Technology Readiness Level Assessments for Research Program Managers and Customers

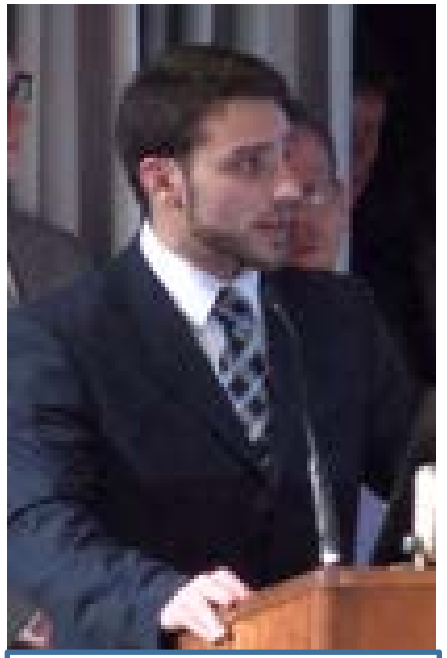
Transportation Research Board Webinar

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

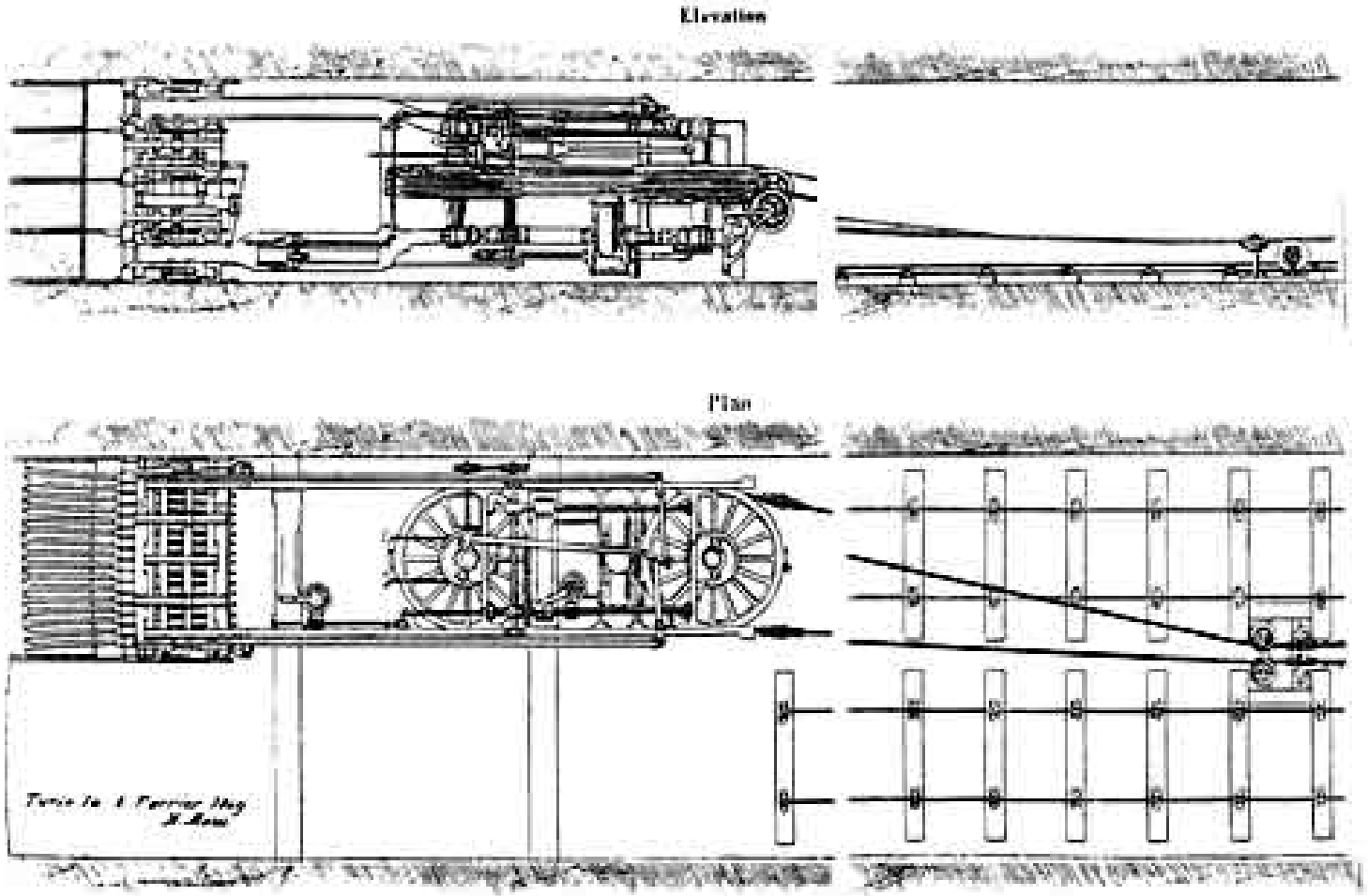
Stephen Lane, VTRC

Technology Readiness Levels

Overview

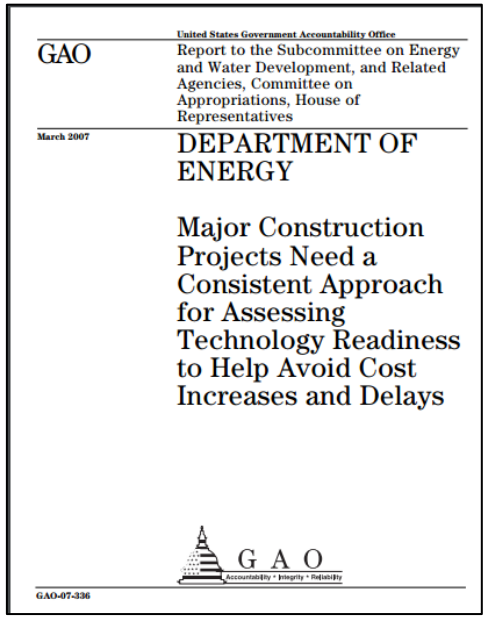
Understanding Technology Maturity

- 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



United States Government Accountability Office

GAO

Report to the Subcommittee on Energy and Water Development, and Related Agencies, Committee on Appropriations, House of Representatives

March 2007

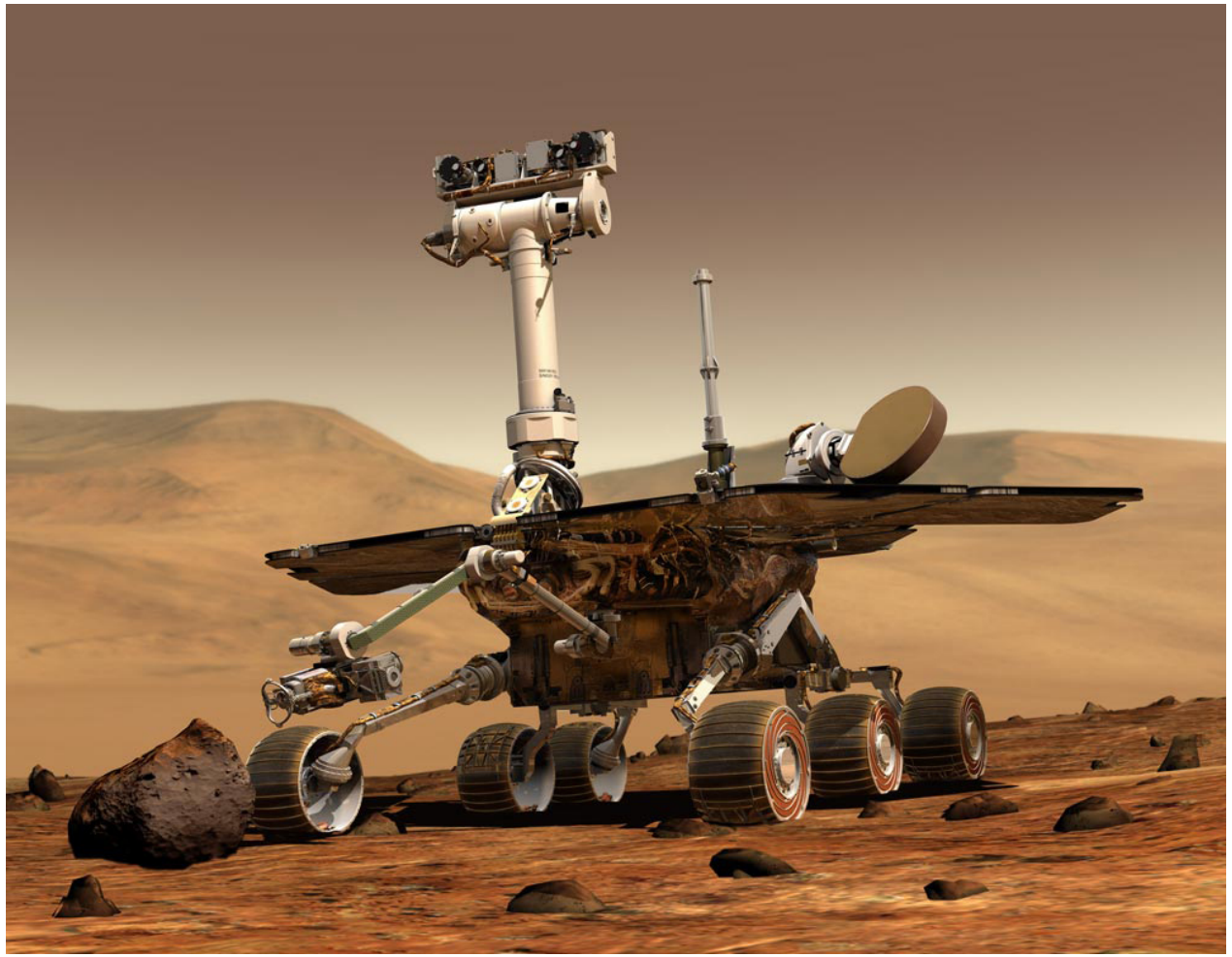
DEPARTMENT OF ENERGY

Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays

GAO

Accountability * Integrity * Reliability

GAO-07-336



Technology Readiness Levels

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

- 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

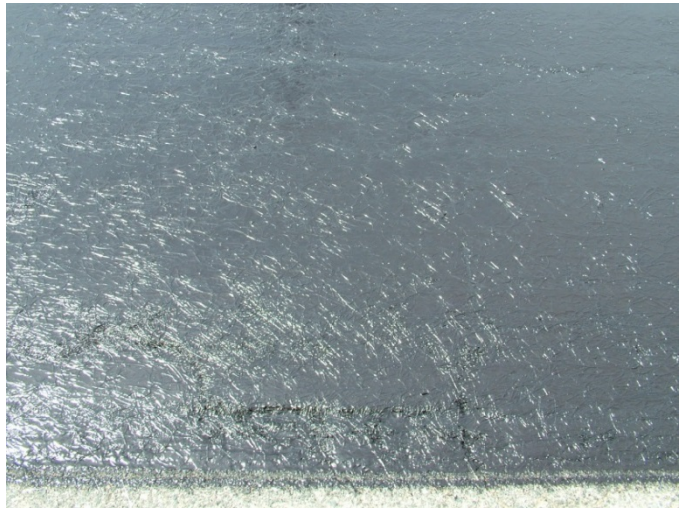
- Improve communication
  - Is your “market-ready” the same as mine?
- Improve outcomes
  - What’s the next step?
- Improve internal assessment
  - Is the research portfolio balanced appropriately?
  - Is this project the right fit?

Table 2 TRL-H Worksheet

	TRL	Description	To achieve the given TRL, you must answer yes to EVERY question. Note uncertainties for discussion.	Yes Note supporting details.	What nee
Basic Research	1	Basic principles and research	Do basic scientific principles support the concept?	MULTIPLE PUBLISHED STUDIES	
			Has the technology development methodology or approach been developed?	REPEATED MULTIPLE TIMES BY OTHERS	
	2	Application formulated	Are potential system applications identified?	CONCEPT DESCRIBED IN PROPOSAL.	
			Are system components and the user interface at least partly described?	DESCRIBED IN PHASE I REPORT.	
			Do preliminary analyses or experiments confirm that the application might meet the user need?	LAB TESTS CONFIRMED IN PHASE II	
	3	Proof of concept	Are system performance metrics established?	DOCUMENTED IN PHASE II REPORT	
			Is system feasibility fully established?	~~POSSIBLE BUT DOCUMENTATION NOT CLEAR~~	
			Do experiments or modeling and simulation validate performance predictions of system capability?	~~MAY REQUIRE~~	MAY TESTS.
			Does the technology address a need or introduce an innovation in the field of transportation?	NEED WELL DESCRIBED	

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



VDOT Pavement Preservation Treatment

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

VDOT Rapid Placement

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

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   - Clearly convey research maturity
   - Identify audiences

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   - Ask key questions in a structured framework
   - Inform research in progress with expert assessment
   - Identify steps to advance maturity
   - Transition results to stakeholders

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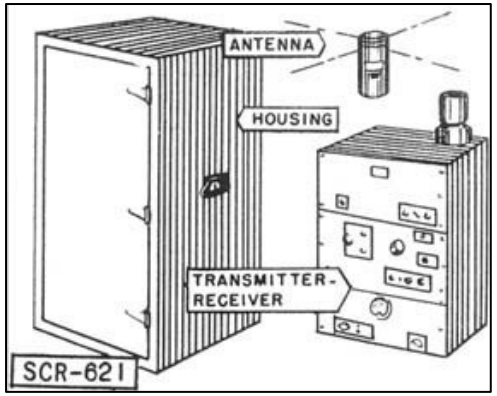
   - Identify audiences
2. Improved outcomes
   - Ask key questions in a structured framework
   - Inform research in progress with expert assessment
   - Identify steps to advance maturity
   - Transition results to stakeholders
3. Improved research program management
   - Establish expectations for research 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

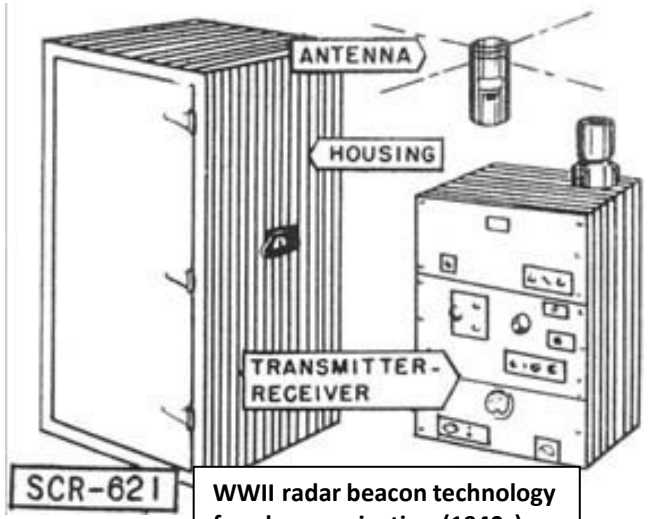
TRL 4-5:
Applied Research

TRL 6-8:
Development

TRL 9:
Implementation

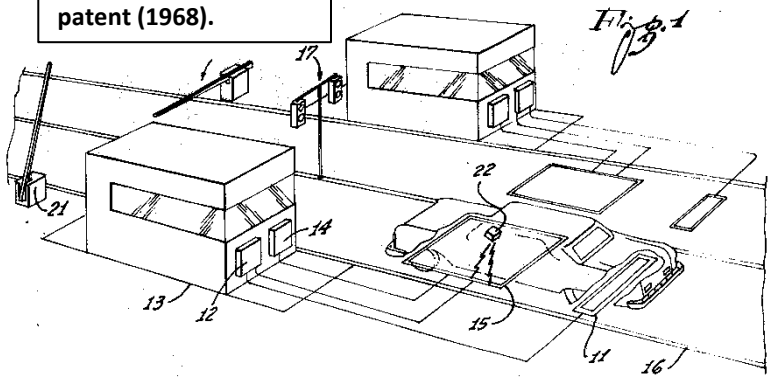
TRL 1-3: Basic Research

- 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)



WWII radar beacon technology for plane navigation (1940s).

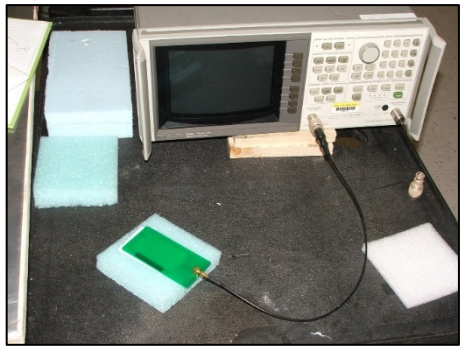
Automated tolling patent (1968).

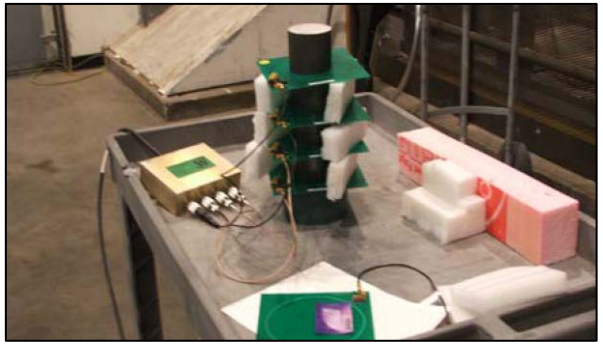


TRL 1-3: Basic Research → **TRL 4-5:** Applied Research → **TRL 6-8:** Development → **TRL 9:** Implementation

TRL 4-5: Applied Research

- RFID tags were validated at Los Alamos National Laboratory (1970s)
- Laboratory research continued on RFID systems (1970s-80s)





TRL 1-3: Basic Research

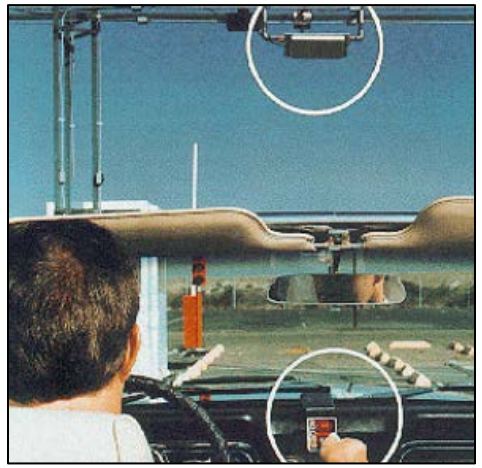
TRL 4-5: Applied Research

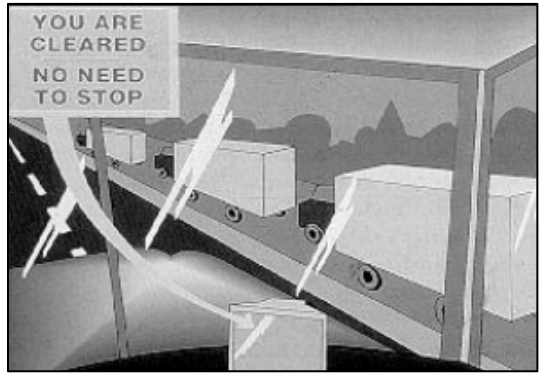
TRL 6-8: Development

TRL 9: Implementation

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 1-3: Basic Research → **TRL 4-5:** Applied Research → **TRL 6-8:** Development → **TRL 9:** Implementation

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

TRL 1-3: Basic Research → **TRL 4-5:** Applied Research → **TRL 6-8:** Development → **TRL 9:** Implementation

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

Pre-Meeting

At the Panel Meeting

Post-Meeting

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?

Pre-Meeting

At the Panel Meeting

Post-Meeting

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

Pre-Meeting

At the Panel Meeting

Post-Meeting

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

Pre-Meeting

At the Panel Meeting

Post-Meeting

TRAs in Practice

Lessons Learned

Example: New Structural Materials

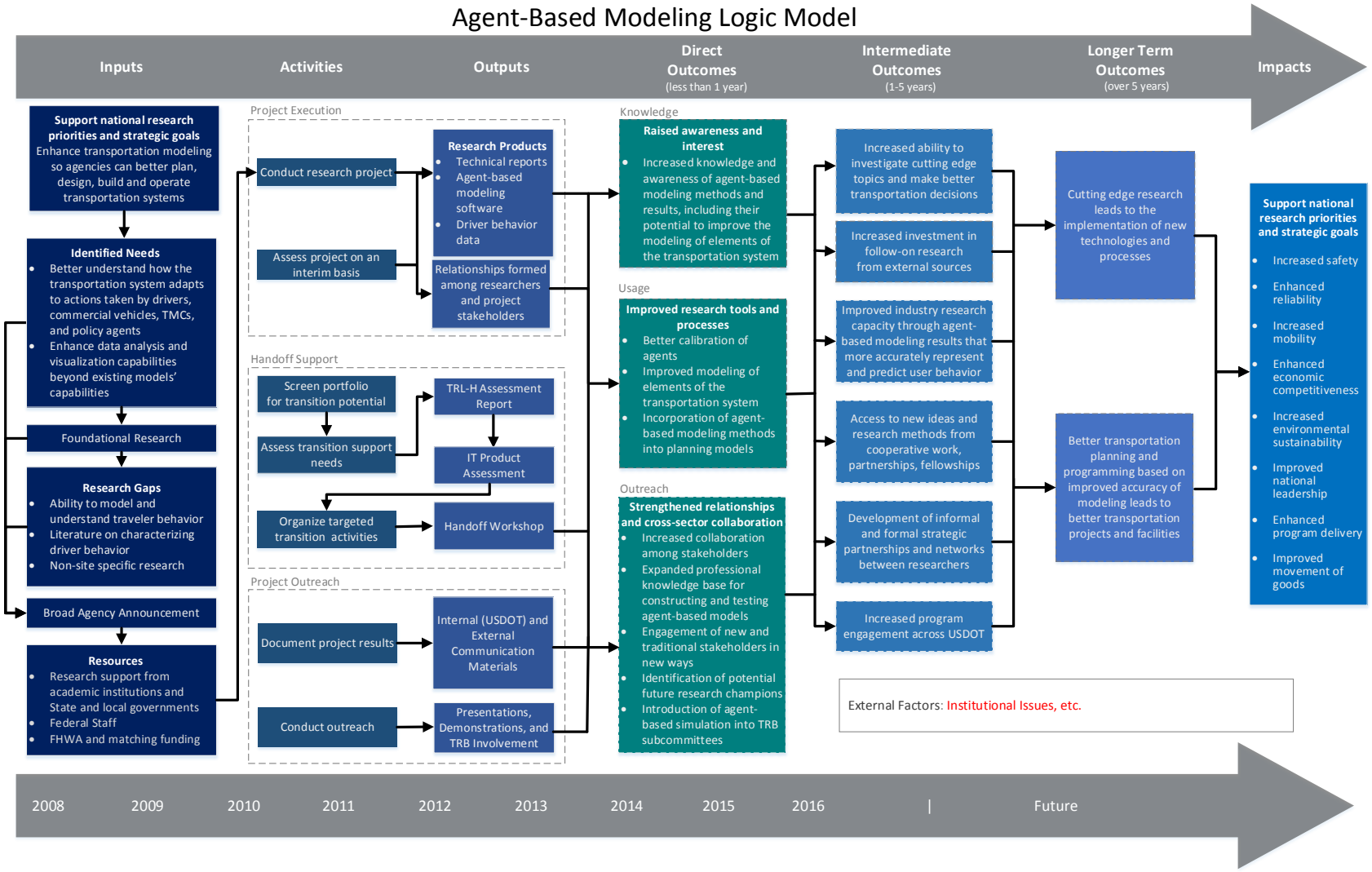
- Location
  - At PI's lab
  - Laboratory tour
  - Grad student/postdoc participation
- Panel Composition
  - State DOT (2)
  - Industry (2)
  - U.S. DOT SME (2)
  - U.S. Army Corps of Engineers (1)
  - Project Lead
- Results
  - Seismic column TRL 4
  - Bridge deck TRL 2
  - Railroad tie TRL 2
- Outcomes
  - 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



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

Discussion

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
  - http://www.antd.nist.gov/wctg/RFID/ISART06-Assisted-LocCom.pdf
- Department of Defense
  - http://www.history.navy.mil/research/library/online-reading-room/title-list-alphabetically/u/operational-characteristics-of-radar-classified-by-tactical-application.html
- 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
  - https://www.pcb.its.dot.gov/eprimer/module8.aspx

Slide 32

- University of Nebraska, Lincoln
- Virginia Tech Transportation Institute