

Modeling System Dynamics

Sarah Sheard

With Andrew Moore and Robert Ferguson

March 21-22, 2014



Copyright 2014 Carnegie Mellon University

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.

NO WARRANTY. THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN “AS-IS” BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

This material has been approved for public release and unlimited distribution.

This material may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at permission@sei.cmu.edu.

Carnegie Mellon[®] is registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

DM-0001106

- What is sustainment?
- Why model sustainment dynamics?
- Factors to model
- What is system dynamics modeling?
- Our model
- Conclusion

- Sustainment: Everything that happens to a system after the production line is closed down (product maintenance, infrastructure)
- Hardware: Repair, Remove corrosion, Replace worn parts
- Software
 - Corrective Maintenance (Bug fixes)
 - Adaptive (fix for changed environment, e.g., other systems, operating system...)
 - Perfective (New requirements)
 - Preventive (reliability/maintainability fixes)

All software sustainment is engineering work

Sustainment has

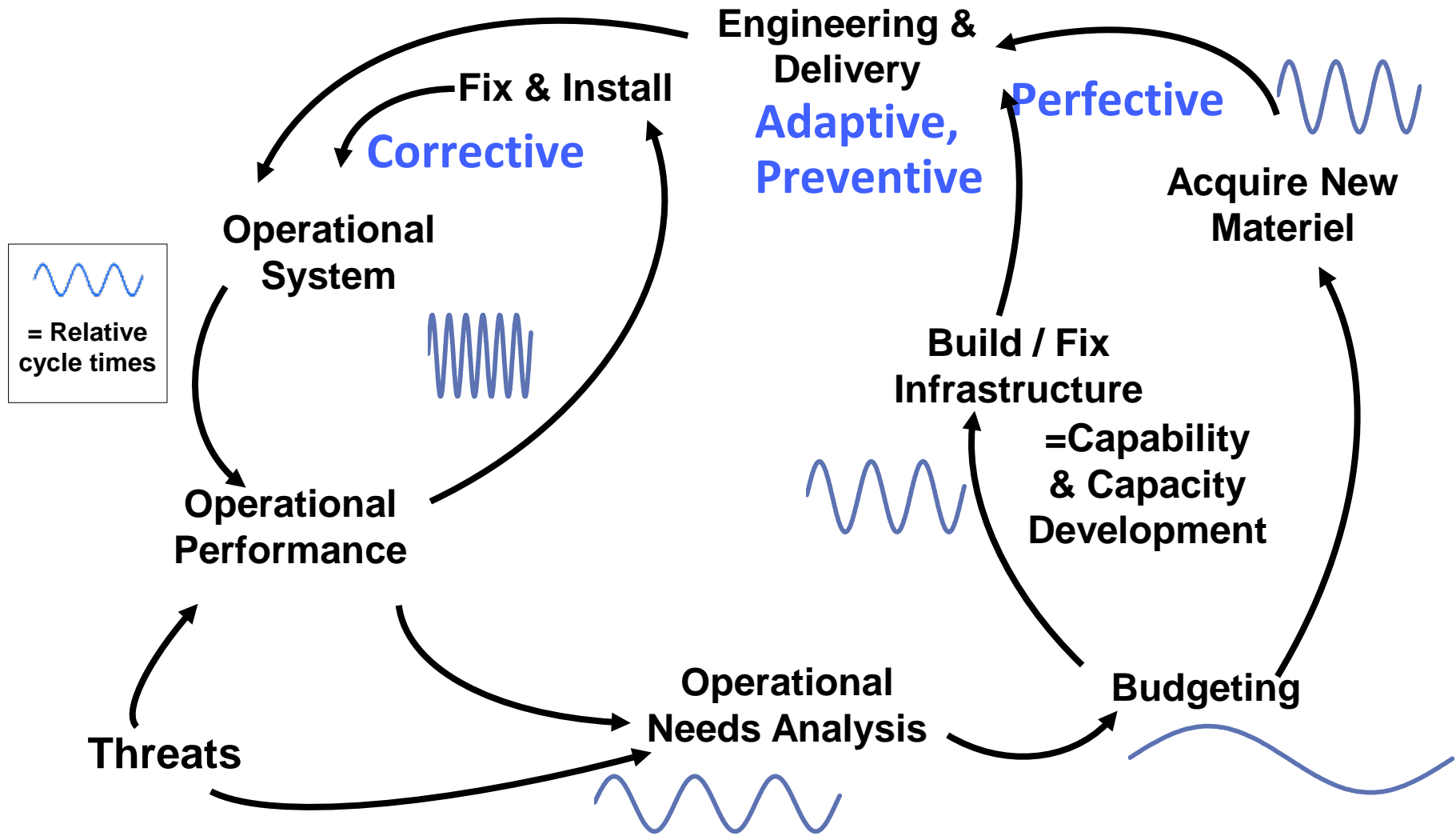
- Many loops
 - bug fixes, small enhancements, large enhancements
- Many stakeholders
 - operational forces, programs, sustainment organizations
- Many funding sources
 - O&M, program procurement, modernization procurement

Simple cost/benefit models fail to capture dynamic nature

- Varying time cycles for decisions
- Dramatic consequences: Funding delays can cause a “tipping point”: recovery very expensive

Dynamic model allows exploration of funding scenarios

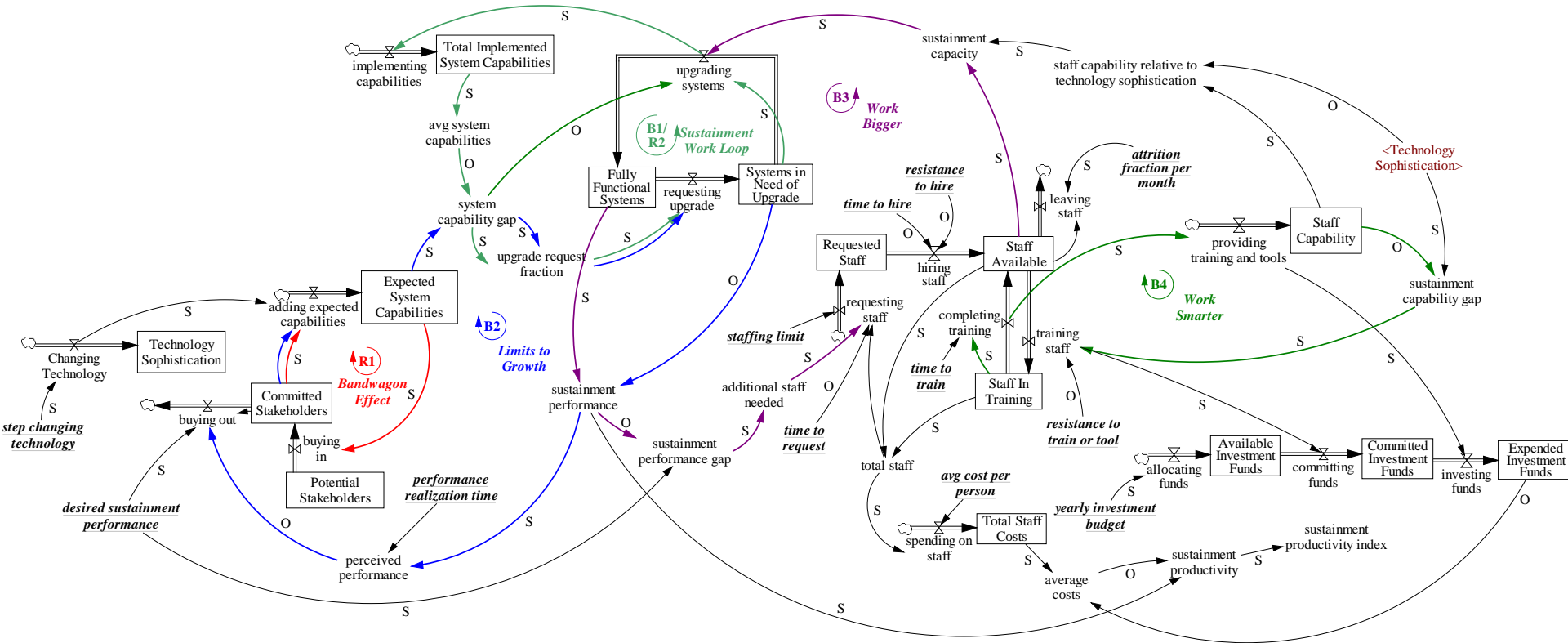
Sustainment Cycles



- ***Sustainment Capability***
 - skills and knowledge held by staff
- ***Sustainment Capacity***
 - amount of sustainment work the staff can do
 - = # staff * capability
- ***Performance***
 - amount of work the staff does, compared to needed
- ***Productivity***
 - amount of work done per unit cost
- ***Desired output***
 - sustained systems, number of system capabilities added

- Create causal loop diagram
 - Stocks (quantities with an amount)
 - Flows (change the amount in stocks)
 - Relationships (and auxiliary variables)
- Simulate
 - Establish equilibrium
 - Pulse
 - Understand results
- Finalize
 - Calibrate
 - Publish
 - Productize

Sustainment Systems Dynamics Diagram



R1: Represents the need for additional missions and additional capability

B1/R2: Demand for sustaining work and development

B2: Sustainment performance vs. System performance and gaps

B3: Efforts to work overtime and do more with less

B4: Building additional capability and capacity to sustain

Not a loop but lower right: Effects of delayed funding decisions and commitment

- Determined sustainment variables
- Dynamic relationships
- Calibrating with customer now
- Can calibrate to your organization

Presenter:

Sarah Sheard

sheard@sei.cmu.edu

(412) 268-7612

Modeling Sustainment Dynamics

BACKUP CHARTS

Calibration and Validation

Comparing performance to goals

