Symposium on Transportation Network Design and Economics: *in honor of Martin Beckmann*
Concluding Comments:
Some thoughts on network design in practice

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High-Speed Intercity Passenger Rail Program

National Summary of Selected Projects

**MIDWEST**
- 24 applications | $2,617 M

**NORTHEAST**
- 22 applications | $485 M

**WEST**
- 22 applications | $2,943 M

**SOUTHEAST**
- 11 applications | $1,876 M

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**Legend**
- **Red**: Consider Development Program
- **Blue**: Projects Laying Foundation for High-Speed Passenger Rail
- **Gray**: Long-Term Vision for High-Speed Passenger Rail
- **Green**: Planning Studies (by state)

*All dollar amounts are conditional and subject to approval prior to grant agreements.*
why formal network design methods are ignored in practice

• Multiple objectives—some difficult to quantify, some not explicit

• Uncertainty in future demand, cost, revenues: require strategy, not only final configuration

• Decision variables—not only whether to build, but also what to build, where to build (location), when to build

• Operational decisions increasingly integral to design:
  – Clearly so in service networks (airlines, supply chains, delivery/pick up...)
  – Increasingly relevant to physical infrastructure: highways, rail, power, telecommunications; e.g. HOT lanes, routing decisions
  – Control variables (prices, traffic, information) have dramatic impact on capacity and performance

• Ad hoc: manual heuristics by which humans grapple with complex decisions—what is most effective way to support decision process?
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)
Who Came First: Chicken or Egg?

- **Should infrastructure lead or lag development?**

- **Tradition in US planning practice is to build infrastructure to meet some exogenously occurring land use/economic development pattern**

- **Developers locate major commercial and residential development**

- **Major infrastructure major tool for influencing development– with greater awareness of environmental objectives– will it be reflected explicitly in network design practice?**

- **Stronger linkage between forecasting, design and decision processes: more flexible tools, more intelligent application**
Coping with uncertain forecasts

Can we do something here to influence the process?
4-step
Sequential
Static

Activity-scheduling,
real-time response to information

Activity-based models

Trip chains

Disaggregate, choice models

Behavioral Realism

Prospect theory, Cumulative PT

Learning dynamics

Bounded rationality, thresholds, heuristics,
Computational process models

Attitudes, perceptions

Random utility

Consumer theory

Dynamics
Dynamics
Behavioral Realism

Learning dynamics

4-step Sequential Static

Dynamic Equilibrium

Convergence? Disequilibrium? Stability?

Dynamics

Evolutionary paths Adaptive strategies
Integra!on Dynamics
Behavioral Realism

4-step Sequential Static

Dynamics

Integration

Freight, logistics
Energy, Environment
Telecommunication, telemobility

Activity and time use decisions
Travel decisions
Residential and land use

NETWORK FLOW PROCESSES
Integration

Behavioral
Realism

Dynamics

4-step
Sequential
Static

Process models of cognition and learning in networks

Interaction, demand & network microsimulation
DISINTEGRATING DEMAND AND SUPPLY

THE KEY IS THE PLATFORM:
SIMULATION-BASED DTA
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DISINTEGRATING DEMAND AND SUPPLY

CRITICAL LINK 1:
LOADING INDIVIDUAL ACTIVITY CHAINS

CRITICAL LINK 2:
MODELING AND ASSIGNING HETEROGENEOUS USERS

CRITICAL LINK 3:
Multi-scale modeling: consistency between temporal scales for different processes
Towards new forecasting paradigm...

Integrated activity-based demand & network microsimulation

Process models of cognition and learning in networks
Towards new forecasting paradigm...

- Forecasting as integral and interactive element of decision-support activity
  
  [“Use of models for decision-making”— Rejected TMIP track—]

- Recognize that forecast activity and demand NOT independent of the action that forecast is intended to guide-- interdependence between actions and outcomes

- Shift from single future point (“final state”) forecasts to modeling evolutionary path, and its dependence on exogenous and endogenous factors

- From OUTCOME emphasis to PROCESS orientation
An equilibrium would be just an extreme state of rare occurrence if it were not stable— that is, if there were no forces which tended to restore equilibrium as soon as small deviations from it occurred.

Besides this stability “in the small” one may consider stability “in the large”— that is, the ability of the system to reach an equilibrium from any initial position.

The study of stability hinges ultimately on the question of how road users adjust themselves to changes— that is, how they adapt the extent of their travel by road and their choice of routes to varying traffic conditions. This, however, is one of the big unknowns of road-user behavior, so at the present stage only conjectures are possible.

from page 70, section 3.3. Stability BMW, 1956
The notion of a static equilibrium of flow in a network may be thought somewhat limited because of the noted periodicity of traffic during the day, week, year and perhaps the business cycle. While the equilibrium mechanism is operative during the relatively short periods of constant load, one would like to see a more comprehensive model which contributes to our understanding of the time pattern itself.

The generation and the economics of traffic peaks are subjects for further inquiry.

An understanding of the dynamic aspects of traffic really depends on an understanding of demand substitution over time.

from page 107, section 5.4 Dynamic Equilibrium Models (in Chapter 5: Some Unsolved Problems)
WHERE TO NOW?

• Beckmann, McGuire and Winsten’s study laid the intellectual and economic-science foundation for transportation systems analysis, planning and evaluation for the rest of the 20th century, and beyond

• The ideas and concepts are fundamental in nature, and unlikely to change in the foreseeable future

• While considerable progress has been made on many of the problems insightfully identified in that seminal work, many remain active areas of investigation; only recently have observational methods become practical to provide empirical support for the theories and methods addressed in that work

• The main areas where potentially significant departures from the principles and methods of that text lie in the contribution of technology to our ability to manage traffic systems, and, more fundamentally, in the kinds of socio-technical changes that pervasive availability of real-time information and ubiquitous access to the internet (e.g. 3G wireless broadband)

• Equilibrium provides convenient reference point for comparative evaluation of contemplated future alternatives. What do we make of day-to-day evolution, disequilibrium, etc...? Will political decision processes in Transportation sector be able to profitably exploit improved understanding of system dynamics for better planning? Will new insights in day-to-day user behavior be leveraged to design more effective policies to improve system performance?
THANK YOU!

Prof. David Boyce
Prof. Marco Nie

Prof. Martin Beckmann
Prof. Anna Nagurney

All our panel chairs and speakers

TC Staff
Rebecca Weaver-Gill
Diana Marek

Our wonderful audience!