

1.201J/11.545J/ESD.210J *Transportation Systems*

Fall 2006

LECTURE 21:
TRANSPORTATION TECHNOLOGIES:
INTELLIGENT TRANSPORTATION SYSTEMS

DISPLAYS

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November 21, 2006

Technology has always been at the heart of transportation and its advances.

Let's consider some of the basic kinds of technology we are interested in

CLASS DISCUSSION

Technologies Related to Transportation

- ◆ Materials
- ◆ Propulsion (e.g. Engines)
- ◆ Fuels
- ◆ Construction Methods
- ◆ Extraction Methods
- ◆ Control
- ◆ Electronic Miniaturization
- ◆ Information Technology
- ◆ Telecommunications
- ◆ Sensors
- ◆ Displays
- ◆ Database Technologies (eg GIS, Mapping)
- ◆ Algorithms/Methods (eg Operations, Demand Modeling)
- ◆ Improved Aerodynamics
- ◆ Manufacturing Advances
- ◆ Supply Chain Management

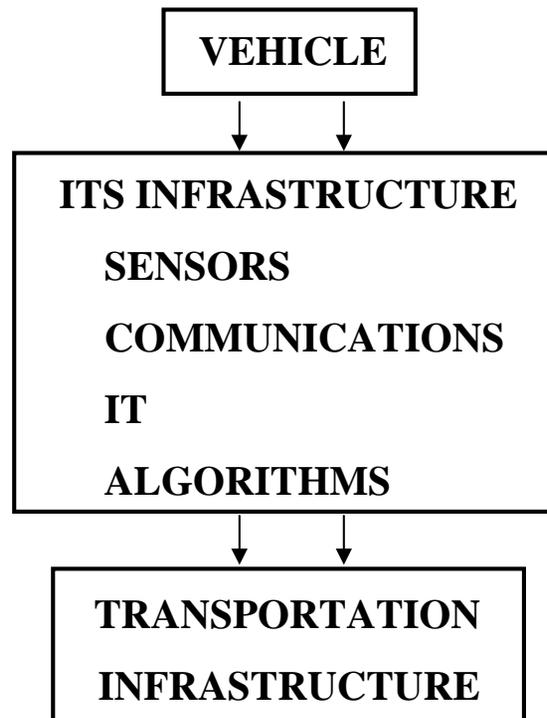
Intelligent Transportation Systems (ITS)

Definition of ITS

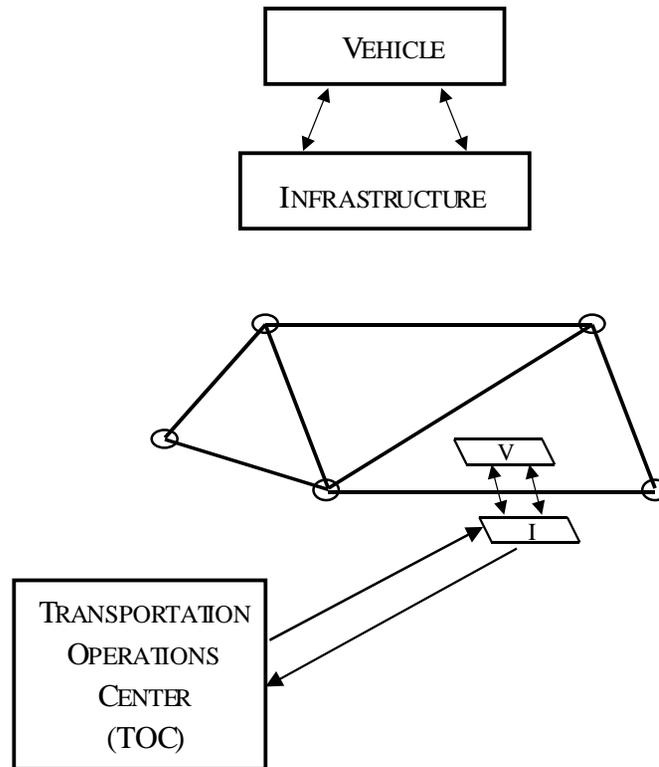
- ◆ Intelligent Transportation Systems (ITS) apply well-established technologies of communications, control, electronics and computer hardware and software to the surface transportation system.

The Fundamental ITS Insight

- ◆ Linkage of vehicle and transportation infrastructure through ITS infrastructure.



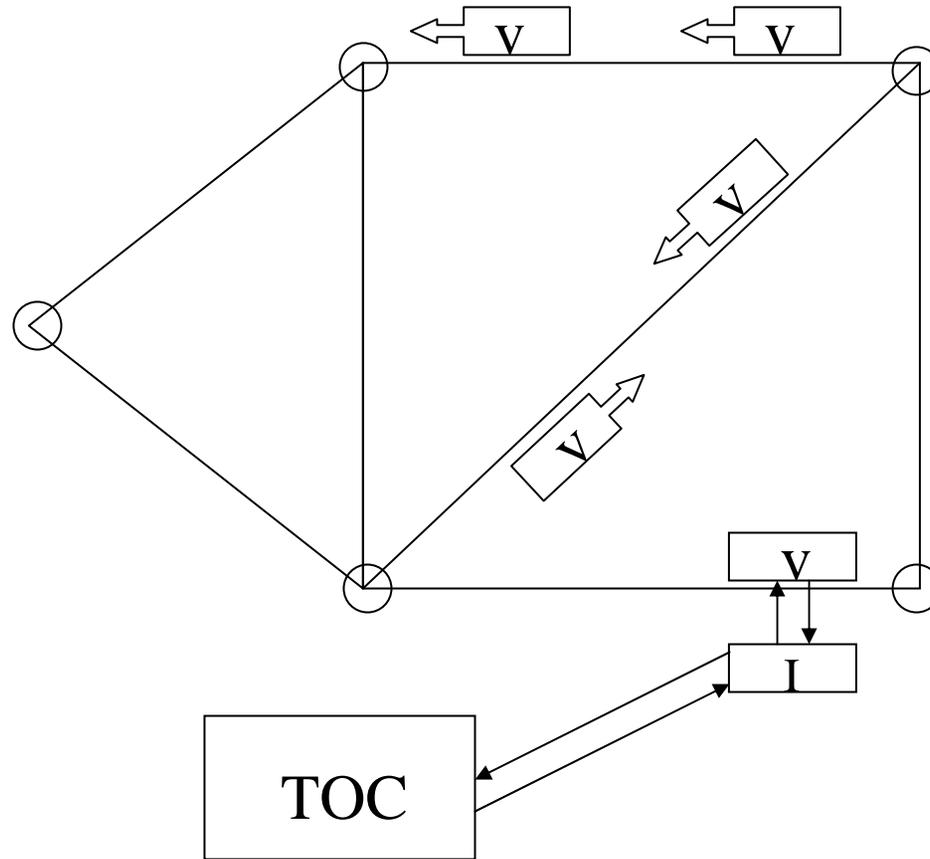
Fundamental ATMS/ATIS Systems



ATMS - - ADVANCED TRANSPORTATION MANAGEMENT
SYSTEM
(OPERATOR)

ATIS - - ADVANCED TRAVELER INFORMATION SYSTEM
(CUSTOMER)

Vehicle-to-Vehicle Communication



Combine centralized network operation with sensing of local conditions via vehicle-to-vehicle communication

The ITS-4 Technologies

- ◆ The ability to *sense* the presence and identity of vehicles or shipments in real-time on the infrastructure through roadside devices or Global Positioning Systems (GPS);
- ◆ The ability to *communicate* (i.e., transmit) large amounts of information cheaper and more reliably;
- ◆ The ability to *process* large amounts of information through advanced information technology; and
- ◆ The ability to *use* this information properly and in real-time in order to achieve better transportation network operations. We use *algorithms* and *mathematical methods* to develop strategies for network control and optimization.

Some Functions

- ◆ Manage and monitor the network traffic flows
- ◆ Provide information on the state of the network
- ◆ Fleet management (vehicle location)
 - ◆ Trucks
 - ◆ Buses
- ◆ Monitoring vehicle condition and status
 - ◆ Trucks
 - ◆ Buses
- ◆ Autonomous systems
 - ◆ Vehicle status
 - ◆ Intelligent cruise control
 - ◆ Obstacle detection

Technology/Institution Issues/Leadership

- ◆ ITS combines high technology and improvements in information systems, communication, sensors, and advanced mathematical methods with the conventional world of surface transportation infrastructure.
- ◆ In addition to technological and systems issues, there are a variety of institutional issues that must be carefully addressed.
- ◆ Substantial leadership will be required to implement ITS as an integrator of transportation, communications and intermodalism on a regional scale.

The Vision for ITS in the U.S. (1992)

- ◆ A national system that operates consistently and efficiently across the U.S. to promote the safe, orderly and expeditious movement of people and freight. Here, recognition of the need to think intermodally and about the needs for *both* personal and freight mobility was explicit.
- ◆ An efficient public transportation system that interacts smoothly with improved highway operations. The concept that ITS had to do more than simply improve single occupancy vehicle level-of-service on highways is captured here.
- ◆ A vigorous U.S. ITS industry supplying both domestic and international needs.

Advanced Transportation Management Systems (ATMS)

- ◆ ATMS will integrate management of various roadway functions. It will predict traffic congestion and provide alternative routing instructions to vehicles over regional areas to improve the efficiency of the highway network and maintain priorities for high-occupancy vehicles.
- ◆ Real-time data will be collected, utilized, and disseminated by ATMS systems and will further alert transit operators of alternative routes to improve transit operations.
- ◆ Dynamic traffic control systems will respond in real-time to changing conditions across different jurisdictions (for example, by routing drivers around accidents).

Incident Management

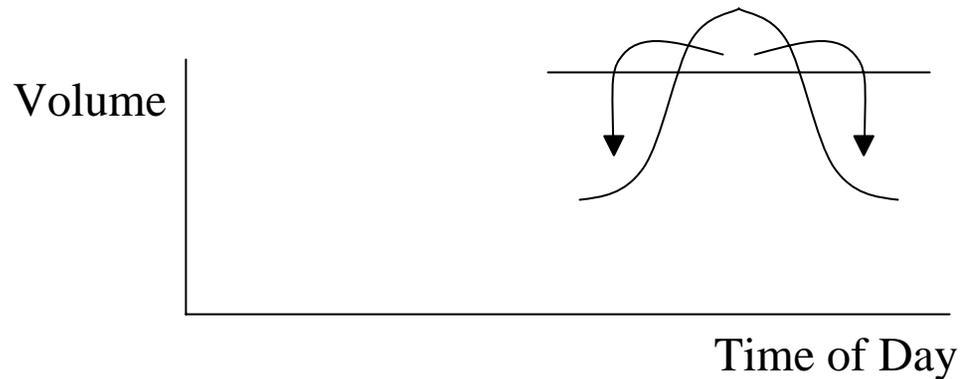
- ◆ We are interested in reducing non-recurring congestion; that is, incident- or accident-based congestion rather than rush hour congestion.
- ◆ One can identify and locate those incidents and remove them quickly, and reduce congestion-based delay substantially.
- ◆ With the technology on the network to measure velocities in real-time everywhere in the network, one can think about being able to identify and locate incidents by various velocity signatures.

Electronic Toll and Traffic Management/Electronic Toll Collection (ETTM/ETC)

- ◆ The basic idea here is that one can detect and identify individual vehicles with road-side readers
- ◆ These readers can debit an account by sensing the transponder carried on your windshield; you pay your toll electronically rather than having to stop and pay.
- ◆ That, in and of itself, reduces congestion.
- ◆ Enables congestion pricing.

Congestion Pricing

- ◆ Charge as a function of time of day/traffic conditions
- ◆ Fundamental idea--peak smoothing



- ◆ Important current application--High-occupancy toll (HOT) lanes
The idea--provide choices--not “one size fits all”

Advanced Traveler Information Systems (ATIS)

- ◆ ATIS will provide data to travelers in their vehicles, in their homes or at their places of work.
- ◆ Information will include: location of incidents, weather problems, road conditions, optimal routings, lane restrictions and in-vehicle signing.
- ◆ Information can be provided both to drivers and to transit users and even to people before a trip to help them decide what mode they should use.
- ◆ “May-Day” calls for help from a disabled vehicle are included here as well.

Interesting Question:

Are ATMS (network management for the “good of all”) and ATIS (traveler information only for those willing to pay for it) competitive or complementary concepts?

DISCUSSIO
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Advanced Vehicle Control Systems (AVCS)

- ◆ Intelligent cruise control, which automatically adjusts the speed of the vehicle to that of the vehicle immediately ahead, is an example of AVCS.
- ◆ More generally, collision warning systems would alert the driver to a possible imminent collision, say, with a roadside obstacle.
- ◆ In more advanced systems, the vehicle would automatically brake or steer away from a collision.
- ◆ These systems are autonomous to the vehicle and can provide substantial benefits by improving safety and reducing accident-induced congestion.

Automated Highway Systems (AHS)

“Hands-off, feet-off, brain-off” driving.

Does this make sense?

What are the barriers to deployment?

“The Devil and
the Governor of Massachusetts”

Commercial Vehicle Operations (CVO)

- ◆ In CVO, the private operators of trucks, vans and taxis are using ITS technologies to improve the productivity of their fleets and the efficiency of their operations.
- ◆ Such concepts as weigh-in-motion (WIM), pre-clearance of trucks across state boundaries, automatic vehicle location for fleet management, on-board safety monitoring devices, are included here.

Advanced Public Transportation Systems (APTS)

- ◆ APTS can use ITS technologies to greatly enhance the accessibility to information for users of public transportation.
- ◆ Also, ITS can improve fare collecting, scheduling of public transportation vehicles, intramodal and intermodal connections, and the utilization of bus fleets.
- ◆ In principle, ITS improves public transportation on both the revenue side (enhanced LOS, especially reliability) and the cost side (improved efficiency)-- but risk-averse transit properties may be slow to adopt advanced technology.

Advanced Rural Transportation Systems (ARTS)

- ◆ How ITS technologies can be applied on relatively low-density roads is a challenge that is being undertaken by many rural states.
- ◆ Safety rather than congestion is the main motivation for ARTS. Single vehicle run-off-the-road accidents are a target here.
- ◆ “May-Day” devices are of particular interest in this environment.
- ◆ Political motivation to include ARTS in ITS

ITS and the Environment: A Plus or a Minus

CLASS DISCUSSION

Rebecca Dodder's MIT PhD thesis addresses
this question

Characteristics

ATMS	Advanced Transportation Management Systems	Network management, including incident management, traffic light control, electronic toll collection, congestion prediction and congestion-ameliorating strategies.
ATIS	Advanced Traveler Information Systems	Information provided to travelers pre-trip and during the trip in the vehicle. ATMS helps provide real-time network information.
AVCS	Advanced Vehicle Control Systems	A set of technologies designed to enhance driver control and vehicle safety. This ranges up to Automated Highway Systems (AHS), where the driver cedes all control to the system.

Characteristics

CVO	Commercial Vehicle Operations	Technologies to enhance commercial fleet productivity, including weigh-in-motion (WIM), pre-clearance procedures, electronic log books, interstate coordination.
APTS	Advanced Public Transportation Systems	Passenger information and technologies to enhance system operations, including fare collection, intramodal and intermodal transfers, scheduling, headway control.
ARTS	Advanced Rural Transportation Systems	Mostly safety and security technologies (e.g., May-Day) for travel in sparsely-settled areas.

Institutional Issues

- ◆ Public-Private Partnerships
- ◆ Organizational Change
- ◆ Transportation Education
- ◆ Legal Liability
- ◆ Political Strength of Traditional Construction Industry

Transportation and Change

- ◆ Changes resulting from the Interstate in the U.S.
 - ◆ The intercity trucking industry was formed and a financial blow was dealt to the railroad industry, as it lost substantial market share in high-value freight. This led, in turn, to a fundamental redefinition of the relationship between the public and private sectors in the freight industry in 1980, through substantial deregulation.
 - ◆ The Interstate led to an unprecedented and unequalled mobility between and into U.S. cities and gave rise to the regional transportation concept, with wholly new methods of planning being required for region-wide analysis and design.

Transportation and Change

(continued)

- ◆ The Interstate System included the development of circumferential belts around major cities, leading to development patterns quite at variance with the ability of public transportation to service it and, as described by authors such as Joel Garreau, the development of “edge cities”, a fundamentally new kind of urban structure.
- ◆ The Interstate led to a fueling of the post-war economic expansion and a period of unprecedented prosperity in the U.S.
- ◆ A “stop the highway” backlash in urban areas resulted from the Interstate, and a political polarization between the build vs. no-build factions became a fact of political life in U.S. transportation.

Transportation and Change

(continued)

- ◆ Changes resulting from ITS
 - ◆ The reinvention of logistics through supply chain management, linking inventory management and transportation in wholly new ways;
 - ◆ Dramatic moves into surface transportation by organizations not traditionally involved, such as the national labs and aerospace companies in the U.S.;
 - ◆ Changes to academia, with new alliances and new academic programs beginning to be formed, and faculty participating in transportation education and research who have never been part of that process before; and
 - ◆ Building of new relationships among public-sector agencies to enable regional and corridor-level system deployment.

Regional Deployment -- A Strategic Vision

- ◆ The strategic vision for ITS, then, is as the integrator of transportation, communications and intermodalism on a regional scale.