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Resilience Week

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Incorporating Human Readiness Levels at Sandia National Laboratories

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Sandia National Laboratories

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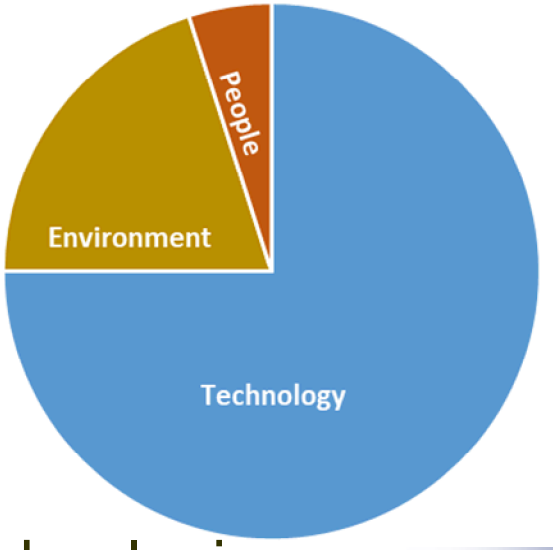
Problem Statement

- SNL systems engineering approach is technology-centric
  - Technology readiness level (TRL) scale focuses on technical maturity
  - TRL scale does not address readiness for human use

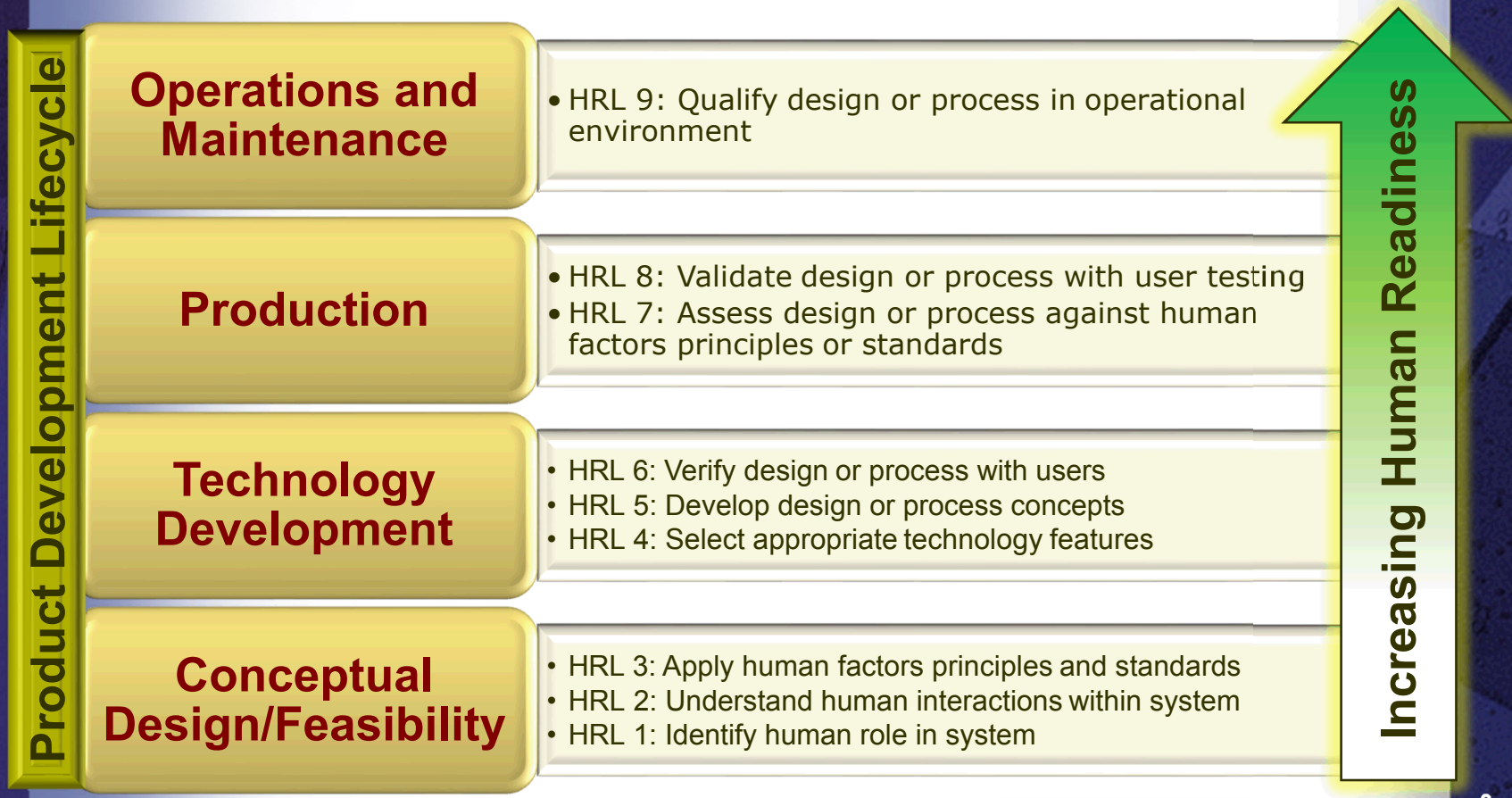


- Mechanisms to equally weight technologies, environment, *and* people are missing:
  - Early in product development
  - Throughout the product lifecycle
  - Systematically across programs

- Study began in 2015 to identify options to incorporate human readiness planning for SNL process and products

HRL Scale Mirrors TRL Scale

- DOD 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



Understanding "Human Readiness"

- Human readiness focuses on how humans interact with technical components
  - What are the human roles in the intended applications?
  - Do technology features account for human capabilities and limitations?

- Neglecting human readiness increases likelihood of system failures due to humans in the system

Makes 3 to 7 errors/hour normally

Up to 15 in unusual situations

Fails once per million hours

U.S. Army Stinger Missile: Issues could have been prevented in design by including "human readiness" concepts

- Actual kill probability less than designed probability
- Assumed perfect human performance

Sandia Study Methodology

- Conducted 24 interviews with 26 individuals
  - Establish current baseline approach
  - Identify views on utility of various options
- Diverse sample of designers and developers
  - **Time at Sandia:** 2 to 55 years (*M* = 18, *SD* = 12)
  - **Age:** 29 to 77 years (*M* = 48, *SD* = 11)

Managers	5
Staff	19

Highest Degree	N
Doctorate	9
Masters	14
Other	1

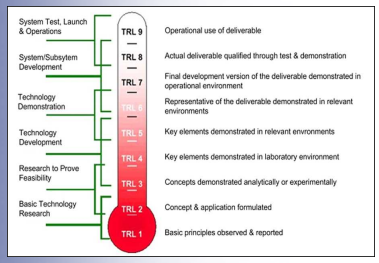
Systems	12
Components	7
Support	5

Possible Options for Sandia

HRL	Description
9	Qualify process in operational environment
8	Validate system integration with user testing
7	Assess process with human in the loop
6	Obtain process feedback from users
5	Develop process concepts
4	Evaluate technologies for human needs
3	Identify applicable human factors principles/guidelines
2	Understand how humans interact within the system
1	Identify human roles in the system

HRL Scale

Supplement TRL scale with separate human readiness scale



TRL+ Scale

Embed human readiness criteria in existing TRL scale

Overview

Sandia has responsibility to provide a balanced systems engineering approach. A balanced approach means that equal weight is afforded to all components of a system—technology, environment, and humans. This RPP identifies the process and requirements to generate human factors products that will support full consideration of the human component of the system.

HF Procedure

Describe HF product realization in stand-alone procedure

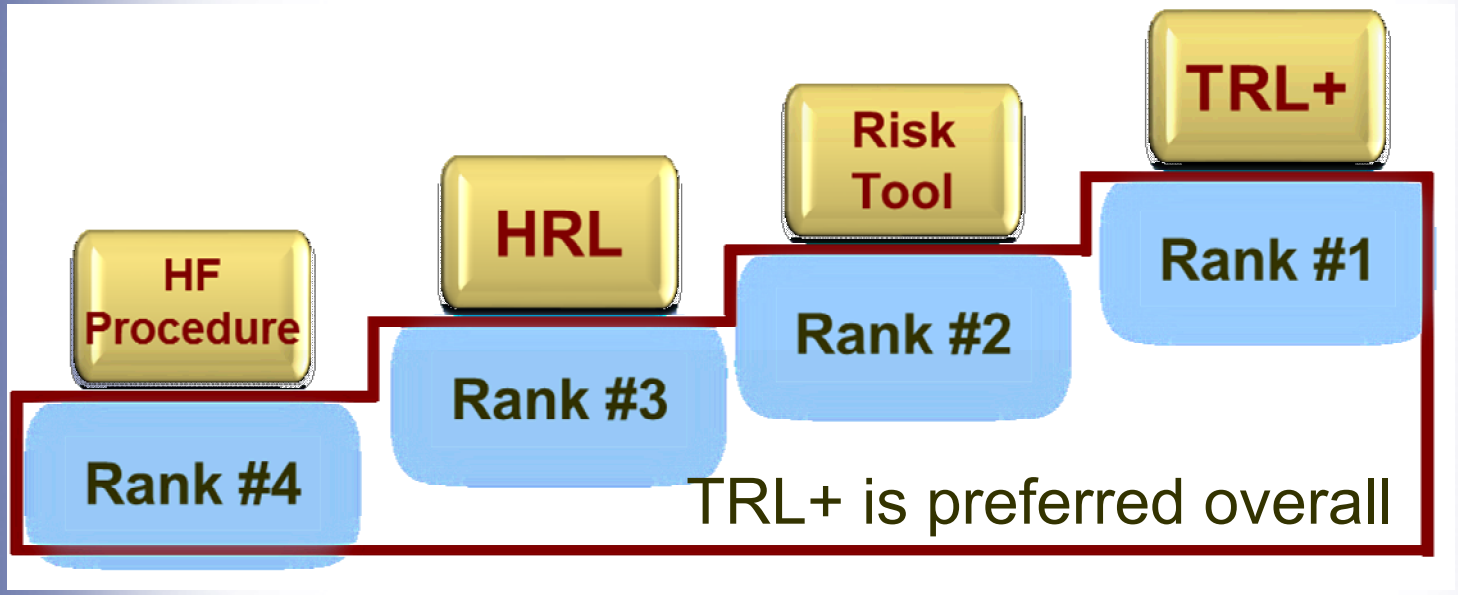
Likelihood \ Impact	Negligible	Minor	Moderate	Significant	Severe
Very Likely	Low Med	Medium	Med Hi	High	High
Likely	Low	Low Med	Medium	Med Hi	High
Possible	Low	Low Med	Medium	Med Hi	Med Hi
Unlikely	Low	Low Med	Low Med	Medium	Med Hi
Very Unlikely	Low	Low	Low Med	Medium	Medium

Risk Tool

Communicate human element risks, consequences, mitigations

Option Rankings

- No clear winner across the board, but multiple analyses show TRL+ ranked #1 most often



- Support personnel and those at Sandia longer see more value in risk tool and less value in procedure
- Managers and younger employees see more value in procedure

Other Recommended Options

Conduct marketing to generate awareness of HF department

Identify high-level HF champion at Sandia

Coordinate with DOE/NNSA for top-level HF requirements

Include HF in required training

Integrate HF into multiple existing processes and documents

Caveats and Concerns

- TRLs are not used universally at Sandia
  - Embedding human readiness concepts in TRL scale could lead to non-use
  - Factors other than technical maturity drive TRLs
- Future applications of TRL+
  - Artificially links independent constructs
  - Lower level human readiness criteria will be missed for re-use hardware starting at higher TRLs
  - Embedding human readiness concepts in TRLs does not mean HF experts will be consulted
  - May be pushback to modify existing TRL scale

Proposed Path Forward

- Recommend graded approach
  - Start with low-cost easy-to-implement options
  - Generate awareness and support
  - Move toward end goal of comprehensive, systematic, and rigorous human readiness approach
- Conduct one or more test cases to refine approach

Level 0 Ad hoc	Level 1 Aware	Level 2 Guided	Level 3 Defined	Level 4 Rigorous
React: Manage HF ad hoc based on team member experience	Educate: Socialize value of HF across development lifecycle	Equip: Provide HF guidance for engineering staff	Integrate: Formalize and integrate HF into systems engineering process	Institutionalize: Incorporate HF into official DOE and NNSA requirements

- Unsystematic
- Inconsistent
- Reactive
- Hit or miss

- Integrated
- Formalized
- Trained
- Institutionalized

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