FLORIDA DEPARTMENT OF TRANSPORTATION

RESEARCH PEER EXCHANGE 2017

FINAL REPORT

[Prepared and submitted in accordance
with 23 CFR 420.207(6)(b)]

FDOT Research Center
605 Suwannee Street, MS 30
Tallahassee, Florida 32399

April 25-27, 2017

Acknowledgments

The Florida Department of Transportation Research Center wishes to express its great appreciation to those who joined us for our 2017 Research Peer Exchange. The three days of presentations, interactions, and brainstorming provided valuable insight into state DOT research roadmaps in the contexts of national agenda/activity and emerging technologies – how a program can work to be aware, agile, and relevant in this environment. The following report records the many ideas that came out of the peer exchange, which will provide a solid basis for a plan of action. Names and contact information for the principal discussants is provided in Chapter VII of the report.

Pictured above:

Ray Derr
Teresa Parker
David Kuehn
Lily Elefteriadou
Joe Horton
Sue Sillick
David Sherman
Mark Norman
Aschkan Omidvar
Steve Andrle
Catherine T. Lawson
James Lou
Christopher Poe
David Jared
Darryll Dockstader
Jeri Shell

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List of Acronyms

AASHTO	American Association of State Highway Transportation Officials
AV	Automated vehicle
AVAIL	Albany Visualization and Informatics Lab, an initiative in the Lewis Mumford Center at the University at Albany, State University of New York
Caltrans	California Department of Transportation
CV	Connected vehicle
DOT	Department of Transportation
DRISI	Division of Research, Innovation, and System Information, a division of Caltrans
EAR	Exploratory Advanced Research, an FHWA program
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GDOT	Georgia Department of Transportation
NCHRP	National Cooperative Highway Research Program
NDS	Naturalistic Driving Survey, a project of SHRP 2
RAC	Research Advisory Committee, an AASHTO committee
RFP	Request for Proposal
ROADS	Reliable Open Accurate Data Sharing, an FDOT project
SCOR	Standing Committee on Research, an AASHTO committee
SHRP 2	Second Strategic Research Highway Program, authorized in 2009
TPF	Transportation Pooled Funds, an FHWA mechanism for funding multistate research
TRB	Transportation Research Board
TSM&O	Transportation Systems Management & Operations
UAS	Unmanned aerial systems
UF	University of Florida
UFTI	University of Florida Transportation Institute

I. Introduction – Welcome, Overview, and Objectives

The FDOT Research Program receives approximately $14 million a year to support its annual research program, which includes pooled fund and cooperative research. Most research is performed by state universities. The Research Center's website, http://www.fdot.gov/research/, includes final reports, summaries of final reports, *Research Showcase* magazine, and other information. The Technology Transfer (T2) program for the state is administered by the University of Florida.

23 CFR Part 420, Subpart B, contains four provisions that each state must meet to be eligible for Federal Highway Administration (FHWA) planning and research funds for its research, development, and technology transfer (RD&T) activities. One requirement is to conduct peer exchanges that consider for improvement the state's RD&T management process or some aspect of the research program and to be willing to participate in peer exchanges held by other states' programs. This report documents the Florida Department of Transportation's peer exchange held on April 25–27, 2017, in partial fulfillment of these requirements.

Members of this Peer Exchange team included

- Steve Andrle – Transportation Research Board (TRB)
- Ray Derr – National Cooperative Highway Research Program (NCHRP)
- Darryll Dockstader – FDOT Research Center
- Dr. Lily Elefteriadou – University of Florida
- King Gee – American Association of State Highway Transportation Officials (AASHTO)
- Joe Horton – Caltrans
- David Jared – Georgia DOT
- David Kuehn – FHWA Exploratory Advanced Research (EAR) Program
- Dr. Catherine T. Lawson – University of Albany
- James Lou – IBM
- Mark Norman – TRB
- Dr. Christopher Poe – Texas A&M Transportation Institute
- David Sherman – FDOT Research Center
- Sue Sillick – Montana DOT

Other participants observing the exchange included

- April Blackburn – FDOT
- Tom Byron – FDOT
- Ed Hutchinson – FDOT
- John Krause – FDOT
- Aschkan Omidvar – University of Florida
- Teresa Parker – FHWA
- Raj V. Ponnaluri – FDOT
- Jeri Shell – University of Florida
- Brent Shore – FDOT
- Jessica VanDenBogaert – FDOT

Each of FDOT's peer exchanges has been substantially different in composition and theme. The first (1997) focused on overall research program management; the second (2002) on opportunities for enhancing the Research Center's relationships with FDOT project managers and universities; the third (2007) on strategic project visioning; and the fourth (2013) on implementation and performance measurement.

State DOT research programs are applied research programs, historically focused on materials and structures. In the last several years, the pace and nature of FDOT's research program have evolved. Increased emphasis on implementation and performance, along with accelerating technology cycles, have placed greater demands on the program to innovate, partner, monitor sometimes hard-to-find or mountainous amounts of relevant activity, and implement and measure outcomes. The theme of this fifth peer exchange was to discuss state DOT research roadmaps in the contexts of national agenda/activity and emerging technologies—to explore how a program can work to be aware, agile, and relevant in this environment.

The report follows the format of the panel and working sessions for the first two days of the exchange (the agenda is presented in appendix A). Three panel sessions were held on day one, focusing on national activity, university and industry activity, and state DOT activity, respectively. The afternoon working session focused on the concept of a transportation research roadmap. The goal of the first half of day two was to workshop and synthesize the ideas generated from a presentation on the FDOT ROADS (<u>R</u>eliable <u>O</u>pen <u>A</u>ccurate <u>D</u>ata <u>S</u>haring) initiative and its implications for research data needs and data creation. The afternoon of day two was devoted to emerging technologies, typified by, but not limited to, automated and connected vehicle issues, and, in the context of the previous sessions, with the goal of developing recommendations for program improvement. Exchange presentations may be found in appendices B and C.

II. National, Industry and University, and State DOT Convergence

1. Participant Presentations on Respective Discourse Concerning Emerging Technologies

Participants delivered presentations discussing research roadmaps, strategic process, emerging technologies, and data. The presentations were delivered across three panel sessions moderated by Steve Andrle and Darryll Dockstader. The following is a list of presentation titles and descriptions in order of delivery. PowerPoint slides for each presentation appear in appendix C.

Panel 1 – The National Picture

Moderator – Steve Andrle

King Gee – AASHTO
Presentation title: "Strategic Research in Context"
Although transportation infrastructure is often considered slow changing, the reality is that there are forces within the transportation sector, outside the transportation sector, within a state, and nationwide that are poised to transform traditional paradigms. Strategic research must anticipate and support an agency's ability to manage and address those changes. The presentation briefly examined these forces and noted some success factors.

Ray Derr – NCHRP
Presentation title: "NCHRP's Research Roadmap Experiences"
Derr discussed NCHRP's experience with roadmapping for their research efforts, including SHRP2, Connected Vehicles/Automated Vehicles, and Transformational Technologies.

David Kuehn – FHWA EAR
Presentation title: "A Map is to Research as Directions are to…"
Kuehn discussed purposes, approaches, and uses of research roadmaps.

Mark Norman – TRB

Presentation title: "Transformational Technologies – Transforming Research"

Norman discussed potential impacts of transformational technologies on our transportation goals, the range of prospective positive and negative outcomes, the role of research in leading us to positive outcomes, and how our approaches to research itself may have to change in an era of transformational technologies.

Panel 2 – Universities and Industry

Moderator – Steve Andrle

Dr. Christopher Poe – Texas A&M Transportation Institute

Presentation title: "Bridging the Gap to Deployment"

Poe discussed the needs of, and approaches to, research and testing of automated and connected vehicle technologies. He highlighted work from both Texas and Florida on automated vehicle proving grounds and the importance of partnerships for pilots and early deployments.

Dr. Catherine T. Lawson – University of Albany

Presentation title: "The Road to the Future is Paved with Data"

While transportation professionals have a long history of using data, new techniques and data sources are creating amazing opportunities and daunting challenges. New York State DOT has taken on the challenge by utilizing data science approaches to meet their data needs (e.g., use of NPMRDS to develop route-level tool suites). Universities have a key role in assisting transportation agencies in advancing their understanding of how best to navigate into the future.

Dr. Lily Elefteriadou – University of Florida

Presentation title: "Developing a Transportation Testbed in Gainesville, Florida: From Concept to Implementation"

Elefteriadou provided background and motivation for the development of this testbed, along with the overall concept and plans for implementation. She also discussed ongoing research at UF on autonomous/connected vehicles. The presentation closed with thoughts on the essential elements for successful implementation.

James Lou – IBM

Presentation title: "Transforming Transportation Management with Cognitive ITS Infrastructure"

Panel 3 – State DOTs

Moderator – Darryll Dockstader

David Jared – Georgia DOT
Presentation title: "Strategic Research at Georgia DOT"
Jared provided an overview of GDOT's entire research program, emphasizing development of research aligned with GDOT strategic goals and the structure supporting such development. Some limited discussion of research roadmaps was included.

Joe Horton – Caltrans
Presentation title: "The Caltrans Research Process"
The presentation discussed the research operations of the Caltrans Division of Research, Innovation, and System Information (DRISI). The presentation covered the mission of DRISI, its research services, governance, and research development. Special attention was given to the areas of research roadmaps, research prioritization, and the handling of emerging technologies.

Sue Sillick – Montana DOT
Presentation title: "Research Roadmaps: Communication, Coordination, and Collaboration"
The presentation focused on the MDT (Montana Department of Transportation) solicitation, prioritization and selection process as well as the coordination and collaboration needed to overcome barriers, making sure the right "players" are involved both nationally and at the state level. Additionally, tools and mechanisms were discussed.

III. Concept of Transportation Research Roadmaps

Darryll Dockstader led an in-depth discussion on the concept of a transportation research roadmap, during which participants discussed opportunities and desired outcomes. Key points of this discussion included:

- Distinguishing between categories (below), which are thematic, and goals, which have direction and measurable purpose
  - Safety
  - Mobility
  - Tech transfer
  - Information
  - Equity
  - Sustainability
  - Economic development
- Determining the goals FDOT will pursue
- Ideas on collaboration including semiannual meetings to revisit transformational technologies issues
  - Meetings to consist of a group of 20-30
- Standing groups could be a challenge since it doesn't fit traditional models of procurement.
- Discussion on how big data is a complementing, vital component

IV. Data and Research

April Blackburn, Chief of Transportation Technology at FDOT, delivered a presentation on the FDOT ROADS initiative which was developed to improve data reliability and simplify data sharing across FDOT, which is vital to decision-making.

The participants actively discussed issues raised within and by this presentation, including the following:

- Communicating throughout the data-gathering process is key to ensure consistent submission of data to allow FDOT to set up mechanisms to best share data among various users.
- Leveraging of expertise to reduce duplication and increase accuracy of data being collected
- Collaborating across multiple disciplines in an effort to understand data needs and develop software
- Exploring the initiative's three vital components:
  - Leveraging available research
  - Requesting additional research
  - Collaborating
- Engaging with industry

V. Emerging Technologies

David Sherman, Research Performance Coordinator for the FDOT Research Center, delivered a presentation highlighting various test beds and initiatives ongoing in Florida.

Following this presentation, Dr. Raj Ponnaluri, State Arterial Management Systems Engineer with FDOT, led a discussion on Transportation Systems Management & Operations (TSM&O) emerging technologies within the Traffic Engineering & Operations Office.

These presentations stimulated a discussion among attendees demonstrating a consensus on the importance of having strong partnerships, including engagement with industry, university, and DOT teams. Collaboration is vital to gain objectivity as well as validation and replication.

VI. Conclusions

This peer exchange benefited from a vibrant team that generated a great deal of mature consideration of the issues. The various perspectives of the state agency, federal, academic, and industry participants made for valuable discussion.

1. Participant Takeaways

Steve Andrle – TRB

No Brainers

1. Align research and field test program with Florida DOT goals and objectives.
2. Continue developing the ROADS data management program.

Ideas

3. Conduct research on “cognitive architecture” and data platforms as recommended by James Lou (IBM) and Catherine T. Lawson (University at Albany).
4. Hire or gain the capability of a data scientist to help structure DOT data.
5. Spend some time and money planning for ingesting and using data from research and field tests. This is a subset of number 4. Look at APIs, open source programming, and other new ways to connect data and users. The data platforms or at least a data framework for research needs to be established.
6. Explore the Capability Maturity Model for planning progress. See SHRP 2 R06 report. Andrle will supply a copy, and it is also available on the TRB website under data and resources (see below).
7. Develop a partnership strategy to capitalize on the test beds and proving grounds in Florida. Take advantage of Florida’s favorable laws on operating automated vehicles. Communicate this capability.
8. Set aside funding for selective implementation of research results. This may mean taking a project from the field test stage to demonstration.
9. Investigate “automated reporting” of results from Florida’s nine research universities, four test beds, and private AV deployment sites (e.g., Babcock Ranch). This can start with simple progress reports and move toward sharing data. Link to others who are (or should be) reporting on the

ten national proving grounds, Smart Cities winner and applicants, the National Connected Vehicle Test Bed, and TRB's forum on Preparing for Automated Vehicles.

Capability Maturity Model – This stepwise model can be combined with steps that need to be taken to achieve each level to form a matrix for future actions.

Levels of Maturity

1. Initial – Disorganized; Work characterized by individual effort needs champions to progress.
2. Repeatable – Processes are documented and repeatable.
3. Defined – Organization has adopted the process and developed standards.
4. Managed – The organization monitors and controls.
5. Optimized – Constant improvement and feedback.

Ray Derr – NCHRP

Takeaways for my work

1. The system for ranking NCHRP problem statements has been embellished over the years but remains basically the same. Elements of the California Research Prioritization Methodology might be useful in reshaping it, particularly in better aligning the program with AASHTO's Strategic Plan.
2. The AASHTO Standing Committee on Research has asked AASHTO committees to develop research roadmaps. The examples provided during the peer exchange could be useful models.
3. Some of Derr's new projects touch upon the data science issues discussed, and he will be better equipped to incorporate them into the panel and scope of work. Derr thinks the Automated Traffic Signal Performance Measures website hosted by the Utah DOT (http://udottraffic.utah.gov/atspm) represents a good model for getting started on open data platforms that facilitate data analytics.

Florida DOT is interested in a broad range of emerging topics, from automated vehicles to bridge sensor systems. A critical need for any of these topics is to obtain a good understanding of what has been learned, either from other research efforts (public sector and private sector) and other deployment efforts. For some problems or issues identified by FDOT staff, a quick literature review would suffice, particularly if it identifies a viable solution. For others, identifying experts from other states and bringing them in for a workshop could be effective. FDOT may decide that some issues warrant a sustained research effort that would benefit from developing a research roadmap, and several examples were presented. For emerging technologies, the rapidly changing environment reduces the viability of a long term plan, and the DOT may be best served by shorter-term, more agile approach. These efforts would benefit from input from a wide range of stakeholders beyond FDOT, including the private sector, academia, and local agencies.

For the testbed being developed through the University of Florida, a diverse oversight group would be useful in setting priorities for activities to be undertaken. Some of these should aim to replicate or validate similar efforts conducted at other facilities in the United States and internationally. Establishing ongoing communications channels with the other testbeds would be valuable in coordinating research efforts and disseminating information and results. The NCHRP has some projects getting underway that could help with these coordination efforts.

Dr. Lily Elefteriadou, University of Florida

1. For the testbed it is important to schedule 6-month reviews with stakeholders (a "Transportation Innovation Forum"?). One of those could be scheduled in conjunction with the annual FAV conference. This review should discuss success stories/performance measurement, other developments around the country and internationally, tech transfer opportunities, decisions on new research, and industry partnerships.
2. The testbed plan should consider both a bottom down and a top up approach. It should consider the overall goals of FDOT (for example, Safety, Mobility, Information/Decision making, Sustainability (including maintenance needs), Equity, Tech transfer, Economic development), and also the availability of new technology and opportunities that can be pursued provided they meet one of the main goals.
3. Projects can be categorized into "families" and frequent meetings should be scheduled with the researchers and stakeholders of each such family to ensure coordination.
4. We should explore collaboration opportunities with the TTI testbed. One item discussed was specifically related to developing a joint RFI for industry.
5. Learned a lot about data analytics and visualization, and we are planning a workshop in early fall, to bring in researchers and practitioners that work in these areas to discuss different approaches and implementations for consideration in our data analytics work for the testbed.

King Gee – AASHTO

Key Ideas/"Take-Aways"

- A "Strategic Road Map" seems a bit contradictory in that being strategic necessarily means one may not want the level of detail in it that a "route map" has to have to guide the way.

  - "Strategic" implies "direction" – even though the destination may be unclear today, it is still essential to have a general sense of the way forward, which will be clearer as the journey progresses.
  - Strategic goals need to be "goals" and not general topic areas, e.g., "safety" is a subject area, and a safety goal might be "reduce traffic fatalities."

- When thinking strategically in the evolving transportation space, we need to think of it as a system (systems thinking) by seeing the infrastructure, the vehicle, and the driver/passenger as a whole. Previously, decisions in one area were "silo-ed," not affecting the other two.
  - The innovations and innovative thinking of academia and industry need to be leveraged and unleashed from traditional limits.
  - This new perspective will be challenging and may require that research contract agreements include provisions to <u>pivot</u> as new information and advances come to light.
  - The new transportation space will bring new business models with old and new partners where FDOT needs to consider its negotiating position strengths to get the best terms for itself and the citizens of Florida.

- A key strategic consideration for FDOT is where it wants to be in, say, 30 years, and what role(s) it wants to be positioned for within Florida and nationally.
  - The illustrations provided by FDOT's Transportation Technology initiative and the TSM&O strategic plan are great examples of proactive strategic direction taken by FDOT supported by specific and concrete actions,
  - Research can help answer the "where" and "roles" for FDOT and provide options for actions to support its journey forward,

- Regarding the emerging areas of CVs and AVs and the UF testbed, FDOT should set some general direction and eventually define some specific functions and desired research answers to be served by the testbed for Florida's aspirations.
  - Given the emerging nature of this space, a tremendous service would be provided by initiating a forum for testbed managers from around the country to meet periodically:
    - To share trends and progress seen at their respective testbeds
    - To identify areas for collaboration <u>and</u> coordination
    - To articulate and reach consensus on gaps that need to be filled with research
    - To present a single point of contact for peer institutions from abroad.

- Ultimately, a key premise should be that emerging technology and potentially transformative technology should be positioned to serve transportation goals and not merely be advanced because they are new and "shiny."
  - Unintended consequences may occur, and research should identify the breadth of unintended consequences that may be unwanted and should note early signs of such consequences emerging so that policy steps may be taken to mitigate negative impacts.

Joe Horton – Caltrans

Caltrans FL Peer Exchange Take-Aways

1. Caltrans wants to improve the implementation and communication of research. The FDOT Research Coordinator position is an intriguing idea that we may incorporate into our business practices.
2. FHWA gave a presentation on research roadmaps that will help Caltrans refine our processes. Differentiating between a landscape roadmap that helps you decide where to go versus a route-style research roadmap that lays out the process to get to the results.
3. Learning about the FL testbeds was helpful. It provides opportunities to collaborate on CV/AV research.
4. Caltrans is interested in the FDOT IT Strategic Management Plan. We would like to learn from their experience and successes.
5. Learning about the changes to the AASHTO restructuring process was useful. We did not realize that the restructuring of RAC and SCOR will lead to a CEO-led Research and Innovation committee. This will change the current AASHTO RAC process. The various state DOTs need to comment on the reorganization so that the activities and research in the national arena continue to progress.
6. DOTs need to work more closely with industry on CV/AV issues. The IBM assertion that "cognitive" technology will be a key technology that will bring information together to the driver is one take-away that DOTs may find useful for industry.
7. Montana DOT developed a crosswalk that ties the old AASHTO structure to the new AASHTO structure, along with the assorted TRB committees. Caltrans is currently adjusting who will attend AASHTO as the main representatives for Caltrans. The crosswalk will provide vital information to ensure Caltrans has the right people participating in the most important AASHTO committees.

Observations

1. The FDOT plan to develop a test bed through the AID process is a great decision. This will help ensure that FDOT is involved with the development of CV/AV solutions so that DOTs are ready for the large scale use of CV/AV. More states need to join in this effort.
2. I applaud the effort by FDOT to develop new tools to assist in the planning and development of needed research to support their efforts in dealing with transformational technologies, such as CV/AV.

David Jared – Georgia DOT

Top Three Take-Homes

1. Research roadmaps can be subdivided into “landscape” maps (where to go) and “route” maps (how to get there). (FHWA)
2. Roadmaps may be incorporated into the existing GDOT research initiation process. (Caltrans)
3. For research on transformational technologies, consider parallel tasking, scenario planning, and open calls for ideas. (TRB)

Day 1 Take-Homes

1. AASHTO
    a. State DOTs are 52 “laboratories” but are shifting from data collection/provision to data purchasing.
    b. Policy research quality is often subpar.
2. TRB
    a. Roadmap considerations: awareness, agility, relevance
3. State University of New York (Albany)
    a. Data should be viewed as an “agile” asset.
    b. Concept of a “data scientist” should be explored to guide data asset management.
    c. Web-based dashboards should be considered for data dissemination.
4. IBM
    a. Data should be considered as a “natural resource” for the 21st century.
    b. Utilize private research findings to extent possible: they can save time.
5. Caltrans
    a. Research ideas come bottom-up; guidance top-down (confirms current GDOT model).
6. University of Florida
    a. Factors to consider in roadmaps: safety, mobility, providing information, technology transfer, economic development, equity, sustainability.

Day 2 Take-Homes

1. Florida DOT
   a. Data governance shouldn't be viewed as scary but as expeditious.
   b. Good data inventory can prevent unnecessary data purchases.
   c. Identify relationship between GDOT-IT and Office of Transportation Data (how could they implement data governance policy?).
2. TRB
   a. Review national concrete research roadmap; adaptable to other pavement research?
   b. Consider more performance-based research, focused on outcomes rather than processes.

David Kuehn – FHWA EAR

1. From King Gee: We are entering a unique time in highway transportation research with raised public awareness and interest created by advances in vehicle automation.
2. On Roadmaps
   a. It can be difficult obtaining and maintaining situational awareness in rapidly advancing areas of research. Many organizations are conducting scans. There is limited sharing of the scanning within or across organizations, which can result in unnecessary duplication. [This could be a good topic of discussion for RAC TKN or PM&Q or for TRB Conduct of Research Committee.]
   b. State DOT and NCHRP research mostly focuses on discrete projects, not programs. Projects often are bottom-up with limited strategic focus.
   c. Transportation Pooled Fund studies can provide a management scheme for research on a topic beyond the fixed period of performance and work scope of a project.
   d. Agencies are seeking methods to increase flexibility in research procurement in response to rapidly changing environments.
3. Communication of Roadmaps
   a. Some roadmaps are prospective, and others retrospective (describe a bundle of projects that came from the ground up). Both can aid in communication.
   b. Communication can aid with cross-cutting issues, e.g., research on when to grout tendons involves structures, materials, and construction areas.
4. Regarding research program management, Caltrans conducts initial stage investigations that often result in identifying solutions developed by others, saving the need for what could be unnecessary duplication of research.
5. Data can be valuable assets resulting from research.
   a. Research programs may benefit by considering data value, lifecycle, and possible re-uses earlier.

    b. It can be difficult to transition data or software developed under research into program tools and data analytics. Coordination with Acquisition and IT are necessary.
6. There is a benefit to strengthening the link between research and policy. Research road maps may not encompass the use of results for policy development or policy change.
7. There is increasing interest in moving research to pilot deployments in the area of connected and automated vehicles.
    a. These activities engage local agencies and universities. There are test bed coalitions in Florida and Texas.
    b. There are questions on how and when to engage industry. [State DOTs perhaps need information about an equivalent to a Cooperative Research and Development Agreement, which federal laboratories use; more information is located at https://www.fhwa.dot.gov/research/tfhrc/labs/collaboration.cfm#.]

Dr. Catherine T. Lawson, University at Albany

Vision

- Research catchment – Consider the concept of a "research catchment" rather than using the term research roadmap or research route map. A research catchment would suggest research could be informed by like-kind research activities that validate and/or compliment research efforts. FDOT should consider capturing data production flows using Application Programming Interfaces (APIs) that could to be accessed using a web-based platform designed to ensure agile access and analytics on the fly.

Approach

- Coordinate test-beds locally, nationally, and internationally to allow for confirmation/validation of test-bed outputs and approaches and rapid identification of next steps (review literature review to identify elements already tested or underway).
- Expand science behind scenario planning to reflect experimental design structure.
- Develop clear direction for dealing with industry partners to make sure DOT research is benefiting equally with private sector.

James Lou, IBM

- Public and private sectors, including academia, should work together on using latest technologies such as IoT, Cloud, Cognitive AI, and Analytics, for ITS deployment. Regular exchange is necessary to synch up on progress.
- A procurement process different from civil infrastructure projects are necessary for ITS and technology projects. The new process will allow technologies to be adopted more rapidly and bring faster benefits (e.g. congestion relief) to the travelling public.
- Research on a cognitive IT architecture for transportation is necessary in light of Big Data, connected vehicles, and Cloud computing. The IT platform includes Cloud infrastructure, Data Analytics, and Cognitive AI Machine Learning. The platform supports multiple ITS applications and serves as the basis for future innovation.

Mark Norman – TRB

- Florida DOT, Texas, California, Montana, and Georgia, and other states are already pursuing innovative approaches to research
  - Florida DOT is already pursuing more than a dozen research projects on connected/automated vehicles.
  - California DOT has considerable experience with research roadmaps.
  - TxDOT Innovate Research Program (no RFPs or problem statements)
  - Georgia DOT annual implementation reports
  - Several states are establishing lead implementation manager positions.
- On the other hand, states are also facing some of the same barriers.
  - State RFPs for ITS projects still use technologies that are 10-15 years old. Most projects do not incorporate latest technologies such as Cloud, Big Data, IoT, and Cognitive Computing. The result is that outdated systems are designed and implemented which deliver reduced benefits to the traveling public. DOTs should consider adopting a suitable procurement method for ITS technology projects that differ from traditional civil infrastructure projects.
- Concept of a research roadmap
  - Needs to track with DOT's overall mission and goals
  - Idea of a dynamic/living research roadmap has value.
  - Standing group that meets at least on a regular basis could also have value.
  - Standing contracts for quick response answers could have value.
  - However, all of these would mean some change from the ways we have historically done business.
  - As in any change, support from top management would be key.

- Potential Impacts on our traditional research processes
  - Redefining our definition of a research “project”
  - Accomplish tasks in parallel rather than in series, and bring together at the end.
  - Consider need to rely more on scenario planning for some topics.
  - Focus RFPs on outcomes rather than processes.
  - Enhance agility/flexibility for researchers and staff.
  - Reduce administrative burdens.
  - Leverage demos and field tests.
  - Look to other sectors for good models.
- Florida DOT’s challenges in addressing research in transformation technologies are not unique.
- Other states are facing similar challenges and questions:
  - What are the issues in this area that can be addressed by research?
  - What research is already underway or planned by others?
  - How can state DOTs keep abreast of all that is happening?
  - What “niches” can/should individual states focus on as part of their own research programs?
  - What opportunities exist or should be created to enable states to collaborate on researching common issues and for “replicating” research results where desirable?
  - How might some of our traditional research processes need to change in this age of transformational technologies?
- Other state DOTs would benefit from a discussion of issues addressed during this peer exchange.
  - AASHTO RAC/TRB State Reps meeting(s) would be a good venue to expand this dialogue.

Teresa Parker – FHWA

- Aligns with FAST-ACT and new future highway funding legislation
- Communication, collaboration, and coordination are extremely important for engaging the public and stakeholders early on in the initiation of potential research projects.
- Emerging Research Projects: Ask the right questions which will aid in reducing time/money.
- On-going feedback on what’s happening from a national/state/university/private sector/international perspective to not reinvent the wheel but to replicate the processes to fit what the state needs
- Possibility to leverage other funding sources for emerging research projects with others
- Data seems to be a big factor in how, what, where, and who can strategically utilize the data.
- Establish a network to keep open dialogue and communication with the peer exchange stakeholders from both past and present.

- Tap into other career discipline areas that you may not even think to consider when defining a purpose and need.

Dr. Christopher Poe, Texas A&M Transportation Institute

Sue Sillick – Montana DOT

- Investigate developing data plans for research projects.
- Incorporate data considerations upfront at the beginning of each project. Identify others who may be able to benefit from project data, and develop it in a manner to facilitate its use.
- Contact John Krause to learn about demonstration UAS projects.
- Remember governance is not scary; it helps us go fast.
- Share FDOT IT strategic plan presentation with MDT staff.
- Share AASHTO-TRB committee's crosswalk with Joe.
- Share Peer Exchange presentations and report with WTI.

2. Research Center Action Plan

As a result of the in-depth discussion throughout the peer exchange, FDOT identified the following items that will be vetted and prioritized in coordination with executive leadership to identify top priorities for action. The list below comprises actions ongoing as well as items for future consideration and development. These will be managed through annual review and reporting.

Initial Action Plan Items

- Consider potential additional project vetting across functional areas against identified key strategic criteria (Horton).
- Consider additional ways to create project cohorts or families.
- Consider potential for standing subject matter teams (cross-functional, potentially cross-sector, national). Formalize approach and possibly provide additional, e.g., consultant or university support to manage (Norman et al.).
- Consider potential for open RFI through UF for campus test bed to attract test bed users (Kuehn, Poe).
- Consider more effective monitoring of test bed areas vis-à-vis national groups (e.g., CV TPF).
- Consider how to expedite project data sharing (real- and near-real-time).

- Guidance (top-down) and project (bottom-up) coordination sharing with leadership and functional areas
- Annual implementation report
- Revisit organizational process and language used in implementing potential changes.

Future Action Plan Items to Be Considered and Developed

- Consider process to effectively and actively manage whatever version of a “roadmap” is considered (Andrle).
- Consider development of key area/focus topics for open call for research ideas/projects (Kuehn).
- Consider how to craft a portfolio of case projects or partner for distributed replication projects at different test beds (Sillick).
- Six-month emerging technology coordination/information sharing meeting
- Topic scouting (maturation of technology) to share with functional areas/leadership to coordinate strategic goals and research portfolio
- Advisory committees in research project selection
- Consider how implementation of solutions can be leveraged to expedite process.
- Immersive research/research catchment – real-time awareness
- Staff assignments for monitoring current event issues in selected areas.
- Expand the science behind scenario planning for potential integration into research projects.
- Develop clear direction for working with industry partners to effectively leverage and understand respective benefits.

VII. The FDOT Research Peer Exchange 2017 Team

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Appendix A – FDOT 2017 Research Peer Exchange: Agenda

Monday, April 24

—	Travel Day	

Tuesday, April 25
Morning Schedule – Auditorium

8:00 am	Introduction – State DOT Research Roadmaps in the Contexts of National Agenda/Activity and Emerging Technologies	Darryll Dockstader
8:30 am	Panel 1 – The National Picture ○ 8:30 King Gee, AASHTO ○ 8:45 Ray Derr, NCHRP ○ 9:00 David Kuehn, FHWA EAR ○ 9:15 Mark Norman, TRB ○ 9:30 Q&A	Moderator: Steve Andrle
9:45 am	Break	
10:00 am	Panel 2 – Universities and Industry ○ 10:00 Dr. Christopher Poe, Texas A&M Transportation Institute ○ 10:15 Dr. Catherine T. Lawson, University at Albany ○ 10:30 Dr. Lily Elefteriadou, University of Florida ○ 10:45 James Lou, IBM ○ 11:00 Q&A	Moderator: Steve Andrle
11:15 am	Break	
11:30 am	Panel 3 – State DOTs ○ 11:30 David Jared, Georgia DOT ○ 11:45 Joe Horton, Caltrans ○ 12:00 Sue Sillick, Montana DOT ○ 12:15 Q&A	Moderator: Darryll Dockstader
12:30 pm	Lunch	

Afternoon Schedule – 336

1:30 pm	Concept of a Research Roadmap	
2:30 pm	Tour of Cascades Park	
3:15 pm	Concept of a Research Roadmap – Discussion (continued)	
5:00 pm	Dinner	

Wednesday, April 26
Morning Schedule – 336

8:00 am	Recap	
8:30 am	ROADS – FDOT's Process – April Blackburn	
9:00 am	And What of Data and Research? ○ Data and Decision-making ○ Data and Performance Analysis ○ Data and Production ○ Data Security	
10:00 am	Break	
10:15 am	Data and Research, Research and Data (continued) – David Sherman, Raj Ponnaluri	
12:00 pm	Lunch	

Afternoon Schedule – 336

1:30 pm	Emerging Technologies ○ What do we mean by emerging technologies ○ AV/CV Projects ○ UF Campus Testbed	
3:30 pm	Break	
3:45 pm	Emerging Technologies (continued)	
5:00 pm	Adjourn	

Thursday, April 27

8:00–11:00 am	Recap, report preparation, and wrap-up	
11:00 am - 12:00 pm	Report out to Brian Blanchard, FDOT Assistant Secretary	

Appendix B – Opening Presentation

Darryll Dockstader – Opening Presentation

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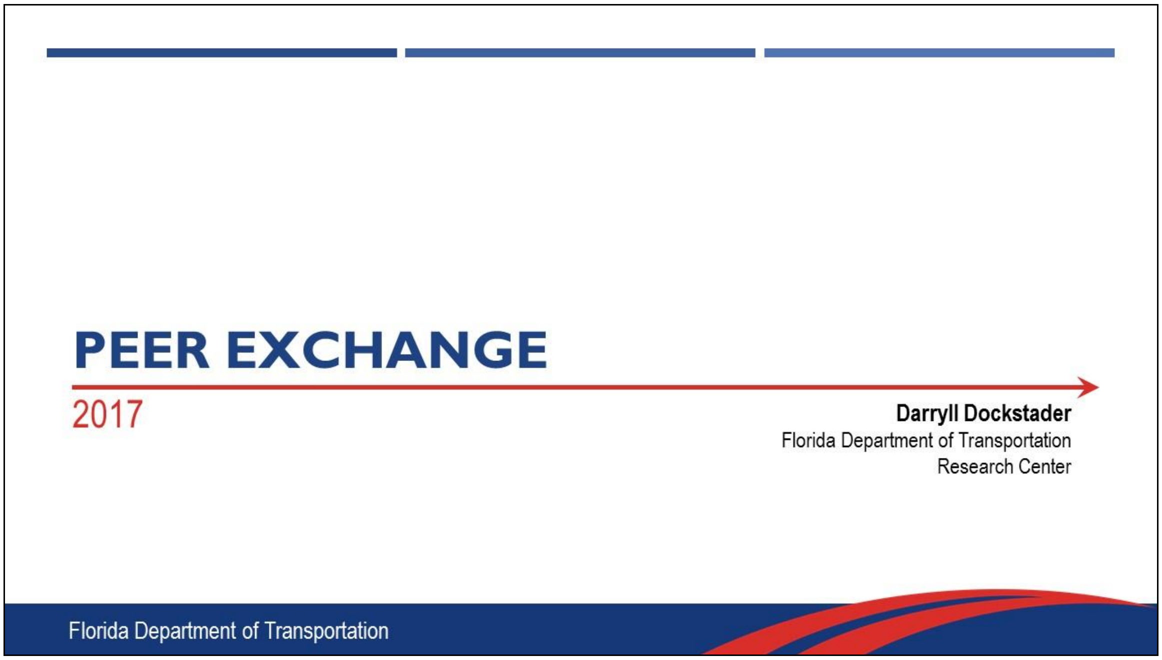

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Dockstader, continued

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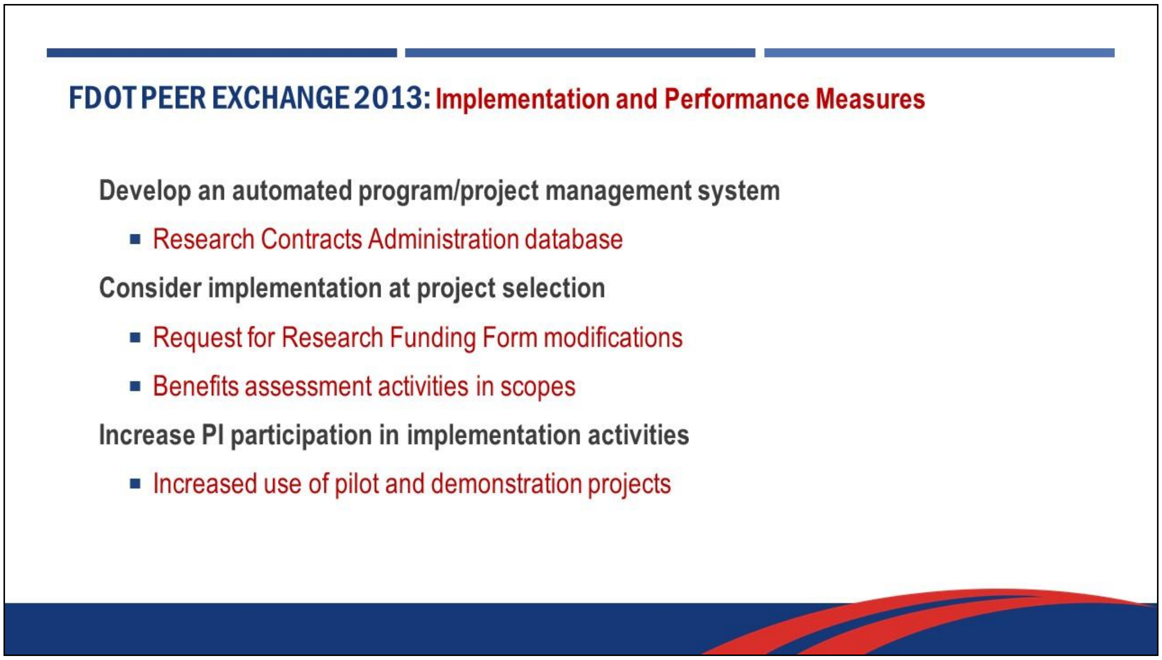

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Dockstader, continued

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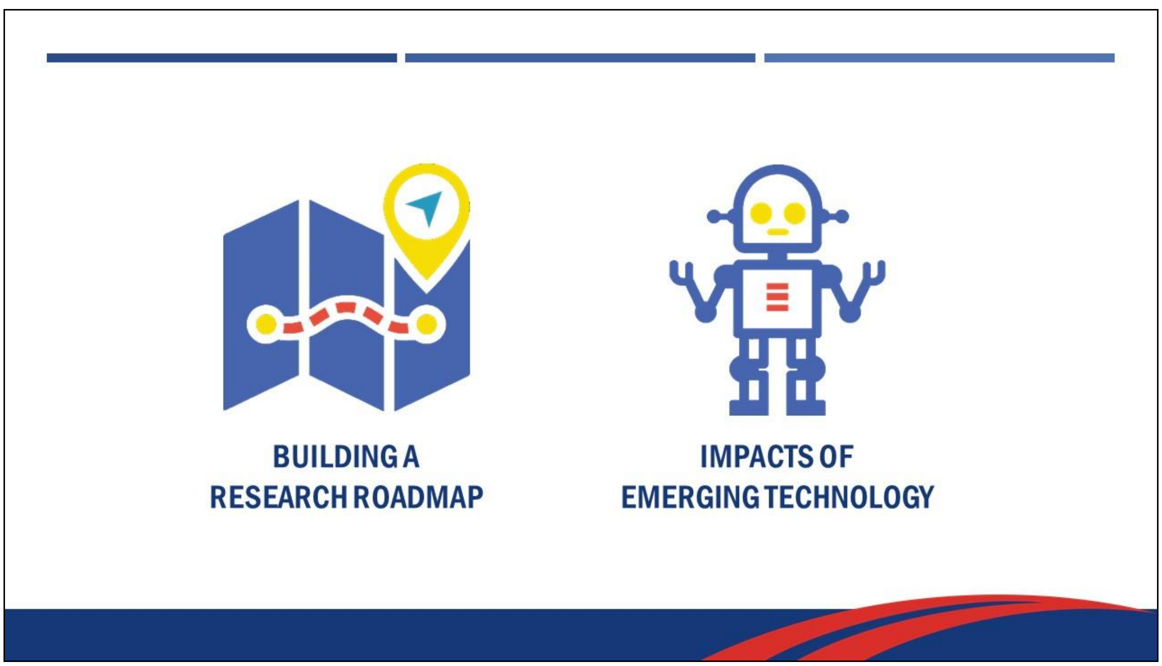

Dockstader, continued

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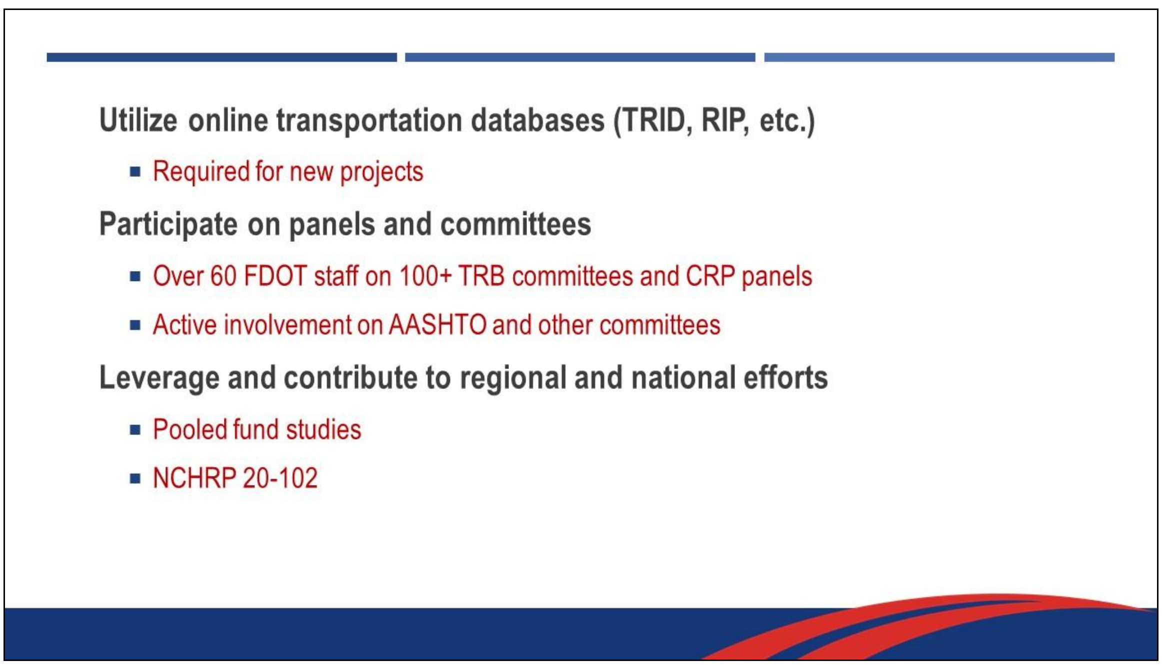

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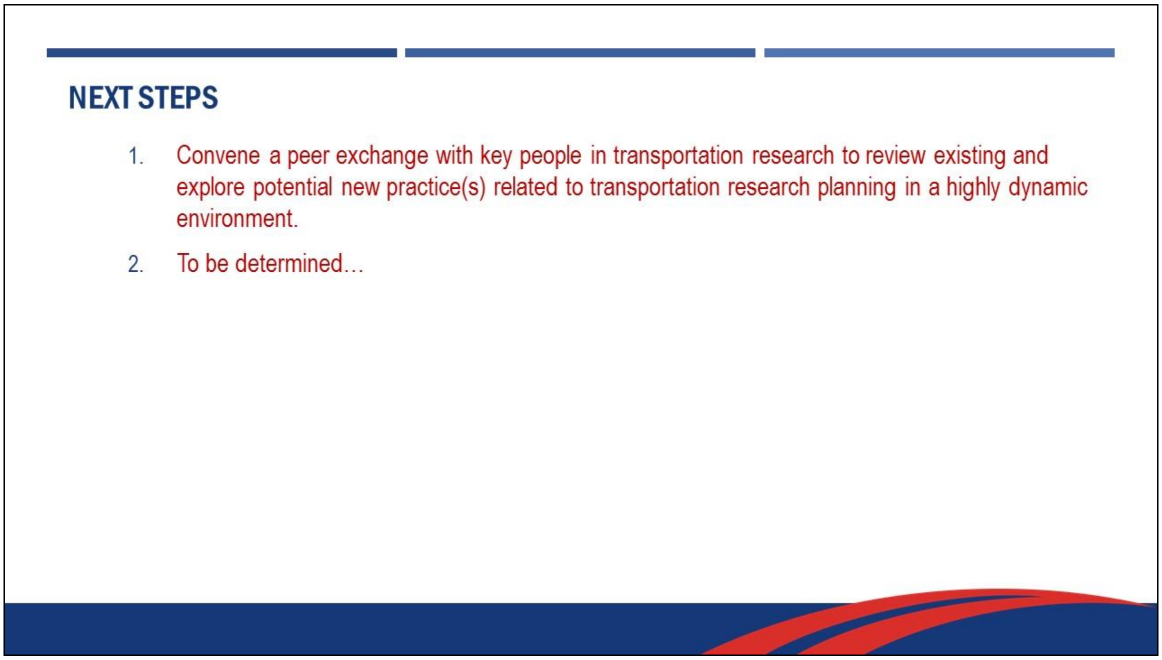

Appendix C – Panel Presentations

King Gee – AASHTO

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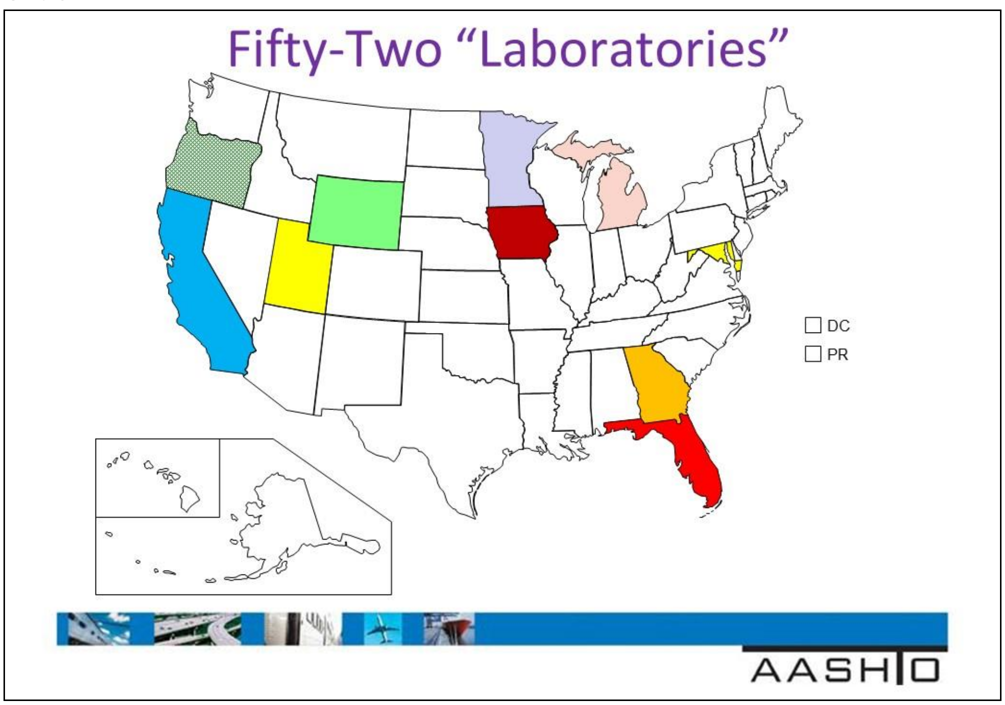

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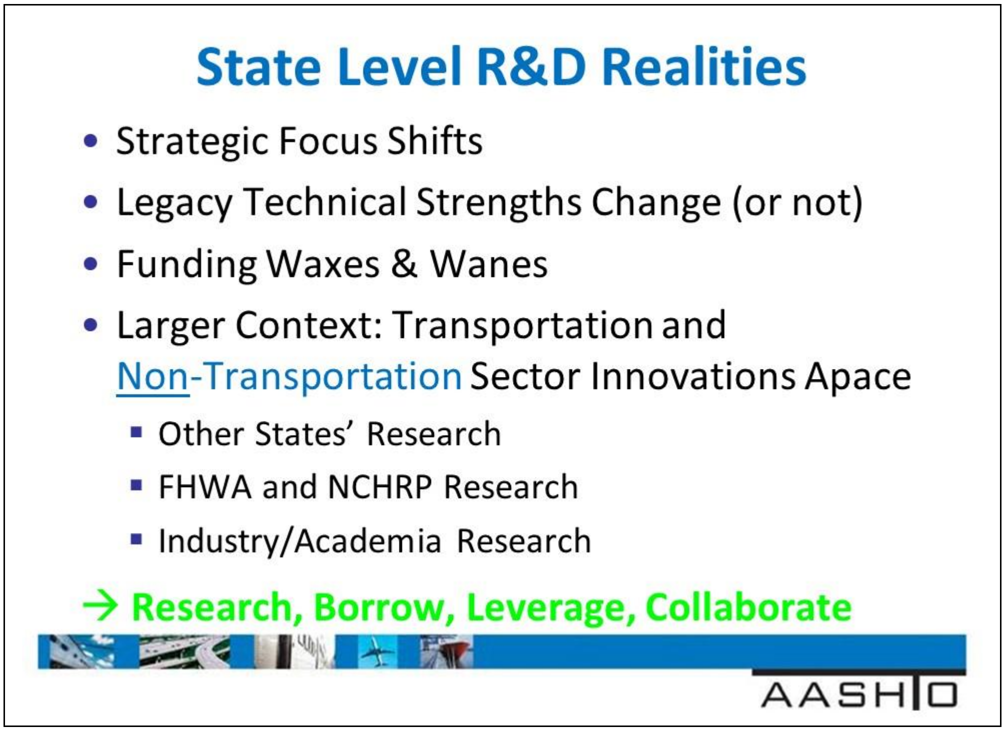

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Gee, continued

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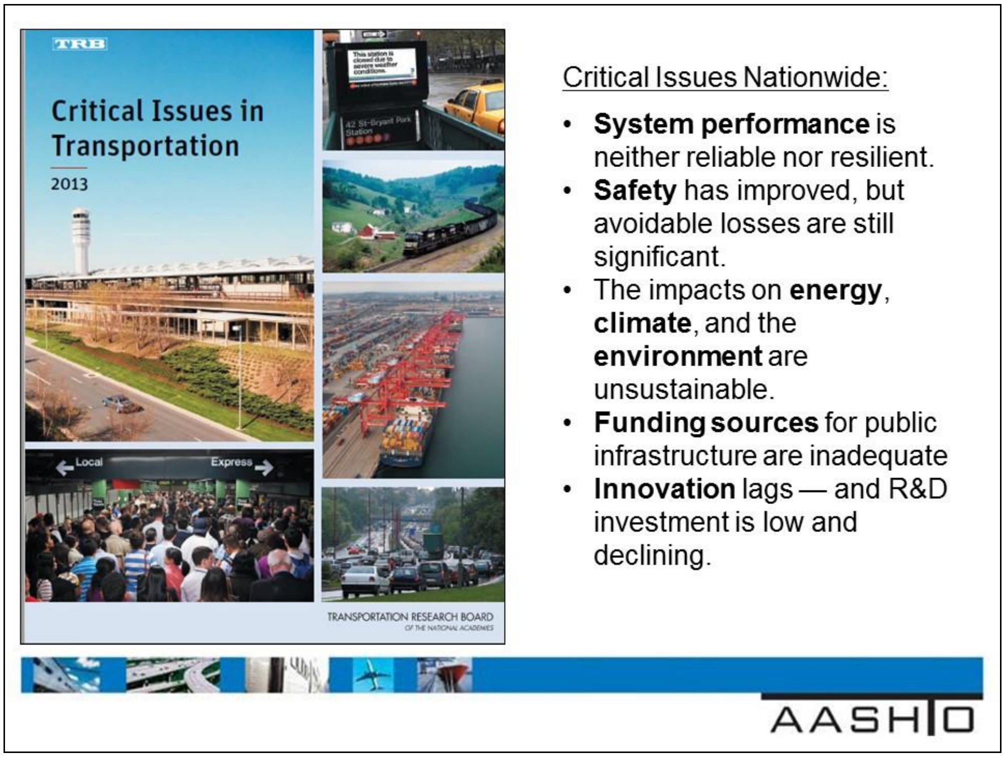

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Gee, continued

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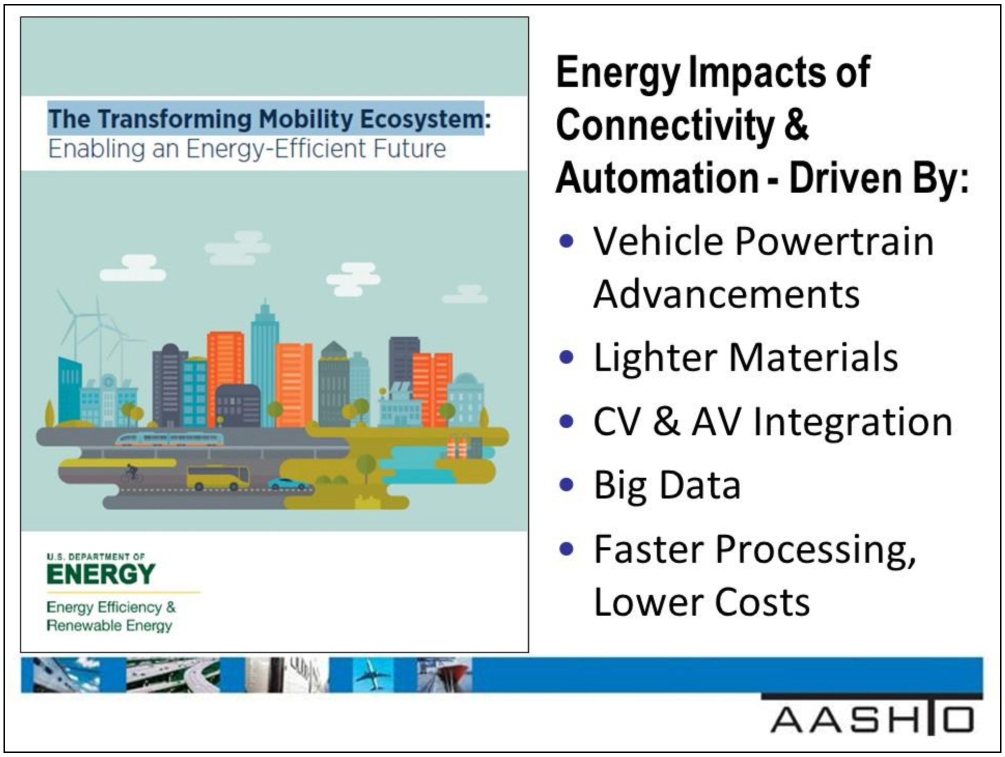

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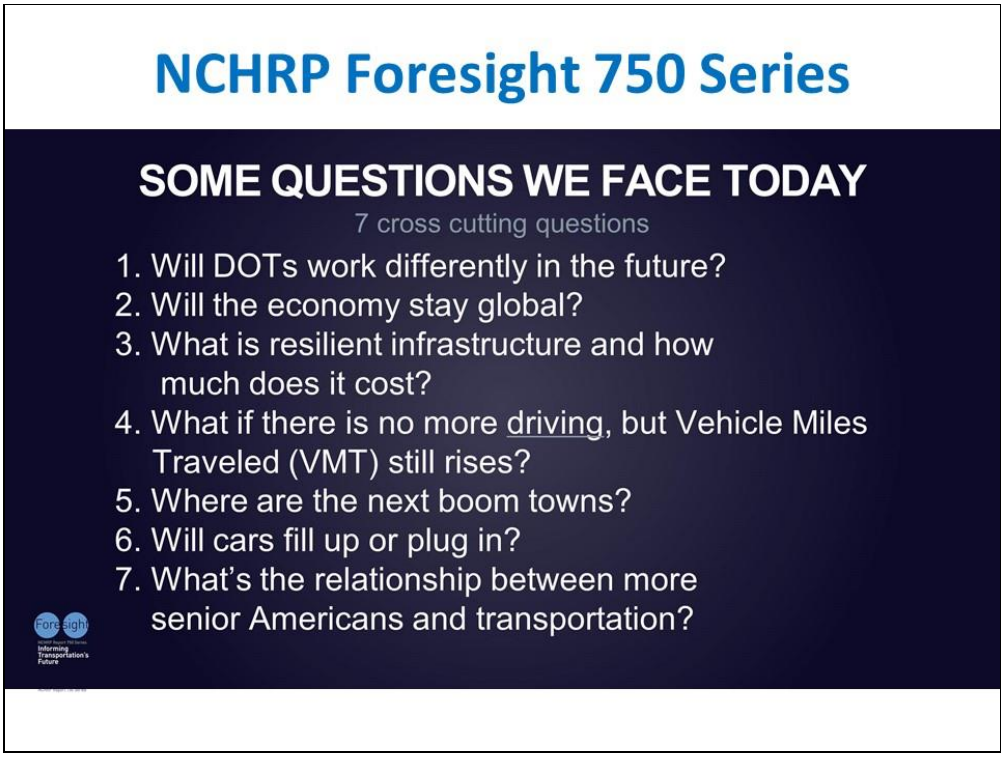

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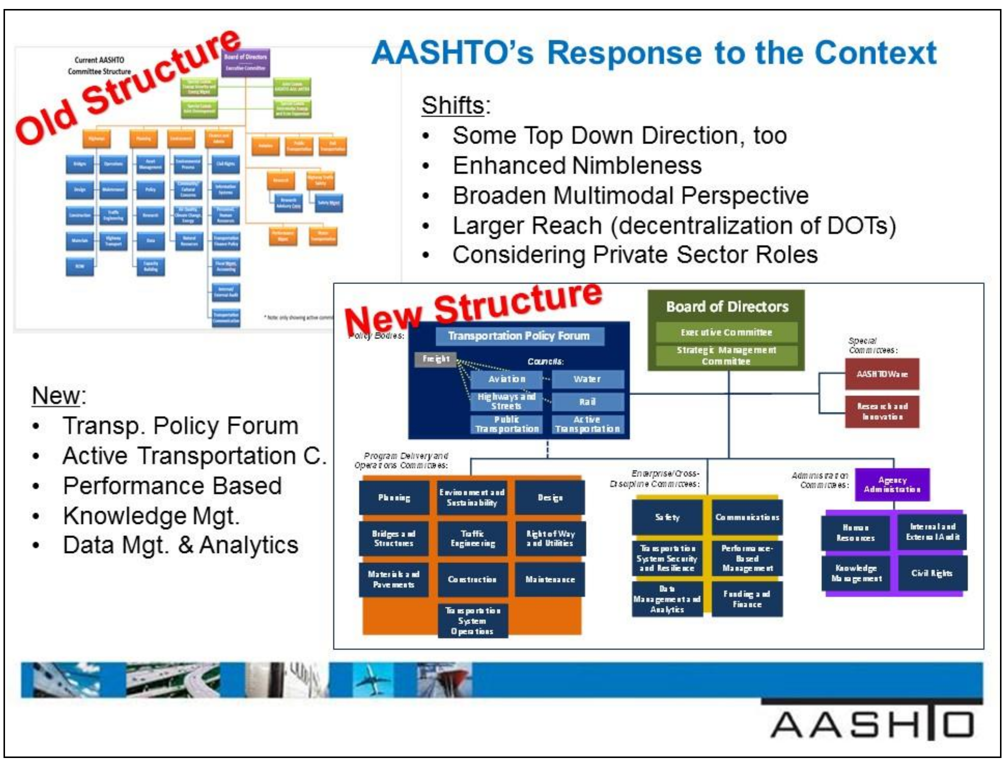

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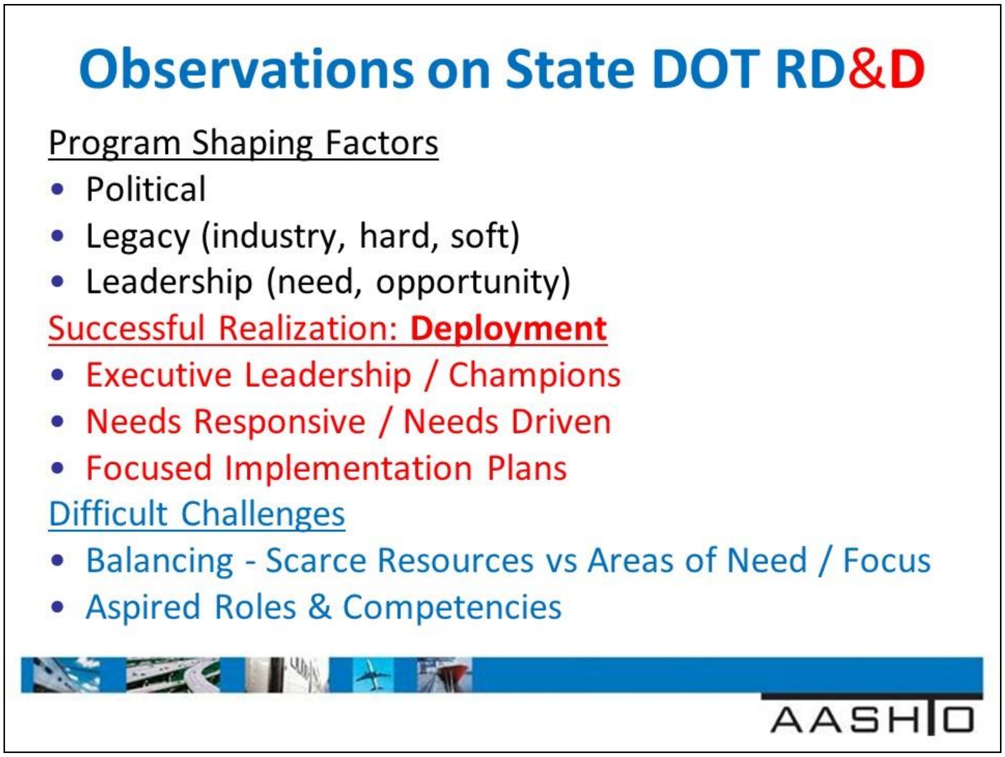

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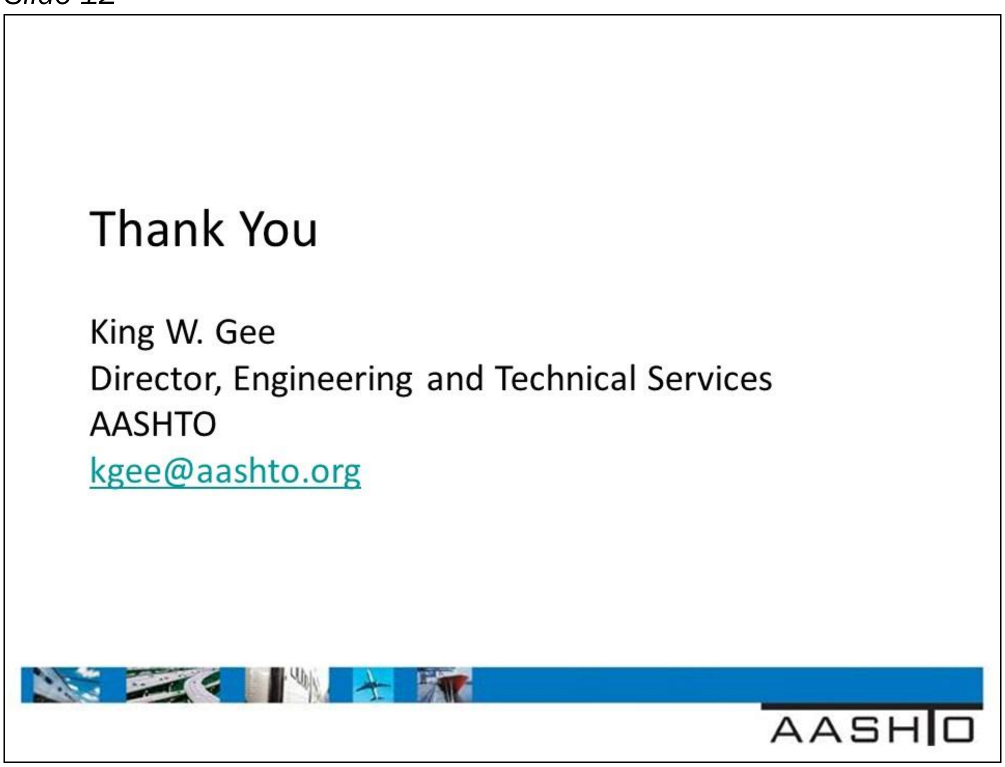

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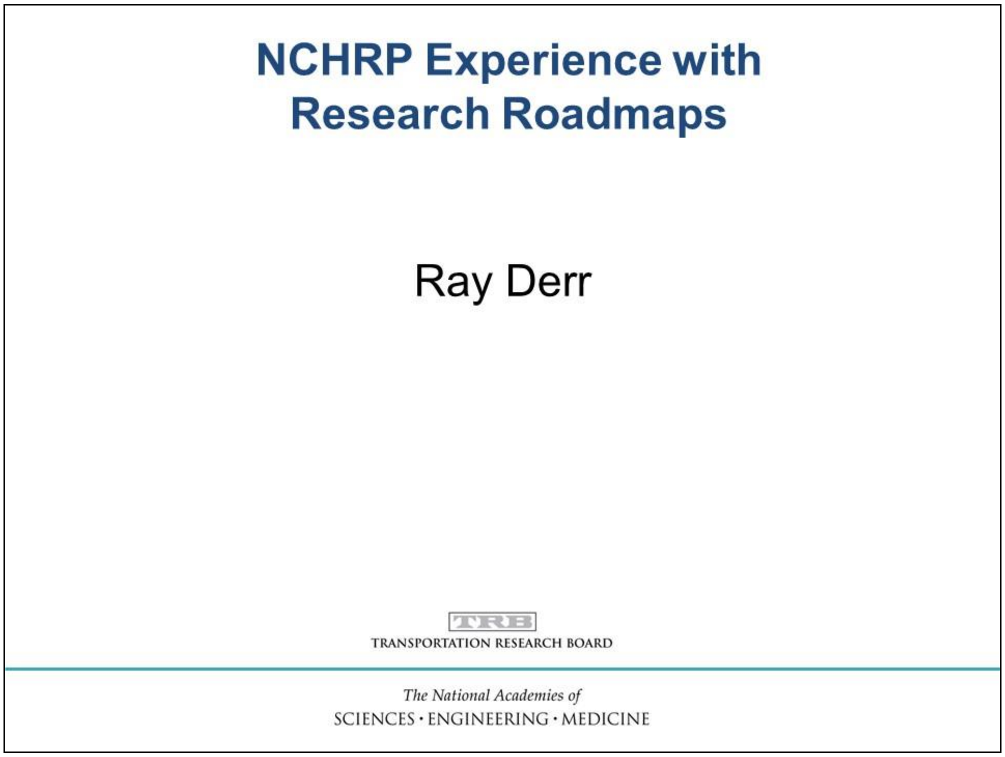
Slide 13

Slide 14

Ray Derr – NCHRP

Slide 1



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Derr, continued

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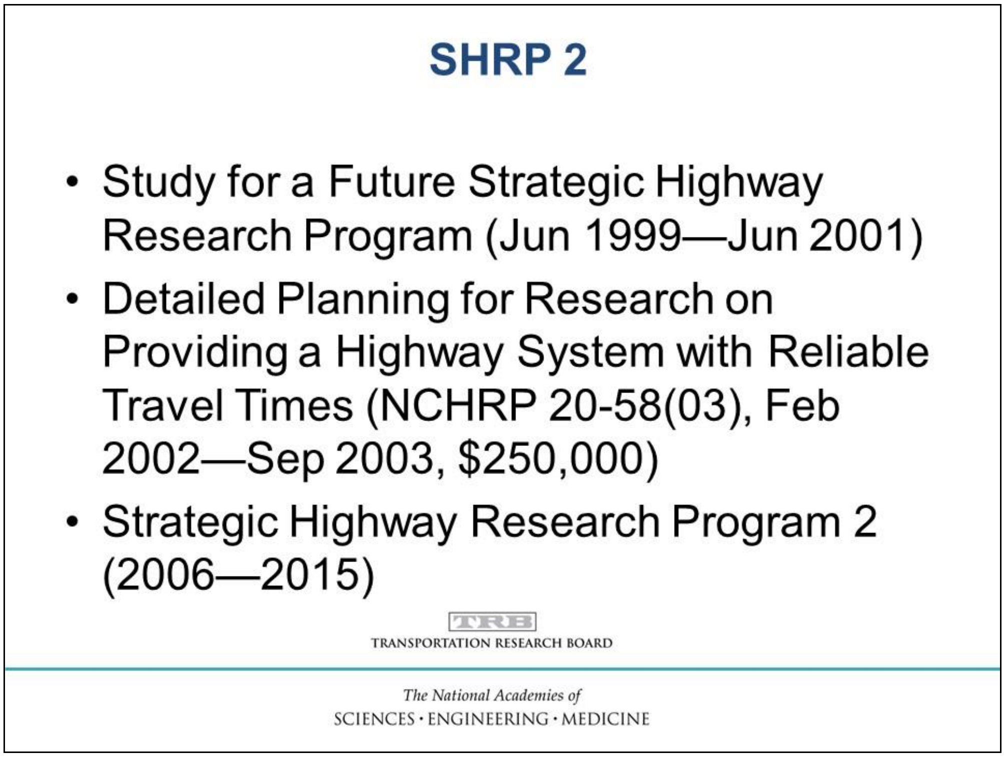

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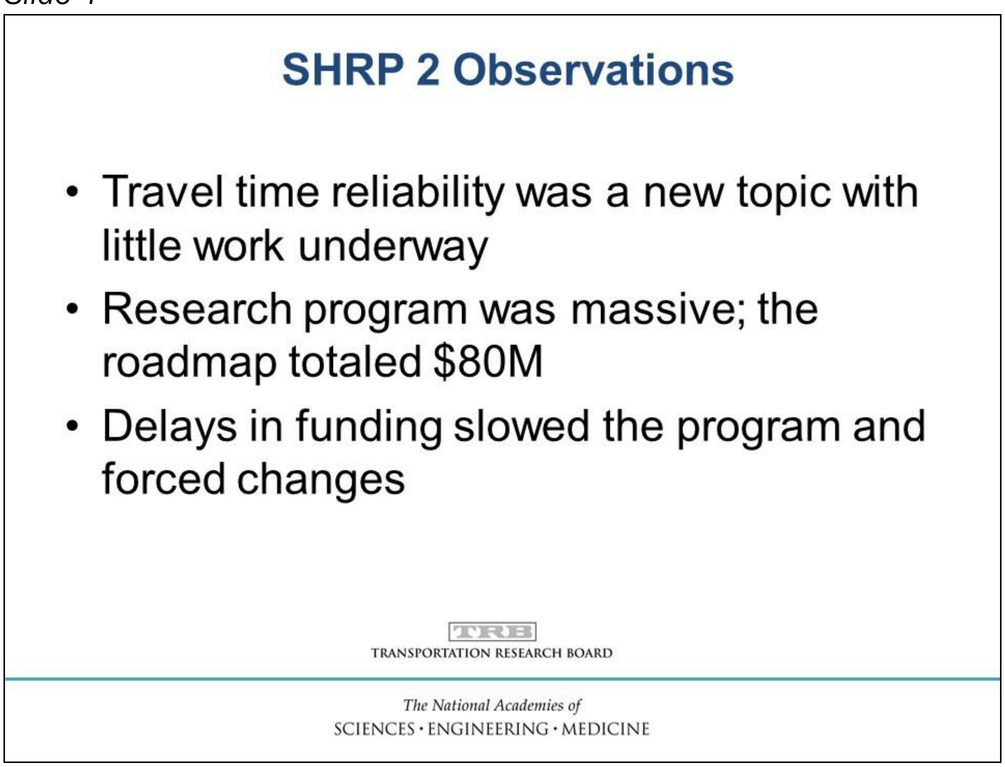

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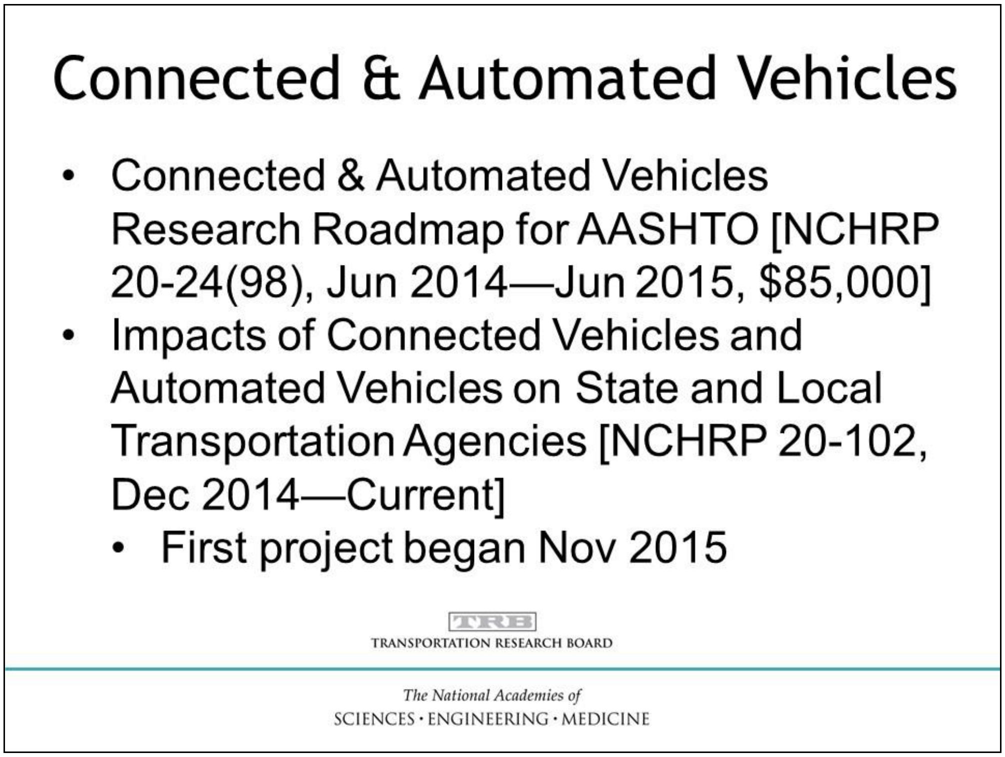

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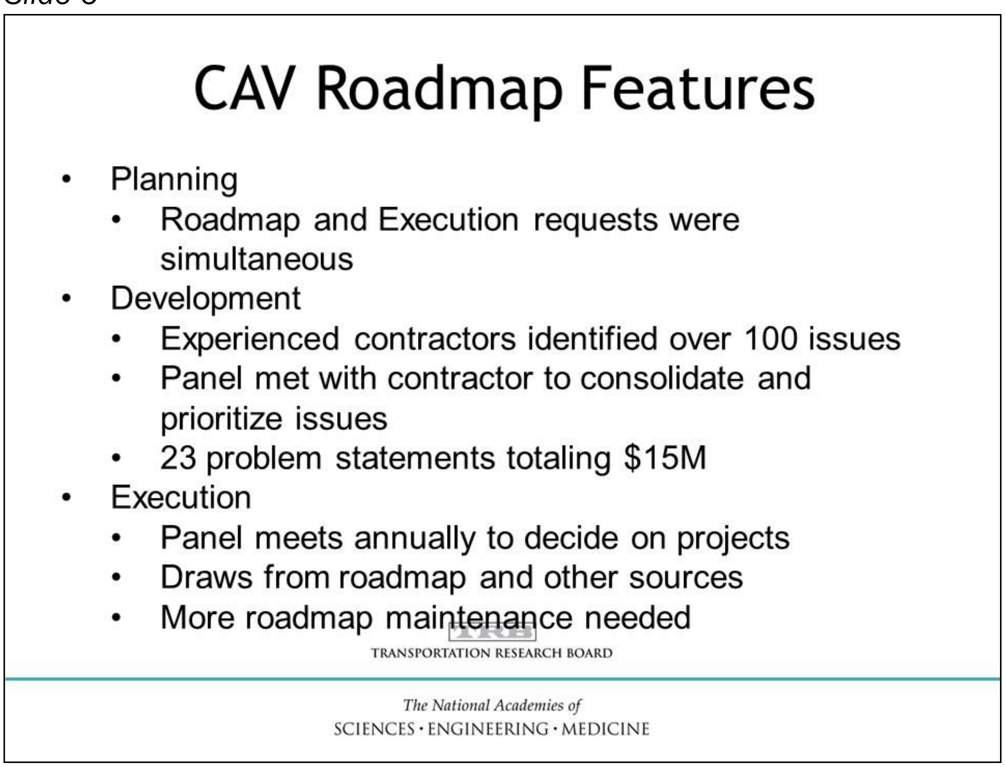

Derr, continued

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Transformational Technologies

- Research Roadmap for Transformational Technologies (Other than CV/AV) [NCHRP 20-113, $250k]
  - Support for TRB Symposium [$130k]
- TRB Partners in Research Symposium: Transformational Technologies in Transportation [Oct 30-Nov 1, 2016]
- Three projects approved in Feb 2017 and Mar 2017

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Transformational Tech. Features

- Planning
  - Symposium planning was extensive
  - Contractor identified participants and developed resources
- Symposium
  - Focused on how public policy objectives can be met through technology initiatives
  - Topical break-out groups to identify issues
  - Three themes
    - Private-sector, public-sector, and academia working together is vital
    - Planning horizons are very different
    - Processes need to change for public sector to keep pace
  - Three problem statements developed
- Execution
  - Process for dialogue still being developed

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Derr, concluded

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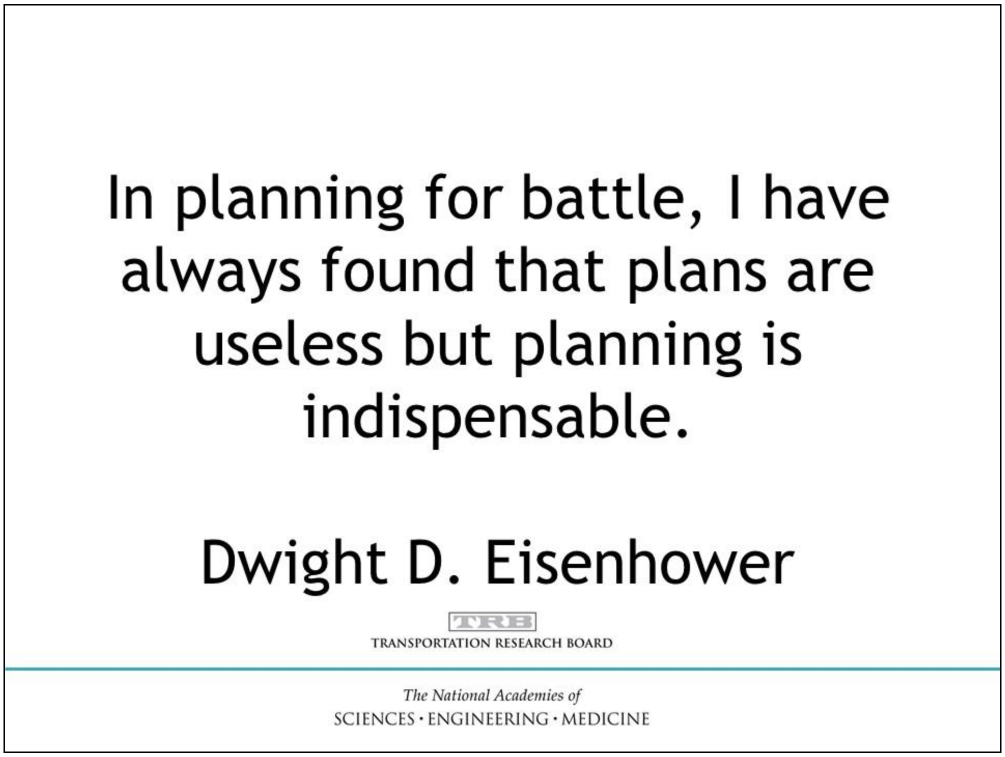

David Kuehn – FHWA EAR

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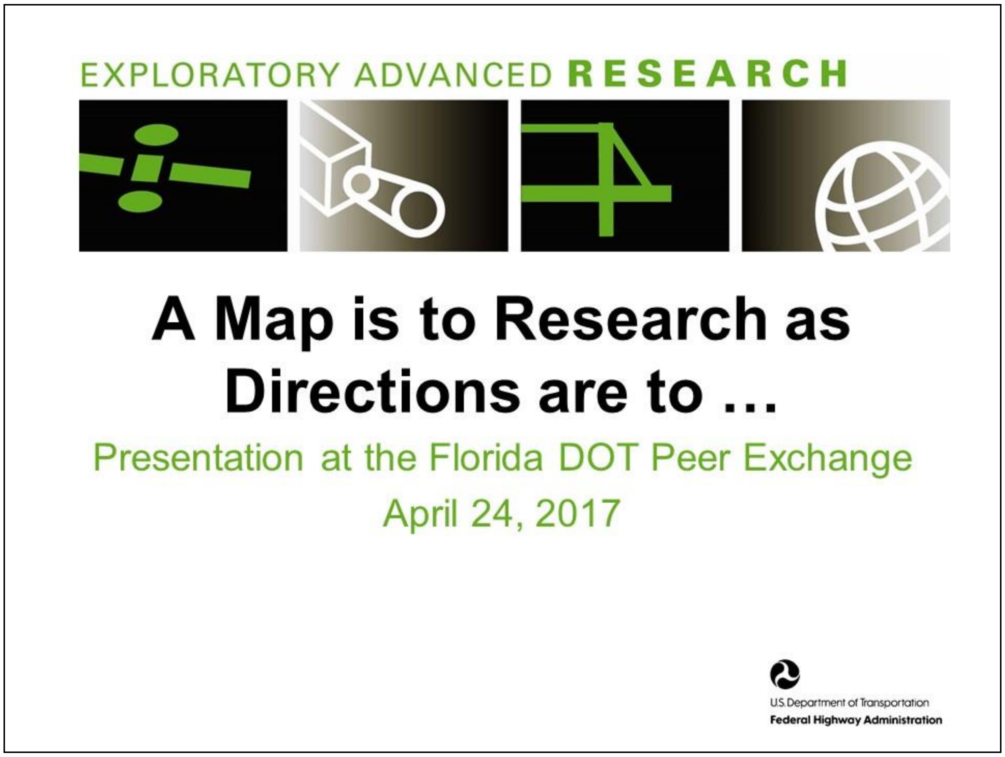

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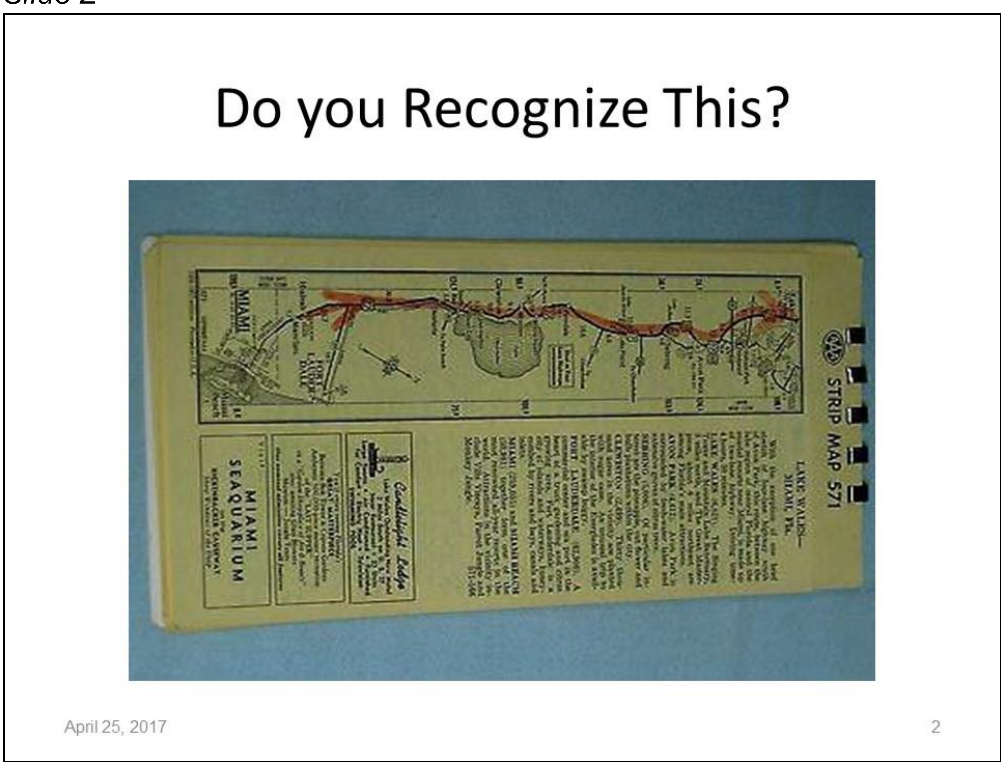

Kuehn, continued

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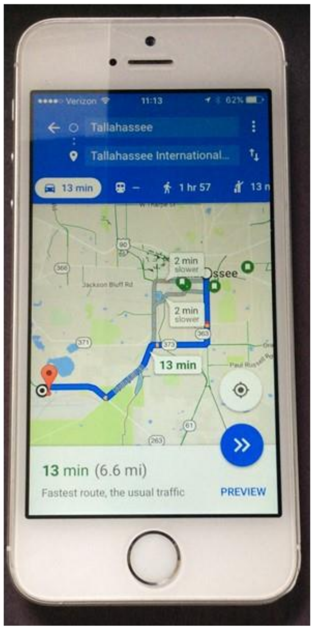

What about This?

April 25, 2017 3

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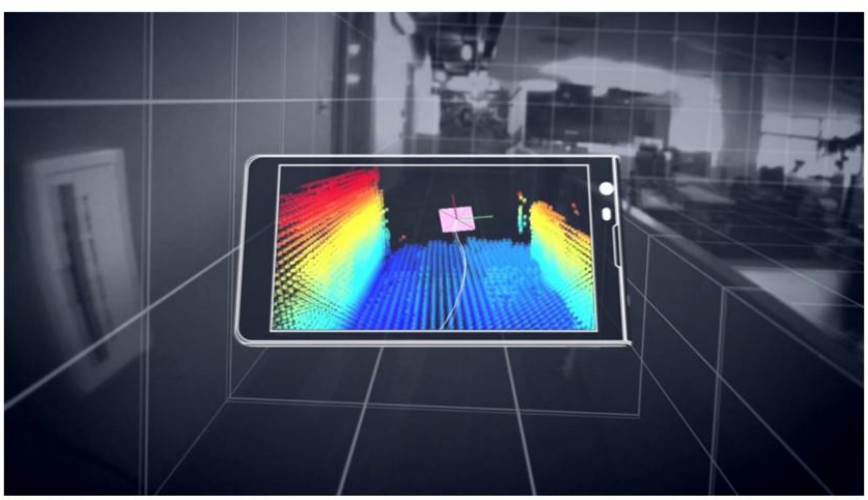
Or This?



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Kuehn, continued

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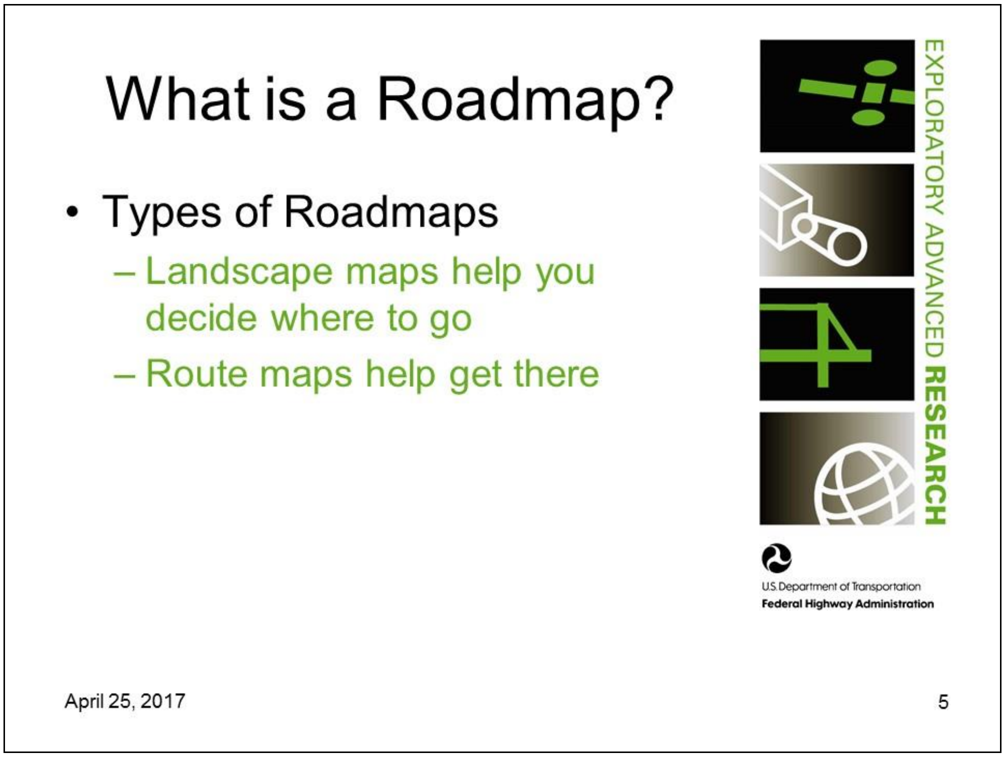

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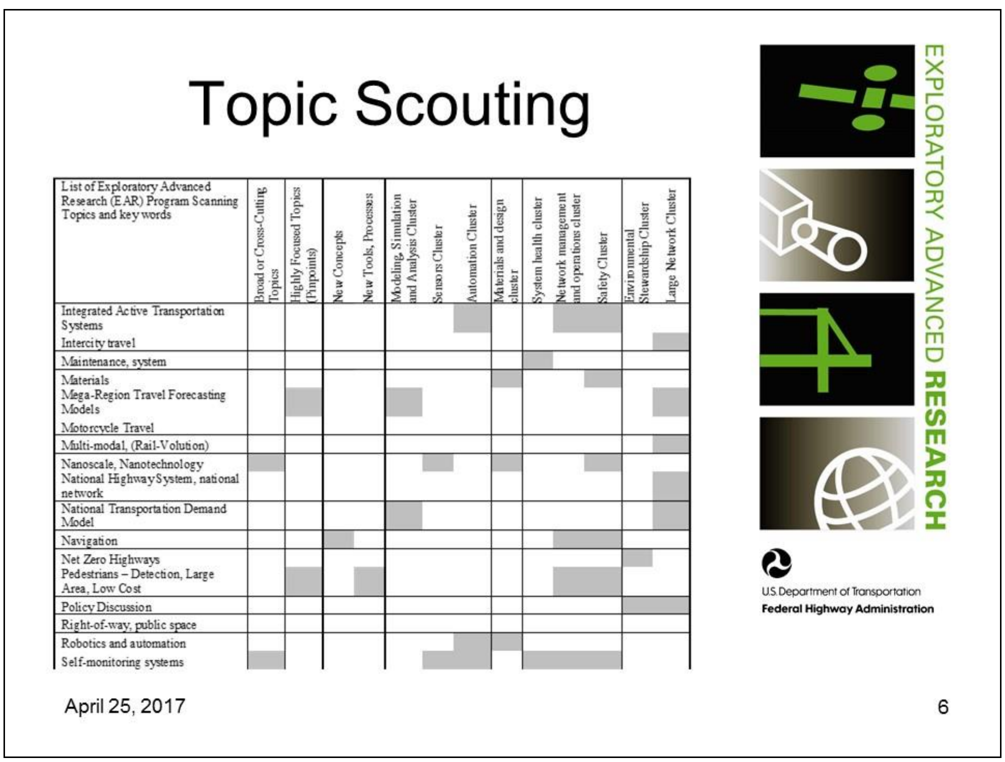

List of Exploratory Advanced Research (EAR) Program Scanning Topics and key words	Broad or Cross-Cutting Topics	Highly Focused Topics (Pinpoints)	New Concepts	New Tools, Processes	Modeling, Simulation and Analysis Cluster	Sensors Cluster	Automation Cluster	Materials and design cluster	System health cluster	Network management and operations cluster	Safety Cluster	Environmental Stewardship Cluster	Large Network Cluster
Integrated Active Transportation Systems													
Intercity travel													
Maintenance, system													
Materials													
Mega-Region Travel Forecasting Models													
Motorcycle Travel													
Multi-modal, (Rail-Volution)													
Nanoscale, Nanotechnology													
National Highway System, national network													
National Transportation Demand Model													
Navigation													
Net Zero Highways													
Pedestrians – Detection, Large Area, Low Cost													
Policy Discussion													
Right-of-way, public space													
Robotics and automation													
Self-monitoring systems													

Kuehn, continued

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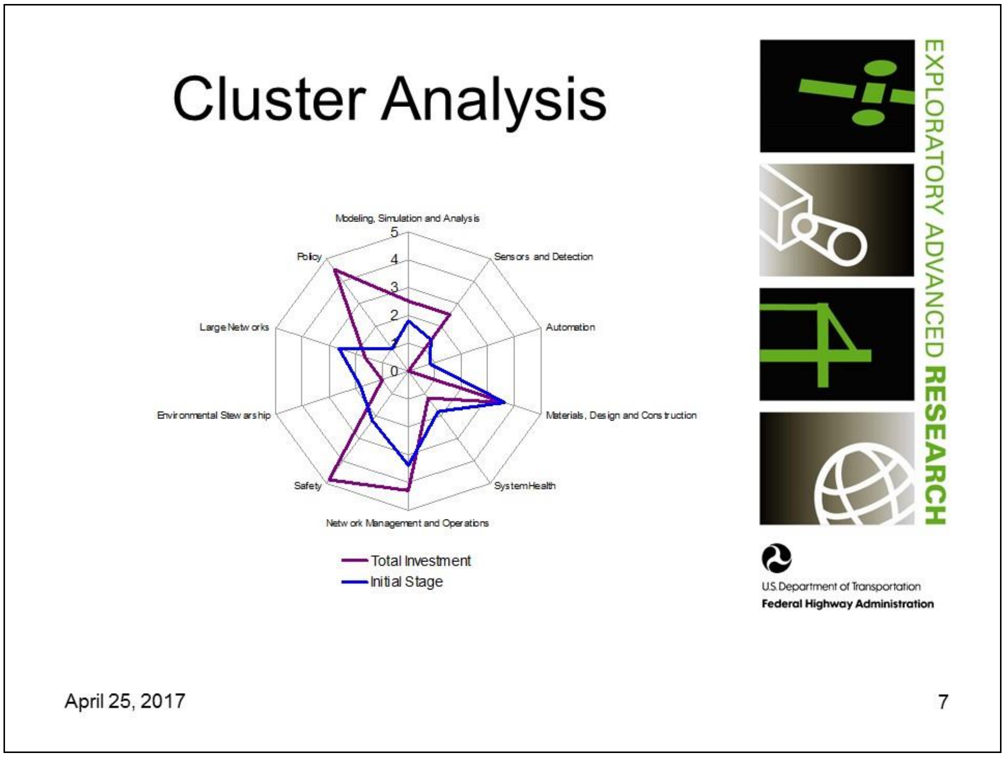

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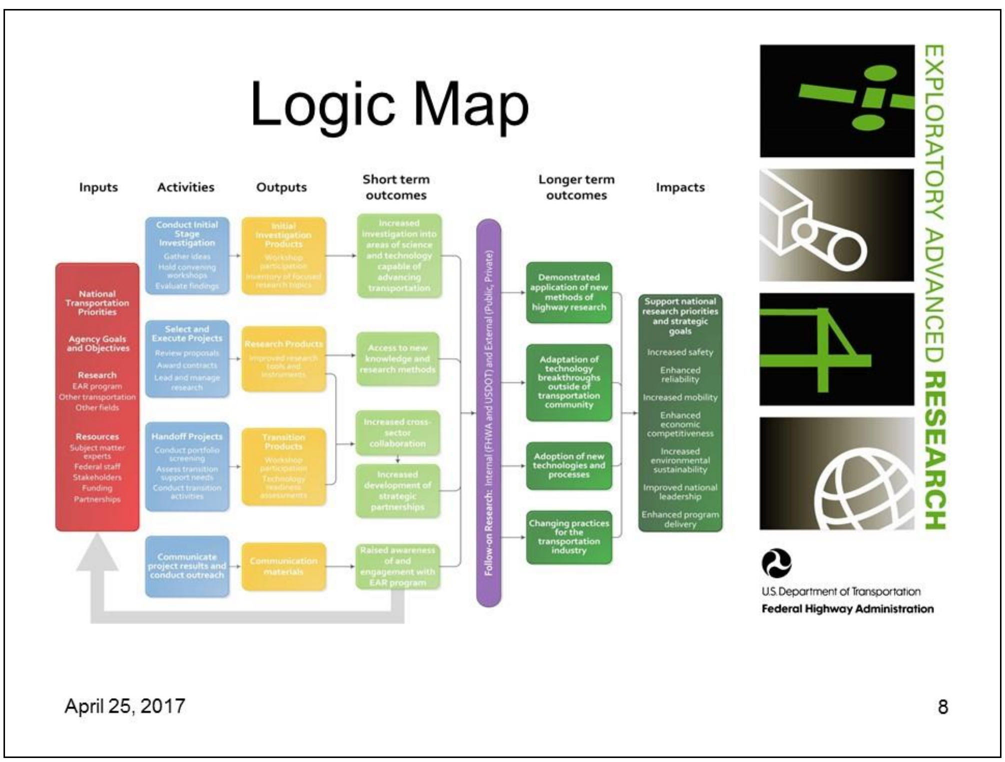

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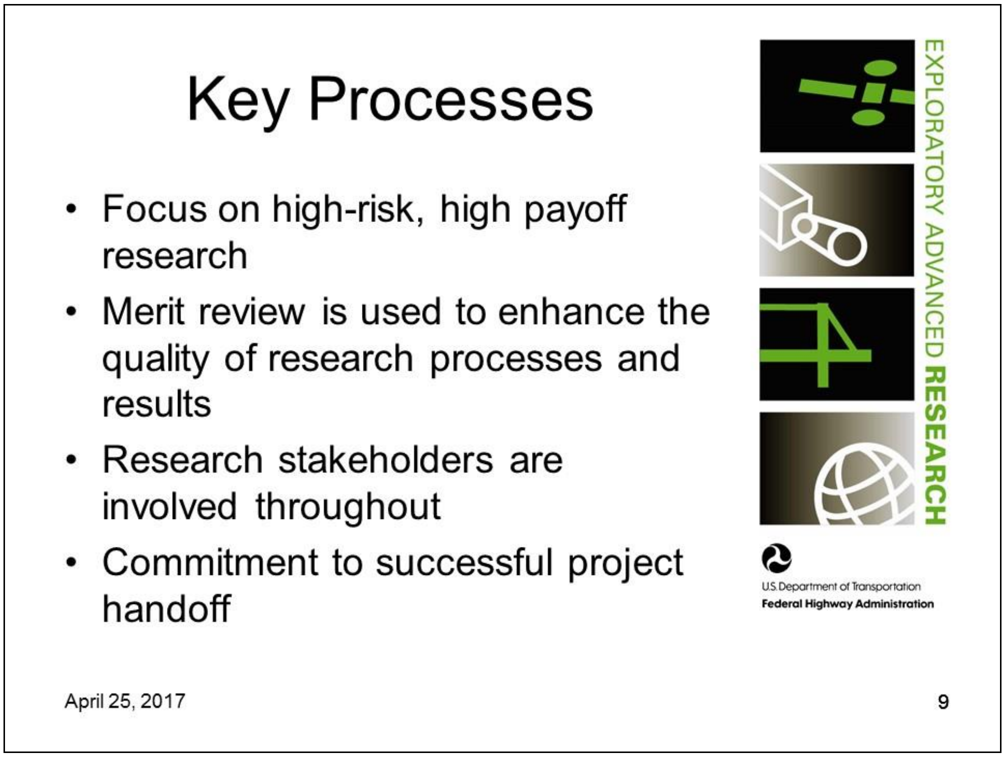

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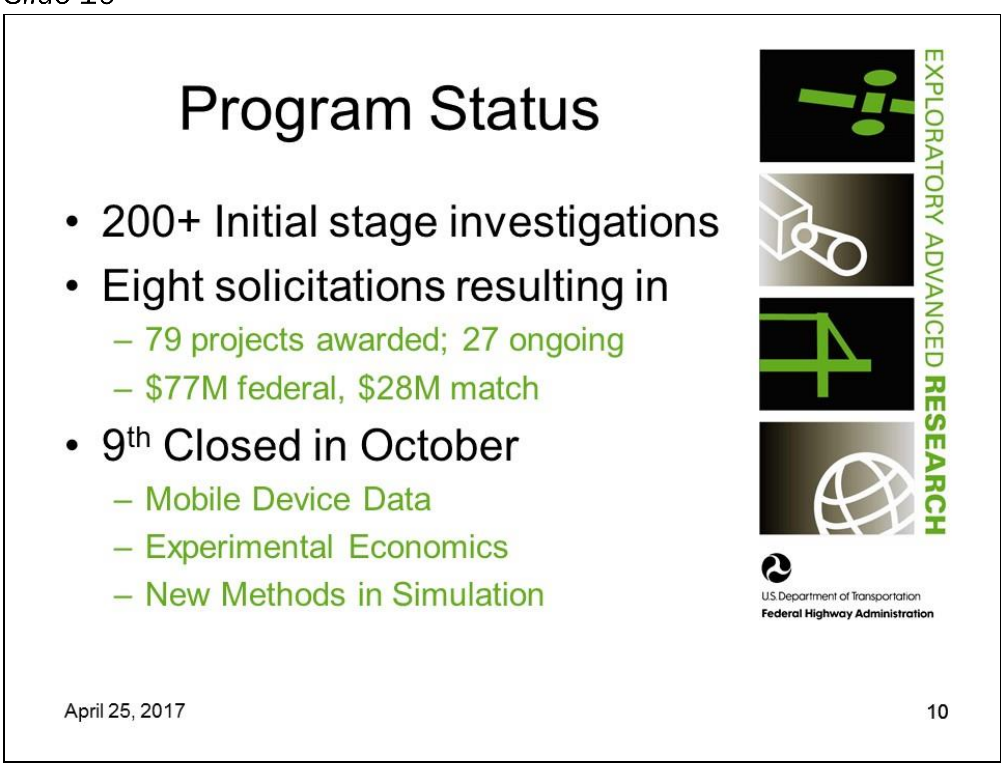

Kuehn, concluded

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Slide 12

Mark Norman – TRB

Slide 1

Slide 2

Norman, continued

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Norman, continued

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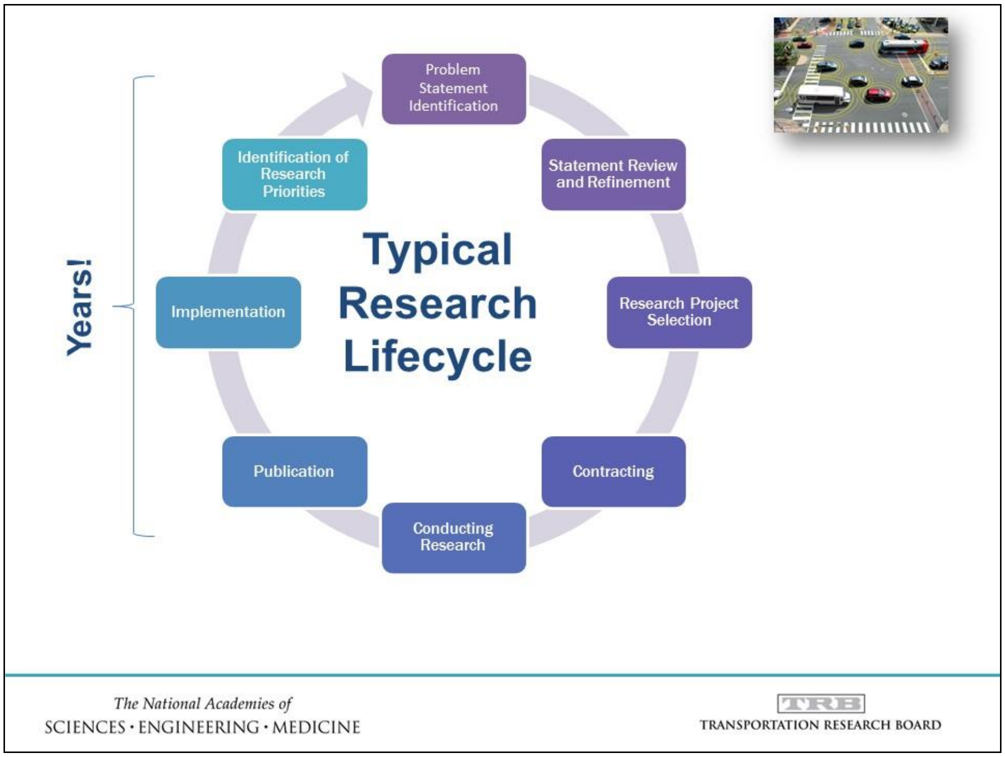

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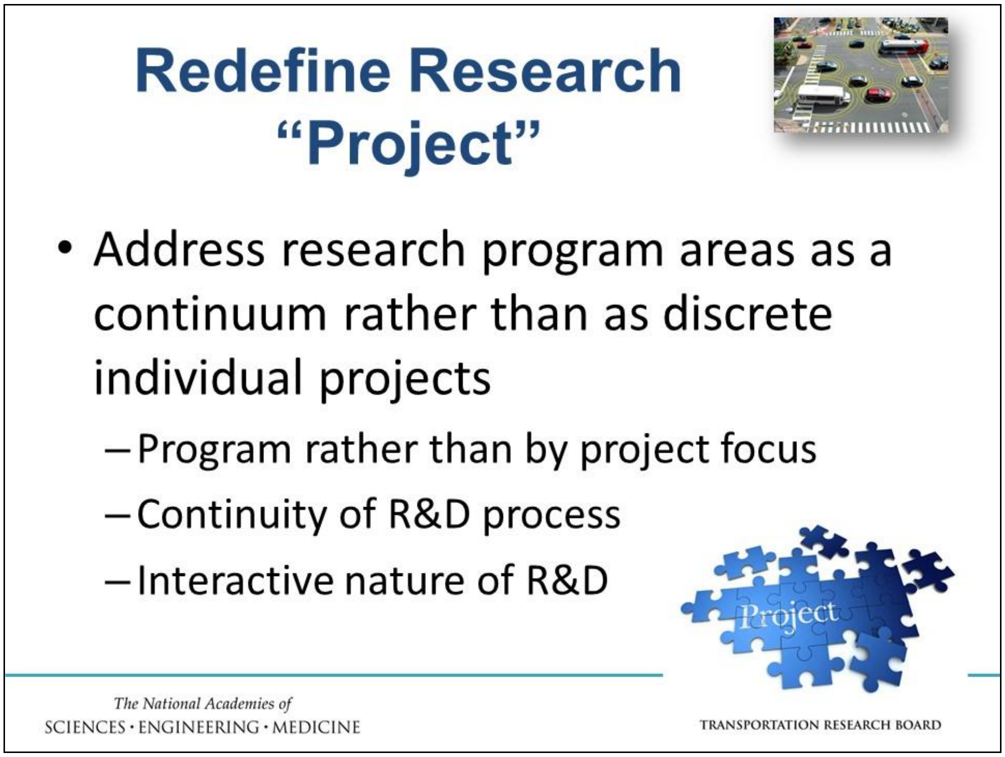

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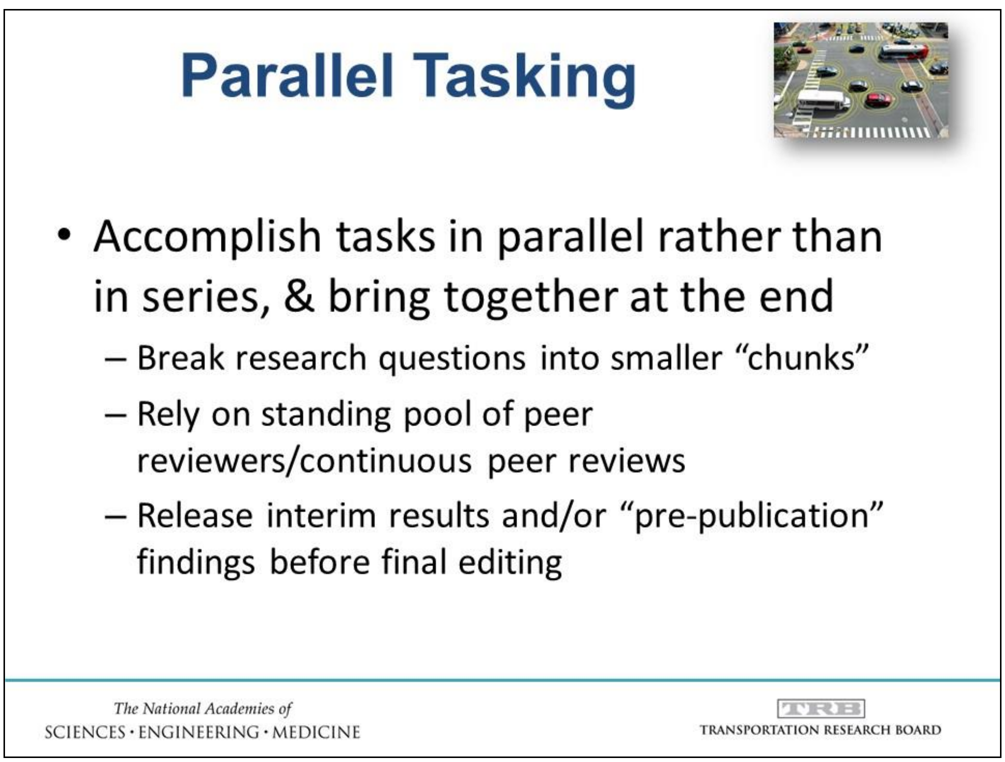

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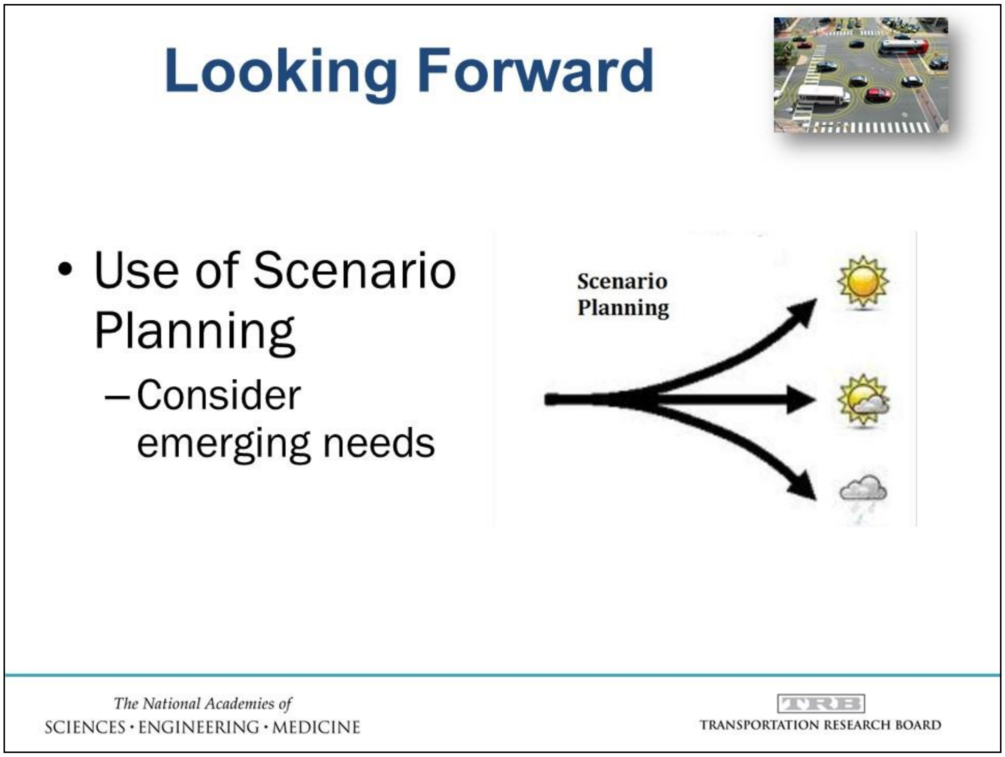

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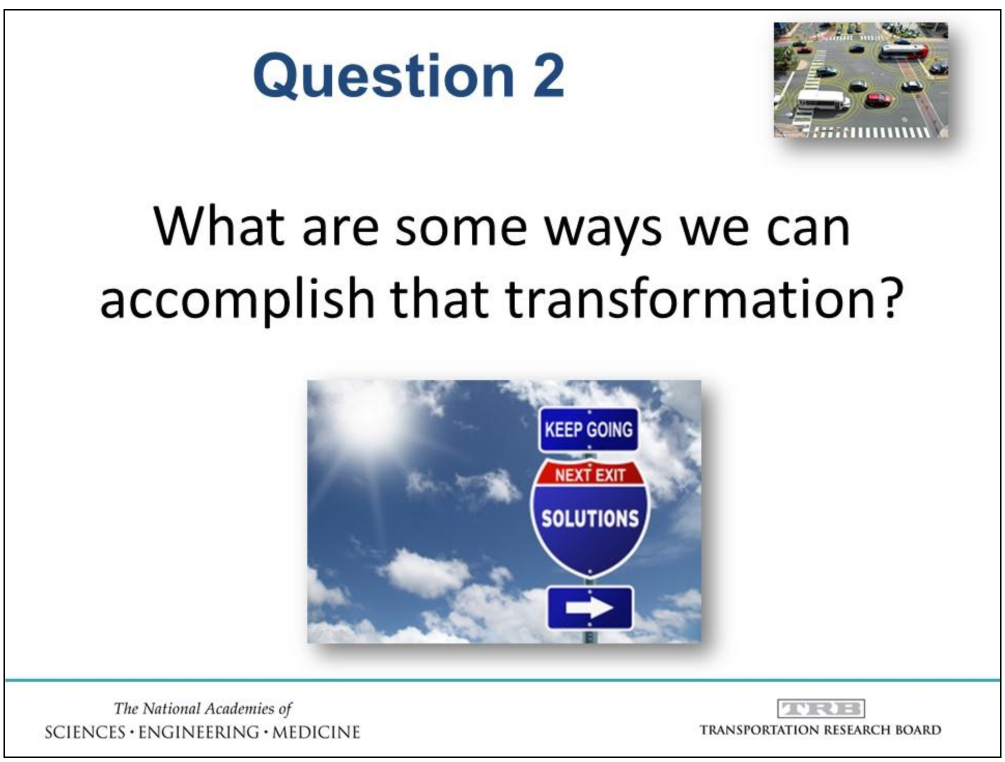

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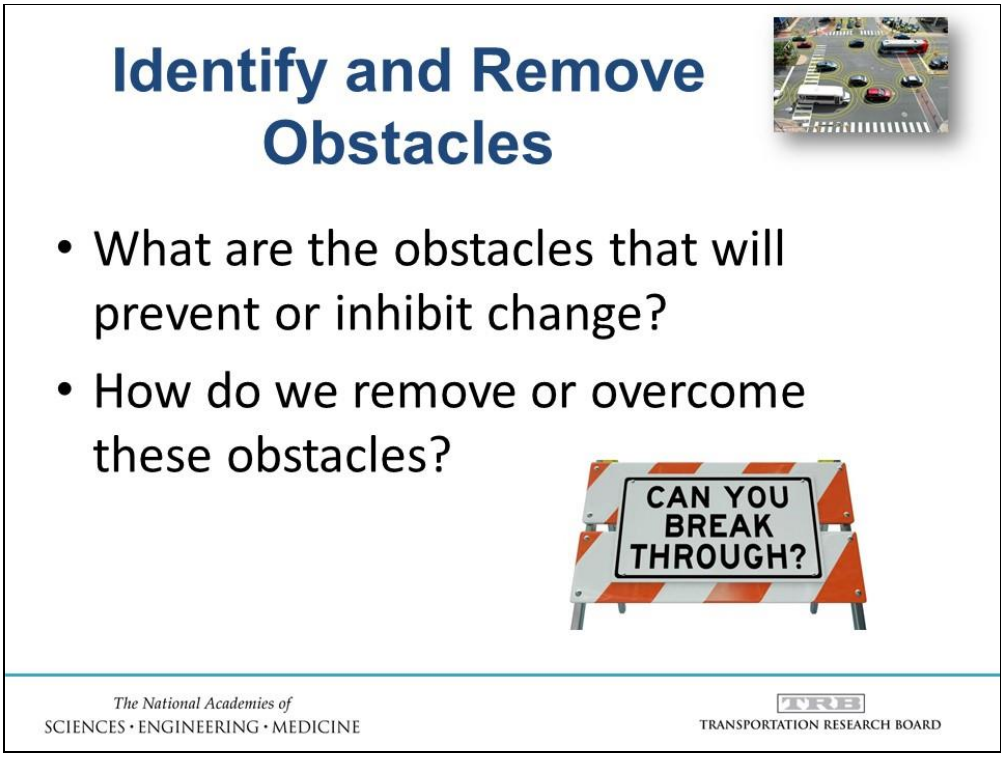

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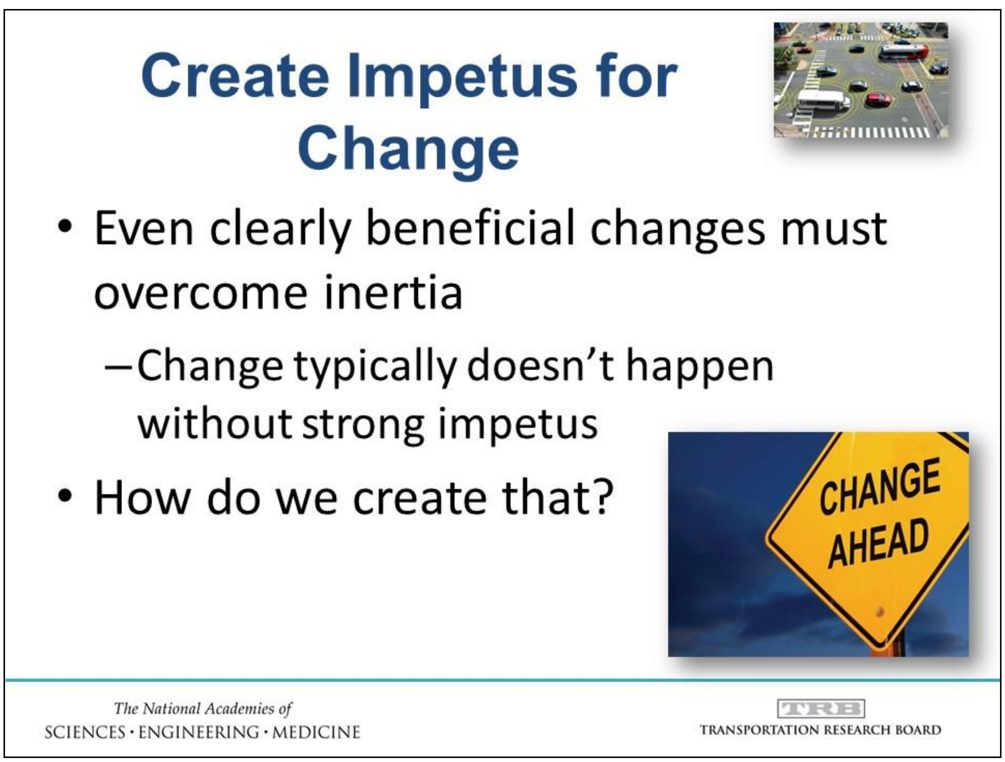

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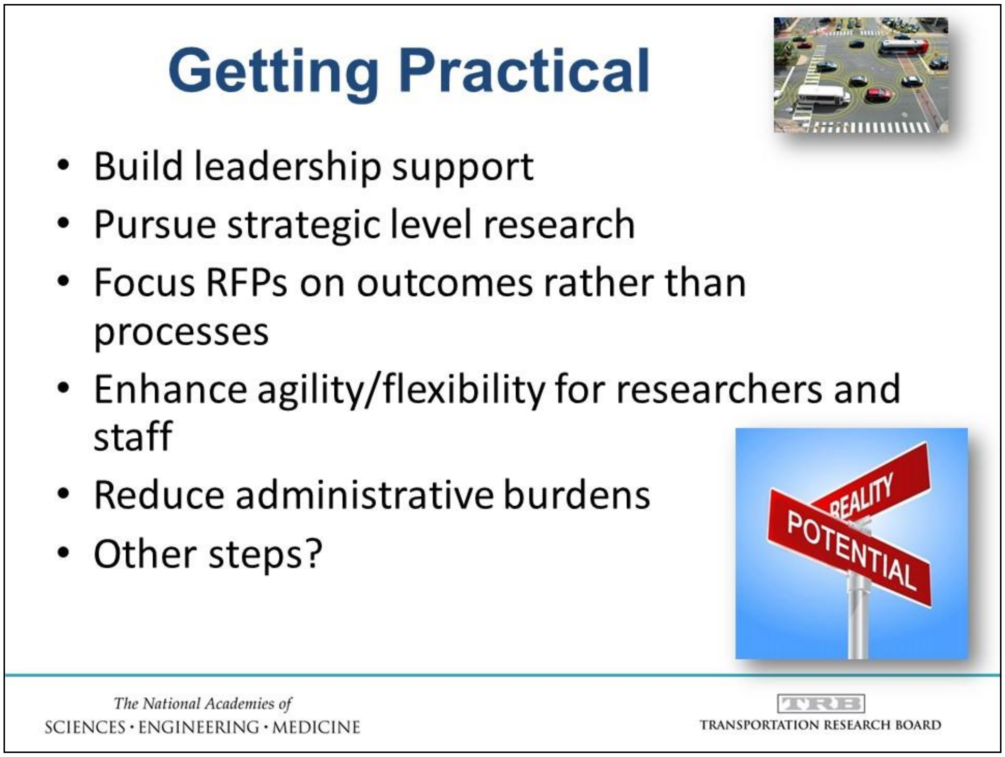

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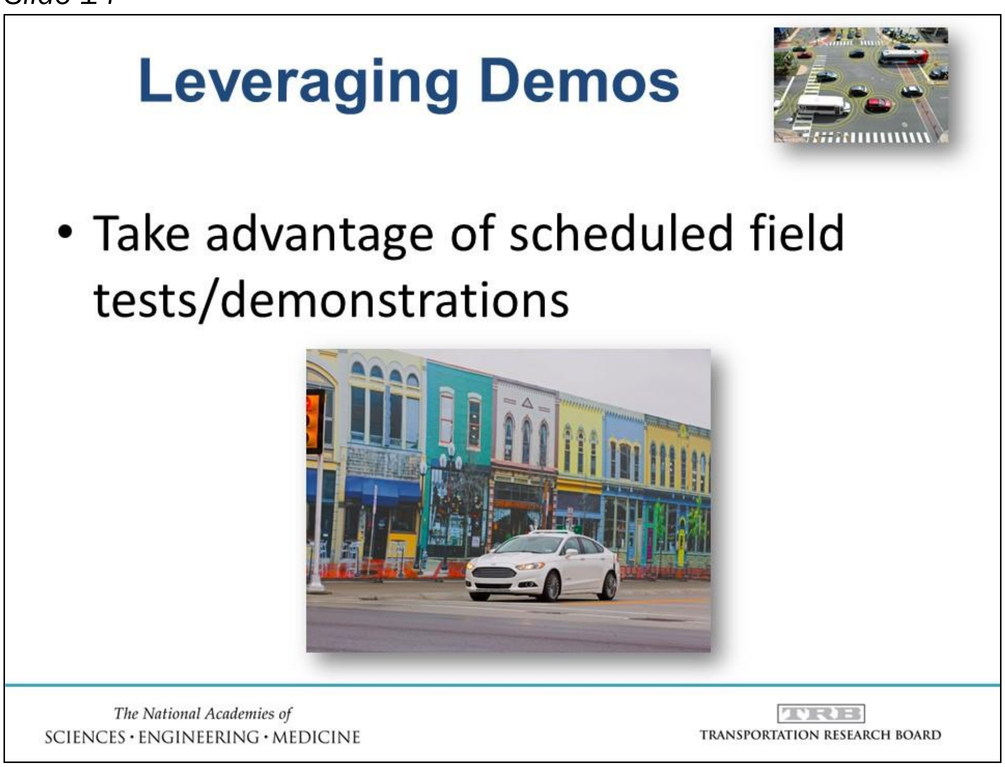

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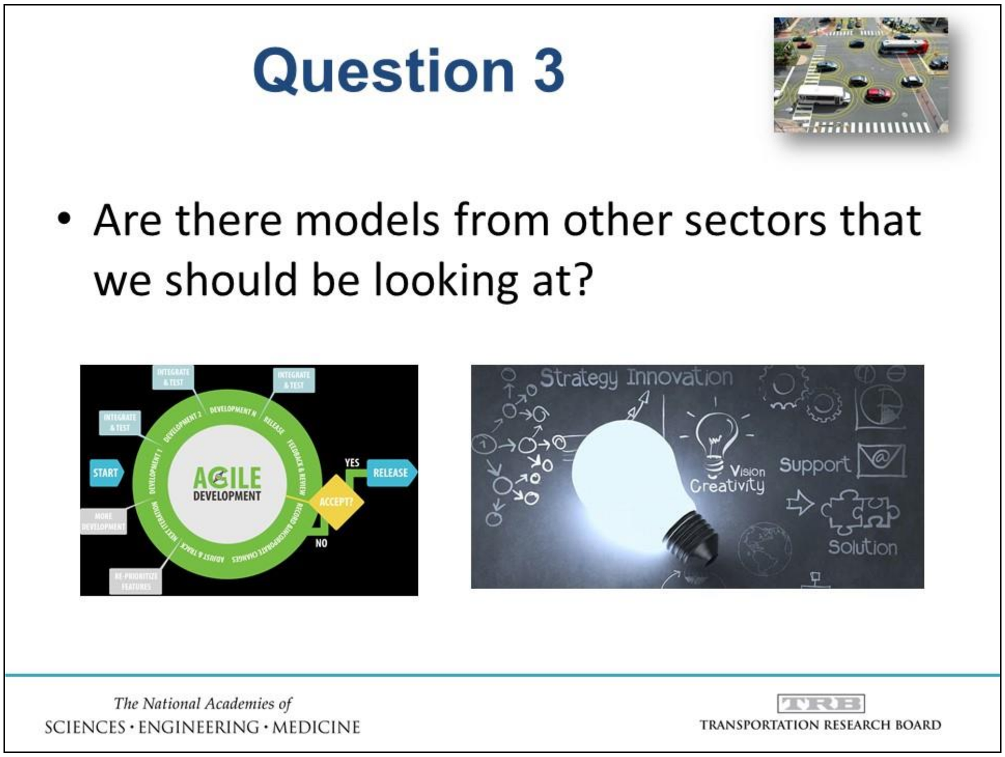

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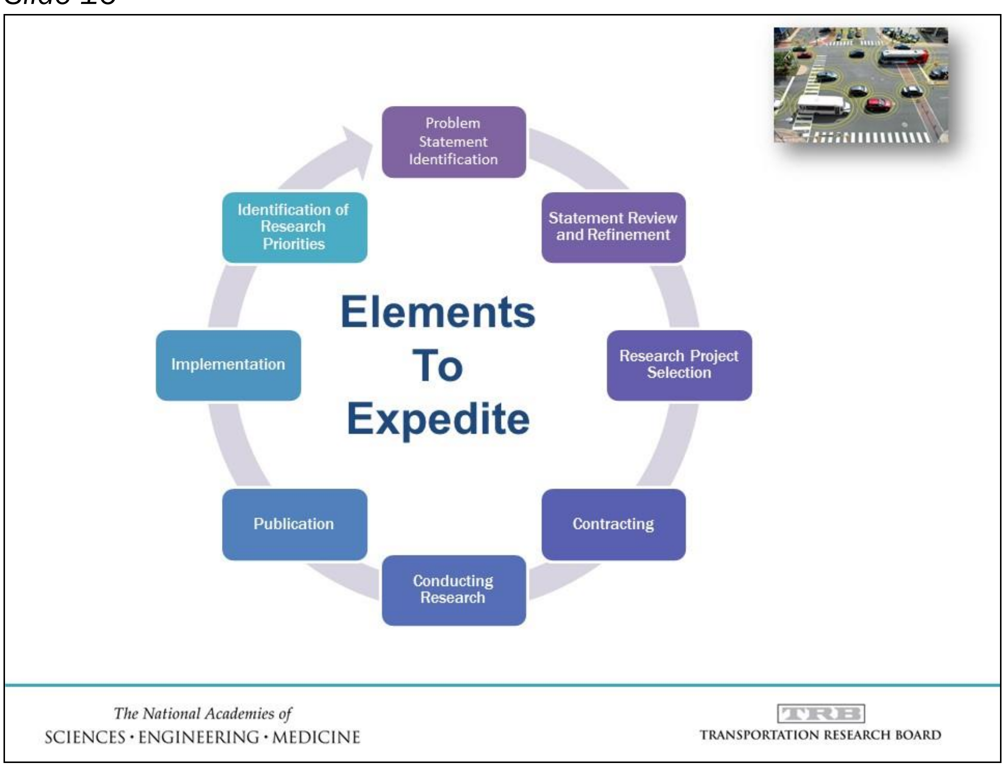

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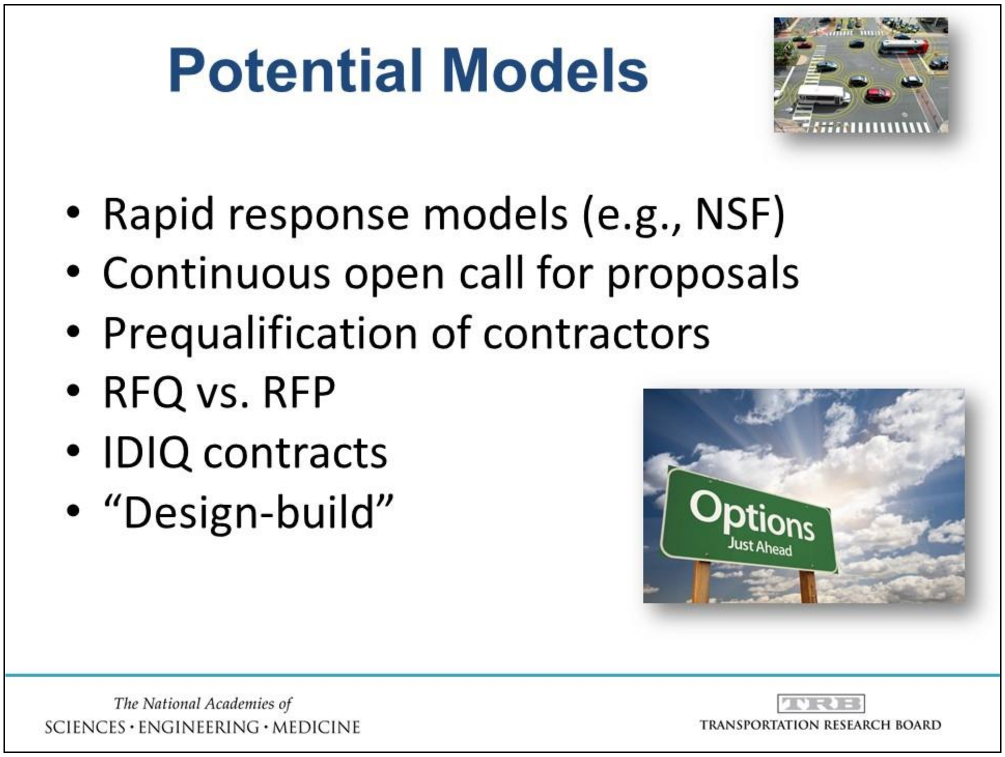

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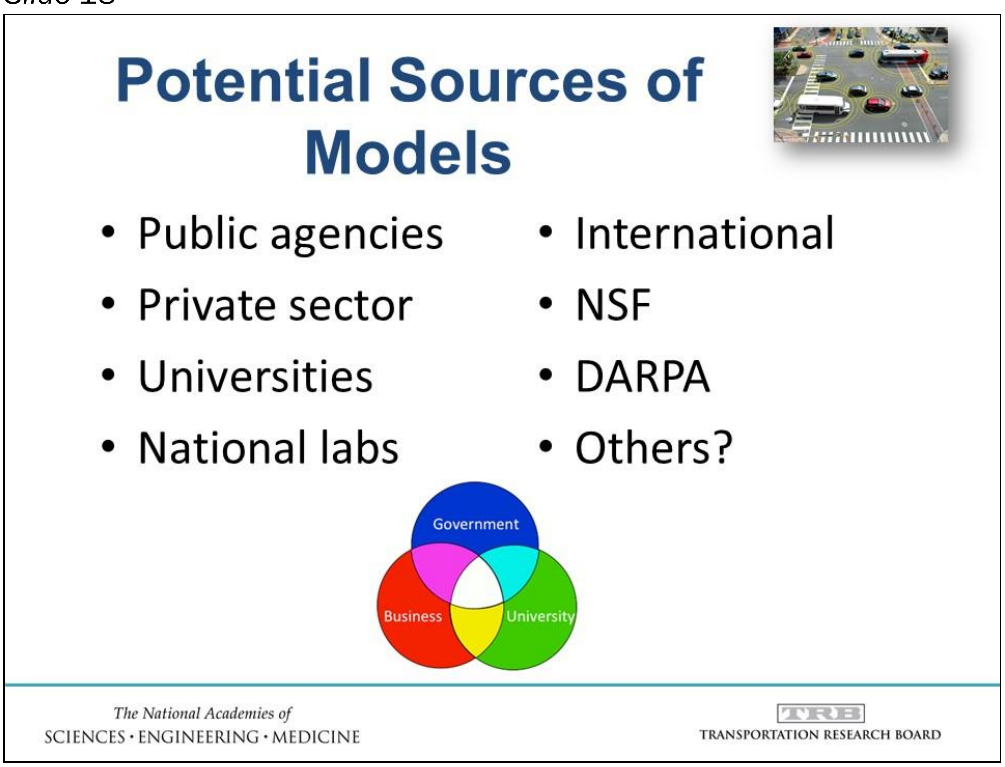

Norman, concluded

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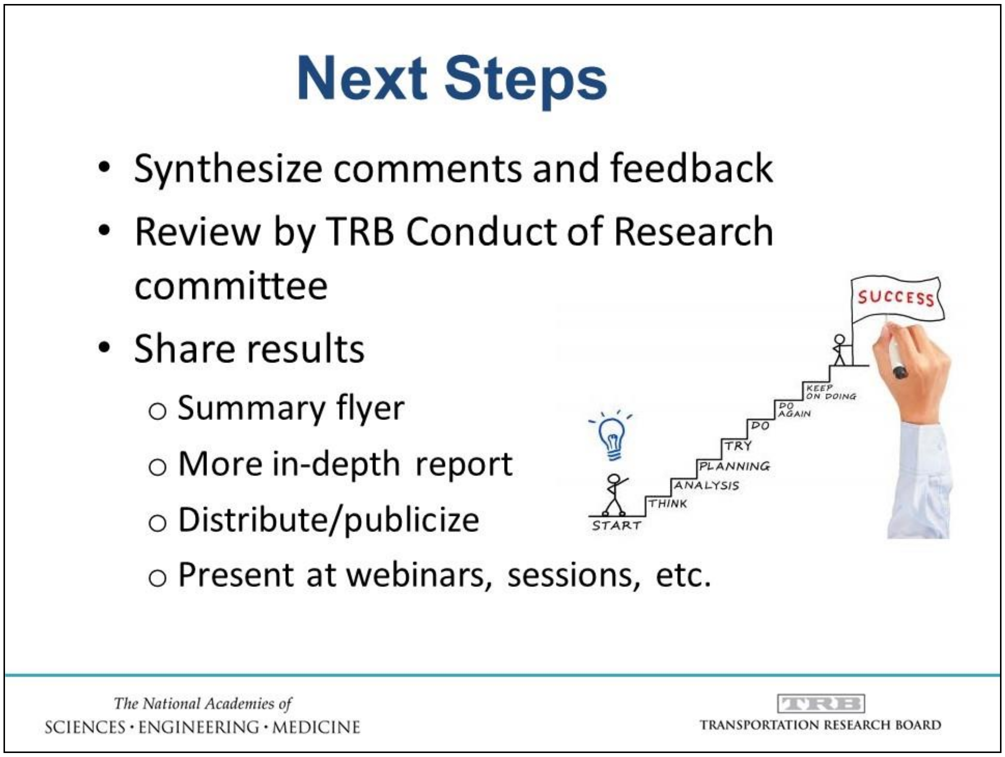

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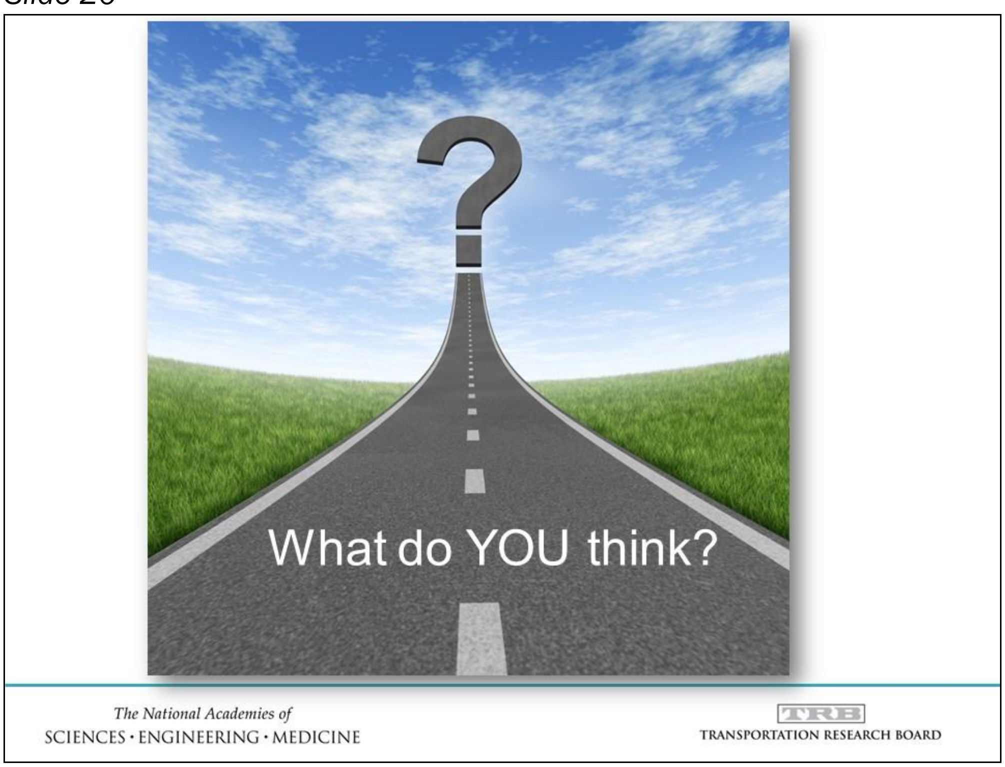

Dr. Christopher Poe – Texas A&M Transportation Institute

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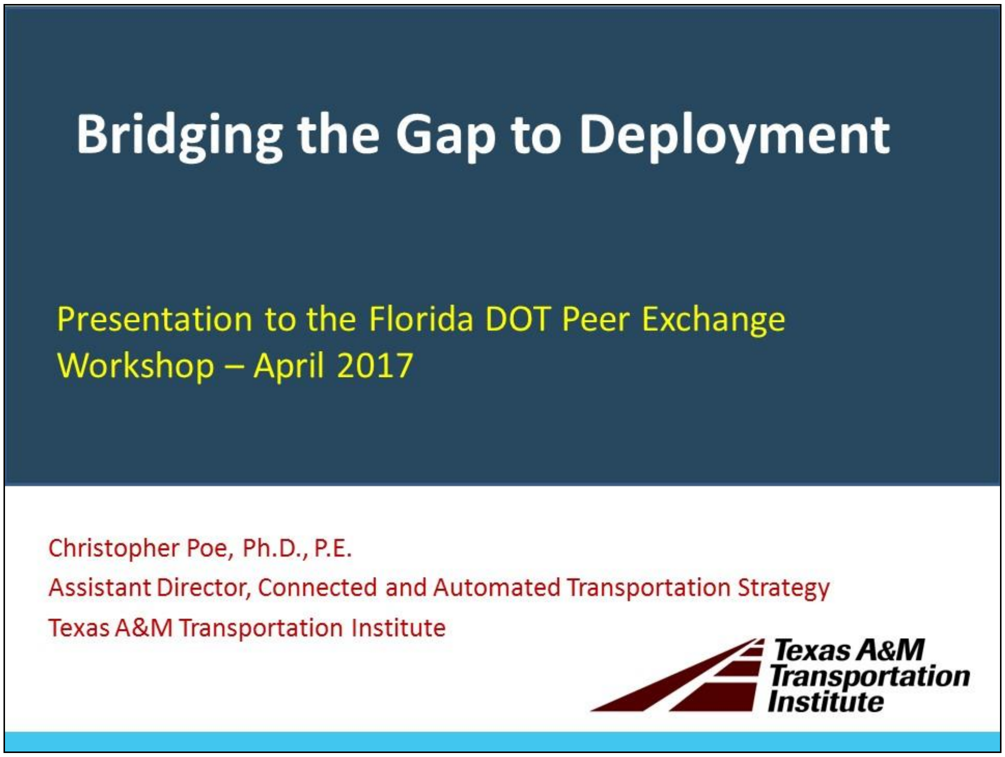

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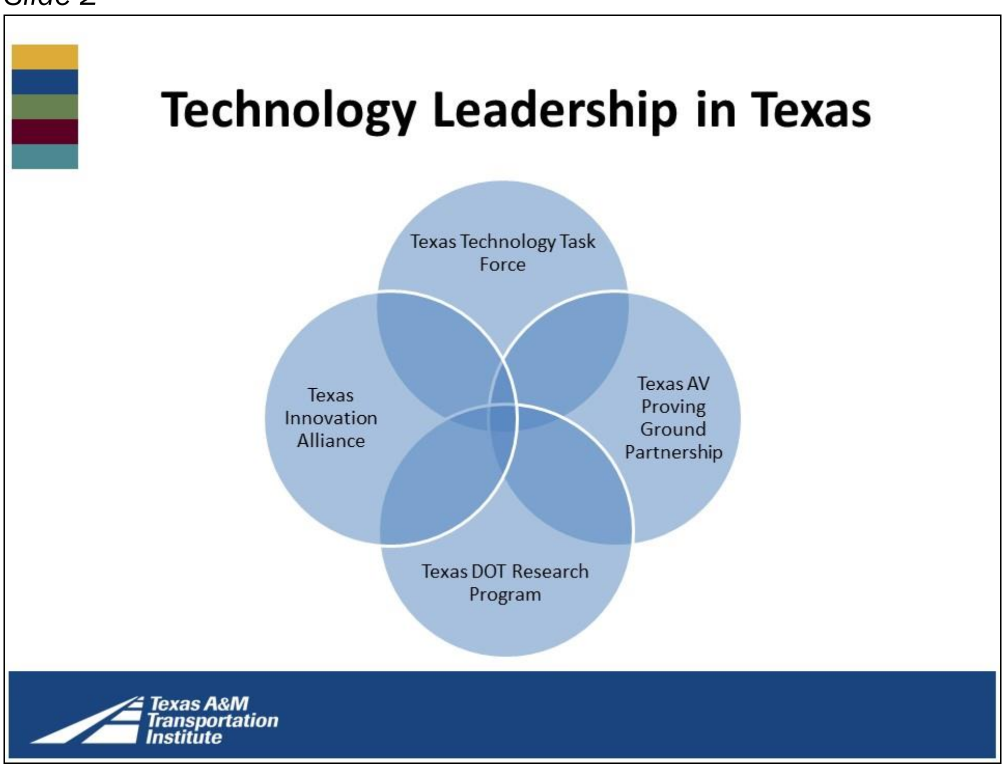

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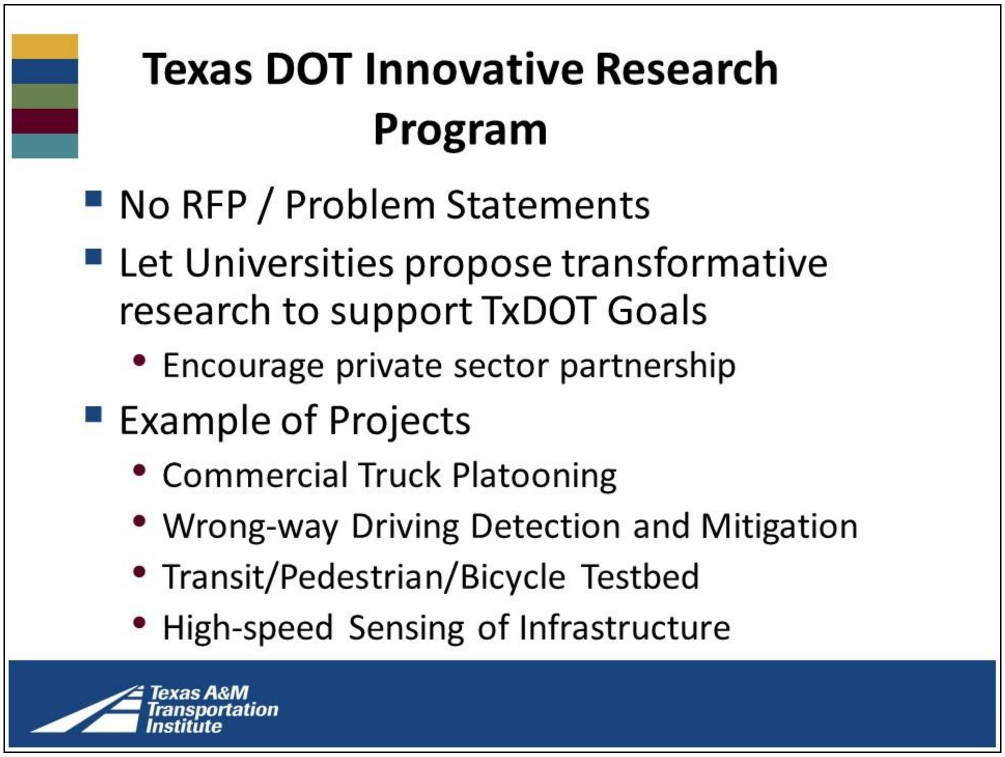

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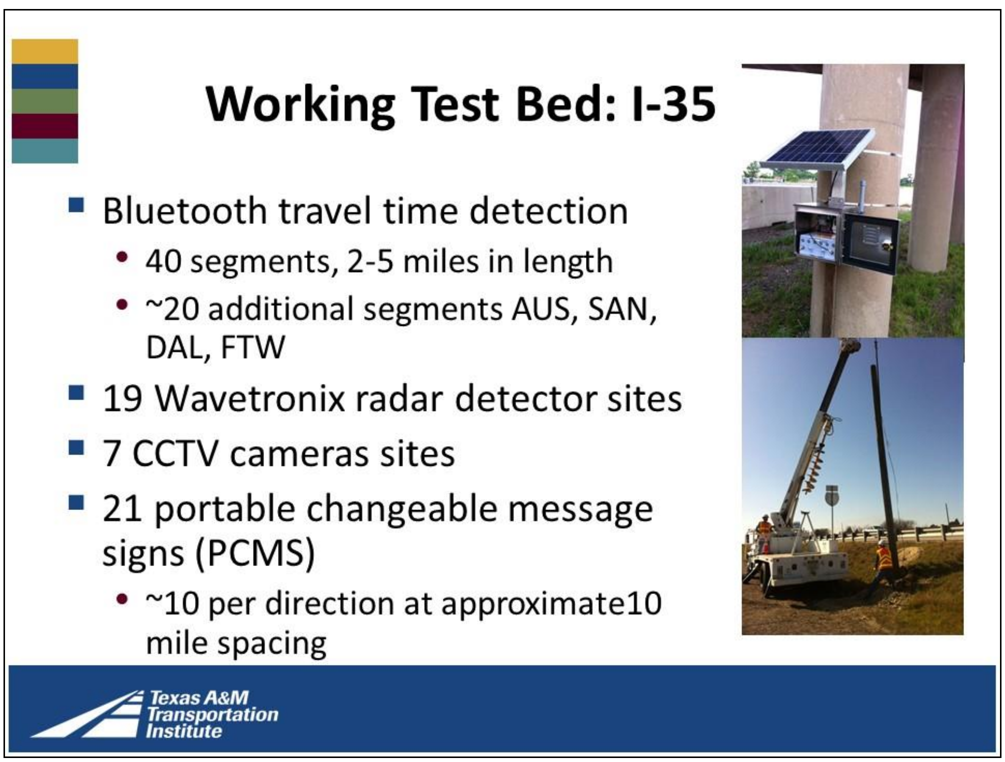

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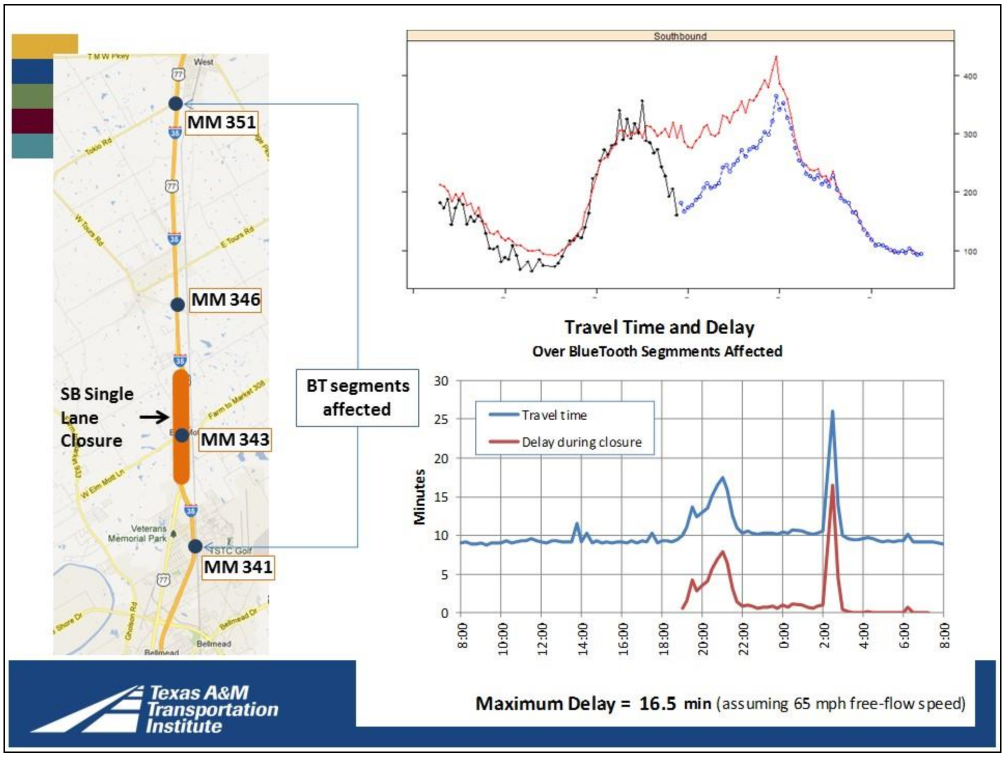

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Poe, continued

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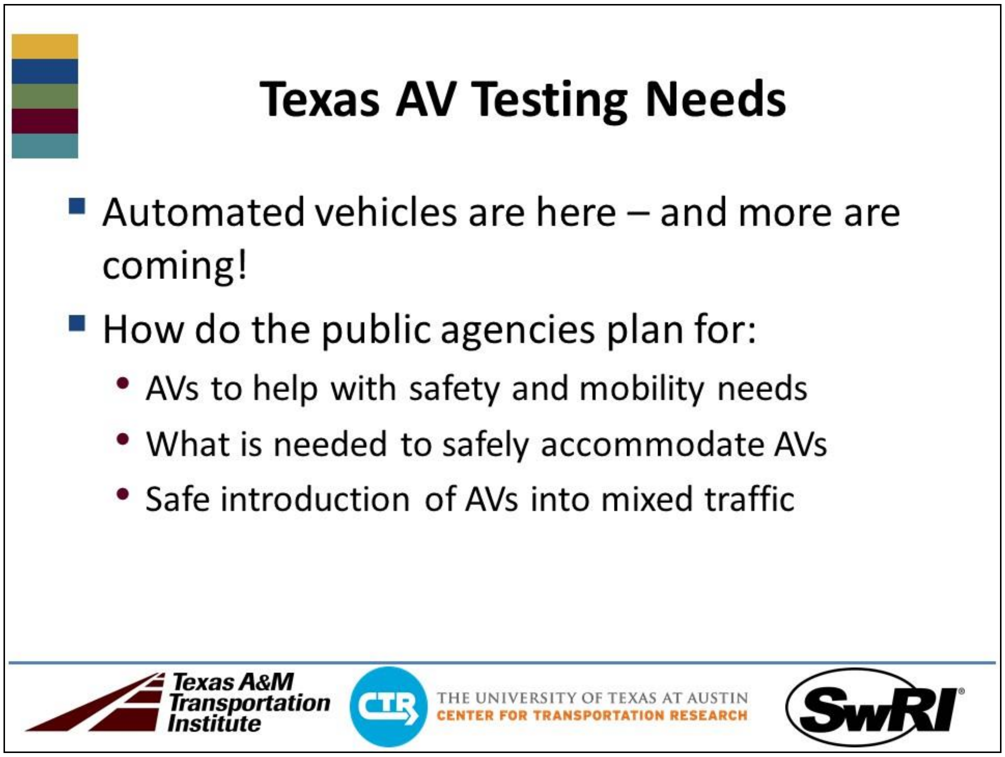

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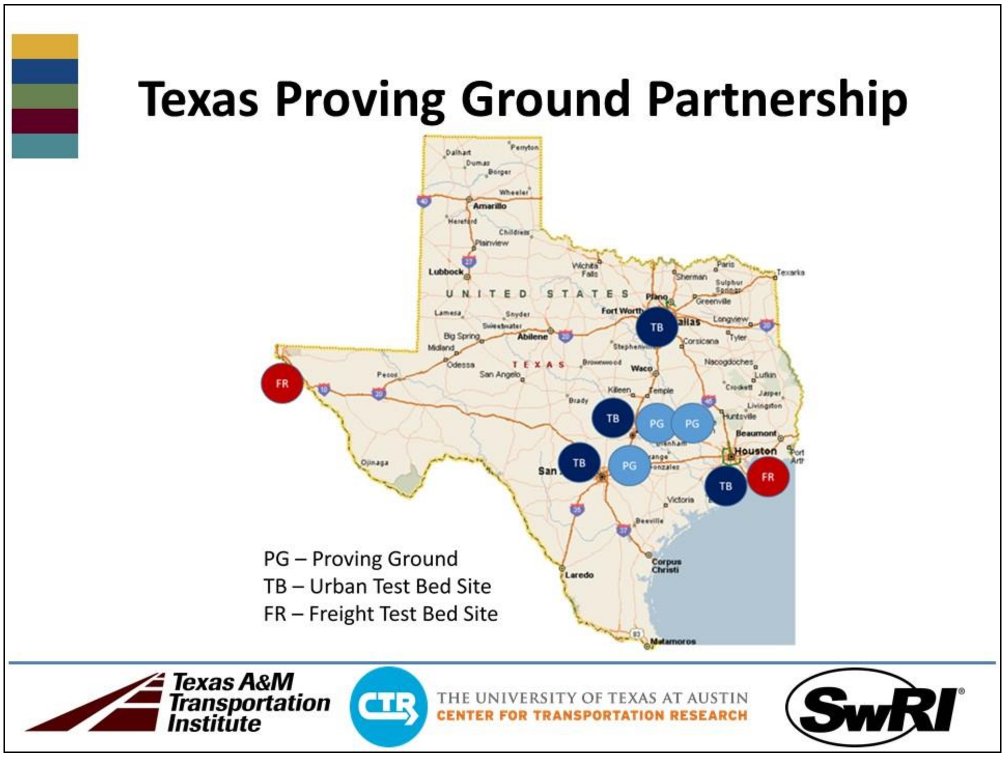

Slide 10

Proving Ground Partners

- Texas A&M, University of Texas, and Southwest Research Institute
- All are conducting AV research
- All have controlled proving grounds on their campuses

Texas A&M Transportation Institute
THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH
SwRI
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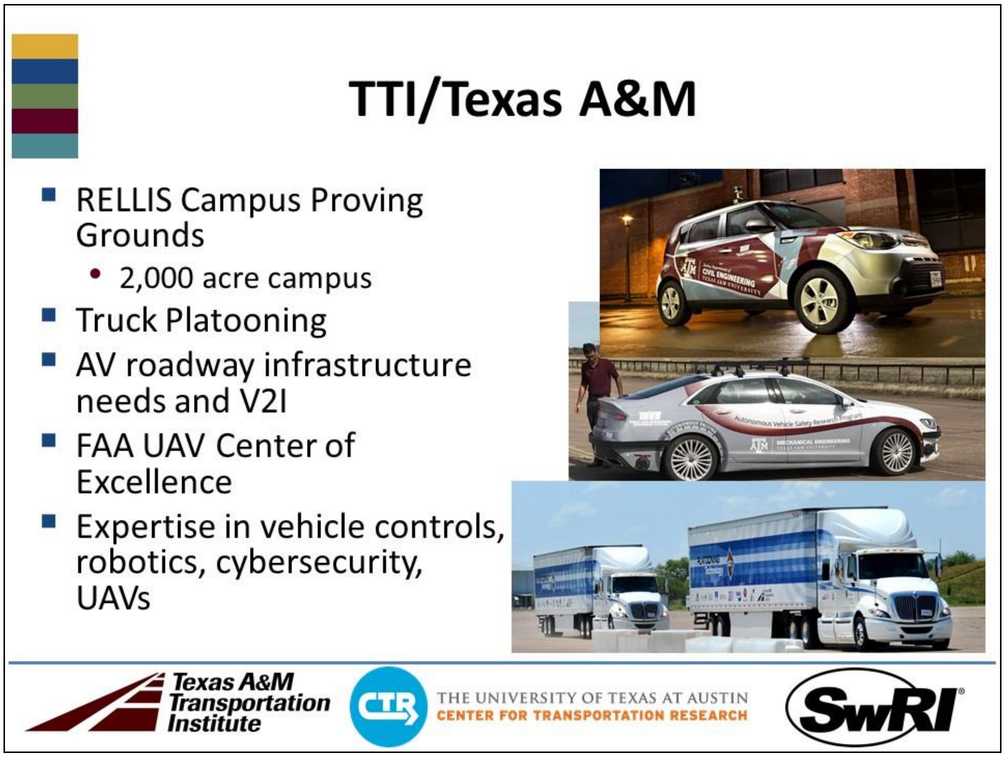
Poe, continued

Slide 11



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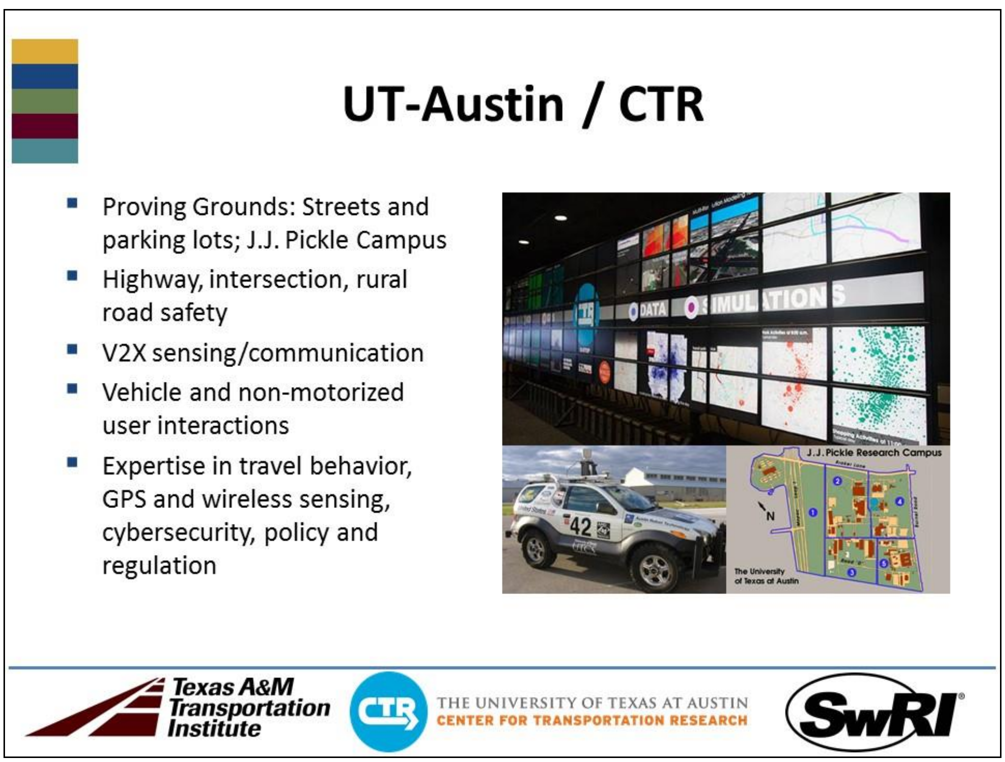
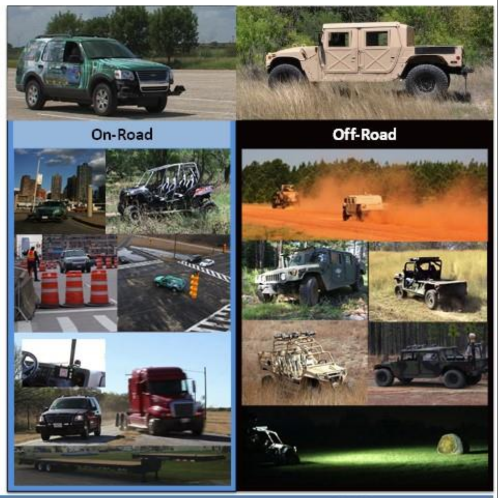


Poe, continued

Slide 13

Southwest Research Institute

- 1,200 acre on- and off-road testing facilities
- Over 20 fully automated vehicle platforms developed (from golf carts to class 8 trucks) for government and commercial clients
- Deploying CAV since 2008
- Specialties include: localization, perception, cybersecurity, connected automation, UAVs



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Slide 14

Urban Test Site Partners

- City of Austin,
- Central Texas Regional Mobility Authority,
- Capital METRO, Capital Area MPO,
- City of Bryan,
- City of College Station,
- Brazos Valley Council of Governments,
- City of Corpus Christi
- Corpus Christi MPO,
- Houston METRO,
- City of Houston,
- Harris County,
- Port of Houston,
- Houston-Galveston Area Council,
- Texas Medical Center,
- University of Houston,
- City of Arlington,
- City of Dallas,
- City of Fort Worth,
- City of Grand Prairie,
- North Central Texas Council of Govts,
- Tarrant County,
- Denton County Transit Authority,
- University of Texas at Arlington,
- City of San Antonio,
- VIA Transit,
- Alamo Area MPO,
- Joint Base San Antonio,
- City of El Paso,
- County of El Paso,
- Camino Real Regional Mobility Authority,
- El Paso MPO,
- Texas Department of Transportation

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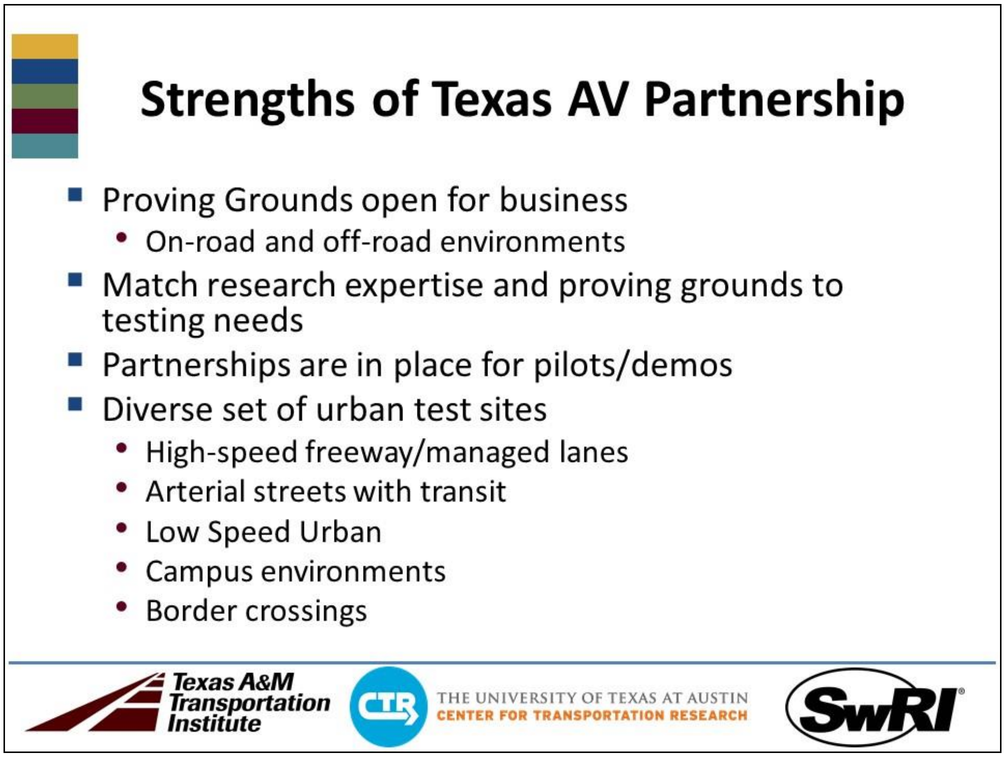
Poe, continued

Slide 15



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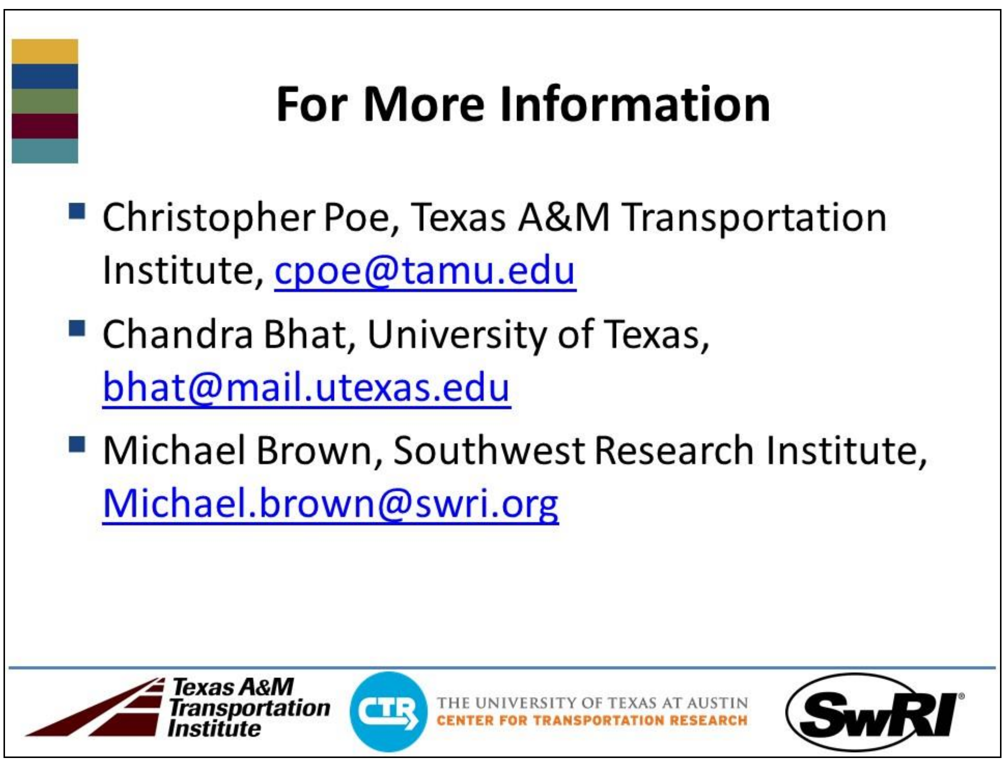

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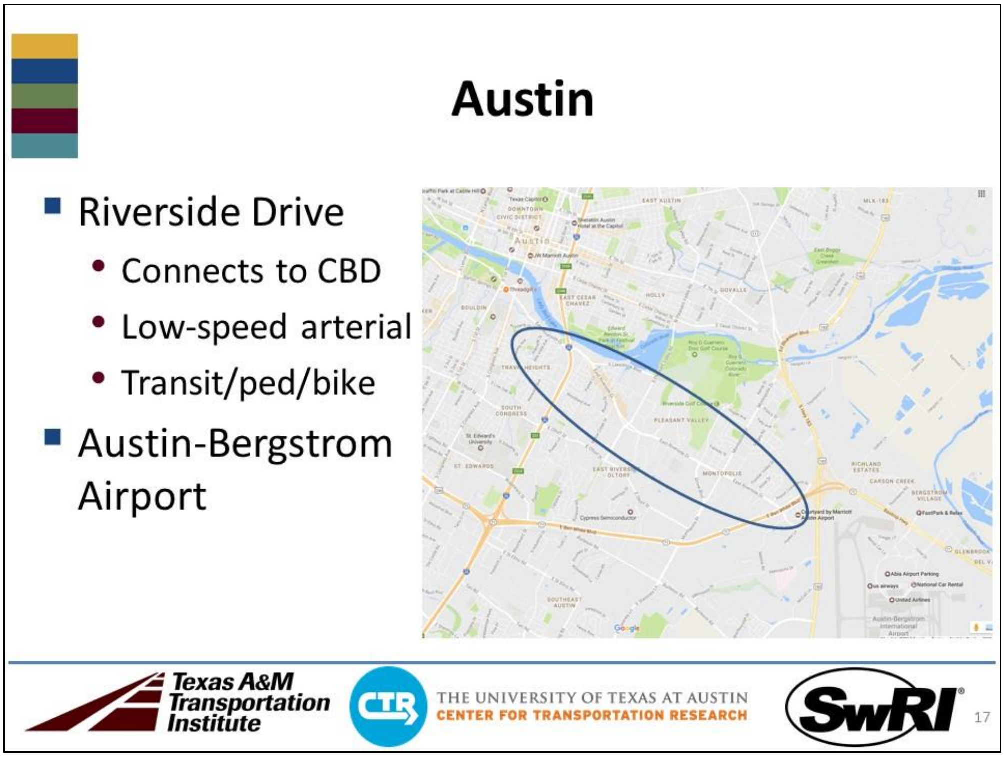

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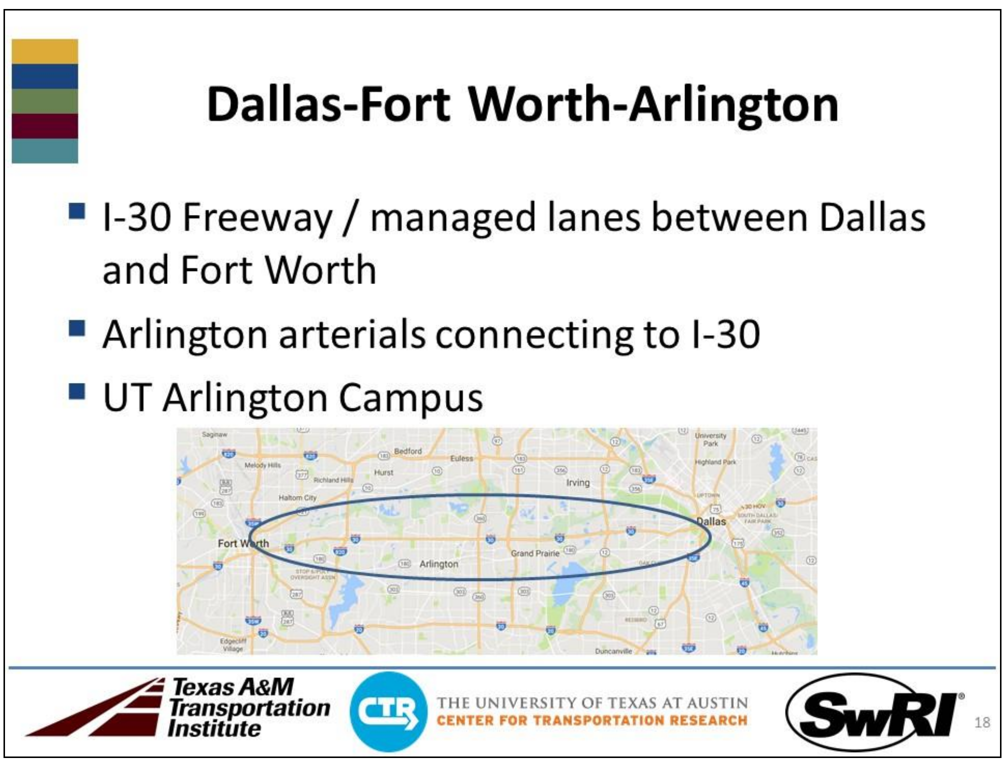

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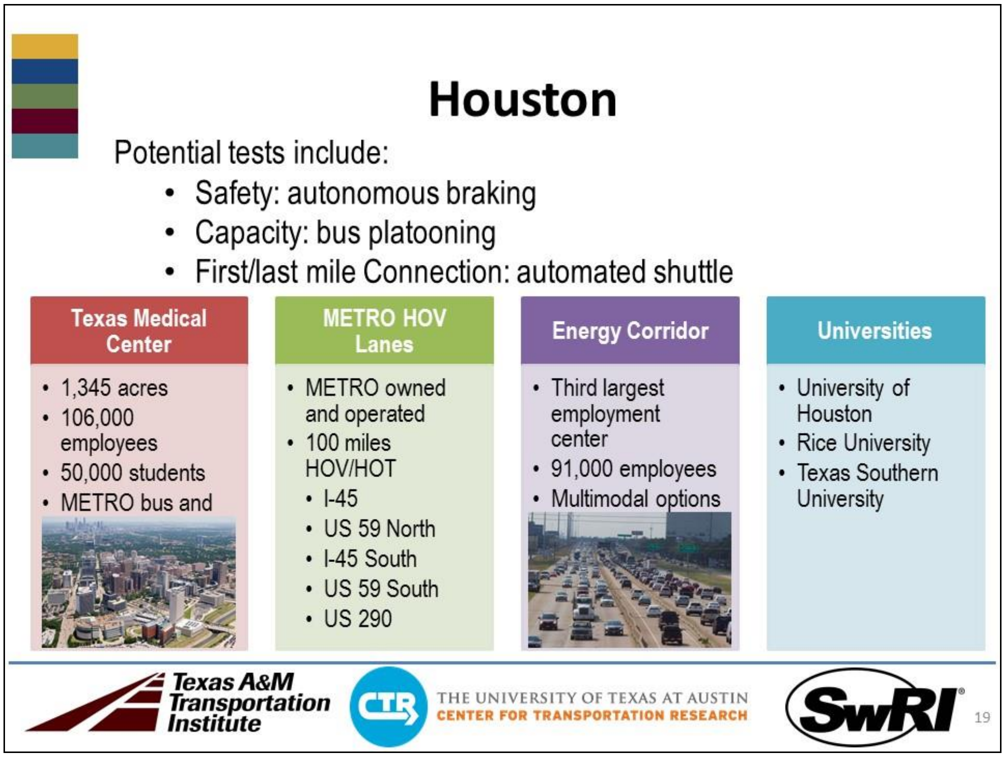

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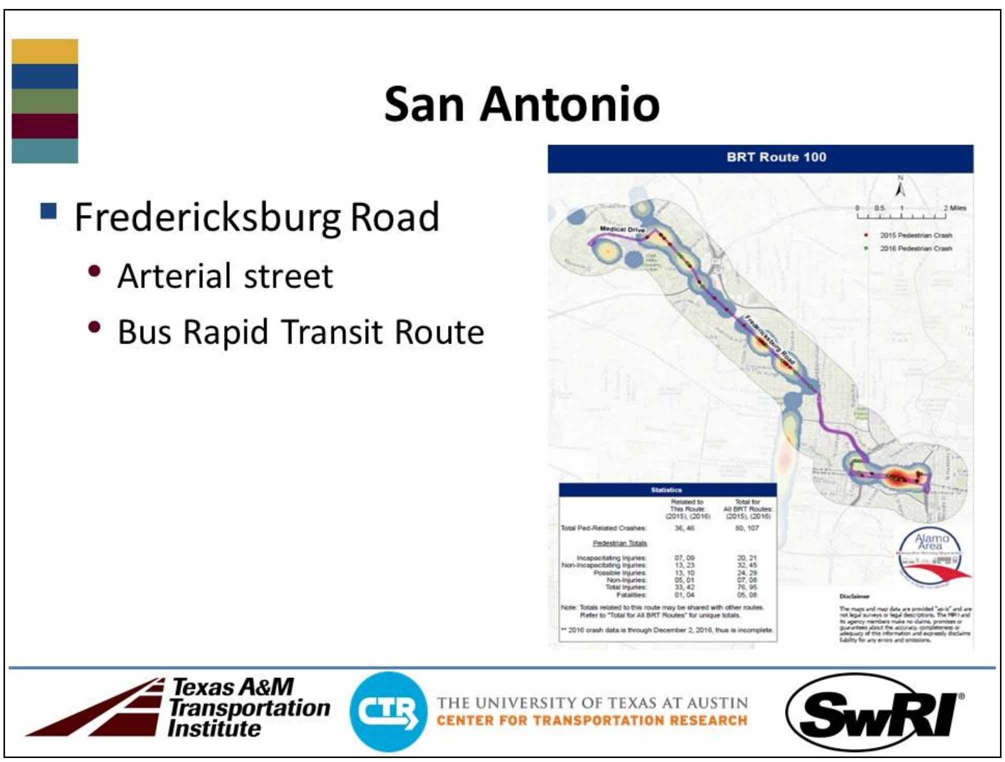

Poe, concluded

Slide 21

El Paso

- AV technologies for freight and passenger border crossings
- Model for other border crossings in Texas and U.S.

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Upcoming Events

- Energy Thought Summit – AV Demonstration
  - Austin, Texas, March 27, 2017
- DIA – Igniting a Smart Texas Revolution
  - Dallas, April 20-21, 2017
- Texas A&M Transportation Technology Conference
  - College Station, May 4/5, 2017
- Data Code-a-thon
  - Austin, July 18/19th
- 2nd Smart State Alliance Summit
  - October, 2017

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Dr. Kate Lawson – University at Albany

Slide 1

Road to the Future is Paved with Data

Dr. Catherine T. Lawson
University at Albany/AVAIL
Peer Exchange/Tallahassee, FL
5/25-5/27, 2017

Slide 2

Traditional Approach:
Data used for decision-making

Lawson, continued

Slide 3

Data as a Resource

- Traditional data sources exist in separate environments (e.g., counts program).
- No data integration capabilities with legacy software and data formats.
- Limited access across agency operations.
- Constant challenges to meet reporting requirements.
- Workforce turnover and retirements.

Slide 4

Data as an "Agile Asset"

- New sources of data now challenge existing practices:
  - The National Performance Management Research Dataset (NPMRDS)
  - Connected Vehicle (CV) data
  - Bridge sensor data

...... and so much more!

Lawson, continued

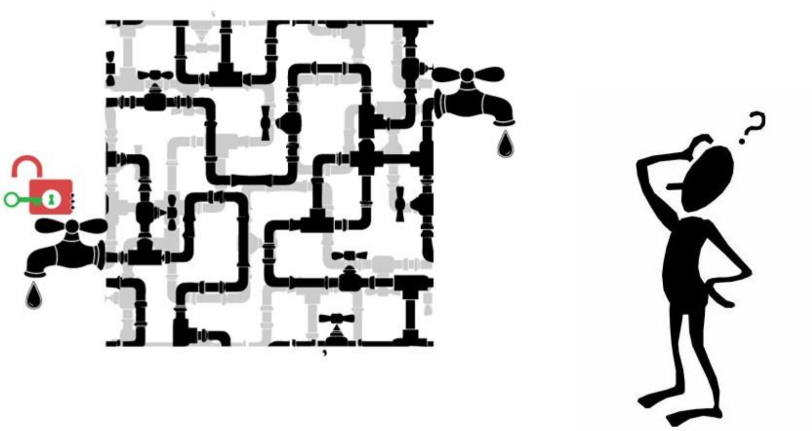
Slide 5

New York State DOT: Taking on the challenge

- Data delivery strategies
- Analytics options
- Organizational approach
- Relationship to workforce needs
- Internal/External dissemination
- Maintainability and investment longevity

Slide 6

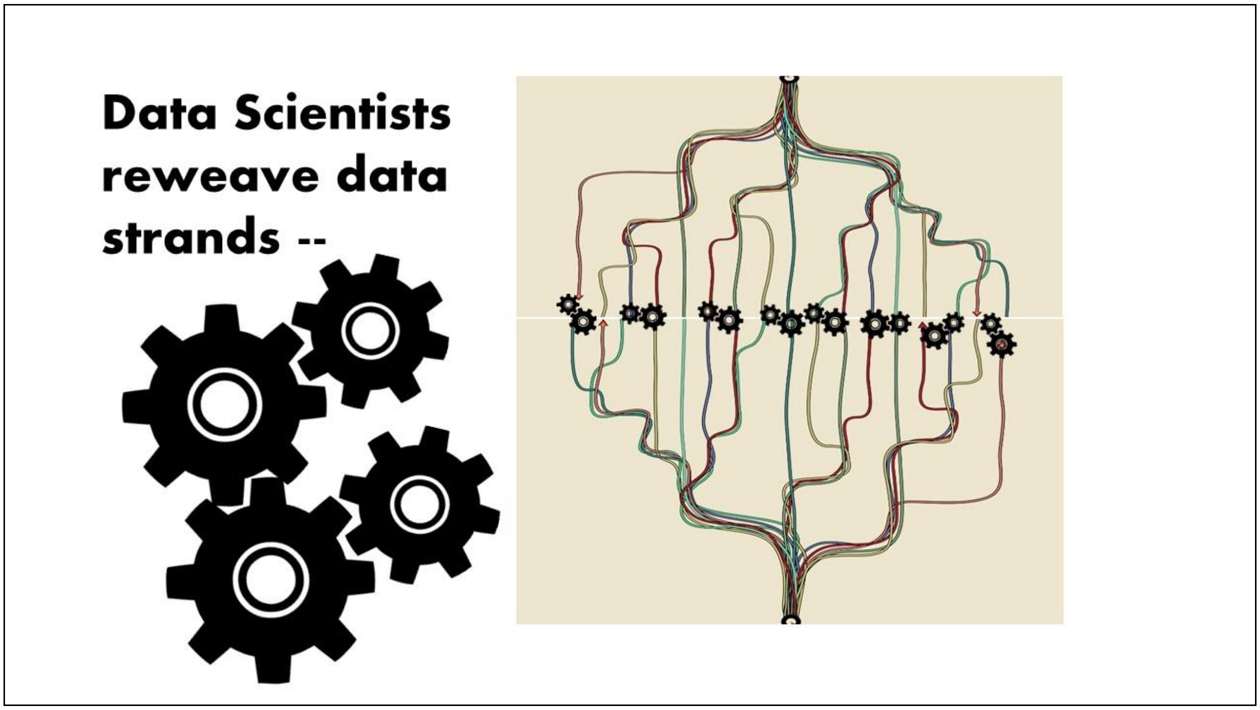
Thinking like a Data Scientist



Application Programming Interfaces (APIs)

Lawson, continued

Slide 7



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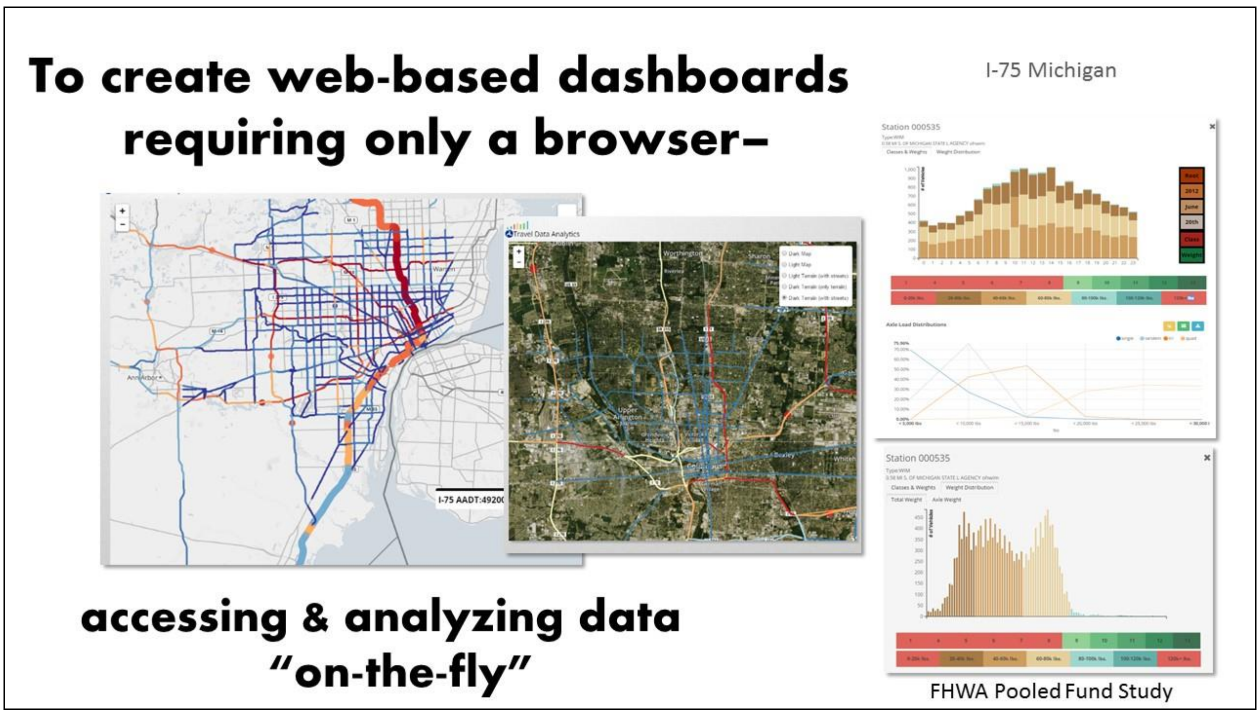

Lawson, continued

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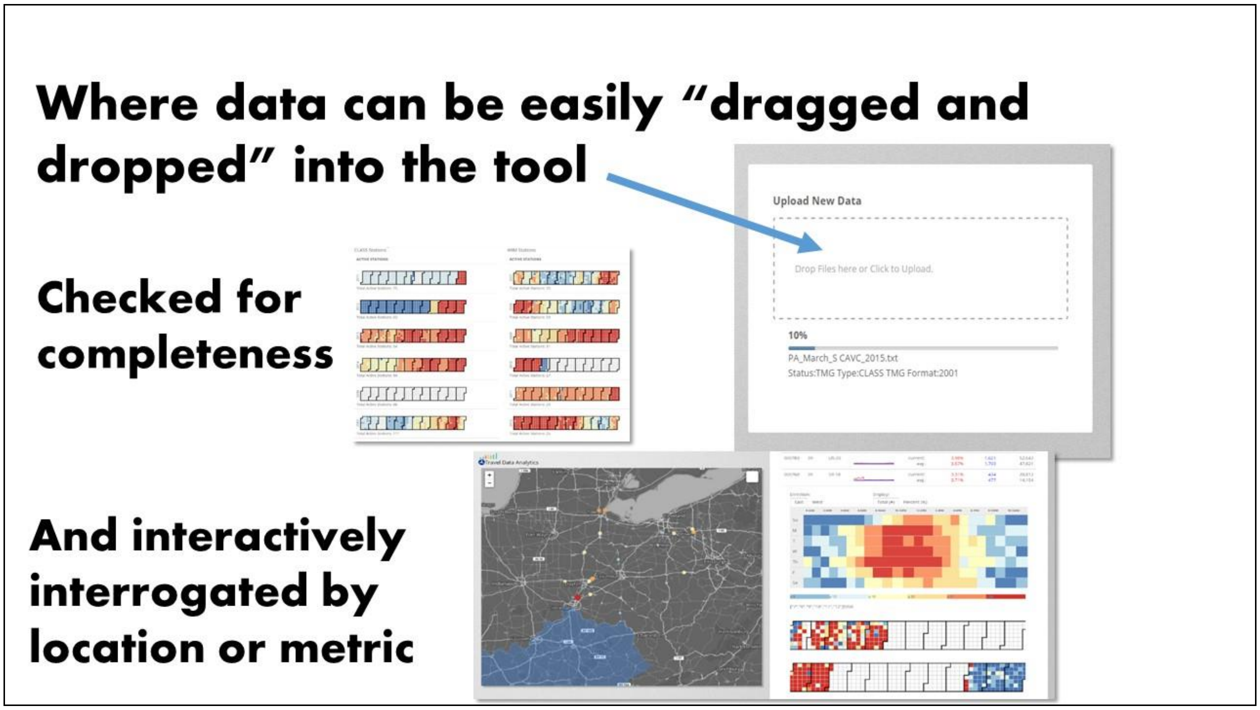

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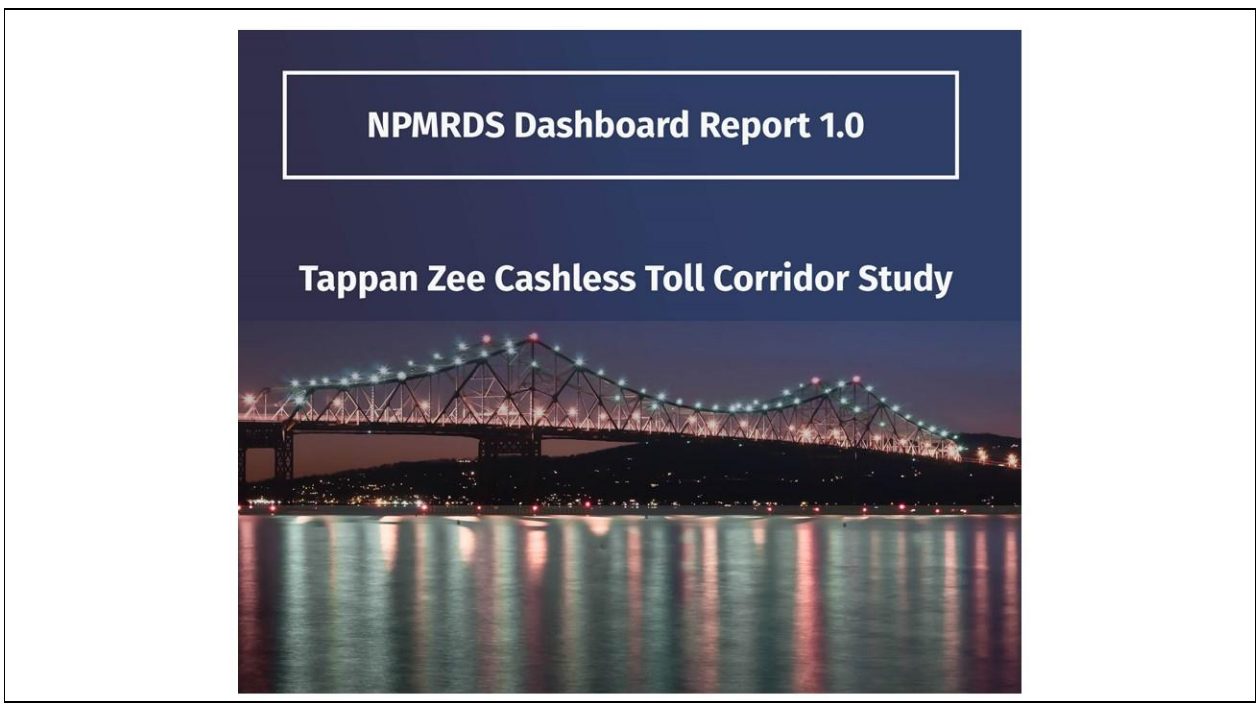

Lawson, continued

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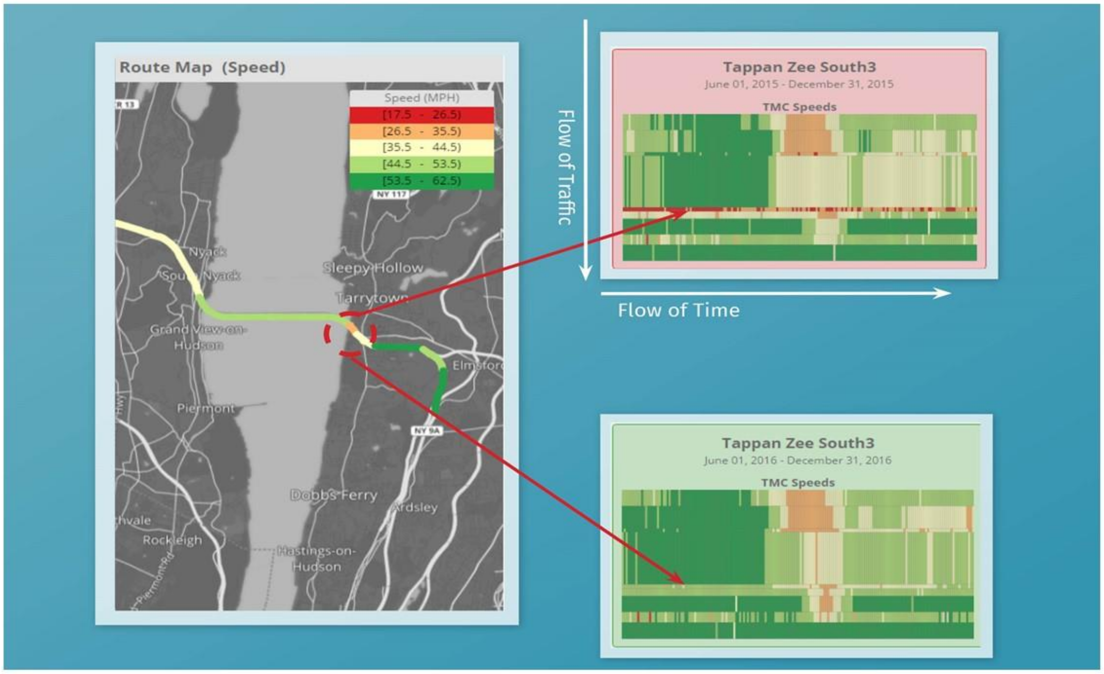


Slide 12

Lawson, continued

Slide 13

This data is as good as gold!!!!!

Slide 14

The Way Forward

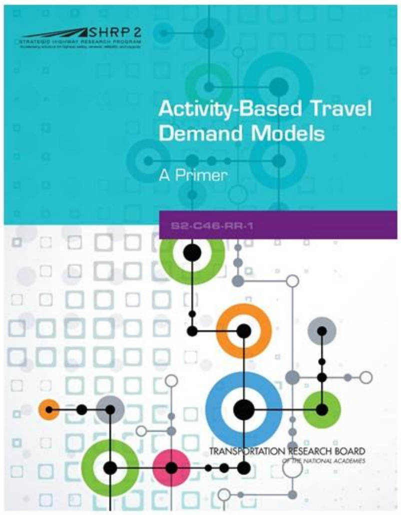
- **Strategic Approach to Data**
  - **Platform Options (e.g., APIs, tools)**
- **Intra-agency Integration**
- **Multi-agency Integration**
- **Regional Integration**
- **Micro- to Mega-scale Geographies**
- **Day Forward Trajectory –**

Think about your data needs for tomorrow - TODAY!

Lawson, concluded

Slide 15

Recommended Reading



Check out Chapter 6 for guidance:

- Lack of Institutional Knowledge
- Staff Resources
- Consultant Assistance
- Interagency Coordination

Slide 16

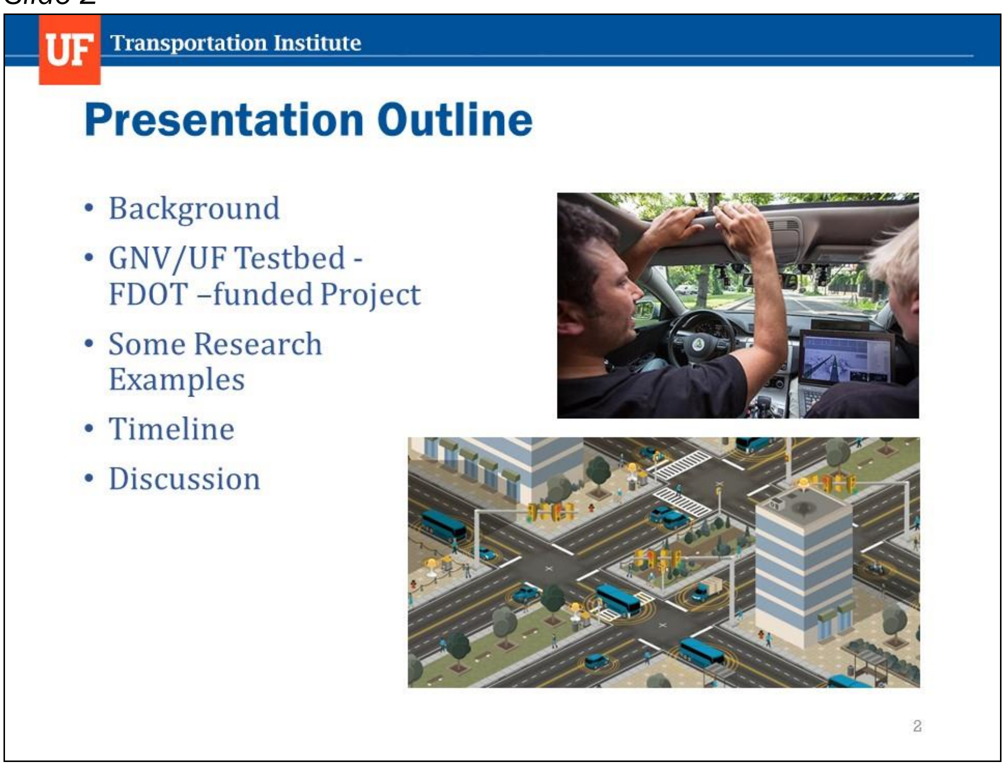
And……………….

- Produce University-level teaching materials in parallel with practice trajectory.
- Aim training at new hires, in addition to internal staff.
- Sponsor "exploration gardens" within Universities as data-oriented test-beds to conduct methodological evaluations.
- Consider Open Source and Open Data to accelerate progress.

Dr. Lily Elefteriadou – University of Florida

Slide 1

Slide 2



Elefteriadou, continued

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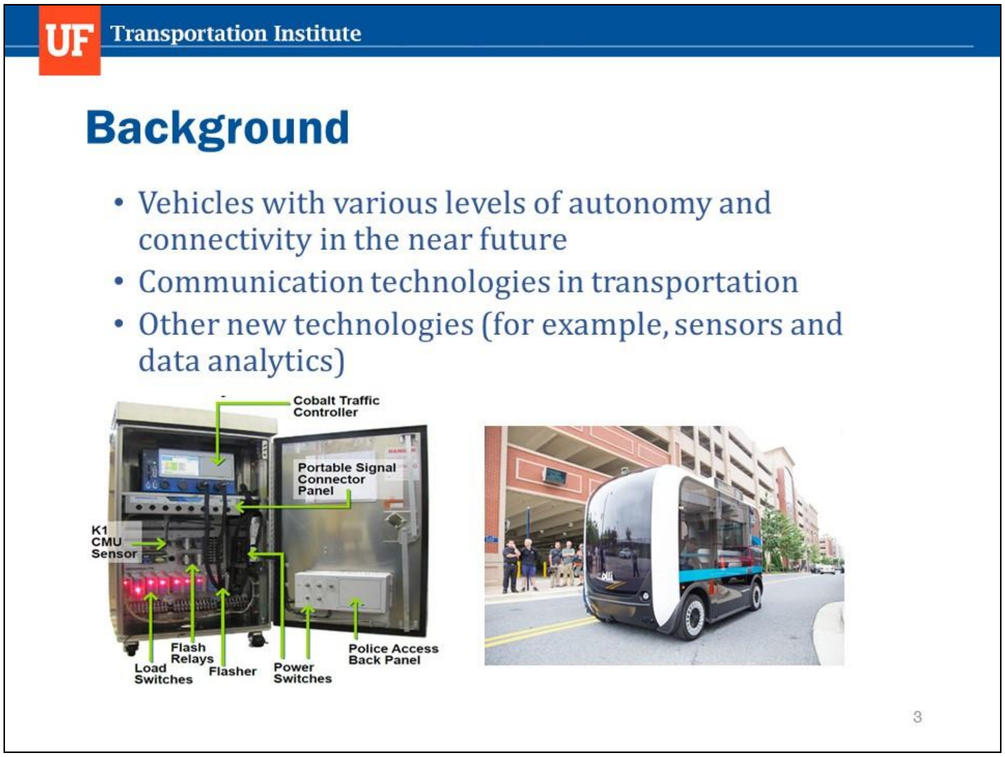

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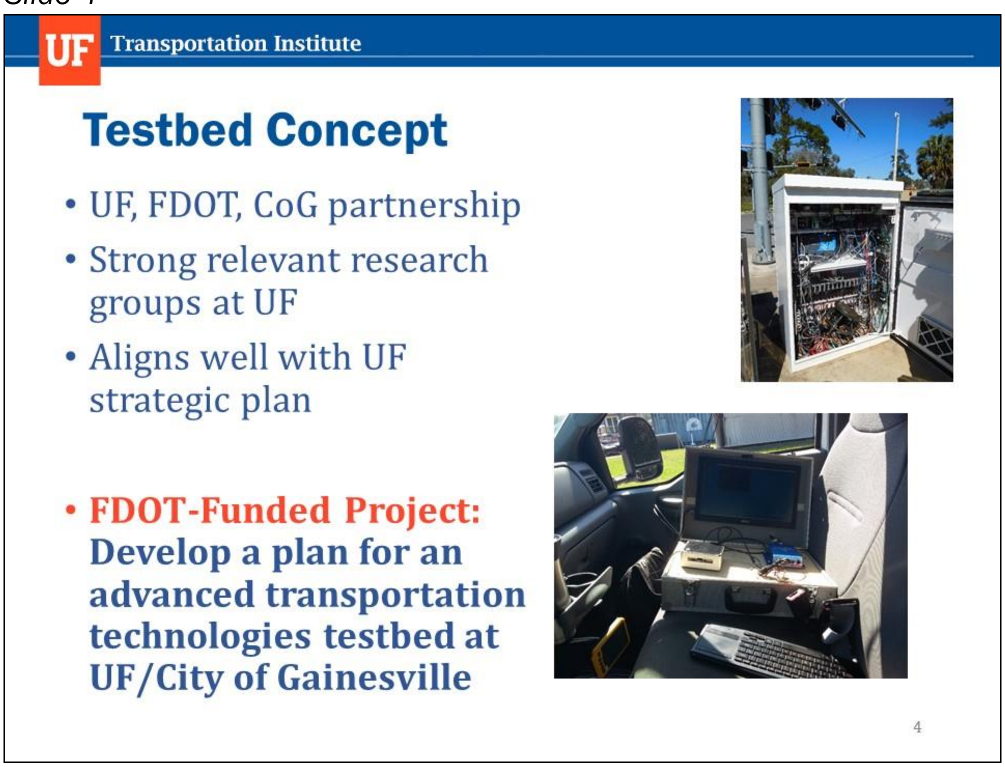

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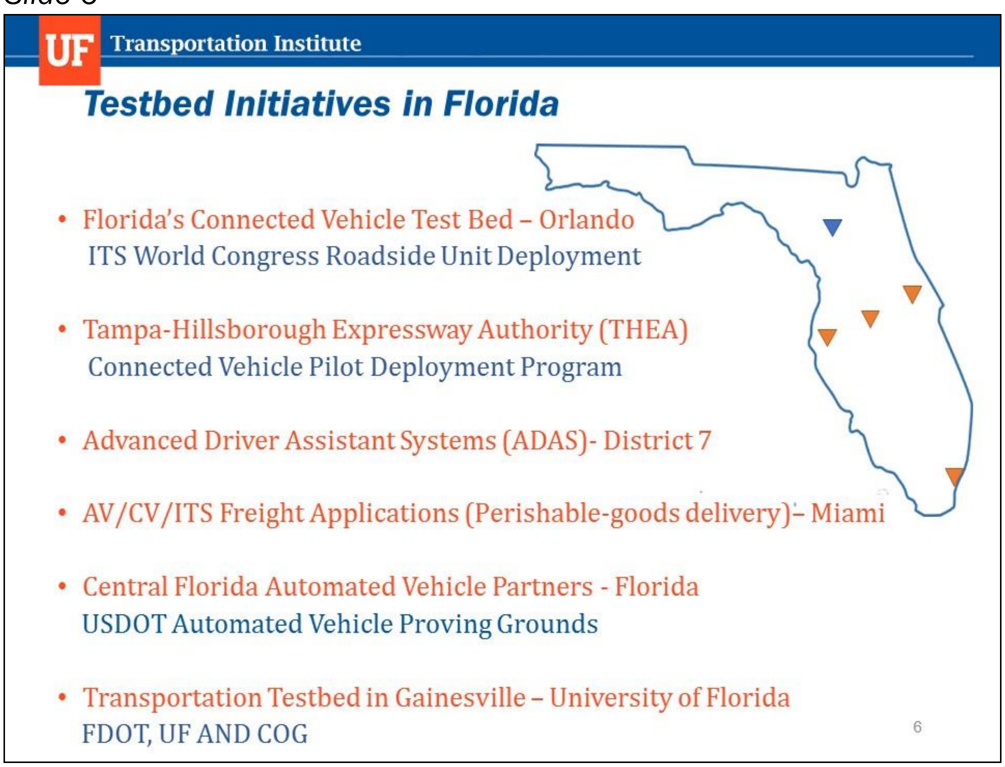

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Slide 10

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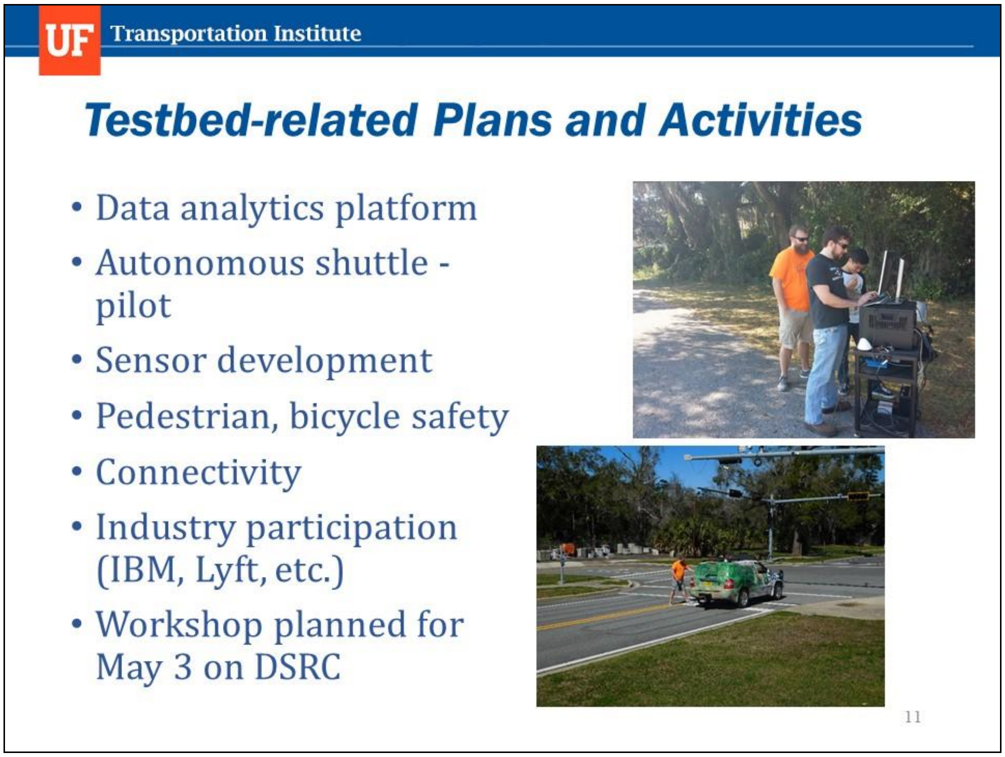

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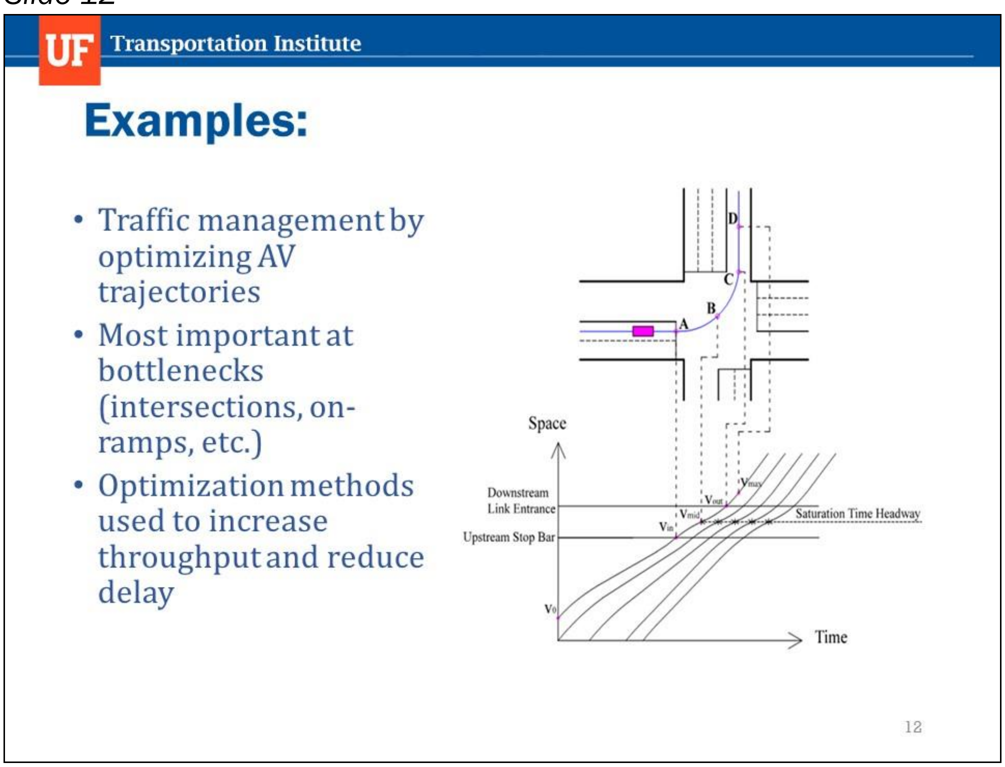

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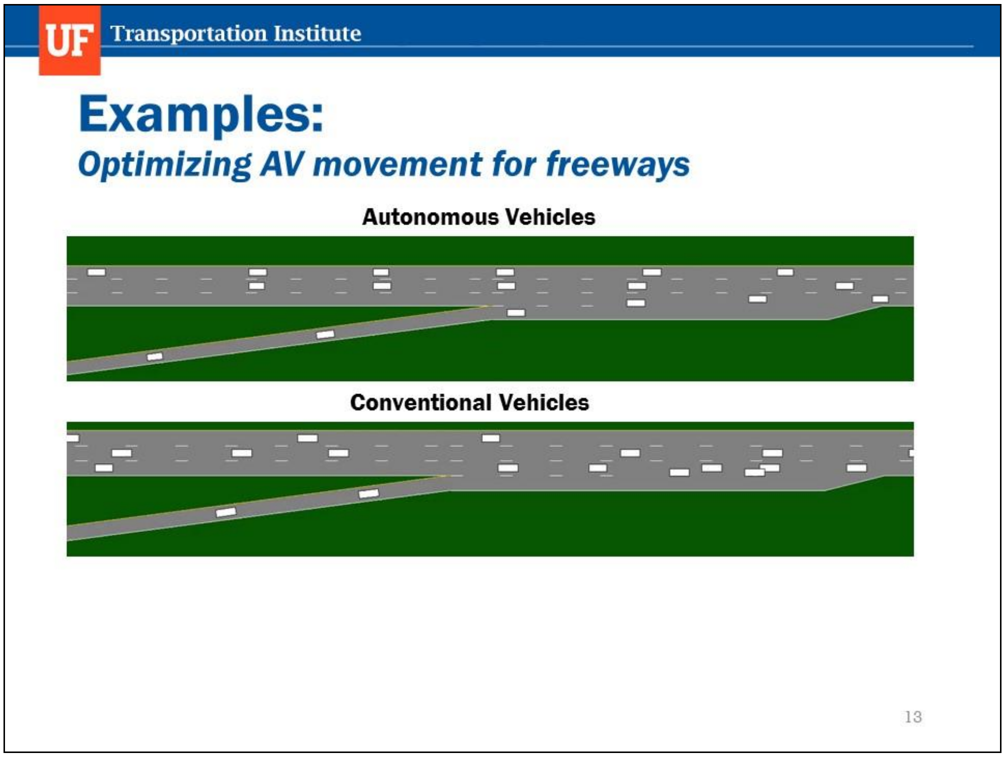

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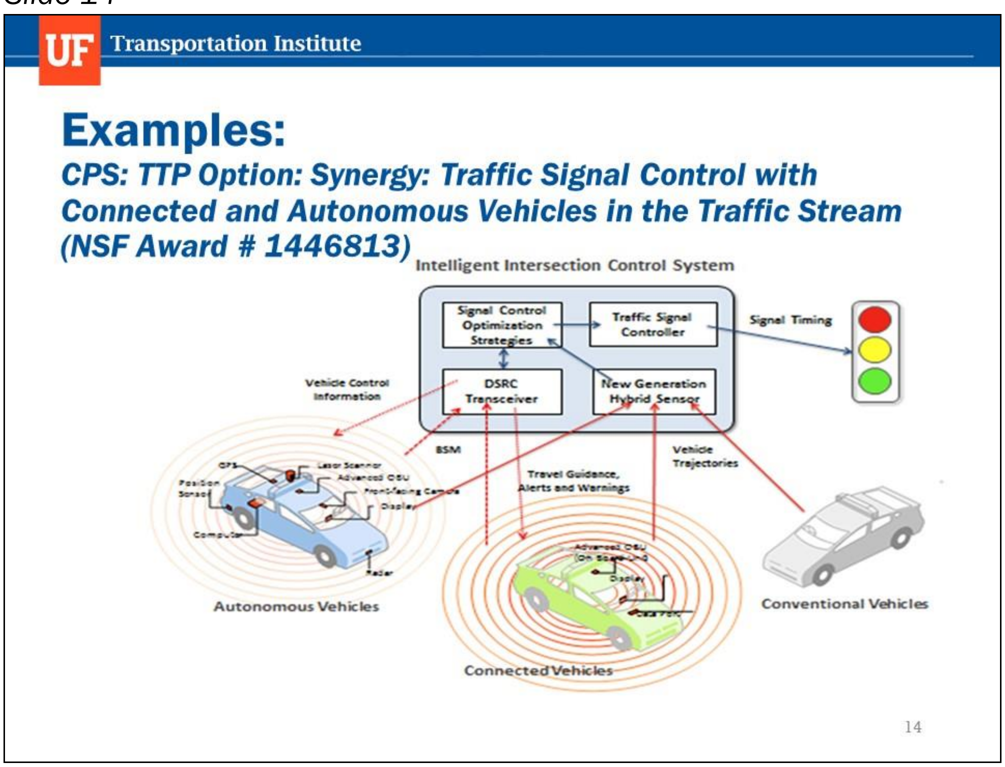

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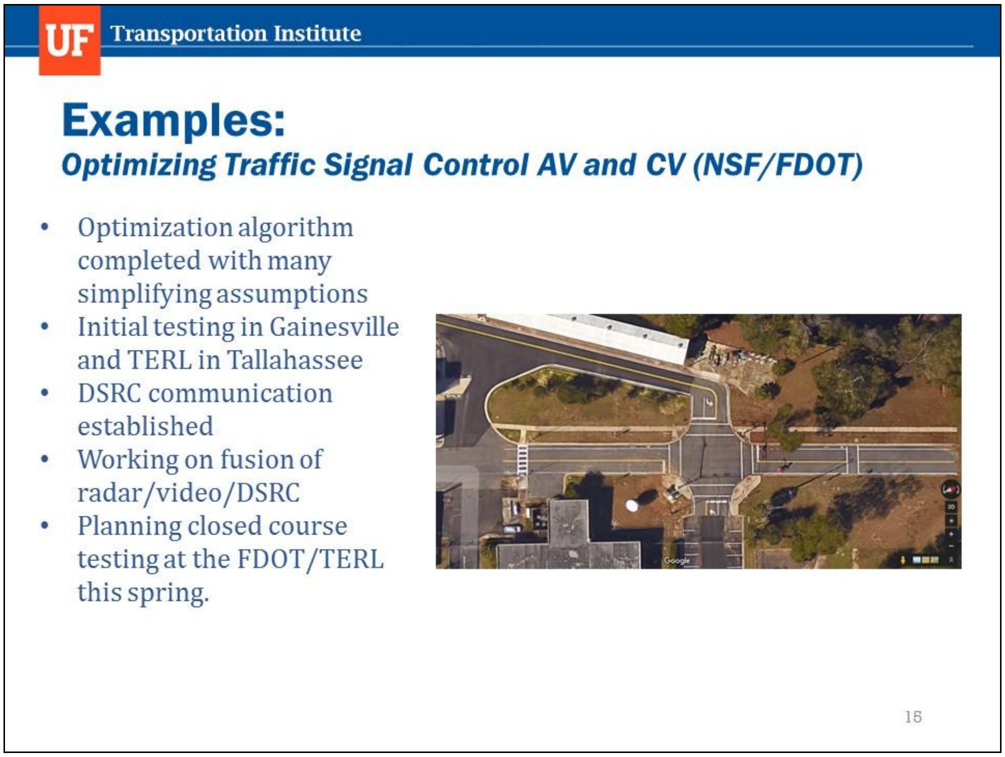

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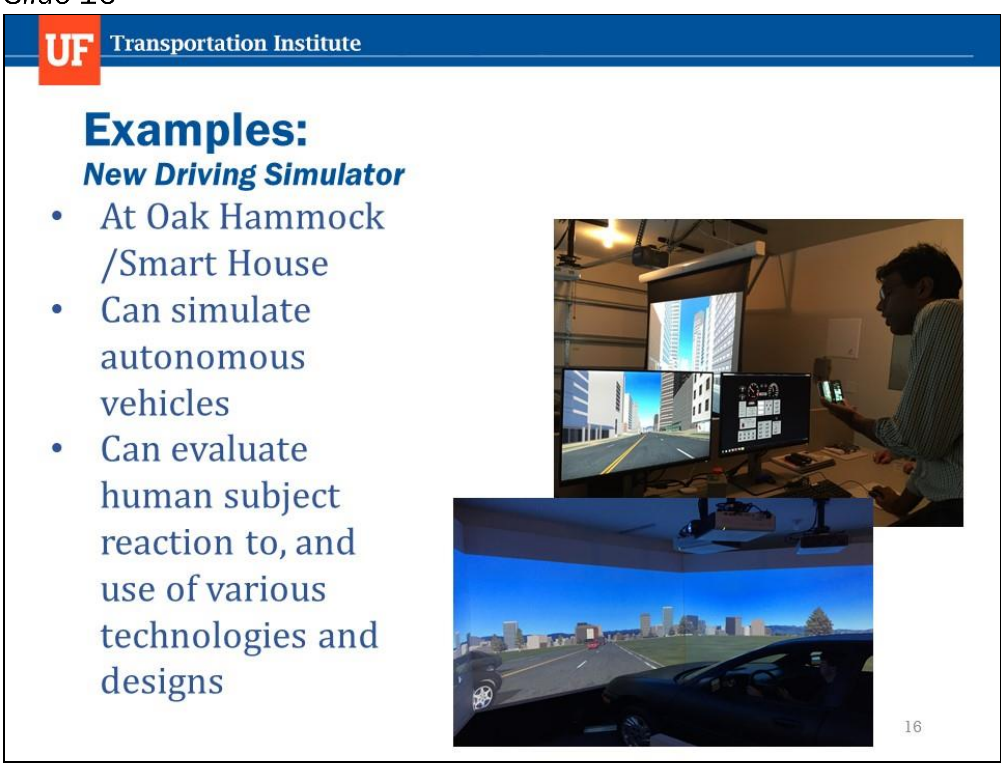

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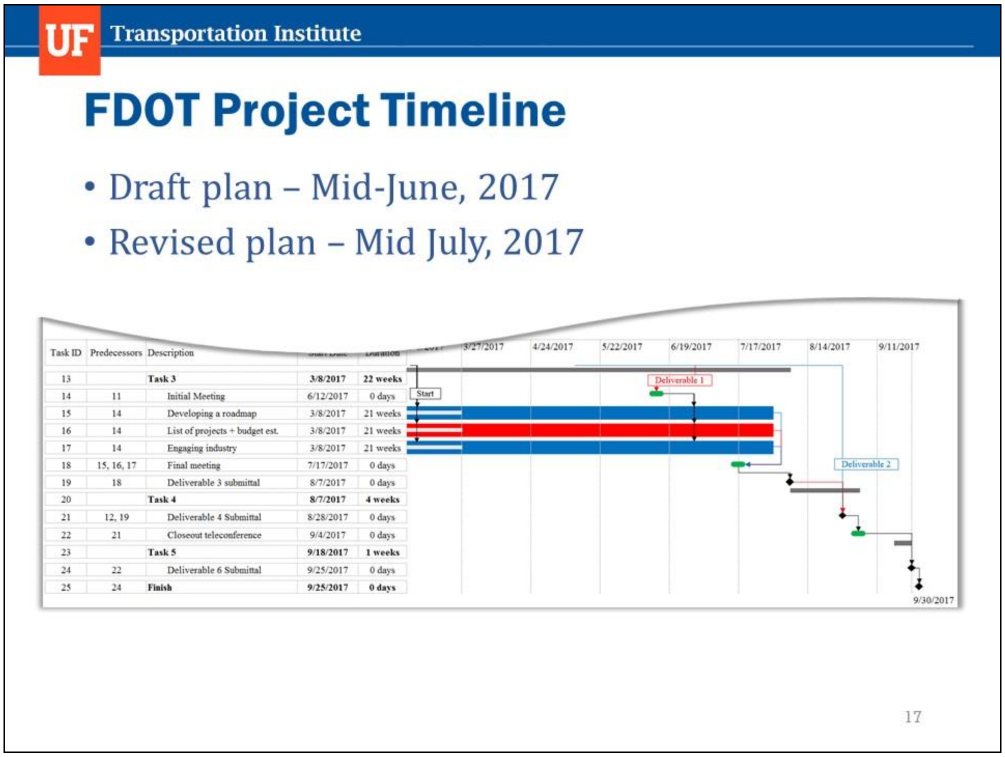

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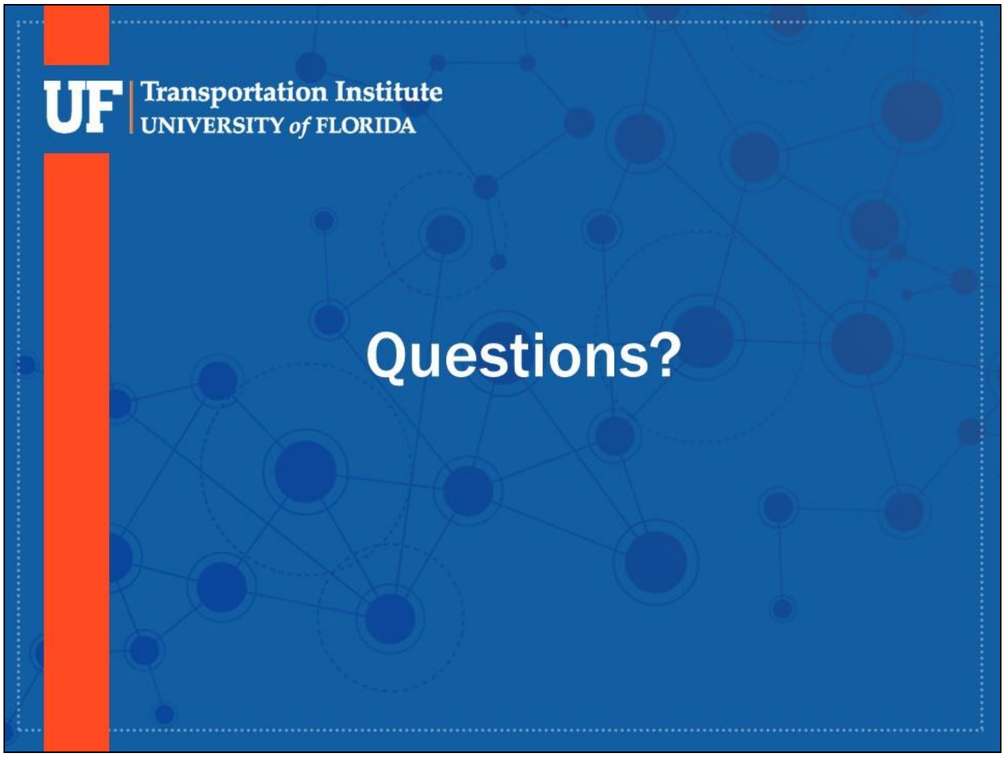
Elefteriadou, concluded

Slide 19



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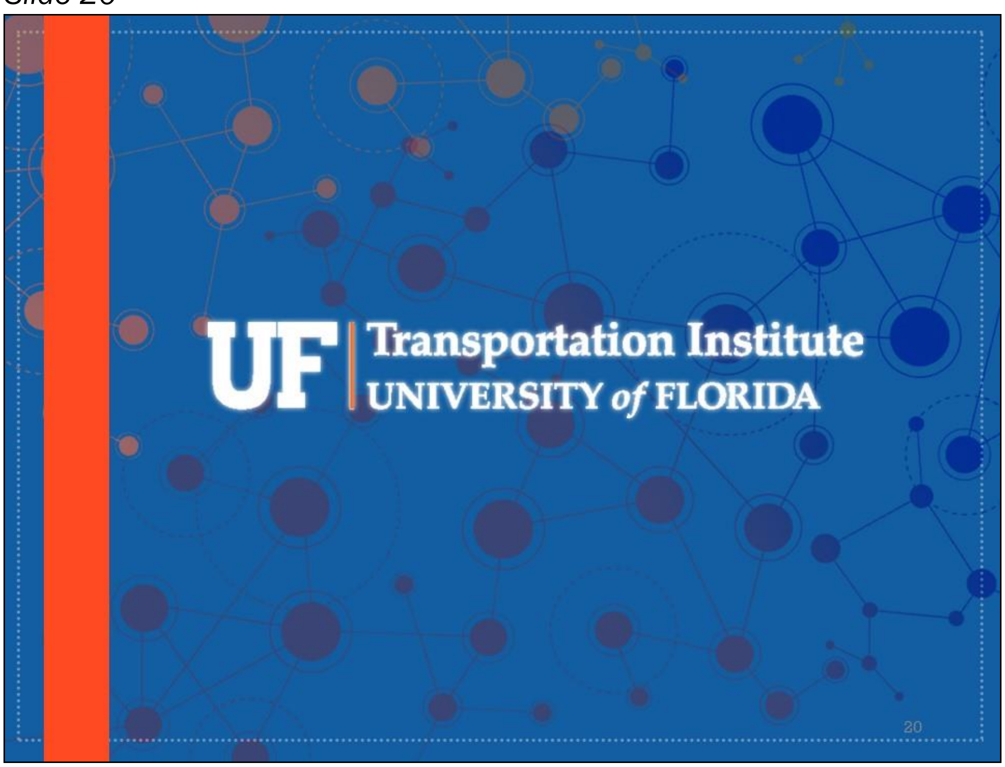
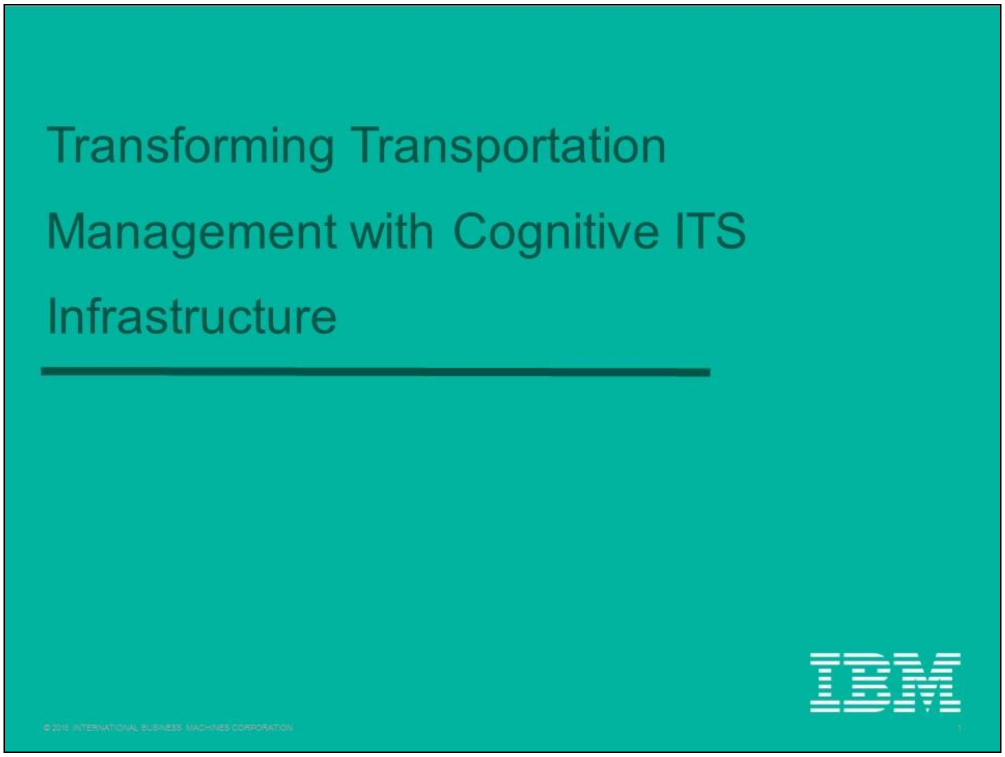


James Lou – IBM

Slide 1



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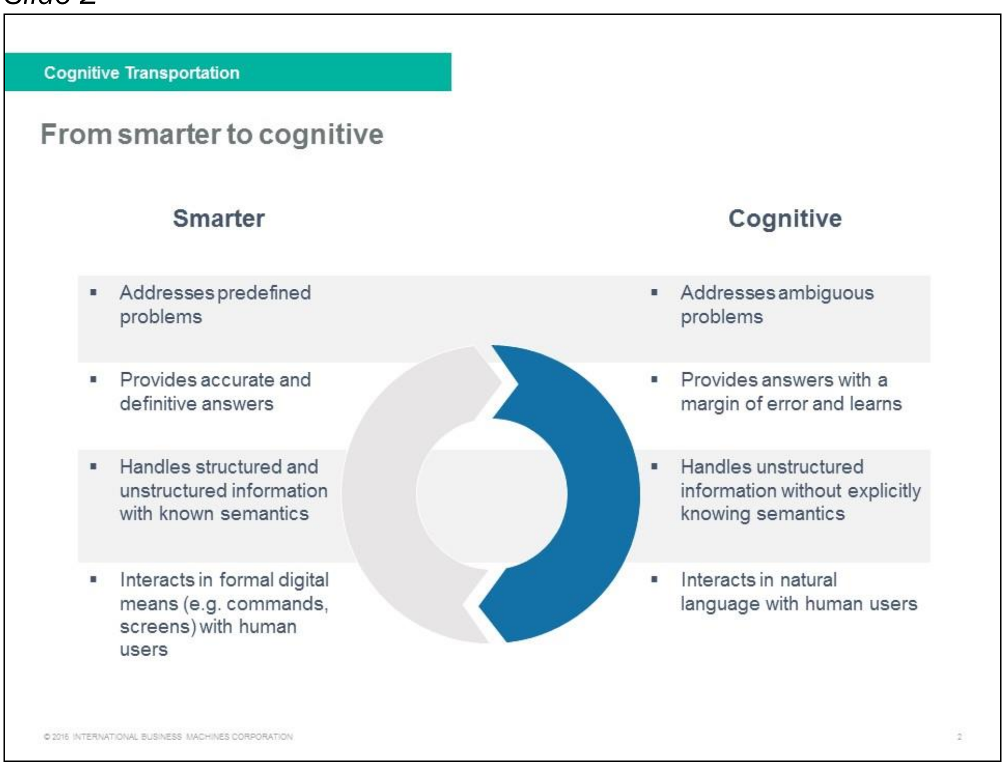

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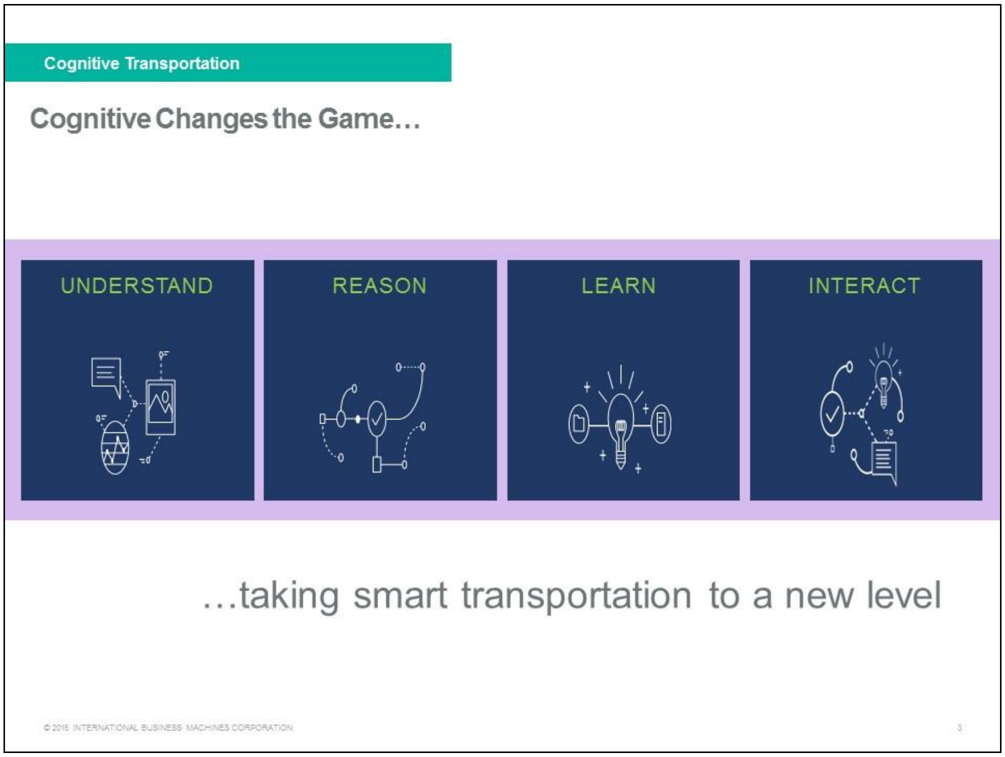

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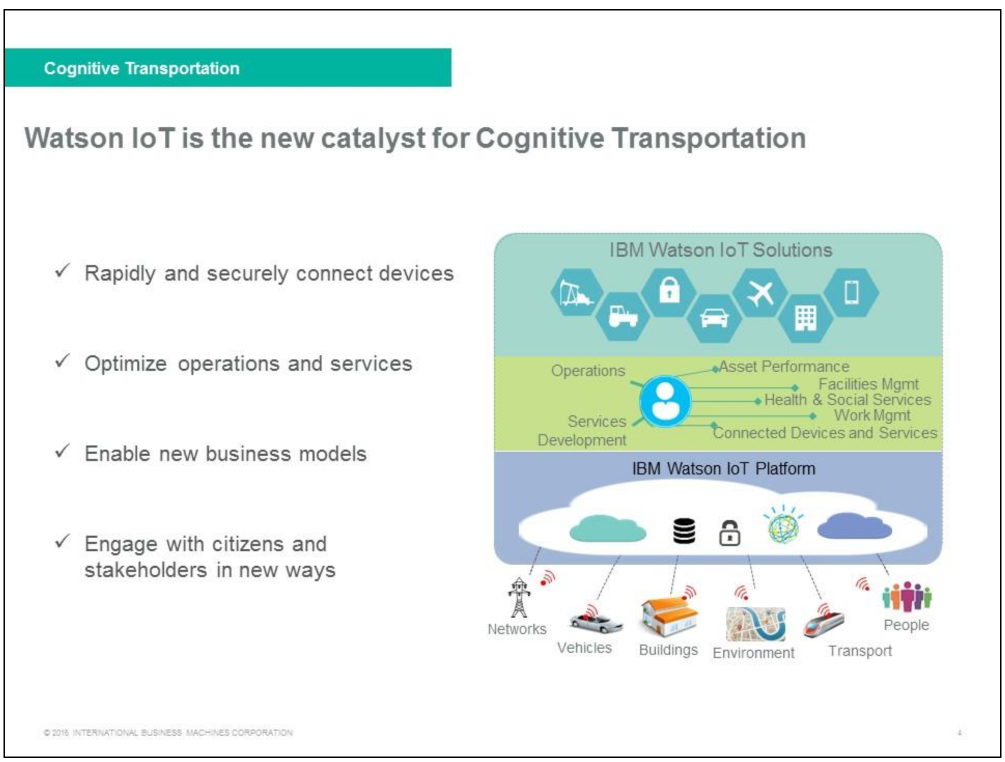

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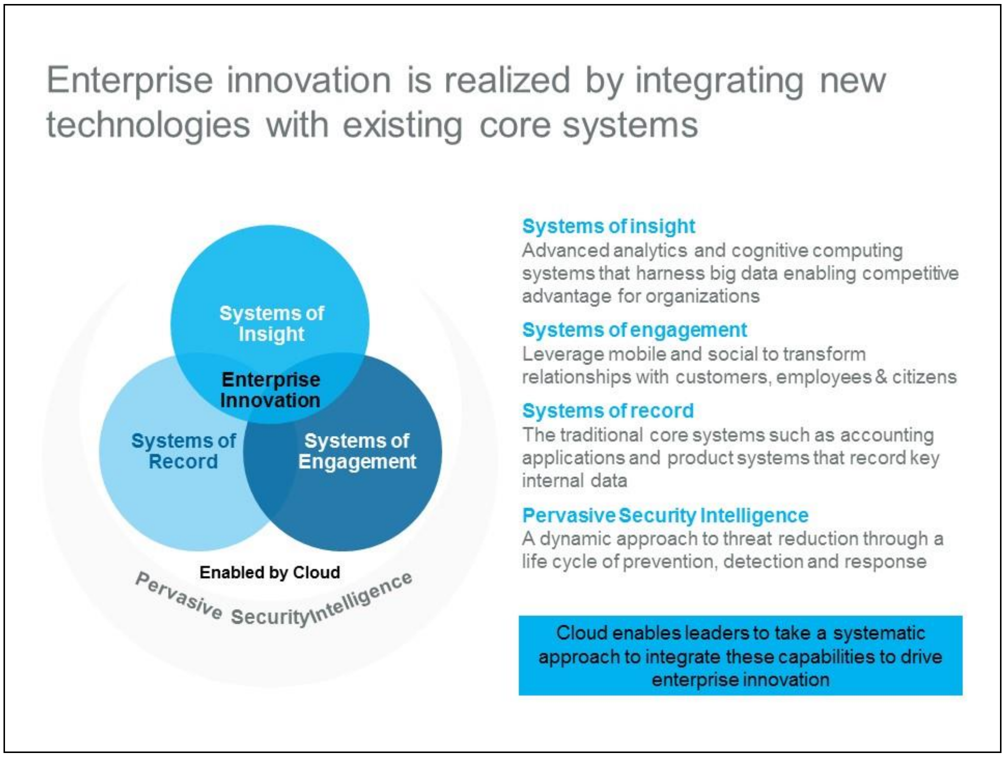

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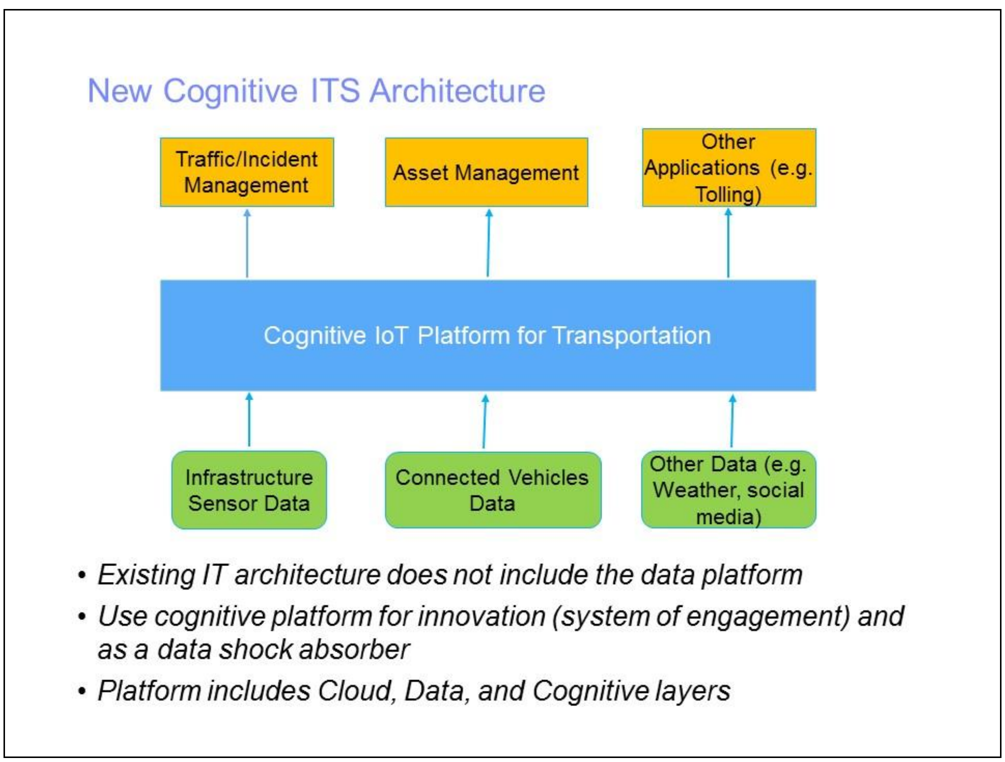

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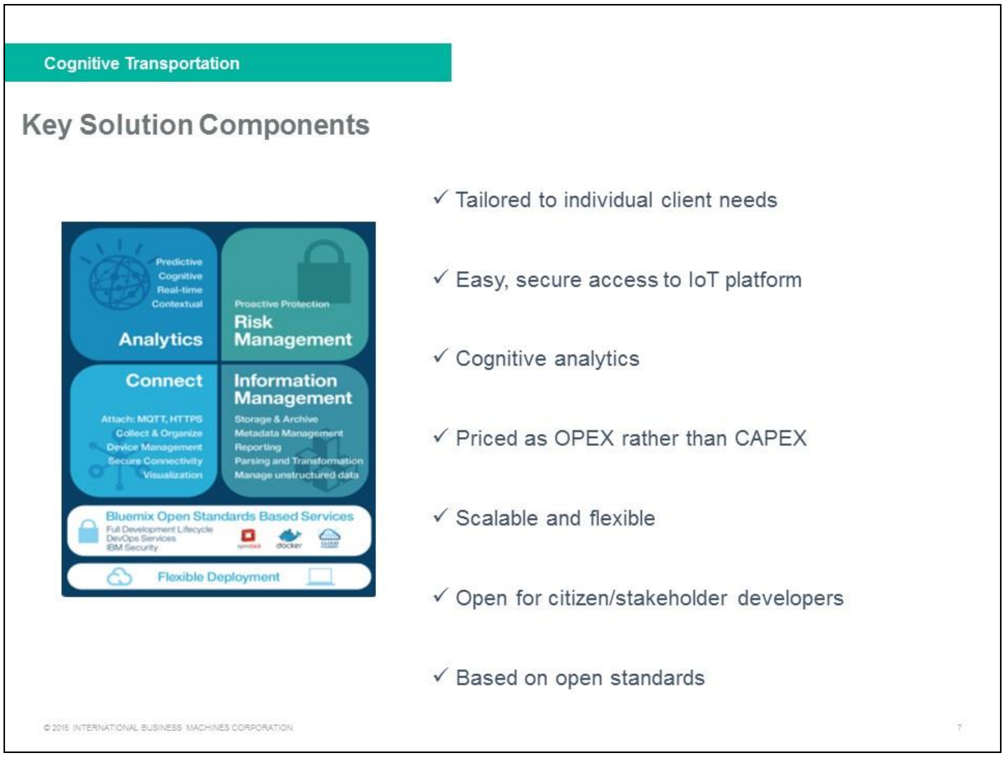

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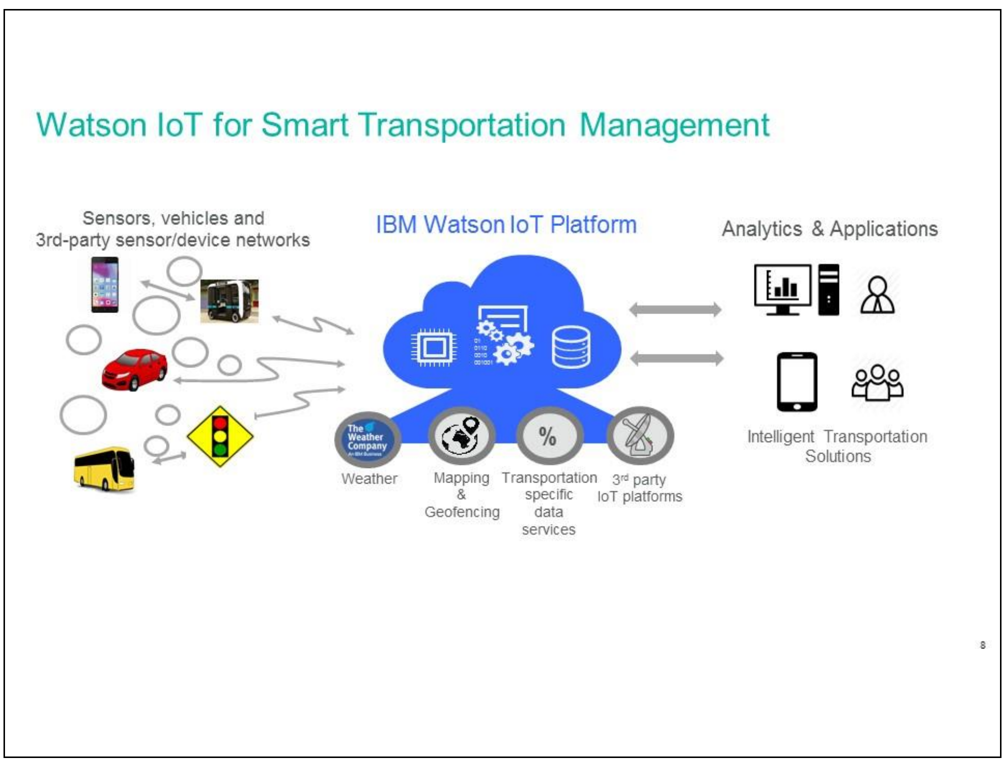

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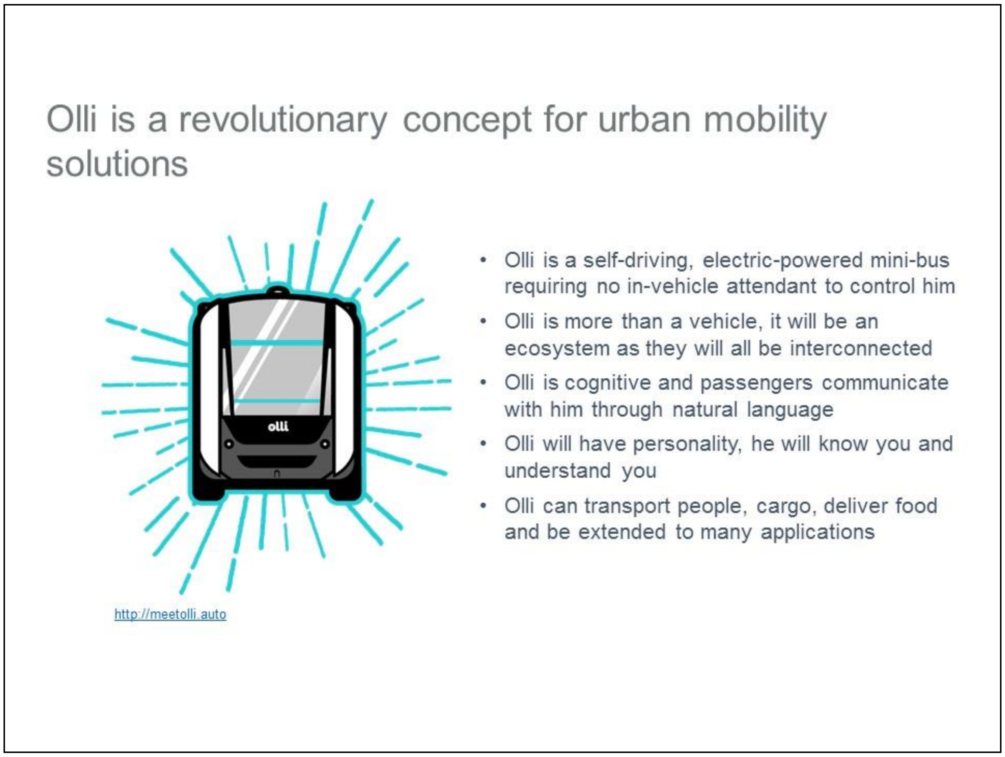

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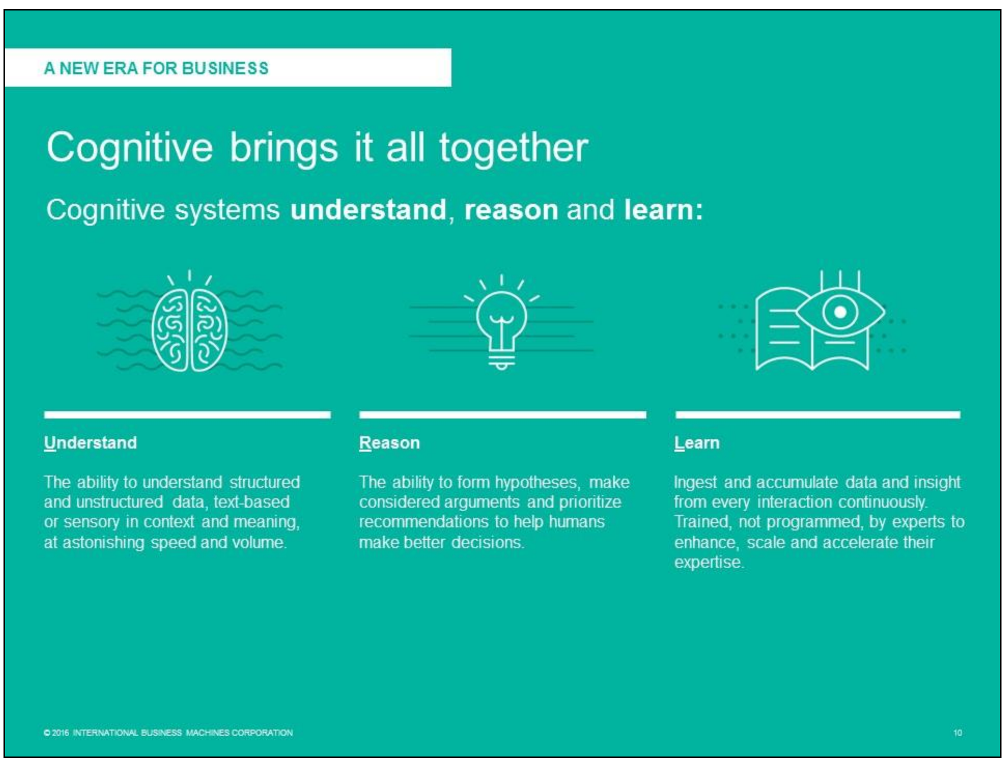

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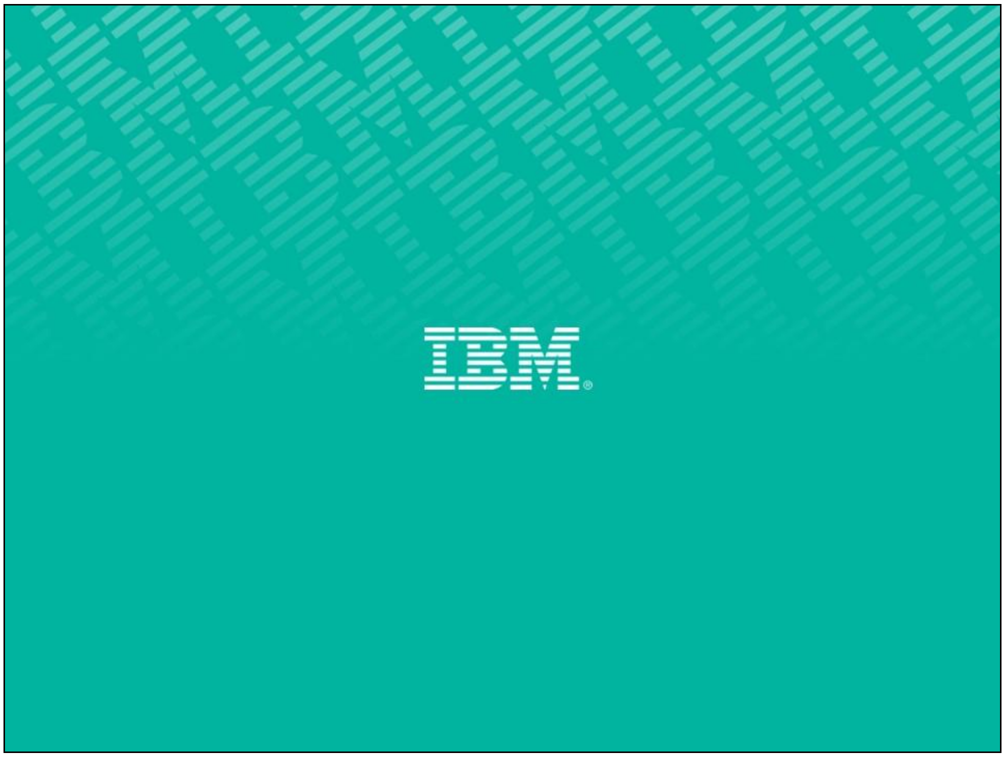
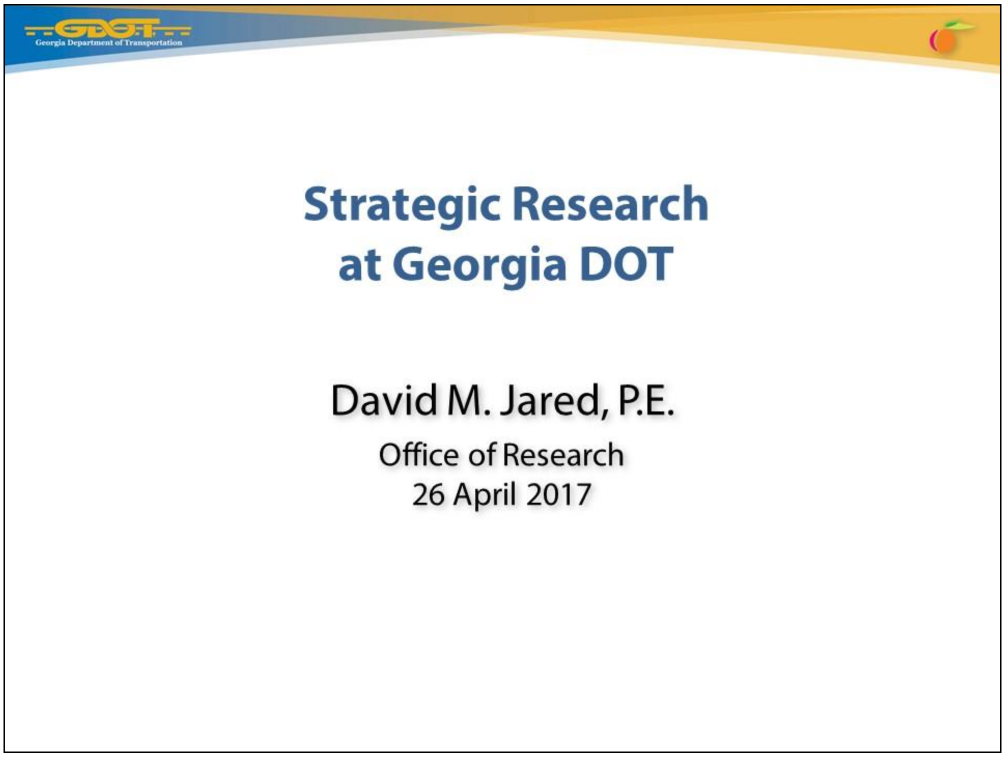


David Jared – Georgia Department of Transportation

Slide 1



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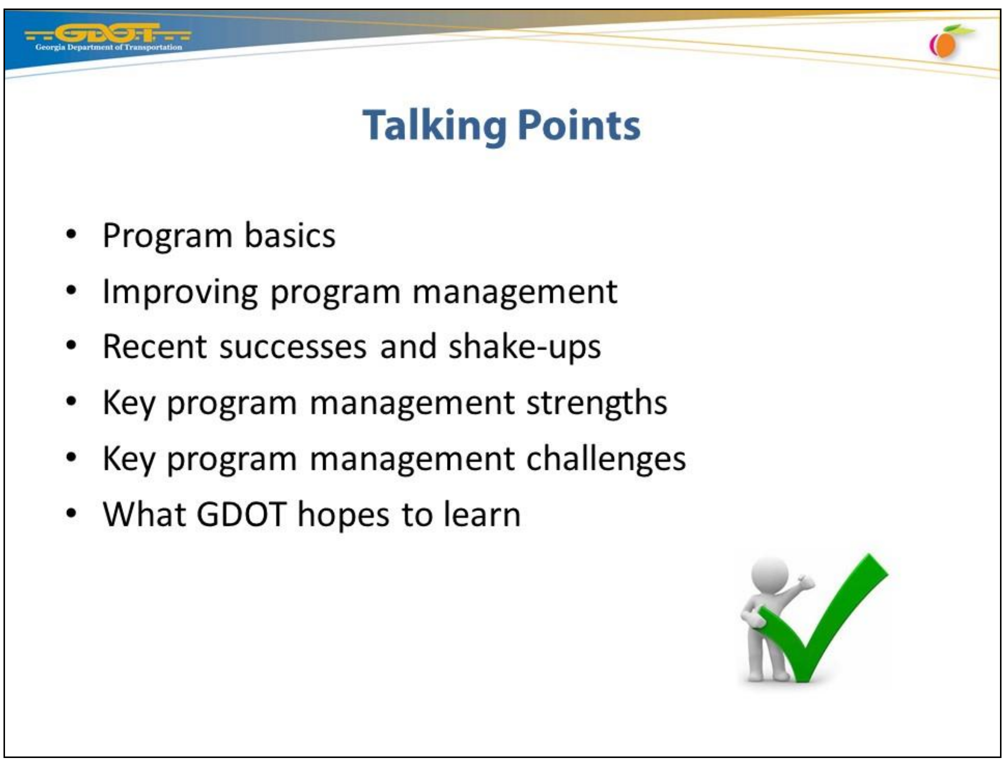

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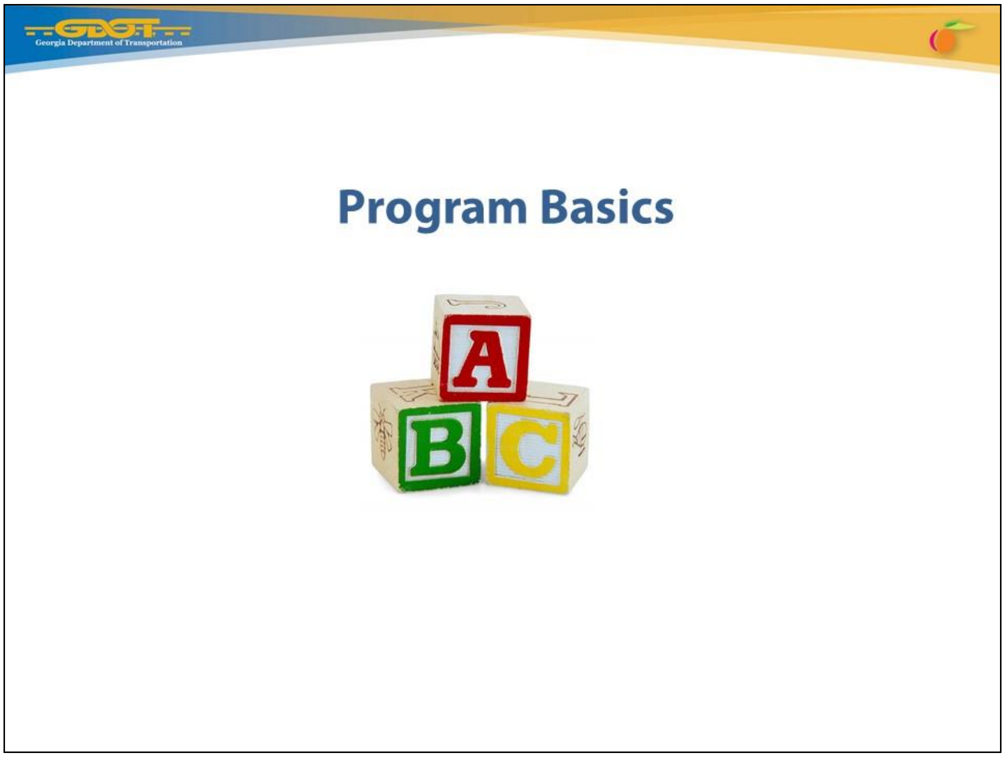

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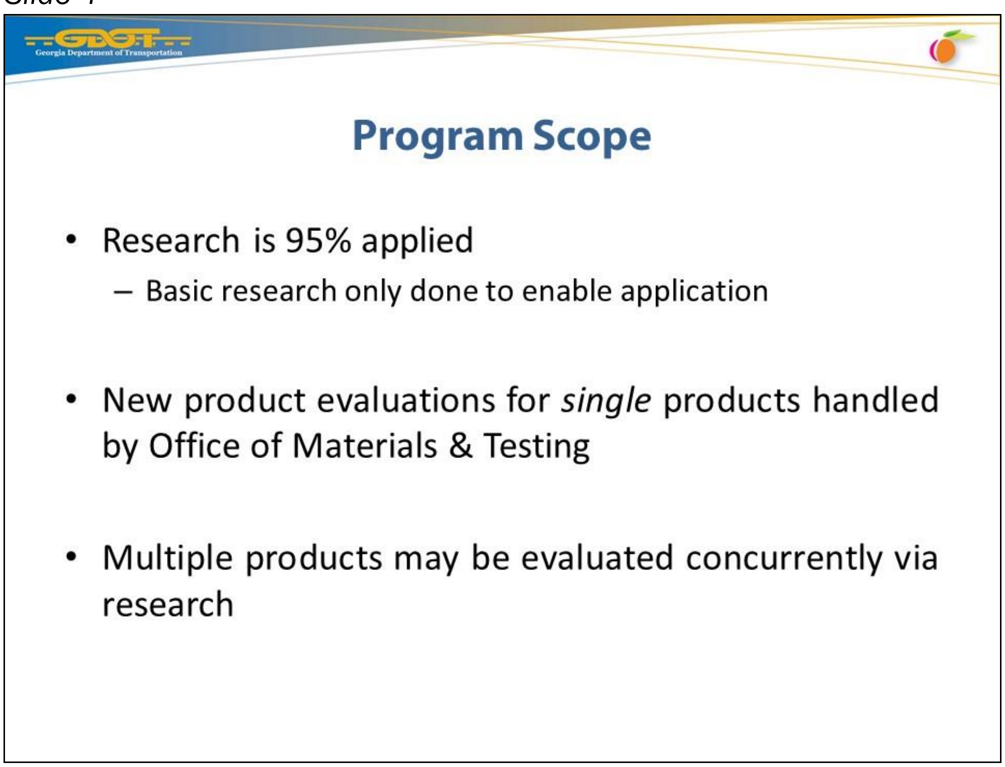

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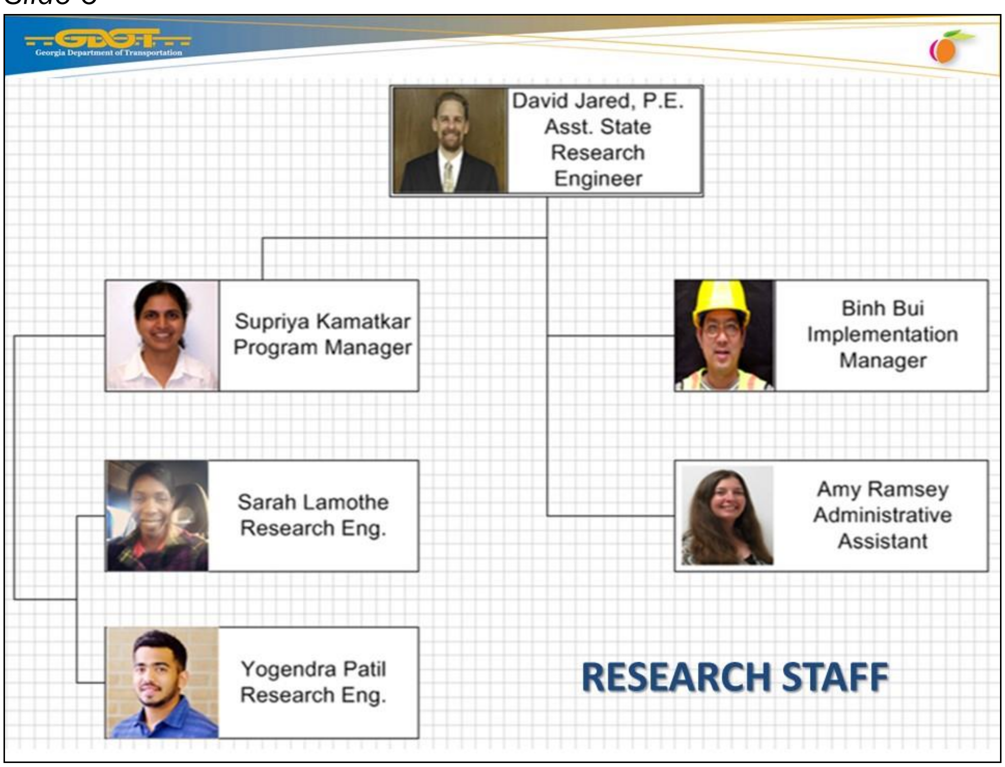

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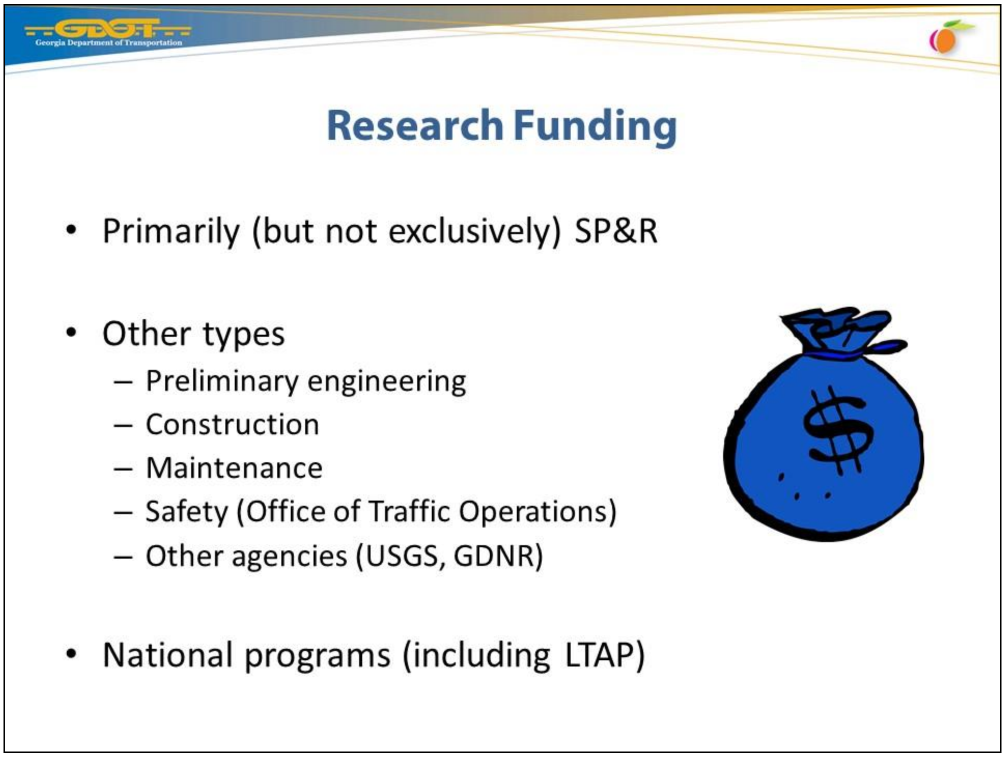

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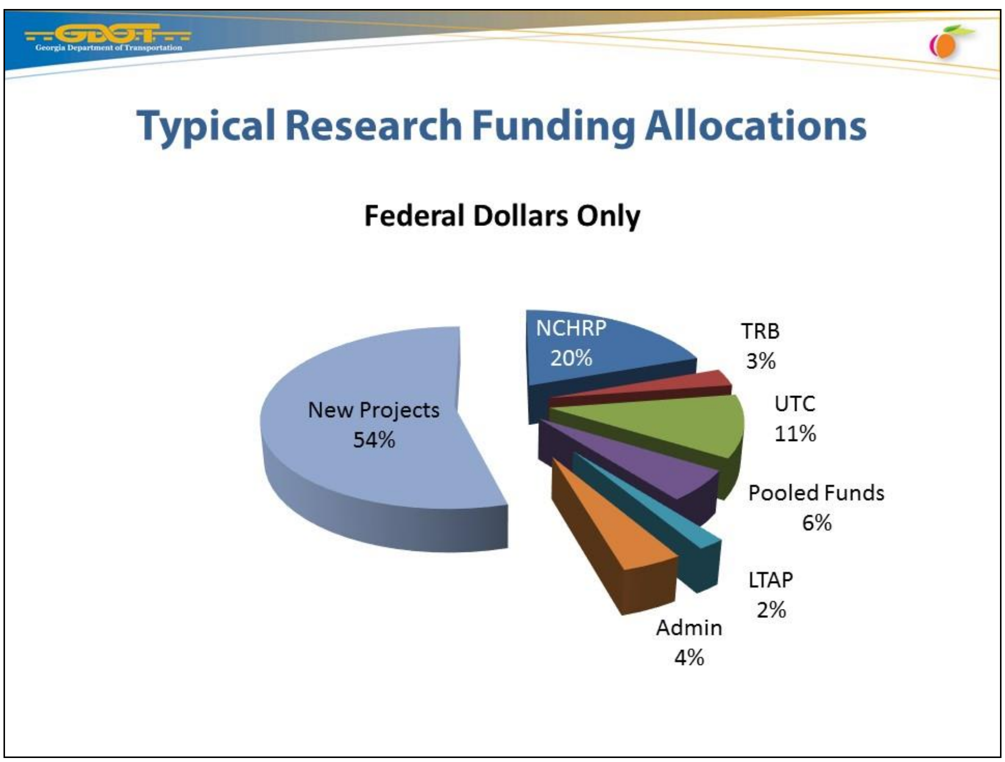

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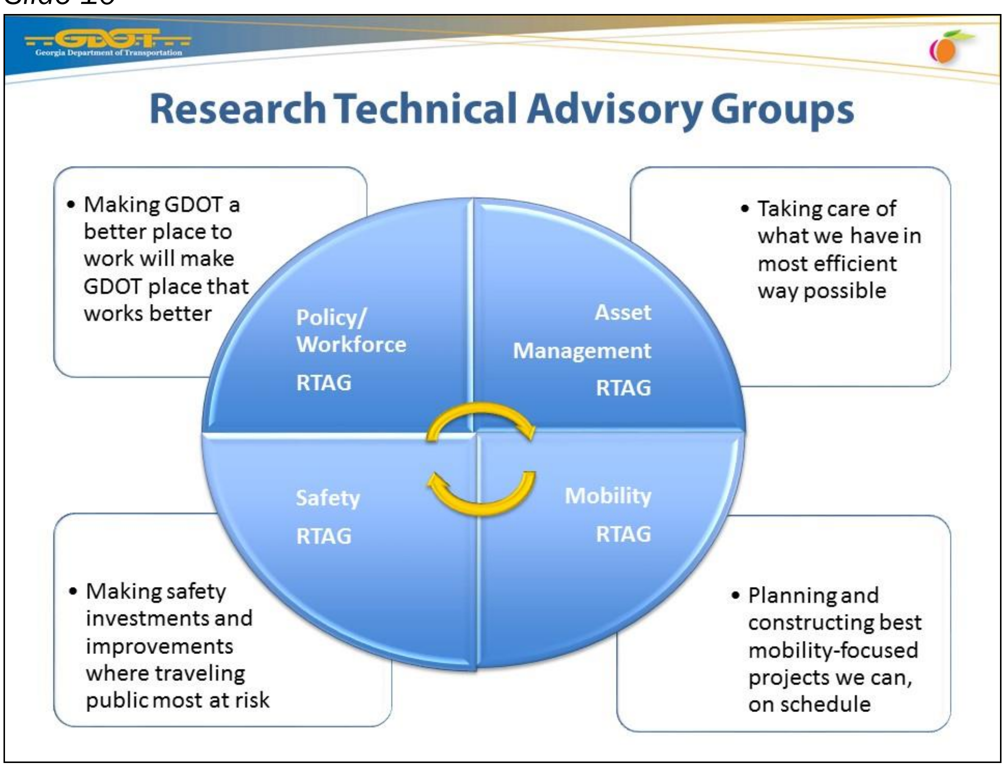

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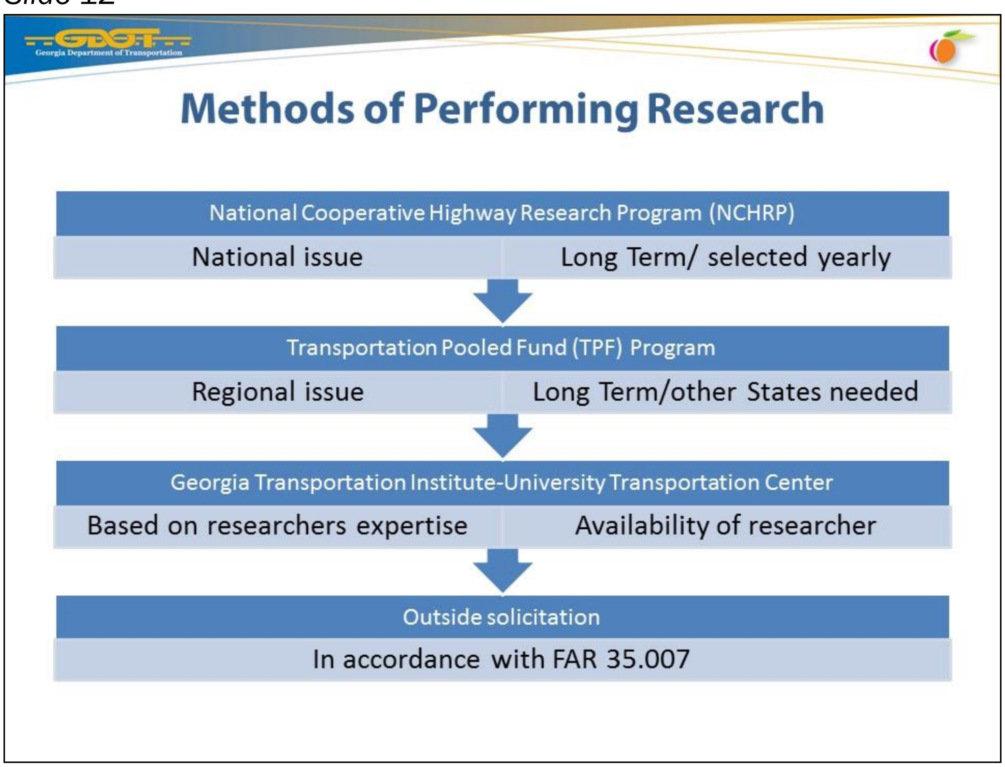

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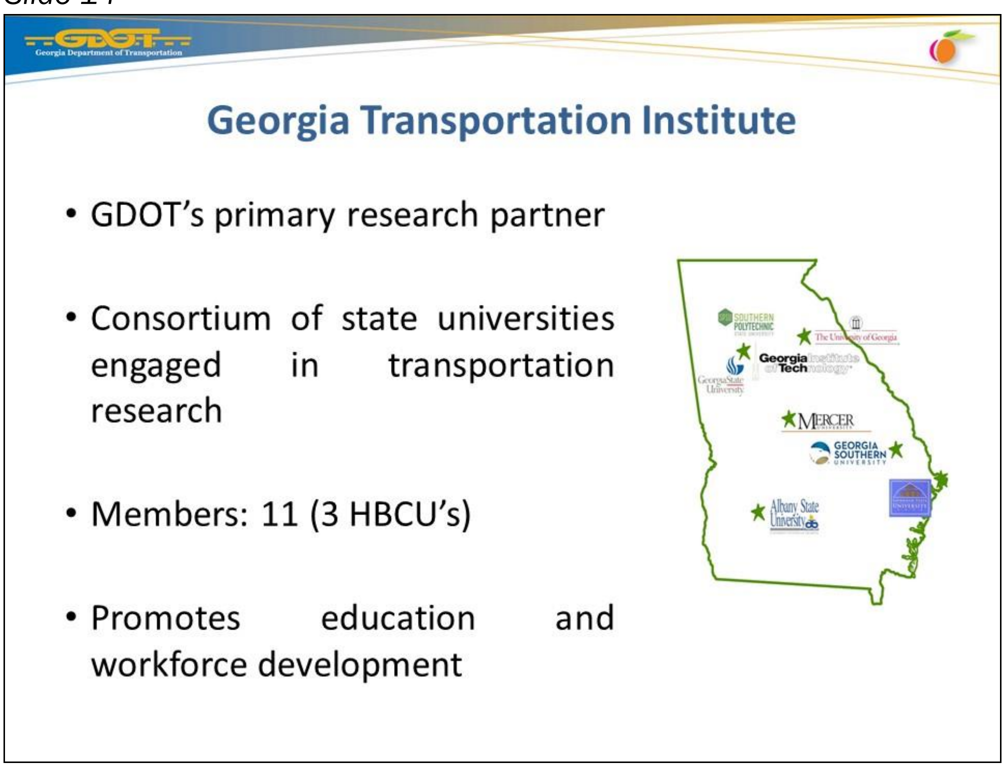

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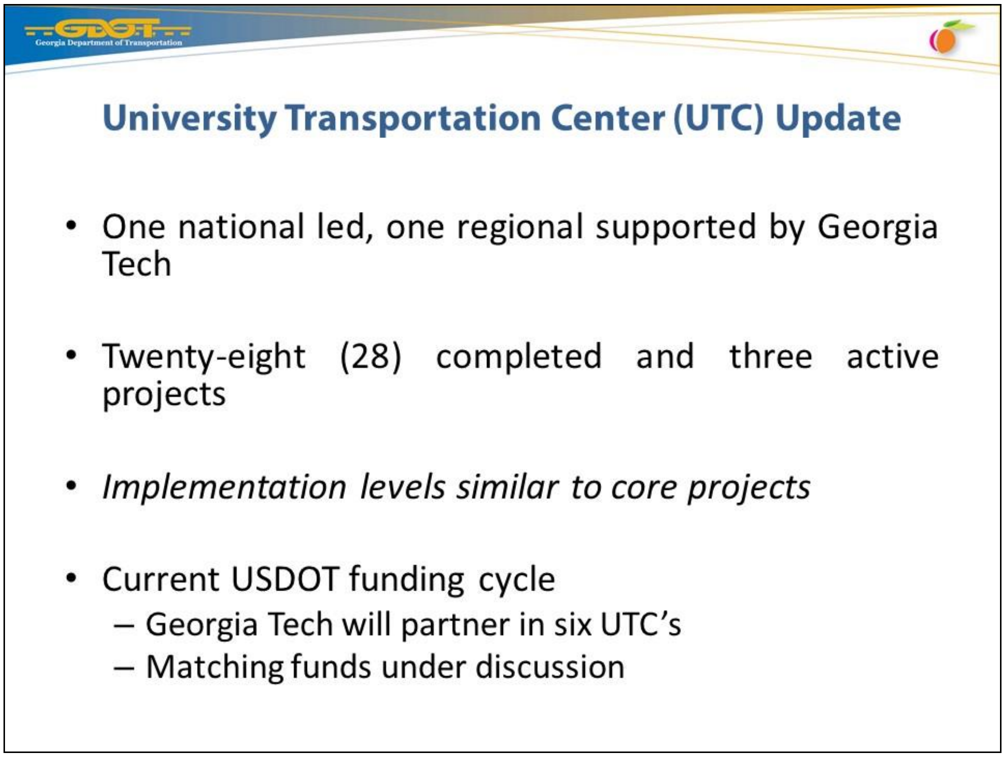

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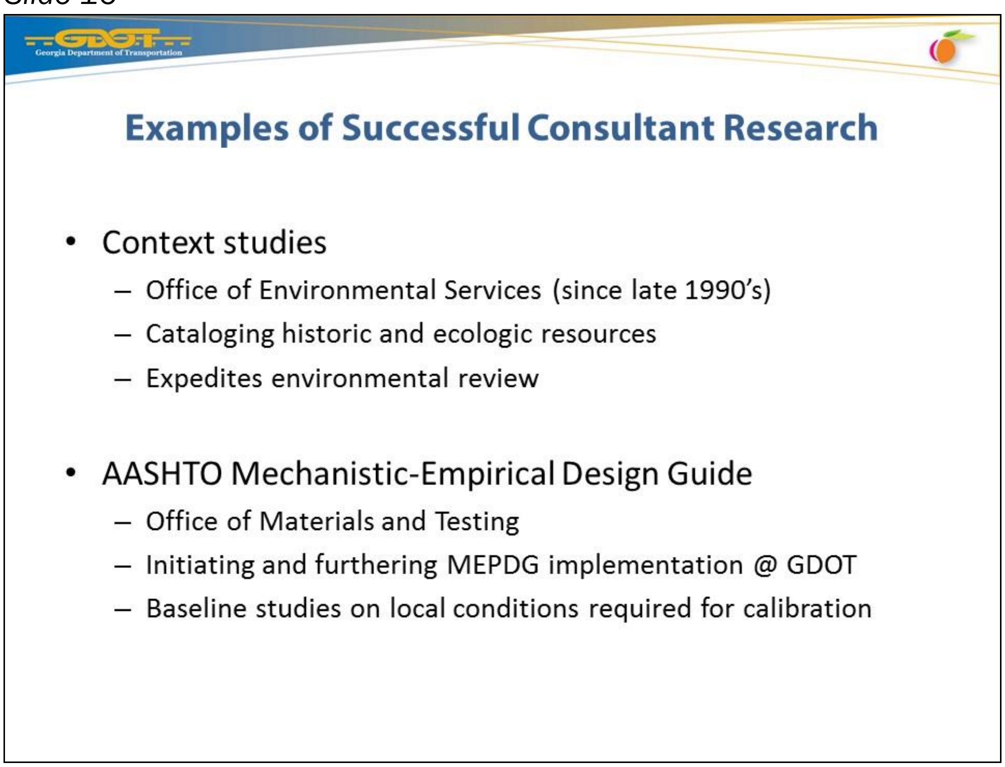

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Slide 17

Slide 18

Jared, continued

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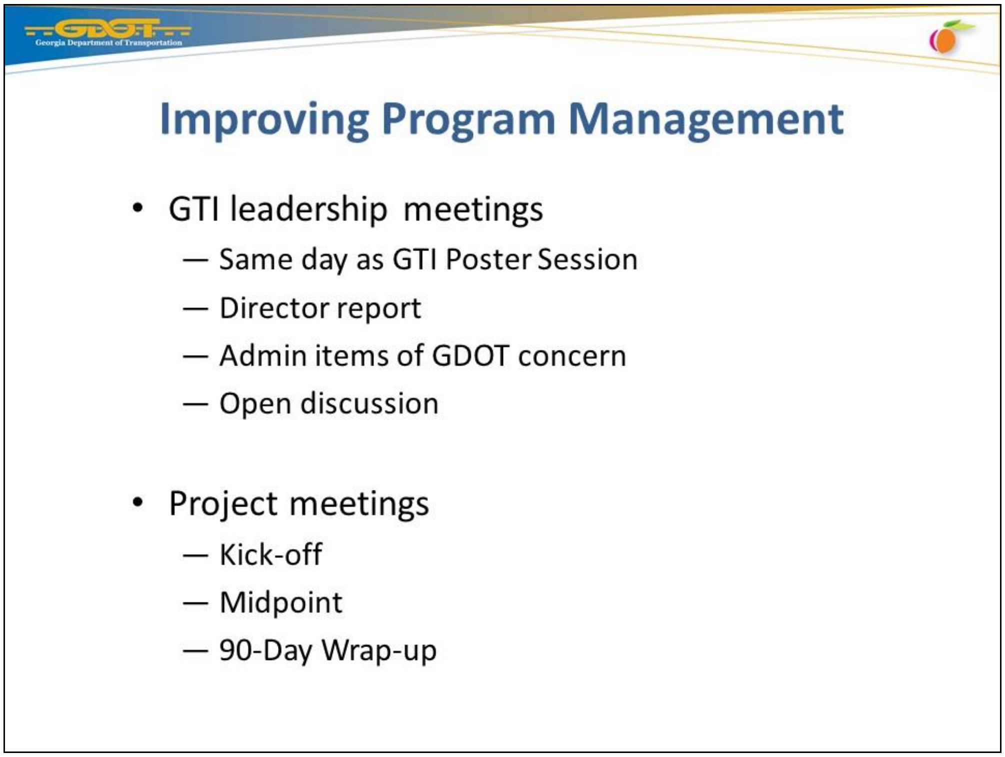

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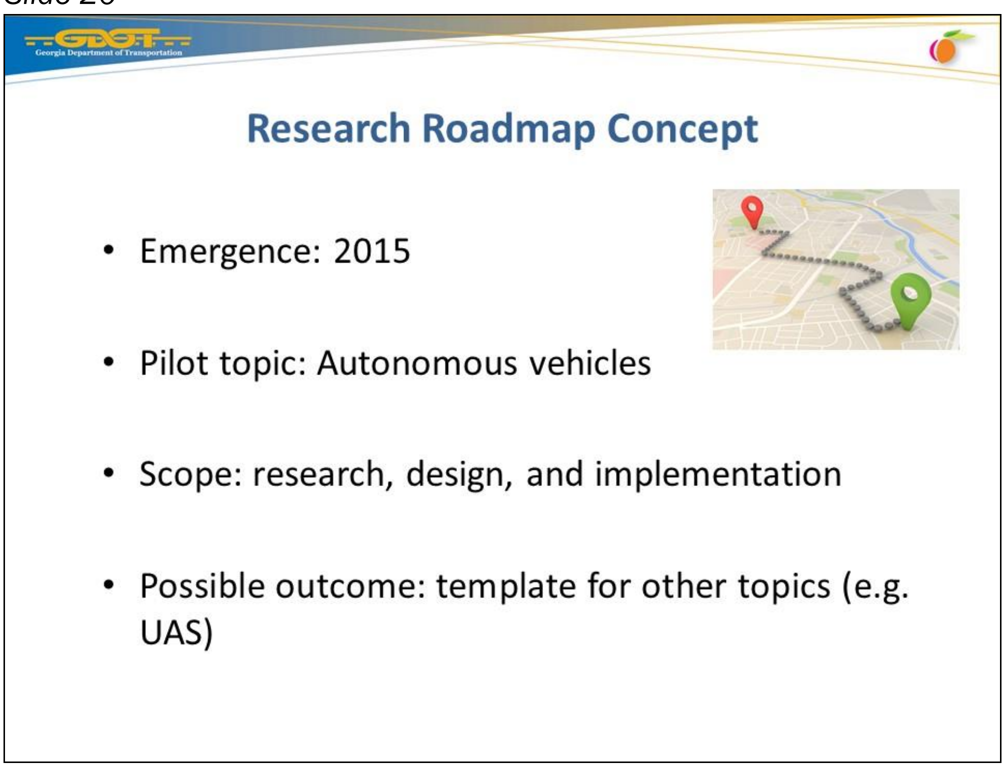

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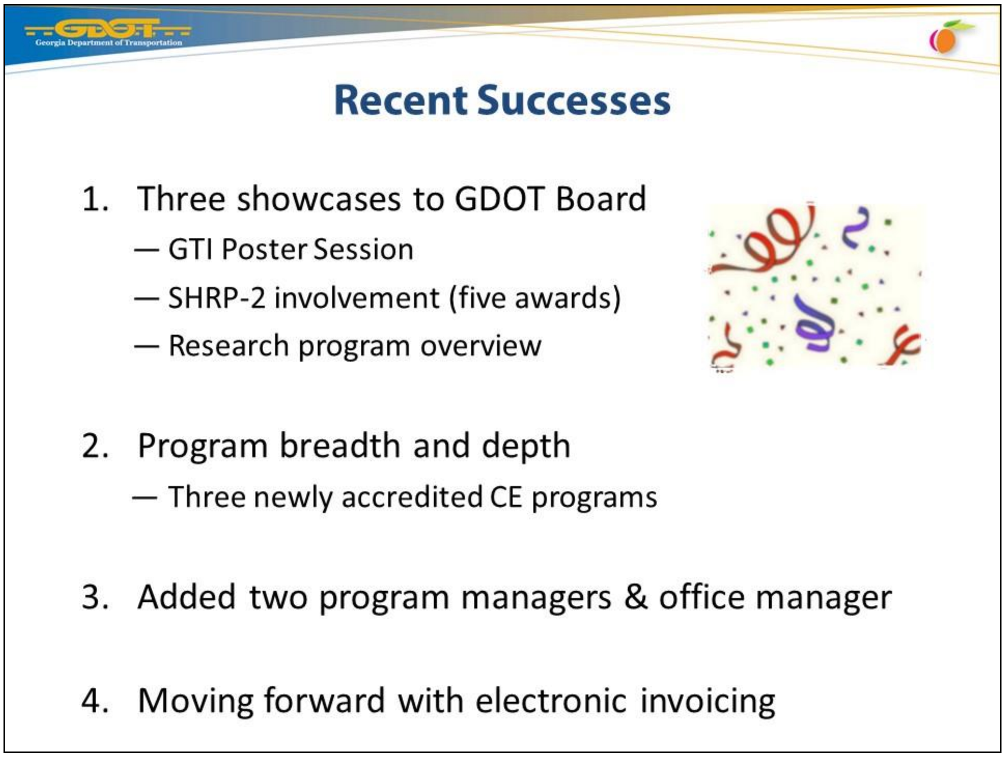

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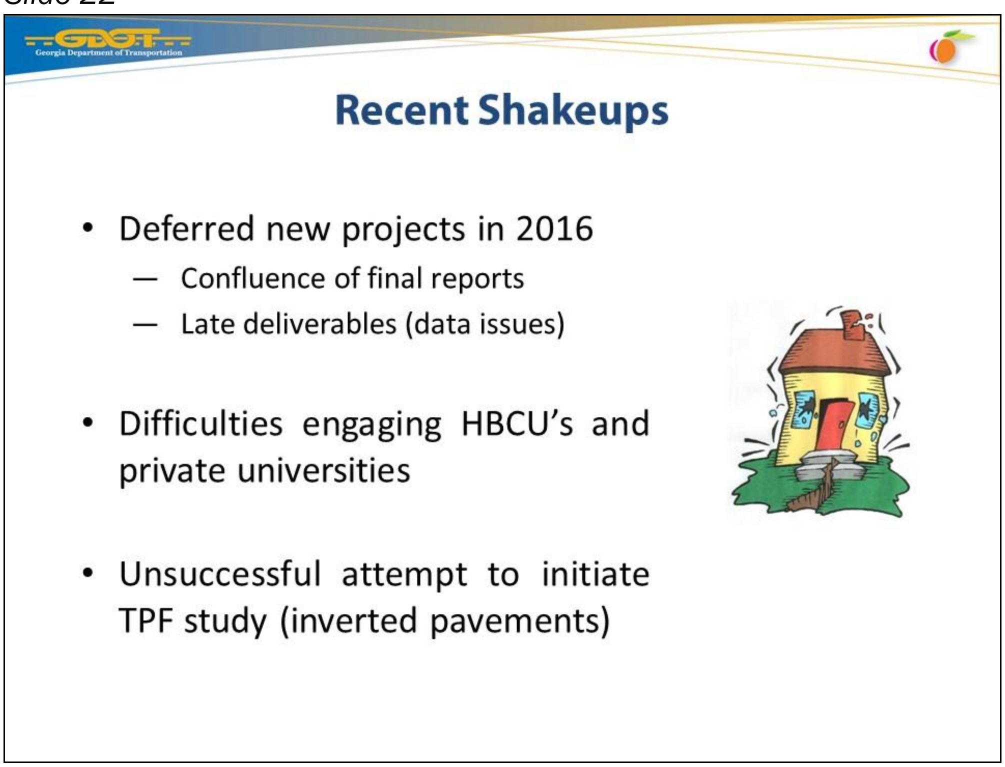

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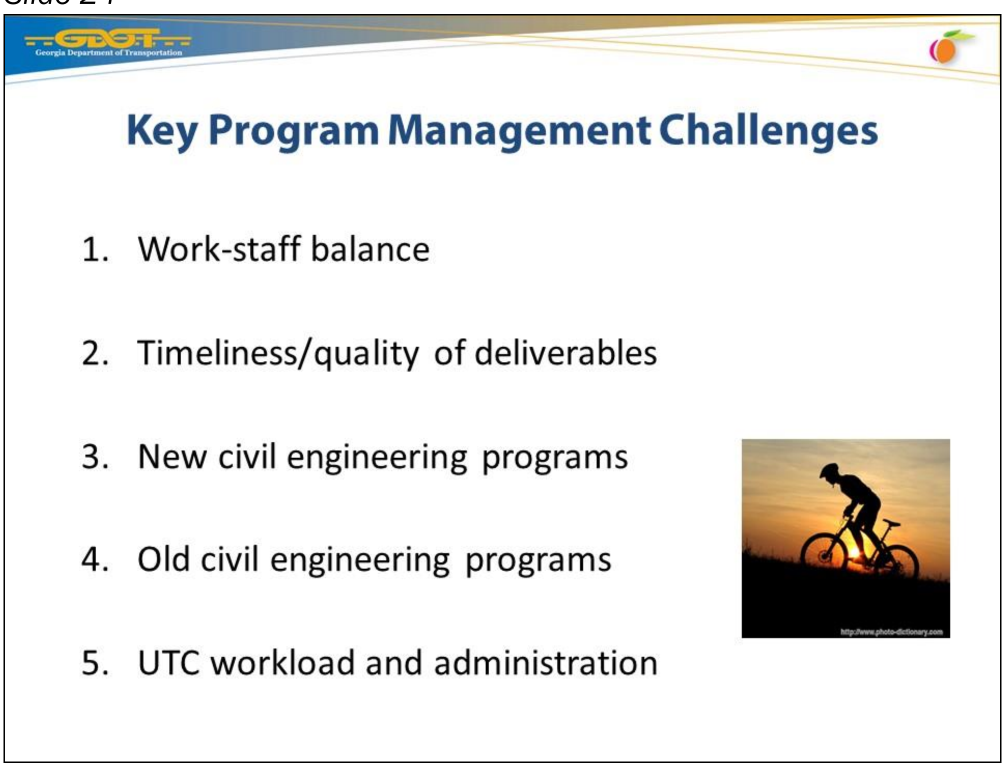

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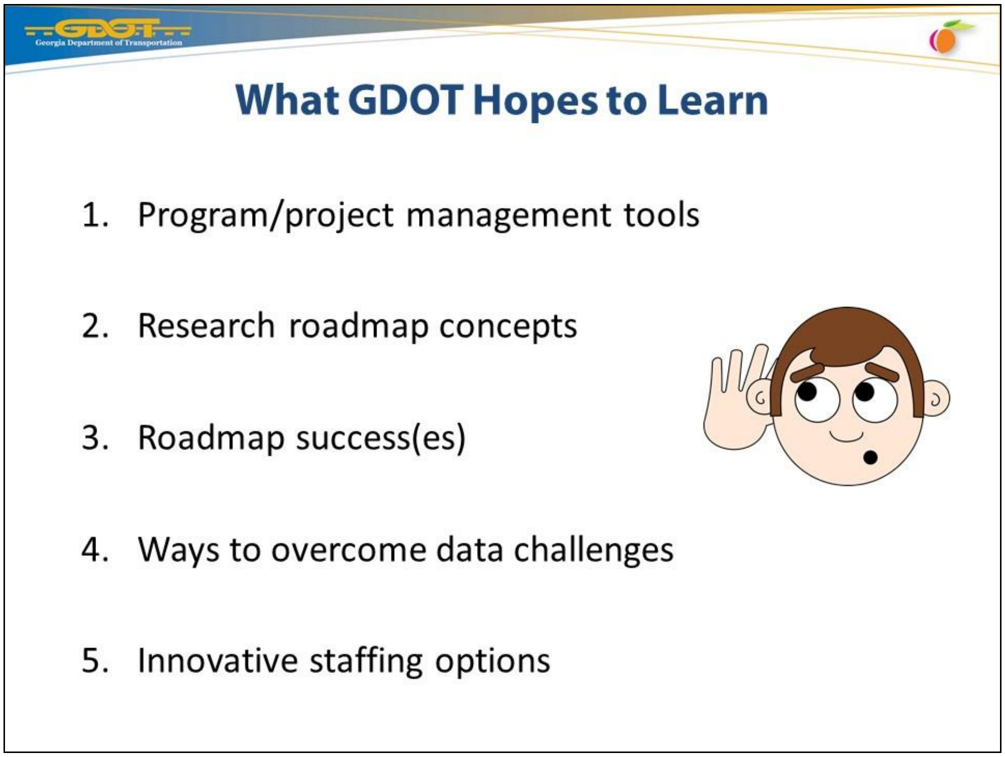

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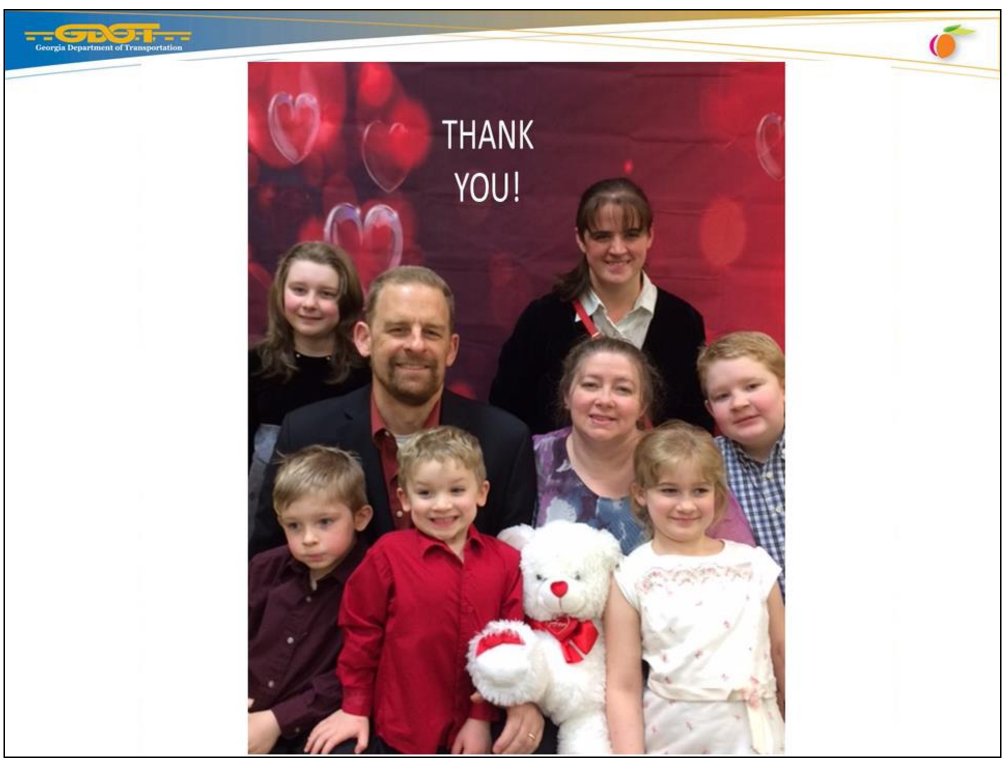


Joe Horton – California Department of Transportation

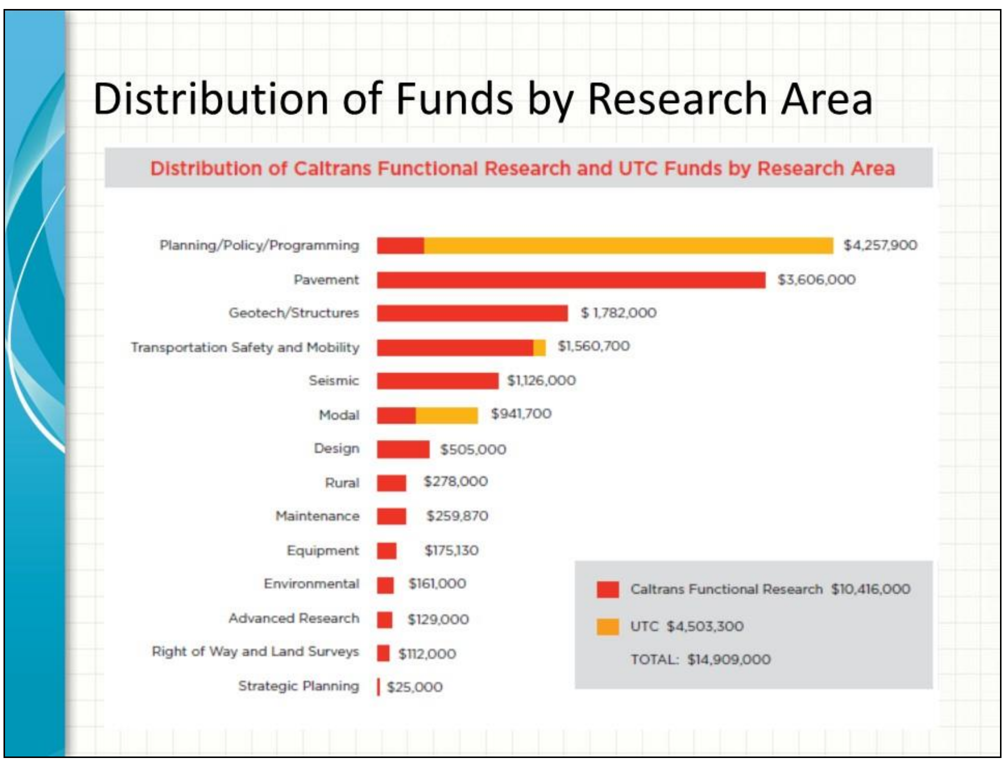
Slide 1

Slide 2

Horton, continued

Slide 3

Slide 4



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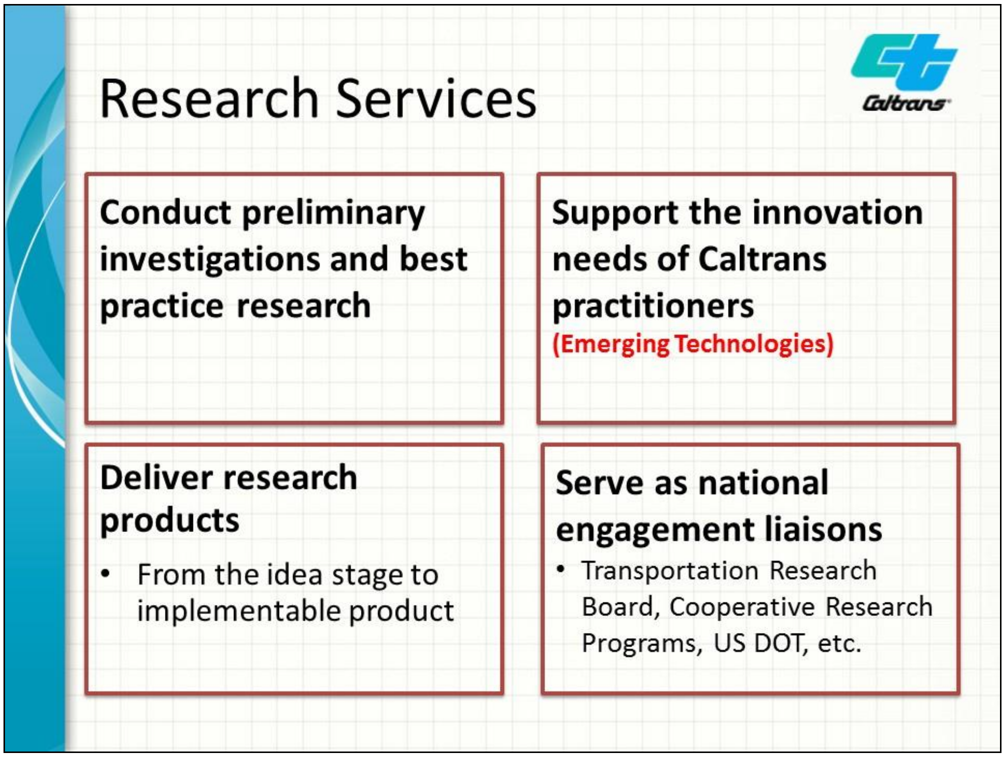

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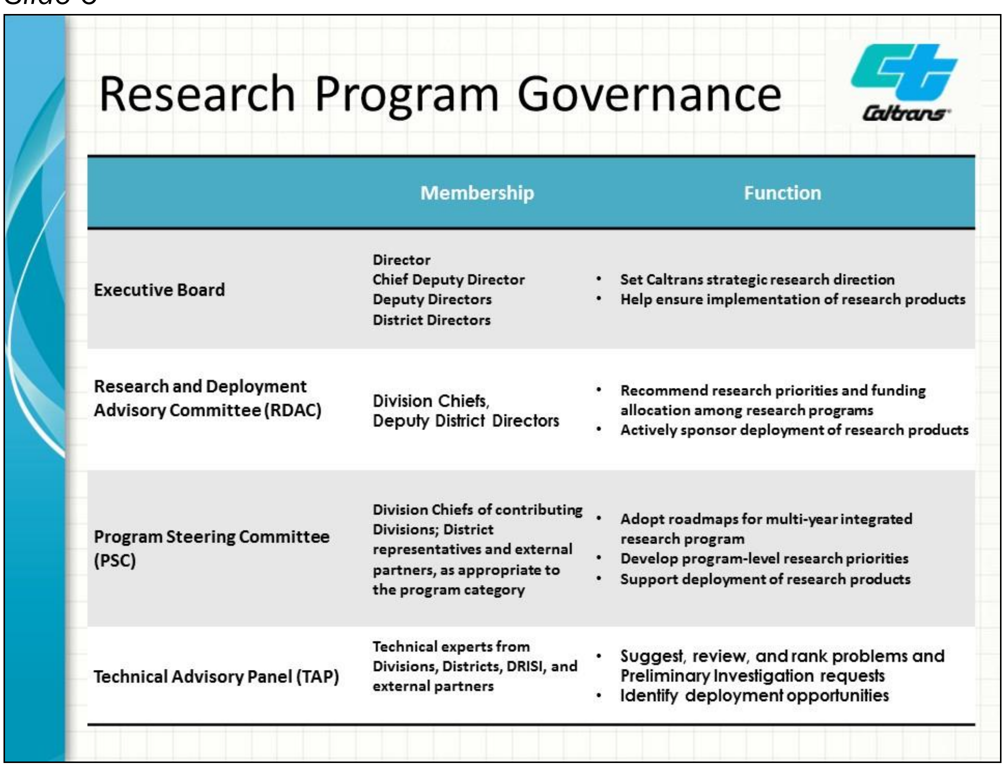

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Slide 7

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Horton, continued

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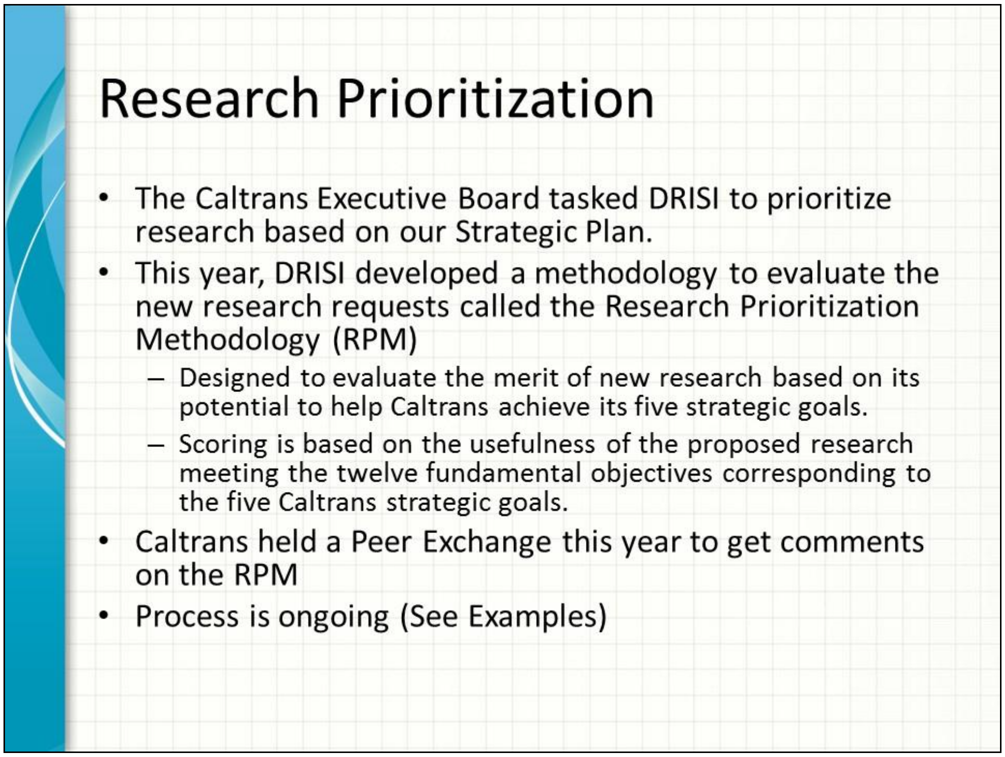

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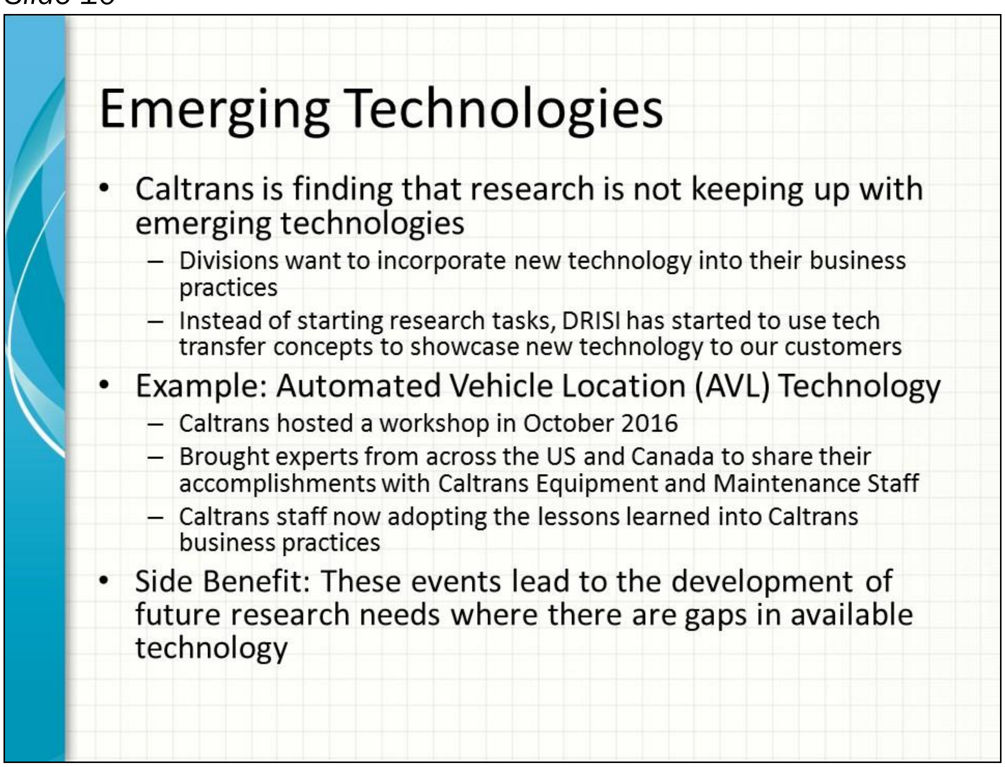

Horton, concluded

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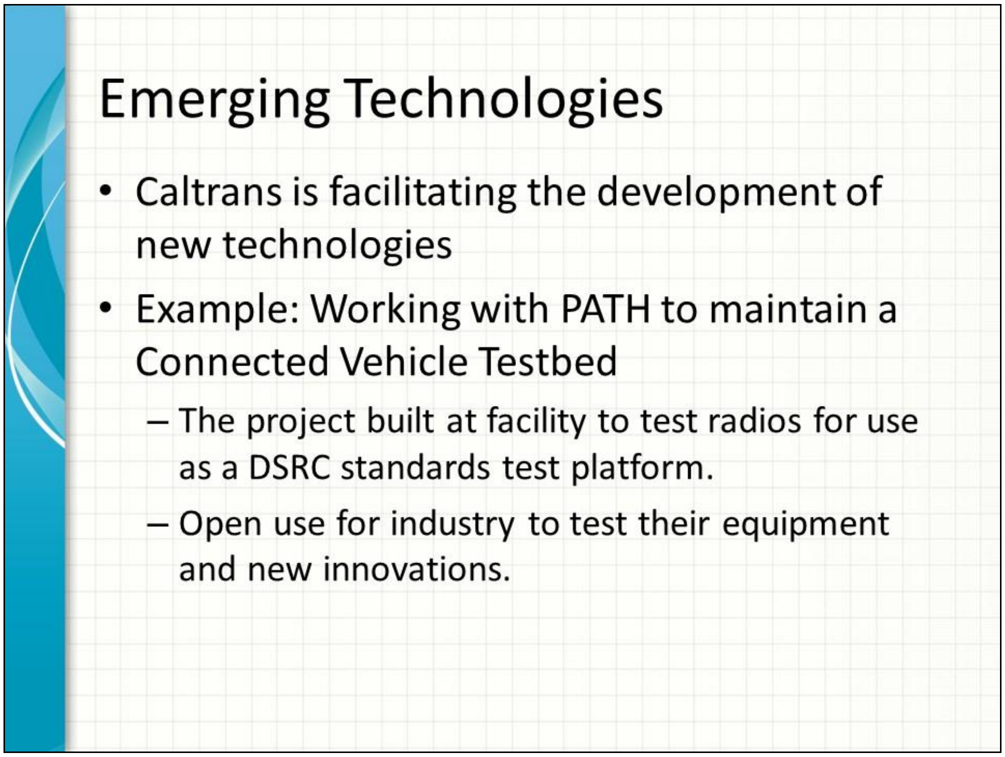

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Sue Sillick – Montana Department of Transportation

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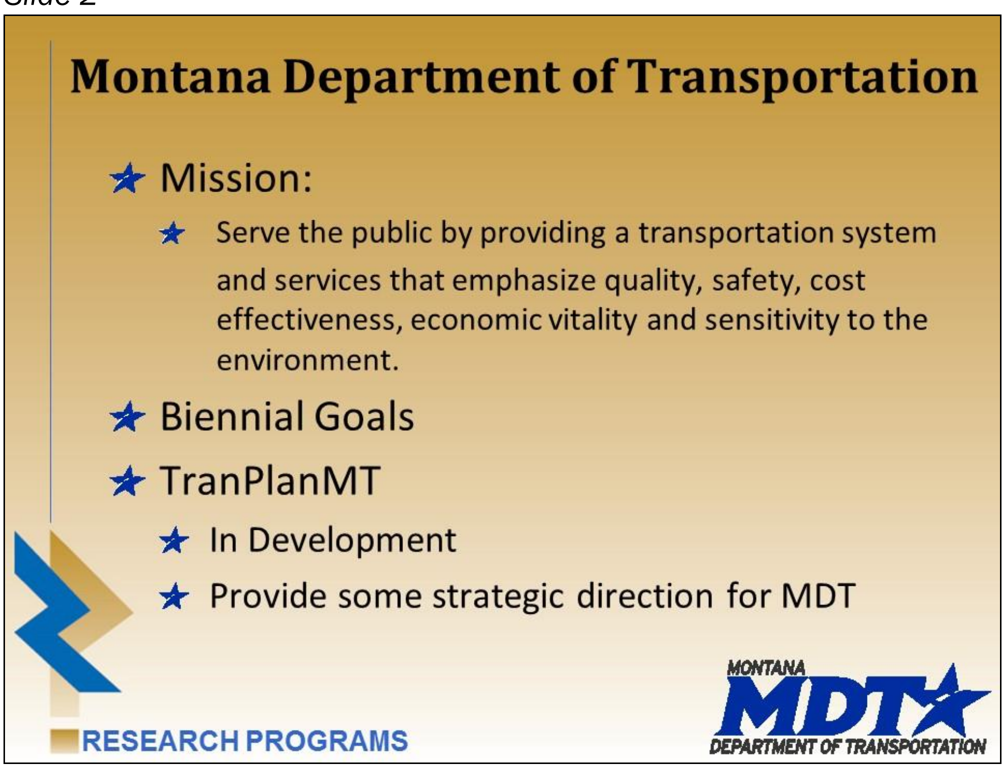
Slide 2



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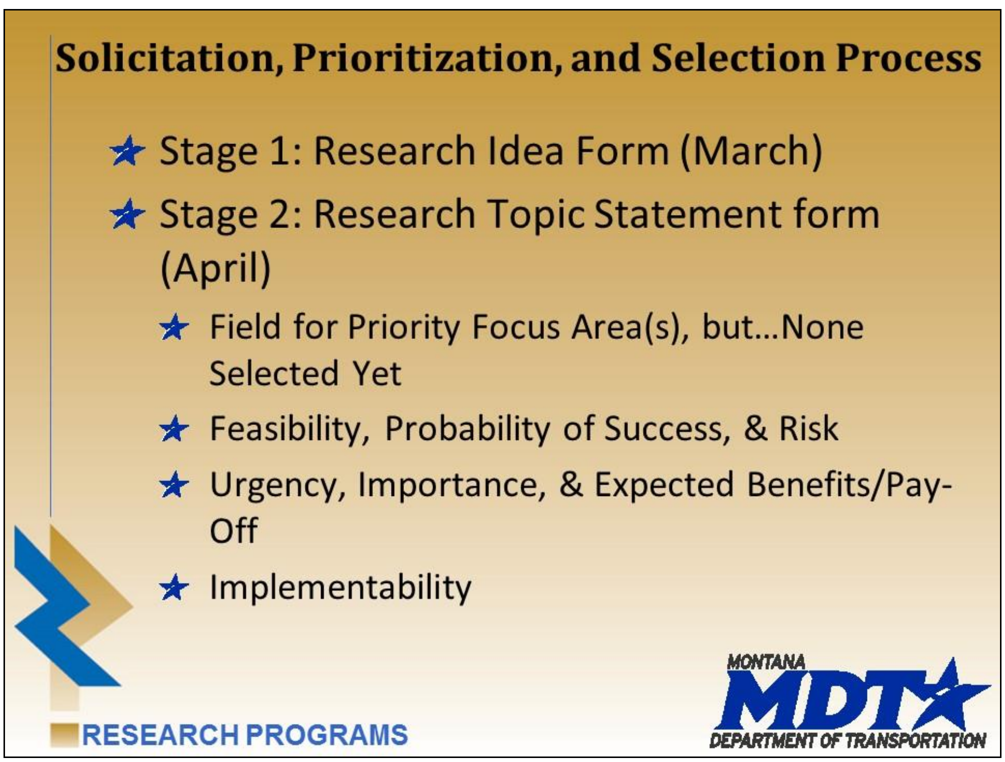

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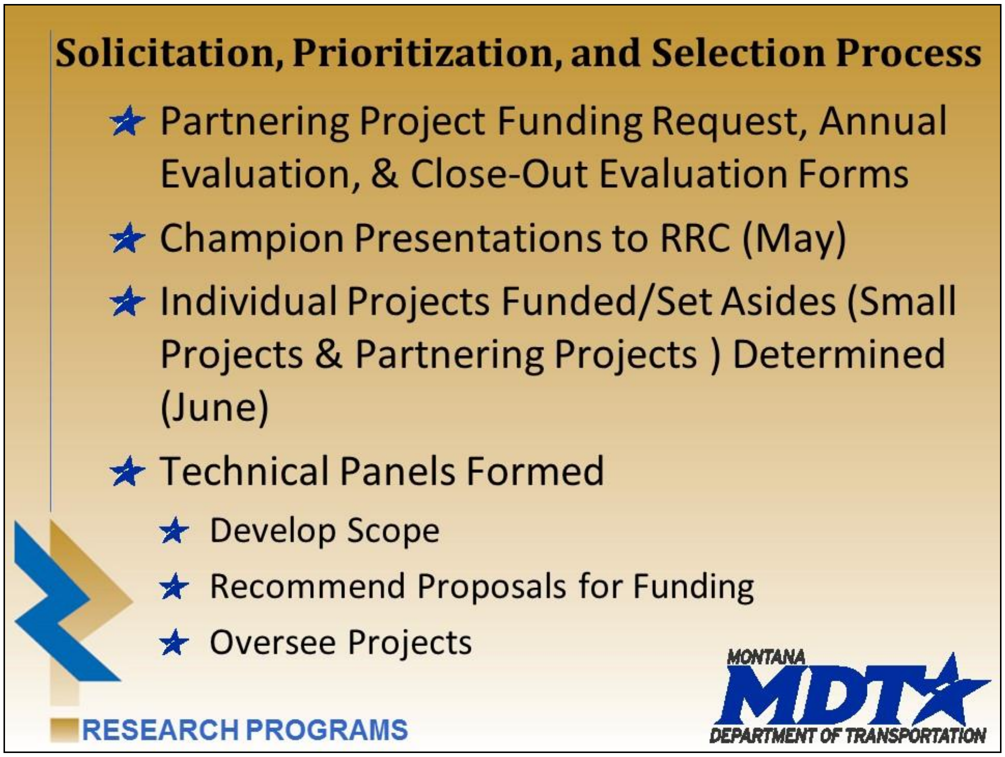

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Sillick, continued

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Sillick, continued

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Slide 10

Sillick, continued

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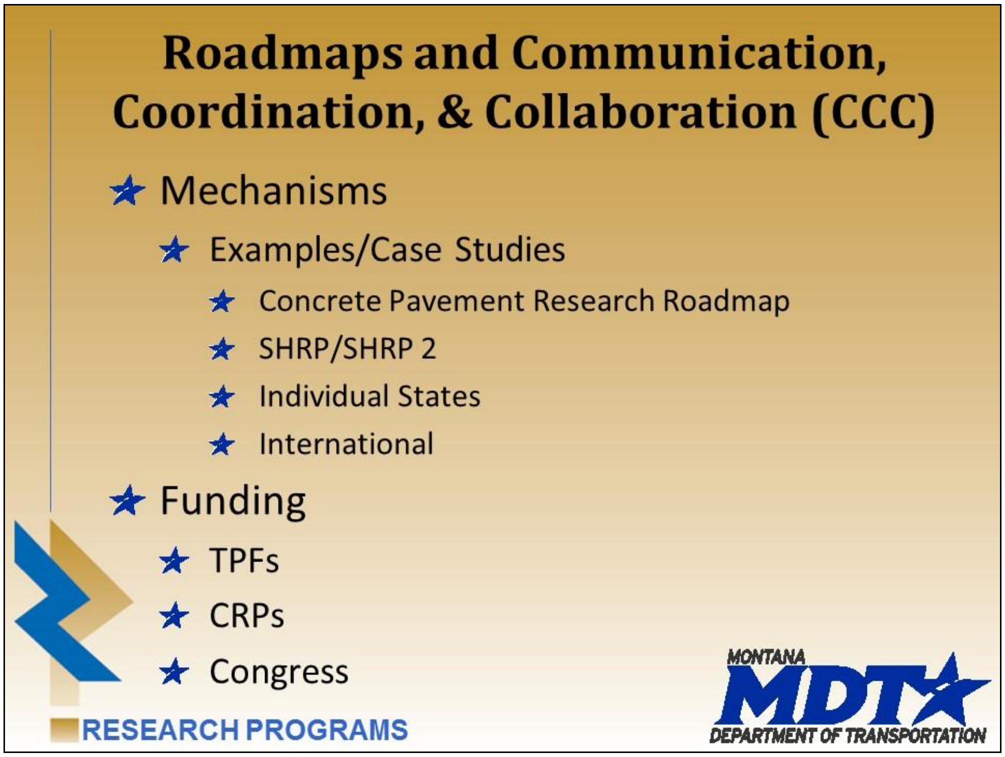


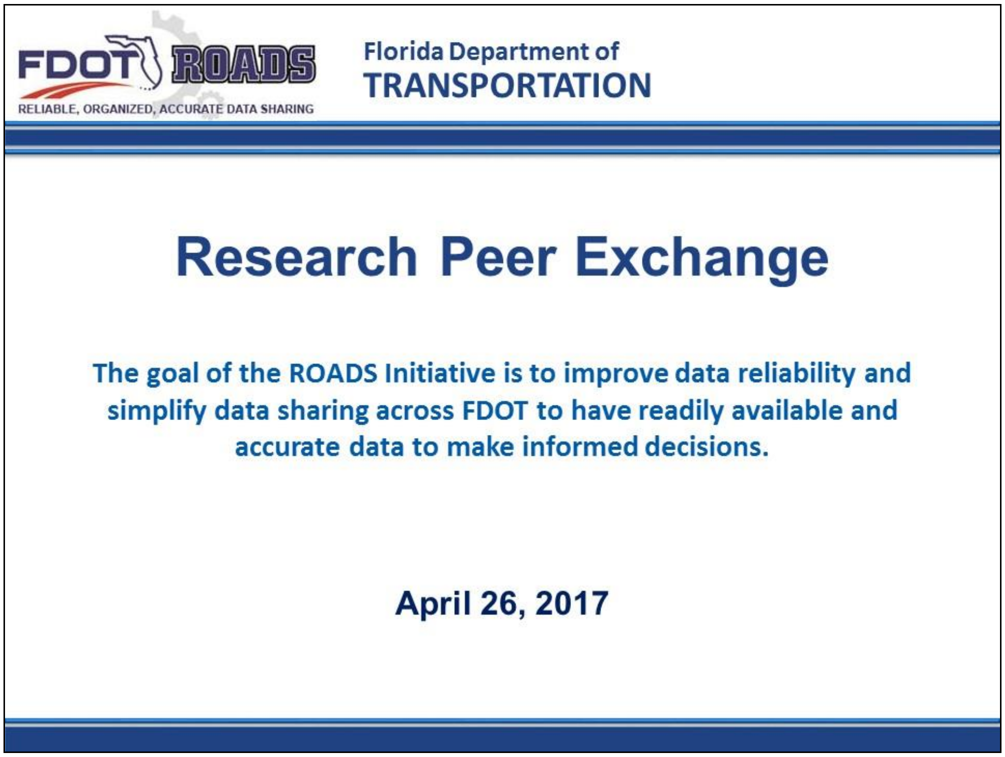
Slide 12

Sillick, concluded

Slide 13

April Blackburn – Florida Department of Transportation

Slide 1



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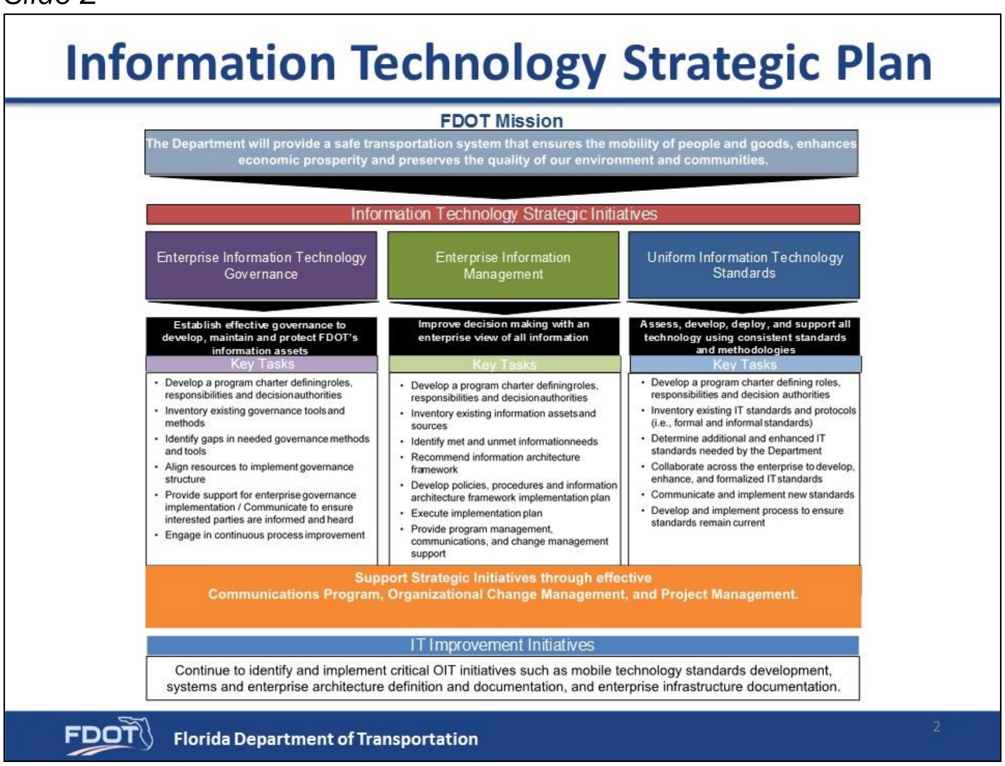

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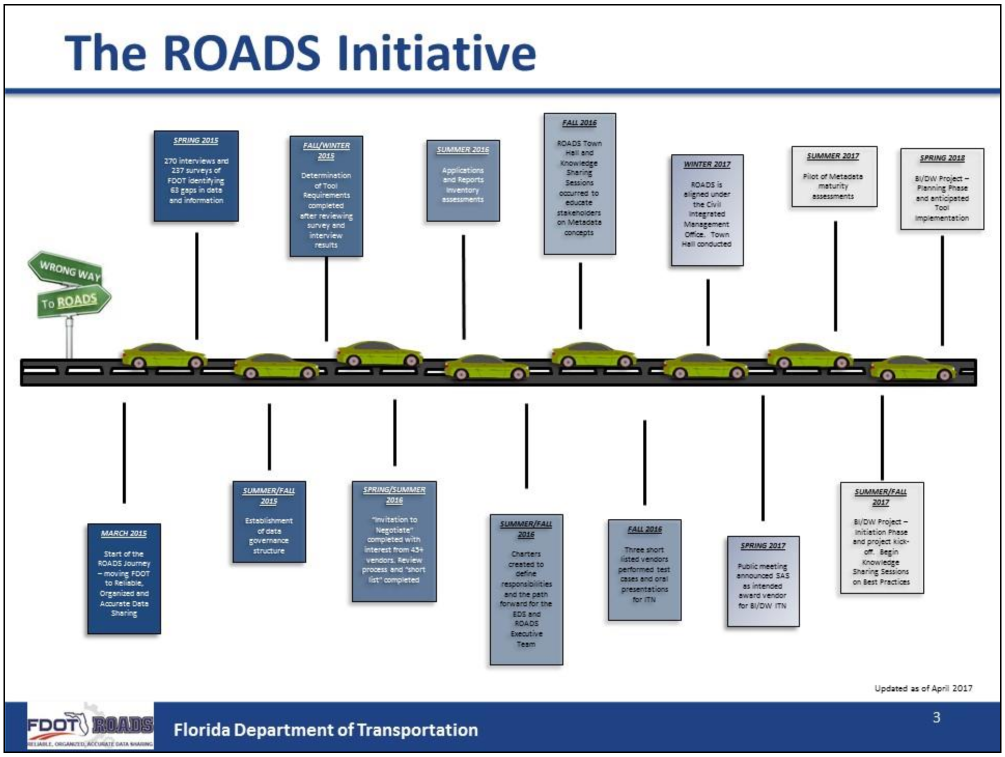

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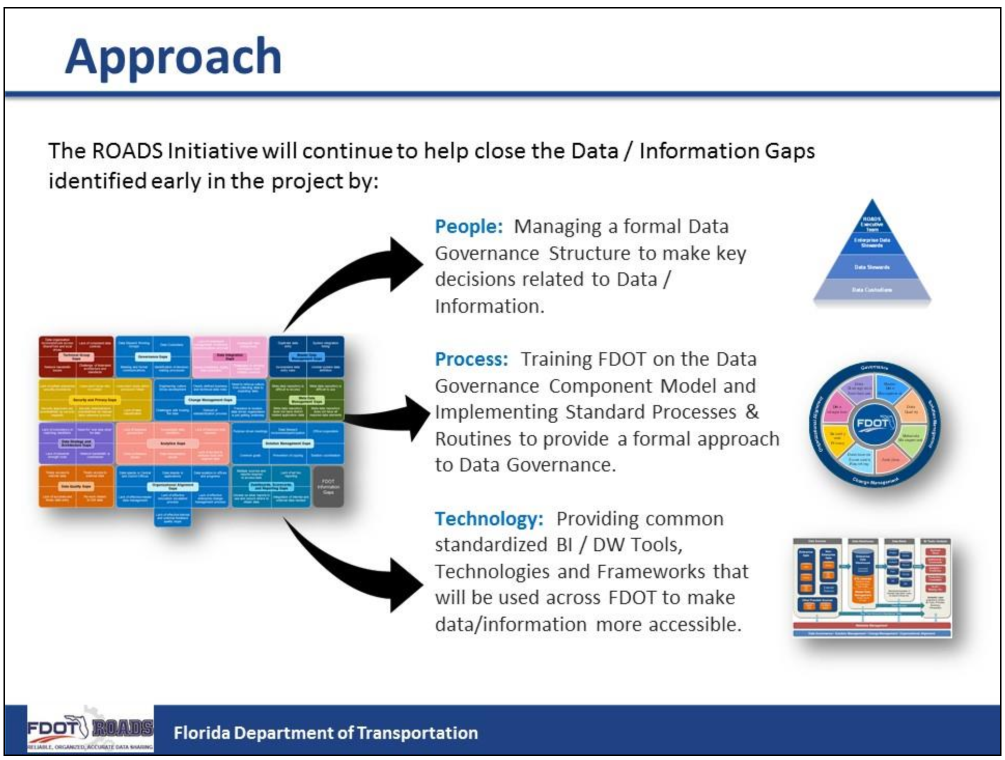

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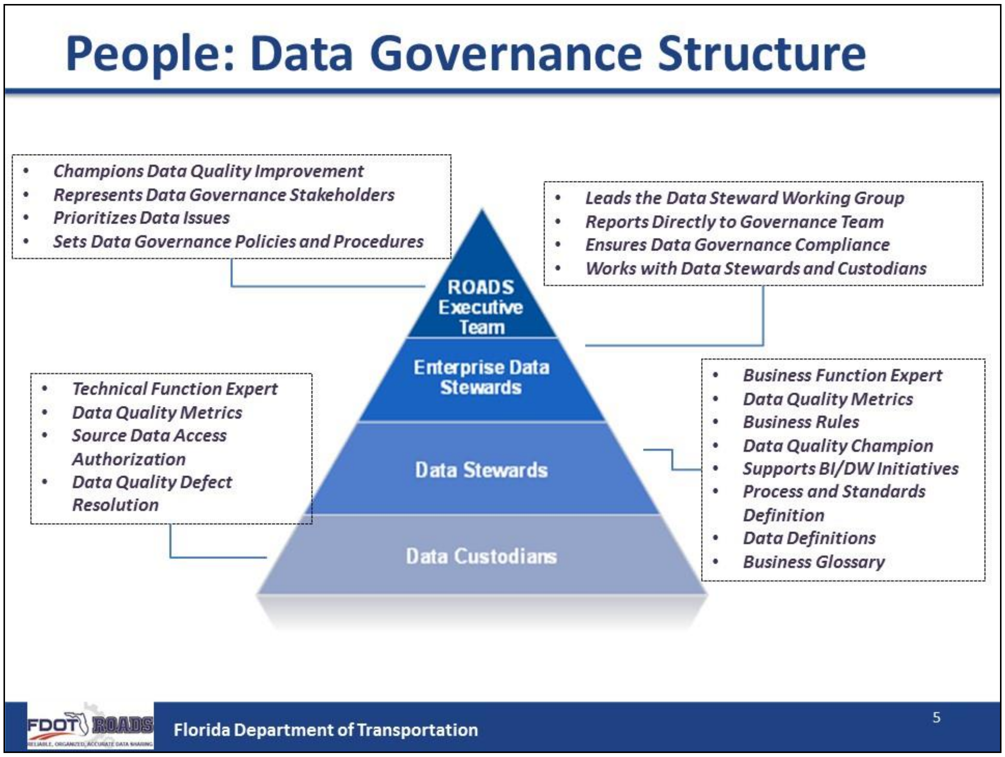

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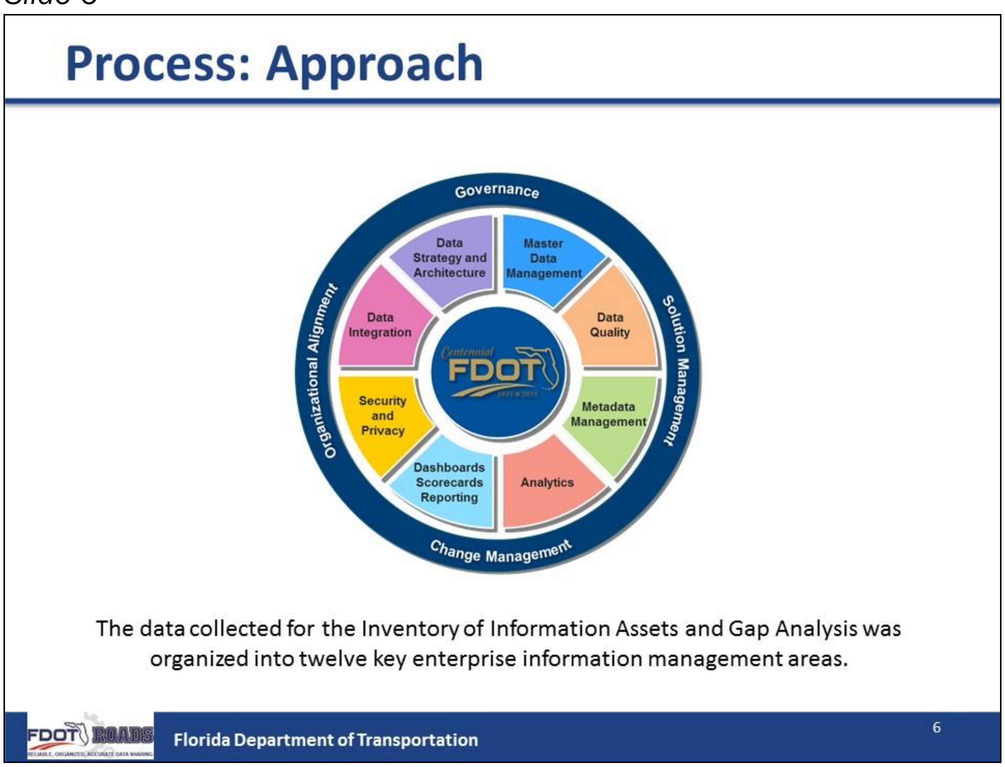

Blackburn, continued

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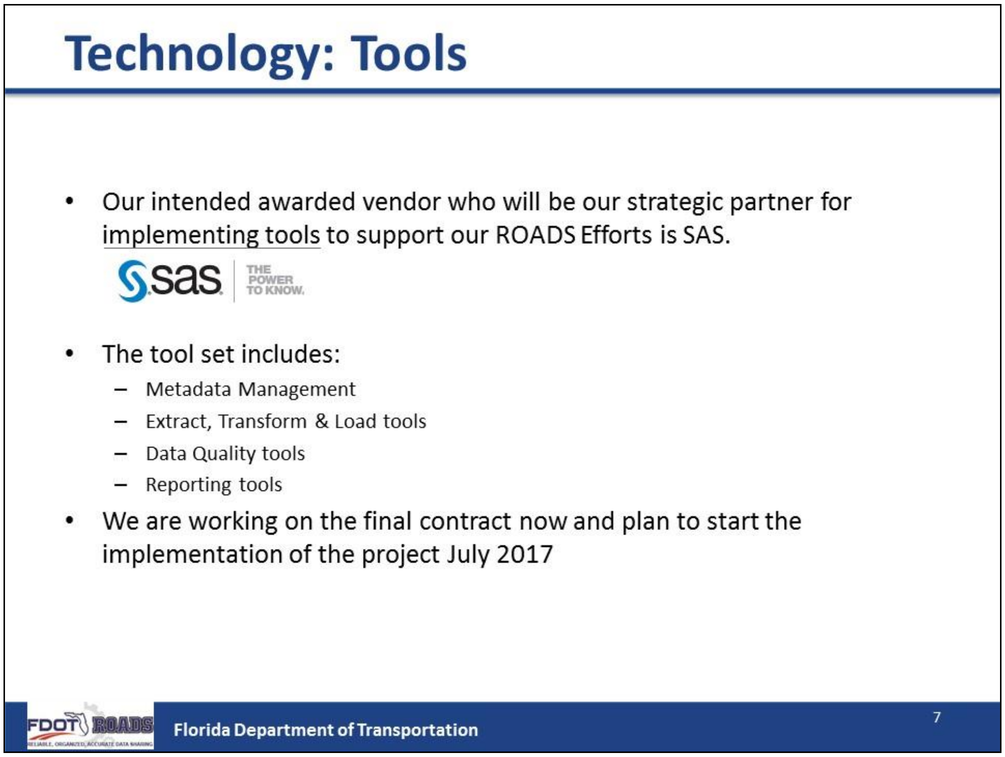

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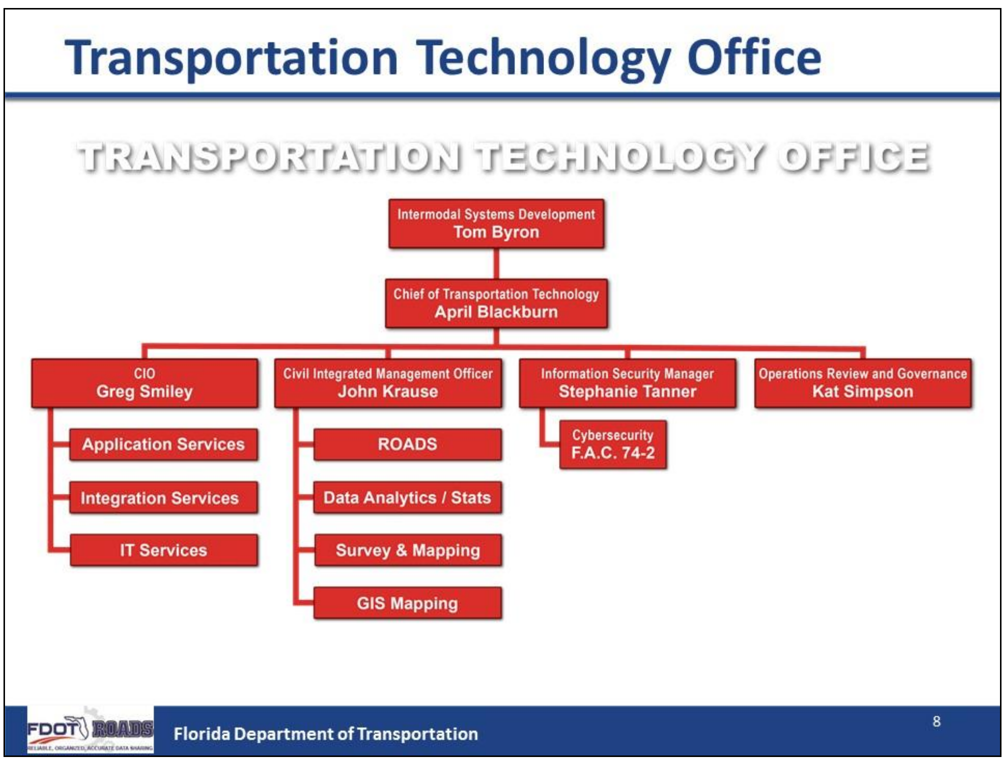

Blackburn, concluded

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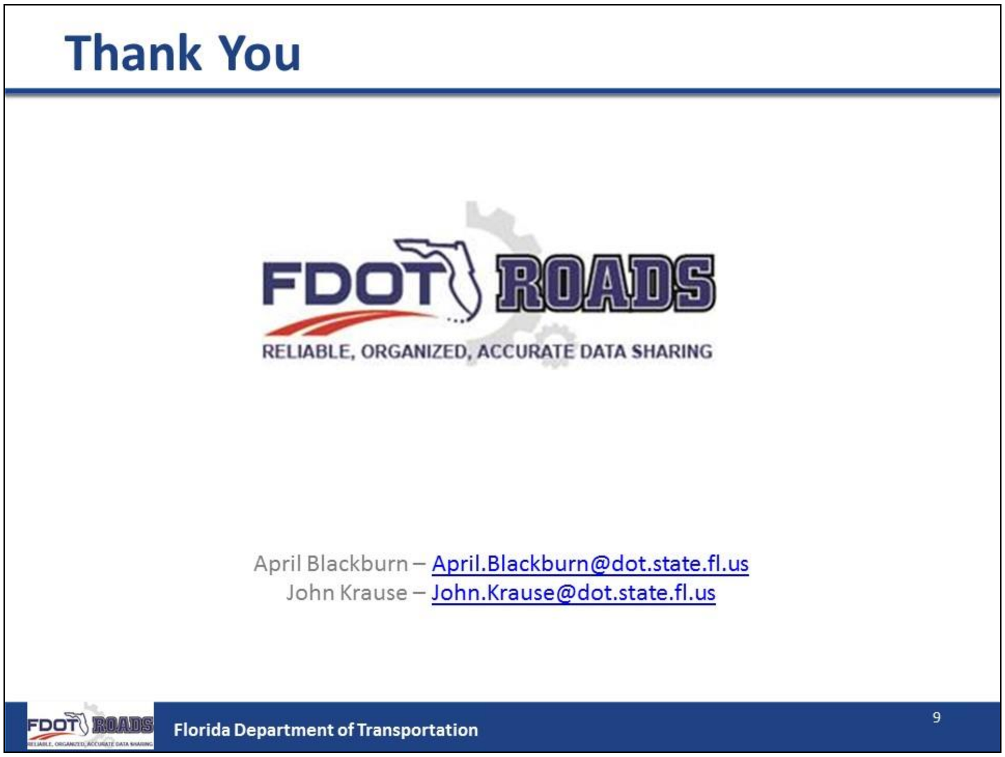
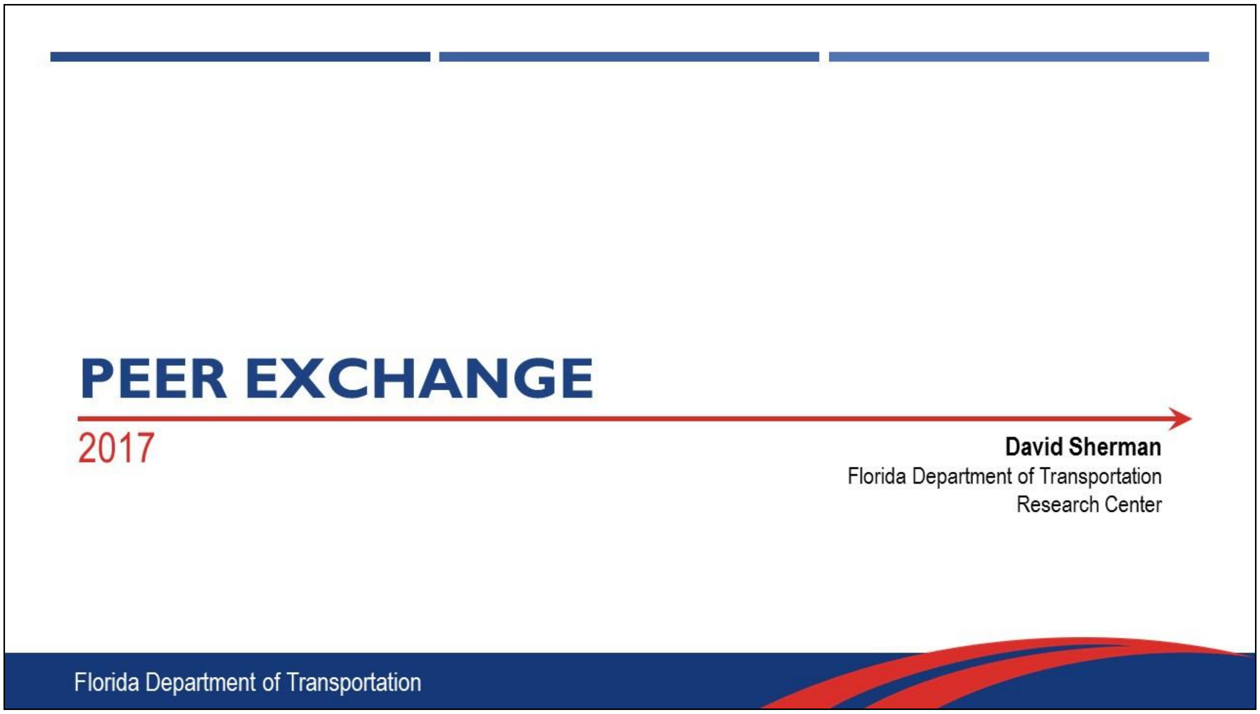


David Sherman – Florida Department of Transportation

Slide 1



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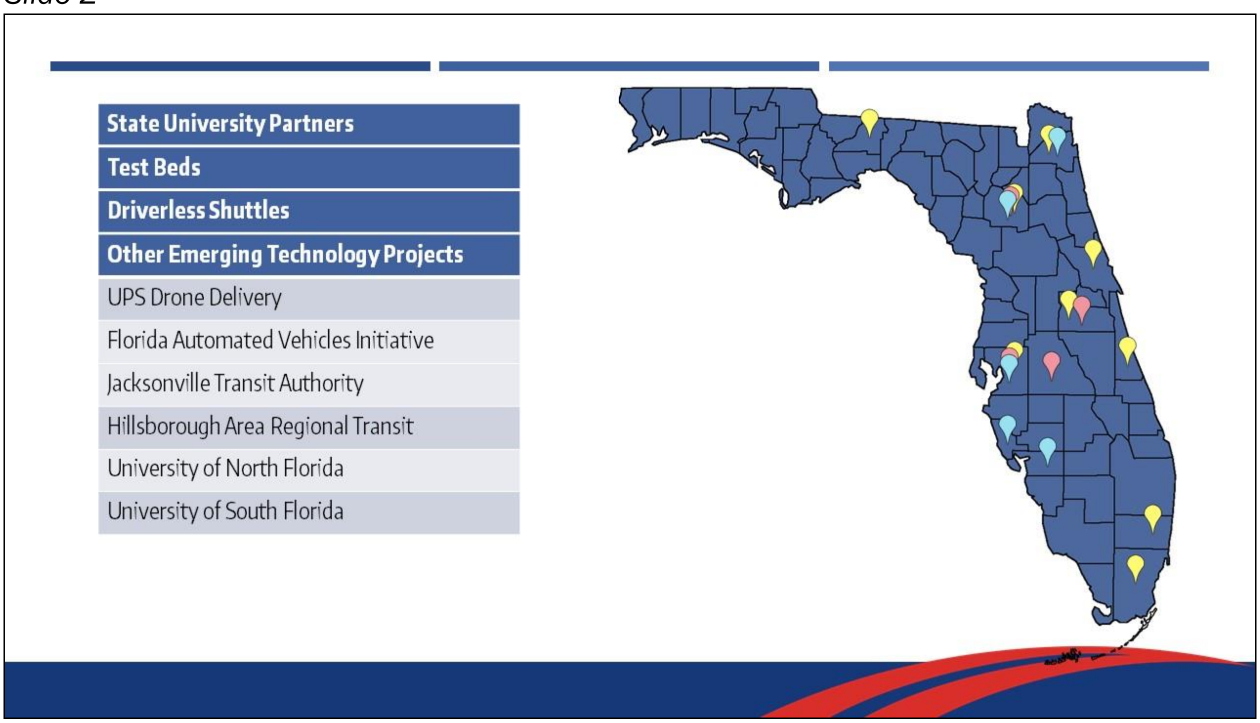

Sherman, concluded

Slide 3

Raj Ponnaluri – Florida Department of Transportation

Slide 1

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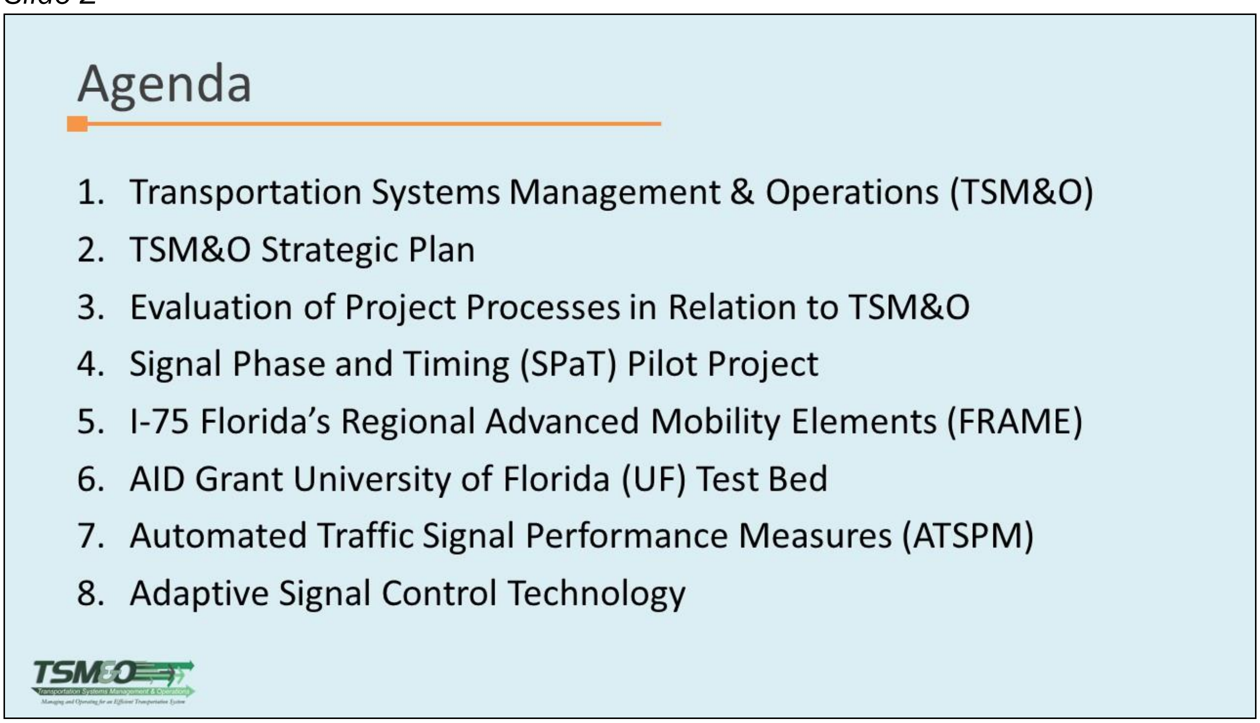


Ponnaluri, continued

Slide 3

Transportation Systems Management & Operations (TSM&O)

- TSM&O is the application of technology and communications to improve the management, operations, safety and efficiency of transportation systems.
- TSM&O involves coordination with various stakeholders ranging from all FDOT Offices to Local Metropolitan Planning Organizations and cuts across all modes of transportation.
- This program develops and applies transportation management and operations solutions that generally do not require major structural alterations of existing or planned roadways.

Slide 4

Strategic Plan

Executive Summary

I. Strategic Plan Development and Background

II. Challenges and Opportunities

III. TSM&O Snapshot – Where We Are Today

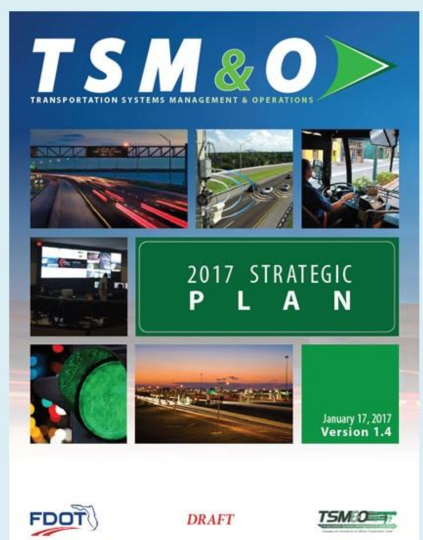
IV. TSM&O Mainstreaming

V. Vision, Mission, and Goals

VI. Roadmap to Achieving TSM&O Goals

VII. TSM&O Resources

VIII. Next Steps and Action Plans



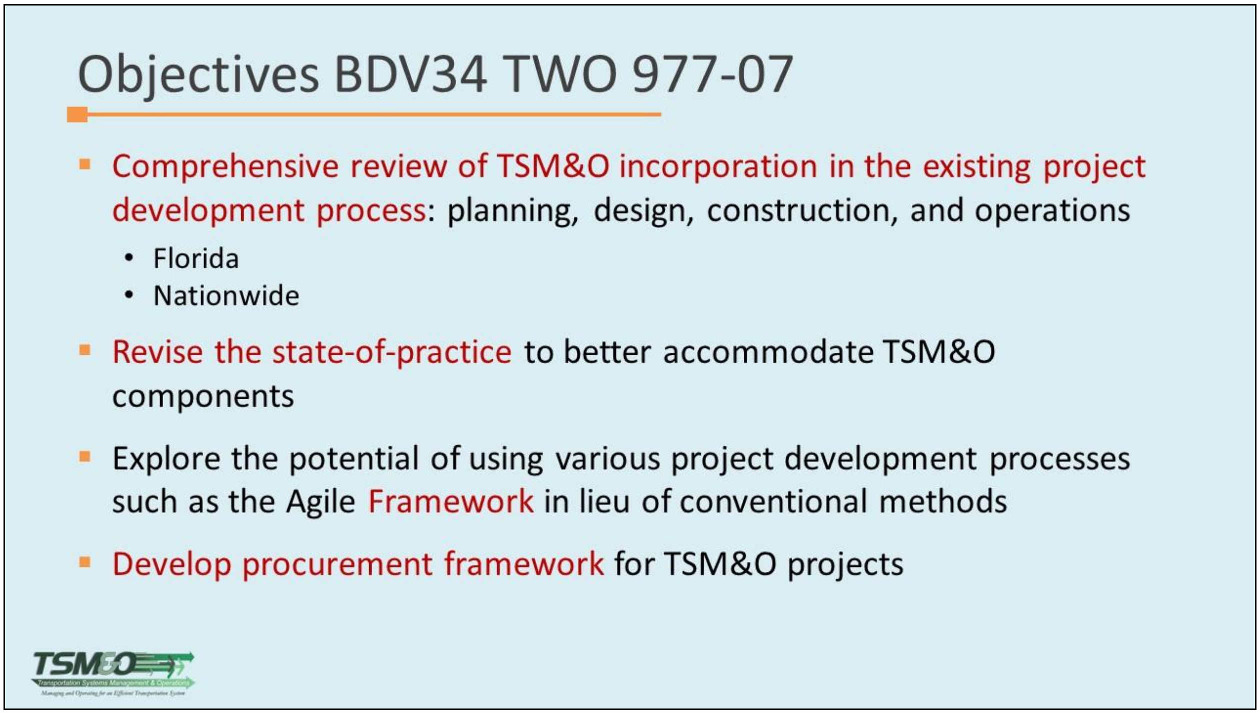
Ponnaluri, continued

Slide 5

Slide 6

Ponnaluri, continued

Slide 7



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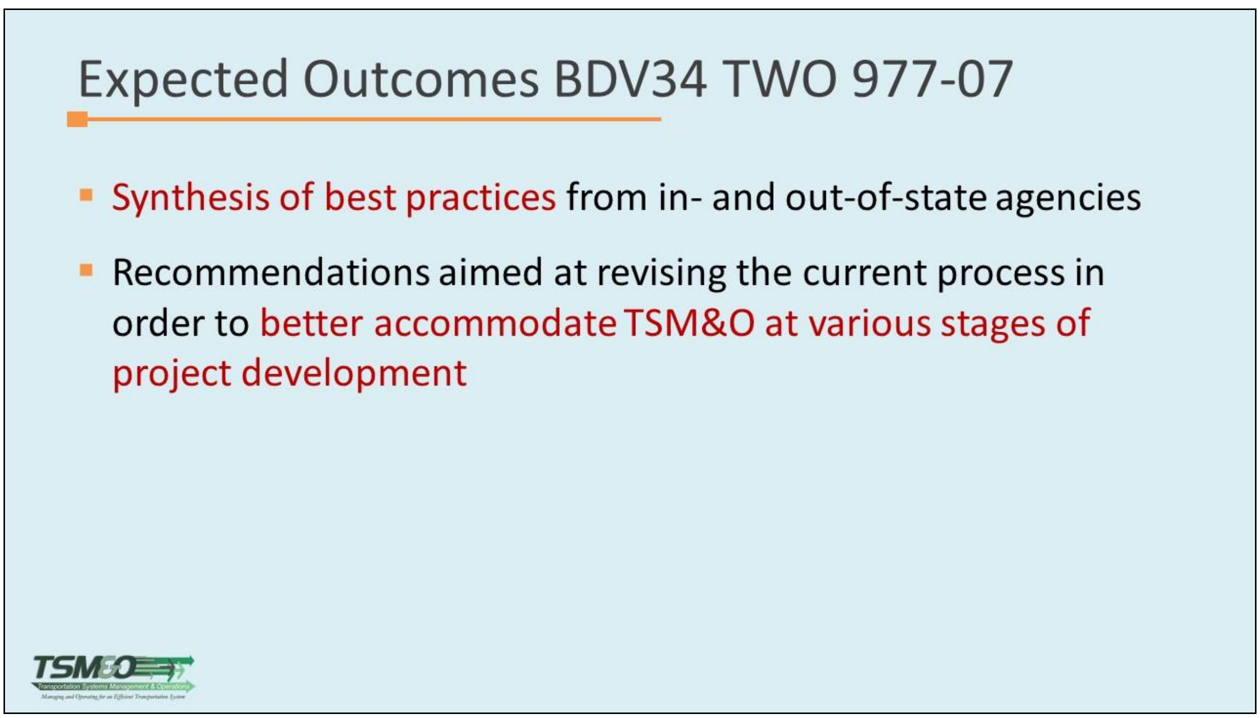

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Slide 9

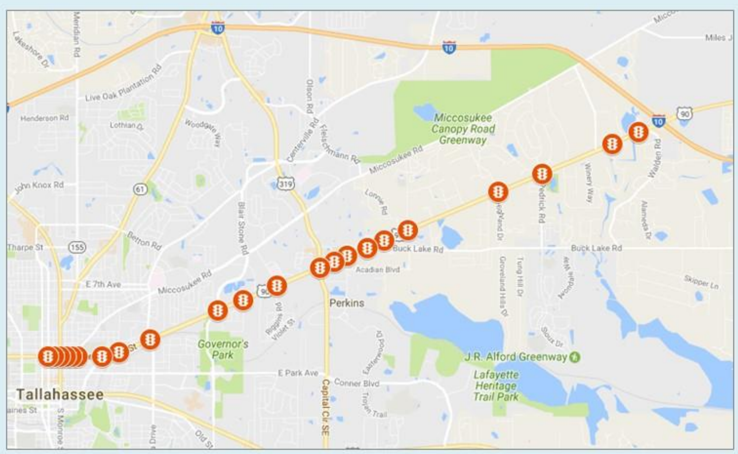
TSM&O Innovation

- Arterial Management
  - Advanced traffic signal performance measures – part of FHWA's Every Day Counts Program
  - Advanced signal control technology – pilot projects underway; before/after studies in progress
  - FHWA workshops planned – on Business Processes and Traffic Signal Action Plans
- Connected Vehicles
  - Signal Phase and Timing (SPaT) pilot project
  - I-75 Florida's Regional Advanced Mobility Elements (FRAME) project
  - University of Florida Test Bed

Slide 10

Signal Phase and Timing (SPaT) Pilot Project

- AASHTO Challenge
- 22 signalized intersections along US 90 (Mahan Drive) in Tallahassee
- FDOT and City of Tallahassee Partnership
  - City to install
- Pre-deployment testing at the Traffic Engineering Research Laboratory (TERL)
- RFP is advertised



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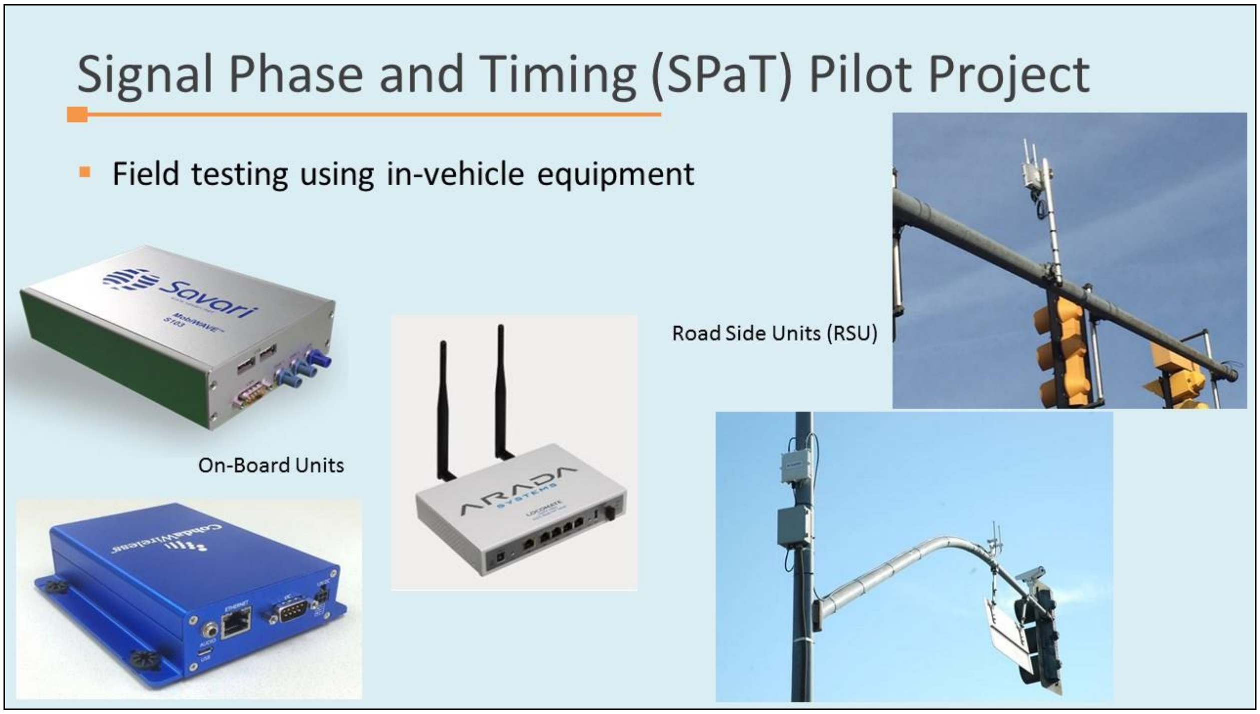

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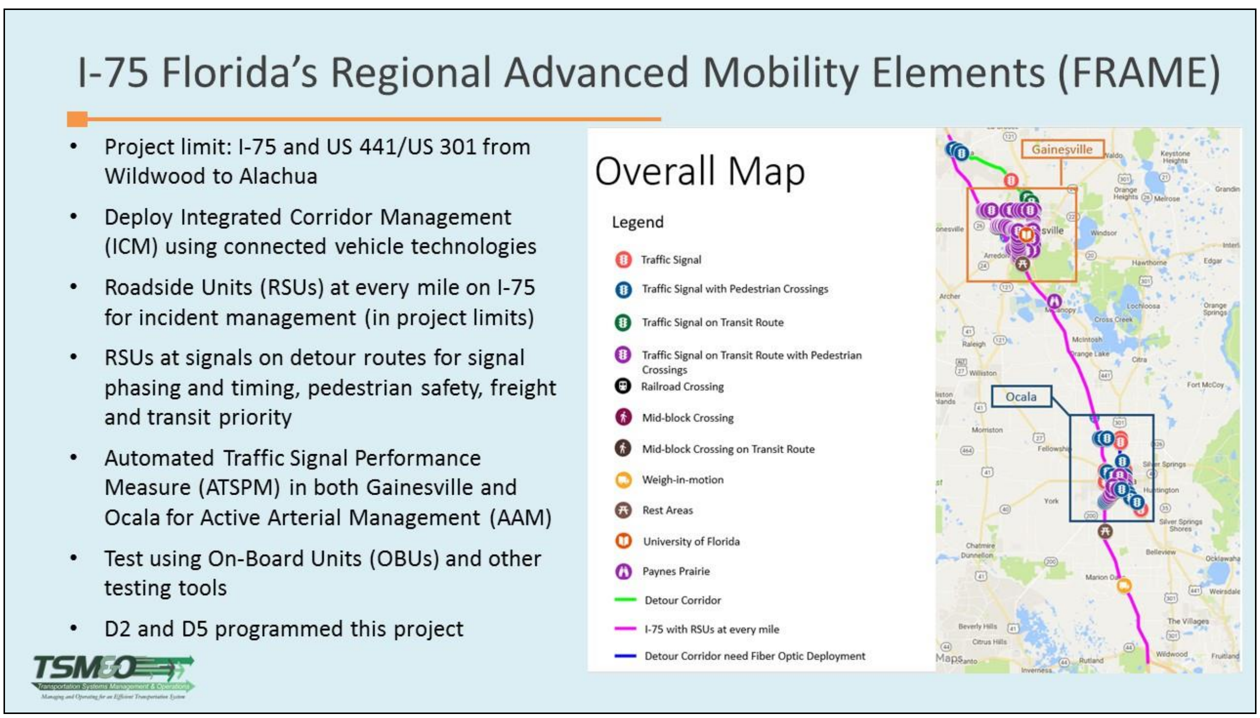

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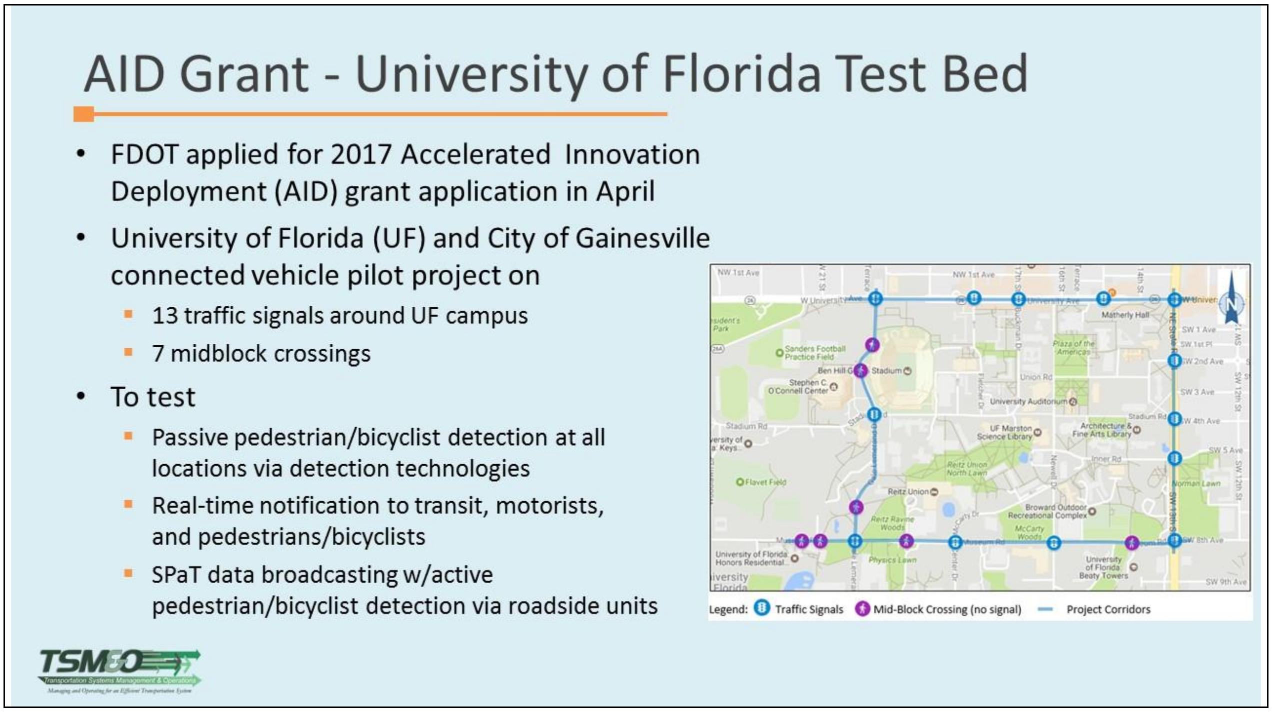

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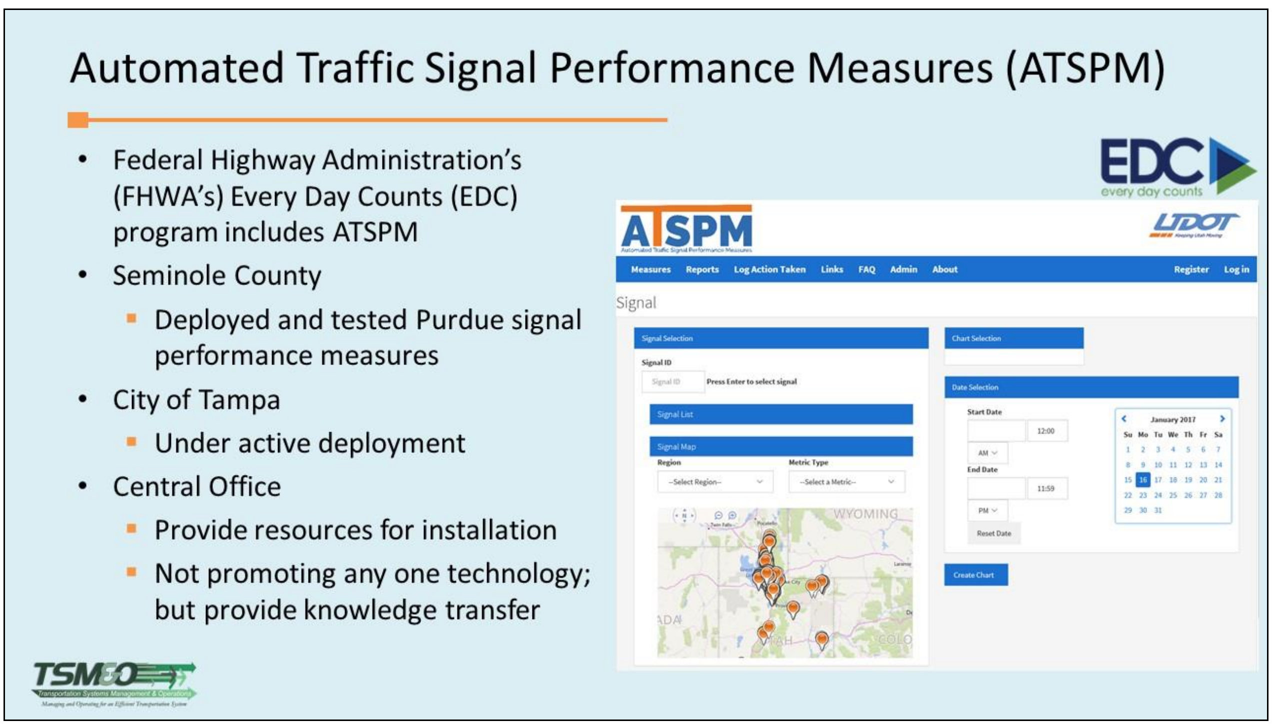


Ponnaluri, continued

Slide 15

FDOT Traffic Signal Performance Measures (TSPM) Study

- Final report published in 2/28/2017
- Report highlights
  - Benefits of TSPM
  - Challenges of TSPM
- Benefits
  - Enhanced system intelligence and remote signal monitoring
  - Travel time savings and reduction in delays
  - Public safety
  - Maintenance cost efficiencies
  - Additional verification of signal performance
  - Public information
  - Low-cost implementation

TSM&O Transportation Systems Management & Operations

Slide 16

Adaptive Signal Control Technology

- Advanced systems automatically adapt to changing traffic demands
- More responsive to unexpected incidents such as weather and traffic crashes
- More responsive to unscheduled events such as holiday traffic

Traffic Signal Controller - cabinet and hardware

Traffic Signal

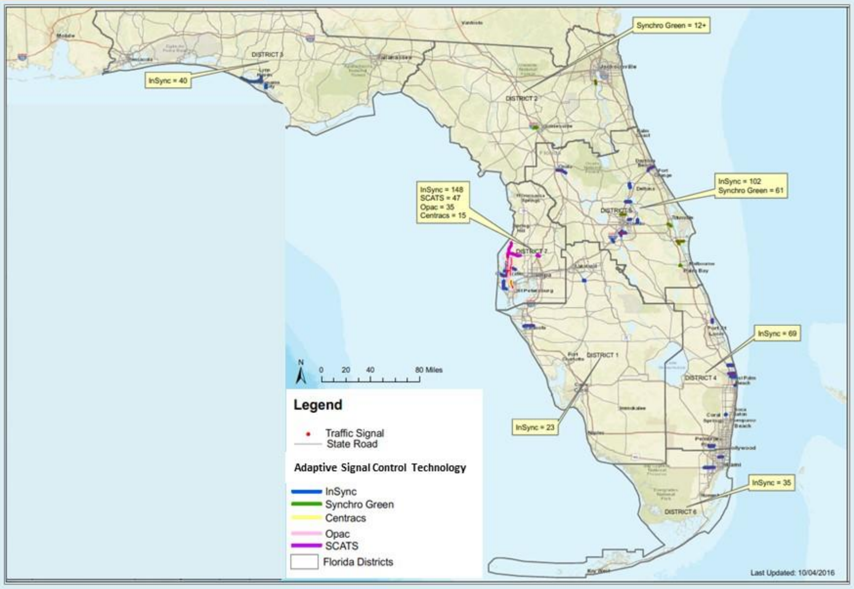
TSM&O Transportation Systems Management & Operations

Ponnaluri, continued

Slide 17

Adaptive Signal Control Technology

- Deploying pilot projects
- Before and after assessments by University of Florida
- Does not work everywhere
  - Low effectiveness on fully saturated corridors during peak periods
- Additional deployments planned on Strategic Intermodal System corridors



TSM&O Transportation Systems Management & Operations

Slide 18

STREET Challenge

- **STREET Vision:** To draw from the Department's vision and TSM&O Strategic Plan of pursuing innovation and deploying emerging technologies which focus on transportation safety and mobility.
- **STREET Mission:** To conceptualize, accelerate deployment, and evaluate emerging TSM&O technologies.
- **Wok Plan / Objectives:**
- Identify regional needs and pilot locations
- Identify deployment-ready connected vehicle and/or emerging technologies (CVET) consistent with the STREET vision
- Develop potential use cases and develop cost estimates
- Prepare a Request for Information (RFI) package to solicit CVET service providers and vendors

TSM&O Transportation Systems Management & Operations

Ponnaluri, continued

Slide 19

Work Plan

- **Wok Plan / Objectives:**
- Choose about 3 to 4 technologies for implementation, deployment, testing and evaluation
- Identify regions for deployment and seek matching funds from federal, state, and local agencies, if feasible from a process and time-perspective
- Select vendors and implement the technologies in the selected regions
- Deploy
- Field test and evaluate the implemented technologies
- Conduct before and after studies to gauge the benefits and deployment challenges
- Prepare documentation as *lessons learned* effort

Slide 20

Potential CVET Applications

- Bike-Ped detection and/or safety including priority phasing for pedestrians (Ped-Sig)
- Pedestrian Alert Systems – alert vehicles when pedestrians are in a crosswalk (Ped-X)
- Forward Collision Warning (FCW) to warn drivers of an impending collision
- Intelligent Traffic Signal (I-SIG) for optimizing traffic flows though signal timing adjustments
- Vehicle Data for Traffic Operations (VDTO) – use Automated Traffic Signal Performance Measures
- Signal Phase and Timing (SPaT) deployment enhancements
- Basic Safety and Info messages for vehicle to infrastructure (V2I) support to industry
- Use of Unmanned Aerial System (UAS) in Traffic Engineering
- Grade Crossing Notification System (GCNS) at highway-rail grade crossings
- Traffic Signal Central System Software (CSS)
- Data Analytics and Decision Support Systems (DSS)

Ponnaluri, concluded

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