Identifying Acquisition Patterns of Failure Using Systems Archetypes

Finding the Root Causes of Acquisition Problems

Bill Novak
Dr. Linda Levine
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Purpose of this Presentation

To show how Systems Thinking and the Systems Archetypes can help to avoid common counter-productive behaviors in software acquisition and development programs

Agenda

- Systems Thinking
- Feedback Loops and Causal Loop Diagrams
- Selected Systems Archetypes
  - Fixes that Fail
  - Shifting the Burden
  - Limits to Growth
- Selected Software Acquisition and Development Archetypes
  - Sacrificing Quality
  - Firefighting
  - The Bow Wave Effect
- Seeing the Bigger Picture and Breaking the Pattern
Why is Software-Intensive Acquisition Hard?

Complex interactions between PMO, contractors, sponsors, and users
Limited visibility into progress and status—hard to comprehend
Significant delays exist between applying changes and seeing results
Unpredictable and unmanageable progress and results
Uncontrolled escalation of situations despite best management efforts
Linear partitioning ("Divide and conquer") isn’t working well
Exponential growth of interactions as size grows linearly
Acquisition Programs are Dynamic Systems

**Complex Interactions**: Interactions between acquisition stakeholders are non-linear

**Non-linear Behavior**: Non-linear behavior defies traditional mathematical analysis because of the presence of feedback

**Non-deterministic**: Complex systems are not deterministic

**Sensitivity to Initial Conditions**: Results may vary greatly due to seemingly insignificant differences in the starting point(s)

**Organizational**: Key issues in software acquisition are management and organizational—not technical

**Partitioning**: Not possible with complex interactions between components
What is Systems Thinking?

Systems Thinking developed from work done by Jay W. Forrester at MIT while modelling electrical feedback effects

- Also exists in economic, political, business, and organizational behaviors

Uses feedback loops to analyze common system structures that either spin out of control, or regulate themselves

Helps identify a system’s underlying structure, and what actions will produce which results (and when)

Systems Thinking teaches us that:

- System behavior is greater than the sum of component behaviors
- “Quick fix” solutions usually have side-effects that make things worse
- Improvement comes only from changing the underlying system structure
Causal Loop Diagrams (CLDs)

Depict qualitative “influencing” relationships (increasing or decreasing) and time delays between key variables that describe the system.

Show relationship direction by labelling them Same (+) or Opposite (-) to indicate how one variable behaves based on the previous variable.

Consist primarily of two types of feedback loops:

- **Reinforcing** – Changes to variables reinforce, moving in one direction.
- **Balancing** – Changes to variables alternate, achieving equilibrium.
Time Delays

Much instability and unpredictability of systems is due to time delays. Time delays obscure the connections in cause-and-effect relationships:

- Side-by-side causes and effects would be “smoking gun” evidence.

People are inherently poor at controlling systems with substantial time delays between cause and effect.

Examples:

- Over-steering a large ship that is slow to respond, so it weaves back and forth.
- A thermostat controlling a low-BTU air conditioner that’s slow to cool, so the house temperature bounces between too hot and too cold.
- Inability to determine which surface, handshake, sneeze, or cough resulted in an infection.
What are the Systems Archetypes?

The Systems Archetypes depict the underlying structures of a set of dynamic behaviors that occur in organizations throughout the world

- Each causal loop diagram tells a familiar, recurring story
- Each describes the system structure that causes the dynamic

Archetypes are used to:

- Identify failure patterns as they develop (recognition)
- Single out root causes (diagnosis)
- Engage in “big picture” thinking (avoid oversimplification)
- Promote shared understanding of problems (build consensus)
- Find interventions to break out of ongoing dynamics (recovery)
- Avoid future counter-productive behaviors (prevention)
Systems Archetypes

Over 10 recurring “systems archetypes” have been identified, including:

**Fixes that Fail**
- A quick fix for a problem has immediate positive results, but its unforeseen long-term consequences worsen the problem.

**Shifting the Burden**
- An expedient solution temporarily solves a problem, but its repeated use makes it harder to use the fundamental solution.

**Limits to Growth**
- Initially rapid growth slows because of an inherent capacity limit in the system that worsens with growth.
“Fixes That Fail” – Systems Archetype

A quick Fix for a Problem Symptom has immediate positive results, but also has long-term Unintended Consequences that, after a delay, worsen the original Problem Symptom as the Fix is used more often.

Based on “Fixes That Fail”
A Symptomatic Solution temporarily solves a Problem Symptom, which later recurs. Its repeated use over the longer term has Side-Effects that make it less and less feasible to use the more effective Fundamental Solution—trapping the organization into using only the Symptomatic Solution. Impatience with the delay makes the organization choose the Symptomatic Solution in the first place.
“Limits to Growth” – Systems Archetype

Initially rapid growth slows because of an inherent capacity limit in the system that worsens with growth. As greater Efforts produce better Performance, there is a greater Limiting Action due to a Constraint in the environment, slowing Performance.

Based on “Shifting the Burden”
Acquisition Archetypes

There are many recurring patterns of behavior in software acquisition and development that have been modelled using Systems Archetypes and CLDs:

- Sacrificing Quality
- Firefighting
- The “Bow Wave” Effect
- Underbidding the Contract
- Shooting the Messenger
- Robbing Peter to Pay Paul
- Longer Begets Bigger

- The 90% Syndrome
- Requirements Scope Creep
- Feeding the Sacred Cow
- Brooks’ Law
- PMO vs. Contractor Hostility
- Staff Burnout and Turnover
- The Improvement Paradox
“Sacrificing Quality” – Acquisition Archetype

As schedule pressure increases...
...and the cycle repeats and worsens.
...which increases schedule pressure...
...quality suffers...
...which reduces errors.
...and errors increase...

Schedule Pressure
Quality
Errors
Rework
Available Resources

However, rework consumes resources...
...requiring more rework...
...quality suffers...
...and errors increase—requiring more re-work. However, re-work consumes resources, which increases schedule pressure, and the cycle repeats and worsens.

As schedule pressure increases, processes are shortcut, quality suffers, and errors increase—requiring more re-work. However, re-work consumes resources, which increases schedule pressure, and the cycle repeats and worsens.

based on “Fixes That Fail”
“Firefighting” – Acquisition Archetype

If a design problems in the current release are higher than the tolerance for them, more resources must be dedicated to fix them. This reduces problems, but now fewer resources can work on the next release. This undermines its early development activities which, after a delay, increases the number of design problems in the next release.
Risky tasks planned for an early spiral to reduce risk are postponed to a later spiral, making near-term performance look better. This increases risk in subsequent spirals by delaying required risky development for which there is now less available schedule to address potential issues, and less flexibility in the system to accommodate changes needed to integrate the new capability.

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**“Bow Wave Effect” – Acquisition Archetype**

**B1**

- Development of Simpler Functionality
- Schedule Pressure
- Other Design Decisions Made
- System Risk
- Ability to Integrate New Capability
- System Modifiability

**B2**

- Development of Complex Functionality
- Delay
- Based on “Shifting the Burden”
The Bigger Picture/Breaking the Pattern

By showing the underlying structure of a dynamic, Causal Loop Diagrams show where best to apply leverage to slow or stop it—for example:

- Change negative dynamics into positive ones by running them backwards
- Slow the acceleration of unwanted reinforcing loops—“When you’re in a hole, stop digging”
- Change the limiting value a balancing loop approaches or oscillates around to something more acceptable.

Each systems archetype has specific interventions for addressing it

Knowing about the most common counter-productive dynamics is the best way to prevent them
Acquisition Archetype Concept Briefs

SEI is producing a set of “Acquisition Archetype” concept briefs, analyzing recurring patterns in actual acquisition programs, and recommending interventions and preventative actions.
Next Steps and Further Information

Extend the set of Acquisition Archetypes

- Eleven Acquisition Archetypes have been described to date
- Plan to identify additional acquisition dynamics and root causes

For additional information

- Visit the SEI website:
  - [http://www.sei.cmu.edu/programs/acquisition-support/pof-intro.html](http://www.sei.cmu.edu/programs/acquisition-support/pof-intro.html)
- Upcoming SEI Technical Note: “Archetypal Patterns of Failure in the Acquisition and Development of Software-Intensive Systems”
- Planned 2008 Workshop: “Avoiding Failure in Software Acquisition”