Applying System Dynamics Modeling to SMC Acquisitions

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We've got a "Wicked Problem*"

- **Wicked Problems have the following criteria**:**
  - They have an evolving set of interlocking issues and constraints.
  - Their constraints change over time, e.g., resources and politics
  - They have many stakeholders who care about how the problem is resolved, which makes the problem solving process fundamentally social.
    - Stakeholders come and go, change their minds, fail to communicate, or otherwise change the rules by which the problem must be solved.
  - They have no definitive Problem, and therefore no definitive Solution. The problem-solving process ends when you run out of time, money, energy, or some other resource, not when some perfect solution emerges.

Additional tools are required to solve this type of problem…..

* Rittle, H. and M. Webber; "Dilemmas in a General Theory of Planning" pp 155-169, *Policy Sciences*, Vol. 4, Elsevier Scientific Publishing Company, Inc., Amsterdam, 1973
** Adapted from: http://www.3m.com/meetingnetwork/readingroom/gdss_wicked.html

System Dynamics:
A Method to Gain Actionable Insights

- **"System Dynamics is the application of feedback control system principles and techniques to managerial, organizational and socioeconomic problems"** (Dr. E. B. Roberts)
- **"System Dynamics is a method of studying the behavior of systems to show how decisions, policies, structures and delays are interrelated to influence growth and stability."** (Mr. J. Forrester)

Characteristic	System Dynamics
Building block	Feedback loops among variables driving behavior
Object of interest	Feedback structure producing variable behavior over time
Research approach	*Inductive*: Infer structure from activities, accumulations and outcomes (model building) *Deductive*: Infer dynamic behaviors from structure (model simulation)

Modeling Provides a Cost Effective Testbed for "What if" Analysis

How Could the Model Building *Process* Help?

Model-building process aids organizational focus and generates constructive conversation

- **Focuses on dynamics through time—more comprehensive than static view**
- **Focuses on the forest *and* the trees, both high-level behaviors of the socioeconomic system and detailed components influencing those behaviors**
- **Requires people to make explicit their assumptions about how work gets done**
- **Depersonalizes conflict by creating transformable "picture" of how things work**
- **Helps people speak specifically and productively about interdependencies**
- **Scenario analysis creates low-cost ways to explore *why* some actions are high-leverage and others aren't**

How Could Modeling *Analysis* Help?

Aids organizational selection of technical solutions

- How is coverage affected by a change in constellation altitude?
- What is the impact on throughput of this system architecture?

Aids organizational selection of policies, strategies and processes

- How does SPO (AF, Aerospace and SETA) size and experience impact acquisition success?
- Is this program executable using the proposed policies, strategies, processes, budget and schedule?
- Where should the SPO focus its effort to make the greatest impact?
- What is the impact of performing these unplanned tasks?
- What is the impact of delays in these decisions?
- What is the impact of product quality on acquisition success?

Presenting Problem

How does System Engineering identify a disconnect?
and
What do we do when we find one?

Disconnect: A latent difference in understanding among groups or individuals that will negatively impact the program should it remain unresolved.

Disconnect Example

- **The contractor responds to a need for change with a proposal**
- **The contractor and the IPT agree to proceed with change "at risk"**
- **The IPT initiates the SPO approval process**
- **During the approval process, stakeholders revise the content of the change**
- **When the approved change is negotiated with the contractor, the contractor objects to the "changed change"**
- **The contractor rejects the approved change**

Disconnect: As these discrepancies accumulate, the contractor's baseline diverges from the SPO-approved baseline—eventually a crisis is recognized.

Focus Question

How to maintain alignment between the SPO-approved and contractor's baselines?

- **SPO change-approval process includes:**
  - Business processes;
  - Cross-organizational structures and information flows;
  - Existing policies and strategies;
  - Stakeholder social networks.
- **Scope**
  - From: Identification of need for change
  - To: Update of CCB-approved baseline

- **SPO change-approval process intended outcomes include:**
  - Timely baseline reconciliation;
  - High-quality product;
  - Decisions that support SPO program and product parameters;
  - Contractor's implementation matching SPO specification.

Project Approach

- **Use model simulation *results* to identify leverage points to improve alignment of SPO-approved and contractor's baselines**
- **Use modeling *process* to build shared understanding of the complex baseline change process**
  - Identify who performs each part of the change-coordination activities, under what conditions
  - Estimate realistic capacities of people responsible for coordinating changes
  - Estimate realistic throughput and cycle-time of change-approval activities
  - Identify delays in the existing change-approval activities
  - Inform stakeholders how their work affects the larger context of the program
  - Help stakeholders develop a common operational language

Model Development Process

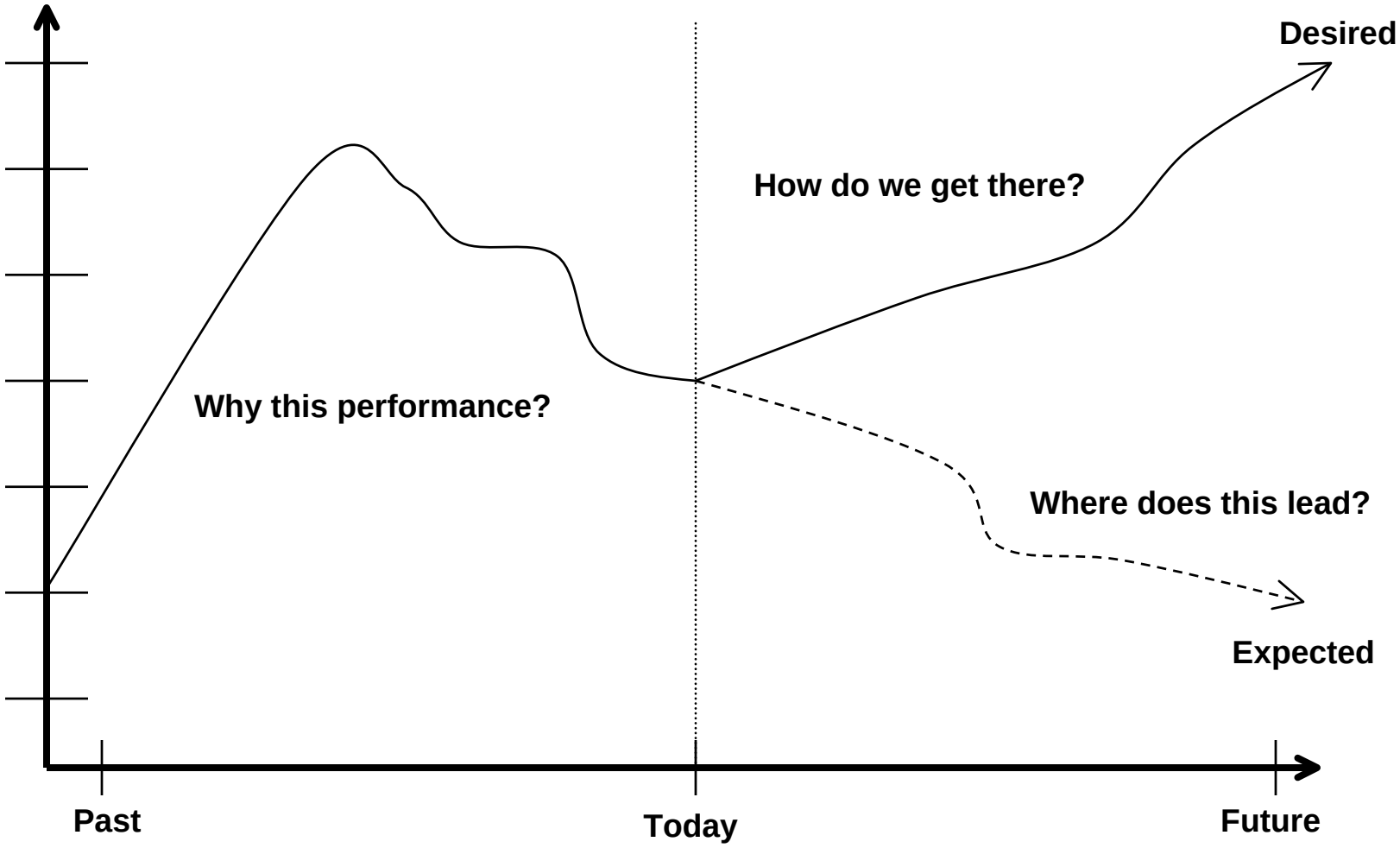
- Develop affinity model to identify emerging themes
- Identify key variables and map their behaviors over time—both historic and future expectations
- Construct causal loop diagrams to establish a dynamic explanation of currently observed behaviors
- Generate stock-flow map from causal loop representation of the system
- Add equations to the stock-flow maps to bring them to life as a simulation
- Compare simulation outputs to historical performance and expectations of subject matter experts
- Design policy and strategies to improve performance

Future

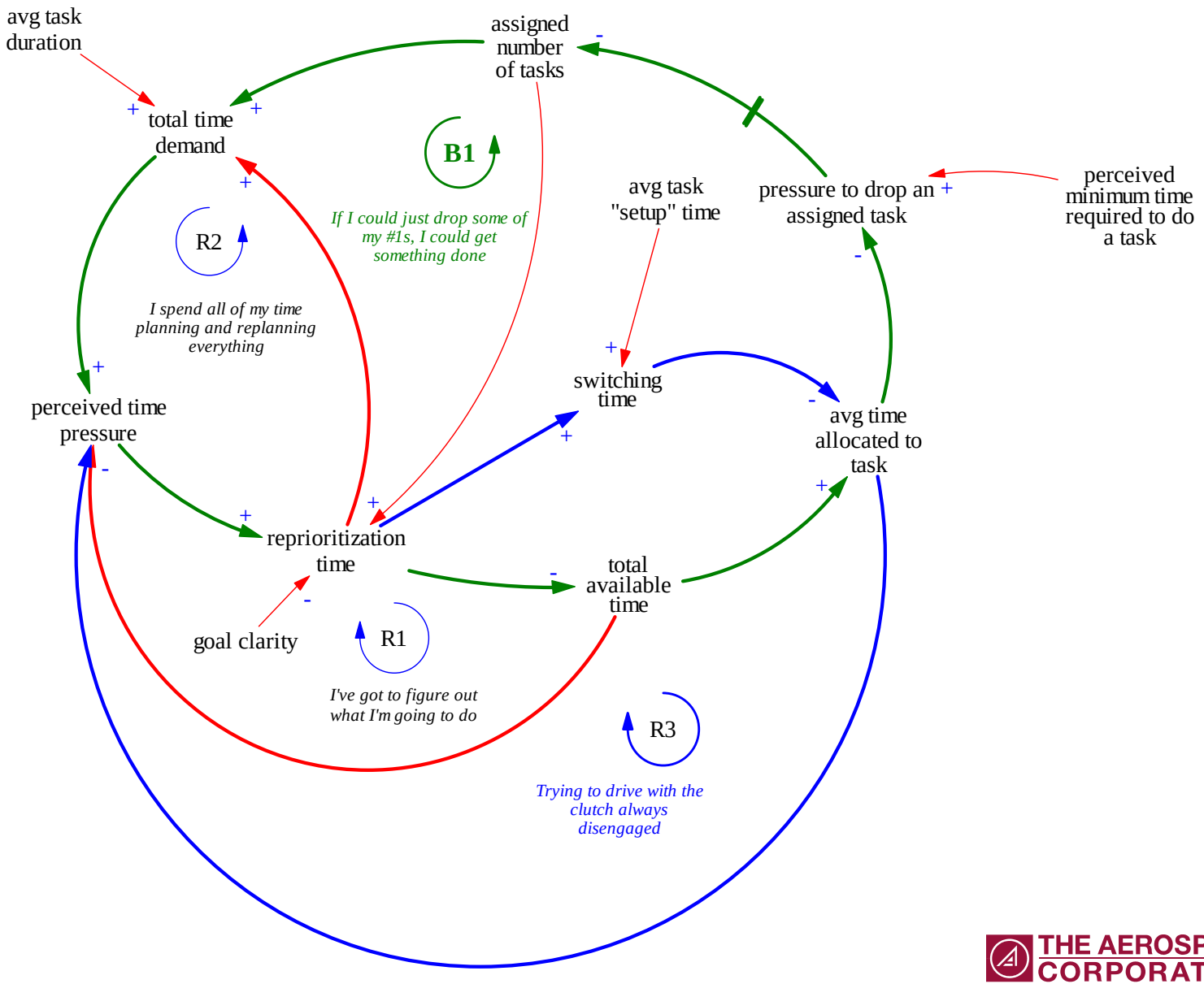
- Complete pilot project
- Given a successful pilot, create internal capability to use these tools on an ongoing basis
- Develop an awareness of how these tools can be used to improve acquisition outcomes
- Integrate the application of these tools into the strategic and tactical management of SMC acquisitions

Appendix

Sample Behavior-Over-Time Graph

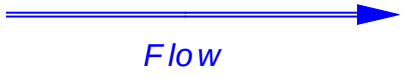


Sample Causal-Loop diagram



Primary elements

- **Stocks suggest a container holding an accumulation of units**

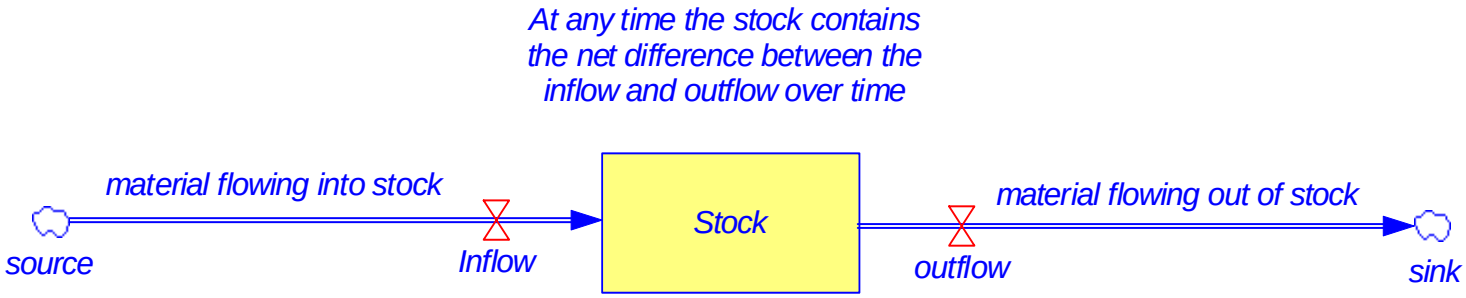


- **Flows suggest a pipe through which units move**

- **Valves are the spigot that controls the rate of flow over time through the pipe**

- **Clouds represent a model boundary and behave as an unlimited source or sink.**

General structure



- **Material flows from the Cloud (source) into the Stock at a rate controlled by the Inflow valve**
- **The Stock holds the material until it flows out**
- **Material flows from the Stock to the Cloud (sink) at a rate controlled by the Outflow valve**
- **If all activity should stop (Inflow & Outflow = zero), then only the Stock will have material in it**

Sample Stock-Flow diagram