Proposed Unified “ility” Definition Framework

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Motivation

- Increased interest in system “ilities”
- Lack of common understanding among practitioners
  - Definitions
  - Relationships between one ility and another
  - Metrics
- Objective: Provide a framework to promote shared discussion of system “ilities”

What are system "ilities"?

- -ility
  - Latin: a suffix; meaning, ability, ability to [do something]
  - In systems engineering "ilities" are desired system properties

- "ilities" describe the system (non-functional) rather than specific system behaviors (functional)
  - Functional requirements define **what** a system is supposed to do; e.g. Performance
  - Non-functional requirements define **how** a system is supposed to be.

Some examples?

- Accessibility
- Accountability
- Adaptability
- Administrability
- Affordability
- Auditability
- Availability
- Credibility
- Compatibility
- Configurability
- Correctness
- Customizability
- Debugability
- Degradability
- Determinability
- Demonstrability
- Dependability
- Deployability
- Distributability
- Durability
- Effectiveness
- Evolvability
- Extensibility
- Fidelity
- Flexibility
- Installability
- Integrity
- Interchangeability
- Interoperability
- Learnability
- Maintainability
- Manageability
- Mobility
- Modifiability
- Modularity
- Operability
- Portability
- Predictability
- Provability
- Recoverability
- Reliability
- Repeatability
- Reproducibility
- Resilience
- Responsiveness
- Reusability
- Robustness
- Safety
- Scalability
- Sustainability
- Serviceability (a.k.a. supportability)
- Securability
- Simplicity
- Stability
- Survivability
- Sustainability
- Tailorability
- Testability
- Timeliness
- Traceability
- Ubiquity
- Understandability
- Upgradability
- Usability
- Versatility

"List of system quality attributes" – Wikipedia, May 2012

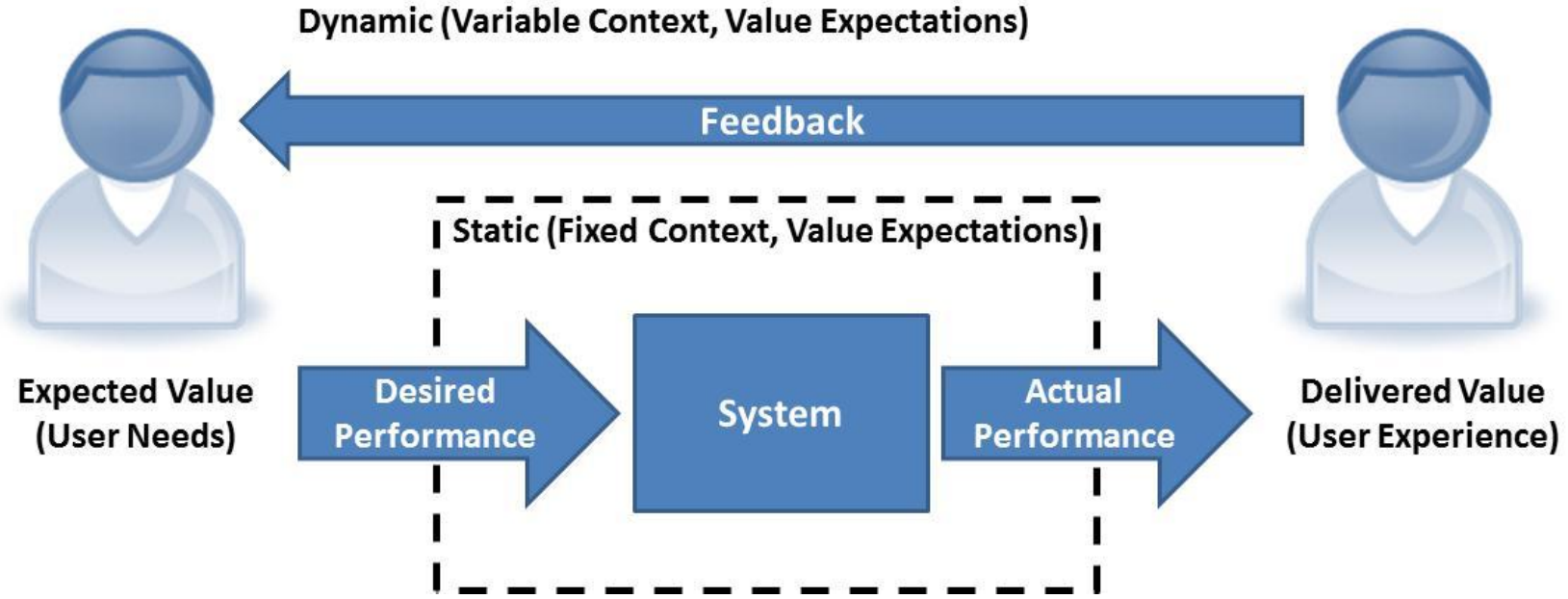
Examples of "ilities" within the DoD

- Safety, Reliability, Availability, Maintainability, Testability (Traditional Systems Engineering)
- Interoperability (Net-Centric Warfare)
- Scalability / Extensibility (Software Design)
- Survivability (Military Platforms: Aircraft, Maritime, Ground)
- Resiliency (Space Systems, Cyber)
  - Engineering Resilient Systems OSD(SE) initiative
- Flexibility (DARPA F6)
- Adaptability (Defense Science Board 2010 Report, DARPA AVM/ META)
- Affordability (Defense Acquisitions)
  - USD/AT&L 2010 Better Buying Power memo " Affordability as a requirement"
- Sustainability (Supply Chain, Industrial Base, Work Force)

Common element: Uncertainty

In system engineering, uncertainties occur in performance & value expectations

- Performance: Variance between actual and desired system performance resulting from uncertainty within contexts (e.g. design, production, operations, etc.)
- Value: Variance in "expected value" resulting from feedback of delivered value, resulting from changing context, stakeholders, needs, etc.



- "ilities" account for a system's ability to **change / react** to uncertainty

Figure adapted from: Ross, A.M., and Rhodes, D.H., "Using Natural Value-centric Time Scales for Conceptualizing System Timelines through Epoch-Era Analysis," INCOSE International Symposium 2008, Utrecht, the Netherlands, June 2008

Designing for Uncertainty

- System "changeability" taxonomy (Ross et al.) provides start for defining system ilities
  - Change Agent
  - Change Effect
  - Change Objective
  - Change Enablers
  - Change Considerations

Ross, A.M., Rhodes, D.H., and Hastings, D.E., "Defining Changeability: Reconciling Flexibility, Adaptability, Scalability, Modifiability, and Robustness for Maintaining Lifecycle Value," *Systems Engineering*, Vol. 11, No. 3, pp. 246-262, Fall 2008.

Change Agents

- Instigator, or force, which employs a given change mechanism in order to achieve a desired change effect

- **Two approaches to choosing a change agent**
  - **Internal:** System self-imposed change (Adaptability)
    - Associated with upfront / current decisions to respond to change (i.e. Pre-planned / Baked – in)
    - Commonly used to address known - knowns
  - **External:** Decision-maker imposed change (Flexibility)
    - Associated with future / delayed decisions to respond to change (i.e. Real options)
    - Used to address known - knowns & known - unknowns

Change Effect

- The difference in system states (performance or value) before and after a change has taken place

- Three choices of change effects
  - Expandability(Do More / Less)
    - Ross et al. references scalability, but expandability used to de-conflict w/ more common scalability definitions
  - Modifiability (Add, Remove, Alter)
  - Robustness (No Change)

Change Objectives

- The specific approach / plan / goal / strategies employed to achieve a desired change effect
  - Objectives enabled by change enablers and must account for change considerations
  - Think of these as common “ility” families.

		Performance Objectives (Static)	Value Objectives (Dynamic)

Change Effect	**Robustness**	Quality (Assurance and control)
		• Safety
		• Reliability
		• Availability
		• Maintainability
		• Testability
			Resiliency
			• Awareness
			• Survivability
			  • Susceptibility
			  • Vulnerability
			  • Recoverability

	Expandability	Scalability	Extensibility
	Modifiability	Configurability	Evolvability

Change Enablers

- Change enablers (e.g. design elements) enable desired objective
  - "How" is the system is designed to change
  - Any one, or combination of, enablers can satisfy an objective
  - Any enabler can satisfy one or more objectives

Change Enablers	• Accessibility • Compatibility • Commonality • Distributability • Durability • Homogeneity • Heterogeneity • Interchangeability • Interoperability	• Mobility • Modularity • Portability • Repairability • Reusability • Serviceability (a.k.a. supportability) • Understandability • Usability / operability

Change Considerations

- Design considerations (e.g. conditions, resources, constraints, etc.) applied to design / operational approaches

  - **Affordability** (Budget)
  - **Sustainability** (Resources)
  - **Agility / Responsiveness** (Schedule / Response time)
  - **Manufacturability** (Technology)
  - **Manageability** (Organizational)

Proposed "ility" Framework

Change Agents		Flexibility (External)	Adaptability (Internal)
Change Effect		**Performance Change Objectives**	**Value Change Objectives**
	Robustness	Quality (Assurance and control) • Safety • Reliability • Availability • Maintainability • Testability	Resiliency • Awareness • Susceptibility • Vulnerability • Recoverability
	Expandability	Scalability	Extensibility
	Modifiability	Configurability	Evolvability
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Change Considerations		• Affordability • Sustainability	• Agility / Responsiveness • Manufacturability

Questions?