Agility in the Future of Systems Engineering
An Interactive Exploration

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Abstract

The Future of Systems Engineering (FuSE) is an INCOSE initiative pursuing INCOSE's Vision 2025 and beyond.

To accomplish this the FuSE initiative encompasses a number of topic areas with active projects to shape the future of systems engineering.

The Agile Systems & SE working group is addressing the FuSE Agility topic area and has identified a roadmap of nine foundational concepts for building the agility vision.

A brief overview of the nine concepts will be presented and then interactive activity will address open aspects of one or two of them.

INCOSE FuSE

Future of Systems Engineering

FuSE Collaborative Community

FuSE Road Map (~January 2020)

The purpose of FuSE is to accelerate the realization of INCOSE's vision

Transforming Systems Engineering – Vision 2025 p. 28

Collaborative engineering across national boundaries, enterprises, and disciplines will be the norm.

Systems engineering practice will deal with systems in a dynamically changing and fully interconnected system of systems context.

Architecture design and analysis practices will enable integration of diverse stakeholder viewpoints to create more evolvable systems.

Design drivers such as cyber-security considerations and resilience will be built into the solution from the beginning.

Composable design methods will leverage reuse and validated patterns to configure and integrate components into system solutions.

Decision support methods will support more rapid analysis of a large number of alternative designs, and optimization of complex systems with multiple variables and uncertainty.

FuSE Agility

**2020 Plan: Identify foundation gaps appropriate to fill in the near term future,
ie, a roadmap of the next part of the agility journey,
not a road atlas of every point the way.**

**We are talking about concept identification, not a handbook of practice mastery,
ie, we need new starting points to fill some transformation gaps.**

What is impeding the practice of agility in SE, that could be rectified now?

TRL Framework (Technology Readiness Level)

Level	Definition	DoD DAG Description
1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3	Analytical and experimental critical function and/or characteristic proof of concept.	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4	Component and/or breadboard validation in laboratory environment.	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
5	Technology validated in relevant environment	
6	Technology demonstrated in relevant environment	
7	System prototype demonstration in operational environment	
8	System complete and qualified	
9	Actual system proven in operational environment	

2020 FuSE Agility project focused on identifying concepts to start work on in 2021.

FuSE Agility Charter 2020

Title: Agility in the Future of Systems Engineering
(a FuSE initiative topic project)

What good will look like:
1. Agile systems-engineering [**process**]: apply agile tactics, techniques, and procedures (TTP's) throughout the system lifecycle.
2. Agile-systems engineering [**technology**]: systems are adaptable to predictable and unpredictable change.
3. Agile-operations [**environment**]: achieve composable workflows to sustain value-delivery under adverse conditions.
4. Agile-workforce [**people**]: achieve ability to adapt to change; skills, knowledge, and efficacy.

What good will look like in 2023-2025:
1. Some degree of agile SE will be influencing system development and ongoing evolution.
2. Experimentation with working patterns for dynamic development.
3. Experimentation with working patterns for continual dynamic adaptation in system operation.

What good will look like by end of 2020:
1. Develop FuSE Agility organizing framework and define integrating agility into systems engineering.
2. Multi-organization collaboration will be active.
3. Identify initial set of foundation concepts.
4. Elaborate on FuSE Agility topic concepts.

Team:
- U.S. DoD – Keith Willett (Lead)
- INCOSE – Rick Dove
- LMC – Robin Yeman
- NASA – Jennifer Stevens
- NGC – Alan Chudnow , Rusty Eckman
- Raytheon – Larri Rosser, Mike Yokell

What is stopping us from doing this now:
1. Narrow perception of *agility* as a software development practice.
2. Lack of a codified approach for multi-discipline agile system engineering; e.g., standards, SE methods/guides.
3. Insufficient stakeholder engagement in the SE process; agile is iterative and prompts attention to hard problems.
4. Current acquisition process, contracts, and projects prompt for features and requirements up front rather than evolution of the solution that coincides with evolution of the problem.

Action plan:

IS2020 initial foundation paper: *Systems Engineering the Conditions of the Possibility*.
1. Ongoing: Facilitate topic development.
2. Mid 2020: Periodic workshops in process to identify initial foundation topics.
3. Late 2020: Additional foundation papers in process.

Foundation Concept – Criteria

Concept can provide new and useful value to the state of practice.

Concept has relevance to systems engineering considerations.

Concept value proposition can be articulated in SE terms.

Concept can b supported by notional examples.

Concept doesn’t yet have sufficient published exposure for SE consideration.

Concept could (or might) be prototyped now.

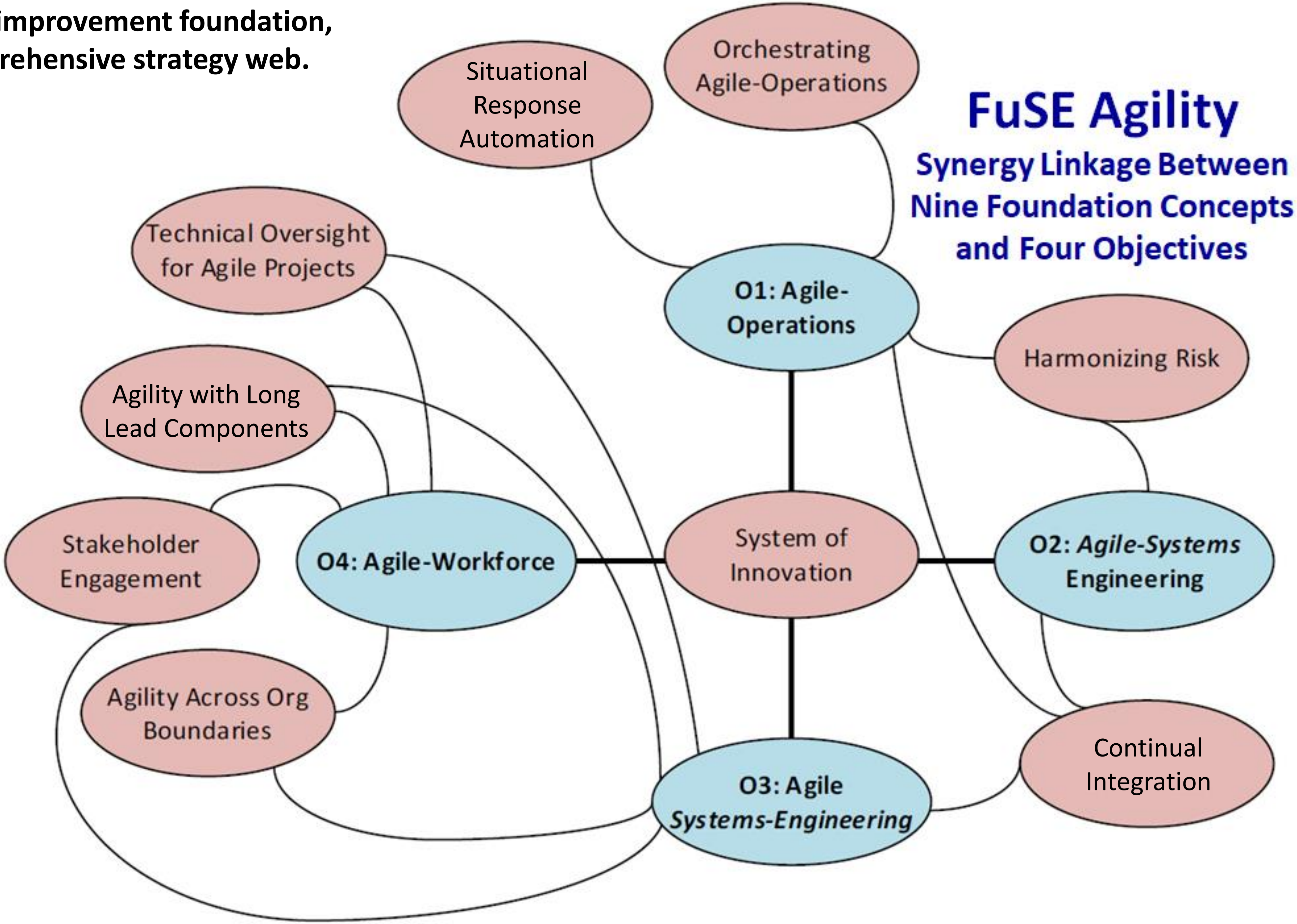
Concept is principally about what to do and why (strategic intent), rather than how (prescriptive tactics), though examples of how lend credence.

Purpose of foundation concept papers is to inspire and instigate pursuit in the systems engineering community.

Development of concept papers is encouraged and open to anyone, individually or in collaboration.

TRL 1, 2, 3, 4

A near-term improvement foundation, not a comprehensive strategy web.



Concept Title	General Problem to Address	General Needs to Fill	General Barriers to Overcome
1. **System of Innovation**	Insufficient learning and knowledge management processes; barriers to learned-knowledge application.	Situational awareness and learning embedded in lifecycle processes; timely/affordable learning-applicatio; knowledge management.	Unclear *what to do* or *where to do it* beyond learning ceremonies and contract obligation satisfaction.
2. **Technical Oversight**	Traditional technical oversight methods are counterproductive in agile programs.	An interactive approach that reveals relevant knowledge for guidance and decision making.	Oversight traditions; standard contract wording; disrespect for oversight.
3. **Stakeholder Engagement**	Timeliness and depth of stakeholder collaborative engagement.	Discovery of true requirements and integration conflicts.	Time involved; travel cost; inconvenient scheduling; lack of motivation.
4. **Agility Across Organizational Boundaries**	Incompatible siloed cultures and languages.	Common language; less handoffs; product-based teams; common metrics.	Functional organizational silos.
5. **Agility with Long Lead Components and Dependencies**	Components and external dependencies with long lead times complicate schedule coordination and disrupt technical performance.	Scheduling and acquisition techniques that better align with agile-SE principles.	[False] justification that long-lead items prohibit the use of agile-SE.
6. **Continual Integration**	Late discovery of integration and requirements issues.	Minimize risk and rework with fast learning; maximize stakeholder engagement.	Development effort and expense; technologies for integrating/testing software prior to HW being ready.
7. **Orchestrating Agile Operations**	Coherence among loosely coupled multi-actor outcomes.	Dynamic operational coordination in real-time.	Ability to encode self-learning, adaptive logic as decision-support for people and for autonomous decision making.
8. **Situational Response Automation**	Decision and action too slow.	Continual dynamic adaptation within cyber-relevant time.	Complicatedness of encoding autonomous governance and adjudication logic and rules; situational awareness that provides necessary inputs.
9. **Harmonizing Risk in Agile Operations**	Agility focus is principally loss avoidance	Expand awareness and operational realization of both the negative side of risk (loss) and the positive side of risk (opportunity, seek gain, optimize).	Silo-thinking and predominance of looking at risk only in terms of loss.

Caveat: Some of the wording has been changed by the presenter to convey his interpretation of the intentions succinctly.

Poll on Problem Resonance

Which ones resonate with moderate to high importance in your experience?

- ❑ Insufficient learning and knowledge management
- ❑ Counterproductive technical oversight processes
- ❑ Timeliness and depth of stakeholder engagement
- ❑ Incompatible siloed cultures and languages
- ❑ Components and external dependencies with long lead times
- ❑ Late discovery of integration and requirements issues
- ❑ Coherence among loosely coupled multi-actor outcomes
- ❑ Decision and action too slow
- ❑ Agility focus is principally loss avoidance

Stakeholder Engagement

Systems engineering benefits when the various stakeholders participate as a collaborating, cooperative, project-encompassing team.

But participation comes in degrees of engagement. At the low end there is simple presence at occasionally scheduled work-in-process reviews. At the high end there is comprehension, inclusion, and contribution at frequent ad-hoc project progress and issue collaborations.

The effectiveness of an agile systems engineering process depends on the timeliness and depth of engagement by stakeholders. This concept addresses core principles and common strategies for improving the effectiveness of stakeholder engagement in all of the forms it may take.

An engagement process will have many different activities to satisfy different needs at different times for different stakeholders. Stakeholders of interest may include managers, system engineers, development engineers, subcontractors, producers, operators, maintainers, customers, and end users.

Engagement is a social activity of collaborative exchange that may occur in a variety of ways, including synchronously and asynchronously, face-to-face and virtually, textually with wikis and commercial project status tools, and experientially with interactive demonstrations.

Every project includes a stakeholder engagement process consisting of a set of activities and procedures for conducting those activities. Stakeholder engagement activities and procedures generally are distributed as parts of other project processes, and not viewed collectively as a system with a common set of social requirements that are addressed by design strategies for effectiveness.

A coherent engagement process facilitates collaboration for relevant information exchange among individuals, cooperation for optimal give and take among individuals, and teaming for collective endeavor toward common purpose.

Engagement effectiveness depends on the experiential quality of the engagement activities for each individual stakeholder. Effective engagement is comfortable, timely, and rewarding.

Interactive Discussion

Stakeholder "Engagement" – what does that mean to you?

Offer some examples of the problem as you have experienced it.

Quality

“Quality is practical, and factories and airlines and hospital labs must be practical.
But it is also moral and aesthetic. And it is also perceptual and subjective (Tom Peters 1989).”

The quality of systems and processes is ultimately measured in the nature of user personal engagement.

Engagement may be enforced, entrapped, or embraced.

- Enforced: This is what I am required to use/do, damn it!
- Entrapped: This is what is available to use/do, alas!
- Embraced: This is a joy to use/do, I love it!

Agile systems engineering requires high engagement, because it is dependent on active awareness, learning, and action. Agility is all about execution.

The art of systems engineering involves

- the quality of experiential system-engagement,
- the factors that encourage engagement behavior, and
- the necessity of engagement for agility.

Stake Holder Engagement

Developers	Subcontractors	Security Engineers
Operators	Producers	Maintainers
Customers	End Users	Management

Typical forms of stakeholder engagement:

Integrated product team (IPT) is a multidisciplinary group of people who are collectively responsible for delivering a defined product or process. The emphasis of the IPT is on involvement of all stakeholders (users, customers, management, developers, contractors) in a collaborative forum. (Wikipedia)

Concurrent engineering (CE) is a work methodology emphasizing the parallelization of tasks, sometimes called simultaneous engineering or integrated product development (IPD) using an integrated product team approach. (Wikipedia)

DevOps is a set of software development practices that combine software development (*Dev*) and information-technology operations (*Ops*) to shorten the systems-development life cycle while delivering features, fixes, and updates frequently in close alignment with business objectives. (Wikipedia)

Contract gate reviews.

Software-sprint deliverable demonstration and usage.

Understanding the Problem

Why is there a problem? (interactive exercise)

Insightful understanding of the problem often makes the solution obvious.

Lockheed IFG Continuous Integration Platform

one promising approach example

In 2015 IFG was in early experimentation with a CIP concept, called the Agile Non-Target Environment (ANTE).

ANTE systems consist of simulated components, previous re-usable components, wip components, finished components, low-fidelity COTS proxies, IFG software work-in-process, and operators.

Of note: ANTE employs lower-fidelity open-market proxy devices with similar capability but lower performance than what is eventually expected.

Subcontractors are required to provide device simulations to ANTE specs.

ANTE concept was self funded for values they expected and realized.

By mid-2017 ANTE was declared a successful experiment, and had achieved eventual applause in customer feedback that values:

- Early and incremental demonstration of working concepts.
- Early exposure to difficulties in need of attention.

Live Virtual Constructive CIP

Live components
(people, things)
Virtual components
(simulations)
Constructive capabilities
(configuration and data management)

L&V components are functional system elements; configured, challenged and monitored by C elements for performance and anomalies.

LVC/CIP… demonstration/test/experimental events can occur at any time with the latest instantiation of simulations & components.

Caveat: LVC internet search is dominated by military training applications.

CIP: Continuous Integration Platform
AAP: Agile Architecture Pattern
OSA: Open Systems Architecture