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: 21st 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.

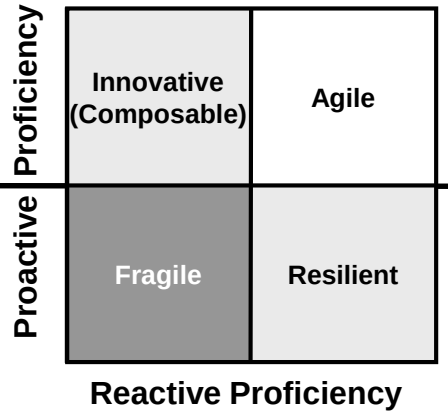
They are complex adaptive systems of systems.

This is the essence of agility.

General Response Domains

for Response Situation Analysis

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



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)

Encapsulated Resources Resources are encapsulated independent units loosely coupled through the passive infrastructure.	Reusable	Scalable	**Evolving Infrastructure** ConOps and resource interface and interaction standards and rules that evolve slowly.
Facilitated Interfacing (Pluggable) Resources & infrastructure have features facilitating easy resource insertion/removal.			**Redundancy and Diversity** Duplicate resources provide fail-soft & capacity options; diversity provides functional options.
Facilitated Reuse Resources are reusable and/or replicable; with supporting facilitation for finding and employing resources.			**Elastic Capacity** Resource populations & functional capacity may be increased & decreased within existing infrastructure.

Reconfigurable	
Peer-Peer Interaction Resources communicate directly on a peer-to-peer relationship; parallel rather than sequential relationships are favored.	**Distributed Control & Information** Decisions made at point of maximum knowledge; information accessible globally but maintained locally.
Deferred Commitment Resource relationships are transient when possible; decisions & fixed bindings are postponed until necessary**.**	**Self-Organization** Resource relationships are self-determined; and resource interaction is self-adjusting or negotiated.

Agile Architecture Pattern (AAP)
Notional Concept: System Response-Construction Kit

Details in www.parshift.com/s/140630IS14-AgileSystemsEngineering-Part1&2.pdf

Integrity Management

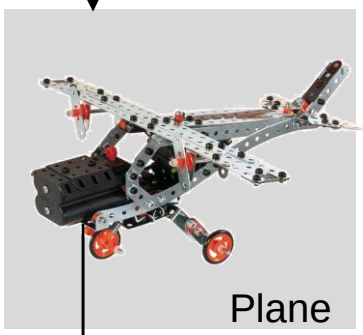
- Resource mix evolution
- Resource readiness
- Situational awareness
- Activity assembly
- Infrastructure evolution

Product System Eng.
Retail Distribution Process
Product Manager
Owner/Builder
Product Manager

Active

Infrastructure

Passive



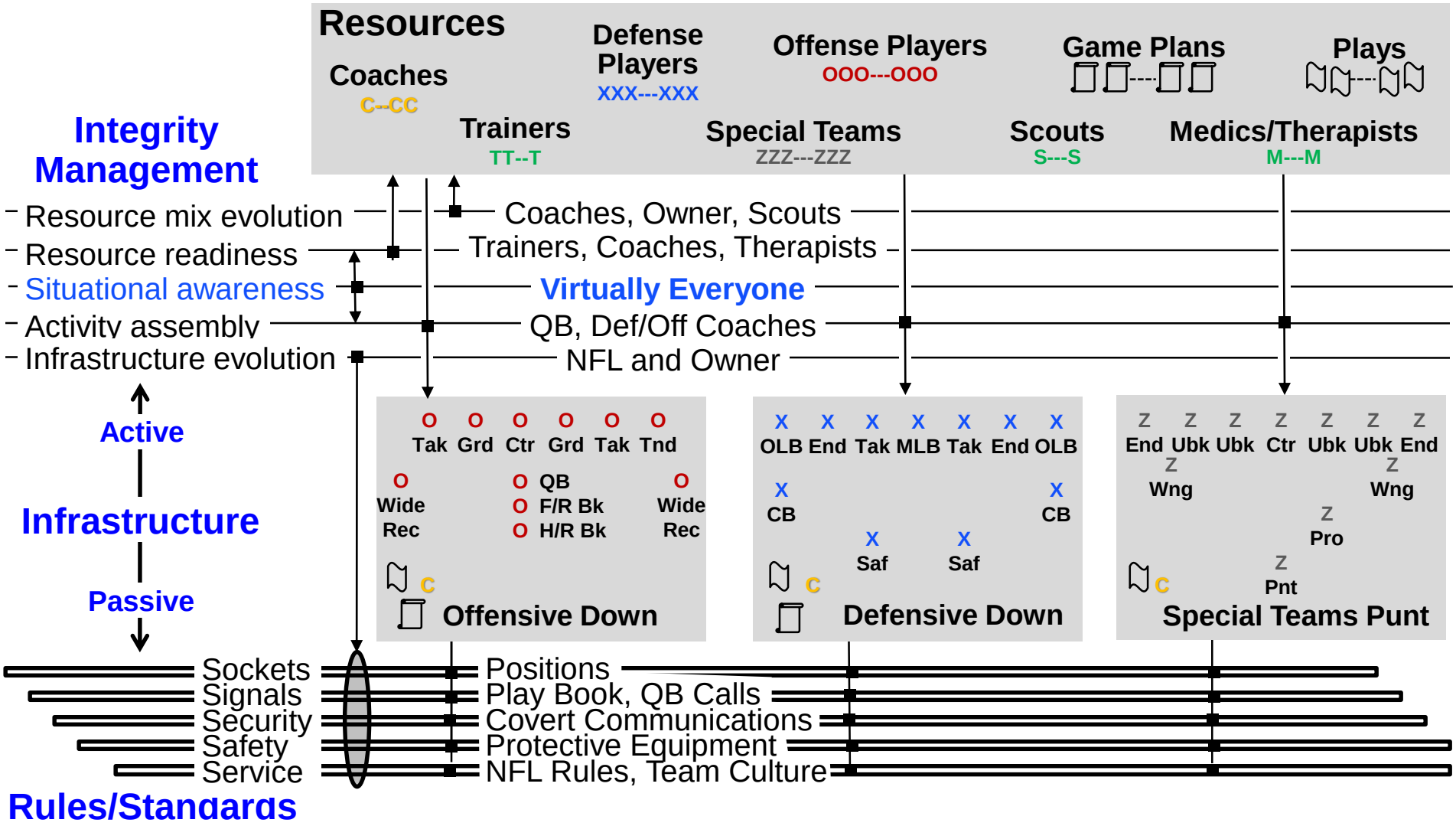
- Sockets
- Signals
- Security
- Safety
- Service

Parts Interconnect Standards
Construction Stability
Single-Source Trusted Parts
Harm-Proofing Standards
Construction Rules & ConOps

Rules/Standards

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

Resources

Governance Team
Business Team
Customers

SE SAFe Elements
TE Tailored Elements
EE Experimental Elements

S - - S Scrum Master
P - - P Product Owner
A - - A Agile Team
O - - O Outsource

Development Teams

Integrity Management

- Resource mix evolution
- Resource readiness
- **Situational awareness**
- Activity assembly
- Infrastructure evolution

Governance Team
Process Mgmnt Team
Process Mgmnt Team
Governance Team
Governance Team

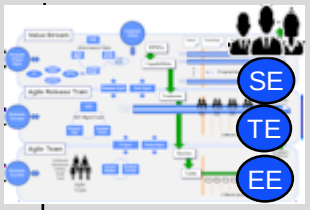
Technical Management
Coach
Virtually Everyone
Scrum Master
Governance Team

Active Facilitating

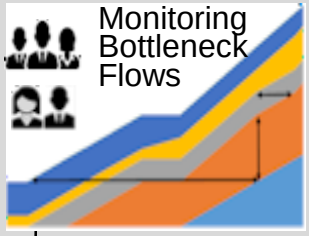
Infrastructure

Passive Enabling

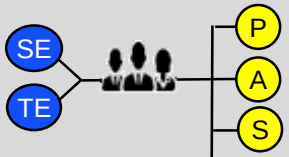
Process Model Evolution



Process Instrumentation

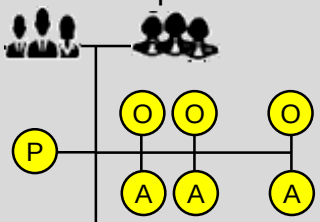


Process Regulation



Training/Coaching/Therapy

Process Experimentation



ANTE SIL

4 activity examples

Sockets
Signals
Security
Safety
Service

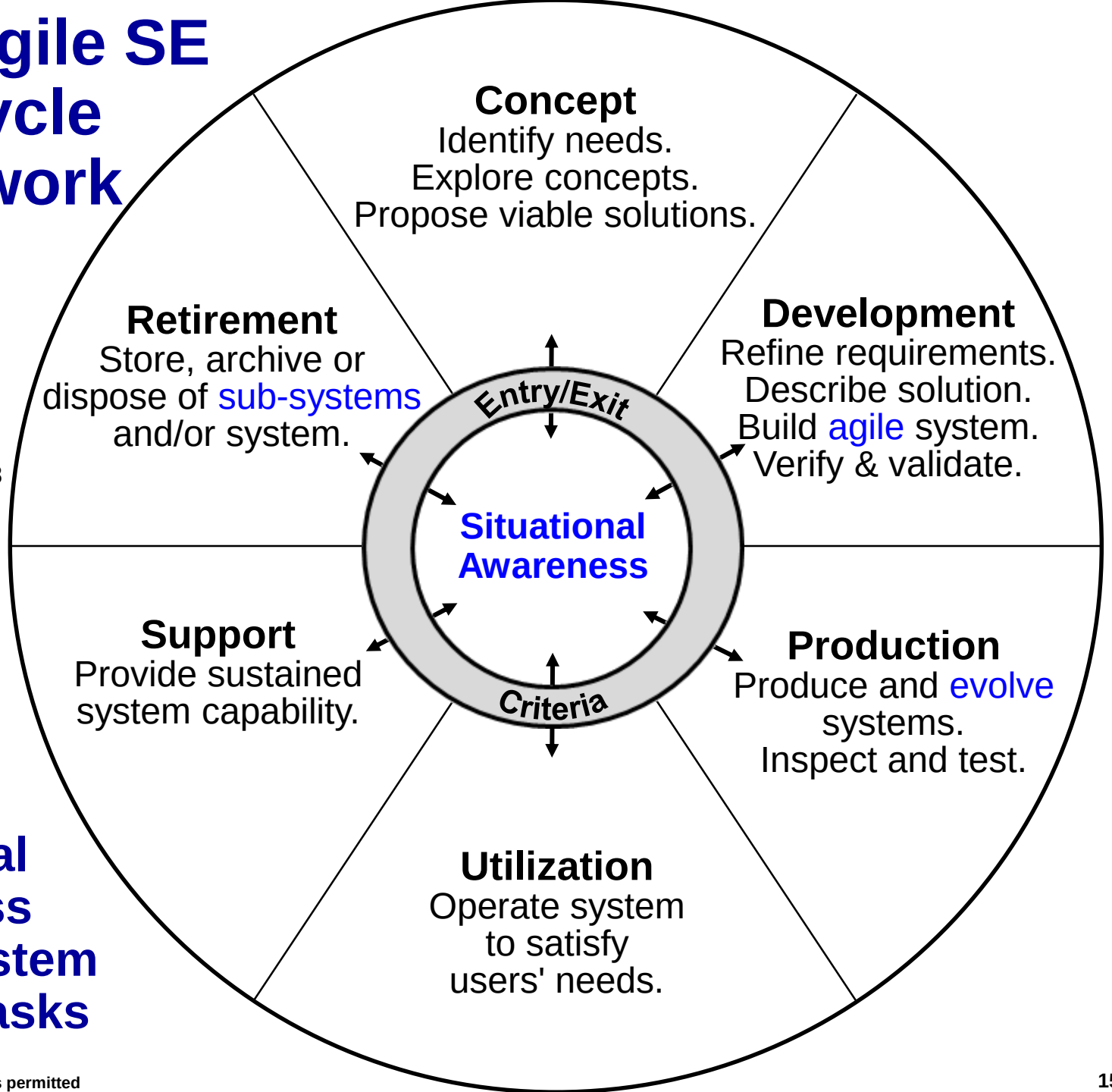
Rules/Standards

Details in IS18 paper at: 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

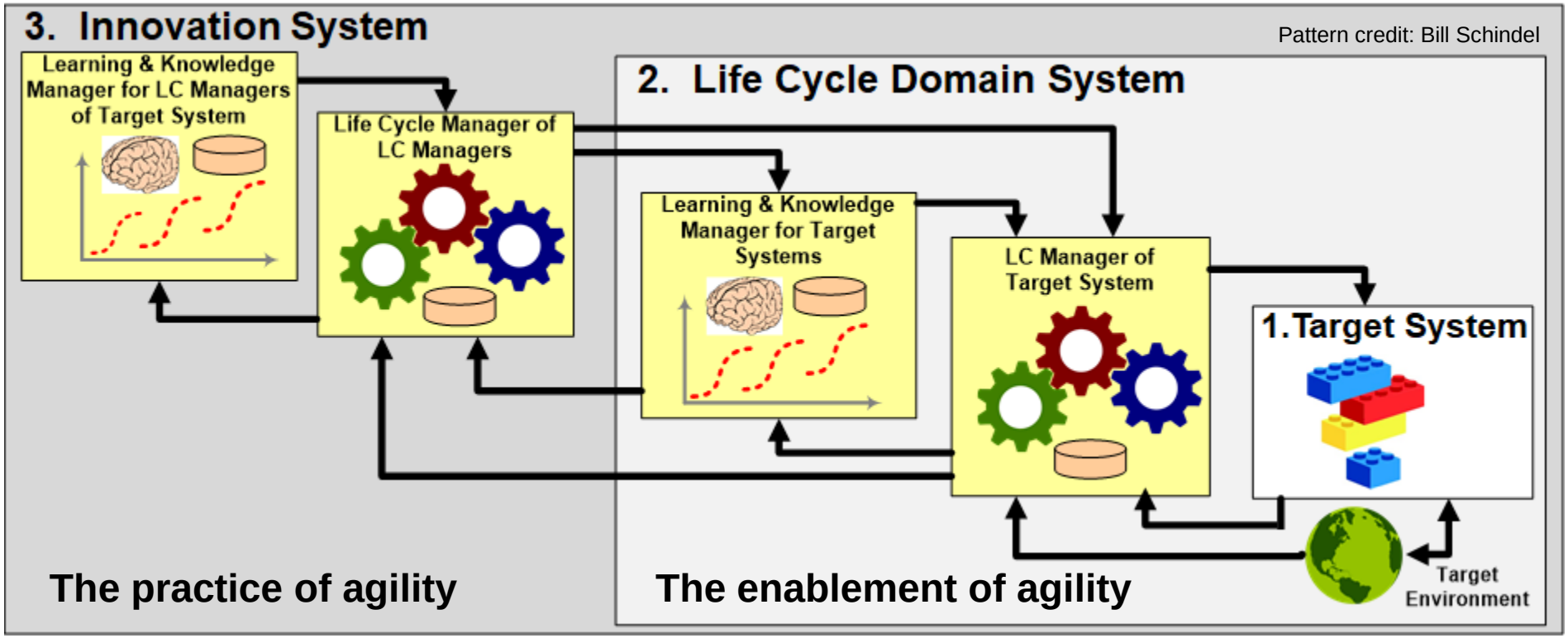
General Agile SE Life Cycle Framework

ISO/IEC/IEEE 24748-1:2018



Situational Awareness Engages System Evolution Tasks

General Operational Pattern
Systems 1, 2, 3 Logical/Behavioral Boundaries



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.

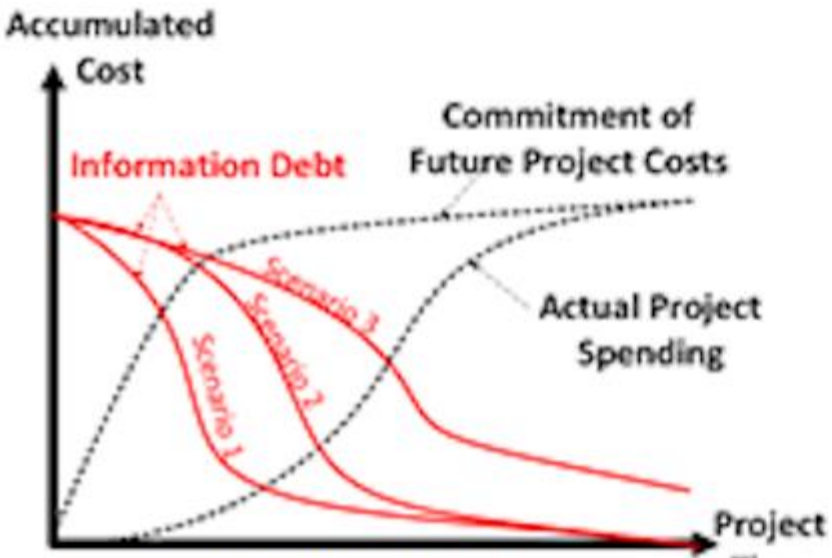
General Response Requirements

Domain		Response Requirements
Proactive	Creation	• Opportunity & risk awareness • Response actions/options • Acculturated memory • Decisions to act
	Improvement	• Awareness/Sensing • Memory in culture, options, ConOps • Action/option effectiveness
	Migration	• New fundamentally-different types of opportunities and risks
	Modification (Capability)	• Actions appropriate for needs • Personnel appropriate for actions
Reactive	Correction	• Insufficient awareness • Ineffective actions/options • Wrong decisions
	Variation	• Effectiveness of actions/options • Effectiveness of evaluation
	Expansion (Capacity)	• Capacity to handle 1-? actions simultaneously
	Reconfigu-ration	• Elements of an action • Response managers/engineers

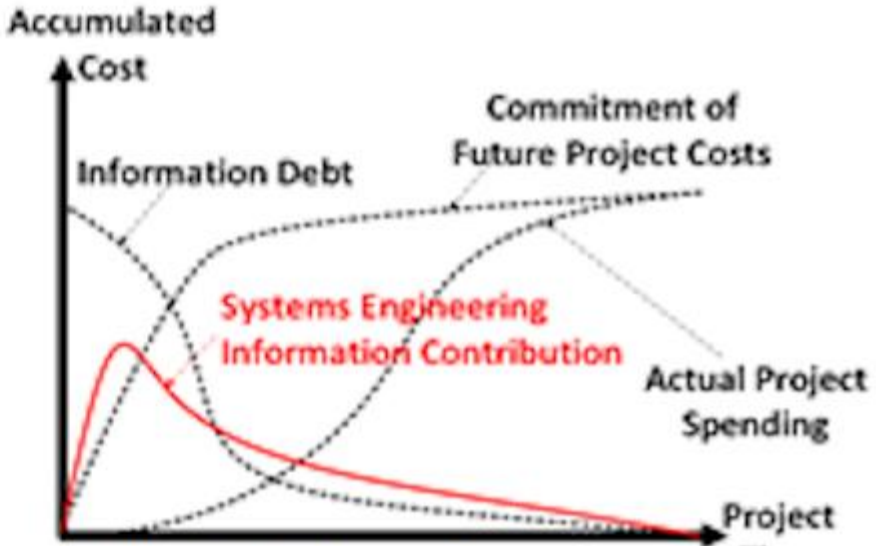
Concept of Information Debt

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

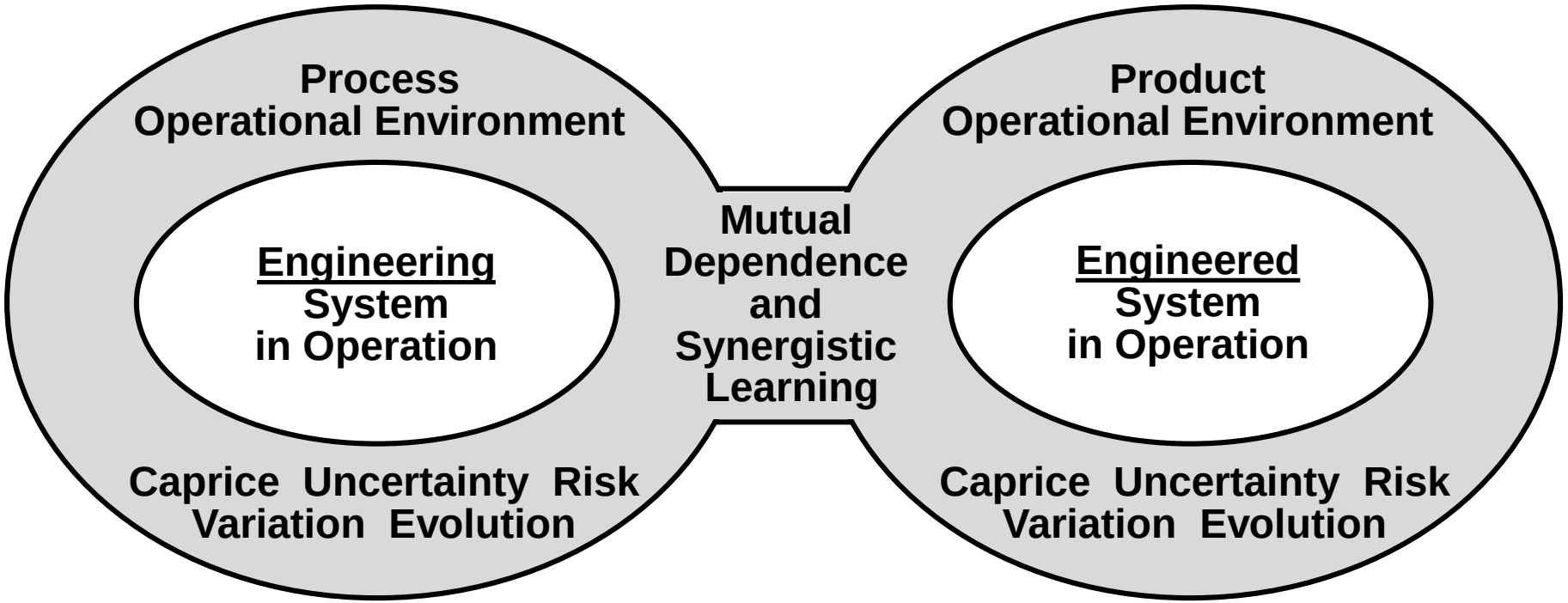


Early SE information reduces information debt

Art Credit: Bill Schindel

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.

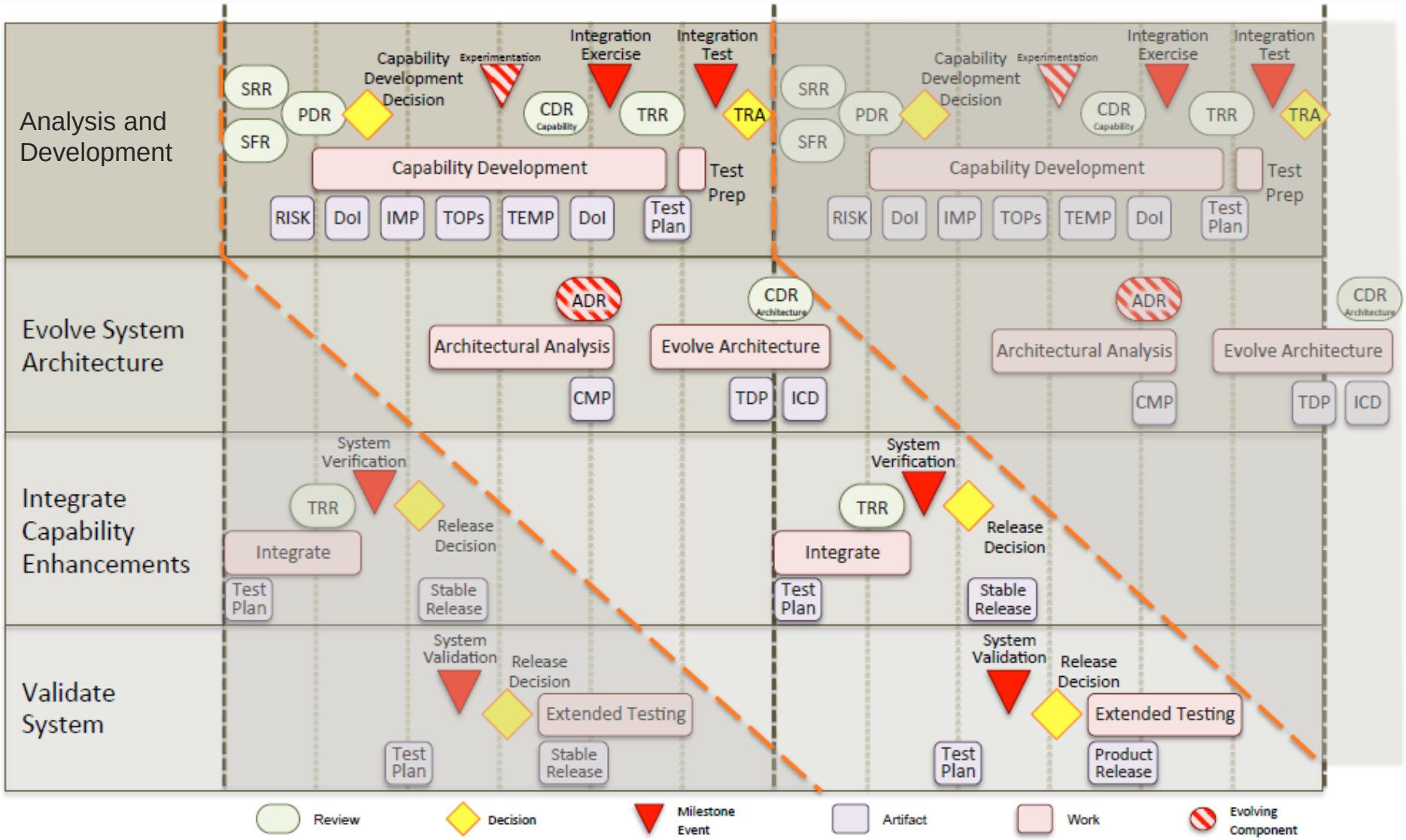
What it does
is respond effectively in a life cycle environment that is capricious, uncertain, risky, variable, and evolving.

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)

Process Macro View: Decoupled Wave-Like Waterfall

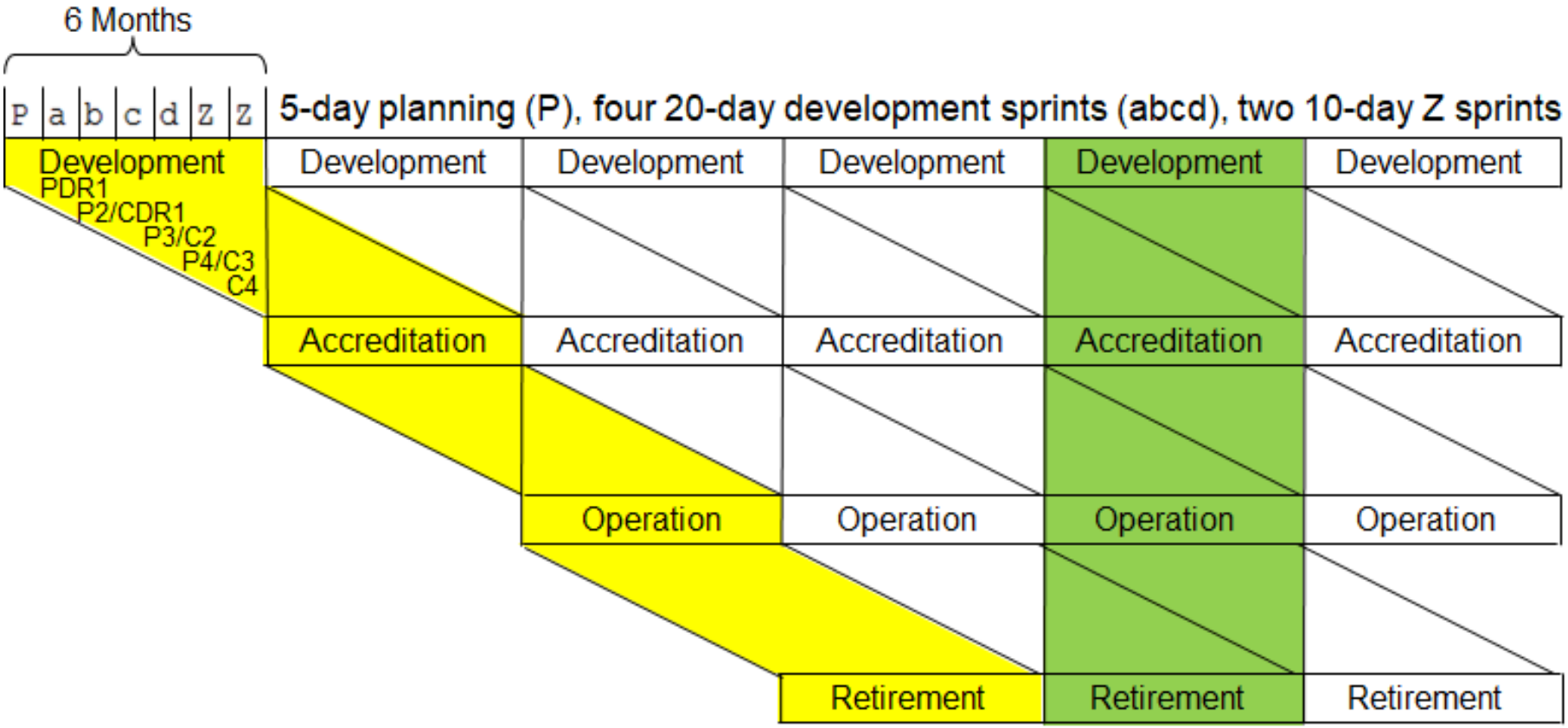


slide credit: Chris Scrapper

NGC SoS Web Portal Evolution SE Process

(www.parshift.com/s/ASELCM-03NGC.pdf)

Process Macro View: Decoupled Wave-Like Waterfall

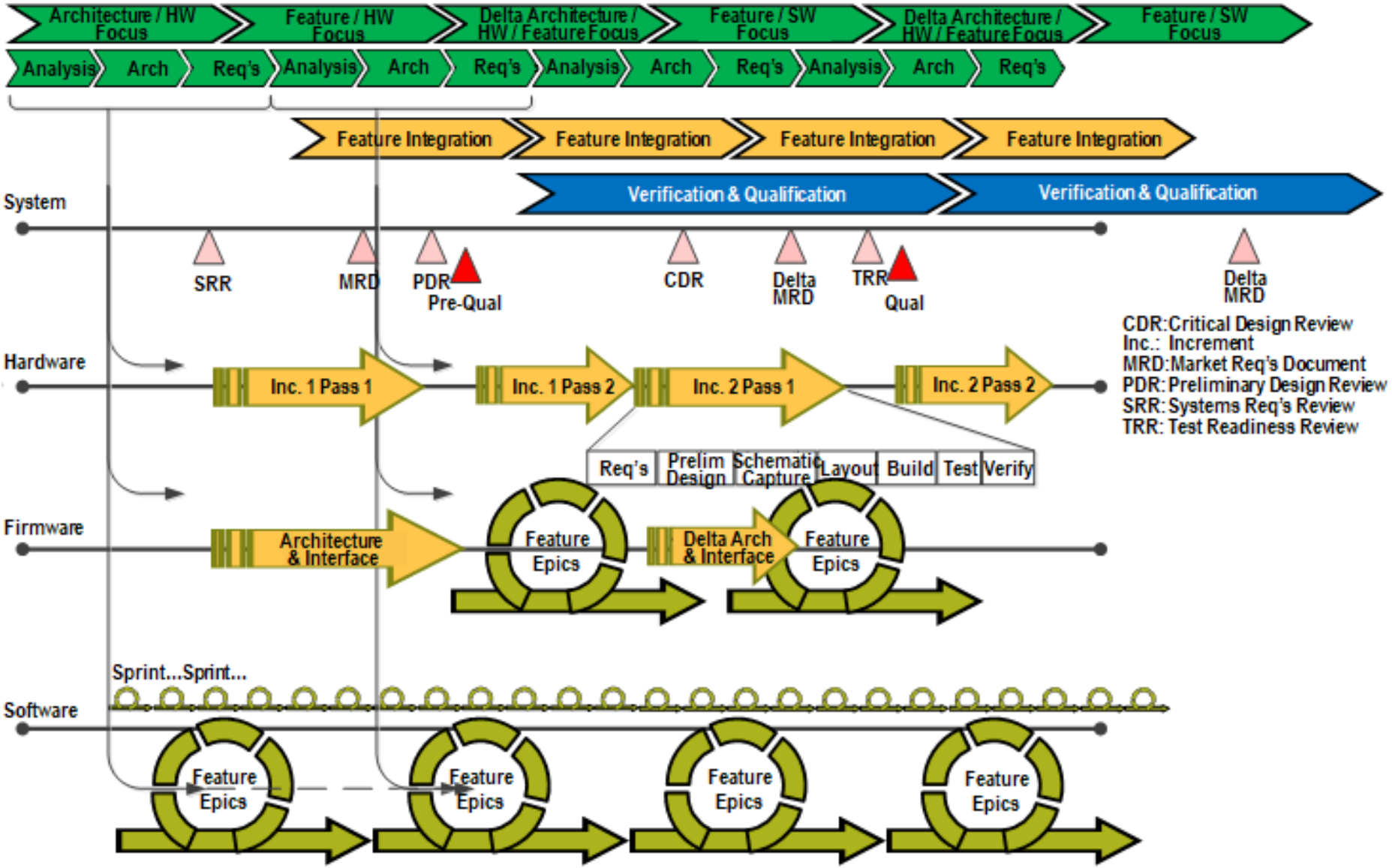


Z sprint: after Dev sprints for fixing defects found during sprint testing.

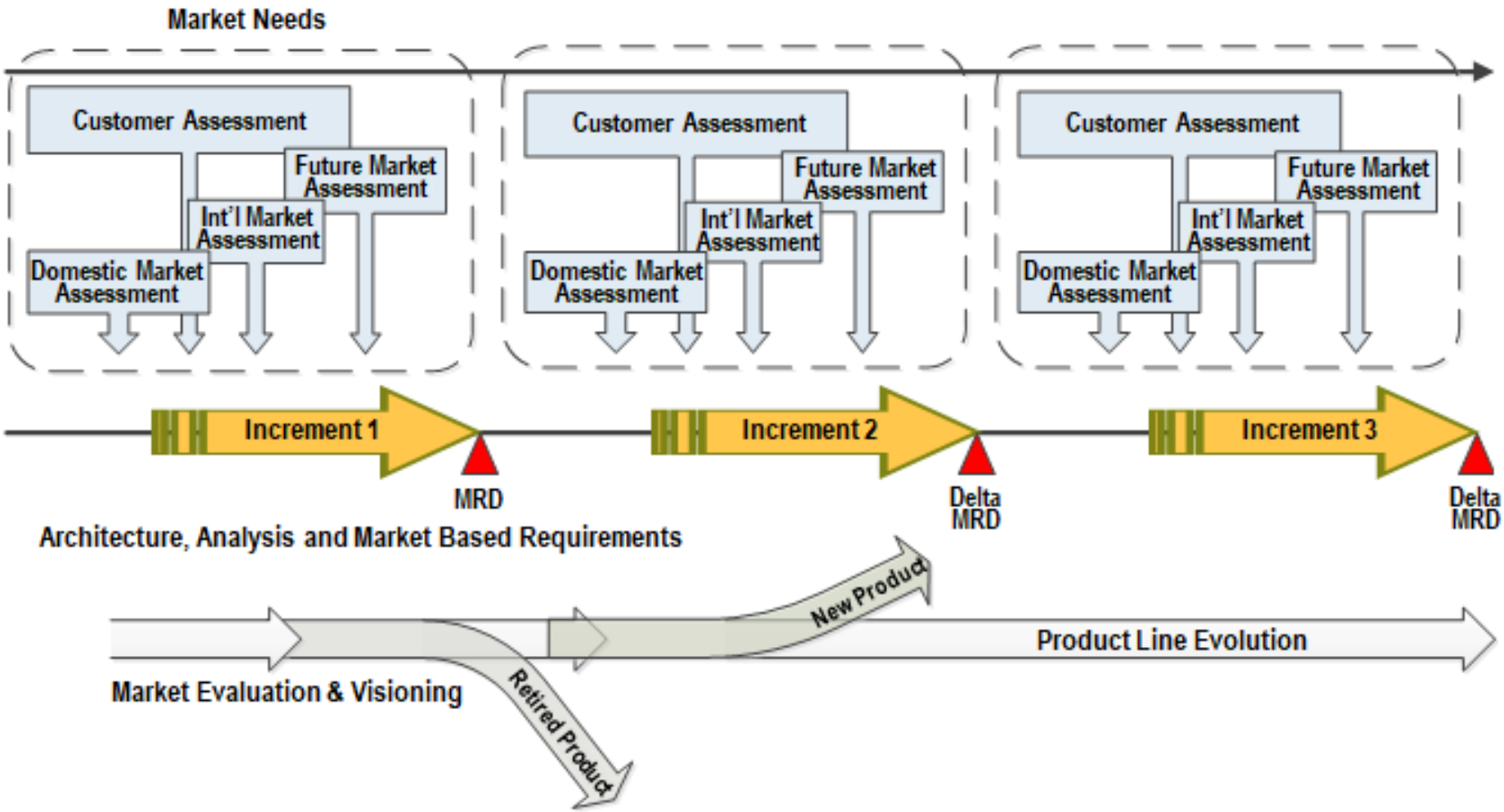
Rockwell Collins Radio Product-Line SE Process

(www.parshift.com/s/ASELCM-02RC.pdf)

Process Macro View: Asynchronously Aligned Discipline Increments



Product Line Evolution View: Incremental Awareness Attention

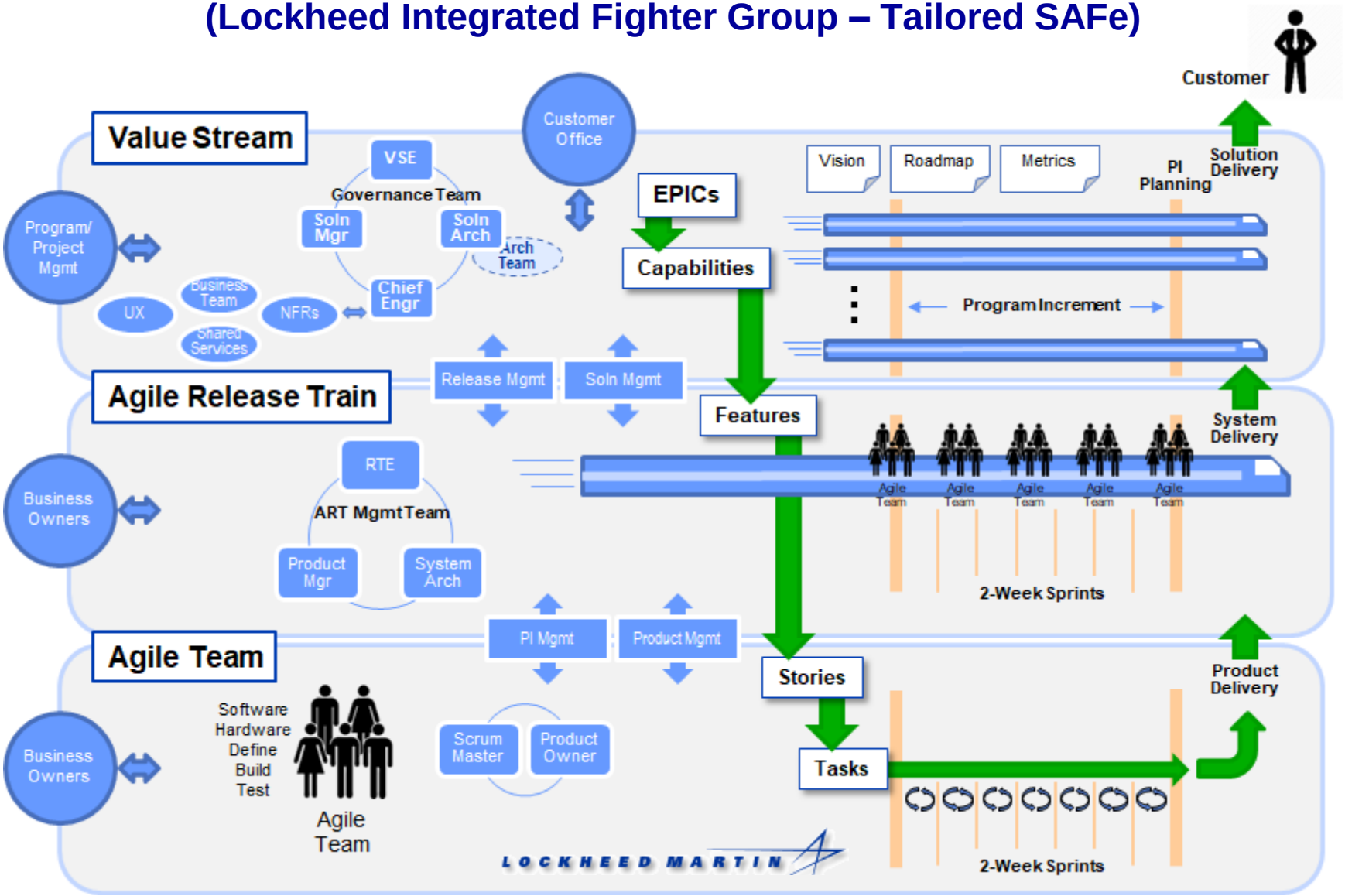


slide credit: Will Hartney

(www.parshift.com/s/ASELCM-04LMC.pdf)

IFG-TS Process Operational Model

(Lockheed Integrated Fighter Group – Tailored SAFe)



Slide credit: Ken Garlington, Lockheed

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

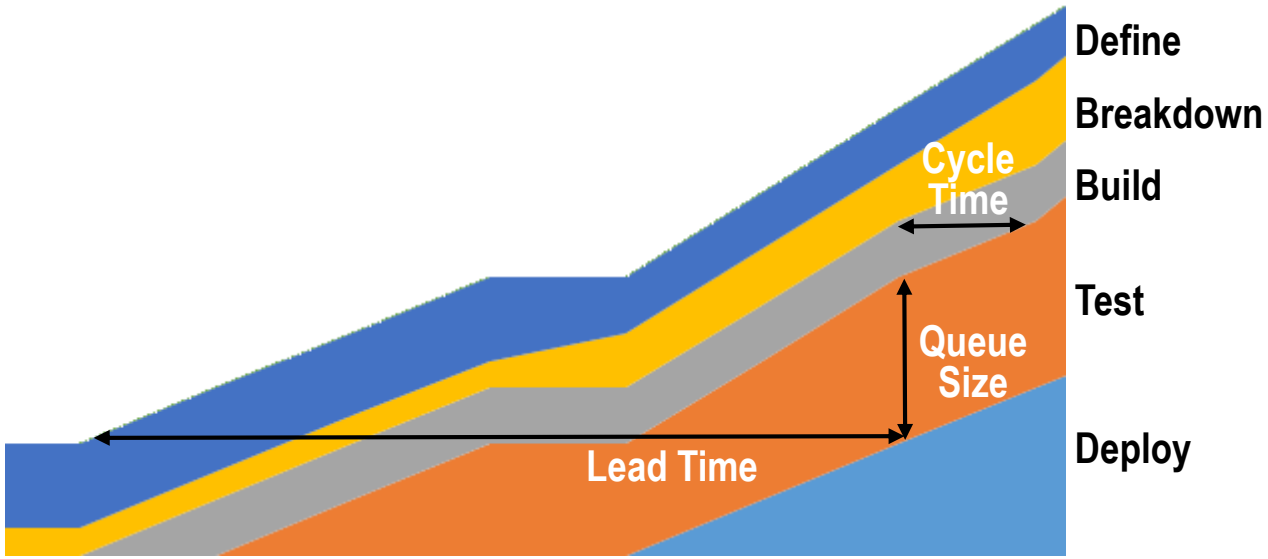
- Open System Architecture (OSA)
- Customer mission needs

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.



Reinertsen, D. G. 2009. *The Principles of Product Development Flow: Second Generation Lean Product Development*. Celeritas Publishing, Redondo Beach, CA, USA.

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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