Preserving and Enhancing the Functionality of Highways in Texas

Workshop

_____ District Office

(date) _____

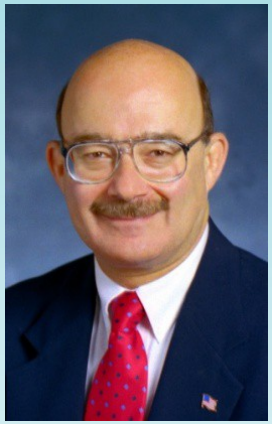
TxDOT Research Project 0-6208-P2

Texas Transportation Institute

Welcome and Introductions

- Instructors

Ed Hard



Brian Bochner

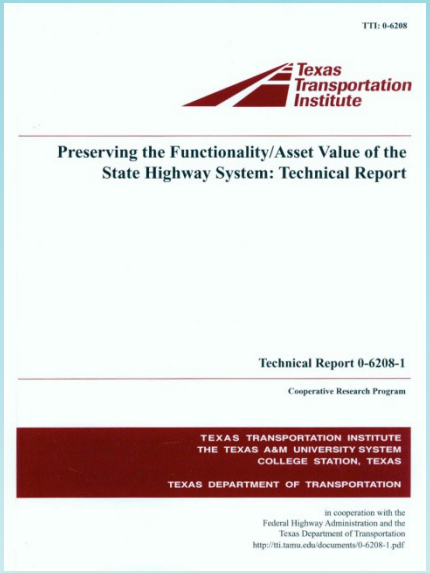
- Participants
  - What is your name?
  - Who are you with?
  - What you do?

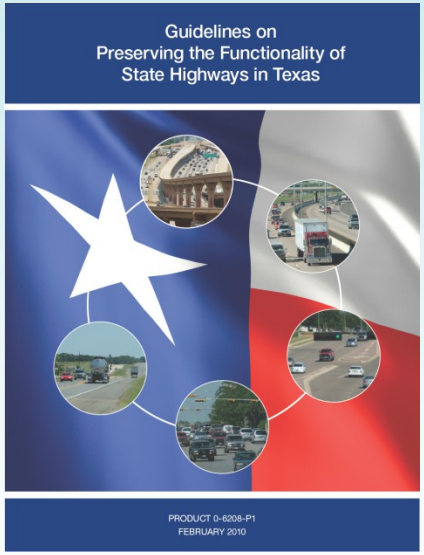
Before We Get Started….

- Basis for Workshop
- Objectives
- What is Functionality?

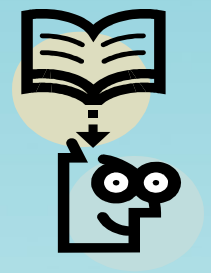
Basis for Workshop

- 2009 RMC Project 0-6208
  - Report 0-6208-1, Preserving the Functionality/Asset Value of the State Highway System
  - 0-6208-P1, Guidelines on Preserving the Functionality of State Highways in Texas
  - 0-6208-S, Summary Report
- Workshop is a Research Implementation project





What the 0-6208 Research Covered



- Losses to highway functionality over time
  - Sources/causes of deterioration
  - Performance measures
  - Counter measures to address
- Reviewed practices and policies in five areas
- Benefits and consequences
- Case studies, lessons learned

Workshop Objectives

- To promote the importance of Highway Functionality
- To review functionality in highway lifecycle
- To provide ‘how to’ materials to preserve, maintain, and enhance functionality
- To promote coordination between TxDOT and its local partners
- To get your input and feedback

What is Functionality?

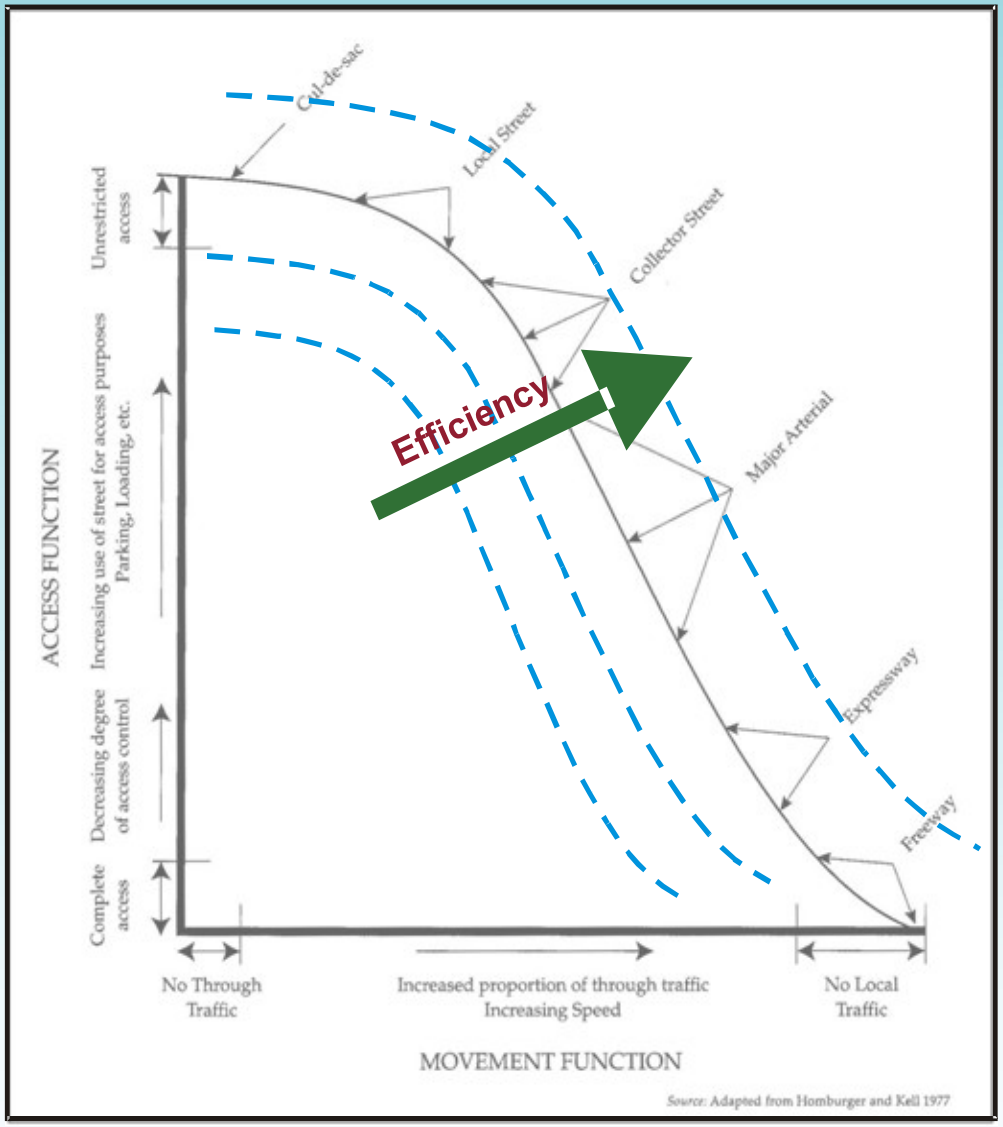
Definition: Facility effectiveness at providing mobility and accessibility in a safe and efficient manner

Attributes:

- Core concept of a transportation system/plan
- Provides network organization through classification
- Establishes priority of mobility vs. access
- Establishes differing roles for

Key Aspects of Functionality

- System balance
- Transitioning
- Integration
- Criteria

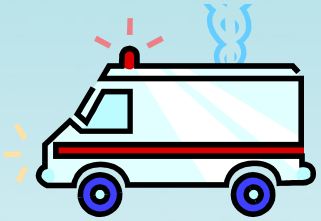


Five Areas Affecting Functionality

Planning and Land Development	Operations and Capacity	Right of Way	Infrastructure and Maintenance	Safety
• TxDOT • TxDOT/local coordination • MPO/regional • City/comprehensive • Development review • County transportation • AM, CM, CP	• Signal coordination and optimization • Facility design • Rehabilitations and Retrofits • Minor enhancements • Traffic control, management • TSM, TDM, and ITS • Network enhancements	• Preservation/ protection • Acquisition • Protection • Utility location and maintenance • Coordination with stakeholders	• Maintenance Practice • Work zone traffic management • Contracting strategies • Life cycle cost decision making • Sustainable materials, equipment, designs • Low maintenance infrastructure components	• Road safety audits • Operational assessments • Crash assessments • Sight distance • Sign assessments and maintenance • Lighting • Traffic Control

Role and Importance of Functionality

- Systemic concept
- Maintain capacity, efficiency, safety
  - Reduce potential for congestion
  - Reduce pollution, maintenance
- Protect value of public investment
- Reduce need for further/unplanned improvements



Agenda Overview

Turn to the First Page of Your Workbook

Preserving and Enhancing the Functionality of Highways in Texas

August 24, 2010
8:30 a.m. – 4:00 p.m.
Waco District Office
100 S. Loop Drive, Waco, Texas

Module	TOPICS
Opening 8:30- 8:45	Welcome and Introductions • Basis for Workshop • Functionality Definition and Components
1 8:45-10:00	Functionality in Planning and Land Development • MPO and Statewide • TxDOT Planning and Design Practices • District Involvement in Local Planning • SH 105 Case Study
Break 10:00 – 10:15	
2a 10:15-11:30	Operational Functionality • Operational Practices • Operations Performance Measures • Causes of Operational Deterioration • Countermeasures
LUNCH 11:30 – 1:00 (on your own)	
2a 1:00-2:15	• Operational Functionality Program • Countermeasure Examples • Exercise
Break 2:15-2:30	
3 2:30–3:15	Functionality Considerations in Right of Way and Utilities • Right-of-Way Acquisition • Right-of-Way Protection • Utility Accommodations • IH-10 Katy Freeway Case Study
4 3:15-3:45	Safety and Functionality • Safety Performance Measures • Causes of Safety Deterioration • Countermeasures for Safety • Road Safety Audits
Closing 3:45-4:00	Participant Feedback

MODULE 1

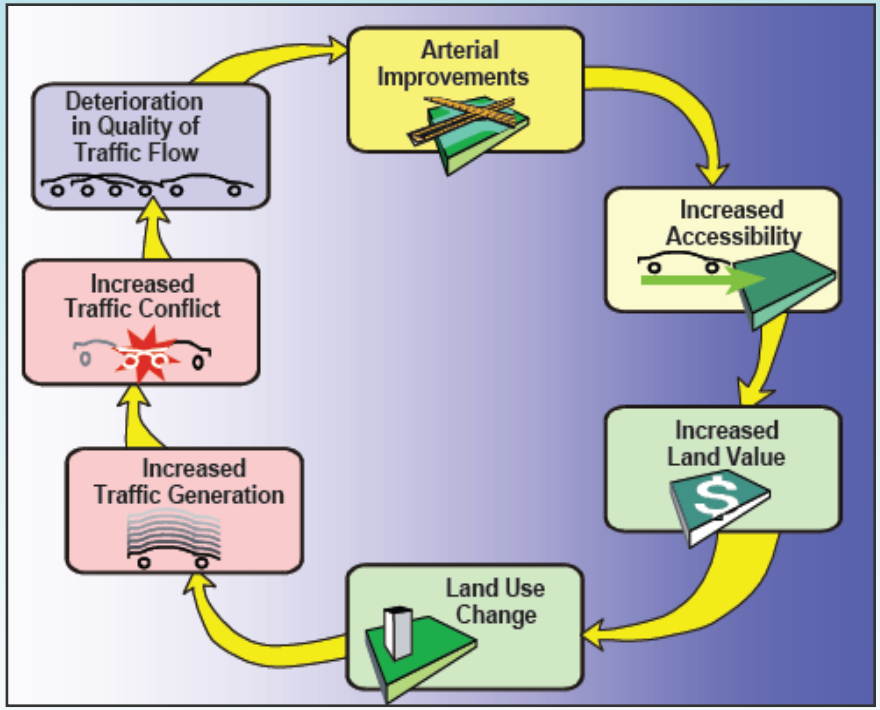
Functionality in Planning and Land Development

What Makes a Highway Function Well?

- Continuity/connectivity
- Capacity
- Operations/efficiency
- Context
- Support system

Planning Functionality Cycle

- Functionality is not a constant
- Changes over time
- Decline in Level of Service
- Improvemen



Source: Institute of Traffic Engineers (ITE), *Transportation and land Development, 2nd Edition*

Functionality in Planning and Land Development

Policies, practices, and actions that help preserve or enhance functionality

- MPO and statewide
  - Statewide Transportation Plan
  - MTPs and UPWPs
  - Congestion Management Programs
- TxDOT planning/design practices

Statewide Transportation Planning

- Develop STP and TPs by TxDOT district
  - Map with functional categories
  - Existing and planned facilities
  - Goals, policies, and criteria to support
- Coordinate functionality on district plans with STP
- Statewide Analysis Model (SAM)

MPO MTPs and UPWPs

- Coordinate functionality of MTPs and local T-fare plans
- Include goals, policies, and initiatives on:
  - Adherence to functional criteria in plan document
  - TSM, TDM, and ITS programs, initiatives
- Use UPWP as mechanism to address functionality
- TIPs: include functionality enhancement as factor in project selection

Other MPO Roles/Practices

- Monitor system effectiveness
- Assist in finding/distributing federal funds (e.g., CMAQ, safety, PL 112)
- Facilitate interagency coordination
- Travel demand modeling
- Education and outreach

Functionality in the Statewide and MPO Planning Process

Plan or Program	Agency	Examples of Means to Address Functionality
UPWP	**MPO**	- Studies on system functionality, CM/CP, and AM - Special studies to ID and prioritize corridors needing functional enhancement or preservation - Education/outreach to policy boards, public, and stakeholders on importance and benefits
STP and MTP	**MPO**	- Development of the plans illustrating existing and future thoroughfares by functional category - Include goals and policies related to adherence to functional criteria, AM, CM/CP, and other initiatives that enhance or preserve functionality
STIP and TIP	**MPO**	- Include benefits to functionality enhancement or preservation as a factor in project selection

Congestion Management Process (CMP) in Planning

- Required of MPOs in TMAs (>200,000 pop)
- Addresses functionality by:
  - Identifying system-wide locations of congestion
  - Determining the causes of congestion
  - Developing, implementing, and evaluating different congestion mitigation strategies
- Includes travel demand reduction and operational management strategies
- CMAQ funds used for studies, implementation projects

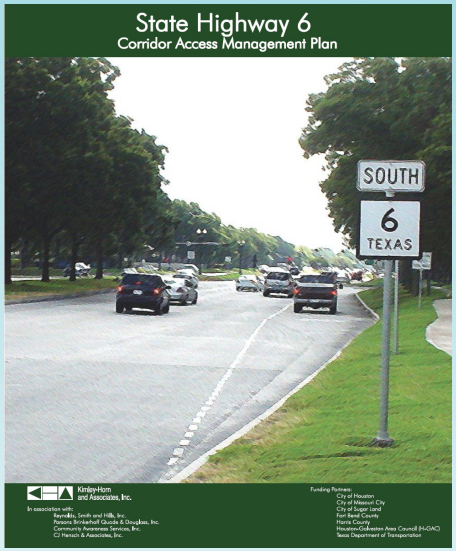
Houston/HGAC Examples

Programs/Initiatives to Enhance Functionality

- Corridor AM studies with follow-up Implementation projects
- Subregional planning initiative
- Safety program

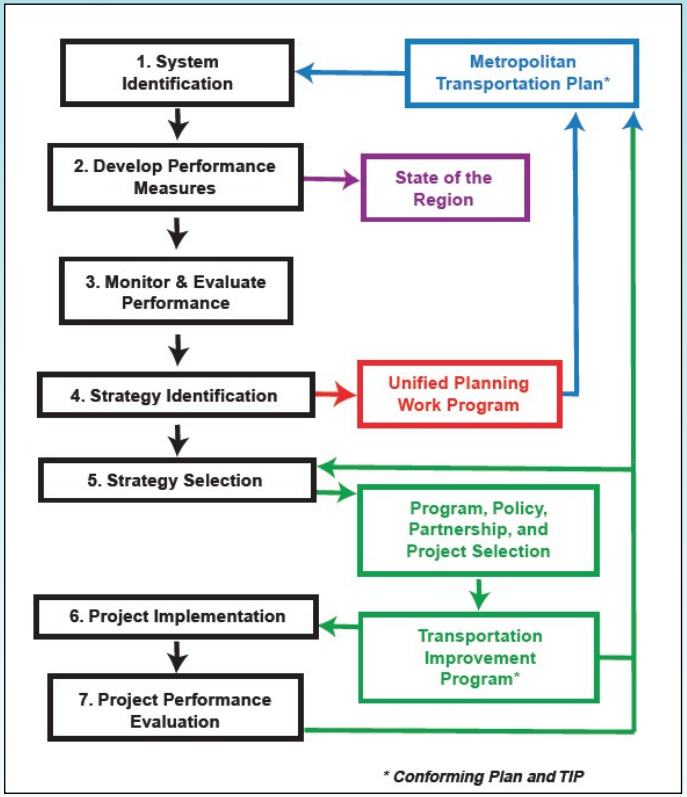
Houston/HGAC Examples

Programs that Enhance Functionality



http://www.h-gac.com/taq/plans_programs/mobility/default.aspx

NCTCOG Congestion Management



Source: NCTCOG. Regional Mobility Initiatives, Vol. XII, No.1. April 2008

NCTCOG North Central Texas Council of Governments

- Integrated into Planning, Programming Process
- 7 Components
- Shows Roles of MTP, UPWP, TIP

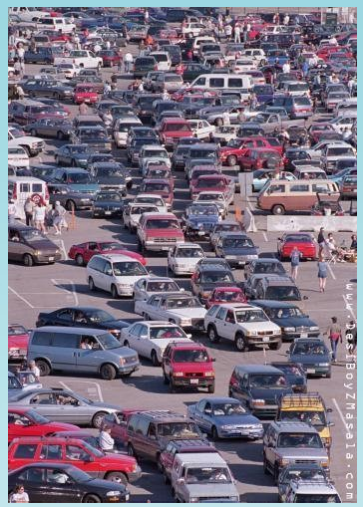
Sample Congestion Management Strategies

Transportation Systems Management (TSM)	Travel Demand Management (TDM)	Intelligent Transportation Systems (ITS)
Signal retiming, upgrades, interconnections, demand-response	Car/van pooling, transit, alternative work schedules, park and ride	Public transportation tracking, fare management/policies
Intersection and street improvements	Congestion pricing, parking mgmt. telecommuting	Traffic surveillance, incident management, electronic tolling
Bottleneck removal	TOD, land use/density controls, in-fill policies, utility extensions	Commercial vehicle electronic clearance, weigh-in-motion, HAZMAT mgmt.
Access and corridor management	Context sensitive design, car-free planning	Maintenance/construction work zone mgmt.
Special event management	TDM marketing education	Emergency management routing, traveler info

TxDOT Planning Practices Impacting Functionality

- System and facility planning
- Access management
- Monitoring operation, safety, and maintenance
- Facility design
- Involvement in local planning and development review
- Frontage road and bypass practices

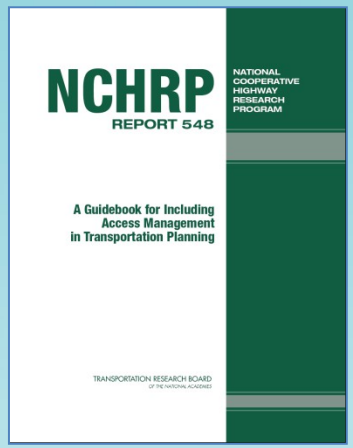
Access Management

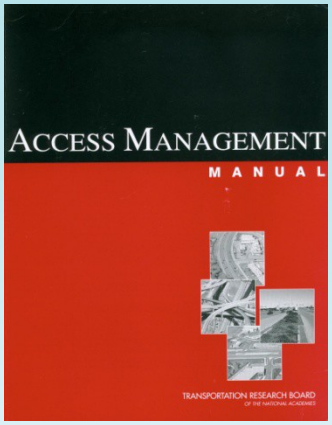


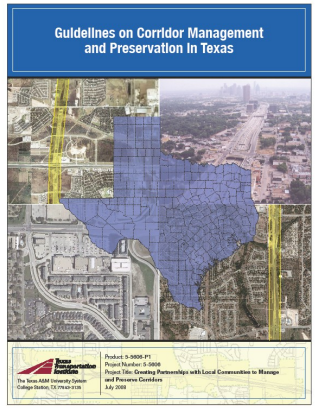
- Apply TxDOT AM Manual on upgrades, rehabs, site plans, plats
- Partner to use local powers
- Provide support, lessons learned to rural areas
- Involve senior local staff in development of TxDOT design schematics
- Other AM actions through ROW, project development, facility design

Access Management

Resources





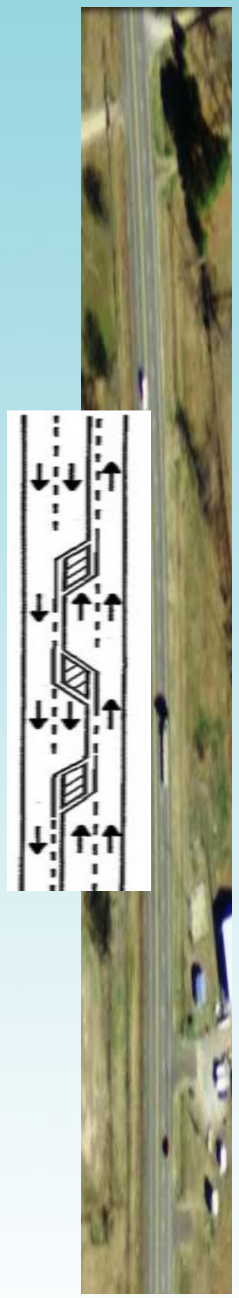


- Guidelines on Corridor Management and Preservation for Texas, 0-5606-P1, 2008
- Texas Access Management Outreach Materials, TTI Report 5-4221-01-P1, 2008
- Recommended Access Management Guidelines for Texas, TTI Report 0-4142-2, 2006
- TxDOT Access Manual, 2003
- Access Management Manual, TRB, 2003
- A Guidebook for Including Access Management in Transportation

Facility Design

Actions to Enhance Functionality

- Continue 4-lane major links with divided highway sections
- Use minor geometric and operational enhancements.
- Enhance 2-lane highways to ‘Super 2s’
- Increase use of expressway and super arterial designs.
- Uphold intended function of loops and bypasses



SH 19 south of Paris, TX - 2+1 in mile increments

Super 2 Designs

- Modify 2-lane highways to remove turning conflicts and/or adding passing lanes
- Includes all/some of these additions
  - Shoulders
  - Turn-lanes at key intersection
  - Passing lanes
- Low cost or interim option
- RMC 0-4064-S or 1, Design Guidelines for Passing Lanes on Two-Lane Roadways, 2001

Uphold Function of Community Loops and Bypasses

- Plan and design new community loops/bypasses as controlled access facilities
  - If designed as surface arterial, should include NTM with 1-mile signal spacing
- No longer fund or permit upgrades to surface arterial loops that
  - Do not include NTMs or
  - Are not conversions to controlled access

Source: Tyler District, R. Redmond

Establish Statewide Policy on Non-Traversable Medians (NTMs)

- All designs with 3 or more dedicated thru lanes should contain a NTM
- All designs should include NTM when existing/projected ADT is ≥ 25,000
- Design for rehab projects should comply with TxDOT access guidelines
- TTI 0-4221-2 and 0-3904, NCHRP 420, and NCHRP 395

Median Studies

- TTI Report 0-3904 - medians have no direct affect on retail sales. Price, quality, service more important.

TTI Report 0-4421-2

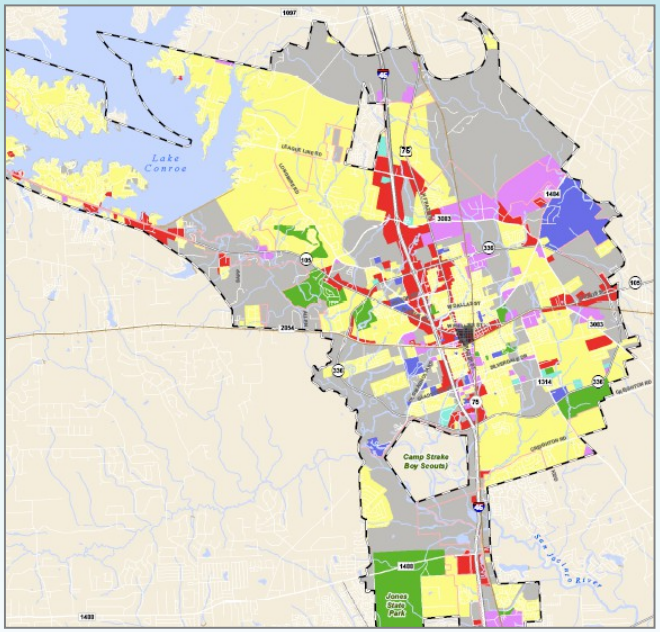
NCHRP 420

Representative Crash Rates (Crashes per Million VMT) by Type of Median – Urban and Suburban Areas			
	Median Type		
Total Access Points per Mile	Undivided	Two-Way Left-Turn Lane	Non Traversable Median
<20	3.8	3.4	2.9
20.01-40	7.3	5.9	5.1
40.01-60	9.4	7.9	6.8
>60	10.6	9.2	8.3
Average Rate	**9.0**	**6.9**	**5.6**

Corridor	ADT	"Before" Median Type	Crash Rate		
			"Before" Condition	Raised Median	Percent Difference
College Station (Texas Avenue)	41,000	TWLTL	4.3	1.8	**-58**
Longview (Loop 281)	23,500	TWLTL	5.2	4.3	**-17**
Tulsa (west) (71st Street)	30,500	Undivided	3.8	2.5	**-34**
Tulsa (west-central) (71st Street)	29,500	Undivided	3.8	1.8	**-53**
Odessa (US 385)	10,600	Undivided	19.6	15.4	**-21**
All Remaining	30,600	Varies	7.0	4.8	**-31**

District Involvement in Local Planning/Development

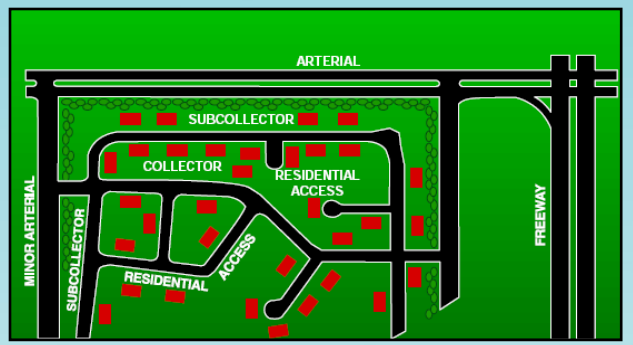
- Comprehensive planning
- Thoroughfare planning
- Development review
- Corridor management



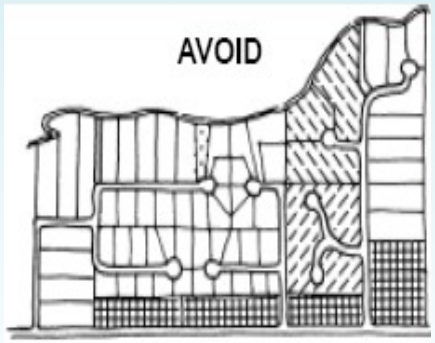
Local Comprehensive Plans (LCPs)

- LCPs impact direction of growth and utilities impacting functionality
- Districts should be involved in LCPs to:
  - Promote policies that protect or enhance functionality
  - Have input on direction of future growth, utility extensions
  - Promote activity-based over strip development along TxDOT corridors
  - Encourage city use of development policies in ETJs

Local Thoroughfare Plans

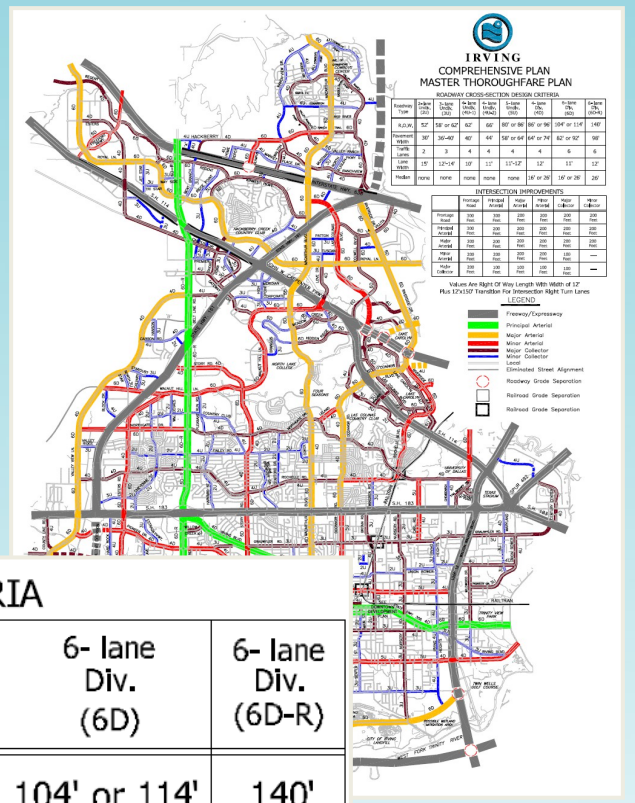


- Review layouts of plans/subdivisions to
  - Limit/avoid minor street connections to state roads
  - Encourage connections between neighborhoods
- Coordinate local T-fare design criteria and ROW standards
- ✓ Get on advisory panels for new plans or plan updates



Source: A Guide to Land Use and Public Transportation, Volume 2 , Snohomish County Transportation Authority

Thoroughfare Spacing and Design Criteria



ROADWAY CROSS-SECTION DESIGN CRITERIA

Roadway Type	2- lane Undiv. (2U)	3- lane Undiv. (3U)	4- lane Undiv. (4U-1)	4- lane Undiv. (4U-2)	5- lane Undiv. (5U)	4- lane Div. (4D)	6- lane Div. (6D)	6- lane Div. (6D-R)
R.O.W.	52'	58' or 62'	62'	66'	80' or 86'	86' or 96'	104' or 114'	140'
Pavement Width	30'	36'-40'	40'	44'	58' or 64'	64' or 74'	82' or 92'	98'
Traffic Lanes	2	3	4	4	4	4	6	6
Lane Width	15'	12'-14'	10'	11'	11'-12'	12'	11'	12'
Median	none	none	none	none	none	16' or 26'	16' or 26'	26'

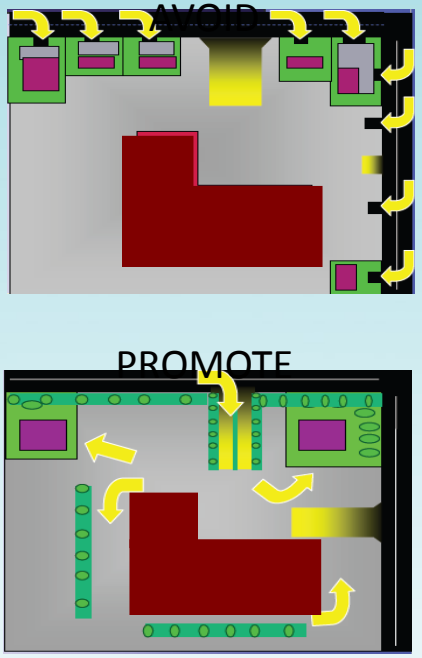
Thoroughfare Spacing and Design Criteria

Characteristic	Arterial	Collector	Local Street
Street Spacing	1 mile	¼ mile	300 ft.
Length	Continuous	½ mile	500 ft.
Lanes	4-6	2	2
Minimum Pavement	64 ft.	36 ft.	32 ft.
Access Spacing	1,300 ft.	300 ft.	60 ft.
Volume	30,000 vehicles per day	5,000 vehicles per day	200 vehicles per day
Striping	Center and lanes	Center	None
Driveway Design	Curb return	Curb return	Dustpan
Parking	Prohibited	Allowed	Encouraged
Median	Yes	No	No
Turn Lane	Yes	No	No
Traffic Signals	Yes	No	No
Residential Access	Prohibited	Indirect	Direct
Maximum Grade	6%	8%	10%
Minimum Radius	1,150 ft.	350 ft.	170 ft.
Pedestrian Crossing	Signalized Intersection	Intersection	Unrestricted
Pedestrians	Few	Many	Frequent
Speed	40 mph	30 mph	20 mph
Building Setback	Considerable	Moderate	Minimum

Source: Marks, H. *Traffic Circulation Planning for Communities*. Gruen Associates, Los Angeles, 1974.

Local Development Review

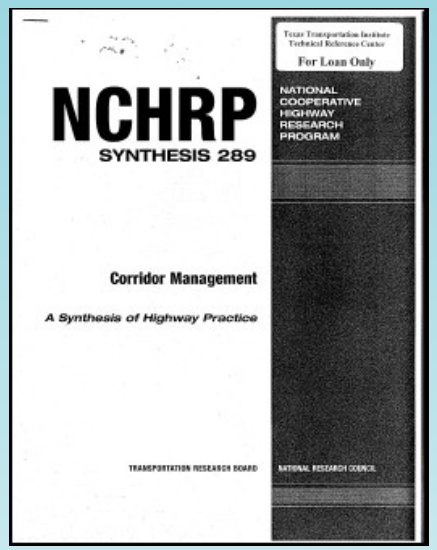
- TxDOT should be involve in the earliest stages
- Routinely review plats and site plans impacting state roads to:
  - Implement access guidelines
  - Prevent narrow lots
  - Encourage on-site connectivity between developments
  - Protect/preserve needed TxDOT ROW

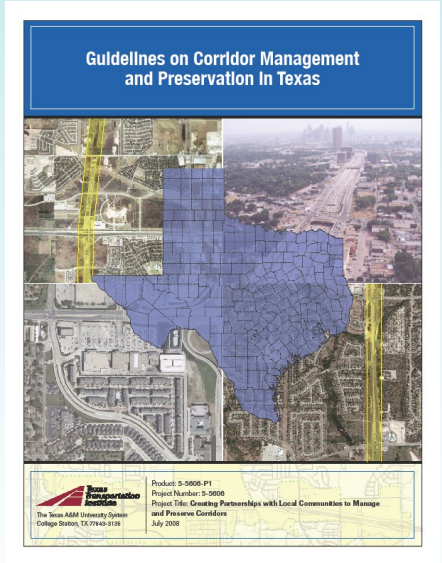


Source: K. Williams, Land Development Regulations That Support Access Management, CUTR, 2002

Corridor Management Plans

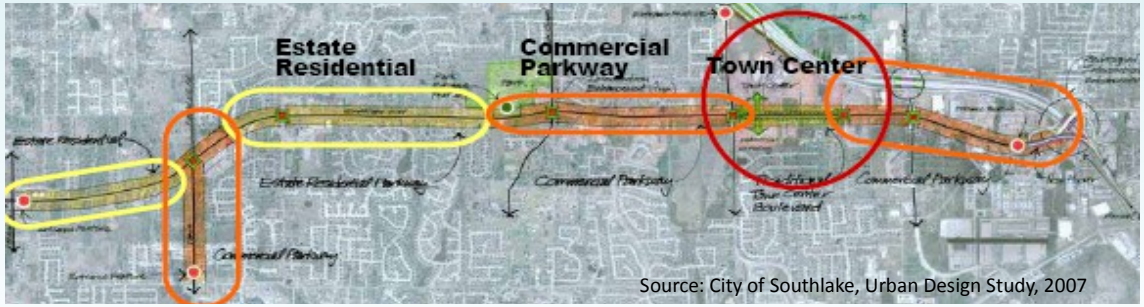
- Long-range comp. Ppan for a corridor
- Coordinates roadway design and function with land use and development
- Combination ‘roadway improvement/land development policy guide’
- Corridor-wide, not piecemeal
- Different types, shapes sizes
- TxDOT project 0-5606





Corridor Management Plans

- Districts should advocate CM plans on TxDOT corridors
- Adopt CM plans with NTMs, signal spacing thresholds, connectivity between developments
- Advocate CM plans in local comp. plans and MPO UPWPs

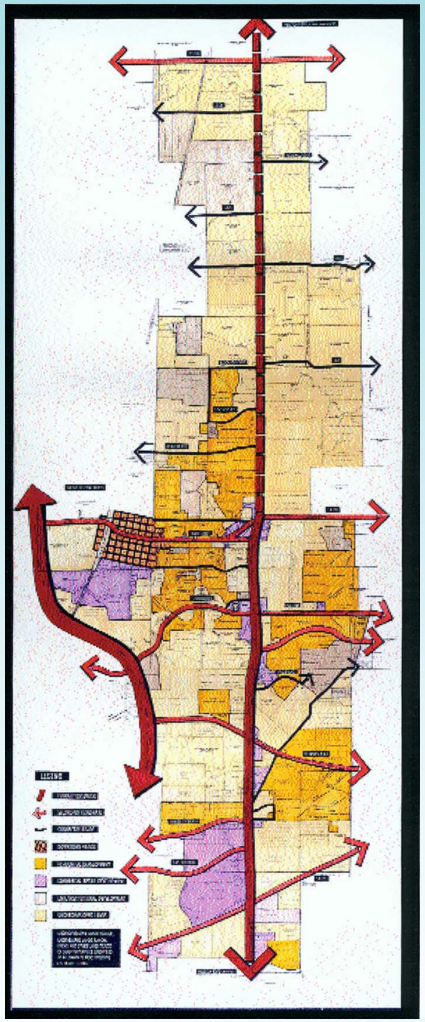


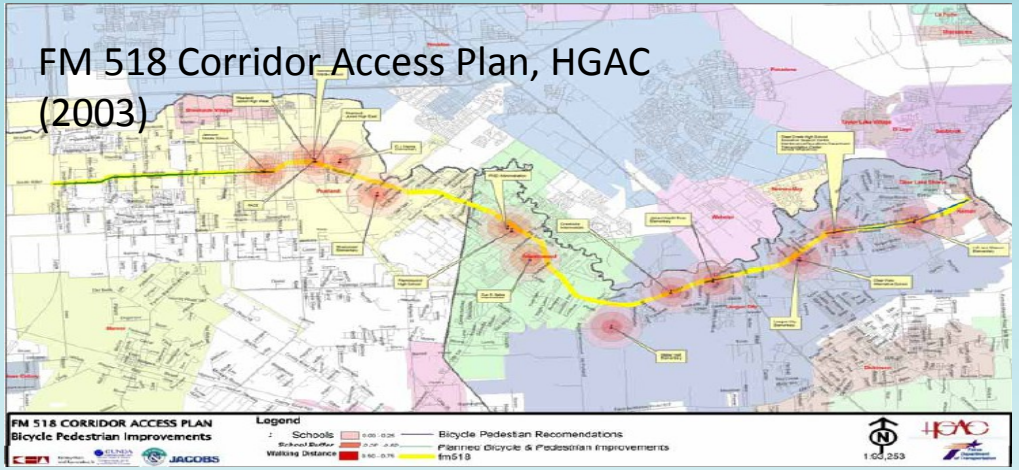
Source: City of Southlake, Urban Design Study, 2007

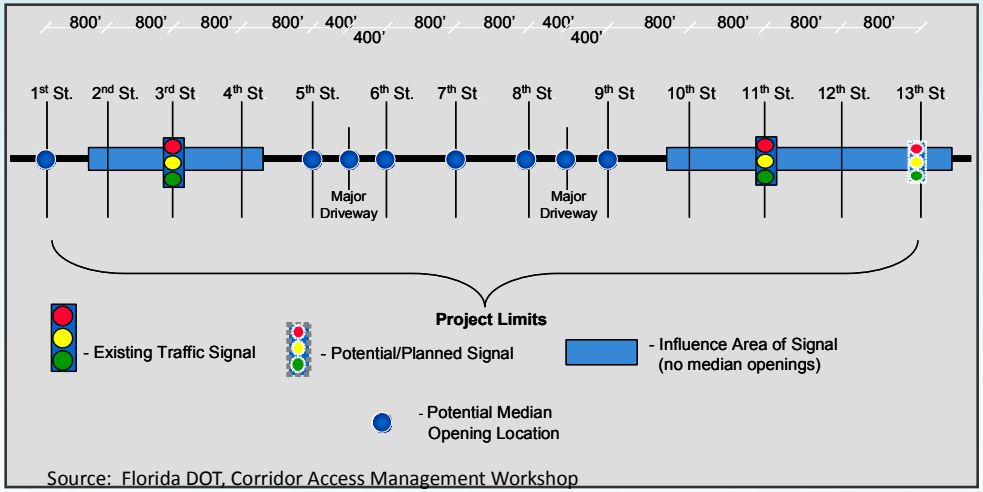
CM Tools

	CM Tool or Technique	City	ETJ	County
Access Management	Driveway Spacing	✓	limited	limited
	Non-Traversable Medians	✓	✓	✓
	Signalized Intersection Spacing	✓	✓	limited
	Arterial Frontage and Backage Roads	✓	limited	
	Acquisition of Access Rights	✓	✓	✓
Zoning and Development Regs	Site Plan review	✓	limited	
	Land Use/Density Controls	✓	limited	v. limited
	Building and Parking Setbacks	✓	v. limited	v. limited
	Corridor Zoning Overlays	✓		
	Driveway Throat Length	✓	limited	
Subdivision Regulations	ROW Dedication Through Platting	✓	✓	v. limited
	ROW Reservations Through Platting	✓	✓	v.limited
	Access Easements	✓	limited	limited
	Minimum Lot Size	✓	limited	limited
	Minimum Lot Width	✓	limited	limited

CM Plan Examples







Sources of Deterioration

Planning/Land Development

- Challenge in coordinating transportation and land use
- Sprawl, decentralized development patterns
- Rampant closely spaced driveways
- Lack of connectivity between developments, parcels
- Challenges in multi-jurisdictional coordination

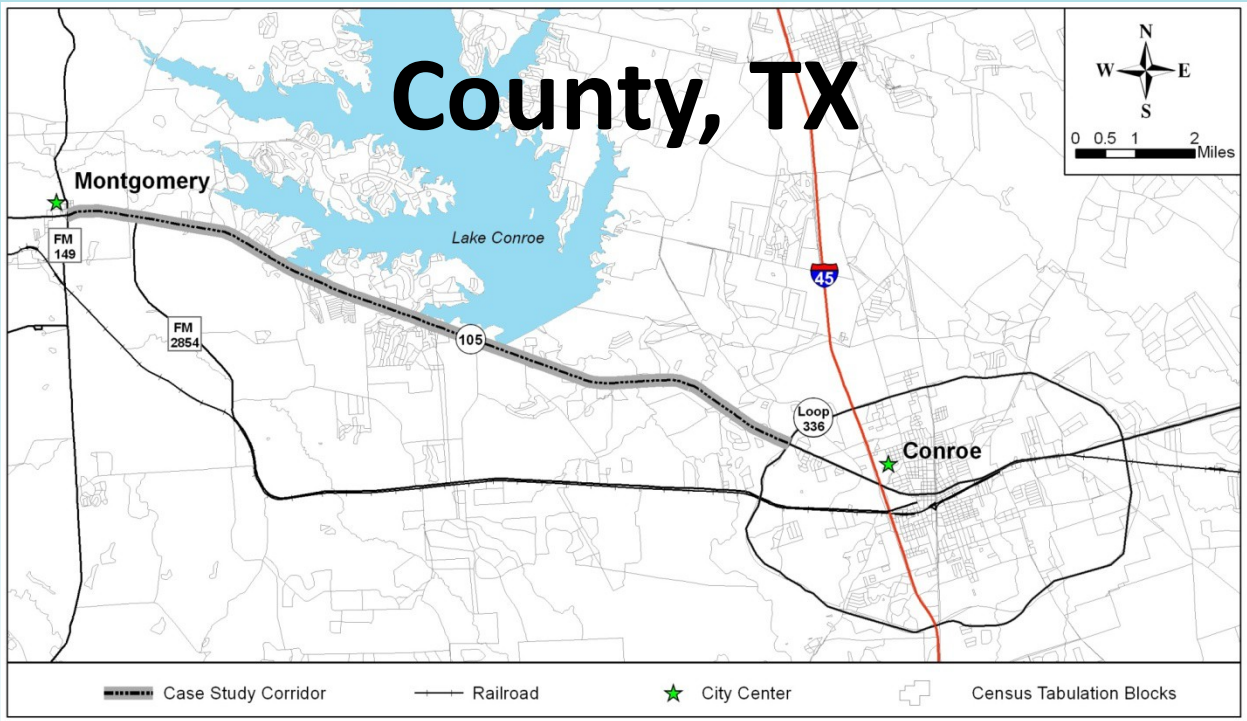
Countermeasures

Planning/Land Development

- TxDOT involvement EARLY in development process
- Corridor management/preservation
- Continue to practice, promote access management
  - Non-traversable medians ahead of development
  - Limit/disallow minor street connections
  - Internal connections between adjacent parcels
- TxDOT – local coordination in project

Functionality Case Study

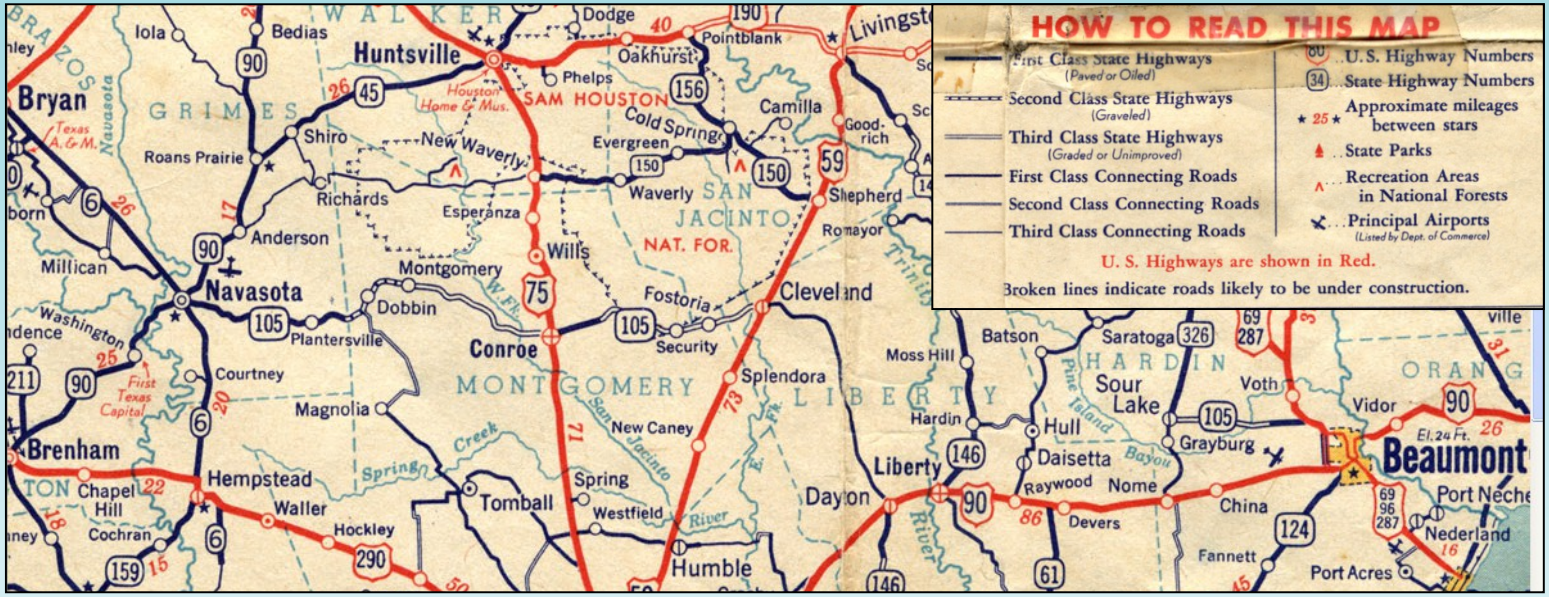
SH 105, Montgomery



Limits: FM 149 in Montgomery to Loop 336 in Conroe

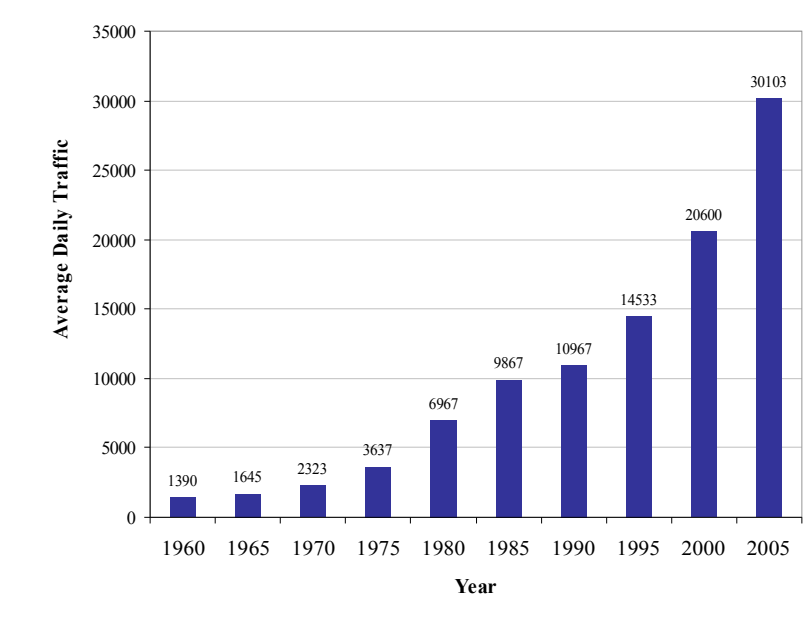
Length: 12.9 miles

SH 105 History



- Rural E-W highway between Brenham and Beaumont
- Proposed in 1930s, Navasota to Moss Hill
- Began with paved, graded, and gravel sections
- Section by Lake Conroe, greatest change

Land Development History



- Lake developed/filled in 1970-73
- Proximity to Houston, recreational and residential attraction spurred rampant growth
- Rapid change from rural character to suburban residential, retail/service commercial
- Need for added capacity rose quickly

Rural Highway to Suburban Arterial

Prior to Existing Cross-section

- Rural 2-lane undivided section, 8-12 ft. unpaved shoulders
- Early 1970s after lake, addition of signals, flashers

Early 1990s Widening/Upgrade

- 4-lane w/TWLTL, 10 ft. shoulder, open ditch – FM 149 - Old River Rd.
- 6-lane w/TWLTL, 10 ft. shoulder, open ditch – Old River – Loop 336
- Included several new signal installations
- Post widening: installation of advanced signal warning flashers

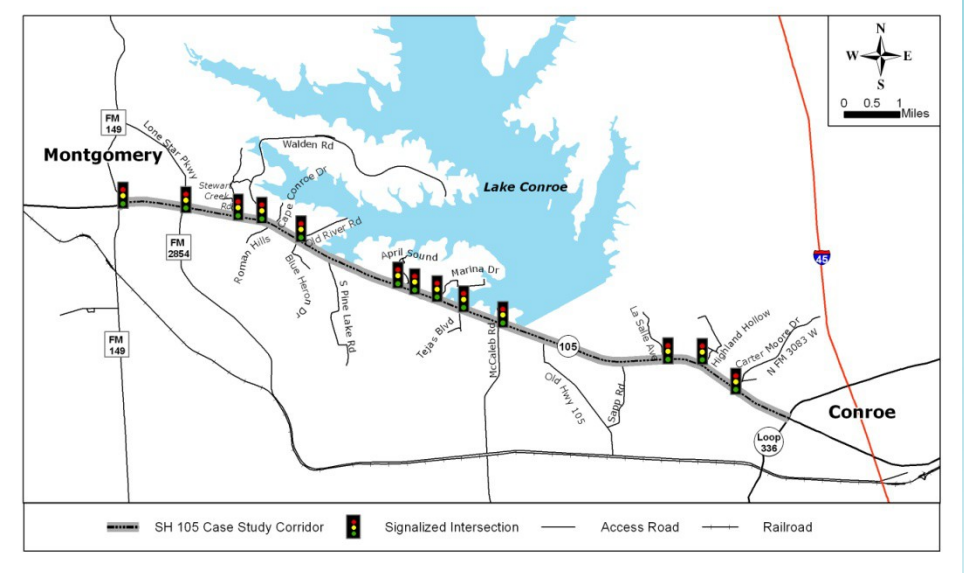
Widening of 4-lane section to 6-lanes in design

Current SH 105 Cross-Sections

7-lane section, east side of corridor study area

5-lane section, west side of corridor study area

Signal Locations and Spacing



- 12 signalized intersections
- All use span wire mounting
- Most have advanced warning beacons
- Spacing: not uniform, some too close

Unsignalized Access

- Current design in place before TxDOT AM guidelines
  - Few access consolidations
  - Few access connections between developments
- 300 access points, average 25/mile
- 39 access points/mile in some segments
- Key source of functionality loss

Regulatory Jurisdictions and Agency Responsibility

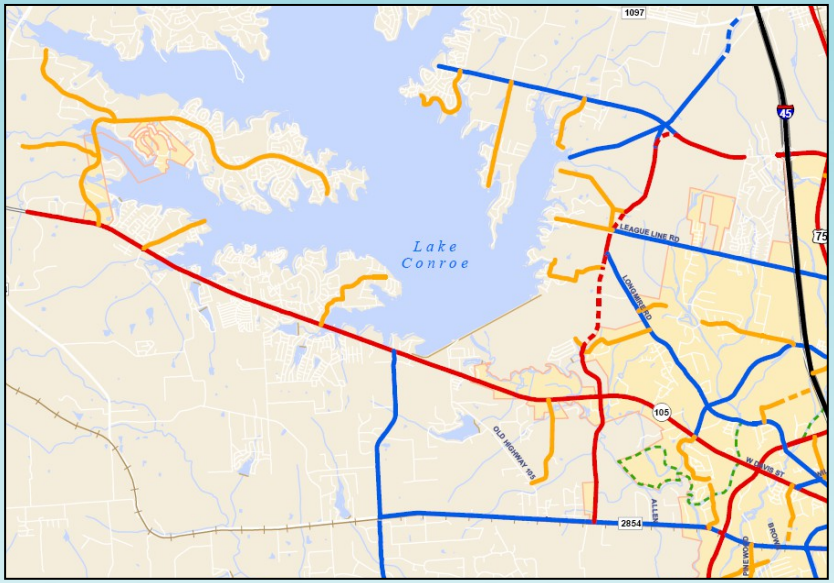
Area	Plats	Site Plans	Building Permits
Conroe City Limits	city	city	city
Conroe Planning Area	city	city	county
ETJ	county	county	county

Development Regulations in Corridor

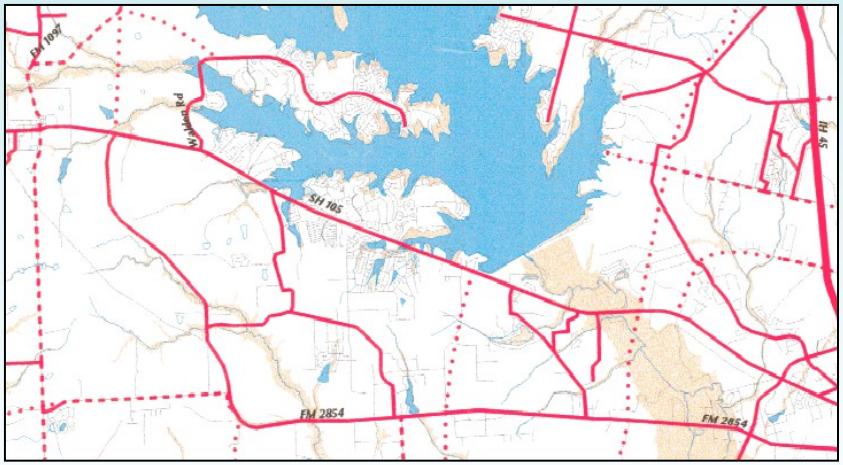
- Have/Use
  - Form based codes (recently)
  - Building setbacks, parking requirements
  - TxDOT Access Guidelines (since 2004)
  - FEMA floodplain compliance, drainage regs
- Don't Have/Use
  - Zoning/land use controls
  - Local access ordinance requirements
  - Access easements/coordination

Thoroughfare Plans Covering Area

City of Conroe
Thoroughfare Plan (2006)



Montgomery County/HGAC
Transportation Plan (1998)



SH 105 Crash History/Safety

Year	Total Crashes	Fatalities
2003	101	0
2004	100	3
2005	115	4
2006	99	1
2007	101	2
2008	109	4
2009 (part)	54	2 (+3?)
Total	679	**16**

Contributors to SH 105 Functionality Loss

- Frequent and closely spaced non-signalized access points
- Lack of vehicular connections between developments
- Facility design: continuous TWLTLs
- Lack of a supporting local street network, neighborhood connectivity
- Signal location and spacing

SH 105 Observations

- Age-old local access vs. regional mobility issue
- SH 105 serves competing dual functions
  - Regional arterial highway
  - Local urban arterial
- Combination of many factors have led to for functionality loss

8. SH 105 from Loop 336 to FM 149

Contributors to SH 105 Functionality Loss

Unincorpo

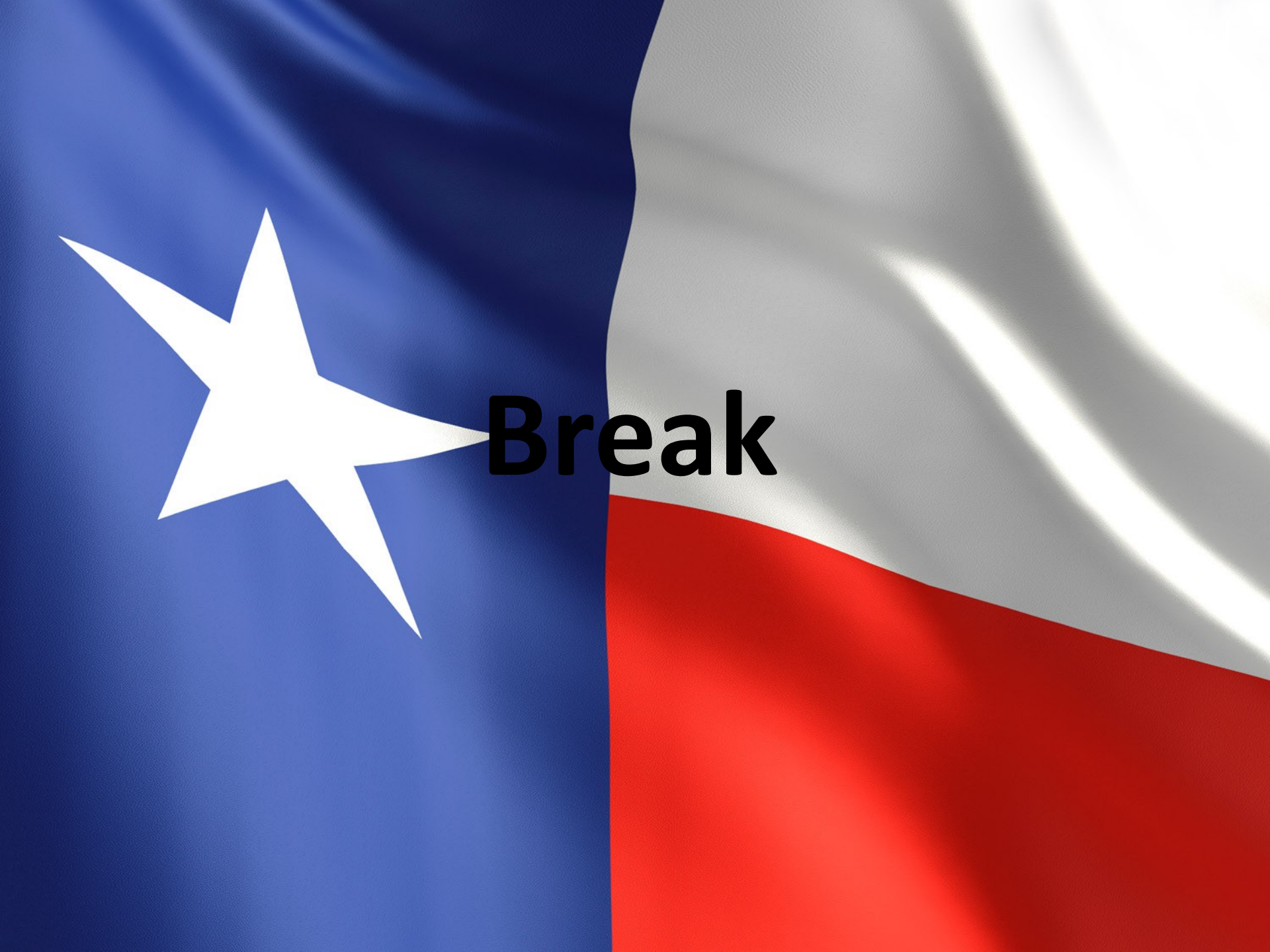
+ rampar
+ absenc
+ no land
+ minimal development regulations
+ little local/TxDOT coordination
+ facility design with no access management provisions

+ business friendly development climate

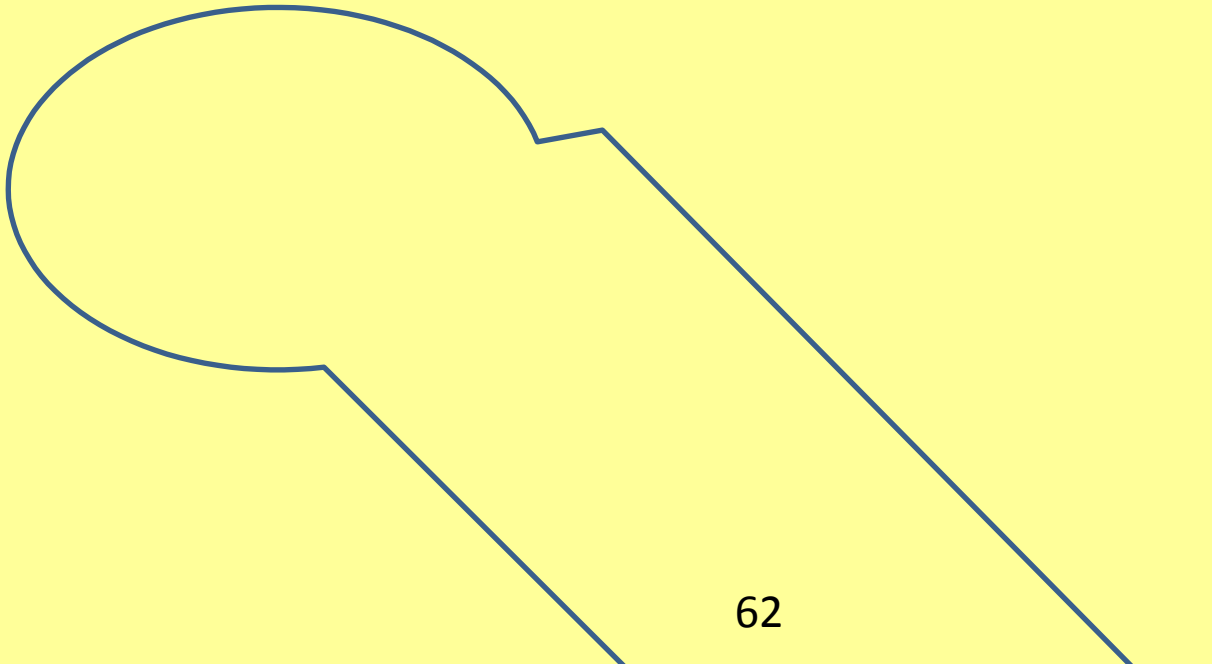
= Unsustainability, reduced service life, need for rehabs sooner, increased safety and operational problems, higher costs, etc.....

SH 105 Discussion

- Is there anything the City of Conroe or Montgomery Co. could or should have done in decades past to prepare for Lake Conroe's development?
- Has the way SH 105 has evolved affected business development and sustainability? Has it affected land values?
- How can safety be improved?
- How would this corridor be different if a corridor management plan had been adopted 20-30 years ago?
- So what's next for this section of SH 105?

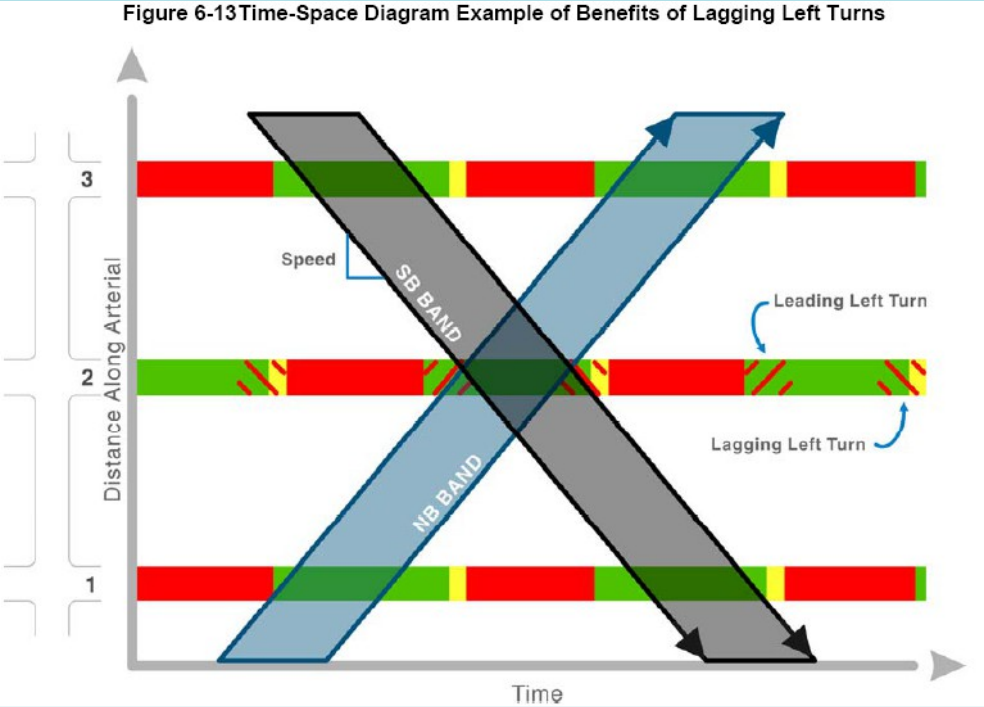

Break


MODULE 2a
Operational Functionality



Categories of Practices Affecting Operations

- Traffic control and management
  - Traffic control
  - Incident management
  - ITS
  - Special use
    - HOV, HOT, toll, etc.
- Signal optimization and coordination
- Facility design and enhancement



Keeping Up with Operational Changes

- Performance measures
- Requests
  - Agencies
  - Businesses
  - Associations
- Complaints

Operations Performance Categories

- Capacity
  - Throughput
- Efficiency
  - Stops, delays, travel time
- Reliability
  - Travel time consistency
- Accommodating temporary conditions
  - Incidents, emergencies
  - Maintenance
  - Construction

Operations Performance Measures

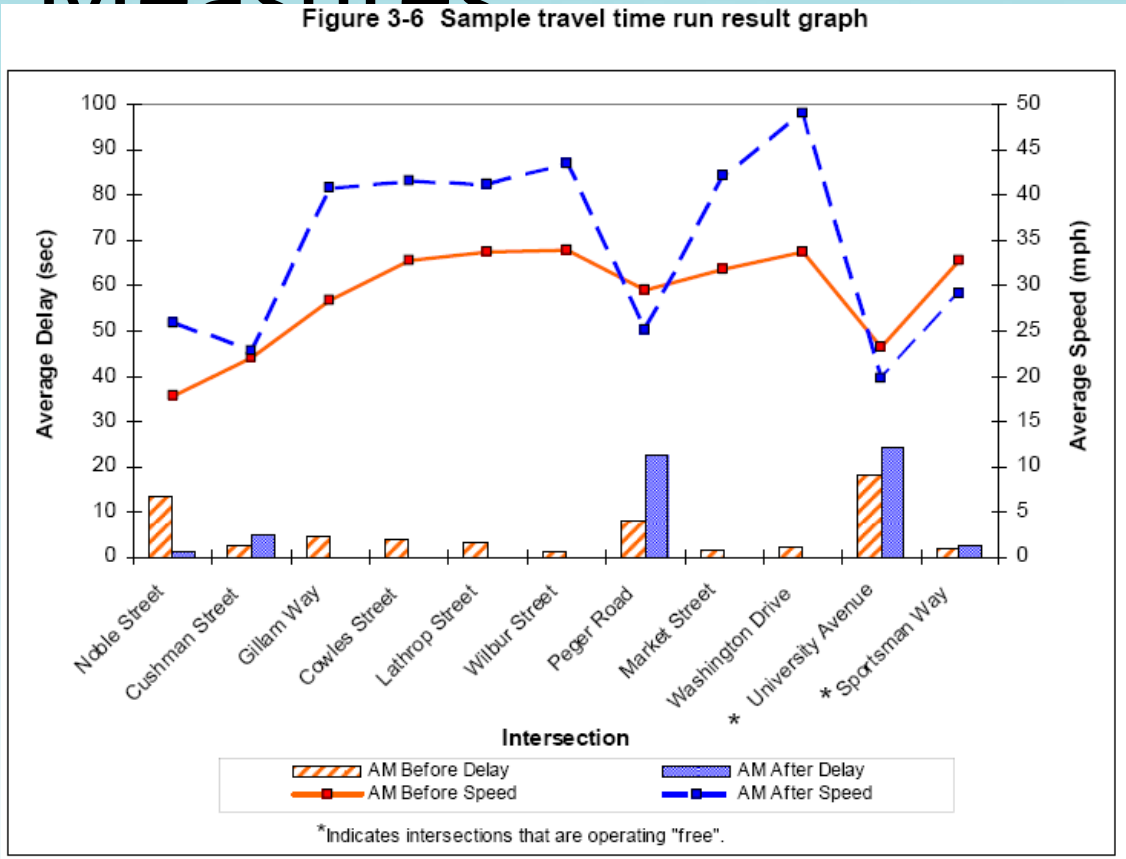
- Level of Service
  - Segment, intersection
  - VMT within LOS ranges
  - Lane miles within LOS ranges
  - Many similar variations

Operations Performance Measures

- Travel time
  - Segment
  - Reliability
- Travel speed
  - Average running speed (by segment)
  - Speed variability
  - VMT within speed ranges
  - Lane miles within speed ranges

Operations Performance Measures

- Delays
- Stops or stopped time
- VMT
- Trends
  - Travel time
  - Running speeds
  - Delays

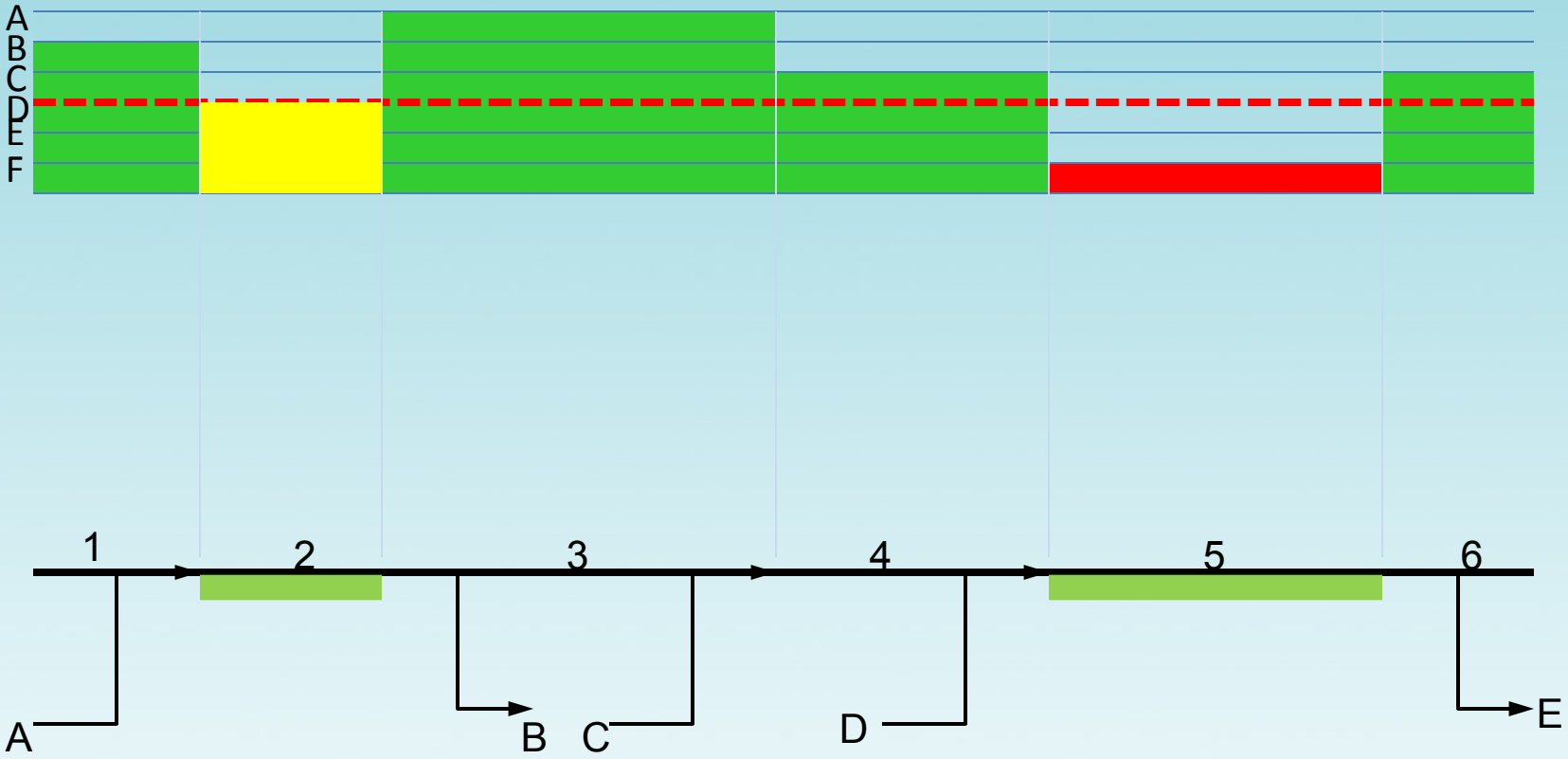


Operations Performance Measur

Use

- Performance measures that:
  - Evaluate desired performance
    - Area or agency goals
    - Local issue areas

Example – LOS Consistency Analysis



Some solutions

- Auxiliary lane
- Braid ramps A-B, D-E
- Reverse ramps A-B or D-E
- Combine C and D access to Ramp C
- Reroute traffic away from Ramps A and/or D
- Meter ramps A, C, and/or D
- Relocate ramps A and/or E to lengthen weaves

Data Sources for Performance Measures

- TxDOT Transportation Planning and Programming Division (TPP)
- TxDOT districts
- MPOs (where existing)
- TxDOT traffic maps
  - http://www.txdot.gov/travel/traffic_maps.htm
- Cities, urban counties
- Traffic management centers

Data for Performance Measures

Data

- Speeds
- Acceleration, deceleration
- Travel times
- Volumes
- Vehicle classifications
- Delays
- Occupancy
- Queues
- Density

Sources

- Traffic management center
- TxDOT counters
- Traffic control systems
- Automated vehicle locators (AVL)
- Closed circuit TV (CCTV)
- Road weather information system

Causes of Operational Deterioration

Types

- Recurring
- Occasional/ temporary
- Infrastructure

Causes of Operational Deterioration

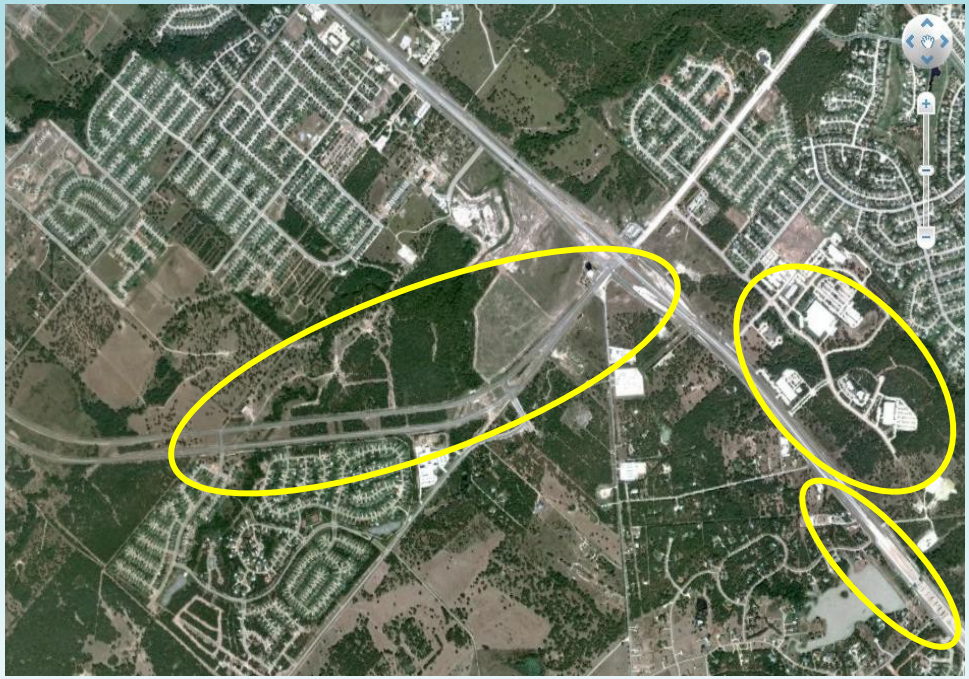
Recurring

- Volume increase
  - Total
  - Merge, weave
  - Trucks, transit
- Travel pattern changes
  - Development, major schedule changes, etc.
    - Local
    - Area

Causes of Operational Deterioration

Recurring (cont.)

- Road access changes
  - Ramps
  - Cross streets
  - Driveways, medians
- Traffic control
  - Not up to warrant levels
  - Signals not retimed
  - Signals not coordinated
  - Suboptimal lane use



Causes of Operational Deteriorati

Occasional/temporary

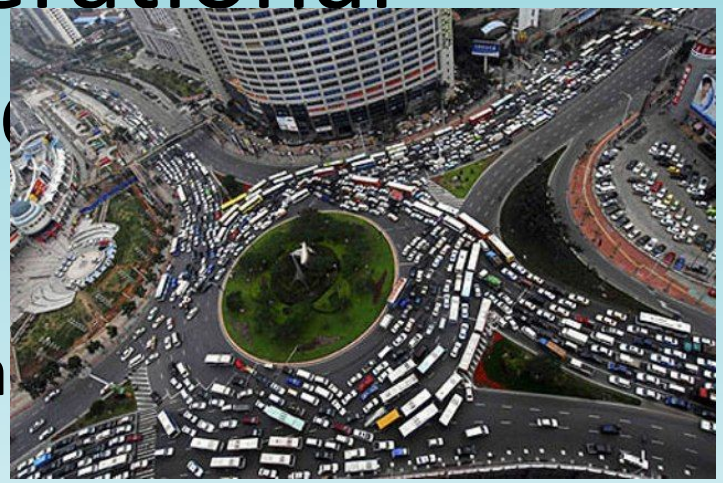
- Incidents
  - Crashes
  - Weather
  - Damage from incidents
- Maintenance
  - Short term
  - Long term
- Construction
- Special events

Causes of Operational Deterioration

Infrastructure

- Pavement condition
- Traffic control device deterioration
- Other maintenance items

Results from Operational Deteriorati



- Congestion
  - Longer travel times
  - Longer goods delivery tim
  - Emergency service delays
  - Increased cut through traffic
  - Higher travel costs
  - Excessive fuel use, pollution
  - Vehicle wear, breakdowns
  - Motorist frustration, stress
- More crashes

Countermeasure Types

1. Operational
2. Infrastructure
3. Financial/pricing

Probably in order of preference

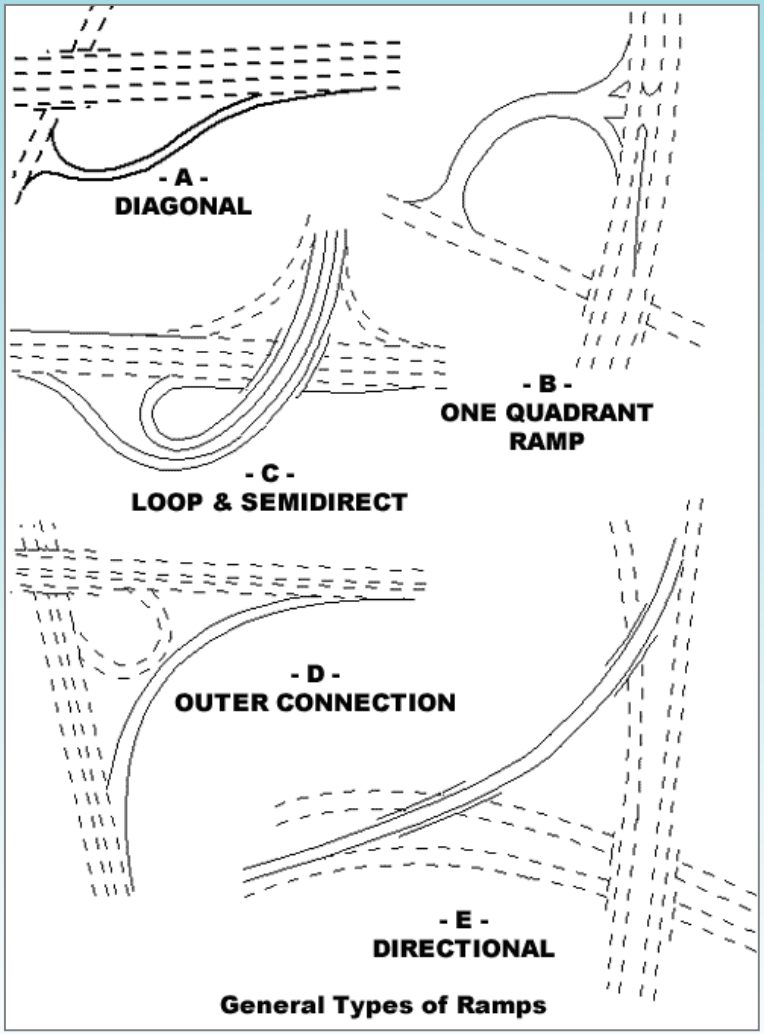
- Cost
- Implementation time
- Ease of implementation

Countermeasure Types

1. Operational
   - Intelligent transportation systems (ITS)
   - Incident management
   - Lane use changes
   - Signal timing, coordination
   - Shoulder use
   - Travel demand management (not covered here)

Countermeasure Types

2. Infrastructure
   - Add lanes
   - Add new facilities
   - Modify, reconfigure design
   - Add HOV, HOT, express, truck, other lanes



Countermeasure Types

3. Financial/pricing
   - Tolls
     - Fixed
     - Variable
   - Permits
     - HOV, HOT lanes
   - Parking

Operational Functionality Program

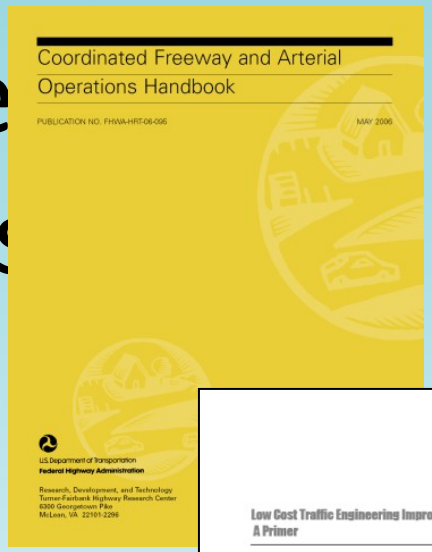
Corridor, area, or regional program

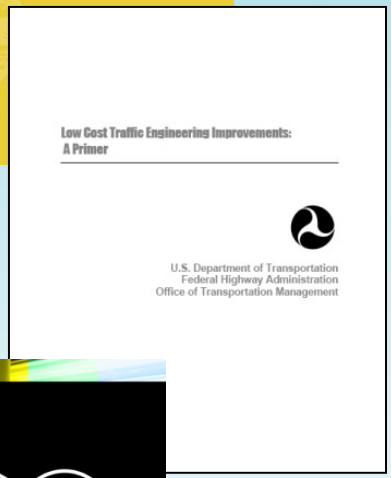
- Work zone management*
- Incident management*
- Special events management*
- Emergency preparedness*
- Facility upgrades, additions*
- Daily recurring operations*
- Signal coordination**

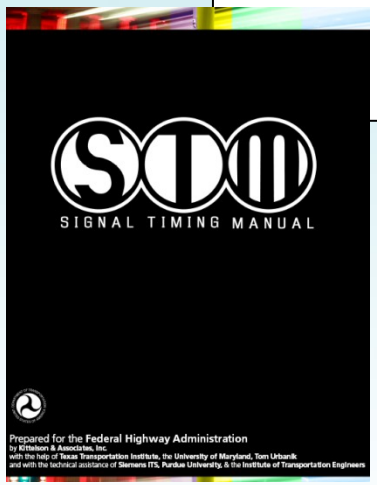
*Coordinate freeway and arterial management

Countermeasure
A Few Source

- FHWA *Freeway Management and Operations Handbook*
- FHWA *Coordinated Freeway and Arterial Management Handbook*
- FHWA *Incident Management Handbook*
- TxDOT *Traffic Signals Manual*
- ITE *Toolbox for Alleviating Traffic Congestion and Enhancing Mobility*
- ITE *Traffic Signal Timing Manual*







Countermeasures - Freeway

Widening

- Auxiliary lanes
- Speed change lanes
- Climbing lanes
- Use of shoulder lanes
- Separate roadways
  - Express
  - Trucks
  - HOV, HOT

Countermeasures - Freeway

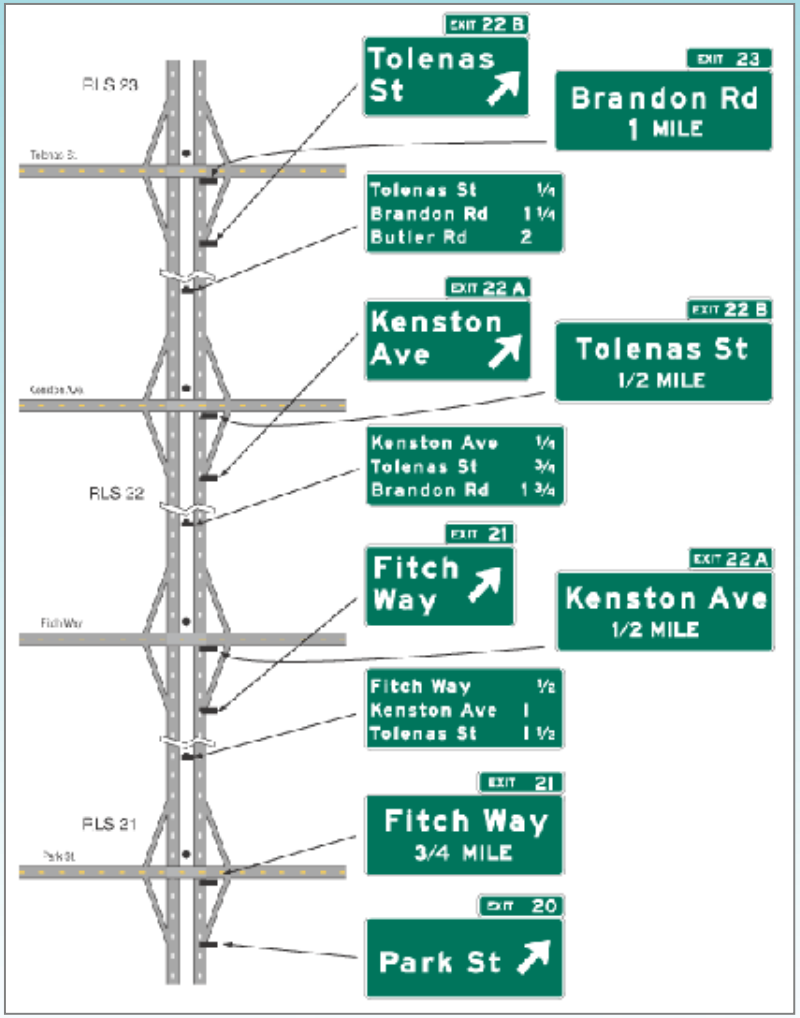
Interchanges

- Weaving sections
- Ramps
  - Added
  - Widened
  - Reconfigured
- Ramp location
  - Separation from intersections, driveways
- Bypass lanes
- CD roads

Countermeasures - Freeway

Signing

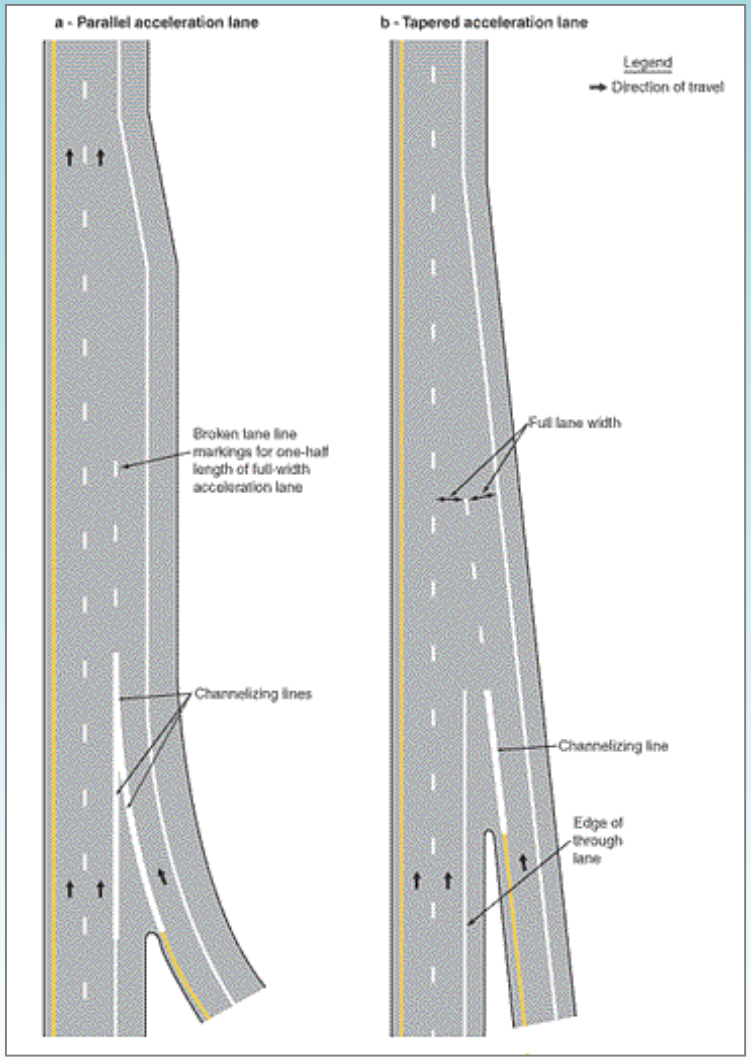
- Directional/guide
- Lane use
- Location, size



Countermeasures - Freeway

Markings

- Merge
- Transitions
- Narrower lanes

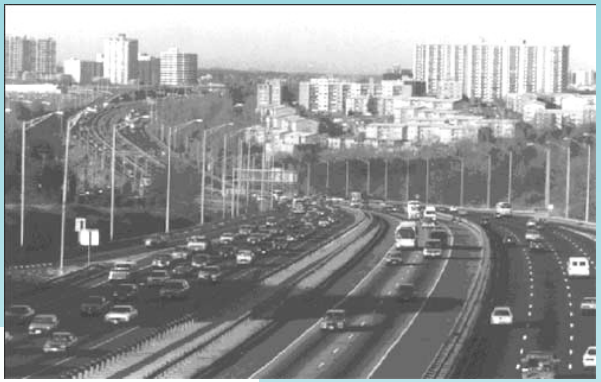


Countermeasures - Freeway

Ramp management

- Metering
- Closure
  - Special events
  - Peaks
- Special use
  - HOV, emergency bypass
- Terminal treatment
  - Widening

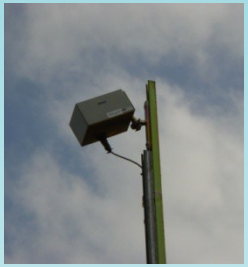
Countermeasures - Freeway



Managed lanes

- HOV
- HOT, express
- Trucks
- Contraflow/reversible
- Toll
- Pricing – variable toll
- Shoulder use
- Work zone
  - Short, long term

Countermeasures - Freeway



Transportation management center (TMC)

- Traffic surveillance and monitoring
  - Real time
  - Trends
- Incident detection and response

Countermeasures - Freeway

Incident management

- Surveillance, detection
- Alternate route plans
- Response
- Clearance, recovery
- Motorist information

Countermeasures - Freeway

Special events

- Emergency
  - Floods
  - Hurricanes
  - Fires
  - Homeland security
- Scheduled
  - Sport
  - Entertainment
  - Security (President)

Countermeasures - Arterials

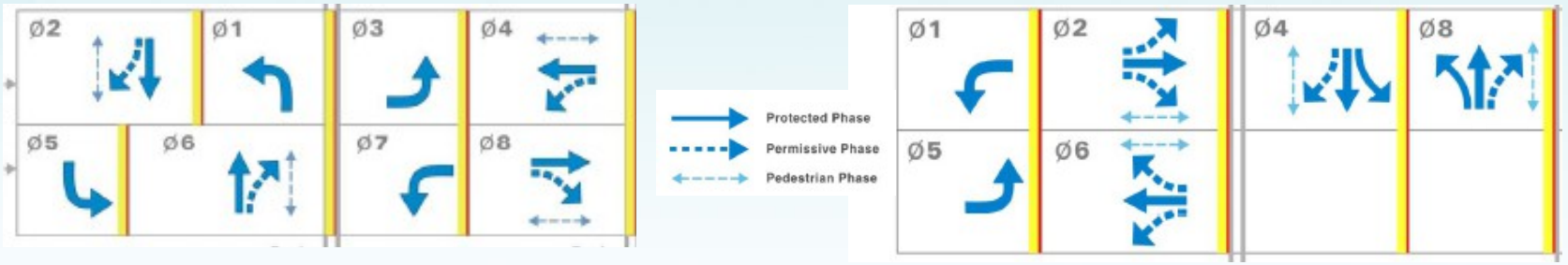
Intersections

- Single or double turn la
- Right turn lanes
- Turn restrictions
- Modified lane use
- Time managed lane use
- Queue jumpers
- Grade separations
- Additional through lanes at intersections

Countermeasures - Arterials

Traffic signals

- Traffic signal system audit (TSSA)
- Traffic signal retiming
- Traffic signal system coordination
- Remove unwarranted signals
- Upgrade signal hardware, software
- Install additional signals
- Relocate signals for coordination



Lead-lag (left) and split phasing (right) examples

Countermeasures - Arterials

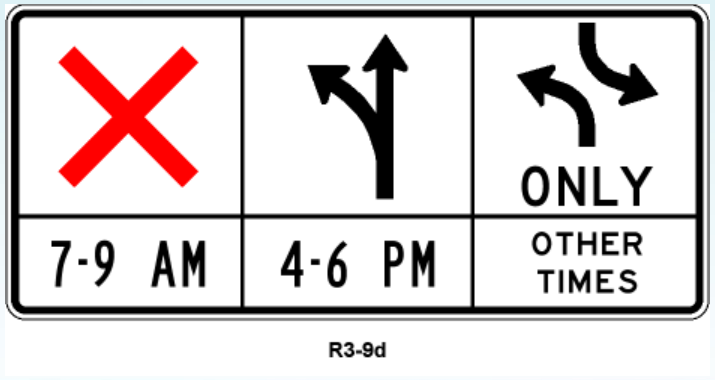
Design improvements

- Increased sight distance
- Improved geometrics
- “Super 2” sections
- Non-traversable medians
- Bus, HOV lanes
- Narrowed lanes to permit more lanes
- Upgrade arterials to expressways
- Add pedestrian/bike facilities
- Access management

Countermeasures - Arterial

Other traffic management

- Traveler information system
- Arterial traffic management system (ATMS)
- Parking restrictions
- Relocate bus stops
- Truck restrictions



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