

# The Modeling Processes

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## References:

1. Sterman, John D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hills. Chapter 3: The Modeling Processes.

# Why Simulation is Essential

- Eliciting and mapping the participant's mental models, while necessary, is far from sufficient. Simulation is the only practical way to test these models.
- Without simulation, conceptual models can only be tested and improved by relying on the learning feedback through the real world.
  - This feedback is very slow and often rendered ineffective by dynamic complexity, time delays, inadequate and ambiguous feedback, poor reasoning skills, defensive reactions, and the costs of experimentation.
- In this circumstances, simulation becomes the only reliable way to test hypotheses and evaluate the likely effects of policies.

# System Dynamics

- System Dynamics is an approach that should help in important top management problems.
- System Dynamics was born at MIT Sloan in the 1950s and developed by Prof. Emeritus Jay W. Forrester.
- System Dynamics helps us understand, design, and manage change.
- Using data and technology, System Dynamics models the relationships between all the parts of a system and how those relationships influence the behavior of the system over time.

# The Purpose of Modeling: Managers as Organization Designers

- In the context of social and business systems, managers play two roles:
  - they are pilots, making decisions
  - they are designers, shaping the organizational structures, strategies, and decision rules that influence how decisions are made.
- Too many managers, especially senior managers, spend far too much time acting as pilots - making decisions, taking control from subordinates - rather than creating an organizational structure consistent with their vision and values and which can be managed well by ordinary people.
- Virtual worlds provide an important tool for managers in both the operation and especially the design of their organizations.

# Selection of Problems

*“The solution to small problems yield small rewards... The goal should be to find management policies and organizational structures that lead to greater success.” – Forrester*

- Focus modeling work on the important issues, on the problems where your work can have lasting benefit, on the problems you care most deeply about.

# The Client and The Modeler

- The Client is
  - NOT the person who brings you in to an organization or champions your work
  - NOT the person who pays for the modeling study, though it is helpful to have contacts, champions, and cash.
- The Client
  - are those people whose behavior must change to solve the problem
  - can be a CEO or a machine operator on the factory floor.
  - can be individuals, groups, or entire communities.
  - can be your academic colleagues, the public at large, or even yourself.

# The Client and The Modeler 2

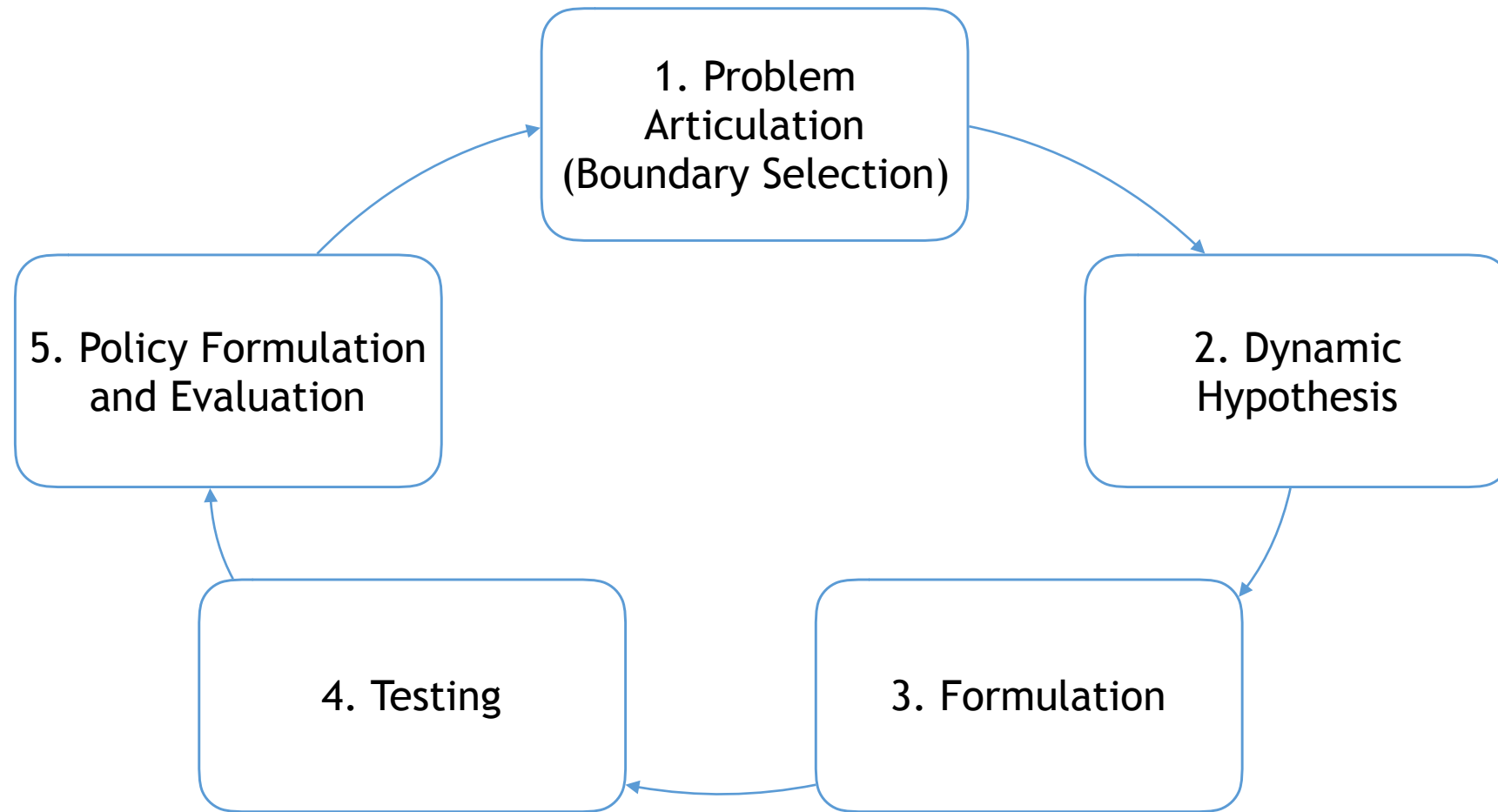
- To be effective, the modeling process must be focused on the clients' needs.
- The clients for a modeling project are busy:
  - they are embroiled in organizational politics. They are looking out for their own careers. Their concern is solving a problem and taking action in the real world. They care little for the elegance of your theory or cleverness of your model.
- Modeling is done to help the client, not for the benefit of the modeler.
  - The client context and real world problem determine the nature of the model
  - The modeling process must be consistent with the client's skills, capabilities, and goals.
  - The purpose is to help the clients solve their problem.
  - If the clients perceive your model does not address their concerns or lose confidence in it, you will have little impact.
  - Focus your modeling work on the problems that keep the clients up at night.

# The Client and The Modeler 3

- Modelers should not automatically accede to clients' requests to include more detail or to focus on one set of issues while ignoring others, just to keep the client on board.
- A good modeling process challenges the clients' conception of the problem.
- Modelers have responsibility to require their clients to justify their opinions, ground their views in data, and consider new viewpoints.
- When the clients ask you to do something you think is unnecessary or misguided, you must work with them to resolve the issue.



# The Modeling Process



# The Modeling Process

## 1. Problem Articulation (Boundary Selection)

- **Theme Selection:** What is the problem? why is it a problem?
- **Key variables:** What are the key variables and concepts we must consider?
- **Time horizon:** How far in the future should we consider? How far back in the past lie the roots of the problem?
- **Dynamic problem definition (reference modes):** What is the historical behavior of the key concepts and variables? What might their behavior in the future?

# The Modeling Process

## 2. Formulation of Dynamic Hypothesis

- **Initial hypothesis generation:** What are current theories of the problematic behavior?
- **Endogenous focus:** Formulate a dynamic hypothesis that explains the dynamics as endogenous consequences of the feedback structure.
- **Mapping:** Develop maps of causal structure based on initial hypothesis, key variables, reference modes, and other available data, using tools such as
  - Model boundary diagrams
  - Subsystem diagrams
  - Causal loop diagrams
  - Stock and flow maps
  - Policy structure diagrams
  - Other facilitation tools

# The Modeling Process

## **3. Formulation of a Simulation Model**

- **Specification** of structure, decision rules.
- **Estimation** of parameters, behavioral relationships, and initial conditions.
- **Tests** for consistency with the purpose and boundary

# The Modeling Process

## 4. Testing

- **Comparison to reference modes:** Does the model reproduce the problem behavior adequately for your purpose?
- **Robustness under extreme conditions:** Does the model behave realistically when stressed by extreme conditions?
- **Sensitivity:** How does the model behave given uncertainty in parameters, initial conditions, model boundary, and aggregation?
- ... **Many other tests**

# The Modeling Process

## 5. Policy Design and Evaluation

- **Scenario specification:** What environmental conditions might arise?
- **Policy design:** What new decision rules, strategies, and structures might be tried in the real world? How can they be represented in the model?
- **“What if...” analysis:** What are the effects of the policies?
- **Sensitivity analysis:** How robust are the policy recommendations under different scenarios and given uncertainties?
- **Interactions of policies:** Do the policies interact? Are there synergies or compensatory responses?

End Slides.