Human Readiness Levels in DOD Acquisition (Panel 17881)

Michael E. Miller, PhD

Associate Professor

Systems Integration

Michael E. Miller: (937) 2555-3636 x4651, michael.miller@afit.edu.

Why Readiness Metrics?

- Provide a repeatable, robust method for judging the development status of a technology (or service)
- Create mechanism for easily communicating development status
- Provide decision support tool for technology investment
- Add objectivity to technology investment during system development

- Provides assurance that a specific technology or system will be capable of satisfying mission objectives when fully qualified

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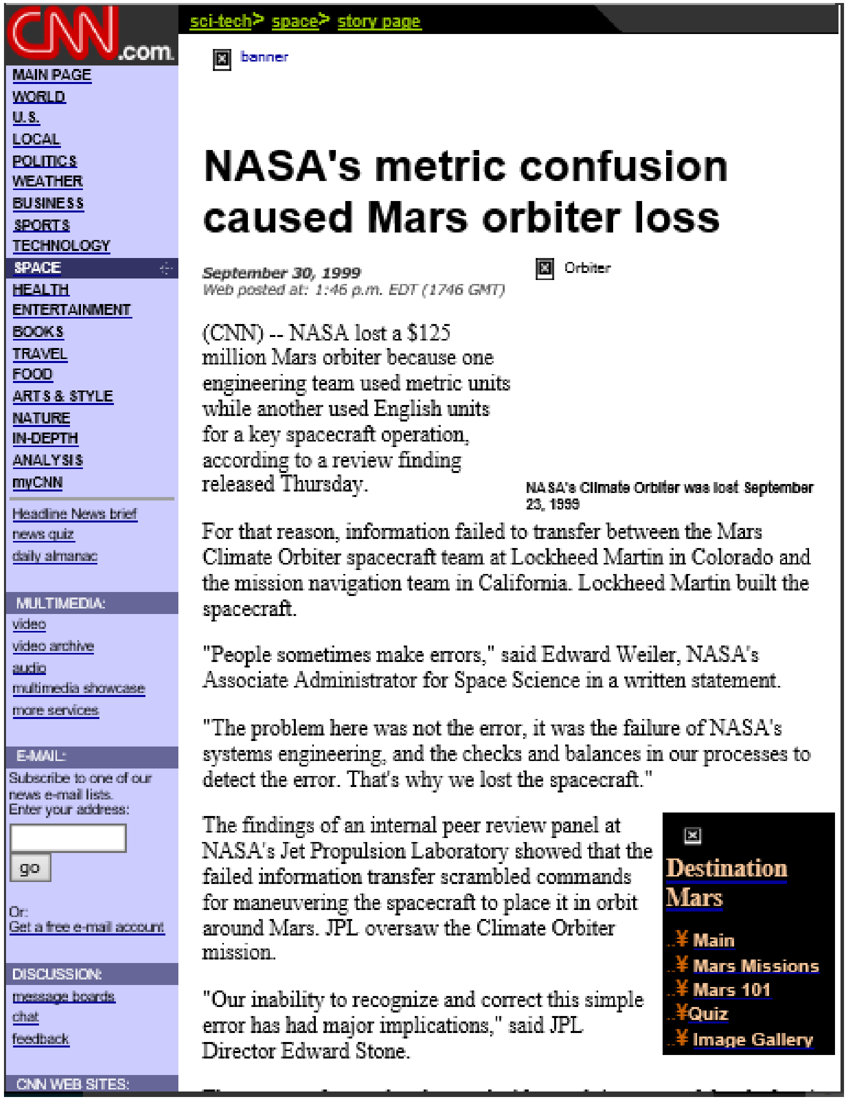
Are TRLs Complete?



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NASA's metric confusion caused Mars orbiter loss

September 30, 1999
Web posted at: 1:46 p.m. EDT (1746 GMT)

Orbiter

NASA's Climate Orbiter was lost September 23, 1999

(CNN) -- NASA lost a $125 million Mars orbiter because one engineering team used metric units while another used English units for a key spacecraft operation, according to a review finding released Thursday.

For that reason, information failed to transfer between the Mars Climate Orbiter spacecraft team at Lockheed Martin in Colorado and the mission navigation team in California. Lockheed Martin built the spacecraft.

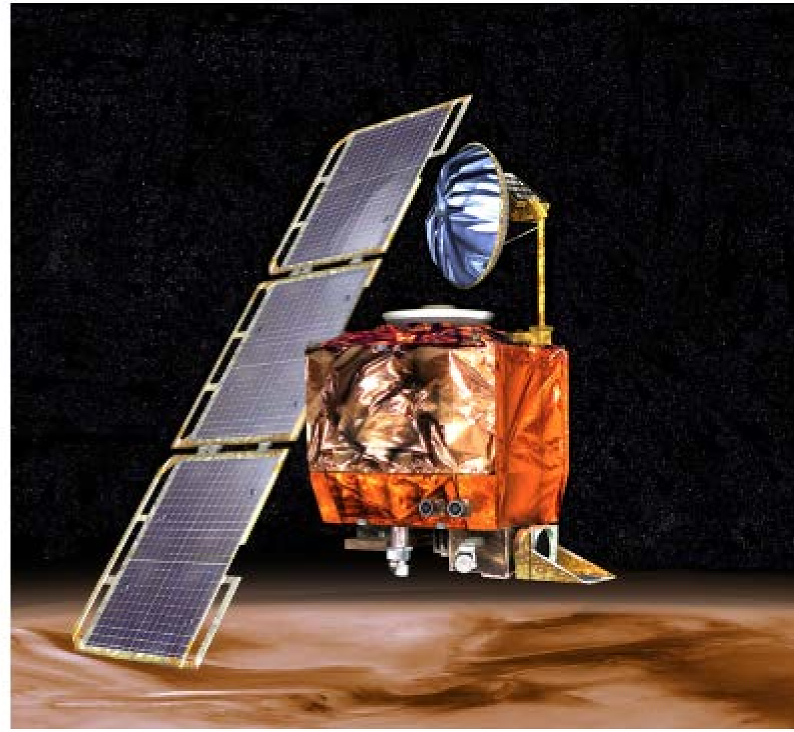
"People sometimes make errors," said Edward Weiler, NASA's Associate Administrator for Space Science in a written statement.

"The problem here was not the error, it was the failure of NASA's systems engineering, and the checks and balances in our processes to detect the error. That's why we lost the spacecraft."

The findings of an internal peer review panel at NASA's Jet Propulsion Laboratory showed that the failed information transfer scrambled commands for maneuvering the spacecraft to place it in orbit around Mars. JPL oversaw the Climate Orbiter mission.

"Our inability to recognize and correct this simple error has had major implications," said JPL Director Edward Stone.

Destination Mars
- Main
- Mars Missions
- Mars 101
- Quiz
- Image Gallery



1999: A disaster investigation board reports that NASA's Mars Climate Orbiter burned up in the Martian atmosphere because engineers failed to convert units from English to metric.

Integration Readiness Level

IRL	Description
1	Interface between two technologies has been identified with sufficient detail to allow characterization of the relationship.
2	There is some level of specificity to characterize the interaction (i.e., ability to influence) between technologies through their interface.
3	The technologies are compatible (i.e. common language) between technologies to orderly and efficiently integrate and interact.
4	There is sufficient detail in the quality and assurance of the integration between technologies.
5	There is sufficient control between technologies necessary to establish, manage, and terminate the integration.
6	The integrating technologies can accept, translate, and structure information for its intended application.
7	The integration between the technologies has been verified and validated with sufficient detail to be actionable.
8	Actual integration completed and mission qualified through test and demonstration, in the system environment.
9	Integration is mission proven through successful mission operations.

Sauser, Brian J., Dr., Jose Ramirez-Marquez, Dr., Romulo Magnaye, and Weiping Tan. *A Systems Approach to Expanding the Technology*. Hoboken, New Jersey: Stevens Institute of Technology, 20 Mar. 2009. Pdf.

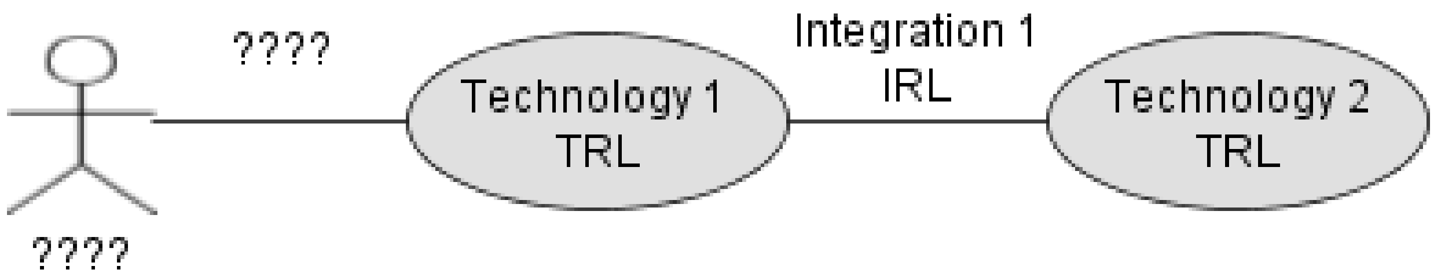
Composite System Readiness Level

SRL	Acquisition Phase	Definitions
0.90 to 1.00	Operations and Support	Execute a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total lifecycle.
0.80 to 0.89	Production	Achieve operational capability that satisfies mission needs.
0.60 to 0.79	System Development and Demonstration	Develop system capability or (increments thereof); reduce integration and manufacturing risk; ensure operational supportability; reduce logistics footprint; design for production; ensure affordability and protection of critical program information; and demonstrate system integration, interoperability, safety and utility.
0.40 to 0.59	Technology Development	Reduce technology risks and determine appropriate set of technologies to integrate into a full system.
0.10 to 0.39	Concept Refinement	Refine initial concept; develop system/technology strategy.

Sauser, B., Ramirez-Marquez, J., Verma, D., & Gove, R. (2006). From TRL to SRL: The Concept of Systems Readiness Levels. *Conference on Systems Engineering Research*, (pp. 1-10). Los Angeles, CA.

Limitations of Current Metrics

- Systems Metrics do not necessarily account for human factors integration
- Human factors or human system integration metrics are separate from systems metrics and do not permit simultaneous evaluation for investment
- Systems metrics do not describe plan for maintaining the technology or system, only technology development



Step 1: Define Terminology

Human Capability Level – How well have we demonstrated the ability to deliver personnel who are equipped to achieve the system objectives under adverse conditions?

Human Integration Readiness Level – How well have we designed the system to enable personnel to perform to achieve system objectives under adverse conditions?

Step 2: Decompose

- Human Capability Level
  - Do we have the right people – Personnel Readiness Level
  - Do we have the right number of people – Manpower RL
  - Are we able to train the people appropriately – Training RL
  - Are we able to feed, nourish, nurture – Habitability RL

- For each user class (operator, maintainer, etc)
  - HCL(class) = (PRL + MRL + TrRL + HaRL)/4

Training Readiness Level

TrRL	Description
1	Develop Training System Concepts
2	Determine training strategy to meet manpower requirements [PR: MRL1]
3	Initial training and performance requirements established
4	Create detailed curriculum for each part of training and demonstrate ability of trainees to perform adequately in a prototype environment without excessive washout rate. [CR: Manpower, Personnel]
5	Revised training demonstrated to equip personnel to meet performance objectives in simulated environment.
6	Prototype training system has demonstrated ability to equip individuals to meet performance objectives in a prototype system [CR: Manpower, Personnel]
7	Training system demonstrated meeting throughput and washout requirements while delivering personnel who meet performance objectives during OT&E
8	Training system demonstrated which meets throughput, washout, and performance objectives which is responsive to process changes
9	Number of adequately trained individuals within the career field are equal to or exceed the manpower needs and a pipeline exists to maintain an adequate number of trained individuals.

Step 2: Decompose

- Human Integration Readiness Level
  - Can individuals achieve goals with interface? – Human Factors Readiness Level
  - Will Individuals be Safe in Operating System? – Safety Readiness Level, Occupational Health Readiness Level
  - How robust is the system to attack – Survivability Readiness Level

- For each user class (operator, maintainer, etc)
  - HIRL(class) = (HfRL, SaRL, ERL, SuRL)/4

Applying HCL and HIRL

- Taxi company that controls self-driving cars
- Taxi monitored by controllers
- Additional personnel include maintenance, valets, etc.

Controller

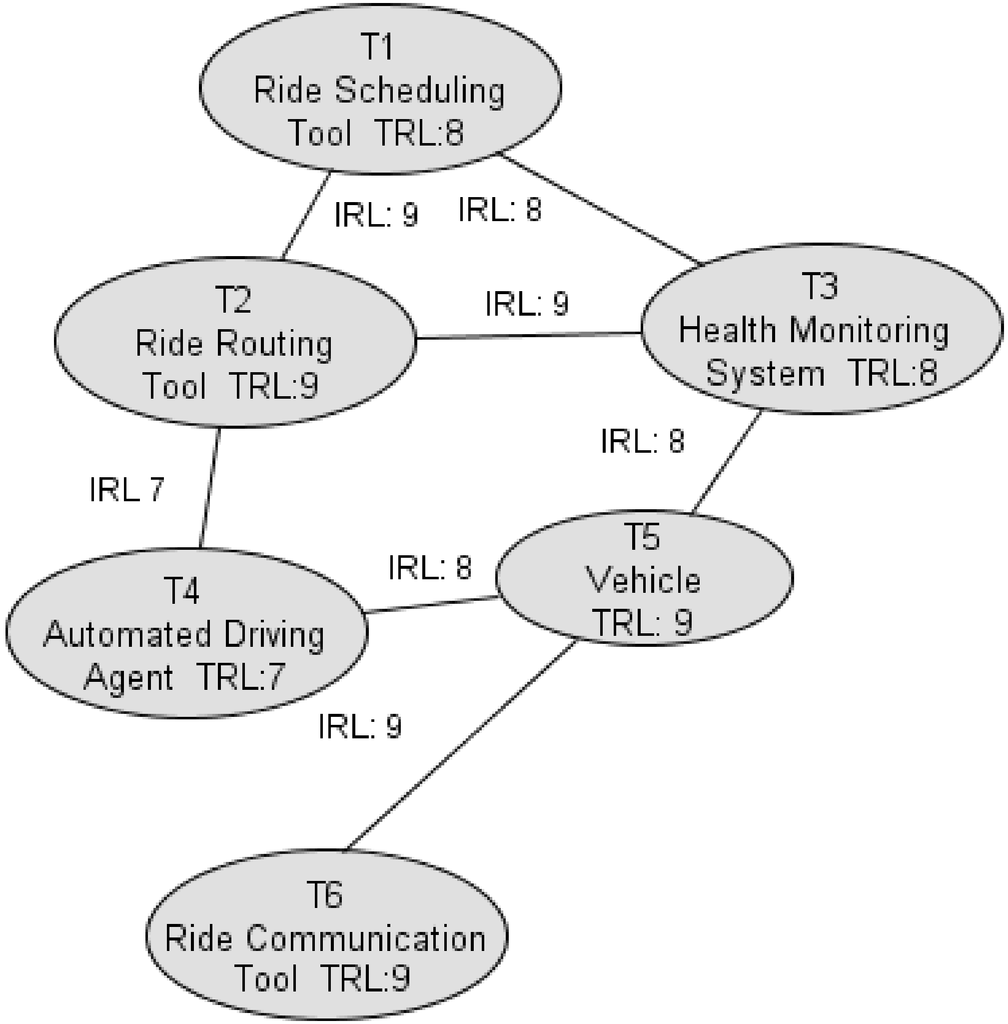
Maintainer

Controller Assistant

Valet

Technology system

The AFIT of Today is the Air Force of Tomorrow.



Technology System

Technology Readiness Levels

	T1	T2	T3	T4	T5	T6
Values	8	9	8	7	9	9

Integration Readiness Levels

	T1	T2	T3	T4	T5	T6
T1	9	9	8	0	0	0
T2	9	9	9	7	0	0
T3	8	9	9	0	8	0
T4	0	7	0	9	8	0
T5	0	0	8	8	9	9
T6	0	0	0	0	9	9

CSRL=.8860

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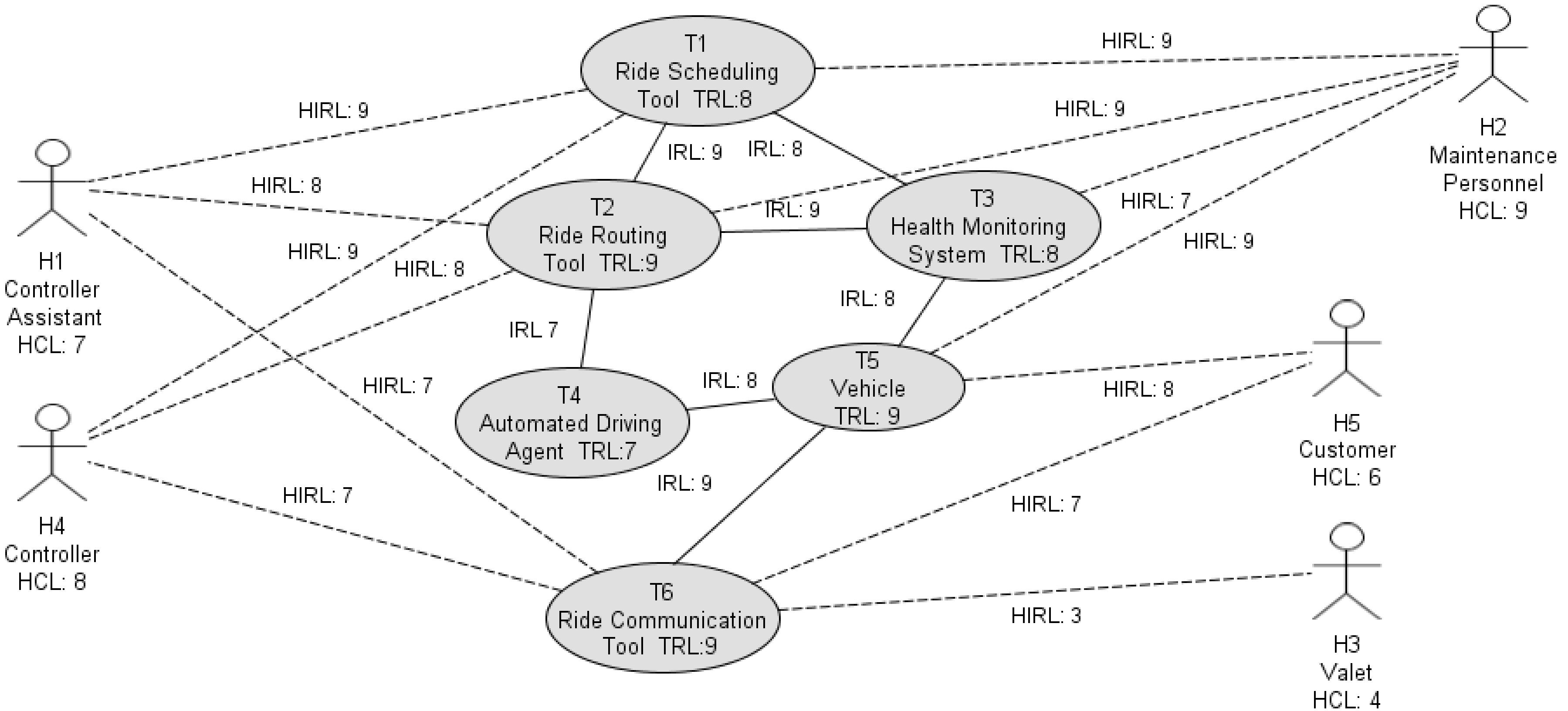
Human-Technology System

The AFIT of Today is the Air Force of Tomorrow.



Human-Technology System

TRL w/ HCL

	T1	T2	T3	T4	T5	T6	H1	H2	H3	H4	H5
Value	8	9	8	7	9	9	7	9	4	8	6

IRL w/ HIRL

	T1	T2	T3	T 4	T5	T6	H1	H2	H3	H4	H5	SRL
T1	9	9	8	0	0	0	9	9	0	9	9	0.859
T2	9	9	9	7	0	0	8	9	0	8	8	0.807
T3	8	9	9	0	8	0	0	7	0	0	0	0.869
T4	0	7	0	9	8	0	0	0	0	0	0	0.815
T5	0	0	8	8	9	9	0	9	0	0	8	0.846
T6	0	0	0	0	9	9	7	0	3	7	7	0.661
H1	9	8	0	0	0	7	9	0	0	0	0	0.833
H2	9	9	7	0	9	0	0	9	0	0	0	0.916
H3	0	0	0	0	0	3	0	0	9	0	0	0.389
H4	9	8	0	0	0	7	0	0	0	9	0	0.861
H5	9	8	0	0	8	7	0	0	0	0	9	0.822

CSRL=.789

Conclusion

- Require A Common Set of Tools, Communicate Human Element Development on Same Scale as Technology
- Require Integration of Human/Technology Elements as well as Human/Technology Development
- Necessary to Facilitate Communication across Human Systems Domains