AN INTRODUCTION TO
INTELLIGENT TRANSPORTATION SYSTEMS

1.212
SPRING 2005

Professor Joseph M. Sussman

Mon/Wed 2:30-4:00

BLOCK 2
(Lectures 4, 5, 6, 7)

ADVANCED TRAVELER
INFORMATION SYSTEMS

SPEAKER: Joseph M. Sussman
MIT

February 14, 2005
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THE QUESTIONS IN ATIS

◆ It ATIS a positive or a negative for ATMS?
◆ How do we gather data about traffic flows?
  ◆ State of knowledge about the system
◆ How do we process it into information useful to travelers?
◆ How do we disseminate the information to travelers?
◆ Of what value is the information?
D. Florian, TPP, “Simulation-based Evaluation of Advanced Traveler Information Services (ATIS)"

![Graph showing travel time (minutes) vs. % of drivers equipped with ATIS. The x-axis represents % of drivers equipped with ATIS, ranging from 0% to 100%, and the y-axis represents travel time (minutes). There are two curves: one for unequipped drivers, which shows an increase in travel time as the percentage of equipped drivers increases, and one for equipped drivers, which shows a decrease in travel time as the percentage of equipped drivers increases. The baseline represents the travel time when no drivers are equipped with ATIS.](image-url)
HOW DO WE GET GOOD DATA ABOUT THE STATE OF THE NETWORK?

◆ First Generation
  ◆ Helicopters -- visual observations, timeliness?

◆ Second Generation
  ◆ Traffic sensors in the road (inductive loops)
  ◆ Simply sense the presence or absence of a vehicle

◆ Third Generation
  ◆ Roadside infrastructure combined with in-vehicle transponder
  ◆ Sense a particular car

◆ Fourth Generation
  ◆ Cell phones
  ◆ GPS
ATIS

- Information to various travelers
  - Auto
  - Transit
  - Freight
- Why do you want it? To improve your LOS in using the transportation system
  - Travel time
  - Reliability
  - Costs
  - Comfort
  - Safety
  - Security

So, what information do you want?
WHAT INFORMATION DO TRAVELERS WANT?

◆ *Static*
  ◆ Routes
  ◆ Schedules (as printed)

◆ *Dynamic*
  ◆ Traffic conditions
  ◆ Route - Real-time
  ◆ Real-time transit schedules
  ◆ Construction sites
  ◆ Incidents
  ◆ Weather (rural areas)
  ◆ Parking lot availability
<table>
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<tr>
<th>Static information -- known in advance, changes infrequently</th>
<th>Planned construction and maintenance activities</th>
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<tbody>
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<td></td>
<td>Special events, such as parades and sporting events</td>
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<td>Toll costs and payment options</td>
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<td>Intermodal connections</td>
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<td>Commercial vehicle regulations, such as hazmat and height and weight restrictions</td>
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<td>Parking locations and costs</td>
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<td>Business listings, such as hotels and gas stations</td>
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<td>Tourist destinations</td>
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<td>Navigational instructions</td>
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<tr>
<th>Real-time information, which changes frequently</th>
<th>Roadway conditions, including congestion and incident information</th>
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<tr>
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<td>Alternate routes</td>
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<td>Road weather conditions, such as snow and fog</td>
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<td>Transit schedule adherence</td>
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<td>Parking lot space availability</td>
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<td>Travel time</td>
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<td>Identification of next stop on train or bus</td>
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VALUE OF INFORMATION

◆ What is the value of the information provided?
◆ Do people have to change routes for information to have value?
◆ Do people *actually change routes*?
  ◆ Two kinds of people
    ◆ Same route all the time virtually no matter what
    ◆ Experimenters
TYPOLOGY (1)

◆ Where to receive information?
  ◆ In car, on transit vehicle, commercial vehicle
  ◆ In office
  ◆ In home or other O/D
  ◆ Anywhere
    ◆ Personal digital assistant
    ◆ Cell phone
  ◆ At transit station
  ◆ Hotel lobby
TYPOLOGY (2)

◆ *When* to receive information?
  ◆ Before trip
  ◆ During trip
  ◆ After trip -- how did I do?

◆ *How* to get information?
  ◆ Radio/TV
  ◆ Interactive TV
  ◆ In-vehicle display via roadside infrastructure
  ◆ Phone
    ◆ Landline
    ◆ Cellular
  ◆ Kiosks
  ◆ Internet
INFORMATION FLOWS

Information flows *both ways* -- we have discussed information from system to traveler -- now, the other way

◆ From traveler to system:
  ◆ Explicit
    ◆ People calling in for traffic information
    ◆ Emergency *SP
    ◆ “Here I am and in trouble” (May Day)
      ◆ GM: Onstar
      ◆ Ford: Wingcast
      ◆ AAA: Response Service Centers
      ◆ Mercedes: ATX
  ◆ Implicit
    ◆ My location and speed
    ◆ ETC site
    ◆ Roadside or in-road infrastructure
Table 5.1: Examples of services that could be enabled using Vehicle Locational Services

<table>
<thead>
<tr>
<th>Navigation</th>
<th>Safety &amp; Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>♦ Dynamic (Real-time) Routing Instructions:</td>
<td>♦ Road Safety</td>
</tr>
<tr>
<td>♦ Route travel time information</td>
<td>♦ Information about local roads and weather conditions.</td>
</tr>
<tr>
<td>♦ Information on alternate routes;</td>
<td>♦ Driver Safety</td>
</tr>
<tr>
<td>♦ Dynamic route guidance between two points; and</td>
<td>♦ Information about nearby accidents and related congestion.</td>
</tr>
<tr>
<td>♦ Estimation of traffic delays.</td>
<td>♦ Emergency Services</td>
</tr>
<tr>
<td>♦ Personalized “To-Do” Lists:</td>
<td>♦ Automatic accident notification</td>
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<tr>
<td>♦ Information on entertainment and other activities of interest to the customer delivered via mobile device or computer.</td>
<td>♦ Anti-Theft Devices</td>
</tr>
<tr>
<td>♦ Travel Support:</td>
<td>♦ Manual/Automatic theft alert</td>
</tr>
<tr>
<td>♦ Location of service stations and parking facilities;</td>
<td>♦ Remote car tracking</td>
</tr>
<tr>
<td>♦ Other travel-related services; and</td>
<td></td>
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<tr>
<td>♦ Information about nearby transit alternatives.</td>
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SOME QUESTIONS

- Can you separate traffic management and traveler information?
- Does it make sense to have one without the other?
- Reporting traffic conditions without doing anything about it.
- Can the for-profit sector compete with people giving away information (radio stations, e.g.)?
- Is there value-added for better information? Do customers act on it?
QUESTIONS/ISSUES

- Value of information -- how to measure?
- Price -- will people pay?
- Costs (and who bears them)
- Quality of information and how to assure
- “Ethics” -- just because you can pay, should you be advantaged in using a public facility?
- Safety -- distraction
- Privacy
- Providing people “wrong” information to enhance overall flows.
- Does ATIS help or hurt congestion -- network operations?
Table 3.1
Summary of ATIS Technologies

<table>
<thead>
<tr>
<th>Sensors and surveillance</th>
<th>Inductive loops</th>
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<td>Piezo sensors</td>
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<td>Radar</td>
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<td>Laser</td>
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<td>CCTV</td>
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<td>Automatic vehicle location</td>
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<td>License-plate readers</td>
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<td>Smart cards and other ITS</td>
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<td>Passenger counters</td>
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<td>Probe data-collection technologies</td>
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<thead>
<tr>
<th>Telecommunications</th>
<th>Cellular wireless</th>
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<td></td>
<td>Wireless application protocol</td>
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<td>Broadcast radio and TV</td>
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<td></td>
<td>Bluetooth</td>
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<td>Copper wireline</td>
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<td></td>
<td>Fiber optics</td>
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<td>Dedicated short-range communications</td>
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<thead>
<tr>
<th>Data and information processing</th>
<th>Data warehousing</th>
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<tr>
<td></td>
<td>Data mining</td>
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<td>On-line analytical processing</td>
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<td>Voice processing</td>
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<td>Speech recognition</td>
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<td>Internet</td>
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<tr>
<th>Information display and delivery</th>
<th>Emergency call boxes</th>
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<td>Kiosks and smart bus stops</td>
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<td>Dynamic message signs</td>
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<td>In-vehicle information systems</td>
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<td>Personal information devices</td>
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<td></td>
<td>In-home or office-based delivery systems</td>
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</table>

ATIS

◆ Public-Sector High-Level Policy Objectives
  ◆ Environmental
  ◆ Economic
  ◆ Social
◆ Supporting Objectives (selected)
  ◆ Best value for public funding
  ◆ Use legacy systems and sunk investment
  ◆ Leveraging effort of others
  ◆ Appropriate opportunities
  ◆ Incorporating the private sector
  ◆ Traveler behavior change
  ◆ Reducing intermodal travel, time
  ◆ Improving quality of service

ATIS -- Private Sector

- Who is the Private Sector?
- Private-Sector Objectives (selected)
  - Making a profit (Drucker says “creating a customer”)
  - Developing sustainable business
  - Public-sector interface
  - Regional-focused activities
  - Finding the best business model
  - Finding and preserving a competitive advantage

The ATIS Supply Chain

- Building the Data Infrastructure
- Collecting the Data
- Fusing the Data
- Adding Value to the Data
- Marketing the Information
- Delivering the Information

BUSINESS MODELS -- Some Examples

- Build
- Collect
- Fuse
- Add Value
- Market
- Distribute

Public  Private
Public  Private
Public  Private
Public  Private
Mobility Technologies: The Traffic.com People

Private Sector Business Model
For ATIS
John Collins
TRB 2003 - Session #465
Company Background

- Contractor for commercial ATIS under $50 million USDOT ITIP program
- Founded in 1998
- Over 225 employees
- Deployed in 14 markets
- Provide data collection, processing and dissemination
- Public and commercial applications
Business Model for ATIS

- Firm-fixed price per metropolitan area:
  - $2M Federal (P.L 107-117 (for 21 named areas))
  - $500K local match
  - $500K+ private investment
- Agencies receive data services for internal use
- Agencies share existing data (non-exclusively)
- Mobility Technologies deploys, operates and maintains sensor network- low risk to Agency
- No O&M costs to Agency
- Revenue share is re-dedicated to ITS
- Mobility Technologies commercializes data
The ITIP Technology

- Solar powered
- Wireless communication
- Modular components
- Non-intrusive
- Cover all lanes
- Workzone safety
- Security applications
Consumer Subscription Service

Telematics/PDAs

Interactive Voice Product
Phone Browser Alerts
Public Agency Internal Website

Operations and Traffic Management

*DOT access to real-time, digital sensor data*

- Region-wide map
- Individual sensor access
- Lane-by-lane data
- Speed, volume and lane occupancy
- Maintenance record database
Agency Benefits of Business Model

- Fixed price -- no risk
- Rapid deployment -- six months from go-ahead
- Privately operated & maintained system
- Enhances overall data collection system
- Roadway system performance
- Expands traveler information: support 511
- Assists operations & incident management
- Provides data for planning studies
- Provides data for air quality analyses
Agency Benefits
(continued)

◆ $2 million to benefit listed cities
◆ Revenue share
◆ Data services
◆ 21 cities committed by July 1, 2002
◆ $12 million available for additional round
Smartroute Systems Field Trip - Next Time -
Tuesday, February 22

Some things to learn:

◆ What is Smartroute Systems Business’ Model? (McQueen, et. al. framework)/
◆ Benefits to customers?
◆ Benefits to travelers?
◆ Benefits to society at large?
◆ Smartroute systems as a national company - does the concept scale?
BUSINESS MODELS -- Some Examples

Build Public
Collect Public Private
Fuse Private
Add Value
Market Private
Distribute Private
TRAFFICMASTER UK (1)

◆ Components
  ◆ Network of traffic sensors
  ◆ Communication network
  ◆ In-vehicle information units
  ◆ National Traffic Data Center (operated by Trafficmaster) (NTDC)

TRAFFICMASTER UK (2)

- Public-Private Partnership
  - General logistics on UKDOT (now DETR)
  - Originally M25
  - Now 15-year commercial license
    - England
    - Scotland
    - Wales
- Initiated September 1900
- March 2000
  - 2400 infrared motorway sensors (wireless, batteries)
  - 7000 passive traffic flow sensors for truck roads

TRAFFICMASTER UK (3)

- Motorway Sensors
  - Measure speeds (averaging 6 vehicles)
  - If < 48 km, sensors communicate to NTDC
  - NTDC communicates to vehicles using wireless paging

TRAFFICMASTER UK (4)

- Truck Roads (Arteries)
  - A lot of variation, unlike motorways
  - Use passive target flow measurements
    (image processing of license plate)

TRAFFICMASTER UK (5)

- Information Delivery
  - Trafficmaster freeway
  - Traffic alert 1740
  - Trafficmaster YQ

FREIGHT RELIABILITY

DRIVEN BY INVENTORY AND STOCK-OUTS
WHAT CAN GO WRONG?

Delays along the way -- service reliability

Inventory at B

80

40

1 2 3

goods don’t arrive

ISSUE: Stock-outs

Time
WHAT CAN GO WRONG?
(CONTINUED)

So, perhaps the customer at B keeps a day's worth of inventory

Problems: Bigger Inventory Warehousing Costs Insurance Costs
A BIG ISSUE -- STOCK-OUTS

◆ WHAT DOES A STOCK-OUT COST?
  ◆ Examples
    ◆ GM Assembly Plant
    ◆ Retail Store
    ◆ Blood Bank
INVENTORY MINIMIZATION

◆ If one needs a greater amount of inventory because of unreliability in the transportation system or probabilistic use rate, you generate costs as a result of needing larger inventory to avoid stock-outs.

◆ We try to balance the costs of additional inventory with the costs of stock-outs.
TOTAL LOGISTICS COSTS (TLC)

Total Logistics Costs (TLC) =

\( f \) (travel time distribution, inventory costs, stock-out costs, ordering costs, value of commodity, transportation rate, etc.)
This probability density function defines how reliable a particular mode is.

TLC is a function of the travel time distribution.

As the average travel time and variance grows, larger inventories are needed.
TRAVELER RELIABILITY

NOW IT IS TIME UTILIZATION
AND NOT INVENTORY WE ARE
CONCERNED WITH
How can you deal with uncertainty in travel times?

- Choose time when conditions are stable
- Choose routes with stable conditions
- Choose routes you know
- Build knowledge through experiment
- Minimize consequences safety margins
- Get better information before the trip or en route

80 min (50%), 60 min (50%)

70 min (100%)

Think we should design unreliable systems for the thrill-seekers?

Yin, Yafeng and Hitoshi Ieda, “Assessing Performance Reliability of Road Networks Under Nonrecurrent Congestion”, Transportation Research Record 1771, National Academy Press, Washington, DC.
Desired Arrival Time = 9 am

for departure times from 7:30-8:30am
What is the overall travel time distribution composed of?
With no traveler information, how would you decide when to leave?

9 am
Utility of Arrival

OR

9 am
Utility of Arrival
Suppose at 7:30, while still at home, you can find out what kind of a day it is

- Light
- Regular
- Terrible

What do you do, based on that information?
So, do you really save *actual* traffic time?

Maybe a little, but not much.

Does that mean there is no value to ATIS?
ATIS Non-User:
Travel Times Based on Past Experience

Figure ES-1: ATIS Non-User Route Choice and Trip Timing

ATIS User:
Reported Travel Times at 8 am

Figure ES-2: ATIS User Route Choice and Trip Timing

MITRETEK
CONCLUSIONS

◆ ATIS benefits are *grossly understated* if only travel time savings are included.

◆ The value of improved on-time reliability is not easily nor directly monetized, but it is clear that many types of travelers can benefit from ATIS.

◆ Trucks delivering auto parts in a just-in-time manufacturing process may highly value any improvement in on-time reliability or reduction in early schedule delay.

◆ Commuters face an on-time requirement not only on the home-to-work leg of their daily trip-making, but increasingly on the work-to-home return trip in order to meet daycare pickup requirements and other commitments.

◆ Improved reliability and predictability of travel are also likely good surrogates for reduced commuter stress.

Overall, ATIS use proved advantageous in efficiently managing the traveler's time. Specific quantitative examples selected from the Washington, DC, case study include:

- Peak-period commuters who do not use ATIS were three to six times more likely to arrive late compared to counterparts who use ATIS;
- Cases where ATIS clearly benefits the user (e.g., ATIS user on-time, non-user late) outweighed cases where ATIS clearly disadvantages the user by five to one;
- ATIS users in peak periods are more frequently on-time than conservative non-users, yet they experience only two-thirds as much early schedule delay as non-users;
- Late shock, the surprise of arriving late, is reduced by 81% through ATIS use.

Simulation Approach

- 72 drivers
- Ages 18-86
- Equal number of males and females
- Familiarity with actual roads (but this was a *simulation*)
THREE LEVELS OF ATIS

- No ATIS
- Basic ATIS
  - Descriptive information about incidents and congestion
  - Location, type of incident
- Enhanced ATIS
  - Basic plus the following
  - Alternative route
  - Incident details
  - Real-time traffic map
  - Live video traffic images
TWO TRAFFIC LEVELS

- Light
- Moderately Heavy

So, Six Experimental Conditions,
Twelve Participants per Condition

Also, incidents built into the simulations
CONCLUSION

◆ ATIS influences en route driver decisionmaking
◆ Drivers will divert
◆ Travel time savings occurred as a function of ATIS features
◆ Same drivers did worse by diverting
◆ Travel level (light vs. moderately heavy) had little effect on driver behavior
◆ Maps work