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
and forward

BLOCK 2
ADVANCED TRAVELER INFORMATION SYSTEMS

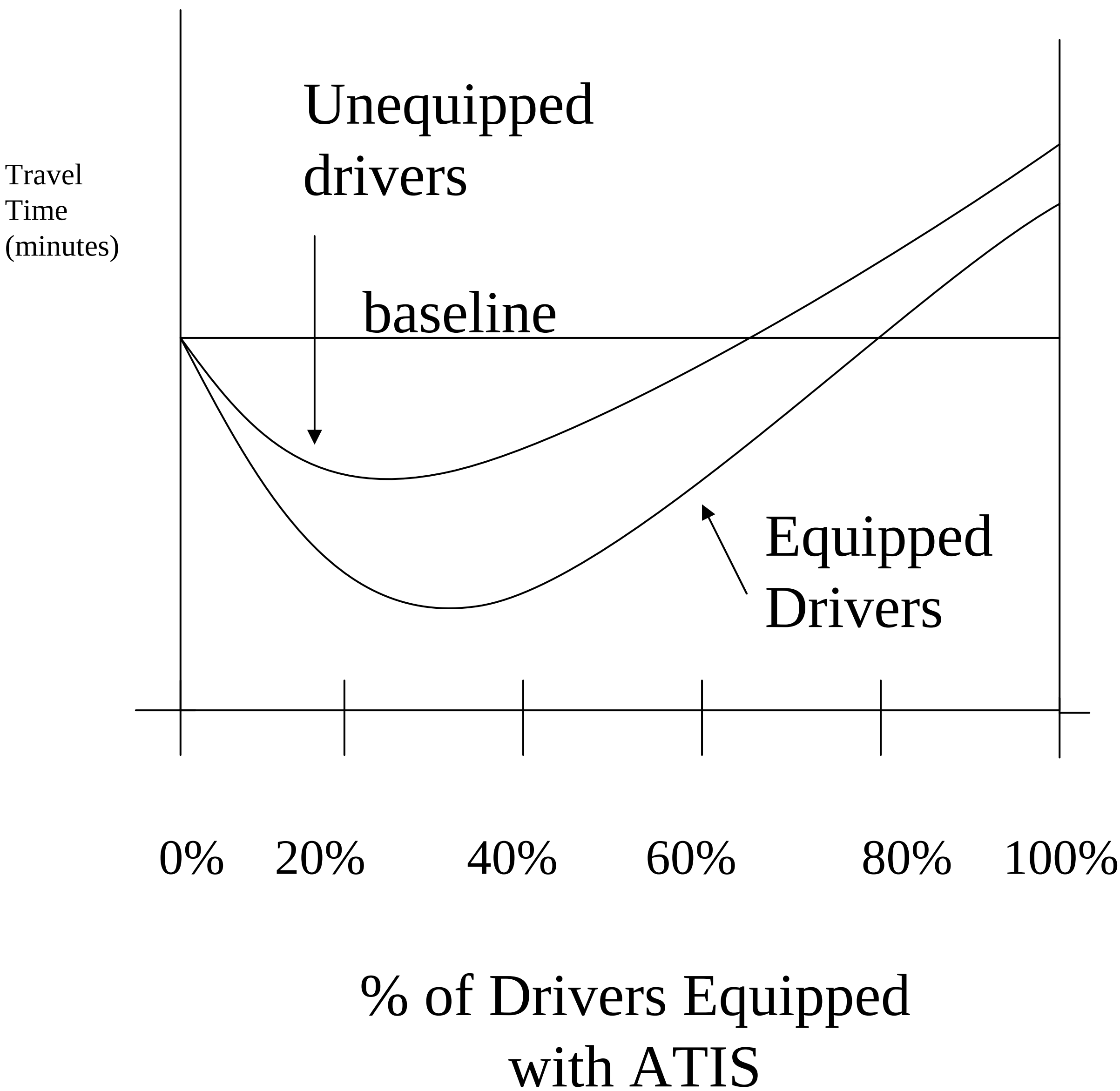
Micro-Schedule

Lecture	Date	Topic
4	2/14/05	Basic ATIS Concepts
5	2/16/05	ATIS (continued)
6	2/22/05 (Tuesday)	Visit to SmartRoute Systems
7	2/23/05	ATIS (continued)
8	2/28/05	Intro to ATMS
9	3/2/05	Consumer Response to ATIS (Jane Lappin, Sean Pierce -- Volpe National Transportation Systems Center)

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)"



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 5-1
Potential Contents of ATIS
Source: *Developing Traveler Information Systems Using the National ITS Architecture* (Washington, D.C.: U.S. Department of Transportation, 1998, pp. 2-3 and 2-4)

Static information -- known in advance, changes infrequently	Planned construction and maintenance activities
	Special events, such as parades and sporting events
	Toll costs and payment options
	Intermodal connections
	Commercial vehicle regulations, such as hazmat and height and weight restrictions
	Parking locations and costs
	Business listings, such as hotels and gas stations
	Tourist destinations
	Navigational instructions
Real-time information, which changes frequently	Roadway conditions, including congestion and incident information
	Alternate routes
	Road weather conditions, such as snow and fog
	Transit schedule adherence
	Parking lot space availability
	Travel time
	Identification of next stop on train or bus

From "Advanced Traveler Information Systems", Carol Zimmerman, Chapter 5 in *Intelligent Transportation Primer*, Institute of Transportation Engineers, Washington, DC, 2001, p. 5-2.

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

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

From "An Analysis of the Impact of Wireless Technology on Public vs. Private Traffic Data Collection, Dissemination, and Use", Armand Ciccarelli, Master's Thesis, Massachusetts Institute of Technology, Cambridge, MA, February 2001, p. 83.

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

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

from McQueen, Bob, Rick Schuman and Kan Chen, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

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

from McQueen, Bob, Rick Schuman and Kan Chen, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

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

from McQueen, Bob, Rick Schuman and Kan Chen, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

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

from McQueen, Bob, Rick Schuman and Kan Chen, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

BUSINESS MODELS -- Some Examples

Build	Public	Public	Public
Collect	↓	Public	Private
Fuse	↓	Private	↓
Add Value	↓	↓	↓
Market	Private	↓	↓
Distribute	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

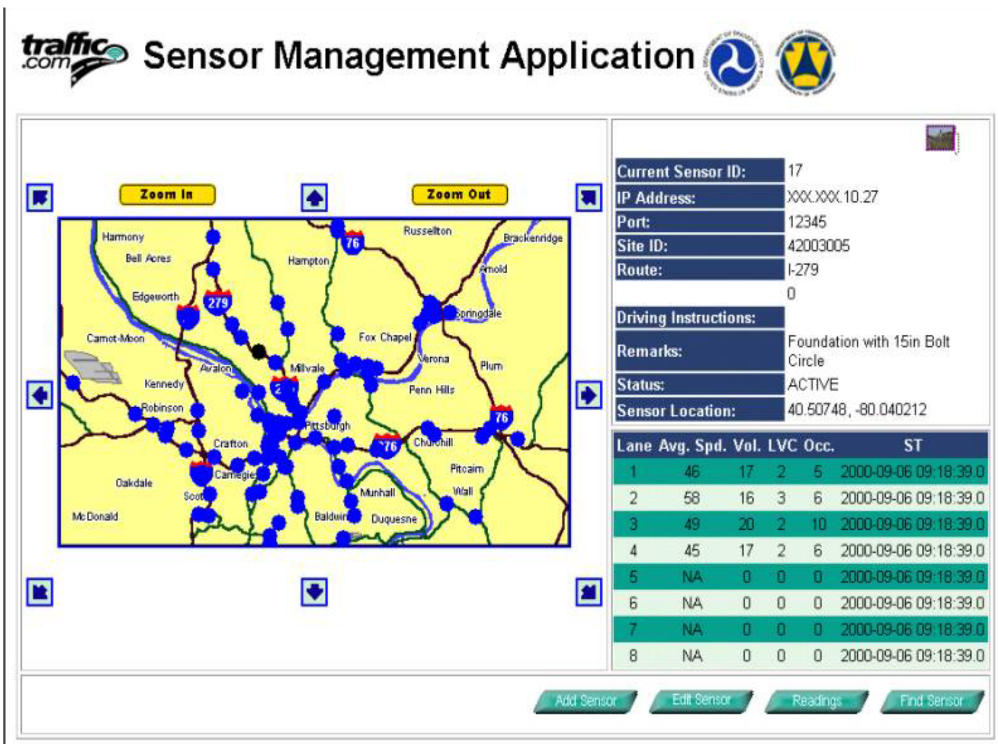
Interactive Voice Product

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	Public	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)

McQueen, Bob, Rick Schuman and Kan Chen, Trafficmaster from Chapter 2, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

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

McQueen, Bob, Rick Schuman and Kan Chen, Trafficmaster from Chapter 2, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

TRAFFICMASTER UK (3)

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

McQueen, Bob, Rick Schuman and Kan Chen, Trafficmaster from Chapter 2, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

TRAFFICMASTER UK (4)

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

McQueen, Bob, Rick Schuman and Kan Chen, Trafficmaster from Chapter 2, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

TRAFFICMASTER UK (5)

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

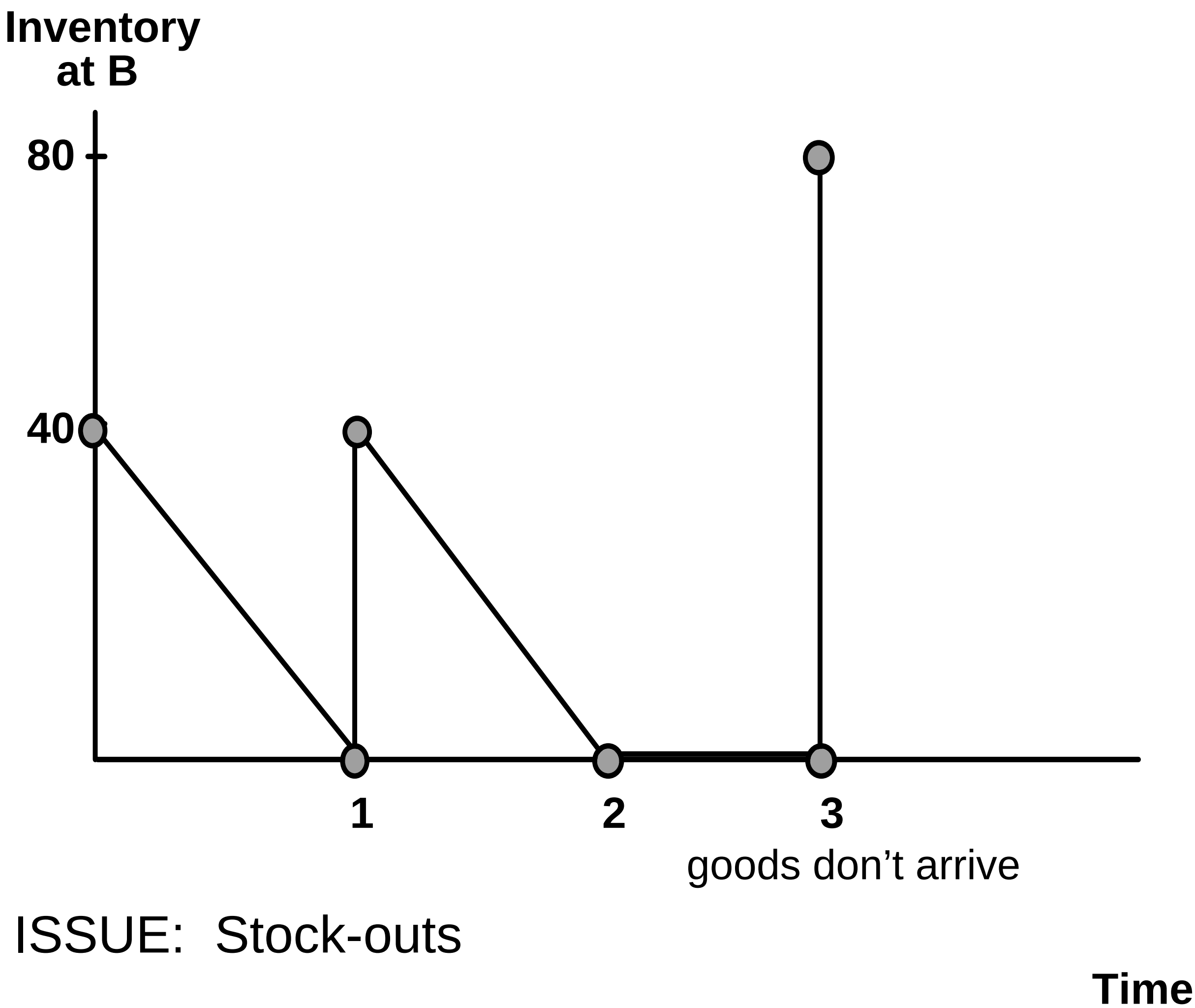
McQueen, Bob, Rick Schuman and Kan Chen, Trafficmaster from Chapter 2, *Advanced Traveler Information Systems*, Artech House, Boston and London, 2002.

FREIGHT RELIABILITY

DRIVEN BY INVENTORY AND STOCK-OUTS

WHAT CAN GO WRONG?

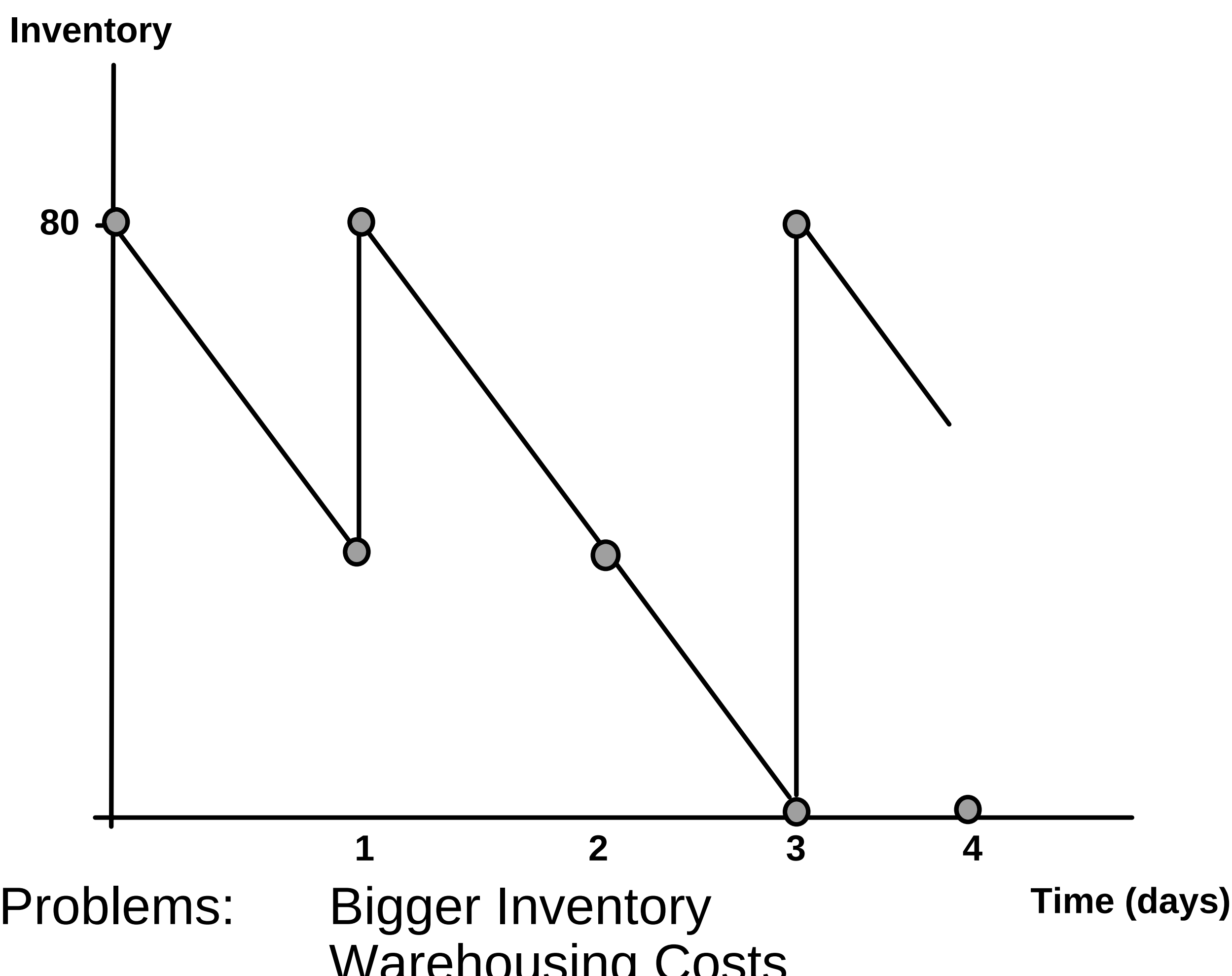
Delays along the way -- service reliability



ISSUE: Stock-outs

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.)

TRAVEL TIME DISTRIBUTION FROM SHIPPER TO RECEIVER

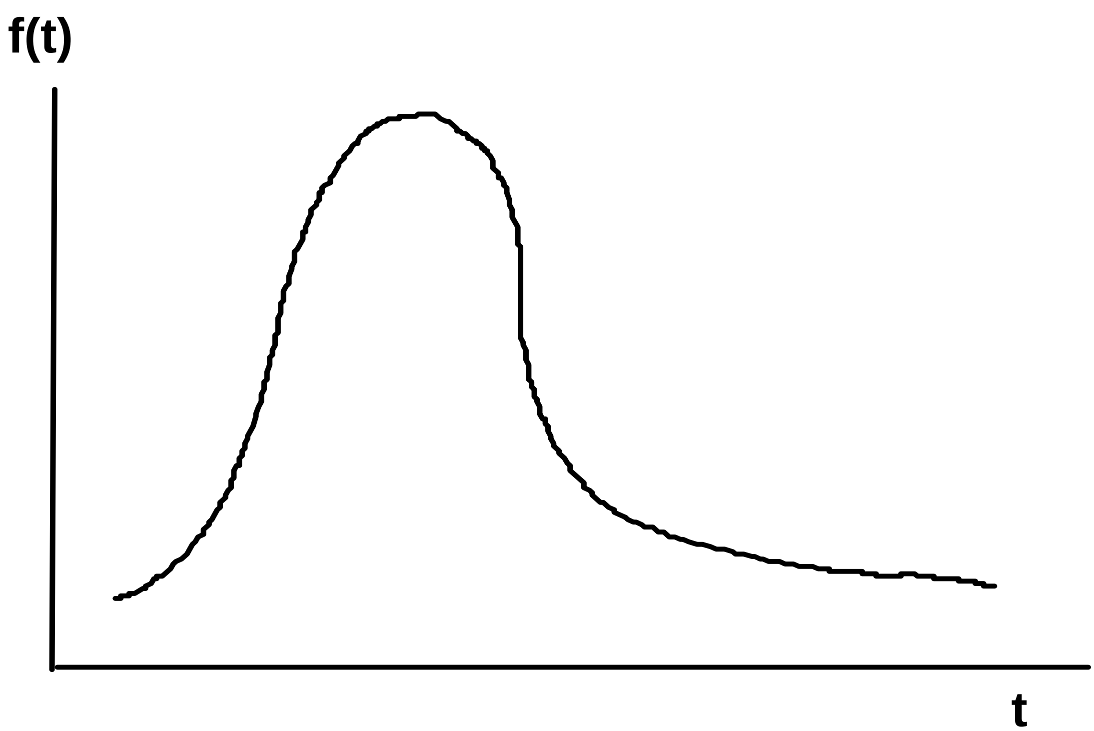


Figure 12.14

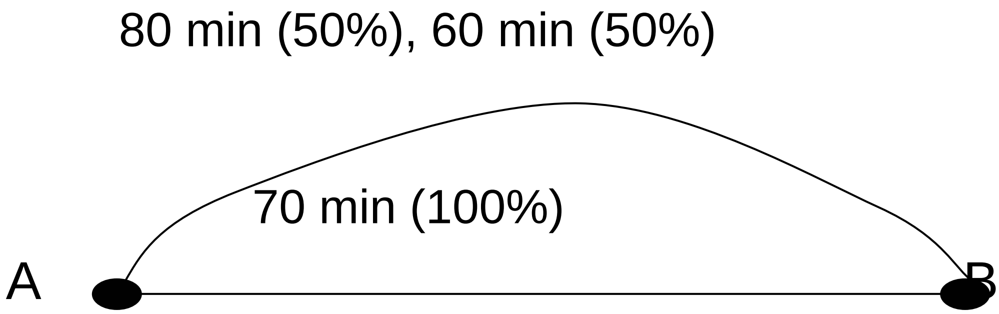
- This probability density function defines how reliable a particular mode is.
- TLC is a function of the travel time distribution.
- As the average travel time and variance grows, larger inventories are needed.

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

Bonsall, Peter, “Travellers’ Response to Uncertainty”, Chapter 1 in *Reliability of Transport Networks*, Bell and Cassir, eds., Research Studies Press Ltd., Baldock, Hertfordshire, England, 2000.

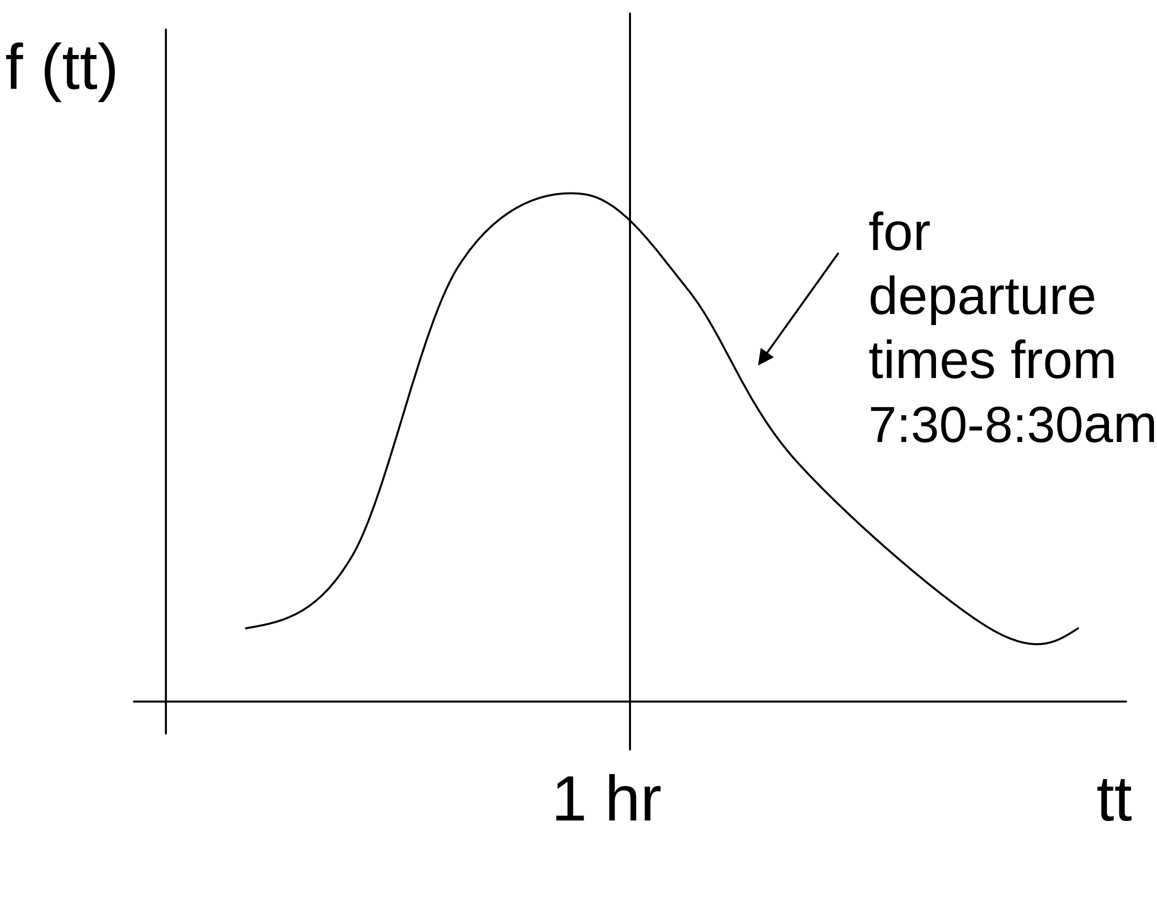


Risk Averse	Bottom
Risk Neutral	Either
Risk Prone	Top

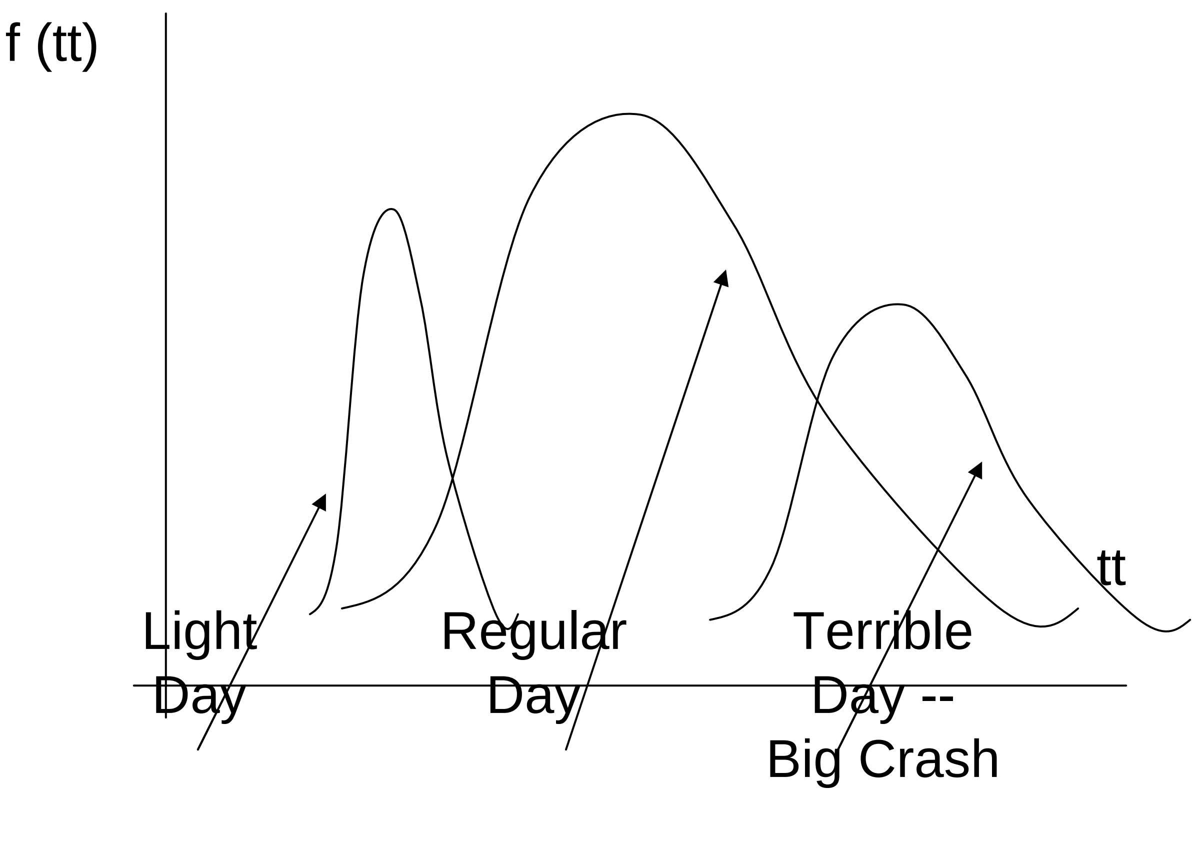
Think we should design unreliable systems for the thrill-seekers?

Yin, Yafeng and Hitoshi Ieda, “Assessing Performance Reliability of Road Networks Under Nonrecurrent Congestion”, *Transportation Research Record 1771*, National Academy Press, Washington, DC.

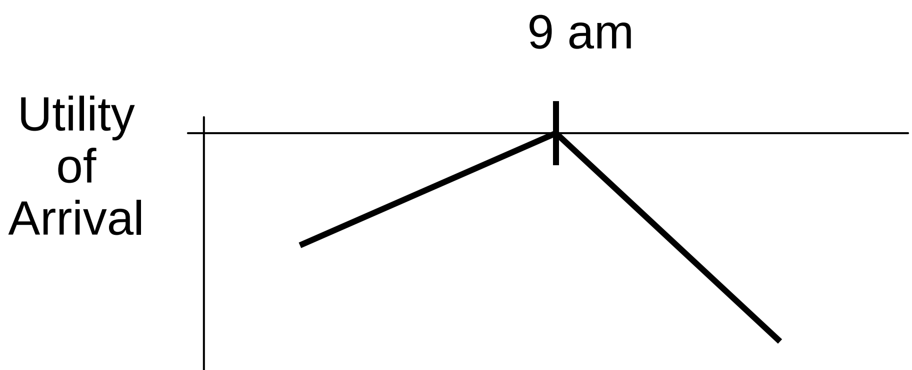
Desired Arrival Time = 9 am



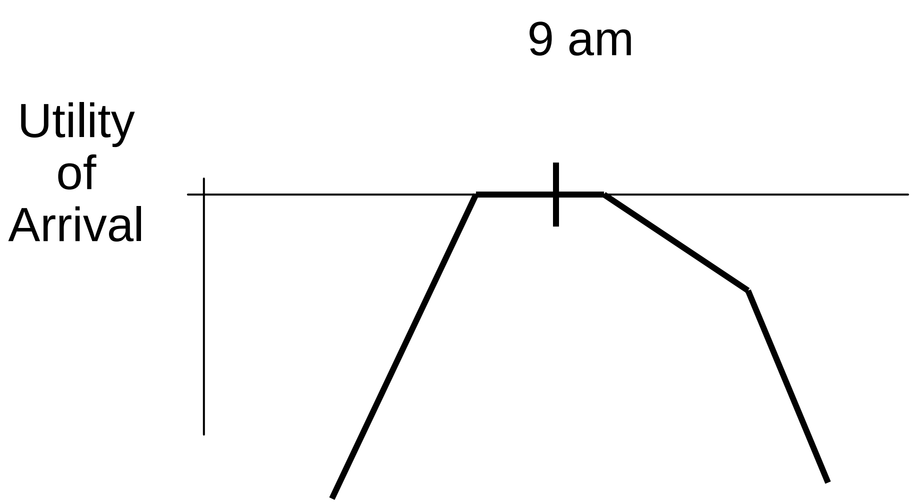
What is the overall travel time distribution composed of?



With no traveler information, how would you decide when to leave?



OR



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

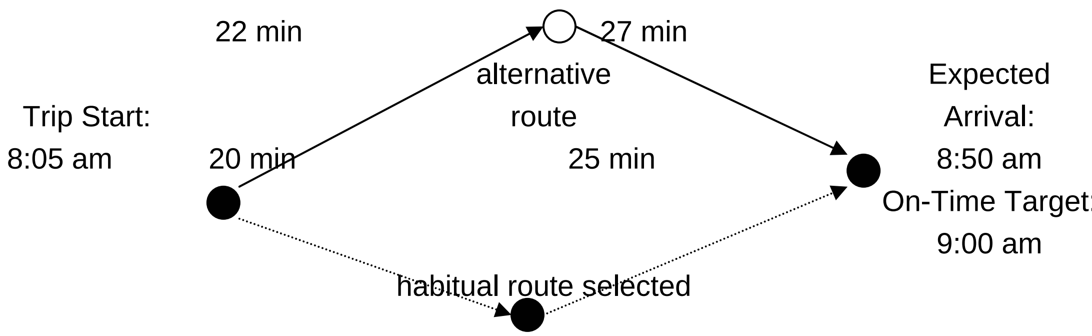


Figure ES-1: ATIS Non-User Route Choice and Trip Timing

ATIS User:
Reported Travel Times at 8 am

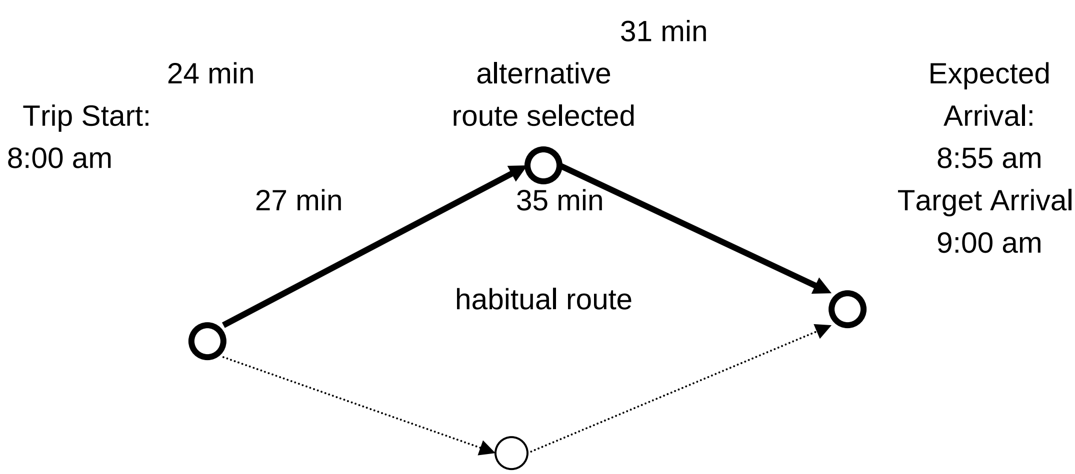


Figure ES-2: ATIS User Route Choice and Trip Timing

Wunderlich, Karl, Matthew Hardy, James Larkin, Vaishali Shah, "On-Time Reliability Impacts of Advanced Traveler Information Services (ATIS): Washington, DC Case Study", Mitretek Systems, McLean, VA, January 2001.

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 monitized, 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.

Wunderlich, Karl, Matthew Hardy, James Larkin, Vaishali Shah, "On-Time Reliability Impacts of Advanced Traveler Information Services (ATIS): Washington, DC Case Study", Mitretek Systems, McLean, VA, January 2001.

MITRETEK CONCLUSIONS (2)

- 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.

Wunderlich, Karl, Matthew Hardy, James Larkin, Vaishali Shah, "On-Time Reliability Impacts of Advanced Traveler Information Services (ATIS): Washington, DC Case Study", Mitretek Systems, McLean, VA, January 2001.

Llaneras, Robert E. and Neil D. Lerner, “The Effects of ATIS on Driver Decision Making”, *ITS Quarterly*, Washington, DC, Summer 2000.

- 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