Exploratory Modeling & Analysis (EMA):

A supporting tool for the adaptive implementation of Intelligent Speed Adaptation (ISA)

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Objectives

- To understand the multi-dimensional nature of policy problems involving 'deep uncertainty'
- To understand the role and added value of EMA in supporting adaptive policymaking
- To identify future research needs in this area

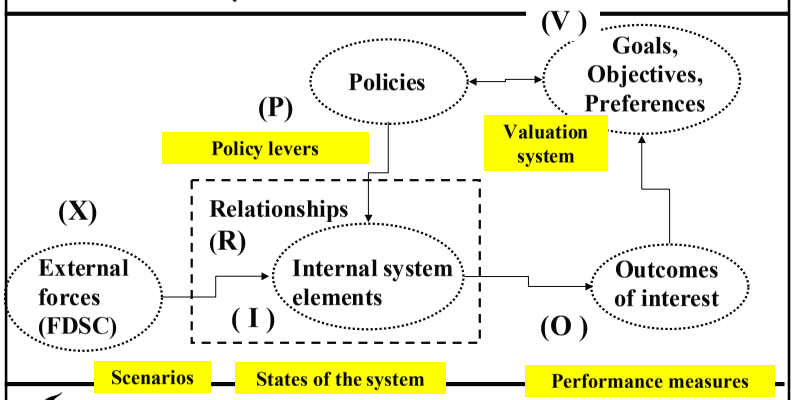
Exploratory Modeling and Analysis (EMA)

" The objective of the method is to gain insights out of uncertain system by exploring as broad assumptions as it is useful so that model users can reason about system behavior"

" the method can be contrasted with the use of models to predict system behavior where models are built by consolidating known facts into a single package"

Bankes, S. (1993). " Exploratory modeling for policy analysis." Operations Research 41(3):435-449

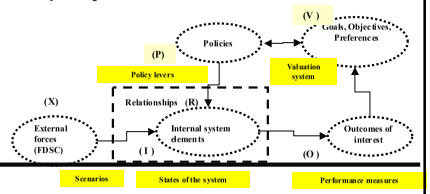
Integrated view of policy analysis (XPIORV framework)



There are Several Types of Uncertainty

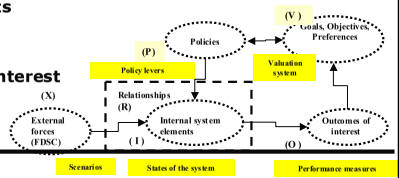
- Scenario uncertainty
  - e.g. relevant scenario factors
- Parametric uncertainty
  - e.g. The values for the inputs of the model
- Structural uncertainty
  - e.g. the causal relationships, functional relationships
- Value uncertainty
  - e.g. how future decision makers value policy outcomes

A condition of deep uncertainty = all types of uncertainty due to lack of knowledge or agreement



Exploratory modeling = collection of plausible models

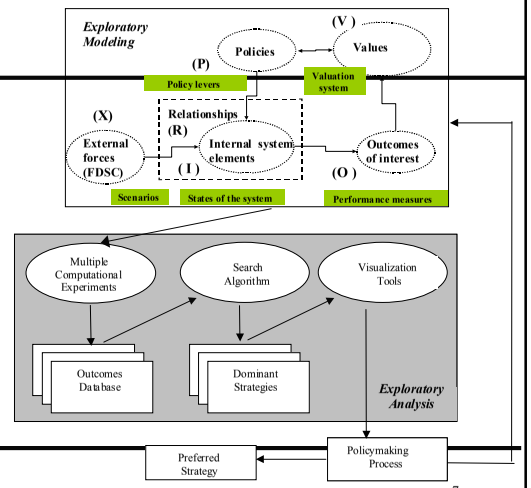
- **Alternative scenarios:**
  - Different level of aggregation
  - Different number and combination of scenario variables
  - Different range of values of scenario variables
- **Alternative states of the system :**
  - Different functional relationships among model outputs and inputs. If Z=f(X,Y), there are different plausible f.
    - Different parameters values
  - Different states of internal elements
- **Different valuation systems:**
  - Different weights on outcomes of interest
  - Different acceptable range of regret values



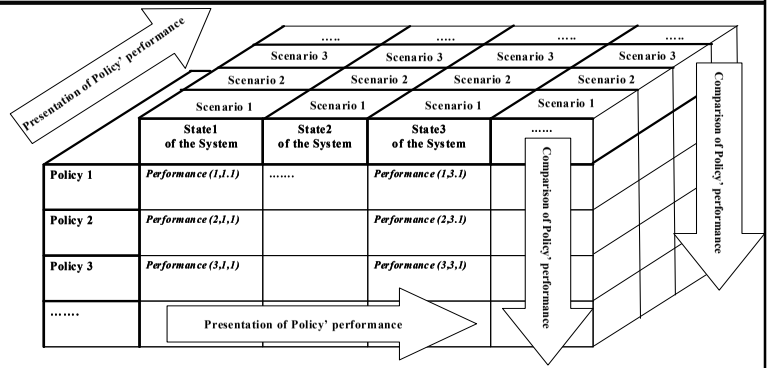
EMA = Exploratory Modeling + exploratory Analysis

• Exploratory modeling defines **alternative representations** of the system of interest

• Exploratory analysis looks for **robust policy**



Model Outcomes Database: searching for robust policy



Case: Adaptive Policy on Implementing ISA

Warren E. Walker, S. Adnan Rahman, and Jonathan Cave, "Adaptive Policies, Policy Analysis, and Policymaking", *European Journal of Operational Research*, Vol. 128, No. 2 (January 2001), pp. 282-289.

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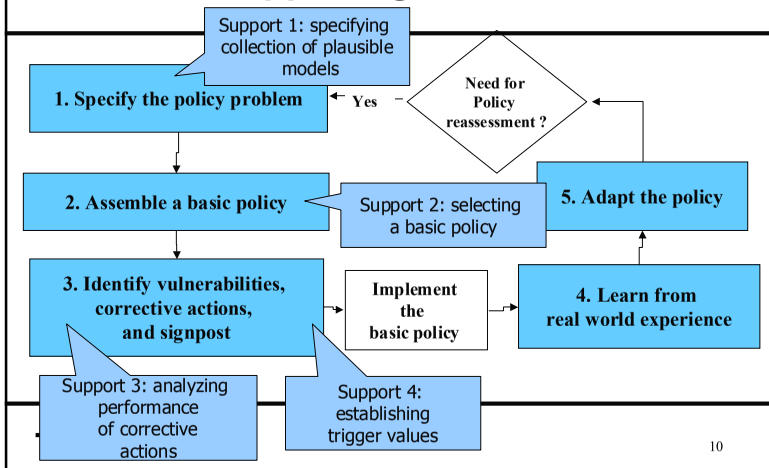
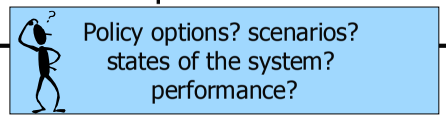
Four Supporting Roles for EMA



Support 1: Specifying a collection of plausible models

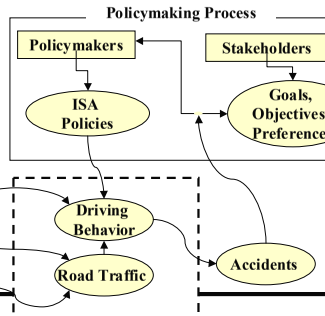


Policy Options:
- Type of ISA
- Targeted driver groups
- Level of penetration

Scenarios:
- Demography: Population's age structure → no. drivers by age
- Demography: urban sprawl → travel pattern → average time on traffic
- Economy: disposal income → car ownership

States of the system:
- Speed profiles
- Speed-accident relationships
- Drivers' acceptance

Performance Measure:
Reduction in accident risk



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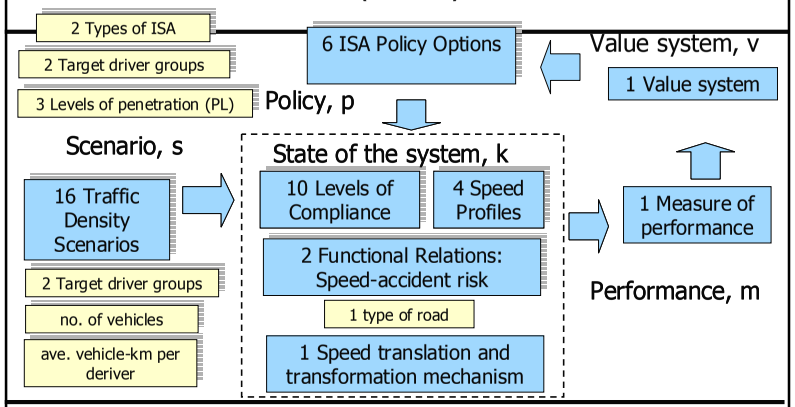
Support 1: Specifying a collection of plausible models (contd.)



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- Total no. operations (runs) = 7680

Criterion for Policy Selection

- **Minimize** Regret: **" Now that it is raining and I am wet, I wish I had brought an umbrella".**
- **You want to** minimize the difference **between your selected action and the best action for a particular situation (over all possible actions)**

$$\text{Relative\_regret}(p, k, s) = \frac{\max_{p'}[\text{Performance}(p', k, s)] - \text{Performance}(p, k, s)}{\max_{p'}[\text{Performance}(p', k, s)]}$$

Category of regret	Range of relative regret, r	
No regret	$0 \le r \le 0.04$	Successful
Mild	$0.05 \le r \le 0.94$	
A lot	$0.95 \le r \le 9.94$	Failure
Overwhelming	$r \ge 9.95$	

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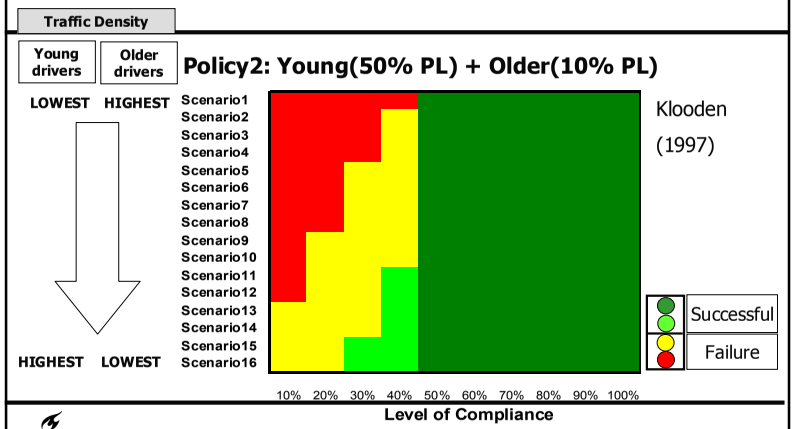
EMA: Search for Pattern ...



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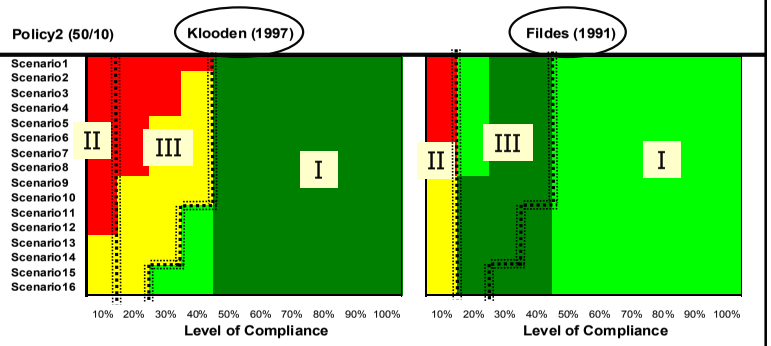
EMA: Search for Pattern... and Robustness



- Zone I: **Policy is SUCCESSFUL for both functions**
- Zone II: **Policy FAILS for both functions**
- Zone III: **No conclusion**

Successful
Failure

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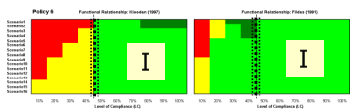
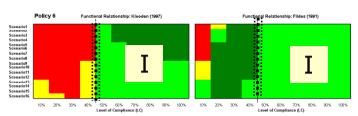
Support 2: Where to start? A basic policy

Basic Policy = **Young(10% PL) + Older(10% PL)**

- Small scale
- Adaptable
- Learning provision
- Robust



[Positive skewed, Symmetric]



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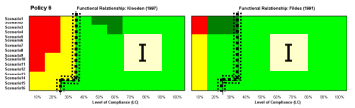

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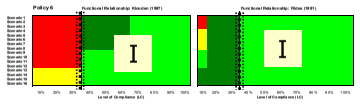

[Symmetric, Positive skewed]

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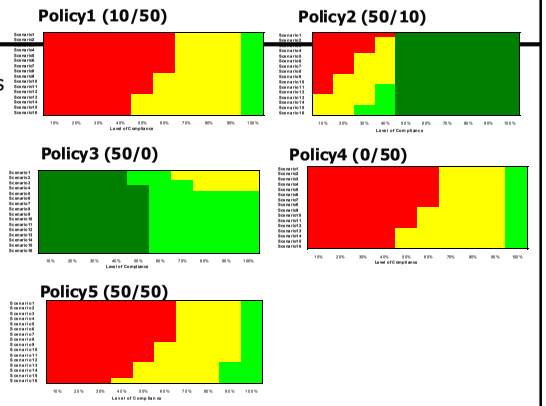
Support 3: Adapt basic policy with corrective actions

- Suppose: young drivers has speeding behavior & Klooden (1997)
- When level of compliance is 70% → **?**
- When level of compliance <50% → **?**
- Policy5 (50/50): more is not necessarily better



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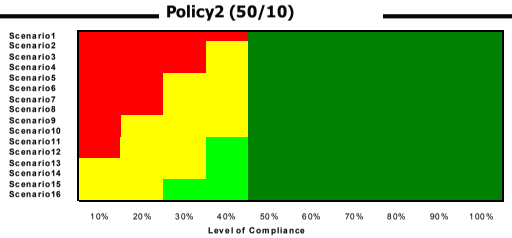
Support 4: Signpost and trigger values by monitoring the MEAN SPEED



Policy2 (50/10)

Change of mean speed for Total Traffic (km/hr)									
0.61	0.51	0.40	0.30	0.20	0.10	0.00	-0.10	-0.21	-0.27
10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Level of Compliance									

Steady state

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Policy Recommendations Based Upon EMA

Policymakers can start to implement ISA in the presence of uncertainties:

- **Use basic policy**
- **Adapt policy as new knowledge is gained and uncertainties are resolved**

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