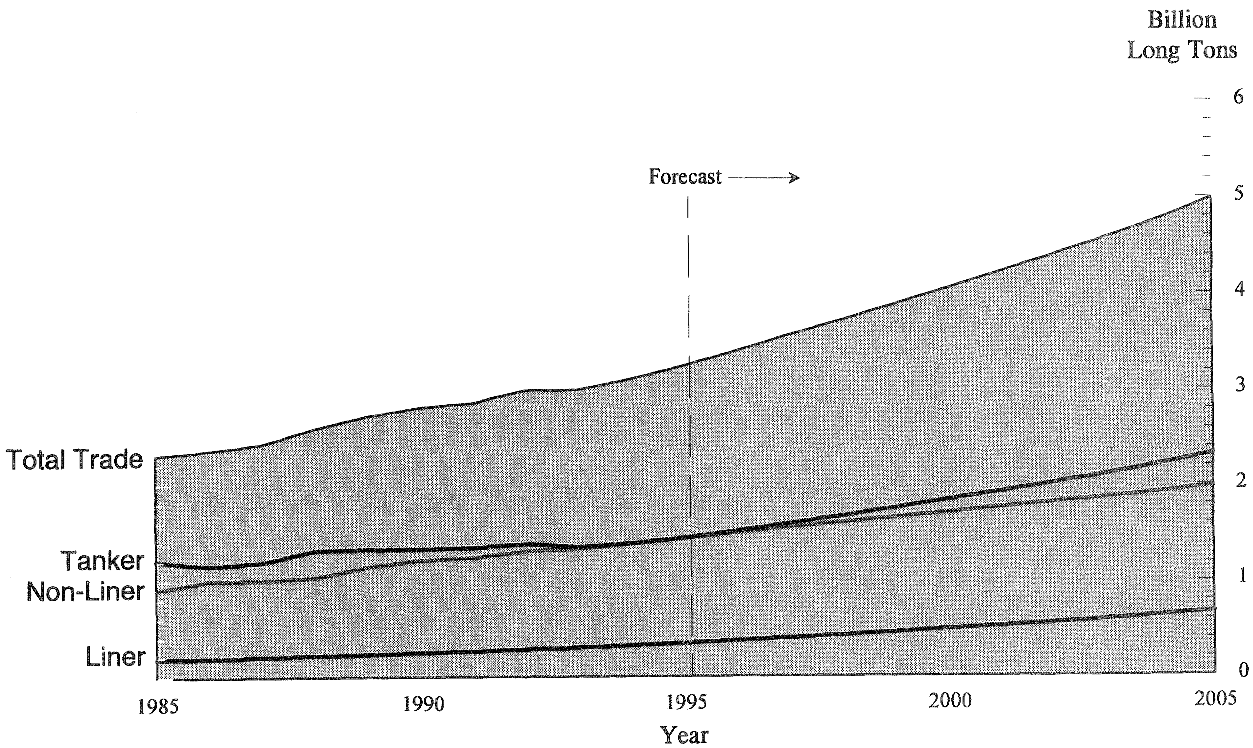
Without a U.S.-flag fleet, the United States, the largest trading nation in the world, would become wholly dependent on foreign shipping lines to carry its exports and imports. American exporters and importers would have no market-based leverage on freight rates and service levels imposed by foreign carriers, and their capacity to compete in foreign markets would suffer.

Furthermore, the United States would lose an effective voice at the IMO, for without a fleet, the U.S. would no longer be considered a flag state and would lose negotiating power regarding the setting of worldwide shipping standards. The only negotiating position left would pertain to port state issues such as safety and the environment.

World Oceanborne Trade

According to DRI/McGraw-Hill and Mercer Management's (DRI/Mercer) World Sea Trade Service Review, First Quarter 1995, world trade expanded from 2.3 billion long tons to 3.1 billion long tons between 1985 and 1994, or at an average annual rate of 3.9 percent. DRI/Mercer projects that during the next 11 years, international oceanborne trade will increase at an annual rate of 4.3 percent (Exhibit 6-47). By 2005, world waterborne trade is projected to approach 5 billion long tons. For the period 1994 to 2005, liner trades will increase at an annual rate of 9.6 percent. For the same period, non-liner and tanker trades will increase at annual rates of 6.1 percent and 3.9 percent respectively. Oceanborne trade is expected to grow at rates significantly higher than those for world gross domestic product (3 percent per year) due to increased specialization (reduction in trade barriers, privatization, advances in transportation and communications) within trading blocks and between nations. Consequently, countries will be trading a larger share of what they produce.

Exhibit 6-47
World Oceanborne Trade
1985-2005

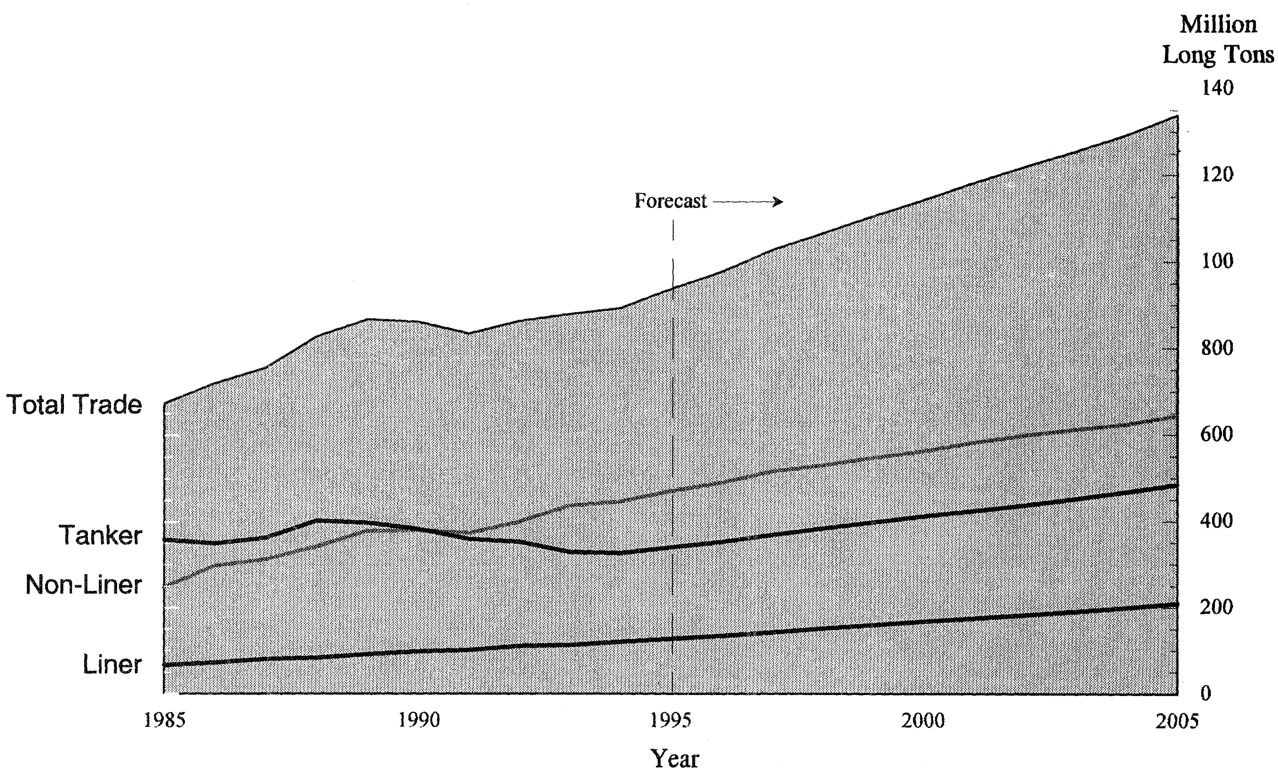


Source: DRI/McGraw-Hill and Mercer Management, World Sea Trade Service Review, First Quarter 1995

U.S. Oceanborne Trade

U.S. oceanborne foreign trade grew from 674 million long tons to 897 million long tons between 1985 and 1994, or at an average annual rate of 3.7 percent. DRI/Mercer projects that for the next 11 years U.S. oceanborne trade will grow at an average annual rate of 4.5 percent (Exhibit 6-48). For the period 1994 to 2005, liner trades will increase at an annual rate of 6.8 percent; non-liner and tanker trades will increase at annual rates of 4.6 percent and 4.2 percent, respectively. DRI/Mercer expects a significant recovery in U.S. grain exports, a major non-liner cargo, which was adversely affected by the 1993 floods. By 2005, U.S. oceanborne trade is projected to be approximately 1.3 billion long tons.

Exhibit 6-48
U.S. Oceanborne Trade
1985-2005



Source: DRI/McGraw-Hill and Mercer Management, World Sea Trade Service Review, First Quarter 1995

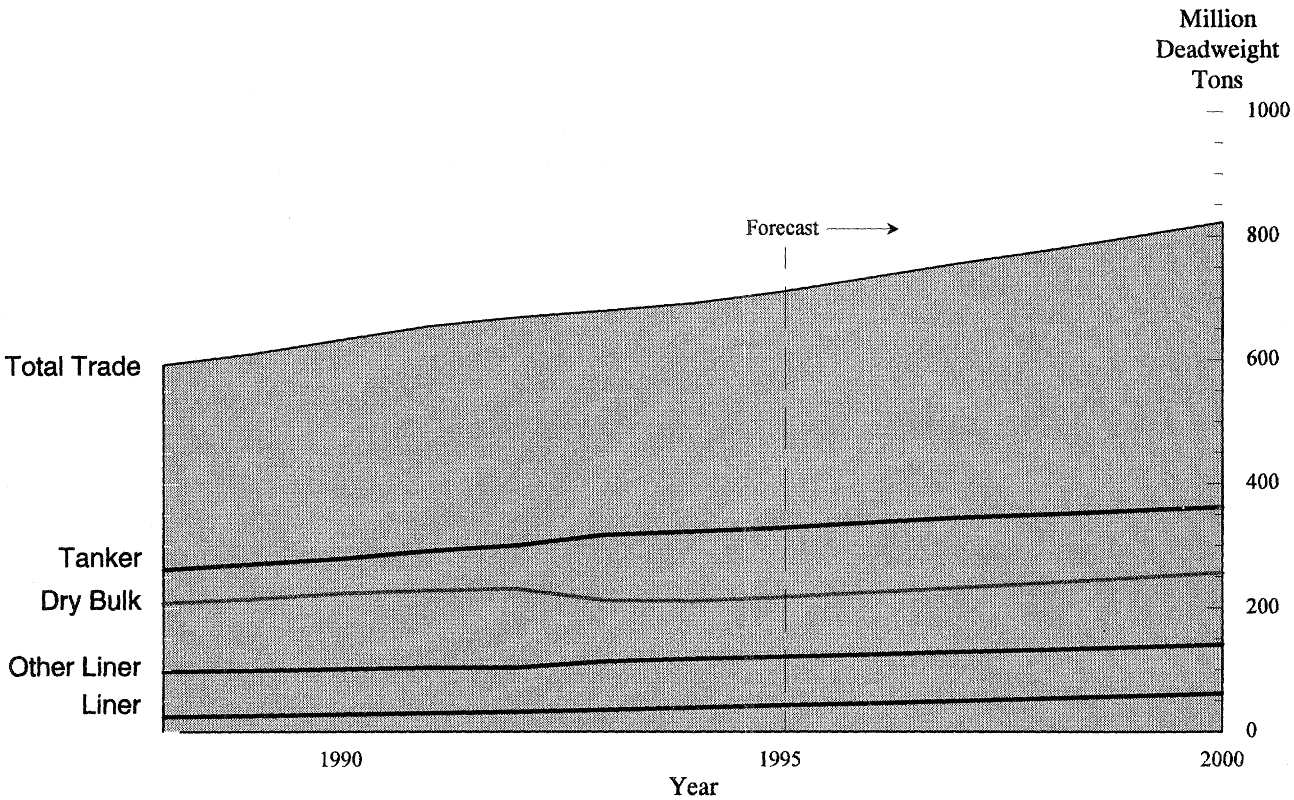
Demand for Ocean Shipping Capacity

Demand for shipping capacity is largely a function of the volume of international oceanborne trade: an expansion (contraction) in international trade will lead to an increase (decrease) in the demand for shipping services. The nature of commodities, however, will affect the type of capacity needed: liner transportation in the U.S. foreign trade depends heavily on the volume of containerized cargoes generated, while the demand for tankers is affected by the proximity of oil supplies, consumption levels, and prices. The amount of dry bulk tonnage required depends largely on the volume of seaborne trade in the major bulk commodities: iron ore, coal and grain.

In addition to the volume of trade, the shipping capacity required in the U.S. foreign trade is dependent on the length of the voyage and loading/unloading time. Vessel speed and utilization rates figure prominently as well.

Exhibit 6-49 shows the fleet forecast produced by DRI/McGraw-Hill and Lloyd's Maritime Information Services (DRI/Lloyd's), by major vessel type. The fleet forecast is simply the fleet capacity required to move the projected trade flows (discussed above). It does not reflect the need to replace existing tonnage. The growth in required fleet capacity generally parallels world trade growth. However, demand for shipping capacity tends to grow at a lower rate due to productivity increases. This is particularly true in the liner segment due to increasing use of containerships (intermodal services) in liner trades. Containerships are generally faster and spend much less time in port than traditional break bulk vessels.

Exhibit 6-49
World Fleet Forecast by Vessel Type



Source: DRI/McGraw-Hill and Lloyd's Maritime Information Services, World Fleet Forecast Service

System Investment Requirements

Previous sections have described the various segments of the waterborne transportation system, its characteristics, performance and the Federal role. It is a blend of public and predominantly private activity and investment which produces the water transportation services that are available today. From the outset, it was not expected that this report would contain a definitive projection of system investment requirements to ensure that such services would be available in the future. Instead, what follows is a compendium of the investment figures which are available from various sources so that the reader can gain some sense of the magnitude of investments being made in the industry. It will also serve to identify gaps in the data which may need to be filled if we are to better define future requirements.

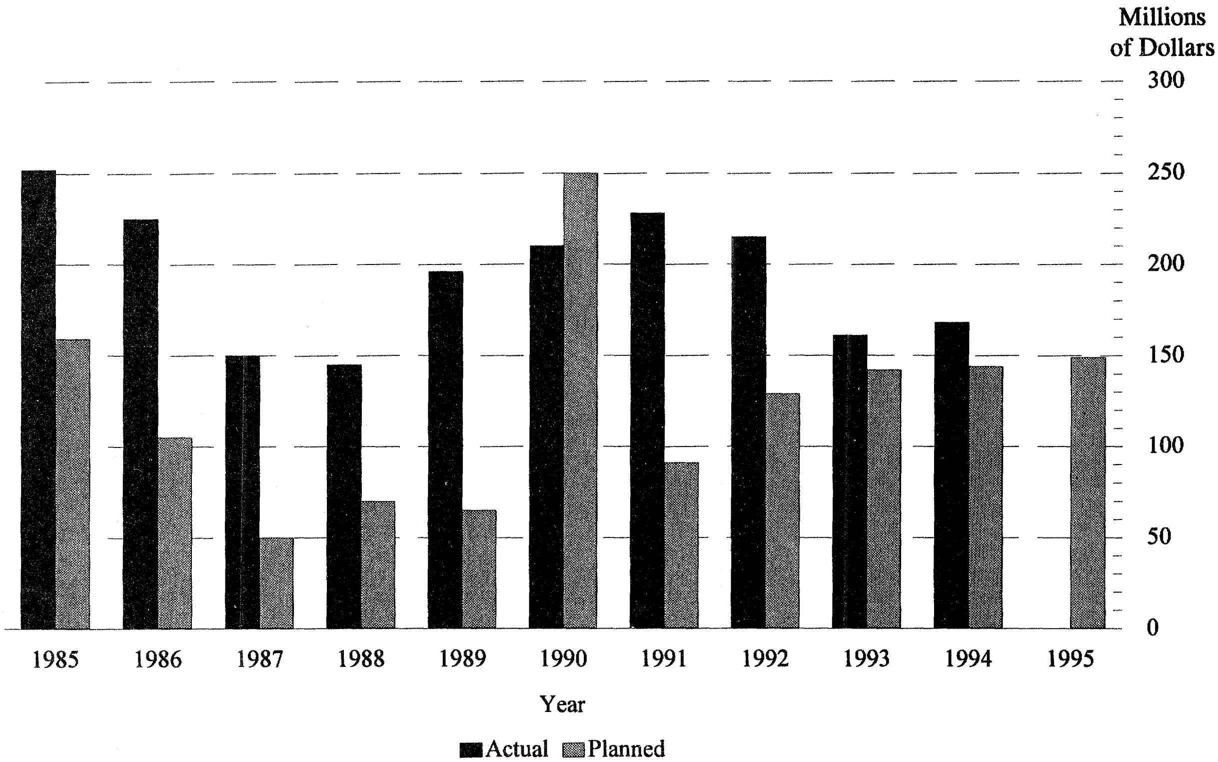
Future investment in the waterborne transportation system will need to continue to be a blend of public (Federal, State and local) and private money, as the industry remains essentially privately capitalized.

With the notable exception of several industry-leading companies, the U.S. international fleet is older and less efficient than its foreign competition. Significant investment in replacement tonnage will be required. Where the replacements are built and what flag they fly will be largely a function of the level of Federal commitment to maintaining a U.S.-flag presence in international trade and a U.S. shipbuilding capability.

Federal funds invested in the maritime industry tend to be highly leveraged. Thus, an annual investment of $100 million in the proposed MSP will maintain an operating liner fleet of 50 U.S.-flag ships operating in international trade (a small fraction of the total operating costs of such a fleet). An appropriation of only $50 million to cover potential defaults can support new ship construction projects worth up to $1 billion under the Title XI financing program.

Exhibit 6-50 shows the $149 million in shipyard facilities expansion and upgrade anticipated for 1995, as well as planned and actual shipbuilding and repair industry capital investments over the past ten years. The National Shipbuilding Initiative (NSI) expanded eligibility for Title XI financing to shipyards for modernization and improvement, and two projects with loan guarantees of $40 million have already been approved. Shipyard prospects as a result of the NSI are for continued significant levels of capital investment instead of a precipitous decline as a result of the loss of Navy work.

Exhibit 6-50
Capital Investments
U.S. Shipbuilding and Repair Industry
1985-1995



Source: Maritime Administration

The forecast data contained in the previous section indicated significant growth in the demand for newbuildings in every major ship type. However, given the age profiles of the existing world fleet, the principal newbuilding demand in the 1990s will come from the requirement to replace existing vessels. Thus, the total shipbuilding demand for any given ship type is made up of a replacement component and a trade-induced component. Since the trade forecasts may vary widely and ultimately depend upon a number of exogenous variables, there is much more certainty associated with the replacement component which is primarily driven by the physical deterioration of ships over time.

Exhibit 6-51 shows the world demand for newbuildings in the 1995 through 2000 period, by major vessel type, split between replacement and trade-induced demand. For simplicity, high and low-range estimates are not presented, although the trade-induced portion may be viewed as effectively the variable segment. The basic replacement assumption is that existing vessels will be replaced when they reach 25 years of age. With the exception of the Cruise/Passenger segment (for which Cruise Line International Association projections are used), the trade-induced newbuilding demand is derived from DRI/Lloyd's World Fleet Forecast Service projections.

Exhibit 6-51
Newbuilding Demand
1995-2000

	Replacement		Trade-Induced		Total	
	Number	DWT (Millions)	Number	DWT (Millions)	Number	DWT (Millions)
Container	187	5.3	632	17.9	819	23.2
Dry Bulk	970	62.4	701	45.1	1,671	107.5
Tanker	1,441	89.5	479	29.7	1,920	119.2
Roll-on/Roll-off	117	1.1	237	2.3	354	3.4
Cruise/Passenger	19	0.1	90	0.5	109	0.6
Other	4,740	32.9	2,001	13.9	6,741	46.8
Total	7,474	191.3	4,140	109.4	11,614	300.7

Nearly two-thirds of the total demand for newbuilding (DWT basis) through the year 2000 will be for replacement vessels. Based upon typical world prices for ships currently on order, the demand for newbuildings worldwide will approximate $267 billion in current dollars over the next five years. Approximately $150 billion would be attributable to replacement requirements, while $117 billion would be attributable to trade growth. The higher than proportional cost associated with the trade growth figures are due to higher growth rates in the container trades and the higher cost of containerships relative to tankers and bulk carriers.

Considering the high percentage of the world fleet which serves the U.S. (i.e., 54 percent of the dry bulk and 40 percent of the tanker fleet), this demand for newbuilding is important to the Nation, as both a shipbuilder and a consumer of the transportation services which the ships will provide.

There is significant lead time in the construction of ships. Consequently, for the relatively short forecast period discussed here, many of the ships are already on order. Exhibit 6-52 describes the current world orderbook for vessels of the type and size which have been discussed throughout this chapter. This illustrates that the renewal and growth of the world international trading fleet is a continuing process.

Exhibit 6-52
Newbuilding Orderbook by Type
January 1, 1995

	Number	Deadweight Tonnage	Average Deadweight Tonnage
Container	260	7,487,141	28,797
Dry Bulk	458	29,461,168	64,326
Tanker	417	26,664,926	63,945
Roll-on/Roll-off	41	401,818	9,800
Cruise/Passenger	29	157,470	5,430
Other	322	2,398,566	7,449
Total	1,527	66,571,089	43,596

Source: Lloyd's Register, January 1, 1995

Demand for replacement tonnage for Jones Act product tankers will increase as the current fleet of 79 tankers in domestic trade is phased out as required by OPA-90 regulations. That phase-out was described earlier, and represents replacement cost of about $3.5 billion in current dollars. Availability of Title XI financing assistance, coupled with a sound shipyard base, will result in an efficient next generation of product tankers to service the Jones Act trades.

Likewise, a modest Federal investment of about $25 million for cargo preference ocean freight differential payments will enable still another segment of the U.S.-flag international fleet to remain available to meet U.S. security needs.

Support for the U.S. Merchant Marine Academy ($31 million) and the six State maritime academies ($9.3 million) ensure a work force able to cope with changing technology and provide the highest possible level of safety responsibility in ship operations. For example, recently acquired modern simulators are used to instruct entry-level officers in safe ship handling, communications, power plant and other aspects of ship operations, thus enhancing officer skills and creating benefits which far exceed the cost. Industry sponsored programs for mariners supplement the Federal investment in officer training.

There is also a critical need for the ship construction workforce to increase productivity so that U.S. shipyards can be more competitive internationally. A public/private investment partnership will help to provide the technology, equipment, and training in advanced series production techniques to enable U.S. shipyards to reduce ship construction costs and to ensure product reliability.

The longshore segment also requires continual training investment to incorporate the rapidly evolving information management and cargo handling systems needed to move the Nation's commerce efficiently through a global transportation network. An example of the Federal Government's success in leveraging a share of this investment has been MARAD's participation in an annual marine terminal training program through which marine terminal operators and their employees, the longshoremen, upgrade their skills via training in the latest developments in transportation technology and information management.

With respect to port infrastructure, there is no Federal investment in shoreside commercial port facilities. The investment is provided by the owners or operators of private sector terminals, by state or local port development organizations and by the lessees of such publicly built facilities. For private investment in terminal facilities and for similar public or private investment on inland waterways, there is no detailed source of information.

For the 5-year period from 1994 through 1998, the public investment in shoreside port facilities for public deep-draft and Great Lakes ports is projected at $5.8 billion. During the 1990s, for this segment of the port industry, average annual investment in shoreside facilities was $668.8 million. Exhibit 6-53 shows this projected investment by region and facility type.

Exhibit 6-53
U.S. Port Capital Expenditures by Type of Facility
Thousands of Dollars
1994-1998

	Type of Facility								
Coast	**General Cargo**	**Inter-modal**	**Dry Bulk**	**Liquid Bulk**	**Passenger**	**Other**	**Infra-structure**	**Dredging**	**Total**
Atlantic	145,359	613,787	37,496	3,450	181,679	91,466	437,100	151,998	1,662,335
Gulf	340,968	152,178	116,109	3,319	50,590	128,215	151,759	44,008	987,146
Pacific	338,004	1,325,676	137,767	4,042	13,645	562,495	544,900	27,415	2,953,944
Great Lakes	2,070	-	15,000	2,000	-	-	2,180	2,250	23,500
Non-Contiguous*	172,566	48,840	-	-	-	13,657	3,300	6,120	244,483
Total	998,967	2,140,481	306,372	12,811	245,914	795,833	1,139,239	231,791	5,871,408
Percent	17.0	36.5	5.2	0.2	4.2	13.6	19.4	3.9	100.0

* Alaska, Hawaii, Puerto Rico, and Virgin Islands

Source: American Association of Port Authorities

Infrastructure investments continue to grow reflecting the competitive pressures for ports to provide better intermodal services. For the forecast period, they will exceed $1.1 billion (19.4 percent) with off-terminal expenditures accounting for two-thirds of the total. The relative decline in projected dredging expenditures may be explained in part by the way some ports report these expenditures. Several port projects are creating land through dredge and fill operations. These expenditures are included in project costs as land acquisition and not dredging.

Capital expenditures for intermodal facilities at U.S. seaports are a subset of the total investment forecast shown in the previous exhibit, and appear as "specialized general cargo" facilities. Total investment in intermodal port facilities accounted for 27.6 percent of total 1993 port capital expenditures and are forecast to account for 36.5 percent during the period 1994 through 1998.

While it is difficult to quantify the investments that ports make in intermodal facilities located outside their terminals, ports are increasingly addressing access issues such as congestion at grade crossings and bridge weight limits. As a result, investments in intermodal projects such as the Alameda Corridor (Ports of Long Beach and Los Angeles) and the Tchoupitoulas Corridor (Port of New Orleans) are becoming an important part of port planning strategy. Also, to cut total throughput time, ports are also investing in inland ports such as the Virginia Inland Port in Front Royal and the two North Carolina inland ports at Greensboro and Charlotte.

Exhibit 6-54 shows historic and projected funds transfer from the Harbor Maintenance Trust Fund to the Corps of Engineers and St. Lawrence Seaway for operations and maintenance expenditures assigned to commercial navigation.

Exhibit 6-54
Expenditures for Operations and Maintenance Dredging
Thousands of Dollars
Fiscal Years 1993-1998

	Fiscal Years					
	1993	1994	1995	1996	1997	1998
Corps of Engineers	446,164	476,890	462,000	528,000	542,000	554,000
St. Lawrence Seaway	13,584	10,915	10,963	11,177	11,382	11,253
Total	459,748	487,805	472,963	539,177	553,382	565,253

FY 1993 figures are those reported by Financial Management Services, Department of the Treasury
FY 1994 figures and beyond are budget from the respective agencies.

Appendix A: Highway Data

Appendix A

Introduction

A current data system is essential to support the analyses that provide the conclusions of this biennial report to the Congress. Data are required to identify the systems being analyzed, to define the extent of these systems, to portray the present conditions and performance of these systems, and to provide a basis from which to project future conditions and performance. This appendix describes the types of data available, the systems used to maintain the data, the uses of the data, and the potential expectations for changes in these systems.

The primary data systems used are the Highway Performance Monitoring System (HPMS) and the National Bridge Inventory (NBI). These are used for the highway and bridge portions of the highway systems, respectively. For more detail on these systems, please refer to the *Highway Performance Monitoring System Field Manual*, August 1993, and subsequent revisions, and the *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*, December 1988.

Highway Performance Monitoring System

The data system designed to address highway conditions and performance is the HPMS. This is the most comprehensive nationwide data system in use for any aspect of the nation's infrastructure. Data collection is the responsibility of the States, and it is updated each year. The States forward the data to the Federal Highway Administration (FHWA), which maintains and uses these data for a variety of strategic planning and highway investment evaluation uses. The Office of Highway Information Management is responsible for receiving, reviewing, and tabulating these data. For 1993 these data underwent a substantial redesign and data elements no longer considered essential for the intended uses of this data were deleted.

Overview

Three categories of data are included in the HPMS. These are (1) the areawide data, (2) the universe data, and (3) the sample section data.

Areawide Data

The areawide data is a summary of total mileage, travel, accidents, local system data, land area, population, and travel activity by vehicle type. Where appropriate, most of these data are reported by functional system and by area type. Area type includes rural, small urban (5,000 to 49,999 population), and urbanized (50,000 and greater population) areas. Mileage, travel, population, and land area are reported for each individual urbanized area.

These data are used in the analyses of emissions, people movement, freight movement, urban transportation programs, and revenue projections. Certain Federal legislative programs include Vehicle-Miles-of-Travel (VMT) estimates as references or as apportionment factors. For example, Federal funds for the Interstate Maintenance Program are based on lane-miles and VMT. The travel estimates reported by the States are an integral part of specific legislative requirements, are included in reports to the Congress, and are being used in day-to-day program and policy evaluation activities, monitoring trends, and in responding to continuing inquiries and requests of the Administration, the Congress, and the public.

Accident data include all injury accidents, fatal and non fatal. The summary of local road data includes mileage by pavement type and traffic volume group. Percent of travel for each of 13 vehicle types is included for each functional system. The vehicle types include motorcycles (optional), passenger cars, other 4-tired vehicles such as pick-ups and vans, buses, and 9 categories of trucks.

Universe Data

The universe data includes comprehensive statewide public road mileage classified by specific categories, and selected roadway physical, operational, and usage characteristics. These data define the extent of all public road mileage by system and jurisdiction, including designated principal arterial or other National Highway System (NHS) mileage not yet built or open to traffic.

The following types of data are included in the 38 data elements included in the universe data:

> ***Identification****, which includes state, county, and rural/small urban/ urbanized area codes and a unique identification or location reference.*
>
> ***System data****, which provides for functional system and NHS data.*
>
> ***Jurisdiction****, which provides for State or local highway systems and special funding categories.*
>
> ***Type of operation****, which includes the identification of the type of facility (1- or 2-way), truck prohibitions, and toll facilities.*
>
> ***Other****, which contains the length, traffic, number of lanes, and certain travel, pavement condition, and geometric data, particularly for the higher functional systems. Some of this data pertains to travel in air quality non-attainment areas.*

Sample Section Data

In addition to the universe data, sample section records contain additional condition, usage, inventory, and operational data for all functional systems except rural minor collectors and rural and urban local roads and streets.

The samples are designed to be statistically valid for each volume group by functional system within each State for the rural area, for all small urban areas collectively, and for many individual urbanized areas. Sampling is valid for urbanized areas with populations greater than 200,000 and for all air quality non-attainment areas.

Each sample section incorporates each data element in the universe data, plus an additional 44 data elements required for the types of analysis and evaluation included in this report and other purposes. The following types of data are included:

Identification*, which contains identification for the sample section.*

Computational elements*, which provides data to expand sample information to universe values.*

Pavement*, contains data to evaluate the physical characteristics of pavement, pavement performance over time, and the need for pavement improvements.*

Improvements*, which describes the last improvement type for the section.*

Geometrics*, which contains the physical attributes used to evaluate the capacity and operating characteristics of the facility.*

Traffic/Capacity*, which provides operational data elements used to calculate the capacity of a section and the need for capacity improvements.*

Environment*, which contains elements that are important to the structural integrity of the section, although they may have little direct effect on the operation of the facility.*

Supplemental data*, which provides data on high-occupancy vehicle lanes and highway surveillance systems.*

System Description

Sampling

The arterial and collector sample panel of sections is the basis of the continuing highway monitoring effort. The data reported for the sampled sections serves as the source of system condition, usage, and operational characteristics, and is used in the calculation of performance measures. The changes in performance over time are determined by using these data as reference points.

To obtain cost-effective, valid comparisons of system performance over time, the sample was designed as a fixed sample. This means that, to the extent feasible, the same sections are inventoried for each cycle. This also means that only those data elements that change over time need be updated on a cyclical basis.

The sample design is capable of producing valid estimates of the condition of the highway systems and the operating and performance characteristics on a State-by-State basis. Rural and small urban functional systems are sampled on a statewide basis. Urbanized areas with populations greater than 200,000 are sampled individually.

Stratification

The sampling plan consists of the random selection of a panel of road sections within predetermined Average Annual Daily Travel (AADT) volume groups for each functional highway system in the rural, small urban, and urbanized areas of the State. The stratification of sections (sampling units) into relatively homogeneous AADT groups produces estimates of greater accuracy with respect to VMT for a smaller number of samples at the functional system level than would be required without stratification. Although stratification of sample selection is based on the critical data element AADT, tests have shown that AADT stratification is compatible with the sampling of non volume-related data elements.

Confidence Level

Sample size requirements for each functional system vary by State according to the total number of road sections, the number of volume groups, and the design precision level. The term "precision level" in this appendix is defined as the degree of confidence that the sampling error of a produced estimate will fall within a desired range. Thus, for a precision level of 80 percent confidence with 10 percent allowable error (80-10), the probability is that 80 times out of 100 the error of a data element estimate will be within 10 percent of its value if a complete inventory were available. Confidence levels for various area and functional system categories for each volume group are presented in Exhibit A-1.

The range of precision levels for urbanized areas varies depending on population, number of urbanized areas per State, whether the sample is for collective or individual urbanized areas in the State, and whether the area is in a National Ambient Air Quality Standards (NAAQS) non-attainment area.

The precision levels stated above and the associated sample sizes relate only to the measurement of AADT. However, the precision levels are such that estimates of similar precision may be obtained for other elements such as pavement roughness.

Exhibit A-1
Highway Performance Monitoring System Database
Confidence Levels for Each Volume Strata

Sample	Functional System	Percent Confidence - Allowable Error
Statewide Total	**Rural**	
	Interstate	90-5
	Other Principal Arterial	90-5
	Minor Arterial	90-10
	Major Collector	80-10
Statewide Total	**Small Urban**	
	Interstate	90-5
	Other Freeway & Expressway	90-5
	Other Principal Arterial	90-5
	Minor Arterial	90-10
	Collector	80-10
	Urbanized Areas	
Individually if population greater than 200,000 or if in air quality non-attainment area	Interstate	80-10 to 90-5
	Other Freeway & Expressway	80-10 to 90-5
	Other Principal Arterial	80-10 to 90-5
	Minor Arterial	70-15 to 90-10
	Collector	70-15 to 90-10

Note: See preceding text

Data Use

Support For Interstate Maintenance Program Apportionments

The apportionment formula under Section 104(b)(5), title 23, United States Code, for resurfacing, restoration, rehabilitation, and reconstructing the Interstate system uses lane miles and VMT on Interstate routes completed and open to traffic. The HPMS serves as a source for these data. Several universe data elements are used specifically for this purpose.

Statistics

The annual publication Highway Statistics uses much of the HPMS data for a major section of the report. The content of the chapter "Roadway Extent, Characteristics, and Performance" is based on the HPMS data.

Support for Analytical Modeling

Analyses to support a variety of requests for information are based on the HPMS data. A major use of the data is to support this report to Congress. However, many tabulations are done throughout the year based on these data.

Data Changes

The data used for this report were furnished in 1994, based on the conditions of the highway systems in 1993. Significant changes were made in the data requirements from previous data requirements.

Urbanized area sampling will be based on each urbanized area of population 200,000 or greater or on individual air quality non-attainment area.

Provision is made for reporting in the metric system.

Reporting is required on additional sample sections for estimating travel in NAAQS non-attainment areas.

Additional information to relate the sample highway sections to a geographic information system is to be reported.

Proposed NHS sample sections are to be identified.

For more detailed information on the HPMS data requirements, the reader is referred to the Highway Performance Monitoring System Field Manual, August 1993, with later supplements, published by the FHWA, Office of Highway Information Management.

NATIONAL BRIDGE INVENTORY (NBI)

An inventory of the Nation's highway bridges is mandated by 23 CFR 650.311 of the National Bridge Inspection Standards (NBIS). This inventory is contained in the NBI, which allows the Secretary of Transportation to report to the Congress on the status of the nation's bridges, to apportion the bridge program funds for replacement and rehabilitation, and to respond to inquiries from all levels of government and the private sector concerning bridges. The NBI is a complete inventory of all public highway bridges, regardless of owner or jurisdiction.

Overview

The primary source for the NBI is the data collected under the requirements of the NBIS, using the specifications of the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges (Coding Guide), 1988.

The total inventory contains records of approximately 575,000 highway bridges, on all of the functional systems. Each record contains 116 fields of data.

The primary NBI data is collected by State or local bridge inspectors, processed by the State highway agencies, and sent to FHWA headquarters. For most bridges, the inspection is performed biennially. However, for certain bridges there are more stringent requirements, and in some cases States have obtained permission from the FHWA to inspect specific bridges on a less frequent basis.

Data Uses

The NBI data is used for managing the Highway Bridge Replacement and Rehabilitation Program which includes apportionments to the States. In addition, many requests for specific details of the NBI data are received from public agencies and from private consultants doing research studies for government agencies. The Defense Department uses the NBI data for the Military Transportation Management Command. The Oak Ridge National Laboratory has used the data to plot maps of bridges on the Interstate System. The Department of Agriculture has used the data in studies of rural highway bridges.

The data is also used in analytical modeling procedures to estimate investment requirements for maintaining or improving the nation's bridges. These data are used in preparing this report, both for estimating future bridge investment requirements and for providing the number of deficient bridges.

There is an ongoing process of checking and analyzing data for consistency and accuracy. Feedback is provided to the States after each data submittal.

Data Contents

The following types of data are included:

Identification, *which includes state, county, route number, and other identification data.*

Structure type, *which include data regarding the type of structure, material, number of spans, etc.*

Age and Service, *which includes data on the age of the structure, number of lanes, and type of service provided.*

Geometric data, *which includes the length, width, and clearance data.*

Navigation data *includes information on navigation control, clearances, and pier protection.*

Classification data, *which includes functional classification of the roadway carried, whether parallel structures exist, toll facilities, and other related information.*

Condition *of the bridge.*

Load Rating and Posting *includes both design and current load ratings, and whether the bridge is posted or closed to traffic.*

Bridge Appraisal *includes the evaluation of the structural capacity, geometry, clearances, waterway adequacy, and other features.*

Proposed Improvements *includes work proposed by the State or other appropriate agency. It also includes estimates of future travel on the bridge.*

Inspections data *includes the date of the last inspection and other aspects of the bridge requiring special inspections.*

Future Data Changes

Conversion of the Coding Guide for implementing conversion to the metric system of units is nearly complete.

Direct electronic transmission of the data from the States to the FHWA Headquarters in Washington is under study.

Further changes to the data elements required to be reported may be considered when the States have more experience with the Bridge Management Systems now required to be implemented under the ISTEA.

Appendix B: Highway Methodology

Appendix B

INTRODUCTION

This appendix describes the methodology used to calculate future highway investment requirements as included in the 1995 Status of the Nation's Surface Transportation System: Conditions and Performance Report to Congress (C&P Report) . This report contains estimates of capital investment requirements from all sources for the period 1994 through 2013. The estimates reflect requirements to repair deficient pavement, eliminate unsafe conditions, and add the capacity necessary either to maintain or to enhance highway system condition, safety and service levels.

Two investment scenarios are evaluated: the **Economic Efficiency** and the **Cost to Maintain** 1993 conditions and performance. The cost to improve conditions and performance given economic criteria, the **Economic Efficiency** scenario, is based on the newly developed Highway Economic Requirements System (HERS). The **Cost to Maintain** relies on the Analytical Process (AP). Both simulation procedures are part of the Highway Performance Monitoring System (HPMS) analytical framework.

The investment scenarios traditionally presented in this report series, the **Cost to Maintain** and the **Cost to Improve**, were both developed using the AP, an engineering-based simulation procedure. The AP estimates the cost of system preservation and added capacity to meet prescribed engineering standards for the physical attributes that describe system condition and performance.

The new **Economic Efficiency** scenario reports the cost to correct existing and accruing deficiencies only when the associated improvements are economically warranted. It balances the tradeoff between minimizing public sector investment and user costs experienced by the motoring public.

The scenarios are addressed in separate sections, with each section organized to follow the analytical building-blocks used in developing the investment requirement estimates. First, the simulation procedures are discussed. Following this is a presentation of supplementary procedures which augment the model-based investment requirements estimates.

HPMS Database

Both simulation procedures rely on the HPMS data system to describe current conditions and performance. The HPMS contains over 110,000 highway sample segments which are statistically sampled by the States to represent traffic volume groups by functional system within rural and small urban areas as well as the majority of unique urbanized areas. Data collection and yearly updating are the responsibilities of the individual States.

For each highway segment, the States supply travel growth forecasts, typically for a 20-year horizon. Also provided is information on a section's pavement, geometry, traffic volume and capacity characteristics, as well as an indication of the last capital improvement implemented. The HPMS database is discussed in Appendix A.

Travel Forecasts

The States forecast travel growth on each of the highway sections that make up the HPMS national sample. The 1994 through 2013 forecast, provided in the 1993 HPMS database, indicates a compound annual growth rate of 2.37 percent. However, this rate was adjusted to achieve consistency, in the 33 most populous urbanized areas, with Metropolitan Planning Organization (MPO) planning constraints and objectives (e.g., conformity mandates associated with the Clean Air Act.) The investment requirements in this report, therefore, reflect a 2.15 percent annual growth rate. (See Exhibit 5-1.)

An adjustment factor was developed based on total MPO vehicle-miles of travel (VMT) projected for the year 2013 versus VMT projected by the States for the same target year. This adjustment was uniformly applied to each HPMS highway segment. The section specificity characteristic of the HPMS database was thereby retained. In other words, this adjustment represents a synthesis of the MPO and State forecasts. No revisions were made to the HPMS forecasts on highway sections outside the most populous 33 urbanized areas. The assumptions underlying and motivating this adjustment are discussed in Chapter 5.

Cost-to-Maintain 1993 Conditions and Performance Scenario

Scenario Objective

The **Cost to Maintain** strategy addresses deficiencies on a system-by-system basis. It seeks to maintain the overall condition and performance of the highway system based on the most recent data. Improvements under this scenario are selected according to relative "cost-effectiveness." The conditions and performance on each link are not necessarily maintained; some will improve and some will deteriorate.

Model-Based Results

Overview: Analytical Process Logic

The simulation process begins by estimating backlog requirements. Then for each funding period, future conditions and performance for each section are simulated as a function of the current state of the segment and the travel growth projections. The model then identifies deficiencies for each section, selects potential improvements and, depending on the availability of funds, simulates some or all of the selected improvements. Conditions on sections that are improved by the model are upgraded to reflect the post-improvement physical characteristics of that improvement.

A typical analysis will cover 20 years, divided into four five-year funding periods. Only one improvement may be implemented for any given section in a funding period, however, a segment may be improved in any year. Further, a segment may have more than one improvement simulated over a 20-year analysis period.

Future Conditions and Performance

Section deterioration is simulated, on a yearly basis, by estimating the combined effects of future travel and aging of a highway's physical and operating characteristics. The degree and rate of physical deterioration is measured primarily as changes in pavement condition. The key determinants of physical condition rate of deterioration are:

pavement type and thickness; and

traffic volume and mix of vehicle types

The rate of highway performance deterioration is measured according to changes in the Volume/ Service Flow (V/SF) ratio, or volume compared to available capacity. The key determinants of performance deterioration are:

number and width of available lanes; and

traffic volume and mix of vehicle types

Deficiency Identification

A highway sample section is considered deficient when specified characteristics fall below the Minimum Condition Standard (MCS). Section attributes checked for deficiencies include lane width, shoulder width and type, surface type and condition, operating speed, volume to surface flow and alignment adequacy. However, only capacity, lane-width or pavement deficiencies can trigger an improvement.

Exhibit B-1
Highway Performance Monitoring System Analytical Process
Cost to Maintain 1993 Conditions and Performance
Rural Minimum Conditions Standards

	Interstate			Other Principal Arterials					
AADT	All Groups			> 6000			< or = 6000		
Terrain*	F	R	M	F	R	M	F	R	M
Lane Width	12	12	12	11	11	11	11	11	11
Right Shoulder Width	8	8	6	8	8	6	8	8	6
Shoulder Type	2	2	2	2	2	2	2	2	2
Pavement Condition	3.0	3.0	3.0	3.0	3.0	3.0	2.8	2.8	2.8
V/SF Ratio	0.75	0.90	0.95	0.75	0.85	0.95	0.75	0.85	0.95
Surface Type	2	2	2	2	2	2	2	2	2
Horizontal Alignment	2	2	2	2	2	2	2	2	2
Vertical Align	2	2	2	2	2	2	2	2	2

*Terrain Types are Flat, Rolling and Mountainous

Shoulder Type Codes:
1 = Surfaced
2 = Stabilized
3 = Earth
4 = Curbed

Surface Type Codes:
1 = High Flexible
2 = High Rigid
3 = Intermediate
4 = Low
5 = Gravel

Determination of MCSs is based on a consensual approach among highway engineering professionals at the Federal and State levels. Exhibits B-1 and B-2 provide the MCS values, by functional system, used to evaluate the 1993 **Cost to Maintain** scenario. Pavement Serviceability Rating (PSR) varies from 1.8 to 3.2. A V/SF of between .75 and 1.00 is used as the threshold at which capacity improvements are simulated. The concepts relating to PSR and V/SF are fully described in Chapter 4.

Minor Arterials						**Major and Minor Collectors**								
> 2000			< or = 2000			> 1000			400 - 1000			< 400		
F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
10	10	10	10	10	10	10	10	10	8	8	8	16	16	16
6	6	4	6	6	4	4	4	4	2	2	2	0	0	0
2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
2.4	2.4	2.4	2.4	2.4	2.4	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8
0.75	0.85	0.95	0.75	0.85	0.95	0.75	0.85	0.95	1.00	1.00	1.00	1.00	1.00	1.00
3	3	3	3	3	3	3	3	3	4	4	4	5	5	5
2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
2	2	2	2	2	2	2	2	2	3	3	3	3	3	3

Horizontal / Vertical Alignment Codes
1 = All Curves Grades Meet Design Standards
2 = Some Curves/Grades Below Design Standards
3 = Curves / Grades With Reduced Speed
4 = Several Curves Unsafe / Significant Reduction of Speed on Grades

Exhibit B-2
Highway Performance Monitoring System Analytical Process
Cost to Maintain 1993 Conditions and Performance
Urban Minimum Conditions Standards

	Interstate	Other Freeways & Expressways	Other Principal Arterials	Minor Arterials	Collectors
V/SF	0.95	0.95	0.95	0.95	0.95
Lane Width	12	11	10	8	8
Surface Type	2	2	2	3	4
Pavement Condition	3.2	3.0	2.8	2.4	2.0
Shoulder Type	1	1	2	3	3
Right Shoulder Width	8	8	6	6	6

Shoulder Type Codes:
1 = Surfaced
2 = Stabilized
3 = Earth
4 = Curbed

Surface Type Codes:
1 = High Flexible
2 = High Rigid
3 = Intermediate
4 = Low
5 = Gravel

Although the MCSs reflect sound engineering judgement, they are not directly based on economic considerations and therefore the use of these standards does not necessarily deliver the most cost efficient program for attaining a given level of highway service, especially as measured by user costs.

Potential Improvement Identification

For each deficient section, an appropriate potential capital improvement is identified. The type of improvement depends on the particular deficiency or combination of deficiencies characterizing a given deficient section.

The candidate improvements are actually improvement packages. In addition to correcting the major identified deficiency, the primary improvement types also include ancillary upgrades to substandard alignment, drainage, surface and shoulder conditions. The AP considers only one improvement package to correct any given deficient section.

The specific improvement type depends on the severity and nature of the deficiency. Improvements are broadly categorized as those occasioned by a condition deficiency and those occasioned by a performance deficiency. Condition requirements refer to minimum acceptable pavement condition. Performance requirements refer to minimum conditions for operating performance usually expressed as V/SF during peak periods.

Physical requirements result in either pavement resurfacing or reconstruction improvements, possibly combined with shoulder, lane width or alignment improvements to eliminate unsafe curves and grades. Performance requirements result in the addition of capacity to the existing roadway, either by converting the road to a freeway type of design, or by adding lanes. Whenever capacity is added in the HPMS simulation procedure, the entire road is resurfaced. This procedure is in keeping with actual State practices.

Potential Improvement Selection

After the AP has identified a deficiency and has specified an appropriate improvement to repair the deficiency, the investment analysis then determines whether sufficient funds are available to effect the needed improvement. When funds are unlimited, the model will implement all potential improvements, correcting all targeted deficiencies. However, when funds are explicitly constrained, or as in the case of the **Cost to Maintain** 1993 conditions and performance scenario, implicitly limited, the model will prioritize potential section improvements according to a "cost-effectiveness index."

The index is a function of the change in a highway section's condition at the end of the analysis period resulting from implementation of a given improvement option compared to the "do nothing" alternative. The AP cost effectiveness index is a function of condition, performance and safety, and is weighted by travel and improvement cost. The model optimizes highway conditions rather than user impacts.

Cost Calculations

For each highway segment in the HPMS database, States indicate the "feasibility" of adding additional capacity. All feasible lane-miles added are provided at "normal cost." Costs are national averages factored to reflect State construction cost differentials. The improvement costs are based on actual costs of typical highway projects.

However, to reflect the fact that growth in travel is rapidly overwhelming available highway capacity and to accommodate capacity demands, the model provides for the addition of lane-miles beyond what the States indicate to be feasible. This capacity is added at "high cost."

This treatment of added lane-miles is consistent with empirical observation. States employ strategies beyond the simple addition of lanes to existing facilities. They construct highways on new, often parallel alignments, within corridors and/or enhance capacity on existing roads through grade-separation structures (elevated or depressed sections) or via acquisition of more costly rights-of-way.

High cost additions increase costs up to 40 percent above the normal costs, adding an average increment of $1 million to the $1.4 million to $3.7 million per lane-mile range for "average" facility expansion.

Since the report is national in scope, and not project specific, no distinction is made between the addition of new lanes to existing roads or the construction of highways on new alignment. The intent is to estimate the costs that would be incurred and not to specify how such improvements would be made on a case by case basis.

Simulation Procedure Adjustments

The **Cost to Maintain** analysis includes additional investment requirements which are calculated independently of the simulation process.

Peak Spreading Procedure

As highway travel increases faster than capacity, congestion in the morning and afternoon peak periods extends for longer periods of time and in more locations. As a result, high traffic volumes occur over more hours of the day and congestion spreads from major facilities to a larger number of parallel facilities that can serve the same trips. These changes in travel behavior make more intensive and efficient use of available highway capacity.

To reflect this phenomenon and reduce the tendency of the simulation procedures to overestimate investment requirements, a spreading of the peak is simulated through the reduction in the percent of future daily travel that is expected to occur during peak periods.

This procedure has been implemented beginning with the 1991 C&P Report and was refined, for the current 1995 C&P Report, to reflect new empirical evidence regarding the percent of travel in peak periods, to limit areas to which the procedure is applied and to adjust the rate at which peak spreading is assumed to take place. These changes moderated the impact of this procedure relative to the procedure applied in the 1991 and 1993 C&P Reports.

Revisions to the Highway Capacity Manual

A new edition of the Highway Capacity Manual (HCM) (Special Report 209 of the Transportation Research Board) was prepared in 1994 and released in early 1995. The revised HCM incorporates changes that affect capacity calculations for several types of highways, especially freeways and other multilane highways. The revised procedures are based on research indicating that a larger number of vehicles per lane per hour are now being accommodated on these highways than formerly. Drivers are now accepting shorter headway between vehicles at higher speeds than was formerly the case.

Transportation System Management

New construction is not the only option that may be considered in combatting increasing congestion. In recent years, State highway agencies have emphasized systems operations and management as a means of increasing highway capacity through maximizing the efficiency of existing facilities. In addition, several urbanized areas have implemented traffic management programs to reduce or more effectively handle peak period traffic. These efforts have been in response to increasing social and environmental concerns, the problem of siting new facilities, and the cost of new highway construction, particularly in higher density and environmentally sensitive areas.

In this analysis, prototypical strategies for both improved traffic operations and management on the supply side have been applied in determining the remaining highway travel demand for which capital investment levels are determined. Freeway surveillance and control, High Occupancy Vehicle facilities, ramp metering, incident management, signalization improvements, traffic channelization, and restriping the existing pavement are the major features chosen to represent capacity enhancement.

The application of this strategy has the potential of increasing the effective capacity of highways—existing or new—by between 30 percent and 65 percent on certain limited access facilities where their application appears to be cost-effective. On non-access controlled facilities, the strategy simulated includes a mix of traffic engineering improvements, including signal coordination, signal removal, and traffic operations improvements. The application of these strategies is expected to provide an additional 25 percent capacity increase on a corresponding subset of non-access controlled arterials.

While the analysis does not indicate which of these traffic management strategies are the most appropriate, it does estimate increased system throughput and potential savings in new highway capacity that could be expected as a result of a systematic nationwide application of a rigorous operations and management strategy. It must be noted that the cost reduction impacts represent an aggressive upper limit of financial impact since such strategies are currently limited to a small proportion of urban areas.

Transportation Demand Management

Travel demand management (TDM) programs include, among other options, enhanced ridesharing and transit programs, parking management, tolls, congestion pricing, and flextime. The effects of any of these TDM strategies are to:

use available highway capacity more effectively

eliminate impediments to smooth traffic flow

reduce peak-hour demand for capacity; and/or

reduce overall travel demand

Significant demand management strategies are assumed inherent in the MPO-consistent travel forecast, as reflected in the current 1995 C&P Report travel growth estimates (see Chapter 5).

Model Based Requirements: Investment and Capacity

Exhibit B-3 provides the average annual investment required to satisfy the **Cost to Maintain** 1993 conditions and performance scenario derived from the HPMS AP approach described above. Exhibit B-4 presents the associated lane-mile requirements.

Exhibit B-3
Cost to Maintain 1993 Highway Conditions and Performance Scenario
Investment Requirements
HPMS Results—Does Not Include Metropolitan Expansion, Local Road, or Incremental Defense Requirements
2.15 Percent Compound Annual Growth
Millions of 1993 Dollars
1994-2013

Functional System	**Capacity**	**System Preservation**	**Total Capacity and System Preservation**	**Annualized Total**
Rural				
Interstate	$21.6	$34.2	$55.8	$2.8
Other Principal Arterial	$14.0	$36.9	$50.9	$2.5
Minor Arterial	$11.1	$40.3	$51.4	$2.6
Major Collector	$8.4	$83.6	$92.0	$4.6
Minor Collector	$1.2	$38.9	$40.1	$2.0
Subtotal	$56.3	$233.9	$290.2	$14.5
Urban				
Interstate	$77.3	$48.9	$126.1	$6.3
Other Freeway and Expressway	$33.4	$20.9	$54.2	$2.7
Other Principal Arterial	$71.0	$63.0	$134.0	$6.7
Minor Arterial	$63.6	$58.7	$122.3	$6.1
Collector	$30.5	$47.1	$77.6	$3.9
Subtotal	$275.7	$238.6	$514.2	$25.7
Total Rural and Urban	$332.0	$472.5	$804.4	$40.2
Annualized (Total/20 Years)	$16.6	$23.6	$40.2	n/a

Note: In their HPMS submittal, the States are no longer required to provide information on rural minor collectors. The corresponding 1992 through 2011 investment requirements were factored for inflation by applying the FHWA Bid Price Index and then added to the model result.

Exhibit B-4
Cost to Maintain Highway Conditions and Performance Scenario
Lane-Mile Requirements
HPMS Results—Does Not Include Metropolitan Expansion, Local Road, or Incremental Defense Requirements
1994-2013

Functional System	1993 Current Lane-Miles	Additional Capacity Lane-Miles			Total Lane-Miles Required 2013
		Standard Cost	High Cost	Total	
Rural					
Interstate	132,239	42,600		42,600	174,839
Other Principal Arterial	238,035	17,381		17,381	255,416
Minor Arterial	286,586	15,741		15,741	302,327
Major Collector	870,689	17,564		17,564	888,253
Minor Collector	564,722	3,806		3,806	568,528
Subtotal	2,092,271	97,092		97,092	2,189,363
Urban					
Interstate	69,135	12,289	8,298	20,587	89,722
Other Freeway and Expressway	39,915	3,872	4,380	8,253	48,168
Other Principal Arterial	176,325	9,934	20,247	30,181	206,506
Minor Arterial	216,233	14,265	18,434	32,699	248,932
Collector	181,035	6,434	10,847	17,281	198,316
Subtotal	682,643	46,794	62,207	109,001	791,644
Total Rural and Urban	2,774,914	143,887	62,207	206,094	2,981,008

Additional Investment Requirements

The HPMS framework supports national level highway investment analysis on most of the existing arterial and collector systems. Additional investment, however, is required to 1) estimate new construction on new rights-of-way, 2) anticipate specific national defense related requirements and 3) correct deficiencies on functional systems not included in the HPMS database. These investment requirements are estimated using supplemental analysis procedures and other sources of data.

Inclusion of these additional requirements provides a more complete accounting of future investment requirements and provides improved comparability between report scenarios and actual investment levels.

Metropolitan Expansion Requirements

To incorporate the basic infrastructure requirements in expanding suburban areas, a procedure was developed to translate the expected population growth in and around urbanized areas into basic network infrastructure, separate from estimates for increased demand on existing facilities. U.S. Census population forecasts were used for each urbanized area to estimate the number of square miles of land currently considered rural that will become urban in nature through 2013, through residential development. Using urban arterial spacing theory, that suggests lane-miles of different functional classes per square mile of development, total infrastructure requirements were estimated to support basic highway mobility in these expanding urban areas. In order to avoid double-counting, future rural highway requirements generated through either the HPMS Analytical Process or the HERS for these expanding areas, were eliminated from the analysis and replaced by the externally developed estimates using arterial spacing principles.

Exhibit B-5
Metropolitan Expansion Lane-Mile Requirements
Billions of 1993 Dollars
1994-2013

Functional System	New Lane-Miles	Cost	Annualized
Interstate	8,643	$20.6	$1.03
Other Freeway and Expressway	4,840	$8.3	$0.41
Other Principal Arterial	15,200	$27.0	$1.35
Minor Arterial	16,400	$23.3	$1.17
Collector	8,100	$13.5	$0.68
Local	300,000	$76.8	$3.84
Total	353,183	$169.6	$8.48
Annualized	17,659	$8.5	n/a

This scenario includes annualized metropolitan expansion requirements of $8.5 billion. These improvements are made at locations that have been, and are expected to be, areas of major highway travel demand increases.

Local Roads

Capital investment on the approximately 2.6 million miles of roads functionally classified as local is a responsibility of State and local governments. The HPMS database does not contain condition and performance information for these facilities. However, this analysis includes an estimate of future local road capital requirements based on a 1990 U.S. Department of Agriculture survey. Local road investment requirements are estimated at $1.0 billion per year. These estimates are for existing local roads; new local road and subdivision road construction is included under the Metropolitan Expansion Requirements.

Defense Highways

The military relies on the highway system for peacetime movement of military shipments, as well as for wartime or emergency mobilization and deployment of military units. A subset of the Interstate and other principal arterial systems has been designated as part of the specially defined STRAHNET. The STRAHNET includes priority connector roads to critical defense installations. For purposes of military mobilization, these highways have been accorded certain design specifications in order to accommodate large and heavy military vehicles.

The current 1995 C&P Report includes an estimate of the capital requirements necessary to achieve these design specifications, above and beyond what would normally be required to accommodate nonmilitary traffic. The incremental STRAHNET requirements are estimated at $600 million over the next 20 years, or $30 million annually.

Final Investment Requirements

Exhibit B-6 summarizes the **Cost to Maintain** 1993 conditions and performance investment requirements for each urban and rural functional classification system. These investment requirements are supplemented by the other highway requirements reported above and reflect adjustments to the simulation procedure as well.

Exhibit B-6
Cost to Maintain 1993 Conditions and Performance
Investment Requirements
Includes Metropolitan Expansion, Local Road, and Incremental Defense Requirements
2.15 Percent Compound Annual Growth
Billions of 1993 Dollars
1994-2013

Functional System	Capacity	System Preservation	Total Capacity and System Preservation	Annualized Total
Rural				
Interstate	$21.6	$34.2	$55.8	$2.8
Other Principal Arterial	$14.0	$36.9	$50.9	$2.5
Minor Arterial	$11.1	$40.3	$51.4	$2.6
Major Collector	$8.4	$83.6	$92.0	$4.6
Minor Collector	$1.2	$38.9	$40.1	$2.0
Local	$0.0	$10.0	$10.0	$0.5
Subtotal	$56.3	$243.9	$300.2	$15.0
Urban				
Interstate	$97.9	$48.9	$146.8	$7.3
Other Freeway and Expressway	$41.7	$20.9	$62.6	$3.1
Other Principal Arterial	$98.0	$63.0	$161.0	$8.1
Minor Arterial	$86.9	$58.7	$145.6	$7.3
Collector	$44.0	$47.1	$91.1	$4.6
Local	$76.8	$10.3	$87.1	$4.4
Subtotal	$445.3	$248.9	$694.2	$34.7
Total Rural and Urban	$501.6	$492.8	$994.4	$49.7

Exhibit B-7 provides the lane-mile requirements associated with the investment levels reported in Exhibit B-6. Current and future lane-miles of highway facilities by functional system in both rural and urban areas are provided. The added lane-mile values are shown in two columns: lane-mile requirements for normal-cost capacity expansion and lane-mile requirements for higher-cost capacity.

Exhibit B-7
Cost to Maintain 1993 Highway Conditions and Performance Scenario
Lane-Mile Requirements
Includes Metropolitan Expansion, Local Road, and Incremental Defense Requirements
1994-2013

Functional System	1993 Current Lane-Miles	Additional Capacity Lane-Miles			Total Lane-Miles Required 2013
		Standard Cost	High Cost	Total	
Rural					
Interstate	132,239	42,600		42,600	174,839
Other Principal Arterial	238,035	17,381		17,381	255,416
Minor Arterial	286,586	15,741		15,741	302,327
Major Collector	870,689	17,564		17,564	888,253
Minor Collector	564,722	3,806		3,806	568,528
Local	4,239,652				4,239,652
Subtotal	6,331,923	97,092		97,092	6,429,015
Urban					
Interstate	69,135	20,932	8,298	29,230	98,365
Other Freeway and Expressway	39,915	8,712	4,380	13,092	53,007
Other Principal Arterial	176,325	25,134	20,247	45,381	221,706
Minor Arterial	216,233	30,665	18,434	49,099	265,332
Collector	181,035	14,534	10,847	25,381	206,416
Local	1,114,616	300,000		300,000	1,414,616
Subtotal	1,797,259	399,977	62,206	462,183	2,259,442
Total Rural and Urban	8,129,182	497,069	62,206	559,275	8,688,457

Economic Efficiency Scenario

Scenario Objective

The **Economic Efficiency** scenario assumes improvement of the Nation's highway system in a manner consistent with economic principles; it presupposes a level of funding sufficient to support an economically efficient highway system. To evaluate this scenario, the HERS will identify existing and accruing system deficiencies, identify corresponding improvements to correct these deficiencies, and implement those improvements which generate benefits in excess of initial cost.

Model-Based Results

Overview: HERS Logic

HERS initiates the analysis process by evaluating the current state of the highway system as provided in the HPMS database. Using section-specific traffic growth projections, HERS forecasts future conditions and performance, by funding period, through the end of the overall analysis period. The model then evaluates each section for existing and accruing deficiencies.

Exhibit B-8
Highway Economic Requirements System
Economic Efficiency Scenario
Rural Minimum Conditions Standards

	Interstate			Other Principal Arterials					
AADT	All Groups			> 6000			< or = 6000		
Terrain*	F	R	M	F	R	M	F	R	M
Lane Width	12	12	12	11	11	11	11	11	11
Right Shoulder Width	8	8	6	8	8	6	8	8	6
Shoulder Type	2	2	2	2	2	2	2	2	2
Pavement Condition	3.0	3.0	3.0	3.0	3.0	3.0	2.8	2.8	2.8
V/SF Ratio	0.75	0.80	0.80	0.75	0.80	0.80	0.75	0.80	0.80
Surface Type	2	2	2	2	2	2	2	2	2
Horizontal Alignment	2	2	2	2	2	2	2	2	2
Vertical Align	2	2	2	2	2	2	2	2	2

*Terrain Types are Flat, Rolling and Mountainous

Shoulder Type Codes:		Surface Type Codes:	
	1 = Surfaced		1 = High Flexible
	2 = Stabilized		2 = High Rigid
	3 = Earth		3 = Intermediate
	4 = Curbed		4 = Low
			5 = Gravel

Economic criteria and analysis is applied to select the "best" set of section improvements for implementation. User and agency benefits and costs associated with potential improvements are simulated and used to evaluate the relative merits of the improvements according to generated net benefits. Improvements are selected for implementation until the system funding constraint or user cost objective, as established by the analyst, is satisfied.

Only improvements generating discounted benefit streams greater than the initial cost of the improvement will be selected. And, in the case of a limited budget, only those improvements with relatively more attractive benefit-cost ratios will be selected for implementation.

This analysis covered 20 years, divided into four five-year funding periods. In the HERS analysis, only one improvement may be implemented for any given section in a funding period and all improvements are implemented at the midpoint of a funding period. A segment may have more than one improvement simulated over a 20-year analysis period.

Minor Arterials						Major and Minor Collectors								
> 2000			< or = 2000			> 1000			400 - 1000			< 400		
F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
10	10	10	10	10	10	10	10	10	8	8	8	8	8	8
6	6	4	6	6	4	4	4	4	2	2	2	0	0	0
2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
2.4	2.4	2.4	2.4	2.4	2.4	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8
0.75	0.80	0.80	0.75	0.80	0.80	0.75	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
3	3	3	3	3	3	3	3	3	4	4	4	5	5	5
2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
2	2	2	2	2	2	2	2	2	3	3	3	3	3	3

Horizontal / Vertical Alignment Codes
1 = All Curves Grades Meet Design Standards
2 = Some Curves/Grades Below Design Standards
3 = Curves / Grades With Reduced Speed
4 = Several Curves Unsafe / Significant Reduction of Speed on Grades

Deficiency Identification. For each funding period of the HERS analysis, the physical operating conditions are compared against standards defined by the analyst. Deficiencies are identified when pavement, geometric, safety or service related considerations deteriorate below the deficiency threshold. These may be higher or lower than the MCSs traditionally used in the AP-based analysis discussed above.

In HERS, deficiency levels assumed in the **Economic Efficiency** scenario are set to levels more stringent than the traditional MCSs (see Exhibit B-9). This provides HERS the opportunity to evaluate a larger number of potential improvements and to find the "best" set of cost-beneficial improvements to be implemented.

Exhibit B-9
Highway Economic Requirements System
Economic Efficiency Scenario
Urban Minimum Conditions Standards

	Interstate	**Other Freeways & Expressways**	**Other Principal Arterials**	**Minor Arterials**	**Collectors**
V/SF	0.80	0.80	0.80	0.80	0.80
Lane Width	12	12	12	12	12
Surface Type	2	2	2	3	4
Pavement Condition	3.4	3.2	3.0	2.6	2.4
Shoulder Type	1	1	2	3	3
Right Shoulder Width	9	9	8	8	6

Shoulder Type Codes:
1 = Surfaced
2 = Stabilized
3 = Earth
4 = Curbed

Surface Type Codes:
1 = High Flexible
2 = High Rigid
3 = Intermediate
4 = Low
5 = Gravel

For example, under the **Economic Efficiency** scenario, the deficiency level used to identify congested sections potentially requiring capacity improvements, was set to V/SF greater than or equal to .80. This is in contrast the MCSs used in the **Cost to Maintain** scenario where a V/SF trigger of between .75 and 1.0 is established. A section having a V/SF greater than .80 would be considered congested, although in the absence of economic evaluation techniques, the engineering community did not believe it to be cost-effective to correct deficiencies below this V/SF. In HERS the deficiency trigger selected is much less critical because the model will evaluate the economic attractiveness of all improvement options and select only those which are cost beneficial.

Potential Improvement Identification. In the case of a section which violates a pavement or capacity deficiency trigger, HERS will identify up to six discrete improvement options to correct varying combinations of its deficient attributes.

The HERS identifies improvements based on improvement options selected from three improvement categories: pavement, widening, and alignment. Improvement types are determined by the combination of options selected from the three improvement categories. The combinations consist of pavement resurfacing or reconstruction possibly with some type of widening and/or alignment option.

Potential Improvement Selection. The HERS applies an incremental benefit-cost analysis (BCA) procedure to select a near-optimal set of improvement options for system-wide implementation, given certain system objectives established by the analyst. The BCA technique compares the cost of implementing an improvement to the benefits expected over the life of the improvement.

The HERS model recognizes direct benefits which accrue to private and commercial highway users in the form of reduced travel time requirements, lower vehicle operating costs, fewer accidents and reduced agency operating costs. In HERS, "costs" are limited to the initial costs associated with implementing the improvement, such as right-of-way acquisition, design construction and so on. All user and operating agency benefits are estimated for the lifetime of the project and discounted to the beginning of the BCA period by applying a discount rate. Discounting accounts for the opportunity cost of withdrawing resources from the economy.

If the analyst has requested that improvements achieving some minimum BCR be implemented, then all such improvements are selected for implementation. Otherwise, the most attractive improvements are selected, in sequence, until all available funds are exhausted or until a user specified minimum level of highway system performance is reached.

In the case of the **Economic Efficiency** scenario, HERS evaluates improvements for a given deficient section and selects the most aggressive improvement having a benefit cost ratio greater than one.

Simulation Procedure Adjustments

Peak Spreading Procedure. This concept was discussed in the preceding AP logic overview. Although the overall HERS approach is similar to the AP's, in the case of HERS the procedure is internalized.

Revisions to the Highway Capacity Manual. In the analysis of the **Economic Efficiency** scenario, the accommodation of revisions to the Highway Capacity Manual was accomplished using the same procedure as outlined in the **Cost to Maintain** (AP) discussion.

Transportation System Management. The application of the TSM procedures to urban areas was handled using the same methodology as for the **Cost to Maintain** scenario.

Transportation Demand Management. The **Economic Efficiency** scenario is developed with the same travel forecast assumptions as used to evaluate the **Cost to Maintain** scenario. Therefore, aggressive TDM strategies are assumed to be inherent in the analysis.

Model Based Investment Requirements

Exhibits B-10 and B-11 provide the average annual investment required to achieve the **Economic Efficiency** strategy as derived from the HERS approach described above, and the associated lane-mile requirements.

Exhibit B-10
Economic Efficiency Scenario
Investment Requirements
HERS Results—Does Not Include Metropolitan Expansion, Local Road, or Incremental Defense Requirements
2.15 Percent Compound Annual Growth
Millions of 1993 Dollars
1994-2013

	Investment Requirements by Improvement Type			
Functional System	**Capacity**	**System Preservation**	**Total Capacity and System Preservation**	**Annualized Total**
Rural				
Interstate	$26.8	$34.9	$61.7	$3.1
Other Principal Arterial	$22.2	$60.7	$82.9	$4.1
Minor Arterial	$15.1	$61.1	$76.2	$3.8
Major Collector	$7.0	$123.5	$130.5	$6.5
Minor Collector	$0.0	$56.5	$56.5	$2.8
Subtotal	$71.1	$336.7	$407.8	$20.4
Urban				
Interstate	$109.3	$58.7	$168.0	$8.4
Other Freeway and Expressway	$54.5	$29.5	$84.0	$4.2
Other Principal Arterial	$104.2	$82.9	$187.1	$9.4
Minor Arterial	$74.3	$91.6	$165.9	$8.3
Collector	$24.3	$70.5	$94.8	$4.7
Subtotal	$366.6	$333.2	$699.8	$35.0
Total Rural and Urban	$437.7	$669.9	$1,107.6	$55.4
Annualized (Total/20 Years)	$21.9	$33.5	$55.4	n/a

Exhibit B-11
Economic Efficiency Scenario
Lane Mile Requirements
HERS Results—Does not include Metropolitan Expansion, Local Road, or Incremental Defense Requirements
1994-2013

Functional System	1993 Current Lane-Miles	Additional Capacity Lane-Miles			Total Lane-Miles Required 2013
		Standard Cost	High Cost	Total	
Rural					
Interstate	132,239	47,294	0	47,294	179,533
Other Principal Arterial	238,035	34,255	0	34,255	272,290
Minor Arterial	286,586	21,321	0	21,321	307,907
Major Collector	870,689	13,173	0	13,173	883,862
Minor Collector	564,722	1,847	0	1,847	566,569
Subtotal	2,092,271	117,890	0	117,890	2,210,161
Urban					
Interstate	69,135	21,878	8,752	30,630	99,765
Other Freeway and Expressway	39,915	9,380	5,081	14,461	54,376
Other Principal Arterial	176,325	29,094	18,947	48,041	224,366
Minor Arterial	216,233	21,179	15,973	37,152	253,385
Collector	181,035	6,555	7,033	13,588	194,623
Subtotal	682,643	88,086	55,786	143,872	826,515
Total Rural and Urban	2,774,914	205,976	55,786	261,762	3,036,676

Additional Investment Requirements

The methodologies used to integrate investment estimates for metropolitan expansion, defense requirements and local roads is identical to those described in the **Cost to Maintain** discussion.

Final Investment Requirements

Exhibit B-12 summarizes the **Economic Efficiency** investment requirements for each urban and rural functional classification system. These investment requirements are supplemented by the other highway requirements reported above and reflect external adjustments to the simulation procedure as well.

Exhibit B-12
Economic Efficiency Scenario
Investment Requirements
Includes Metropolitan Expansion, Local Road, and Incremental Defense Requirements
2.15 Percent Compound Annual Growth

	Investment Requirements by Improvement Type			
Functional System	**Capacity**	**System Preservation**	**Total Capacity and System Preservation**	**Annualized Total**
Rural				
Interstate	$26.8	$34.9	$61.7	$3.1
Other Principal Arterial	$22.2	$60.7	$82.9	$4.1
Minor Arterial	$15.1	$61.1	$76.2	$3.8
Major Collector	$7.0	$123.5	$130.5	$6.5
Minor Collector	$0.0	$56.5	$56.5	$2.8
Local	$0.0	$14.3	$14.3	$0.7
Subtotal	$71.1	$351.0	$422.1	$21.1
Urban				
Interstate	$129.9	$58.7	$188.6	$9.4
Other Freeway and Expressway	$62.8	$29.5	$92.3	$4.6
Other Principal Arterial	$131.2	$82.9	$214.1	$10.7
Minor Arterial	$97.6	$91.6	$189.2	$9.5
Collector	$37.8	$70.5	$108.3	$5.4
Local	$76.8	$10.3	$87.1	$4.4
Subtotal	$536.1	$343.5	$879.6	$44.0
Total Rural and Urban	$607.2	$694.5	$1,301.7	$65.1

Exhibit B-13 reports the lane-mile requirements associated with the investment levels provided in Exhibit B-12. Current and future lane-miles of highway facilities by functional system in both rural and urban areas are provided. The added lane-mile values are shown in two columns: lane-mile requirements for normal-cost capacity expansion and lane-mile requirements for higher-cost capacity.

Exhibit B-13
Economic Efficiency Scenario
Lane-Mile Requirements
Includes Metropolitan Expansion, Local Road, and Incremental Defense Requirements
1994-2013

		Additional Capacity Lane-Miles			
Functional System	**1993 Current Lane-Miles**	**Standard Cost**	**High Cost**	**Total**	**Total Lane-Miles Required 2013**
Rural					
Interstate	132,239	47,294	0	47,294	179,533
Other Principal Arterial	238,035	34,255	0	34,255	272,290
Minor Arterial	286,586	21,321	0	21,321	307,907
Major Collector	870,689	13,173	0	13,173	883,862
Minor Collector	564,722	1,847	0	1,847	566,569
Local	4,239,652				4,239,652
Subtotal	6,331,923	117,890	0	117,890	6,449,813
Urban					
Interstate	69,135	30,521	8,752	39,273	108,408
Other Freeway and Expressway	39,915	14,220	5,081	19,301	59,216
Other Principal Arterial	176,325	44,294	18,947	63,241	239,566
Minor Arterial	216,233	37,579	15,973	53,552	269,785
Collector	181,035	14,655	7,033	21,688	202,723
Local	1,114,616	300,000		300,000	1,414,616
Subtotal	1,797,259	441,269	55,786	497,055	2,294,314
Total Rural and Urban	8,129,182	559,159	55,786	614,945	8,744,127

Comparison of 1994 Investments with Related 1993 Capital Expenditures

Investment estimates in this chapter are reported on a 20-year basis. To provide linkage between these 20-year investment estimates and the consideration of actual current year budget options, this section offers a comparison of investment requirements and actual recent capital outlays by all units of government for highways, bridges, and transit capital improvements.

Exhibit B-14 shows 1994 investment requirements with actual 1993 capital outlay by all units of government for improvements included in this report. (Certain types of economic development improvements made by States are not simulated in this report, and have been removed to simplify comparison). The 1994 investment requirement assumes that system preservation improvements, including pavement, bridge, and certain transit improvements, will occur equally on an annualized basis over the 20-year analysis period. Capacity requirements for both highways and transit increase at a rate equal to the increase in travel growth. As a result, the investment required in the early years of the 20-year analysis period would be less than in later years.

Exhibit B-14
1994 Investment Required for Highways (All Systems, Including Local) versus 1993 Capital Outlay*
Billions of Dollars

All Systems (Includes Local)

1994 Cost to Maintain			1994 Economic Efficiency			1993 Capital Outlay*
Capacity Expansion	System Preservation	Total	Capacity Expansion	System Preservation	Total	
$20.2	$24.6	$44.8	$24.6	$34.7	$59.3	$28.8

*Capital outlay related to capital investment requirements.

Exhibits B-15 and B-16 provide the year-by-year estimates for pavement and capacity investment requirements.

Exhibit B-15
Cost to Maintain Conditions and Performance (All Systems)
Annual Investment Requirements
Millions of 1993 Dollars
1994-2013

		Capacity Additions			
Year	Pavement	Existing System	Metropolitan Expansion	Total	Grand Total
Average	24.6	16.6	8.5	25.1	49.7
1994	24.6	13.4	6.8	20.2	44.8
1995	24.6	13.7	7.0	20.6	45.2
1996	24.6	14.0	7.1	21.1	45.7
1997	24.6	14.3	7.3	21.6	46.2
1998	24.6	14.6	7.5	22.0	46.6
1999	24.6	14.9	7.6	22.5	47.1
2000	24.6	15.2	7.8	23.0	47.6
2001	24.6	15.6	8.0	23.5	48.1
2002	24.6	15.9	8.1	24.0	48.6
2003	24.6	16.2	8.3	24.6	49.2
2004	24.6	16.6	8.5	25.1	49.7
2005	24.6	17.0	8.7	25.6	50.2
2006	24.6	17.3	8.9	26.2	50.8
2007	24.6	17.7	9.1	26.8	51.4
2008	24.6	18.1	9.3	27.3	51.9
2009	24.6	18.5	9.5	27.9	52.5
2010	24.6	18.9	9.7	28.5	53.1
2011	24.6	19.3	9.9	29.1	53.7
2012	24.6	19.7	10.1	29.8	54.4
2013	24.6	20.1	10.3	30.4	55.0

Exhibit B-16
Economic Efficiency (All Systems)
Annual Investment Requirements
Millions of 1993 Dollars
1994-2013

Year	Pavement	Capacity Additions: Existing System	Capacity Additions: Metropolitan Expansion	Capacity Additions: Total	Grand Total
Average	34.8	21.9	8.5	30.4	65.2
1994	34.8	17.6	6.8	24.5	59.3
1995	34.8	18.0	7.0	25.0	59.8
1996	34.8	18.4	7.1	25.5	60.3
1997	34.8	18.8	7.3	26.1	60.9
1998	34.8	19.2	7.5	26.7	61.5
1999	34.8	19.6	7.6	27.3	62.1
2000	34.8	20.1	7.8	27.9	62.7
2001	34.8	20.5	8.0	28.5	63.3
2002	34.8	21.0	8.1	29.1	63.9
2003	34.8	21.4	8.3	29.7	64.5
2004	34.8	21.9	8.5	30.4	65.2
2005	34.8	22.4	8.7	31.1	65.9
2006	34.8	22.9	8.9	31.7	66.5
2007	34.8	23.3	9.1	32.4	67.2
2008	34.8	23.8	9.3	33.1	67.9
2009	34.8	24.4	9.5	33.8	68.6
2010	34.8	24.9	9.7	34.5	69.3
2011	34.8	25.4	9.9	35.3	70.1
2012	34.8	26.0	10.1	36.0	70.8
2013	34.8	26.5	10.3	36.8	71.6

Appendix C: Bridge Methodology

Appendix C

Purpose and Scope of the Bridge Needs and Investment Process

The Highway Performance Monitoring System (HPMS) Analytical Process (AP) is used to estimate current and future highway investment requirements and to assess the results of investment strategies for highway systems. However, this process does not specifically address bridge needs resulting from structural or functional deficiencies. The Bridge Needs and Investment Process (BNIP) is the mechanism used to address these types of bridge deficiencies and the resultant investment requirements.

The process uses the National Bridge Inventory data furnished by the States for each public road bridge in the country with a length of 20 feet or greater. These data are furnished to the Federal Highway Administration (FHWA) in accordance with the requirements of the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, December 1988, (hereinafter called the "Coding Guide"). See Appendix A for more detail on this data system.

The BNIP is used to estimate the current and future needs of the nation's bridges. This process will estimate bridge investment requirements that currently exist and that can be expected to accrue during a specified analysis period. The process will also provide results of alternative funding strategies, and will determine the overall trends under any particular funding scenario.

To accomplish these objectives, each structure to be analyzed is examined and a determination is made whether the structure is deficient. An improvement is selected to correct each identified deficiency, and the cost of the improvement is estimated. The improvement is simulated by upgrading the data elements affected by the improvement. The major steps of the process are described below.

For more details of the process please refer to the publication Bridge Needs and Investment Process (BNIP), January 1991, Federal Highway Administration, Office of Environment and Planning (hereinafter called BNIP documentation).

Investment Requirements Analysis

The analysis process includes a deficiency analysis to identify deficiencies, improvement selection to determine what type of improvement is appropriate, improvement simulation to determine the results of the selected improvement, and cost estimation to determine the cost of the selected improvement.

Deficiency Analysis

The analysis begins by placing each structure into one of three categories. These three categories are:

structurally deficient,

functionally deficient, and

functionally adequate.

Subsequent steps in the analysis differ depending on the deficiency category in which a bridge is classified.

The three major components of a bridge that are analyzed are:

deck,

superstructure, and

substructure.

Note that the values in the exhibits in this appendix that contain minimum tolerable conditions, design standards, and other values used in the analysis are default values. These are the values that have been used in the national analysis, but may be changed by the user of the software.

Structurally Deficient

The first step is to determine if a bridge is structurally deficient. The data elements checked to determine whether a bridge will be placed in this category are listed in Exhibit C-1. If the structure meets any one of these criteria it is structurally deficient. Bridges and culverts are treated the same in this step of the analysis.

Functionally Deficient

If a bridge is not found to be structurally deficient, it is then checked to determine whether it is functionally deficient. If any one of the minimum tolerable conditions (MTC) are not met, the structure is functionally deficient. Exhibit C-2 contains the MTC values for bridge roadway width and Exhibit C-3 contains the values for vertical clearance and waterway adequacy. If a culvert does have a deck or bridge roadway width coded, the analysis assumes a buried culvert and does not consider these two items in analyzing this culvert.

Exhibit C-1
Criteria for Structurally Deficient Bridges

Item #	Description	Bridge Loading
66	Inventory Rating (normal maximum load)	
	Interstate and Other Freeways & Expressways	Less than HS-15
	Other Principle Arterials	Less than HS-15
64	Operating Rating (maximum infrequent load)	
	Minor Arterial	Less than HS-15
	Collectors	Less than HS-15
	Local	Less than HS-15

Note: Item numbers refer to those listed in the Bridge Coding Guide.

Functionally Adequate

If a bridge does not fall into one of the above two categories, it is classed as functionally adequate. For functionally adequate bridges, a table of MTCs is checked to determine whether a condition deficiency exists.

The MTCs are threshold levels used by the process to identify deficiencies. A condition deficiency is identified by comparing the values of condition ratings for the deck, superstructure, substructure, or culvert to the MTCs. If the ratings do not meet the values of the MTC for any element, the bridge is deficient. Condition MTCs are listed in Exhibit C-4.

These MTC values are classed by rural and urban areas, by functional class, and by replacement or rehabilitation. The replacement and rehabilitation categories relate to the type of improvement that will result (see "Improvement Selection," below). That is, if the condition value of any element is less than the replacement MTC value, the element needs replacement. If the value is less than the rehabilitation MTC value, but not less than the replacement MTC value, the element needs rehabilitation.

Improvement Selection

There are three general types of improvements that are simulated by the process: replacement, widening, and rehabilitation. Replacement is complete replacement of the structure. The replacement structure is constructed to all applicable design standards for loading, width, and horizontal and vertical clearances. Widening may include rehabilitation of certain elements of the structure. Rehabilitation may include rehabilitation of any or all all elements of the structure and replacement of certain elements such as the deck. The type of improvement considered depends on the deficiency category of the bridge.

Exhibit C-2
Bridge Width: Minimum Tolerable Conditions

	Lane Width	Shoulder Width	Bridge Roadway Width
Interstate and Other Freeways & Expressways	11	3	30
Arterials			
AADT < =400	10	2	
AADT = 401-100	11	2	
AADT >100	11	3	
Collectors			
AADT < =2000	10	1	
AADT = 2001-4000	11	1	
AADT >4000	11	3	
Local Roads and Streets			
AADT < =50	9	0	
AADT = 51-250	10	0	
AADT = 251-1000	10	1	
AADT = 1001-4000	11	1	
AADT >4000	11	3	

Note: Bridge Roadway Width (item #51) is the sum of all lane widths and shoulder widths on the bridge. Examples are as follows:

Interstate and Other Freeway and Expressway: Minimum Roadway Width for 3-lane directional bridge
3 lanes x 11 feet + 2 shoulders x 3 feet = 39 feet

Arterials: Minimum Roadway Width for 2-lane bridge, current AADT = 500
2 lanes x 11 feet + 2 shoulders x 2 feet = 26 feet

Collectors: Minimum Roadway Width for 2-lane bridge, current AADT = 1500
2 lanes x 10 feet + 2 shouders x 1 foot = 22 feet

Local Roads: Minimum Roadway Width for 2-lane bridge, current AADT = 200
2 lanes x 10 feet + 2 shouders x 0 feet = 20 feet

Exhibit C-3
Vertical Clearance: Minimum Tolerable Condition

Functional Class	Clearance
Rural	
Interstate	14 feet
Arterial	14 feet
Collector	14 feet
Local	14 Feet
Urban	
Interstate and Other Freeways & Expressways	14 feet
Interstate	14 feet
Arterial	14 feet
Collector	14 feet

Note: This table applies to both data elements listed below.

Item #53 Minimum Vertical Clearance Over Bridge Roadway
Item #54 Minimum Vertical Underclearance

Waterway Adequacy: Minimum Tolerable Condition

Item # 71 Appraisal Rating of 3

Exhibit C-4
Condition Deficiencies for Functionally Adequate Structures

Rural -- Needs Replacement/Needs Rehabilitation

Data Elements	Item Number	Interstate	Other Principle Arterial	Minor Arterial	Major Collector	Minor Collector	Local
Condition							
Deck	#58	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0	3.0/3.0
Superstructure	#59	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0	3.0/3.0
Substructure	#60	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0	3.0/3.0
Culvert	#62	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0	3.0/3.0

Urban -- Needs Replacement/Needs Rehabilitation

Data Elements	Item Number	Interstate	Other Freeway & Expressway	Other Principle Arterial	Minor Arterial	Collector	Local
Deck	#58	3.0/5.0	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0
Superstructure	#59	3.0/5.0	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0
Substructure	#60	3.0/5.0	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0
Culvert	#62	3.0/5.0	3.0/5.0	3.0/4.5	3.0/4.0	3.0/4.0	3.0/4.0

Structurally Deficient

When a bridge is classified as structurally deficient, the improvement will be replacement of the structure or major rehabilitation. If the adjusted design load is less than the minimum tolerable load for the structure, the improvement will be replacement. If the superstructure or substructure condition is less than the minimum tolerable condition value for replacement, the bridge will be replaced. Otherwise, major rehabilitation is considered.

Functionally Deficient

For a bridge classified as functionally deficient, the improvement will be either widening or replacement. If widening is selected, rehabilitation may also be done to either the superstructure and/or the substructure if needed. Any rehabilitation needed to the deck that is being widened is included in the widening improvement.

Certain conditions must be met before widening a bridge is warranted. If these warrants are met, other conditions are examined to determine whether widening would correct the deficiencies of the structure.

> *If the bridge roadway width (item #51) is deficient, widening is warranted. Width deficiency is determined by comparing the existing bridge roadway width to the values in the MTC tables in Exhibit C-3.*
>
> *Some structure types are not appropriate or feasible to widen. Structure types 310 (steel through truss), 702 (timber), and 999 (all other) will not be widened. All other types are considered feasible to widen.*

Functionally Adequate

If the bridge is functionally adequate and no major bridge component falls below any of the MTC values, no improvement is selected. If any major bridge component fails the MTC criteria, rehabilitation will be selected.

Rehabilitation may include any one of several combinations of rehabilitation or replacement of major components of the structure. For example, it could include deck rehabilitation only, or it could include deck replacement and superstructure rehabilitation. Replacement of a functionally adequate structure would be done only if the substructure failed the replacement MTC value.

If the superstructure and substructure condition ratings do not pass the minimum tolerable conditions test for replacement, the bridge will be replaced. If the condition ratings are less than rehabilitation but greater than replacement MTC values, rehabilitation of the deficient component will be done in conjunction with widening.

If there are other functional deficiencies that would not be corrected by widening, another action will be selected. Or, if the substructure needs rehabilitation, and if the bridge is more than 80 years old, bridge replacement is selected.

Whether rehabilitation or replacement is done for any particular bridge component depends on the condition rating of that component. If the condition rating is less than the replacement MTC value, then replacement will be selected for that component. If the condition rating is less than the MTC value for rehabilitation but not less than the value for replacement, rehabilitation will be selected for that component.

Look-Ahead Feature

When an improvement is selected, the analysis looks ahead a specified number of years (the default is 10 years) to determine whether other deficiencies will occur within this time frame. If other deficiencies are predicted to occur, correction of these deficiencies will be included in the selected improvement.

If replacement is the selected improvement, there is no need to look ahead. A replacement structure is built to design standards and would not be expected to become deficient within the look-ahead time period.

If widening is the selected improvement, the look-ahead feature is applied to the superstructure and substructure to insure that the widened deck is placed on a sound structure. Both load rating and condition ratings are checked.

If rehabilitation is the selected improvement, the look-ahead analysis checks for a need to widen the structure within the time period. It also insures that all major bridge components that are predicted to become deficient within the time period are rehabilitated. Both condition ratings and load rating are checked.

Improvement Simulation

Improvement simulation involves changing the data elements that are affected by the improvement. In the case of replacement or rehabilitation of major bridge components, this involves upgrading the condition rating of the component. Where widening is done, the bridge roadway width and the deck width will be changed. When bridge replacement is done, not only may width and length change, but other dimensions such as vertical clearance may also change.

Exhibit C-5 contains the design loading used for a replacement structure, Exhibit C-6 contains the lane and shoulder widths, and Exhibit C-7 contains the vertical clearances.

Exhibit C-5
Design Standards: Bridge Load Capacity
Rural and Urban

Functional Class	Inventory Rating
Interstate and Other Freeway & Expressway	HS-20
Other Principle Arterial	HS-20
Minor Arterial	HS-20
Collector	HS-20
Local	HS-20

Exhibit C-6
Design Standards: Bridge Width Default Values

Design standards for bridge roadway width are used for replaced or widened bridges. Also, when a bridge is replaced or widened, the bridge roadway width should should generally not be less than the approach roadway width (item #32). Bridge Roadway Width (item #51) is the sum of all lane widths and shoulder widths on the bridge.

The design Average Annual Daily Traffic (AADT) is generally the traffic volume projected to occur 20 years from the time of the improvement. For 2-way bridges, Average Daily Traffic (ADT) is 2-way, for 1-way bridges, ADT is 1-way.

DHV = Design year AADT x K-factor
Bridge roadway width = Number of lanes x lane width + 2 x shoulder width.

Functional Class -- Urban	**Lane Width**	**Left Shoulder Width**	**Right Shoulder Width**
Interstate and Other Freeway & Expressway	12	6	10
Arterials			
AADT <=50	11	4	4
AADT = 51-100	12	6	6
AADT = 101-200	12	6	6
AADT = 201-400	12	8	8
AADT >400	12	10	10
Collectors			
AADT <=50	10	2	2
AADT = 51-100	11	3	3
AADT = 101-200	12	3	3
AADT = 201-400	12	4	6
AADT >400	12	6	6
Local Roads and Streets			
AADT <=50	10	2	2
AADT = 51-100	11	3	3
AADT = 101-200	12	3	3
AADT = 201-400	12	4	6
AADT >400	12	6	6

Example: Interstate and other freeways and expressways: Minimum bridge roadway width for 2 lanes is 2 x 12' lanes + 10' right shoulder + 6' left shoulder = 40 feet.

Exhibit C-7
Design Standards: Vertical Clearance

Functional Class	Clearance
Rural	
Interstate	16 feet, 6 inches
Arterial	14 feet, 6 inches
Collector	14 feet, 6 inches
Local	14 feet, 6 inches
Urban	
Interstate and Other Freeway & Expressway	14 feet, 6 inches
Arterial	14 feet, 6 inches
Collector	14 feet, 6 inches
Local	14 feet, 6 inches

Note: This table applies to both data elements listed below:

Item #53	Minimum Vertical Clearance Over Bridge Roadway
Item #54	Minimum Vertical Underclearance

To allow for time to implement an action, improvements are simulated one year later than the deficiencies are identified.

Replacement

A bridge replacement will improve the bridge to a "new" condition rating. All applicable data elements used in the working file will be upgraded to new condition, and will meet the applicable design standards (Exhibits C-5, C-6, and C-7). Replacement does not change the structure type, except for timber bridges, where the type is changed to code 302, steel stringer/multi-beam or girder. Type 302 is the most common type of bridge in the length range of most timber bridges. This change is made to avoid a relatively rapid rate of deterioration, typical of timber bridges, after replacement.

Widening

New or widened bridges are constructed to design standards for the specific category of bridge, for 20-year design traffic. The design standards specify the bridge roadway width (item #51). The total deck width (item #52) provides for safety walks and railing. The deck width after replacement or widening is equal to the bridge roadway width plus an allowance for walks and railings. This allowance is the same as in the original structure, which is the difference between the width values for items #51 and #52.

Rehabilitation

A rehabilitation will generally result in a condition rating less than new but better than the rehabilitation MTC value. Any components that are replaced under rehabilitation are rated as new condition. If the load rating is deficient, it is increased to the design standard value when rehabilitation is done.

Deterioration Relationships

A traffic growth factor is applied to the ADT when analyzing the bridge records for accruing deficiencies. This factor is determined from the inspection year ADT and the future year ADT for each structure. The change in traffic volumes over time is used in determining bridge roadway width. However, the process does not relate the capacity of the roadway carried by the bridge to the capacity of the bridge to accommodate this volume of traffic. Widening of bridges because additional lanes are required to accommodate travel growth is addressed in the highway analysis procedures.

Condition deterioration relationships were developed for the major bridge components of deck, superstructure, and substructure. Other elements that are deteriorated in this model are:

Item #62	Culvert conditions
Item #66	Inventory rating (adjusted load) or
Item #64	Operating rating (adjusted load)
Item #67	Structural condition appraisal

The deterioration of each of these elements is addressed in the BNIP Documentation.

<u>Major Bridge Components</u>. Separate relationships were developed for each of the major bridge components: deck, superstructure, and substructure. These relationships are used for a culvert only if the culvert has a condition rating coded for these elements. The bridge deterioration equation is shown in Exhibit C-8.

Exhibit C-8
Bridge Deterioration Equation

CONCAL = CONREC - (A x AGE x AGEFACT + B x ADT x DECKAGE) * [1 / (1 + ELF)]

Where:

CONCAL =	the condition rating of the bridge component after the deterioration cycle
CONREC =	the condition rating of the bridge component before the deterioration cycle.
A =	the AGE coefficient
AGE =	the number of years since the last condition rating
AGEFACT =	a factor to increase the deterioration rate for bridges more than 25 years old
B =	the AGE*ADT coefficient
ADT =	the average daily traffic on the bridge
DECKAGE =	the number of years since the last condition rating; this term is used only for deck condition
ELF =	a factor to decrease the deterioration rate of bridge decks built after 1975

Note: Appendix E in the BNIP documentation lists the A and B coefficients for all States, for the deck, superstructure, and substructure.

Culvert Deterioration. The deterioration of the culvert condition element is based on an assumed life of 80 years. The deterioration equation is given in the BNIP Documentation. When a culvert is coded with values for deck, superstructure, or substructure, the basic deterioration equation given for these major bridge components is used.

Load Capacity. The deterioration of the load carrying capacity of a bridge is applied to the inventory rating (item #66) or operating rating (item #64). This deterioration is based on the conditions rating of the superstructure or substructure condition rating, whichever is lower. See the BNIP documentation for details.

Structural Condition Appraisal. The deterioration of structural condition is also based on the deteriorated condition of the superstructure and substructure. The value of the structural condition is decreased so that it equals the value of the condition rating of whichever of these two major bridge components has the lower value. For example, if the structural condition is 4, and the condition ratings of the superstructure and substructure are reduced to 3.6 and 3.9, respectively, the structural condition appraisal is reduced to 3.6.

Cost Estimation

The costs used for improvement actions vary by State and Federal-aid system. All costs are based on the cost to replace the structure, and rehabilitation costs are a percentage of replacement cost depending on the extent of the rehabilitation. Costs for culverts that have deck values coded are based on the deck area. Costs for buried culverts, which have no deck area coded, are based on the length along the roadway centerline.

Replacement

When the type of improvement is replacement, the bridge replacement cost for the Federal-aid system on which the bridge is located is used. This cost is then multiplied by the deck area of the new bridge. There is also a constant cost applied to each replacement bridge to account for work that must be done for any bridge that is replaced.

Culverts that have deck area coded use the same procedure, except that the constant cost is not used. The cost of culvert replacement is a percentage of the cost to replace a bridge with the same deck area.

The costs for buried culverts are estimated by linear foot along the roadway centerline, by length category.

Widening

When widening is performed, the cost to widen the bridge is the replacement costs multiplied by the cost factors shown in Exhibit C-13. Widening costs include the costs for any required rehabilitation of the existing deck. Widening costs are based on the added deck area. If rehabilitation of the superstructure or substructure are required, additional costs are used. These costs are based on the original deck area. For buried culverts the rehabilitation cost is a percentage of culvert replacement cost.

Rehabilitation

When rehabilitation is selected, the cost to replace the bridge is multiplied by the factors contained in Exhibit C-13 for the specific type of rehabilitation, using the existing deck area. The cost for rehabilitation or replacement is calculated as a percentage of the replacement costs for the bridge. For buried culverts the rehabilitation cost is a percentage of the replacement cost.

INVESTMENT ANALYSIS

The investment analysis is an option that can be added to the needs analysis. It cannot be run without the needs analysis, upon which it builds. The investment analysis provides for the input of a specific investment amount for each of up to four funding periods. These funding periods can analyze a total planning horizon of up to 20 years.

This process is typically run for a 20-year overall analysis period consisting of four 5-year funding periods. For each funding period, the process identifies deficiencies, selects improvements to correct the deficiencies, simulates the improvements and then determines which improvements will be implemented. The results of the investment analysis for each funding period are used for the following funding period.

It should be noted that while the user specifies annual funds, the temporal distribution of funds is based on the entire funding period. This means that needs are addressed as they are identified at any time during the funding period. While the total funding for any funding period equals the annual funds times the number of years in the period, the funds are expended when needs are identified. Thus the distribution of funds expended may not be the same for each year.

When funds are limited, it is necessary to decide which deficient structures are most in need of improvement. This is done by a priority ranking procedure. This ranking scheme is not based directly on economic criteria and is not an optimization process. It uses the data elements listed below to determine the ranking for improvements. The elements used in the ranking procedure are:

deficiency category,

functional class,

annual average daily traffic, and

detour length and operational status.

The specific procedures used to determine the ranking points are described in the BNIP documentation.

Analysis Results

The printed output of the needs and investment analyses lists the options in effect. These include the inventory year, the base year for the analysis, the cycle length, and the factor for extending bridge life of decks with deck protection.

The output also contains the criteria for deficient structures. These are the criteria for determining the deficiency category of each structure. This includes the minimum tolerable conditions for structures classified as functionally adequate. The number of structures that failed the specified criteria are shown. Design standards are contained in another output table.

Summaries can be generated by Federal-aid system or functional class. If Federal-aid system is chosen, rural and urban summaries can be printed either separately or combined.

The base year summaries can be used to determine the existing conditions of bridges and to compare with projected conditions. These summaries contain:

The distribution of condition ratings by deck, superstructure, and substructure. The culvert condition ratings are also included.

The numbers of deficient bridges, by deficiency category of structurally deficient, functionally deficient, and functionally adequate.

The needs estimate can include both backlog needs and needs for a projected analysis period. The summary contains:

The number of deficient bridges and the costs of the selected improvements. These are listed by the general improvement types of (1) rehabilitation, (2) widening, and (3) replacement.

The numbers of structures and the costs are tabulated by backlog needs, needs for each of up to 4 specified time periods, and a total of all deficient bridges and costs of improvements. The number of deficient bridges funded and not funded are shown.

The averaged condition values for the bridge population, and the funds expended in the analysis are also displayed.

The summaries for the investment analysis are similar, but they contain improvements that can be funded with the specified level of investment.

Conclusion

The BNIP has been developed to estimate the current and future needs of the nation's bridges. This process will estimate bridge investment requirements that currently exist and that can be expected to accrue during a specified analysis period. The process will also provide results of alternative funding strategies, and will determine the overall trends under any particular funding scenario.

It can be used to determine the annual level of capital investment required to maintain current overall bridge conditions, to improve bridges to a specified standard over a given period of years, or to estimate the results of a given annual investment.

With the results of these analyses, the decisionmaker or legislative body can more reasonably determine the level of investment required to accomplish the desired goals or to determine the results of realistic levels of investment.

Appendix D: Transit Methodology

Appendix D

Introduction

Estimates of the investment requirements for transit are made using a building block approach. Estimates of the investments required to maintain and improve transit conditions focus on the costs to deal with the equipment and facilities used to provide current levels of service. The role of transit in overall transportation performance is related to the amount of transit service provided. Thus, the transit investment levels needed to maintain or improve overall transportation system performance are based on the costs of the new transit infrastructure needed to support the increased service levels inherent in the investment scenarios.

The following four investment requirement levels are calculated based on information on each element of transit capital stock (e.g., bus and rail rolling stock, facilities, etc.):

The cost to maintain 1993 conditions;

The cost to maintain 1993 performance, defined as increasing service levels necessary to meet the transit travel growth inherent in the maintain conditions and performance scenario;

The cost to improve conditions, defined as restoring all transit equipment and facilities to good condition at the end of the 20-year analysis period; and

The cost to improve performance (user costs), defined as increasing service levels necessary to meet the transit travel growth inherent in the improve conditions and performance scenario, at a higher level of service than in the maintain current performance scenario, in terms of speed, comfort, and convenience.

Cost to Maintain 1993 Conditions

Bus and Other Non-Rail Services

To maintain 1993 bus and other non-rail service conditions, vehicles must be replaced in accordance with present replacement schedules, mid-life rebuilds must be accomplished, and facilities invested in at levels sufficient to keep conditions stable. In addition, the additional costs imposed by the Americans with Disabilities Act (ADA) and Clean Air Act (CAA) must be addressed.

Urban Vehicle Replacement

The annual investments required for urban vehicle replacement are calculated by taking the current fleet inventory from Section 15 and by determining how many vehicles of each type need to be replaced each year to maintain the current average fleet age, as reported in Chapter 4. The annual replacement requirement is then multiplied by the average cost of a new vehicle. Exhibit D-1 shows the total number of vehicles of each type included in the Section 15 inventory, the average years between replacements needed to maintain current fleet age, and the average cost per replacement vehicle.

To calculate replacement needs to maintain 1993 conditions, the number of vehicles was divided by the current replacement cycle to calculate the annual replacement requirement by vehicle type. This was then multiplied by the average replacement costs to obtain the total annual cost by vehicle type. Adding these figures gives the total annual vehicle replacement cost to maintain current vehicle conditions.

Average bus costs were calculated using Fiscal Year (FY) 1993 grant obligation data obtained from Federal Transit Administration's (FTA) Grants Management Information System (GMIS). For each grant obligated during the fiscal year, GMIS data provides the number of vehicles and the total cost of the vehicles to be purchased with the grant, where the number of vehicles is estimated by the grantee. GMIS data is considered reliable since it is used to produce the approved budget for the project.

The validity of the data was verified by a grant-by-grant analysis of unit vehicle costs, by vehicle type. Data for all grants having per unit costs significantly above or below the norm was verified by: 1) reviewing any descriptive comments included in the project approval and 2) if necessary, contacting the appropriate FTA regional office and/or grantee for additional information. The same methodology was used to identify and extract those grants obligated for standard size alternative fueled vehicles. Aggregate per unit vehicle costs and the total number of vehicles were cross-checked with similar data reported in FTA's annual Statistical Summaries on Grant Assistance Programs.

Exhibit D-1
Number of Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle
Cost to Maintain Conditions and Performance

Type of Vehicle	Number Areas Over 1 Million	Number Areas Under 1 Million	Replacement Cycle (years)	Average Replacement Cost
Motor Bus Service				
Articulated Buses	1,744	59	15	$315,000
Trolley Buses	830	35	15	$300,000
Full-Size Buses	34,971	11,819	15	$217,000
Mid-Size Buses	1,240	2,194	12	$200,000
Small Buses	592	753	9	$95,000
Vans and Other	65	114	5	$32,000
Total	39,442	14,974		
Demand Response Service				
Articulated Buses	4	0	15	$315,000
Trolley Buses	0	0	15	$300,000
Full-Size Buses	51	165	15	$217,000
Mid-Size Buses	21	139	12	$200,000
Small Buses	1,127	1,591	9	$95,000
Vans and Other	6,889	4,686	9	$32,000
Total	8,092	6,581		
Vanpool Service				
Vans	1,226	544	5	$32,000
Ferryboat Service				
Ferryboats	75	13	30	$5,000,000

Source: Federal Transit Administration (FTA) analysis of Section 15 data and FTA grants data

Urban Vehicle Midlife Rebuilds

In order to assure that vehicles stay in usable condition for their entire useful life, transit operators must make mid-life investments in certain major components. Under FTA proposed guidelines, these costs are eligible as capital expenses. To estimate the annual investment level required to make mid-life rebuilds, the number of large vehicles requiring such investments (articulated buses, trolley buses, and full-size transit buses) is divided by the replacement rate. The resulting annual rebuild requirement is multiplied by the current average cost of such investments, about $50,000 based on FTA staff analysis of recent projects of this type, and data from the Metropolitan Transportation Commission in San Francisco.

Urban Facility Recapitalization

Bus and other non-rail services require a variety of support facilities such as light maintenance facilities as well as other capital stock such as terminals, park and ride lots, waiting facilities, shelters, and transfer facilities. As noted in Chapter 4, data is now available on the current condition of maintenance facilities and on the current plans which operators have for their replacement and/or recapitalization.

A recent detailed review of the recapitalization needs of bus maintenance facilities provides information to assess the requirements related to these facilities. Transit operators were asked to provide information on the amount of capital expenditures programmed for the next 5 years for bus facilities. In addition to the total capital expenditures planned, they were also asked to categorize the projected expenditures in the five following categories:

New -- Construction of a new facility which does not replace an existing facility.

Replacement -- Construction of a new facility to replace an existing facility.

Expansion -- Addition of capacity to an existing facility.

Rehabilitation -- Upgrading of an existing facility.

Other-- Miscellaneous expenditures, primarily underground storage tanks and alternative fuel projects.

The sum of the investments programmed by transit operators for 1993 to 1997 for the Nation's bus support facilities was $2.1 billion. However, this may be an underestimate due to uncertainties about the costs of meeting the requirements due to new technology (i.e., alternative fuels) and recent legislative requirements (i.e., ADA, underground storage tanks, and Clean Air).

Reports submitted by transit operators indicate that, while some of the facilities may be new from an engineering standpoint, when considered in terms of the purpose of the investment, they in fact represented expansion of existing maintenance capabilities or replacement of existing facilities for the purpose of obtaining a facility of improved condition. Examples included new bus servicing facilities added to an existing maintenance facility or the demolition of an older building and construction of a new building on the same site.

To translate the capital programs of the transit operators into estimates of bus maintenance facility capital needs in terms of the investment scenarios used in this report, FTA staff conducted further analysis of the data reported by the operators. In order to estimate the capital costs to achieve the goals of each scenario related to bus maintenance facilities, the projects reported by the transit operators were classified as to their purpose, as follows.

Where new facility construction or facility expansion was programmed, additional information was obtained to determine whether the purpose of the project was to 1) improve maintenance capabilities while maintaining current service levels or 2) actually increase the level of transit service provided. Those new or expansion projects whose purpose was to expand service were considered to be those needed to maintain current performance, by expanding transit service consistent with recent trends. Because of the limited number of projects programmed for the purpose of expanding service, the amount of increased service which would be supported by these facilities was well within the amount estimated in this report to maintain current performance levels. Therefore, none of the expenditures programmed in the report for maintenance facilities can be assumed to be for the purpose of improving performance.

Those new or expansion projects whose purpose was to improve maintenance capabilities at facilities considered to be in poor, substandard, or adequate condition were judged to be those needed to improve current conditions. In addition, those projects which were designed for the purpose of rehabilitating or replacing existing facilities in less-than-good condition were also judged to be those needed to improve current conditions.

Those projects classified as new or expansion whose purpose was to improve maintenance capability at facilities judged to already be in good or better condition, but not to increase service levels, were judged to be those needed to maintain current conditions. This is because, while they would improve the condition of the facility, they would not change the conditions or performance of the service provided to the public, which is the basis for the definition of the investment requirements scenario. In addition, those projects which were for the purpose of rehabilitating or replacing existing facilities which were already in good or better condition were judged to be those needed to maintain those conditions.

To take account of the fact that the facilities covered by the study represented 95 percent of the bus facility capacity in the United States (U.S.), investment requirements were divided by 0.95. An additional expansion factor was applied to account for those facilities in good or better condition for which no current capital investment is planned but which will need reinvestment at some time during the 20-year period covered by the analysis in this Report to maintain those conditions.

Similar detailed information is not available on the current conditions of other capital stock, such as terminals, park-and-ride lots, waiting facilities, etc., nor on recapitalization plans for such facilities. The best source of information on such capital stock is recent spending for these purposes. Based on analysis of data reported in the FTA document, 1993 Statistical Summaries - Grant Assistance Programs, over the last 5 years FTA has made grants for other bus facilities (such as terminals, shelters, etc.) equal to about two-thirds of the amount granted for vehicles. This factor was multiplied by the vehicle replacement cost estimated earlier to determine the cost to recapitalize other bus related facilities. A review of recent Transportation Improvement Programs (TIPs) and Long Range Transportation Plans (LRTPs) indicates that Metropolitan Planning Organizations (MPOs) are programming about 57 percent as much for non-maintenance facilities as for vehicles, confirming use of the long-standing relationship from recent FTA grants.

Rural Vehicle Replacement

Rural vehicle replacement investment requirements are calculated in the same manner as urban vehicle replacements. As described in Chapter 4, recent data is available from the Community Transportation Association of America (CTAA) on the rural transit fleet, including number of vehicles and average fleet age. The **Cost to Maintain** conditions is calculated by determining the number of vehicles which must be replaced annually to maintain the current average fleet age, multiplied by the average cost per replacement vehicles. The average replacement vehicle cost is from the same FTA staff analysis of FY 1993 grants described above. Exhibit D-2 shows the data used for these calculations.

Rural Transit Facilities

Recent data is reported on the condition of rural transit facilities in Chapter 4. However, no information is available on required recapitalization costs. FTA grants for all urban facilities have totaled about the same amount as grants for vehicles over the last 5 years. Rural area facility needs are likely to be proportionally less than urban needs since, because of the nature of rural service, there is less of a requirement for ancillary facilities such as terminals, stations, transfer facilities, and park-and-ride lots. Accordingly, for the purposes of this analysis, rural facility needs are calculated at about one-half of rural vehicle needs.

Exhibit D-2
Number of Rural Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle
Cost to Maintain Conditions and Performance Scenario

Type of Vehicle	Number	Replacement Cycle (years)	Average Replacement Cost
Large Buses	733	15	$217,000
Mid-Size Buses	1,100	12	$200,000
Small Buses	2,567	9	$95,000
Vans and Other	7,823	5	$32,000
Total	12,223		

Source: Community Transportation Association of America data and Federal Transit Administration grants data

Specialized Service Vehicles

As described in Chapter 2, the total number of vehicles serving elderly and disabled persons in agencies which have received FTA assistance under the Section 16(b)(2) program is about 29,000. As described in Chapter 4, recent data is available from the CTAA on the specialized transit fleet, including number of vehicles and average fleet age. The **Cost to Maintain** conditions is calculated by determining the number of vehicles which must be replaced annually to maintain the current average fleet age, multiplied by the average cost per replacement vehicles. The average replacement vehicle cost is from the same FTA staff analysis of FY 1993 grants described above. Exhibit D-3 shows the data used for these calculations.

Exhibit D-3
Number of Specialized Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle
Cost to Maintain Conditions and Performance Scenario

Type of Vehicle	Number in Areas Over 1 Million	Number in Areas Under 1 Million	Replacement Cycle (years)	Average Replacement Cost
Mid-Size Buses	47	264	12	$200,000
Small Buses	788	4,463	9	$95,000
Vans and Other	3,566	20,205	5	$32,000
Total	4,401	24,932		

Source: Community Transportation Association of America data and Federal Transit Administration grants data

Specialized Service Facilities

Using the same approach as for rural services, it is estimated that facilities for services to elderly persons and persons with disabilities are likely to be needed at about one-half the vehicle recapitalization cost.

Costs of Compliance with the Americans with Disabilities Act

Operators of urban and rural bus services will be required under the ADA to equip all new fixed route vehicles with lifts so that they are accessible to wheelchair users. In addition, operators of fixed route bus service will be required to provide complementary paratransit service for those who by reason of disability cannot use accessible fixed route service.

The costs of complying with these requirements were estimated based on analysis of 540 paratransit plans and 708 key station plans submitted to FTA in 1992 and early 1993 by the transit operators. Industry and FTA transit bus sales data were also used. These estimates have subsequently been changed to reflect revisions made by the industry after FTA review of these plans.

The estimates do not reflect the cost of providing ADA service to rural (Section 18) demand responsive systems, private, non-profit organizations (such as Section 16 providers), private providers of transportation to the general public (airport or hotel shuttles), or private taxi services. The total annual cost estimates are in the range of those developed for the Regulatory Impact Analysis that accompanied Department of Transportation's final rule on the ADA (a total of $700 million to $900 million).

Included in these estimates are the following cost components:

> ***Bus Lift Costs:*** *These are recurring capital costs of lifts/ramps on public, fixed-route transit buses. Under the ADA, all new transit buses purchased must be accessible. The estimate is based on an incremental cost of $18,000 for the cost per lift and installed securement items. Prior to passage of the ADA, only 35 percent of the vehicles in the active bus fleet were wheelchair accessible. In 1993, three years after enactment, the lift manufacturers, the American Public Transit Association (APTA), Project ACTION, and FTA estimate that the fleet is over 50 percent lift- or ramp-equipped. As all new urban transit vehicles must be ADA-accessible, these costs have already been included in the average capital costs assumed for replacement transit vehicles.*
>
> ***Key Rail Station Capital Investment:*** *These are the nonrecurring capital cost to install elevators, raise platforms, and add communication equipment, signs, and platform edge warning strips to make the 708 key rail stations in the 37 rail systems ADA accessible. The estimate extends over the maximum allowable 30-year period, and assumes these costs will discontinue once the current backlog of ADA key station deficiencies is eliminated. Most of the costs will be expended during the first decade, the 1991 to 2000 ten-year period. After the year 2000, with few stations remaining to be completed, capital renovation costs for these stations will become negligible.*

__Urban Paratransit Capital Costs:__ These are the recurring costs of purchasing vans and buses to provide ADA paratransit service to complement public, fixed-route service. These costs also include equipment such as lifts/ramps and raised roofs on vans, computer-aided paratransit dispatching systems, and van and bus associated maintenance equipment and garage facilities. The estimate is at full implementation, and based on ADA paratransit plans submitted to FTA in 1993.

__Railcar Accessibility Costs:__ This is the recurring capital cost of modifying railcars to be ADA-accessible. The estimate is based on the Regulatory Impact Analysis that accompanied DOT's final rule on the ADA. Under the ADA, rapid, light, and commuter rail operators must provide one accessible car per train by 1995. Few railcars were fully accessible prior to the enactment of the ADA. Currently, all rapid railcars are accessible to wheelchair users, but few are accessible to persons with hearing or low-vision impairments. Most light and commuter railcars are not accessible to wheelchair users or other persons with disabilities.

__Rural Paratransit Capital Costs:__ These are the recurring cost of purchasing vans and buses to provide ADA paratransit service to complement public, fixed-route service in non-urbanized areas. The estimate is at full implementation, and based on ADA paratransit plans submitted to FTA in 1993. These costs also include equipment such as lifts/ramps and raised roofs on vans, computer-aided paratransit dispatching systems, and van and bus associated maintenance equipment and garage facilities.

Clean Air Act Amendment/National Energy Policy Act Costs

The Clean Air Act Amendments. In accordance with the Clean Air Act Amendments (CAAA) of 1990, the Environmental Protection Agency has reissued emission standards which all new standard-size transit buses purchased in nonattainment areas must meet. To date, engine manufacturers have been able to meet all emission standards by modifying existing diesel engines to run on advanced, low-sulfur diesel fuel, and by equipping the exhaust system with a catalytic converter. Furthermore, the engine manufacturers have indicated that they expect to meet all future emission standards by continuing to improve upon this technology, including the 0.05 gm/bhp/hr standard for particulate matter (PM-10) in 1996 and the 4.0 gm/bhp/hr standard for nitrogen oxides (NO_x) in 1998. As additional evidence in support of their position, the only domestic manufacturer of the alternative pollution reduction technology for diesel engines, particulate traps, ceased production of such traps in 1994.

The result of the engine manufacturers success in meeting the requirements of the CAAA to date with existing diesel technology is that the incremental costs directly attributable to the CAAA will be much less than if other technologies are required. However, this does not consider that the CAAA and Energy Policy Act of 1992 may have spurred additional, stricter state and local initiatives. Therefore, it is reasonable to include in the overall estimate of transit investment requirements the incremental costs of the most common alternative fuel technologies as well as those for diesel, as discussed in the following sections.

Energy Policy Act. The Energy Policy Act established goals to replace, beginning in the year 2000, 30 percent of the petroleum fuel used by transportation with alternative fuels by 2010. To achieve these goals, the Act requires the following percentages of new vehicles purchased by government and private fleet operators to be alternative fueled: 20 percent in model year 2002; 40 percent in model year 2003; 60 percent in model year 2004; and 70 percent in model year 2005 and thereafter. Whether or not urban transit bus fleets will be included in this program, and the extent to which they would be included, must be determined through a formal rulemaking process initiated by the Department of Energy. The final rule would be due January 1, 2000. The fact that some requirement may be imposed as a result of the Energy Policy Act is also a reason to include some alternative fuel costs in the overall estimate of transit investment requirements.

The Alternative Fuels Market. Alternative fueled buses have become increasingly popular in recent years due to several different factors. For one, transit operators have purchased alternative fueled and particulate trap equipped vehicles to test their reliability and performance in anticipation that they would eventually be required to meet Federal requirements. Just as importantly, states, localities, and transit operators have adopted policies in response to local environmental and economic concerns that require the purchase of alternative fueled buses. As previously stated, several transit operators in major metropolitan areas have recently announced that all future bus purchases will be exclusively for buses powered by natural gas.

Analysis of FTA 1993 grant obligation data indicates that 23 percent of all standard size (35 and 40 foot) buses to be purchased with FY 1993 obligations are alternative fueled, or 531 out of 2,332 buses. In addition, analysis of FTA data on major demonstration programs shows that 1,043 alternative fueled buses (including 804 standard size) are currently in service, and another 1,086 are on order or are planned for purchasing (including 944 standard size).

This data also shows that natural gas has become the alternative fuel of choice. Of all alternative fueled buses on order or planned, 62 percent (669) are liquefied natural gas (LNG), and 35 percent (383) are compressed natural gas (CNG). Currently, 119 LNG and 350 CNG buses are in service.

Methanol currently accounts for the largest share of such buses in service at 370, but none are on order. Likewise, 552 standard size buses equipped with particulate traps are in service and 395 are on order, but recent developments suggest that this will not be a growing market.

Estimates of the Incremental Costs of the Clean Air Act Amendments and Energy Policy Act. Direct and indirect incremental cost estimates are based primarily on a 1992 study supplemented with industry interviews and analysis of FTA grant records (GMIS). Direct costs reflect modifications to existing diesel technology and are defined as those costs directly attributable to meeting the requirements of the CAAA.

The incremental cost incurred by transit operators in acquiring new standard size diesel buses that meet CAAA requirements is estimated at $6,000 to $7,000 per bus in 1990 dollars. This consists of $1,000 to $2,000 for a catalytic converter and $5,000 for advanced fuel injection. The price of small buses should not be affected. As noted earlier, catalytic converters are already being used on transit buses to meet current emissions standards and their costs are likely to be included in the vehicle replacement costs estimated earlier using FTA grant records. Therefore, this analysis uses the $5,000 cost of advanced fuel injections as the basis for the incremental cost and assumes all new large and mid-size buses purchased in areas of over 1 million population are equipped with this technology. In 1994 dollars, this is an incremental capital cost required to maintain conditions of the national transit bus fleet of $5,646 per large and medium size bus.

Indirect costs reflect the conversion to alternative fuels and consider the case in which operators purchase alternative fuel technologies in response to: 1) a high degree of uncertainty about the future of existing technology, either due to the CAAA or Energy Policy Act; or 2) state and local initiatives enacted, in part, following the lead of this legislation. Exhibit D-4 shows incremental costs of complete conversion of fleets in major metropolitan areas to alternative fuels. The costs are expressed as annual averages for three major alternative fuels.

Exhibit D-4
Conversion to Alternative Fuels
Average Annual Incremental Costs
Millions of 1994 Dollars
1994-2013

	Methanol	Compressed Natural Gas	Liquefied Natural Gas
Maintenance Facilities	$46.7	$84.6	$51.0
Vehicles	$19.2	$55.2	$29.9
Total Capital Costs	$65.9	$139.8	$80.9

Source: Battelle—Columbus, 1992

These estimates should reasonably approximate the maximum impact of the CAAA or full implementation of the Energy Policy Act. Based on recent experience, for purposes of this analysis, the midpoint between CNG and LNG was used. Note, however, that average costs obscure changes over time in the cost attributable to each category. During the initial years, costs will be primarily attributable to maintenance facility conversions, while in later years costs will become increasingly attributable to continued vehicle acquisition. Exhibit D-5 shows the estimated per-vehicle and per-facility cost. Key assumptions in this analysis are as follows:

Operators do not change service levels to cover the costs due to alternative fuel conversion.

A 100 percent conversion to alternative fuels by affected operators, which translates to a 96 percent conversion of the standard size bus fleet and a 15 percent conversion of the small bus fleet. Excluded were fleets with less than 10 buses in non-attainment areas greater than 250,000 or less than 20 buses in all other areas over 250,000, and all fleets in areas under 250,000.

Fleets are converted as follows: small bus facility conversions begin in 1994, and small bus fleets are 100 percent alternative fueled by 2005; standard size bus facility conversions begin in 1996, and standard size fleets are 100 percent alternative fueled by 2015.

The "baseline" standard size vehicle from which incremental costs are derived was a diesel bus equipped with a particulate trap using advanced diesel fuel, where the cost attributable to the particulate trap (long-run, full-production cost) is $1,500. As noted above, vehicle manufacturers have been able to meet the standard without use of a particulate trap. Because of the small estimated cost, this does not materially change the results of the analysis.

Incremental vehicle costs decline as production increases.

Exhibit D-5
Incremental Estimates per Vehicle and Facility
1990 Dollars

	Methanol	Compressed Natural Gas	Liquefied Natural Gas
Facility Conversion			
Standard Size Buses	2,934,800	5,388,400	3,543,600
Small Buses	794,000	1,197,900	NA
Vehicles			
Standard-Size Buses			
Year 2000	24,350	36,300	27,600
2003-2015	3,950	14,800	6,900
Small Buses			
1995-2015	1,200	2,700	3,300
Operating Fuel - Annual			
Standard-Size Buses			
1995	10,404	(356)	89
2000	10,227	0	534
2015	4,891	3,735	5,158
Small Buses			
1995	1,442	(766)	NA
2000	1,383	(677)	NA
2015	265	206	NA

Source: Battelle—Columbus, 1992

Recent Alternative Fuels Acquisitions. Analysis of FTA obligations for all standard size (35 and 40 foot) buses in FY 1993 shows that approximately 23 percent was for alternative fueled vehicles, with an average cost per vehicle of approximately $294,000 (compared to $217,000 for standard size diesel buses). This represents a $77,000 premium for alternative fueled standard size buses. This would have suggested that the above estimates were substantially lower than based on recent grant history. Similar data for smaller buses is not available.

However, based on several recent orders for alternative fueled buses by transit operators in major metropolitan areas, this cost differential has narrowed substantially. Seattle Metro's order for 360 standard size LNG buses, although recently canceled for reasons unrelated to cost, suggests comparable incremental costs. In planning their order, Seattle forecasted a $20,000 to $30,000 premium per bus, which was confirmed by the bids received. They also estimated $3 million in retrofit costs for a 200-bus facility. Discussions with representatives of operators in Los Angeles and New York City suggest similar experiences.

Rail Systems

The cost to maintain 1993 conditions on rail systems includes: 1) the cost of maintaining conditions of the physical infrastructure on the older rail transit systems, 2) the costs of replacing and recapitalizing rail vehicles, and 3) the costs associated with meeting requirements such as the ADA.

Rail System Infrastructure Recapitalization

As noted in Chapter 4, the recent update of the Rail Modernization Study provides the best source of information on current conditions in the Nation's rail systems. Both the update and the original Rail Modernization Study focused on estimating the cost needed to bring rail systems to a good state of repair over a 10-year period. This originally estimated cost ($25.5 billion in 1994 dollars), and the more recent update ($17.6 billion in 1994 dollars), includes elements which relate to both recapitalization investment levels being discussed in this report. Analysis of the improvements programmed over the 10-year period assessed in the original Rail Modernization Study indicates that the average annual expenditure of $2,620 million in 1983 dollars is made up of $1,070 million in ongoing costs needed to maintain current conditions and $1,542 million in costs needed to improve conditions and retire the backlog of deferred investment needs.

In order to be consistent with the treatment of vehicle replacement costs used for bus and other non-rail service, vehicle-related costs will rely on estimates based on the current fleet rather than the Rail Modernization Study estimates. Of the $1,070 million in ongoing costs to maintain current conditions, a portion is vehicle related, and must be excluded. Of the $2,620 million in annual investment requirements, $492 million (or 18.8 percent) was vehicle-related. Assuming that this same proportionate share of all the costs applies to the recurring costs estimated in the Rail Modernization study leaves an annual cost to maintain conditions of physical infrastructure of $845 million per year in 1993.

Rail Vehicle Replacement

Estimates of the annual investment required for rail vehicle replacement are derived by an approach similar to that used for buses and other vehicles. The estimates are calculated by taking the current fleet inventory from Section 15 and by determining how many vehicles of each type need to be replaced each year to maintain the current average fleet age, as reported in Chapter 4. The annual replacement requirement is then multiplied by the average cost of a new vehicle. Data on average costs was obtained from analysis of recent rail vehicle acquisitions. Exhibit D-6 shows the total number of vehicles of each type included in the Section 15 inventory, the average years between replacements needed to maintain current fleet age, and the average cost per replacement vehicle.

Exhibit D-6
Number of Rail Transit Vehicles, Replacement Cycle, and Average Replacement Cost by Type of Vehicle
Cost to Maintain Conditions and Performance Scenario

Type of Vehicle	Number in Areas Over 1 Million	Number in Areas Under 1 Million	Replacement Cycle (years)	Average Replacement Cost
Rapid Rail	10,074	0	35	$2,000,000
Light Rail	908	35	33	$2,500,000
Locomotives	551	5	30	$2,300,000
Commuter Rail Trailers	2,382	20	38	$1,500,000
Commuter Rail Self-Propelled Cars	2,526	0	35	$2,100,000
Automated Guideway	28	2	30	$1,400,000
Other Rail	51	4	30	$2,000,000

Source: Community Transportation Association of America and Federal Transit Administration grants data

Data on rail vehicle acquisitions was obtained from the APTA report, 1993 Transit Passenger Vehicle Fleet Inventory. This report contains information on vehicle acquisitions in 1990 through 1992, and includes the number of vehicles ordered, the price per vehicle, and information about the characteristics of the vehicles. For each vehicle type reported, acquisition prices were inflated to 1993 dollars using the Gross National Product Implicit Price Deflator, and a weighted average calculated.

Rail Vehicle Midlife Rebuilds

As with bus systems, in order to assure that vehicles stay in usable condition for their entire useful life, rail system operators must make mid-life investments in certain major components. Under FTA guidelines, these costs are eligible as capital expenses. To estimate the annual investment level required to make mid-life rebuilds, the number of rail vehicles requiring such investments is divided by the replacement rate. The resulting annual rebuild requirement is multiplied by the current average cost of such investments, about one half the costs of replacing each vehicle.

Americans with Disabilities Act Costs

Under the ADA, operators of rail systems are required to provide at least one car per train that is accessible to wheelchair users and other persons with disabilities within 5 years and also ensure that "key stations" on their systems are likewise accessible within 3 to 30 years, depending on complexity. This will require rail systems to incur costs to retrofit stations to make them accessible. In addition, the one car per train requirement will require systems either to retrofit existing vehicles or purchase accessible vehicles more rapidly than normal fleet replacement schedules would require. In addition, operators of rail systems will be required to provide complementary paratransit service for those who cannot use accessible fixed rail service. (The cost for complementary service for rail systems is included above in the calculation of the costs of bus-related ADA services.) The total costs of making key stations accessible and the incremental cost of acquiring replacement vehicles more quickly than otherwise necessary to meet the one car per train within 5 years requirement have been estimated based on plans submitted by the operators.

Cost to Maintain Performance

Amount of Additional Transit Service Required

To complete the estimate of the **Cost to Maintain** 1993 conditions and performance, it is necessary to estimate the additional transit investment required to increase service levels sufficient for transit to capture the portion of the increased travel demand which each scenario calls for to be accommodated on transit. The amount of travel demand to be accommodated is based on the forecasts made by the MPOs in preparation of their most recent TIPs and LRTPs.

To determine the appropriate transit travel demand forecasts the TIPs and LRTPs from a sample of urbanized areas were reviewed, as shown in Exhibit D-7.

Exhibit D-7
Number of Long-Range Plans and Transportation Improvement Programs Reviewed to Develop Transit Travel Demand Forecasts

Area Size	**Total Number of Areas**	**Original Sample**	**TIPs Obtained**	**LRTPs Obtained**
Over 1 Million	33	33	33	32
500,000 to 1 Million	24	24	22	17
Under 500,000	338	73	62	44
Total	395	130	11	93

Source: Booz—Allen and Hamilton, 1995

For each plan, the current amount of transit travel (in terms of passenger miles) and the future transit travel forecast inherent in the plan was determined. Where the amounts were not included in the published documents, the appropriate values were obtained directly from the MPO. Where possible, forecasts to the year 2015 were obtained. Otherwise, the rate of annual rate of increase in transit use represented by the transit travel forecast for the year closest to 2015 was used to calculate a 2015 value. A weighted average increase in transit travel for the period 1990 to 2015, and an annual growth rate were calculated from these values, using 1993 transit passenger miles as the basis for weighting. Exhibit D-8 displays the results. It should be noted that there was substantial variation in the MPO forecasts, from -0.2 percent to 9.4 percent per year (in Los Angeles), although most MPOs forecast growth rates of under 4.0 percent. The large rate of growth forecast for the Los Angeles area had a significant impact on the estimates of transit investment requirements. If the rate of growth for the Los Angeles area is assumed to be the same as for the other areas over 1 million without rail (2.3 percent), then the estimate of the **Cost to Maintain** conditions and performance and the **Cost to Improve** conditions and performance would each be reduced by about 15 percent.

Exhibit D-8
Transit Travel Growth Estimates from Analysis of Metropolitan Planning Organization Long-Range Plans and Transportation Improvement Programs Compared to Actual Experience
1993-2013

Urbanized Area Type	**Forecast Future Annual Growth Rate in Transit Travel 1993-2013**	**Actual Annual Growth Rate in Transit Travel 1983-1993**
Existing Rail Areas Over 1 Million	0.82%	-1.32%
Other Areas Over 1 Million	4.52%	4.27%
Areas Under 1 Million	2.19%	1.10%
Overall Average	2.36%	0.11%

Source: Booz—Allen and Hamilton, 1995, Federal Transit Administration

Using 1993 transit travel as a base, this amounts to a total increase in transit use of 21.5 billion passenger miles per year, over the 20-year analysis period, or an average of 1,075 million per year. This represents a 59 percent increase over current levels. Based on past analyses of the most likely location for increased transit use, about one half of this travel is assumed to occur in the core of urbanized areas, and about one half in the remaining portions of urbanized areas.

To determine the distribution of the additional transit service by service type at the Maintain Performance level, the assumptions shown in Exhibit D-9 were made as to how much of this travel would be handled by 1) increased existing rail service, 2) new fixed guideway service, and 3) increased bus service. The assumptions are based on the kind of service which would most likely be required in each classification by urban area size and location. For example, in the core of the areas with existing rail systems, it is most likely that increased travel would be handled by increased service on those existing systems. Similarly, in the smallest urbanized areas, it is likely that increased bus service would have to be provided.

Exhibit D-9
Type of Transit Service Assumed by Urbanized Area Size and Type and Location within Urbanized Areas
Cost to Maintain Conditions and Performance Scenario
1994-2013

	Location Within Urbanized Area	
Urbanized Area Size	**Urban Core**	**Remainder of Urban Area**
Areas Over 1 Million with Rail	100% Expanded Rail Service	50% New Fixed Guideway Service 50% Increased Bus Service
Areas Over 1 Million without Rail	50% New Fixed Guideway Service 50% Increased Bus Service	1/3 New Fixed Guideway Service 2/3 Increased Bus Service
500,000 to 1 Million	1/3 New Fixed Guideway Service 2/3 Increased Bus Service	100% Expanded Bus Service
Under 500,000	100% Expanded Bus Service	100% Expanded Bus Service

Source: Federal Transit Administration

The total amount of increased passenger miles for each type of service increase was divided by 20 to determine the average annual increase in transit service that would be required to accommodate the increased transit travel. The results are shown in Exhibit D-10.

Exhibit D-10
Average Annual Increase in Transit Travel Demand by Service Type
Cost to Maintain Conditions and Performance Scenario
Millions of Passenger Miles
1994-2013

	Type of Transit Service		
Urbanized Area Size	**Expanded Rail Service**	**New Fixed Guideway Service**	**Expanded Bus Service**
Areas Over 1 Million	95	244	638
Areas Under 1 Million	0	8	90

Source: Federal Transit Administration

Cost of Expanded Existing Rail Services

To calculate the cost of providing the expanded existing rail service, it is assumed that these service increases will be accommodated through increased service frequency, rather than investments in new infrastructure. This is reasonable since many rail systems could easily handle more or longer trains without modifying stations, signals, or other physical facilities. Currently, each rapid and commuter rail vehicle handles about 1.10 million passenger miles per year. Thus, to accommodate the additional 95 million passenger miles per year, an additional 86 vehicles must be purchased each year. The average cost per vehicle is calculated using the current fleet mix and the data on recent vehicle acquisitions used earlier to calculate the replacement costs, giving an average of $1.95 million per year. Applying this average to the number of new vehicles needed each year gives the total annual cost to increase rail service to maintain performance.

Cost to Provide New Fixed Guideway Services

To assure that investment in new fixed guideway services, and other major investments, are cost-effective, in 1984 the DOT issued a Major Investment Policy which required that projects funded with discretionary capital assistance produced benefits which were commensurate with their costs. To do so, the DOT stated that projects must have a total annualized incremental cost of no more than $6.00 per new transit rider attracted compared with the best noncapital-intensive alternative (the "Transportation System Management" alternative). This value was calculated based on the total value of an average foregone automobile trip, factored upward to account for both user and nonuser benefits.

A recent analysis focused on a series of recent past investments and recalculated anticipated benefits accruing from the new transit invesmtents, as well as several others which are now in the final stages of development, and found that these investments all had benefits which were well in excess of their total costs. Benefits considered included improved air quality, reduced noise, reduced highway congestion and reduced automobile accidents. The analysis found that the weighted average value of the benefits accruing per new rider was about $9.00, although there is substantial variation from city to city and project to project. Given inflation since 1984, this is consistent with the earlier estimate. On the basis of an average 10-mile work trip, this translates to an average value per passenger mile of $0.90. Recent experience indicates that of the total annualized cost of new rail investments, about 80 percent is made up of annualized capital costs and the remainder of the annual incremental operating cost of increased transit service. On this basis, a cost-effective rail investment would have an annualized capital cost of no more than $0.72 per incremental passenger mile. Using the factors which were applied to calculate the annualized capital costs of these projects, this translates to an up-front capital investment of about $6.65 per incremental annual passenger mile.

As noted earlier, new fixed guideway services would be expected to accommodate about 252 million new passenger miles per year. Using this estimate of the maximum reasonable cost to ensure that these investments are cost-effective times this number of annual passenger miles gives the total amount of new fixed guideway investments needed to generate this incremental rail patronage.

Cost of Expanded Bus and Paratransit Service

Since the number of bus and paratransit revenue vehicle hours per peak vehicle tended to stay fairly constant through the 1980's, it is likely that any increase in revenue vehicle hours will have to be matched by at least an equivalent increase in the number of transit vehicles. Since the additional service would be provided at the margin, it is more likely that a higher rate of increase in bus service would be needed to match the recent rate of increase in transit passenger miles. However, as a conservative estimate, it is assumed that the present average of 302,000 annual passenger miles per bus and paratransit vehicle per year in areas over 1 million and 163,000 passenger miles per bus and paratransit vehicle per year in smaller areas would be maintained. This means that an additional 2,109 buses and paratransit vehicles per year would be needed in areas over 1 million and 554 buses and paratransit vehicles would be needed in areas under 1 million.

To estimate the cost of these vehicles, the average cost per vehicle was calculated using the data used above to calculate vehicle replacement costs, weighted by the number of vehicles of each type in the current fleet. For areas over 1 million, the average cost per conventional vehicle is $202,000; for areas under 1 million $170,000. Because of the CAAA, buses in areas of over 1 million population are likely to be alternatively fueled. These figures thus include an incremental cost of about $20,000 per vehicle to the capital cost to account for the likely use of alternative fuel vehicles. To calculate the cost of additional maintenance facilities, it was assumed that the same ratio between vehicle replacement and maintenance facility recapitalization as was used in the estimate of the cost to maintain current conditions would continue to apply. The result is a total capital cost per additional vehicle of about $368,000 in areas over 1 million population and $314,000 in areas under 1 million population. Applying these values to the increased fleet requirements results in the estimate of the cost to expand bus services to maintain performance.

Cost to Improve Conditions

The investment requirements estimated to improve conditions are based on the cost of restoration of all existing transit equipment and facilities to a good state of repair by the end of the 20-year analysis period assumed in this report. The investment requirements estimated to maintain conditions included only the costs of keeping conditions constant, because they addressed only the costs of restoring equipment as it wears out. However, these estimates did not address the fact that the current conditions of the equipment and facilities are not adequate. As noted, there are buses which are older than their desirable useful lives and a substantial amount of rail equipment and facilities in less-than-good condition. This section estimates the costs of eliminating this backlog, bringing the average fleet age down to the desirable useful life standards and bringing rail equipment and facilities to good condition over a 20-year period.

Bus and Other Non-Rail Service

Urban Vehicle Replacement

As noted in Chapter 4, there are a total of 13,548 urban transit buses and other non-rail vehicles in excess of the useful life guidelines set by FTA. While the condition of these vehicles is not known, their age indicates that they have exceeded FTA guidelines for minimum useful life and should be retired and replaced with new vehicles. Multiplying the number of vehicles of each type which are in excess of FTA's useful life guidelines by average vehicle replacement costs, including the costs of achieving CAAA and Energy Policy Act goals, results in the estimate of the cost to replace all of these vehicles, which represents the urban vehicle replacement backlog.

To improve conditions by keeping the bus fleet at an average age consistent with FTA's minimum useful life guidelines will require faster replacements of vehicles than calculated to maintain current conditions. The incremental cost of replacing vehicles in accordance with these guidelines is calculated by comparing the number of vehicles which have to be replaced annually to maintain conditions with that required at the optimum rate. For example, full-size bus replacements in urban transit service would have to increase from 3,119 per year to 3,889. The increased replacement requirement is multiplied by the average replacement cost for each vehicle type, using the same data as was used to calculate the basic replacement requirement, including CAAA and Energy Policy Act related costs.

Replacing vehicles at these increased rates would eliminate the entire backlog estimated above during the 20-year analysis period used in this report, thus no increase in the annual incremental cost is required to assure that the backlog is eliminated by the end of the analysis period.

Urban Facility Recapitalization

The estimates used earlier to calculate the cost of keeping transit facilities at their present condition is a reasonable basis for estimating the value of the backlog of urban facility investment requirements. That is, total expenditures for all facilities have in recent years been equal to that spent on vehicles. Further, review of recent TIPs and LRTPs indicates that MPOs are programming approximately equal amounts for vehicles as for facilities. Using this factor assumes that bus facilities are in approximately the same condition as vehicles. This is reasonable, since there is no incentive for localities to have spending patterns which would favor improvements on facilities over vehicle replacements. In addition, it is borne out by the information on bus facility conditions described in Chapter 4. Therefore, the total bus facilities requirement ($914 million in the **Cost to Maintain** scenario plus $514 million in the **Cost to Improve** scenario) is estimated to be about the same as the vehicle requirement ($1,105 million in the **Cost to Maintain** scenario plus $362 million in the **Cost to Improve** scenario).

The recent detailed review of the recapitalization needs of bus maintenance facilities is the best source of information to assess the improvement requirements related to these facilities. The approach used to relate the costs estimated in that study to the investment scenarios included in this report is described above.

No similar detailed data is available on non-maintenance facilities. As noted earlier, in recent years expenditures for non-maintenance facilities have run at two-thirds of the level of vehicle expenditures. Similarly, MPO plans and programs indicate programming at about 57 percent of the cost of vehicles. Thus, the cost to improve conditions to a good state of repair on urban transit facilities is estimated at two thirds of the increased investment needs to replace vehicles over the maintain conditions rate.

Rural Vehicle Replacements

The investments required to improve conditions through rural vehicle replacements and the backlog of such investments is calculated in the same manner as urban vehicle replacements. As noted in Chapter 4, there are a total of 4,834 rural transit vehicles in excess of the minimum useful life guidelines set by FTA. While the condition of these vehicles is not known, their age indicates that they have exceeded FTA guidelines for minimum useful life and should be retired and replaced with new vehicles. The backlog of rural vehicle replacement needs is calculated by multiplying the number of overage vehicles by the average vehicle replacement costs obtained by FTA staff from analysis of FY 1993 grants.

To improve conditions by keeping the rural transit fleet at an average age consistent with FTA's minimum useful life guidelines will require faster replacements of vehicles than calculated to maintain current conditions. The incremental cost of replacing vehicles in accordance with these guidelines is calculated by comparing the number of vehicles which have to be replaced annually to maintain conditions with that required at the optimum rate. For example, rural van replacements would have to increase from 1,565 per year to 1,956. The increased replacement requirement is multiplied by the average replacement cost for each vehicle type, using the same data as was used to calculate the basic replacement requirement.

Rural Transit Facilities

The estimates used earlier to calculate the cost of keeping transit facilities at their present condition is a reasonable basis for estimating the value of the backlog of rural facility investment requirements. That is, total expenditures for all urban facilities have in recent years been equal to that spent on vehicles. Similarly, it is assumed that rural facility needs are somewhat less than urban facility requirements, so that a factor of one-half vehicle cost was used above to estimate rural facility investment requirements to maintain conditions. Using this factor to estimate the rural transit facilities backlog involves the assumption that bus facilities are in approximately the same condition as vehicles. As with urban buses, this is reasonable, since it can be assumed there is no incentive for localities to have spending patterns which would favor improvements on facilities over vehicle replacements.

The cost to improve conditions to a good state of repair on rural transit facilities is estimated at one half of the sum of the increased investment needs to replace vehicles over the maintain conditions rate. This gives a reasonable estimate of the annual cost to restore these facilities to a good state of repair by the end of the 20-year analysis period.

Specialized Service Vehicle Replacements

Specialized service vehicle replacement investment requirements and backlog are calculated in the same manner as urban vehicle replacements. As noted in Chapter 4, there are a total of 11,220 specialized service vehicles in excess of the minimum useful life guidelines set by FTA. While the condition of these vehicles is not known, their age indicates that they have exceeded FTA guidelines for minimum useful life and should be retired and replaced with new vehicles. The value of specialized service vehicle replacement backlog is calculated by multiplying the number of overage vehicles by the average vehicle replacement costs (based on FY 1993 grants).

To improve conditions and performance by keeping the specialized service fleet at an average age consistent with FTA's minimum useful life guidelines will require faster replacement of vehicles than calculated to maintain current conditions. The incremental cost of replacing vehicles in accordance with these guidelines in calculated by comparing the number of vehicles which have to be replaced annually to maintain conditions with that required at the optimum rate. For example, specialized service van replacements would have to increase from 2,038 per year to 2,547. The increased replacement requirement is multiplied by the average replacement cost for each vehicle type, using the same data as was used to calculate the basic replacement requirement.

Specialized Service Facilities

The estimates used earlier to calculate the cost of keeping transit facilities at their present condition is a reasonable basis for estimating the value of the backlog of specialized service facility investment requirements. That is, total expenditures for all urban facilities have in recent years been equal to that spent on vehicles. Similarly, it is assumed that specialized service facility needs are somewhat less than urban facility requirements, so that a factor of one-half vehicle cost was used above to estimate specialized service facility investment requirements to maintain conditions. Using this factor to estimate the specialized service facilities backlog involves the assumption that specialized service facilities are in approximately the same condition as vehicles. As with urban buses, this is reasonable, since it can be assumed there is no incentive for localities to have spending patterns which would favor improvements on facilities over vehicle replacements.

The cost to improve conditions to a good state of repair on specialized service facilities is estimated at two thirds of the sum of the increased investment needs to replace vehicles over the maintain conditions rate. This gives a reasonable estimate of the annual cost to restore these facilities to a good state of repair over a 20-year period.

Rail Systems

Rail System Infrastructure Improvement

As noted above, the Rail Modernization Study Update provides estimates of the cost to restore facilities and equipment to a good state of repair over a 10-year period. The total cost estimated to achieve this goal was estimated at $17.6 billion in 1993 dollars. Of this amount, $14.62 billion in 1993 dollars is for non-vehicle costs. As noted earlier, some of this is the cost to maintain conditions at good levels once these levels are achieved. Based on the Rail Modernization Study, that amount is $8.46 billion. This leaves a total non-vehicle backlog of $6.17 billion. Over a 20-year period, the estimated cost to restore the non-vehicle backlog is calculated as 1/20th of that amount.

Rail Vehicle Replacements

Rail vehicle replacement backlog and investment requirements to improve conditions is calculated in the same manner as urban vehicle replacements. As noted in Chapter 4, there are a total of 3,852 rail transit vehicles in excess of the minimum useful life guidelines set by FTA. While the condition of these vehicles is not known, their age indicates that they have exceeded FTA guidelines for minimum useful life and should be retired and replaced with new vehicles. The backlog of rail vehicle replacements is calculated by multiplying the number of overage vehicles of each type by the average vehicle replacement costs (based on recent rail vehicle procurements).

To improve conditions and performance by keeping the rail transit fleet at an average age consistent with FTA's minimum useful life guidelines will require faster replacements of vehicles than calculated to maintain current conditions. The incremental cost of replacing vehicles in accordance with these guidelines is calculated by comparing the number of vehicles which have to be replaced annually to maintain conditions with that required at the optimum rate. For example, rapid transit vehicle replacements would have to increase from 288 per year to 403. The increased replacement requirement is multiplied by the average replacement cost for each vehicle type, using the same data as was used to calculate the basic replacement requirement.

Replacing vehicles at this rate will not eliminate the vehicle backlog at the end of the 20-year analysis period. Analysis of the fleet inventory reveals that a slightly faster rate (an additional 72 vehicles per year), or about 10 percent more than that estimated to meet the 25 year replacement rate assumed in the above analysis of the cost to improve conditions by increasing the rate of replacements to optimum levels. This is multiplied by the average cost to replace these vehicles to calculate the additional expenditure needed to fully restore the fleet to good condition at the end of 20 years.

Rail Vehicle Midlife Rebuilds

To improve conditions and performance by keeping the condition of the rail transit fleet at a good state once improved, mid-life rebuilds should occur at a rate consistent with FTA's minimum useful life guidelines. This will require a faster rate of such rebuilds than calculated to maintain current conditions. The incremental cost of conducting these rebuilds at the faster rate is calculated by comparing the number of vehicles which have to be rebuilt annually to maintain conditions with that required at the optimum rate. For example, commuter rail self-propelled vehicle rebuilds would have to increase from 72 per year to 101. The increased rebuild requirement is multiplied by the average rebuild cost for each vehicle type, using the same data as was used to calculate the basic rebuild requirement.

Cost to Improve Performance (User Costs)

Dimensions of Transit Performance to be Improved

To improve transit performance, transit speeds, comfort and convenience, coverage, and door-to-door travel times must improve. These are the dimensions used in Chapter 4 to describe the current performance of transit, and are reflected in such factors as the relative speed of transit trips, the percentage of transit riders who must stand or otherwise travel in overcrowded conditions, and the availability of transit service to the nation's citizens who have a need for local mobility. This improvement in performance is designed to provide a level of service sufficient to attract the patronage which was used in the MPO forecasts of transit travel demand. It represents achievement of certain minimum conditions, and thus is similar to the approach used historically to estimate highway investment requirements. In that approach, the **Cost to Improve** conditions and performance scenario estimates the cost to achieve a set of minimum conditions, including Level of Service D (see Chapter 4 for definition) on all facilities. It is also similar to the approach now being used in the **Economic Efficiency** scenario based on the Highway Economics Requirements System. In this approach, improvements are selected based on benefit cost calculations in which many of the benefits measures represent savings in highway user costs. The improvements in transit speed, comfort, and convenience included in this scenario similarly result in savings in transit user costs (travel time, waiting time, and discomfort).

More work needs to be done in analyzing the relationship between transit supply and demand for investment requirement estimation purposes. In the meantime, this report assumes that, absent other policy changes, this improved level of service would be necessary to attract the patronage forecast by the MPOs. If this assumption is correct, the benefits of the **Cost to Improve** scenario are commensurate with the costs of achieving them.

Increasing Transit Speed

Both transit investment requirements scenarios include the same amount of transit travel demand, derived from the MPO estimates. However, for the purposes of the analysis of the cost to achieve different levels of performance, the mix of transit services to handle the increased travel demand will change. Rail and other fixed guideway transit systems provide a higher level of service in terms of speed. Thus, for the Improve Performance calculation, the mix of services shown in Exhibit D-11 was used to provide the increased services needed to handle the foregone lane mileage. This change in service level mix will reduce user travel time.

Again, the total amount of increased passenger miles for each of these types of service increase were divided by 20 to determine how much of an annual increase in transit service would be required. The results are shown in Exhibit D-12, which again account for the transit travel demand increases obtained from the MPO forecasts.

Exhibit D-11
Type of Transit Service Assumed by Urbanized Area Size and Type and Location within Urbanized Areas
Cost to Improve Conditions and Performance Scenario
1994-2013

	Location Within Urbanized Area	
Urbanized Area Size	**Urban Core**	**Remainder of Urban Area**
Areas Over 1 Million with Rail	100% Expanded Rail Service	2/3 New Fixed Guideway Service 1/3 Increased Bus Service
Areas Over 1 Million without Rail	2/3 New Fixed Guideway Service 1/3 Increased Bus Service	50% New Fixed Guideway Service 50% Increased Bus Service
500,000 to 1 Million	50% New Fixed Guideway Service 50% Increased Bus Service	1/3 New Fixed Guideway Service 2/3 Increased Bus Service
Under 500,000	100% Expanded Bus Service	100% Expanded Bus Service

Source: Federal Transit Administration

Exhibit D-12
Average Annual Increase in Transit Travel Demand by Service Type
Cost to Maintain Conditions and Performance Scenario
Millions of Passenger Miles
1994-2013

	Type of Transit Service		
Urbanized Area Size	**Expanded Rail Service**	**New Fixed Guideway Service**	**Expanded Bus Service**
Areas Over 1 Million	95	522	359
Areas Under 1 Million	0	20	78

Source: Federal Transit Administration

The total remains an average annual increase in transit service of 1,075 million passenger miles, or about 3.0 percent of the 1993 level. At the end of 20 years, transit service will have increased by about 21.5 billion passenger miles, or 59 percent over 1993 levels, however, the mix of service between bus and rail will be different than that calculated to maintain performance.

The same approach used to calculate the costs of providing the service level increase to maintain performance was used to calculate the cost of increasing transit service levels under this scenario. The only difference is in the mix of services provided. The cost of expanded rail service remains the same. The cost of new fixed guideway service increases while the cost of providing additional bus service declines. The total cost to provide the increased transit service to handle the increase in travel demand not handled by highway capacity, at improved system speeds, is thus about 20 percent higher than the cost to handle this increase calculated in the maintain performance scenario.

Cost to Improve Comfort, Convenience and Door-to-Door Travel Time

Data on transit performance included in Chapter 4 indicates that 29 percent of transit riders cannot find a seat for their trip. This represents a level of overcrowding which makes transit less convenient and comfortable than it could be. As described in Chapter 4, more detailed data on transit performance in these terms is not available. However, the cost to improve transit performance (User Cost) will include an increase in transit service levels to handle this demand at a higher level of comfort and convenience. To do so, the cost to provide transit service levels 30 percent over that already calculated for the **Cost to Maintain** 1993 conditions and performance scenario was estimated. While these increased service levels would have the most direct effect on the ability of transit to provide a comfortable ride, this increase will also improve the convenience of transit and reduce door-to-door travel time. Reduced service headways which could be provided under this scenario would also result in reduced waiting times. In addition, the need to transfer could be reduced, depending on how the additional service was deployed. These are other important dimensions of the quality of transit service used in Chapter 4.

To validate the amount of service used as the basis for the Improve Performance (User Cost) scenario, an analysis of the costs and benefits was conducted. The analysis focused on the benefits achieved from the increased service in terms of the reduced waiting time for transit users, and the reduction in the amount of time which would be spent standing. Analysis from London Transport indicates that transit users value time spent transferring about 4.0 times the amount spent seated on a vehicle, time spent waiting about 2.5 times the amount of time spent seated in a vehicle, and time spent standing on a vehicle about 2.0 times the amount of time spent seated in a vehicle. The analysis calculated the value of reduced transfer and waiting time by assessing the reduction in headway which would be achieved in the Improve performance scenario, compared with the Maintain performance scenario. The value of reduced standing was calculated by assessing the amount of time seated versus standing in each scenario. In sum, the net present value of the benefits to transit users from reduced transferring, waiting and standing in the Improve Performance (User Cost) scenario would be more than the net present value of the incremental capital and operating costs of providing the additional service included in the Improve Performance (User Cost) scenario.

To estimate the cost of the increased transit service levels needed to improve comfort and convenience, it is assumed that these increased service levels would require commensurate increases in the bus and rail fleet. The scenario described above, in which transit service levels are increased to handle the increased transit travel forecast by the MPO's, but at higher speeds than at the **Cost to Maintain** conditions and performance level, would require a rail fleet of about 17,258 vehicles for existing rail systems by the end of the 20-year analysis period. To meet the higher service quality goal inherent in this scenario would require an additional 5,177 vehicles, or 259 per year. Using the average per vehicle cost estimated above, the cost of these additional rail vehicles is calculated.

The higher level of transit service would also apply to the new rail systems included in this scenario. Using the same average number of passenger miles handled by each vehicle used earlier indicates that a fleet of 9,827 new vehicles would be needed for the new rail transit service. Thus, to meet the higher service quality goal inherent in this scenario, an additional 2,948 rail vehicles would be needed. Using the same average capital cost per vehicle results in the estimate of the cost of additional new rail system service.

The higher level of bus service quality inherent in this scenario would require an increase in the bus fleet from the previously estimated 59,610 to 77,439 in areas of over 1 million and from 21,858 to 28,416 in areas below 1 million. Using the same average per vehicle cost for rolling stock and facilities described earlier gives an estimate of the additional need for improved bus service quality.

Cost to Improve Coverage in Rural Areas

According to the CTAA, 40 percent of the nation's non-urbanized population is in areas not served by rural transit systems supported by Section 18. Another 29 percent live in areas where the average amount of service is less than 60 percent of the national average, in terms of annual trips per carless household. CTAA estimates that an increase of 48 percent in the amount of rural transit service would be required to provide service to all rural areas, and to increase service levels to the current national average level in those areas with low current levels of service.

To estimate the cost of increasing service levels by 48 percent, it was assumed that the present Section 18 fleet would have to be expanded by this amount. This would require an additional 5,867 vehicles over the present 12,223 vehicle fleet. To estimate the annual capital investment needed to achieve this increase in service over a 20-year period, the figure was divided by 20 and multiplied by an estimate of the average total capital cost to provide rural service. This was estimated by using the current average capital cost of $58,430 per vehicle plus one-half this amount for maintenance facilities. This is based on recent grant records which indicated that annual facility needs equal about one-half of vehicle needs in dollar terms.

Development of Improved Information on Transit Capital Requirements

Throughout this report there have been frequent references to the quality and validity of the data used for making estimates of mass transit capital needs. While projections contained in this report are unquestionably sounder than those in past reports, it must be recognized that if future reports are to see continued improvement, even better data will be needed. For example, while the recent Rail Modernization Study Update provided more current information about the conditions of the rail systems in 1991, this was a one-time effort whose results are already becoming dated. Better, more current information as to the current conditions of these rail systems would be helpful. In addition, a continuing process to collect and analyze such information would provide more detailed trend data in order to continue to track this important element of transit infrastructure.

Similarly, while the information provided for the age of bus vehicle fleet is quite reliable, and a recent study addressed bus maintenance facilities, there is no equivalent estimate available on the condition and needs related to other bus facilities. This report has used historical spending patterns to estimate needs in this area, a valid method but not an ideal one.

In order to improve the quality of data that will be used in future reports, FTA has embarked on a major effort focusing on use of the products of the Metropolitan and Statewide Transportation Planning and Programming Process. Currently, metropolitan areas are required to develop LRTPs and TIPs identifying investment projects to be conducted in the area in the near-term. These plans and programs are required by Section 8 of the Federal Transit Act, which calls for a planning process which results in these products. Section 8 and the implementing Joint Planning Regulations provide more detail on how these plans are to be developed and what the TIP must contain.

For the purposes of estimating transit capital investment needs, this process already provides useful information. The TIPs have lists of programmed projects which indicate what improvements are likely in the next few years. The Transportation Plans are more expansive efforts and include broad-scale proposals for both major and minor changes in each area's transportation system. Efforts are underway to build on the information base that is implicit in the entire transportation planning process (i.e., LRTP and TIP already being developed in all urbanized areas) and use this to generate better data and information for estimating mass transit capital investment needs as mandated by 49 USC 308(e), the statutory grounding of this report.

A second major addition to the transportation planning and programming process with an implication for this report is the requirement that States develop Public Transportation Facilities and Equipment Management Systems (PTMS). The PTMS will include inventories of transit facilities and equipment in each State and measurement of their conditions. This information, to be collected by the States from transit operators, will provide a systematic basis for the compilation of information on a National level of the conditions of transit equipment and facilities. FTA intends to gather information contained in the PTMS and create an overall picture of transit conditions.

The Interim Final Rule requiring PTMS was published on December 1, 1993 and provides for a phase-in period. By October 1, 1994, States are required to have defined their PTMS, which includes the data and the approach to be used to determine the conditions of transit infrastructure. By October 1, 1995, data collection must be underway. By October 1, 1996, the system must be fully operational. FTA intends to begin using the initial data collected for the PTMS in the 1997 version of this report, due to Congress in January of that year.

Another source of information for this report is detailed information collected by transit operators, States, and MPOs on the conditions of transit systems under their jurisdiction. These studies are often prepared to support detailed planning for the rehabilitation of these assets or for longer term financial planning designed to assure that adequate resources are available to maintain and operate the system. FTA intends to collect such studies and use summaries of their findings to assure that the estimates made in this report on the basis of National figures on transit conditions and performance accurately reflect more detailed studies of these issues. This information will be available for the next version of this report, due to Congress in January 1997.

Publication No. FHWA-PL-96-007
HPP-21/1-96(3M)QE