ITS and Air Quality
A Critical Look

April 6, 2005
1.212 Introduction to ITS
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Outline

- **Is ITS good or bad for air quality?**
  - Which ITS applications have been shown to affect air quality, *and how*?
  - Are there ITS applications specifically oriented toward air quality, energy use, and the environment?
  - When deploying multiple ITS services, how can one assess the overall air quality impacts?
  - What does this all mean for ITS Architectures?

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ATMS (recurrent congestion)

- Reductions are possible from reduced congestion and smoother traffic flows
- Higher speeds may increase or reduce emissions, depending upon the pollutant
- In the short to medium term, increasing the effective capacity, and thus the volume of vehicles, may worsen localized air quality
- Long-term increases in trip-making and higher VMT may negate early benefits at a regional level

ATMS (non-recurrent congestion)

- Reductions are possible from reduced congestion and smoother traffic flows
- May be able to minimize the negative “side effects” of reducing recurrent congestion
- Increased reliability
- Often more effective when coupled with ATIS-based strategies

ATIS

- **Improved route information may reduce emissions**
  - Individual: more efficient trip-chaining
  - Network: congestion reduction
- **Could increase VMT by re-rerouting to longer-distance but faster routes**
- **Could decrease VMT by re-rerouting to shorter routes (arterials versus freeways)**
- **May increase overall travel through changes in trip-making behavior, such as more non-peak travel or peak spreading**
- **Net impact depends on VMT and emission rates**

APTS

- **Emissions may be reduced through greater use of public transportation rather than private auto use**
  – Improved operations
  – Improved perception & comfort
- **Operational improvements may reduce emissions from the transit vehicle fleet**

CVO

- Improve fleet operations may reduce number of vehicles required for given freight movements
- May reduce impact on congestion in urban areas by avoiding particular routes or hours
- Permits closer monitoring of vehicle performance, fuel use, and emissions

AVCS

- **Can be used for more efficient driving (e.g., less aggressive accelerations and stops)**
- **Advanced Highway Systems face same issues at ATMS - could dramatically increase effective capacity, leading to increased emissions**

Congestion and emissions

- **Does improving *congestion* improve *air quality*?**
  - Smoother traffic flow: stop-and-go traffic generates more emissions
  - Faster traffic flow: at which point is that no longer beneficial?
  - In the long-run, will it just create more traffic?
- **Can you *manage*, not build, your way out of congestion?**
  - What are the relative impacts of addressing congestion through operations v. building more capacity?
  - Can ITS minimize the negative impacts of more capacity?

"Sustainable Use" of ITS

- **Most of the ITS subsystems can have either positive or negative air quality impacts**
  - Depends upon the design of the system
  - Use of performance measures that are compatible with air quality
  - Ability to price may be key to sustainable use

- **Are there ITS technologies specifically oriented toward air quality improvements?**
- **How do we incorporate them into the ITS architecture?**

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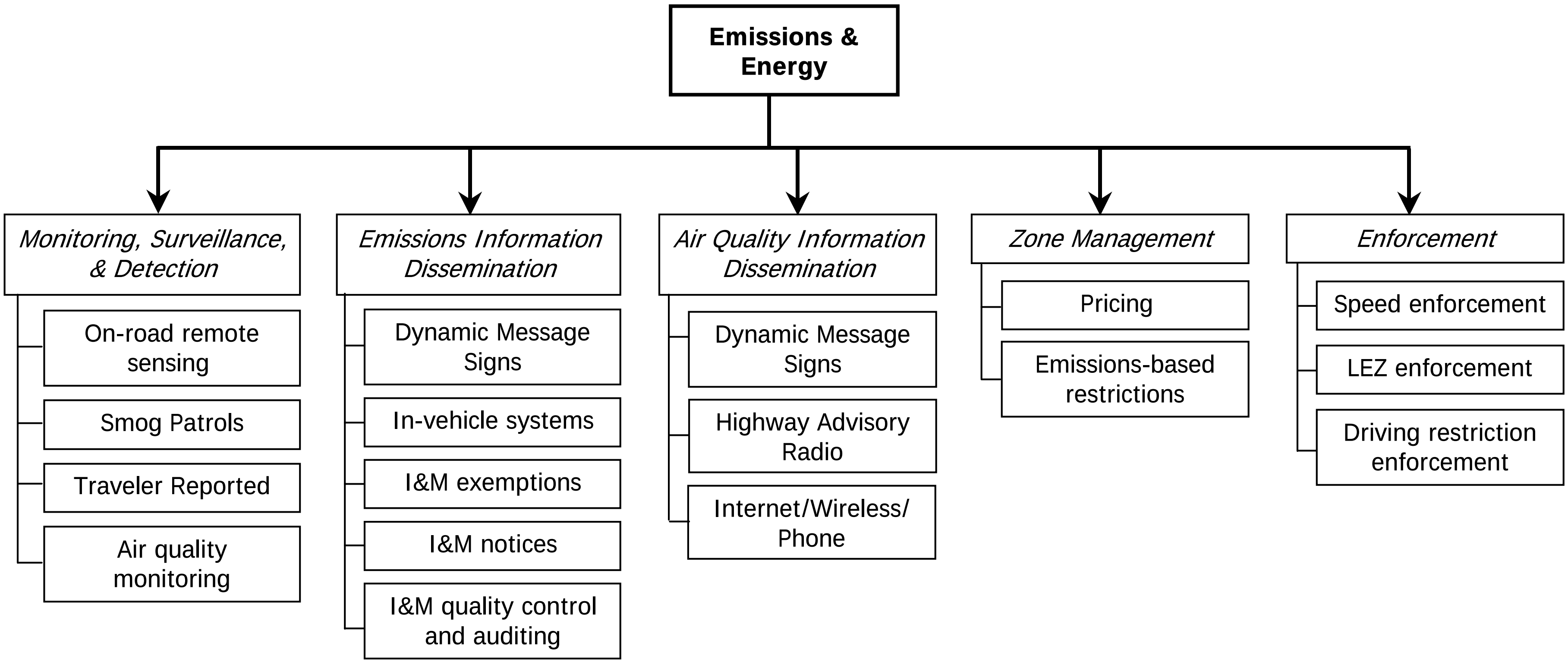
Emissions and Energy

- **Can we expand the current ITS taxonomy to more creatively consider ITS technologies and bundles of technologies that reduce the social impacts of air pollution and energy use?**
- **The ITS-4**
  - Sense
  - Communicate (i.e. Transmit)
  - Process
  - Use
- **Building off the user service: “Emissions Testing and Mitigation” in the ITS Architecture**

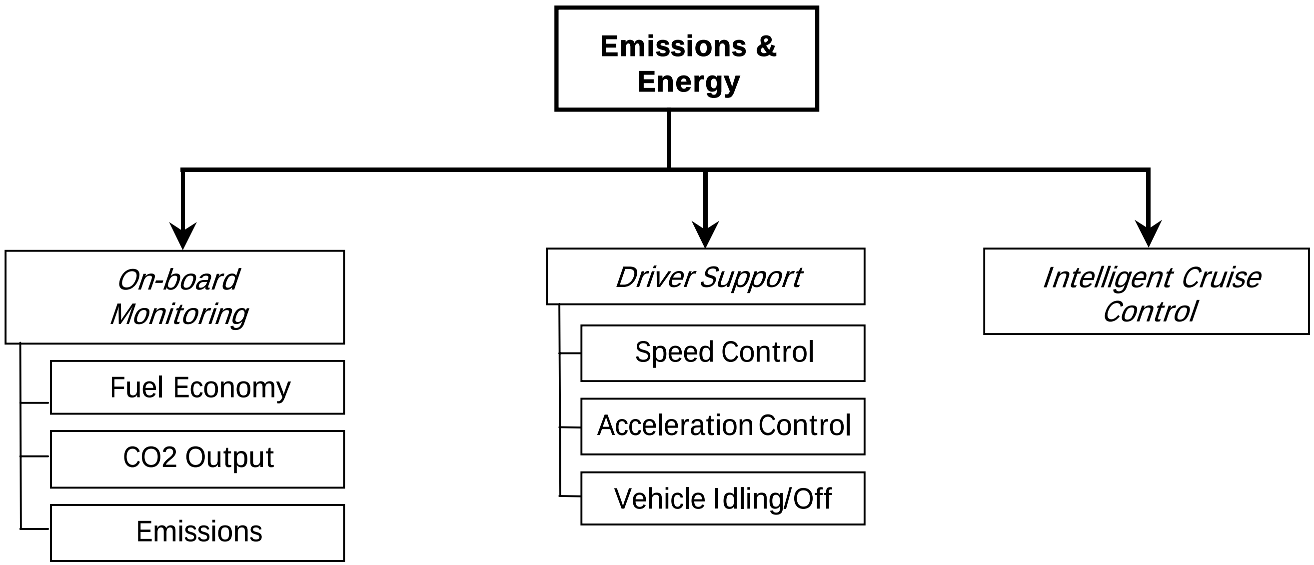
Expanding the ITS Taxonomy

Intelligent Infrastructure



Expanding the ITS Taxonomy

Intelligent Vehicles



- **Applications specifically oriented towards air quality**

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ITS and Air Quality

- **How do we measure the impacts?**
  - What are the key variables that determine emissions of pollutants?
  - How does ITS impacts those variables?

- **Making the step from emissions to air quality adds even more complexity**
  - For example, HC or NOx limited ozone production
  - Most factors are external to transportation

ITS and Air Quality

- **8 Mechanisms: Private Auto Fleet**

Private

  - VMT for Private Auto Fleet (network level)
  - Traffic Volume/Throughput (corridor level)
  - Traffic Speed
  - Traffic Dynamics (idling, starts/stops, acceleration)
  - Fleet Composition (number or % of high emitters)

ITS and Air Quality

- **8 Mechanisms: Public Transportation Fleet**

Private
  - VMT for Private Auto Fleet (network level)
  - Traffic Volume/Throughput (corridor level)
  - Traffic Speed
  - Traffic Dynamics (idling, starts/stops, acceleration)
  - Fleet Composition (number or % of high emitters)
  - Mode Share (split between transit, auto, walk/bike)

Public
  - VMT for Transit Fleet
  - Transit Driving Cycle (speed, dwell/idling, starts/stops)
  - Transit Fleet Operations (occupancy, # of vehicles)

Calculating Emissions

Total Emissions (kg of HC, NOx, CO, PM) =

(grams/mile)*(vehicle miles traveled)

+ (grams/hour)*(hours idle time)

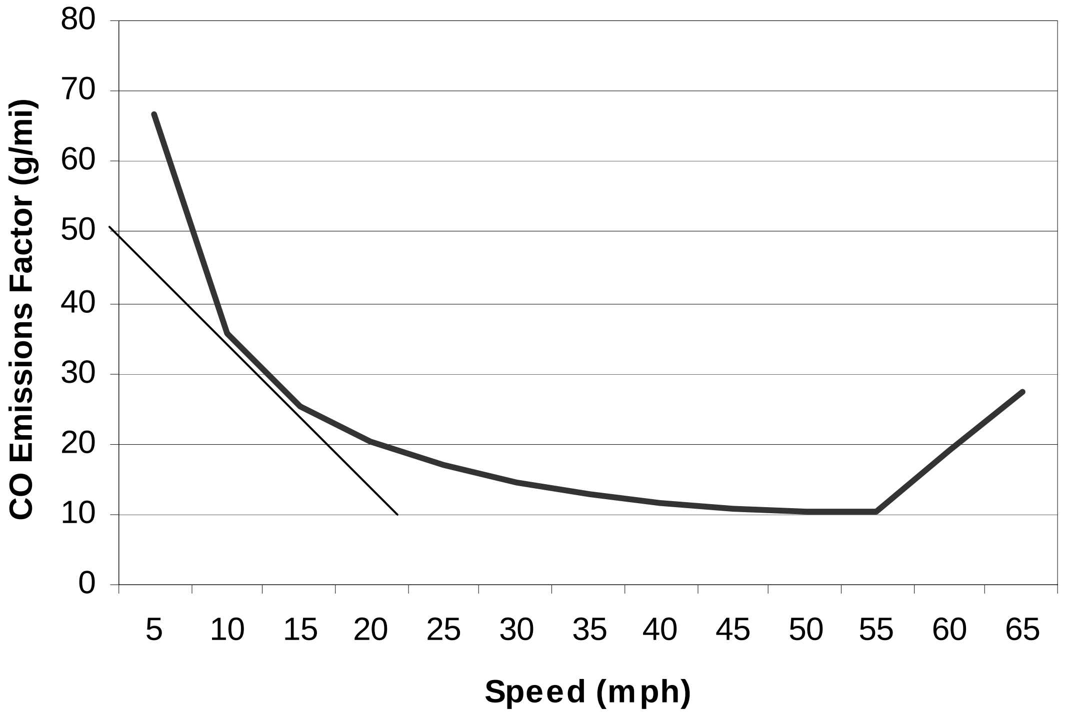
fleet composition

VMT
Volume

fleet composition
speed
traffic dynamics
transit driving cycle

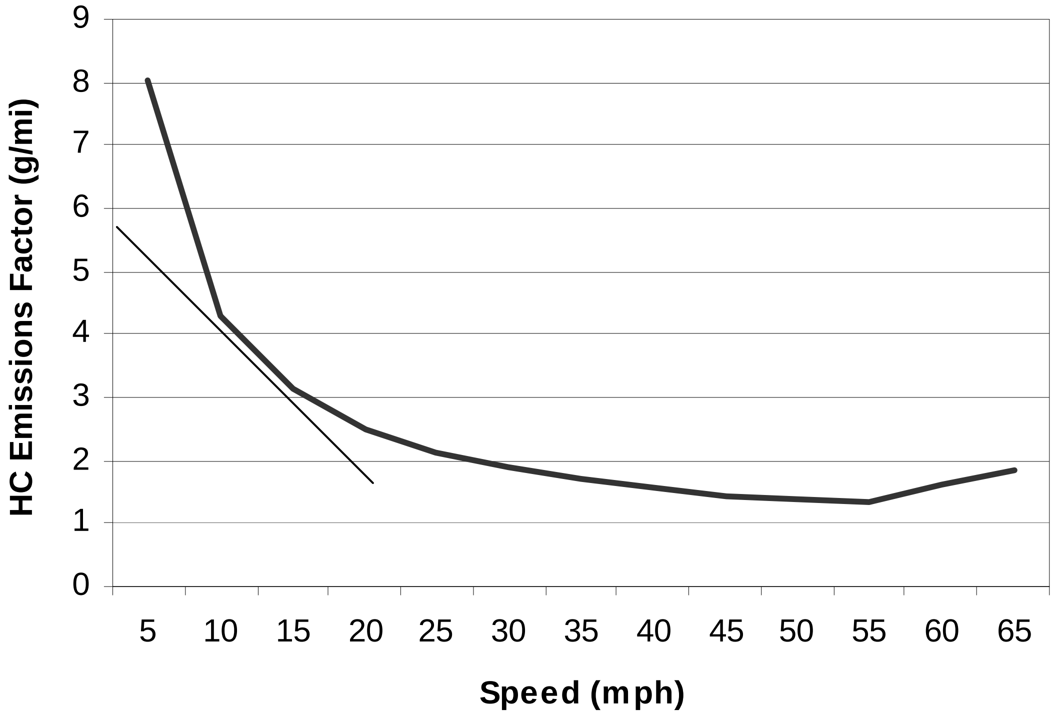
traffic dynamics
transit driving cycle

Speed and Emissions - CO

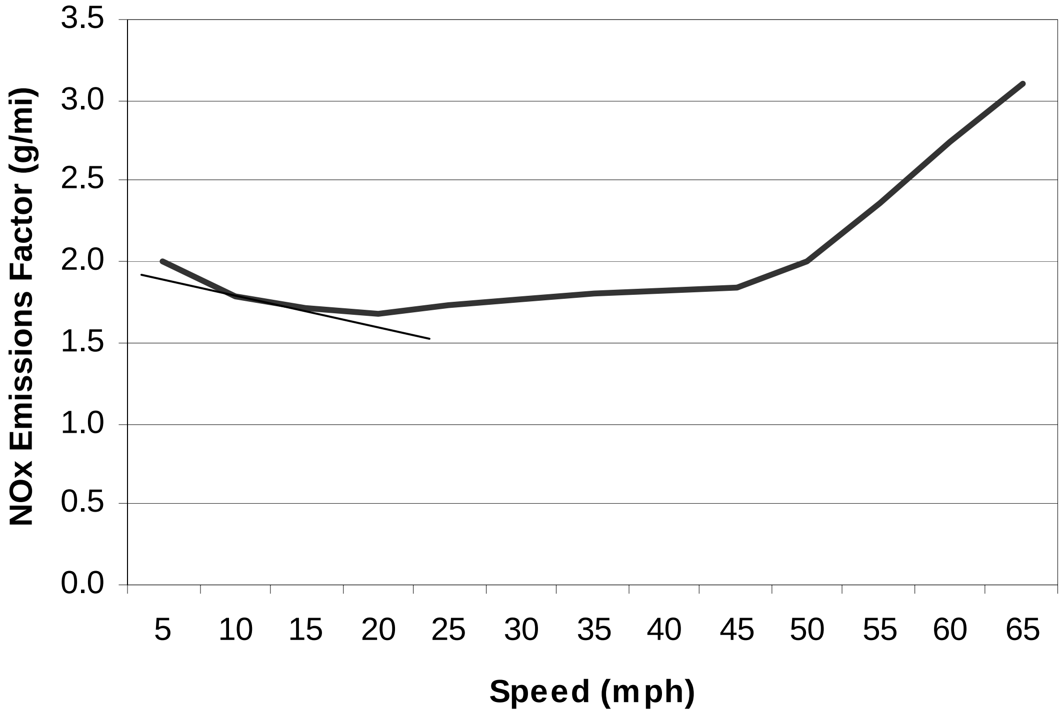


National Highway Institute, 1995

Speed and Emissions - HC



Speed and Emissions - NOx



What's wrong with this picture?

- **Syracuse Signal Interconnect Project**

	AM Peak Period			PM Peak Period		
	Before	*After*	*% change*	*Before*	*After*	*% change*
Average Speed (mph)	14	15	7.1%	12	14	16.7%
Fuel Use (gallons)	490	447	-8.8%	546	475	-13.0%
CO (kg)	34.24	31.27	-8.7%	38.15	33.2	-13.0%
NOx (kg)	6.66	6.08	-8.7%	7.42	6.46	-12.9%
VOC (kg)	7.94	7.25	-8.7%	8.84	7.69	-13.0%

http://www.benefitcost.its.dot.gov/

Speed, Stops and Accelerations

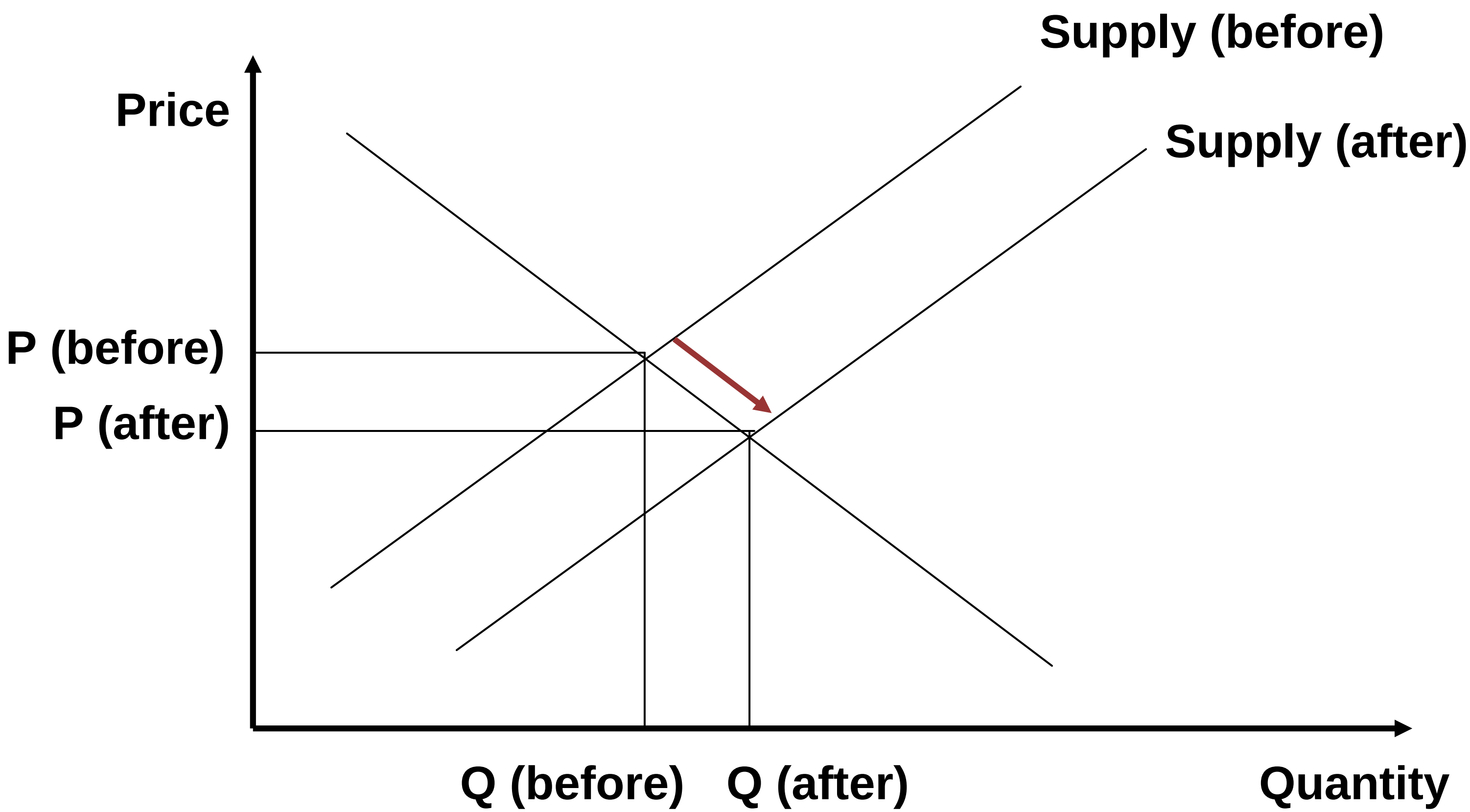
- **Using average network speed to estimate emissions factors is problematic**
- **For emissions factors, focus not just on the *change* in speed, but where you are on the emissions factors curve**
- **Acceleration is usually more important than decelerations and stops (idling)**
- **Microsimulation models will hopefully be able to provide the detail needed to understand the impacts of ITS on the vehicle driving cycle**

Vehicle miles traveled

- **How does ITS change vehicle miles traveled?**
  - Changing capacity
  - Changing perceptions of travel time
  - Providing information for trip making decisions

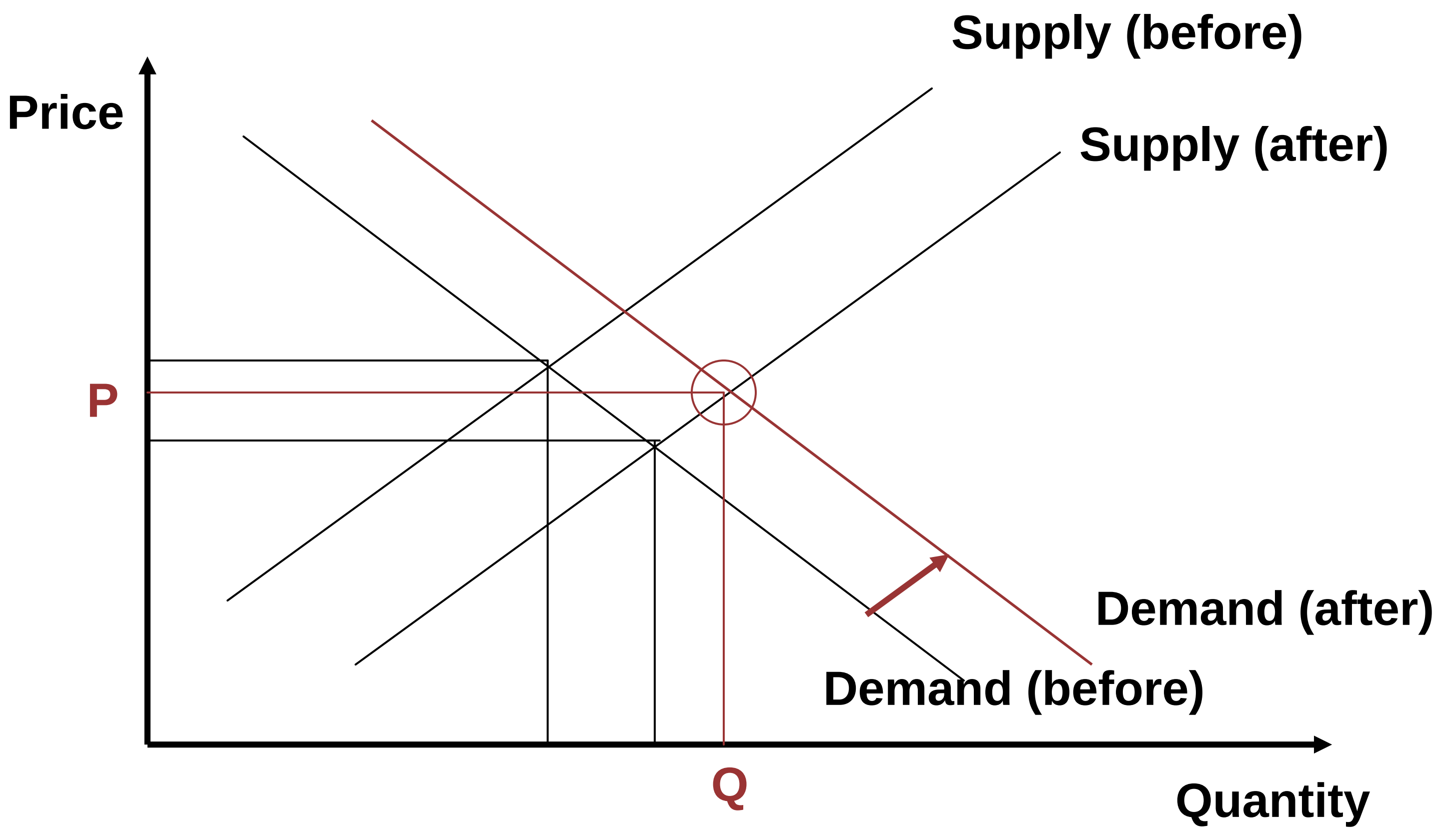
- **Does induced demand play a role with ITS?**
- **Are we “rearranging the deck chairs on the Titanic?”**

Induced travel – the basics



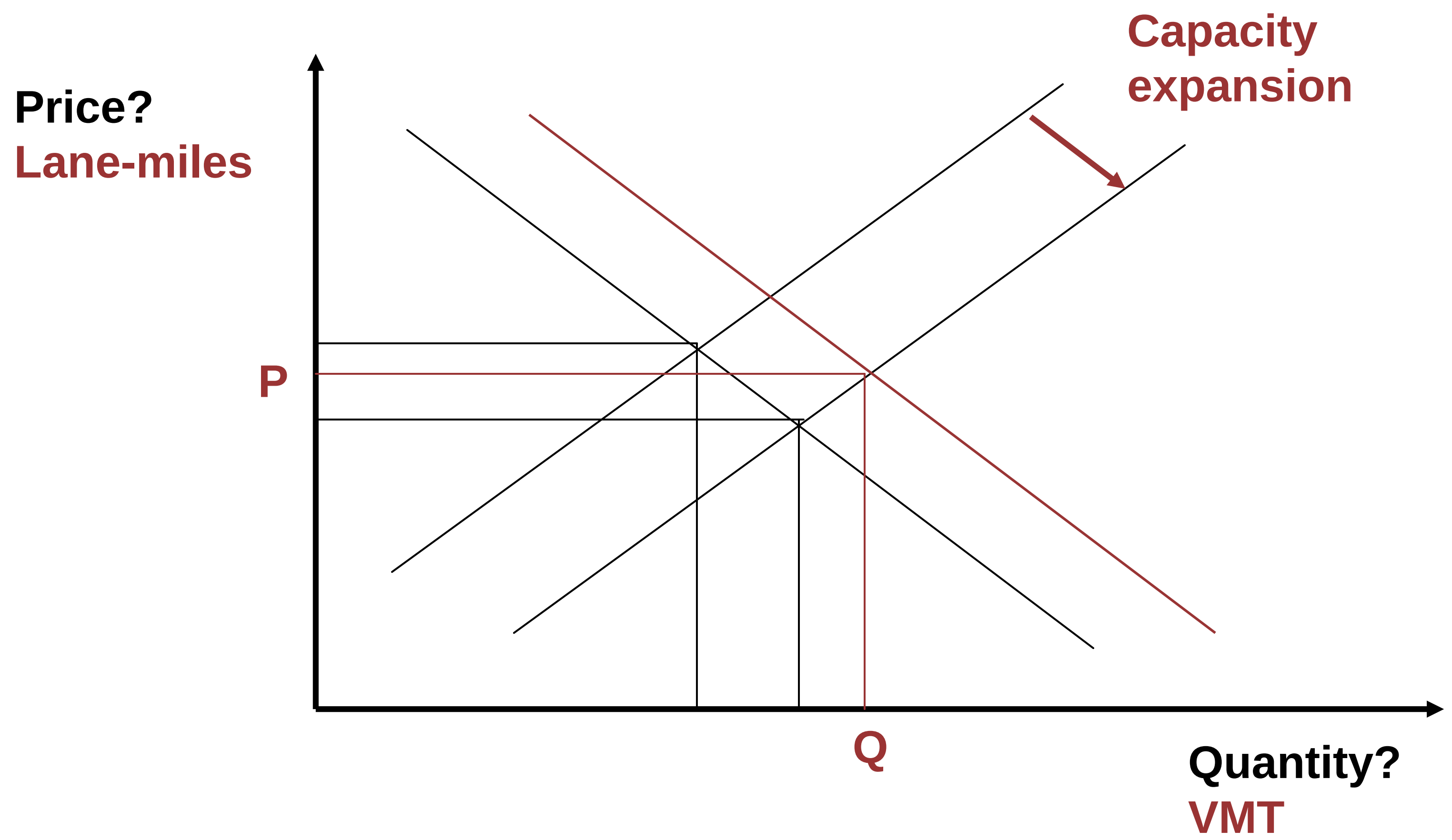
Noland and Lem (2001)

Induced travel – the basics



Noland and Lem (2001)

Induced travel – measuring P & Q

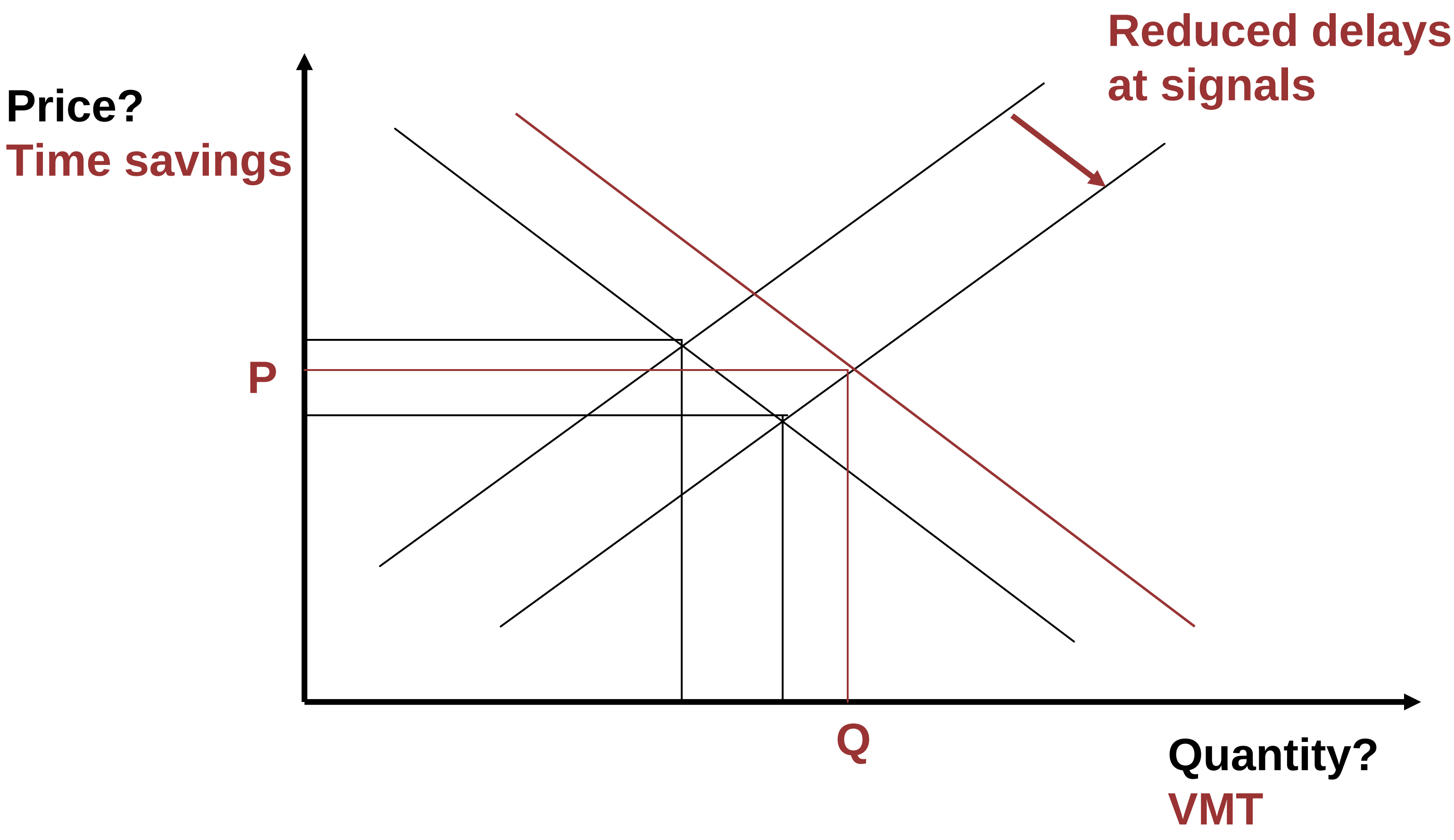


Noland and Lem (2001)

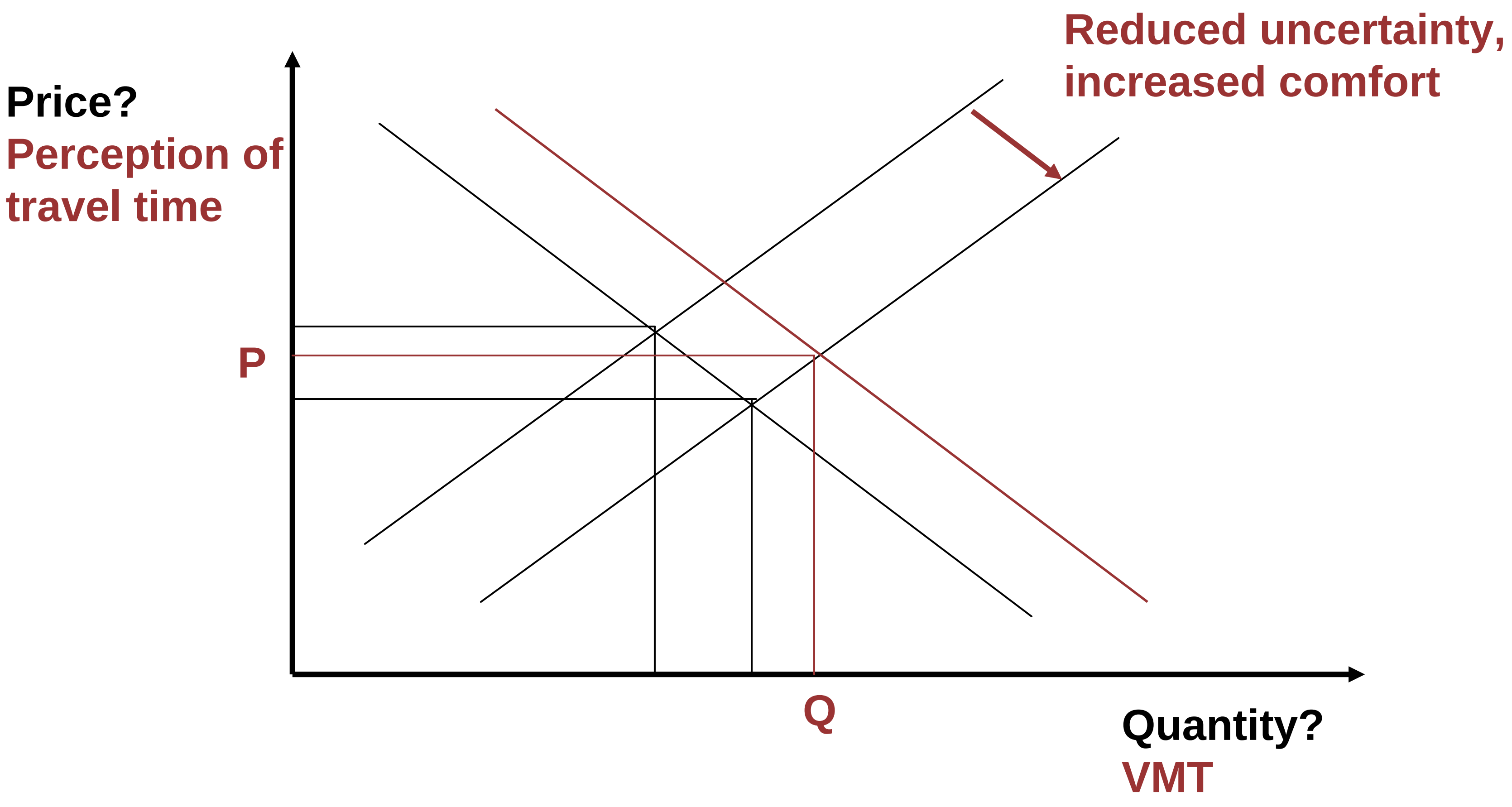
Induced Travel

Behavioral Changes	Induced Travel?	Conditions
Short-run Impacts		
Change time-of-day of travel	No	Can lead to changes in amount of travel
Change route of travel	Possibly	Increased VMT if changes are to longer routes
Medium-run Impacts		
Change destination of travel	Possibly	Increased VMT if destinations are most distant
Change mode of travel	Yes	Switch from public transit to private auto
Change amount of travel	Yes	Increase in total number of trips
Long-run Impacts		
Change spatial allocation of activities	Yes	Increased VMT if repeated origins (home) and destinations (jobs, malls) are more spread out
Change in auto ownership levels	Yes	Can lead to permanent change in mode and amount of travel

Induced travel – ATMS



Induced travel – ATIS



ITS-induced travel

- **Price has both a monetary and value of time component**
- **Capacity expansion (lane-miles) is a proxy measure for travel time savings**
- **Time is relative**
- **To what extent can ITS:**
  - (1) produce travel time savings, or
  - (2) change the perceived value of travel time, or
  - (3) change travel behavior without changing (1) or (2)?
- **Pricing enables more control by balancing the value of time savings with monetary price**

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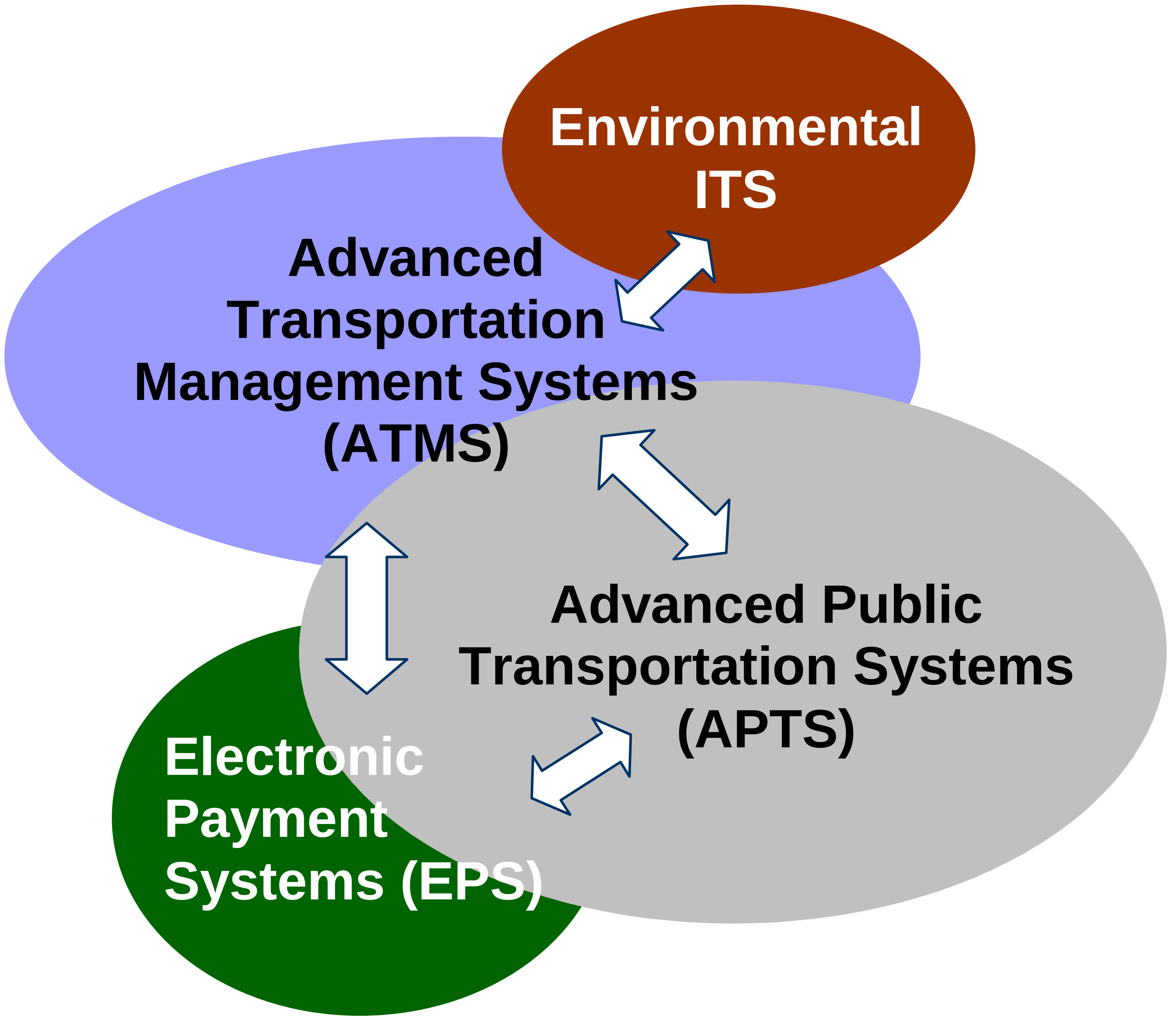
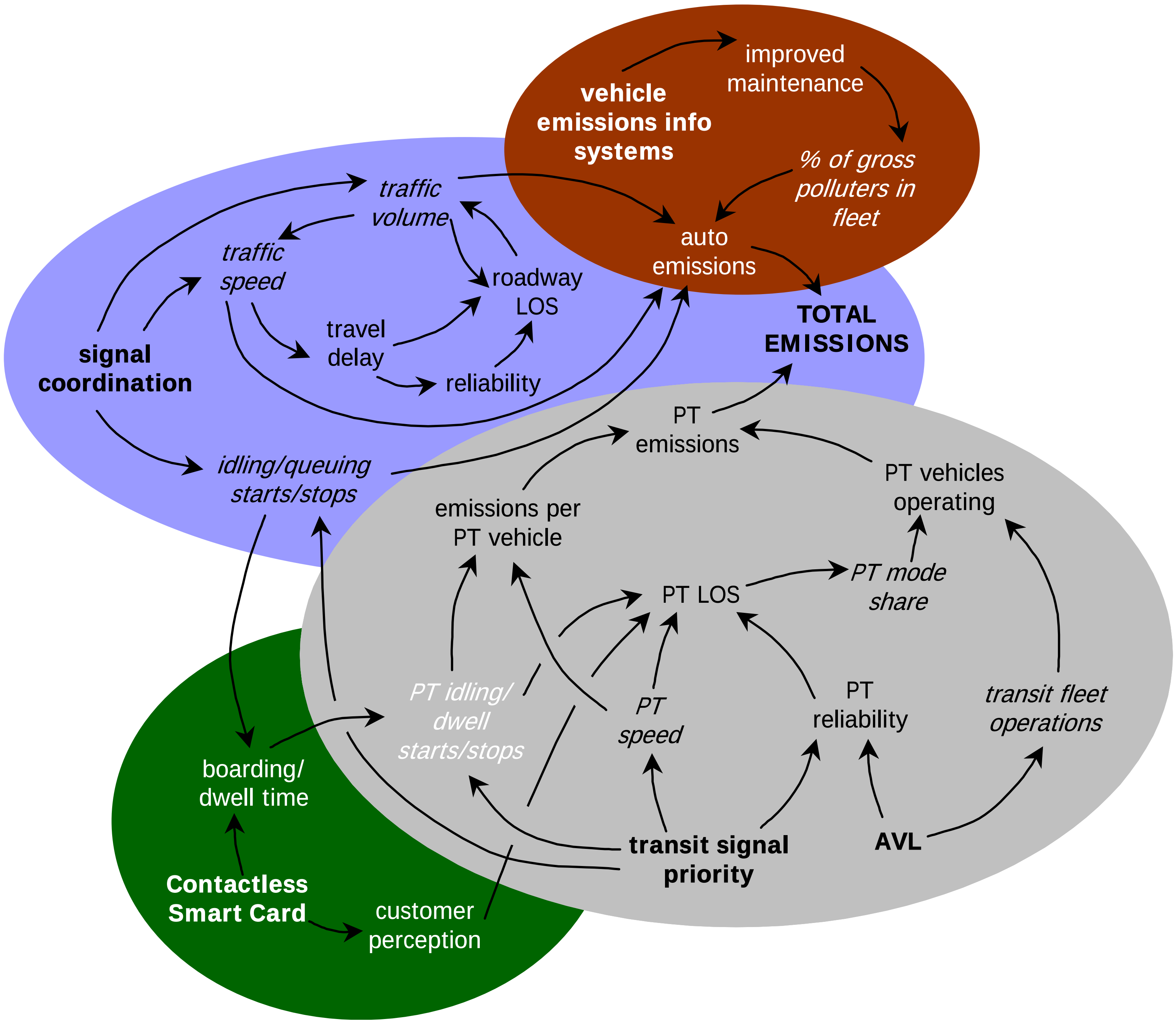
A Systems Framework

- **ITS deployment in a metropolitan area is a highly complex system**
- **Many systems, and many interactions *within* and *between* systems**
- ***Qualitative* framework, but complementary to the *quantitative* modeling necessary in order to characterize impacts**
  - Most studies model air quality impacts of only one or maximum two ITS applications at a time
  - First, we need to “map” all of these interactions, in order to identify *what* to model or measure


Environmental ITS
Advanced Transportation Management Systems (ATMS)
Advanced Public Transportation Systems (APTS)
Electronic Payment Systems (EPS)



vehicle emissions info systems
improved maintenance
% of gross polluters in fleet
auto emissions
TOTAL EMISSIONS
traffic volume
traffic speed
roadway LOS
travel delay
reliability
signal coordination
idling/queuing starts/stops
PT emissions
PT vehicles operating
emissions per PT vehicle
PT LOS
PT mode share
PT idling/ dwell starts/stops
PT speed
PT reliability
transit fleet operations
boarding/ dwell time
transit signal priority
AVL
Contactless Smart Card
customer perception

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ITS Architectures and Air Quality

- **What does air quality mean for ITS?**
  - For cities with air quality problems, emissions impacts of ITS Architectures may be highly important
  - In the US, cities must meet requirements for “conformity” between transportation and air quality plans
  - Also a concern for cities such as Mexico City

ITS Architectures and Air Quality

- **Challenges**
  - Positive air quality impacts often assumed without rigorous documentation
  - Still not mainstreamed in the transportation planning process
  - Often an add-on to transportation modeling
- **Opportunities**
  - Idea of environmental, specifically emissions management "user services" is not new
  - Can leverage air quality benefits of ITS to access federal funding or maintain conformity

Three approaches

- **Measuring/modeling emissions impacts of planned ITS deployments**
  - Passive approach
  - Simply tracking/reporting impacts
- **Maximize possible air quality reductions from existing or planned ITS deployments**
  - More proactive
  - Using feedback to “tweak” ITS deployments
- **Deploy technologies within the “Emissions and Environment” subsystem**
  - Most aggresive
  - Requires integration of sensing technologies and response/control strategies

Takeaways

- **Nearly all ITS subsystems can have important air quality impacts, positive or negative**
  - Need to understand the underlying factors
  - Need more experience with integrated deployment of Emissions and Energy ITS
- **ITS can lead to induced travel**
  - But, ITS also provides the tools to cope with it through pricing
  - ITS also enables us to think differently about induced travel
- **Architecture development can take various approaches to integrating air quality concerns**
  - Depends on severity of air pollution
  - Will require additional inter-organizational cooperation with air quality agencies