Fueling the Debate:
Network Modeling, Behavior Change, and Intelligent Transportation Solutions to Support Transportation Decision-Making and Policy

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Presentation Outline

- Complexity of transportation systems
- Emerging technologies—intelligent transportation systems
- Modeling framework: anatomy of fuel-consum ing transportation activities
- Interventions and barriers
- Synergistic themes and opportunities
Why Are Transportation Systems Complex?

- Complex dynamic spatial systems
- Organized hierarchical network structure
- Deliver services that meet critical human needs
- Carry time-varying, stochastic origin-destination flows
- Require control architectures and operational rules to avoid conflict and maximize efficient utilization of resources

UNIQUE FEATURES:
It’s in the PHYSICS!

Interplay between micro behavior of individual particles and macro properties of traffic system (collective effects)
FUNDAMENTAL SOURCE OF DIFFICULTY:

HUMAN BEINGS

The Problem: Optimize dynamic stochastic systems in which people are essential elements.

Physics of the problem involve:

Complex interaction among humans/vehicles over time and space in physical environment (under real-time information).
Characteristics of transportation systems

Cognitive and behavioral limitations of human drivers are at the root of system inefficiency.

Perception time lags, reaction times, and a natural tendency towards over-reaction under stressful situations or perceived risk result in volatility, congestion, instability, frustrating stop-and-go patterns, “phantom bottlenecks”, capacity loss, and other component- and toll related issues.

TO DO GOOD PHYSICS, YOU NEED GOOD OBSERVATION
Characteristics of transportation systems

• Behavioral considerations and attitudes of human drivers, households and logistics managers are at the root of fuel inefficient patterns

  Activity patterns and resource allocation decisions reflect individual preferences and lifestyles acquired in times where fuel supply concerns were minimal.

  Different time frames for interventions—different impacts from short to medium to long runs

  Small changes at the margin could have meaningful impact.
The overarching rationale of ITS is that developments in sensing, location, information and communication technologies can be put to effective use in improving the **performance** of transportation systems and facilities in terms of mobility, safety, resilience, and sustainability.
Next Generation of ITS Application

- ITS successfully applied to affect traffic operations; on single-facility, or single subsystem basis
  - e.g. surveillance and incident response on freeways,
  - Ramp metering on freeways
  - Traffic responsive traffic signal control
  - Electronic and camera enforcement
  - ETC toll payment systems

- The next stage: integrated application of operational strategies, jointly with demand management measures, at corridor, multi-mode, multi-jurisdiction level, to improve conditions through both better operations and more efficient demand-level responses.
TWO MAIN AREAS FOR DEVELOPING TRANSPORTATION SYSTEM INTELLIGENCE

Realization I
Eliminate or reduce individual human error, and the system will operate more efficiently.

Small changes in household and firm individual patterns could lead to significant gains in fuel efficient sustainable lifestyles.
TWO MAIN AREAS FOR DEVELOPING TRANSPORTATION SYSTEM INTELLIGENCE

Realization I
Eliminate or reduce individual human error, and the system will operate more efficiently. Small changes in household and firm individual patterns could lead to significant gains in fuel efficient sustainable lifestyles.

Realization II
Monitor the state of the system at all times, and it would be possible to intervene and apply control actions-in real-time to best utilize available resources.
Vehicle Trajectories & Activities

Fuel Consumed

Individual and Household Activities

Activity/Trip chains

Vehicle Trajectories & (“modal”) Activities
CONCEPTUAL FRAMEWORK

“DEMAND”

- VEHICLE HOLDINGS AND USE DECISIONS
- ACTIVITY DECISIONS
- TRAVEL DECISIONS

Individual and Household Activities

Activity/Trip chains

FUEL CONSUMPTION

- Vehicle Trajectories & (“modal”) Activities

EMISSIONS

Location-Specific Time-Varying Emissions

“SUPPLY”

NETWORK MODELING

Fuel Consumed
CONCEPTUAL FRAMEWORK

“DEMAND”
- VEHICLE HOLDINGS AND USE DECISIONS
  - ACTIVITY DECISIONS
    - Time and Money Expenditures
    - Participation and time allocation
    - Sequencing/Scheduling
  - TRAVEL DECISIONS
    - Virtual vs. physical
    - Timing
    - Location
    - Mode
    - ...

Fuel Consumed
Location-Specific Time-Varying Emissions

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"SUPPLY"

NETWORK MODELING
- ROUTING
- NETWORK LOADING
- Vehicle and Flow Propagation
- Iterative consistent procedures

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FUEL CONSUMPTION

Level of Service Attributes

Vehicle Trajectories (“modal”) Activities

EMISSIONS
CONCEPTUAL FRAMEWORK

“DEMAND”

FUEL CONSUMPTION

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Location-Specific Time-Varying Emissions

Vehicle Trajectories (“modal”) Activities

Commercial vehicle Fleet delivery schedules

Individual and Household Activities

Activity/Trip chains

FIRM LOGISTICS DECISIONS
- Production
- Sourcing
- Inventory and warehousing
- Shipment size and frequency
- Mode

MOBILE SERVICE PERSONNEL
- Location
- Duration
- Teaming
- Sequencing and Scheduling
- ...

Network Modeling- Routing- Network Loading- Vehicle and Flow Propagation- Iterative consistent procedures

FUEL CONSUMPTION

Firm Logistics Decisions- Production- Sourcing- Inventory and warehousing- Shipment size and frequency- Mode

Mobile Service Personnel- Location- Duration- Teaming- Sequencing and Scheduling- ...

Network Modeling- Routing- Network Loading- Vehicle and Flow Propagation- Iterative consistent procedures

Location-Specific Time-Varying Emissions

Vehicle Trajectories (“modal”) Activities

Level of Service Attributes

Fuel Consumed
SUPPLY MANAGEMENT

DEMAND MANAGEMENT

POLICY LAYER

INPUTS

LAND USE
SOCIO-ECON-DEMO DISTRIBUTIONS
VEHICLE/FUEL USE CONTROLS
PRICING
• Vehicles
• Fuels
• Transport

INFORMATION

NETWORK STRUCTURE
FUEL DISTRIBUTION

“DEMAND”

VEHICLE HOLDINGS AND USE DECISIONS

ACTIVITY DECISIONS
- Time and Money Expenditures
- Participation and time allocation
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TRAVEL DECISIONS
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SUPPLY MANAGEMENT
Towards a Taxonomy for policy interventions

**Dimensions:** Readiness for deployment

- Time Frames
- Magnitude and uncertainty of impact
- Implementation and adoption barriers
  - technological
  - political
  - economic
  - logistical and tactical

Agents involved: government, users, industry (oil, auto, alt. energies)…
Synergistic Research Themes and Opportunities

• Collaborative logistics and real-time information for efficient freight logistics

• (FUEL) Disruption management, preparedness and system resiliency

• Intelligent transportation solutions—real-time system operation, peer-to-peer communication for fuel-efficient system operation

• Activity chains, household interactions and vehicle use: understanding and affecting behavior change

• Plug-in hybrids: adoption and evolution path of emerging vehicle and fuel technologies
Thank You!