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Resilience Week
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Incorporating Human Readiness Levels at Sandia National Laboratories

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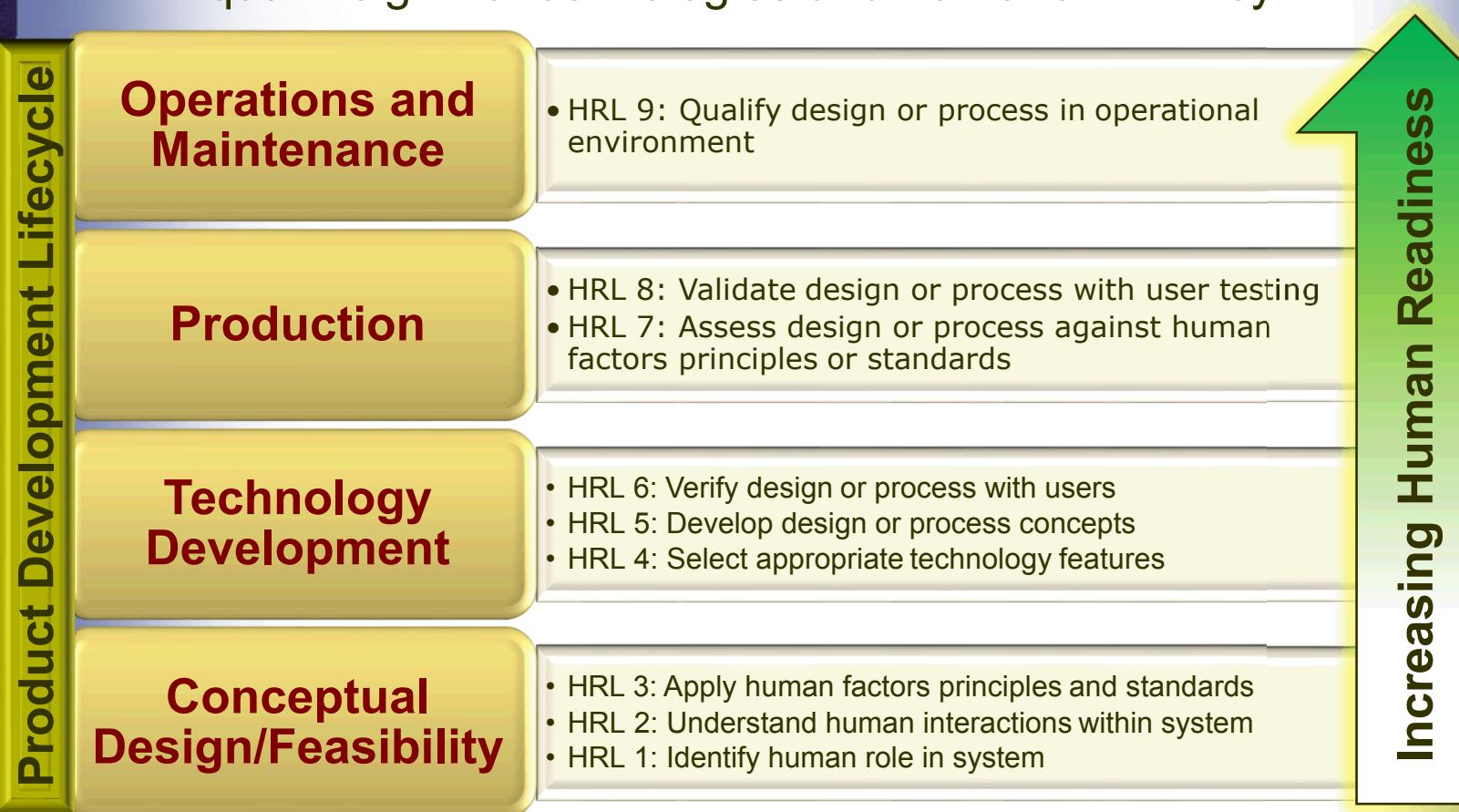


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- Sandia National Laboratories systems engineering approach for product development is technology-centric
 - Technology readiness level (TRL) scale focuses on technical maturity
 - TRL scale does not address whether the technology is ready for people to use
- Mechanisms to ensure a balanced approach that includes the human component are missing:
 - Early in product development
 - Throughout the product lifecycle
 - Systematically across programs
- Sandia initiated a study in 2015 to identify options to address this issue

HRL Scale Mirrors TRL Scale

- DOD has been working on “Human Readiness Levels” (HRL) since 2010 to supplement existing TRL scale
 - Is the technology ready for human use?
 - Equal weight to technologies *and* humans within system



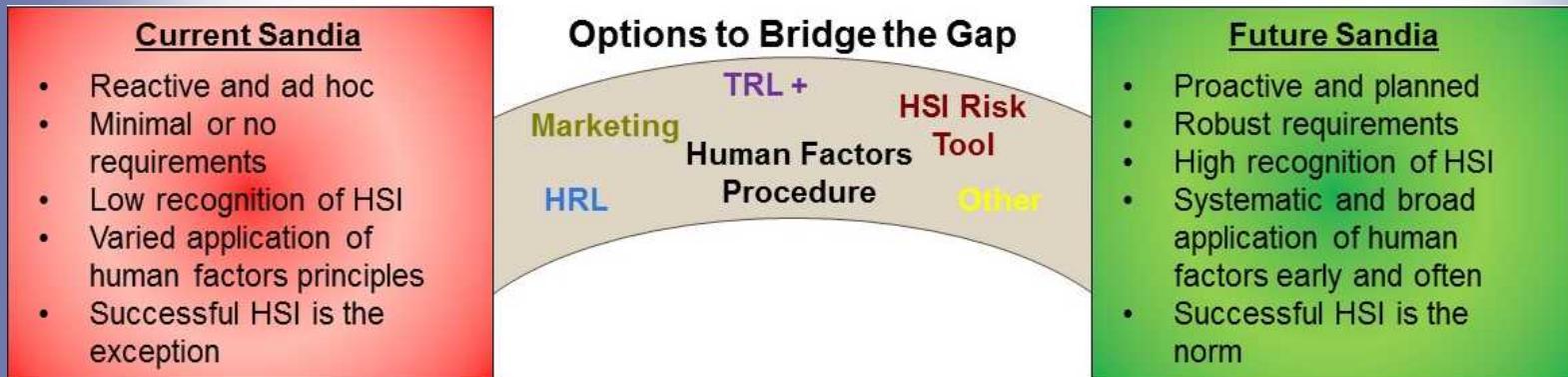
- Human readiness focuses on how humans interact with technical components
 - What are the human roles in the intended applications? Inspector? Monitor? Maintainer?
 - Do technology features account for human capabilities and limitations? Can people see the display?
- Neglecting human readiness means system failures will occur due to humans—largest error-making component in a system
 - People normally make 3 to 7 errors/hour; up to 15 errors/hour in unusual conditions—3 million to 15 million errors per million hours
 - By comparison, toggle switches fail once per million hours
- Example: U.S. Army Stinger missile system at TRL 9
 - Designed to support a .6 probability of kill
 - Actual probability of kill (with operators in the loop) was .3
 - Designers assumed human performance would be perfect

Stinger issues could have been addressed early by expanding “system probability of kill” beyond strictly mechanical components to include “human readiness.”

- Capitalize on previous DOD research
- Identify optimal approaches to incorporate human readiness planning for Sandia process and products
- Baseline current product development approaches
- Gauge staff views of various options to prompt human readiness assessments
- Identify guidance to facilitate consistent human systems integration (HSI)
- Conduct test case(s) to assess viability of identified option(s)

Possible Options for Sandia

Plan for the Human Element throughout Lifecycle



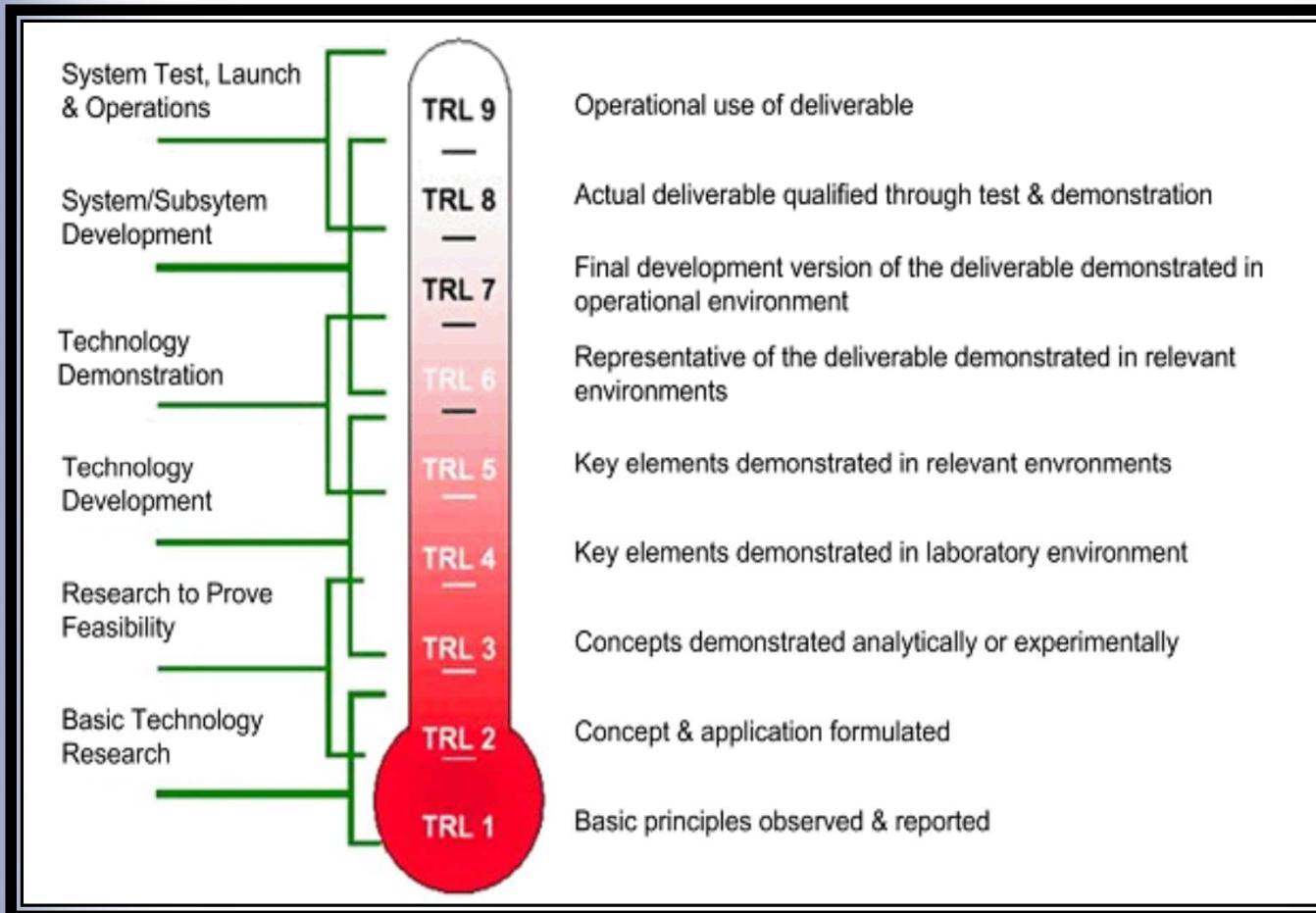
Option	Description
TRL+	Redefine "technology maturity" in existing TRL scale to include maturity for human use and add considerations relevant to maturity for human use to existing TRL exit criteria
HRL	Add separate HRL scale to supplement existing TRL scale during design
HSI Risk Tool	Add tool to characterize HSI risks, consequences, and mitigations early in design
Human Factors Procedure	Develop procedure to incorporate human component during product realization; add references to the human factors procedure in existing product realization procedures
Marketing	Plan and launch a campaign to market Sandia Human Factors Department
Other	Identify alternative approaches through staff and manager discussions

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Backup Slides

- Technology readiness levels (TRL) are a widely accepted metric to assess technology maturity
 - Nine levels of technology maturity provide a common tool to communicate maturity
 - Facilitate consistent assessments within and across different technologies
 - Support program risk assessments
 - Used throughout the DOD and other government agencies
- TRL scale focuses on technical maturity
- TRL scale does not address whether the technology is ready for people to use

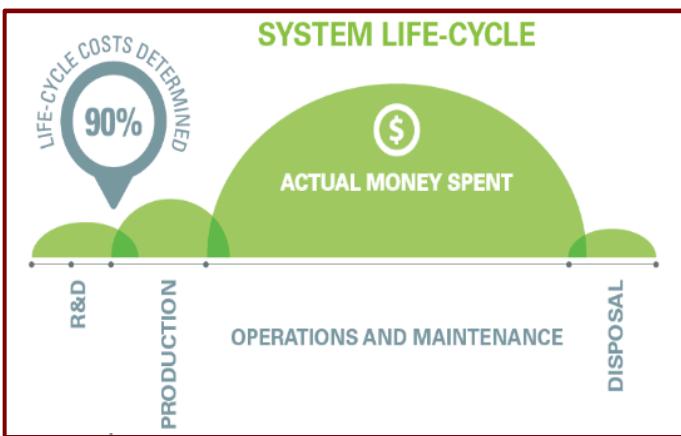
TRL Scale at Sandia



- DOD has been working on the concept of “Human Readiness Levels” (HRL) since 2010
 - Possible supplement to existing TRL scale to balance current systems engineering approaches
 - Is the technology ready for human use?
 - Have features necessary for usability and operator effectiveness been engineered into the design?
 - Equal weight to technologies *and* humans within system
- Key researchers
 - Dr. Hector Acosta, 711th Human Performance Wing
 - Maj Erik Phillips (2010), Naval Postgraduate School
 - Dr. Mica Endsley (2014), former Chief Scientist of the Air Force
 - Michael O’Neil (2014), Naval Postgraduate School

- TRL 3: Concepts demonstrated analytically or experimentally
 - Identify intended applications
 - Develop analytical models or lab prototypes to demonstrate proof-of-concept
- TRL 3 activities focus on advancing the maturity of technical components of the system
- Addressing human readiness focuses on how humans interact with technical components
 - What are the human roles in the intended applications? Inspector? Monitor? Maintainer?
 - Do features of the lab prototype account for human capabilities and limitations? Can people see the display? Can the range of intended users reach knobs and dials?

- Mitigate program risk, improve system performance (minimize human error), and reduce lifecycle costs
- Address the largest error-generating component in the system early and often to minimize system failures
- Address human readiness early to reduce total lifecycle costs
 - 90% of lifecycle costs are determined by the end of R&D—at a point when the human element has not typically been considered
 - Large portion of O&M funds are spent to correct human error issues—identifiable only *after* the system is developed under current approaches



- Early HRL iterations focused on *what* should be done, but not how or to what criterion
- HRL scale has not been formally adopted anywhere
- DOD feedback suggests reluctance to introduce *another* readiness scale
- Current DOD efforts are moving away from a separate HRL scale, while still retaining critical concepts embedded in HRL scale
 - Focusing on performance- and risk-based assessments
 - Risk tool to facilitate communication of human readiness program risks, consequences, and mitigations

HRL References

Endsley, M. (2014). *Human system integration: Challenges and opportunities*. PowerPoint slides retrieved from <http://www.acq.osd.mil>

O'Neil, M. P. (2014). *Development of a human systems integration framework for Coast Guard acquisition* (Unpublished master's thesis). Naval Postgraduate School: Monterey, California.

Phillips, E. L. (2010). *The development and initial evaluation of the human readiness level framework* (Unpublished master's thesis). Naval Postgraduate School: Monterey, California.