Air Force Research Laboratory

Integrity ★ Service ★ Excellence

Limitations of Readiness Levels

Date: 26 October 2011

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Overview

- What they are (and are not)
- What they're good for (and not good for)
- Ways to determine readiness levels
- Application issues
- Emerging solutions

Readiness Levels

- **Give snapshot of a technology's maturity at a given instant**
- **Provide a quick description of the current state of a technology**
  - **At its most basic, it is defined at a given point in time by what has been done and under what conditions. ***
- **Provide a common reference point among technology developers, system integrators and users**

Ref: W. L. Nolte, Did I Ever Tell You about the Whale? or Measuring Technology Maturity, 2008
** J.W. Bilbro, "Impact of Technology Maturity on Programs & Projects" 2007*

What they are not

- **Predictive tools**
- **Metric for Program risk**
- **Metric for Program health**
- **Complete measure of System Readiness**

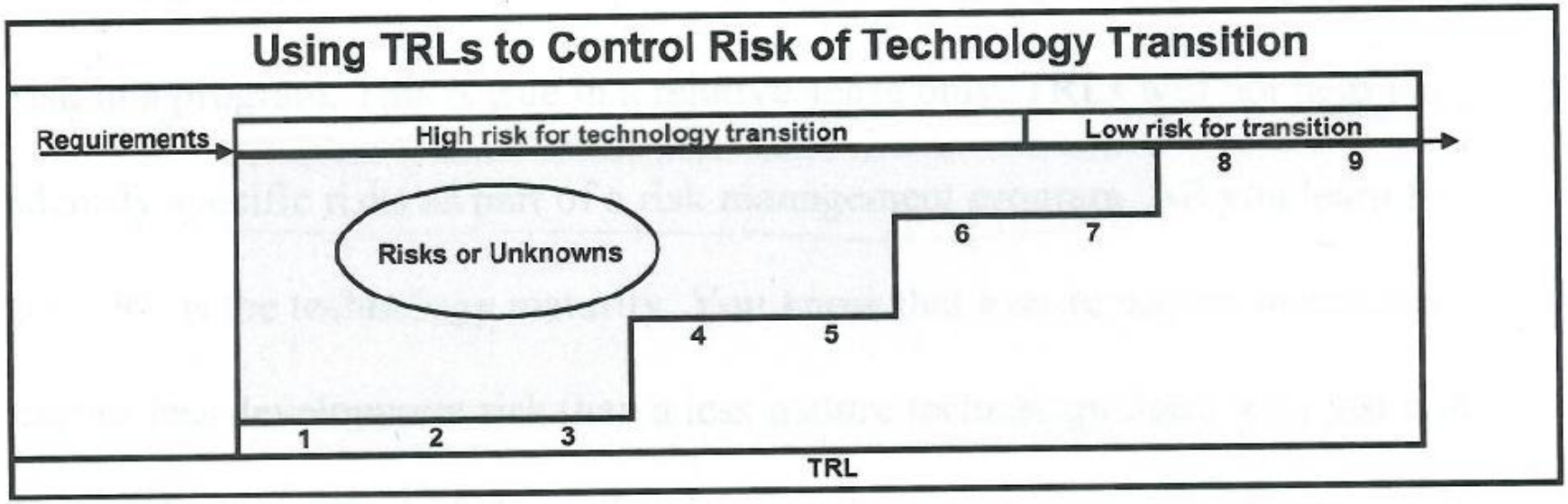
Ref: W. L. Nolte, Did I Ever Tell You about the Whale? or Measuring Technology Maturity, 2008

What they're good for

- **Useful for benchmarking maturity**
- **Milestones and Exit Criteria**
  - **Certification for Milestone B (Statutory Reqt)**
  - **Indication of how much maturation work has been completed**
  - **Indication of how much maturation work is remaining**
- **Avoid misunderstandings and ambiguities in the technology transition process**
- **Can be an indicator of a program's risk**

Ref: W. L. Nolte, Did I Ever Tell You about the Whale? or Measuring Technology Maturity, 2008

TRL as a Measure of Program Risk



Adapted from 1999 GAO Report GAO/NSIAD-99-162 "Better Management of Technology Development Can Improve Weapon System Outcomes"

Ref: W. L. Nolte, Did I Ever Tell You about the Whale? or Measuring Technology Maturity, 2008

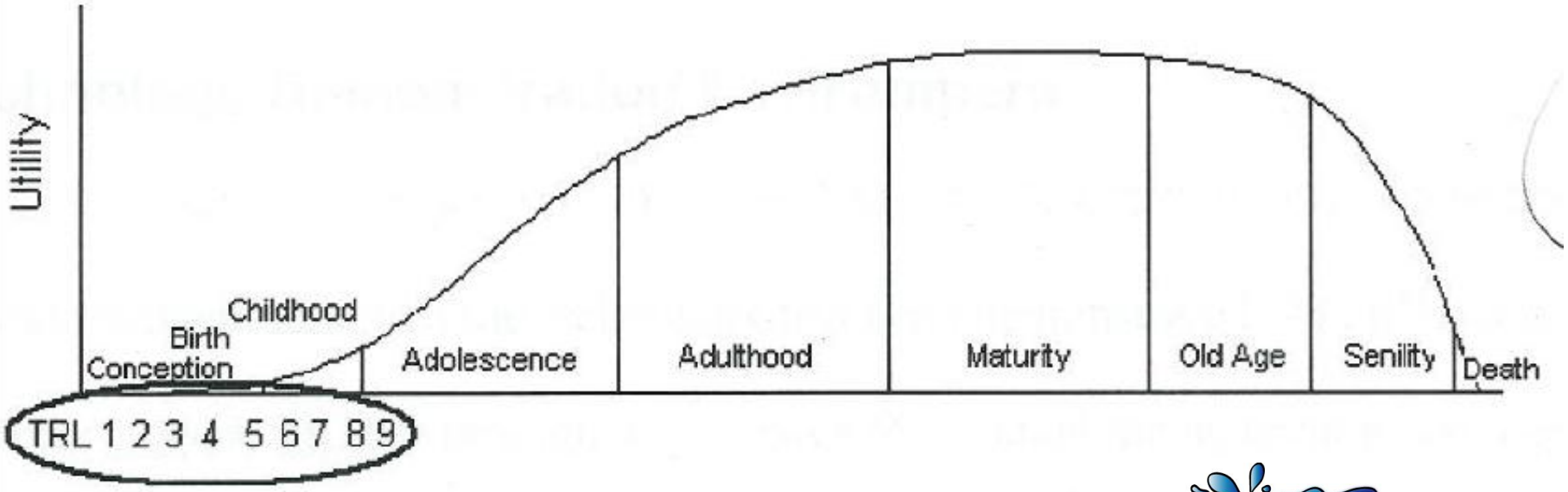
What they're not good for

- **Measures only part of multi-dimensional Readiness state**
- **Predictive value is low**
  - **Lack info on how difficult it will be to achieve the next level of Readiness**
  - **Can not determine the coming obsolescence of a particular technology**
- **No specific program risks, only general ones**
  - **A readiness-level type approach aggregates issues together too much and you lose insight to the problem***

** Ref: Jim Thompson, "Integration Risk Assessment," 13th NDIA SE Conference)*

Ref: W. L. Nolte, Did I Ever Tell You about the Whale? or Measuring Technology Maturity, 2008

Technology Life Cycle with TRLs (Not Acquisition Life Cycle)



Like most Readiness Levels, TRLs occur early in the technology life cycle

Ref: W. L. Nolte, Did I Ever Tell You about the Whale? or Measuring Technology Maturity, 2008

Ways to Determine Readiness Levels

- **Applying given definitions**
  - **e. g. DoD TRA Deskbook**
- **Looking at demonstration environment**
- **Producing supporting information**
- **Using a special purpose software tool, if available**

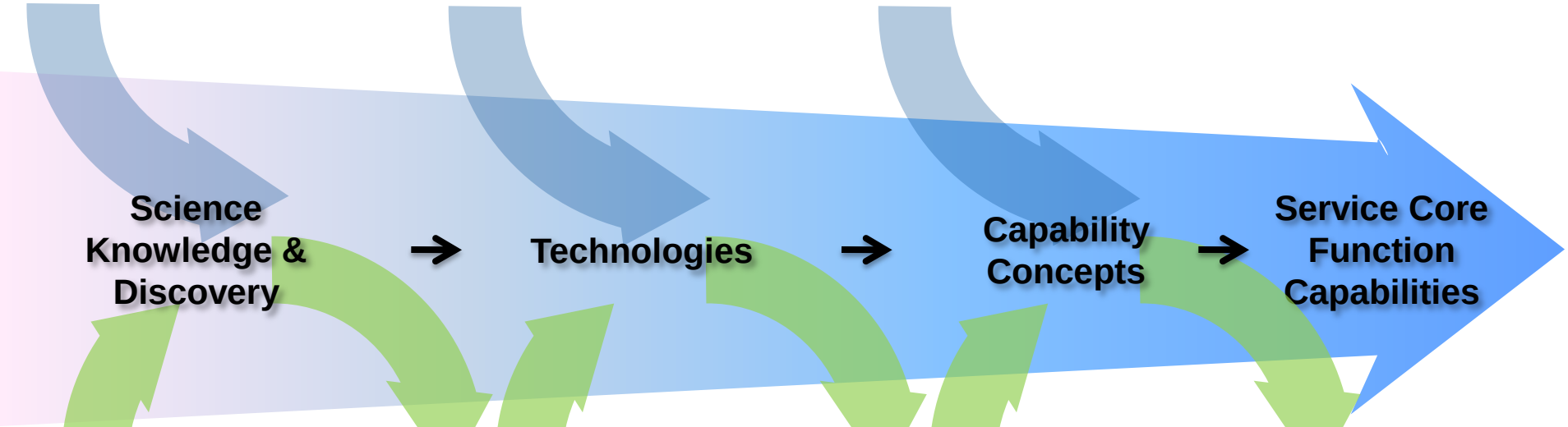
- **Random number generator**
  NOT RECOMMENDED!

Application issues

- Tend to over estimate technology maturity
- Identification of proper system granularity and critical system elements for Readiness Level evaluation
- Readiness levels can be variables that depend on capability requirements
- Contractual requirement for readiness level assessment is afterthought
- Availability of proprietary documentation that supports Readiness Level assessment
- Missing essential steps in developing and maturing System Readiness Level
- Multi-dimensional nature of System Readiness

Turning Science Into Capability

Air Force Strategy
Technology Horizons + **Center Needs** + **MAJCOM Needs**



Outputs:
- New technologies
- "The realm of the possible…"
- Tech Transfer/Tech Transition

Outputs:
- Mature Technologies
- New Capability Concepts
- Tech Transfer/Tech Transition

Outputs:
- Mature Capability Concepts
- Tech Transfer/Tech Transition

TRL 1-3 **TRL 4-5** **TRL 6-7** **TRL 8-9**

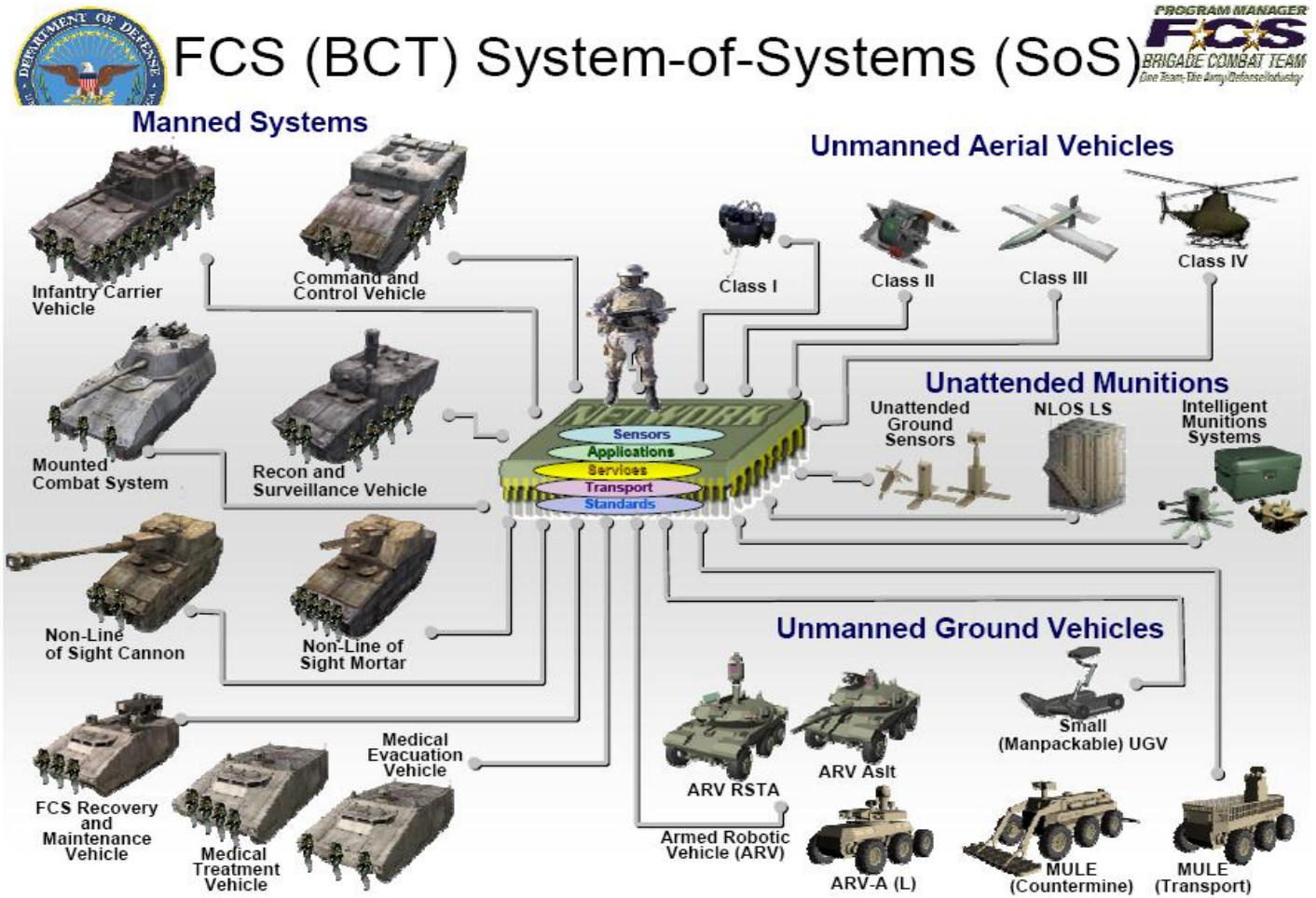
Critical Technology Element (CTE) Defined

A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements (within acceptable cost and schedule limits) and if the technology element or its application is either new or novel or in an area that poses major technological risk during detailed design or demonstration.

CTEs may be hardware or software at the subsystem or component level

Ref: DoD Technology Readiness Assessment (TRA) Deskbook, July 2009

System of Systems Example



Ref: K. Baldwin, "Defense View on Considerations for Systems of Systems SE," 2006

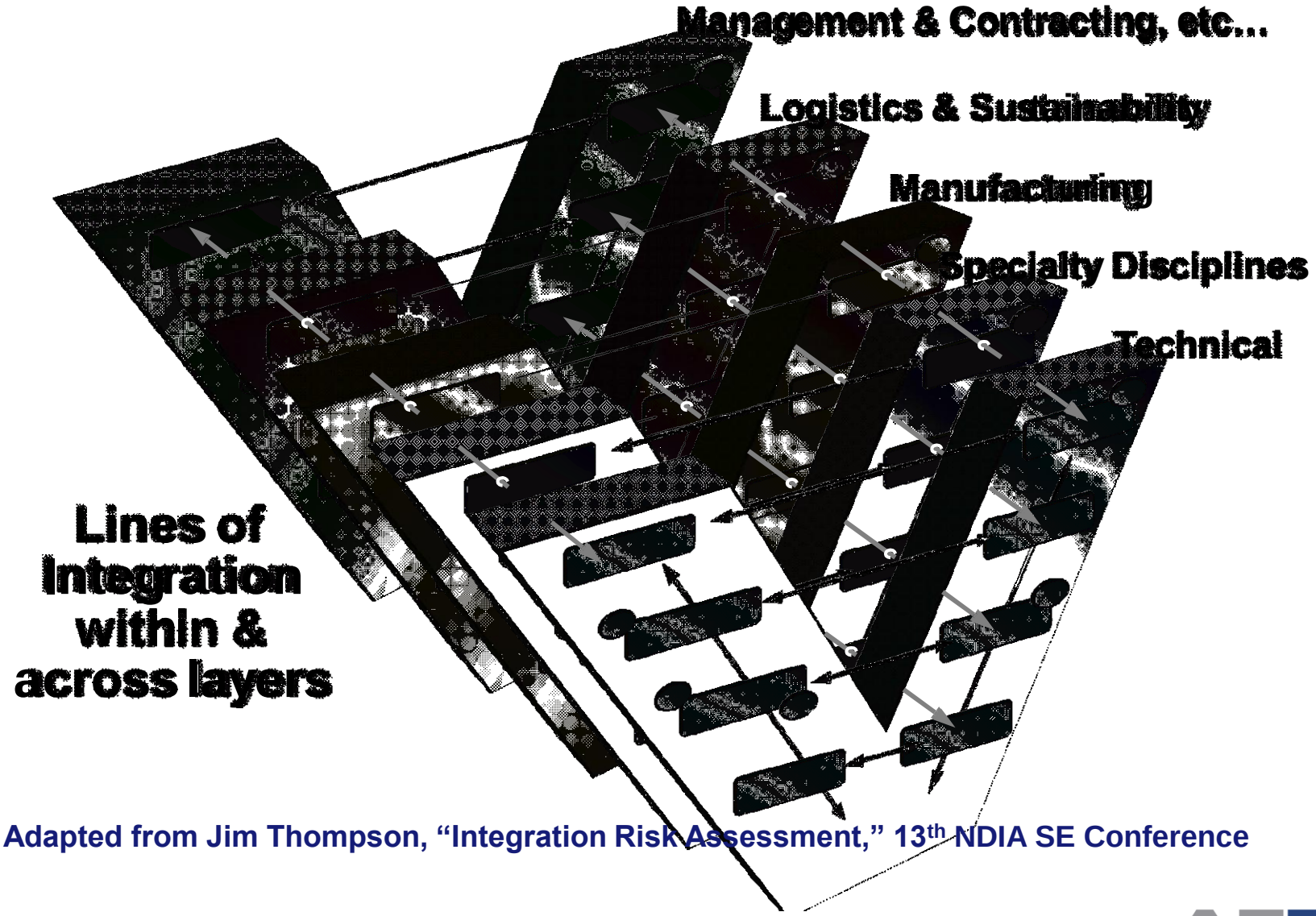
TRL Calculator Questions provide checklist for essential Readiness steps

TRL 6 (Check all that apply or use sliders)	
B	Cross technology issue measurement and performance characteristic validations completed
H	Quality and reliability levels established
B	Frequent design changes occur
H	Draft design drawings are nearly complete
B	Operating environment for eventual system known
B	Collection of actual maintainability, reliability, and supportability data has been started
B	Design to cost goals identified
H	Investment needs for process and tooling determined
B	M&S used to simulate system performance in an operational environment
B	Final Test & Evaluation Master Plan (TEMP)
H	Factory acceptance testing of laboratory system in laboratory setting
B	Representative model / prototype tested in high-fidelity lab / simulated operational environment
B	Realistic environment outside the lab, but not the eventual operating environment

TRL Calculator Version 2.2 Available at:

http://www.afit.edu/cse/page.cfm?page=164&sub=95

Multi-dimensional nature of System Readiness



Adapted from Jim Thompson, "Integration Risk Assessment," 13th NDIA SE Conference

Multi-dimensional nature of System Readiness / Emerging Solutions

- **Other Uses of Readiness Levels**
  - ***Looking at the Full Picture: Evaluating Alternatives with the Execution Risk Assessment Framework (Robert Henry, MITRE Corp)***
  - ***Adopting a Stage-Gated Technology Development and Maturity Assessment Methodology Leading to Improved Technology Transition (Jeff Craver, DAU)***
  - Lessons Learned In Performing Technology Maturity Assessment For A milestone B Review of An Acquisition Category Vehicle Program (Jerome Tzau, Army TARDEC)

Emerging Solutions for Multi-dimensional nature of Readiness

- **New and improved Readiness Levels**
  - Readiness Level Proliferation (Bill Nolte, AFRL)
  - Manufacturing Readiness Levels: An essential SE tool to identify and manage manufacturing risk for affordability (Dr Tom Christian, AF Center for Systems Engineering)
  - Vector-Based Metrics for Assessing Technology Maturity (Dr Gerald Sleefe, Sandia Nat'l Lab)
  - Update to ISO TRL Standard (Jim Bilbro, JB Consulting Intl)
- **Measuring Readiness**
  - Lean Systems Engineering Metrics (Tim Olson, Lean Solns Inst)
  - Why Affordability Is A Systems Engineering Metric (Quentin Redman, Price Systems)
  - Systems Engineering and the Forgotten "-illities" (James Willis, SPEC Innovations)