

# **Agile Systems Engineering**

## **San Diego Mini Conference Keynote**

**December 1, 2018**

**UCSD Extension, 6256 Greenwich Dr, San Diego, CA**

# Agility Knowledge Development

**In the '90s we analyzed hundreds of real-world systems and processes that exhibited agility, asking how they did that, and converged on fundamental structural patterns that fit facts.**

**Recently we have analyzed real-world SE processes that exhibit agility, asking how they do that, and converging on fundamental behavior patterns that fit facts.**

**No conjecture, no kinda good idea, no opinion.**

# Agility Interest – Origin

- 1991** – US SecDef funded project at Lehigh University to identify next manufacturing competitive focus beyond Lean
  - 13 companies participated full-time in 3-month workshop
  - 2 vol report: 21<sup>st</sup> Century Manufacturing Enterprise Strategy
  - Problem/opportunity defined (for manufacturing enterprises)
- 1992** – Agile Manufacturing Enterprise Forum founded at Lehigh, funded by Texas Instruments and General Motors
  - Purpose: Identify nature of Agile solution
  - Method: Industry collaborative workshop groups
- 1994** – DARPA/NSF establish \$5 Million x 5 year funding
  - Name changed to Agility Forum (any kind of enterprise/system)
  - Research steering group and agenda established
  - 250+ orgs, 1000+ participants in focused workshop groups
  - Conferences, papers, reference base, tools, reference model
- 1998** – Mission accomplished, Agility Forum dissolved
  - Agility pursuit by industry and IT vendors entrenched

# Agile Systems Engineering Life Cycle Model (ASELCM)

**An INCOSE Project to...**

- Discover generic principles/patterns that are necessary for effective agile systems engineering of SW/FW/HW projects**
- Publish informative case studies**
- Build evidence-based generic agile-SE life cycle model to inform effective implementation**

**And ...**

- Provide material for next INCOSE Handbook revision**
- Influence published standards**

# **ASELCM Project Status**

**2015 Four On-Site Analytical Workshop**

**2016 Four Case Studies Written**

**2017 Key Findings Emerged**

- **Life Cycle Model Framework**
- **General operational pattern**
- **General operational principles**
- **General problem-space characterization**
- **General response requirements**
- **Concept of Information Debt**

**2018 Activity and Focus:**

- **Tutorials**
- **INSIGHT Theme Issue Q2**
- **INCOSE Webinar Sept 2018**
- **IS19 findings paper submitted**

**2019 Plan**

- **Produce an INCOSE product**

# Value Proposition for Agility

**Faster, lower cost system development?**

**An appealing argument, but only a side effect (at best).**

**The value proposition for agility is Risk Management.**

**Sustainability of project/process/product at risk.**

# Assertions

**Sustainable systems are living systems  
capable of  
responding effectively  
to their environment.**

**They are reactively resilient  
and  
proactively innovative.**

**They are complex adaptive systems of systems.**

**This is the essence of agility.**

# General Response Domains

for Response Situation Analysis

Response Domain		General Characteristic
<b>Proactive</b>	<b>Creation (and Elimination)</b>	<p><b>Proactive</b></p> <hr/> <p><b>Innovative/Composable</b>  <b>Creates Opportunity</b>  <b>Takes Preemptive Initiative</b></p>
	<b>Improvement</b>	
	<b>Migration</b>	
	<b>Modification (of Capability)</b>	
<b>Reactive</b>	<b>Correction</b>	<p><b>Reactive</b></p> <hr/> <p><b>Resilient</b>  <b>Seizes Opportunity</b>  <b>Copes with Adverse Events</b></p>
	<b>Variation</b>	
	<b>Expansion (of Capacity)</b>	
	<b>Reconfiguration</b>	

<b>Proactive Proficiency</b>	Innovative (Composable)	Agile
	Fragile	Resilient
	<b>Reactive Proficiency</b>	



# General Response Metrics

An *effective response* capability is:

- timely (**fast enough** to deliver value),
- affordable (can be repeated as often as necessary),
- predictable (can be counted on to meet the need),
- comprehensive (everything within mission boundary).

Not FAST!!!  
...just fast enough

**Agility is the ability to survive and thrive  
in an unpredictable and uncertain environment**

**Agility is Risk Management:  
decreasing vulnerability and risk by  
increasing response options and predictability**

# General Design Principles

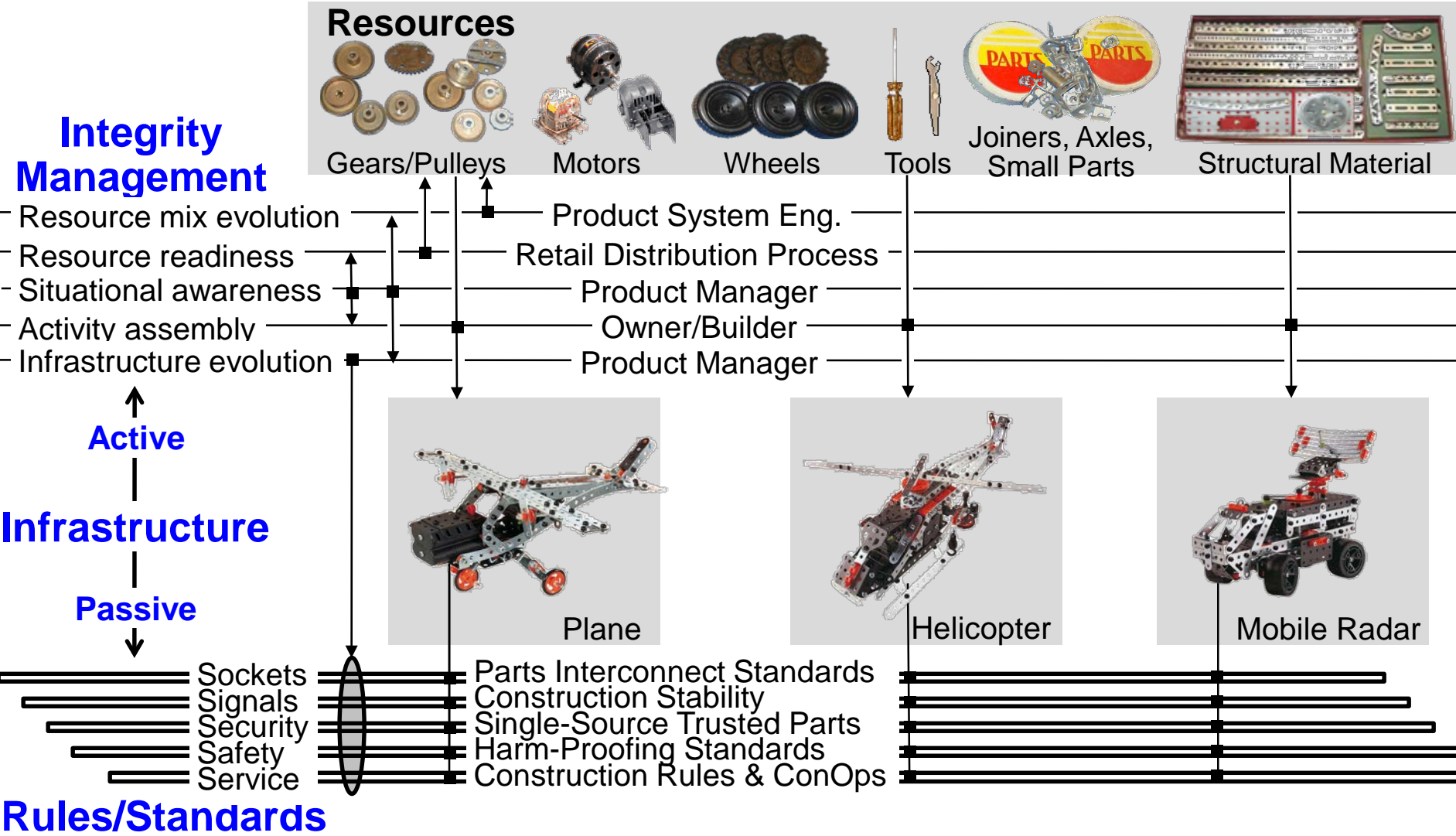
Reconfigurable, Reusable, Scalable (Think: Plug-and-Play, Drag-and-drop)

<p><b>Encapsulated Resources</b> Resources are encapsulated independent units loosely coupled through the passive infrastructure.</p>	<p>Reusable</p>	<p>Scalable</p>	<p><b>Evolving Infrastructure</b> ConOps and resource interface and interaction standards and rules that evolve slowly.</p>
<p><b>Facilitated Interfacing (Pluggable)</b> Resources &amp; infrastructure have features facilitating easy resource insertion/removal.</p>			<p><b>Redundancy and Diversity</b> Duplicate resources provide fail-soft &amp; capacity options; diversity provides functional options.</p>
<p><b>Facilitated Reuse</b> Resources are reusable and/or replicable; with supporting facilitation for finding and employing resources.</p>			<p><b>Elastic Capacity</b> Resource populations &amp; functional capacity may be increased &amp; decreased within existing infrastructure.</p>
<p><b>Reconfigurable</b></p>			
<p><b>Peer-Peer Interaction</b> Resources communicate directly on a peer-to-peer relationship; parallel rather than sequential relationships are favored.</p>	<p><b>Distributed Control &amp; Information</b> Decisions made at point of maximum knowledge; information accessible globally but maintained locally.</p>		
<p><b>Deferred Commitment</b> Resource relationships are transient when possible; decisions &amp; fixed bindings are postponed until necessary.</p>	<p><b>Self-Organization</b> Resource relationships are self-determined; and resource interaction is self-adjusting or negotiated.</p>		

# Agile Architecture Pattern (AAP)

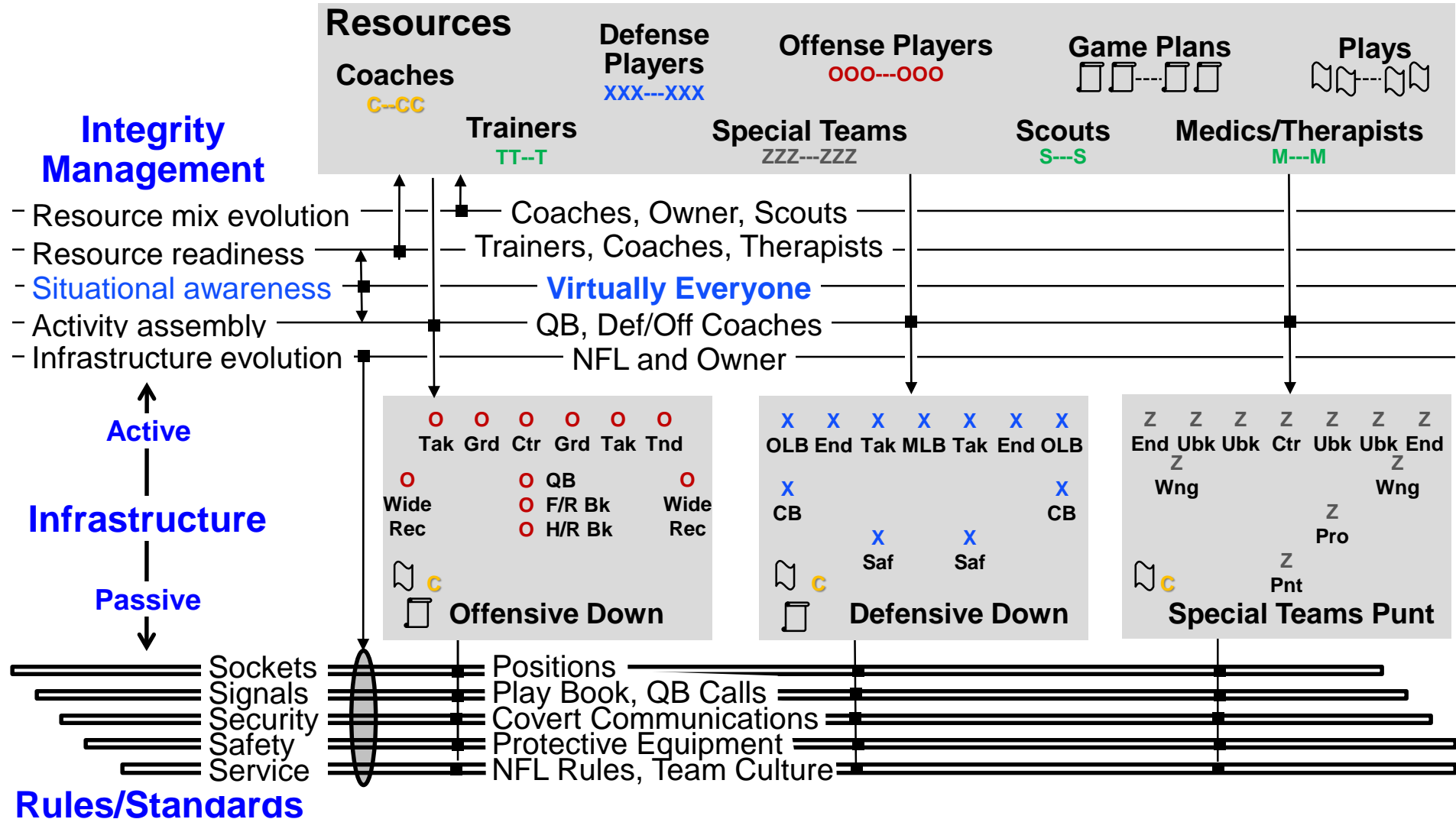
## Notional Concept: System Response-Construction Kit

Details in [www.parshift.com/s/140630IS14-AgileSystemsEngineering-Part1&2.pdf](http://www.parshift.com/s/140630IS14-AgileSystemsEngineering-Part1&2.pdf)



# Agile Architecture Pattern for USA Football

Drag-and-drop resources in a plug-and-play infrastructure



(a concept example, not exhaustive)

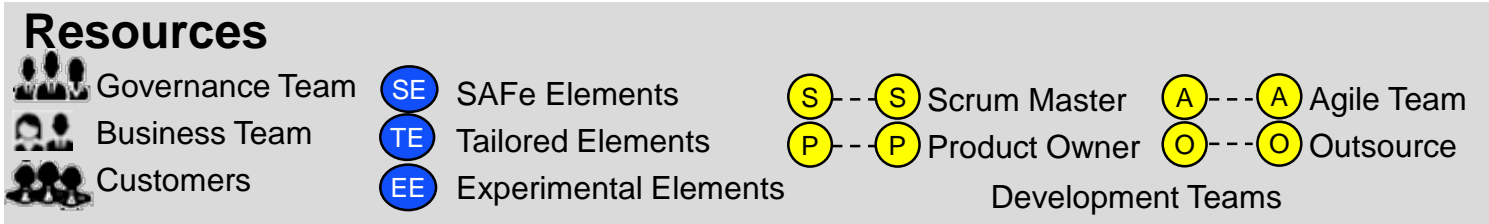
# Sustaining Agility Requires ...

- Proactive awareness of situations needing responses
- Effective options appropriate for responses
- Assembly of timely responses

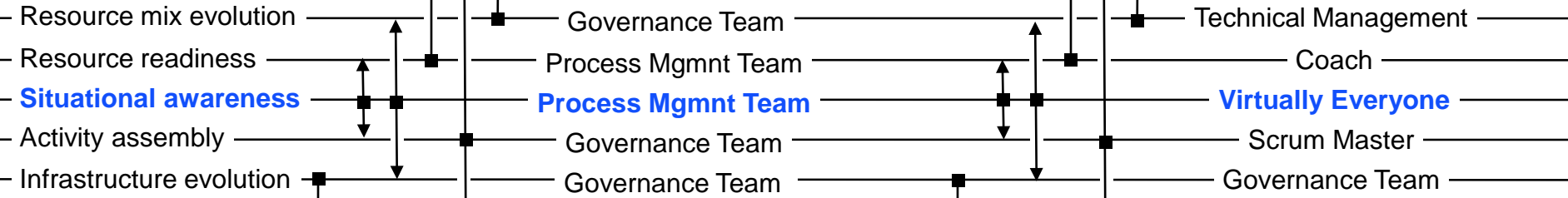
## Five Agility-Sustaining Responsibilities:

1. Resource Mix Evolution
2. Resource Readiness
3. **Situational Awareness**
4. Response Assembly
5. Infrastructure Evolution

# Lockheed Martin IFG, Tailored SAFe-Like Process



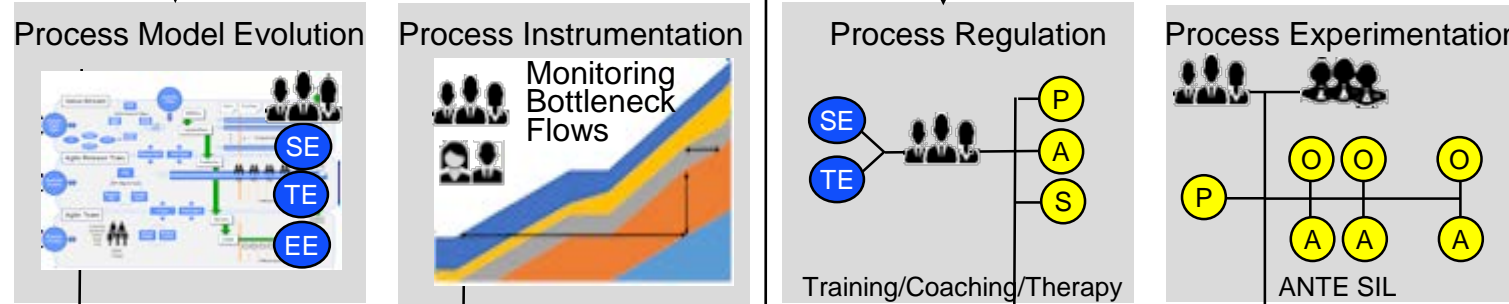
## Integrity Management



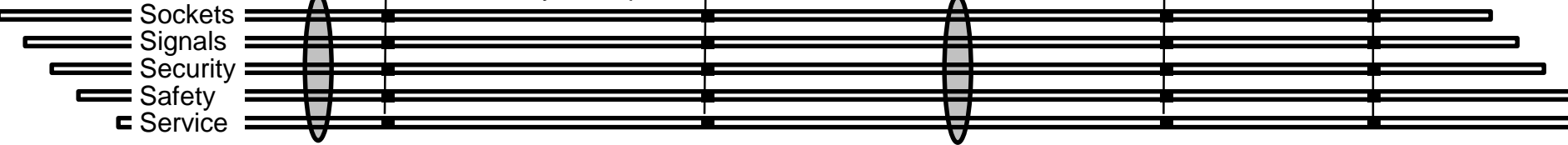
## Active Facilitating

## Infrastructure

## Passive Enabling



4 activity examples



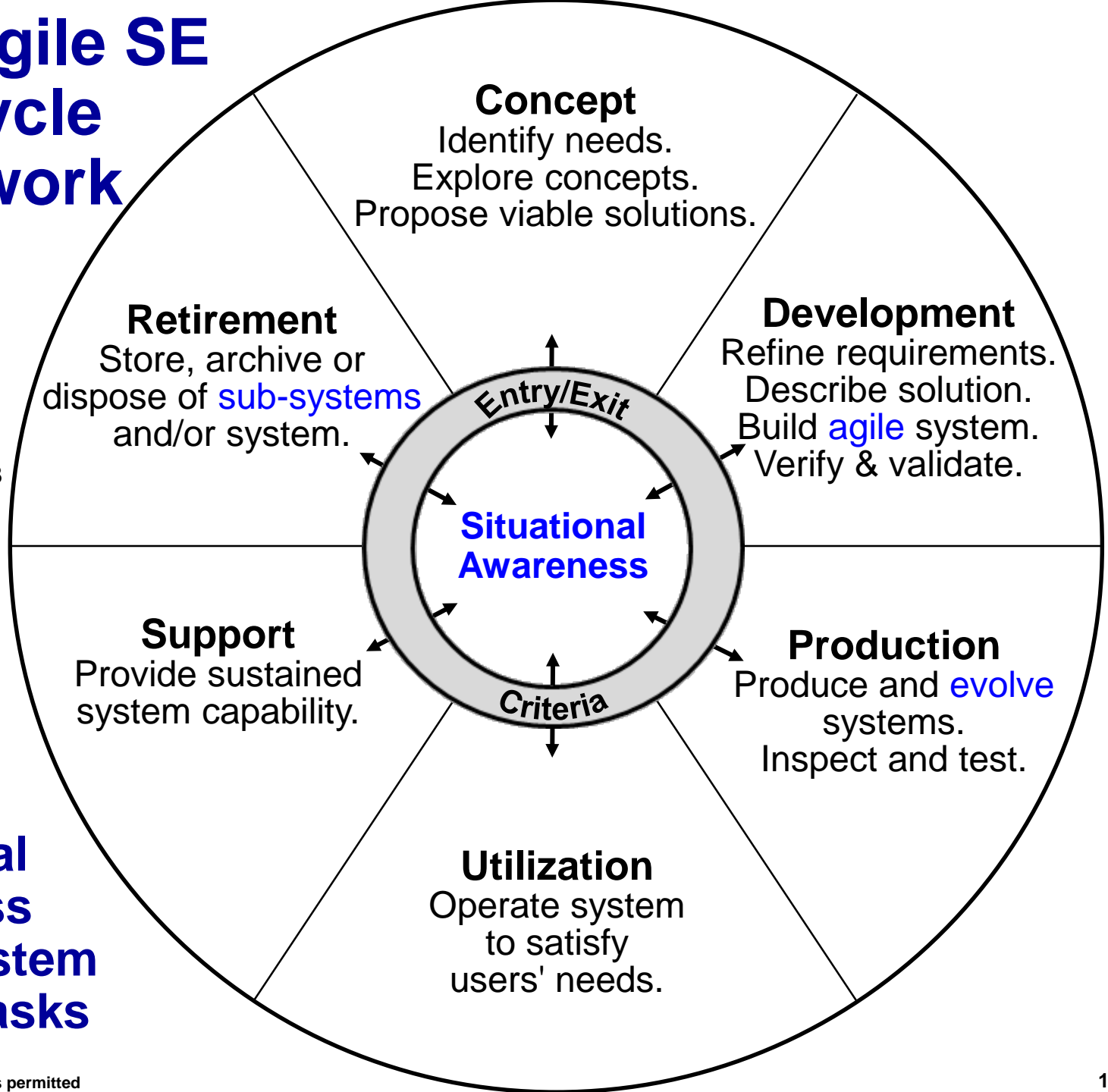
## Rules/Standards

Details in IS18 paper at: [www.parshift.com/s/ASELCM-04LMC.pdf](http://www.parshift.com/s/ASELCM-04LMC.pdf)

- Sockets: Roles, Teams, Meeting formats, ANTE/Simulation frameworks
- Signals: Flow, Info debt, Process conformance, Experiment results, Contract performance
- Security: Executive commitment, Governance, Cultural consistency
- Safety: Information radiators, No-penalty measurement, Flow monitoring/mitigation, Real-time status information, 2-3 PI look-ahead
- Service (ConOps): Operational model, Cadence, Customer/User involvement, Experimental learning, Systems 1-2-3 AAPs

# General Agile SE Life Cycle Framework

ISO/IEC/IEEE 24748-1:2018



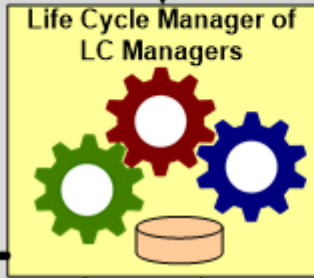
**Situational  
Awareness  
Engages System  
Evolution Tasks**

# General Operational Pattern

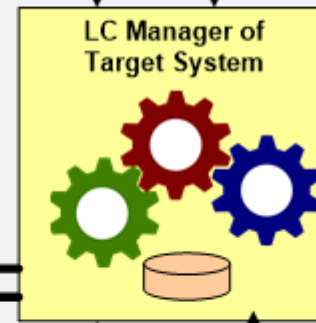
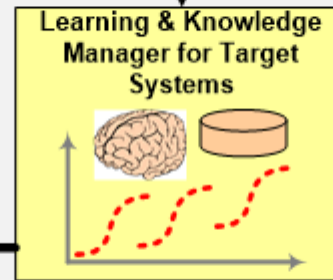
## Systems 1, 2, 3 Logical/Behavioral Boundaries

Pattern credit: Bill Schindel

### 3. Innovation System



### 2. Life Cycle Domain System



### 1. Target System



Target Environment

The practice of agility

The enablement of agility



# General Operational Principles

## **Sensing** (observing, orienting)

- **External awareness**
- **Internal awareness**
- **Sense making**

## **Responding** (deciding, acting)

- **Decision making (timely, informed)**
- **Action making**
- **Action evaluation**

## **Evolving**

- **Experimentation**
- **Evaluation**
- **Memory**

# General Problem-Space Characterization

## CURVE

Internal and external environmental forces

**Caprice:** Unknowable situations.

Unanticipated system-environment change.

**Uncertainty:** Randomness with unknowable probabilities.

Kinetic and potential forces present in the system

**Risk:** Randomness with knowable probabilities.

Relevance of current system-dynamics understanding.

**Variation:** Knowable variables and associated variance ranges.

Temporal excursions on existing behavior attractor.

**Evolution:** Gradual successive developments.

Experimentation and natural selection at work.

# General Response Requirements

Domain		Response Requirements	
Proactive	Creation	<ul style="list-style-type: none"> <li>• Opportunity &amp; risk awareness</li> <li>• Response actions/options</li> </ul>	<ul style="list-style-type: none"> <li>• Acculturated memory</li> <li>• Decisions to act</li> </ul>
	Improvement	<ul style="list-style-type: none"> <li>• Awareness/Sensing</li> <li>• Memory in culture, options, ConOps</li> </ul>	<ul style="list-style-type: none"> <li>• Action/option effectiveness</li> </ul>
	Migration	<ul style="list-style-type: none"> <li>• New fundamentally-different types of opportunities and risks</li> </ul>	
	Modification (Capability)	<ul style="list-style-type: none"> <li>• Actions appropriate for needs</li> <li>• Personnel appropriate for actions</li> </ul>	
Reactive	Correction	<ul style="list-style-type: none"> <li>• Insufficient awareness</li> <li>• Ineffective actions/options</li> </ul>	<ul style="list-style-type: none"> <li>• Wrong decisions</li> </ul>
	Variation	<ul style="list-style-type: none"> <li>• Effectiveness of actions/options</li> <li>• Effectiveness of evaluation</li> </ul>	
	Expansion (Capacity)	<ul style="list-style-type: none"> <li>• Capacity to handle 1-? actions simultaneously</li> </ul>	
	Reconfiguration	<ul style="list-style-type: none"> <li>• Elements of an action</li> <li>• Response managers/engineers</li> </ul>	

# Concept of Information Debt

The difference between the information currently available and the information needed to deliver and support the life cycle.

Early stage systems engineering reduces information debt without equivalent surge in systems engineering expense.



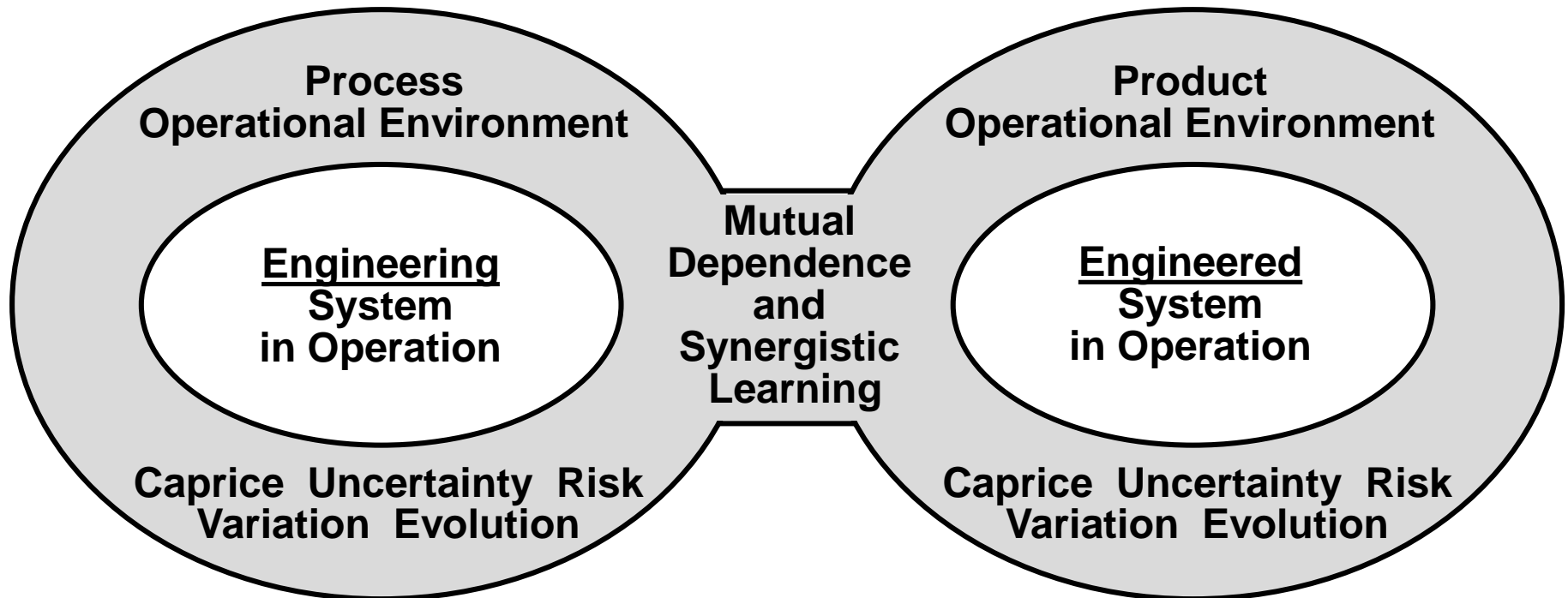
Scenario 3 illustrates the worrisome case



Early SE information reduces information debt

# You can't have an agile engineering process if it doesn't engineer an agile product, and vice versa

(a first principle)



# Agile Systems-Engineering

**Definition is rooted in what it does, not how it does it.**

**What it does**

**is respond effectively in a life cycle environment that is capricious, uncertain, risky, variable, and evolving.**

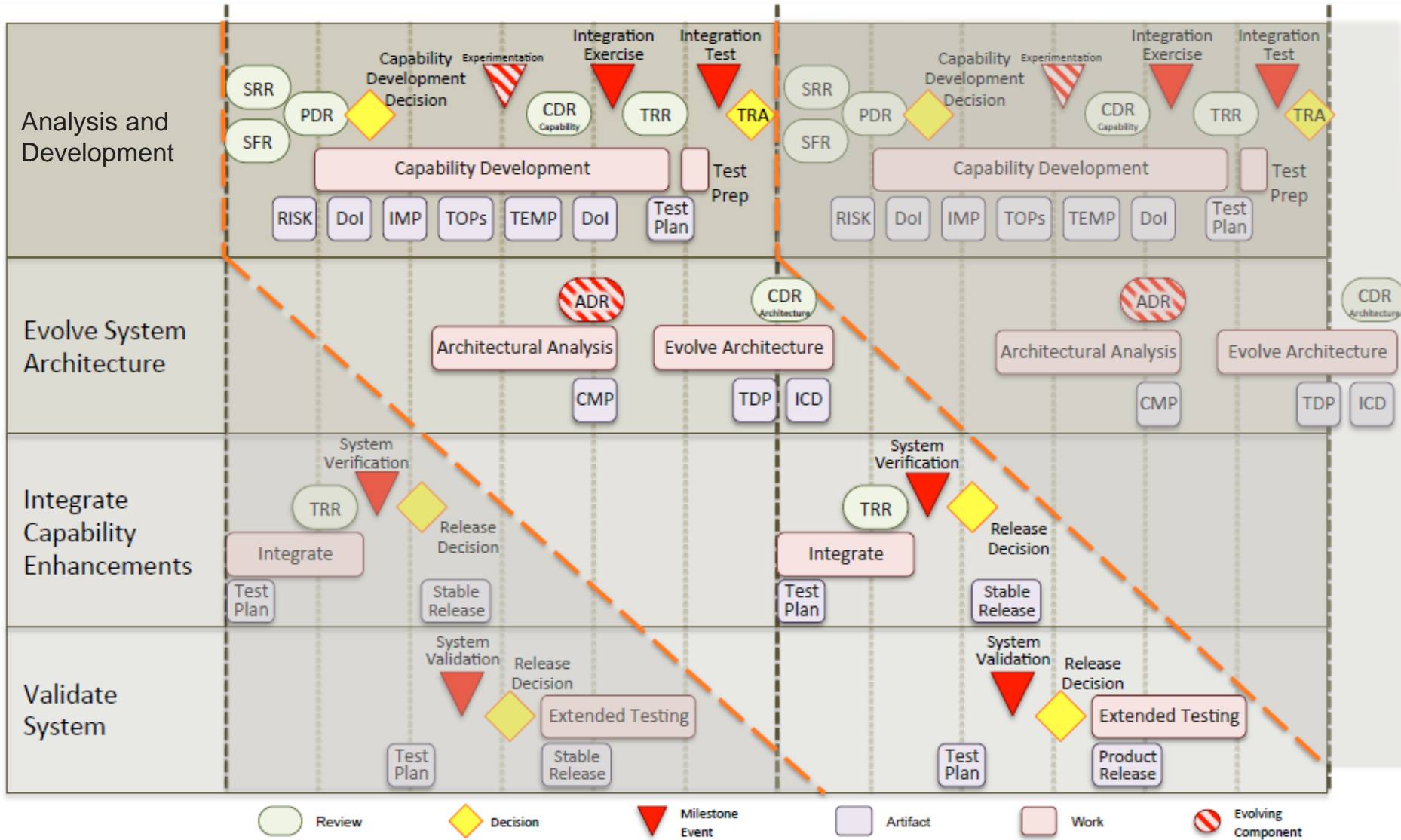
**How it does that**

**is a product of analyzing response requirements dictated by the nature of a specific life cycle environment.**

# Spawar SCPac Tech Innovation SE Process

([www.parshift.com/s/ASELCM-01SSCPac.pdf](http://www.parshift.com/s/ASELCM-01SSCPac.pdf))

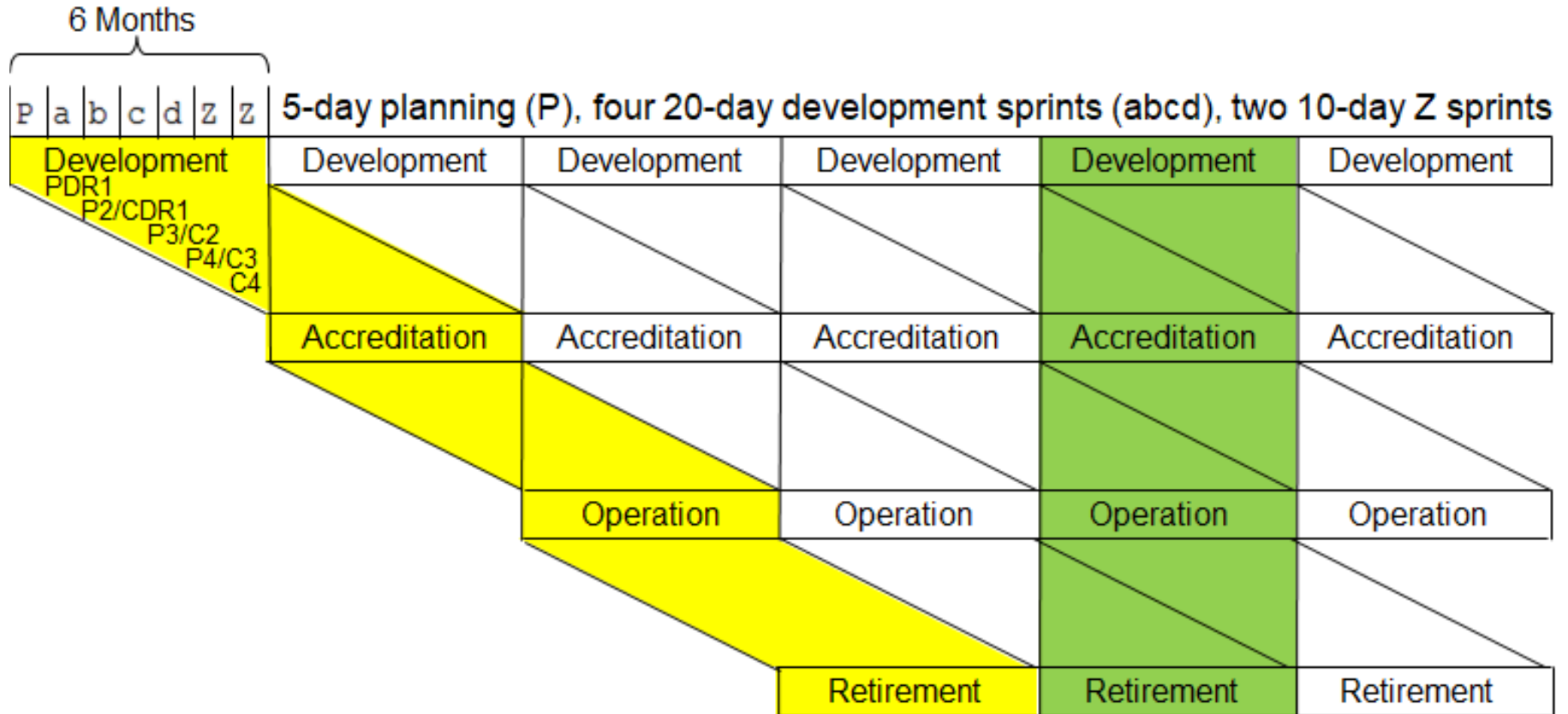
## Process Macro View: Decoupled Wave-Like Waterfall



# NGC SoS Web Portal Evolution SE Process

([www.parshift.com/s/ASELCM-03NGC.pdf](http://www.parshift.com/s/ASELCM-03NGC.pdf))

## Process Macro View: Decoupled Wave-Like Waterfall



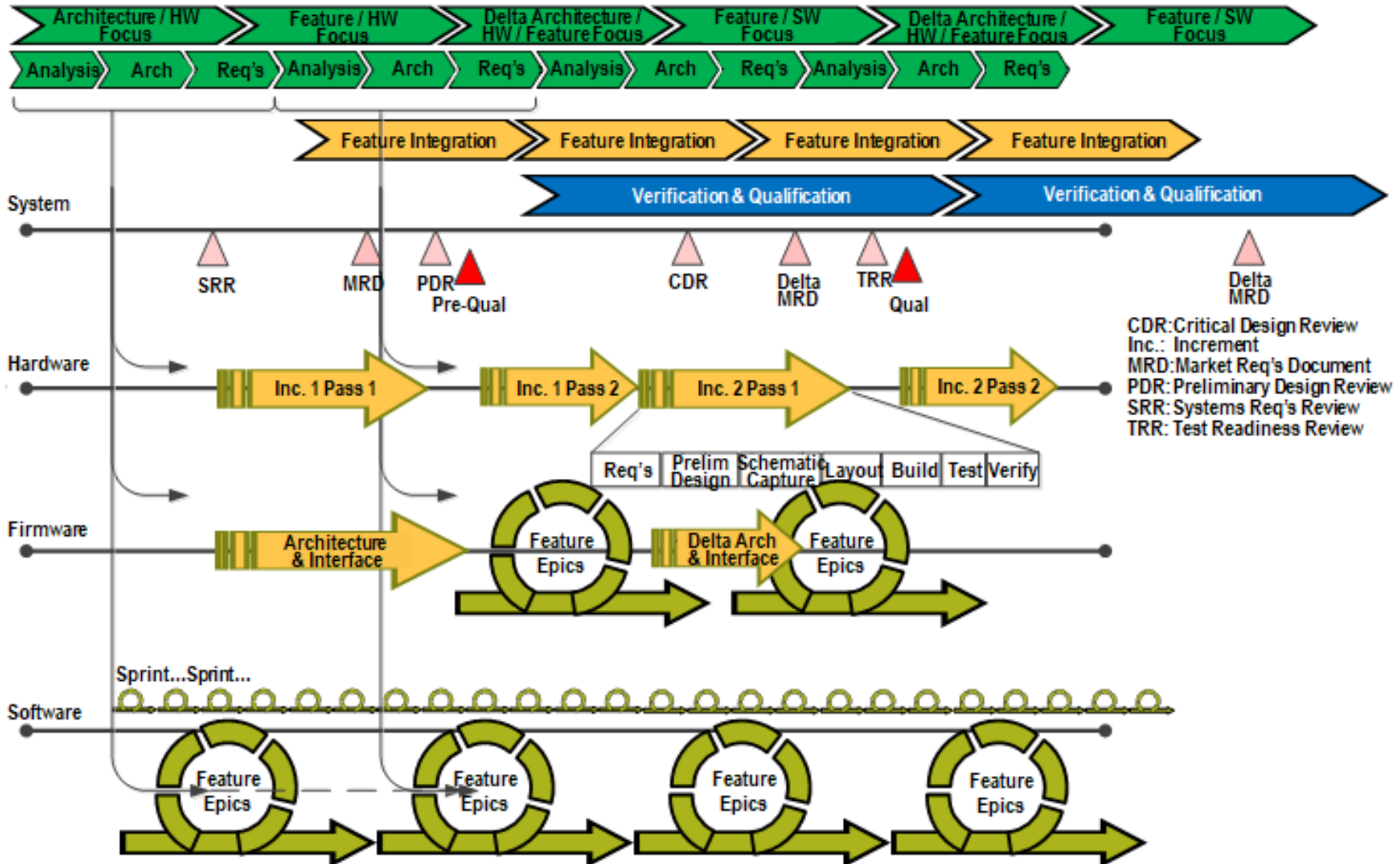
Z sprint: after Dev sprints for fixing defects found during sprint testing.



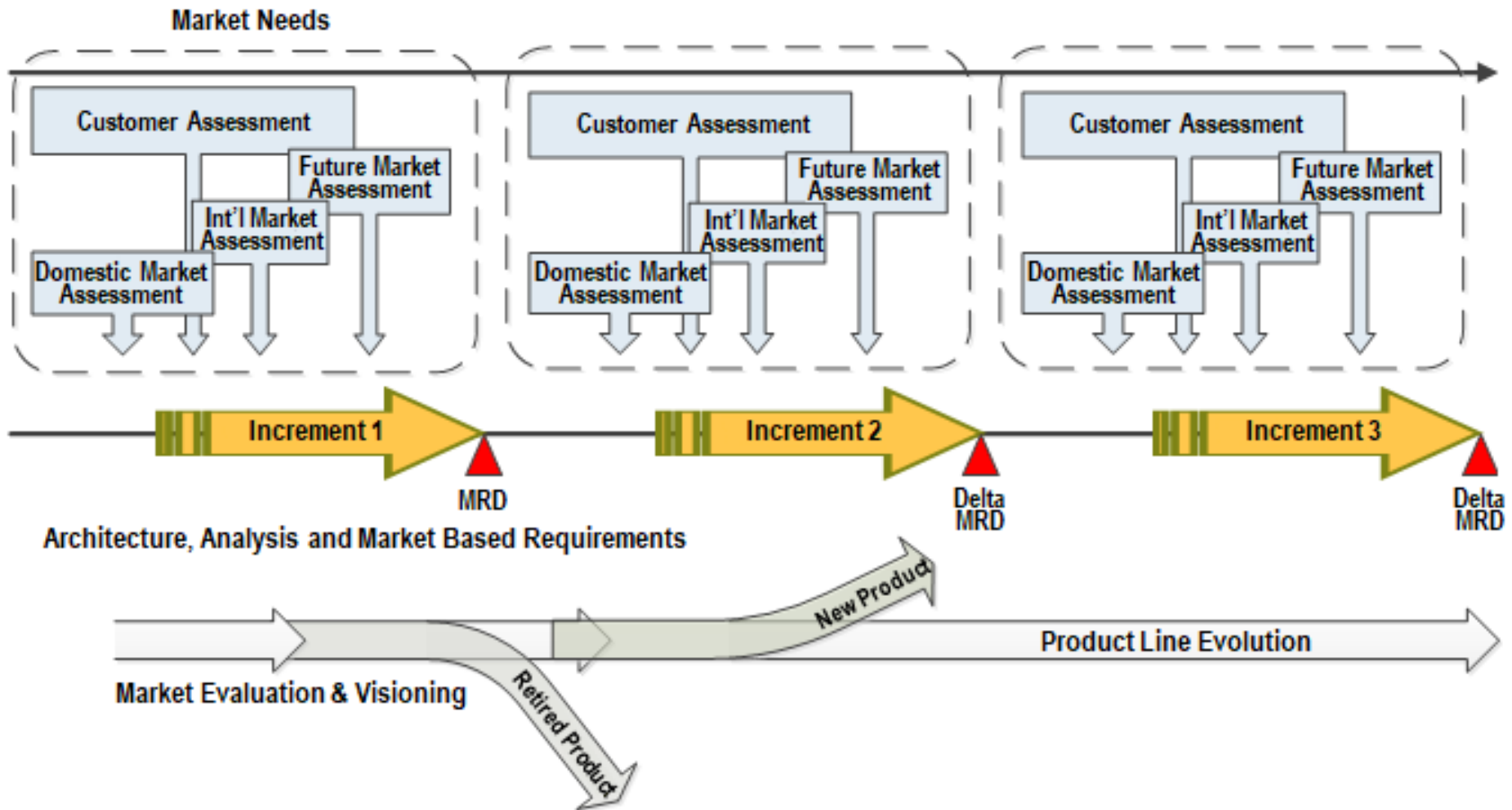
# Rockwell Collins Radio Product-Line SE Process

([www.parshift.com/s/ASELCM-02RC.pdf](http://www.parshift.com/s/ASELCM-02RC.pdf))

## Process Macro View: Asynchronously Aligned Discipline Increments

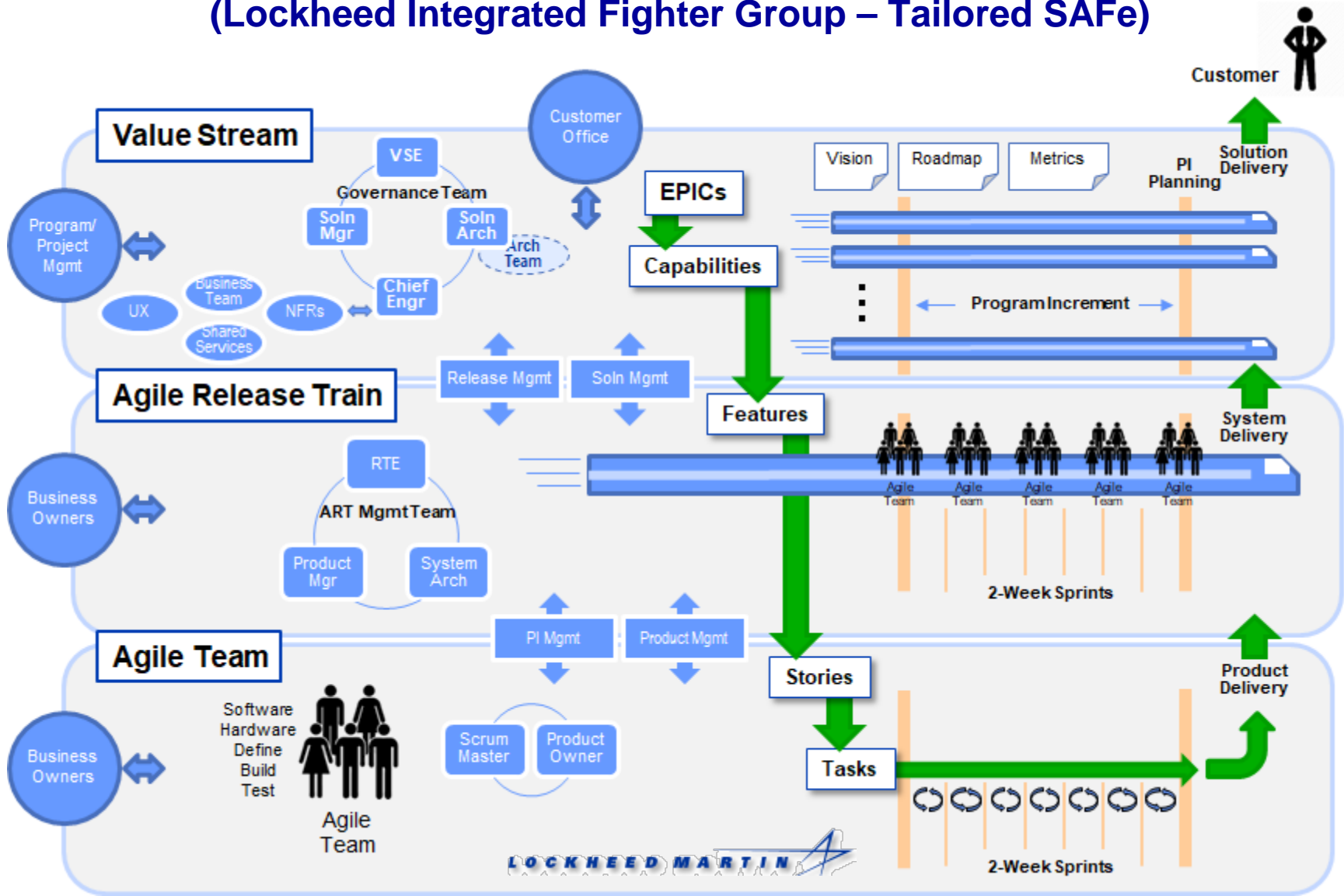


# Product Line Evolution View: Incremental Awareness Attention



# IFG-TS Process Operational Model

(Lockheed Integrated Fighter Group – Tailored SAFe)



# IFG-TS CURVE Example

Selected examples as presented by them

## Caprice

- Urgent pre-emptive customer needs
- Project scope change

## Uncertainty

- Effectiveness of process
- Team-member engagement with agile approach

## Risk

- Cultural incompatibility
- Ability to keep and attract talent

## Variation

- Multiple-project resource conflicts (e.g. test facilities)
- Requirements of differing importance levels

## Evolution

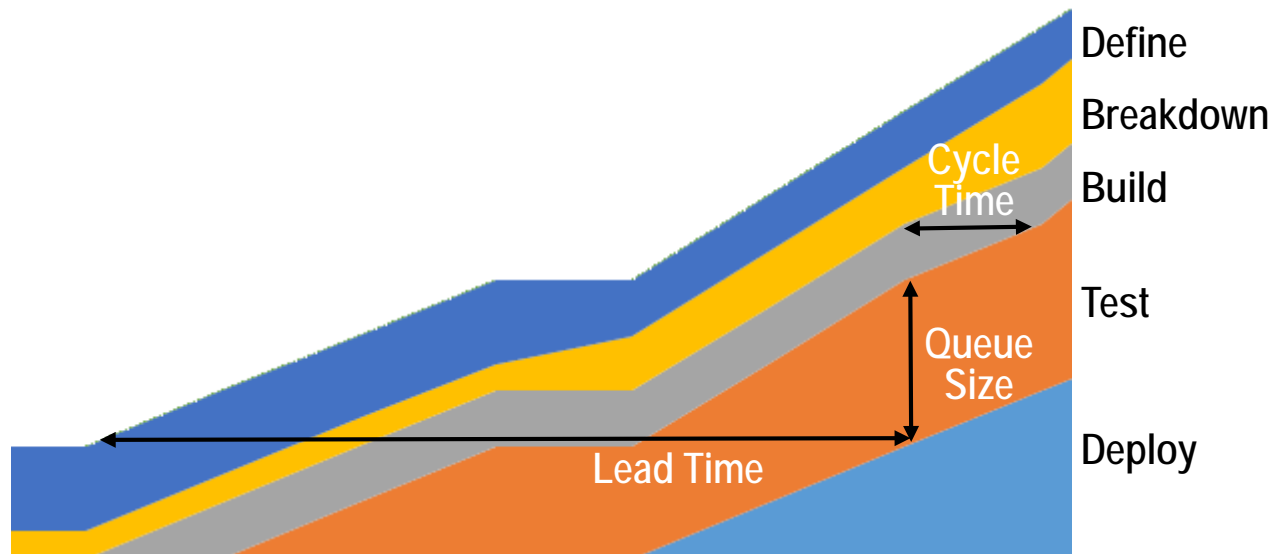
- Open System Architecture (OSA)
- Customer mission needs

# One Active Awareness Example at IFG

Process instrumentation for work flow.

Queue size predicts test-facility cycle time.

Frequent bottleneck mitigated by managing queue size.



# Another Active Awareness Example at IFG

**Preliminary system integration lab (SIL).**

**Conceptually a Live, Virtual, Constructive (LVC) environment.**

**From project start, an integrated evolving system of:**

- **software wip,**
- **simulated devices,**
- **low-fidelity COTS devices,**
- **high fidelity final devices,**
- **operators.**

**Customer feedback values:**

- **early & incremental demonstration of working concepts**
- **advanced exposure to difficulties in need of attention.**

# Emergent Operational Principles

**All ASELCM case studies enable and facilitate (with different methods):**

- **Project situational sensing and response.**
- **Team-members' engagement sensing and response.**
- **Development-issue sensing and response.**
- **Integration-issue sensing and response.**
- **Assimilated shared-culture and evolution.**
- **Process and procedure evolution.**
- **Product evolution.**

**Three Categories of Fundamental Principles Emerge:**

- **Sense/Monitor – awareness is the driver of agility**
- **Respond/Mitigate – action is the expression of agility**
- **Evolve – applied learning is the sustainer of agility**

# Agility Operational Principles

## **Sensing** (observe, orient)

- **External awareness (proactive alertness)**
- **Internal awareness (proactive alertness)**
- **Sense making (risk & opportunity analysis, trade space analysis)**

## **Responding** (decide, act)

- **Decision making (timely, informed)**
- **Action making (invoke/configure process activity for the situation)**
- **Action evaluation (validation & verification)**

## **Evolving** (improve above with more knowledge and better capability)

- **Experimentation (variations on process ConOps)**
- **Evaluation (internal and external judgement)**
- **Memory (evolving cultural, response capabilities, and process-ConOps)**



# Relevant References and Additional Info

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