Technology Readiness Level Assessments for Research Program Managers and Customers

Transportation Research Board Webinar
April 28, 2016
Agenda

- Introductions
- About Technology Readiness Levels
- Conducting Technology Readiness Assessments
- TRAs in Practice/Lessons Learned
- Q&A
Presenters

Andrew Berthaume, Volpe Center

David Kuehn, Federal Highway Administration

Elizabeth Machek, Volpe Center

Stephen Lane, VTRC
Technology Readiness Levels

Overview
Understanding Technology Maturity

• Tunnel Boring Machine: In the 19th century, repeatedly a colossal failure

• In the 1950s, engineers re-adapted technology developed for mining coal, which is soft, for tunneling harder rock.
TRL History

• Developed by NASA in the 1980s
• Adopted by DoD in the late 1990s
• Adapted by many industries since
## Technology Readiness Levels

### Phase TRL Description

<table>
<thead>
<tr>
<th>Phase</th>
<th>TRL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Research</td>
<td>1</td>
<td>Basic principles and research</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Application formulated</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Proof of concept</td>
</tr>
<tr>
<td>Applied Research</td>
<td>4</td>
<td>Components validated in laboratory environment</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Integrated components demonstrated in a laboratory environment</td>
</tr>
<tr>
<td>Development</td>
<td>6</td>
<td>Prototype demonstrated in relevant environment</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Prototype demonstrated in operational environment</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Technology proven in operational environment</td>
</tr>
<tr>
<td>Implementation</td>
<td>9</td>
<td>Technology refined and adopted</td>
</tr>
</tbody>
</table>

- **Assess technology maturity on a 1-9 scale**
- **Ask two key questions**
  - How complete was the technology when it was tested?
  - How representative was the test environment?
FHWA Interest

• Improve communication
  • Is your “market-ready” the same as mine?

• Improve outcomes
  • What’s the next step?

• Improve internal assessment
  • Is the research portfolio balanced appropriately?
  • Is this project the right fit?
State DOT Interest

• Provide structured framework for assessing research needs and research products
• Review panels often quite diverse in skill set and function
• Readiness level assessment provides common focus allowing proper scoping of the needed effort
• The scope and scale of the assessment will be different at state DOT
  • Adjust to fit your needs
State DOT Interest

• Broad application
  • New products
  • New processes
  • Technology transfer
  • State Transportation Innovation Council (STIC) efforts
• Questions at various levels can be fine-tuned to fit the issue at hand
TRL Scale Development and Deployment

Foundation
- Literature Review
- SME Interview
- Engagement with GAO

Scale Development
- Language simplification
- Desktop testing for software, hardware, and processes

Piloting and Refinement
- EAR
- SBIR
- SHRP2
- Pooled Funds

Implementation
- Post-event debrief
- Process improvement
Benefits of TRLs

1. Improved communication
2. Improved outcomes
3. Improved research program management
Benefits of TRLs

1. Improved communication
   • Clearly convey research maturity
   • Identify audiences
Benefits of TRLs

1. Improved communication
   • Clearly convey research maturity
   • Identify audiences

2. Improved outcomes
   • Ask key questions in a structured framework
   • Inform research in progress with expert assessment
   • Identify steps to advance maturity
   • Transition results to stakeholders
Benefits of TRLs

1. Improved communication
   • Clearly convey research maturity
   • Identify audiences

2. Improved outcomes
   • Ask key questions in a structured framework
   • Inform research in progress with expert assessment
   • Identify steps to advance maturity
   • Transition results to stakeholders

3. Improved research program management
   • Establish expectations for research progress
   • Review the alignment of projects with program objectives
Limitations of TRLs

• Provide a measure of technology maturity only.
  • Do not assess the risk, cost and feasibility of advancing to the next level.
  • Should be used in concert with other assessment tools.
  • Poor fit for measuring success of outreach or training, or adoption

• Risk of oversimplification
  • Project value cannot be reduced to a single number.
TRL Example: Electronic Toll Collection

TRL 1-3: Basic Research

TRL 4-5: Applied Research

TRL 6-8: Development

TRL 9: Implementation
TRL 1-3: Basic Research

- Radio transponders, the basic precursors to RFID technology, developed (1940s)
- Post-war patents identify ETC as a potential application of radio transponders (1950s-60s)
- Development of passive radio transponder with memory (1970s)
• RFID tags were validated at Los Alamos National Laboratory (1970s)
• Laboratory research continued on RFID systems (1970s-80s)
TRL 6-8: Development

- Early prototypes were tested on closed courses and public roads (1980s)
- Temporary installations were replaced by larger deployments with more readers and transponders
- Initial pilots were open to limited users but eventually, many open the system up to more users
TRL 9: Implementation

• Early adopters implemented ETC solutions (late 1980s)
• More states tested and adopted ETC and developed new concepts (1990s)
• As of 2009, FHWA requires all new toll facilities with Federal funding to use ETC
Technology Readiness Assessments

Process
Conducting a Technology Readiness Assessment

- Pre-Meeting
  - Goals
  - Timing and Location
  - Panelists
  - Materials
- At the Panel Meeting
  - Roles
- Post-Meeting
  - Documentation
  - Follow-up
Determine your goals

• What is the critical technology to be assessed?
• What application, or applications will the panel assess?
• What is the intended operating environment for each application?
Set a Date and Location

• **Timing**
  • To inform decision point
  • ~4-6 months in advance of conclusion

• **Location**
  • Virtual
  • In-Person
    • At research site
    • Coordinated with relevant workshop/conference
    • Neutral location

• **Length**
Invite Panelists

- 4-6 panelists (including chair)
- Panel composition suggestions
  - Academic
  - Practitioner
  - Stakeholder
  - End User
  - Sponsoring Agency Representative
Prepare Materials

- Process Documents
  - TRL Scale
  - Goal of the TRA
  - Key Technology, Application(s), Operating Environment(s)

- Project Documentation
  - PI Questionnaire
  - Presentations
  - Research Reports
  - Published Papers

- Coordination
  - Pre-Meeting Conference Call
Determine Roles

- Panel Chair
- Panelists
- Research Team Representative
- Staff Support
  - Facilitation
  - Documentation
  - Remote Participation Support
Decide What’s Next

- TRA Report
- Real-time feedback to research team
- Recommendations for immediate next steps
  - draft work scopes for next research
  - logic models
- Debrief and identify process improvements
Example: New Structural Materials

• Location
  • At PI’s lab
  • Laboratory tour
  • Grad student/postdoc participation

• Panel Composition
  • State DOT (2)
  • Industry (2)
  • U.S. DOT SME (2)
  • U.S. Army Corps of Engineers (1)
  • Project Lead

• Results
  • Seismic column TRL 4
  • Bridge deck TRL 2
  • Railroad tie TRL 2

• Outcomes
  • Commissioned economic study on materials costs
  • Developed Statements of Work by application type
Example: Energy in the Right-of-Way

- **Location**
  - Two virtual meetings

- **Panel Composition**
  - State DOT (2)
  - Industry (3)
  - U.S. DOT SME (5)
  - DOE SME(1)
  - Project Lead

- **Results**
  - TRL 2-3
  - TRL 5-6

- **Outcomes**
  - Identified next steps to advance maturity
    - Traffic safety performance (collision)
    - Testing is less than ideal weather conditions
Example: Portfolio Assessment

- 3 projects
  - TRL 2
  - TRL 2/3
  - TRL 4-6
- Some panelist overlap
- Results informed development of a topical logic model

Agent-Based Modeling Logic Model

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Activities</th>
<th>Outputs</th>
<th>Direct Outcomes (1-3 years)</th>
<th>Intermediate Outcomes (1-5 years)</th>
<th>Longer Term Outcomes (over 5 years)</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support national research priorities and strategic goals</td>
<td>Conduct research project</td>
<td>Knowledge</td>
<td>Increased awareness and interest</td>
<td>Increased ability to investigate cutting edge topics and make better transportation decisions</td>
<td>Support national research priorities and strategic goals</td>
<td>Increased safety, enhanced reliability, increased mobility, enhanced economic competitiveness, increased environmental sustainability, improved national leadership, enhanced program delivery, improved responsiveness of goods</td>
</tr>
<tr>
<td>Identified Needs</td>
<td>Assess project on an interim basis</td>
<td>Research Products</td>
<td>Agent-based modeling software</td>
<td>Increased investment in follow-on research from external sources</td>
<td></td>
<td>Support national research priorities and strategic goals</td>
</tr>
<tr>
<td>Topical logic model development of a results informed research priorities and strategic goals</td>
<td>Research Gaps</td>
<td>Improved research tools and processes</td>
<td>Better calibration of agents</td>
<td>Access to new ideas and research methods from cooperative work, partnerships, fellowships</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Capabilities</td>
<td>Screen portfolio for transition potential</td>
<td>Foundational Research</td>
<td>Increased program delivery</td>
<td>Development of informal and formal strategic partnerships and collaborations between researchers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identified needs</td>
<td>Assess transition support needs</td>
<td>Research Gaps</td>
<td>Increased collaboration among stakeholders</td>
<td>Increased program engagement across USDOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broad Agency Announcement</td>
<td>Organize targeted transition activities</td>
<td>Research Capabilities</td>
<td>Enhanced leadership</td>
<td>Better transportation planning and programming based on improved accuracy of modeling leads to better transportation projects and facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>Document project results</td>
<td>Research Gaps</td>
<td>Increased safety</td>
<td>Improved program engagement across USDOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conduct outreach</td>
<td>Research Capabilities</td>
<td>Enhanced mobility</td>
<td>Improved program engagement across USDOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relationships formed</td>
<td>Conduct outreach</td>
<td>Research Capabilities</td>
<td>Increased safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal (USDOT) and external (state, other) partnerships and networks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


• Increased program delivery
• Improved responsiveness of goods
• Improved program engagement across USDOT
• Better transportation planning and programming based on improved accuracy of modeling leads to better transportation projects and facilities
• Development of informal and formal strategic partnerships and collaborations between researchers
• Increased program engagement across USDOT
• Enhanced leadership
• Improved safety, enhanced reliability, increased mobility, enhanced economic competitiveness, increased environmental sustainability, improved national leadership, enhanced program delivery, improved responsiveness of goods

External Factors: Institutional Issues, etc.
Possible Next Steps

- Program-Level Logic Map
- Market Analysis
- Barrier, Level of Effort Analysis
- Stakeholder Meetings
- Data Documentation
Lessons Learned

• Use assessments strategically
  • Is there interest in moving forward with the project?
  • Is the project outcome very clear?

• Set expectations early
  • With the research team
  • With the panelists

• The value is in the discussion, not the number
  • Panelists may identify additional research needs or ambiguities for clarification
Thank you!
Questions?

For More Information:
http://www.fhwa.dot.gov/advancedresearch/trl_h.cfm
Photo Credits

Slides 1 and 31
• University of California, Berkeley

Slide 5
• Henri-Joseph Maus

Slide 6
• NASA
  • http://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-mars-k4.html

Slides 9 and 10
• Virginia DOT (Stephen Lane)

Slide 13
• halfpoint / 123RF Stock Photo

Slide 14
• Volpe Center, Fecht

Slide 15
• nexusplexus / 123RF Stock Photo

Slides 17-21
• National Institute of Standards and Technology
  • http://www.antd.nist.gov/wctg/RFID/RFIDassist.htm

• Department of Defense

• Patent and Trademark Office
  • https://www.google.com/patents/US3602881

• Department of Transportation
  • Volpe Center
    • https://www.environment.fhwa.dot.gov/strmlng/newsletters/jul13nl.asp
    • https://www.fhwa.dot.gov/publications/publicroads/05jul/01.cfm
    • https://www.fhwa.dot.gov/publications/publicroads/93fall/alongroad.cfm
    • https://www.fhwa.dot.gov/publications/publicroads/96spring/p96sp23.cfm
    • http://www.ops.fhwa.dot.gov/plan4ops/focus_areas/organizing_for_op.htm

Slide 32
• University of Nebraska, Lincoln
• Virginia Tech Transportation Institute