System Dynamics of Sustainment

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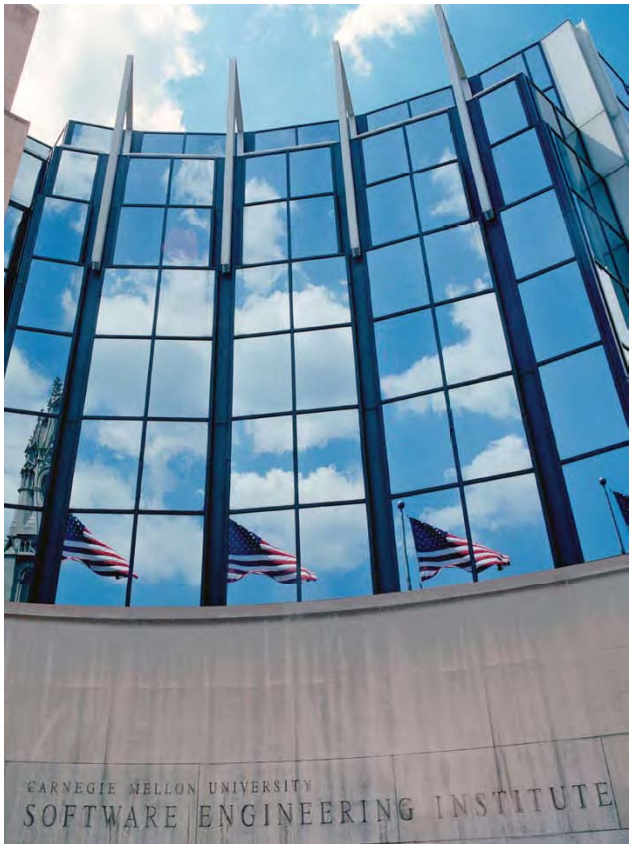
SEI Objectives

The SEI works to:

- Identify, research, evaluate, and advise on software engineering technologies, trends, and practices
- Collaborate with and leverage work found in industrial research, academia, and government laboratories
- Mature promising software engineering technologies to enable standards, transition, and adoption
- Enable government & industry organizations to make measured improvements in their software engineering practices



Agenda

Background: The problem

What Generates the Need for Sustainment Work?

The system dynamics model and gaps as forces

Scenarios (threat, support technology, workforce)

Outcomes of scenarios

Plans

Background

DoD: Rising cost of software sustainment

Big, complicated problem

- Multiple stakeholders with different value systems decide budgets
- Constantly changing technology
- Constantly changing threat space
- Inventive users discovering new applications for products
- Highly coupled, interdependent environment (systems talk to each other)
- Unstructured and not well-managed portfolio of products

Making progress requires

- Portfolio approach to management
- Better funding, budgeting processes
- Better system architecture
- Better and improving sustainment processes
- ...

Research Questions

How can sustainment organizations constantly learn and adapt

1. How can we identify the funding needs?
2. What has to be learned for the next release?
3. What happens if/when funding is delayed?

What are the connections between stakeholders?

What are the opportunities to measure the business processes?

Need for Sustainment Work

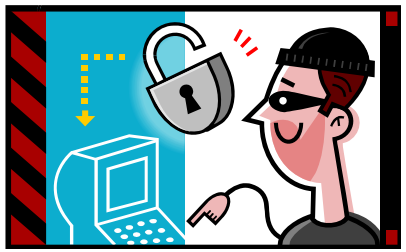
Update requests come from many sources

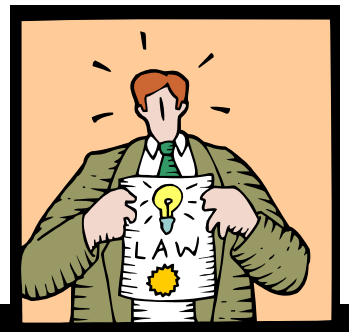
Program: fighter aircraft

- User community (warfighter, logistics)
- External systems (C4I, supplies, maintenance)

Demand types:

- Feature enhancement (new users, different uses, coalitions, new threat)
- Performance improvement (technology opportunity or threat)
- “Real options” – opportunity to invest for future value
- Preventative measures: Information Assurance, security
- Bug Fixes
- Respond to External Change: New OS, new processor, new sensor





Gaps as Sustainment System Forces

System Gap: Difference between **strategy** and **operations**

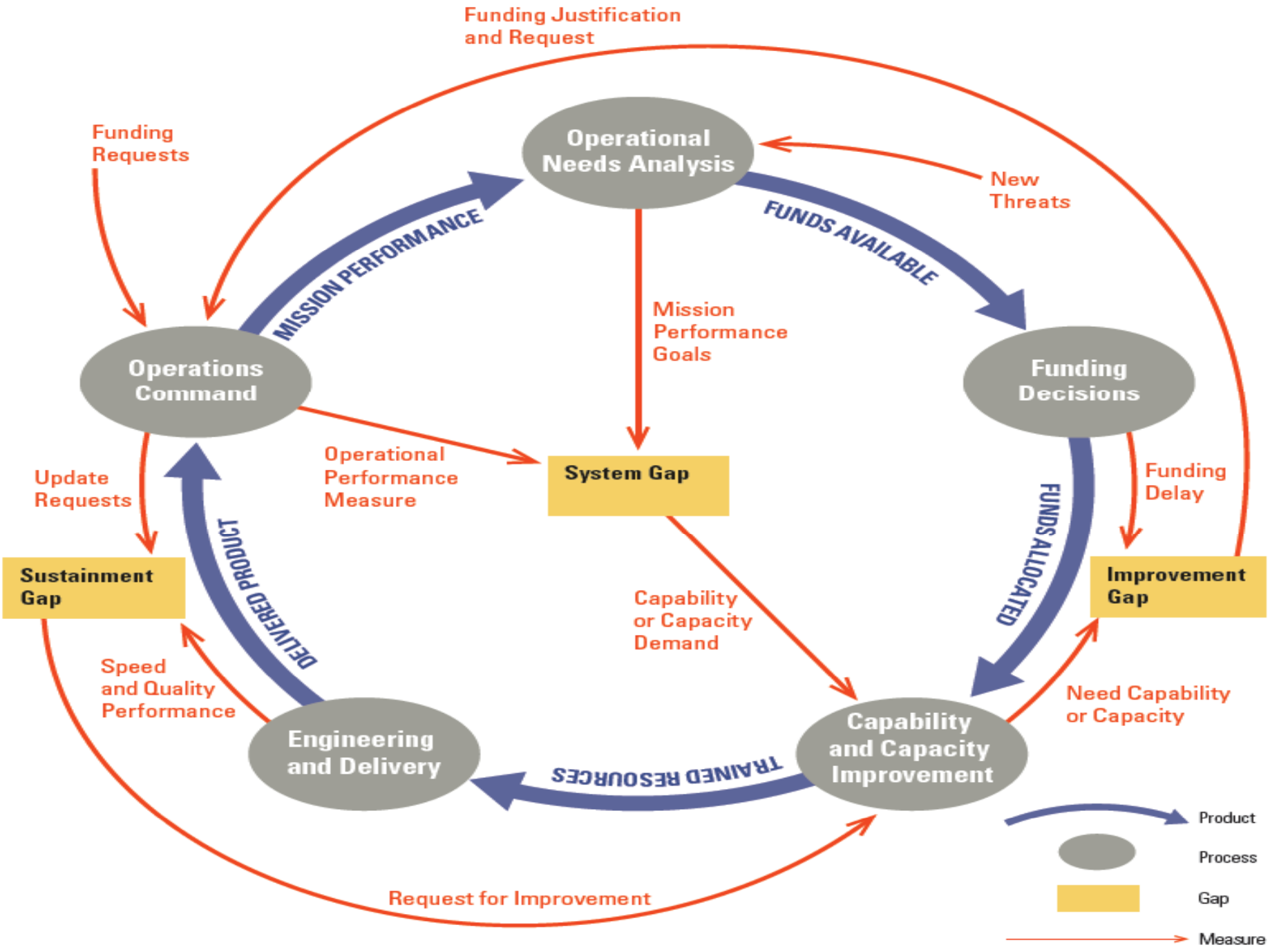
- Mission Planning: effectively "strategic management" determines which battles are to be fought with what operational capabilities. The measure of interest is the capacity of current operational capability.
  - Capacity: how much work can be done (battles can we fight)?
  - Capability: what are the skills, tools and methods we can bring to the fight?
- Operations: Operational performance as a percentage of total capability and the measures of successful performance.

Sustainment Gap: Difference between **operations** and **sustainment**

- Sustainment: Close the gap between potential capacity and available capacity. Also update operational capability with new capabilities.

[Sustainment] Improvement Gap: **Funds needed – Funds available**

- Funds required to update sustainment capability to address operational capability and capacity concerns. Funding is often deferred or delayed.


Funding Justification and Request
Funding Requests
Operational Needs Analysis
New Threats
MISSION PERFORMANCE
FUNDS AVAILABLE
Mission Performance Goals
Operations Command
Funding Decisions
Update Requests
Operational Performance Measure
System Gap
Funding Delay
Sustainment Gap
DELIVERED PRODUCT
FUNDS ALLOCATED
Improvement Gap
Capability or Capacity Demand
Speed and Quality Performance
Need Capability or Capacity
Engineering and Delivery
TRAINED RESOURCES
Capability and Capacity Improvement
Request for Improvement
Product
Process
Gap
Measure

How Gaps Act as Forces

System Gap (Strategy - Operations) Causes…

- Operations to request additional support from Sustainment.
  - Greater throughput = Increase your capacity to do sustainment; and do it faster.
  - Fix bugs that compromise operational capacity and capability.
  - Add enhancement to improve operational capability and capacity.
- Alternative: Go for a “Modernization Project” or new product..

Sustainment Gap (Operations – Sustainment) Causes …

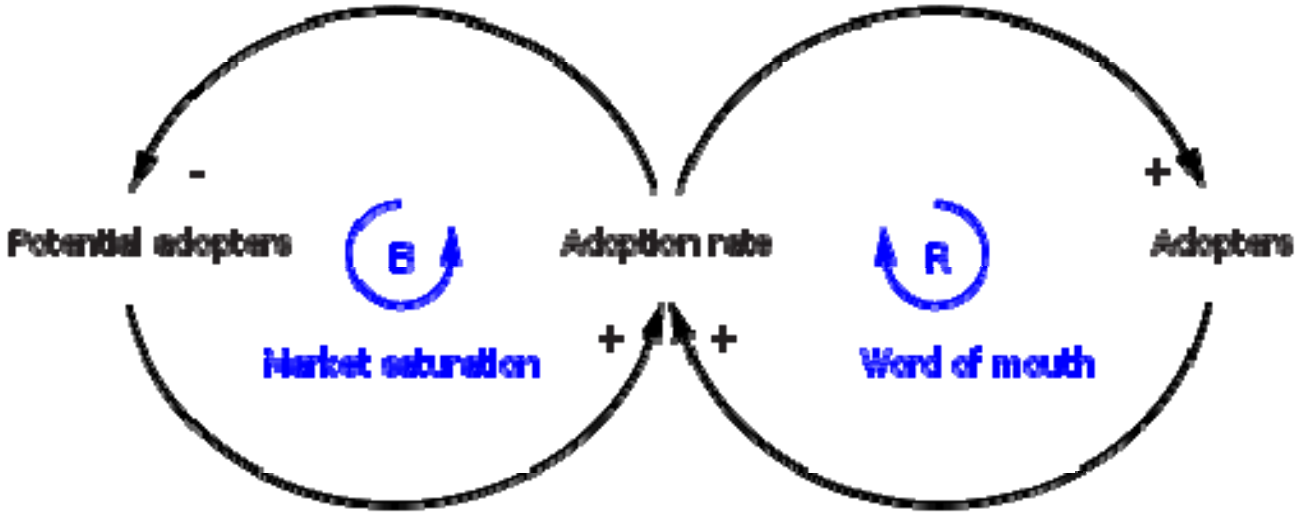
- Sustainment organization to request updates to tools, skills and processes. Some internal improvement efforts will cover some of the work.
- Requests that require changes to technology of product or development process result in capital requests and training requests.

Improvement Gap (Improvement need – Funding) Causes …

- Both the sustainment gap and the systems gap to grow.
- Delays in funding or partial funding have the same effect on sustainment.

Systems Dynamics: Reinforcing and Balancing

Reinforcing and Balancing loops: “Limits to Growth Archetype”



“R” Reinforcing loops cause geometric growth rates.

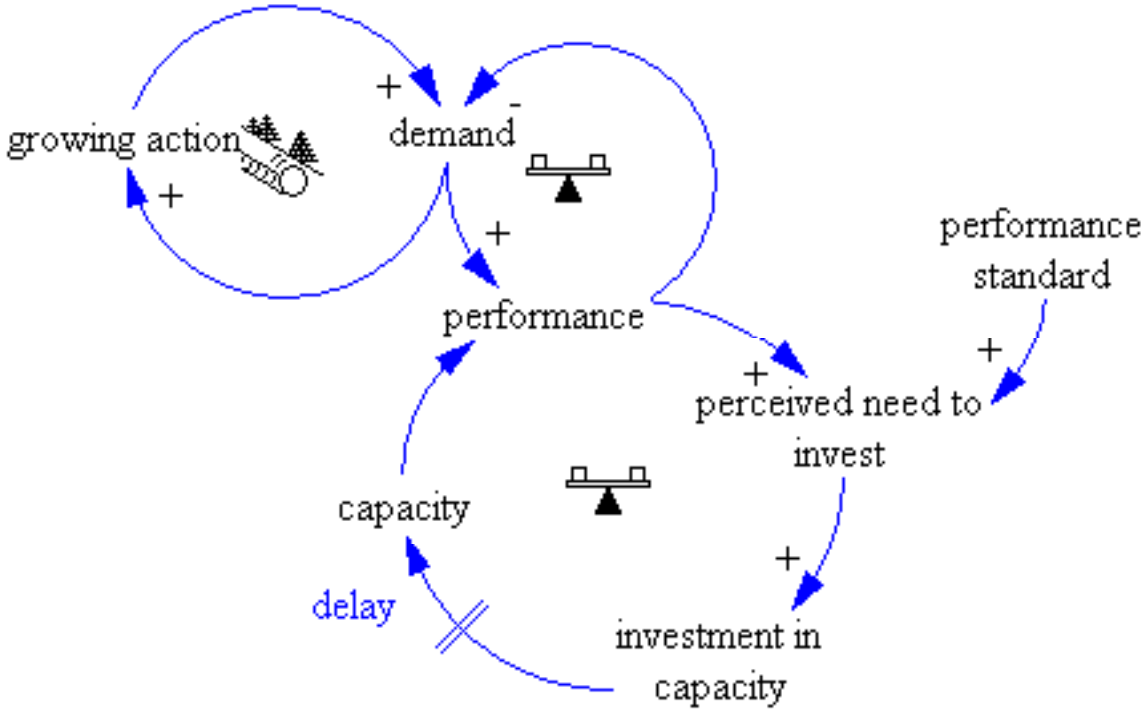
“B” Balancing loops create exponential decay rates.

Growth and Underinvestment “Archetype”

Our “loops” are Operations, Sustainment, Sustainment Investment

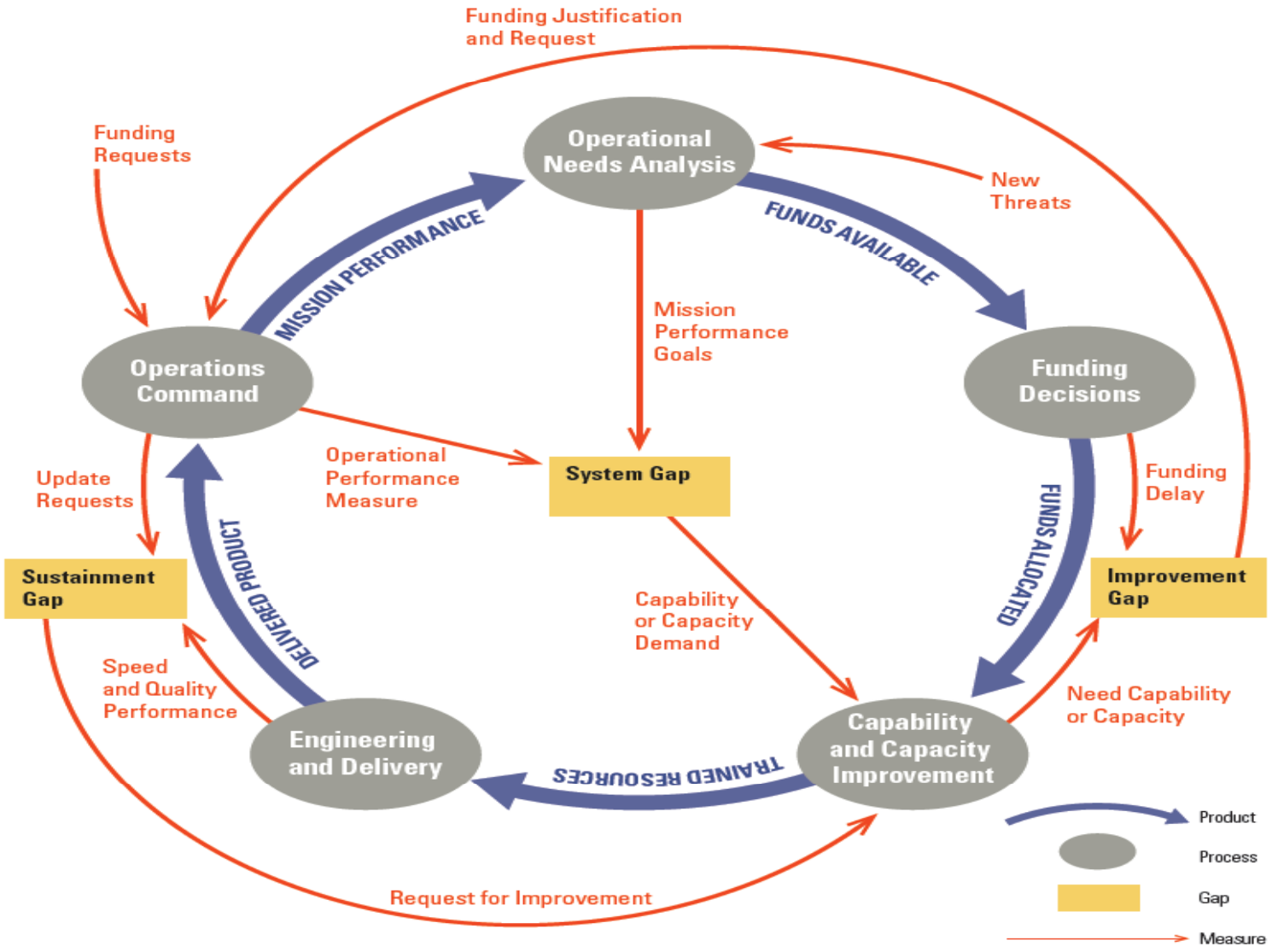
System Performance Gap=Demand

Sustainment Performance =Performance

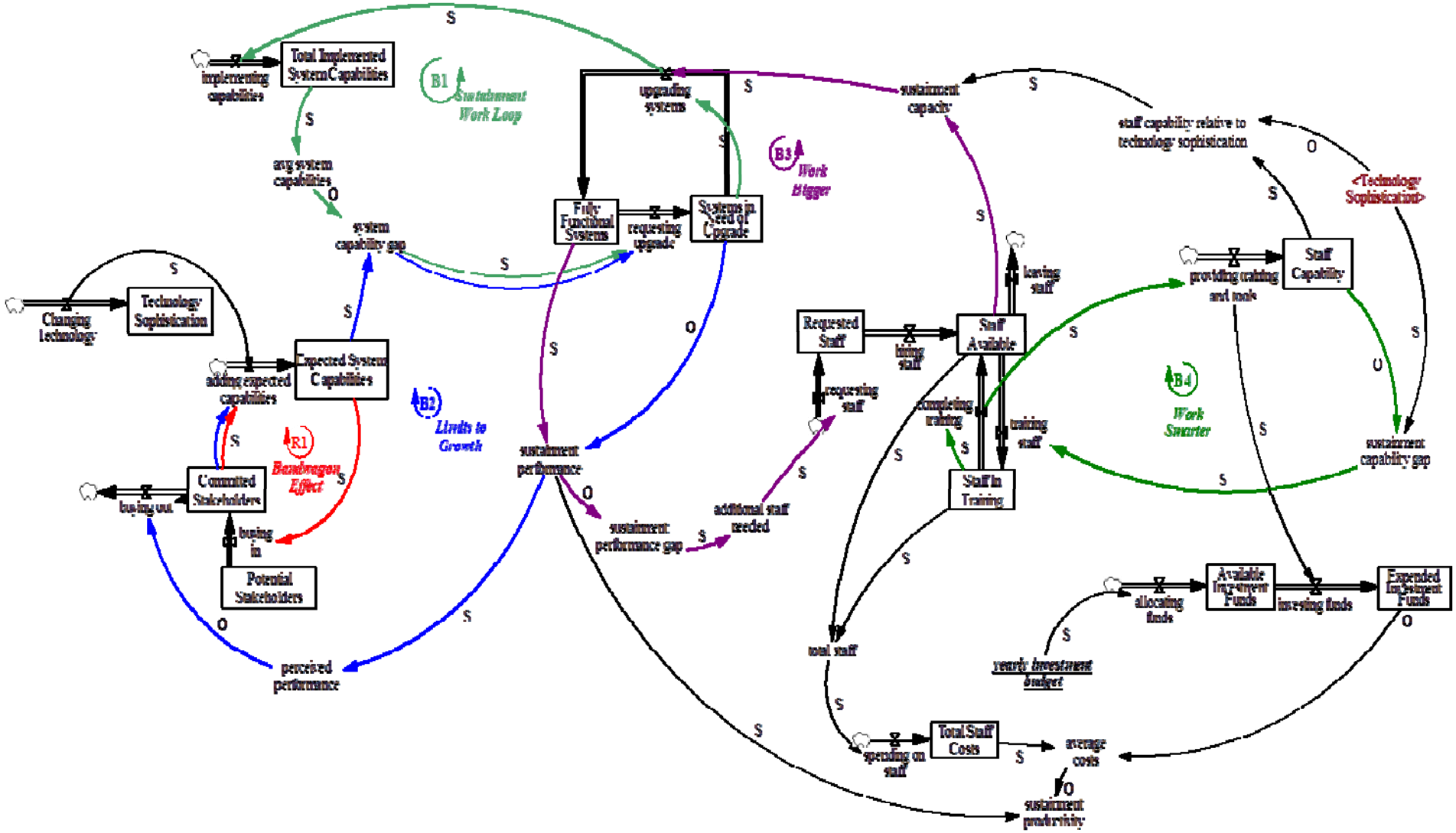


Sustainment = Growth and Underinvestment

Three Gaps but more processes to define the loops.



Simplified View of Simulation Model



Testing the Simulation with Scenarios

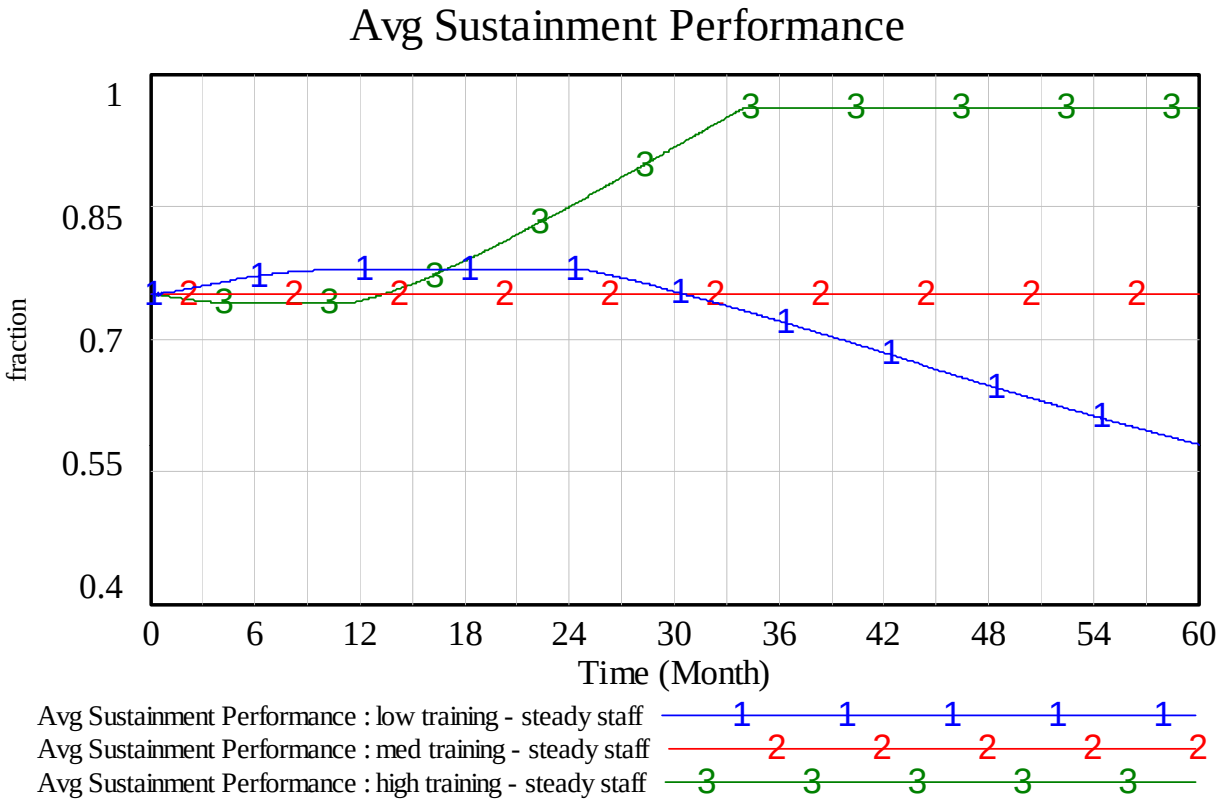
Test a Simulation by

1. Create a stable model with all forces and flows in equilibrium.
2. Plan scenarios to test the response.
3. Run scenarios and validate the responses (data or interviews).
4. Revise equations if needed.

Suggested Sustainment Scenarios

- New threat or opportunity involving a technology change is requested by planners.
  - Sustainers recognize requirement for changes to skills, tools and process.
  - Sustainers request capital funds to improve capability.
  - Test scenarios with different funding delays
- Sequestration leads to furloughs resulting in loss of sustainment capacity.
  - What are the responses?
  - Do responses match actuals
- Funding Delays

Outcomes



Shows what happens as we increase or decrease training.
If we train less, productivity temporarily increases before attrition drains skills.
If we train more, we get an increase until we get to a new steady state.

Plans

Calibrate the model with a real sustaining organization

- Sequestration and new technology changes will both help

Extend the model to investigate the additional problems of a portfolio

- More projects create more opportunities for change
- More projects help to balance resources without dependence on consultants

Benefits of Working with the SEI

Direct access to leading edge software engineering technology

Opportunity for transition of technology for competitive advantage

Non-disclosure policies protect proprietary information

Potential for licensing technology developed as a result of collaboration

Fast-track contracting for Federal organizations

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