International Council on Systems Engineering
A better world through a systems approach

Conserving Energy as a Strategy for Dealing with Uncertainty and Dynamics in SE

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Abstract

**Being agile conserves resources
in a situational engagement with
uncertainty and dynamics in pursuit of an outcome.**

**Uncertain knowledge and dynamic environments
present the *risk* of exhausting limited resources
before a valued return is achieved.**

**Conserving those resources
optimizes the possibility of valuable outcome achievement.**

**We will explore resource conservation
as systems thinking in practice and synergy in process,
and the implications of doing so.**

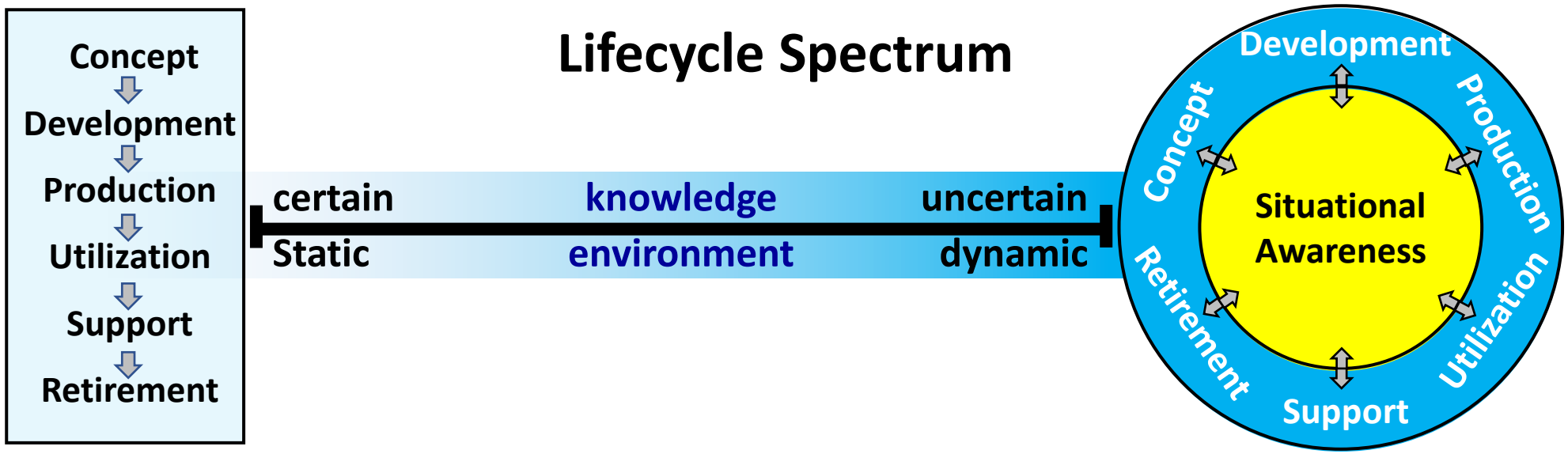
Instigation

INCOSE's 4-page Primer for
Systems Engineering Agility
outlines eight strategic aspects;
what and why – not how.

A 50-page Guide is now in development.
A deeper dive on the strategic focus (what and why),
with a variety of implementation examples (how).

The deeper dive has revealed
new questions and new points of view
being explored for possible value.

Context



Extremely Sequential

Required Order

Plan Driven

Extremely Agile

No Order Required

Situation Driven

Agility

Grace,

Efficiency,

Effectiveness

of Engagement

Systems Engineering Agility Primer (Just a Visual)

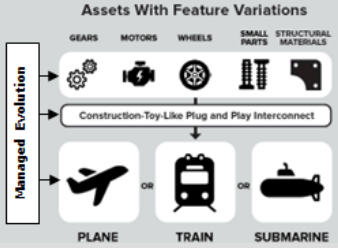
Adaptable Modular Architectures

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.



Composable reconfigurable constructions

Iterative Incremental Development

Needs: Minimize rework, maximize quality, facilitate 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.

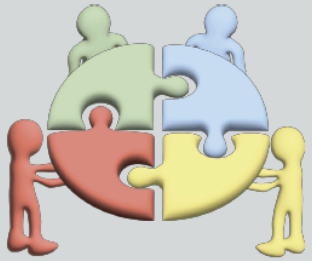
Iterative capability improvements (looping) and incremental capability additions (successive development periods).

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.

Iteratively evolving self-driving technology integration platform.

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.

Air traffic control – alert, in-the-moment, constant attention

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.

Attentive decisions change wrong tires that would take toll every lap

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.

Information containers of any kind, available to all, and typically digital.

Being Agile

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.

Agility emerges from synergistic relationships among aspects.

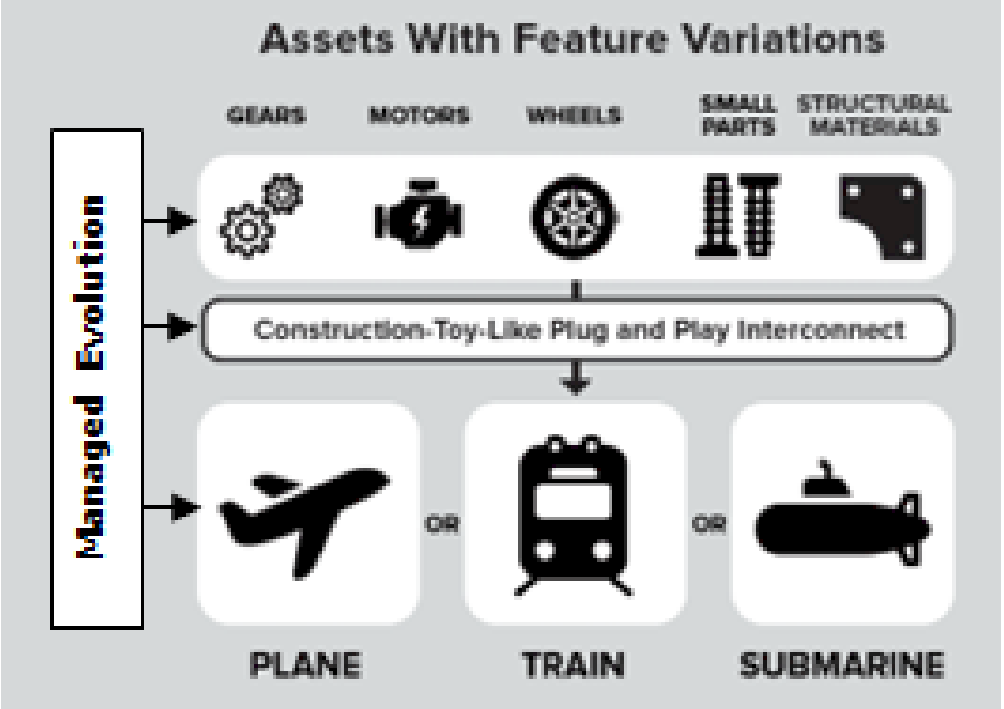
Adaptable Modular Architectures

Behavior Lense:

Composable and reconfigurable designs from evolving variations of reusable assets

Conservation Lense:

Streamlines systems composition with reusable and modifiable parts



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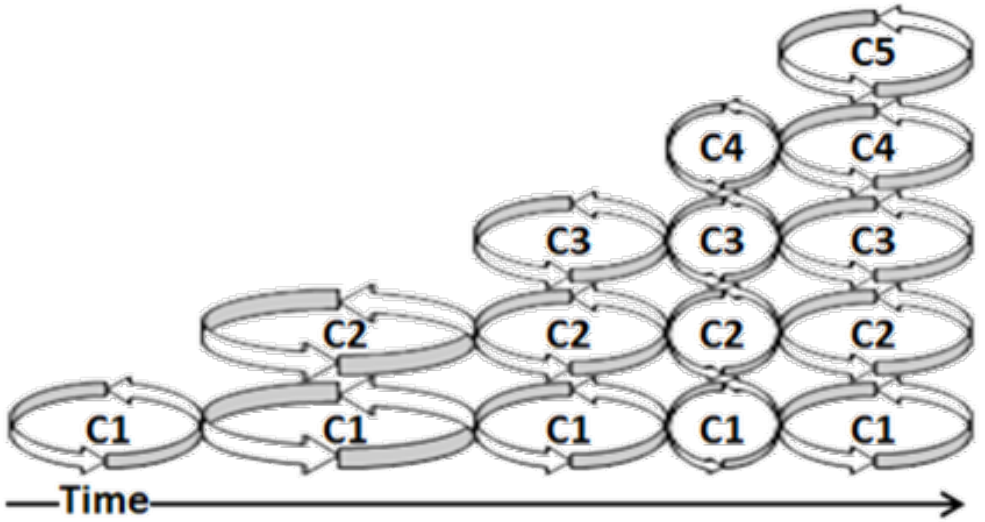

Iterative capability improvements and incremental capability additions

Attentive Situational Awareness

Behavior Lense:

Active monitoring and evaluation of relevant internal and external environment factors

Conservation Lense:

Reveals problems/opportunities that would consume more time and cost later

Air traffic control – alert, in-the-moment, constant attention

Attentive Decision Making

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Systemic linkage of situational awareness to decisive action

Conservation Lense:

Optimizes decision timing to minimize no-return expenditures

Attentive decisions change wrong tires that would take toll every lap

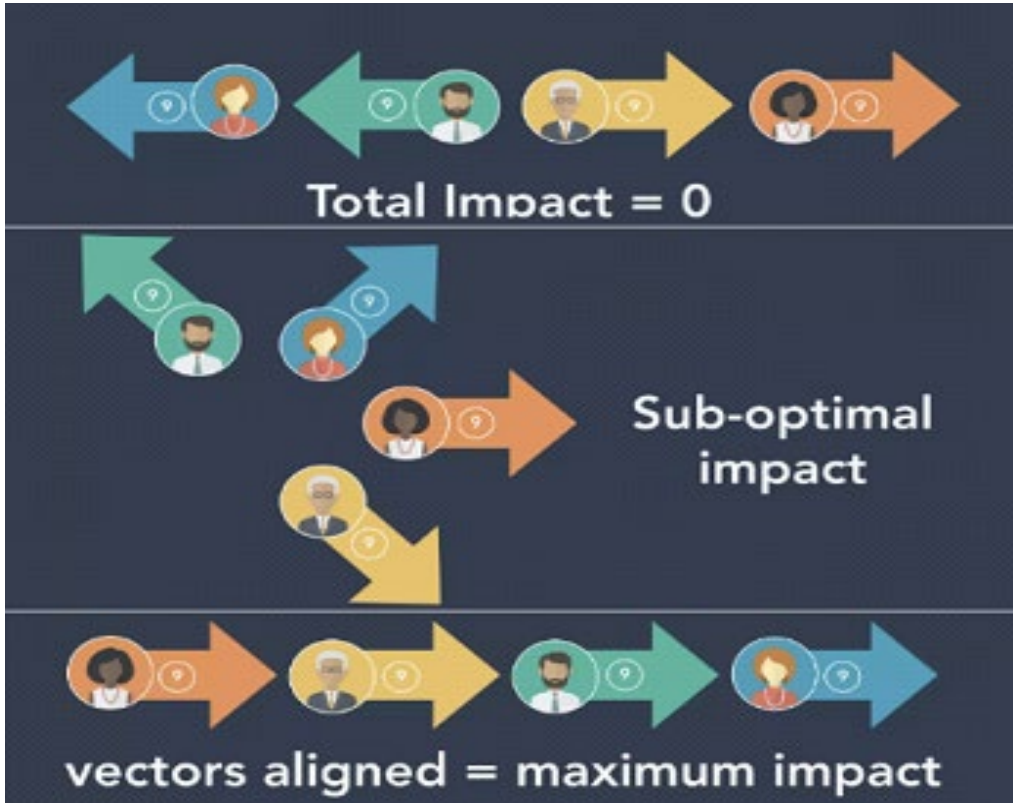
Common-Mission Teaming

Behavior Lense:

Engaged collaboration, cooperation, and teaming among all relevant stakeholders

Conservation Lense:

Minimizes counter productive effort by aligning teamwork



Team alignment determines total impact (art: D. Shah, 2020)

Shared-Knowledge Management

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Conservation Lense:

Minimizes incompatible effort and facilitates implementation synergy

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Continual Integration & Test

Behavior Lense:

Integrated test and demonstration of work-in-process

Conservation Lense:

Minimizes cost and effort to mitigate integration issues

An iteratively evolving, self-driving technology, integration platform used at US Navy project

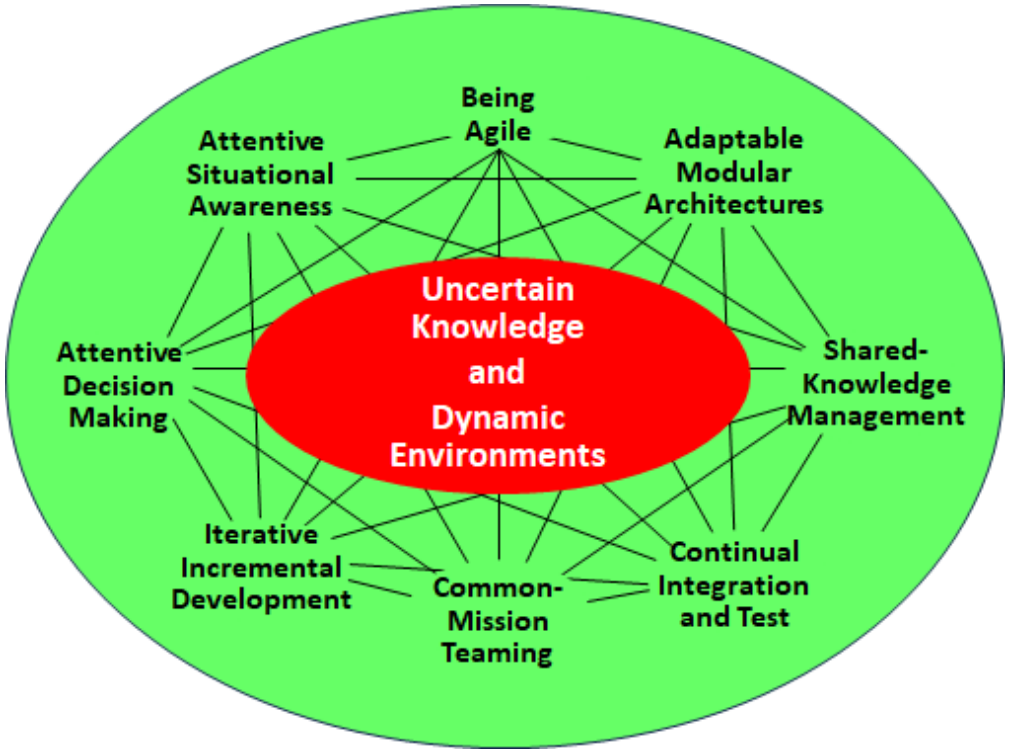
Being Agile

Behavior Lense:

Sense-respond-evolve engagement with a dynamic environment

Conservation Lense:

Grace, efficiency, and effectiveness of situation-driven engagement

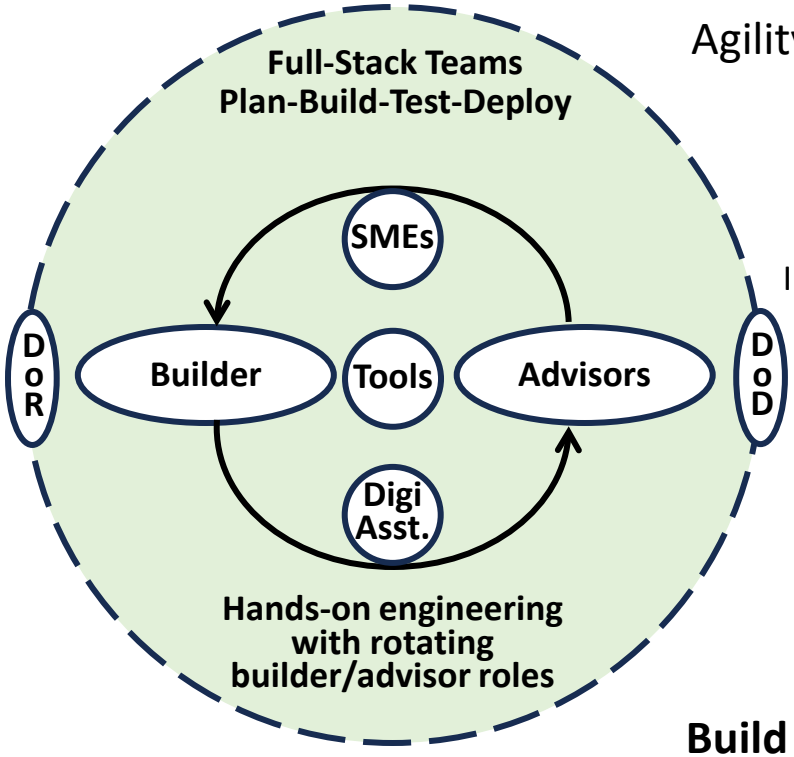


Agility emerges from sense-respond-evolve synergy among Aspects

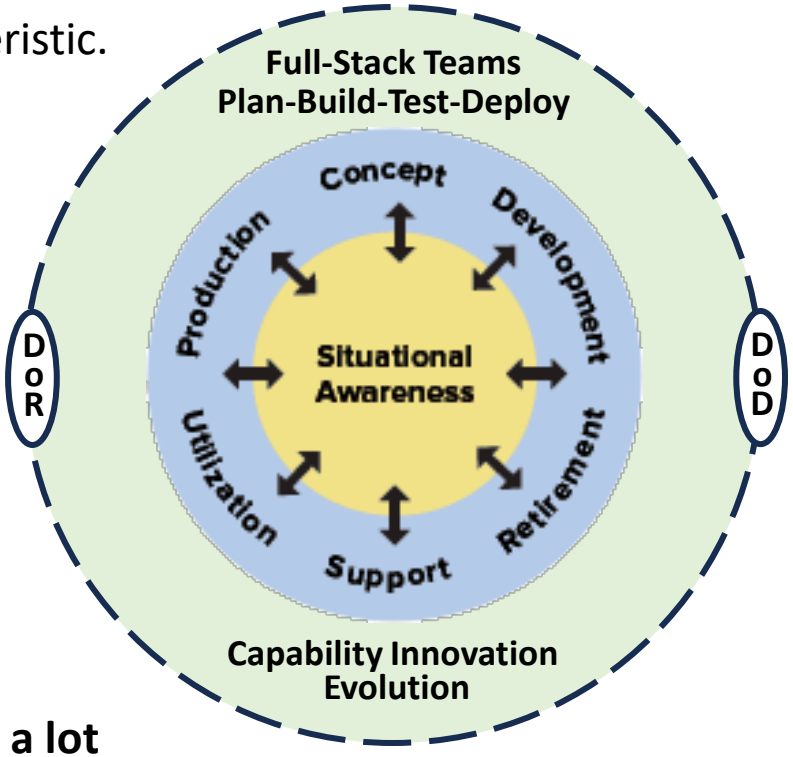
On Emergence

Group Experiential Engineering at Tesla

The driving mission is innovation.
Agility is an emergent characteristic.



IS25 Paper
Innovation Engineering at Tesla –
Agility as a Cultural Practice



Build a little, test a little, learn a lot
(Rear Admiral Wayne E. Meyer, USN)

Aspects are not overtly discernable as separable strategies,
but appear as a merged, overlapping, simultaneous way of working,
a holistic cultural behavior.

On Synergy

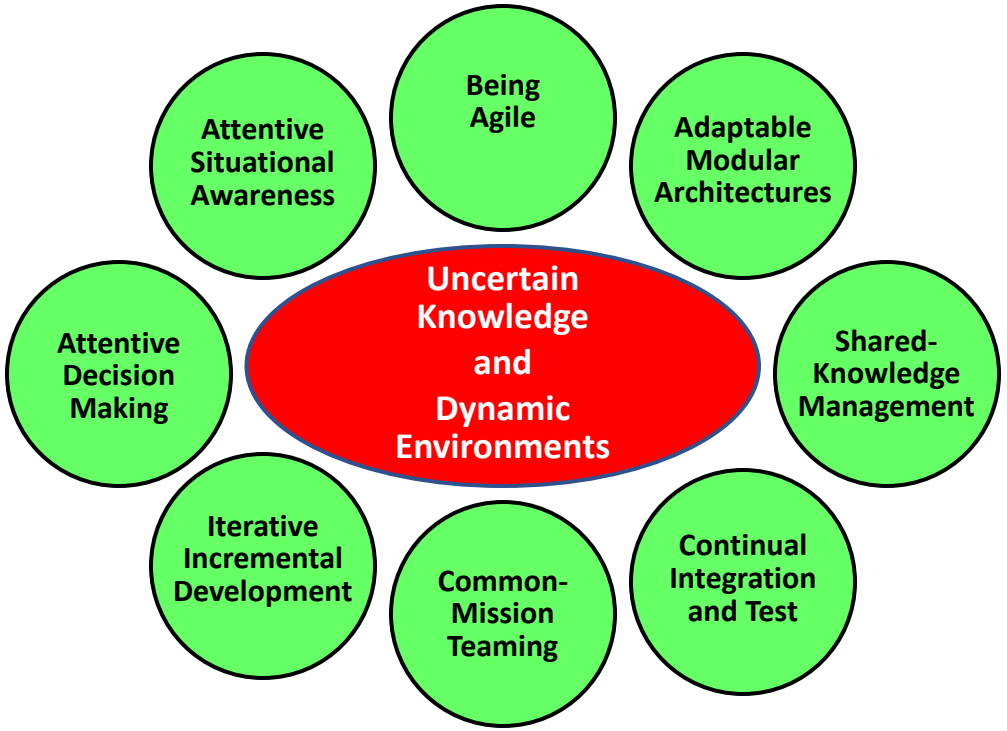
harmonious, cohesive, coherent

Chords of music are pleasing and comfortable
because of how the parts complement each other,

whereas discordant sounds
don't feel harmonious, cohesive, coherent.

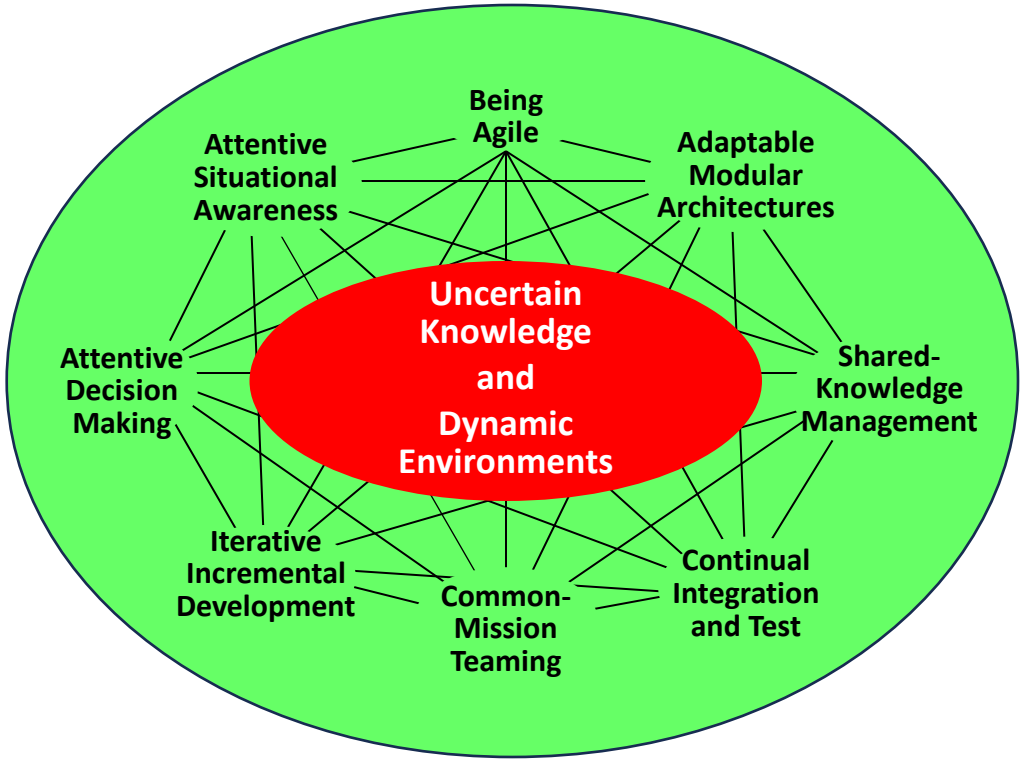
Agility (e.g., in dance and sword fighting) manifests as
grace, efficiency, and effectiveness
of engagement.

Agility is an Emergent Behavior of Synergistic Aspect Relationships



Reductionist (Structural) View

Characterizes an aspect's nature in isolation independent of its relationships.



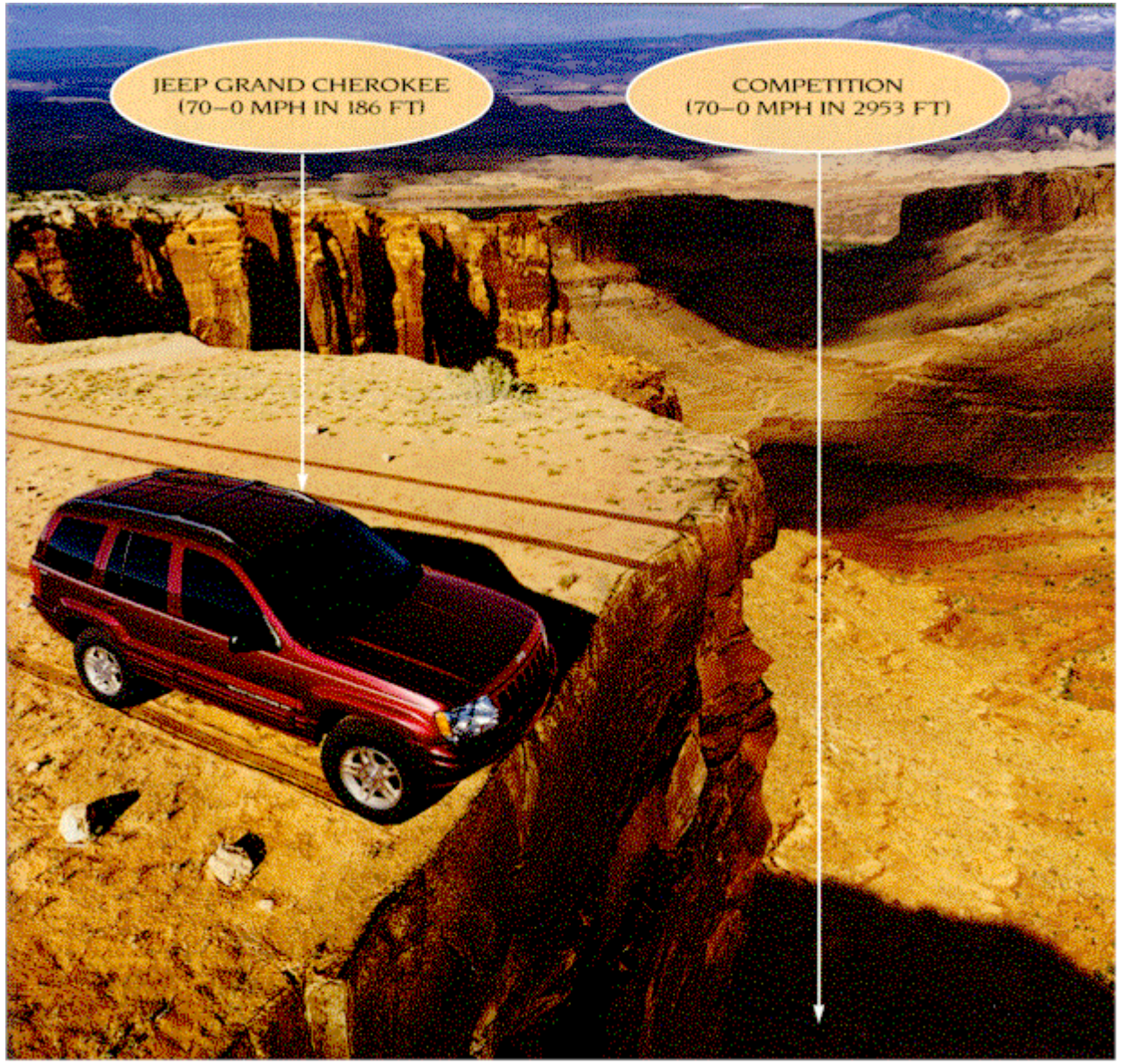
Holistic (Behavioral) View

A network of synergistic aspect relationships that manifest as holistic systemic behavior.

Bifocal Lenses

Aspect	Behavior Lense	Conservation Lense
Adaptable Modular Architectures	Composable and reconfigurable designs from evolving variations of reusable assets	Streamlines systems composition with reusable and modifiable parts
Iterative Incremental Development	Incremental loops of building, evaluating, correcting, and improving capabilities	Minimizes rework, maximizes quality, facilitates innovation
Attentive Situational Awareness	Active monitoring and evaluation of relevant internal and external environment factors	Reveals problems/opportunities that would consume more time and cost later
Attentive Decision Making	Systemic linkage of situational awareness to decisive action	Optimizes decision timing to minimize no-return expenditures
Common-Mission Teaming	Engaged collaboration, cooperation, and teaming among all relevant stakeholders	Minimizes counter productive effort by aligning teamwork
Shared-Knowledge Management	Integrated test and demonstration of work-in-process	Minimizes incompatible effort and facilitates implementation synergy
Continual Integration & Test	Facilitated communication, collaboration, and knowledge curation	Minimizes cost and effort to mitigate integration issues
Being Agile	Sense-respond-evolve engagement with a dynamic environment	Grace, efficiency, and effectiveness of situation-driven engagement

Inertia – The Bane of Agility



Implications

Grace, efficiency, effectiveness.

Conservation of resources
is an operating objective & metric of being agile.

A metric to evaluate and improve strategic aspects independently.

A metric to evaluate and improve synergy & balance among Aspects.

Not an end – a means.