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INCOSE Webinar Series

Wednesday 20th September 2023 – Webinar 167

Agile Systems Engineering – It's Not Your Father's Oldsmobile

Rick Dove

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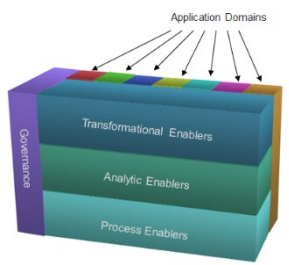

- To provide a forum for experts in the field of Systems Engineering to present information on the “State of the Art”
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Choreography

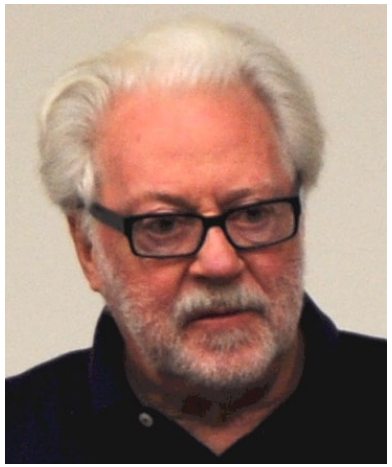
1. Andy Pickard (your host) will introduce the Webinar and the speaker
2. Rick Dove will speak for about 40 to 45 minutes
3. During his talk, participants can write questions using the Zoom Q&A window
4. After Rick completes his talk, he will spend 10 minutes answering questions that Andy selects from those submitted by the audience
5. Andy Pickard will provide information about upcoming Webinars and then end this session
6. This Webinar is being recorded and will be made available on the INCOSE website to members and employees of CAB organizations

Webinar

Agile SE Processes 206:
Agile Systems Engineering … It's Not Your Father's Oldsmobile

20-Sep-2023

Rick Dove
Anthem, AZ, dove@parshift.com, 575-770-7101
Independent Operator
Chair: INCOSE WG for Agile Systems & Systems Engineering



Agile 206 webinar slides: Agile SE … It's Not Your Father's Oldsmobile
Agile 205 webinar slides: Agile SE in the Future of Systems Engineering
Agile 204 webinar slides: Agile SE Life Cycle Model
Agile 203 webinar slides: Agile SE Agility as a System
Agile 202 webinar slides: Agile SE Continuous Integration
Agile 201 webinar slides: Agile SE Problem Space Requirements
Agile 106 webinar slides: Agile System/Process as Risk Management
Agile 105 webinar slides: Agile System/Process Operational Awareness
Agile 104 webinar slides: Agile System/Process Engagement Quality
Agile 103 webinar slides: Agile System/Process Design Principles
Agile 102 webinar slides: Agile System/Process Design Requirements
Agile 101 webinar slides: Agile System/Process Architecture Pattern
(updated asynchronously from time-to-time)

Agile Systems Engineering … It's Not Your Father's Oldsmobile*

The Manifesto for Agile Software Development and related processes like Scrum are well known, and well suited to software engineering.

But software engineering is very different than electronic engineering, mechanical engineering, and systems engineering.

Engineering today needs the agility to anticipate and effectively respond to increasingly dynamic and uncertain environments.

While tactical methods (the how part) for engineering agility necessarily vary among different engineering domains, strategies (the what and why parts) for achieving these common goals are domain independent.

Research has shown us fundamental common strategies that enable agility in any domain; but each domain needs to express these patterns differently to fit the nature of that domain.

This presentation will profile eight strategic aspects ~~and contrast examples of their tactical manifestations in systems engineering and software engineering.~~ with application examples of extreme agility as practiced at Tesla and SpaceX.

*Oldsmobile's 1989 advertising phrase attempting to appeal to a younger generation.

Systems Engineering Agility

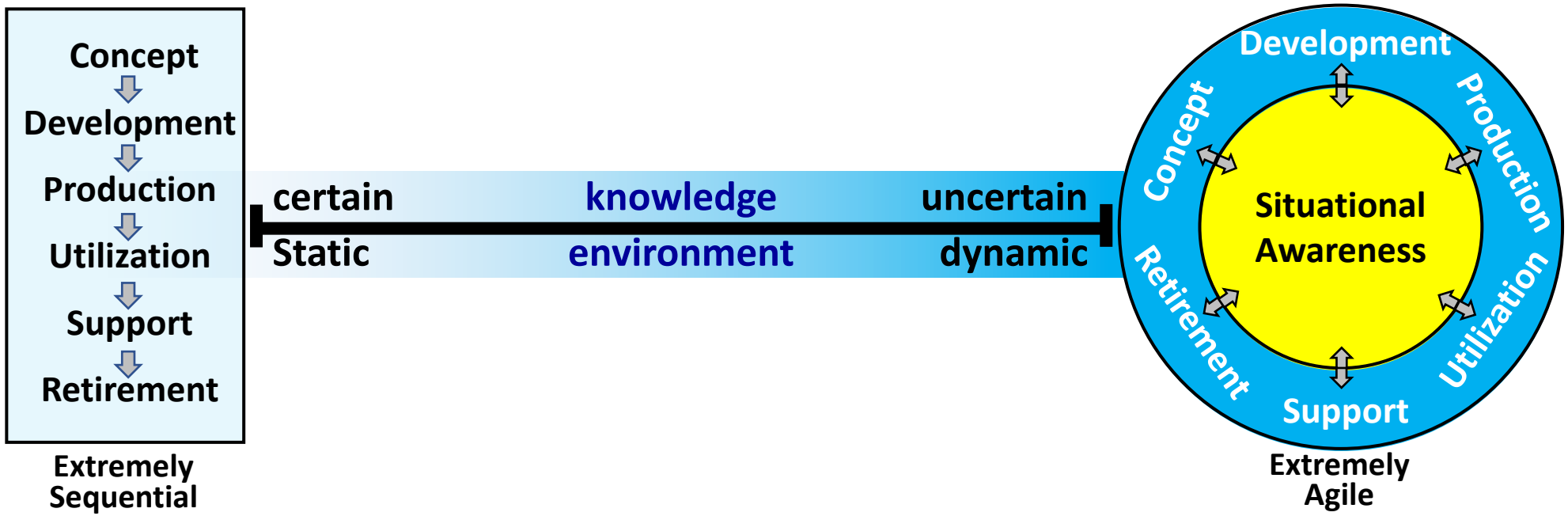
Agile systems engineering is a strategy-driven method for designing, building, sustaining, and evolving systems when knowledge is uncertain and/or environments are dynamic.

Agile systems engineering is *being* agile, not *doing* agile.

Agile System Engineering is a what, not a how; a strategic intent, not a tactical method.

There are many different methods that can be adopted, adapted, or crafted to suite project contexts and organizational cultures; but all share the same goals and strategies for being.

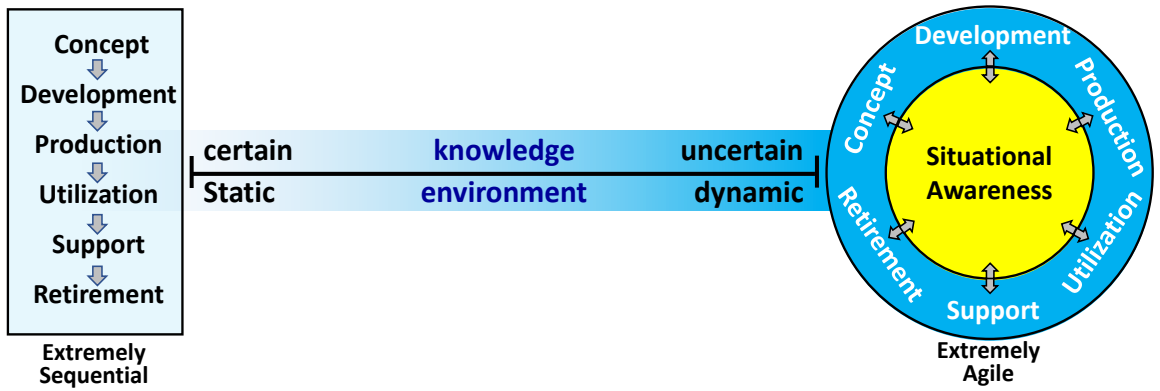
Life Cycle Spectrum



Agile systems engineering is first and foremost systems engineering as it is known through its ISO/IEC/IEEE standards, the Vee model, the INCOSE Systems Engineering Handbook, and however it is practiced by organizations that design, build, and sustain systems.

What distinguishes it as "agile" systems engineering is its leverage of situational awareness, its enablement of continual system evolution, and its intent to satisfy mission rather than plan.

Context



INCOSE's Vision 2035 expressed a fundamental **need**:
"Systems engineering anticipates and effectively responds to an increasingly dynamic and uncertain environment."

Ashby's law expresses a timeless **need**:
"When the variety or complexity of the environment exceeds the capacity of a system the environment will dominate and ultimately destroy that system."

Asynchronous Stage Activity

- You're using a personal computer in the morning = utilization stage.
- In the afternoon an SSD (Solid State Drive) is installed = production/deployment stage.
- Which replaces the Hard Drive = retirement.
- Next day the BIOS are adjusted for optimal SSD performance = support stage.
- Supplier is creating a new widescreen monitor based on market demand research = development stage.
- Supplier is always dreaming up product line extensions = concept stage.

Concurrent Stage Activity

- You're driving a year-old Tesla = utilization stage.
- Simultaneously Tesla is downloading an AI upgrade = production/deployment stage.
- Simultaneously that upgrade is replacing an older capability = retirement stage.
- Simultaneously engineers are creating a market-desired faster charge capability = development stage.
- Simultaneously engineers are dreaming up tomorrow's upgrade = concept stage.
- Simultaneously Tesla is asking to schedule a part-replacement house call based on monitored stats = support stage.

Value Proposition for Agile <any kind of> Engineering

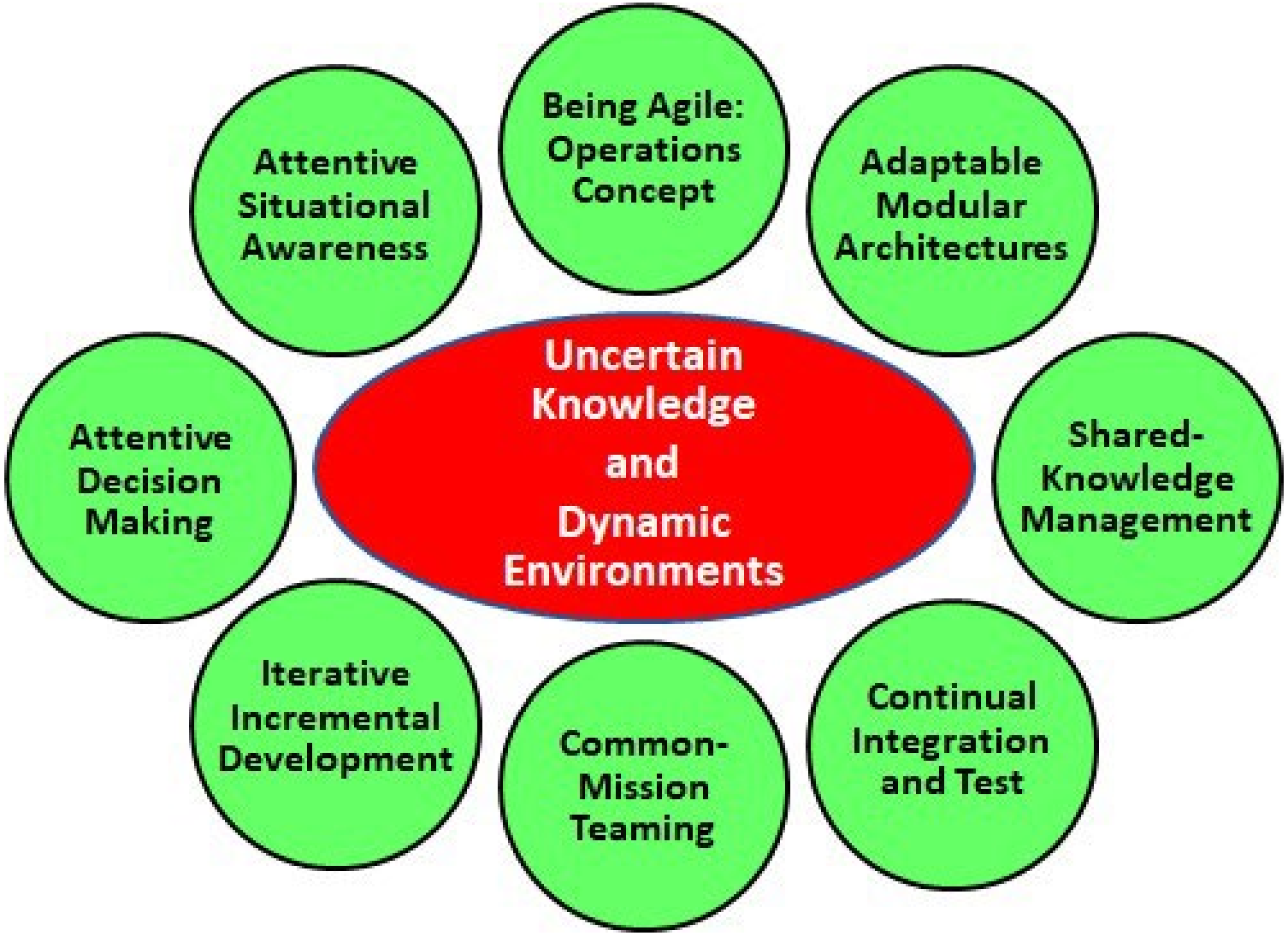
Minimize rework

Maximize quality

Drive innovation

Eight Strategic Aspects That Enable Agility

www.parshift.com/s/230715IS23-AgileSE-EightCoreAspects.pdf



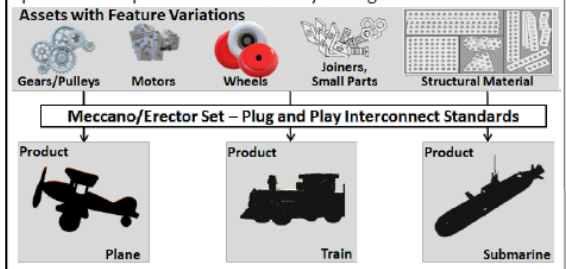
Adaptable Modular Architectures

Needs: Facilitated product and process experimentation, modification, and evolution.

Behaviors: Composable and reconfigurable product and process designs from variations of reusable assets.

Discussion: One fixed process approach won't fit all projects, so an appropriate process should be easy to compose and evolve according to context and usage experience. Variations of reusable assets are built over time as features are modified for different contextual usage.

A hallmark of agile systems engineering is iterative incremental development, which modifies work in process as suitability is repetitively evaluated. The agility of the process depends upon the agility of the product – so both process and product can be easily changed.



Notional Agile Architecture Pattern

Attentive Situational Awareness

Needs: Timely knowledge of emergent risks and opportunities.

Behaviors: Active monitoring and evaluation of relevant internal and external operational-environment factors.

Discussion: Are things being done right (internal awareness) and are the right things being done (external awareness)? Having the agile capability for timely and cost-effective change does little good if you don't know when that ability should be exercised. Situational awareness can be enhanced with systemic methods and mechanisms.

Alert in-the-moment constant attention

Common-Mission Teaming

Needs: Coherent collective pursuit of a common mission.

Behaviors: Engaged collaboration, cooperation, and teaming among all relevant stakeholders.

Discussion: Collaboration, cooperation, and teaming are not synonymous, and need individual support attention. Collaboration is an act of relevant information exchange among individuals, cooperation is an act of optimal give and take among individuals, and teaming is an act of collective endeavor toward a common purpose.

Tightly integrated coherent operation

Continual Integration & Test

Needs: Early revelation of system integration issues.

Behaviors: Integrated test and demonstration of work-in-process.

Discussion: Discovering integration issues late in development activities can impact cost and schedule with major rework. Synchronizing multiple domain engineering activities via continual integration and test provides faster and clearer insight into potential system integration issues.

SpaWar iteratively evolving unmanned technology integration platform.

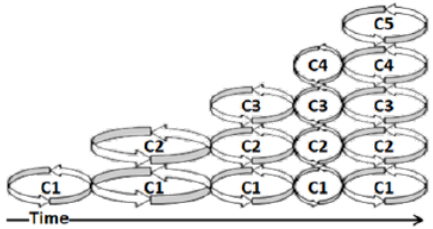
Iterative Incremental Development

Needs: Minimize rework, maximize quality, drive innovation.

Behaviors: Incremental loops of building, evaluating, correcting, and improving capabilities.

Discussion: Generally increments *create* capabilities and iterations add and augment features to *improve* capabilities.

- Increment cycles are beneficially timed to coordinate events such as integrated testing and evaluation, capability deployment, experimental deployment, or release to production.
- Increments may have constant or variable cadence to accommodate management standards or operational dynamics.
- Iteration cycles are beneficially timed to minimize rework cost as a project learns experimentally and empirically.



Iterative capability improvements (looping) and incremental capability additions (successive development periods)

Attentive Decision Making

Needs: Timely corrective and improvement actions.

Behaviors: Systemic linkage of situational awareness to decisive action.

Discussion: Empower decision making at the point of most knowledge. As a counter example, technical debt (a term for knowing something needs correction or improvement but postponing action) is situational awareness without a causal link to prompt action.

John Boyd's OODA loop

Shared-Knowledge Management

Needs: Accelerated mutual learning and single source of truth for internal and external stakeholders.

Behaviors: Facilitated communication, collaboration, and knowledge curation.

Discussion: There are two kinds of knowledge to consider. Short time frame operational knowledge: what happened, what's happening, what's planned to happen. Long time frame curated knowledge: what do we know of reusable relevance, e.g., digital artifacts, lessons learned, and proven practices.

Depicted books represent information containers of any kind; but typically digital

Being Agile: Operations Concept

Needs: Attentive operational response to evolving knowledge and dynamic environments.

Behaviors: Sensing, responding, evolving.

Discussion: Agile systems engineering is not about doing Agile, it is about being agile. Being agile is a behavior, not a procedure – a behavior sensitive to threats and opportunities in the operational environment, decisive when faced with threat or opportunity, and driven to improve these capabilities. Deciding how to implement any of the core aspects, even this one, should be done with sense-respond-evolve principles in mind as aspect objectives.

Three principles that operationalize agility

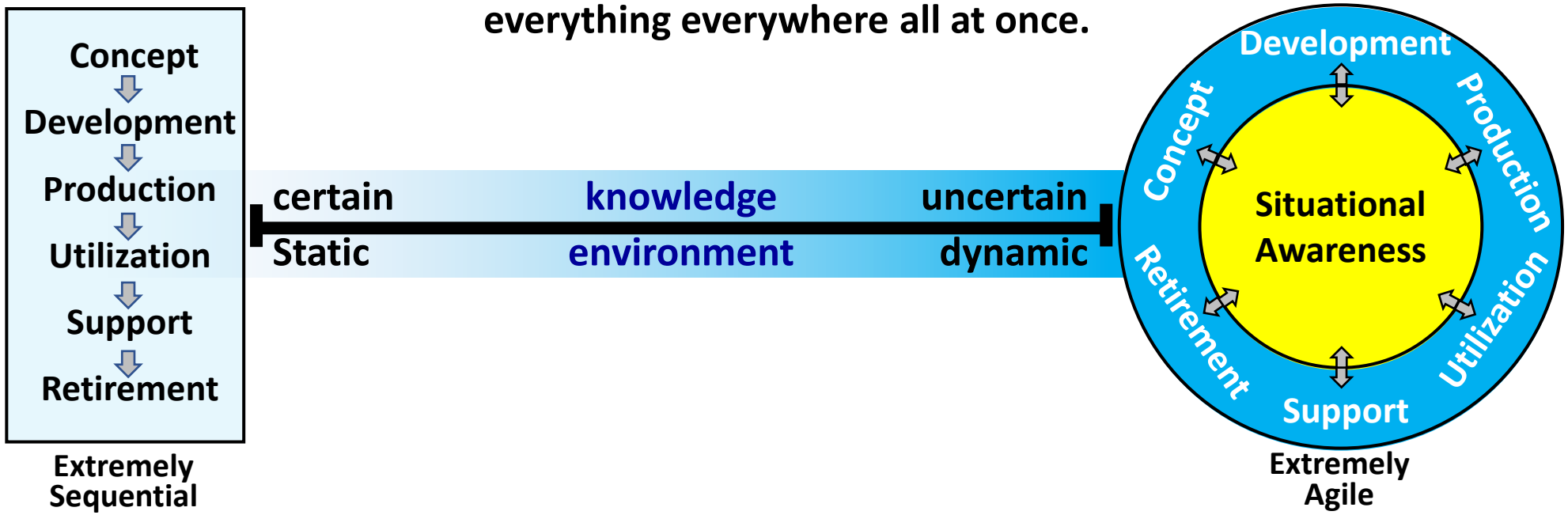
Extremely Agile

Case examples will be drawn from what is publicly available about Tesla's engineering agility – mainly from video accountings of Joe Justice's engagements at Tesla as an employee and at SpaceX as an observer.

Caveat: drawn from ongoing product evolution engineering, not from develop-from-scratch engineering, i.e., not about cybertruck birth, rather about continuous daily innovation of the S3, X, and Y.

However, it is about
an omnipresent pervasive cultural infrastructure
that channels all engineering activity …

everything everywhere all at once.



Tesla – From a Distance

Vehicles coming off the production line evolve continuously for better performance and lower cost.

Production methods evolve continuously for higher quality, lower cost, and smaller footprint.

Factory construction methods evolve continuously for speed-to-operation.

Vertical integration is employed to drive constant innovation in key subsystems and avoid supply chain issues.

Key subsystem suppliers are required to improve delivered components weekly.

Production expects, and is designed to accommodate, constant change in all subsystems and parts.

Significant investment in, and usage, of AI/ML.

Flat organization – virtually no manager positions.

High-mission driven: accelerate the advent of sustainable energy (Patents are freely shared and license free).

Expected employee priority: Speed of innovation and dedication to immediate & long term missions.

Object-oriented modular architecture is a first principle and dominant pattern for everything: part design, process design, production design, facility design, teaming design, …

Tesla & SpaceX – top 2 desires for engineering graduates.

Adaptable Modular Architectures

Why/Need: Facilitated product and process experimentation, modification, and evolution.

What/Behavior: Composable and reconfigurable product and process designs from variations of reusable assets.

How/ConOps: Module interconnect specs and facilitation (process/tooling) to find, employ, and evolve available reusable assets.

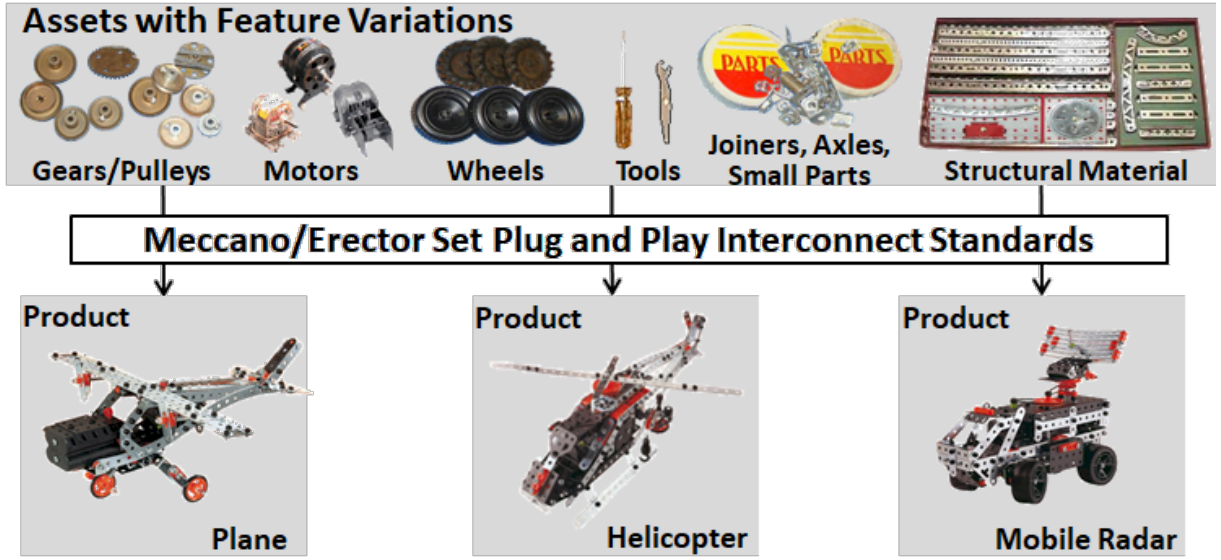
Heuristic: Encapsulate modules to preclude cross-module dependencies and enable independent evolution and innovation.

Theory/Look:

- Uncertainty: Architecture enables affordable experimental learning to reduce uncertainty.
- Dynamics: Architecture facilitates timely composable response to opportunities and threats.

Practice/Feel at Tesla:

- Tesla and SpaceX use modular architectures with module-interconnect specs for everything: product, process, facility, production, tooling, and people.
- Interconnect specs are allowed to evolve asynchronously with backward compatible adaptors.
- Adaptable modular architectures appear to be a dominant mental pattern for all types of systems at Tesla and SpaceX.



Iconic Agile Architecture Pattern

Iterative Incremental Development

Why/Need: Minimize rework, maximize quality, drive innovation.

What/Behavior: Incremental loops of building, evaluating, correcting, improving, and delivering capabilities.

How/ConOps: Try something, evaluate it, incorporate it or try something else

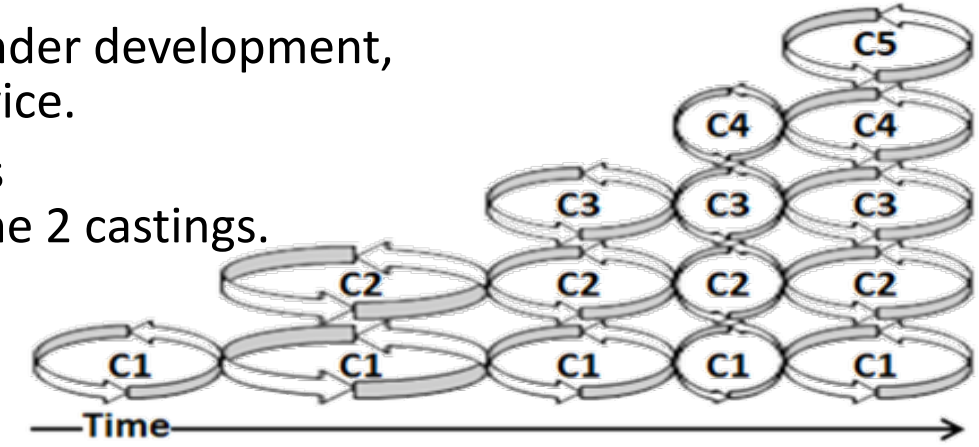
Heuristic: build a little, test a little, learn a lot.

Theory/Look:

- Uncertainty: rapid experimental development, test, and evaluation resolves uncertainties.
- Dynamics: Iterations and increments enable and facilitate changing goals to fit changing needs.

Practice/Feel at Tesla:

- At Tesla every car on the production line is represented in the graphic below as a full column, where many capabilities are potentially improved and new capabilities may or may not be added.
- "Tesla makes 60 part changes a day. 60 new parts introduced in production and sold to customers every day."
  Joe Justice, 7-Jul-2022, Tesla's Secret Process for Rapid Innovation, www.youtube.com/watch?v=FE7OUGC4OB8, 14:15
- At Tesla full self driving is an incremental capability currently under development, and expected to be an optional upgrade for existing cars in service.
- Body sections that began as hundreds of welded & bolted parts were iteratively improved (same capability) over time to become 2 castings.
- SpaceX: Raptor engines are built on a 2-day cycle and no two of them are the same as each build introduces innovations.
  Joe Justice, 7-Jul-2022, Tesla's Secret Process for Rapid Innovation, www.youtube.com/watch?v=FE7OUGC4OB8, 15:50
- Speed of safety certification dictates iteration speed, so every car drives itself through an in-factory certification test and registers that result with NHTSA.



Iterative capability improvements (looping) and incremental capability additions (successive columns)

Common-Mission Teaming

Why/Need: Coherent collective pursuit of a common mission.

What/Behavior: Engaged collaboration, cooperation, and teaming among all relevant stakeholders.

How/ConOps: Team actively senses and corrects mission divergence.

Heuristic: Maintain team stability and mission focus until done to avoid switching costs.

Theory/Look:

- Uncertainty: Team cognition and awareness greater than individual sum emerges through interactions.
- Dynamics: Mission dominance enables dynamic adjustments of methods.

Practice/Feel at Tesla:

- Teaming opportunities are posted dynamically on personal phone and on ubiquitous monitor boards to attract immediate opt-in participation, much like *Open Space* conference technique (join us for what's happening at location X).
- 3.5 page employee handbook establishes guardrails and behavior expectations for collaborative opt-in teaming.
- Teams function much like *Mobs* in software development, i.e., everyone works on the same thing at the same time in the same space, with rotating roles of driver and navigators.
  Joe Justice, 9-Aug-2023, MobAI with Joe Justice, www.youtube.com/watch?v=Fh_FDGiTvcg
- Mission is constant innovation to improve performance (of everything) and reduce number of parts, process steps, lines of code (in all job descriptions).

Tightly integrated coherent operation

Shared-Knowledge Management

Why/Need: Accelerated mutual learning and single source of truth for internal and external stakeholders.

What/behavior: Facilitated communication, collaboration, and knowledge curation.

How/ConOps: New knowledge processes – evaluate/codify/add. Old knowledge processes – find/access/prune.

Heuristic: Automate where possible for relevant acquisition, evolution, and distribution.

Theory/Look:

- Uncertainty: Access to relevant knowledge reduces uncertainty.
- Dynamics: Accessible reusable knowledge provides more options for quick response.

Practice/Feel at Tesla:

- Digital Self Management (DSM) is AI machine-learning software that learns, evolves, and provides data for personal decision making, for design improvement assistance, and product improvement evaluation. Evolving DSM data seta are shared among all factories.
- "There are no bosses, your manager is data." Any approval that waits for a manager is automated by software. This software has largely replaced management, allowing nearly 100% of staff to be an engineer, directly improving products every day.
  Joe Justice, Digital self management, 9-Mar-2023, www.youtube.com/watch?v=qypG12NUtgo
- Each station in the factory has DSM, which creates a real-time instant feedback loop for skill and job improvement, and for product and production improvement.
- As to project status radiators: No product backlog or Kanban board, there is only a doing column on ubiquitous monitor boards and on all phones. Most projects are extremely short so the focus is on what's happening now.

Information containers of any kind; but typically digital

Attentive Situational Awareness

Why/Need: Timely knowledge of emergent risks and opportunities.

What/Behavior: Active monitoring and evaluation of internal & external operational-environment factors.

How/ConOps: Data-sensing instrumentation, data-driven monitoring and decision triggers, and effectiveness-driven improvement.

Heuristic: Socialize and automate awareness to focus attention on doing things right and doing right things.

Theory/Look:

- Uncertainty: Data-driven feedback on operations and operational results reduces situational uncertainty.
- Dynamics: Attentive situation awareness is the enabling capability for sensing and responding to dynamics.

Practice/Feel at Tesla:

- Ubiquitous data-driven DSM-AI/ML for continuously-improved situational awareness at every factory station.
- DSM-AI, for instance, measures paint quality on a dozen dimensions. Its data set is very high res images of every car's painted surfaces. If an improvement is tried it can tell immediately if it is better.
  Joe Justice, 14-Feb-2023, Ways of Working at Tesla, www.youtube.com/watch?v=lGw3Z9Kk5Iw 44:50
- Mob engineering motivated to innovate has many eyes, ears, and sensitivities monitoring global information for opportunity and threat.
- Car usage is monitored: how it is being used by people, how it is used as a machine, how suitable it is for sustained service.
- Autobidder (software) does mass polls in seconds to find suppliers with prices, capabilities, track records – solved chip shortage issues.
  MunWai Consulting, 2023, Agile @ Tesla Audio Episode 10: "Agile", https://munwaic.com/podcasts/agile-tesla/ 20:00

Alert in-the-moment constant attention

Attentive Decision Making

Why/Need: Timely corrective and improvement actions.

What/Behavior: Systemic linkage of situational awareness to decisive action.

How/ConOps: Awareness triggered decision needs, decision debt monitoring, effectiveness-driven improvement.

Heuristic: Enable decision making at the point of most knowledge: local awareness or remote expertise.

Theory/Look:

- Uncertainty: A decision is a learning experience that reduces uncertainty whether right or wrong.
- Dynamics: Attentive decisions are timely responses to mitigate environmental dynamics.

Practice/Feel at Tesla:

- "Replacing human decision points with apps is the digital backbone of a modern company and fundamentally determines the speed of product development and response. Digital Self Management means saying 'why would we ever ask a human to decide this?!' And being honest."
  Joe Justice, Digital self management, 9-Mar-2023, www.youtube.com/watch?v=qypG12NUtgo 9:18
- DSM-AI/ML is attentive awareness that provides data for immediate deployment decisions. Data authorizes the decision, no other authority is required.
- "You don't have to ask Elon 'Should I put the new heat pump in the car?' If your automated tests passed that is your boss. You deploy immediately."
  Joe Justice, Digital self management, 9-Mar-2023, www.youtube.com/watch?v=qypG12NUtgo 20:11
- Customer service options and scheduling decisions are driven by on-board operational monitors and digital twin profiles – no human in the loop.

John Boyd's OODA loop

Continual Integration & Test

Why/Need: Early revelation of system integration issues.

What/Behavior: Integrated test and demonstration of work-in-process.

How/ConOps: Automate testing and evaluation to drive iterative improvement

Heuristic: Incrementally and asynchronously integrate work-in-process and automated regression testing.

Theory/Look:

- Uncertainty: Reduces uncertainty of integration issues.
- Dynamics: Reveals conflicts among components and conflicts between system and operational situation.

Practice/Feel at Tesla:

- Every car has potentially new components so each component and car on the production line is a work-in-process, automated-test, integration platform.
- "Every single car and rocket puts itself through automated testing of every non-destructive compliance and certification test. This is called 'Factory Mode' and it is where autopilot came from. In Factory Mode cars run their own regression tests as they are being assembled, and display that information."
  Joe Justice, 9-Mar-2023, www.youtube.com/watch?v=qypG12NUtgo 11:20
- "Modules of the car are individually tested and regression tested in Factory Mode, then tested again as soon as they are connected on the car.
  Joe Justice, 9-Mar-2023, www.youtube.com/watch?v=qypG12NUtgo 11:54
- Factory mode autopilot: the car drives itself through certification testing.

Iteratively evolving technology integration platform.

Being Agile: Operations Concept

Why/Need: Attentive operational response to evolving knowledge and dynamic environments.

What/Behavior: Sensing, responding, evolving.

How/ConOps: Design and use a sense-respond-evolve SE ConOps process – as a system.

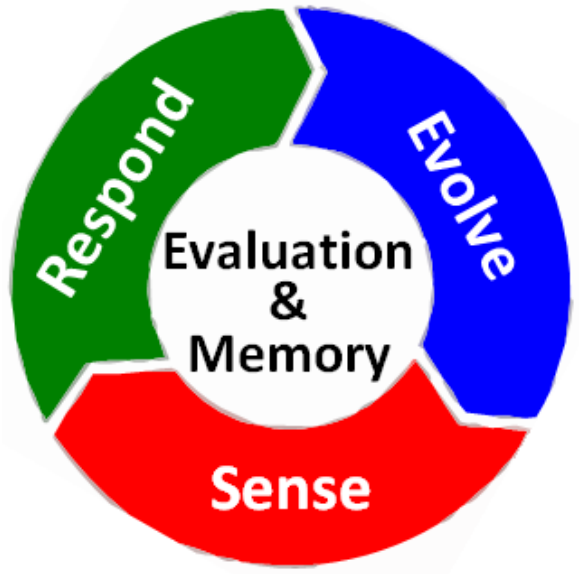
Heuristic: Keep your eyes on the road and your hands upon the wheel – for in-the-moment engagement.

Theory/Look:

- Uncertainty: Experimentally probe and prototype to test and resolve uncertain knowledge
- Dynamics: Sense-respond-evolve compatibly in concert with environmental changes.

Practice/Feel at Tesla:

- "Pace of innovation is the only thing that matters – not cost per unit, not management efficiency, no other metric is above pace of innovation."
  Joe Justice, 6-Apr-2022, Radical Unbossing at Tesla, Joe Justice, www.youtube.com/watch?v=ozdBx1SG-vo
- The machine that makes the machine is where SE attention is principally focused.
- "The goal is for 100% of staff to be engineers in hardware and software. Any work that requires taking someone away from engineering is automated as much as practical." Joe Justice, 9-Mar-2023, Digital self management, www.youtube.com/watch?v=qypG12NUtgo
- Suppliers and supplies change a lot and rapidly, so processes have high variability to deal with – a concept counter to what tradition considers necessary. The score is on outcome, not on conformance to process, and on outcome improvements, not outcome consistency.
  Joe Justice, 14-Feb-2023, Ways of Working at Tesla, www.youtube.com/watch?v=lGw3Z9Kk5Iw
- Key-component suppliers (e.g. Bosch, Panasonic, 3M) are required to improve their components weekly.



Three principles that operationalize agility

Tesla – Up Close and Personal

Adaptable Modular Architectures:
- Product, engineering process, production, and factory composed of encapsulated modules with stable interfaces.
- Process of Open Space mob-teaming supported by Digital Self Management awareness-decision tools.

Iterative Incremental Development:
- Continual independent parallel evolution of encapsulated product, production, and facility modules.

Attentive Situational Awareness:
- DSM-AI/ML tool has task-specific data sets to continually & immediately evaluate outcome results.
- DSM-AI/ML tool has answers for management questions – eliminating need for human manager.
- Autobidder (software) does mass polls in seconds to find suppliers with prices, capabilities, and track record.

Attentive Decision Making:
- DSM-AI/ML tool has task-specific data sets to continually & immediately evaluate outcome results.
- DSM-AI/ML tool has answers for management questions – eliminating human manager functions and needs
- Customer service option and scheduling driven by on-board operational monitors and digital twin profile.

Common-Mission Teaming:
- Opt-in mission-pulled team composition.
- Clear and monitored mission focus to minimize/eliminate multi-mission switching costs.

Shared-Knowledge Management:
- DSM-AI/ML curation and dissemination.

Continual Integration & Test:
- Every car has potentially new components and each component and car is an automated integration & test platform.

Being Agile: OpsCon
- Continual mission-driven innovation on performance, efficiency, and cost of product and production.
- Operational culture has no need or use for agility procedures and agility management processes.

Purpose of case story development was to see if Tesla uses strategic aspects beyond the eight. None were found. A revelation, however, was that data driven tooling (DSM-AI/ML) is a key Tesla agility enabler functioning as an automated implementation and systemic connection of Attentive Situational Awareness to Attentive Decision Making.

Take Aways

that don't require radical reorganization or impossible cultural change – appropriate where benefits can be gained

Mob engineering – for critical engineering issues/opportunities, everybody necessary and useful in the same room at the same time working together until the mission is completed. Not as a transformed way of life, but it might grow in usage with successes and experience.

Management automation – not wholesale, but incremental identification of what waits for approvals and decisions that could be automated, with priority on low hanging fruit and high-pain delays.

Automated regression testing of incrementally-integrated work in process.

Incentivize cost/time/quality improvements on outcomes and methods – even if that's only in your personal cadre of influence (coworkers, direct/indirect reports – recognition, respect, reputation)

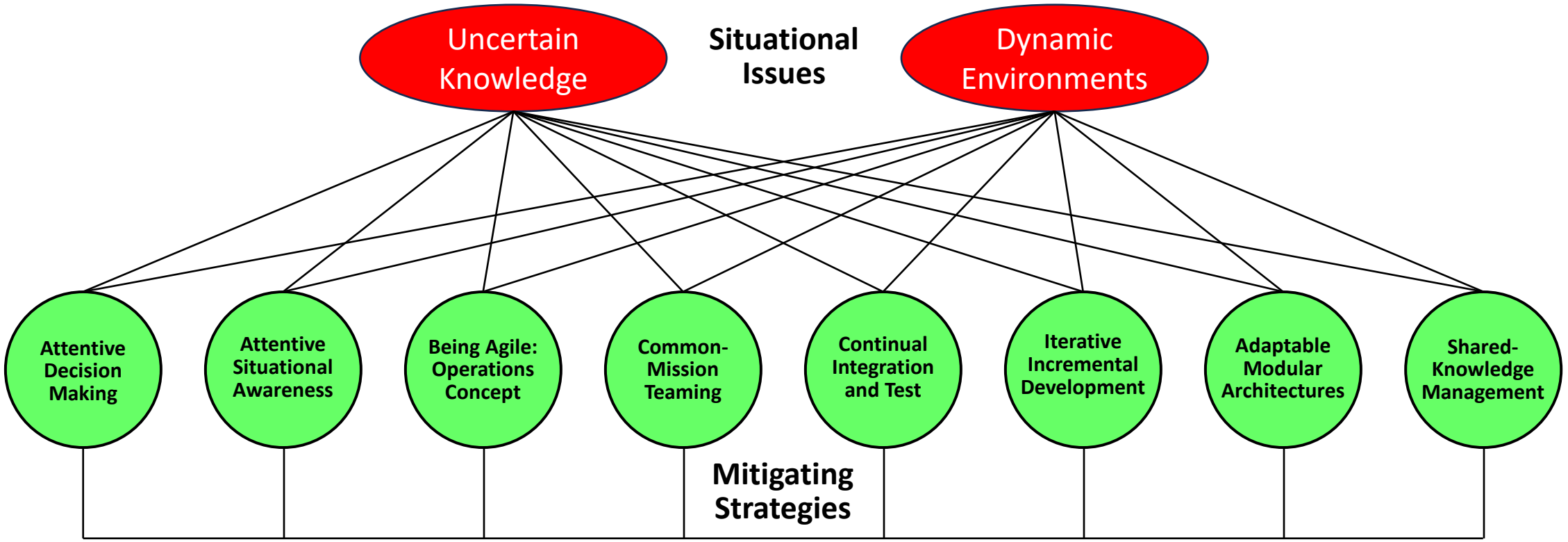
Engineering designers and production designers work together simultaneously – iteratively designing (or improving the design) of a subsystem/component/part and how to produce it.

Production line designed for, and comfortable with, part/component/subsystem variation

Continuous improvement required of key component/subsystem suppliers.

…

Wrap Up



Employment Considerations

- Leveraging aspect synergies
- Avoiding aspect conflicts
- Organizational readiness
- Continuous iterative improvement

Common Strategies, Different Tactics

Provocative examples: many contrasts can be listed in each row depending upon project context.

Strategic Aspect	Software Engineering	Systems Engineering
Product-Line Architecture	• Standard interface • COTS object-oriented integrated dev environment	• Proprietary interface • MOSA design effort
Iterative Incremental Development	• Tight • Test time stability	• Loose • Test facility conflicts
Attentive Situational Awareness	• Introspective • Frequent user feedback	• Extrospective • Sparse user feedback
Attentive Decision Making	• Simple • Few people	• Complicated • Many people
Common-Mission Teaming	• Homogeneous • Shared language	• Heterogeneous • Different languages
Shared Knowledge Management	• Code libraries • Integrated tools	• PLM • Federated tools
Continual Integration and Test	• Common platforms • Synchronous	• Proprietary platforms • Asynchronous
Being Agile: Operations Concept	• Do Agile • Many COTS Options	• Be agile • Home grown and tailored

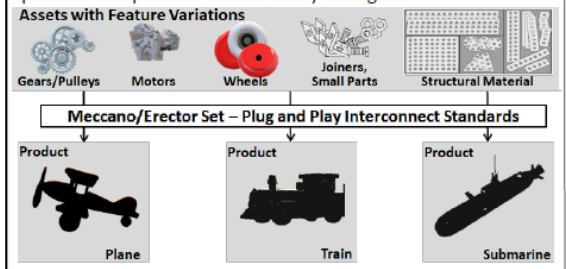
Adaptable Modular Architectures

Needs: Facilitated product and process experimentation, modification, and evolution.

Behaviors: Composable and reconfigurable product and process designs from variations of reusable assets.

Discussion: One fixed process approach won't fit all projects, so an appropriate process should be easy to compose and evolve according to context and usage experience. Variations of reusable assets are built over time as features are modified for different contextual usage.

A hallmark of agile systems engineering is iterative incremental development, which modifies work in process as suitability is repetitively evaluated. The agility of the process depends upon the agility of the product – so both process and product can be easily changed.



Notional Agile Architecture Pattern

Attentive Situational Awareness

Needs: Timely knowledge of emergent risks and opportunities.

Behaviors: Active monitoring and evaluation of relevant internal and external operational-environment factors.

Discussion: Are things being done right (internal awareness) and are the right things being done (external awareness)? Having the agile capability for timely and cost-effective change does little good if you don't know when that ability should be exercised. Situational awareness can be enhanced with systemic methods and mechanisms.

Alert in-the-moment constant attention

Common-Mission Teaming

Needs: Coherent collective pursuit of a common mission.

Behaviors: Engaged collaboration, cooperation, and teaming among all relevant stakeholders.

Discussion: Collaboration, cooperation, and teaming are not synonymous, and need individual support attention. Collaboration is an act of relevant information exchange among individuals, cooperation is an act of optimal give and take among individuals, and teaming is an act of collective endeavor toward a common purpose.

Tightly integrated coherent operation

Continual Integration & Test

Needs: Early revelation of system integration issues.

Behaviors: Integrated test and demonstration of work-in-process.

Discussion: Discovering integration issues late in development activities can impact cost and schedule with major rework. Synchronizing multiple domain engineering activities via continual integration and test provides faster and clearer insight into potential system integration issues.

SpaWar iteratively evolving unmanned technology integration platform.

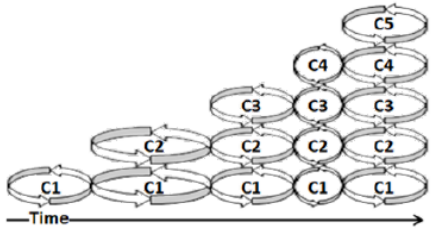
Iterative Incremental Development

Needs: Minimize rework, maximize quality, drive innovation.

Behaviors: Incremental loops of building, evaluating, correcting, and improving capabilities.

Discussion: Generally increments *create* capabilities and iterations add and augment features to *improve* capabilities.

- Increment cycles are beneficially timed to coordinate events such as integrated testing and evaluation, capability deployment, experimental deployment, or release to production.
- Increments may have constant or variable cadence to accommodate management standards or operational dynamics.
- Iteration cycles are beneficially timed to minimize rework cost as a project learns experimentally and empirically.



Iterative capability improvements (looping) and incremental capability additions (successive development periods)

Attentive Decision Making

Needs: Timely corrective and improvement actions.

Behaviors: Systemic linkage of situational awareness to decisive action.

Discussion: Empower decision making at the point of most knowledge. As a counter example, technical debt (a term for knowing something needs correction or improvement but postponing action) is situational awareness without a causal link to prompt action.

John Boyd's OODA loop

Shared-Knowledge Management

Needs: Accelerated mutual learning and single source of truth for internal and external stakeholders.

Behaviors: Facilitated communication, collaboration, and knowledge curation.

Discussion: There are two kinds of knowledge to consider. Short time frame operational knowledge: what happened, what's happening, what's planned to happen. Long time frame curated knowledge: what do we know of reusable relevance, e.g., digital artifacts, lessons learned, and proven practices.

Depicted books represent information containers of any kind; but typically digital

Being Agile: Operations Concept

Needs: Attentive operational response to evolving knowledge and dynamic environments.

Behaviors: Sensing, responding, evolving.

Discussion: Agile systems engineering is not about doing Agile, it is about being agile. Being agile is a behavior, not a procedure – a behavior sensitive to threats and opportunities in the operational environment, decisive when faced with threat or opportunity, and driven to improve these capabilities. Deciding how to implement any of the core aspects, even this one, should be done with sense-respond-evolve principles in mind as aspect objectives.

Three principles that operationalize agility

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(updated asynchronously from time-to-time)

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Webinar ID: Webinar 045 Dove 19 September 2012 Agile Systems & Processes 101

Upcoming Webinars (tentative schedule)

Who	What	When
Lou Wheatcraft	New Version of the Guide to Writing Requirements (GtWR)	Wednesday 18th October 2023 at 11am EDT
Dick Fairley	Systems Engineering & Software Engineering; Interactions Among People, Processes & Technologies	Wednesday 15th November 2023 at 11am EST

Invitations will be emailed in advance and informational updates will be placed on www.incose.org

Go to http://www.incose.org/products-and-publications/webinars for more info on the webinar series, including a way to view the last 164 Webinars and soon – this one!

Information on the webinars can now be accessed through the Professional Development Portal (PDP), at https://www.incose.org/_pdp/advanced-search-the-content-catalog - search for "Webinars"

Joining instructions will added around two weeks before each webinar is scheduled to take place.

Upcoming Events

SAE/NASA/INCOSE Energy and Mobility Conference
Cleveland, Ohio, USA
12 – 15 September 2023
https://www.energyandmobility.org/

ENERGY&MOBILITY
TECHNOLOGY, SYSTEMS AND VALUE CHAIN
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Questions: *Is our modern civilization "Sustainable"? Can our aging and fragile electric grid support the coming "Transportation Electrification"? How will emerging technologies integrate EVs and electric airborne systems for urban mobility? – and… Can we hope to achieve a "NetZero" Carbon Climate without bankrupting our children?*

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INCOSE 6th Western States Regional Conference (WSRC)
Richland, Washington, USA
14 – 16 September 2023
https://www.incose.org/wsrc/wsrc-home

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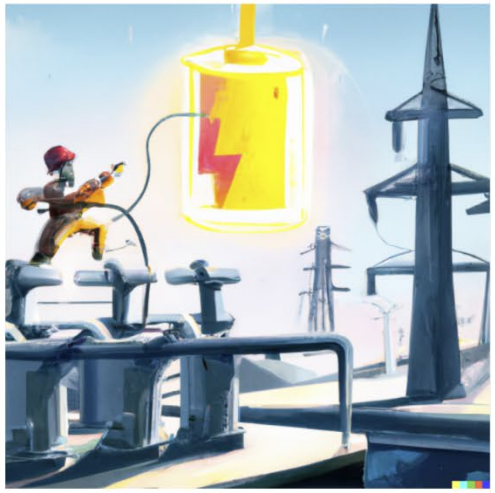
Hosted by the Cascade Chapter of the International Council on Systems Engineering (INCOSE).

September 14 - 16, 2023
Pacific Northwest National Lab (PNNL)
650 Horn Rapids Road
Richland, Washington (map)

Come try Tri-Cities!

The WSRC is a 3-day event showcasing presentations, keynotes, tutorials, and tours all focusing on topics related to systems engineering. The WSRC is not just for INCOSE members or systems engineers. It's an opportunity for project managers, educators, technology professionals, and others who have a 'systems thinking' mindset to share with one another about how to apply systems approaches to solve challenging problems. You can even take your INCOSE System Engineering Professional (SEP) Certification Exam during the event! Please Join Us!



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