The 7th ITS ISRAEL CONFERENCE

TRAFFIC MANAGEMENT, SMART CITIES AND CONNECTED VEHICLES – REALIZING THE POTENTIAL OF ITS

Prof. Nathan H. Gartner
University of Massachusetts
Lowell, MA, USA
November 27, 2014

SMART CITIES

"Charles Dickens portrayed the 18th century as a tale of two cities; the 21st century, though, will be a tale of Smart Cities."

- Sarwant Singh

Forbes (6/19/2014)

http://www.forbes.com/sites/sarwantsingh/2014/06/19/smart-cities-a-1-5-trillion-market-opportunity/

SMART CITIES

Scope

Early 1990's

- Coined to signify how urban development was turning towards technology, innovation and globalization: The use of information technology to meet the challenges of cities within a global knowledge economy.

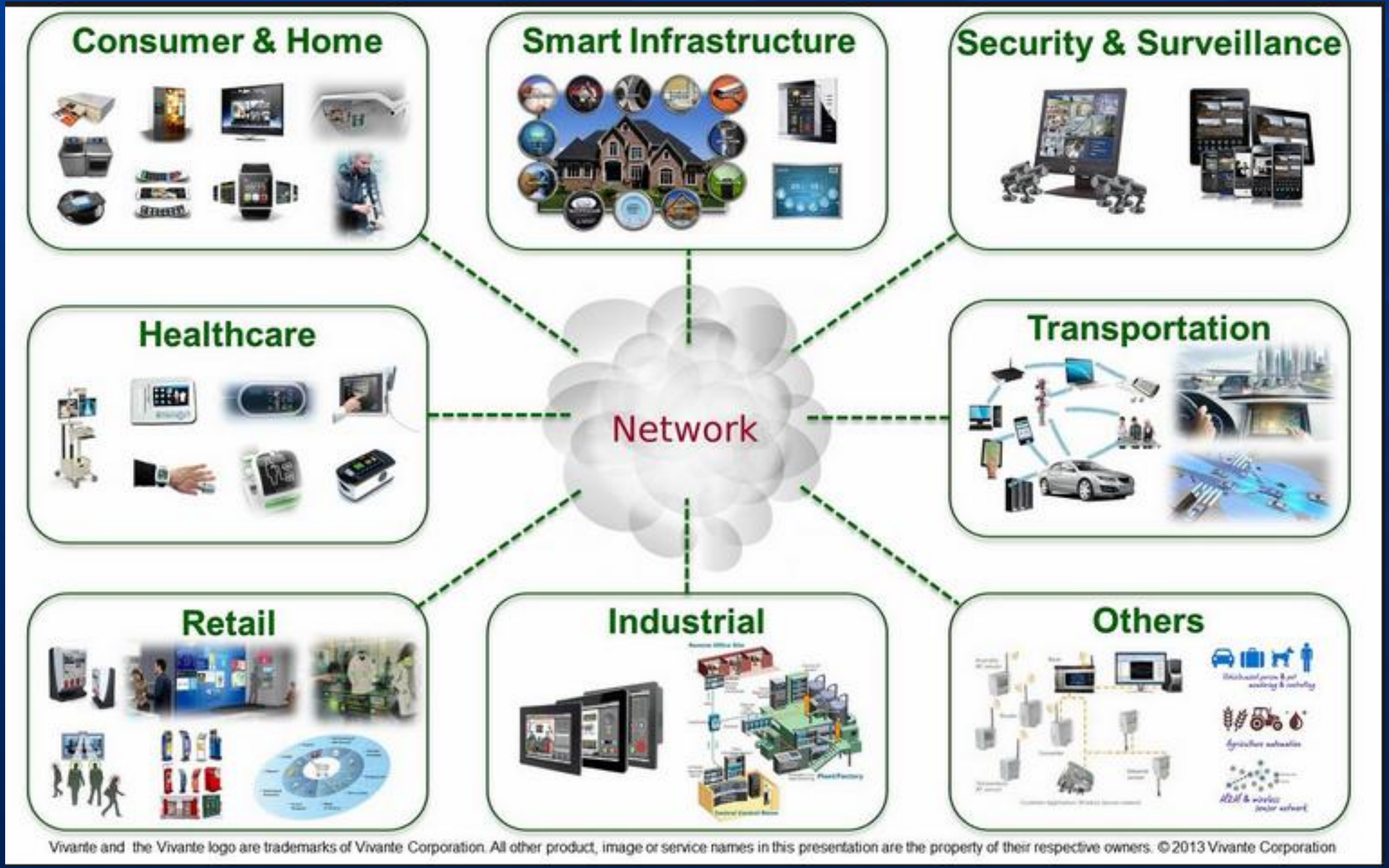
Today

- Interest in smart cities can be attributed to the strong concern for sustainability, and to the rise of new Internet technologies, such as mobile devices, the semantic web, cloud computing, and the Internet of Things (IoT).

FHWA Report Smart Cities: Intelligent Transportation and Smart Grid Standards for Electrical Lighting and Management Systems **Gridaptive Technologies** ©2012

INTERNET OF THINGS (IoT)

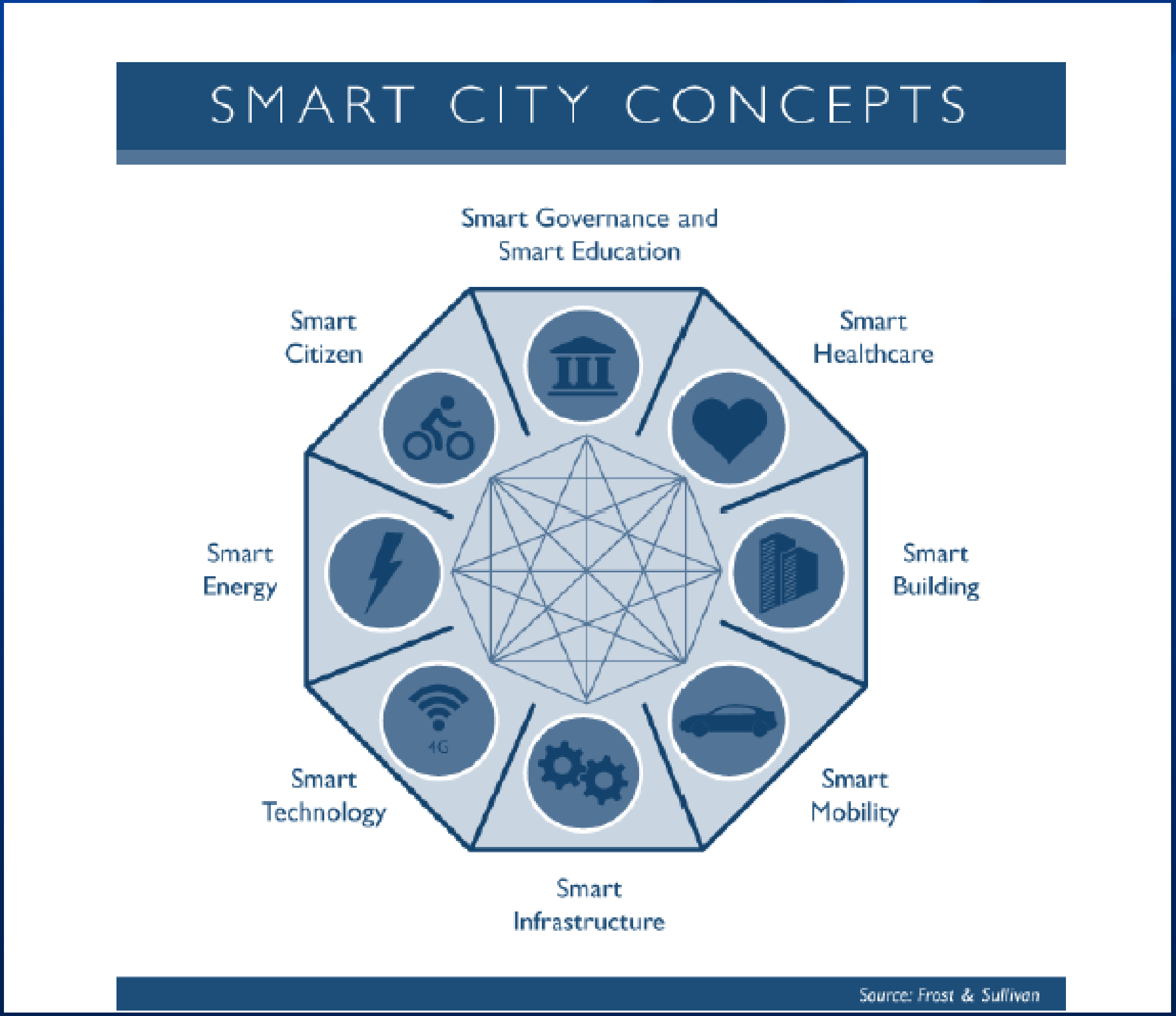
The network of physical objects that contain embedded technology to communicate and sense or interact with their internal states and the external environment.



Source: https://bensontao.files.wordpress.com/2013/10/vivante-iot-ecosystem.jpg

SMART CITIES

Parameters



- A city with at least five of these 'smart' parameters is defined as a '*smart city.*'
- *26 smart cities around the world by 2025.*
- *50% of these cities will be in North America and Europe.*

http://www.forbes.com/sites/sarwantsingh/2014/06/19/smart-cities-a-1-5-trillion-market-opportunity/

SMART CITIES

Economics

- $1.5 Trillion Global Market Potential
- Energy, Healthcare, Transportation, Buildings, Infrastructure and Governance.
- 4 models for building smart cities:
  - Build Own Operate (BOO)
  - Build Operate transfer (BOT)
  - Build Operate Manage (BOM)
  - Open Business Model (OBM)

http://www.forbes.com/sites/sarwantsingh/2014/06/19/smart-cities-a-1-5-trillion-market-opportunity/

FINANCIAL TIMES

The Future of the Car

Friday, 21 November, 2014

FINANCIAL TIMES

Internet connectivity in cars is becoming more common globally

FINANCIAL TIMES

Augmented reality windshields are on the verge of entering production

FINANCIAL TIMES

Introduction of automatic braking will save lives

FINANCIAL TIMES

Hydrogen and electric vehicles battle for supremacy

FINANCIAL TIMES

Constant monitoring raises privacy and safety issues

The important question is:

CAN WE SOLVE THE TRAFFIC CONGESTION PROBLEM ?

WARDROP Principles

Principle 1:

Under equilibrium conditions traffic arranges itself in congested networks such that all used routes between an O-D pair have equal and minimum costs, while all unused routes have greater or equal costs.

WARDROP Principles

Corollary:

Under equilibrium conditions, traffic will be such that no individual trip maker can reduce his path costs by switching routes.

WARDROP Principles

Principle 2:

Under system optimization conditions traffic should be arranged in congested networks in such a way that the average (or total) travel cost is minimized.

ITS APPLICATIONS IN THE U.S.

- Integrated Corridor Management System
- TrEPS – Traffic Estimation and Prediction System
- Connected Vehicle Research Program

INTEGRATED CORRIDOR MANAGEMENT SYSTEMS (ICMS)

ICM is a tool in the congestion management toolbox that seeks to optimize the use of existing infrastructure assets and leverage unused capacity along urban corridors.

ICM manages the corridor as a multimodal transportation system rather than managing individual assets.

Source: http://www.its.dot.gov/icms/

ICM PIONEER SITES

RITA

Eight *pioneer sites* selected as critical partners in development, deployment and evaluation of ICM strategies.

- Dallas, Texas
- Houston, Texas
- Minneapolis, Minnesota
- Montgomery County, Maryland
- Oakland, California
- San Antonio, Texas
- San Diego, California
- Seattle, Washington

ICM PIONEER SITES

	Corridor Assets to Be Integrated with ICM									
	Freeway			Arterial	Bus			Rail		
Pioneer Site Location	HOV	Tolling	Value Pricing	Real-Time Control	Fixed Route	Express Buses	Bus Rapid Transit	Commuter Rail	Light Rail	Subway/Heavy Rail
Dallas, Texas	◆	◆		◆	◆	◆			◆	
Houston, Texas	◆	◆	◆	◆	◆	◆	◆			
Minneapolis, Minnesota	◆	◆	◆	◆	◆	◆	◆			
Montgomery County, Maryland	◆			◆	◆	◆		◆		◆
Oakland, California	◆	◆		◆	◆	◆	◆	◆		◆
San Antonio, Texas				◆	◆	◆				
San Diego, California	◆	◆	◆	◆	◆	◆	◆			
Seattle, Washington	◆			◆	◆	◆		◆	◆	

ICM BENEFITS

Data from Pioneer Sites

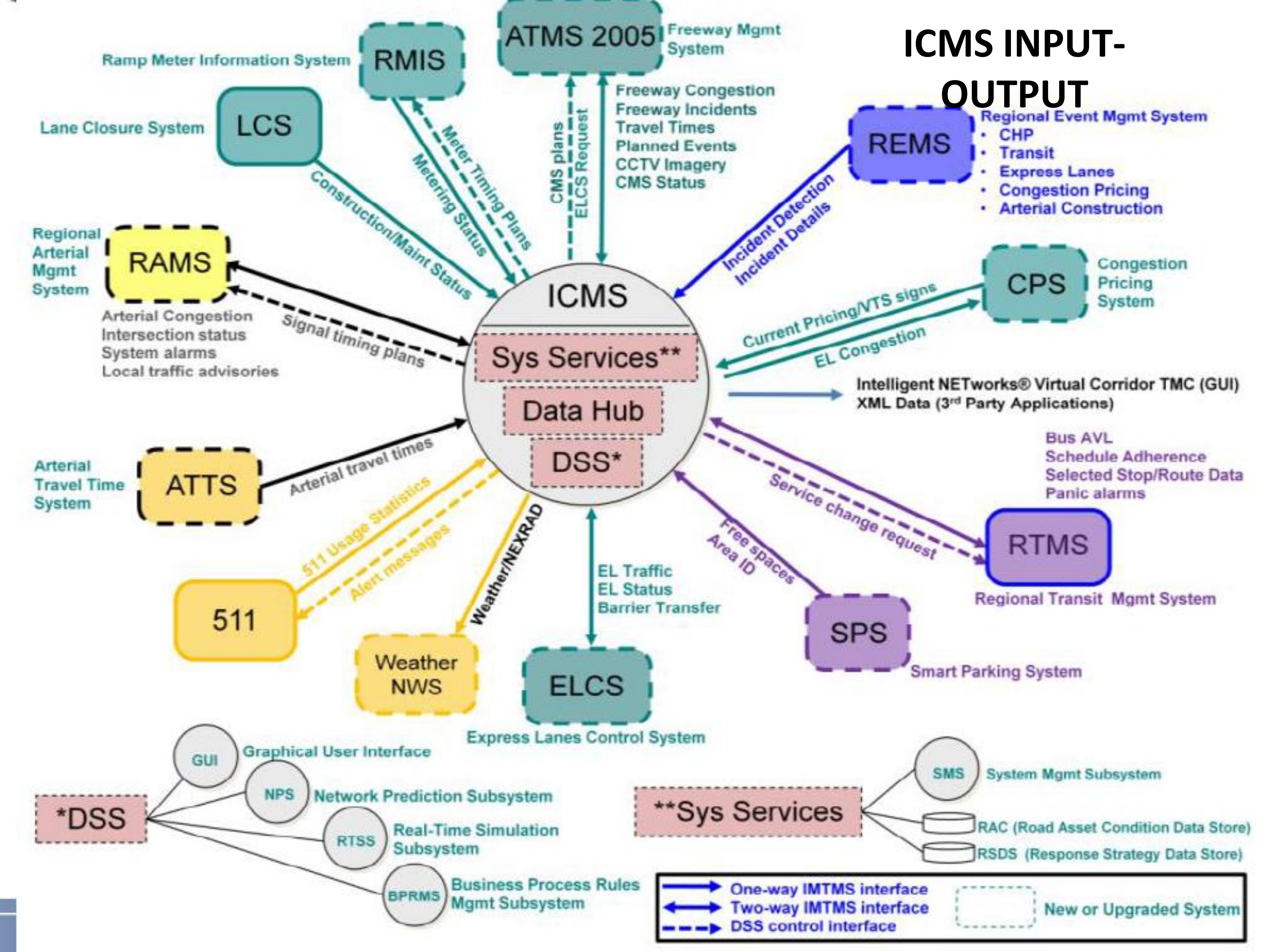
Table 1. Expected Annual ICM Benefits of Pioneer Sites

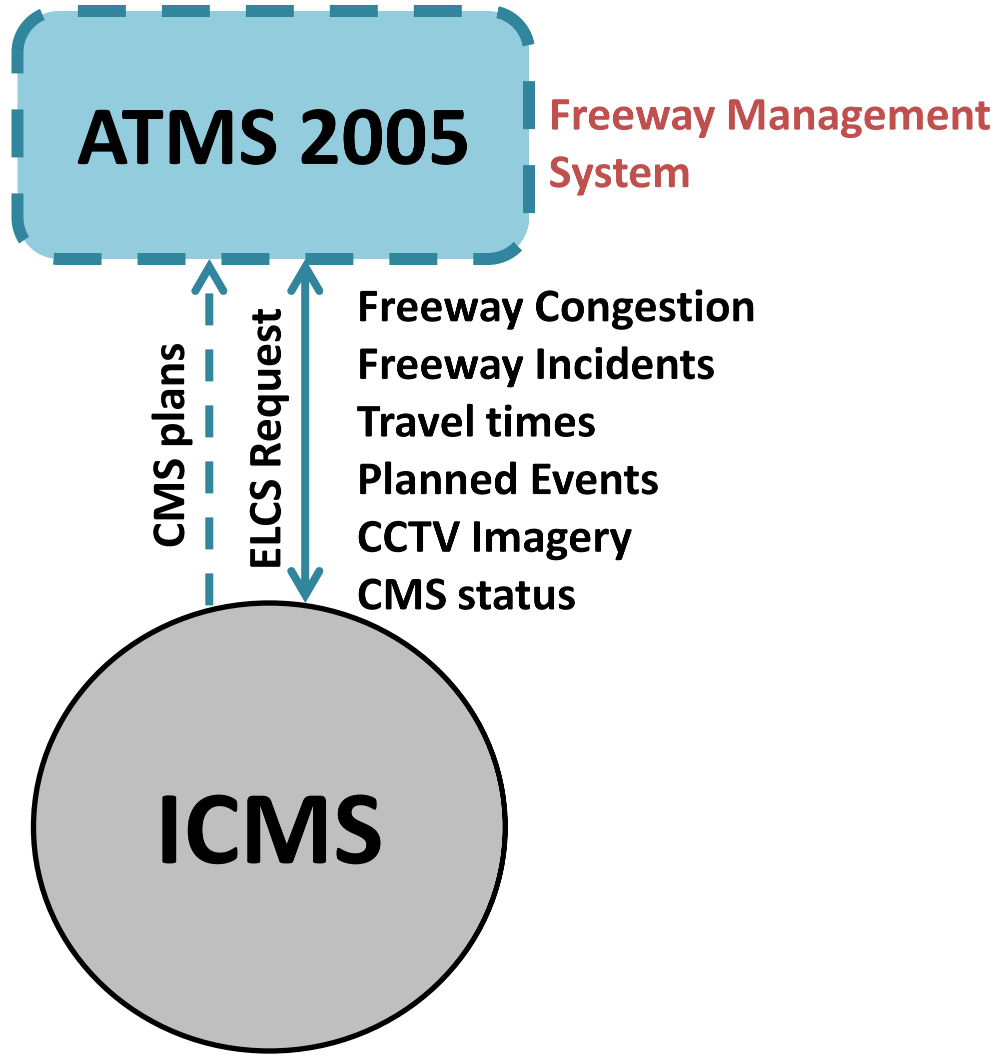
Benefit (from Simulations)	Dallas	Minneapolis	San Diego
Annual Travel Time Savings (Person-Hours)	740,000	132,000	246,000
Improvement in Travel Time Reliability (Reduction in Travel Time Variance)	3%	4. 4%	10. 6%
Gallons of Fuel Saved Annually	981,000	17,600	323,000
Tons of Mobile Emissions Saved Annually	9,400	175	3,100
10-Year Net Benefit	$264M	$82M	$104M
10-Year Cost	$14M	$4M	$12M
Benefit-Cost Ratio	20:1	22:1	10:1

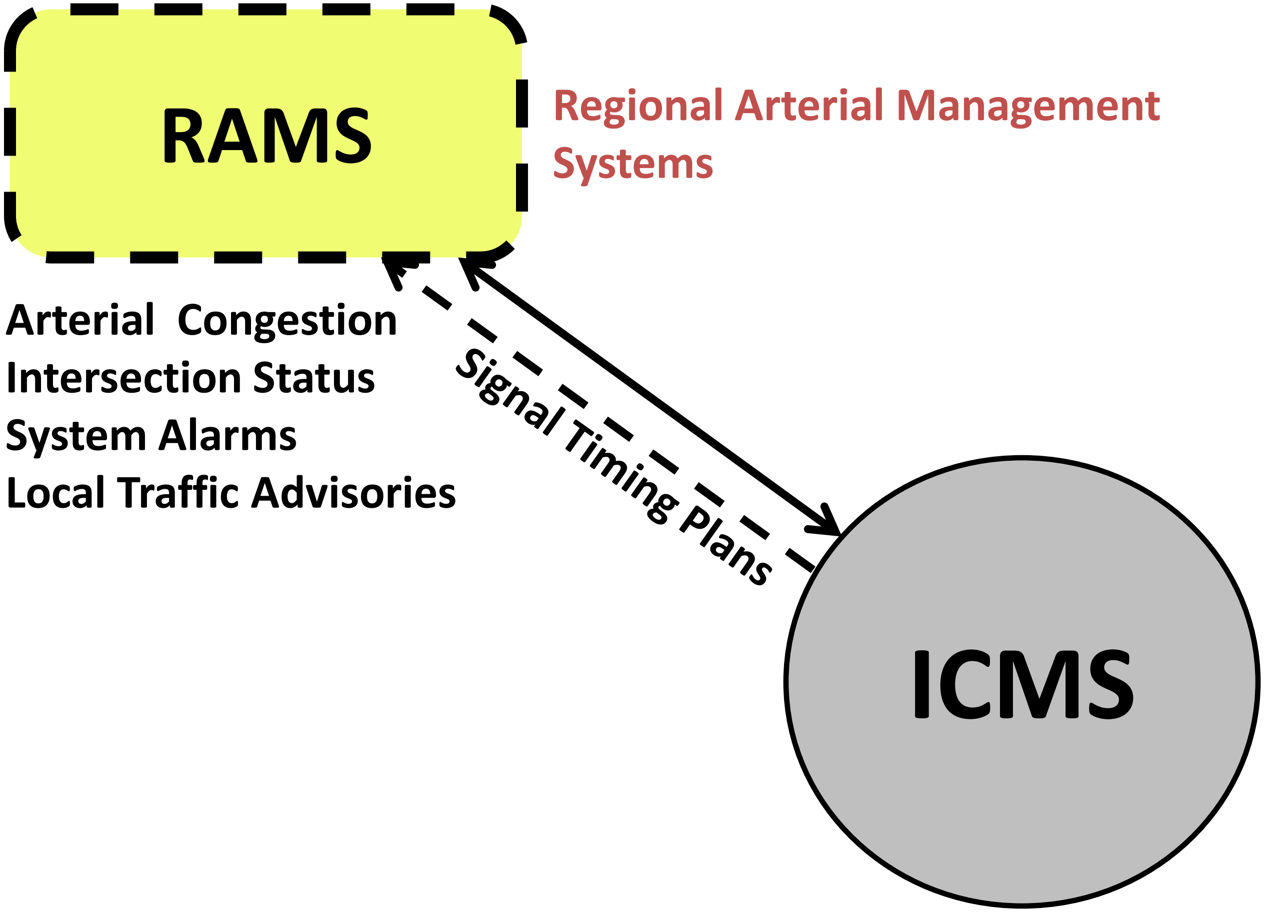
[Source: Draft Integrated Corridor Management Analysis, Modeling, and Simulation (AMS) for Three Stage 2 Pioneer Sites, U.S. DOT, April 2011, unpublished.]

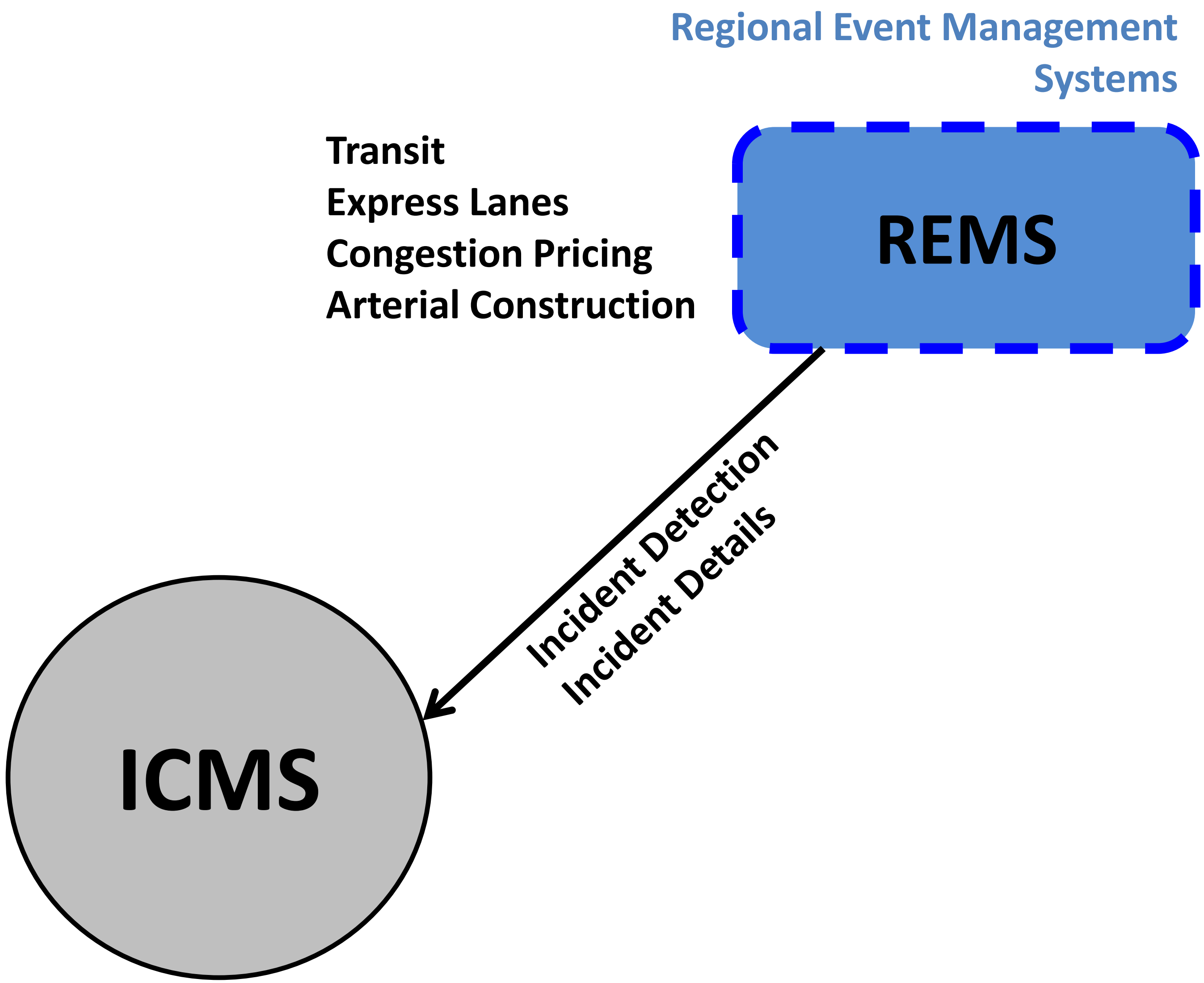
Source: http://ntl.bts.gov/lib/47000/47600/47670/FHWA-JPO-12-075_FinalPKG_508.pdf

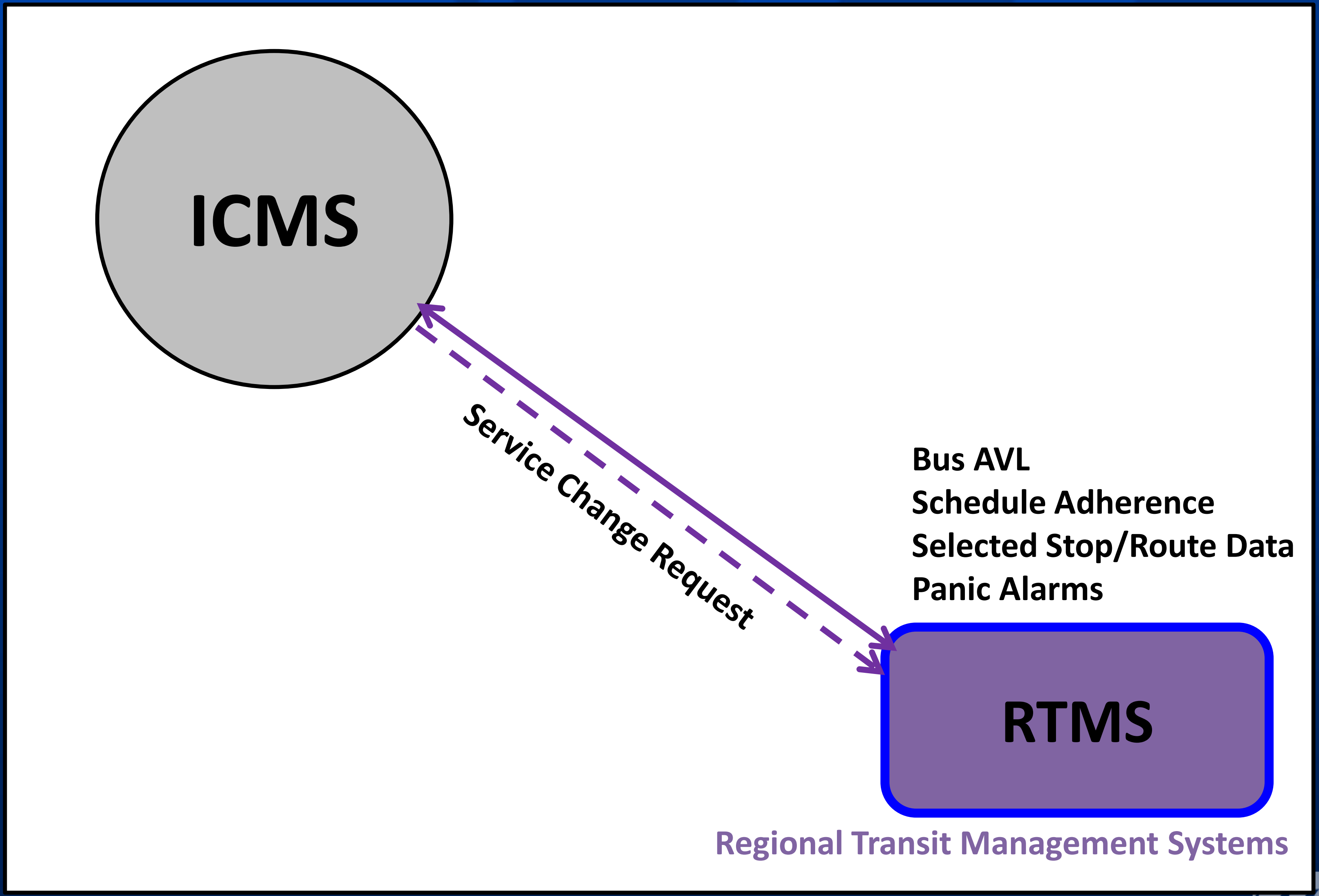
ICMS INPUT-OUTPUT




ATMS 2005
Freeway Management System
CMS plans
ELCS Request
Freeway Congestion
Freeway Incidents
Travel times
Planned Events
CCTV Imagery
CMS status
ICMS


RAMS
Regional Arterial Management Systems
Arterial Congestion
Intersection Status
System Alarms
Local Traffic Advisories
Signal Timing Plans
ICMS


Regional Event Management Systems
Transit
Express Lanes
Congestion Pricing
Arterial Construction
REMS
Incident Detection
Incident Details
ICMS


ICMS
Service Change Request
Bus AVL
Schedule Adherence
Selected Stop/Route Data
Panic Alarms
RTMS
Regional Transit Management Systems

ICMS Innovation

Traditional Traffic Management

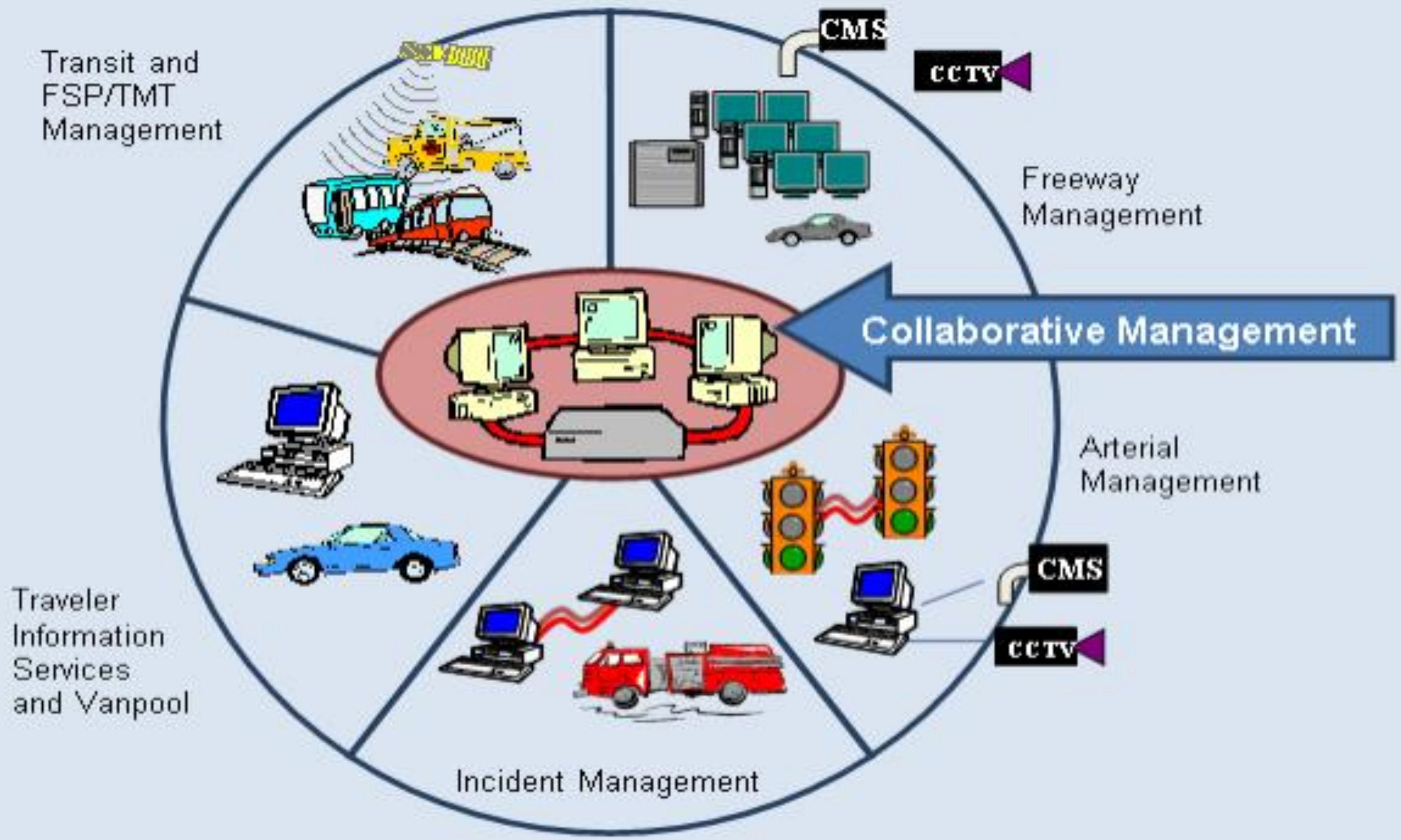
Detect → Verify → Respond

Integrated Corridor Management

Predict → Act → Prevent

SAN DIEGO ICMS

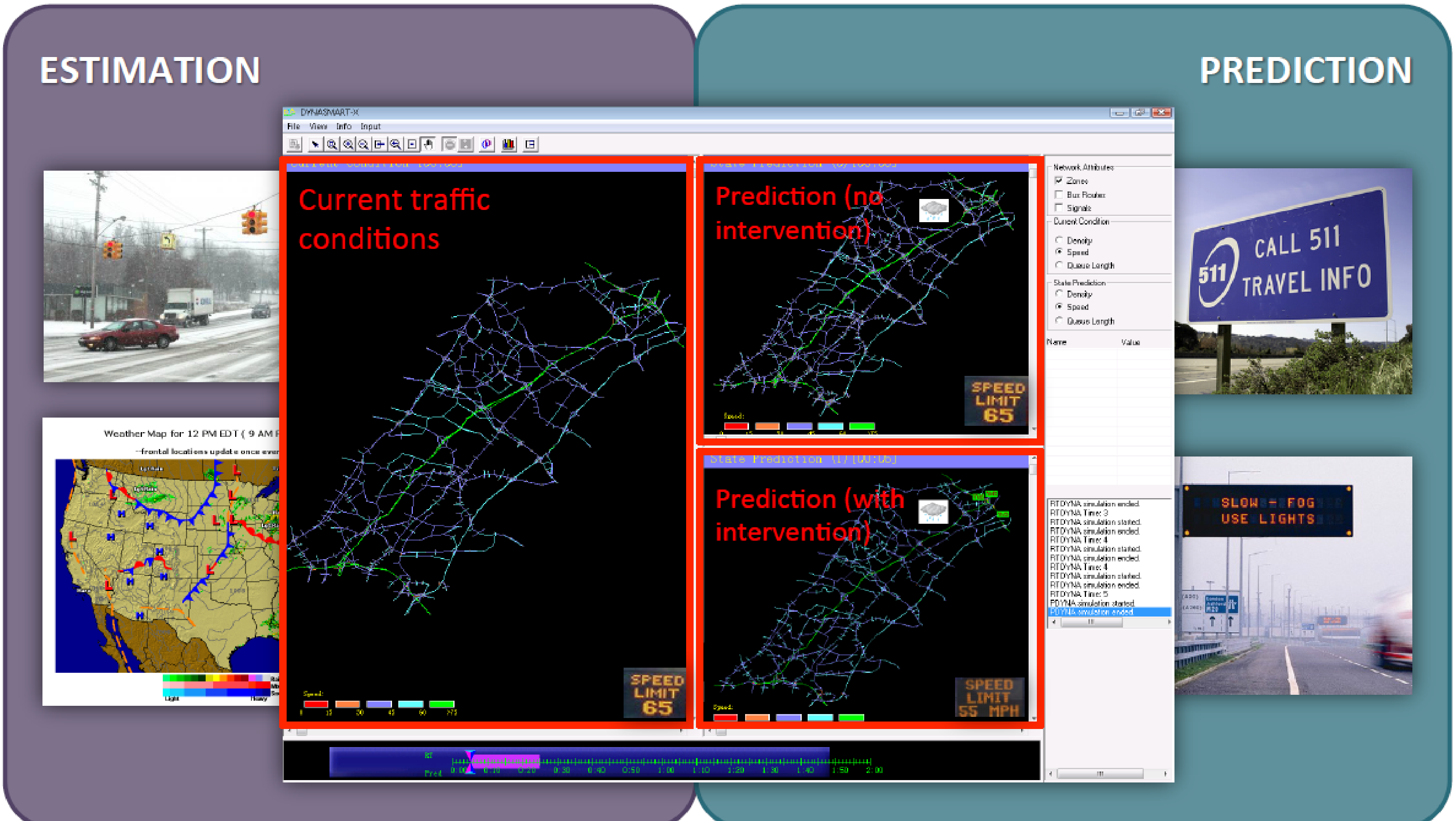
Coordination of Transportation Modes



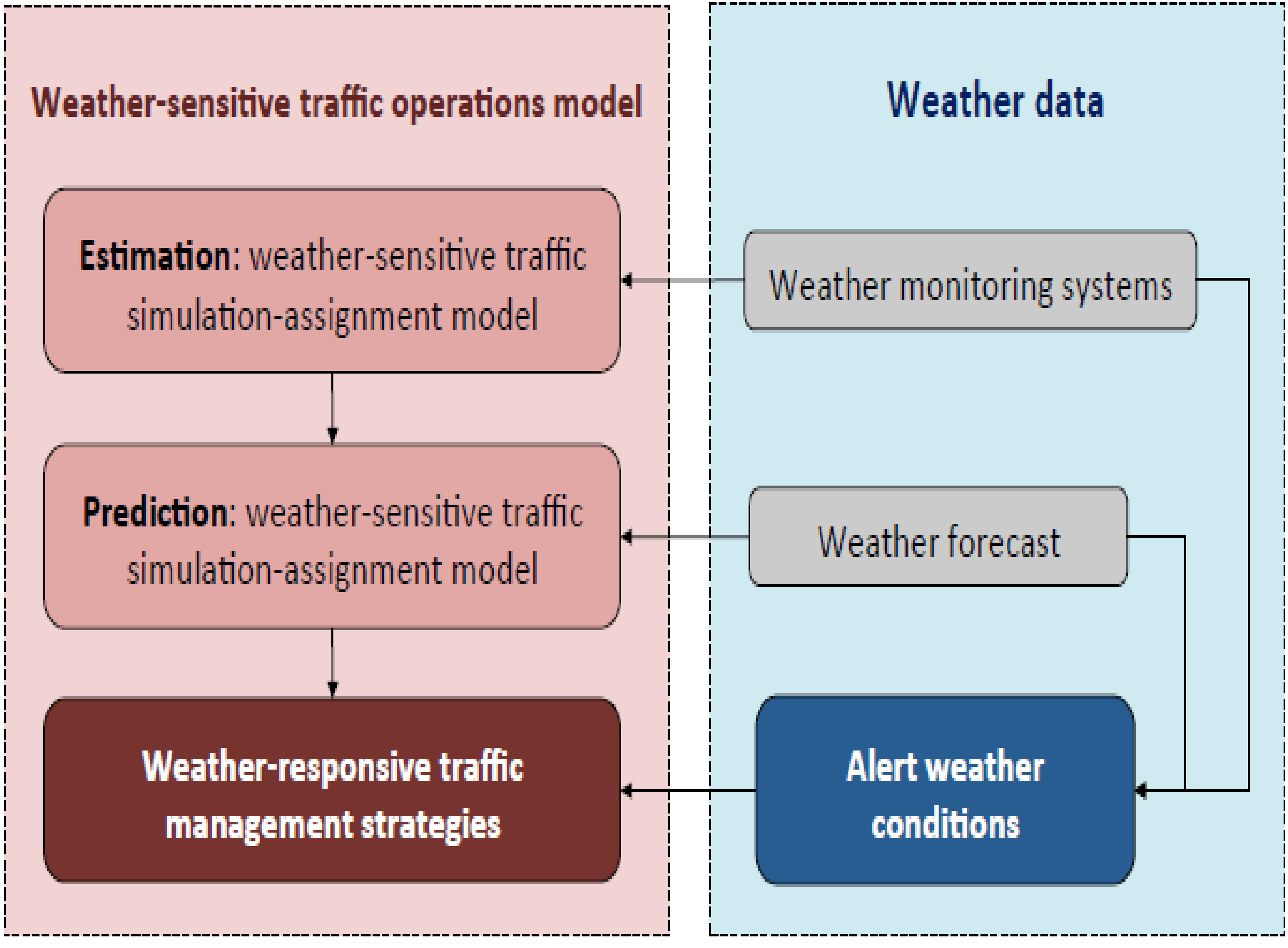
[Source: San Diego ICM Pioneer Site Kick Off Meeting presentation, October 24, 2006, unpublished.]

Traffic Estimation and Prediction System (TrEPS)

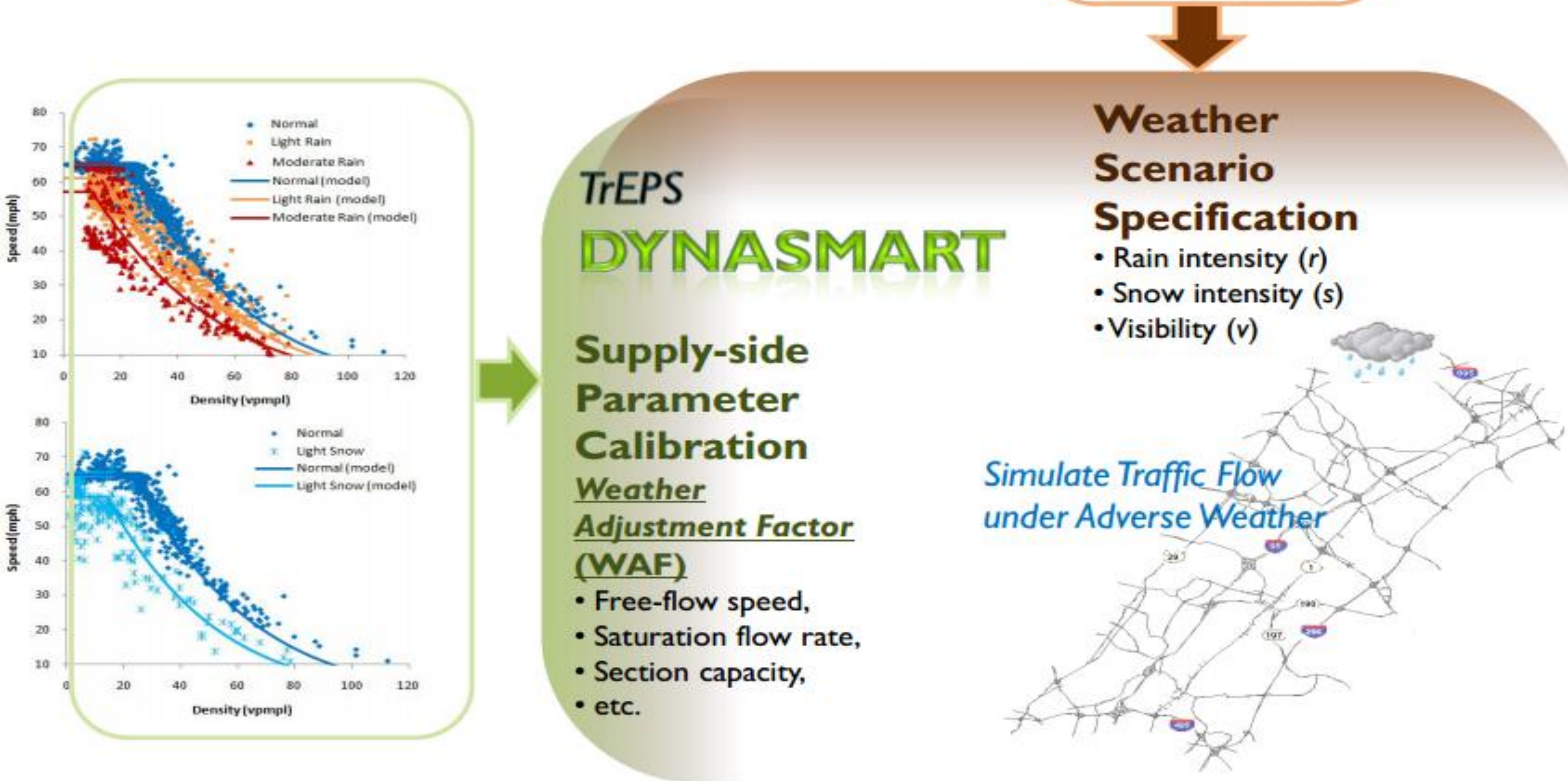
DYNASMART-X



http://www.its.dot.gov/road_weather/pdf/wrtm/Session2-3b_BobbyHaas_Wx-TrEPS.pdf


Weather-sensitive traffic operations model
Weather data
Estimation: weather-sensitive traffic simulation-assignment model
Weather monitoring systems
Prediction: weather-sensitive traffic simulation-assignment model
Weather forecast
Weather-responsive traffic management strategies
Alert weather conditions

Simulation of Different Weather Scenarios in TrEPS using DYNASMART-X



Weather Related Traffic Management (WRTM) Strategies using DYNASMART-X

Weather controlled variable speed limit sign

TrEPS

DYNASMART

Traffic Control

Variable Speed Limits via VMS

Signal Control

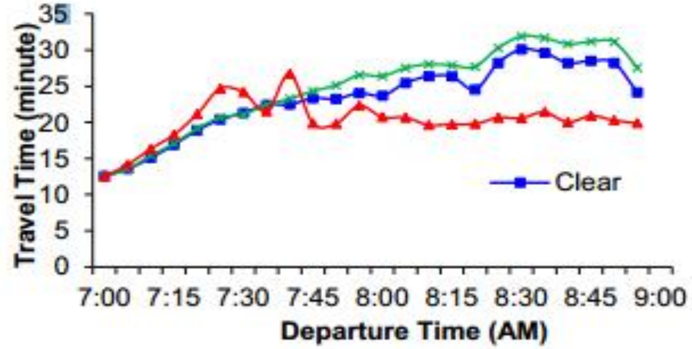
Ramp Metering

Evaluate the effectiveness of advisory/control strategies

Traffic Advisory

Variable Message Sign

- Speed reduction
- Optional detour
- Travel penalty (extra delay) warning



WRTM Application of Wx-TrEPS

Identify and select study networks

↓

Calibrate and validate off-line and on-line Wx-TrEPS models

↓

Identify existing or recommended WRTM strategies

↓

Implement and evaluate WRTM strategies using Wx-TrEPS

RECENT APPLICATIONS

Wx-TrEPS Evaluation of WRTM Strategies

Estimate effectiveness of different WRTM strategies:

- Demand Management
- Variable Speed Limits
- Optional Detour VMS

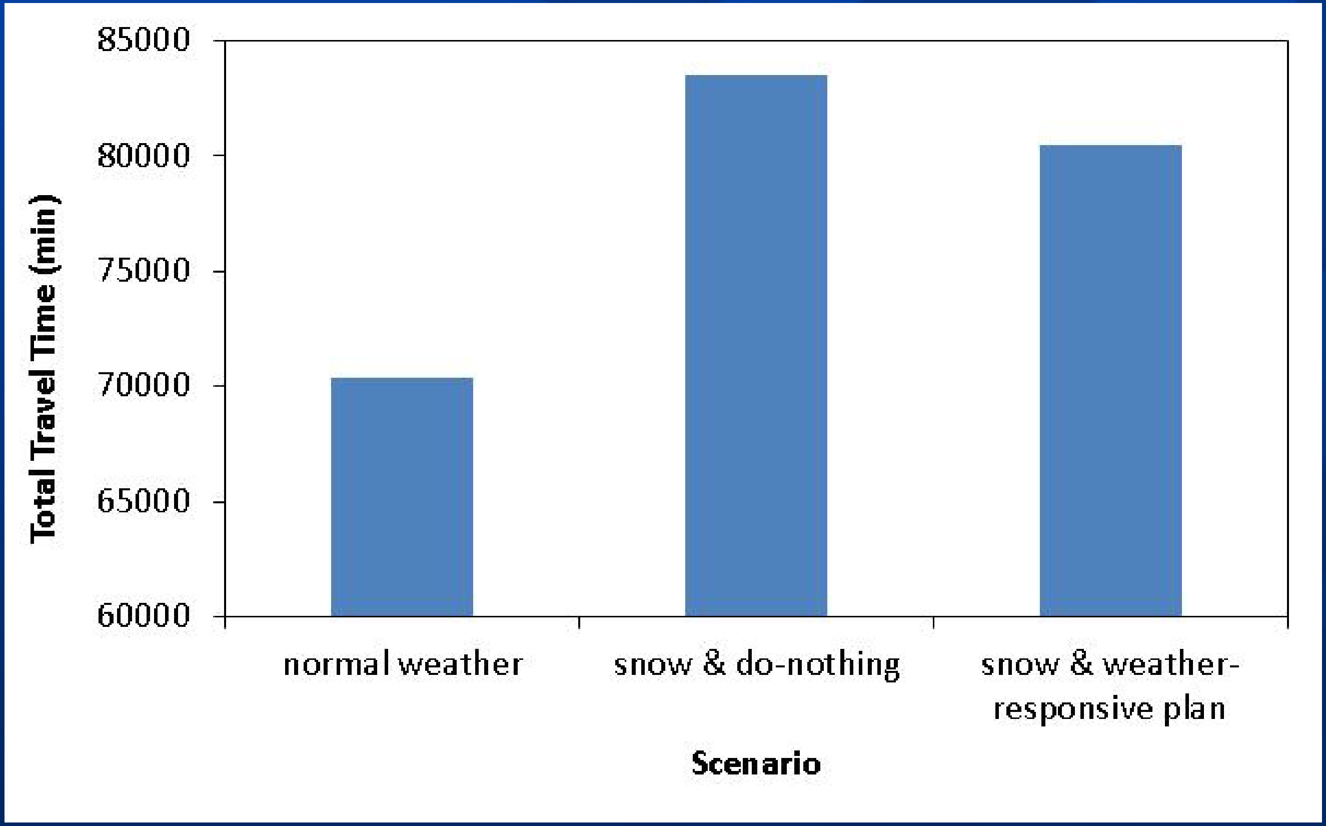
Utah DOT Implementation

Use Wx-TrEPS to analyze and evaluate weather responsive traffic signal timing plans on Riverdale Road in Ogden, Utah.

(off-line and in real-time)

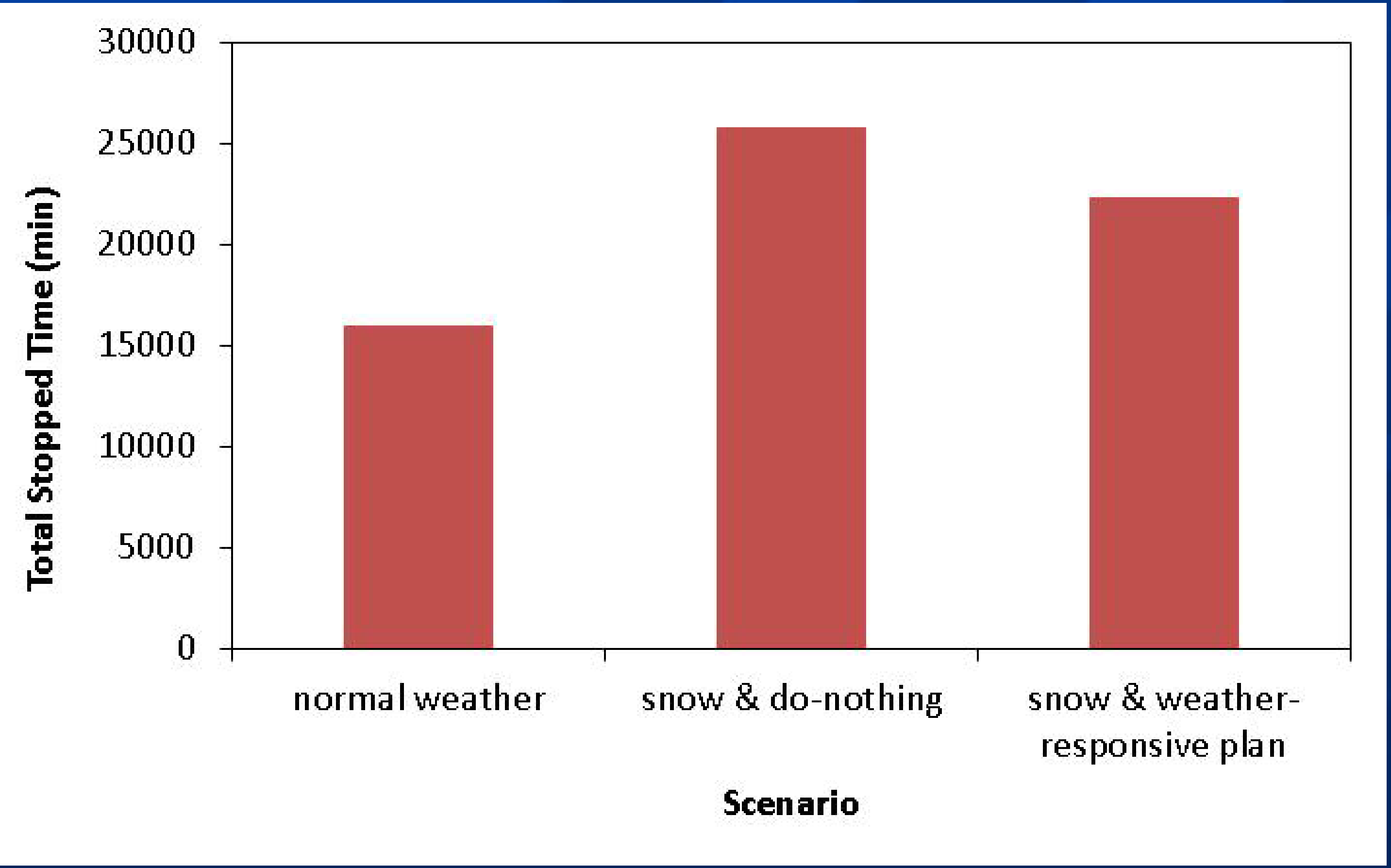
Intersection ID	Location
5000	700 West
5001	900 West
5002	1050 West
5003	I-84 SPUI
5004	1500 West
5005	Chimes View Dr.
5007	Wall
5008	Shopko
5009	300 West
5012	Grant/3th St
5020	550 West

IMPLEMENTATION RESULTS
Aggregated Total Travel Time



UMASS LOWELL

IMPLEMENTATION RESULTS
Aggregated Total Stopped Time



UMASS LOWELL

DECISION SUPPORT SYSTEM

Example: Weather Sensitive TrEPS (Traffic Estimation and Prediction Systems)

- Compare estimated state of network and predicted state of the network in terms of:
  - Free-flow speed
  - Saturation flow rate
  - Section capacity etc.
- On-line generation and real-time evaluation of a wide range of measures, including information supply to users, VMS displays, coordinated signal timing for diversion paths, as well as weather-related interventions (through variable speed displays, advisory information, signal timing adjustments and so on)

http://www.its.dot.gov/road_weather/pdf/wrtm/Session2-3b_BobbyHaas_Wx-TrEPS.pdf

CONNECTED VEHICLE RESEARCH (CVR)

Definition

A fully connected transportation system that makes the most of multi-modal, transformational applications that ensure safe, stable, interoperable, reliable system operations and minimize risk and maximize opportunities

Source: http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm

CONNECTED VEHICLE RESEARCH (CVR)

Vision

Connected vehicles use communications technology to allow cars, trucks, transit vehicles, traffic signals, work zones, and even pedestrians to “talk” to each other and exchange valuable information that could help avoid crashes and hazards.

Connected vehicles have the potential to transform the way Americans travel through the creation of a safe, interoperable wireless communications network—a system that includes cars, buses, trucks, trains, traffic signals, cellphones, and other devices.


Vehicle to Infrastructure (V2I)
Vehicle to Vehicle (V2V)

CONNECTED VEHICLE RESEARCH (CVR)

APPLICATIONS

V2V Safety Applications

- Emergency Brake Light Warning
- Forward Collision Warning
- Intersection Movement Assist
- Blind Spot and Lane Change Warning
- Do Not Pass Warning
- Control Loss Warning

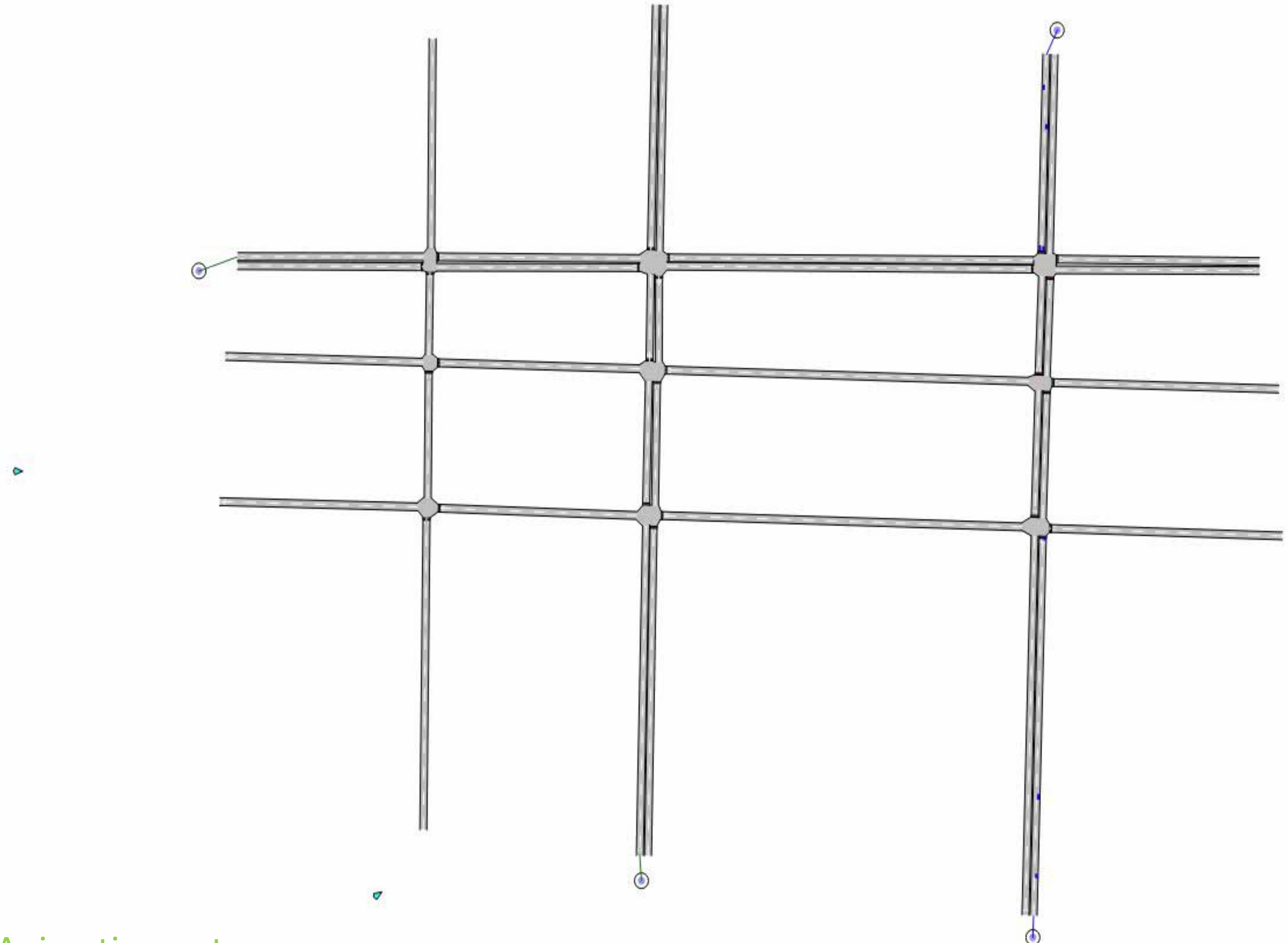
V2I Mobility Applications

- Intelligent Traffic Signals
- Speed Harmonization
- Enable Traveler Information
- Transit Connection
- Incident Management

V2I Environmental Applications

- Eco-Signal Systems
- Eco-Routing
- Smart Parking
- AFY Charging/Fueling Information

Animation of Route-Based Traffic Signal Control



Note: Animation not seen

TRAVEL TIME BUDGETS (TTB)

Definition

- Individuals’ average daily travel time tends to be relatively constant.
- People have a certain non-zero amount of time that they are willing to/want to spend on travel.
- People make adjustments to minimize deviating from this travel budget.
- Average travel time budget is relatively stable across time and space.

TRAVEL TIME BUDGET (TTB)

Statistics

TTB	References
1.1-1.3 hours/traveler/day	(Zahavi & Ryan, 1980); (Zahavi & Talvitie, 1980)
430 hours/person/year	(Hupkes, 1982)
50 mins-1.1 hours/person/day	(Beiber et al., 1994)
1.1 hours/person/day	(Schafer & Victor, 2000)
1.3 hours/person/day	(Vilhelmson, 1999)

TRAVEL TIME BUDGET (TTB)

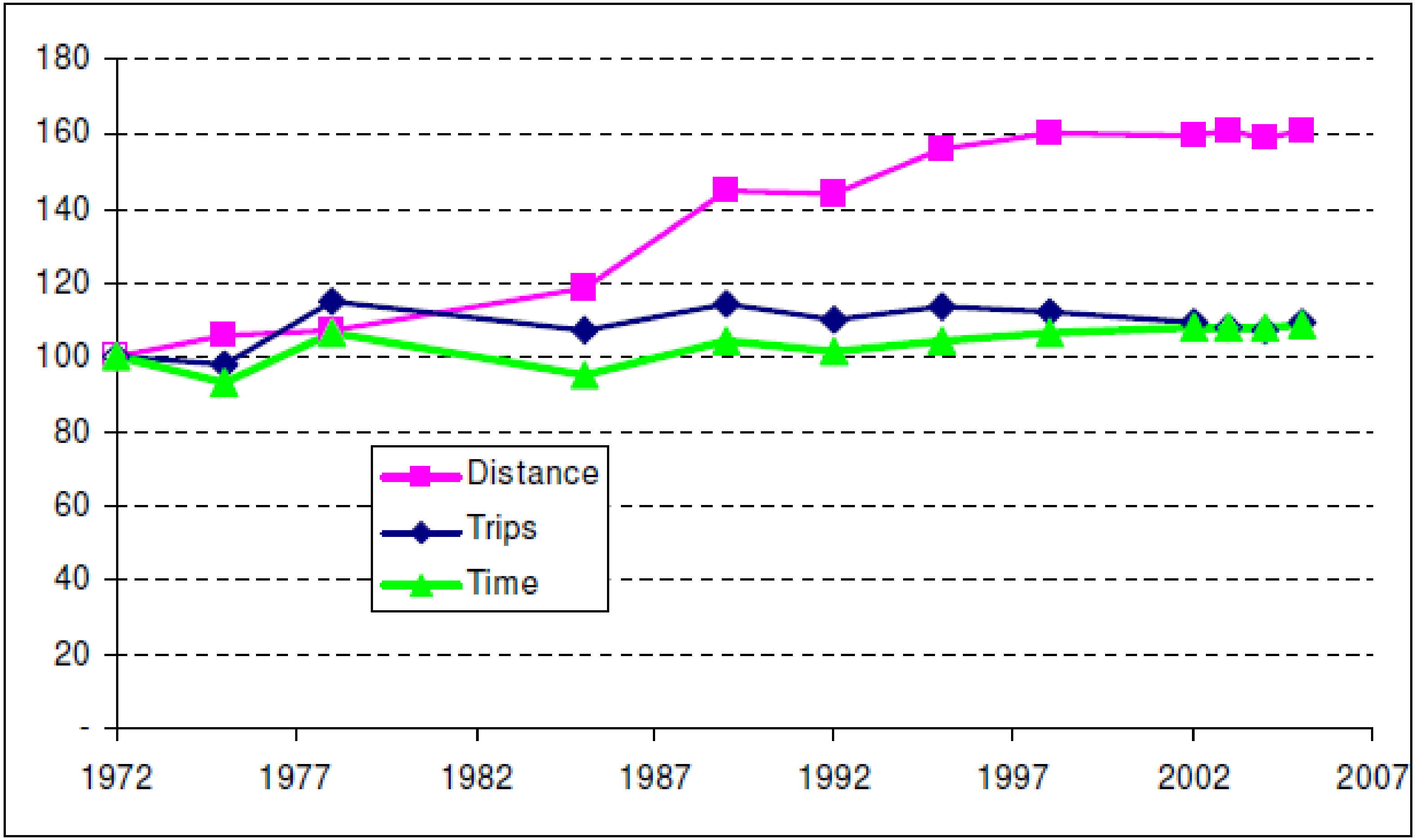
Zahavi's Principle

It is a common observation that at the aggregate level, when travel speeds increase over time – whether due to improvements in technology or additions of capacity to the system – travel distances tend to increase so as to keep travel times approximately constant.

(Zahavi and Ryan, 1980; Hupkes, 1982; Marchetti, 1994; Barnes and Davis, 2001).

CONSISTENCY OF TRAVEL TIME

Annual per Person Travel Characteristics from Great Britain National Travel Surveys 1972/73 to 2005

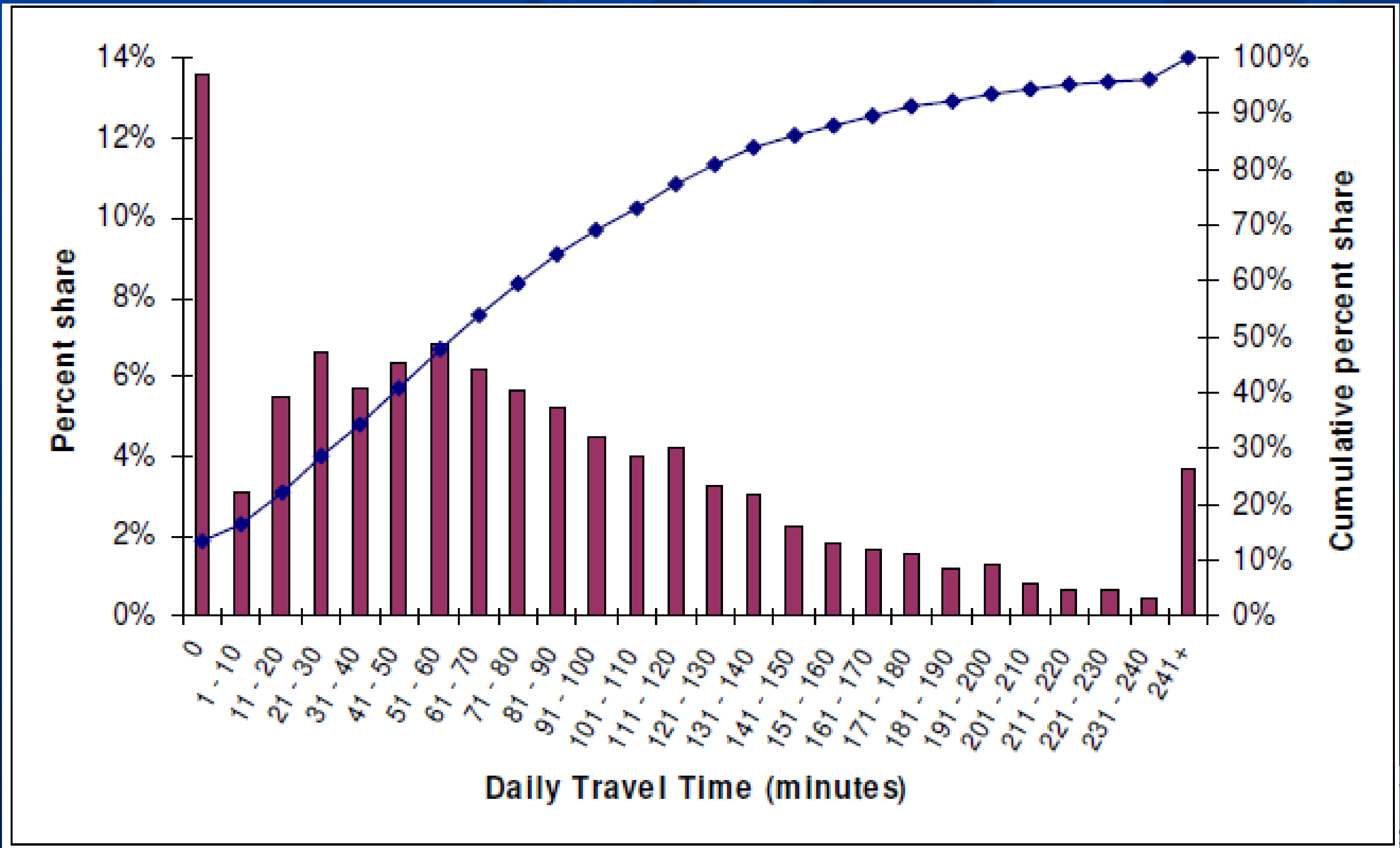


Data from 1995 onwards have been weighted, causing a one-off uplift between 1992/94 and 1995/97.

Source: Department for Transport (2006) Table 2.1

VARIATION OF TRAVEL TIME BETWEEN INDIVIDUALS

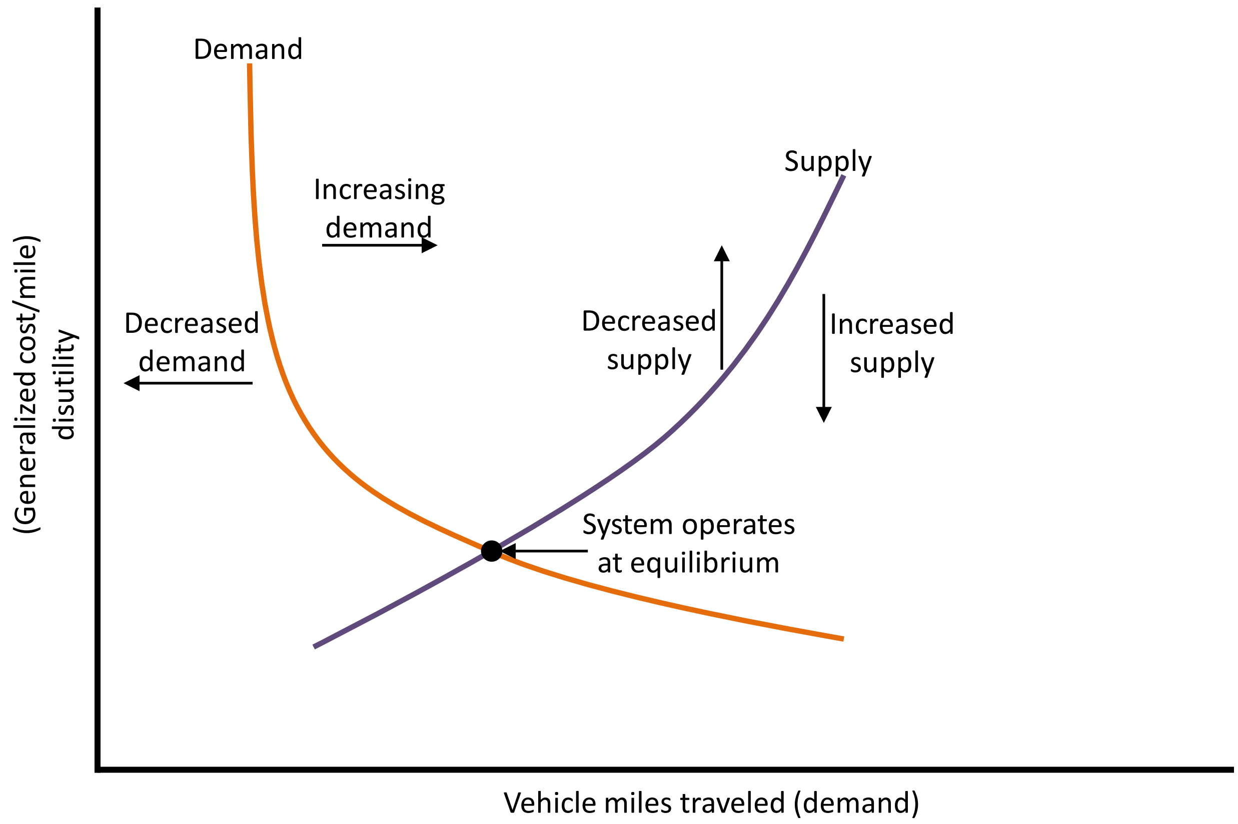
Daily Travel Time for Individuals in 2005 in Sydney,



Source: Frank Milthorpe, 30th Australian Transport Research Forum

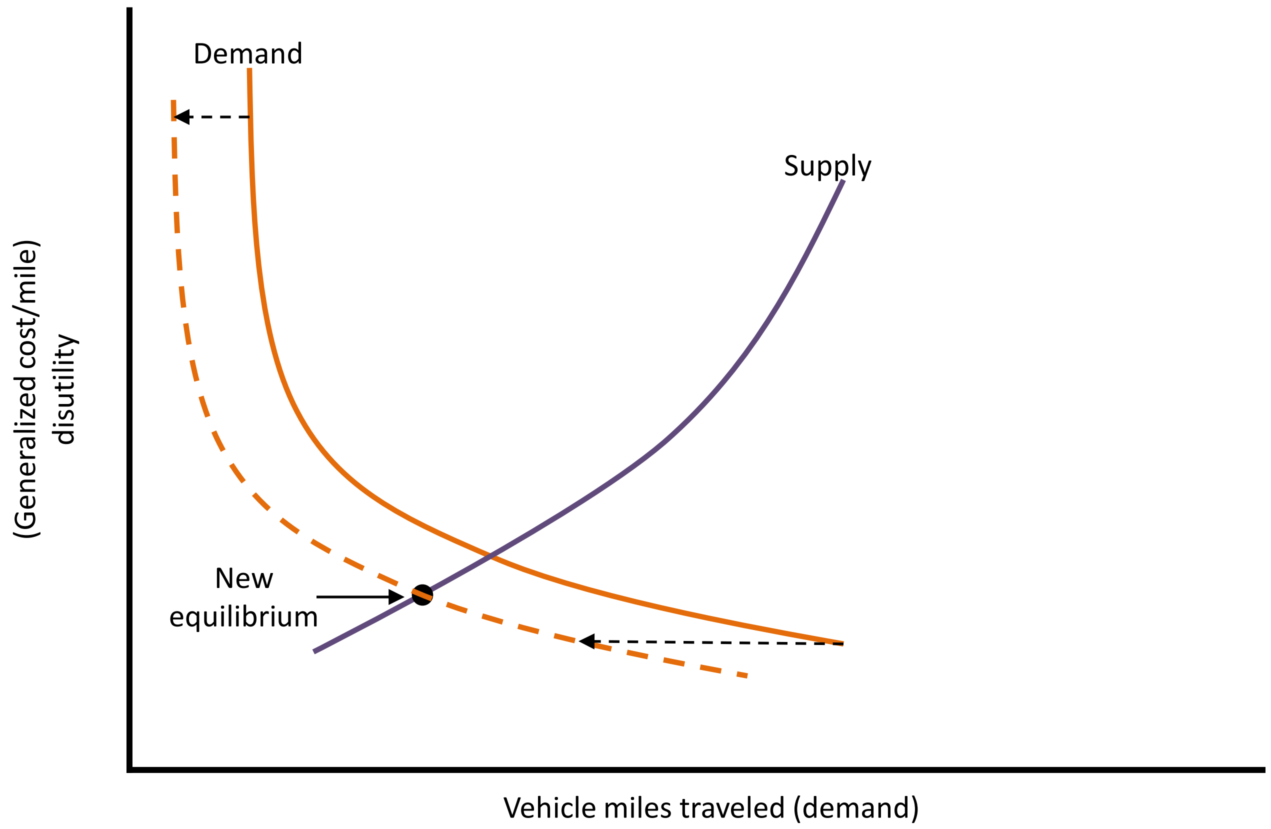
TRAVEL TIME BUDGET (TTB)

Supply and Demand Relationships for Urban Transportation



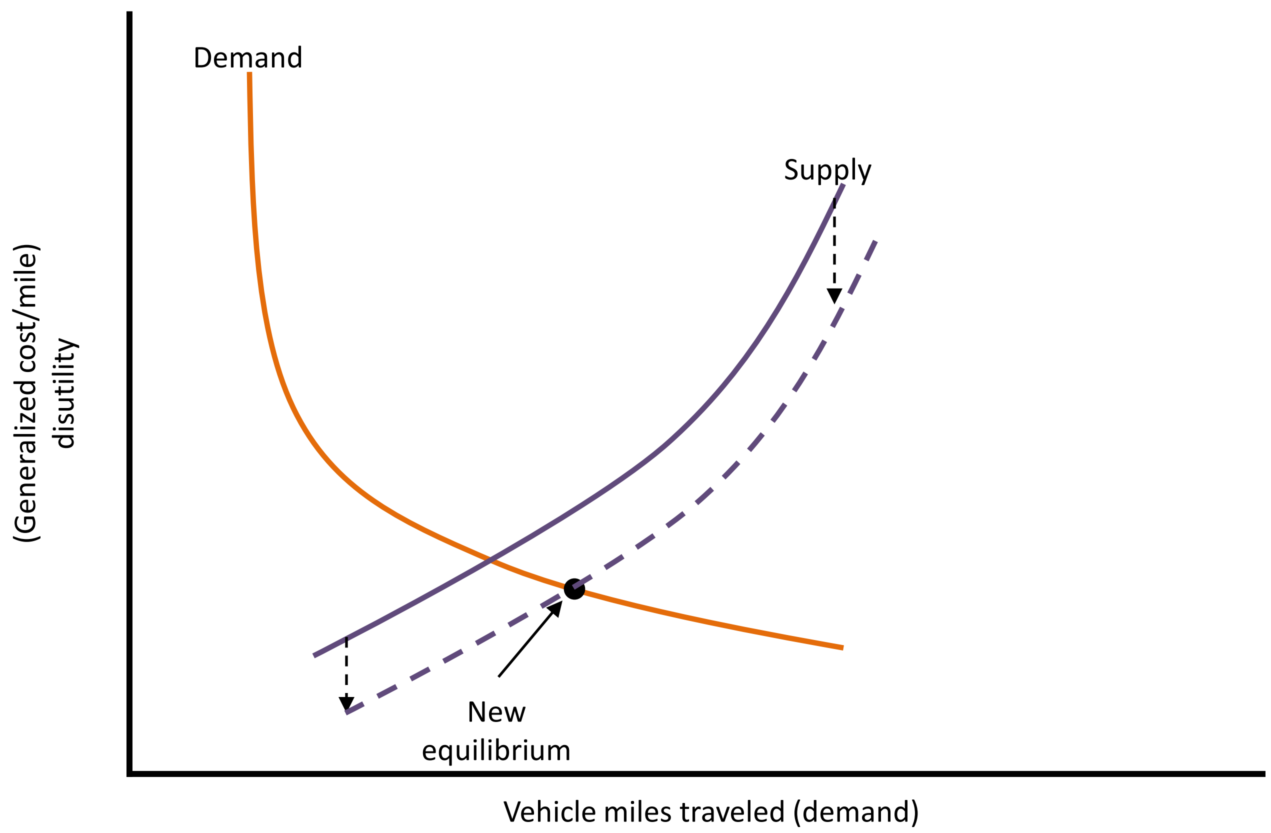
TRAVEL TIME BUDGET (TTB)

Change in Equilibrium with Reduced Demand



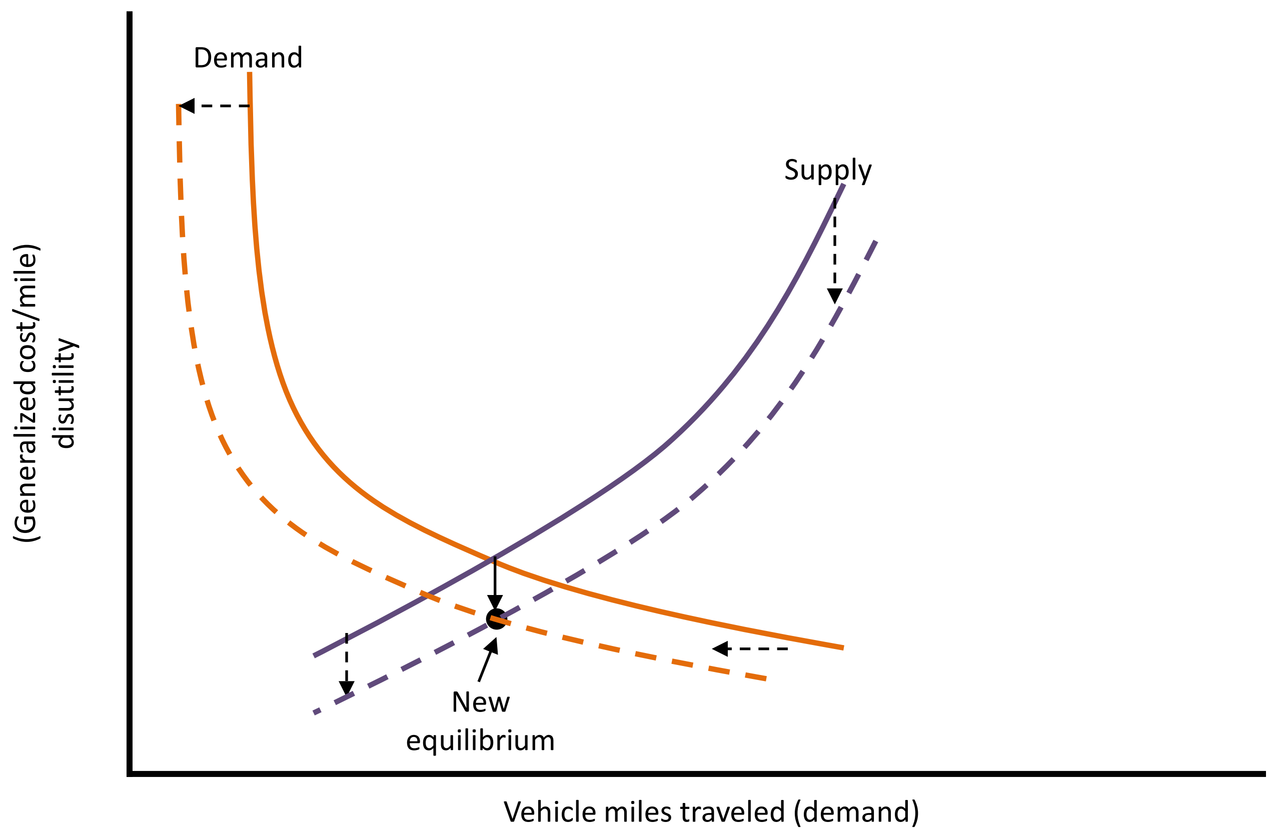
TRAVEL TIME BUDGET (TTB)

Change in Equilibrium with Increased Supply



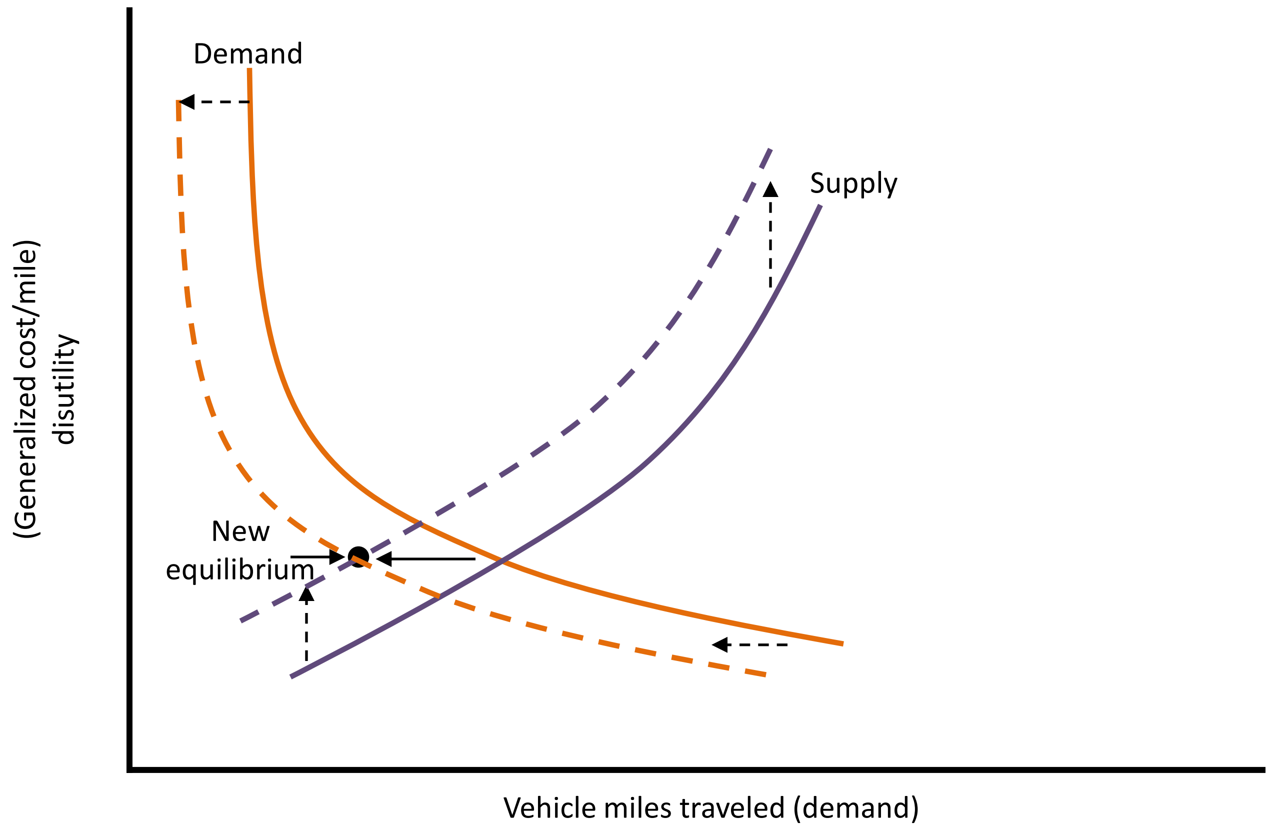
TRAVEL TIME BUDGET (TTB)

Change in Equilibrium with Reduced Demand and Increased Supply



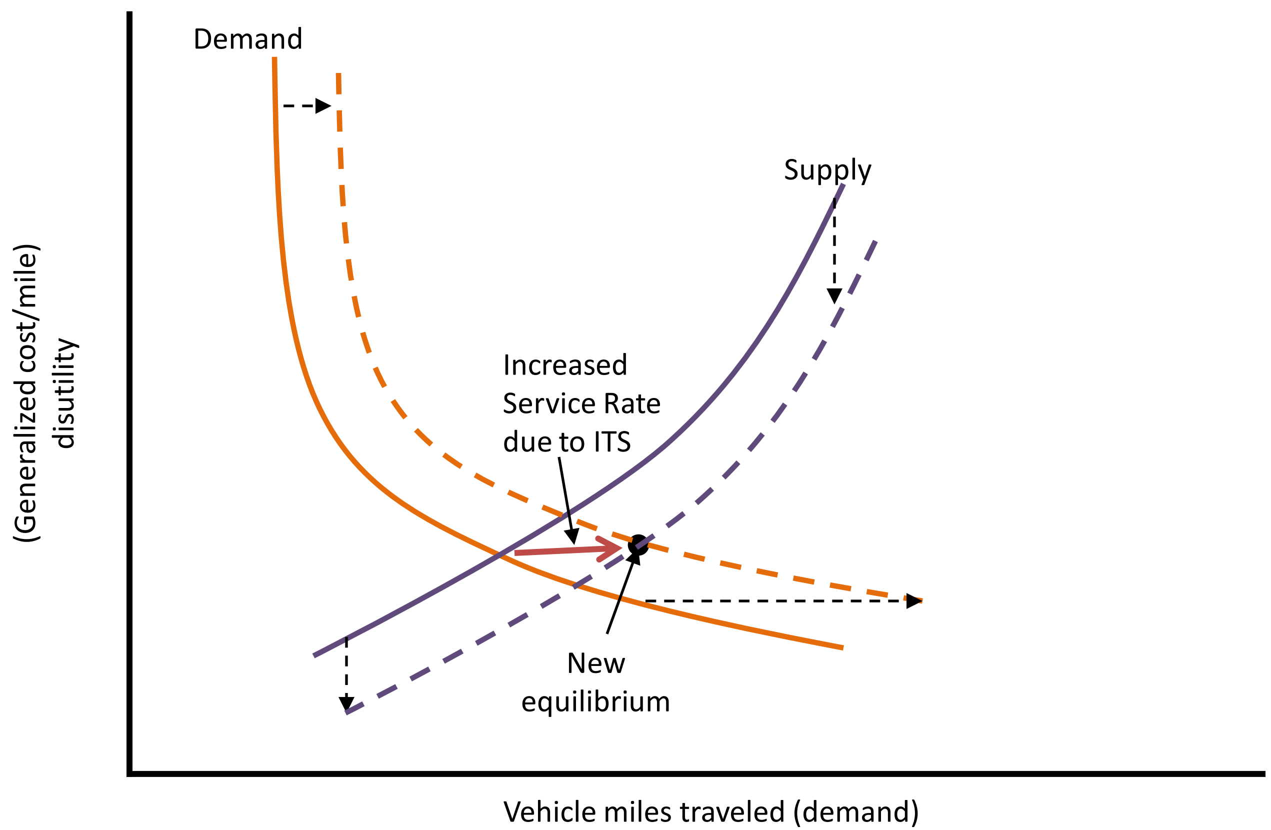
TRAVEL TIME BUDGET (TTB)

Change in Equilibrium with Reduced Demand and Degraded Supply



TRAVEL TIME BUDGET (TTB)

Change in Equilibrium with Increased Supply and Increased Demand



CONCLUSIONS

- We are in the midst of a fundamental revolution in transportation technology.
- Advanced technology expands supply and improves the level-of-service with increasing demands.
- However, the “congestion problem” is unlikely to be “solved” by ITS alone.

CONCLUSIONS

- The key to traffic management is the ability to predict changes in demand and/or supply and be pro-active.
- Decision support systems can provide on-line generation and real-time evaluation of a wide range of measures.
- Connected and autonomous technology will be beneficial when operating in concert with smart infrastructure.

THANK YOU!

Nathan_Gartner@uml.edu