

System Dynamics of Sustainment

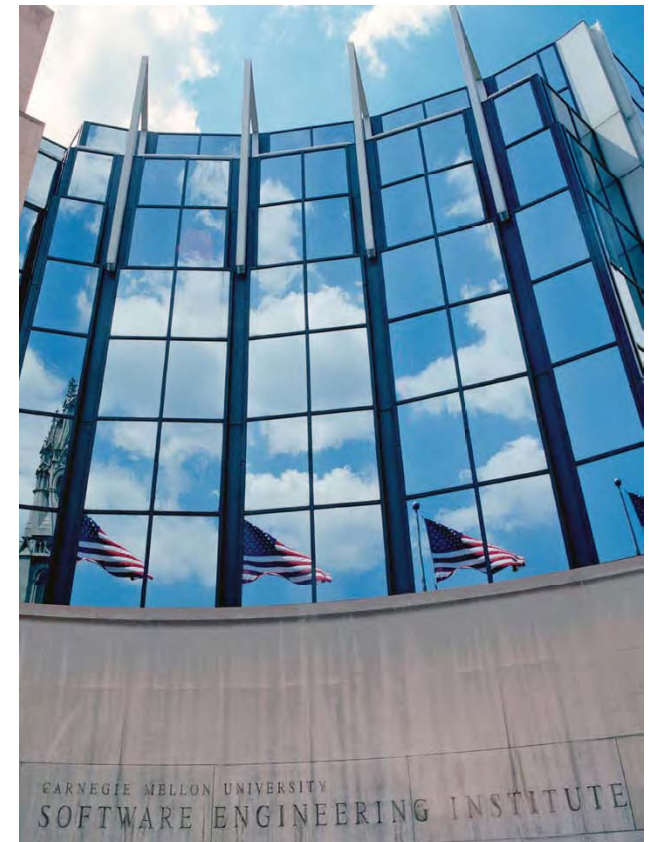
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SEI Objectives

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
- Incentive 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

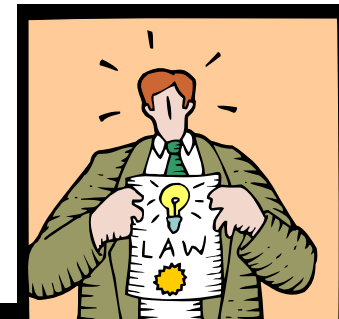
Update requests come from many sources

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.

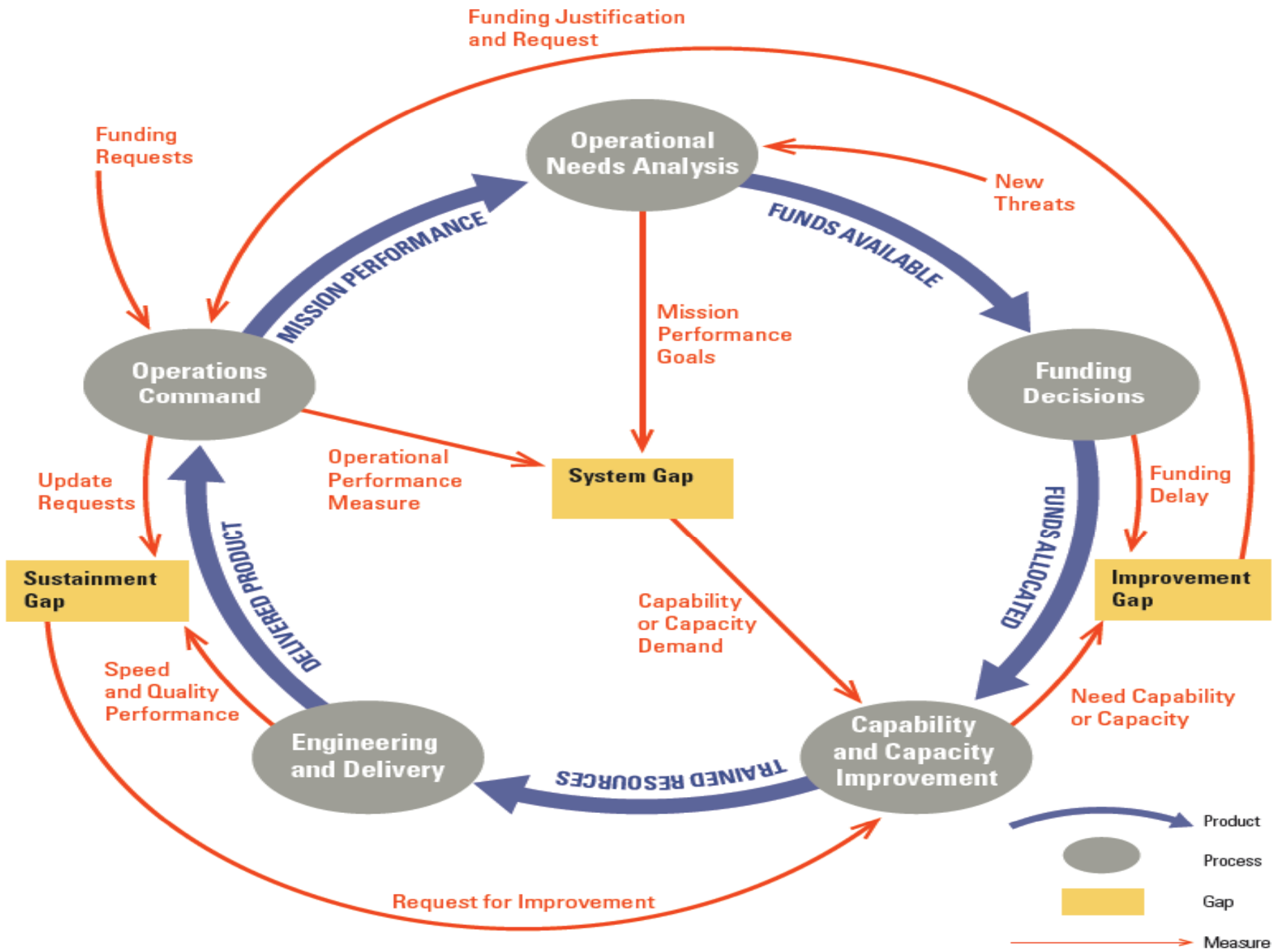
Sustainment Gap: Difference between **operations** and **sustainment**

- 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

Operations Command

FUNDS AVAILABLE

Mission Performance Goals

Funding Decisions

MISSION PERFORMANCE

Operational Performance Measure

System Gap

Funding Delay

Update Requests

FUNDS ALLOCATED

Improvement Gap

Sustainment Gap

DELIVERED PRODUCT

Speed and Quality Performance

Capability or Capacity Demand

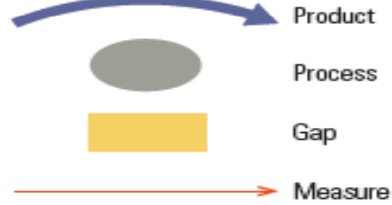
Capability and Capacity Improvement

Need Capability or Capacity

Engineering and Delivery

TRAINED RESOURCES

Request for Improvement



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.

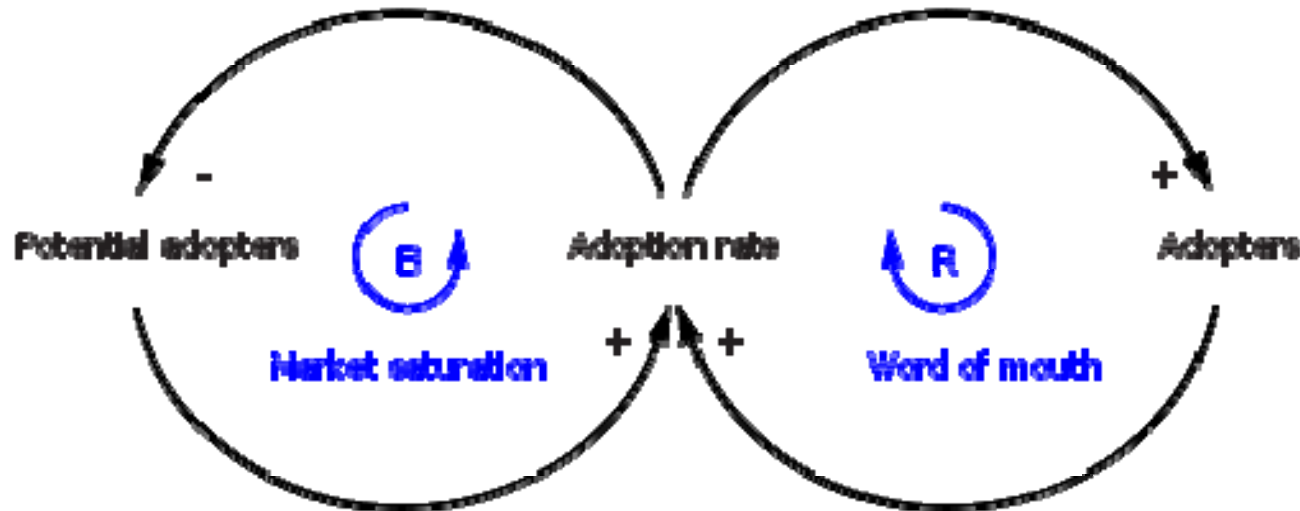
Improvement Gap (Improvement need – Funding) Causes ...

- 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.

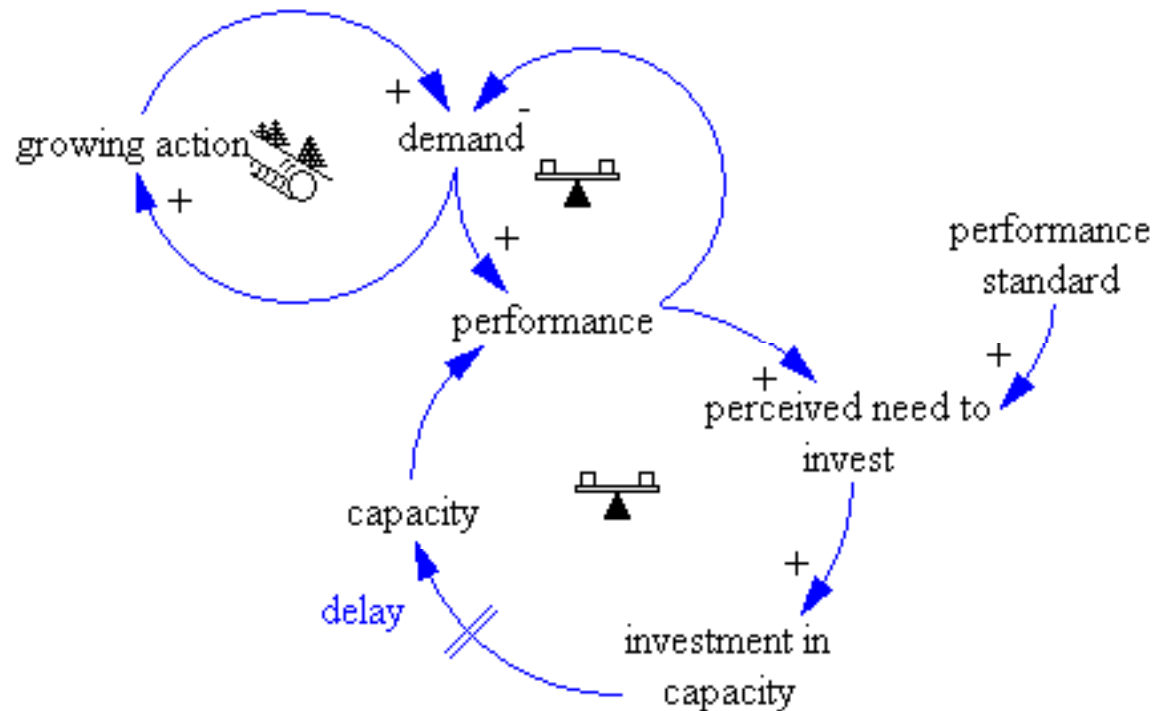


Growth and Underinvestment “Archetype”

Our “loops” are Operations, Sustainment, Sustainment Investment

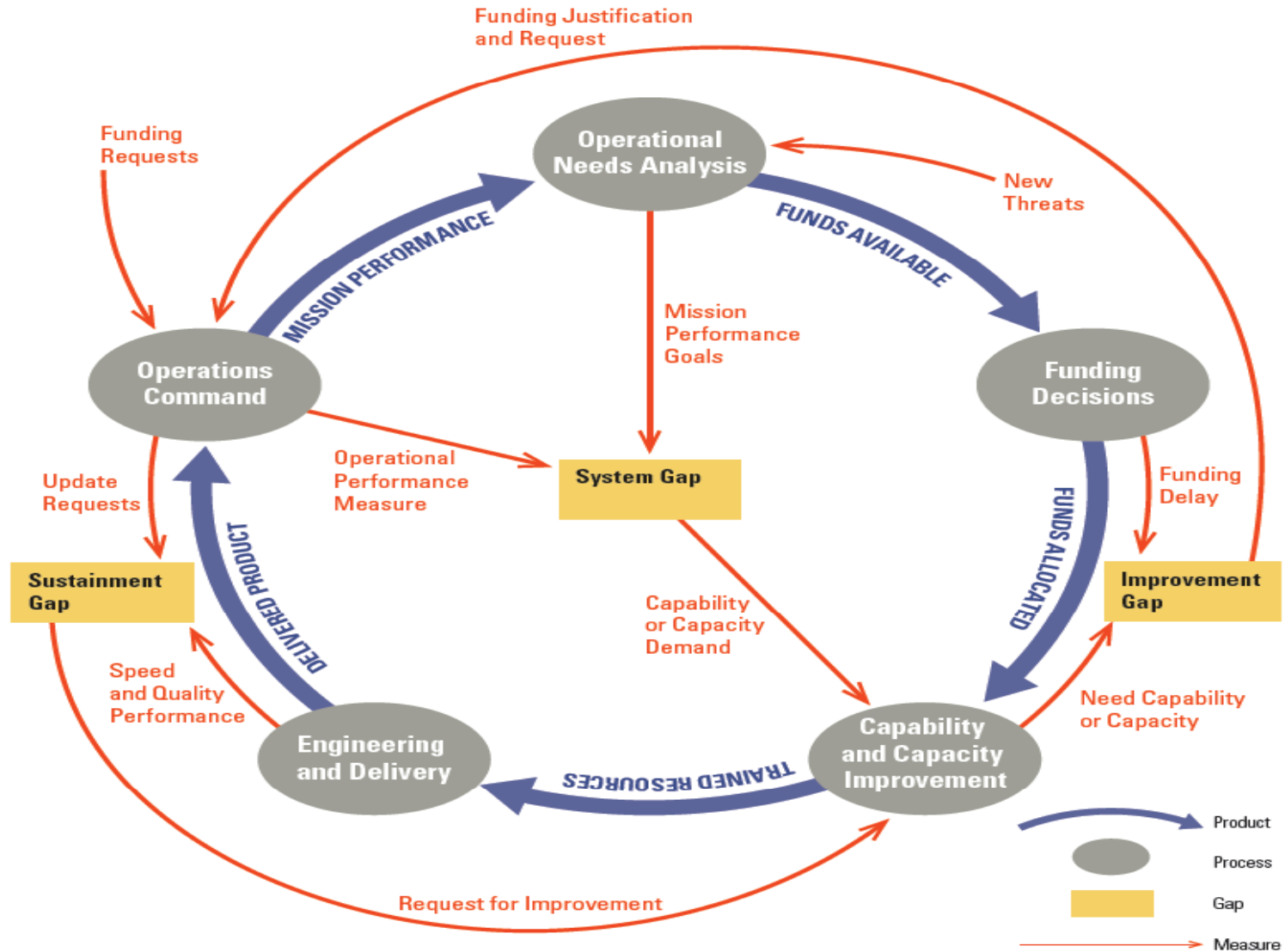
System Performance Gap=Demand

Sustainment Performance =Performance

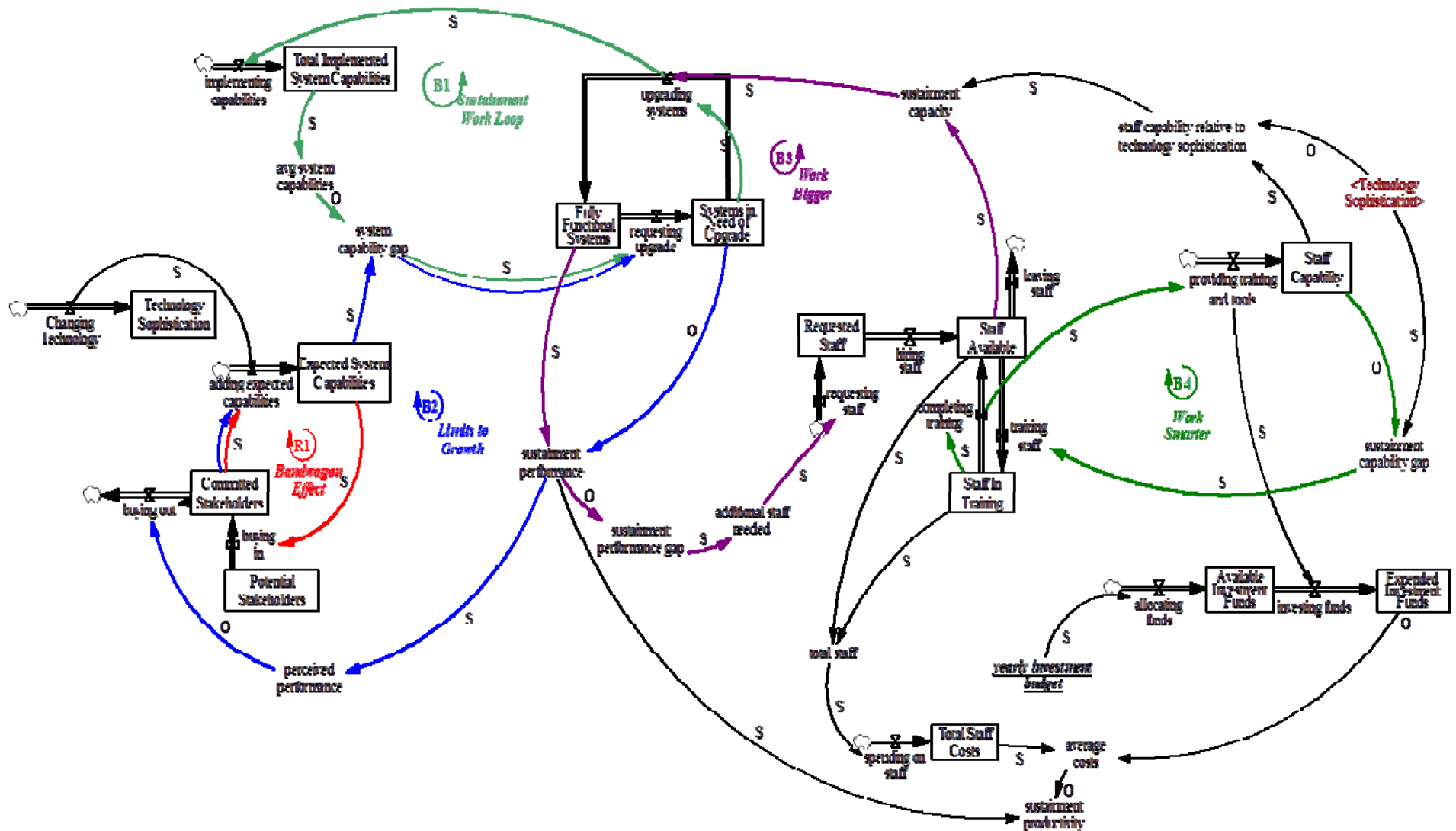


Sustainment = Growth and Underinvestment

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.

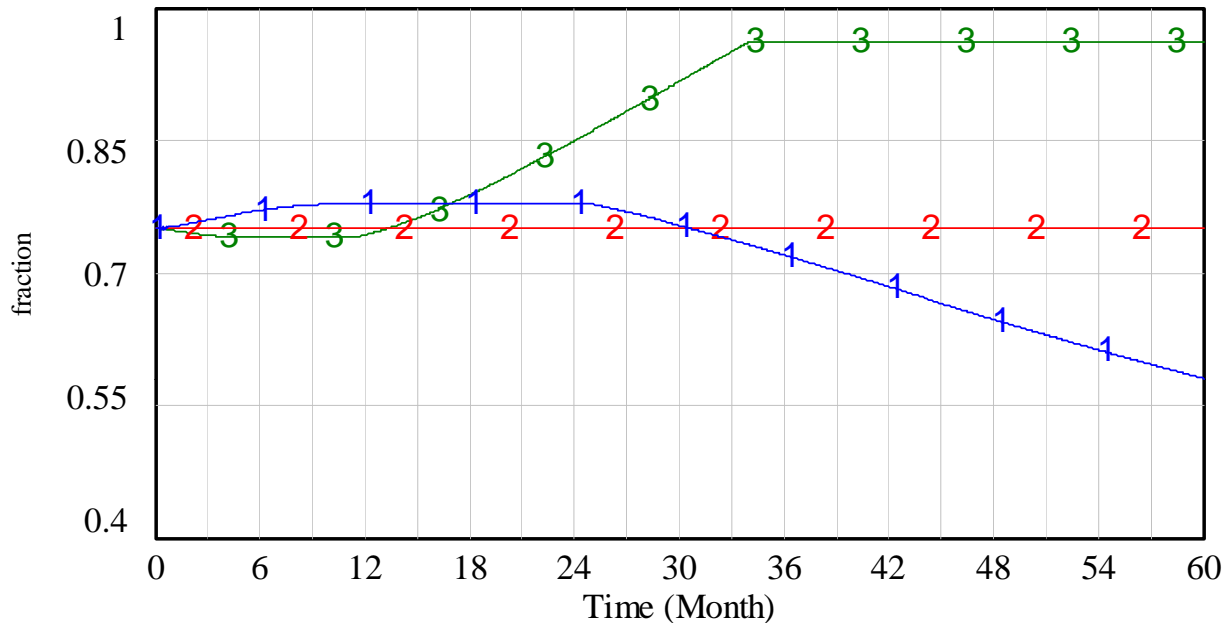
Suggested Sustainment Scenarios

- 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

Avg Sustainment Performance



Avg Sustainment Performance : low training - steady staff — 1 — 1 — 1 — 1 — 1 —
 Avg Sustainment Performance : med training - steady staff — 2 — 2 — 2 — 2 — 2 —
 Avg Sustainment Performance : high training - steady staff — 3 — 3 — 3 — 3 — 3 —

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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This material is based upon work funded and supported by the Department of Defense under Contract No. FA8721-05-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

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