AGENDA

- I. Phase I Summary
  - a) Review of Phase I: Stuart Anderson
  - b) Plan for Phase II, Task 6: Stuart Anderson
- II. Task 6: White Paper Visions
  - a) Methodology for Developing the White Paper Visions: Stuart Anderson
  - b) Baseline Scenario: Peter Bishop
  - c) Summary of Context Scenarios: Peter Bishop
  - d) Common Themes and Implications: Peter Bishop
  - e) White Papers (next page)

AGENDA

- White Papers
  - Traffic Services – Ginger Goodin
  - Pavement & Materials – David Newcomb
  - Construction – Stuart Anderson
  - Transportation Structures – John Mander
  - Roadside and Drainage – Beverly Storey
  - Connectivity – Ginger Goodin

AGENDA

- III. Task 7
  a) Workshop: Strategy Development: Stuart Anderson/Peter Bishop
  b) Example of Transferring the Visions into Strategies and Ultimately to Guidance
     - Pavement & Materials – David Newcomb
     - Construction – Stuart Anderson
  c) Path Forward: Assessing White Paper Visions: Stuart Anderson

AGENDA

- IV. Task 8
  a) Preparing the Phase II Interim Report
- V. Schedule
  a) Milestones and Schedule to Complete the Project
- VI. Discussion

Project Summary

- Problem Statement
  - The transportation industry will continually face emerging and new challenges that may influence transportation priorities and needs, particularly with regard to the preservation, maintenance, and renewal of the highway infrastructure.
- Objectives
  - Develop guidance for transportation stakeholders for using emerging materials, tools, approaches, and technologies that could be used to deal with long-range (30 to 50 years) highway infrastructure maintenance, preservation, and renewal needs and ensure satisfactory system condition and performance.

Project Summary

- Four phases
  - PHASE I – Scenarios and Impacts
  - PHASE II – Vision Development
  - PHASE III – Guidance and Communication
  - PHASE IV - Deliverables

❑ PHASE I SUMMARY

a) Review of Phase I: Stuart Anderson

b) Plan for Phase II, Task 6: Stuart Anderson

Review of Phase I

- Objective
  - Identified future factors and trends that could significantly influence infrastructure maintenance, preservation, and renewal.
  - Assessed the likelihood and impact of various scenarios on future needs.

Review of Phase I

- 13 technical areas

1) Technology and innovations
2) the environment
3) system performance
4) security
5) natural-resource availability
6) finance and budget
7) human resources
8) coordination
9) regulations and policies
10) demographics
11) customer needs and expectations
12) traffic
13) safety

Review of Phase I

- Methodology
  - Future Studies aka Future Forecasting
    - Futures studies is an interdisciplinary field, studying yesterday's and today's changes, and aggregating and analyzing both lay and professional perspectives and strategies with respect to the world of tomorrow. It includes analyzing the sources, patterns, and causes of change and stability in an attempt to to map plausible futures and ultimately influence change toward a more preferable future.
  - Futurist
    - One who uses evidence and imagination to describe alternative plausible futures and assist others to envision and work toward their preferred future.

Some other definitions you may want to use

- "Futurists are those who survey and explore the full range of plausible futures…The key underlying principle is that the future is actually a set of futures from which a subsequent present will be drawn

- "[Futures Studies includes] two major divisions: (1) mapping the changes in the world and (2) influencing those changes toward a more preferable future.

- "The two forms are inter-related. Forecasting helps one understand the future and discover options about how to best navigate it, and planning helps one identify their preferred future option, develop plans for realizing it, and bringing it about through action ."

--*Teaching about the Future,* Peter Bishop & Andy Hines, Palgrave Macmillan, 2010.

Review of Phase I

- Methodology
  - Forecasting Methods
    - Many different methods available
    - Methods used in this research
      - Trend analysis
      - Cross impact analysis
      - Statistics, including factor analysis
      - Scenario development
      - Futures workshops

Step 1 – Drivers of Change (Interim Report:65

- Climate Change
- Economic Growth
- Priority on Environmental Quality
- Funding
  - Amount
  - Proportion Private
- Government Role
  - Large/small (attitudes toward regulation and tax)
  - Federal/State/Local
- Mobility
  - Demand (need to work, shop)
  - Capacity/access
  - Expectation for mobility
- Population Density
- Transportation Choices/ Complexity
- Public Commitment to Sustainability
- Resources/Energy Supply (supply + tax = price)
  - Supply
  - Demand (global)
  - Gas or Carbon Tax
  - Price
- Road Freight (amount, proportion)
- Security
- Technological Innovation
  - Physical, fixed
  - Information Technology

Step 2 – Future Driver Behavior (IR:67)

Driver	Trend rate, expectation	Alternative	Rationale
Climate change	Some, slow	Abrupt climate change Cooling Geoengineering Carbon sequestration, extraction	Arctic methane Sunspots
Economic growth	Some, slow	Flat to decline Dollar collapse, no longer reserve currency Re-growth	Global competition Protectionism US debt Bio/nano-tech industries Higher transportation costs
Funding Amount	Less, fast, per unit More, slow, total Near-term peak	Up, slow Up, fast	Better economy Political pressure from transport User fees (public acceptance, Interstate tolling, technology) Natural disaster Gas tax

Step 3 – Baseline Scenario (IR:71; Task 6 Rep:30)

1. Sohat **more demand for mobility** based on growing population and economic activity
2. On the other hand, **flat or slightly less funding for transportation** based on the fuel tax due to somewhat lower VMT per capita due to
   - Higher fuel prices
   - More use of public transit
   - More efficient vehicles
   - Less driving by the younger generation
   - More natural gas vehicles being fueled at home
3. As a result,
   - A higher proportion of funding for maintenance and less if any funding for new capacity
   - A higher proportion of funding for new capacity from the private sector along with a sharp increase in toll roads
   - Somewhat more congestion leading to even less VMT due to flex days, telecommuting and bundling trips
   - Less emphasis on rural highways relative to urban ones
   - Eventually even higher population density closer to work and retail, reducing VMT even further

Step 3 – Baseline Scenario (cont'd)

4. **Much higher use of information technology** in both vehicles and infrastructure, increasing safety and flow at the same time

5. **Less opportunity to expand rights of way** in urban areas meaning the use of existing right of way for a more complex mixture of transportation modes—free, HOV, HOT, and toll lanes along with rail, bus, and bicycle lanes

6. **Increasing environmental concerns** requiring less waste and lower energy construction and maintenance practices

7. **More severe weather**, including extreme temperatures, storms and drought, increasing the deterioration of roadways; more highways underwater in low lying areas requiring more protection from more frequent and severe storms

8. **More freight** due to larger population and more economic activity leading to increased wear on the roadways

Step 4 – Cross-Impact Matrix (IR:87)

Requirement – Better support for scenario selection

Approach – Cluster drivers using factor analysis

Cause (Driver)	Effect					
	1*	2	3	4	5	6
1. Climate change		–	+			+
2. Economic growth	+		–	+	+	
3. Priority on environmental quality	–	–		–		+
4. Funding—amount		+				
5. Funding—proportion private				+		–
6. Government role—large/small	–	–		+	–	

Step 5 – Correlation Matrix (IR:92)

Treating the matrix as a data set with 18 variables in the columns and 18 'subjects' in the rows.

	1	2	3	4	5	6
1. Climate change	1.00	0.32	–0.48	0.00	0.50	–0.17
2. Economic growth	0.32	1.00	–0.37	–0.16	0.00	–0.52
3. Priority on environmental quality	–0.48	–0.37	1.00	–0.19	–0.32	0.04
4. Funding—amount	0.00	–0.16	–0.19	1.00	–0.32	–0.04
5. Funding—proportion private	0.50	0.00	–0.32	–0.32	1.00	0.33
6. Government role—large/small	–0.17	–0.52	0.04	–0.04	0.33	1.00

Step 6 – Factor Analysis (IR:94)

Cluster the drivers
from the correlation matrix
into a suitable number of factors.

	F1	F2	F3
Proportion of variance	27%	15%	10%
Cumulative proportion of variance	27%	42%	52%
High	Climate change Economic growth Mobility—demand Mobility—capacity and access Resources/energy—supply Resources/energy—demand Road freight Technology—physical and fixed Technology—IT Transportation choices/complexity	Funding—amount Resources/energy—gas or carbon tax Security Technology—physical and fixed	Government role Resources/energy—price Technology—IT

Step 7 – Scenarios (IR:100)

Name the factors based on the drivers that loaded on each factor.

Scenario	Key drivers	Scenario kernel	Theme
Back to the Future	High economic growth High transport use High resource use High technology development	The economy returns to health and transportation has the technology and resources to grow again.	**High Resource**
Government Redux	High transport funding through new taxes More highway technology	The government re-asserts itself as the primary driver of transportation in the U.S. and develops the funding resources to do so.	
Bits over Buses	Funding private Govt role centralized High gas price High IT	Higher than expected increase in crude oil reduces the ability of ordinary people to travel as much as they used to. They turn instead to an expanded Internet, not only for communication, but for most work and leisure activities that used to require physical movement.	**Low Demand**

Step 7 – Scenarios (cont'd)

Name the factors based on the drivers that loaded on each factor.

Scenario	Key drivers	Scenario kernel	Theme
Many Ways to Go	Economic growth Funding amount Funding private Centralized govt role Gas/carbon taxes High technology development Multi-modal approaches	The government seeks new revenue in gas and carbon taxes, but rather than investing in the existing transportation system, it puts its money into new transport and information technology leading to a complex, but efficient transportation system that includes significant shares of many different modes.	**Low Demand**
Escape to the Centers	High population density Low mobility capacity Low security	The lack of mobility and increased threats to their well-being drive people out of the suburbs and into the city, reducing the demand for transportation—the arrival of the vision for the advocates of smart growth.	
Meltdown	Climate change Env quality/sustainability Gas/carbon tax Govt role Pop density	The pessimistic scenarios for climate change ended being more accurate than the optimistic ones. As a result, the most important priority for the next few decades was struggling with nature rather than growing the economy.	**Collapse**

Common Themes and Uncertainties

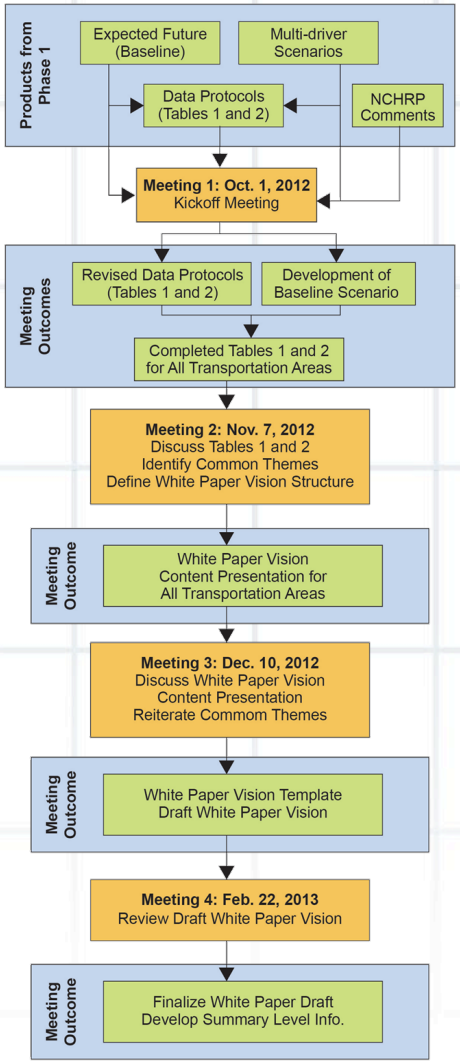
- State of the economy?
  - Strong economic growth
  - Economic collapse
- Level of VMT?
  - Cost of fuel
  - Opportunity for remote interaction using IT (*Bits)*
  - More effective multi-modal solutions (*Many ways)*
  - Denser urban form (*Escape)*
- Better or worse condition to due to more or less freight use?
- Transportation resources available?
  - Less due to more efficient vehicles and/or lower VMT
  - More due to economic growth
  - More or less due to higher (carbon?) or lower tax rates
- Use of IT in construction, maintenance and operations?
- Impact of climate change on highway condition?
- Political support for sustainable practices?

Phase II Objectives

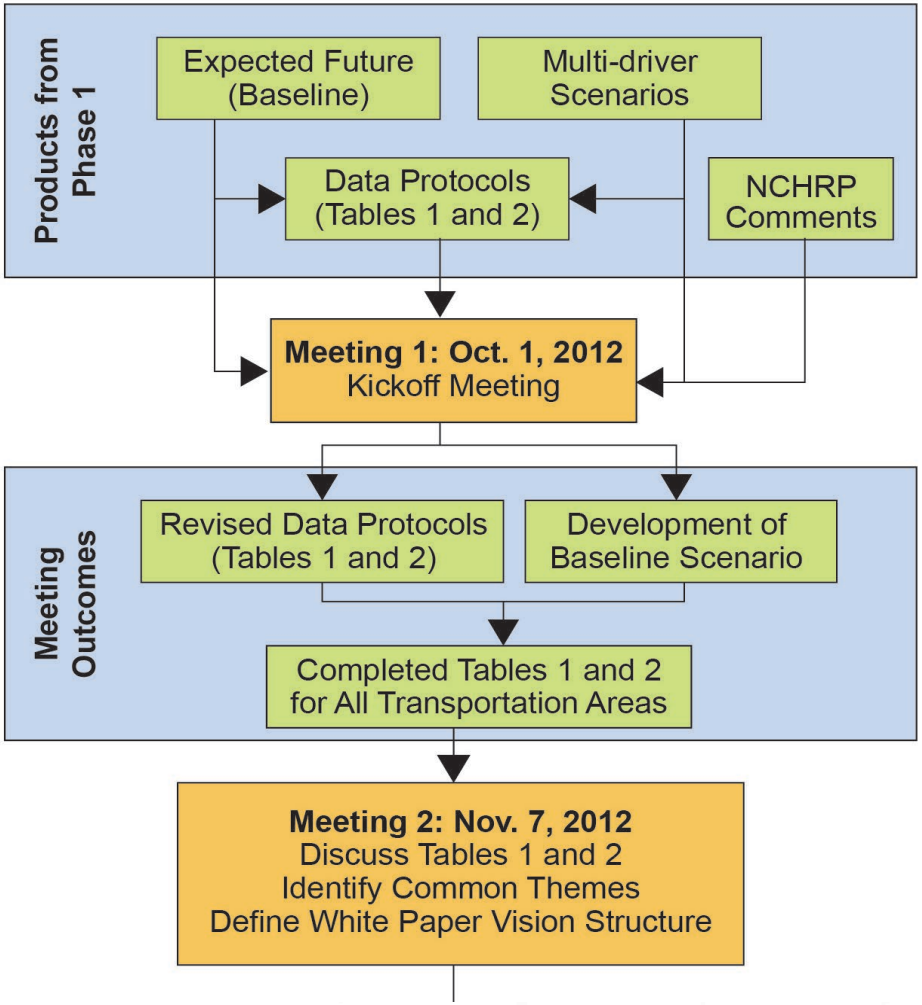
- Objective
  - Develop a white paper vision for each of the six transportation areas that reflects the future needs (30 to 50 years) as related to maintenance, preservation, and renewal of highway infrastructure.
- 6 transportation areas
  - Traffic services
  - Pavement & materials
  - Construction
  - Transportation structures
  - Roadside and drainage
  - Connectivity

Plan for Phase II, Task 6

- Collaborative Research Team Approach
  - Entire research group meetings
  - Individual team meetings
  - Use of data collection protocols
  - White paper vision template
  - Summary level information



Plan for Phase II, Task 6



Task 6 – Data Collection Protocol

- Objective
  - to facilitate the development of the white paper visions

Table 1 (Expected future drivers)	**Table 2** (Six scenarios)
What drivers?	Plausible, impact?
What effects?	What effect?
Obstacles vs. opportunities?	Obstacles vs. opportunities?
Strategies?	Strategies

Driver	Expectation—Trend, Rate	Check the 3–5 Most Important Drivers
1. Climate change	More, moderate	
2. Economic growth	Some, slow	✓
3. Priority on environmental quality/public commitment to sustainability	More, medium	
4. Funding—amount	Less, fast	✓

Driver *(Number, Name)*	Effect on Capital Phases (Planning, Scoping, Design, and Construction) *If the Driver Continues as It Is Today*	Effect on Operational Phases (Maintenance, Preservation, and Renewal) *If the Driver Continues as It Is Today*
2. Economic growth (Some, slow)	Small but incremental investment for new infrastructure 2	Larger focus on maintaining existing infrastructure 4
5. Funding-amount (Less, fast)	Not much funding to build any new infrastructure if cash strapped 1	Heavy focus is on fixing, utilizing existing infrastructure 5

Driver *(Number, Name)*	Obstacles	Opportunities
2. Economic growth (Some, slow)	Difficult to justify building new infrastructure Lack of money to fix existing infrastructure	May not need as much new construction, opportunity to develop methods to renew existing facilities
5. Funding-amount (Less, fast)	Difficult to build new infrastructure and fix existing infrastructure without adequate funding	Innovative funding mechanisms. Private sector involvement. People become more acceptable of user fees.

Driver *(Number, Name)*	Strategies			
	Materials	Tools	Approaches	Technologies
2. Economic growth (Some, slow)	Cheaper materials that last long, lighter vehicle frames leading to less deterioration, self-healing material that requires less maintenance	Enterprise GIS based predictive models that can optimize when to replace existing infrastructures (trying to reduce spending or optimize spending)	Need to encourage innovative financing strategies. Use of public investment. Increase taxes, user fees to continue to build and maintain	Technologies to support lighter materials, mass production of cheaper materials, automated construction equipment with GPS system, modular construction
5. Funding-amount (Less, fast)	Cheaper materials that last long, lighter vehicle frames leading to less deterioration, self-healing material that requires less maintenance	Enterprise GIS based predictive models that can optimize when to replace existing infrastructures (trying to reduce spending or optimize spending)	Need to encourage innovative financing strategies. Use of public investment. Increase taxes, user fees to continue to build and maintain	Technologies to support lighter materials, mass production of cheaper materials, automated construction equipment with GPS system, modular construction

Task 6 – Data Collection Protocol

- Objective
  - to facilitate the development of the white paper visions

Table 1 (Expected future drivers)	Table 2 (Six scenarios)
What drivers?	Plausible, impact?
What effects?	What effect?
Obstacles vs. opportunities?	Obstacles vs. opportunities?
Strategies?	Strategies

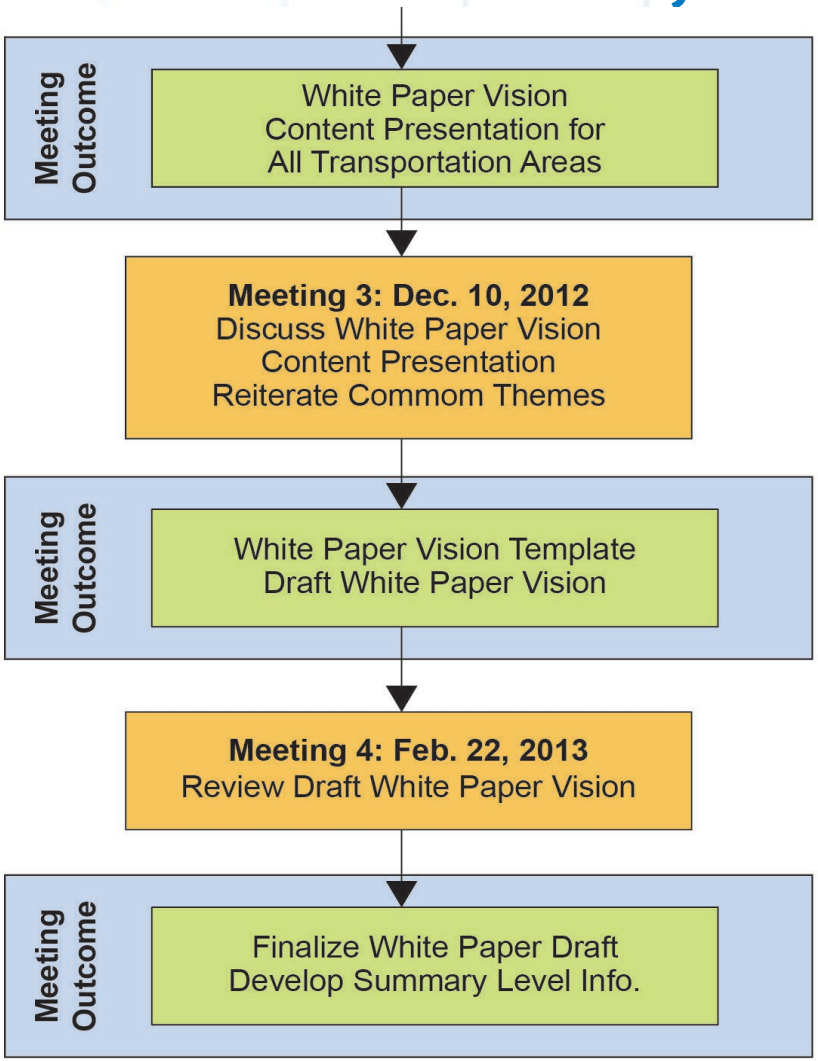
Scenario	Key Drivers	Kernel	Plausibility	Impact
1. Back to the Future	High economic growth High transport use High resource use High technology development	The economy returns to health, and transportation has the technology and resources to grow again.	4 3 2 1	4 3 2 1
2. Government Redux	High transport funding through new taxes and user fees More highway technology	The government reasserts itself as the primary driver of transportation in the United States and develops the funding resources to do so.	4 3 2 1 People hesitant to go this path?	4 3 2 1 If this was to happen, more funding will allow more construction activities

Scenario	Effect on Capital Phases (Planning, Scoping, Design, and Construction) *If the Driver Continues as It Is Today*	Effect on Operational Phases (Maintenance, Preservation, and Renewal) *If the Driver Continues as It Is Today*
1. Back to the Future	Slow and steady investment	Major expense and effort on maintaining and renewal existing system. In particular to renewing systems to meet sustainable goals
2. Government Redux	More balance between capital and operational investments. Given adequate funding level, there may be a push to develop new infrastructure that meets the sustainability goals.	Major expense and effort on maintaining and renewal existing system. In particular to renewing systems to meet sustainable goals

Scenario	Obstacles	Opportunities
1. Back to the Future	Do not see much growth and not much spent on capital projects. But maybe that is a good thing.	More opportunities to test new technology and innovations. Major development in maintaining existing roadways, more environmental friendly practices and materials.
2. Government Redux	More taxes? Private companies may not be really encouraged to be innovative and take bigger risk for reward. Government in control of R&D.	Funding is available to allow for more opportunities if needed.

Scenario	Strategies			
	Materials	**Tools**	**Approaches**	**Technologies**
1. Back to the Future	Sustainable materials, reusable materials, self-maintainable materials (glass roads with solar panels)	Strips in pavement that allow automatic ice melting Skid preventing tires Auto control vehicles for dangers, lane changes	More R&D, sustainable practices, sustainable materials, lean practices	Driverless, smart cars Premium electric vehicles 100% Solar battery cars
2. Government Redux	Sustainable materials, reusable materials, self-maintainable materials (glass roads with solar panels)	Automatic BIM and 4D modeling with concept and pictures	More R&D to increase construction safety and sustainable construction	Robotics in construction Paperless construction with foldable computers

Plan for Phase II, Task 6



❑ TASK 6: WHITE PAPER VISIONS

Methodology for Developing the White Paper Visions

- Identification of common themes
  - Qualitative analysis
  - Use of observation techniques
  - Constant comparison method
  - Search for causal, conditional relationships
- White paper template
  - Common structure

- TRAFFIC SERVICES
- PAVEMENT & MATERIALS
- CONSTRUCTION
- TRANSPORTATION STRUCTURES
- ROADSIDE AND DRAINAGE
- CONNECTIVITY

Scenarios Addressed in Each Technical-Area White Paper

Technical Area	Baseline Scenario (Managed Decline)	Higher Resource Scenarios		Lower Demand Scenarios			Disruptive Scenario (Meltdown)
		Back to the Future	Government Redux	Bits over Buses	Many Ways to Go	Escape to the Centers	
Traffic Services	✓	✓				✓	✓
Pavements and Materials	✓	✓		✓			✓
Construction	✓	✓			✓		✓
Transportation Structures	✓	✓				✓	✓
Roadside and Drainage	✓	✓			✓		✓
Connectivity	✓		✓	✓			✓

- TRAFFIC SERVICES
- PAVEMENT & MATERIALS
- CONSTRUCTION
- TRANSPORTATION STRUCTURES
- ROADSIDE AND DRAINAGE
- CONNECTIVITY

Description of Transportation Area: Traffic Services

- The management and operation of traffic using devices and technologies to maximize throughput and minimize impacts to system reliability
- Devices and technologies:
  - Static and dynamic signs
  - Signals
  - Pavement markings
  - Roadside lighting
  - ITS

Scenarios Covered in Traffic Services White Paper

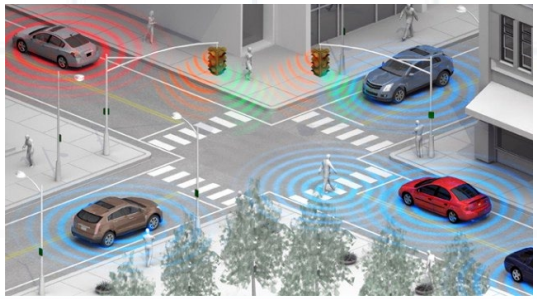
Technical Area	Baseline Scenario (Managed Decline)	Higher Resource Scenarios		Lower Demand Scenarios			Disruptive Scenario (Meltdown)
		Back to the Future	Government Redux	Bits over Buses	Many Ways to Go	Escape to the Centers	
Traffic Services	✓	✓				✓	✓
Pavements and Materials	✓	✓		✓			✓
Construction	✓	✓			✓		✓
Transportation Structures	✓	✓				✓	✓
Roadside and Drainage	✓	✓			✓		✓
Connectivity	✓		✓	✓			✓

Description of the Baseline Scenario

- Trends follow current projections
  - Funding shifts from capacity additions to ITS operations
  - Dynamic signs and pavement markings
  - Management and operations shift to the private sector
  - Increased VMT and freight demand through technology-enabled mobility
    - Larger loads
    - Freight trains

First Alternative Scenario: Back to the Future

- Shift from capacity increases to operations and traffic services
  - DOTs improve efficiency to reduce congestion
  - Investments in V2I sensors to smooth traffic operations
  - Technology requires retooling workforce
    - Cybersecurity and connected vehicles
    - Analyzing transportation performance data to optimize roadway operations



Second Alternative Scenario: Escape to the Center

- Focus on operations and throughput in urban areas
  - ITS focus on operational optimization through cross-modal data integration
  - Dynamic signals and traffic control devices respond in real-time to demand
  - Standardized and seamless user fee collections
  - Some management and operations shift to private sector

Third Alternative Scenario: Meltdown

- Rapid climate change requires rethinking transportation
  - VMT decreases with carbon taxes and caps
  - Federal policies incentivize states heavily to reduce dependence on non-renewable resources
  - Traveler information and in-vehicle communication for emergency weather and evacuations
  - Integration of data across modes and government agencies for operational optimization

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools		Technologies		Approaches		
	Traffic Control Device Materials	Data Management	V2I Integration	IT Integration and Standardization across Modes	Funding Allocation to Operations	Privatization	Workforce Training
Baseline (Managed Decline)					✓	✓	✓
Back to the Future							
Escape to the Centers							
Meltdown							

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools		Technologies		Approaches		
	Traffic Control Device Materials	Data Management	V2I Integration	IT Integration and Standardization across Modes	Funding Allocation to Operations	Privatization	Workforce Training
Baseline (Managed Decline)							
Back to the Future		✓	✓		✓		✓
Escape to the Centers							
Meltdown							

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools		Technologies		Approaches		
	Traffic Control Device Materials	Data Management	V2I Integration	IT Integration and Standardization across Modes	Funding Allocation to Operations	Privatization	Workforce Training
Baseline (Managed Decline)							
Back to the Future							
Escape to the Centers			✓	✓	✓	✓	✓
Meltdown							

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools		Technologies		Approaches		
	Traffic Control Device Materials	Data Management	V2I Integration	IT Integration and Standardization across Modes	Funding Allocation to Operations	Privatization	Workforce Training
Baseline (Managed Decline)							
Back to the Future							
Escape to the Centers							
Meltdown	✓	✓		✓	✓	✓	✓

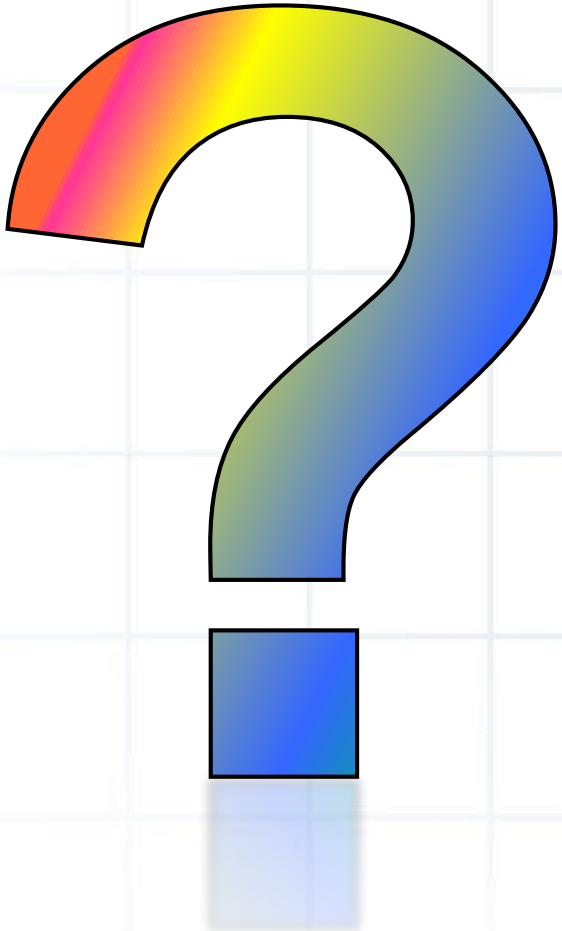
Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools		Technologies		Approaches		
	Traffic Control Device Materials	Data Management	V2I Integration	IT Integration and Standardization across Modes	Funding Allocation to Operations	Privatization	Workforce Training
Baseline (Managed Decline)					✓	✓	✓
Back to the Future		✓	✓		✓		✓
Escape to the Centers			✓	✓	✓	✓	✓
Meltdown	✓	✓		✓	✓	✓	✓

Implications for State Transportation Agencies

- Funding Constraints
  - Shift from “build it” to “operate it” mentality
- Private Sector
  - Next-generation in-vehicle technologies
  - Traffic data
  - Pay-for-use service provision
- Workforce Training
  - IT integration, standardization, & data management
  - Legal and financial skills to manage and structure organizational agreements

DISCUSSION

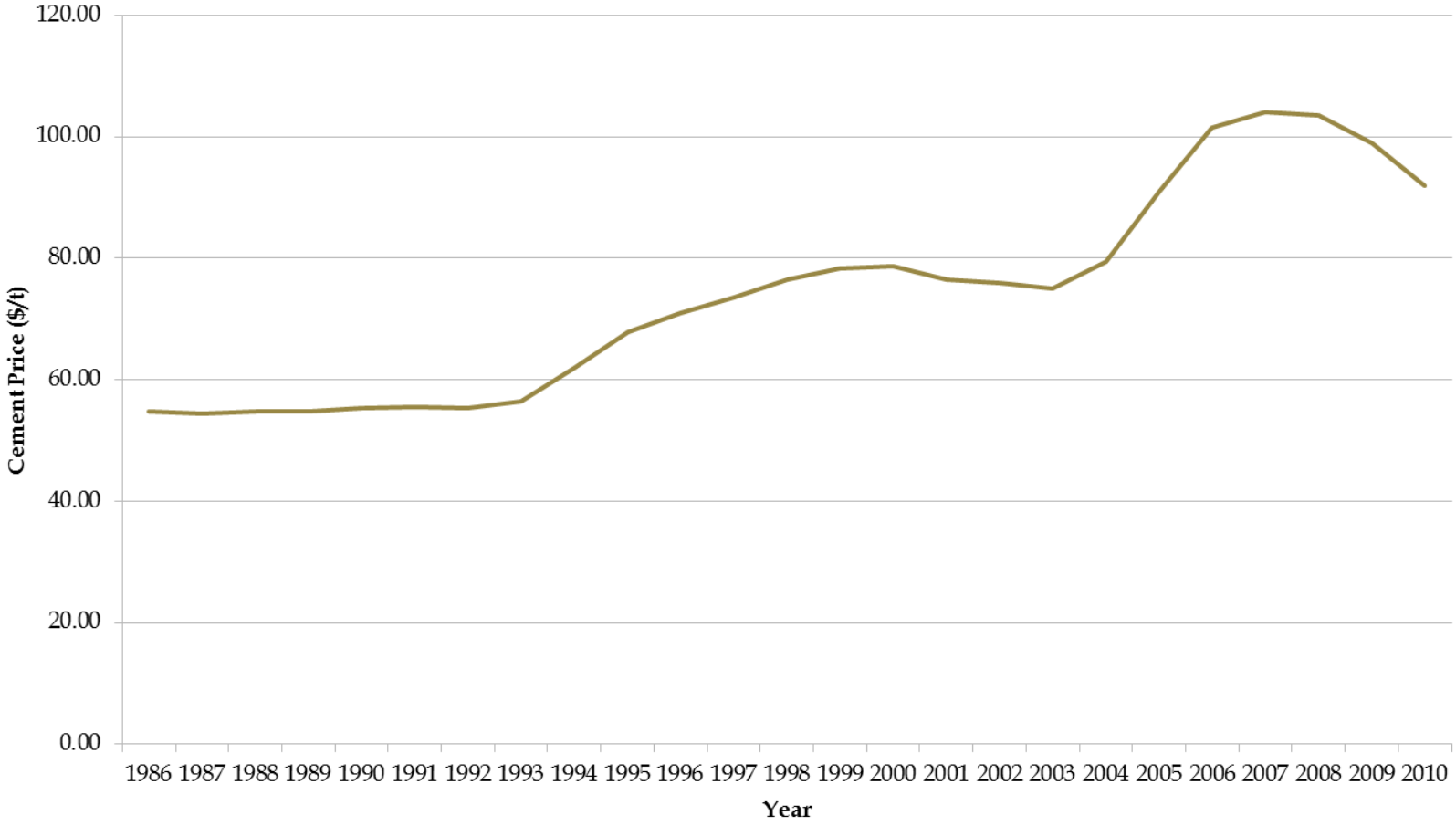


- TRAFFIC SERVICES
- **PAVEMENT & MATERIALS**
- CONSTRUCTION
- TRANSPORTATION STRUCTURES
- ROADSIDE AND DRAINAGE
- CONNECTIVITY

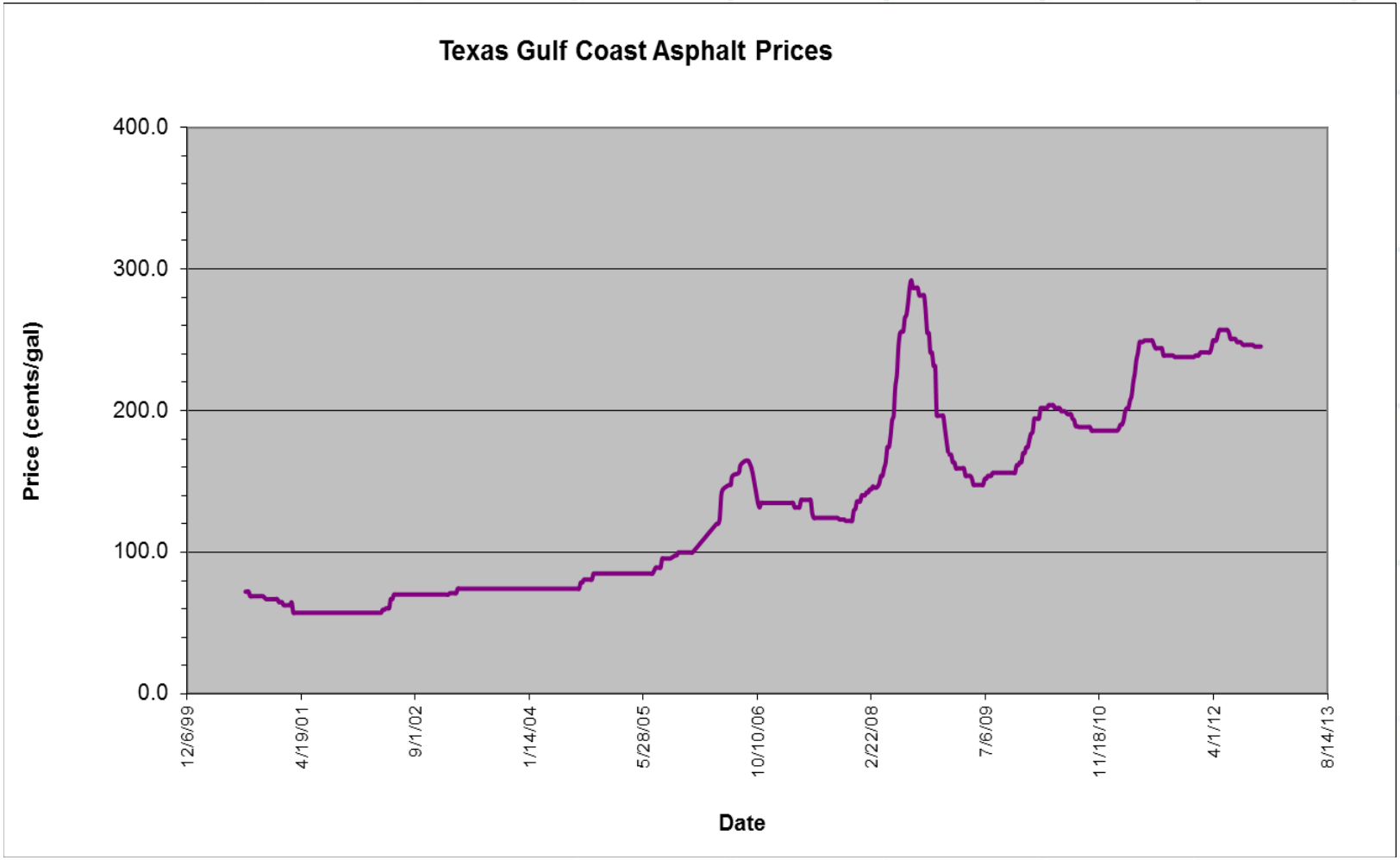
Description of Transportation Area: Pavements and Materials

- Pavements
  - Mix Type Selection
  - Pavement Design
  - Placement/Compaction
  - Pavement Preservation
- Materials
  - Raw Material Production
  - Use of Recycled Materials
  - Mixture Design
  - Production of Finished Materials

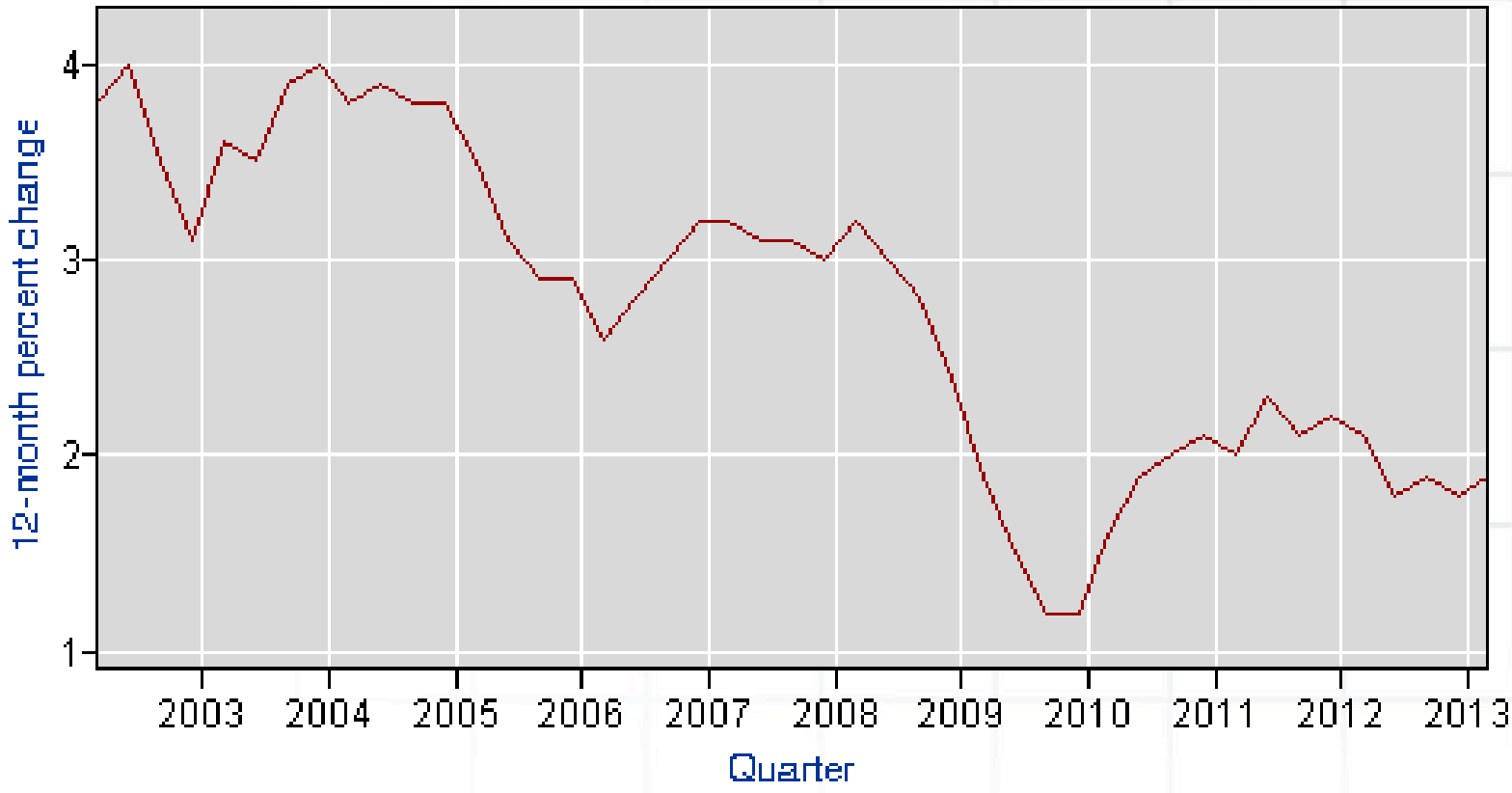
Cement Prices 1986 - 2010



Asphalt Prices 2000 - 2012



BLS Labor Cost Index – Private Industry



Scenarios Covered in the Pavements and Materials White Paper

Technical Area	Baseline Scenario (Managed Decline)	Higher Resource Scenarios		Lower Demand Scenarios			Disruptive Scenario (Meltdown)
		Back to the Future	Government Redux	Bits over Buses	Many Ways to Go	Escape to the Centers	
Traffic Services	✓	✓				✓	✓
Pavements and Materials	✓	✓		✓			✓
Construction	✓	✓			✓		✓
Transportation Structures	✓	✓				✓	✓
Roadside and Drainage	✓	✓			✓		✓
Connectivity	✓		✓	✓			✓

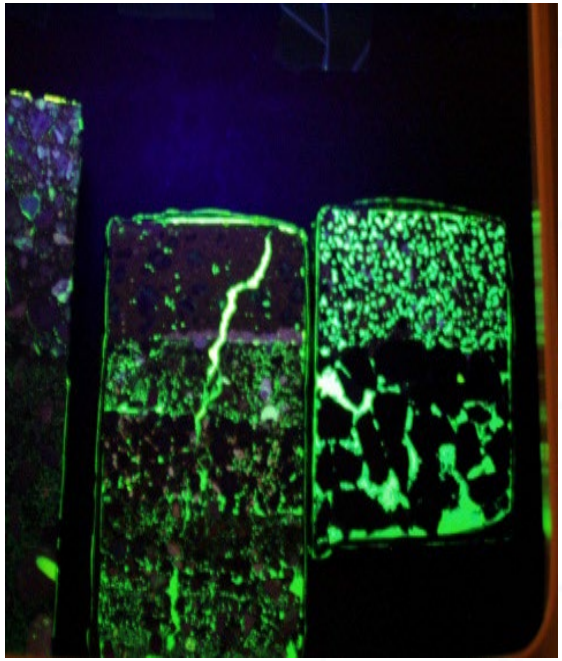
Description of the Baseline Scenario

- Conditions
  - Slow Economic Development
  - More Energy Demand
  - Slow Technology Development
  - Smaller Government Role
- Implications
  - Emphasis on Pavement Preservation
  - High Energy $ = High Construction $
  - More Efficient Construction

Potential for New Materials, Tools, Technology, and Approaches

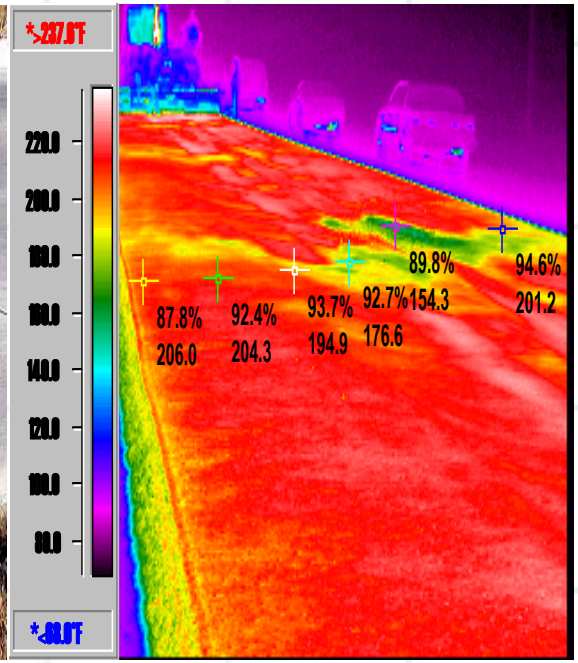
Multi-driver Scenarios	Materials			Tools		Technologies			Approaches		
	Effective Design	Efficient Construction	Recycling	Mechanistic Design	Automated QC/QA	Intelligent Construction	Intelligent Production	Robotics	Sustainability	Sensor Deployment	Workforce Training
Baseline (Managed Decline)	✓	✓	✓	✓	✓	✓	✓	✓			✓
Back to the Future											
Bits over Buses											
Meltdown											

Nondestructive Testing



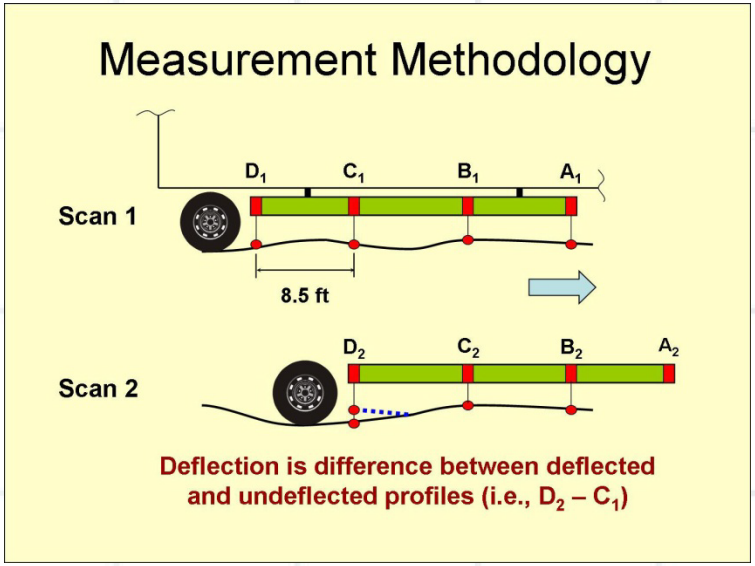
Ultraviolet

Visible



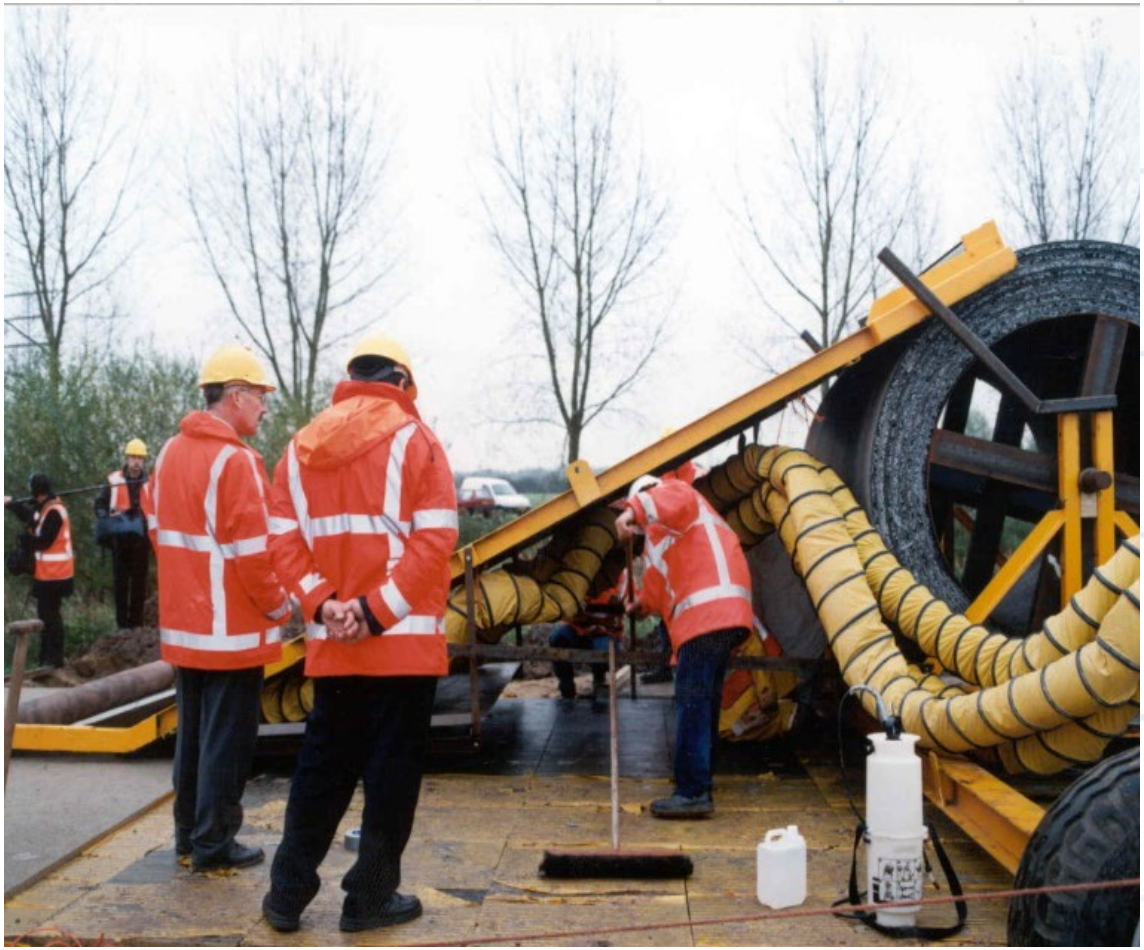
Infrared

Nondestructive Testing at Highway Speeds



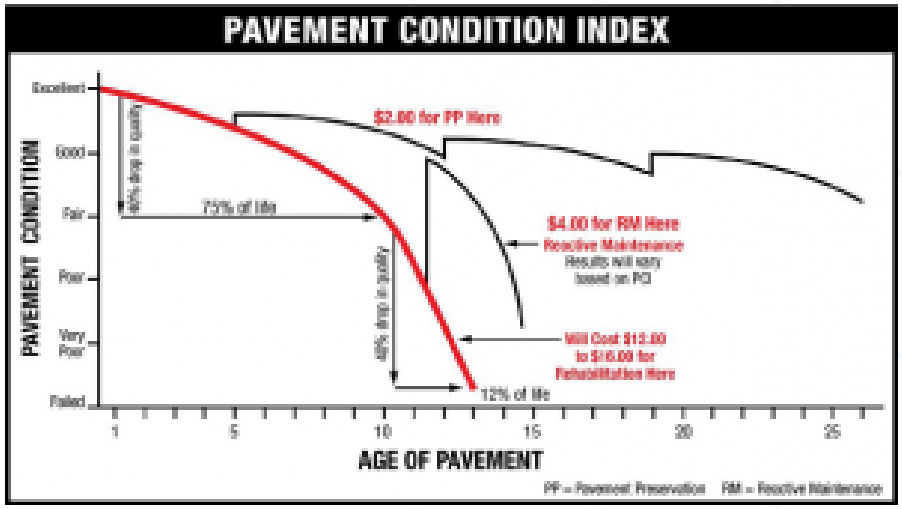
Robotics in Work Zones

Road-on-a-Roll



Modular Pavements

Sustainability



ASPHALT
100% RECYCLABLE

Green Highway Forum
Stewardship, Safety & Sustainability

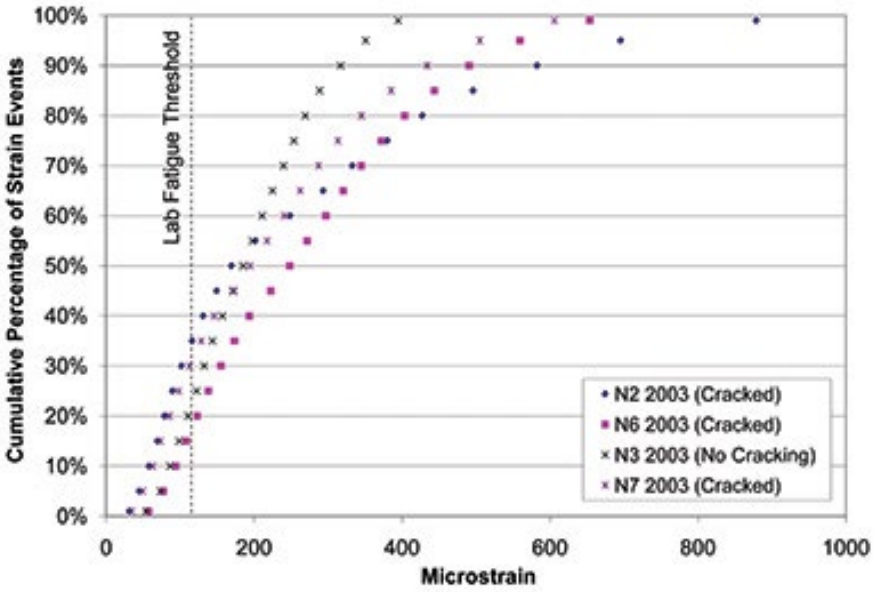
Recycling

Alternative Binders

Future of Asphalt Paving

http://www.volvoce.com/constructionequipment/corporate/en-gb/innovation/concept_vehicles/fenix_paver/fenix_video/pages/fenix_video.aspx

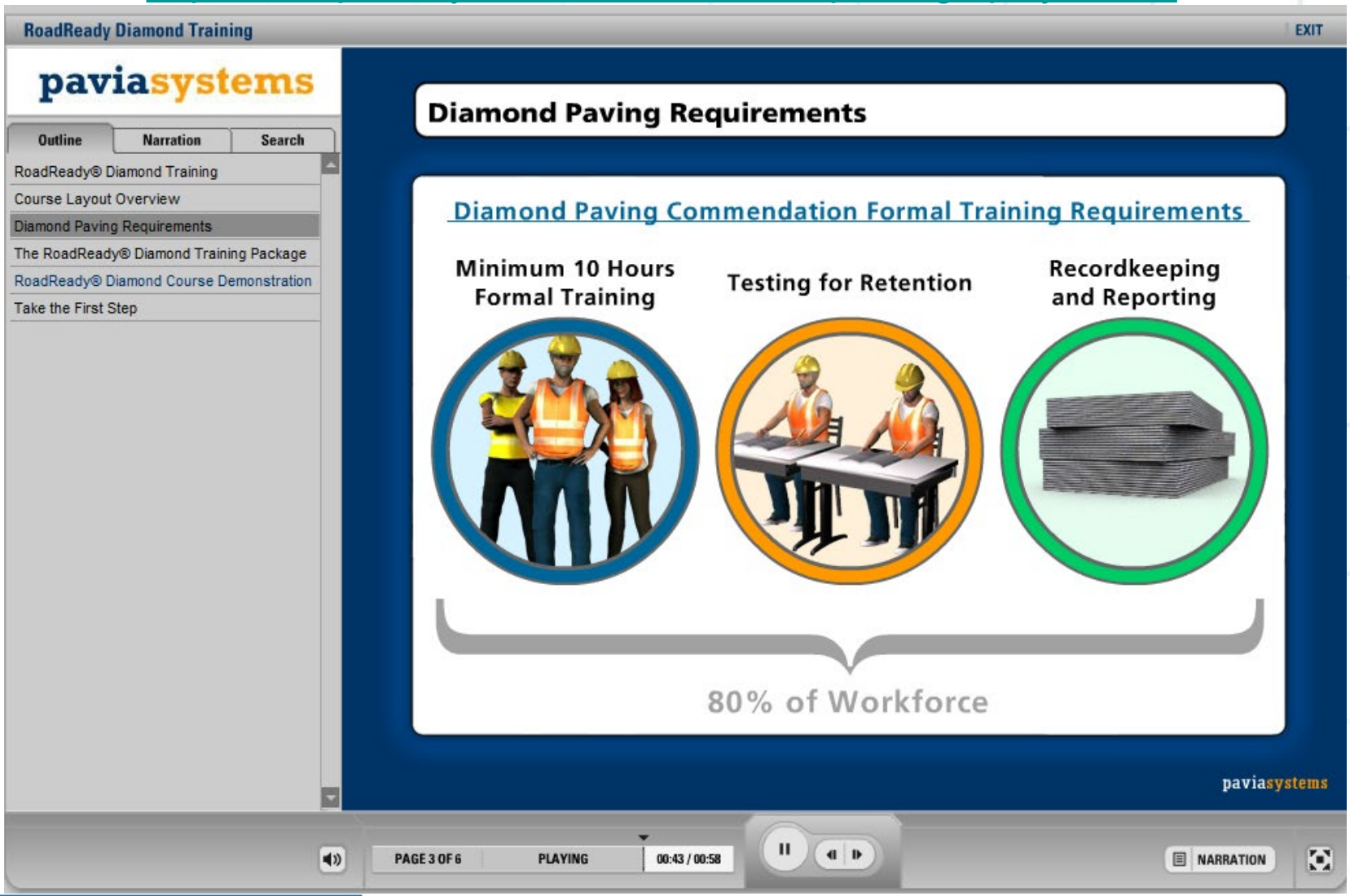
Pavement Sensors – Health Monitoring



Future Roller Operator

Work Force Training

http://www.paviasystems.com/diamond/package/player.html



First Alternative Scenario: Back to the Future

- Conditions
  - Healthy Economy
  - Plentiful Funding
- Implications
  - High Energy $ = High Materials $
  - Material/Labor Shortages
  - Large Projects Feasible – time to make hay
  - Less Innovation/Implementation
  - Improvements in Construction/Safety

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials			Tools		Technologies			Approaches		
	Effective Design	Efficient Construction	Recycling	Mechanistic Design	Automated QC/QA	Intelligent Construction	Intelligent Production	Robotics	Sustainability	Sensor Deployment	Workforce Training
Baseline (Managed Decline)											
Back to the Future		✓	✓	✓	✓	✓				✓	✓
Bits over Buses											
Meltdown											

Second Alternative Scenario: Bits Over Buses

- Conditions
  - High Energy Costs
  - Less Personal Travel
  - Easier to Move Commodities and Goods
- Implications
  - Construction Costs Higher
  - Fewer Projects – More Competition
  - More Focus on Preservation
  - Alternative Binders
  - Neglect of Secondary System

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials			Tools		Technologies			Approaches		
	Effective Design	Efficient Construction	Recycling	Mechanistic Design	Automated QC/QA	Intelligent Construction	Intelligent Production	Robotics	Sustainability	Sensor Deployment	Workforce Training
Baseline (Managed Decline)											
Back to the Future											
Bits over Buses									✓	✓	✓
Meltdown											

Third Alternative Scenario: Meltdown

- Conditions
  - Immediate Response to Global Warming
  - Environmental Regulation & Monitoring
- Implications
  - Much More Innovation
  - Green Construction – Guidelines/Metrics
  - Construction – Reduced Emissions/Congestion
  - Maintenance/Preservation – Primary Mode
  - Recycling/Alternate Binders
  - Neglect of Secondary Roads

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials			Tools		Technologies			Approaches		
	Effective Design	Efficient Construction	Recycling	Mechanistic Design	Automated QC/QA	Intelligent Construction	Intelligent Production	Robotics	Sustainability	Sensor Deployment	Workforce Training
Baseline (Managed Decline)											
Back to the Future											
Bits over Buses											
Meltdown	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials			Tools		Technologies			Approaches		
	Effective Design	Efficient Construction	Recycling	Mechanistic Design	Automated QC/QA	Intelligent Construction	Intelligent Production	Robotics	Sustainability	Sensor Deployment	Workforce Training
Baseline (Managed Decline)	✓	✓	✓	✓	✓	✓	✓	✓			✓
Back to the Future		✓	✓	✓	✓	✓				✓	✓
Bits over Buses									✓	✓	✓
Meltdown	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

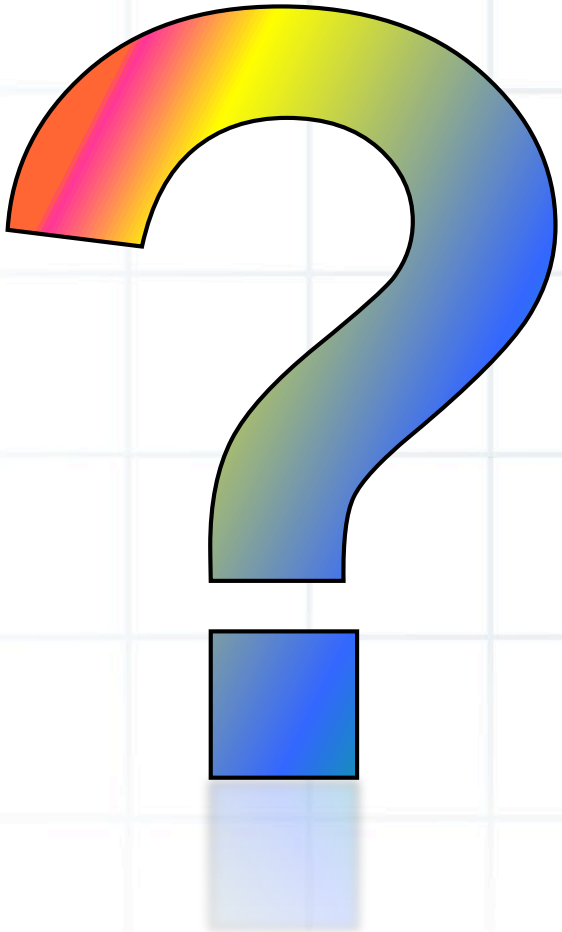
Implications for State Transportation Agencies

- Innovation
  - Required when conditions at their worst
  - In good times, less incentive to change
- Sustainability
  - Will take on more importance
  - Efficient (long-life) designs
  - Porous pavements
  - Recycling

Implications for State Transportation Agencies

- Efficient Construction, Automated QC/QA, Intelligent Construction
  - Important in any scenario for competition
  - Agencies will need to adjust to allow
  - Performance specifications
  - Rapid construction important in all cases
- Workforce Training
  - Important in any scenario for competition
  - Remote equipment operation
  - Real-time feedback

DISCUSSION



- TRAFFIC SERVICES
- PAVEMENT & MATERIALS
- **CONSTRUCTION**
- TRANSPORTATION STRUCTURES
- ROADSIDE AND DRAINAGE
- CONNECTIVITY

Description of Transportation Area: Construction

- New and maintain infrastructures
  - Transportation predesign
  - Design
  - Building and assembly services
  - Means and methods
- Activities
  - Earthwork
  - Install traffic control devices
  - Pavement
  - Structures

Scenarios Covered in the Construction White Paper

Technical Area	Baseline Scenario (Managed Decline)	Higher Resource Scenarios		Lower Demand Scenarios			Disruptive Scenario (Meltdown)
		Back to the Future	Government Redux	Bits over Buses	Many Ways to Go	Escape to the Centers	
Traffic Services	✓	✓				✓	✓
Pavements and Materials	✓	✓		✓			✓
Construction	✓	✓			✓		✓
Transportation Structures	✓	✓				✓	✓
Roadside and Drainage	✓	✓			✓		✓
Connectivity	✓		✓	✓			✓

Description of the Baseline Scenario

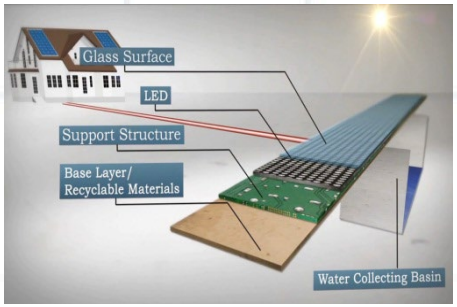
- Challenge in Maintenance and Renewal
  - More dependence on public transit system
    - Construct innovative public transit system
  - More private execution of design & construction process
    - Innovative project deliver and contracting method
  - More development in IT
    - Semi-autonomous heavy construction equipment
  - Concern for sustainability
    - Fuel-efficient heavy construction equipment
  - More sophisticated construction workforce

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials	Tools		Technologies		Approaches			
	Innovative Materials	Light and Medium-Duty Equipment	Models and Simulations	Wireless Communication	Visualization	Sustainability	Innovative Financing	Workforce Training	Outsourcing Heavy-Duty and Specialized Equipment
Baseline (Managed Decline)						✓	✓		
Back to the Future	✓		✓		✓	✓		✓	
Many Ways to Go	✓	✓		✓	✓	✓	✓	✓	
Meltdown			✓			✓	✓	✓	✓

First Alternative Scenario: Back to the Future

- Advancement in IT
  - Totally autonomous construction equipment
  - Superior construction working conditions
- Integrated project delivery process
- Development of sustainable materials
  - Innovative road systems



Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials	Tools		Technologies		Approaches			
	Innovative Materials	Light and Medium-Duty Equipment	Models and Simulations	Wireless Communication	Visualization	Sustainability	Innovative Financing	Workforce Training	Outsourcing Heavy-Duty and Specialized Equipment
Baseline (Managed Decline)						✓	✓		
Back to the Future	✓		✓		✓	✓		✓	
Many Ways to Go	✓	✓		✓	✓	✓	✓	✓	
Meltdown			✓			✓	✓	✓	✓

Second Alternative Scenario: Many Ways to Go

- Focus on both new system and maintenance
- Funding for innovative transportation systems
  - Shift to the private sector
  - New skill sets
  - Complex construction execution and quality control
  - Techniques for modularization and deconstruction
  - Innovation in recycling of construction materials

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials	Tools		Technologies		Approaches			
	Innovative Materials	Light and Medium-Duty Equipment	Models and Simulations	Wireless Communication	Visualization	Sustainability	Innovative Financing	Workforce Training	Outsourcing Heavy-Duty and Specialized Equipment
Baseline (Managed Decline)						✓	✓		
Back to the Future	✓		✓		✓	✓		✓	
Many Ways to Go	✓	✓		✓	✓	✓	✓	✓	
Meltdown			✓			✓	✓	✓	✓

Third Alternative Scenario: Meltdown

- Abrupt climate change shifts priorities from growing the economy to struggling with nature.
  - Construction focuses on maintenance activities
- Climate change impacts current design and construction norms and standards.

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials	Tools		Technologies		Approaches			
	Innovative Materials	Light and Medium-Duty Equipment	Models and Simulations	Wireless Communication	Visualization	Sustainability	Innovative Financing	Workforce Training	Outsourcing Heavy-Duty and Specialized Equipment
Baseline (Managed Decline)						✓	✓		
Back to the Future	✓		✓		✓	✓		✓	
Many Ways to Go	✓	✓		✓	✓	✓	✓	✓	
Meltdown			✓			✓	✓	✓	✓

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Materials	Tools		Technologies		Approaches			
	Innovative Materials	Light and Medium-Duty Equipment	Models and Simulations	Wireless Communication	Visualization	Sustainability	Innovative Financing	Workforce Training	Outsourcing Heavy-Duty and Specialized Equipment
Baseline (Managed Decline)						✓	✓		
Back to the Future	✓		✓		✓	✓		✓	
Many Ways to Go	✓	✓		✓	✓	✓	✓	✓	
Meltdown			✓			✓	✓	✓	✓

Implications for State Transportation Agencies

- *Sustainability*
  - Incentives
  - Visualization techniques and simulation methods
- *Innovative Financing*
  - Private sector's responsibility
  - Capital projects vs. operation or expansion
- *Workforce Training*
  - Sustainable funding
  - Health and safety

- TRAFFIC SERVICES
- PAVEMENT & MATERIALS
- CONSTRUCTION
- **TRANSPORTATION STRUCTURES**
- ROADSIDE AND DRAINAGE
- CONNECTIVITY

- TRAFFIC SERVICES
- PAVEMENT & MATERIALS
- CONSTRUCTION
- TRANSPORTATION STRUCTURES
- **ROADSIDE AND DRAINAGE**
- CONNECTIVITY

- TRAFFIC SERVICES
- PAVEMENT & MATERIALS
- CONSTRUCTION
- TRANSPORTATION STRUCTURES
- ROADSIDE AND DRAINAGE
- **CONNECTIVITY**

Description of Transportation Area: Connectivity

- Focuses on the interconnection between highways and:
  - Transit
  - Aviation
  - Ports
  - Trains
  - Subways
  - Pedestrian
  - Cycling
- Concentration on impacts from modes with opportunities for direct highway integration

Scenarios Covered in the Connectivity White Paper

Technical Area	Baseline Scenario (Managed Decline)	Higher Resource Scenarios		Lower Demand Scenarios			Disruptive Scenario (Meltdown)
		Back to the Future	Government Redux	Bits over Buses	Many Ways to Go	Escape to the Centers	
Traffic Services	✓	✓				✓	✓
Pavements and Materials	✓	✓		✓			✓
Construction	✓	✓			✓		✓
Transportation Structures	✓	✓				✓	✓
Roadside and Drainage	✓	✓			✓		✓
Connectivity	✓		✓	✓			✓

Description of the Baseline Scenario

- Society could benefit greatly from transit and multi-modal services
  - Funding is scarce
    - Heavy reliance on innovative, user fee-based projects (MLs, HOT, etc.)
    - PPPs flourish
    - Privately provided transit increases
  - Localities that invest in multi-modal and transit early gain a competitive edge

First Alternative Scenario: Government Redux

- Government reasserts itself
  - Increased funding for traditional capacity transportation projects
    - General revenues and user fees
  - Diminished demand for transit
  - DOTs and other transportation agencies are reorganized into highly efficient, strategically managed units
  - Heavy focus on ITS and improving road operations

Second Alternative Scenario: Bits Over Buses

- Diminished demand through technology
  - Commuting decreases, congestion eases
  - Transit demand and supply are low
  - Companies still must ship goods, and freight increases as consumer-level trips decrease
    - DOTs focus on improving freight throughput and efficiency
    - Special use facilities are converted to freight hubs and dedicated truck lanes, ROW is converted to rail

Third Alternative Scenario: Meltdown

- Society refocuses priorities in the face of dramatic climate changes
  - Carbon taxes and caps increase SOV operation costs, decreasing use
  - Transit and multi-modal transportation become true substitute goods for SOVs
  - States and cities invest heavily in transit and multi-modal travel solutions
  - DOTs refocus on optimizing multi-modal integration through gathering and analyzing data
  - Managed and special use lanes proliferate as carpooling becomes the norm

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools			Technologies	Approaches		
	Managed Lanes	Dedicated Structures	Dedicated Truck Lanes	IT Integration and Standardization across Modes	Alternative Funding	Future Organizational Structures	Workforce Training
Baseline (Managed Decline)					✓	✓	✓
Bits over Buses							
Government Redux							
Meltdown							

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools			Technologies	Approaches		
	Managed Lanes	Dedicated Structures	Dedicated Truck Lanes	IT Integration and Standardization across Modes	Alternative Funding	Future Organizational Structures	Workforce Training
Baseline (Managed Decline)							
Bits over Buses		✓	✓		✓		✓
Government Redux							
Meltdown							

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools			Technologies	Approaches		
	Managed Lanes	Dedicated Structures	Dedicated Truck Lanes	IT Integration and Standardization across Modes	Alternative Funding	Future Organizational Structures	Workforce Training
Baseline (Managed Decline)							
Bits over Buses							
Government Redux				✓	✓	✓	✓
Meltdown							

Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools			Technologies	Approaches		
	Managed Lanes	Dedicated Structures	Dedicated Truck Lanes	IT Integration and Standardization across Modes	Alternative Funding	Future Organizational Structures	Workforce Training
Baseline (Managed Decline)							
Bits over Buses							
Government Redux							
Meltdown	✓	✓	✓	✓	✓	✓	✓

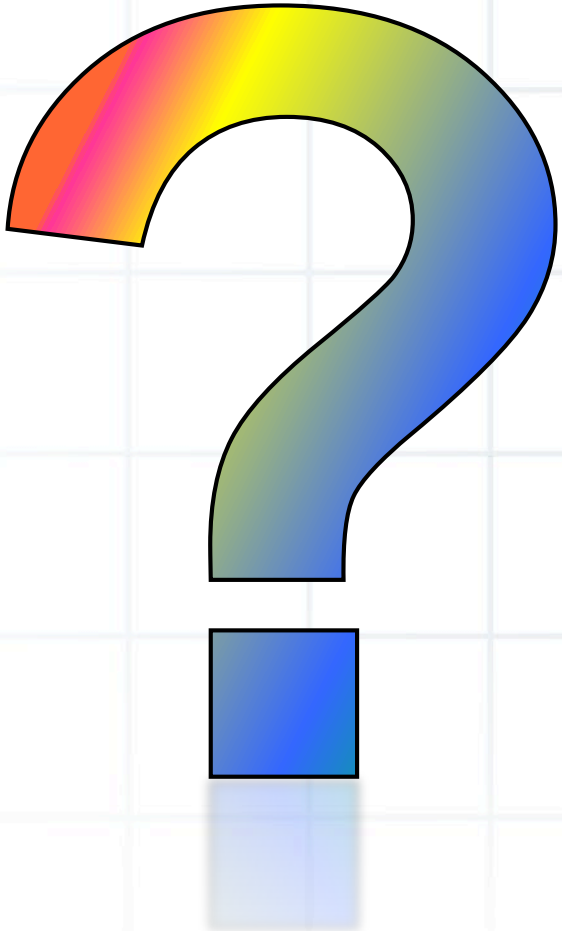
Potential for New Materials, Tools, Technology, and Approaches

Multi-driver Scenarios	Tools			Technologies	Approaches		
	Managed Lanes	Dedicated Structures	Dedicated Truck Lanes	IT Integration and Standardization across Modes	Alternative Funding	Future Organizational Structures	Workforce Training
Baseline (Managed Decline)					✓	✓	✓
Bits over Buses		✓	✓		✓		✓
Government Redux				✓	✓	✓	✓
Meltdown	✓	✓	✓	✓	✓	✓	✓

Implications for State Transportation Agencies

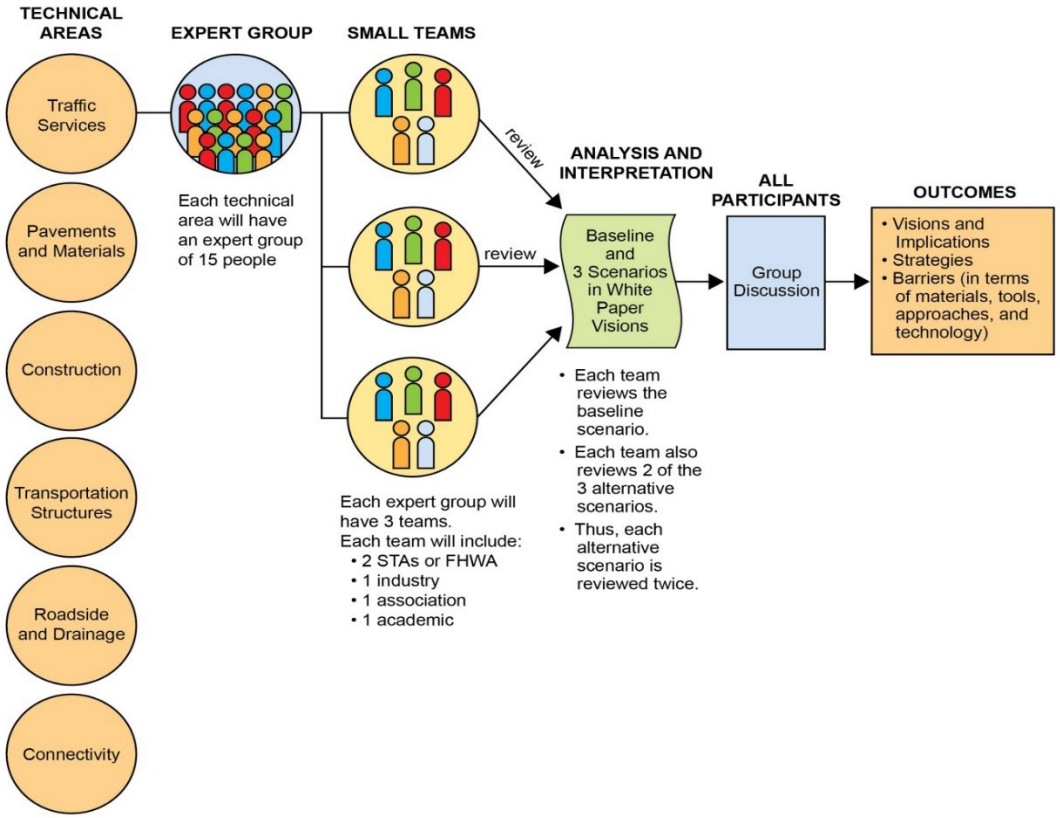
- Use of alternative funding
  - User fees and PPPs can generate revenues and decrease congestion in the scarce worlds
- Changes to organizational structure
  - DOTs and local transportation agencies may need to vertically integrate to increase efficiencies
  - Mergers among fragmented local transportation agencies
- Changes to organizational function and workforce
  - Staff at transportation agencies resemble IT departments
  - Data integration and analysis to optimize multi-modal performance
  - Install, maintain, and operate new sensors and other data gathering devices

DISCUSSION



❑ TASK 7

Path Forward: Assessing White Paper Visions



Path Forward: Workshop

- Schedule
  - Brief of the whole project and the scenarios over lunch and into the afternoon.
  - Discussion of the scenarios for the rest of the afternoon.
  - Homework to brainstorm strategies over evening or early morning.
  - Do the Implications Analysis in the morning that results in candidate strategies.
  - Selection of final strategies in the early afternoon.

Path Forward: Workshop

- Option 1: Conduct all transportation area workshops in a single setting
  - Brief context scenarios all in one setting
  - Need qualified facilitators
  - Possibly need to audio record for the team's DOT consultants
- Option 2: Conduct individual transportation area workshops
  - Conduct 2-day sessions in 3 different weeks
  - Reduced travel cost, possible hotel deals
  - Breakup by regions if needed (East and West coasts and one in Midwest)

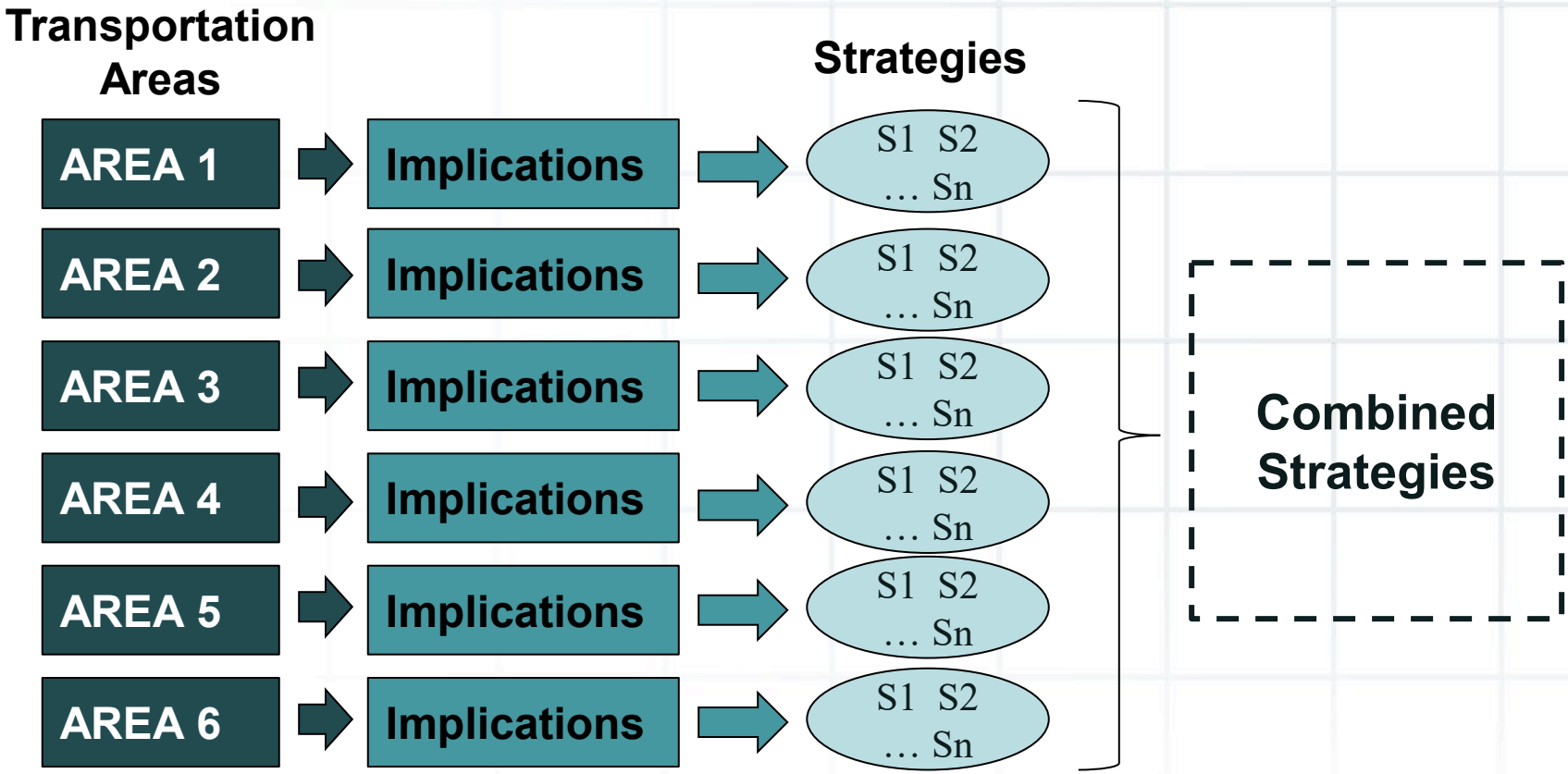
Developing Strategies for Transportation Agencies

Technical Area	Implication 1	Implication 2	Implication 3
Traffic Services	Funding Allocation to Operations	Privatization	Workforce Training
Pavements and Materials	Sustainability	Efficient Construction, Automated QC/QA, and Intelligent Construction	Workforce Training
Construction	Sustainability	Innovative Financing	Workforce Training
Transportation Structures	Moderate Mechanization	Accelerated Construction	PPP Emphasis
Roadside and Drainage	Sustainable Practices	Workforce Training	-
Connectivity	Alternative Funding	Future Organizational Structures	Workforce Training

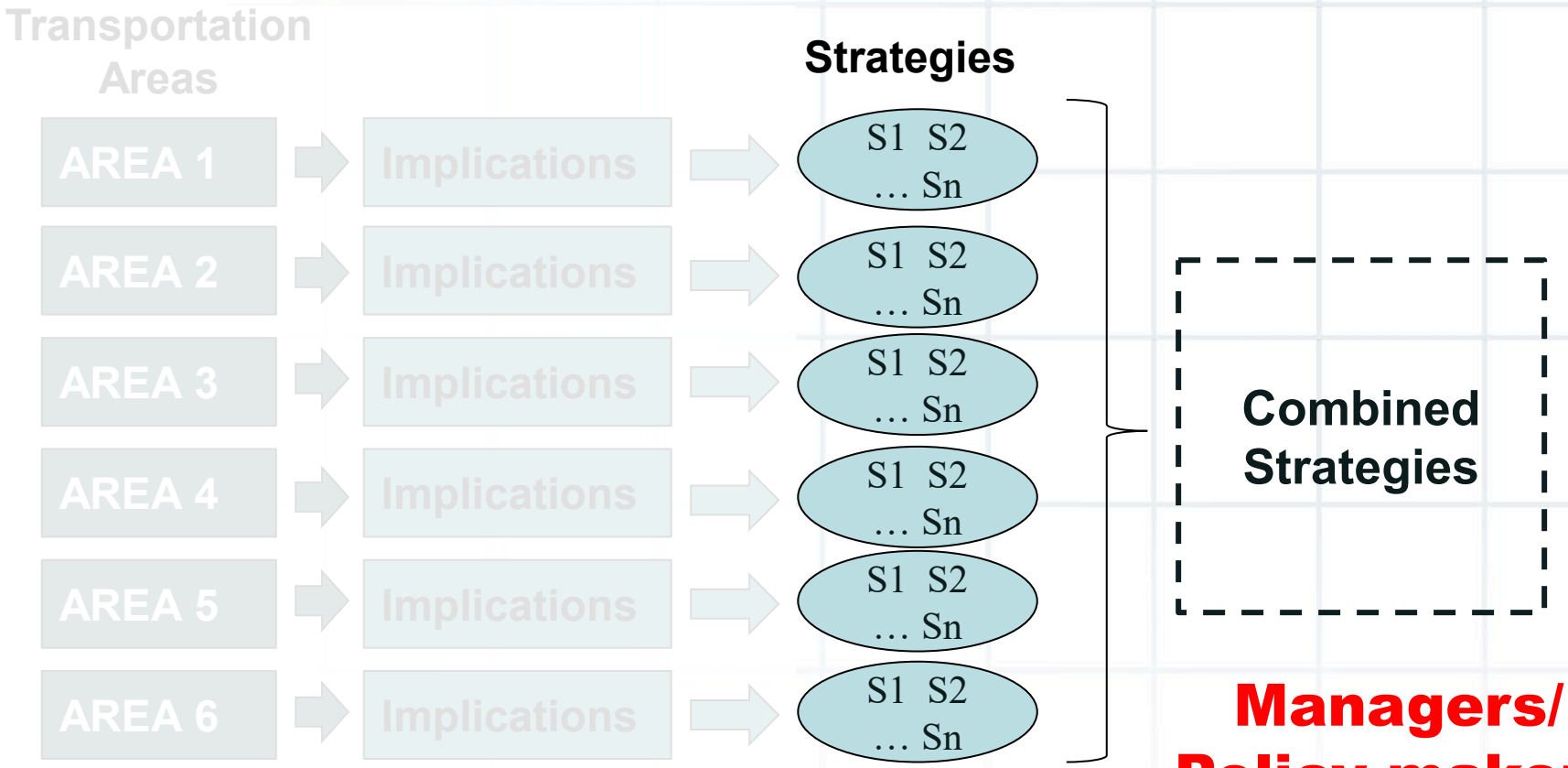
Developing Strategies for Transportation Agencies

Technical Area	Implication 1	Implication 2	Implication 3
Traffic Services	Funding Allocation to Operations	Privatization	Workforce Training
Pavements and Materials	Sustainability	Efficient Construction, Automated QC/QA, and Intelligent Construction	Workforce Training
Construction	Sustainability	Innovative Financing	Workforce Training
Transportation Structures	Moderate Mechanization	Accelerated Construction	PPP Emphasis
Roadside and Drainage	Sustainable Practices	Workforce Training	-
Connectivity	Alternative Funding	Future Organizational Structures	Workforce Training

Developing Strategies for Transportation Agencies



Developing Strategies for Transportation Agencies



Example of Transferring the Visions into Strategies and Ultimately to Guidance

Pavement & Materials

Example of Transferring the Visions into Strategies and Ultimately to Guidance

Example of Transferring the Visions into Strategies and Ultimately to Guidance

- Implications for DOTs
  - *Present* workforce versus *future* workforce
  - *Baseline* scenario versus *alternative* scenarios
  - *Executives* versus *individual* transportation areas

Construction

Example of Transferring the Visions into Strategies and Ultimately to Guidance

- Strategies
  - DOT partner with different education institutions to address future skill requirements
  - DOT partner with technology development firms to enhance future computing capabilities
- Guidance
  - DOT partner with student co-op programs to develop workforce readiness skills
  - DOT partner with colleges/universities on faculty enrichment programs
  - DOT develop mentor programs for university students
  - Use of more technology based curriculum
  - DOT partner with computer based platforms and equipment companies to train students

❑ TASK 8 - PREPARING PHASE II INTERIM REPORT

❑ SCHEDULE

❑ DISCUSSION

QUESTIONS?