RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

Linking Forecasts to Action:

Roles, Uses, & Misuses of Forecasts in Transportation, Land Use, and Environmental Decision-Making

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Why Do We "Plan" for the Future?

- **Uncertainty makes us uncomfortable. Not knowing what to expect next is disconcerting**
- **Walking into a wilderness with a map lessens uncertainty; having a map alleviates discomfort but does not remove it entirely…**
  - **The map could be wrong**
  - **I could be reading it incorrectly**
  - **Unexpected events could make it difficult for me to follow the map**
- **These issues complicate things but don't lead us to enter a wilderness without a map**

Having a "Plan" for the Future Doesn't Require "Forecasting" – So Why Do we Forecast?

- **Ancient city plans and toad plans were aesthetic undertakings or based on ideal futures**
  - **The ancient world didn't change as rapidly as our world and most factors shaping the future were perceived as being relatively constant and under the control of rulers**

- **Plans can be based on standards, norms, or widely shared goals that reflect broad social agreement on principles**
  - **Instead of starting our plans with forecasts we could start with goals or objectives like clean air or zero growth in greenhouse gas emissions**

Only 100-125 Years Ago

- **The notion evolved that plans could be “rational” or “scientific” rather than primarily aesthetic or utopian…and that would be an improvement**
- **Part of the evolution of social science, professional government, “Taylorism”**
- **The first forecasts were made of population growth and economic activity**
- **1908 Burnham Plan for Chicago**

Forecasting is a Fundamental Part of the Political Process

- **Contending interest groups (e.g. pro-growth and anti sprawl; developers and environmentalists) disagree on fundamental principles**
- **Forecasts establish the boundaries of the playing field on which they carry out their contests**
- **We cannot resolve fundamental value differences through political debate, but can reach accommodation on courses of action "required" of us collectively because we agree on what forecasts tell us are "needed."**

We use Forecasts of Many types and at Many Scales to Arrive at Political Agreements About Courses of Action

- **Traffic to be generated by a single new building**
- **Population growth and change at a neighborhood, urban or metropolitan level**
- **Greenhouse gas emissions at a global scale**
- **Political action is possible because we agree to argue about particular forecasts rather than to attack one another's fundamental values. We can eventually agree with one another about forecasts without having to agree about fundamental values**

This "Political Role" of Forecasting Helps Us Understand One of the Big Mysteries of Forecasting

- **Academics ponder why governments almost never look backward to see whether forecasts made in the past were right or wrong: why keep doing something if you don't assess whether its working?**

- **The fact is that our past forecasts are almost always wrong, but their accuracy is not politically important. They served their purposes by facilitating agreements that led to agreements that allowed actions to be taken**

Boston Central Artery: The "Big Dig"

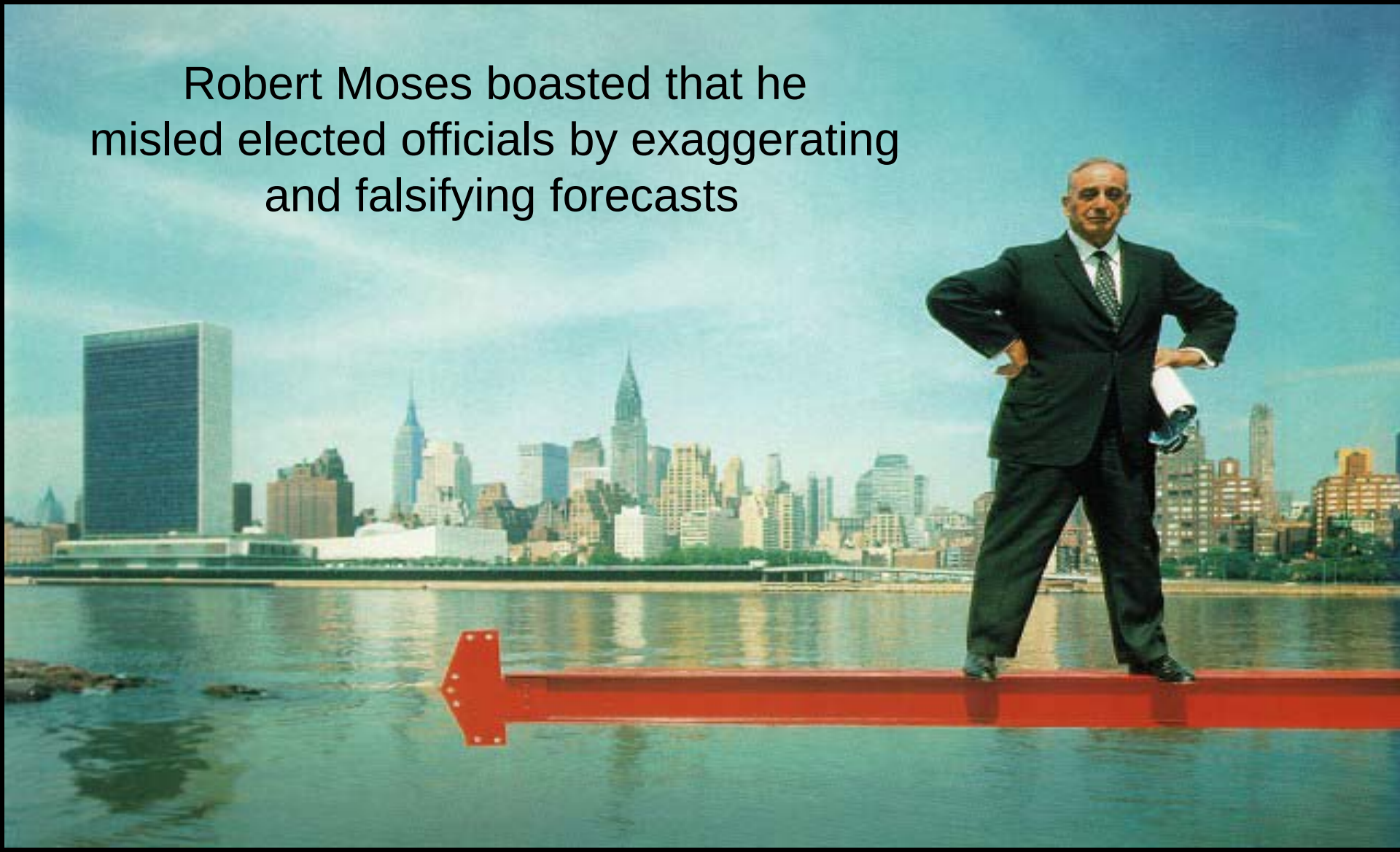
- **Original cost forecast to be: $2.6 billion**
- **Actual cost to complete: $16 - $17 billion**
- **Forecast completion date: 1998**
- **Actual completion date: 2007 - 2008**

Replacement of Eastern Span of San Francisco Bay Bridge

- **Replacing eastern span because of seismic problems revealed by Loma Prieta Earthquake**
- **Cost forecast of $1.6 billion in 2001 for the largest component contract**
- **Bids opened in 2004; a single bid was received for $5.4 billion**

Miami Subway

All costs in 1988 dollars	Forecasts	Actual
Capital cost:	$1.069 b	$1.341 b
Annual oper cost:	$29.4 m	$37.9 m
Daily riders:	202,000	36,700
Total cost per passenger:	$2.41	$16.73
Subsidy per rider @ $1.50 fare:	$0.91	$16.73


Robert Moses boasted that he misled elected officials by exaggerating and falsifying forecasts

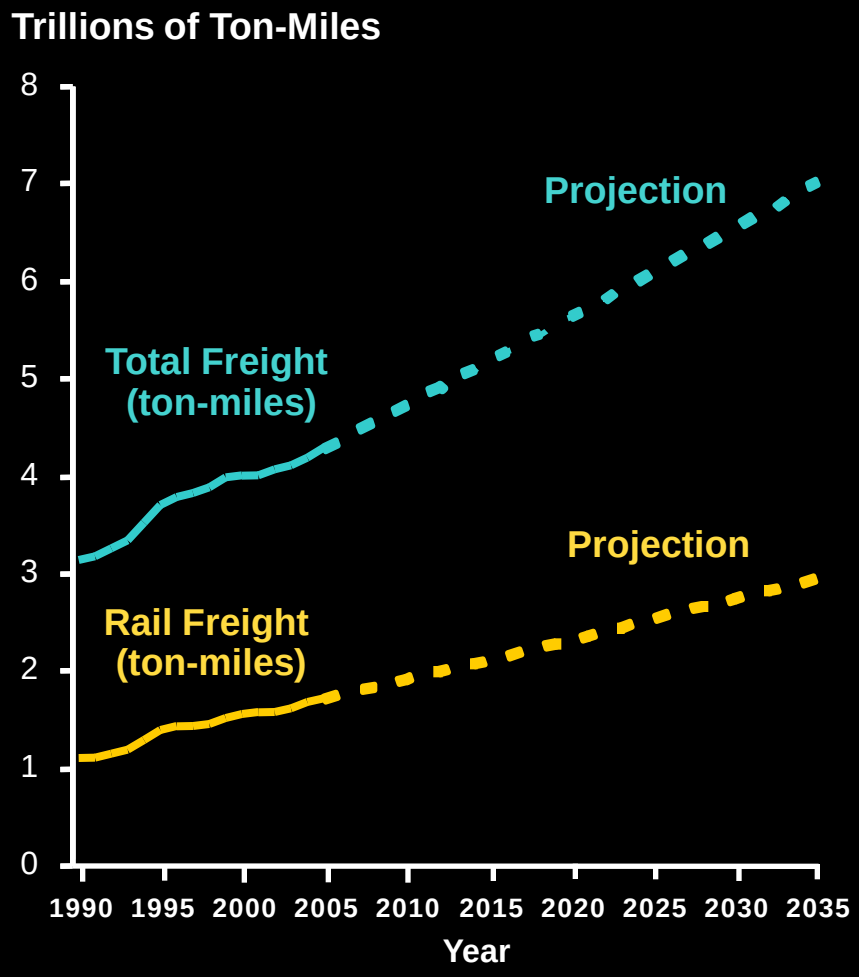
Every Forecast is Based Upon

- **A method or model for projection**
- **Data with which to operate the model**
- **Assumptions**

Assumptions are the most critical element of any forecast and rarely are debated

Forecasts are Not Merely "Projections" or "Extrapolations"

- Projections or extrapolations are the "mathematical" extension of past trends
- They tell us what will happen if certain agreed upon trends continue into the future….if birth rates, death rates, immigration rates, levels of economic activity, the price energy then xxx will be yyy in the year 2040.
- But, the critical input that determines a forecast's outcome is the assumptions….about, for example, what will immigration rates or energy prices actually turn out to be



Source: U.S. DOT 2006

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Some Forecasts Work Well Over Long Periods Because "Stability" and "Regularity" mean that Realistic Assumptions can be Made

- **Population that will reach retirement age**
- **School enrollments**

Land Use, Transportation, and Environment Forecasts Do Not Work Well Over Long Periods and Give Us Particular Challenges

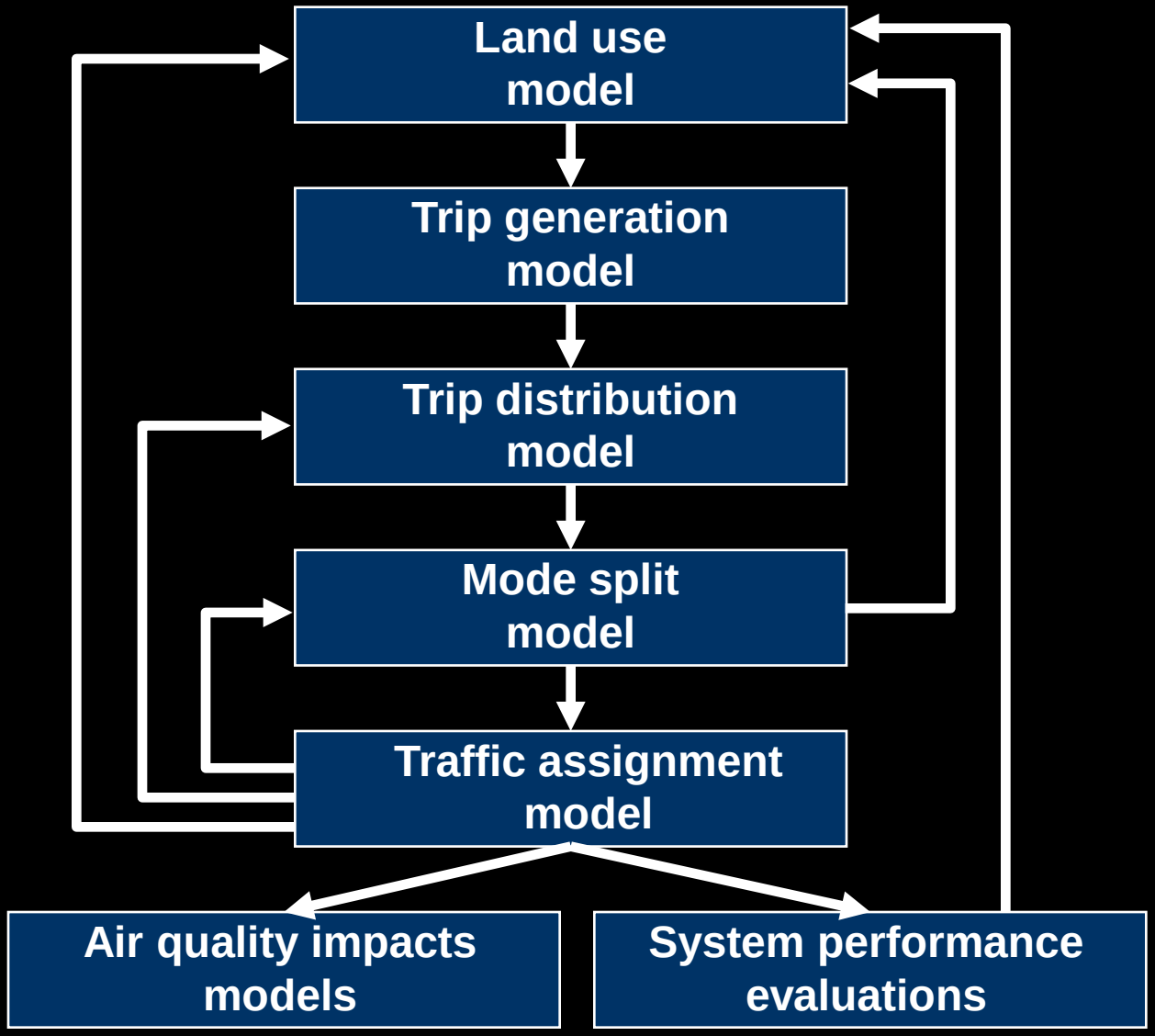
- **All three elements of forecasting are problems**
  - **Inadequate data**
  - **Complicated and outdated models**
  - **Assumptions can vary wildly and are influenced by value judgments (sprawl vs. high density futures?)**

- **Interactions among transportation, land use and environment are very complex, each is simultaneously both cause and effect and what we assume about the future can vary a lot depending upon highly subjective, value-laden assumptions**

Land Use – Transportation Models

- **Were developed in 1950-60s to determine size and location of major capital facilities**
- **Were “retrofitted” in 1980-90s to tack on air quality estimation**
- **Models were “retrofitted” again to accommodate “travel demand management” strategies**
- **Complex linear models yet complexity is illusory…inadequate representation of prices; not suited to policies seeking to minimize fuel consumption or greenhouse gas emissions**

Land Use, Transportation, and Environmental Models are Used in Sequence



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Fundamental Problem With This Approach

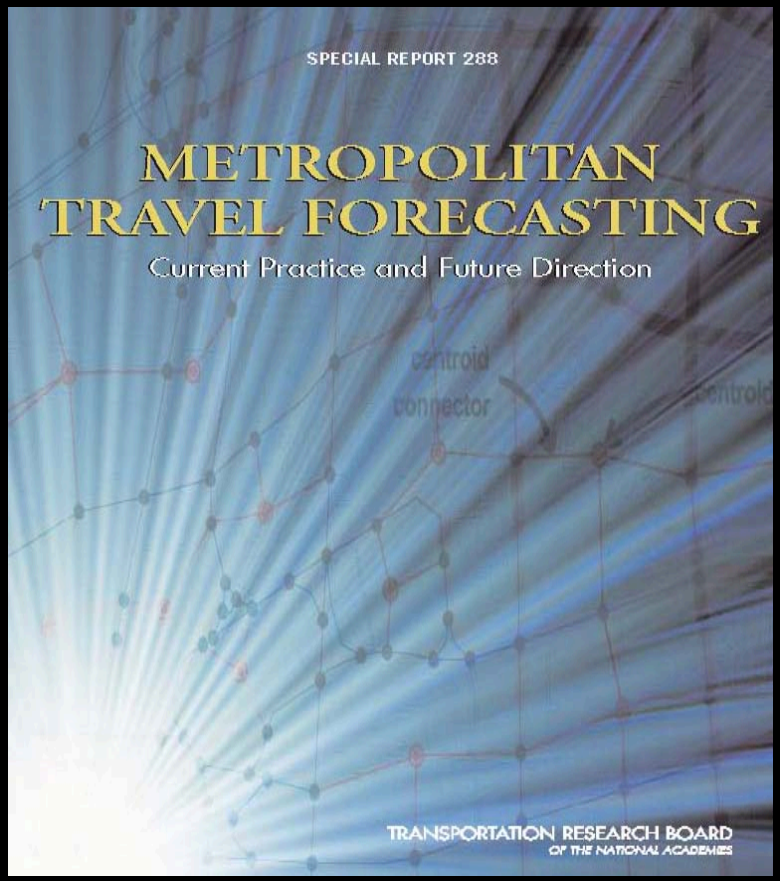
- **We try to forecast specific future outcomes as though we could be certain of them, when the most fundamental truth is the uncertainty in the data, the relationships among the variables and the nature of change coming in the next few decades . . .**

- **We make assumptions that are necessary for us to arrive at single predictions of future values of traffic flows and environmental impacts even though these are really characterized by enormous uncertainty**

Regional Land Use-Transportation-Environment Forecasts Cannot be Right

- **Our forecasting models are linear; outputs of one form inputs to the next and there are many in the series**
- **We try to combine assumptions and models and the data we have to actually estimate what population, spatial distribution of activities, land use, travel volumes, and congestion levels will be in 2030 or beyond as though we can ultimately arrive at "the best" forecast of what the future will be**
- **This gives poor results because it depends on myriad assumptions**
- **We know many of those assumptions will be proven wrong by the passage of time, and we don't know to what extent the forecasts will be wrong as a result**

Metropolitan Travel Forecasting: Current Practice and Future Direction Transportation Research Board Special Report No. 2008



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Findings

4-step model is the basic approach (estimate trips, distribute among origins and destinations, determine mode, assign to network)

Basic framework unchanged for over 50 years

- **Many variations in complexity of approach**
- **Complex issues lead to complex models (e.g. travel models linked with land use models)**
- **San Francisco City, Columbus Ohio MPO, and New York MTC have adopted more advanced approaches**
- **There is no single approach to travel forecasting that is "correct" for all MPOs**
- **The planning context and the nature of questions being asked should determine the type and complexity of model tools employed**

Findings – Current Models Are

Inadequate for demand analysis of many applications

- **Induced travel**
- **Land use policies**
- **HOT lanes and time variable road pricing**
- **Environmental justice assessments**
- **Telecommuting**
- **Mode of access to transit**
- **Traveler response to congested networks**
- **Policies aimed at accommodating travel while minimizing fuel use and greenhouse gas emissions**

Findings – Current Practice

- **Inadequate data**
- **Optimism bias**
- **Quality control**
- **Validation errors**

Findings – Obstacles to Model Improvement

- **Preoccupation with meeting immediate demands of production**
- **Fear of legal challenges causes agencies to avoid innovations**
- **Significant budget and staff limitations**
- **Insufficient evidence that advanced models can be implemented for a reasonable cost and provide significant improvements**
- **Poor/inadequate data**

Current Planning Methods Seek One Future Tree Instead of Understanding Forests

- Traditional analytic methods use point estimates instead of working with uncertainties as the fundamental planning context

- Some choices confront decisionmakers with deep uncertainty, where
  - They do not know, and/or key parties to the decision do not agree on, the system model, prior probabilities, and/or "cost" function

- Decisions can go awry if decisionmakers assume risks are well-characterized when they are not
  - Uncertainties are grossly underestimated
  - Competing analyses can contribute to gridlock
  - Misplaced concreteness can blind decision-makers to surprise

A New Way of Thinking About Land Use-Transportation-Environment Forecasts Would Be To

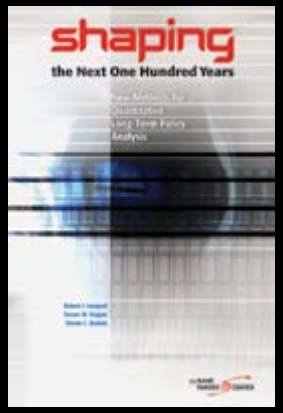
- **Try to identify future plans that are "robust" rather than "optimal," in that they fare well under a wide range of values of key variables rather than perform best when a single future has been forecast**

- **Use computer modeling to test thousands of forecasts and reach conclusions about which assumptions are the "load bearing" ones; then focus on exploring those assumptions most closely**

Robust Decision Making (RDM) Helps Make Plans Robust Over Multiple Views of the Future

Key Robust Decision Making Concepts:

- **Construct ensemble of long-term scenarios that highlight key tradeoffs among near-term policy choices**
- **Consider near-term choices as one step in a sequence of decisions that evolve over time**
- **Use robustness criteria to compare alternative strategies**
  - **A robust strategy performs well compared to the alternatives over a wide range of plausible futures**



New Technology Allows Computer to Serve As "Prosthesis for the Imagination"

- **Robust Decision Making (RDM) is a quantitative decision analytic approach that**
  - **Characterizes uncertainty with multiple, rather than single, views of the future**
  - **Evaluates alternative decision options with a robustness, rather than optimality, criterion**
  - **Runs models many times to identify vulnerabilities of plans and evaluate potential responses**

- **RDM combines key advantages of scenario planning and quantitative decision analysis in ways that**
  - **Decision makers find credible**
  - **Contribute usefully to contentious debates**

RDM Has Effectively Addressed Many Types of Decisions Under Deep Uncertainty

Energy, Environment, and Climate Change	• Long-Range Natural Resource Management • Renewable portfolios standards • Center on climate change decision making
National Security	• Federal terrorism insurance program • Response to ambiguous warning • Force procurement and deployment • Pre-conflict shaping strategies
Commercial-Sector Applications	• Electric utilities' strategies under deregulation • Product and technology planning in the auto industry

RDM Enables Effective Planning Based on Multiple Views of Future

- **Use many scenarios to imagine the future**
  - **Not a single forecast**
- **Seek robust strategies that do well across many scenarios assessed according to several values**
  - **Not optimal strategies**
- **Employ strategies that evolve over time in response to changing conditions**
  - **Not "fixed" strategies**
- **Use computer as “prosthesis for the imagination”**
  - **Not a calculator**

Conclusion
"The Future is Not What it Used to be"

- **It is possible to think differently about the future and especially to think differently about the roles and uses of forecasts**
- **We have in the past "done our best" to forecast a future even though we knew there was uncertainty and forecasts are "always wrong" . . . that approach is rapidly going out of date**
- **We can use modern forecasting methods to mobilize our understanding of uncertainty**
- **Land Use –Transportation- Environment is a prime area for robust decision making but planners have been resistant to changing their world view**