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IVHS Architecture Development Program

DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA

April 1994

IVHS AMERICA

The U.S. Department of Transportation

Through the Intermodal Surface Transportation Efficiency Act of 1991, Congress gave the U.S. Department of Transportation the responsibility of providing leadership and guidance necessary to ensure national IVHS compatibility. To achieve this compatibility, USDOT has initiated a program to develop a National IVHS Architecture.

IVHS AMERICA

The Intelligent Vehicle-Highway Society of America is a non-profit educational and scientific association incorporated in August 1990. IVHS AMERICA's mission is to accelerate the deployment of IVHS in the U.S. and is chartered as a utilized Federal Advisory Committee to the U.S. Department of Transportation. In 1992, IVHS AMERICA identified the development of a national IVHS architecture as the program's top priority.

FOREWORD

A major national initiative is underway to apply proven information, communications and control technologies to surface transportation to improve its efficiency and reduce its negative impacts. Collectively, these applications are known as Intelligent Vehicle-Highway Systems-or IVHS-and are expected to create a $200 billion industry over the next 20 years.

IVHS will be applied to all types of vehicles (trucks, buses and cars), to information devices (signs, computers, kiosks, and hand-held devices), and to all parts of the surface transportation system (freeways, urban arterials, rural roads, transit stations, ports, and intermodal connections). Deploying IVHS can improve safety, reduce congestion, improve mobility and accessability, reduce environmental impact and increase energy efficiency, improve economic productivity and create a domestic IVHS industry.

The U.S. Department of Transportation (USDOT) and the Intelligent Vehicle-Highway Society of America (IVHS AMERICA) are working with many organizations at the national and international levels to make IVHS a reality.

However, decisions on the nature and extent of IVHS implementation will be made primarily by state, regional and local agencies, product and service providers, transit and commercial fleet operators, consumers and public interest groups-not USDOT and IVHS AMERICA. The ultimate course of IVHS will depend upon the collective efforts of these "stakeholders."

Our transportation system is national in scope, with people and goods able to move across jurisdictional boundaries with ease. To continue to foster this free movement, Congress has directed USDOT to ensure the nationwide compatibility of IVHS. To achieve this compatibility, USDOT is in the early stages of a program to develop a common IVHS framework-a system architecture. Four alternative architectures are being studied as part of the IVHS Architecture Development Program, with the goal of establishing a national IVHS architecture by mid- 1996.

To be effective, the IVHS architecture must meet and balance the needs of many different stakeholders or run the risk of losing the opportunity to deploy IVHS in a coherent, integrated manner. Therefore, we are all IVHS stakeholders. The architecture development program has been designed to foster active stakeholder involvement to deliver an architecture that is acceptable to stakeholders, advances their interests and addresses their concerns.

This document provides the latest information on the IVHS Architecture Development Program, highlighting the four architectures being developed. This document also contains a mechanism by which stakeholders can give feedback. The feedback will both help refine the architectures and enable succeeding review cycles to focus on issues that are of primary interest to stakeholders.

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BACKGROUND

Surface transportation in the United States is at a crossroads. The mobility we prize so highly is threatened. Many of the nation's roads are badly clogged. Congestion continues to increase, and the conventional approach of the pas-building more roads-will not work in many areas of the country, for both financial and environmental reasons.

Safety continues to be a prime concern. In 1991, 41,000 people died in traffic accidents, and more than 5 million were injured. Public transportation systems, chronically short of funds, are seen by many as an unattractive alternative to driving.

Congestion takes its toll, too, in lost productivity, costing the nation billions annually. Traffic accidents-many caused by congestion itself-drain away billions more each year. Dollars alone can't measure the loss of life or consequences of long-term injury. There are also other costs. For example, inefficient movement of vehicles reduces productivity, wastes energy, and increases emissions; trucks, buses, and automobiles idled in traffic waste billions of gallons of fuel and needlessly emit tons of pollutants each year.

Recognition of these problems led to the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The purpose of ISTEA is clearly annunciated in its statement of policy: "...to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner."

There is no single answer to the set of complex transportation problems that confront us. But a group of technologies known as Intelligent Vehicle-Highway Systems (IVHS) can help tremendously in meeting the goals of ISTEA. Indeed, Congress recognized this in the Act by authorizing a $660 million IVHS program as part of ISTEA. IVHS is composed of a number of technologies, including information processing, communications, control, and electronics. Intelligently joining these technologies to our transportation system can save lives, time, and money, improving our quality of life.

Goals for IVHS in the U.S.

* Improved safety
* Reduced congestion
* increased and higher quality mobility
* Reduced environmental impact
* Improved energy efficiency
* Improved economic productivity
* A viable U.S. IVHS industry

IVHS can improve safety, reduce congestion, enhance mobility, minimize environmental impact, save energy, and promote economic productivity in our transportation system. It will multiply the effectiveness of future spending on highway construction and maintenance and will increase the attractiveness of public transportation. IVHS will be as basic a transportation raw material as concrete, asphalt, or steel rail.

IVHS is not a distant vision. Already, real systems, products, and services are being tested throughout the U.S. Some first-generation systems are on the market or in the final stages of development. More than 20 real-world operational tests are now under way or are planned as federal/state/private ventures to evaluate more advanced IVHS concepts and components.

Over the next 20 years, a national IVHS program could have a greater societal impact than even the Interstate Highway System. As with the Interstate, effects are difficult to predict at the outset of the program. Still, it is clear that IVHS can yield substantial benefits widely distributed among our society. There are benefits, for instance, for rural drivers as well as those in congested metropolitan areas; for older as well as younger drivers; and for the current riders of public transportation systems as well as those who will be attracted to public transportation by the enhancements that IVHS helps make possible.

Because of the anticipated scale of the economic, legal, and social effects of IVHS, it is important that there be penetrating, systematic evaluation of IVHS, particularly in its formative stages. To achieve this systematic evaluation at the national level, a program planning process has been established by which all interested parties in IVHS can work together to implement IVHS. An early outcome of the planning process was the identification of a number of capabilities-“user services”-that, if deployed, will collectively meet the goals of IVHS.

Currently, there are 28 user services which fall into the following six general areas. These services and service areas may change over time as more information is gained from tests and more groups get involved in IVHS.

IVHS User Services

Travel and Traffic Management
- Pre Trip Travel Information
- En Route Driver Information
- Traveler Services Information
- Route Guidance
- Ride Matching **and** Reservation
- Incident Management
- Travel Demand Management
- Traffic Control

Public Transportation Management
- En Route Transit Information
- Public Transportation Management
- Personalized Public Transit
- Public Travel Security

Electronic Payment
- Electronic Payment Services

Commercial Vehicle Operations
- Commercial Vehicle Electronic Clearance
- Automated Roadside Safety Inspection
- Commercial Vehicle Administrative Processes
- On-Board Safety Monitoring
- Commercial Fleet Management
- Hazardous Material Incident Notification

Emergency Management
- Emergency Vehicle Management
- Emergency Notification and Personal Security

Advanced Vehicle Safety Systems
- Longitudinal Collision Avoidance
- Lateral Collision Avoidance
- Intersection Collision Avoidance
- Vision Enhancement for Crash Avoidance
- Safety Readiness
- Pre-Crash Restraint Deployment
- Automated Vehicle Operation

Travel and Traffic Management services provide an array of information services to help travelers plan trips and avoid delays. This category of services also encourages the use of high occupancy vehicles and provides traffic control procedures and mechanisms.

Public Transportation Management improves the efficiency, safety, and effectiveness of public transportation systems for providers and customers alike. This category of services will make public transportation more attractive to potential customers.

Electronic Payment services will link all modes of transportation (intermodal transportation) under one simple, convenient payment system. This **new** system will help reduce delays in fee collection and provide accurate data for systems management.

Commercial Vehicle Operations will help streamline administrative procedures, improve safety, and help efficiently manage commercial fleets.

Emergency Management services help improve emergency notification and response times and enhance resource allocation.

Advanced Vehicle Safety Systems provide various forms of collision avoidance and safety precautions. Automated vehicles remain a longer term objective.

IVHS development is moving rapidly and products are already coming to market in many of these areas. Requirements for some areas are evolving in parallel with development in others. The goal, nonetheless, is a well-integrated system in which the services are all linked practically and cost-effectively to provide greater capabilities than could be achieved separately.

This document focuses on a major initiative in the IVHS program aimed at achieving the goal of an integrated system for IVHS applications — the IVHS Architecture Development Program. This document serves as a status report on the architecture development program as well as a mechanism for those interested, to provide feedback on the progress to date.

THE IVHS ARCHITECTURE DEVELOPMENT PROGRAM

The Intermodal Surface Transportation Efficiency Act of 199 1 (ISTEA) gives USDOT the responsibility of providing the leadership and guidance necessary to ensure national IVHS compatibility over the long term. That compatibility relies upon establishing a unifying national IVHS architecture.

A thoughtfully designed IVHS architecture will ensure that the deployment of IVHS user services occurs within the most sensible system framework. It will also ensure that a nationally compatible system linking all modes of transportation emerges, instead of local or regional pockets of IVHS that will not accommodate intercity travel or cross-country goods movements.

The establishment of a national IVHS architecture will not only ensure national compatibility but also be beneficial to individual stakeholders. An architecture will allow stakeholders to adopt the elements of IVHS in the manner and timeframe of their choosing, enable these elements to be supplied by multiple vendors, serve as the foundation for standards that can reduce duplication of effort by the stakeholders, speed the introduction of IVHS products and services and reduce the risk for the private sector developing these products and services.

Schedule

USDOT has initiated the National IVHS Architecture Development Program. In September 1993, USDOT selected teams led by Hughes Aircraft, Loral-IBM, Rockwell International, and Westinghouse Electric to each develop an alternative IVHS architecture. Each architecture is based on a twenty year planning horizon (1992-2012) and addresses the current set of User Services. The program is proceeding in two phases. Phase I will last 15 months from September 1993 to December 1994.

System Architecture and IVHS

What is a System Architecture?

/ System engineering methodologies have been created to develop and implement large multi-faceted systems like IVHS. These methodologies are commonly used in defense and aerospace programs and in technology-based commercial systems, such as computers and communications, "The initial step common to the initiation of major new systems is the development of a system architecture.

/ A system architecture is the framework that describes how system components interact and work together to achieve total system goals. It describes the system operation, what each component of the system does and what information is exchanged among the components.

/ A system architecture is different from a system design. Within the framework of an architecture, many different designs can be implemented. Home stereo systems provide a good example of the importance of establishing an architecture Consumers, or users, determine what capabilities they want in a stereo system (e.g.+ compact disk, tape player or turntable) Based on cost and performance. Since the home stereo industry has an established architecture, product suppliers offer components that consumers know will work together.

IVHS Architecture

/ The development of an architecture is a systematic process. It involves understanding goals, requirements, different operational concepts, and enabling technologies to provide Important system capabilities, The User Services can be thought of as the requirements of an IVHS architecture.

/ A well-defined IVHS architecture will accommodate different levels of implem- entation, different system designs, and flexibility to allow system evolution over time. This allows different goals to be supported across many regions. For example, different user services will be important to rural and urban areas.

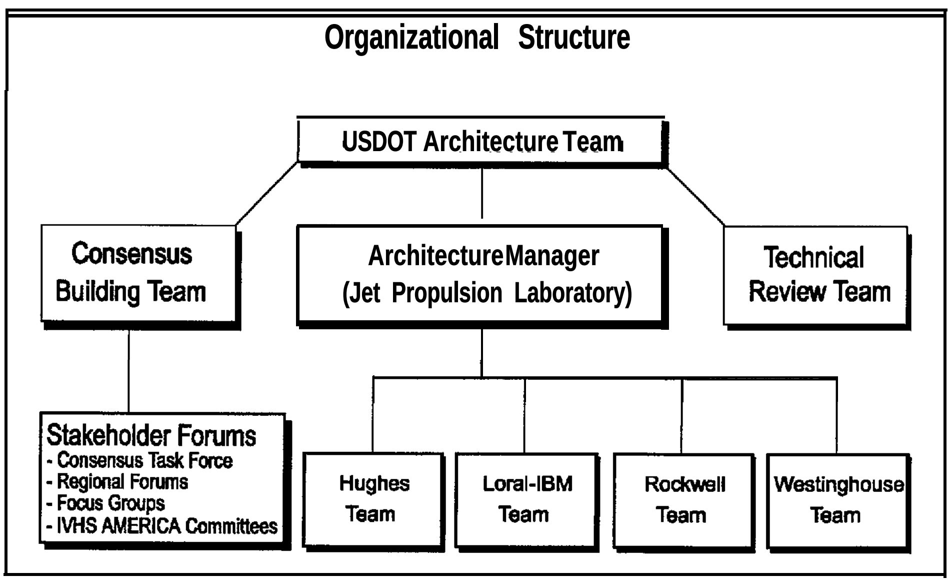
/ In addition, the well-developed IVHS architecture will:

- Foster evolutionary development of IVHS that readily accommodates new products as needs and goals change and technology advances;
- Reduce the cost of individual components by clearly defining their functions, encouraging competition by the private sector; and
- Identify necessary interfaces between components, an essential step toward defining common interface standards & protocols.

and will result in multiple architecture definitions. The teams with the most promising architectures will continue into Phase II. Lasting 19 months from December 1994 to July 1996, Phase II will focus on detailed evaluation of the remaining alternatives. Throughout both phases, the consortia will have the opportunity to refine their architectures as they gain further knowledge and insight. At the conclusion of Phase II in mid-1996, a national IVHS architecture will emerge. This program is based on, and tracks with, a recommended approach from IVHS AMERICA.

Organizational Structure

Management of the Architecture Development Program is vested in the USDOT Architecture Team, comprised of representatives from USDOT's Federal Highway Administration, Federal Transit Administration, and National Highway Traffic Safety Administration, as well as MITRE Corporation. The Jet Propulsion Laboratory has been selected by USDOT to serve as the Architecture Manager, providing day-to-day management oversight of the teams. A team of private sector and academic technical experts-the Technical Review Team-will review the technical soundness of the architecture alternatives submitted by the teams at certain program milestones. A consensus building team, staffed jointly by USDOT and IVHS AMERICA, will transmit information to and receive feedback from interests outside the technical development program.



Consensus Building

It is vital that the architecture be designed in a systematic fashion so that all issues are addressed openly and directly, rather than having the architecture evolve in an ad hoc fashion. During the architecture development program, the key to success will be involving major stakeholders-those directly affected or influenced by the introduction of IVHS- in the decision-making process. Those who will use, design, build, operate, maintain, and be impacted by these systems must jointly decide upon a common system architecture.

These stakeholders have helped design, a consensus building process to gain cooperation among many classes of stakeholders in achieving the goal of a nationally compatible intelligent transportation system. Since critical policy issues are being addressed by the architecture alternatives, the consensus building process allows-and ensures-that stakeholders are aware of these policy issues and are able to provide meaningful feedback and input as it relates to these issues.

Four mechanisms are being used to interact with IVHS stakeholders:

- **IVHS Architecture Consensus Task Force.** Comprised of approximately 40 IVHS stakeholders, primarily associations/ societies and interest groups, the Task Force will transmit information to and present feedback from their consti-tuents. Representation on the Task Force is expected to evolve as the program progresses.

- **Regional Architecture Forums.** During each "review cycle", (see below) public meetings will be held in the ten USDOT regions to present the current status of the architecture alternatives and allow local feedback.

- **IVHS AMERICA.** The technical committees of IVHS AMERICA will be provided with information and will generate feedback on the architecture alternatives.

- **Focus Groups.** As appropriate, focus groups will be conducted to provide a better understanding of key issues and the views of key stakeholders.

Consensus building activities will focus around four major program milestones. At these points, or "review cycles", the latest information on the developing alternatives, along with mechanisms to provide feedback, will be made available to the stakeholders through the aforementioned mechanisms. The goals of these review cycles and their dates are as follows:

1. **April/May 1994 — Overviews** of the four architectures being developed and the socioeconomic implications being considered in their development will be presented. Feedback will refine the architectures and identify issues that are of primary interest to stakeholders.

2. November 1994 — Refined architectures will be presented. Feedback will help narrow the four architectures to the most promising.

3. June 1995 — The remaining architectures will be presented in further detail, along with evaluation results. Feedback will be used **to** make final refinements.

4. May 1996 — The final architectures will be presented. Feedback will aid in determining which is chosen as the national IVHS architecture.

The consensus building process will aim to develop general support within the broad stakeholder community behind the ultimate national architecture; since it is not possible to obtain total agreement by all stakeholders on all facets of the selected architecture.

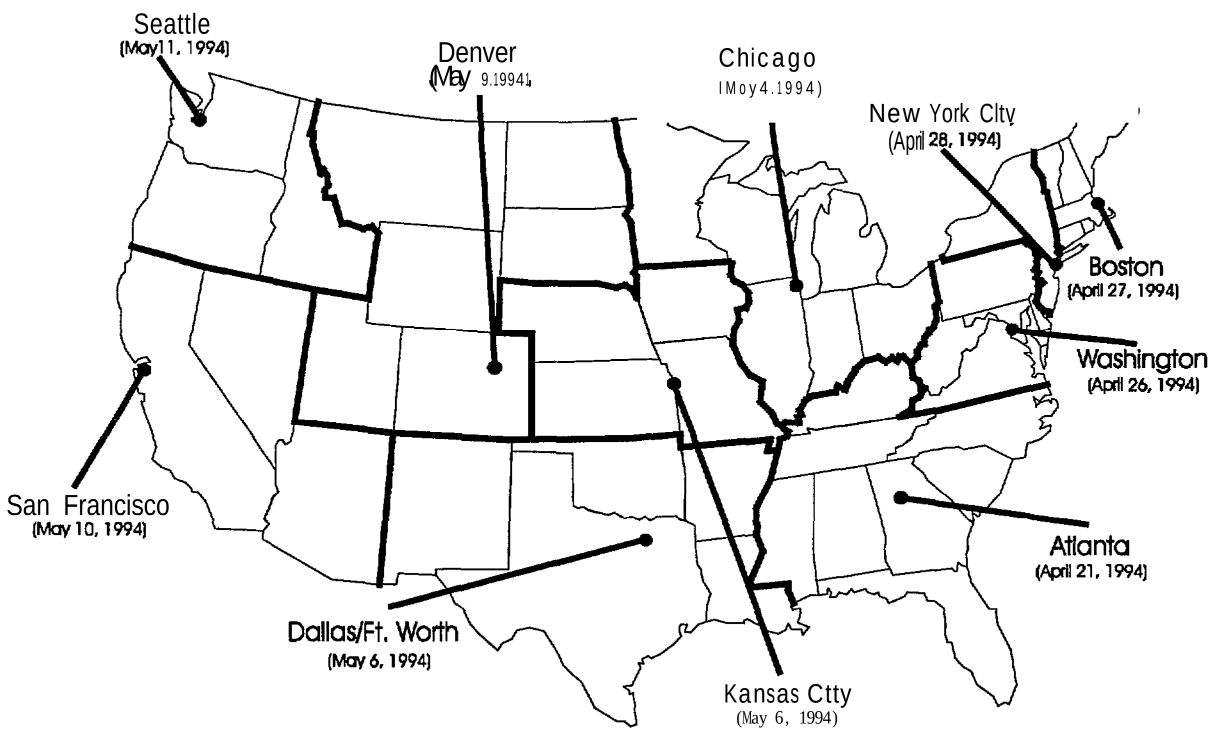
IVHS Architecture Consensus Task Force

- American Association of Motor Vehicle Administrators
- American Association of State Highway and Transportation Officials
- American Association of Port Authorities
- American Association of Retired Persons
- American Automobile Association
- American Automobile Manufacturers Association
- American Bus Association
- American Consulting Engineer Council
- American Electronics Association
- American Portland Cement Alliance
- American Public Transit Association
- American Public Works Association
- American Road and Transportation Builders Association
- American Trucking Associations Foundation
- Association of American Railroads
- Council of Standards Organizations
- Council of University Transportation Centers
- Electronic Industries Association
- Environmental Defense Fund
- Human Factors & Ergonomics Society
- Institute of Transportation Engineers
- International Bridge, Tunnel and Turnpike Association
- International Taxicab and Livery Association
- IVHS Canada
- National Association of County Officials
- National Association of Governors' Highway Safety Representatives
- National Association of Regional Councils
- National Conference of State Legislatures
- National Emergency Number Association
- National Governors' Association
- National Industrial Transportation League
- National League of Cities
- National Private Truck Council
- National Safety Council
- Public Technology, Inc.
- State and Territorial Air Pollution Program Administration/Association of Local Air Pollution Control Officials
- Surface Transportation Policy Project
- Telecommunications Industry Association
- United Bus Owners of America
- United States Chamber of Commerce

Status

The first program milestone has arrived. The focus of the review cycle currently underway is to provide stakeholders a first look at the developing architecture alternatives, focusing on the current thinking of what capabilities will be accommodated, IVHS User Services, and an initial set of high-level factors, called Implications, that define important stakeholder interests and help highlight strengths and weaknesses of the architecture alternatives. This information will allow stakeholders to provide meaningful feedback that will both improve the architectures and enable succeeding review cycles to focus on the issues that are of interest to stakeholders.

Dates and Locations of Regional Architecture Forums



IVHS AMERICA Committees and Task Forces

- Advanced Public Transportation Systems
- Advanced Rural Transportation Systems
- Advanced Traffic Management Systems
- Advanced Traveler Information Systems
- Advanced Vehicle Control Systems
- Benefits, Evaluation and Costs
- Commercial Vehicle Operations
- Energy and Environment

- Institutional Issues
- Legal Issues
- Safety and Human Factors
- Standards and Protocols
- System Architecture
- Communications Spectrum Task Force
- Societal Implications Task Force
- Travel Demand and Telecommuting Task Force

USERSERVICES

To achieve IVHS goals, a number of capabilities, or “user services” have been identified. There are currently 28 services in the broad areas of Travel and Traffic Management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, and Advanced Vehicle Safety Systems. While still evolving, these services collectively define near, mid, and long term capabilities that will likely comprise IVHS. Consequently, each architecture alternative will address all of the following 28 user services.

Travel and Traffic Management

PRE-TRIP TRAVEL INFORMATION

Provides information for selecting the best departure times, transportation modes, and routes.

Travelers access a complete range of intermodal transportation information at home, work, and other major sites where trips originate. For example, timely information on transit routes, schedules, transfers and fares, and ride matching services are included. Real-time information on accidents, road construction, alternate routes, traffic speeds along given routes, parking conditions, event schedules, and weather information complete the service. Based on this information, the traveler can select the best departure time, route and modes of travel, or decide to postpone or not to make the trip at all. Reducing congestion and improving mobility benefits all potential travelers.

EN-ROUTE DRIVER INFORMATION

Driver advisories and in-vehicle signing improve convenience and safety.

Driver advisories are similar to pre-trip planning information, but are provided once travel begins.Driver advisories convey information about traffic conditions incidents, construction, transit schedules, and weather conditions to drivers of personal, commercial and public transit vehicles. This information allows a driver to select the best route, or shift to another mode mid-trip if desired.

In-vehicle signing, the second component of en-route driver information, would provide the same types of information found on physical road signs today, directly in the vehicle. The service could be extended to include warnings of road conditions and safe speeds for specific types of vehicles (e.g., autos, buses, large trucks), but potential users include drivers of all types of vehicles. This service might be especially useful to elderly drivers, or in rural areas with large numbers of tourists and unusual or hazardous roadway conditions.

TRAVELER SERVICES INFORMATION

> **Provides a reference directory, of *"yellow pages", of service information.***

Provides quick access to travel related services and facilities. Examples of information that might be included are the location, operating hours, and availability of food, parking, auto repair, hospitals, and police facilities. Traveler services information would be accessible in the home, office or other public locations to help plan trips, and might also be available en route. When fully deployed, this service will connect users and providers interactively, to request and provide needed information. A comprehensive, integrated service could support financial transactions like automatic billing for purchases.

IVHS User Services

Travel and Traffic Management
- Pre-Trip Travel Information
- En-Route Driver Information
- Traveler Services Information
- Route Guidance
- Ride Matching and Reservation
- Incident Management
- Travel Demand Management
- Traffic Control

Public Transportation Management
- En Route Transit Information
- Public Transportation Management
- Personalized Public Transit
- Public Travel Security

Electronic Payment
- Electronic Payment Services

Commercial Vehicle Operations
- Commercial Vehicle Electronic Clearance
- Automated Roadside Safety Inspection
- Commercial Vehicle Administrative Processes
- On-Board Safety Monitoring
- Commercial Fleet Management
- Hazardous Material Incident Notification

Emergency Management
- Emergency Vehicle Management
- Emergency Notification and Personal Security

Advanced Vehicle Safety Systems
- Longitudinal Collision Avoidance
- Lateral Collision Avoidance
- Intersection Collision Avoidance
- Vision Enhancement for Crash Avoidance
- Safety Readiness
- Pre-Crash Restraint Deployment
- Automated Vehicle Operation

Route Guidance

Provides travelers with simple instructions on how to reach their destinations.

Provides a suggested route to reach a specified destination. Early route guidance systems will be based on static information about the roadway network, transit schedules, etc. When fully deployed, route guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system. The route guidance service will consider traffic conditions, status and schedule of transit systems, and road closures in developing the best route. Directions will generally consist of simple instructions on turns or other upcoming maneuvers. Users of the service include not only drivers of all types of vehicles, but also non-vehicular travelers, such as pedestrians or bicyclists, who could get specialized route guidance from a hand-held device.

Ride Matching and Reservation

Makes ride sharing more convenient.

Provides real-time ride matching information and reservations to users in their homes, offices or other locations, and assists transportation providers with vehicle assignments and scheduling. The service will also provide a clearinghouse for financial transactions. This will expand the market for ridesharing as an alternative to single occupant automobile travel, and will provide for enhanced alternatives for special population groups, such as the elderly or the handicapped. Convenient ride sharing is especially important to commuters.

Incident Management

Helps officials quickly identify incidents and implement a response to minimize their effects on traffic.

Enhances existing capabilities for detecting incidents and taking the appropriate actions in response to them. The service will help officials quickly and accurately identify a variety of incidents, and to implement a response which minimizes the effects of these incidents on the movement of people and goods. Traffic movement adjustments over a wide area would be executed through the Traffic Control user service, while decisions at the site of the incident will be made by police agencies. In addition, the service will help officials to predict traffic or highway conditions so that they can take action in advance to prevent potential incidents or minimize their impacts. While the users of this service are primarily public officials, commercial and transit operators, and the traveling public all benefit from improved incident management capabilities.

Travel Demand Management

Supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.

Generates and communicates management and control strategies that support the implementation of programs to (1) reduce the number of individuals who choose to drive alone, especially to work, (2) increase the use of high occupancy vehicles and transit, (3) reduce the impacts of high polluting vehicles, and (4) provide a variety of mobility options for those who wish to travel in a more efficient manner, for example in non-peak periods. The service allows employers to better accommodate the needs and lifestyles of employees by encouraging alternative work arrangements such as variable work hours, compressed work weeks, and telecommuting. Travel demand management strategies could ultimately be applied dynamically, when congestion or pollution conditions warrant. For example, disincentives such as increased tolls and parking fees could be applied during pollution alerts or when major incidents occur, while transit fares would be lowered to accommodate the increased number of travelers changing modes from driving alone. Such strategies will reduce the negative impacts of traffic congestion on the environment and overall quality of life.

TRAFFIC CONTROL

Manages the movement of traffic on streets and highways.

Integrates and adaptively controls the freeway and surface street systems to improve the flow of traffic, give preference to transit and other high occupancy vehicles, and minimize congestion while maximizing the movement of people and goods. Through appropriate traffic controls, the service will also promote the safety of non-vehicular travelers, such as pedestrians and bicyclists. This service gathers data from the transportation system, fuses it into usable information, and uses it to determine the optimum assignment of right-of-way to vehicles and pedestrians. The real-time traffic information collected by the Traffic Control service also provides the foundation for many other user services.

While the actual users of the service will generally be public transportation officials, drivers of all types of vehicles, transit riders, pedestrians, bicyclists, and other travelers benefit from improved traffic flow.

Public Transportation Management

EN ROUTE TRANSIT INFORMATION

Provides information *to travelers using public transportation after they begin their trips.*

Provides the same type of information as pre-trip planning services, once public transportation travel begins. Real-time, accurate transit service information on board the vehicle helps travelers make effective transfer decisions and itinerary modifications as needed while a trip in underway.

PUBLIC TRANSPORTATION MANAGEMENT

Automates *operations, planning, and management functions of public transit systems.*

Computer analysis of real-time vehicle and facility status will improve operations and maintenance. The analysis identifies deviations from schedule and provides potential solutions to dispatchers and drivers. Integrating this capability with the Traffic Control Service can help maintain transportation schedules and assure transfer connections in inter-modal transportation. Information regarding passenger loading, bus running times, and mileage accumulated will help improve service and facilitate administrative reporting. Automatically recording and verifying performed tasks will enhance transit personnel management. Improved efficiency benefits transit providers and customers alike.

PERSONALIZED PUBLIC TRANSIT

Flexibly routed transit *vehicles offer more convenient service to customers.*

Small publicly or privately operated vehicles operate on-demand assignments to pick up passengers who have requested service and deliver them to their destinations. Route deviation schemes, where vehicles would leave a fixed route for a short distance to pick up or discharge passengers, is another way of improving service under certain conditions. These transit vehicles can consist of small buses, taxicabs, or other small shared ride vehicles. They can essentially provide "door-to-door" service, expanding a route's coverage area in less populated locations and neighborhoods. This service can potentially provide transportation at lower cost and with greater convenience than conventional fixed route transit.

PUBLIC TRAVEL SECURITY

Creates a secure environment for public transportation patrons and operators.

Systems monitor the environment in transit stations, parking lots, bus stops, and transit vehicles and generate alarms either automatically or manually as necessary. This improves security for both transit riders and operators. Transportation agencies and authorities can integrate this user service with other anti-crime plans.

Electronic Payment

ELECTRONIC PAYMENT SERVICES

Allow travelers to pay for transportation services electronically with "smart cards"

Will foster intermodal travel by providing a common electronic payment medium for all transportation modes and functions, including tolls, transit fares, and parking. A common service fee and payment structure, employing multi-use "smart cards", could integrate all modes of transportation including roadway pricing options. The flexibility electronic payment services offer will have an impact on travel demand management. In particular, they will enable relatively easy application of road pricing policies and could significantly influence departure times and mode selection. Electronic payment's primary benefit is convenience for all travelers and transportation providers.

Commercial Vehicle Operations

COMMERCIAL VEHICLE ELECTRONIC CLEARANCE

Facilitates domestic and international border clearance, minimizing stops.

This service will enable transponder-equipped trucks and buses to have their safety status, credentials, and weight checked at mainline speeds. Vehicles that are safe and legal and have no outstanding out-of-service citations will be allowed to pass the inspection/weigh facility without delay.

By working with Mexico and Canada, a more efficient traffic flow would be provided at border crossings and the deployment of technologies in these countries could ultimately prevent overweight, unsafe, or improperly registered vehicles from entering the United States. Truckers, shippers, and regulators will all benefit from improved productivity.

Automated Roadside Safety Inspection

Facilitates roadside inspections.

Automated roadside inspections would allow "real-time" access at the roadside to the safety performance record of carriers, vehicles, and drivers. Such access will help determine which vehicle or driver should be stopped for an inspection, as well as ensuring timely correction of previously identified problems.

It would, for example, allow for more rapid and accurate inspection of brake performance at the roadside. Through the use of sensors and diagnostics, it would efficiently check vehicle systems and driver requirements and ultimately driver alertness and fitness for duty. Improved safety benefits truckers, shippers and regulators.

Commercial Vehicle Administrative Processes

Provides electronic purchasing of credentials and automated mileage and fuel reporting.

Electronically purchasing credentials would provide the carrier with the capability to electronically purchase annual and temporary credentials via computer link. It will reduce burdensome paperwork and processing time for both the states and the motor carriers.

For automated mileage and fuel reporting and auditing, this service would enable participating interstate carriers to electronically capture mileage, fuel purchased, trip, and vehicle data by state. It would also automatically determine mileage traveled and fuel purchased in each state, for use by the carrier in preparing fuel tax and registration reports to the states. Currently, the administrative burden on carriers to collect and report mileage and fuel purchased within each state is significant. This service would significantly reduce the cost for collecting both types of data.

On-Board Safety Monitoring

Senses the safety status of a commercial vehicle, cargo, and driver.

On-board systems would monitor the safety status of a vehicle, cargo, and driver at mainline speeds. Vehicle monitoring would include sensing and collecting data on the condition of critical vehicle components such as brakes, tires, and lights, and determining thresholds for warnings and countermeasures. Cargo monitoring would involve sensing unsafe conditions relating to vehicle cargo, such as shifts in cargo while the vehicle is in operation. Driver monitoring is envisioned to include the monitoring of driving time and alertness using non-intrusive technology and the development of warning systems for the driver, the carrier, and the enforcement official. A warning of unsafe condition would first be provided to the driver, then to the carrier and roadside enforcement officials and would possibly prevent an accident before it happens. This service would minimize driver and equipment-related accidents for participating carriers.

Commercial Fleet Management

The availability of real-time traffic information and vehicle location for commercial vehicles would help dispatchers to better manage fleet operations by helping their drivers to avoid congested areas and would

Provides communications between drivers, dispatchers, and intermodal transportation providers.

also improve the reliability and efficiency of carriers' pickup-and-delivery operations. The benefits from this service would be substantial for those intermodal and timesensitive fleets that can use these IVHS technologies to make their operations more efficient and reliable.

HAZARDOUS MATERIALS AND INCIDENT NOTIFICATION

Provides immediate notification of an incident and immediate request for assistance.

Enhances the safety of shipments of hazardous materials by providing enforcement and response teams with timely, accurate information on cargo contents to enable them to react properly in emergency situations. The system would focus on determining when an incident involving a truck carrying hazardous material occurs, the nature and location of the incident, and the material or combination of materials involved so that the incident can be handled properly.

Emergency Management

EMERGENCY VEHICLE MANAGEMENT

Reduces the time it takes to respond to incident notification.

This user service includes three capabilities: fleet management, route guidance, and signal priority. Fleet management will improve the display of emergency vehicle locations and help dispatchers efficiently task the units that can most quickly reach an incident site. Route guidance directs emergency vehicles to an incident location. Signal priority clears traffic signals in an emergency vehicle's route. Primary users include police, fire, and medical units.

EMERGENCY NOTIFICATION AND PERSONAL SECURITY

Provides immediate notification of an incident and an immediate request for assistance.

This service includes two capabilities: driver and personal security and automatic collision notification. Driver and personal security capabilities provide for user initiated distress signals for incidents like mechanical breakdowns and carjackings. Automatic collision notification identifies a collision and automatically sends information regarding location, nature, and severity to emergency personnel.

Advanced Vehicle Safety Systems

LONGITUDINAL COLLISION AVOIDANCE

Helps prevent head-on and rear-end collisions between vehicles and other objects or pedestrians

Helps reduce the number and severity of collisions. It includes the sensing of potential or impending collisions, prompting a driver's avoidance actions, and temporarily controlling the vehicle.

LATERAL COLLISION AVOIDANCE

Helps prevent collisions when vehicles leave their lane of travel.

Provides crash warnings and controls for lane changes and road departures. It will help reduce the number of lateral collisions involving two or more vehicles, or crashes involving a single vehicle leaving the roadway.

For lane changes, a situation display can continuously monitor the vehicle's blind spot and drivers can be actively warned of an impending collision. If needed, automatic control can effectively respond to situations very rapidly. Warning systems can also alert a driver to an impending road departure, provide help in keeping the vehicle in the lane, and ultimately provide automatic control of steering and throttle in dangerous situations.

INTERSECTION COLLISION AVOIDANCE

Helps prevent collisions at intersections.

Warns drivers of imminent collisions when approaching or crossing an intersection that has traffic control (e.g. stop signs or traffic signals). This service also alerts the driver when the right-of-way at the intersection is unclear or ambiguous.

VISION ENHANCEMENT FOR CRASH AVOIDANCE

Improves the driver's ability to see the roadway and objects that are on or along the roadway.

Improved visibility would allow the driver to avoid potential collisions with other vehicles or obstacles in the roadway, as well as help the driver comply with traffic signs and signals. This service requires in-vehicle equipment for sensing potential hazards, processing this information, and displaying it in a way that is useful to a driver.

SAFETY READINESS

Provides warnings regarding the condition of the driver, the vehicle, and the roadway.

In-vehicle equipment could unobtrusively gauge a driver's condition and provide a warning if he or she is drowsy or otherwise impaired. This service could also internally monitor critical components of an auto beyond the standard oil pressure and engine temperature lights. Equipment within the vehicle could also detect unsafe road conditions, such as bridge icing and standing water on a roadway, and provide a warning to the driver.

PRE-CRASH RESTRAINT DEPLOYMENT

Anticipates an imminent collision and activates passenger safety systems prior to collision.

Identifies the velocity, mass, and direction of the vehicles and objects involved in a potential crash and the number, location, and major physical characteristics of any occupants. Responses include tightening lap-shoulder belts, arming and deploying air bags at an optimal pressure, and deploying roll bars.

AUTOMATED VEHICLE OPERATION

Provides a fully automated 'hands off"

Automated vehicle operations are a long term goal of IVHS which would provide vast improvements in safety by creating a nearly accident free driving environment. Drivers could buy vehicles with the necessary instrumentation or retrofit an existing vehicle. Vehicles that are incapable of automated operation, during some transition period, will drive in lanes without automation.

STAKEHOLDER EVALUATION IMPLICATIONS

Each of the four teams was selected in part because they are developing their architecture based on slightly different assumptions and philosophical viewpoints. But, if they provide similar services, then what makes the architectures different in the eyes of a stakeholder? The answer lies in the broader implications that would result from implementing an architecture. These implications are the high-level technical, financial, legal, institutional and political effects that may arise from an architecture.

It is likely that the architectures will have different implications. It is these implications that will serve as the mechanism for stakeholders to evaluate the architectures when they are fully developed. An extensive effort has been underway to determine what implications are of primary interest to the diverse set of stakeholders involved in IVHS. Working with stakeholders-but without any information on the architecture alternatives-a preliminary set of implications has been identified.

This review period provides an opportunity to refine the implications and determine which implications are important to each type of stakeholder. This information will be used to tailor the descriptions of the architectures in succeeding reviews to address the implications of interest to each type of stakeholder. This will enable the teams to provide targeted information from which stakeholders can provide better feedback.

The implications themselves do not imply any merit or priority in the way the architecture alternatives address them. Associating value and priority with each implication area is intentionally left for the stakeholders to provide as feedback. Your perspective is essential for identifying and refining implications that are of particular interest to you. The following ten areas have been identified as potential key areas of interest:

Deployment

This area describes how the architectures address IVHS deployment and flexibility. For example, how simple are the architectures to comprehend? And will this simplicity encourage rapid product development and deployment? To what extent do the architectures accommodate technology and service evolution plus infrastructure modifications? Do the architectures accommodate new IVHS services as well as interaction with non-IVHS services (financial, information, telecommunications, etc.)? And to what extent do the architectures accommodate non-standard system components?

Equity

This implication evaluates the distribution of benefits and costs for a given architecture. For instance, will the architectures allow all demographic segments of society (e.g., elderly, disabled, impoverished) access to IVHS? If not, will they still receive some benefits? Will all regions of the United States have access? Will it spread IVHS to urban, suburban and rural communities alike? Will all environmental climates have access to IVHS? Will those who pay the costs receive the benefits proportionally? Will windfall gains accrue to certain users?

Financing

This area describes the impact of the architectures on financing IVHS deployment, operations, and system maintenance, particularly in the infrastructure. For example, what are the estimated capital requirements to deploy, operate, and maintain the architectures? How will the expected benefits and investment opportunities of the architectures attract capital? And to what extent will funding instability affect the architectures? Will the architectures accommodate fee for service mechanisms?

Institutions

Institutional issues discribe the impact of the architectures on institutions and organizations. Questions to consider include: To what extent do the architectures accommodate a full range of public/private partnership arrangements? Rely upon cooperation within and between organizations? And require establishing new organizations? Related questions include how sensitive are the architectures to major stakeholders' participation? and how will the architectures affect traditional roles and responsibilities and enhance organizational learning?

Market

Market implications describe the effect of architectures on the development of an IVHS market as well as the effect on other existing or future markets. Potential questions include: What is the aggregate market potential and the rate of market development, both nationally and internationally, as a result of an architecture? What are the effects on the development of a U.S. IVHS industry and international competitiveness? Are architectures sensitive to under-saturation market penetration (when benefits do not accrue to early users) and over-saturation market penetration (when too many users reduce benefits)? Will the architecture allow easy market access to new supplier or impact related industries?

IVHS Architecture implication Areas

Deployment:	Impact on the rate of NHS deployment
· **Equity:**	Effect on the distribution of benefits and costs
Financing:	Impact on financing deployment, operations, and maintenance
· **Institutions:**	Impact on institutions and organizations
Market:	Effect on the development of an IVHS market
Operations & Maintenance:	Impact of operating and maintaining IVHS
Policy & Regulation:	Effect on implementing current and setting future policies and regulations
· **Privacy:**	Effect on the privacy of individuals and organizations
Safety:	Impact on transportation system safety
Standards:	Effect on current and future standardization efforts

Operations and Maintenance

Operations and maintenance impact infrastructure and users alike. To what extent do the architectures affect costs? Do the architectures accommodate existing resources and procedures of the operating organization or require new resources and procedures? What are the operations and maintenance needs of the infrastructure and for consumers and commercial users? Do the architectures imply clear operations and maintenance roles?

Policy and Regulation

Architecture alternatives may impact the implementation of current and future laws, policies and regulation. Factors to consider include: To what extent do the architectures support the goals of intermodalism, decentralized decision-making, and improved planning of the Intermodal Surface Transportation Efficiency Act of 1991? Do the architectures support the goals of improved air quality described in the Clean Air Act Amendments of 1990 and commercial vehicle safety regulations? To what extent do the architectures require or encourage the enactment of new laws policies in the areas of safety, liability and indemnification, procurement, and property rights?

Privacy

This area describes the effect of the architectures on the privacy of individuals and organizations. Factors to consider include: Will the architectures require some level of mandatory participation? Will there be information security safeguards? Will there be the opportunity for the marketplace to use gathered information and will the architectures accommodate law enforcement capabilities?

Safety

This area describes how the architectures address the broad topic of system safety. Questions to consider include: How do the architectures address the concepts of fail-safe, fail-soft, and graceful degradation? And to what extent do the architectures enable the development of safety standards?

Standards

This area discusses how the architectures accommodate the development of standards and protocols. Questions to consider include: To what extent do the architectures enable the adoption of performance and interface standards and information protocols? And to what extent do the architectures encourage competition among product and service suppliers.

ARCHITECTURE CONCEPTS

The four architecture development teams each have a distinct approach. The following summaries provide an overview of each approach, with emphasis on user services and implication areas of particular interest to their approach. These summaries appear exactly as the architecture development teams provided them. ***USDOT and IVHS AMERICA have not verified or endorsed this information.***

HUGHES AIRCRAFT

VISION

Travelers will feel that the transportation system, infrastructure and vehicle working together, has been designed and is being operated for their benefit. Travel will be simpler to plan and to dynamically change in response to real-time traffic conditions. Inter-modal travel will be effortless. Traffic control will be highly responsive to traffic conditions, reducing congestion. Tolls will be collected without slowing down vehicles. Commercial vehicles will encounter minimal delays in fulfilling regulations. Emergency vehicles will reach their destinations more quickly. Road hazard warnings from the infrastructure and in-vehicle collision avoidance equipment will significantly improve driving safety.

Hughes Aircraft, lead

Delco Electronics
Electronic Data Systems
General Motors
Hickling
JHK & Associates
Michigan DOT
Minnesota DOT
Sprint
University of Minnesota

Vehicle and infrastructure will be integrated. The vehicle will actually be a part of the infrastructure, providing real-time data from the road. The infrastructure will provide the vehicle with safety warnings, travel advisories, route directions, and roadside sign and yellow pages information. Toll collection and commercial vehicle operations will be two-way transactions.

Close cooperation of traffic, transit, and emergency fleet managements will be synergistic. Each will contribute to the knowledge of traffic conditions, and transit scheduling and emergency vehicle routing will be greatly facilitated.

Public Sector Agencies will be provided with the latest traffic data and tools to continuously tine tune the performance of the transportation system. Private Sector firms will develop new markets for services and products for both the vehicle owner and the infrastructure. Private/Public partnerships will evolve to accelerate the realization of the IVHS Architecture.

PHILOSOPHY

The basic in-vehicle equipment required to implement the architecture must be minimum cost in order to obtain wide acceptance and to avoid creating an elitist system. However, the in-vehicle architecture must be extensible to a family of higher priced compatible products which allow the driver to take advantage of the range of features available from the transportation system.

The architecture must take maximum advantage of the systems currently in operation. This minimizes up-front costs for the new system and reduces deployment time.

A decentralized architecture is the best approach to maximum reliability at the lowest cost. Failure of a system component may degrade the performance of the system an acceptable amount, but will not cause the system to fail. Cost is lower because the individual system components do not need to be as reliable as the overall system must be. Distributing processing into the vehicles is an example: loss of road data from one or more vehicles may make the data transmitted to the TMC temporarily less accurate, but information continues to be available from other vehicles.

The architecture must be implementable with a set of modular system components which fit together via standardized interfaces. This allows systems to be customized to meet the requirements of an individual Agency, to be expanded in coverage and to be upgraded with new technology. The concept applies to the infrastructure, the vehicle, and the communications links between them.

The architecture must accommodate a solution to the "chicken and egg" problem: The Public Sector Agency will not provide the infrastructure to interface to IVHS-equipped vehicles until there is a population of such vehicles. The Private Sector can not sell IVHS vehicle equipment if there is no infrastructure to interface with.

The architecture should minimize the need to install equipment in the road because of high installation and maintenance costs, disruption to traffic, and poor reliability.

There are roles to be played by Private/Public partnerships in providing IVHS-related services to the consumer and in building, operating and maintaining infrastructure. These partnerships are critical the success of IVHS because of limitations in available Government funding.

ASSUMPTIONS AND GUIDING PRINCIPLES

Electronic toll collection and commercial vehicle weigh-station communications both employ the same type of vehicle-infrastructure communications that the IVHS architecture will use. It is assumed that these two markets will result in enough penetration of the in-vehicle equipment to induce Transportation Agencies to install their own infrastructure equipment and begin to collect traffic data from the equipped vehicles. It is assumed that only a small percentage of equipped vehicles (perhaps 5%) are needed initially to begin to provide meaningful road data to the infrastructure.

Vehicles equipped with computers which perform navigation, route selection and route guidance will proliferate, creating a demand for real-time traffic congestion information from the Transportation Agencies. This will induce the Agencies to broadcast this information (in computer format) to enable these vehicles to reroute around congestion.

GPS receivers, which continuously provide vehicle location, are assumed to be in a large percentage of the vehicles. CD-ROMs are assumed to be dual purpose, entertainment and database, and also to installed in a large percentage of the vehicles. It is assumed that these two equipments will be interfaced to each other to locate vehicle position on the map and to filter pertinent traffic information from an area-wide radio broadcast.

Wide-band communications are assumed to be available and affordable for implementing the communications between road and TMC as a result of the demand for the “information super-highway” by cable and phone companies. This communication link will make it feasible to transmit both live video from selected road sites and traffic, road, and weather data from all road sites to the TMC.

KEY USER SERVICES AND IMPLICATION AREAS

Architecture

The Architecture is diagrammed in Figure 1.

The Transportation Management Centers (TMCs) monitor and control the entire system. The TMC collects real-time traffic dam from road sites, analyzes it, and generates traffic congestion information to be provided to vehicles passing these sites, and to a radio station which broadcasts this information (in computer format) to all vehicles in the area. Traffic incidents are recognized and vehicles are rerouted while the incidents are cleared. Congestion is reduced by control of traffic signal and ramp meter timing and by advisories and rerouting directions given to drivers.

The TMC coordinates its efforts with the organizations authorized to dispatch or provide information to emergency vehicles, tow trucks, law enforcement vehicles and transit vehicles.

The TMC supplies service providers with real-time traffic information and transit schedules. These service providers deliver route guidance instructions to vehicles either by cellular phone or via the TMC infrastructure. They also provide information to the cable TV companies who provide interactive TV to homes, offices, kiosks and bus shelters.

The tag-beacon equipment provides a two-way, computer format radio communication link between the infrastructure and the passing vehicles. The tag is the vehicle component; it is the size of a deck of playing cards and will be priced about $25. It is mounted in the windshield of the vehicles. The beacon is the infrastructure component. It is about the size and price (initial unit price of less than $1000) of an Apple Computer "Newton" product. It is mounted on a pole at the side of the road. The beacons are typically placed at 0.5 mile intervals along major arterials, highways and freeways.

The beacon has a range of approximately 100 feet. It is designed to be able to exchange a number of messages with each passing vehicle while the vehicle is within this range. It can read data messages from the vehicle's tag or write data messages into the tag. Messages can also be written into all vehicles as they pass a beacon (this is called a local broadcast). The tag presents messages it receives for the driver (e.g., EXIT AT MAIN) on a display or through an audio converter. The tag-beacon communication link is used in implementation of many of the User Services, as is discussed in the next section.

The Architecture stresses the acquisition of reliable, useful, and high quality data from the road. The better the data, the better the traveler information produced by the TMC and the monitoring and control performed by the TMC. Road data provided by the vehicles complements the traffic data provided by fixed surveillance sensors such as the traditional traffic loops. Research indicates that the combination of the two may greatly improve the TMC's ability to predict the build up of congestion. Fixed sensors using a variety of technologies will gradually replace the traffic loops, providing more useful data and eliminating the need to install equipment in the road. Radar and video image processing sensors will be used widely.

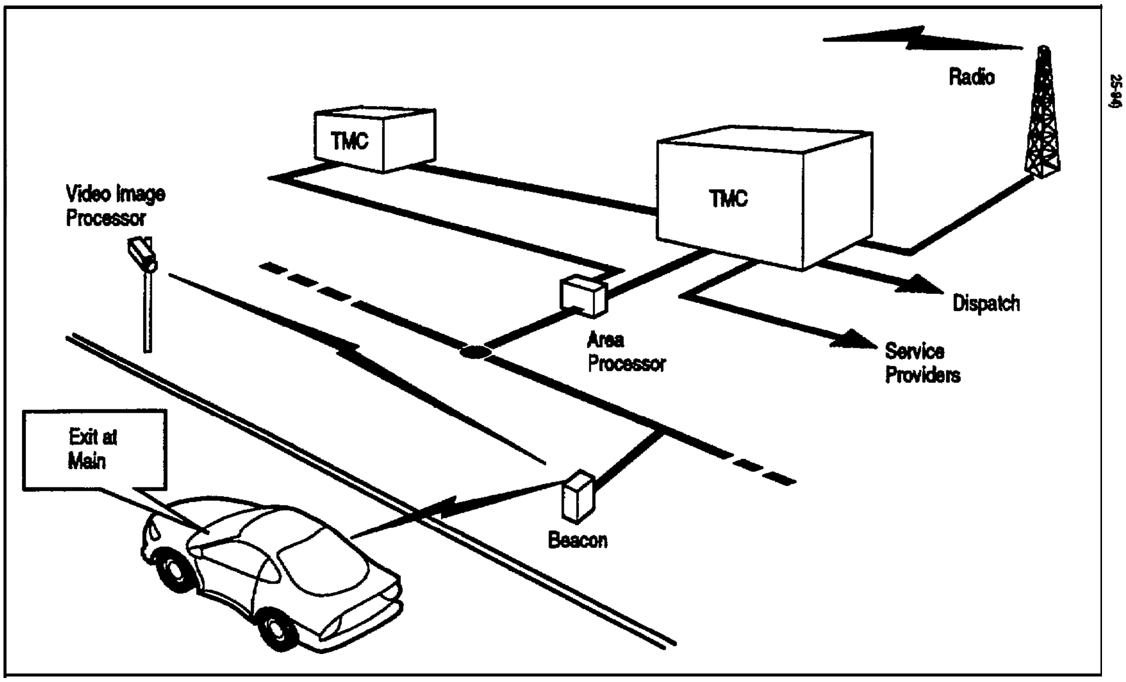


Figure 1. Basic Architecture

Closed Circuit TV (CCTV) will be installed at road sites to enable the TMC to instantaneously view a suspected incident, assess the situation, and take corrective action. Fiber optic land-lines will provide the bandwidth required to send live video to the TMC.

The system is designed such that failure of a single subsystem will not cause failure of the system. The TMC is continuously in contact with a back-up TMC. In a crisis, the Area Processors would be switched to the back-up TMC. The TMC communicates with the road site beacons via the Area Processors, each of which communicates with multiple beacons. Each beacon is connected to two Area Processors, so that failure of an Area Processor will not cause a loss of beacon data.

Vehicle Based User Services

Figure 2 shows the Vehicle-Based User Services. As indicated, these Services involve private, commercial, and transit vehicles.

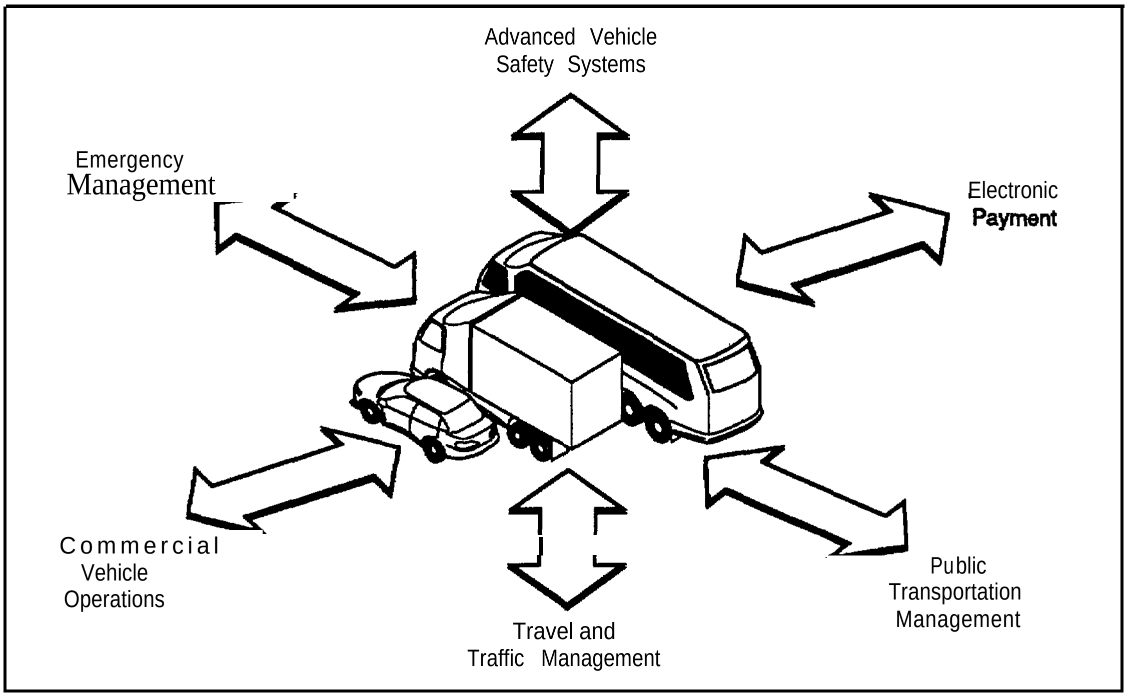


Figure 2. Vehicle Based User Services

TRAVEL AND TRAFFIC MANAGEMENT
TRAFFIC

Vehicles equipped with the basic tag are used to perform the probe function. As the probe vehicle passes a beacon its tag transmits the ID of the last beacon that it passed and the time elapsed since it passed that last beacon. The current beacon provides the TMC with the elapsed time and the ID of last and current beacons. This “link” travel time data, in conjunction with data from fixed surveillance sensors, is the primary data used by the TMC to monitor congestion.

Vehicles equipped with a tag which is interfaced with the vehicle’s computer are able to provide the “superprobe” function. As the superprobe vehicle passes a beacon its tag transmits a message containing data which the vehicle has recorded since it passed the last beacon. This data includes a sequence of vehicle speed measurements, abrupt steering actions, road icing and fog conditions, and engine pollution parameters. It is believed that this data will significantly add to the TMC’s ability to successfully predict congestion build-up, quickly detect incidents, and provide traffic accurate and timely advisories.

Origin/Destination (O/D) data defines the travel patterns through the Transportation System. This data is crucial to the TMC in developing and updating its traffic/transit control strategy and in planning system improvements. The Architecture provides the capability to continuously update the O/D database. The procedure is to write an Origin code in all tagged vehicles leaving a selected origin area and then reporting to the TMC where in the system this Origin code is subsequently read.

TRAVEL AND TRAFFIC MANAGEMENT - TRAVEL

Beacons attached to road-side signs will continuously transmit the sign message (e.g., freeway off ramp sign) to passing vehicles. Within the vehicle the tag would present the sign information on a display, in the same shape and color as the real sign. The driver can replay a sign and can ask for an alert when a particular sign is passed.

"Yellow Pages" refers to road-side business signs. These are handled just like road signs, but could add sales messages, such as room availability and rate for a motel sign.

Travel advisory messages would be transmitted from the TMC to all vehicles passing a specified beacon. The advisory message would be displayed in the vehicle, indicating the location of an incident ahead of the driver, the road blockage condition, the cause of the congestion and the rerouting advice to the driver.

Route guidance is a sequence of "maneuvers" (e.g., continue on Main until Maple, turn left onto Maple street) which are the instructions for following a selected route. A route guidance message transmits these maneuvers to the tag which stores them in its memory. The driver can sequence through the maneuvers manually by pushing a button to see the next maneuver on the display as he completed the current maneuver. Alternatively, the maneuver list would be automatically sequenced when imbedded codes match the GPS reading or match the ID of a beacon being passed. A more sophisticated in-vehicle system would display the maneuvers graphically as the vehicle navigates with the help of a map database.

The route may be selected by the TMC or by a service provider. A more sophisticated in-vehicle system would generate its own route, using an in-vehicle road database. Both approaches would take into account real-time traffic conditions, and both would offer rerouting in the case of traffic congestion. The TMC retains the ability to influence rerouting so as to avoid rerouting every vehicle into the same alternate route.

COMMERCIAL VEHICLE OPERATIONS

Commercial vehicles obtain preclearance from weigh stations along the road, eliminating the need to pull off into the weigh stations. The commercial vehicle maintains a "trip packet", containing information on driver and vehicle. As the vehicle approaches a weigh station, the vehicle is weighed in motion (WIM). A beacon reads the vehicle's trip packet (via the tag and from an on-board computer) and compares the packet weight data with the WIM data. If the two measurements are close enough and there is no problem with licenses or permits, the next beacon tells the vehicle that it is precleared and does not have to pull off into the weigh station.

This same on-board computer and tag-beacon communications enables a number of administrative tasks to be automated, including purchasing credentials, and recording mileage, fuel purchased, etc. by state.

EMERGENCY MANAGEMENT

Stolen vehicle recovery is a bi-product of the tag-beacon system. A person reporting his vehicle stolen will provide his tag ID. Law Enforcement will program beacons in the area to monitor for the vehicle with this tag and report its location and heading. (Of course, to be effective the tag must be placed where it would not be easily removed.)

A call for help (MAYDAY) from a vehicle is handled in two ways. A vehicle in range of a beacon can communicate via the beacon, which acts like an electronic call box. A cellular phone provides another way to provide this service. The Architecture includes an automatic MAYDAY call initiation activated when the air bag is activated.

ADVANCED VEHICLE SAFETY SYSTEMS

Vehicle knowledge of the geometry of the road ahead of the vehicle can significantly reduce certain types of accidents. Beacons are installed with fixed messages describing the coordinates of the road, especially at the start of sharp curves in the road or off-ramps; these messages are sent to the in-vehicle computer. Beacons are also installed on a temporary basis in areas of road repair or road hazards, in which case these beacons are the equivalent of the traffic engineer's orange cones. Commercial vehicles are programmed to warn the driver of excessive speed for the road geometry ahead. Adaptive cruise, which uses radar to keep a constant distance from the vehicle in front, can be made more effective by using the geometry data to augment its radar data processing.

Longitudinal and lateral collision avoidance will be implemented with radar technology. Intersectional collision avoidance may employ an architecture which interties beacons on each intersecting road.

ELECTRONIC PAYMENT

The basic tag is essentially used as a vehicle-mounted credit card or debit card which can be processed via the beacon. The original intent of the tag-beacon was toll collection, where it eliminates the need for the driver to drive through a toll booth. However, it can be used for any in vehicle-based transaction, such as paying for parking or even for take-out at McDonalds. An alternate approach uses a “Smart” card plugged into the tag, and removable from the vehicle for use in other debit card purposes. This Smart card concept will be used to simplify the use of inter-modal transportation.

PUBLIC TRANSPORTATION MANAGEMENT

Transit vehicles will be equipped with tags. Beacons will be positioned at each schedule point along fixed-route transit. Schedule variance is reported by the beacon to the transit management. Route advisories and road hazard and congestion warnings are transmitted to the transit vehicle via tag-beacon.

Non-fixed route transit (e.g., Dial-A-Ride) will use the route selection and guidance to determine the fastest route for picking up and delivering its passengers.

Implication Areas

PRIVACY

The Architecture does not require anyone to give up their privacy. The tag-beacon approach uses “blind” IDs. A vehicle owner stores a unique randomly chosen ID into the tag when it is purchased. No one other than that person needs to know the ID.

There are four exceptions to this rule and they are accepted by the owner/driver involved. Two of them, Commercial Vehicle Operations and transit transactions require that individual vehicles be identified.

The other two are transactions in which the vehicle owner wants the ID to be known temporarily. Stolen vehicle recovery is based upon beacons monitoring for the owner’s vehicle ID. The fourth exception is toll collection where the vehicle owner prefers a credit card rather than a cash card form of payment. (Note that the privacy risk associated with credit card use is something which most people accept.)

EQUITY

The Architecture is a non-elitist system. Within the next 5 years, the cost to the vehicle owner will be less than $25 for a basic tag capable of toll collection and probe operations, and $50 with a display for traveler information, to as much as $500 for equipment which can do in-vehicle route selection and guidance using real-time traffic data from the TMC.

Older and visual impaired drivers are provided with customized in-vehicle displays. Foreign-language speakers and travelers with special needs (e.g., wheel chair) are accommodated throughout the Architecture.

Multi-modal transportation is made more accessible and easier to use by use of interactive TV and dynamically routed ride sharing and Dial-A-Ride vehicles. The interactive TV will allow the travelers to request to see the current location of their bus as it travels towards the bus shelter or bus station. Road-side signs will be posted at freeway exits leading to transit stations; these signs will inform drivers how much time they have to exit the freeway and catch the next bus or train.

DEPLOYMENT

Two elements of the Architecture are already appearing in the market **and** are creating a market pull for this Architecture. Tags are in use for toll collection, commercial vehicle weigh station preclearance, and transit vehicle tracking and communications. The first operational tests using these tags to perform the probe function are underway.

In parallel, the in-vehicle route selection/guidance systems have been demonstrated and first units are on the market. The first market area is the rental vehicle agencies who have customers who are unfamiliar with the area in which they are driving.

These first deployments will be followed by in-vehicle signing and broader availability of real-time traffic data (in operational test now). These deployments will provide the market pull towards full scale IVHS deployment.

MARKET

The in-vehicle computing needs will spark a second Personal Computer (PC) revolution. Vehicle manufacturers are beginning to think in terms of a computer architecture within the vehicle, one which will accept a range of hardware options. Software and databases, developed by independent vendors, will begin to appear to provide the driver/owner with features reminiscent of the PC software. The IVHS Architecture will benefit by an active market bringing lower costs and greater capabilities.

The wireless communications industry is entering its own revolution, similar to the PC revolution. The IVHS Architecture will benefit by an active market bringing lower costs and more robust radio products.

Installation of fiber optic communications (the “information super highway”) is accelerating dramatically, pushed by cable and phone companies. The Architecture takes advantage of this fiber optics revolution to provide the bandwidth for on-demand CCTV surveillance.

REGULATION-CLEAN AIR

The Architecture provides the means for measuring, at road sites, local air pollution and weather conditions, and vehicle speed, acceleration, and engine performance parameters. The TMC can respond with a pollution reduction strategy involving speed advisories, ramp meter timing, arterial signal timing, and, if necessary, road pricing.

THE SYSTEM IN OPERATION

Figure 3 shows a typical incident scenario and the Architecture's response to the incident

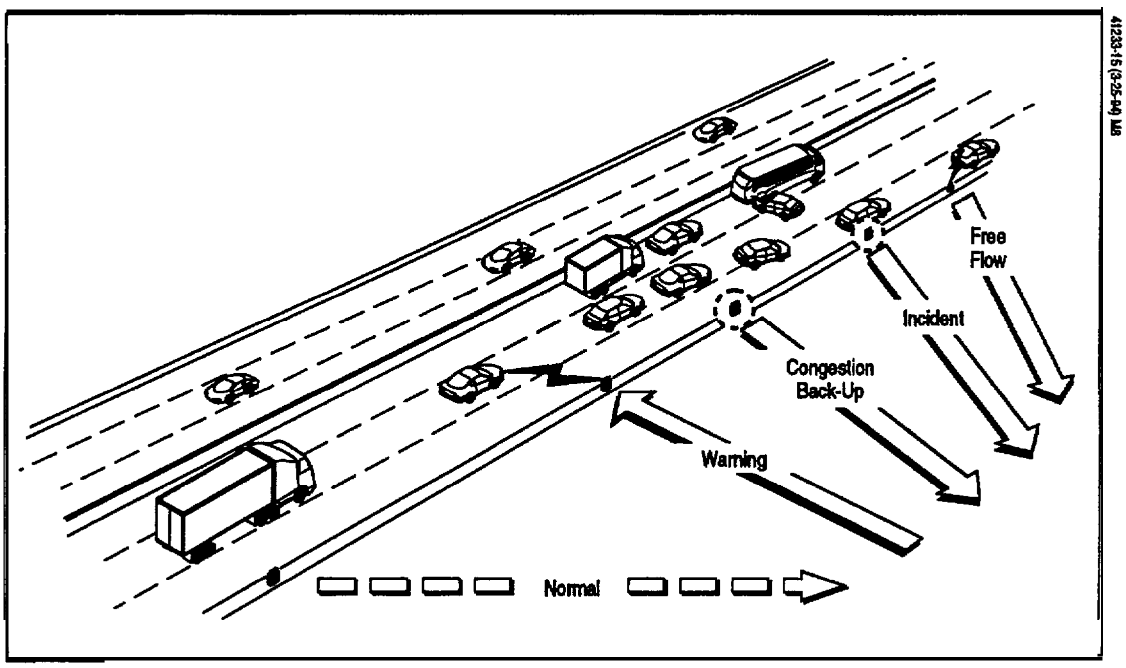


Figure 3. System in Operation

The scenario shows a 6-lane freeway with beacons (shown as small black boxes) along the road. The beacons shown in the dotted circles are "virtual" beacons, a distinction which will be explained below. The arrows indicate the flow of information between beacons and the TMC. One of the arrows is shown dotted to indicate that where road conditions are normal, only summary information is transmitted to the TMC.

The incident is a vehicle collided with a bus, blocking the two left lanes. Vehicles are beginning to back up behind the incident. They are very slowly funneling around the incident in the right lane. Two vehicles have cleared the incident and are suddenly accelerating to normal freeway speed.

The first vehicle to clear the incident is in range of a beacon. It transmits a superprobe message which reports that it is now in free flow, but that its speed had dropped from 60 MPH to 5 MPH 2/3 of a mile ago, and had returned to 55 MPH l/3 of a mile ago. From the TMC's viewpoint, it is as though there was a beacon l/3 mile back reporting an incident, and another one 2/3 mile back reporting the beginning of the back-up. These are defined as "virtual" beacons.

The TMC, receiving these virtual beacon incident messages, begins transmitting warning messages via up-stream beacons. The vehicle shown receiving a warning message will slow down and avoid causing a secondary accident. Vehicles further upstream will receive messages advising them to exit the freeway at the next off ramp, take an arterial street and re-enter the freeway at a particular on-ramp.

Whereas, conventional fixed surveillance sensors report traffic at fixed locations along the road, the TMC can program the vehicles to report exceptional conditions anywhere along the road they are traveling. Information is stored in the vehicle as it drives through an area of interest, and is accessed as it passes the next beacon.

The TMC also has control of the pre-processing of data performed at each level: vehicle, beacon, and Area Processor. Under normal traffic conditions only summary data is reported to the next level, but under abnormal conditions detailed information is provided to the TMC for situation assessment.

With the ability to program where data is collected, and how much data is collected, the TMC has the ability to dynamically focus its resources to work each incident. With the continuous collection of O/D and vehicle classification data, the TMC has the tools to optimize its traffic control plans. The Architecture specifies a dynamic, continuously improving Transportation System!

LORAL-IBM

INTRODUCTION

Loral, lead
IBM
Siemens
University of Michigan
Road Commision for Oakland County
New Jersey Highway Authority
Louis Berger and Associates
Ameritect

In this system concept overview, we will describe and explain the LORAL-IBM IVHS Architecture and the implications of our Architecture to various stakeholders.

To do this, we will share with you our vision of a ***fully-integrated*** *IVHS system.* It is a flexible, modular system that is based on existing institutions (agencies and services), used as building blocks. A system designed to share information and optimally coordinate transportation activities on the local, regional, and national levels. A system based on adaptive technology which we know can, and will, change over time to meet the ever-changing transportation needs of our country.

ARCHITECTURE PRINCIPLES

The principles of our Architecture are based on a simple fact: ***Each city, town, village and rural area in America is unique.*** And, while most of them share some problems in common, it is their differences that require a system that can adapt to the individual needs of each community. Thus, the Architecture must be flexible in these key elements:

- **Response to Local Transportation Needs**
- **Integration of Existing Agencies and Services (Institutions)**
- **Deployment**
- **Cost and Financing**

To be flexible and adaptive, our Architecture is Modular in design. The modularity allows individual elements to be added, subtracted, or altered, as needed. In this way, the LORAL-IBM architecture can deliver all IVHS User Services, with the following added benefits:

- It is *tailored to the needs of each community,* in both the public and the private sectors;
- It *invites and encourages private investment and participation;*
- It *builds on existing transportation facilities and institutions;*
- It offers *universal access,* with *low individual entry-level cost,* so virtually everyone can participate and receive benefits, immediately.

ARCHITECTURE OVERVIEW

The LORAL-IBM Architecture is based on the concept of a *Fully-Integrated Transportation System.* Multiple sources provide information which is gathered, processed, and disseminated. Each transportation system element (traveler, agency, company, vehicle, etc.) has access to all of the information it needs to perform its function in the best possible way.

The deployment begins at the local level, by creating a system which we will call a local IVHS District. We view the Traffic Management Center (TMC) as being the hub of IVHS activity at the local level. This, however, raises the question of the boundaries of a TMC-based IVHS District. While we talk about a national IVHS deployment, we by no means intend to imply that the transportation system of the nation will be managed by a single authority. For various institutional reasons, including local procurement practices, it is likely that a TMC will supervise a relatively small subset of the nation's roadways, from a few square miles to a maximum of a few hundred miles. In keeping with established partitioning of roadway authorities, there will typically be several TMCs in a major metropolitan area. However, it is important to *match the boundaries of an IVHS District with the boundaries of the problem. This* means that, as long as traffic within the jurisdiction of a particular TMC interacts with that of neighboring TMCs, our architecture will coordinate the function of these TMCs in order to achieve a harmonious delivery of their services through collaboration.

The diagram, Overview of IVHS District, shows a prototypical configuration. Here we see many elements that share information, such as Travelers, Public Transit (buses or fixed-rail systems), Vehicles, Emergency Management (commonly represented as the

911 emergency telephone service), Traveler Service (like AAA or a travel agent), Fleet Management (a car rental or trucking company), and others. The center of all this information processing activity is the Traffic Management Center, which collects and processes transportation information, provides traffic management of the roadways, and disseminates optimal transportation information to travelers and other transportation system agencies and companies.

The combination of all these elements interacting and communicating with each other defines the local transportation system (IVHS District). Each IVHS District is designed specifically to support local transportation requirements; *no two IVHS Districts are alike. This* is why the modular LORAL-IBM Architecture offers flexibility to change or alter not only the structure, but also the areas of responsibility, depending on the existing infrastructure.

One of the most significant contributions to the decrease of congestion in metropolitan areas is the increased use of public transportation. However, in addition to the American public's love for personal cars, there are many disincentives for using public transit. Some of them, such as price, are addressable through policy decisions which take into account regional transportation planning considerations rather than just operating costs of individual subsystems. Others, like information concerning public transit schedules, are correctable through the use of advanced information systems. In addition to providing the means for implementing regional transportation planning policies, our architecture provides:

- Improved on-time operation and timely information on public transit schedules to users, at trip planning time, to increase use of public transit;

- Improved public transit vehicle schedule adherence by coordinating traffic signals with individual vehicle routes;

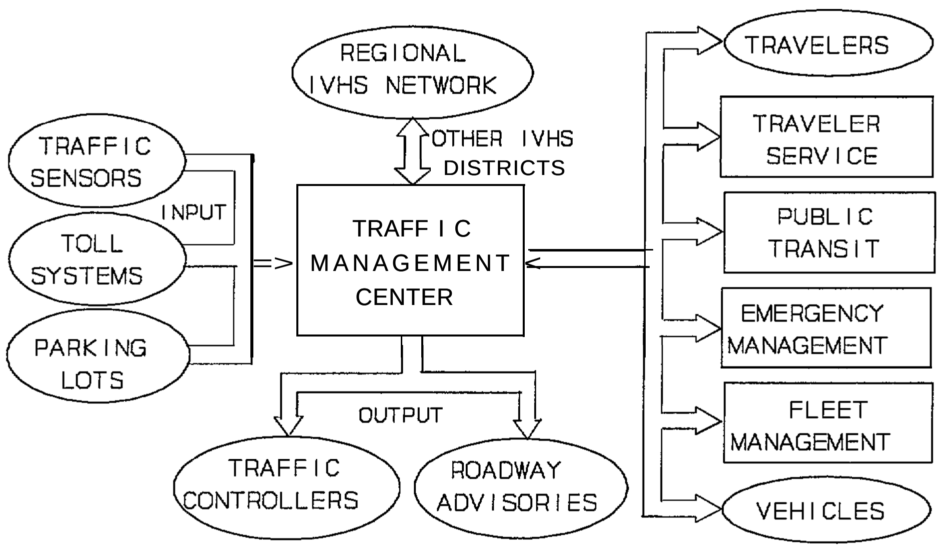
- Improved utilization of HOV lanes and other ride-sharing possibilities through ride-matching.

The architecture provides the means for coordination of transportation system issues, including Public Transit issues, at regional levels and even at higher levels including, for example, major multi-state transportation corridors. The illustration, Fully-

Integrated IVHS Architecture, diagrams the networking that creates a fully-integrated national IVHS Information Highway.

First, it is important that each IVHS District communicate with its neighbors. In the LORAL-IBM Architecture, this is not a problem, since they all use the same standard communicationsinterfaces. Through this communication, and by sharing information and coordinating regional transportation

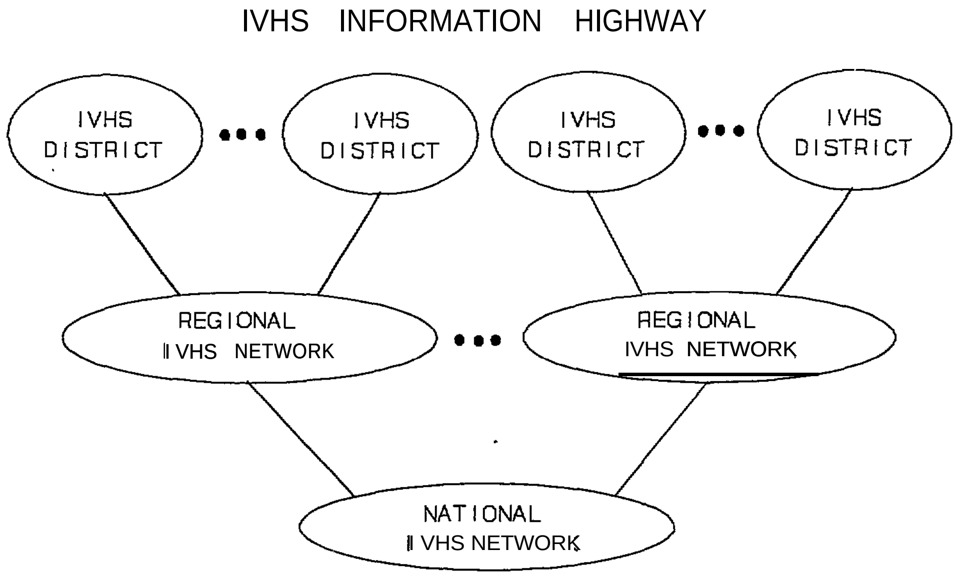
Overview of IVHS District



activities, a Regional IVHS Network is created. A region is defined as a set of IVHS Districts with transportation commonalities, such as the Detroit Tri-County area, the Philadelphia 5-County area, and so forth. This does not imply a requirement for any new regional authority, but simply the means to enable information-sharing and coordination at the regional level.

Within an IVHS region, the average driver will often pass through several IVHS Districts during a trip. The Regional IVHS Network presents a seamless view (offering the best possible information) of the complete route, since it is not limited by the boundaries of any District. But the Regional IVHS Network is important to more than just the casual traveler or even the

Fully-Integrated IVHS Architecture



habitual commuter. The scheduled routes of public transportation vehicles will frequently cross District boundaries, and paratransit vehicles may also pass through multiple Districts. Emergency vehicles - ambulances, fire engines, police - often must pass from one District to another, and must have the best, safest and fastest route, which can be different from one day to the next - often from one hour to the next. The communication capability between Districts within a Region provides the seamless view. Another function of the Regional IVHS Network is coordination and rerouting of traffic due to a traffic accident or construction.

Finally, each Regional IVHS is connected with all the others to form the National IVHS Network. The national network also fills specific transportation needs, including long trip planning. Further, commercial vehicles can receive other benefits. In addition to being given the most efficient, safest routes, interstate trucks can obtain pre-clearances, maintain an accessible file of safety checks and services, and automate much of the paperwork.

And, because the whole system communicates in both directions, an IVHS District can draw on national information sources to support local planning efforts.

In summary, the LORAL-IBM IVHS Architecture provides:

National Compatibility through the IVHS Information Highway, which provides a fully-integrated system;

Flexibility and Adaptability by building with existing transportation system elements, starting at local levels;

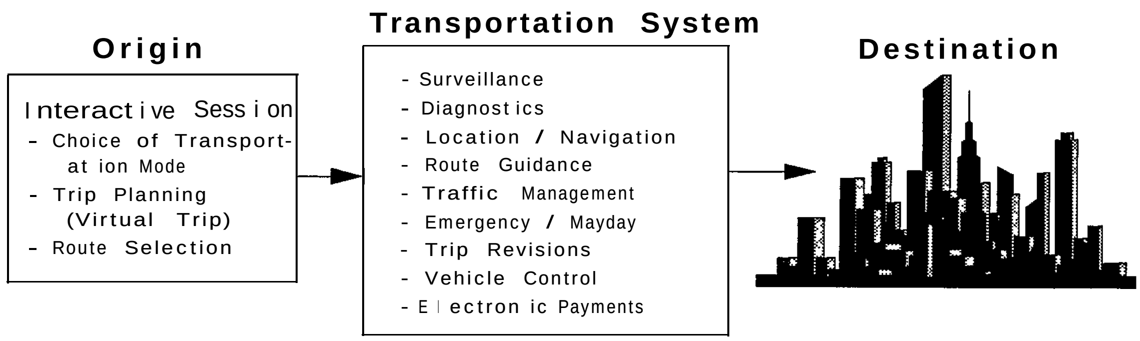
Modularity to allow the system to be tailored to the changing transportation needs locally, regionally, and nationally.

A FUTURE TRIP

Let us now take a look at a trip at some future time, when IVHS deployment is well underway, as illustrated in the figure A Future Trip. Before setting out on a trip, a user might modify a personalized profile that he maintains with a Travel Service Provider, then plan the trip aided by inputs from the system as well as information available at home, at a kiosk, or on-board the vehicle. A user might even examine a "virtual trip", playing out what the driver sees during the trip in order to get familiar with features that can provide bearings. This trip planning process takes into account the local terrain as well as historical records of traffic in the area, and any information available about current traffic conditions. At this trip planning stage, a user selects a route, or accepts a recommendation from the system. The selected route is compatible with reasonably accurate estimates of expected traffic patterns through the system that the TMC can produce on the basis of information received from both infrastructure sensors and other system users. This route is optimal in the sense that it minimizes contention with other drivers, and takes into account the predicted congestion.

Once a driver enters a vehicle into the traffic, the vehicle begins to transmit information to the system about road and traffic conditions. On the basis of this information, the system adopts appropriate strategies for deployment of traffic in the area, in a way that minimizes inconveniences to the users and offers

A Future Trip



alternate routes in congested situations. Total integration of IVHS services allows the coordination of traffic control signals for actual rather than assumed traffic streams, improving the efficiency of the overall system and smoothing the flow of traffic. At times of heavy traffic, the selected routes offered by the system provide the best possible mitigation of congestion for all users. At moderate levels of traffic, centralized route guidance is tied to adaptive coordination of traffic lights to achieve smooth, uninterrupted flow of traffic. Finally, at low traffic levels, the selected route becomes a personal “green wave”, allowing individual users to proceed through a sequence of traffic lights without stopping. Since the system knows the route of the vehicle, it gives the driver preferential treatment as long as there is no competing demand. Route revisions are implemented in response to emergencies such as roadway incidents. Mayday functions are an integral part of the system, activated automatically in case of major collisions, without the intervention of an incapacitated driver if necessary.

It is important to point out a key operating principle in the above scenario. Congestion occurs when the throughput of the system is not capable of handling the demands on the system. There are two things one can do to alleviate congestion: decrease the demand, or increase the system throughput. Many of the IVHS User Services address the first approach to the congestion problem, decreasing demand. For example, promoting the use of Public Transit and Paratransit, and all forms of Travel Demand Management, aim at reducing the demand on the system. On the other hand, other IVHS User Services address the throughput issues. For example, improved adaptive traffic control is intended to improve traffic flow characteristics, and thus the overall system throughput. Only anticipatory action by a central optimizing function, such as the TMC, can achieve global optimization, by extrapolating into the future and recommending routes for users that avoid congestion as much as possible. It may very well be that we will not be able to optimize traffic flow to totally eliminate congestion in every case. But by a judicious selection of individual routes, based on complete current and predicted information, distributing traffic across the system in a way that maximizes the use of available roadway resources, we can maximize throughput and thus reduce congestion.

ARCHITECTURE IMPLICATIONS

Now let's examine some of the implications the LORAL-IBM System will have on both the public and private sectors.

We said earlier that our approach to IVHS is based on an Adaptive, highly Flexible Architecture. In that context, the LORAL-IBM System will work well with the three key stakeholder groups involved in the IVHS Consensus-Building effort. It will:

- **Adapt to the *Community and Its Institutions***
- **Adapt to the *Needs of the People***
- **Invite and Encourage *Private Sector Investment***

Let's look at these groups, one at a time.

ADAPTING TO THE *COMMUNITY AND ITS INSTITUTIONS*

FINANCING

We are currently performing cost studies that will determine overall IVHS financial needs. At this time, it is clear that regional flexibility - the modular approach -will have a positive impact on the cost of the system. Since each local IVHS District will know its own needs as well as its own financial limitations, each District can be designed and deployed, accordingly.

The system starts by creating an information base, or pool, which will gather, process and disseminate basic traffic information. To do this, a basic system is created with public funds, which the federal government will help to finance. Integration of existing transportation system agencies will enable transportation system coordination. As the information pool grows, there will be increased participation by the private sector. Private companies, such as commercial carriers, private transportation companies and traveler service providers, will participate in the coordination of transportation system operations, will pay to access the information; many will resell it, for profit. It creates a public service supported by private enterprise.

Institutions & Organizations

This architecture not only encourages, but is dependent upon existing institutions and organizations to continue in their roles. It is the establishment of superior communication *among* them that helps each do its job better. For example, a 911 emergency can be handled faster and safer just by knowing traffic and road conditions. If a truck carrying hazardous waste overturns on a freeway, emergency vehicles and equipment can be moved quickly to the site. At the same time, traffic can be diverted to avoid the incident and can be given the safest route away from the hazard. Our Architecture is designed to bridge among all institutions. Yet, no one institution or organization will usurp another's authority; the architecture will simply help them all work together, as it helps each do its job better. An important premise of our architecture is that *pooling promotes partnerships.* Each participant puts in a piece; each gets back a whole.

Operations & Maintenance

Operations and maintenance responsibility is assumed to be retained by the agencies and companies which own and manage specific transportation facilities. It is anticipated that IVHS TMCs will be extensively automated, minimizing operational staffing needs. Emphasis will be placed on the use of commercial off-the-shelf (COTS) equipment wherever applicable, to avoid the typically high maintenance costs of specialized equipment. Our Architecture supports the consistent application of regional transportation pricing policies, and enables various fee-for-service collaborations with private investors, that can provide funds to offset operations and maintenance costs.

POLICY & REGULATION

The LORAL-IBM Architecture enables consistent application of transportation system policies, including safety policies, at local, regional and national levels, using the IVHS Information Highway for uniform access to policy information. Since the architecture gathers and communicates information up to the national level, it enables more efficient movement of interstate trucks, and includes provisions for authorities to remotely access commercial vehicle and professional driver records. This helps identify repeat offenders, and aids the enforcement and implementation of commercial vehicle regulations.

ADAPTING TO THE NEEDS OF THE PEOPLE

EQUITY Virtually anyone can access the LORAL-IBM IVHS System. At the entry level, a car radio or Radio Data Set will provide the basic in-vehicle service to drivers; people at home or work can access travel information using telephones, fax machines, information kiosks, personal computers, interactive TV sets and other means. Advanced in-vehicle systems will provide increased access levels that will be important for many business and commercial applications (delivery services, realtors, sales representatives, repair services, etc.). People who do not choose to access will still receive some benefit, since traffic in general will flow more freely, with less congestion. While each region can build at its own rate, due to the modularity, every region with IVHS deployment of *any* system will have access, because all system elements together create a national network.

PRIVACY There is no mandatory participation required of any citizen with respect to his or her privacy. IVHS should be viewed as a *subscription* rather *than* a *participation service. Our Architecture* will provide for safeguarding of any personal or private information within the System, including locations and records of commercial vehicles, and financial transaction information associated with electronic payments of tolls, fees and fares. These safeguards will be implemented using advanced, secure, encryption and authentication techniques.

SAFETY The LORAL-IBM Architecture defines requirements for Fail-Safe, Fail-Soft., and Graceful Degradation. Layers of protection will be built into the implemented IVHS System such as redundancies and backups of critical information.

INVITING & ENCOURAGING *PRIVATE SECTOR INVESTMENT*

MARKET A major concept of *our* Architecture is *this: The greater the level of participation and interconnection, the better it gets.* We know from our modeling and simulations that, while the basic System works well, as more vehicles are equipped as probes the System will work better. When public busses, commercial trucks, fleets, and other users participate, the overall availability of information increases significantly. More users means more information, which creates a better System. Our studies show that the capacity to disseminate this information (using digital cellular communications, beacons, etc.) will far exceed the demands.

The LORAL-IBM Architecture will strongly encourage development of the IVHS Industry, because we are identifying the necessary and correct standards to assure IVHS suppliers that their investments in products and services will address a broad market. Our Architecture will appeal strongly to independent service providers who will purchase information, develop new products and services, then sell them, often back through the System, to subscribers. We anticipate the rapid growth of a U.S. IVHS industry serving a large international market which will encourage competition among product and service suppliers.

DEPLOYMENT

The LORAL-IBM Architecture is simple to comprehend and implement because it is built by networking existing transportation system elements using available communications capabilities. The concept is to interconnect transportation system agencies, companies and users in order to share information, enable coordination of transportation functions, and deliver the full set of IVHS User Services. The architecture will encourage early product development and deployment and will attract value-added service providers.

Our Architecture is *flexible* in terms of how, when, and in what order the various elements of the system are installed or interconnected; it is necessary only to establish the TMC in order to create a viable IVHS District. Because the System is *modular,* each District can evolve in stages. And because the needs of each community are different, the priorities can be identified and addressed, autonomously.

STANDARDS

Our Architecture defines needed requirements for performance and interface standards. But it does not *invent* new standards unnecessarily if existing standards can be applied. For example, it is expected that IVHS communications standards will, in most cases, be based on existing computer network and communications protocols. New or revised standards may be required for interfaces between vehicles and roadway systems, or between roadway systems and TMCs; requirements for these standards will be established by the Architecture. The Architecture will specify requirements for critical aspects of IVHS performance, system databases, traffic modeling, and so forth. Initial IVHS standards will evolve over time, and the IVHS industry will build on these standards.

LORAL-IBM IVHS ARCHITECTURE SUMMARY

The LORAL-IBM IVHS System Architecture is *adaptive, flexible, and modular*, and *invites and encourages both public sector and private sector participation.*

ADAPTIVE

It begins at the local level by acknowledging the differences among individual cities, towns, villages and rural areas. It allows each local area to design an IVHS District system unique to its own transportation demands and requirements.

FLEXIBLE

Each area can set its own priorities and build its own IVHS District based on those priorities, adding User Service features on an as-needed basis as financing becomes available.

MODULAR

Each IVHS District can add User Service capabilities as needed, using modular building blocks defined by the architecture.

INVITES PARTICIPATION

Since federal and local public funding will typically be employed to seed the initial deployment of local IVHS Districts, and since the information-sharing and cooperative operational benefits of participation by various public sector and private sector agencies and companies are expected to far outweigh the costs, our Architecture will invite and strongly encourage participation by these various transportation system elements.

Finally, it is designed to work with the existing infrastructures while enabling them to grow; it fully utilizes existing Institutions as part of the network; it has been created by a team of world leaders in the design and deployment of IVHS Systems.

ROCKWELL INTERNATIONAL

PHILOSOPHY

Rockwell International, lead

Apogee Research
California PATH
California DOT
George Mason University
GTE Laboratories
Honeywell
Iowa State University

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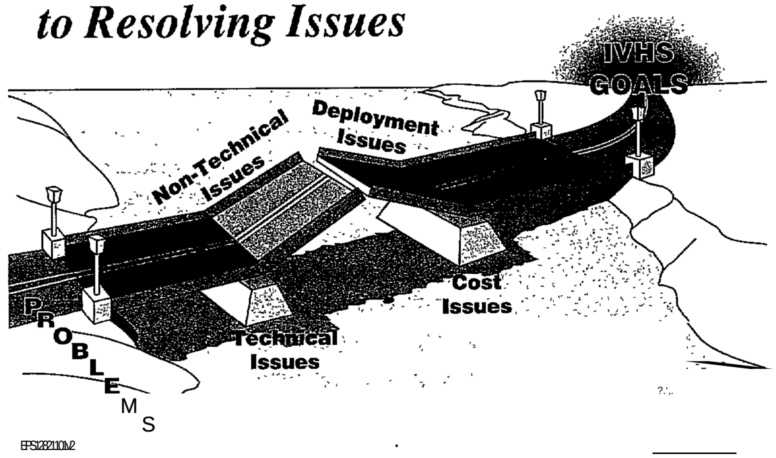
Framework designed to integrate all modes of transportation

The Rockwell Team's approach to the development of a national system architecture stresses an unbiased, balanced approach. Unbiased in that we are not promoting one particular technology over another and balanced in that technical, non-technical/institutional, deployment, and cost issues are given equal emphasis in the development process. Technical and cost issues form the foundation to achieve the IVHS goals, whereas the amenable resolution of non-technical/institutional and deployment issues will determine the social and organizational acceptance of IVHS. Without a balance, the full benefits of IVHS technologies will not be achieved.

The overarching goal of the Rockwell Team's architecture development effort is to map out a low-risk, high-benefit approach for the implementation of an architecture framework. The architecture framework will integrate all modes of transportation (airplanes, ships, rail, buses, trucks, cars, etc.) to equitably benefit users and the national economy through the safe and efficient movement of people, goods, and information with less congestion, less pollution, greater safety, and greater energy efficiency, while maintaining the privacy of individuals and corporations. In the near term, the architecture will help speed up the introduction of IVHS technologies, and in the long term, it will create an IVHS industry and support a sustainable, evolutionary, and highly productive transportation system.

The Rockwell Team's underlying philosophy is to develop an architecture that is highly robust and flexible, providing an accommodative, open framework that efficiently supports user service functionality while addressing the needs of transportation planners, implementors, operators, maintainers, service providers, IVHS product developers, and ultimately the users. The architecture is being developed to allow the widest possible range of options, stressing

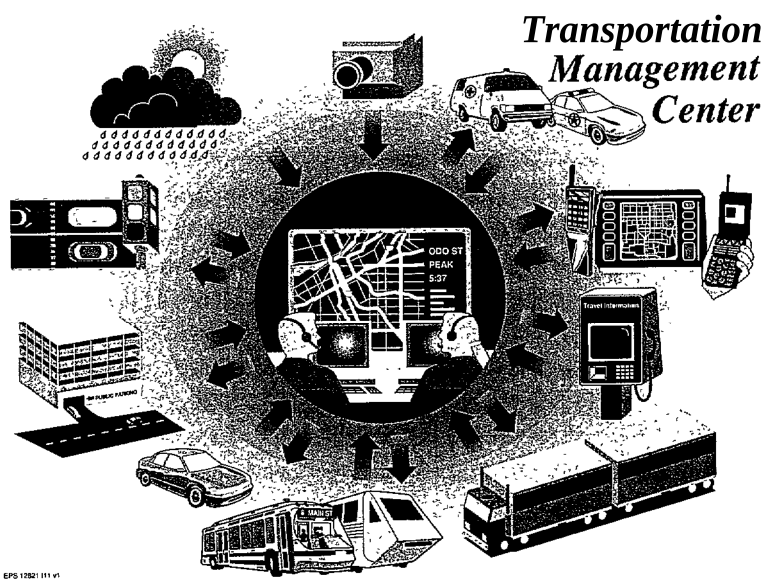
Rockwell Team Approach Stresses an Unbiased, Balanced Approach to Resolving Issues



compatibility and interoperability where required. This flexibility permits the accommodation of existing transportation infrastructure, as well as a wide range of future uncertainties, including: advancements in technology, changes in non-IVHS government policies, changes in individual/societal values, and changes in the economy and demography of the nation and its diverse regional parts. The Rockwell Team's architecture seeks to accommodate diverse users, providing viable options to all sections of the nation and their varying transportation needs. State, regional, and local agencies will be able to select the technologies, services, and system implementations that best fit their local values and requirements. This flexibility provides attractive opportunities for the private sector, paving the way for pubic/private partnerships that will speed up the deployment of IVHS technologies.

Transportation Management Center

The intermodal Transportation Management Center (TMC) is the major building block of the transportation system. It provides the foundation for many of the present 28 user services, integrating and disseminating information to provide the necessary user service functionality. In the Rockwell Team's architecture, the user service functionality has been distributed across modular subsystems. The modular subsystems have been defined in an implementation independent manner and structured to present a general purpose interface to the remainder of the system. Flexibility in the distribution of functionality within the infrastructure, supports distributed, centralized, and hybrid system configurations for TMCs, while accommodating interagency/inter-jurisdictional coordination and/or region-wide TMC system control. The flexibility of the architecture provides a readily accessible path for incremental growth of a TMC's capabilities. By specifying interfaces, not an implementation approach, the architecture is sensitive to jurisdictional preferences and needs and their desire to maintain their autonomy and maintain control over their facilities, even though they may be a part of a coordinated, interagency transportation system. As needs expand, the architecture supports the addition of



Architecture flexibility driven by sensitivity to jurisdictional preferences and needs added capabilities through replication and permits system upgrades without extensive equipment changes by minimizing the architecture's sensitivity to technological variability and evolution. Enhanced reliability, maintainability, and graceful degraded mode system operation are inherent in the modular subsystem approach.

The communications architecture framework that links the modular subsystems supports several communication technologies and accommodates both wide-area and short-range information transfers. The wide-area element includes wireline and wireless communication technologies, and will incorporate both existing and emerging communications infrastructures. Factors being considered in the selection process include: market adoption, uninterrupted, seamless coverage, spectrum efficiency, security/privacy, acceptable user/provider costs, and the flexibility of two-way information exchanges. Although the wide-area communications element focuses on extensive two-way information transfer mechanisms, it will also include simple broadcast capabilities, such as those used for disseminating highway advisory messages.

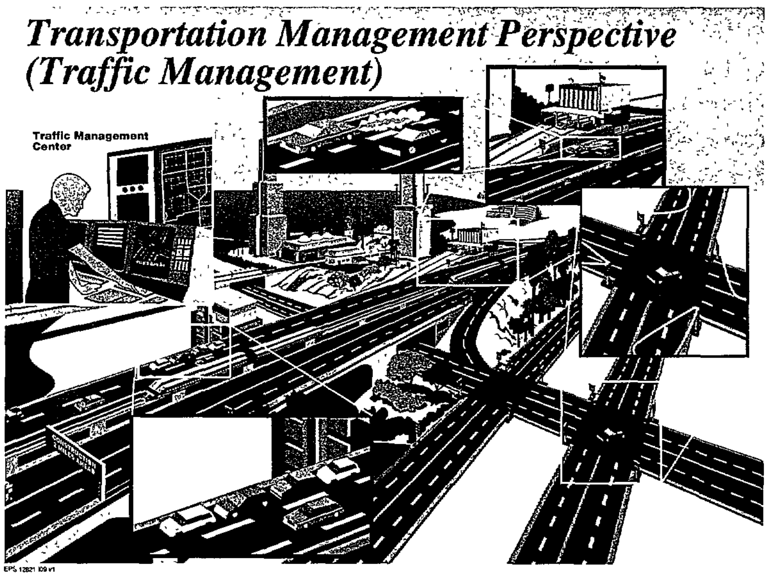
Short-range wireless communications have been divided into two distinct elements. The first element covers the mobile-fixed air-interface, such as tag readers for electronic toll collection or commercial truck operations. The mobile-fixed air-interface may or may not share spectrum with other applications. The second element covers the dedicated mobile-mobile air-interface, such as the critical inter-communications between automated vehicles. Frequency and bandwidth allocations must be set aside for short range communications, as well as message format and protocol standards to support nationwide compatibility and interoperability.

TRAFFIC MANAGEMENT PERSPECTIVE

> *Architecture supports and enhances* ***existing infrastructure***

Many Traffic Management Centers today are implemented using proprietary, centralized traffic control systems that are vendor-specific in terms of hardware and software. In general, these systems operate independently, without a means for sharing information with other systems. In the Rockwell Team's architecture approach, provisions have been made to interface to existing infrastructure systems. Through the application of filters, existing infrastructure systems can interface with the system architecture by first translating the information to be exchanged into the format and protocol specified by the architecture standards.

In the Rockwell Team's architecture, the detection, surveillance, communication, and computing capabilities of the Traffic Management Center are utilized to verify and enforce access to high occupancy vehicle (HOV) priority facilities, to perform remote sensing of vehicle emissions, to collect flexible tolls, to perform traffic management and intersection collision avoidance functions, and to control the access and



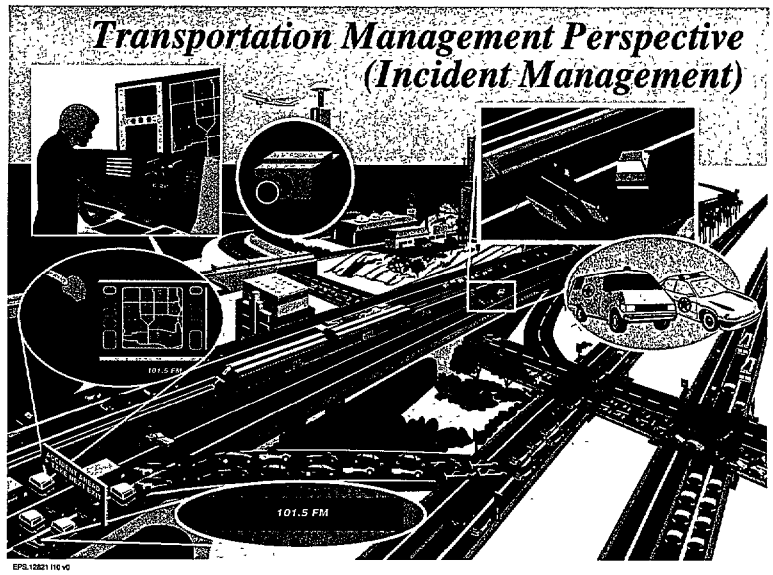
operation of properly equipped vehicles on the Automated Highway System (AHS). Information collected by the Traffic Management Center will be archived for future use in supporting planning and the establishment of land use policies.

In some parts of the nation, emergency vehicles and selected transit vehicles are being "green waved" through selected traffic corridors as part of HOV priority operations. The Rockwell Team's architecture extends this capability to other HOV modes of travel. Enforcement functions have been included to prevent abuse.

It is estimated that fifty per cent of the vehicle-based air pollution is produced by less than ten per cent of the vehicles on the road. The architecture support the use of road side monitors to detect and identify "gross air polluters" and notify them to bring their vehicles in for inspection. Using an "exception" rather than a "rule-based" inspection system has the potential to be more effective and less expensive in managing the pollution generated by vehicles.

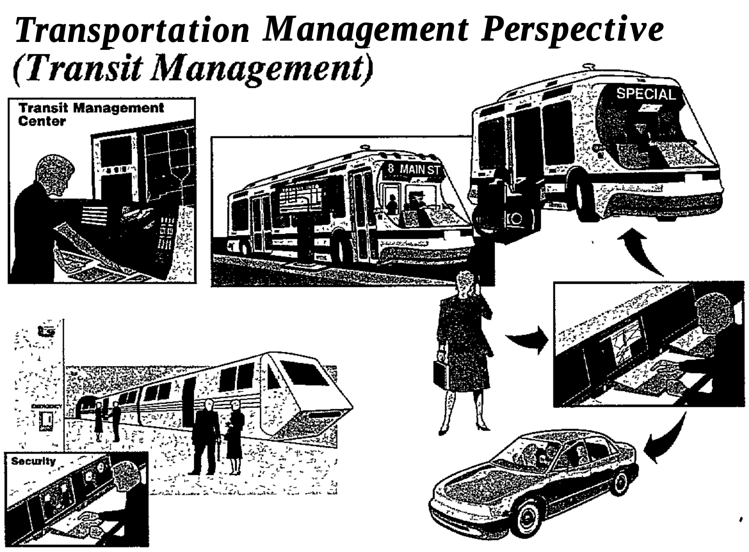
INCIDENT MANAGEMENT PERSPECTIVE

The Rockwell Team's architecture supports the use of MAYDAY transmissions and an array of sensors and phoned in reports to detect and verify incidents. It supports operator initiated or automatic dispatch of police, fire, and paramedic emergency vehicles. Public service broadcasts are sent out over radio, TV, and Highway Advisory Radio (HAR), with information on suggested alternate routes. Value added service providers and/or public transportation authorities would update traffic reports and affected intermodal schedule information. Traveler's would access the information at kiosks, over computer networks, from in-vehicle displays, over the vehicle's entertainment system, and through the telephone network, cellular, or personal communications services (PCS). The TMC would use changeable message signs (CMSs) to direct travelers away from the affected area and to inform them of alternate routes. For those vehicles equipped with route guidance systems, the TMC would temporarily control the routing to balance the demand over the arterials parallel to the affected stretch of the freeway. By optimizing the network operations, vehicles diverted off the congested highway could then be "green waved" through the arterial network.



TRANSIT MANAGEMENT PERSPECTIVE

From the transit management perspective, the Rockwell Team's architecture integrates the traveler, travel modes, field sensors and detectors, traffic control devices, fare and toll collection components, and transit vehicle monitoring sensors for complete transportation systems management and modal integration. Functionalities have been provided for computer-aided dispatching, computer-aided service restoration, and transit vehicle service monitoring. Service monitoring has been further decomposed to support vehicle position determination, schedule/route adherence, collection of ridership data, vehicle operational/component status, plus the gathering of various statistical data. Current position location data is used to determine schedule performance. Through coordination with the TMC, the architecture supports transit vehicle traffic signal preemtion to improve on-time performance. Real-time position information is passed to the Traveler Services Information database where it is accessed and conveyed to the traveling public through pre-trip and en-route travel information systems and displays. Service providers have access to the same database and provide value added services to their subscribers. All collected data is archived for future use in planning routes and establishing schedules that best support the public and to assist in scheduling maintenance and the completion of management reports.



The Rockwell Team's architecture is being structured to support three levels of public transportation. They are fixed route, flexible route within a corridor, and full demand-responsive (paratransit) feeder service. The three levels are coordinated using on-board vehicle navigation equipment and wide-area communications to assist dispatchers in identifying vehicle locations, in guiding drivers to demand pick up points, and to time transfers. Users would use existing telecommunication services to determine the available modes of travel, schedules, location of pick up and transfer points, the time of arrival at the desired destination, and to make reservations. Provisions are made in the architecture to support user profile databases to support paratransit operation and personalized public transportation.

Architecture emphasizes Public Transit/HOV *Travel*

Carpools and vanpools still play an active part in reducing highway congestion during peak travel hours. They have the added benefit of reducing the cost of the commute to the participants. The architecture supports the storage of user profile information to facilitate carpool/vanpool ride matching.

The architecture also supports real-time rideshare matching. Provisions have been made in the architecture to place the user profile information for pre-qualified participants in a database. The database is searched each time a trip request is made to determine if other participants in the program are traveling in the same direction and at the same time.

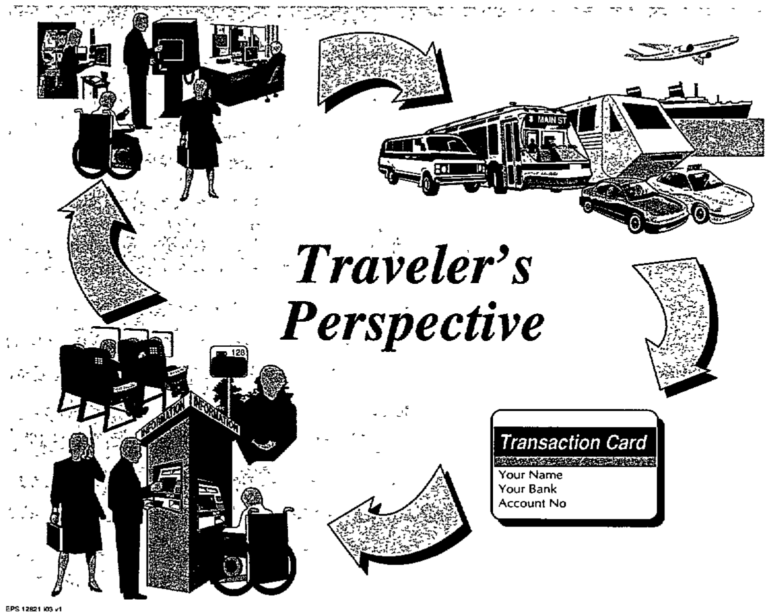
The automobile separates its passengers from the surrounding environment, providing a perception of security and personal control. Public transit must establish the same atmosphere of security and control if ridership is not to be negatively affected. The architecture addresses the issue by providing the functions of surveillance and traveler emergency notification. It supports emergency notification from entry devices located throughout the infrastucture or through personal communications services (PCS).

Traveler's Perspective

In 1973, there were on average 1.94 travelers per each vehicle mile driven. In 1991, that ratio had fallen to 1.62. Similarly, in 1973, there were on average 12.16 passengers per bus mile driven, whereas in 1991, that ratio had fallen to 9.69. Clearly, the use of ride sharing and public transit has declined. The lack of real-time sources of reliable information for travel options and modal combinations has contributed to the problem. Awareness that public transportation is a reasonable alternative to private vehicles as the preferred mode of travel is expected to lead to its increased usage. Moving travelers from single occupancy vehicles to public transit and/or HOV will provide the greatest pay back due to IVHS technologies in terms of reduced congestion and reduced levels of travel generated pollution.

Integrated, real-time transportation information encourages multi-modal travel

The Rockwell Team's architecture supports the concept of Smart Traveler technologies. Smart Traveler technologies provide open access



to real-time sources of information on all modal transportation choices. Smart Traveler applications generally fall into three service categories: Pre-trip Travel Information, En-Route Travel Information, and Traveler Services Information.

PRE-TRIP TRAVEL INFORMATION

Pre-Trip Travel Information will be available at home, work, transit stations, and at a variety of other locations to help the traveler select modes of travel, schedule, and route decisions prior to departure. The architecture supports the information being provided through a public agency and/or private service provider. Information can be accessed by all through existing and planned telecommunications services including: in-home interactive TV, computers, personal data assistants, telephones, mobile phones, information kiosks, and personal communications services (PCS). Information relating to modal choices, transit routes, schedules, transfers, fares, and the availability of ridesharing opportunities will be stored in a shared database. Included in the database would be information covering real-time updates on incidents, accidents, construction and alternate routes, traffic speeds along specified routes, predicted travel times, parking availability and reservation, event schedules, and expected weather conditions. Access to basic information, such as modal choices, transit routes, schedules, fares, etc., would be provided free. Value added services, such as personalized trip planning, would be charged a fee for use. The architecture supports the payment of fares for all modes of travel, parking, and information services using an electronic Transaction Card.

EN-ROUTE TRAVEL INFORMATION

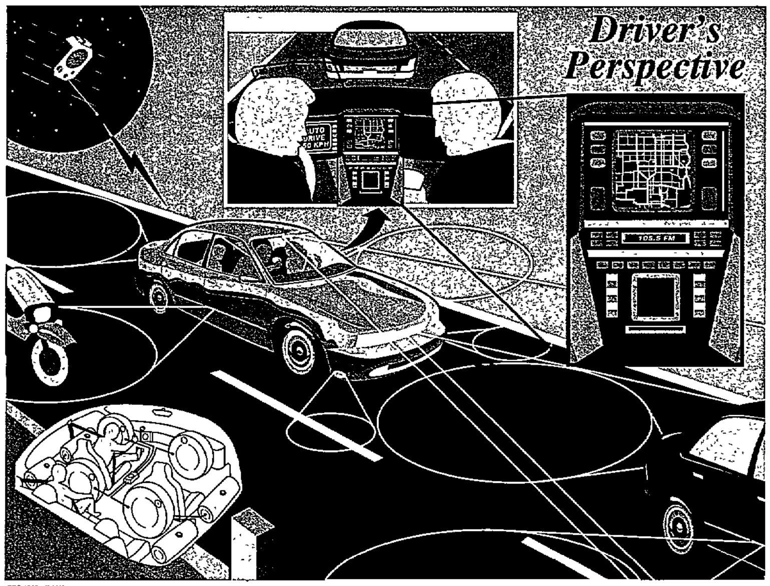
The architecture supports En-Route Travel Information in much the same way it supports pre-trip planning. While en-route, the traveler could interface with the information database through the same wireless media used previously, as well as through interactive displays provided at transit stops and on-board transit vehicles. A range of access options would be available to the user from basic schedule information provided at no fee, to extended, personalized service provided on a fee for use basis.

TRAVEL SERVICES INFORMATION

The architecture provides the functions to support Traveler Services Information. The traveler could access the service in the same way Pre-Trip and En-Route Travel Information is accessed. The Traveler Services Information, which includes electronic profiles for a range of service providers, is integrated in the architecture with other information available to the traveler. Access to this integrated information would support the traveler in making dynamic planning decisions which would allow the traveler access to desired and/or required services along the optimum routes. These services would be primarily developed and operated by the private sector. Access would be on a fee for use basis or costs could be recovered through listing of businesses, etc., similar to the telephone yellow page listings.

Driver's Perspective

The Rockwell Team's architecture supports the vehicle-to-infrastructure and vehicle-to-vehicle interfaces/communications required for automated vehicle operation and implementation of collision avoidance

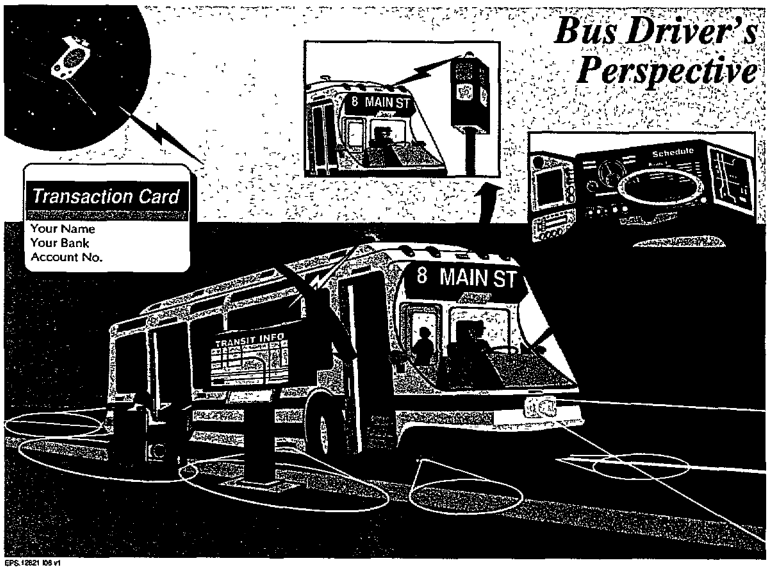


technologies, automatic vehicle identification (AVI), automatic toll collection, demand pricing, MAYDAY notification, safety readiness checks, route guidance, and access to Traveler Services Information and En-Route Travel Information service providers. The in-vehicle communications package includes the wide-area element, as well as both the short-range mobile-fixed air-interface and mobile-mobile air-interface wireless communications elements. Highway Advisory Radio (HAR) broadcasts would be received over the vehicle entertainment system.

In one approach being examined, the advanced sensors for collision avoidance applications, collision restraint devices, AVI, communications, position location, and route guidance hardware, including map databases, would be purchased with the vehicle. Position location would be provided through the Global Positioning System (GPS). The route guidance hardware in the vehicle would operate in one of three modes. Route guidance could be purchased from a service provider, provided by a TMC during periods of heavy congestion, such as following an accident, or performed within the vehicle with updates on traffic conditions being provided by digital communications with the infrastructure detailing link status changes. A basic set of services, such as MAYDAY notification and receipt of HAR messages, would be packaged in the standard vehicle equipment package and made available as an after market item for older vehicles.

Bus Driver's Perspective

In the Rockwell Team's architecture approach, technology applicable to vehicles is also directly applicable to transit vehicles. The transit vehicle would be equipped with both wide-area and short-range communications. Location data would be supplied by GPS. Route guidance could be controlled by the Transit Management Center, a service provider, or on-board the transit vehicle, depending on preferences and needs. Real-time traffic update inputs would be provided by the local/regional TMC. The transit vehicle would be equipped with automatic passenger counters, vehicle diagnostics, electronic Transaction Card readers, automated demand-responsive dispatch systems, on-board automatic guidance and collision avoidance/warning equipment, alternate fuel/propulsion systems, automated wheel chair docking equipment, and precision transit vehicle positioning sensors to facilitate easy access for handicapped riders.

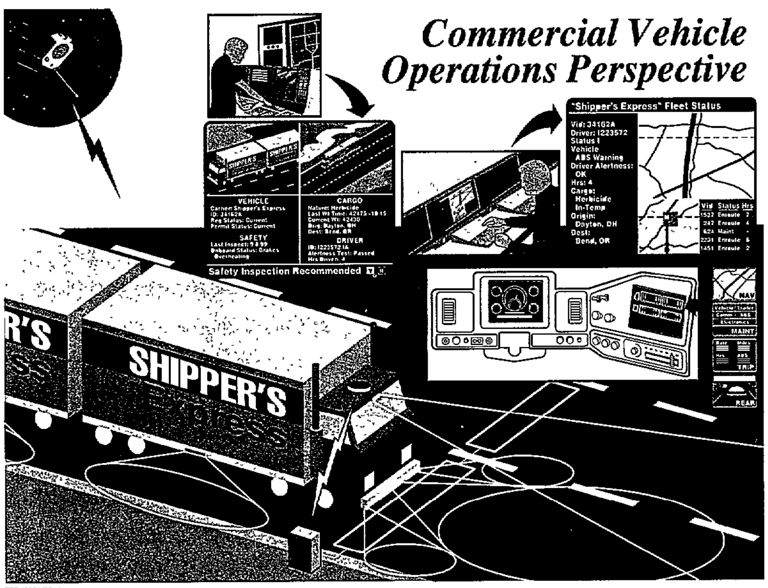


Commercial Vehicle Operations Perspective

Flexibility addresses state regulators and trucking needs

In 1991, trucks accounted for 28.8 percent of traffic fatalities, a number whose percentage has been slowly increasing over the past 11 years. The percentage of truck vehicle-miles driven on rural highways, as compared to urban highways, has decreased from 54.6% to 48.1% over the same 11 years. As urban/suburban areas continue to expand and commercial vehicle driving increases in these areas, the impact of the IVHS User Services on the Commercial Vehicle Operations (CVO) function will have major socio-economic benefits.

The architecture looks at both the short-haul and the long-haul CVO user service perspectives. Trucking operations in these two areas have similar as well as unique requirements. The short-haul provider is interested in trip planning, local dispatching and rerouting, local area congestion, and electronic toll service. The long-haul provider is interested in several short haul services, however he is also interested in automatic safety and load inspection at port of entry/state line crossings, weigh-in-motion, optimum load/mileage dispatch information, improved reporting (less paperwork) for tariff fees settlement, and vehicle safety monitoring and maintenance scheduling. The Rockwell Team's architecture identifies the critical, short-range vehicle to infrastructure communications interface without constraining the company's options for wide-area communications between the vehicle and its own operations center (dispatcher). The vehicles will be equipped with sensors for headway holding, lane holding, blind spot and rear viewing/backing imaging to provide the driver with improved safety. The vehicle will have route guidance capability. It will be provided either in the vehicle, through the operations dispatcher, or from an external service provider. The architecture will be flexible in allowing the market to decide the most cost effective way of providing this service and will only define the necessary interfaces that are required for interstate operations.

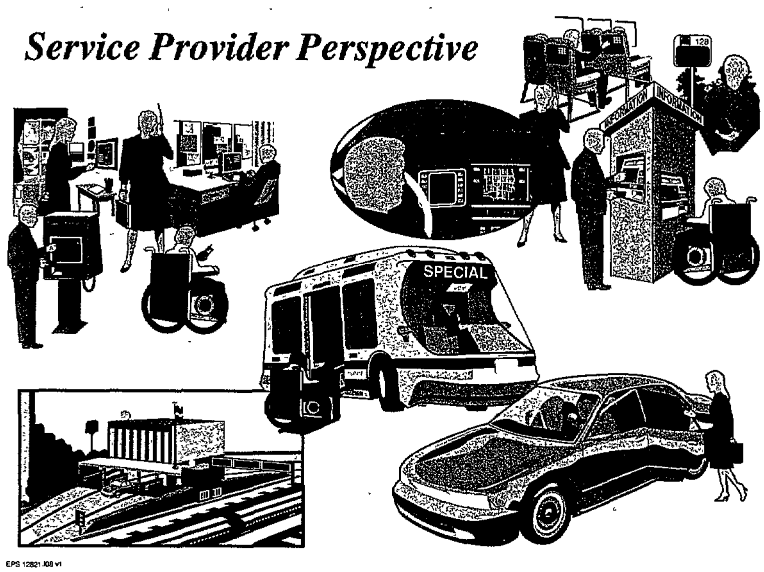


Short-range wireless communications between the vehicle and the roadside are used for credential checks, driver status, rolling vehicle safety inspections, as well as mileage reporting and state tax payment. For interoperability, the Rockwell Team's architecture will recommend a standard information protocol for electronic transferring of information between the vehicle and the roadside for nonstop vehicle operation. In addition, the architecture will recommend a standard for HAZMAT reporting.

Service Provider Perspective

Market forces not architecture mandates will drive private service provider participation

Service Providers supply information to travelers to allow them a choice in mode of travel, route, schedule, cost, and access to services to enhance the convenience and enjoyment of the trip. Service providers are likely to have the most significant presence in Traveler Service Information, Route Guidance or En-route Driver Information, Electronic Payment, and personalized public transit.



Ultimately, some Service Provider participation may take place in all of the user service areas. Market Forces, rather than architecture mandates, will drive ultimate participation. The architecture provides a framework that creates opportunities for private and public service providers alike, so that the most efficient solution that meets a region's values and needs is achieved.

Summary

The Rockwell Team's approach is to provide an open and flexible architecture framework which balances the cost-benefits of deploying IVHS technologies against any potential disbenefits to the environment and society. It is sensitive to the diverse preferences and needs of users across the nation and it provides incentives for public/private partnerships.

The Rockwell Team's approach is to ensure that the sum is greater than the parts by leveraging commonality and capitalizing on the synergism between services. These advantages can be achieved through concentrating on interface definitions at the very highest level — between Traffic Management, Transit Management, Emergency Management, Traveler Information centers, and the end users. By keeping this emphasis on high level interfaces, the architecture supports a wide range of existing implementations without being constrained as technology evolves beyond what is known today, at the same time maintaining the most important architecture benefits.

The architecture framework minimizes mandated constraints on system design while promoting technology enhancements and service expansion. Its goal is to provide improved safety, reduced congestion, reduced generation of pollutants, and encourage technology market expansion.

WESTINGHOUSE ELECTRIC

Westinghouse Electric, lead

Bell Atlantic Mobil Systems
Calspan
Florida DOT
University of Florida
Harris
Frederic R. Harris

The Westinghouse Team's architecture satisfies the functional requirements of all user services while providing the following unique features to help solve the nation's short and long-term transportation problems:

- Maximize the people-carrying capacity of the transportation system by enhancing transit, paratransit, and HOV usage
- Provide cost-effective methods for traffic management and incident management
- Promote widespread usage of traffic emergency notification (Mayday) using low-cost technologies
- Enhance interagency coordination while preserving the operational autonomy of individual agencies
- Minimize in-vehicle equipment costs to promote widespread usage of traveler advisory information
- Reduce commercial vehicle regulatory enforcement and compliance costs and facilitate intermodal freight transportation
- Maximize opportunities for public/private partnership in IVHS infrastructure investments
- Maximize opportunities for privatization of relevant IVHS user services

To support these functional features, we have developed a list of relevant technical features (see Table 1) from which our candidate architecture was designed. The rationale for providing these functional features is as follows.

Maximize people-carrying capacity of the transportation system by enhancing transit, paratransit, and HOV usage. In 1989, approximately 70% of peak hour travel along urban interstate highways occurred under congested conditions.' "Projected traffic growth, coupled with the difficulty of providing adequate additional lanes for new capacity, suggests that congestion will continue to be a major issues in many metropolitan areas."2 To combat urban traffic congestion, the use of transit and other high-occupancy travel modes must be encouraged. Today, unfortunately, there are not enough people using transit (only 5% of work trips are carried by public transportation3) or other forms of ride sharing (the average vehicle occupancy is 1.12 persons per vehicle4 in 1990 and falling).

Some of the underlying problems for this mode-choice imbalance are the low-density land use patterns that exist and the deteriorating transit service reliability and efficiency. To reverse this trend and encourage mode shift from single-occupancy to high-occupancy travel modes, we should attempt to **bring people to transit systems** and, at the same time, improve the transit operational efficiency. Our operational concept is to use paratransit services to feed mainline transit services. The major requirements to support this concept include:

- A real-time, accurate transit traveler information system to help reduce passenger wait times and to change the perceived unreliability and unpredictability of transit services.

- A Computer Aided Dispatch and Automated Vehicle Location (CAD/AVL) system to help track transit and paratransit vehicles to maximize their responsiveness to the travel demand and to provide real-time transit service information to the customers (Figure 1).

- Smart cards to provide billing conveniences and ease of intermodal travel. With this travel fee payment method and the proper protection of the user's privacy, trip origin and destination information may also be collected to enhance transit systems planning.

FUNCTIONAL FEATURES	TECHNICAL FEATURES
Maximize the people-carrying capacity of the transportation system by enhancing transit, paratransit, and HOV usage	. Computer Aided Dispatch/Automatic Vehicle Location for transit and paratransit fleet management Route and schedule adherence tracking Adaptive (dynamic) routing and scheduling . Smart card for multimodal transportation debit/credit card and trip origin-destination data collection . Transit user information system Compatible with home and office equipment Personal Communications Device Static and dynamic information . Multi-role paratransit Transit feeder operations during peak periods Demand-responsive operations during off-peak periods Local merchandise delivery during off-peak periods . Low-cost, zero emission electric transit and paratransit vehicles
Provide cost-effective methods for traffic management and incident management	. Low-cost, over-head mounted local area detectors & sensors . Wide-area traffic sensors . Traffic incident management aircraft
Promote widespread usage of traffic emergency notification (Mayday) using low-cost technologies	. Cellular Telephones . Cellular System Infrastructure for Vehicle Location . Low-Cost Manual and Automatic Mayday Transmitters
Enhance interagency coordination while preserving the operational autonomy of individual agencies	. High-speed data link . Information security and privacy . Database management
Minimize in-vehicle equipment costs to promote wide-spread usage of traveler advisory information	. Digital Audio Broadcast . Radio Data System-Traffic Message Channel . Home and office communication devices for pre-trip planning
Reduce commercial vehicle regulatory enforcement and compliance costs and facilitate intermodal freight transportation	. Weigh-in-motion . Computer Aided Dispatch/Automatic Vehicle Location for fleet management . Trip Planning . Electronic Data Interchange (EDI) . Point of Sales (POS)
Maximize opportunities for public/private partnership in IVHS infrastructure investments	. Establishment of Transportation Information Exchange Node and its parent network at the state and interstate level . Communications network for multimodal Traveler Information Services
Maximize opportunities for privatization of relevant IVHS user services	. Traveler service info., trip planning, and route guidance . Road user fee collection . Commercial fleet tracking and credential management . Dynamic ride sharing management . Transit feeder services . Traveler security and emergency assistance

Table 1 - Our candidate architecture focuses on solving transportation problems and promotes private participation in providing IVHS services

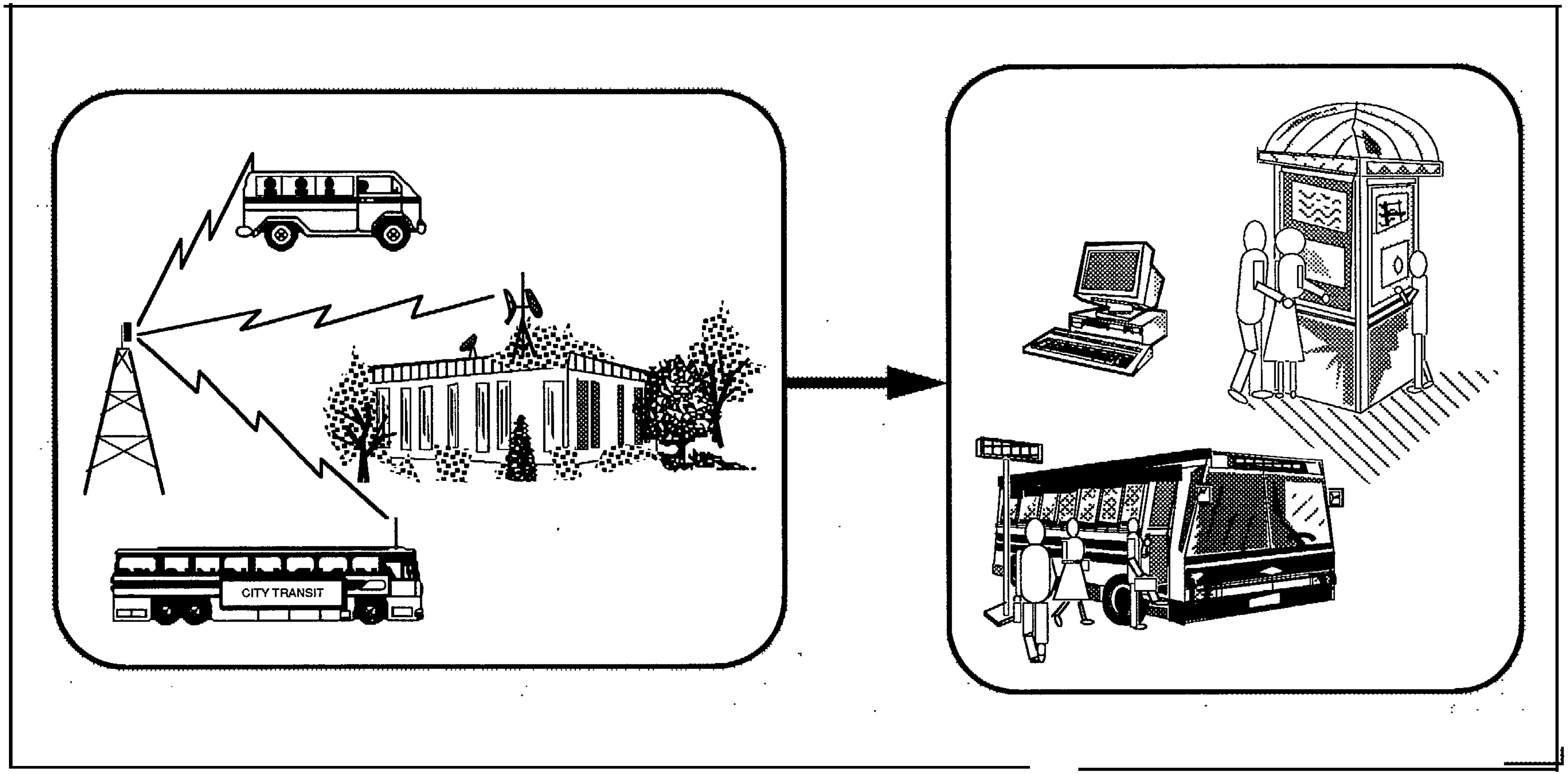


Figure 1 - A Computer Aided Dispatch/Automatic Vehicle Location system enhances the on-time performance of transit and paratransit vehicles and provides accurate, real-time service information to riders.

- Electric-powered transit and paratransit vehicles for selected routes to minimize operating and maintenance cost. Advances in electric vehicle technology appear to hold promises for relieving the financial problems facing today's public transportation providers. Initial estimates have shown that for passenger cars, the operating cost per mile of an electric car is about 30% of that of a conventional one.'

Some of the direct benefits of this concept are:

- Significantly reducing traffic congestion, energy consumption and pollution emissions.

- The passenger-carrying capacity of transit and paratransit systems can be increased much quicker than that of the highway system, offering realizable benefits in the early phase of the national IVHS deployment cycle.

- Enhanced mobility of the population who do not have access to a vehicle.

Provide cost-effective methods for traffic management and incident management. Real-time traffic information is a key element of IVHS and necessary to support virtually all user services. Since the U.S. has more than 4 million miles of roads, of which more than 700,000 miles are in the urban areas, it would require substantial investments to install a comprehensive traffic monitoring and surveillance network. Thus, to be cost effective our architecture has been designed to accommodate a variety of traffic detection techniques including both land-based and airborne. This ability is particularly important to allow technology insertion during the evolution of IVHS. The requirements for this concept are:

- Low-cost, overhead mounted, spot traffic detectors. In recent years, a number of such detectors are emerging to replace the inductive loop detectors. Although new detectors are not yet in the deployment phase, they appear to offer a cost effective solution for area-wide traffic monitoring and surveillance.

- Land-based wide-area traffic surveillance systems to provide macroscopic traffic flow data. The major benefit of such systems is in their ability to monitor a sector of a metropolitan area with minimal communications and data processing requirements.

- Airborne surveillance technologies (including radar, infrared, and video) are being used for non-defense purposes, especially in traffic monitoring and tracking. The benefits of a surveillance aircraft are in its ability to quickly verify traffic incidents, assess the requirements for incident clearance, and provide a wide-area situational awareness to effectively help manage traffic around an incident site. The savings in unnecessary delay resulting from quick incident response and clearance are very significant since about 65% of today's urban freeway delay is due to non-recurring incidents[6].

Promote widespread usage of traffic emergency notification (Mayday) using low-cost technologies. We expect that cellular telephone service will be more affordable and available to the large majority of travelers in urban as well as rural areas. A cellular telephone is probably the most effective means for requesting Mayday services. Other personal communications devices are also expected to be widely used and can assume the Mayday transmission function. For those people who do not have access to a cellular telephone, we emphasize the development of low-cost automatic (i.e., signals are transmitted under crash conditions) and manual Mayday signal transmitters using the cellular system infrastructure for signal reception and vehicle location.

The ability to receive and locate the Mayday signals is only half of the story. Our architecture provides the flexibility for a public organization (e.g., traffic operations center) or private organization (e.g., traveler service center) to organize and assist in the emergency response effort.

Enhance interagency coordination while preserving the operational autonomy of individual agencies. The Westinghouse Team recognizes the challenge of resolving institutional issues among many jurisdictions and governmental departments within a metropolitan area as well as among states. To meet this challenge, our architecture allows different jurisdictions and agencies to share their data, on a voluntary basis, either directly through a data link network or indirectly through an information exchange mechanism (which may be organized at the metropolitan level). Our concept of multiagency information exchange is in line with and reinforces the new role and importance of the Metropolitan Planning Organizations (MPO's) emphasized in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). With a means to share information, regional alliances are expected to be formed to further realize the mutual benefits (e.g., the I-95 Corridor Coalition).

Our architecture for interagency and inter-jurisdictional coordination is based on four interrelated but well-defined functions (Figure 2): intermodal passenger transportation management; congestion and incident management; HAZMAT tracking and emergency management; and commercial vehicle operations regulatory support. The sharing of information not only enhances the operational effectiveness of each agency, but also provides the critical support and coordination needed during traffic-related and non-traffic related emergency situations (e.g., a major evacuation of population due to HAZMAT releases or natural disasters).

Minimize in-vehicle equipment requirements and costs to promote widespread usage of traveler advisory information. Since about 88 percent of Americans drive to work7, widespread dissemination of traveler advisory information is necessary for any control strategies to be effective. According to a recent study', more than 75% of freeway commuters are willing to change route, mode, departure time, or a combination thereof to avoid traffic congestion. Thus, to reach this group of people, our architecture emphasizes the low-cost feature of in-vehicle equipment (such as FM subcarrier and Digital Audio Broadcast) for traveler advisory information reception. Also, our emphasis is in providing pre-trip planning information at home or in the office to more effectively influence people's travel choices.

Our architecture also accommodates sophisticated traveler information systems such as route guidance and route selection for those who are willing to pay for the service (e.g., local small-package delivery fleet, taxis, and tourists).

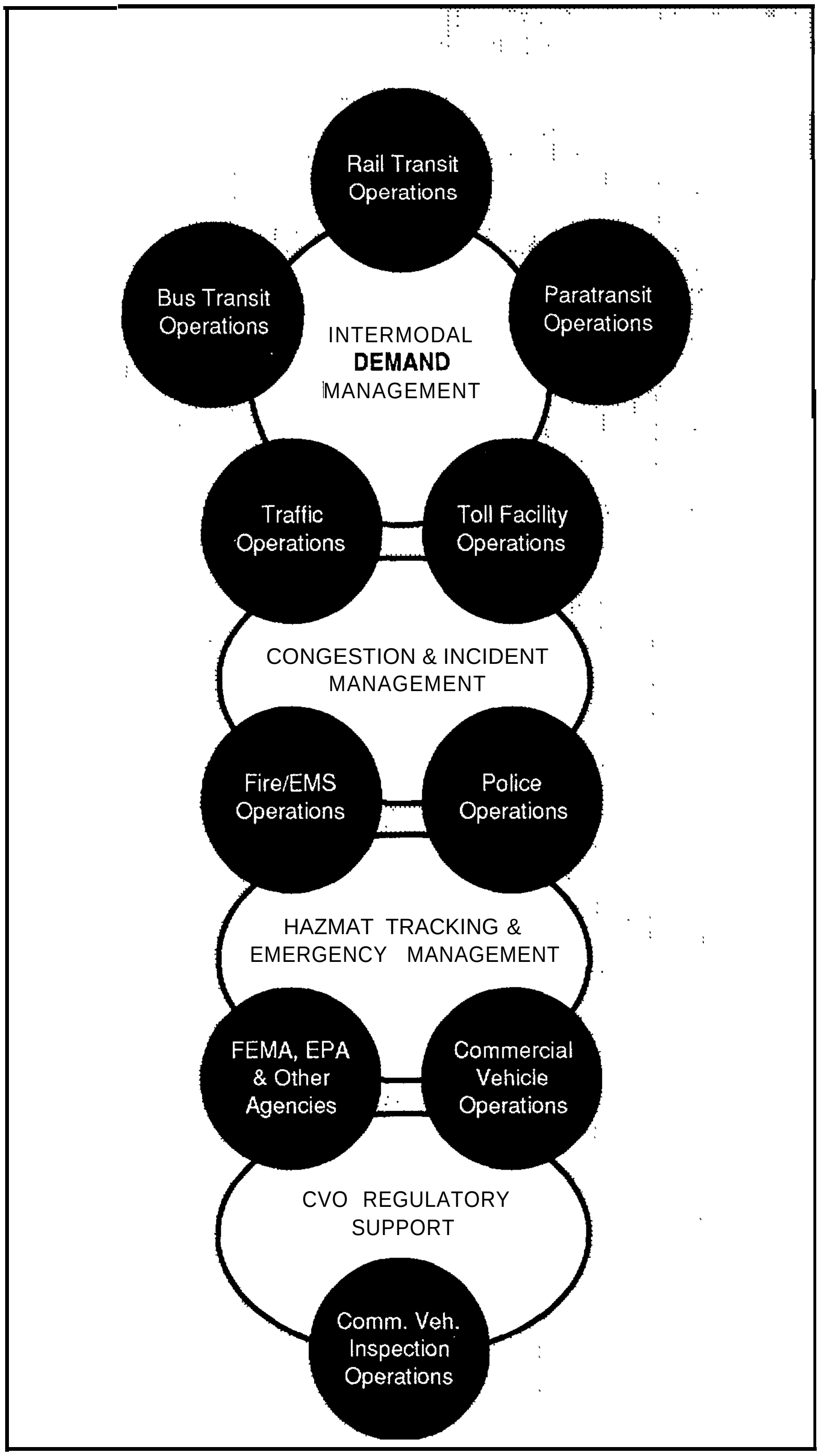


Figure 2 - Our architecture supports interjurisdictional and interagency coordination to enhance individual organization's effectiveness

Reduce commercial vehicle regulatory enforcement and compliance costs and facilitate intermodal freight transportation. The increasing trend of freight transportation by trucks (40 percent in 1991 compared to 35 percent in 1970 [9]) has resulted in more resources being dedicated to commercial vehicle regulatory enforcement and compliance. Our architecture, on the one hand, provides means to reduce the delay incurred during vehicle inspection and credential verification as described in the user services. On the other hand, our architecture facilitates information exchange between the carriers and government agencies to effectively plan truck routes and achieve just-in-time deliveries.

Maximize opportunities for public/private partnership in IVHS infra-structure investments. Our architecture delineates the significance of an integrated transportation information system (through transportation information exchange) to support many user services. This system features collaborative traffic information acquisition, data fusion, and secured high-speed data links. Because of the commercial value of this information base, opportunities for public/private partnership are possible to benefit both sectors and to share the investment cost of IVHS.

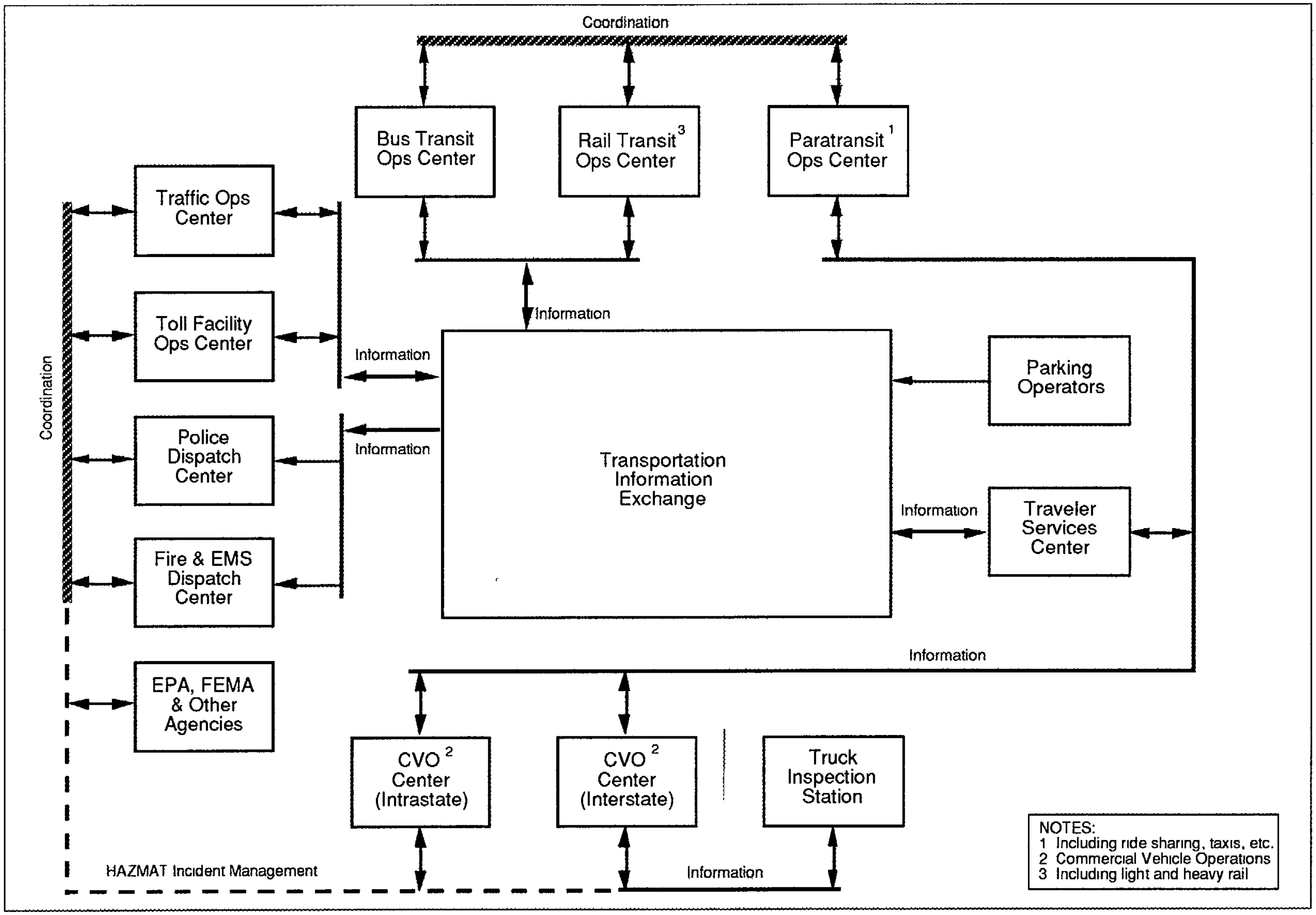
Maximize opportunities for privatization of relevant IVHS user services. Our architecture facilitates the establishment of a variety of traveler service centers to support personal as well as commercial transportation needs at both the local and interstate levels. Although these services are envisioned as private businesses, the means for collaboration and sharing of information with public agencies is inherent in the architecture. For example, a traveler service center can provide “sanitized” probe data collected from its customers (or subscribers) to traffic authority to supplement and enhance the traffic information database of the metropolitan area. Such collaboration has a potential for reducing the infrastructure investment requirements.

Based on the above unique features and the requirements described in the user services, the Westinghouse Team's architecture provides the necessary linkages to facilitate multimodal transportation of people and goods, to improve travel safety, and to enhance interagency coordination (see Figure 3). With in this framework of the architecture, the deployment of systems to support the various user services will be evolutionary. Our deployment strategy is to recognize the needs of those systems that will result in early benefits to: (a) society by reducing traffic congestion, pollution emissions, and energy consumption; and (b) the economy by reducing freight transportation delays and costs. The candidate systems for early deployment are:

- Multimodal traveler information systems
- Transit and personalized public transit management systems
- Traffic monitoring and control systems
- Incident detection and management systems
- Commercial vehicle pre-clearance systems
- Commercial vehicle administrative support systems

Given the state of development of our architecture at this time, which is about half way through the project, it is not possible for us to address all the implications of interest in details. However, we have developed approaches to addressing these implication areas as shown in Table 2.

In summary, the Westinghouse Team's architecture emphasizes the ability to increase the people-carrying capacity of the public transportation systems to combat traffic congestion; to improve safety through low-cost incident notification and integrated emergency responses; to enhance economic productivity of commercial vehicles; and to facilitate interagency cooperation to bring about mutual operational efficiency and effectiveness.



Figugre 3 - The Westinghouse Team's architecture focuses on moving people to reduce congestion, preserves individual agency's operational autonomy, enhances interagency cooperation for effective incident management and intermodal travel, and promotes private business participation.

ARCHITECTURE IMPLICATIONS	WESTINGHOUSE TEAM'S APPROACH
Deployment	Providing early benefits in reducing traffic congestion and freight transportation cost
Equity	Enhancing equity by clearly separating public, private, and partnership IVHS services
Financing	Encouraging private financing to minimize the possible impacts of funding instability
Institutions	Preserving the role of existing institutions while providing catalysts for inter-organization cooperation
Safety	Focusing on traveler safety as well as system operational safety
Market	Enhancing competition and facilitates market penetration through open architecture
Operations and Maintenance	Providing a framework for gradual changes in system operations and maintenance
Policy and Regulation	Offering a solid basis to support environmental and transportation policies and regulations
Privacy	Providing safeguards to protect organizational and personal privacy
Standards	Promoting the establishment of standards and their associated evolutionary plan

Table 2 - Our Architecture Addresses All Areas of Implications

1 Highway Statistics, 1990
2 Strategic plan for Intelligent Vehicle-Highway Systems in the United States, 1992
3 U.S. DOT, National Strategic Transportation Planning Study, March 1990
4 Eno Foundation for Transportation, Inc. *Commuting in America*
5 Westinghouse Electric Corporation, Internal Study, 1992
6 IVHS America's Strategic Plan, 1992 p.II-10
7 Highway Users Federation, *Highway Fact Book,* 1992
8 Haselkom, M, W. Bar-field, J. Spyridakis, and L. Conquest. *Improving Motorist Information Systems: Toward a User-Based Motorist Information System for the Puget Sound Area,* Washington State Transportation Center, RP GC 8286, Task 26, Seattle, WA, April 1990.
9 American Association of Railroads

FEEDBACK

Feedback during this review cycle will identify important issues and help refine the architecture alternatives. The following form focuses on the issues, needs, and concerns of implementing IVHS. The answers to these questions provides the development teams with valuable insights. The form includes four categories:

- **STAKEHOLDERS CLASSIFICATION.** Identifies stakeholders in terms of the functions their employing organization performs.
- **USER SERVICES.** Establishes qualitative stakeholder preferences concerning the IVHS user service bundles.
- **IMPLICATIONS.** Provides qualitative stakeholder perspectives concerning the socioeconomic implications of the IVHS architecture alternatives.
- **ISSUES.** Identifies your top three issues regarding implementation.

Fax or mail your Feedback Form to:

Valerie Cassan
IVHS AMERICA
400 Virginia Ave. S.W.
Suite 800
Washington, DC 20024-2730
FAX: 202.484.3483

IVHS ARCHITECTURE INTERIM REVIEW FEEDBACK FORM

IVHS AMERICA

1. STAKEHOLDER CLASSIFICATION: *Circle the ONE letter that best describes your organization.*

1) PUBLIC SECTOR INFRASTRUCTURE PROVIDERS
   a. Regional (e.g., MPO)
   b. Local (e.g., City, County)
   c. State
   d. Toll agencies

2) PRIVATE SECTOR PRODUCT AND SERVICE PROVIDERS
   e. Vehicle manufacturers and equipment suppliers
   f. Information technology products and services
   g. Construction
   h. System integrators and consultants

3) USERS AND FLEET OPERATORS
   i. Public fleet operators (e.g., Transit, Public Safety)
   j. Private fleet operators
   k. Individual travelers

4) NATIONAL INTERESTS
   l. Federal government
   m. Public interest groups

2. USER SERVICES: *Comment on any USER SERVICES (pages 11-18)* you would add, delete, or modify.

TRAVEL AND TRAFFIC MANAGEMENT

PUBLIC TRANSPORTATION MANAGEMENT

ELECTRONIC PAYMENT

COMMERCIAL VEHICLE OPERATIONS

EMERGENCY VEHICLE MANAGEMENT

ADVANCED VEHICLE SAFETY SYSTEMS

3. IMPLICATIONS: *Comment on any IMPLICATION AREAS (pages 19-22) you would add, delete, or modify.*

DEPLOYMENT, EQUITY, FINANCING, INSTITUTIONS, MARKET, OPERATION AND MAINTENANCE, POLICY AND REGULATION, PRIVACY, SAFETY, STANDARDS.

4. ISSUES: *List the top three issues, needs, or concerns that you want to have considered as the architectures are developed.*

1.

2.

3.

COMMENTS