Strategic Issues Facing Transportation, Volume 1: Scenario Planning for Freight Transportation Infrastructure Investment

DETAILS

155 pages | 8.5 x 11 | PAPERBACK

ISBN 978-0-309-25892-0 | DOI 10.17226/22628

AUTHORS

Caplice, Chris; and Phadnis, Shardul

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 750

Strategic Issues Facing Transportation

Volume 1: Scenario Planning for Freight Transportation Infrastructure Investment

Chris Caplice
Shardul Phadnis
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, MA

Subscriber Categories
Freight Transportation • Planning and Forecasting • Terminals and Facilities

Research sponsored by the American Association of State Highway and Transportation Officials
in cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2013
www.TRB.org

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Academies was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NCHRP REPORT 750

Project 20-83(1)
ISSN 0077-5614
ISBN 978-0-309-25892-0
Library of Congress Control Number 2013932452

COPYRIGHT INFORMATION

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

The Transportation Research Board of the National Academies, the National Research Council, and the sponsors of the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the report.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at:

http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

COOPERATIVE RESEARCH PROGRAMS

CRP STAFF FOR NCHRP REPORT 750, Volume 1

Christopher W. Jenks, *Director, Cooperative Research Programs*
Crawford F. Jencks, *Deputy Director, Cooperative Research Programs*
William C. Rogers, *Senior Program Officer*
Charlotte Thomas, *Senior Program Assistant*
Eileen P. Delaney, *Director of Publications*
Scott E. Hitchcock, *Editor*

NCHRP PROJECT 20-83(1) PANEL
Area of Special Projects

Barbara A. Ivanov, *Washington State DOT, Olympia, WA* (Chair)
Steven A. Brown, *Port Authority of New York & New Jersey, New York, NY*
Robert Costello, *American Trucking Associations, Arlington, VA*
John T. Gray, *Association of American Railroads, Washington, DC*
Jeffrey D. Holt, *BMO Capital Markets, Inc., Huntsville, UT*
John Isbell, *Starboard Alliance, LLC, Manzanita, OR*
H. Thomas Kornegay, *Consultant, Houston, TX*
Bruce E. Seely, *Michigan Technological University, Houghton, MI*
Keith M. Sherman, *Consultant, Petersburg, IL*
Kenneth R. Wykle, *National Defense Transportation Association, Alexandria, VA*
Tony Furst, *FHWA Liaison*
Leo Penne, *AASHTO Liaison*
Joseph R. Morris, *TRB Liaison*
Thomas Palmerlee, *TRB Liaison*
Ann R. Purdue, *TRB Liaison*

FOREWORD

By William C. Rogers
Staff Officer
Transportation Research Board

Major trends affecting the future of the United States and the world will dramatically reshape transportation priorities and needs. The American Association of State Highway and Transportation Officials established the NCHRP Project 20-83 research series to examine global and domestic long-range strategic issues and their implications for departments of transportation (DOTs) to help prepare the DOTs for the challenges and benefits created by these trends. *NCHRP Report 750: Strategic Issues Facing Transportation, Volume 1: Scenario Planning for Freight Transportation Infrastructure Investment* is the first report in this series.

NCHRP Report 750, Volume 1 provides decision makers with a critical analysis of the driving forces behind high-impact economic and social changes as well as sourcing patterns that may affect the U.S. freight transportation system. A detailed discussion of the driving forces is contained in *NCHRP Web-Only Document 195: Driving Forces Influencing Future Freight Flows. NCHRP Report 750, Volume 1* also introduces scenario planning as a tool that can be used in conjunction with other planning methods to improve the quality of long-range transportation infrastructure planning.

The U.S. freight transportation system is a key underpinning of American economic activity. Understanding the driving forces that could most significantly affect the transportation system over the next 50 years will allow local, regional, and national transportation decision makers to anticipate and invest in transportation system improvements that enable the system to continue to provide key structural support to the U.S. economy. Foreseeing changes over the longer term future and the consequences of such changes is difficult but not entirely impossible. Management strategies that recognize emerging trends and are flexible, adaptive, and able to respond effectively will help ensure that the transportation system continues to support the growth of the economy and the delivery of an increasingly high quality of life for the nation. By identifying the most significant trends and other forces between now and 2050, considering plausible trend lines (scenarios) for these forces, examining how they might interact with each other, identifying what indicators should be monitored and what the potential tipping points are that would indicate a systematic shift, and determining how the indicators can be monitored, decision makers will be enabled to make better infrastructure investments.

Under NCHRP Project 20-83(01), the Massachusetts Institute of Technology was asked to provide decision makers with a critical analysis of the driving forces behind high-impact economic changes and business sourcing patterns that may affect the U.S. freight transportation system. To accomplish the research objective, the research team catalogued and assessed driving forces, points where systemic changes occur, leading indicators, and critical

dependencies, as well as the relative importance of these factors to future freight patterns. The research team then identified plausible representative scenarios of driving forces and their impacts on future levels and patterns of freight movement, fully articulated to enable "what-if" discussions of consequences, opportunities, and threats posed. The team also identified the means for realizing, accommodating, or managing policy strategies under the various scenarios.

Four future scenarios were developed as part of the research project, as well as a detailed methodology for planners to follow to conduct their own scenario planning workshops, and are included herein on this report's companion DVD package and are available for download as an ISO image on the TRB website (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

CONTENTS

SECTION 1

Introduction and Background

The future rarely moves in predictable, incremental ways. Often seemingly small changes in technology, demographics, regulations, economics, or a myriad of other factors have dramatic and unintended impacts on how any organization (public or private) plans and operates. These nonlinear impacts are very difficult to predict using traditional forecasting methods and techniques since they, by definition, do not follow any historical patterns.

For example, few in April 1956 would have foreseen the global trade implications (and resulting freight infrastructure requirements) of Malcolm McLean's small experimental move of 58 metal containers on the ship the *Ideal-X* from Newark to Houston. What had been intended as a way to reduce traffic congestion on the highways through short sea shipping along the East Coast ended up playing a key role in making offshoring of manufacturing in low-cost locations across the globe economically viable. Containerization is ultimately the driving force behind the tremendous infrastructure projects at and adjacent to ports on the East and West Coasts as well as the Gulf. While this impact might seem obvious in retrospect, it certainly was not at the time.

Are we facing a similar situation today? In 10, 20, 30 years from now, will people look back and be amazed that we were unable to predict the full impact that some new innovation had on the economy? Probably. It is never easy at any point in time to be able to predict which, out of all of the possible future outcomes, will actually happen and should therefore be planned for.

For example, consider the effect of digitization. We are all familiar with the impact that digitization has had on recorded music, movies, and books. What was once a physical product that had to be sourced, manufactured, and distributed has been transformed into a purely digital form that can be reproduced and delivered almost instantaneously at close to no cost. The reduction in the number of physical retailers, increased incidence of piracy, and the collapse of much of the logistics supporting these industries have been well reported. The bankruptcy of such stalwart companies such as Blockbuster (video rental), Kodak (photography), and Borders (book retailer) is an example of how disruptive these step changes can be to companies and industries. All information-based products seem to be headed in the same direction.

However, what about physical products? Will personal microfabrication technologies, such as additive manufacturing or three-dimensional printing, become widely adopted and transform the consumer package goods industry in a similar fashion? Imagine if each small city or town had the ability to manufacture (and personalize) the majority of the products used every day within their own community—using only basic raw materials. How would that change the industry, the logistics providers, and the retailers? What would the supporting infrastructure need to look like? Or will it never take hold?

It is not just technology. Consider the impact of changes in government regulations. Suppose that environmental regulations within the next 20 years require the tagging and tracking of

potentially hazardous or recyclable materials with the retailer being responsible for safe disposal. What new challenges and market opportunities would this create? Again, how would the underlying freight transportation infrastructure need to change?

Or demographics. The percentage of people worldwide living within urban areas has increased from 30 percent in 1950 to almost 50 percent today—with forecasts putting this at 60 percent by 2030. The distribution of this population between top-tier and second-tier cities is less certain, however. In the United States (U.S.), for example, of the 15 fastest growing urban areas from 1990 to 2010, only one was in the top in 1990. The idea of urban logistics is no longer just a problem for New York City, Los Angeles, and Chicago. How will this increased urban concentration of residences across the United States affect the way products are manufactured and distributed? Will this mean that the local urban governments will need to take ownership of the last mile distribution? How will the underlying freight transportation infrastructure need to adapt to meet these changing requirements?

There are countless other examples of potential step changes in economics, energy, regulations, technology, and other areas that can have tremendous impacts on how businesses and other organizations operate in the future.

1.1 Challenges Specific to Transportation Planning

While it is a very difficult thing for a *company* to try to plan for these different potential outcomes, it is even more difficult for the *governments* to do so—especially when it comes to infrastructure investment. Not only do public-sector investments require consensus across a wide variety of diverse and competing stakeholders, the projects also take a very long time.

The planning lifecycle of public infrastructure projects needs to be measured in decades, as opposed to months or quarters as is the case for most businesses. For example, one of the most successful freight infrastructure projects is the Alameda Corridor. This 20-mile-long partially sunken intermodal corridor links the ports of Long Beach and Los Angeles to the transcontinental rail lines near Los Angeles. While initial planning began in 1981, approval did not occur until 1994, construction began in 1997, and it was finally opened for traffic in 2002. The Alameda Corridor took over 20 years from concept to first use and is considered to be a very successful project! Similarly, the Big Dig or Central Artery/Tunnel Project in Boston, Massachusetts, took slightly over 25 years from planning to first opening.

This lengthy gestation time is not a reflection on the competence of the planners or officials involved—it is the nature of building public infrastructure. Also, the design lives of these structures are very long. For example, the Alameda Corridor had a 20-plus-years design life. So, the original design in 1981 had to forecast traffic patterns and flows 30 to 40 years in the future. Thus, the time spent in planning is obviously worthwhile. In any case, it makes the government's task of trying to forecast and plan in an uncertain future exceptionally difficult.

A project that is entering the planning stage in 2012 will probably not be ready for use until 2020 at the earliest and most likely 2030 or later. And then it is expected to have a life of up to 50 or 75 years beyond that. So the idea of trying to develop a better planning method for uncertain events in the future fits very well to the planning horizon that the government is required to live with.

Additionally, the United States freight transportation network is a highly complex system serving a diverse set of stakeholders and facing tremendous uncertainties and risk. It is also massive, consisting of almost a million miles of federal-aid highways, over a hundred thousand miles of railroad, over ten thousand miles of inland waterways, and more than a million miles

of pipeline. The system, as a whole, moves more than 50 million tons of freight valued at over 45 billion dollars each day.

The complexity arises from more than size, however. Most shipments traveling through the system usually involve two or more organizations, cross multiple borders (municipality, state, or international), and utilize a mix of both public and private infrastructure. One of the defining characteristics of freight transportation is the incredibly diverse set of stakeholders engaged in its design, planning, management, and operations. This set of stakeholders includes shippers (ranging from retailers to manufacturers to distributors and beyond), carriers (across all physical and economic modes such as full truckload, less than truckload, parcel, national rail, short-haul rail, air, barge, and pipeline), third-party firms (such as brokers, forwarders, and third-party logistics providers), and governmental agencies (at the federal, state, regional, and metropolitan planning organization (MPO) levels). It is estimated that over 117 million households, 7.6 million business establishments, and almost one hundred thousand units of government are involved in freight transportation every day ("Freight Facts and Figures 2010," U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations).

Unfortunately, the planning and strategic development conducted by these key stakeholders (shippers, carriers, third parties, and government agencies) is usually insular and does not involve the other stakeholders. There is tremendous "silo-ing" within freight transportation. Each stakeholder group tends to hold its own conferences, belong to different professional organizations, and lobby independently. This separation is even worse when considering the gap between the private and the public sectors. A 2005 survey of over 500 shippers, carriers, third-party providers, and government officials from the federal, state, and local levels found that two-thirds of shippers and more than half of the carriers had never met with any government official at any level! (Caplice, C., and E. Blanco. 2006. *Freight Transportation Infrastructure Survey: Causes and Solutions to the Current Capacity Crisis,* MIT Center for Transportation and Logistics (CTL) Working Paper Series, Cambridge, MA.)

Adding to the vast size, inherent complexity, and diverse set of stakeholders, are the increasingly high levels of uncertainty that the U.S. freight transportation system must address. Much of the uncertainty comes from forces outside of the stakeholders' immediate control. These include the price and availability of fuel, emerging technologies, demographic trends, national and global economic conditions, international balance of trade, regulatory concerns, and many more.

For all of these reasons, the ability to effectively plan for future freight infrastructure investments is becoming both more critical and more difficult for government planning agencies at all levels.

1.2 Research Project Objectives

This research project has two major objectives. First, it provides decision makers (at all levels and across all stakeholders) with a critical and comprehensive analysis of the factors, trends, and uncertainties that may affect the U.S. freight transportation system over the next 30 to 50 years. Second, and most importantly, it introduces the Scenario Planning Methodology to these decision makers (primarily at the state department of transportation (DOT) level) for their use in creating a more flexible, adaptive, and responsive transportation management strategy on an ongoing basis. As a side benefit, this methodology will engender more productive interaction between the diverse stakeholders of the U.S. freight transportation system.

It is important to point out that this project was *not* to develop the official version of the future for the U.S. freight transportation system to be used by all of the decision makers. As mentioned above, the system is too large and complex and faces too many uncertainties for this to be possible. Also, the planning and assessment of policy and management strategies should be an ongoing

process involving as many stakeholders as possible—not a one-time event. Therefore, the project will not simply provide a static list of actions that a DOT might undertake to prepare for the future. Instead, it will provide a set of customized scenario planning tools and procedures that can be adopted and immediately implemented by the various decision makers across the stakeholders.

1.3 Background on the Scenario Planning Methodology

Scenario planning is a process of long-term strategic planning that involves the development and use of future scenarios of the problem or system at hand. A scenario is simply a vision of a possible future state of the world and the relevant environment. Scenarios are methodically constructed stories about alternative futures in which today's decisions might play out. A good scenario must be plausible, internally consistent, and challenging for strategic purposes. It should make the decision makers see the future in new ways and question their unspoken assumptions. A scenario planning engagement should involve the use of multiple, mutually exclusive scenarios.

In addition to gaining key insights through this process, decision makers uncover their hidden assumptions about the future and possible opportunities. A major impediment to planning successfully in the face of uncertainty is that we become tethered to established beliefs and accepted wisdom—in other words, hidden assumptions. Yet to operate effectively in this environment, we must open up our minds to multiple possibilities, rather than use mental constructs that are rooted in past experience and guided by personal beliefs and preferences.

Scenario planning as a methodology grew out of military planning in World War II. It has long been the practice in the U.S. Air Force and other branches of the military to envision different potential future engagements or situations and then to develop appropriate strategies. These forms of "sandbox exercises" were used by the military throughout the Cold War, and beyond, to train its leaders and planners with the ability to consider multiple potential situations and to adapt accordingly.

The RAND Corporation, a not-for-profit think tank founded in 1948, was one of the pioneers of scenario planning in the 1950s and the 1960s. At that point in time, however, most of these planning engagements were more along the line of scenario analysis than scenario planning. The distinction is that probabilities for each potential outcome are estimated and used during scenario analysis, while this is eschewed for scenario planning. Scenario analysis utilizes game theory to a greater extent than scenario planning, which is designed to be more of a brainstorming and thought-expanding tool. Herman Kahn, the founder of the Hudson Institute and a leading futurist, was part of the RAND team that developed scenarios centered on nuclear warfare. Kahn also became one of the first people to apply the scenario planning techniques to businesses. He, for example, developed scenarios foretelling the rise of Japan as an economic powerhouse.

It was in the 1970s that scenario planning became truly established. Pierre Wack, a planner in the group planning department of Royal Dutch/Shell, was charged with looking for events that would cause changes in oil prices. Oil prices had been relatively stable since World War II and the conventional wisdom did not see any reasons why this would change. Wack and his team developed two scenarios. The first was a reflection of the conventional wisdom where oil prices moved along historical trends. The second scenario, however, made the dramatic assumption that the Organization of Petroleum Exporting Countries (OPEC) nations would not renew their oil agreements that were set to retire in 1975. Instead, they would leverage the United States' growing dependence on their oil and withhold the supply, thus dramatically driving the price of oil up. Both scenarios were briefed to senior management along with price projections and other statistics, but senior management did not take any immediate actions.

Wack made the realization that to make management truly understand and prepare for potential unforeseen effects was to get it emotionally engaged—not just by presenting financial projections. He fleshed out his scenarios, especially the second more controversial one, with detailed descriptions of the ramifications and the aftermath of what a strong OPEC would look like. This included the realization that they should be prepared to be part of a slow-growth industry.

In 1973, the second scenario essentially came true following the Yom Kippur war. While the Shell management had not taken proactive steps for preparing for this outcome, they had become emotionally prepared for such an event. The energy crisis hit all oil firms hard, but throughout the 1970s Shell grew from being one of the smallest of the seven major oil firms to being, arguably, the most profitable. The upper management at Shell had been able to react quickly to the unfolding events in part due to Wack's earlier scenario planning engagements.

This marked a dramatic change in how scenario planning was viewed. Instead of being treated as a forecasting or prognostication tool, it was used as a way of changing the way decision makers think. Peter Schwartz notes that this was when it became apparent that the end result of scenario planning for any organization "is not an accurate picture of tomorrow, but better decisions about the future" (Schwartz, 1991).

Over the past 40 years, a number of organizations and companies have used scenario planning to help them better prepare their leaders and managers to make better decisions. These have included the Australian government, AutoNation, BASF, British Airways, California Teachers Association, Cisco, Corning, Disney, General Electric, JDS Uniphase, KinderCare (a large U.S. chain of day care centers), Mercedes, UPS, the United States Environmental Protection Agency, the World Bank, and others. Several references on scenario planning and its history and use can be found in the References section of this report.

1.4 Organization of the Report

The remainder of the report is organized as follows. Section Two describes the methodology used to develop the scenarios. Traditional methods are presented along with examples from different organizations. These methods are then compared and contrasted with the methodology used for the development of the Future Freight Flows (FFF) scenarios created as part of this project. Section Three provides an overview of the scenarios themselves. Each of the four scenarios is described and compared. Section Four details how these scenarios were used in the six Scenario Planning Workshops held across the United States in the fall of 2010 through the summer of 2011. Section Five summarizes the results of the workshops. Section Six provides suggestions on how the scenario planning process can be incorporated into existing freight infrastructure processes within a state department of transportation. Finally, Section Seven concludes the report and provides recommended areas for future research. There are also five appendices to the report that provide greater detail on the Future Freight Flow symposium held at MIT and the six workshops held across the United States.

SECTION 2

Scenario Development

This section provides an overview of the traditional formal process used by most organizations to create scenarios. We also provide several examples of how this was used and the resulting scenarios. We then explain why the development of the Future Freight Flows (FFF) scenarios differed from traditional ones. Finally, we detail the method used and the resulting analysis of driving forces and critical uncertainties.

2.1 Traditional Scenario Planning Process

While there is not a single, formal process for developing scenarios, there are generally accepted practices. For an in-depth review of scenario planning methodologies, see Phadnis (2012). The most commonly used, or referenced, method is associated with Peter Schwartz who founded the firm Global Business Network. Schwartz's method has eight steps, as follows:

1. **Identify Focal Issue**—What is the central question to be answered?
2. **Identify Key Local Factors**—These are things that influence the success or failure of the focal issue and usually relate to stakeholders of the organization.
3. **Identify Driving Forces**—These are macro factors that affect the organization but are neither controlled nor influenced by it.
4. **Rank Driving Forces by Importance and Uncertainty**—This ranking helps focus scenario creation on the critical forces.
5. **Select Scenario Logic**—Scenario logic is the set of the most critical driving forces, which are specified to take different values in the different scenarios being developed. The most common method of choosing scenario logic is to oppose the two most important and uncertain driving forces thereby creating a two by two matrix and thus four potential outcomes.
6. **Flesh Out the Scenarios**—After specifying the logic, the less critical factors are feathered in to create realistic and internally consistent scenarios.
7. **Apply the Scenarios and Uncover Implications**—Appropriate stakeholders are invited to evaluate the focus issue in different scenarios. The resulting scenario-specific evaluations are contrasted to identify the robust and contingent decisions.
8. **Identify Leading Indicators and Signposts**—Scenario evaluation separates robust strategies (useful in all scenarios) from contingent ones (useful in some but not all scenarios). Leading indicators and signposts are the variables that help discriminate among the scenarios to suggest which scenario the world may be heading toward.

Other methods have similar steps, but with different names. For example, Scearce and Fulton (2004) have five stages: *Orient* (Schwartz steps 1 to 3), *Explore* (4), *Synthesize* (5 and 6), *Act* (7), and *Monitor* (8). Garvin and Levesque (2006) also describe a five-step process: *Define Focal Issue* (1), *Define Driving Forces* (2 and 3), *Create Scenarios with Narratives* (4 to 6), *Define Options* (7), and *Integrate* (8). Lindgren and Bandhold (2009) have a five-step process they trademarked as

TAIDA: Tracking (1), *Analyzing* (2 to 5), *Imaging* (6), *Deciding* (7), and *Acting* (8). The tasks within each step for these different methods are essentially identical.

In any case, the development of the scenarios involves a tremendous amount of interviews and discussions with the stakeholders most affected by the scenario. The scenarios are in effect customized to that organization and to that organization's specific focal issue.

2.2 Criteria of Good Scenarios

One of the most difficult questions related to the scenario creation process is how to evaluate the quality of scenarios created by the process. Scenarios are *planning aids* used to develop long-range plans by considering potentially different futures; they are not *predictions.* Therefore, their validity cannot be evaluated by seeing if one of the scenarios in a set comes to fruition. In lieu of objective tests, scenario planning literature provides the desired attributes of scenarios. These can be divided into two groups: qualities of good scenario sets and qualities of good scenarios (Lindgren and Bandhold, 2009; Phadnis, 2012).

Desired attributes of scenario sets include the following:

- **Number of Scenarios**—Two to four.
- **Challenging**—The scenarios should challenge the organization's conventional wisdom about the future. If they only reflect the current thinking then the resulting brainstorming will not uncover new insights. These are typically achieved by having multiple, diverse scenarios in a scenario set.
- **Differentiated**—The scenarios should present stark and dramatically different future environments. If the scenarios are too similar to each other, the exercise will be limited and will tend to stay in the commonly accepted bounds of the projected future.
- **Contain Alternatives**—There should not be a favorite or preferred scenario. Avoid perfect "heaven or hell on earth" scenarios. Also, avoid creating scenarios that reflect either the organization's established vision or the current forecast of the future. These "unofficial–official" scenarios tend to attract and anchor stakeholders and lead them to ignore the other scenarios. This defeats the purpose of the exercise.

Desired attributes of scenarios include the following:

- **Centered on the Focal Issue**—The scenarios should capture the ultimate decision the organization is trying to make. The underlying structure of the scenarios should be based on the decision at hand.
- **Plausible**—The users should believe that the scenario can "grow logically from the past and the present" (van der Heijden, 2005). Having a scenario with "save the world" technology, for example, can be unrealistic.
- **Internally Consistent**—The logic in the scenario should be consistent, that is, the scenario's internal logic needs to be aligned. One aspect of the scenario cannot contradict others. This also helps improve plausibility.
- **Memorable**—The scenarios should be easy to recall after an event. The names, for example, should be descriptive, evocative, and catchy. The names of the scenarios will ultimately become touchstones for future conversations. They can form a common language or shortcut codes within the organization to connote a certain outcome.
- **Doesn't Answer the Focal Question Directly**—The material developed for the scenario should not overtly answer the focal question. The purpose of using scenarios is to provide decision makers an alternate vision of the future and to let them apply their knowledge to devise creative solutions suitable for that vision. Prescribing answers in the scenario suggests that scenario-creator(s) know(s) the decision context better than the people who live in it.

In most cases, these scenarios are developed in an iterative fashion. The initial scenarios are tested in small groups for plausibility, consistency, and so forth and are continually tweaked until they represent a full set of potential futures from which to work.

2.3 Examples of Scenario Planning Initiatives

In this section, we briefly describe some of the scenarios created and used by different organizations in their long-range planning. The objective here is to illustrate how critical uncertainties are combined to form multiple scenarios. Note that publication of scenarios used by organizations for long-range planning is rather an exception than the norm, because of their strategic value to the organization.

2.3.1 United Parcel Service 1997—Centennial Scenarios of 2007

The United Parcel Service (UPS) is one of the organizations that has embraced the culture of scenario planning for developing long-range plans. The first reported use of scenario planning at UPS was in 1997. Today, scenario planning is now an accepted and integral component of the UPS strategy development and analysis process. Engagements vary in planning horizon (1 to 3 years versus decades), scope (global versus regional), and breadth (single topic versus multiple) (Rogers, 2011).

In 1997 UPS developed a set of scenarios for use in its larger strategy planning process in order to better prepare for its 100th anniversary in 2007 (see Garvin and Levesque, 2006 or De Wit and Meyer, 2010). Extensive interviews of executives, managers, and others were conducted both inside and outside of UPS. The ultimate focal question was: "What is UPS's global business in this ever-changing competitive environment?"

From the driving forces identified through interviews and discussions, two were found to be most critical for the focal question: (1) "Market Environment," defined as the level of cross-border trade, which could be either "regional/national with border restrictions" or "free-flowing global trade," and (2) "Demand Characteristics," referring to the nature of the UPS consumers, which could lie on the continuum between "traditional users of UPS services" and "proactive, sophisticated consumers demanding high value-added supply chain services." Combinations of the two extreme values of these two driving forces yielded four scenarios: "Tangled Paths" which described a nationalistic world with tight border controls and demanding customers; "Regressive World," a world with restrictions on cross-border trade and traditional customers; "Global Scale Prevails," a world with global trade where customers preferred traditional services; and "Brave New World," a flat world of global trade and customers demanding high value-added supply chain solutions.

The use of these 1997 scenarios made the UPS managers aware of establishing a retail presence, to meet the needs of the sophisticated customers—if the world were to evolve that way. After monitoring of the business environment and detailed analysis for a few years, UPS ultimately decided to acquire Mail Boxes Etc.—a network of retail stores providing business services—to gain a retail presence to attract the sophisticated consumers.

2.3.2 United Parcel Service 2004—Horizon 2017 Scenarios

In 2004, UPS launched another round of scenario planning to develop a new set of scenarios, as some of the driving forces that were uncertainties in 1997—such as industry consolidation, growth of the Internet—had been resolved, and new uncertain driving forces seemed to be influencing UPS's future business environment. Using a similar process for creating scenarios as it did in 1997, except with input from a broader group of academics, politicians, key customers,

and the like, four scenarios were developed to answer the focal question: "What is the future of UPS's world market and major regional markets in 2017?" The two driving forces forming the backbone of the scenarios were (1) "Commerce, Business Model, and Demand," described as either "traditional, proprietary, and incremental" or "proactive, open, and collaborative" business models in two scenarios each and (2) "Business Environment," described as either "harmonious, aligned, free, fluid, and borderless" or "chaotic, fragmented, and bordered." The two scenarios with traditional business models were "Company City" (harmonious environment) and "Bordered Disorder" (chaotic); the two scenarios with collaborative business models were "Networks without Borders" (harmonious) and "Connected Chaos" (chaotic).

2.3.3 Cisco 2010—Evolving Internet of 2025 Scenarios

In 2010, working with GBN, Cisco developed a set of scenarios to help it answer two fundamental questions: "What forces will shape the Internet between now and 2025?" and "How might the use of the Internet and IP networks evolve?" (Cisco and GBN(Global Business Network), 2010). Cisco conducted several dozen in-depth interviews with Cisco executives and managers as well as thought leaders from across multiple industries and domains. Based on this research they developed 14 "drivers of change" that they felt could dramatically change the environment. These were later grouped into three critical "Axes of Uncertainty:" "Network Build-Out" (either limited or extensive global broadband network), "Technological Progress" (incremental or breakthroughs), and "User Behavior" (constrained or unbridled use of the Internet). Instead of developing eight potential scenarios—the natural result of the combinations of three forces—Cisco created four representative ones, preferring those that were rather novel and divergent, yet still realistic. The four scenarios were "Fluid Frontiers" (technological breakthroughs, extensive Internet use, but limited broadband network), "Insecure Growth" (extensive network, technological breakthroughs, but limited Internet use), "Short of the Promise" (extensive network, but incremental technological developments and limited Internet use), and "Bursting at the Seams" (extensive Internet use, but limited broadband network and incremental technological advances).

2.3.4 Shell Oil 2005—Global 2025 Scenarios

Shell has been using scenarios for long-range planning since 1967—beginning with the "Year 2000" Study—and is considered a pioneer user of scenario planning in the business world. In 2005, Shell published its scenarios for the time period up to 2025 (Royal Dutch Shell, 2005). Instead of developing four scenarios from combinations of two extreme values of two critical driving forces, Shell developed three scenarios using a method it called *"two wins–one loss."* Three driving forces—"Market Incentives," "Community," and "Coercion/Regulation"—form the backbone of these scenarios. In each scenario, two of the three forces dominate the third force, resulting into "Low Trust Globalization" (market efficiency and regulations for security important), "Open Doors" (market efficiency and social justice important), and "Flags" (social justice and regulations important).

2.3.5 U.S. Pharmaceutical Supply Chain 2011–2016

In 2010 and 2011, researchers at MIT Center for Transportation & Logistics (CTL) developed four scenarios of the U.S. pharmaceutical distribution supply chain, for a 5-year planning horizon (Phadnis, 2012). The scenarios were developed for a firm operating in this industry to help answer the question "what supply chain strategy should the firm adopt to support its pharmaceutical distribution over the next 5 years?" The project sponsor (Senior Vice President, Operations) identified a group of 25 middle and senior executives to participate in the scenario study. Through interviews with these executives and industry research, the researchers identified 35 local factors and 14 driving forces relevant to the focal question. The executives evaluated the impact of

the local factors on the focal issue and assessed the relationship between driving forces and local factors. This data was used to estimate the effect of driving forces on the focal issue. Two driving forces—"Health of the U.S. Economy" (weak, strong) and "Complexity of U.S. Healthcare Supply Chains" (low, high)—formed the backbone of four scenarios, which included "Frenzy" (highly complex supply chains due to increased points of care, regulations, and so forth—operating in a weak economy where only large firms have survived and consolidated); "Innovo-Nation" (highly complex supply chains delivering temperature-sensitive drugs in a complex regulatory environment and a strong economy in which smaller biotech firms flourish); "Hiber-Nation" (weak economy in which firms have resorted to cost reduction by cutting down innovation, reducing product variety, and simplifying their supply chains); and "Zen" (strong economy that enabled an information technology revolution in healthcare, allowing patients to seek advice and buy prescription drugs online in the U.S.; this reduced the importance of brick-and-mortar stores and greatly reduced the complexity of the U.S. pharmaceutical supply chains).

2.3.6 Chemical Industry Supply Chains in South America—2020

In 2011, a team of researchers at MIT CTL helped supply chain planners at a multi-national chemical firm's South American business develop scenarios to answer the focal question "what should the firm's supply chain strategy in South America be to support the business growth planned through year 2020?" CTL researchers identified the driving forces that were possibly relevant to the focal issue via industry research. The local factors were identified in a workshop with the planners, who also evaluated the relevance of the driving forces vis-à-vis the focal decision and mapped the relationship between local factors and driving forces. The resulting assessment of driving forces' impact on the focal decision and their uncertainties revealed from industry research was used to develop three scenarios. Three driving forces—"Trading Blocs" (little global trade but free trade within South America, or free global trade), "Logistics Infrastructure in South America" (adequate or inadequate), "Sustainability" (high environmental consciousness, environmental concerns secondary to economic goals)—emerged as the most critical for the focal decision. Three scenarios were created: "Home Alone" (free global trade, supported by logistics infrastructure that is adequate to meet demand, and customers are willing to pay for green products), "Green South America" (divided world in which trading blocs have significantly restricted trade within South America, where logistics infrastructure cannot support the demand from customers willing to pay for green products), and "Latin Power" (world divided by trading blocs, where flourishing trade within South America is enabled by a developed infrastructure that is adequate to meet demand, and where economic and other concerns have taken a precedence over environmental friendliness).

2.3.7 Other Scenario Studies

There is no shortage of scenarios, many of which are publically available. We do not intend to be exhaustive in our illustration of scenario studies. Given below are a few sources of scenario studies the reader may refer to for more examples.

- Five scenarios of logistics in 2050 developed by DHL ("Delivering Tomorrow: Logistics 2050—A Scenario Study").
- Four "extreme scenarios" of the future of logistics in year 2025 developed by Supply Chain Management Institute and European Business School.
- Cousens et al. (2002) catalog 17 sets of scenarios, developed by organizations such as the Economist, Central Intelligence Agency (CIA), World Energy Council, and so forth.
- Ringland (1998) cites organizations that have developed scenarios.
- In 2007, MIT CTL developed three scenarios—Spin City, Synchronicity, and Alien Nation—to think about different visions of global trade.

2.4 FFF versus Traditional Scenario Development

The process used to develop the four FFF scenarios for this project had similarities and differences as compared to more traditional scenario planning engagements, such as the examples in the previous section. The basic eight step process as outlined in Section 2.1 was followed. However, there were four unique aspects to this project that required us to modify the process somewhat.

The first unique aspect is that the FFF scenarios had to be designed so that they could be used "out of the box" by different decision makers than the ones who helped develop them. In the traditional process, the people who help develop the scenario also apply the scenario. This means that the executives become very well attuned to and familiar with the driving forces, key local factors, and critical uncertainties involved. For the FFF project, the users will be exposed to scenario planning and the specific scenarios for the first time when they engage in a workshop.

Second, the scenarios had to be flexible enough to be used by planners in different levels of government: federal, state, local, MPO. The scenarios had to be general enough to be used at any level without significant customization. This meant that the scenarios could not drill down to state- or MPO-specific issues but instead had to stay at the national level with macroeconomic forces.

Third, the scenarios had to be generalizable enough to be used at different levels of regional specificity (nation, state, multi-state, city, county) and geography. We had to make the scenarios flexible enough to be used at any location within the United States and at essentially any level of specificity. Again, this forced us to remain at a national level. We could not include forces or uncertainties that dealt with one state or another. These local customizations could always be added to the formal descriptions.

Fourth, the strategic question or focal issue will change with each user. In traditional scenario planning, the scenarios are designed around a core question. For the FFF scenarios, we had to assume a generic question, "Where should investments in freight transportation infrastructure be made in [location TBD] today for the year 2040?" Different users might have slightly different questions, such as, "What should the priorities for the DOT be?" or "How should we fund different port investments?"

The project dictated that the development and use of the scenarios be divided into three phases. Each of these phases can be mapped to the eight steps discussed in Section 2.1. The first phase focused on the analysis of the critical uncertainties and the driving forces (covering steps 1 to 4). The second phase was dedicated to the writing and full development of the scenarios (steps 5 and 6). Finally, the third phase involved testing the scenarios in six workshops across the United States (steps 7 and 8). Figure 1 illustrates the steps taken in each of the first two phases. The details for phase three are discussed in Section 4.

The process started with the FFF Symposium at which thought leaders from five primary dimensions (social, technology, environment, economic, and political) presented potential future trends to a hand-picked group of expert practitioners. The selection of the expert practitioners replaced the one-on-one interviews used in traditional scenario development. This led to a brainstorming session during which the attendees generated potential Driving Forces and critical uncertainties. These were then analyzed, harmonized, and consolidated into 12 representative "Snapshot Scenarios." These Snapshot Scenarios were presented back to the practitioners in an interactive setting in which they developed estimates of each force's influence/uncertainty over time, its impact on freight flows, and how it would stress the existing U.S. infrastructure.

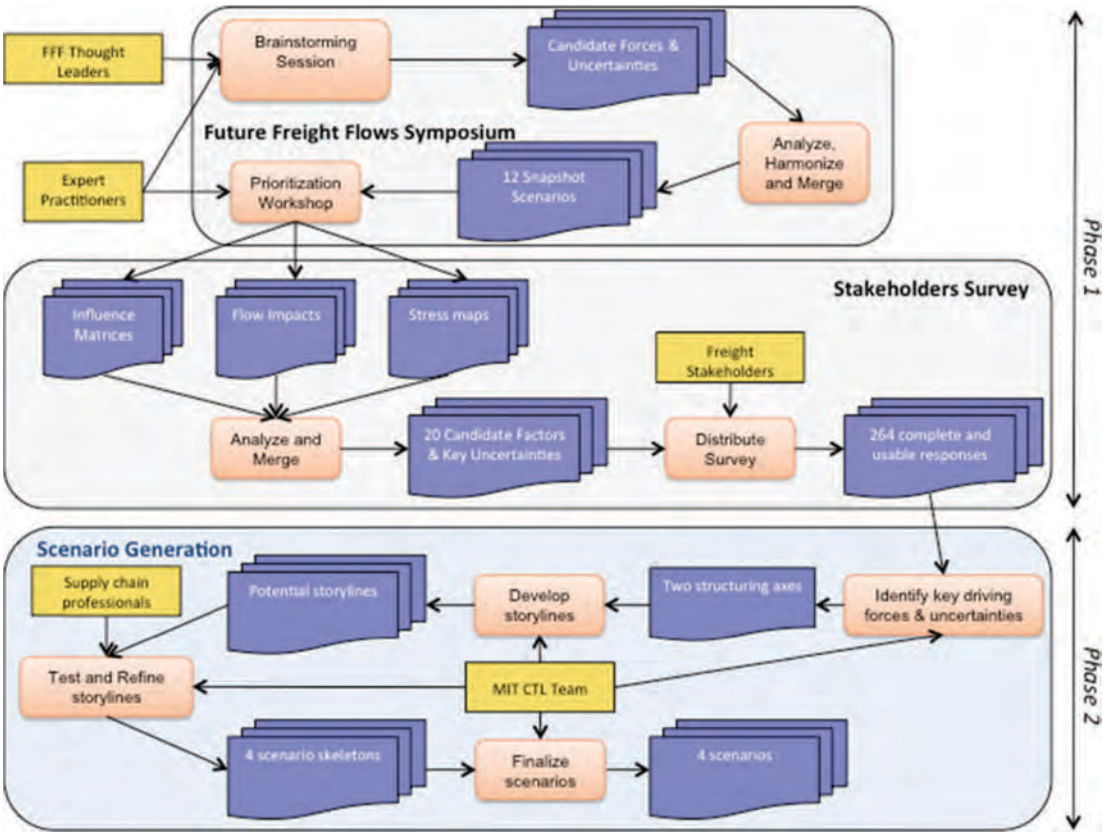


Figure 1. Process used for the development of the FFF scenarios.

The results of these 12 analyses were analyzed and translated into 20 more detailed Driving Forces. The Driving Forces were incorporated into a survey that was distributed to a large set of freight stakeholders for further prioritization. The survey respondents came from a diverse set of practitioners to include shippers, carriers, third-party logistics providers, and governmental transportation planners at the federal, state, and local levels. The results of the survey were analyzed to determine the key dimensions or axes that should be used in the development of the future scenarios.

The remainder of this section is organized as follows. Section 2.5 provides details on the process and methodology used to uncover the driving forces and critical uncertainties. This includes a discussion of the FFF Symposium, a review of the workshop materials tested, and a summary of the stakeholders survey instrument. Section 2.6 presents the combined analysis of the results from these activities.

2.5 Generation of Driving Forces and Critical Uncertainties

This section describes the process used by the research team to develop the underlying logic that will define the scenarios.

2.5.1 Future Freight Flow Symposium

The FFF Symposium was held March 11–12, 2010. The final agenda and attendance list is attached in Appendix A. A total of 60 handpicked non-MIT professionals participated as "expert practitioners."

The symposium opened with a restatement of the objective of the project as a whole and of the two-day symposium in particular. Additionally, the attendees were introduced to the concept of flow impacts. This was done in order to get the attendees to focus specifically on how any potential force or uncertainty would affect freight flows within a specified region. For the purpose of this symposium, we focused on the United States as a whole. However, all of the analysis and methods can be used on any predefined region or area.

2.5.1.1 Flow Impacts

There are an unlimited number of potential events, trends, or occurrences that can happen in the future. It is almost impossible to identify, much less plan for, all of these potential events. Instead, it is useful to translate these into a finite set of outcome types. We refer to these as flow impacts.

We created five flow impacts that capture the effect that any potential driving force or critical uncertainty might have on FFF. These are shown graphically in Figure 2.

Sourcing patterns capture any changes in the location of the origins for most freight movements. This includes procurement of raw materials, manufacturing, and distribution. Changes to flow destinations capture any shifting in the locations of final demand—such as increased urbanization. Routing impacts capture any changes that affect the path that product will take to move from origin to destination. This could include, for example, changes in mode, such as from over-the-road truck to intermodal or rail. Changes to a region's flow volume include any increase or decrease to the total tonnage or volume. Finally, value density impacts capture events that change the characteristics of the freight being shipped. The value density is used as a proxy for all of the various changes that can occur since this ratio is a primary criterion for mode choice as well as supply chain network design. Products with a higher value density (think diamonds) tend to be shipped by faster more expensive modes (air) than lower value density products (bricks).

In order to illustrate how the flow impacts are used, consider the effect that containerization has had on business. Containerization has very strong sourcing pattern impacts since it enabled the offshoring of manufacturing across the globe. This shifted the point of origin for most manufactured products from domestic locations distributed across the country to a handful of ports—mainly on the West Coast. Containerization also has strong routing impacts since this shifting increased flow through fewer collection points (ports) and tended to use intermodal transportation to move the product inland to major metropolitan areas. There was minimal flow destination impact since containerization has not really changed location of the ultimate

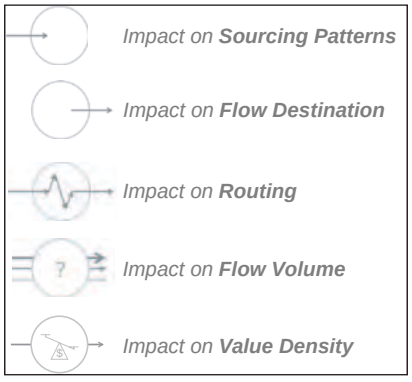


Figure 2. Descriptions of flow impacts.

demand. There was strong flow volume impact as the number of containers moved through the United States increased dramatically. Finally, containerization has not significantly impacted the value density of the freight. Other technological innovations over the past 30 years have caused the value density to increase.

2.5.1.2 Thought Leader Presentations and Brainstorming Sessions

The first day (Thursday, March 11) was a diverging session in which the participants were encouraged to brainstorm potential critical uncertainties and driving forces. The day consisted of seven speakers presenting different visions of the future along standard STEEP themes (social, technological, environmental, economic, and political). The expert practitioner participants were also asked to brainstorm their own potential driving forces during the sessions. The seven topics and keynote speakers were as follows:

- *A Nation Of Floridas: Aging, Changing Lifestyles & The Future of Freight,*
  Dr. Joseph Coughlin, Director, MIT Agelab.
- *After The Storm: New Challenges for the Global Economy in 2010–2030,*
  Sara Johnson, IHS Global Insight.
- *Public Policy and Freight,*
  David Luberoff, Harvard University Kennedy School of Government.
- *Transporting Bits and Atoms,*
  Professor Neil Gershenfeld, MIT Center for Bits and Atoms.
- *The New Age of Sensing,*
  Prof. Sanjay Sarma, MIT Mechanical Engineering.
- *Wired for Innovation: How IT Is Reshaping the Economy,*
  Prof. Erik Brynjolfsson, MIT Sloan School of Management.
- *Measuring and Managing Sustainability,*
  Dr. Jonathan Johnson, The Sustainability Consortium.

Complete summaries of each of the thought leaders' presentations are in Appendix B, while video and slides are available on the companion DVD package and online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

After each speaker, the attendees were asked to write down the three most critical drivers from that presentation that they thought might impact the FFF for the United States. Additionally, they were asked to classify which of the five Flow Impacts this force or uncertainty fit into. A sample sheet is shown in Figure 3.

The attendees were asked to complete a separate sheet after each of the seven speakers as well as an additional one at the end of the day to capture any factors that were missed. Over 1,200 individual candidate drivers were collected.

The sheets were collected after each session and the team began harmonizing them. As expected, there was a fair amount of redundancy in the responses. Also, many of the responses tended to mirror the speakers' specific points. Beyond this, however, we were able to collect a large number of interesting and oftentimes unexpected responses. Unfortunately, we found that the respondents' classification of the specific flow impacts for each driver was not worth capturing. In most cases, the attendees simply checked all of the boxes for each driver.

The team boiled the submitted drivers down into 12 representative snapshot scenarios. The snapshot scenarios were then used in Friday's interactive workshop.

2.5.1.3 Interactive Workshop

The objective of the Friday session was to merge all of the different ideas and concepts that came up in the previous day's discussions. The attendees were divided into six cross-industry

Name _____ Session: "A Nation of Floridas", Joe Coughlin

Based on what you heard in this session, write down the three most critical drivers that you think might impact the future freight flows for the United States. Place a checkmark in the relevant impact dimensions and feel free to provide a short description of each driver.

Driver	Impact on Freight Flows					Comments / Description
	Sourcing Patterns	*Flow Destination*	*Routing*	*Volume*	*Value Density*	

From the Thursday brainstorming sessions

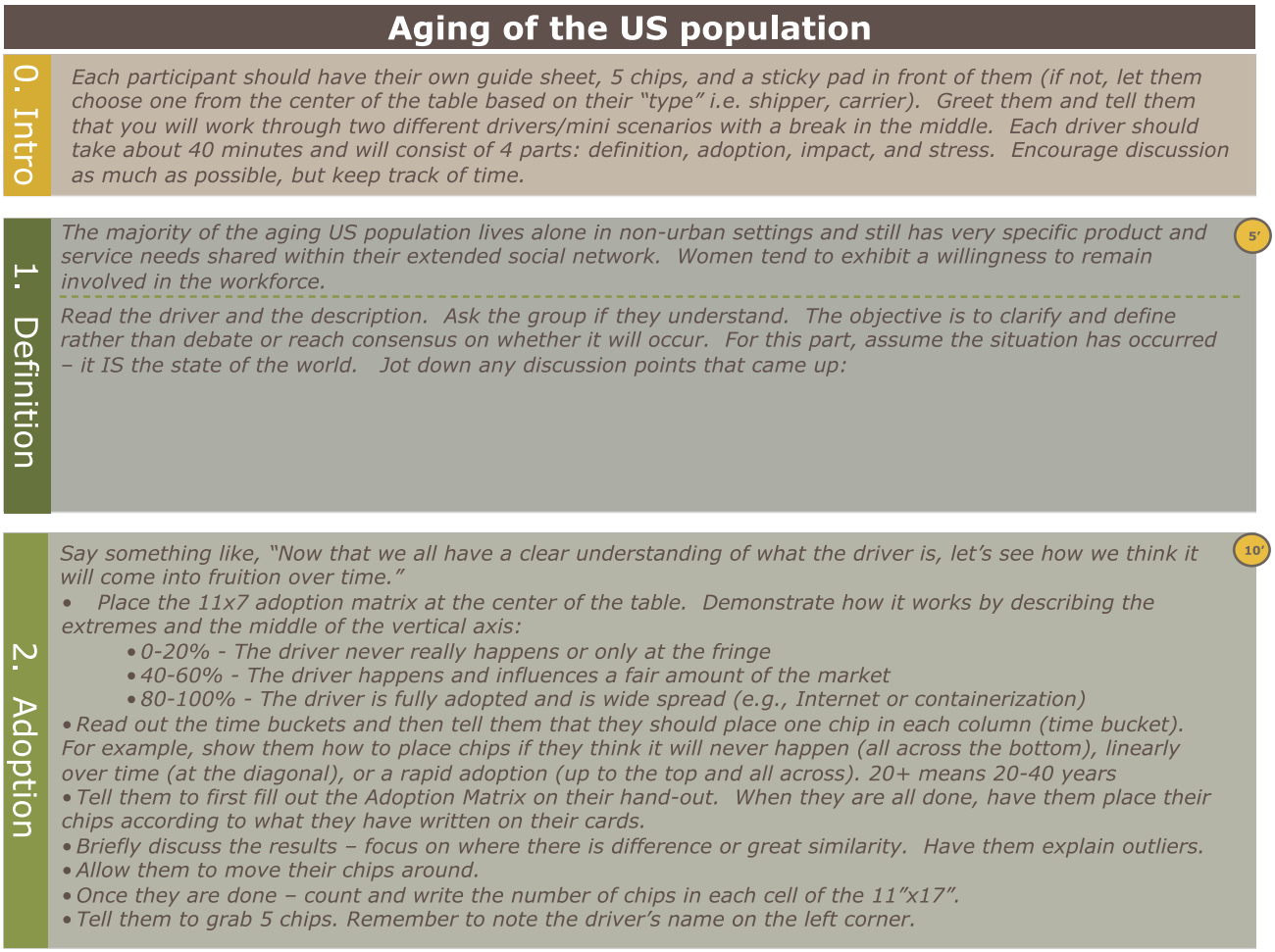
Figure 3. Potential driving forces/corresponding flow impacts data sheet.

groups and assigned two snapshot scenarios. Each team, facilitated by an MIT researcher, worked through a series of five tasks, as follows:

- **Definition**—the facilitator makes sure the team understands the Snapshot Scenario they are assigned.
- **Adoption/Influence Matrix**—the team estimates when and if the specific driver will influence the market.
- **Flow Impacts**—the facilitator asks the team to provide insights into how the specific driver would affect the freight system: sourcing patterns, destination distribution, routing, flow volume, and value density.
- **Stress Map**—the team allocates its assigned poker chips (used choice indicator) to a set of predetermined areas on an infrastructure map of the United States based on how it would be stressed under the given driving force.
- **Wrap Up**—the team can provides any detail on what was missed.

The facilitator's guide with instructions is shown in Figure 4 and Figure 5. The participants each had a worksheet outlining these steps, as shown in Figure 6 and Figure 7.

For the adoption matrix (see the middle section of Figure 6), each participant had poker chips—one for each time frame—and they had to place them according to the level of adoption or influence of that driver by that time period. They did this individually and then, after discussion,



Note: The yellow circles to the right of each section contain the number of minutes each section is expected to take.

Figure 4. Facilitator's guide to interactive workshop (part 1).

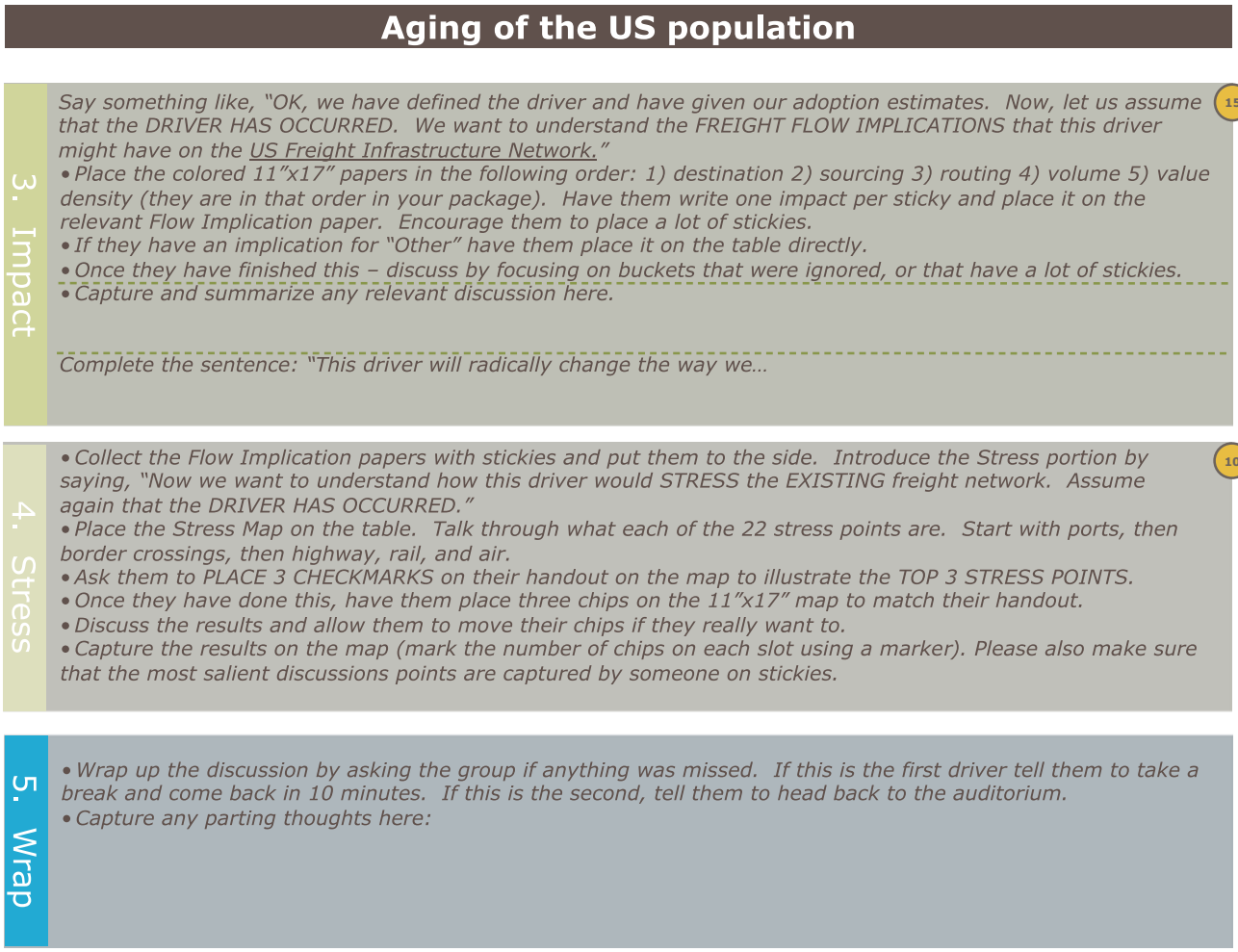
were allowed to change their choices. We found very little change in the individual versus team based influence curves.

For the flow impacts task, the participants wrote specific impacts for that scenario on sticky pads and classified them under the appropriate flow impact. This was not a very fruitful portion of the exercise as the attendees had a hard time clearly separating the flow classifications. Finally, on the stress map, each participant placed three chips on the communal map. This was very successful—the participants tended to discuss this with each other as they placed their chips. A refinement would be to have them set a benchmark or baseline level of stress prior to "betting" on the impact of the scenario under question. There were also recommendations on how to modify the stress map to include more and different investment options.

The adoption/impact matrices and summaries of the flow implications for each of the 12 snapshot scenarios are shown in Appendix C. Additionally, a description of the discussion and debate arising from two of the snapshot scenarios is captured in Appendix D.

2.5.2 Stakeholders Survey

Following the workshop, the team created a web-based survey containing a set of representative driving forces that were culled from the analysis of the workshop results.



Note: The yellow circles to the right of each section contain the number of minutes each section is expected to take.

Figure 5. Facilitator's guide to interactive workshop (part 2).

The objective of the survey was to prioritize the set of driving forces and critical uncertainties that were generated by our industry experts. A wider net was thrown to incorporate a larger set of perspectives. Because this was going out to a large number of individuals, it had to be self-explanatory and short. Based on the 12 snapshot scenarios in combination with the feedback received from participants at the end of the March 11–12 Symposium, we developed 20 comprehensively described driving forces and asked each respondent to assess both the impact (assuming it occurs) and the probability of it even occurring. For the impact, respondents rated each force on a scale of 1 (no impact at all) to 5 (tremendous impact). For the probability, they indicated how widespread the factor will be over the next 10 to 20 years by selecting from the following choices (on a 1 to 5 scale):

1. Unlikely to Happen (0–20%).
2. Present at Fringes Only (20–40%).
3. Generally Present (40–60%).
4. Widely Present (60–80%).
5. Omnipresent (80–100%).

The survey also collected information on role, industry, company size, and other demographic information.

Group Number: 1 Shipper ☐ Carrier ☐ 3PL ☐ Gov. ☐ Acad. ☐

Driver

1. Definition

XXXXX

2. Adoption Matrix

Place one chip per column.

Adoption	*Timeline*				
	0 – 2 yrs	*2 – 5 yrs*	*5 – 10 yrs*	*10 – 20 yrs*	*20 – 40 yrs*
80-100%					
60-80%					
40-60%					
20-40%					
0-20%					

3. Freight Flow Impacts

In this section, you will be asked to describe how this driver will impact sourcing patterns, flow destination, routing, flow volume and value density. Capture your thoughts on post-its and place them in the relevant bucket on the table.

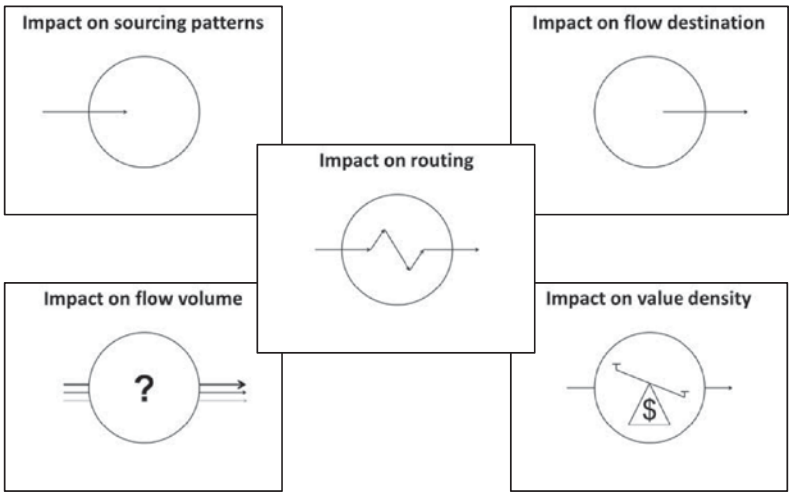


Figure 6. Adoption matrix/flow impacts from participants' sample form (front).

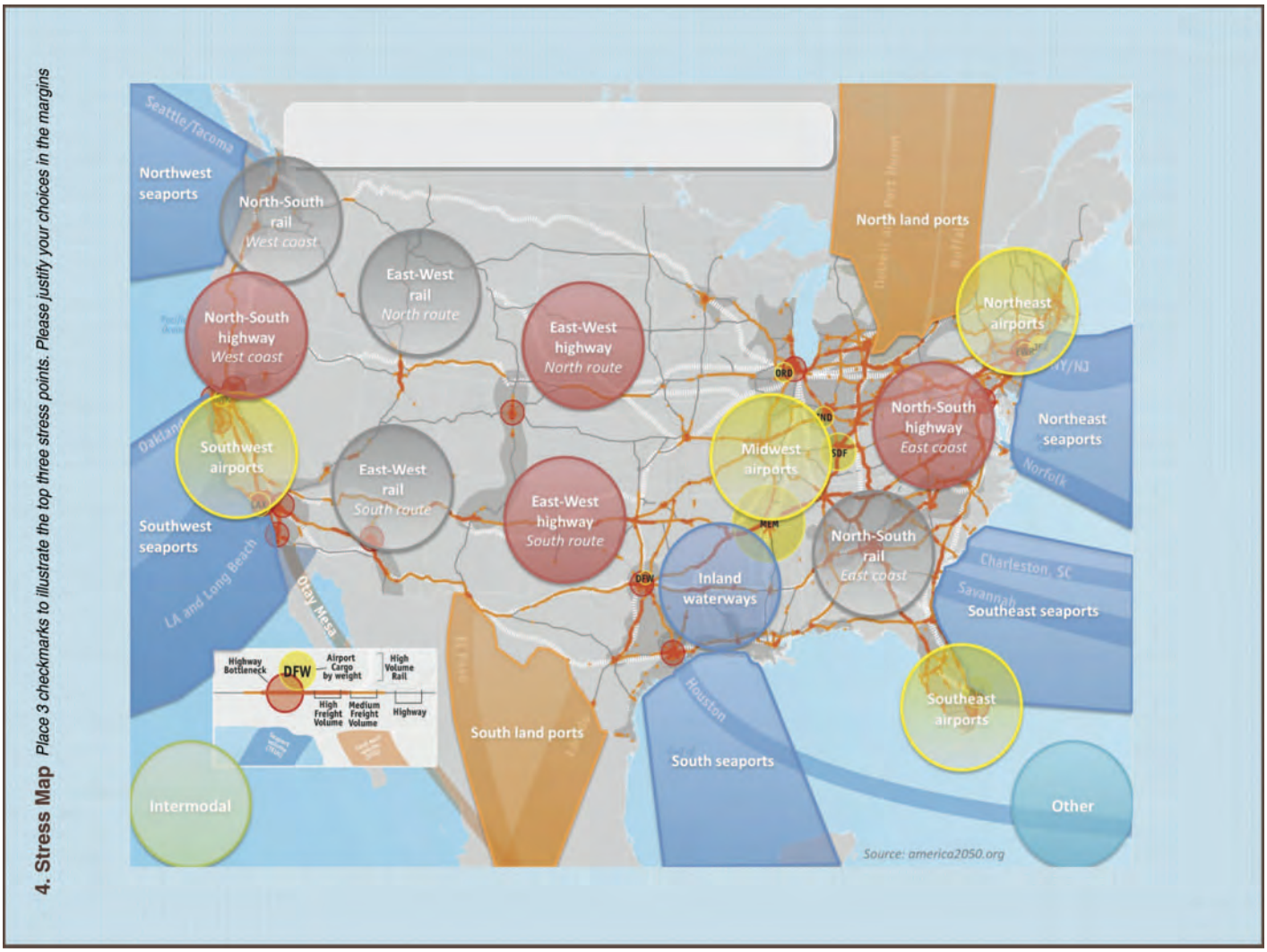


Figure 7. Stress Map of the United States from participants' sample form (back).

The survey instrument was completed and sent out in April 2010. A total of 264 complete and usable responses were collected from professionals across multiple industries and backgrounds. The results are discussed in Section 2.6, below.

2.6 Analysis of Driving Forces

While the initial brainstorming session yielded over 1,200 potential critical factors to consider, most of these were repetitive or obvious. It became apparent that most of the attendees were heavily influenced by both their current work situation as well as the topics addressed by the specific speakers. For example, Professor Gershenfeld's presentation on personal fabrication generated many suggestions of this having an impact—but, since we did not have a specific presentation on nanotechnology, for example, no one mentioned it. Similarly, the rising and volatile cost of oil was another common submission—which is predominately a current concern.

However, several potential factors came out of the analysis of these responses. We harmonized the responses and generated 12 factors that we called snapshot scenarios. Each of the snapshot scenarios is essentially a bundle of common driving forces. It is worth noting that the snapshot

scenarios were formulated as end states rather than trends. Indeed, our experience proves that people react better to a description of what the future may look like rather than a simple direction it may take.

2.6.1 Snapshot Scenarios

The 12 Snapshot Scenarios were as follows:

2.6.1.1 Aging of the U.S. Population

The majority of the aging U.S. population lives alone in non-urban settings and still has very specific product and service needs shared within their extended social network. Women tend to exhibit a willingness to remain involved in the workforce.

2.6.1.2 Increase in Global Trade

Global trade has made the majority of the countries strongly interdependent. This leads to higher volatility and extreme swings in GDP growth. Protectionism occurs but is only reactionary and is not permanent. The system is generally resilient with fluid trading blocks.

2.6.1.3 Rising Power of Emerging Markets

The dollar and the Euro have weakened. Emerging markets gained in affluence and purchasing power as well as political stability and financial strength. They are less focused on exporting as a means to grow and thus, are importing more.

2.6.1.4 International Climate Regulation

Climate change proved to be a reality with rising sea levels and higher overall temperature. However, the major disruptions actually stemmed from the higher variability in weather systems leading to more extreme and abrupt manifestations. A sense of urgency shared across developing and developed countries led to the creation of a Global Environment Council, which redefined business rules and regulations globally in alignment with the World Trade Organization (WTO).

2.6.1.5 Rise of Protectionism

Following the COP15 debacle and a longer than anticipated recession, countries reacted by raising tariffs and duties to protect their own industries. (The COP15 was the 5th session of the Conference of the Parties from 15 countries that met in Copenhagen in December 2009 to discuss climate change policies. It was noted for its failure to come to any conclusions or consensus.) While the U.S. tried to save the WTO, internal debates between the states led to the U.S. also adopting protectionist measures—sealing the fate of the WTO.

2.6.1.6 New Technology: Personal Fabrication

Fueled by the innovative high-tech tools, personal fabrication has become a reality. Open-source design and social network platforms empower people with creating the products that best reflect their personal universe and needs. Although more manufacturing will be done locally in the U.S., automation limits the number of jobs created.

2.6.1.7 New Technology: The "Senseable" Network

Cheap wireless technology enables ubiquitous presence of sensors on products, vehicles, and the infrastructure. This allows collection, transmission, and analysis of multiple attributes such as temperature, humidity, location, and the like.

2.6.1.8 Increase in Sustainability Regulations

Several layers of all-encompassing regulations at the international, federal, and state levels are enacted. These regulations cover at varying degrees social responsibility, environmental emissions, resource usage, and trade practices. This results in a patchwork of often conflicting rules and penalties.

2.6.1.9 Increase in Sustainability Customer Demand

Consumer demand for sustainable products is a reality led by different segments of the population including aging baby boomers, young mothers, and so forth. This is further fueled by innovative technology that enables consumers to make real-time decisions at the point of purchase.

2.6.1.10 Rise in Global Security Concerns

Due to heightened security concerns, federal regulations now require 100% scanning and tracking of all flows within and across the country. These procedures require state-of-the-art technology that both consumes time and is costly.

2.6.1.11 Rise in Commodity Prices and Availability

Unreliable supply or unpredictable demand has led to dramatic increase in volatility and price of commodities, including oil, metals, grain, and the like. Financial markets have further exacerbated the situation and new technologies have failed to solve the issue.

2.6.1.12 Additional Points of Entry Open Up

The Panama Canal is completed. The Northwest Passage is now open during summer. Manufacturing is no longer concentrated in the Pacific Rim as regions such as Africa have emerged as reliable suppliers for Europe and North America.

2.6.2 Impact Matrices/Influence Curves

The influence curve for each driving force is a graphical representation of how that factor will influence business (and thus potential freight flows) over time. We selected five time buckets (0 to 2 years, 2 to 5 years, 5 to 10 years, 10 to 20 years, and 20 to 40 years). The 0 to 2 years bucket can be considered current day while the 2 to 5 and 5 to 10 year buckets are more short term and the 10+ year buckets are long term. A k-means cluster analysis was conducted on the influence curves to identify any patterns. We found that all of the driving forces followed one of four types of influence curves: steady growth, rapid growth, peak and crest, and flat. These are shown in slightly stylized form in Figure 8.

The steady growth and rapid growth factors tend to start and end in the same places, but the path is very different. The steady growth forces tend to start out slowly but gather steam and eventually have widespread influence. The rapid growth forces have a more accelerated influence that reaches steady state. Peak and crest forces exhibit a rising influence but at some point lose their influence. The idea is that as the factor becomes widespread, the businesses and the economy adapt to it, and it loses any of its individual influence. Finally, there are flat forces that never really influence either the freight patterns or business in general.

2.6.3 Analysis of Snapshot Scenarios

The detailed impact matrices for each snapshot scenario are shown in Appendix C. Table 1 provides a summary of the scenarios in terms of the general classification (social, technology, economic, environmental, and political), the flow impact (sourcing, destinations, routing, volume, and value density), and influence type (steady growth, rapid growth, peak and crest, and flat).

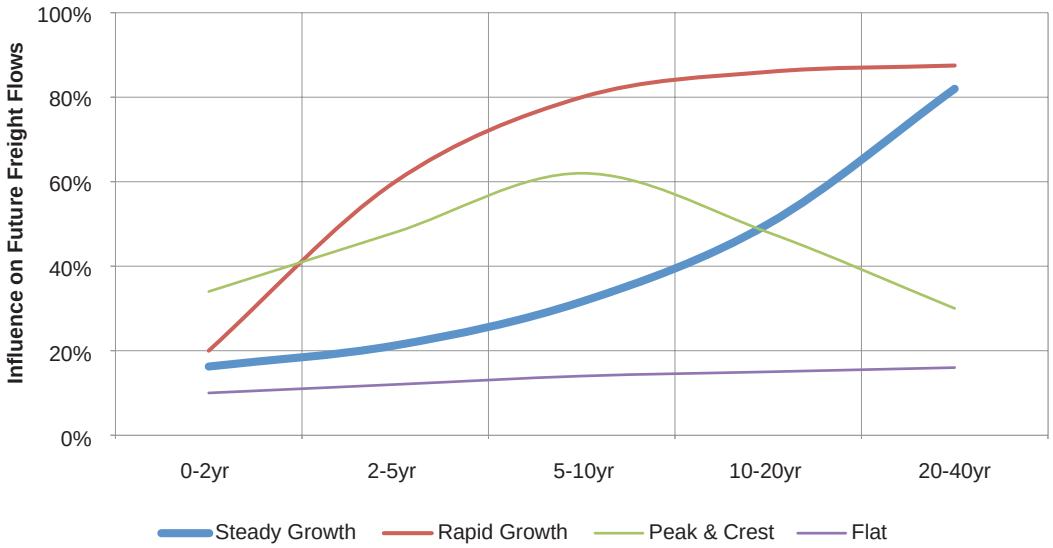


Figure 8. Types of influence curves.

Table 1. Classification of the 12 single-shot driving forces.

	Classification					Flow Impact					Influence Type				
Driving Force	**Social**	**Technology**	**Economic**	**Environmental**	**Political**	**Sourcing**	**Destinations**	**Routing**	**Volume**	**Value Density**	**Steady Growth**	**Rapid Growth**	**Peak and Crest**	**Flat**	**Comment**
Aging of the U.S. Population	X						X	X		⇑	X				Predetermined element
Increase in Global Trade			X			X		X	⇑	⇔		X			Tight consensus—potential blind spot
Rising Power of Emerging Markets			X		X		X	X	⇑	⇔	X				Tied to global trade
International Climate Regulation				X	X	X		X		⇓	X				Low uncertainty in short and mid term – high in long term
Rise of Protectionism			X			X	X	X	⇓				X		High uncertainty with decreasing impact
Personal Fabrication		X	X			X		X	⇓	⇓	X				High uncertainty in the long term
The "Senseable" Network		X						X				X			Predetermined element
Increase in Sustainability Regulations				X	X	X		X	⇓	⇑		X			Moderate levels of uncertainty
Increase in Sustainability Customer Demand	X			X		X		X	⇓	⇑	X				Uncertainty and impact increases with time
Rise in Global Security Concerns			X		X	X		X						X	Very low uncertainty and impact levels—potential blind spot
Rise in Commodity Prices and Availability			X			X	X			⇑		X			Too general for commodities—need to isolate fuel
Additional Points of Entry Open			X			X		X	⇑		X				Uncertainty and impact increases with time

X = classification; ⇑ = flow impact increases; ⇓ = flow impact decreases; ⇔ = mixed flow impact.

Note from Table 1 that the scenarios were a mix of social, technology, economic, environmental, and political forces. The flow impact and the influence type ratings were culled from the workshop responses. Some key takeaways from this analysis are as follows:

- The participants tended to be overly influenced by current events and situations. The "Rise in Commodity Prices" force included fuel along with other commodities. The influence of fuel on the transportation professionals overwhelmed the other commodity effects. We separated out fuel from other commodities going forward.
- The attendees classified the "Aging of the U.S. Population" force as being a steady growth type. While this force will have tremendous effect on freight flows, it can be considered a predetermined element. That is, it is a force that is slow changing and will occur regardless of the scenario. The idea is that while this might be a driving force, it will occur in any and all futures and thus is not a defining or differentiating factor. We further refined the demographic forces for the stakeholders survey. Specifically, we focused on two of the more contentious aspects of demographic trends for the survey: life expectancy and urban density.
- The "Senseable Network" force, like the aging force, was also seen to be a predetermined element. The presence of easily accessible sensor data should be included in all future scenarios.
- The "Increase in Global Trade" force was interesting in that it had tight consensus in the group for being rapid growth. This implies that there might be a blind spot in the participants' forecast of the future. This force is essentially an extension of the situation today—so it can be considered the "unofficial-official" future. It was important to further refine this in the survey to understand the dimensions of global trade that might have severe implications.
- The "Rise in Protectionism" force was unique in that it was thought to have peak and crest type of influence. As protectionism increases, it has less of an effect over time. This was the only force that fit this pattern.
- The three environmental forces (international climate regulation, increase in sustainability regulations, and increase in sustainability customer demand) were designed to capture different aspects of the environment's impact on freight flows. The first captured the impact of international regulations and bureaucracy, the second captured the impact of domestic "top-down" green rules, and the last captured "bottom-up" or demand-driven green practices. The top-down forces were viewed as being more likely to occur and have more impact than the consumer-driven force.
- The "Security Concerns" force was viewed as having little to no impact or influence on business. It was thought that this is more of the current situation and might be considered a predetermined element as well as a potential blind spot.

2.6.4 Stakeholder Survey

Based on the results of the interactive workshop, a set of 20 more refined driving forces were created as shown in Tables 2 and 3.

As shown in Table 4, there was a wide range of responses in terms of the expected impact and probability of occurrence.

The average value (for both impact and probability) is the average ranking from 1 (low) to 5 (high). The standard deviation is a measure of the dispersion around the mean or average value. The coefficient of variation is the ratio of the standard deviation to the mean—it essentially normalizes the variability. The columns with the rank are simply the ranking of each of the forces by average, standard deviation, and coefficient of variation, respectively—having a score of "1" respectively means having the highest average, the lowest standard deviation, and the lowest coefficient of variation.

Table 2. Candidate driving forces for stakeholders survey (part 1).

Driving Force	Description	Social	Technology	Economic	Environmental	Political	Sourcing	Destinations	Routing	Volume	Value Density
Re-domestication of manufacturing	Substantial re-domestication of manufacturing back to the United States			X			X	X	X		X
Reduction in global trade	Sustained reduction in global trade volume (both imports and exports) possibly due to rise of protectionism, pandemics, etc.			X			X			X	
Increased security threats	Large increase in both the number and magnitude of security threats (domestic and abroad)	X					X		X	X	
Green regulations	Stringent environmental and sustainability regulations adopted and strictly enforced by the United States and most other countries					X			X	X	X
High and volatile fuel prices	Dramatic increase in price and volatility of all oil-based fuels			X			X	X	X	X	X
Rise of BRIC markets	Ascendancy of consumer markets in Brazil, Russia, India, China, and other countries leading to increased demand for products manufactured in the United States			X				X		X	X
Low-cost batch manufacturing	Widespread adoption of technologies enabling efficient and low-cost small batch manufacturing for most consumer goods		X				X			X	X
Online retailing	Dramatic shift towards online purchase and point-of-use delivery leading to reduction of physical retail stores		X	X				X	X	X	X
"Senseable" network	Widespread ability to capture and monetize real-time sensing data on all products, vehicles, and facilities across a supply chain at essentially no cost		X						X		
Recycling regulations	Omnipresent enforcement of regulations and rules requiring recycling and re-use of all manufactured products				X	X			X	X	
Average age of 100	Average life expectancy reaching 100 years in the United States	X						X			X

Note: BRIC = Brazil, Russia, India, China.

Figure 9 plots the impact against the probability for each of the 20 driving forces. The driving force in the upper right corner (high impact and high probability) is the high and volatile fuel price force.

Another way to look at the driving forces is to compare how they rank. Figure 10 plots the rankings of each of the driving forces for impact versus probability. Note that most of the forces have correlated probabilities and impacts. There are some anomalies, however.

Reducing global trade and the re-domestication of manufacturing are both viewed to be very impactful (ranked 4th and 6th respectively) but are viewed to be extremely unlikely to occur (ranked 25th and 24th respectively). This implies that these might be blind spots worth including in the potential scenarios. Conversely, the recycling regulations, online retailing, and battery vehicles forces are viewed as being very likely to happen (ranked 5th, 4th, and 2nd, respectively) but will have next to no impact (ranked 10th, 12th, and 17th, respectively). These appear to be forces that are already having an effect today and should probably be considered as predetermined elements.

Figure 11 shows the driving forces grouped into their STEEP classifications and plotted for impact versus probability. Note that the political forces are both the least impactful as a group, and the least likely to occur. The other four categories are fairly similar in location.

Table 3. Candidate driving forces for stakeholders survey (part 2).

Driving Force	Description	Social	Technology	Economic	Environmental	Political	Sourcing	Destinations	Routing	Volume	Value Density
East Coast ports	Shifting point of entry for a majority of imports to the East Coast (e.g., due to rise in manufacturing in Africa, more ships using the Panama Canal, etc.)			X			X		X	X	
New agriculture powerhouses	New countries (such as Russia or India) emerging as agricultural powerhouses supplanting the United States in some food commodities			X				X	X	X	X
Water scarcity	Pervasive water scarcity in some regions leading to a reduction in exporting products that either contain water (e.g., fruit) or require a water intensive manufacturing process (e.g., soda, electronic chips)				X		X		X		X
Green customer demand	The sustainability and environmental "friendliness" of a product becoming the dominant factor for consumer demand for most products supplanting cost	X			X		X	X	X		
Mega cities	Over 90% of the United States consumers living and working in mega-region cities and built up urban areas	X						X	X		X
Zero immigration	Immigration into the United States reduced essentially to zero					X		X	X		
Battery vehicles	New battery technologies dramatically reducing the cost and increasing the efficiency and range of electronic vehicles		X					X	X		X
Commodity price volatility	Shifting geopolitics and other factors leading to tremendous price volatility for almost all commodities such as wheat, copper, and lithium			X			X		X	X	
Increased value density	Advancements in manufacturing, materials and other technologies increasing the average value per ton moved in the United States from ~$700 per ton (in 2008) to over $2000 per ton		X						X	X	X

The full distributions and plots of the probability versus the impact for each driving force are shown in Figures 12 to 16.

Further analysis of the driving forces did not reveal any significant correlations in the rating of probability and impact to background (shipper, carrier, government, etc.), position (C-level, vice president, director, manager), sector, or firm size.

The following insights were gathered from the survey results:

- Most of the driving forces had highly correlated probabilities and impacts. This indicates that the survey respondents did not separate out the two different dimensions. The cases where there were anomalies stand out.
- The following forces appear to be predetermined and therefore will be included to some degree in each of the proposed scenarios: high and volatile fuel prices, battery vehicles, "senseable" networks, and online retailing.
- The two forces that seemed to be the most impactful without the corresponding high probabilities are reducing global trade and re-domestication of manufacturing. These are related

Table 4. Stakeholders survey summary of impact/probability rankings.

	Impact of Driving Force						Probability of Driving Force					
Driving Force	Average Value	Standard Deviation	Coefficient of Variation	Average Rank	Standard Deviation Rank	Coefficient of Variation Rank	Average Value	Standard Deviation	Coefficient of Variation	Average Rank	Standard Deviation Rank	Coefficient of Variation Rank
Re-domestication of manufacturing	3.63	1.23	0.34	6	8	8	2.20	0.78	0.36	18	3	12
Reduction in global trade	3.70	1.23	0.33	4	9	7	2.20	0.84	0.38	19	7	17
Increased security threats	3.68	0.95	0.26	5	4	3	3.19	1.08	0.34	7	16	10
Green regulations	3.73	0.89	0.24	3	2	2	3.20	0.93	0.29	6	9	4
High and volatile fuel prices	4.44	0.67	0.15	1	1	1	3.94	0.83	0.21	1	6	1
Rise of BRIC markets	3.43	1.24	0.36	8	11	11	3.10	1.09	0.35	9	17	11
Low-cost batch manufacturing	3.22	1.31	0.41	14	15	13	2.79	1.04	0.37	12	12	15
Online retailing	3.26	1.54	0.47	12	18	16	3.21	1.07	0.33	4	15	9
"Senseable" networks	3.74	1.02	0.27	2	6	4	3.36	1.20	0.36	3	19	13
Recycling regulations	3.35	0.99	0.30	10	5	6	3.20	0.99	0.31	5	10	6
Average age of 100	3.05	1.30	0.43	15	14	15	2.39	1.27	0.53	17	20	20
East Coast ports	3.02	1.27	0.42	16	12	14	2.63	0.83	0.31	15	5	7
New agriculture powerhouses	2.62	1.64	0.63	20	20	20	2.54	0.80	0.32	16	4	8
Water scarcity	2.92	1.57	0.54	18	19	18	2.80	1.04	0.37	11	14	14
Green customer demand	3.32	0.95	0.29	11	3	5	2.71	1.04	0.38	13	13	18
Mega cities	3.24	1.14	0.35	13	7	10	2.91	1.11	0.38	10	18	16
Zero immigration	2.72	1.50	0.55	19	17	19	1.58	0.70	0.44	20	1	19
Battery vehicles	2.93	1.39	0.48	17	16	17	3.43	1.00	0.29	2	11	5
Commodity price volatility	3.53	1.24	0.35	7	10	9	3.11	0.86	0.28	8	8	2
Increased value density	3.38	1.28	0.38	9	13	12	2.65	0.75	0.28	14	2	3

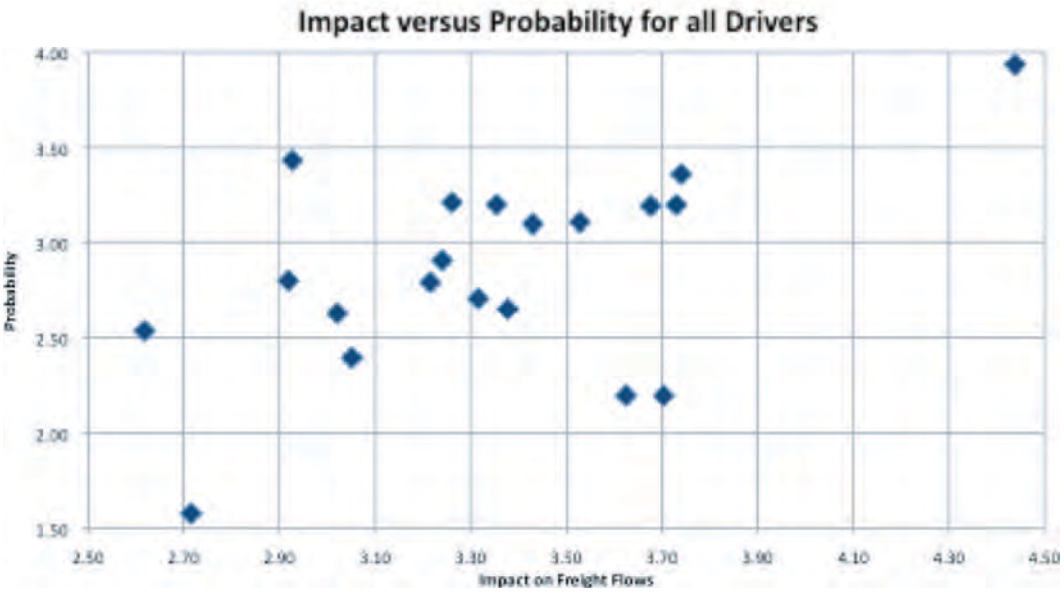


Figure 9. Driving forces plotted as average impact/average probability.

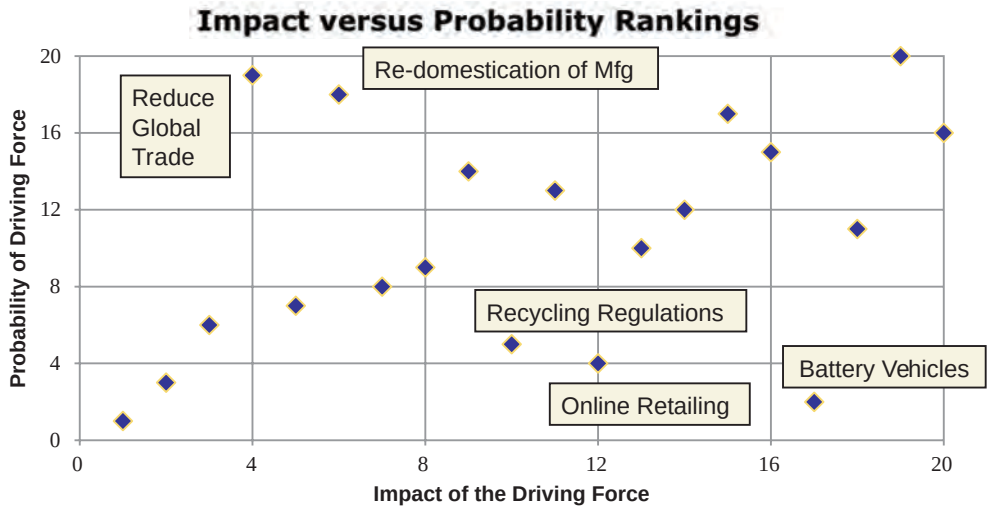


Figure 10. Plot of impact rank/probability rank.

in that they both signal a retreat from the global trading trends of the past half of a century. These are wild cards that bear inclusion in the final scenarios.

- The coefficient of variation is a good indicator of uncertainty or variability. The driving forces with the most variability in the probability of occurring are average age of 100, zero immigration, green customer demand, and reduction in global trade. The high coefficient of variation (CV) numbers indicate a lot of disagreement over the potential outcome and while these forces might not define the different scenarios, they should be included.
- While forces previously identified as either predetermined or wild cards will constitute the main features of the future scenarios, the rest of the forces will not be overlooked but rather woven into the storyline to enrich the scenarios on a case by case basis.

2.7 Selection of the Scenario Logic

Based on the survey results and the input from the expert practitioners during the FFF symposium, the team began identifying and classifying the different driving forces in order to select the underlying logic for the scenarios. Several ways of looking at the data were used.

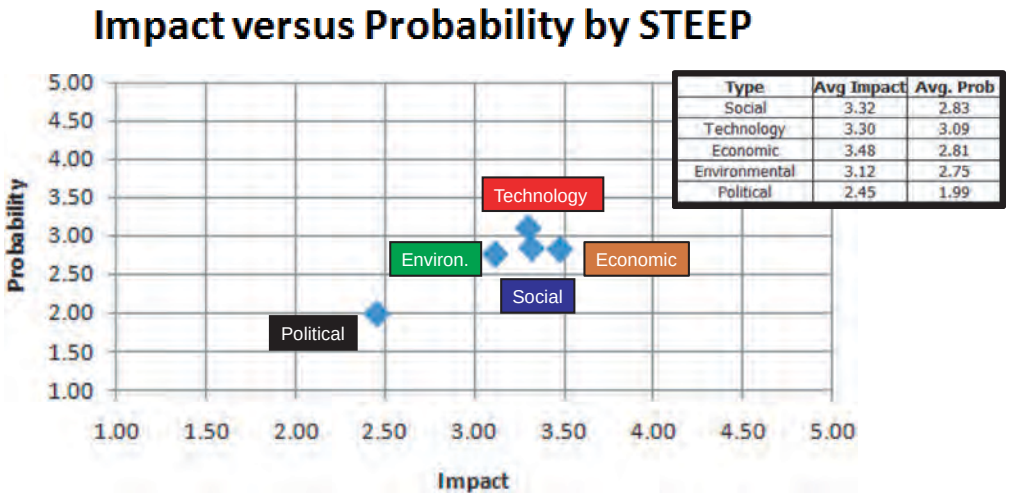


Figure 11. Plot of STEEP factors for impact versus probability.

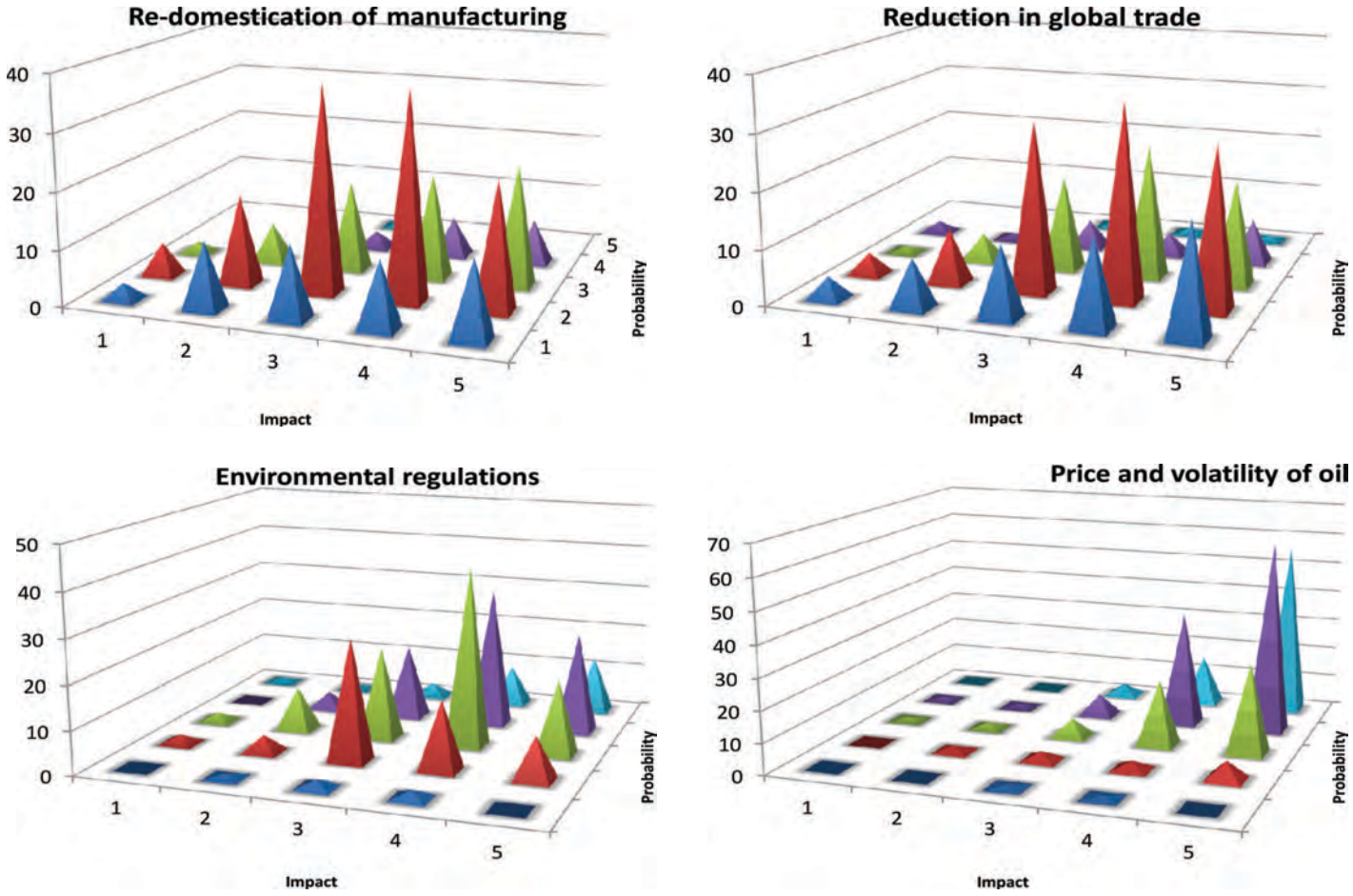


Figure 12. Histogram of candidate driving forces (part 1 of 5).

2.7.1 Classification of Driving Forces

One approach was to cluster the different forces and classify them based on their probability and impact scores. Forces with high impact and high probability were called *structuring forces.* Forces with low impact and high probability were labeled *background forces.* Forces with high impact and low probability were called *wild cards.* And, finally, forces with low impact and low probability were labeled *variations to theme.* The reason for clustering and classifying the forces in this way is to identify any insights into the practitioners' "mental models" of the world.

2.7.1.1 Structuring Forces

These are forces for which both the impact and the probability of occurrence are rated very high. These can be highly influenced by what the participants are experiencing today. They are important, but might not be uncertain enough to be used to define the scenario logic. These forces were as follows:

- Dramatic increase in price and volatility of all oil-based fuels.
- Stringent environmental and sustainability regulations adopted and strictly enforced by the United States and most other countries.
- Large increase in both the number and magnitude of security threats (domestic and abroad).
- Widespread ability to capture and monetize real-time sensing data on all products, vehicles, and facilities across a supply chain at essentially no cost.

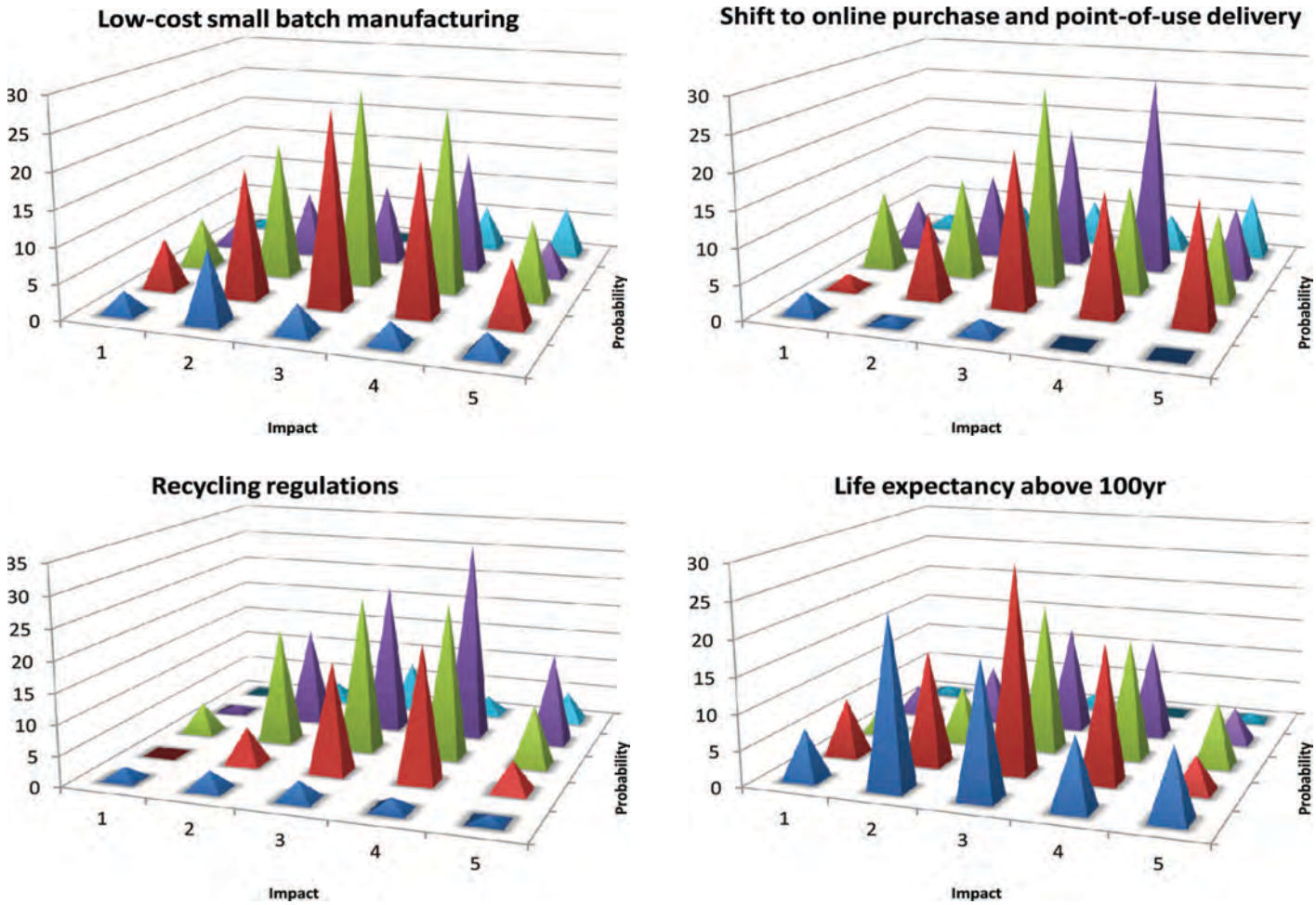


Figure 13. Histogram of candidate driving forces (part 2 of 5).

- Ascendancy of consumer markets in Brazil, Russia, India, China, and other countries leading to increased demand for products manufactured in the United States.
- Shifting geopolitics and other factors leading to tremendous price volatility for almost all commodities such as wheat, copper, and lithium.
- Omnipresent enforcement of regulations and rules requiring recycling and re-use of all manufactured products.

2.7.1.2 Background Forces

These are forces for which the impact is low while the probability of occurrence is rated high. These are less critical in the formulation of scenario logic. However, different elements can be woven into the larger background stories for the scenarios. These forces were as follows:

- Dramatic shift towards online purchase and point-of-use delivery leading to reduction of physical retail stores.
- Over 90% of the United States consumers living and working in mega-region cities and built-up urban areas.
- New battery technologies dramatically reducing the cost and increasing the efficiency and range of electronic vehicles.

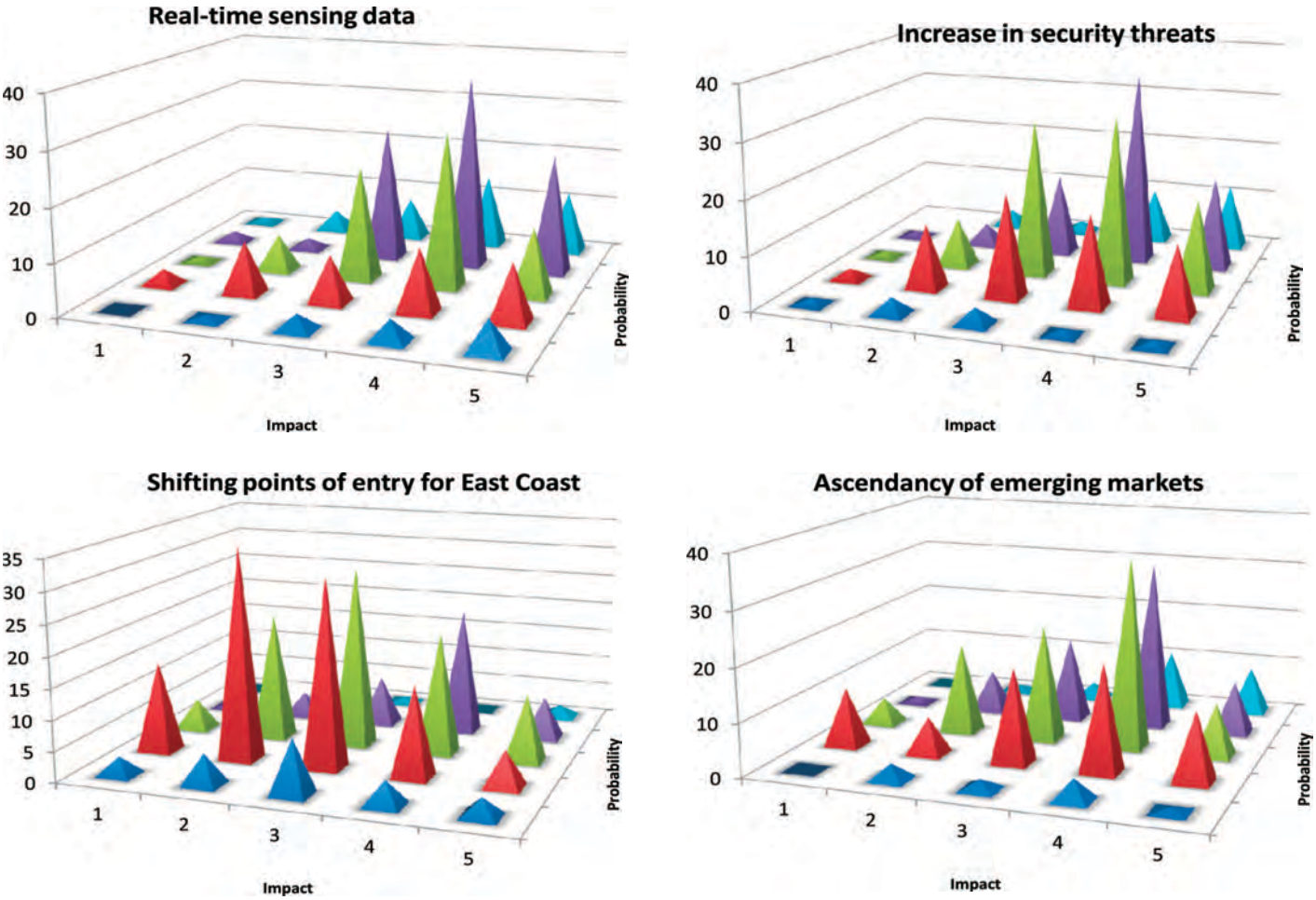


Figure 14. Histogram of candidate driving forces (part 3 of 5).

2.7.1.3 Variations to Theme

These are forces for which the impact and the probability of occurrence are rated low. Interestingly, these can become cornerstones of the scenarios. Forces that are viewed as highly improbable can be blind spots. These forces were as follows:

- The sustainability and environmental "friendliness" of a product becoming the dominant factor for consumer demand for most products, supplanting cost.
- Widespread adoption of technologies enabling efficient and low-cost small batch manufacturing for most consumer goods.
- Shifting point of entry for a majority of imports to the East Coast (e.g., due to rise in manufacturing in Africa, more ships using the Panama Canal, etc.).
- Average life expectancy reaching 100 years in the United States.
- Pervasive water scarcity in some regions leading to a reduction in exporting products that either contain water (e.g., fruit) or require a water intensive manufacturing process (e.g., soda, electronic chips).
- Immigration into the United States reduced essentially to zero.
- New countries (such as Russia or India) emerging as agricultural powerhouses supplanting the United States in some food commodities.

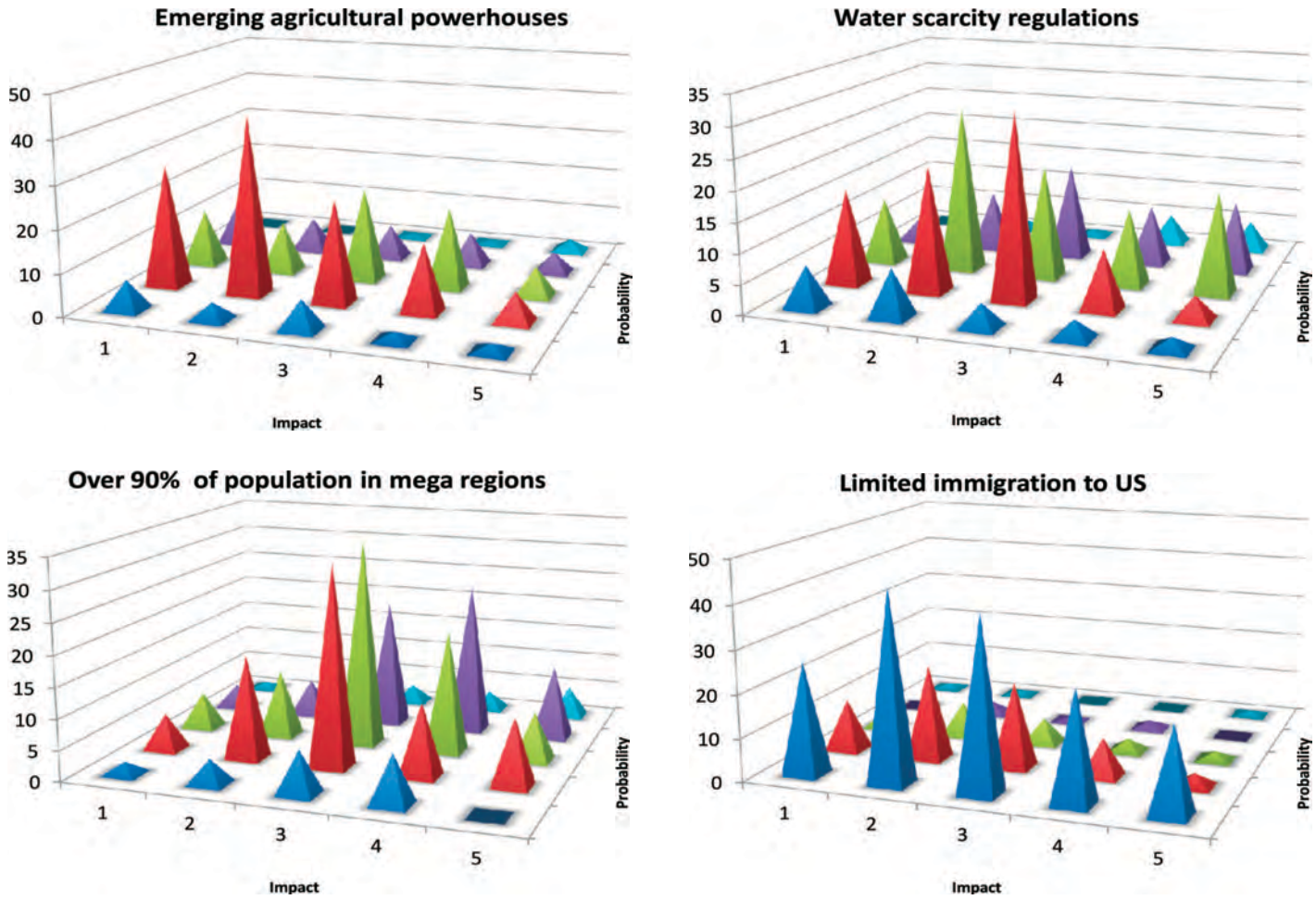


Figure 15. Histogram of candidate driving forces (part 4 of 5).

2.7.1.4 Wild Cards

These are forces for which the impact is high while the probability of occurrence is rated low. These are even more important to the scenario logic. These forces can represent things that the practitioners believe could dramatically change their operations, but since they have too low a probability of occurring, are most likely not planned for. These forces were as follows:

- Substantial re-domestication of manufacturing back to the United States.
- Sustained reduction in global trade volume (both imports and exports) possibly due to rise of protectionism, pandemics, etc.
- Advancements in manufacturing, materials, and other technologies increasing the average value per ton moved in the United States from ~$700 per ton (in 2008) to over $2000 per ton.

2.7.2 Other Forces

In addition to the 20 candidate forces that were evaluated in the survey, we asked for suggestions on other driving forces that were not included. We received over 100 open-ended responses. The

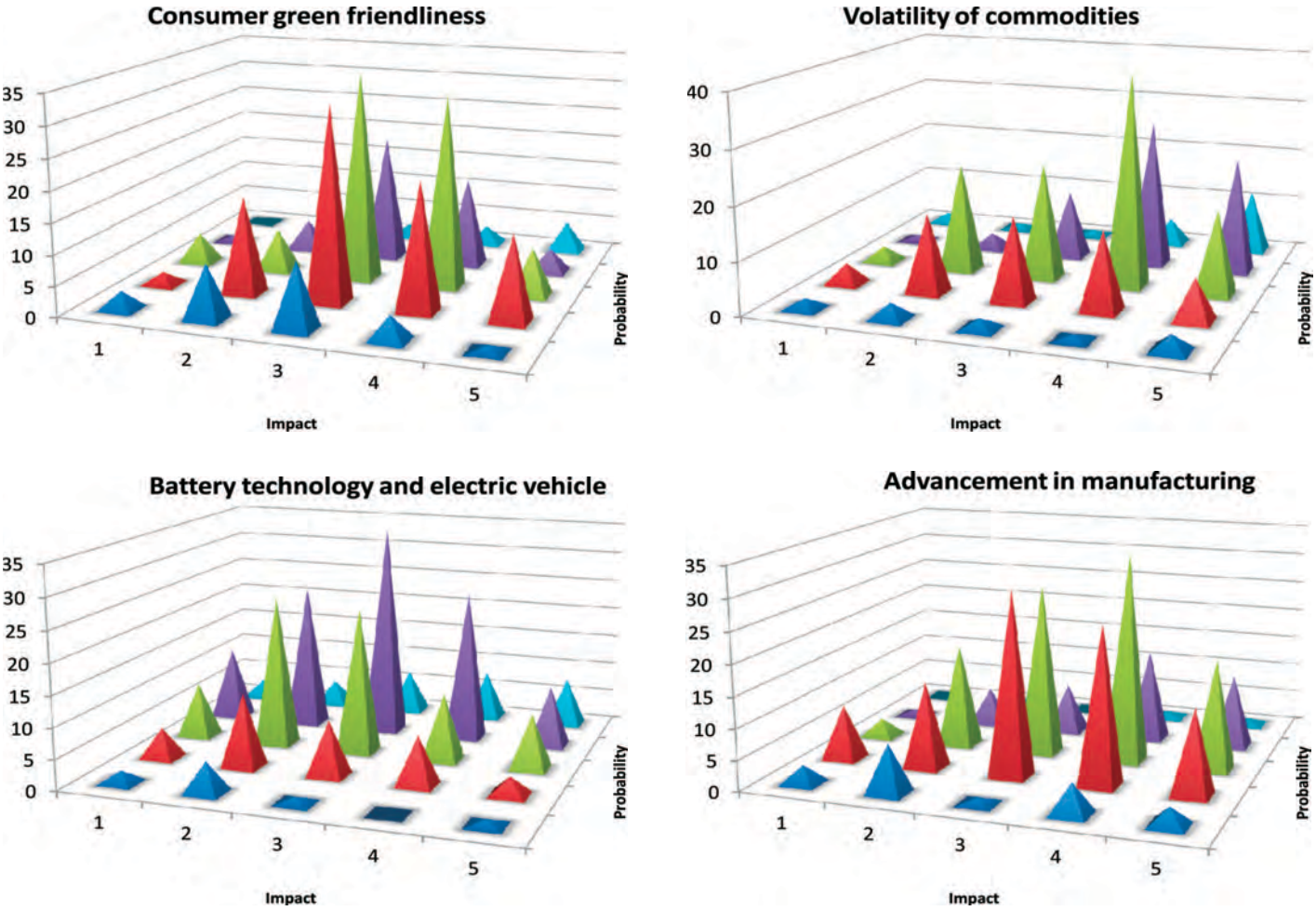


Figure 16. Histogram of candidate driving forces (part 5 of 5).

three most common were: aging transportation infrastructure, green energy for transportation, and growing labor strength. Others that were collected include the following:

- Increased worker and driver requirements.
- Increasing disparity of knowledge workers versus manual labor.
- World population levels.
- Digitization and miniaturization of supply chains.
- Level of taxation for businesses.
- Stronger non-U.S. trading blocs (less Asian dependence on U.S.).
- Changing cultural face of America (Hispanics).
- Rising sea levels.
- Dollar valuation.
- Solvency of airline industry.
- Rising power of China.
- Opening of Northwest Passage.
- Forming of political and trading blocs (Venezuela, Bolivia, and Iran).
- Lack of credit availability.
- Advances in robotics make logistics workers redundant.

Several of these mirrored some of the other forces—such as non-U.S. trading blocs. Some of these were included in the eventual scenarios.

2.7.3 Summary of Scenario Logic

Out of the analysis, several key elements arose. These helped to determine which forces and uncertainties should be used to define the scenarios, which to feather in, and which to ignore.

A number of the forces (aging population and increasing urbanization) were found to be so exceptionally certain to occur that they were classified as predetermined. This means that the trends are in effect and are exceptionally unlikely to deviate. These forces were to be included in all of the scenarios. The only exception to this is that the specific geographies for the increased urbanization to occur were allowed to vary between mega-cities (New York City, Chicago, etc.) and second-tier cities (Madison, Burlington, Boise).

Another group of forces had high levels of uncertainty with two (or more) potential end points. These included the level of trade (ranging from global to blocs to regions to local only); resource availability (ranging from restricted and allocated to available); and manufacturing structure (ranging from highly centralized to decentralized). These became prime candidates for the opposing structure to create the scenarios.

In the end, the team selected to frame the scenarios by juxtaposing the global trade and the resource availability forces. The resulting scenarios are discussed in the following section.

SECTION 3

Future Freight Flow Scenarios

Four scenarios were created based on the structural axes of level of global trade and resource availability.

3.1 Scenario Overviews

Global Marketplace (high global trade and high resource availability) is a highly competitive and volatile world. Open, vigorous trade between virtually all nations has led to market-based approaches to most contemporary challenges.

One World Order (high global trade and low or restricted resource availability) is a highly regulated and managed world. Facing global scarcity of key resources, nations establish international rules to ensure their fair and sustainable use. Global trade thrives, but the very visible hand of regulation, at times an iron fist in a velvet glove, shapes its course.

Millions of Markets (low global trade and high resource availability) is a world where advanced technological breakthroughs have enabled the United States (and other countries) to become highly self-reliant in terms of energy, agriculture, manufacturing, and other needs. There is increased migration toward smaller urban areas that are supported by nearby regional innovation hubs that can manufacture highly customized goods.

Naftástique! (low global trade and low resource availability) is a world where trade has moved away from a single global market toward a number of emerging regional trading blocs. China, Europe, and South America form their own clusters. The United States leads an effort to make North America a self-sufficient economic community.

In addition to the two structural axes, the scenarios incorporated a number of other forces. In order to keep the number of scenarios to four, we could not create separate scenarios for each combination of forces. Instead, these were feathered in to help make the scenarios more believable and to provide depth. (See Table 5.)

A variety of collateral was developed for use in a Scenario Planning Toolkit to support each of the scenarios. These "immersion tools" included separate brochures with narratives and comparative charts as well as an assortment of introductory and "newscast" videos. The complete Scenario Planning Toolkit can be found on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

3.2 Individual Scenario Narratives

In order to provide some additional context while reading how the scenarios were applied, this section contains the narratives for each of the four scenarios.

Table 5. Driving forces used for each scenario.

Driving Force	*Naftástique!*	*One World Order*	*Global Marketplace*	*Millions of Markets*
Global Trade	Low	High	High	Low (physical)
Resource Availability	Low	Low	High	High
Energy Cost Level	High	High	Low	Low
Energy Cost Variability	Low	High	High	Low
Level of Environmental Awareness	Same as Today	High	Low	High
Population Dispersion	Growth in SW	Growth in Biggest	Growth in Biggest Cities	Rise in Mid-Tiered Cities
Energy Sources	Majority NA	Mix Foreign & Domestic	Majority Foreign	Majority Domestic
Level of Migration	High w/in Bloc, Low between	High	High	Low
Migration Policy	High	High	Low	Low
Currency Fluctuations	Low w/in Bloc	High	Moderate	Low

3.2.1 *Global Marketplace* Narrative

U.S. firms have established and maintain intense collaboration with companies across the world. The private sector has taken the lead in addressing the pressing issues of the day. Any attempt by governments to get involved in regulating business is seen as unnecessary intrusion. Citizens trust markets and they are more than willing to allow them to "work the magic." So far, their patience and confidence in the market forces has paid off. Case in point is the now routine hassle-free immigration across most nations and the dramatic increase in global food production.

Traditional powerhouses such as Japan, Germany, and the United States no longer control the capabilities and resources needed to manufacture highly specialized, high-value products. Although developing countries are not on par with the advanced nations yet, they have found niches and are investing heavily in developing their industrial competencies. To exploit their comparative advantages, countries are specializing in producing what they do best and rely on other countries—halfway across the world in some cases—for everything else they need. The interconnectedness and speed of this global market has a very clear downside as well: increased volatility. For example, a labor strike in South Korea can have huge ripple effects in a Madison, Wisconsin manufacturing plant. As a result, firms are taking extensive precautions to keep the flow of goods both smooth and secure.

Affordable and seamless supply chains are encouraging companies to invest in global manufacturing capabilities with most large firms using a mix of offshore and near-shore plants to remain low-cost and flexible. The cost of moving goods anywhere in the world is very reasonable, primarily due to new and cheaper energy sources and technologies and non-obtrusive environmental regulations. Energy costs, although relatively low, remain extremely volatile because of the continual natural and man-made supply disruptions of oil-based fuels.

Raw materials and commodities are brought to the market from all over the world, as there are minimal trade barriers limiting their availability. The free flow of goods is, however, driving extreme volatility in commodity prices, which is a persistent problem for most firms. Therefore, price—rather than access—is the key criterion for choosing a commodity item. Postponement of final product customization until the very end has led to higher value density in products being

moved within the United States. Retail sales are predominantly conducted online, even for grocery vendors. With a significant proportion of the U.S. population living in large and dense cities, individual delivery to residences is the norm in most retail transactions.

The collaboration between firms across national boundaries has further expanded the regional markets to the point that they have overlapped and blended into a single, global market, with a minimal set of regulations in place. It is said by cynics that, in this brave new world, "the only regulation is that there are no regulations." Finally, a true global marketplace has emerged, where ideas, technology, labor, and goods are exchanged freely and quickly.

3.2.2 *One World Order* Narrative

It has become clear that oil production has peaked. Renewable energy technologies have failed to live up to the heightened expectations of replacing coal and oil. The environmental crisis faced by the world's population has taken on an urgent dimension, as looming scarcity increases social and political tensions within and across nations. Policy avenues are aggressively pursued at a global level to ensure equitable access to clean air, drinkable water, and healthy food for vast populations across the world, as well as the raw materials and energy required to sustain their communities.

Fearing conflicts and war over the growing scarcity of vital resources, the governments of the most powerful countries come together to create a supranational entity, the World Sustainable Trade Organization (WSTO), to regulate the use of resources and resolve disputes among nations. While many see the WSTO as a replacement for the World Trade Organization, it is in fact much stronger than the WTO ever was. The WSTO reaches far beyond trade and has been given real teeth for strict enforcement. Also, through monitoring and reporting, it dictates efficiency and penalizes waste, prioritizing usage according to global needs. All world powers and most other countries have signed the Charter of the WSTO, and are working towards full compliance with its regulatory framework.

Paradoxically, and despite the forecasts of detractors, global trade has not only remained strong, but it has actually continued to thrive in this heavily regulated world. The regulation-based system of balancing availability and needs did not replace the traditional market-based system of balancing supply and demand. Instead, it has redefined boundaries of the free market, therefore complementing it in unexpected ways. For example, grains are shipped from greener regions where they are produced in abundance to places where the land is not fertile. Metals are shipped in the opposite direction, from the arid yet mineral-rich countries toward the agricultural foci of the world. Technology and labor follow a similar pattern: less developed countries serve as providers of young labor for more technologically advanced countries, which in turn export their technology and knowledge back to the developing countries in the form of finished goods and services. Many analysts describe the new system as one of "global optima" for the long run, where the objective is sustainable use, not just short-term corporate profits.

What gives shape to trade flows is not the invisible hand of the market, but a very visible body of regulations. Many people view these regulations as a "green bureaucracy" and a necessary nuisance. At the end of the day, while individual firms still get to make—for the most part—their own decisions as to what to produce and where, it is in the "how" that the influence of the WSTO's global bureaucracy and its ever growing tapestry of regulations play an influential role, sending the right signals to the market: how much water can be used, how much CO_2 can be emitted, how discards should be recycled, and so forth. As a result, the speed of global trade—once mercurial and chaotic in the days of globalization—has slowed down into an optimized order, more entangled in regulations and quotas, yet less volatile and, in consequence, more predictable.

Forged by the struggle for survival of globalized markets, firms have adapted relatively quickly to the new demands of a regulated world. Tracking and offsetting of greenhouse gases, even to

the level of zero emissions, is now a prerequisite for doing business. Manufacturers with similar needs have grouped together to create large-scale facilities, known as production clusters, where they find relief in numbers. They have found it is more cost effective to comply with tight regulations when the cost of required technology can be shared by many. Production clusters, coupled with ultra-efficient supply chains that make use of sensing and advanced computing, are emerging as the greenest solution.

Regulations for urban areas have also forced local governments to adapt. Through a series of stick-and-carrot regulations, the WSTO has sent municipalities a clear message: cities must clean up their acts, too. Regulations promote a more efficient use of energy and water in urban areas, a reduction in transportation emissions, and a more effective treatment of waste and sewage. The largest cities in the world now compete for subsidies, and try to avoid penalties, on the basis of improving their performance against a series of sustainability indexes. As a result, large cities have continued to grow even bigger, even as they strive to make their environmental footprint smaller and easier to offset.

Regulators have become aware that online purchasing has a much higher carbon footprint than shopping in person. In order to offset the higher per-pound emissions of home delivery, most states in the U.S. have mandated parcel carriers to charge customers a flat tax on all home deliveries. The effect of this tax is felt more on smaller, cheaper packages. Since for consumers it makes little sense to pay a $5 tax for the home delivery of a $10 book, most large cities have seen the appearance of consolidation centers, where goods from many retailers are consolidated and delivered to the final customer only when a certain amount of products have accumulated. This has radically changed "last mile" delivery of goods in metropolitan areas.

3.2.3 *Naftástique!* Narrative

A lack of significant technological advances, coupled with continued growth of the world's population has pushed the ability of most nations to provide for their citizens. Basic commodities have become scarce. Relationships among world powers are strained by prolonged and intense competition for raw materials and energy sources. Military and political tensions follow. Inward facing policies designed to protect dwindling resources have served to reduce and fragment global trade through tariffs and trade barriers. Regional trading blocs have emerged across the globe.

China, for example, has forged a particularly intense alliance with Africa. Many African nations, rich in natural resources and desperate for investments and new technology, found a natural partner in the resource-starved and over-populated China. Intense trade of materials, technology, and labor started taking place inside this Sino-African economic bloc, with the Yuan as the de facto currency. Other regional blocs have emerged over the past 30 years. The European bloc, trading almost exclusively with Russia and the Middle East, has adopted the Euro. Powerhouse Brazil led the Mercosur bloc; Japan, Korea, and Southeast Asian nations formed a Pacific bloc. Smaller countries were forced to ally themselves with existing blocs to keep their economies alive. However, a few larger nations like India, Venezuela, and Australia decided to remain "unaligned" to any particular bloc and trade with all clusters.

The United States formed its own bloc along with Canada and Mexico, called the North American Economic Community (NAMEC). Complementing each other in natural resources, technological capabilities, and workforce availability, NAMEC has emerged as a strong economic cluster. Commerce among NAMEC nations has increased tremendously. U.S. borders with Canada and Mexico are essentially seamless for freight and passenger movements. Widespread use of domestic natural gas and coal, and heavy investment in renewable sources, made the North American nations less dependent on foreign oil. While energy prices inside NAMEC tend to be higher than the historical averages, they are also significantly less volatile than in the past.

The United States undertook a re-domestication of manufacturing to NAMEC countries, with a clear emphasis on promoting processes that take advantage of local resources and talent. Migration among NAMEC nations has become fluid. U.S. work visas are issued for millions of young workers from both Canada and Mexico. Millions of aging Americans retire to Mexico and Canada. This influx of retirees has made some parts of the Mexican coastline the "New Florida," creating new demand south of the border for higher-value goods.

Environmental regulations are driven from the bottom-up by activism of the consumers inside the blocs. Previously disparate environmental regulations in Mexico, the United States, and Canada have been uniformed into a stricter corpus of rules. Rising temperatures have increased the agricultural output of countries located in higher latitudes. In North America, Canada's production of cereals and other agricultural produce has increased dramatically. So far, however, the global increase in temperatures has had no major impact on coastal cities and in the operation of maritime ports.

Fixed currency exchange rates are established within the blocs, which in turn has stabilized currency fluctuations across blocs. While the majority of global trade is conducted within regional trading blocs, there is still trade between the blocs. This inter-bloc trade is, however, mostly limited to supplementing technologies and materials that are not available in member nations. Many are surprised that despite the lack of a true global market the regional clusters manage to operate as self-contained trade systems. Inside each of these blocs, trade links have led to stronger political links and a sense of shared purpose. Member nations take pride in working together towards self-sufficiency.

3.2.4 *Millions of Markets* Narrative

The past three decades have been witness to tremendous technological advances and social changes that have led to a high level of regional self-reliance in matters of energy, health, food production, and manufacturing. Not only has the United States as a whole become highly self-sufficient, individual regions and cities have also become much more self-sustaining. The primary drivers of these changes were technical breakthroughs that are collectively referred to now as the "Three Pillars."

The first pillar is energy independence. Advances in drilling techniques and improved seismic testing enabled the economical location, capture, and production of tremendous quantities of natural gas from the massive shale formations along the Atlantic coastline. At the same time, improvements in the efficiency and safety of nuclear generators led to a "Nuclear Renaissance." Renewable energy sources, such as solar and wind power, while still being pursued, have had only minor impact on the total United States energy production. Natural gas and nuclear power have led to almost complete energy independence for the United States and have facilitated the widespread decentralization of affordable and stable electricity production. This contributed to the growing adoption of initially hybrid but eventually completely electronic vehicles.

The second pillar is the widespread use of intelligent manufacturing. These advances enabled the production of small to medium batches of a wide variety of products at reasonable costs. Essentially, the cost advantages of leveraging economies of scale that dominated manufacturing throughout the past several decades of the 20th century were replaced by the ability to cheaply produce a wide range of highly customized products. While manufacturing has not advanced to the stage of "home replicators" that enthusiasts once envisioned, it has led to the development of regional manufacturing hubs across the country. These manufacturing facilities are close to consumption centers and are fueling the expectations of consumers for rapid creation and delivery of highly personalized goods. A key innovation that transformed the manufacturing industry was the separation of the digital design from the physical production process. This has

in turn lead to the creation of a new industry sector of pure digital design firms that develop and sell small-run or custom designs.

The third technological advancement was the widespread adoption and use of virtualization. Working and shopping from home—or from any other location—has become the standard rather than the exception for many people. Most households order products and services directly from the home and receive them there as well. Online shopping with prompt delivery to residences has largely replaced physical stores. People still go shopping in person—but the retail experience has evolved into an event rather than just a way to acquire physical products—similar to how movie theaters adapted when home entertainment systems were introduced. As goods and services have become more mobile than people, there is less physical commuting to work. Ironically, the level of travel for pleasure has increased since a large percentage of the workforce can work from any location.

A social change that has emerged over the last several decades is the increase in social interaction—both virtually and in person. It appears that while people can now work and live totally isolated from other humans, very few actually do. Instead, there has been a groundswell migration towards "livable cities" of a moderate size where people can enjoy the benefits of interacting with others in an urban setting without the drawbacks of an impersonal mega-city.

In this widely fragmented, yet highly connected society, small and mid-sized cities are growing at a faster rate than the mega-cities. Local governments compete with each other to attract investments to create "innovation clusters" that feature a mix of technology, manufacturing, and distribution facilities.

Technological advancements and cheaper energy have ushered in a new age of affluence: average household income has increased, personal consumption has soared, and standards of living have improved. It is not a technology-utopia, however. The income gap has widened between the traditional "blue collar," "white collar," and the newly established "no collar" creative class. Many traditional jobs have been displaced and those workers struggle to find new vocations. This is especially true for older workers who are not as able to adapt to the newer technology. Also, while new agricultural techniques, mainly genetically modified fruits, vegetables, fish, and livestock, have significantly increased the quantity and variety of food products available to consumers; there has been a significant amount of resistance from some sectors of the population. Food considered "100% Organic" is generally available, but at a much higher cost. In this fast-paced environment, the optimal production site is closer to consumption centers. The affluent and savvy buyers of this world demand products customized to their needs and tastes. While American consumers prefer locally produced goods, they are not inherently against foreign products, provided they meet their high expectations of personalization and delivery speed.

Trade between countries is still active, but for the first time in history, the value of imported and exported services exceeds that of goods. The United States is a net exporting country when considering services, such as digital designs. Physical trade still occurs, but at a lower level and in different forms. For example, global trade of raw materials has increased while transportation of finished goods has decreased. Raw materials and components are transformed into goods when and where demanded by the final consumer. Also, intellectual property that is used within most local manufacturing is traded freely across the globe although there are some risks concerning theft of these "recipes" and instructions in certain areas of the world.

SECTION 4

Scenario Planning Workshop Design

The research team conducted six Future Freight Flows Scenario Planning workshops from November 4, 2010 to June 28, 2011. In order to test the validity and the robustness of both the scenarios and the workshop methodology, each workshop was held in a different location and explored a different set of strategic questions. The workshops were run with a local host organization and were held in the locations listed in Table 6.

The six workshops were similar in that each included a diverse set of stakeholders who discussed and debated potential infrastructure investment strategies across different potential future scenarios through both small and large group activities. While the framework was common, each workshop was unique in that it was designed specifically for that host organization and the respective geographic region. There are nine key design components for running a scenario planning workshop, as follows:

- Scope (geographic and planning horizon).
- Objective (visioning or evaluating).
- Duration (half day, full day, multi-day).
- Participants (stakeholder distribution and level).
- Strategic Questions (what to have the teams decide or provide input on).
- Evaluation Elements (infrastructure segments, corridors, themes, etc.).
- Evaluation Mechanism (voting rules and data collection methods).
- Scenarios (which future scenarios to employ and what collateral to use).
- Debrief (how to present outcomes and to whom).

Over the course of the six workshops, the research team tried different designs in order to test the effectiveness of each element.

In each workshop, the participants discussed potential investment strategies for their specific regions in question. While each workshop focused on a different region and had a different set of strategies to evaluate, each region's investment options could be roughly categorized into three common classes: gateways, corridors, and connectors.

Gateways are points of entry for freight into the geographic region in scope. These cover water, air, and land (both rail and road), ports, and border crossings. Corridors are the high-volume trunk lines that connect different locations across the region. They consist of highways, rail lines, and waterways. Connectors are the elements of the infrastructure that enable the movement of freight between the production or consumption locations and the corridors.

Looking across all of the workshops, we found that the overall priority of investment for future freight flows favored connectors first, then corridors, and finally gateways. There were exceptions, of course. But, in general, the connectors were viewed as being critical to any future freight system, while currently experiencing under-investment. Corridors (mainly highways and railroads) were

Table 6. The six future freight flows workshops.

ID	Date	Host Organization	Location
DVRPC	Nov 4, 2010	Delaware Valley Regional Planning Commission (DVRPC)	Philadelphia, PA
MNDOT	Feb 11, 2011	Minnesota Department of Transportation (MNDOT) and the Metropolitan Council	St. Paul, MN
WSDOT	Mar 9, 2011	Washington State Department of Transportation (WSDOT)	Seattle, WA
POLB	Apr 13, 2011	Port of Long Beach (POLB)	Long Beach, CA
GDOT	May 9, 2011	Georgia Department of Transportation (GDOT) and the Atlanta Regional Council (ARC)	Atlanta, GA
U.S.DOT	Jun 28, 2011	U.S. Department of Transportation (U.S.DOT)	Washington, D.C.

seen as important, but additional funding was not seen as being as critical since they have been the focus of investment for a fairly long time. The gateways were the least favored investment class across all the workshops. Interestingly, though, gateways were seen as being exceptionally important within the *Global Marketplace* scenarios whenever they were run! Because the *Global Marketplace* scenario was viewed by the workshop participants both as the most similar to today and the most likely to occur, this finding identifies a potential blind spot in planning where a single future is unconsciously designed for.

Confirming the importance of connectors to freight infrastructure, the workshop participants overwhelmingly identified "develop or improve intermodal connections" as the most critical initiative to pursue. This initiative took slightly different forms in each workshop as dictated by the specific freight network of the region in question, but was dominant across all workshops and scenarios. The next closest common initiatives were "develop freight-only corridors" and "standardize regulations to facilitate freight."

Overall, the six workshops demonstrated that government planning agencies could successfully complement their existing methodologies using scenario planning. The final deliverables from this project included a "Scenario Planning Toolkit" that contains all materials needed to run a scenario planning workshop. It is available on the companion DVD package and online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

The remainder of this section is organized as follows. Section 4.1 presents the design of the six workshops, including the duration and objective of each workshop, infrastructure segments evaluated, scenarios used, types of participants, and so forth. Section 4.2 describes the process used for the six workshops. This section presents how workshop participants were engaged in the scenario planning process, questions asked, and tools used for extracting insights from the participants. The results from these workshops are discussed in Section 5.

4.1 Workshop Design

This section describes the choices made for various components of the six Future Freight Flows workshops. This section begins by describing the nature of engagement between the MIT research team and the host organization for each workshop (Section 4.1.1). This is followed by a discussion of how the nine design components were selected for each workshop (Section 4.1.2). Finally, we describe the skills required to facilitate a workshop in Section 4.1.3. The gist of this section is contained in more of a workbook format in the Future Freight Flows Workshop Planning Guide (available on the companion DVD package and online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

4.1.1 Engagement with the Planning Organization

The project team from the MIT Center for Transportation & Logistics (CTL) started the engagement with each host organization about 8 weeks prior to the workshop. Regularly scheduled phone calls were conducted between MIT and the host throughout the planning period. The workshop dates and locations were usually set in the first call. The later calls were used to make various choices about the design of the workshop. These choices are presented in Section 4.1.2, in rough chronological order.

The level of engagement of the host organization in planning the workshop varied across the six workshops and ranged from being intimately involved in all aspects of the planning details to essentially just providing space to run the workshop. As a general observation, we found that the more engaged the host organization was in the design, development, and delivery of the workshop, the more successful it was.

The planning agencies at the DVRPC, MNDOT, WSDOT, and U.S.DOT were the most heavily involved hosts. DVRPC took the most effort in the logistics and execution of the workshop—most of the details of the later workshops used the material developed at this first session to include the logo itself. MNDOT, along with the Metropolitan Council and the Volpe Center, focused the workshop design to complement an existing planning project for the twin cities. Together, the three organizations chalked the scope of the project and customized the focus of the workshop on "themes" rather than specific investments. They also took copious notes of the discussions facilitated by the scenario planning session and used the output of the workshop in their ongoing project. WSDOT took much initiative in planning the workshop and selecting the portfolio of attendees. They focused on evaluating entire corridors for freight movement and combined some of the "open-ended" aspects from the MNDOT session. The U.S.DOT sessions tackled the more difficult national problem by introducing components of a freight network (gateways, corridors, and connectors) instead of specific modal infrastructure segments. Also, we utilized interactive electronic polling response tools during this national session.

4.1.2 Workshop Design Components

The general framework of each workshop was the same. There was an introduction to the concepts and approach followed by small group immersion and breakout sessions, with a final group debrief and discussion. Within this general structure, however, each workshop was designed differently using nine key components. These are as follows, in roughly chronological order they should be selected:

- ***Scope*** (geographic and planning horizon).
- ***Objective*** (visioning or evaluating).
- ***Duration*** (half day, full day, multi-day).
- ***Participants*** (stakeholder distribution and level).
- ***Strategic Questions*** (on what to have the teams decide or provide input).
- ***Evaluation Elements*** (infrastructure segments, corridors, themes, etc.).
- ***Evaluation Mechanism*** (voting rules and data collection methods).
- ***Scenarios*** (which future scenarios to employ and what collateral to use).
- ***Debrief*** (how to present outcomes and to whom).

As mentioned in the opening paragraph, the sections are presented in the chronological order in which they were chosen by the planning organization and research team. The following sections describe each individual design component, discuss how they were selected for each workshop, and provide a recommendation for future workshops.

4.1.2.1 Scope

The selection of the scope should be the first element decided for any workshop. The scope includes the geographic region being considered (state, national, multi-state, etc.) as well as the desired planning horizon (10, 20, 30 years, etc.). The scope was usually agreed upon during the first phone call between the research team and the planning organization—right after the date and location of the workshop was set.

The geographic regions differed for each workshop but, with the exception of POLB, each was the area under the jurisdiction of the host organization. POLB used a multi-state geographic region to get at the import/export issues that cross multiple state and jurisdictional lines. The geographic scope for each workshop is listed below.

DVRPC: City of Philadelphia and the nine counties (five in Pennsylvania, four in New Jersey) for which the Delaware Valley Regional Planning Commission develops plans.
MNDOT: Entire state of Minnesota, with an emphasis on the Saint Paul and Minneapolis metropolitan areas.
WSDOT: Entire state of Washington.
POLB: All major corridors and ports in the Los Angeles and Southern California area that connect the port with the rest of the U.S.
GDOT: Entire state of Georgia.
U.S.DOT: The contiguous 48 states of the United States.

As discussed later in the report, evaluation elements used within a workshop can fall outside of the geographic region if they affect the area under consideration. For example, for the WSDOT workshop, a Canadian highway was one of the potential investment segments. Similarly, improvements to water ports in neighboring states were considered in the GDOT workshop.

The same planning horizon was used for each of the workshops: 20 to 30 years from today. The scenario collateral for all of the workshops used the date of November 2, 2037 for the newscast videos that were shown as part of the scenario immersion process.

For future workshops, we recommend that the geographic scope be in line with the jurisdictional control or responsibility of the host organization. This provides more in-depth knowledge for the underlying network and increases the quality of the preparation.

4.1.2.2 Objective (Visioning or Evaluating)

Scenario planning workshops are designed to either enable visioning of potential future strategies or facilitate the evaluation, ranking, and selection of a strategy from an existing set of potential choices. Visioning workshops are pure brainstorming exercises that are used to develop new unfettered thoughts or ideas: a "clean sheet of paper" approach.

Evaluating workshops, however, require the participants to compare and contrast between a set of alternatives. This forces the participants to make choices and trade-offs, debating the pros and cons of the alternatives with each other.

Both workshop objectives have strengths and weaknesses. Visioning workshops are good for areas where innovative thinking is required and no established options are desirable or sufficient. These sessions are great for bringing up new and out of the box ideas, but they rarely drive to a consensus or produce an actionable recommendation. These sessions tend to have very open-ended discussions and are more akin to a brainstorming session that generates ideas rather than makes decisions. Evaluation workshops are just the opposite. Presenting a closed set of options to a group of participants focuses the participants' attention and forces them to make decisions. There is a risk of missing potential strategies not initially considered, but providing an "other" category can mitigate this. Collecting, harmonizing, and analyzing evaluation data is much easier than visioning data.

Of course, most workshops will combine a mix of these approaches, but, in general, a workshop will lean one way or another. Presenting options in a visioning session can lead to some anchoring of discussion by some participants.

The DVRPC and U.S.DOT workshops were pure evaluation exercises: the participants evaluated the chosen infrastructure segments and did not engage in any visioning or open-ended exercises. The U.S.DOT workshop did, however, employ a series of more in-depth evaluation questions that explored funding and other issues beyond selecting investments. These additional evaluation questions served as a starting point for the larger group discussions—and helped to bring out more "visioning" comments in the final debrief session. The MNDOT workshop was predominantly a visioning exercise. The remaining three workshops (WSDOT, POLB, and GDOT) were predominately evaluation workshops with a small amount of visioning in each of the small group breakout sessions.

For future workshops, we recommend that if time and schedule permits, the host initially runs an open-ended visioning session with a small, core group of stakeholders. Then, using the suggested approaches and strategies from this session as the set of strategies to pick from, they can run a series of evaluation workshops for a larger set of stakeholders. In the evaluation workshops there should still be some open-ended element to capture things that have not been previously considered. As was done in the U.S.DOT workshop, the use of more focused follow-on evaluation questions can help generate additional discussion and more open-ended comments. As one host mentioned, the actual selection of the potential investments is not as important as understanding the thinking and the logic that went into that selection.

4.1.2.3 Duration (Half Day, Full Day, Multi-day)

Future Freight Flows scenario planning workshops have been run in durations ranging from half to a full day. The DVRPC was the only half-day workshop that the research team ran. Afterwards, the MIT team realized that a four-hour workshop did not provide sufficient time to understand the scenarios, explore their implications, and evaluate various infrastructure segments and/or generate ideas for strategies in each scenario. All of the remaining five workshops lasted three-quarters of a day or about 6 hours.

In all of these workshops, however, we found that the debriefing session of the results was always rushed. We recommend that for future workshops, a second day be included for a detailed debrief of the results from the session to a select group of decision makers. The workshop itself should remain 6 hours—any longer taxes the attention span and attentiveness of the participants.

4.1.2.4 Participants (Stakeholder Distribution and Level)

Participation in all six workshops was by invitation only with a priority going to individuals with first-hand knowledge of the region's freight infrastructure needs. This suggested that government transportation planners in the region, shippers, carriers, as well as community and environmental groups be invited to participate in the workshop. This also suggested that consulting firms and independent consultants should not be invited, unless such a person was deemed to be highly insightful by the host organization.

The number of people from each category who agreed to actively participate (which excludes members of the host/planning organization participating as note takers) in each workshop is mentioned in Table 7.

Once the workshop date, location, and duration were finalized, MIT and the host organization started identifying and contacting the potential participants (about 6 to 8 weeks before the workshop). Besides MIT and the planning organization, the candidate participants for the workshops were also sought through recommendations from the members of the research panel.

Table 7. Number of invitees agreeing to participate (by category).

Participant Category	DVRPC	MNDOT	WSDOT	POLB	GDOT	U.S.DOT	TOTAL
3PL	8	3		2	5	5	**23**
Academic	1		2	2	1		**6**
Association	2		4	1	1		**8**
Carrier	15	12	8	10	3	9	**57**
Citizens, environment	4						**4**
Consultant		5	2	2	3		**12**
Government—Fed	2		5		1	3	**11**
Government—Local	15	17	12		8		**52**
Government—State	5	8	10	3	5	2	**33**
Panel	2			4		5	**11**
Port	6		8	5		9	**28**
Shipper	8	8	10	12	9	13	**60**
Total:	**68**	**53**	**61**	**41**	**36**	**46**	**305**

Note: 3PL = third-party logistics.

The participants from varied backgrounds were invited to attend the workshop. While they were categorized slightly differently for each workshop, the participants fell into three large groups: shippers, carriers, and public sector. Within these groups there were 12 more specific categories.

4.1.2.5 Strategic Questions (What to Have the Teams Decide or Provide Input On)

Once they were immersed in their respective future scenarios, the workshop participants were tasked with addressing one or more strategic questions. Table 8 shows the specific questions used for each of the workshops.

Table 8. Strategic questions for each workshop.

Workshop	Objective	Strategic Question(s)
DVRPC	Evaluating	"Which infrastructure investment bundles [should] we invest in TODAY to prepare for the scenario in YEAR 2037?"
MNDOT	Visioning	"How should MNDOT prioritize different themes?" "What initiatives within each theme should be pursued today to improve freight infrastructure in 2037?"
WSDOT	Evaluating	"Which freight investment segments will be most critical in 2037?" "What will be the primary (and secondary) freight corridor in 2037?" "What are some initiatives that WSDOT should take to improve this freight corridor?"
POLB	Evaluating	"Which freight infrastructure segments should be invested in TODAY to be ready for the year 2037?" "What initiatives should be undertaken TODAY to prepare for this scenario?"
GDOT	Evaluating	"Which freight infrastructure segments should be invested in TODAY to be ready for the year 2037?" "What actionable initiatives should be undertaken TODAY to prepare for this scenario?"
U.S.DOT	Evaluating	"Where should we prioritize federal funds NOW given that the future described in your scenario in 2037 is going to occur?" "What level of investment should the federal government take for each type of infrastructure (maintain existing, improve existing, or add new)?" "Where should the policy be made (local or federal) and how should primary funding be provided (private, public, private–public)?"

The strategic questions for all of the workshops, except MNDOT, were very similar, differing only in the naming of the options (investment bundles, segments, etc.) and some follow-on questions. The MNDOT workshop was a visioning session so its questions were more open ended. Even the prioritization of the freight action bundles (FABs) was more open ended—real trade-offs were hard to make as the FABs consisted of "highway system improvements/congestion management," "rail, water, and air improvements/congestion management," "modal balance and intermodal options," "land-use strategies," and "policy and regulatory initiatives."

The main point of the strategic questions was to get the participants to think of present-day actions or investments to take given that their assigned future scenario occurs. The participants were typically told to ignore where the funds will come from or the timing or sequencing of the funding.

For future workshops, we recommend that the host continue to have the participants vote on the priority of the individual options but that the follow-on questions can be more open ended. Forcing the participants to make hard decisions between the competing alternatives brings up valuable discussion that leads to potential insights on future freight flows. Also, it is important that the host organization capture the decision making behind the specific votes.

4.1.2.6 Evaluation Elements (Infrastructure Segments, Corridors, Themes, etc.)

The selection of the elements or segments to evaluate was usually the most discussed component of the workshop design. The elements had to be finalized no later than 2 weeks before the workshop, as they were used in a pre-workshop survey conducted by MIT as part of the research project.

Generally, each element consisted of a single-mode contiguous artery used for transporting freight in the defined region. The choice of elements was made by the host organization alone (e.g., WSDOT), primarily by MIT (e.g., POLB, GDOT), or jointly (e.g., DVRPC). As discussed earlier, MNDOT did not have elements per se, but instead created FABs that were more thematic than infrastructure oriented. For the U.S.DOT workshop, the elements chosen were *not specific* physical elements of the freight infrastructure, but rather mode-independent classes of infrastructure: gateways, corridors, and connectors.

In fact, all of the elements used in the five evaluation workshops can be categorized into the three classes used in the U.S.DOT workshop: gateways, corridors, and connectors. Gateways are points of entry for freight into the geographic region in scope. These cover water, air, and land (both rail and road) ports and border crossings. Corridors are the high-volume trunk lines that connect different locations across the region. They consist of highways, rail lines, and waterways. Connectors are the elements of the infrastructure that enable the movement of freight between the production or consumption locations and the corridors. The gateways, corridors, and connectors chosen for the evaluation workshops were often, but not always, specified by the mode. The number of segments of each type used in the workshops is listed in Table 9.

There was significant discussion with the host organizations as to the number, size, and form of the elements to use. For future workshops, we recommend that between eight and a dozen elements be selected. Using fewer than this does not appear to provide sufficient variety while providing more than a dozen elements to evaluate seems to overwhelm the participants. We recommend that the elements selected be of sufficient size or magnitude to be worth the discussion and be important to multiple stakeholders (improving a specific exit ramp, for example, is too small of an element). Also, the elements should not already be in the current funded investment plan. The challenge is to select elements that are big enough to warrant the discussion, but specific enough to avoid generalities (such as, "build more roads"). We like the idea of examining the complete infrastructure in a region and classifying it into the three major categories (corridors, gateways, and connectors) and making sure that each category is represented. If there are multiples of each (such as more than one seaport or airport), they can be collapsed into common group categories without any loss of detail. The distinctions between the multiple

Table 9. Types of infrastructure segments used in workshops.

		DVRPC	WSDOT	POLB	GDOT	U.S.DOT
Gateways	Border crossings					2
	Water ports	1	1	1	2	3
	Airports	1	2	1	1	1
Corridors	Highways	3	7	6	4	3†
	Rail lines	1	3	4	4	
	Waterways		1			
	Pipeline		1			
Connectors	Local roads / freight connectors	1		1	1	2†
	Short-line rail	1	1	2		
	Intermodal facilities				1	1
Number of segments used:		**8**	**16**	**15**	**13**	**12**

†The three corridors and the two connectors in the U.S.DOT workshop were specified without any modes. The workshop participants were asked to consider the corridors and connectors to consist of any one or more modes.

airports in a category, for example, can be explored during the discussion. Finally, maintenance of the existing infrastructure should not be included as a unique element. We recommend to the host state that it is assumed that maintenance is taken care of separately.

4.1.2.7 Evaluation Mechanism (Voting Rules and Data Collection Methods)

There is extensive academic literature on how to design voting or evaluation mechanisms. The rules used within an election, for example, can influence the outcome, encourage or discourage collusion, and shift power to or from minority blocks. Most of the literature deals with the pros and cons of using single-winner versus multiple-winner voting schemes. We focused solely on multiple-winner voting mechanisms since the objective of the exercise is to encourage discussion of all elements—not just a selection of the single most critical element. It is important to remember that the objective is to enable and encourage discussion amongst the various stakeholders—not to elect specific investments.

Three different forms of voting were presented as options to the host organizations: single voting, cumulative voting, and ranked voting. Each is explained below with the assumption that there are *n* elements and *m* votes per participant.

- ***Single Voting*** is where each voter places one vote each on up to *m* different elements. Obviously, *m* must be less than *n.* This is essentially a way to pick *m* "winners" (and thus *m*-*n* "losers") out of *n* total elements. The advantage of single voting is that it allows preference to be shown for a set of elements without specifically singling out any individual one. Some of the host organizations expressed concern that some government participants would be reluctant to endorse specific investments in the workshop in fear their decision would be considered official policy. The downside of this mechanism is that it does not allow for a voter to distinguish the magnitude of their support for each element.
- ***Cumulative Voting*** is where each voter places up to *m* votes on any of the *n* elements. The value of *m* can be larger than *n.* For example, each voter could be given 100 points to allocate as they see fit amongst the *n* elements. The benefit of this approach is that the degree of support is readily evident in the voting. The downside is that a single voter or minority block of voters can dominate by placing all of their votes on a single choice. Limiting *m* to be close to or smaller than *n* can minimize this effect.

- ***Forced Ranking*** is where each voter places n votes for his or her first choice, n–1 votes for his or her second choice, n–2 votes for his or her third choice, and so on. Each voter is essentially rank ordering the n elements. If all elements are to be ranked, then each voter would need $n(n+1)/2$ votes. If only a subset is to be ranked, say, $k < n$, then each voter would get $k(k+1)/2$ votes. This mechanism brings out each voter's priority, but does not reveal the degree of preference between the elements. This also minimizes the minority block issue.

While there was initially a lot of discussion with the host organization on how to vote, we ended up using some form of cumulative voting in each workshop. Professional weight poker chips were used for casting the votes on a large sheet of paper that geographically displays the different elements. Using poker chips forced the participants to get up and physically place their chips around a table, forcing interaction with each other and making the votes more visible. It also reinforced the sense of playing a game and this led to more interesting and open discussions. In all of the workshops except the U.S.DOT, each voter was given 100 points worth of chips in 25-, 10-, and 5-point increments. Thus, they essentially had 20 votes each. For the U.S.DOT, we restricted the number of votes to 12, the same as the number of elements (12), and each chip counted as one vote. This was a better method since it made counting faster and removed the need to make change.

In addition to these "positive" votes, we introduced the concept of "negative" or "veto" votes. Each voter was given three black poker chips—We actually had a skull and crossbones embossed on them for effect!!—that they could use to express their opposition to a specific element. They *had* to place at least one and up to three negative votes on different elements with only one negative vote per element allowed (single voting). The negative votes were used to force each participant to say no to something. It is a truism in management that having a strategy means saying "no" to something. We wanted to force this aspect in order to get more discussion out of the participants. It was very successful. Negative voting was not used in MNDOT since the FABs were not conducive to this mechanism. For example, we could not envision a voter saying no to "land-use strategies" or "policy and regulatory initiatives." The FABs were not designed to be traded off. We found that, in general, private-sector participants tended to use more negative votes than public-sector participants.

For future workshops, we recommend that a hybrid positive/negative voting mechanism be used with poker chips. For positive voting, a cumulative mechanism should be used with each voter receiving as many chips as there are elements to evaluate (n). For negative voting, a single vote mechanism should be used with each voter receiving three chips of which they have to use at least one. The combination of positive and negative votes worked well in establishing points of discussion during the breakout sessions—which is the sole purpose of the voting mechanism.

4.1.2.8 Scenarios (Which Future Scenarios to Employ and Collateral to Use)

Four scenarios were created for the project: *Global Marketplace, Naftástique!, One World Order,* and *Millions of Markets. Millions of Markets* was initially called *Technology Savior* in the first three workshops. The name was changed to remove the anchoring bias of the name to all things technological. Full descriptions of these are not included in this report. Each scenario describes the world assuming a different set of macro sociotechnical and economic factors. The primary driving forces were level of trade (global to regional) and availability of resources (high to low).

Whenever possible, we used all four scenarios within a workshop. However, the decision of the number of scenarios to use was based on the number of workshop participants. The optimal size of a breakout section is between 10 and 15 people. Thus, this decision was made as late as about one week before the workshop. Table 10 shows which scenarios were used in each of the six workshops (indicated with an "x").

With the exception of the workshops at the POLB and GDOT, each workshop used all four scenarios. POLB and GDOT each used only three scenarios because to their smaller size. The

Table 10. Scenarios used in future freight flows workshops.

	DVRPC	MNDOT	WSDOT	POLB	GDOT	U.S.DOT
Global Marketplace	X	X	X	X		X
Millions of Markets	X	X	X		X	X
Naftástique!	X	X	X	X	X	X
One World Order	X	X	X	X	X	X

selection of which scenarios to use if the attendance does not justify using all four is arbitrary, but since *Global Marketplace* is consistently viewed as most like today, we recommend removing this one first. We do recommend, however, that during the debrief session all four scenarios are discussed and presented. Similarly, if the attendance is so large that the breakout sessions exceed 15 people, multiple separate breakout sessions can be run using the same scenario.

For future workshops, we recommend that the host organization target a total attendance of 60 people. The number of breakout groups should be determined by dividing the number of confirmed attendees by four.

- If this number is between 10 and 15, use all four scenarios.
- If this number is less than 10, find the largest number of breakout groups that gives you at least 10 per group: this is the number of scenarios to use. We recommend (not that strongly, though) that the scenarios be used in this priority order: *Naftástique!, One World Order, Millions of Market,* and *Global Marketplace.*
- If this number is greater than 15, find the smallest number of breakout groups that gives you no more than 15 per group: this is the number of scenario breakout sessions you will need to run. We recommend that the selection of which scenarios to double up on be in the same order as above.

The assignment of specific attendees to specific scenarios should be made about a week before the workshop. This was done ahead of the workshop since the brochures were sent out ahead of time. The selection was made such that each scenario had the same number of participants and roughly the same proportion of participants from different categories. When it was not possible to evenly distribute members of one category across all chosen scenarios, similar categories were combined and then the participants from the broader categories were randomly assigned to the selected scenarios. This method of sampling is known as stratified sampling, and is used in order to have a diverse perspective represented in each scenario and to have a mix of perspectives across all selected scenarios.

The same collateral should be used within each breakout session regardless of the number of scenarios being run. This should include the respective brochure and the newscast video.

4.1.2.9 Debrief (How to Present Outcomes and to Whom)

In each of the scenarios, we held a debrief session with all of the participants present. Additionally, for some of the workshops we held informal post-debrief sessions with the host organization members alone. The specific results will be discussed in Section 5.

For future workshops, we recommend a two-tiered debrief approach. First, we recommend that the host organization run a "public" debrief during the workshop. This should follow the same format as was done in the six workshops. The objective is to give the participants an idea of the consensus and differences in investment strategies between the future scenarios. If facilitated correctly, this session is great for getting insights from the attendees.

Second, we recommend a more formal and longer "private" debrief be held for just the host organization one or more days later. This session would go into much more depth and the objective

would be for the host to wring as much insight as possible out of the results. By holding it a few days later, it allows the team to clean up and spend more time with the results of the sessions.

4.1.3 Workshop Facilitation

One of the deliverables for the Future Freight Flows project is a facilitator's guide that will outline how a scenario planning workshop should be conducted. A team of researchers at the MIT CTL, having the experience of conducting dozens of scenario planning workshops, facilitated all six workshops in this project. For each workshop, the team prepared a facilitator's guide, which all facilitators followed. These can be found in Appendix E, Exhibits 2 through 7.

After the first workshop, the MIT team varied the process followed in the subsequent workshops based on what had worked well previously and what needed to be improved. In three workshops (DVRPC, MNDOT, and WSDOT), the staff at the host/planning organization or the agency's collaborators helped the MIT facilitators during the scenario breakout sessions by taking notes and answering any participants' questions about the freight transportation infrastructure in the region being considered. For example, associates from the Volpe Center worked with the associates from MNDOT and the Metropolitan Council at the MNDOT workshop.

Initially, we had planned for the facilitator role to be taken over by the host organization. The MIT team had planned to develop and use a "train the trainers" approach over the course of the six workshops. This was not successful. We found that while the host organizations had domain and local expertise on the freight network, they did not typically possess the required group facilitation skills. We inadvertently discovered that having non-host affiliated facilitators led to a more trusted session. The MIT facilitators, for example, had no vested interests in the outcome of the workshop. Some hosts mentioned that if members of the local DOT facilitated the session, it would be perceived that they were biasing the discussion to their preferred investment decisions. For this reason, we recommend having non-interested third-party facilitators for future workshops.

4.1.4 Summary

This section presented the design of the six scenario planning workshops in the Future Freight Flows project. We pointed out the similarities and differences in the designs of the six workshops along the nine key dimensions: Scope, Objective, Duration, Participants, Strategic Questions, Evaluation Elements, Evaluation Mechanisms, Scenarios, and Debriefs. The next section describes the process that brought these different elements together to facilitate a strategic conversation about investing in the region's freight infrastructure to be prepared for an unknown and unpredictable future 20 to 30 years from now.

4.2 Future Freight Flows Workshops: Process

This section describes the specific scenario planning process used at the six workshops. There are four subsections. The first subsection (4.2.1) presents the resources used in the workshop. This consists of the "human resources," that is, the roles performed by various actors in the workshop, facilities and equipment, and reading and voting material. Subsections 4.2.2, 4.2.3, and 4.2.4 present the activities performed before, during, and after the workshop, respectively.

4.2.1 Resources Used in the Workshop

This section describes various resources used in the six workshops. This section first describes the roles played by various members of the MIT team and the host organization. This is followed

by the facilities and equipment used for the workshop, folders prepared for individual participants, scenario videos, and the instruments used for voting.

4.2.1.1 Roles

The personnel from MIT and the host organization performed eight roles. The roles are described below.

- ***Host:*** The host, a high-level executive at the host/planning agency, whose role was to welcome the workshop participants, and inform them of the importance of the workshop for which they were going to invest a day of their time. The following were the hosts at the workshops:
  - DVRPC: Mr. Barry Seymour, Executive Director of Delaware Valley Regional Planning Commission.
  - MNDOT: Mr. Bill Gardner, Director of Freight, Rail and Waterways for Minnesota Department of Transportation.
  - WSDOT: Ms. Paula Hammond, Secretary of the Washington State Department of Transportation.
  - POLB: Mr. Eric C. Shen, Director of Transportation Planning for the Port of Long Beach, California.
  - GDOT: None. The Georgia DOT preferred to participate in the session but not publically endorse it. This decision was announced to the MIT team a few weeks prior to the workshop.
  - U.S.DOT: Mr. John Horsley, Executive Director of the American Association of State Highway and Transportation Officials (AASHTO).
- ***Planning Manager:*** The planning manager was the one who had been engaged with MIT in designing the workshop for the 8 to 12 weeks leading to the workshop day. In many workshops, the planning manager—Ms. Barbara Ivanov at WSDOT being a great example—took the leadership role of ensuring that the insights collected at this workshop would be brought into the organization's planning process. In all workshops, except the POLB and GDOT workshops, the planning manager described the infrastructure segments to the workshop participants.
- ***Lead Facilitator:*** The role of the lead facilitator was to set the stage for a productive scenario planning session. At the beginning of each workshop, the lead facilitator introduced the workshop participants to the philosophy of scenario planning and described how the workshop would be conducted. For all six workshops, Dr. Chris Caplice of MIT played this role.
- ***Scenario Facilitator:*** The role of the scenario facilitators was to facilitate the discussion within their breakout groups. The main objective of the facilitator was to help the participants in his/her group immerse themselves into the scenario. The facilitator then helped them apply their knowledge and insights to express through a voting mechanism the utility of the candidate freight segments in their scenario. The scenario facilitator had to manage the dynamic interaction within the group so that individual group members could express their unique insights and then combine the individual insights to bring forth the group's insights. Five experienced facilitators from MIT—Dr. Chris Caplice, Jim Rice, Dr. Mahender Singh, Dr. Roberto Perez-Franco, and Shardul Phadnis—played this role in the six workshops.
- ***Note Takers:*** The responsibility of the note takers was to capture the insights being shared by the participants in the breakout session. They were members of the planning organization, and were used in the first three workshops. Each breakout group had one or two listeners.
- ***Associate Facilitator:*** In three workshops (DVRPC, MNDOT, and WSDOT), the associate facilitator helped the lead facilitator compile the data generated by individual scenario teams during the breakout sessions. This helped to expedite the cross-scenario analysis so that a fairly thorough analysis could be presented to the workshop participants during the debrief and discussion session. Miguel Sánchez-Valero of MIT played this role. After the WSDOT workshop, the MIT researchers enhanced the spreadsheets used for analyzing the data by the scenario team. This automated much of the analysis, and the role of the associate facilitator was eliminated for the last three workshops.

- ***Cross-Scenario Facilitator:*** The role of the cross-scenario facilitator was to orchestrate the presentation of results from individual scenarios, engage the participants in comparing the results across scenarios, and to present the cross-scenario analysis. Dr. Caplice of MIT played this role in the first three and the last (U.S.DOT) workshop. Shardul Phadnis of MIT played this role in the POLB and GDOT workshops.
- ***Organization and Reception:*** Eric Greimann of MIT played this role. Before the workshop, he helped organize the resources needed for the workshop by coordinating with representatives from the planning organization. On the day of the workshop, Eric manned the registration desk, signed in the attendees, and handed out individual folders containing the material used in the workshop.

4.2.1.2 Facilities and Equipment

Three types of facilities and equipment were used in all six workshops, as follows:

- ***Conference Room:*** This room was large enough to seat the entire group of workshop attendees. The room had large projector screens and audio-visual equipment that were used for the PowerPoint presentations.
- ***Breakout Rooms:*** The breakout sessions were conducted in separate rooms—one for each scenario. Whenever possible, the participants were seated around tables in a U-shape so they faced each other and the facilitator. Each breakout room had audio-visual equipment, which was used for showing the video of the newscast in each scenario.
- ***Audio-Visual (AV) Equipment:*** Each breakout room had a projector, a screen, and speakers. The AV equipment in the breakout rooms was used to show the video of each scenario (audio needed). The AV equipment in the main conference room was used to show the videos of all four scenarios during lunch and for the presentations before and after the interactive workshop breakouts.

4.2.1.3 Individual Folders

Each workshop participant received a folder containing information about the exercise when he or she registered in the morning. The folders were made specific to each scenario. Each folder contained a copy of the day's agenda, a brief description of freight infrastructure segments (or FABs in MNDOT), maps of the segment (except for the MNDOT and U.S.DOT workshops), and the brochure of the participant's assigned scenario.

4.2.1.4 Scenario Videos

Each breakout group was shown a scenario-specific newscast video. The video first describes the scenario in about 30 seconds, and then shows a newscast from that scenario dated Nov 2, 2037. The video lasts for about six minutes. The reason for using this video is to help the participants immerse themselves in the scenario by showing them a vivid description of the world. After the breakout sessions, all participants saw either a summary video of all of the scenarios, or each of the individual newscast videos of all four scenarios before engaging in a cross-scenario analysis.

4.2.1.5 Voting Instruments

Three instruments were used in each breakout session to facilitate voting.

- ***Individual Investment Decision Form:*** Each participant in the scenario breakout session was given one form to write his/her individual vote. For "evaluation" workshops, the form listed all the infrastructure segments chosen for the workshop, with spaces to write the number of positive (votes) or negative (veto) points assigned by the participant to that segment. For the "visioning" (MNDOT) workshop, this form listed the five FABs considered and a box for writing the points assigned to that FAB. All forms also had a space for the participant to write in the infrastructure segment or FAB not covered in the list provided. The segments on the

"evaluation" forms were presented together according to their modes. The reason for using these forms was to allow the individuals to write their investment decision based only on their own thoughts and insights before participating in a group discussion and voting process.

- ***Voting Chips:*** Professional size and weight poker chips were used for the participants to reveal their votes to the entire group. The chips made the votes of the entire group participating in a scenario "visual" and facilitated the discussion about the utility of various segments perceived by the members of the group. For the "evaluation" workshop, the participants were given chips of three different colors, representing three different values (blue for 25, red for 10, and white for 5 points), to represent the positive votes and black chips to represent the veto votes. For the details of the voting mechanism, please refer to the reports for individual workshops in Appendix E.
- ***Group Voting Sheets:*** A form listing all the infrastructure segments or the FABs was used for the group members to place their voting chips on to represent their individual votes. The scenario facilitator tallied all the votes on each segment or FAB and wrote the total on the form. If any participant changed his/her vote after the group discussed the votes, the changed vote was noted on the form. The final tally of votes from this form was entered into the spreadsheets used by MIT to summarize the group's vote in each scenario and to compare the votes across scenarios.

4.2.2 Pre-Workshop Activities

One week before the workshop, the workshop participants were sent a pre-workshop survey via email. This survey was a part of the research work conducted by MIT during the Future Freight Flows Symposium. The objective of the pre-workshop survey was to capture the workshop participants' assessments of the usefulness of investing in various freight infrastructure segments used in the workshop. The survey was conducted in all except the MNDOT workshop since that particular workshop did not involve any evaluation of infrastructure segments. After completing the survey, each participant was sent reading material for the workshop. This included a web-link to the scenario he or she was assigned to, description of the infrastructure segments used in the workshop, and a one-page description of the workshop.

4.2.3 Workshop-Day Activities

With the exception of the first workshop (DVRPC), all other workshops were 6 to 8 hours long. The DVRPC workshop was a half day exercise held from 8 a.m. to 1 p.m. The agendas for all six workshops are presented in Exhibit 1 in Appendix E. All workshops began with the registration and signing in of the participants. After signing in, the participants were given name tags and their individual folders containing material related to the workshop. The duration of each workshop was divided in three large blocks: introduction, interactive workshop, and debrief and discussion. The activities performed in each are explained in Sections 4.2.3.1 to 4.2.3.4 below.

4.2.3.1 Introduction

The introduction consisted of three segments: a *welcome* to the workshop participants, an *introduction to scenario planning* method, and an *introduction to the infrastructure segments* chosen for the workshop.

- ***Welcome:*** A high-level executive at the host organization (such as Ms. Paula Hammond at WSDOT or Mr. Bill Gardner at MNDOT) kicked off the workshop with a welcome. Besides formally welcoming the participants to the workshop, the *hosts* also noted that their organizations were planning to bring the results of the workshop into their planning process. This speech was an endorsement to the gravity of the workshop. While most workshops had a high-profile official from the planning organization give this speech, not all did due to different levels of involvement of the agencies. The *lead facilitator* gave the welcome address at POLB (Long Beach) and GDOT (Atlanta) workshops.

- ***Introduction to Scenario Planning:*** In all six workshops, the *lead facilitator* (Dr. Chris Caplice of MIT) introduced the workshop participants to scenario planning. Dr. Caplice used several examples of societal, technological, and political changes that have happened over 20 to 30 years to show that the world we live in today was far different from the 1980s, and could not have been predicted 30 years ago. He also used examples of forecasts being egregiously wrong, to make a case for using scenario planning. This presentation evolved over the series of workshops, and was generally the highest rated part of the exercise. This presentation lasted between 30 and 45 minutes. The PowerPoint slides are part of the Scenario Planning Toolkit and are available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").
- ***Introduction to Freight Infrastructure Segments:*** In this part of the introduction, the infrastructure segments to be evaluated in the workshop were illustrated to the participants. The goal of doing this was to ensure that all participants had a uniform understanding of what the segments meant. Where applicable, the segments were shown on maps of the region. In the MNDOT workshop, where FABs were used instead of infrastructure segments, this section described the FABs. The introduction to segments or FABs generally took about 15 minutes, and was done by either the *planning manager* (such as Ms. Barbara Ivanov at WSDOT) or the *lead facilitator.*

At the conclusion of this introductory section, the group took a 15-minute break before participating in the interactive workshop. Before breaking, the *lead facilitator* informed the participants of the "rules of engagement" in the interactive workshop: no questioning of the scenario, no criticism of ideas, and free sharing of insights.

4.2.3.2 Breakout Sessions

For the individual, small group breakout sessions, the participants broke into their pre-assigned groups—one per scenario. The purpose of this exercise was to identify how the planning organization should prioritize its investments in the region's freight infrastructure in order to be prepared for each scenario. The interactive workshops consisted of several segments lasting from 15 to 30 minutes each. The segments of this session were always performed in the same order, as mentioned below.

- ***Scenario Immersion:*** At the beginning of the interactive workshop, the scenario facilitators asked their groups to "live in the year 2037" in their scenarios. The participants were then asked to describe the scenario. (All participants were sent the scenario and asked to read it before the workshop.) All scenario facilitators had lists of important facets of their respective scenarios, and facilitated the discussion so that the group would identify most, if not all, of those features. Following this, the scenario facilitators showed the scenario videos (Section 4.2.1.4). The four "Future Newscast" videos are part of the Scenario Planning Toolkit and are available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment"). The goal of the immersion was to ensure that all participants had understood their scenario well, so they could judge the usefulness of investing in various segments or identify the initiatives for the scenario. Scenario immersion took approximately 30 minutes.
- ***Scenario Implications:*** After the immersion, the participants were asked to identify the implications of the scenario for the region's freight infrastructure. The implications were of five types: origin, destination, volume, value density, and the transportation mode of the freight originating, coming into, and passing through the region. Identification of implications took approximately 15 minutes.
- ***Individual Voting:*** After immersion and identifying implications, the participants were asked to work individually and answer how freight infrastructure funds should be invested today to prepare for the scenario. The participants first wrote their answers individually on the "Individual invest decisions form" (see Section 4.2.1.5) and then placed voting chips on the

"group voting sheets." The voting exercise took about 20 minutes. The group took a brief break following the voting, during which the scenario facilitator tallied the group's vote. Templates for collecting these votes are part of the Scenario Planning Toolkit and are available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment"). In the "visioning" exercise conducted at MNDOT, the participants wrote their ideas for initiatives in different FABs on sticky notes and posted them on a flip chart. The group and the scenario facilitator summarized the ideas to reveal common themes.

- ***Group Discussion and Consensus:*** The scenario facilitator then discussed the group's vote, to identify the reasons why the group had voted as it did. In the workshops where used, the note takers (Section 4.2.1.1) captured the insights shared by the workshop participants. After the discussion, the participants were allowed to change their votes. The group discussions typically lasted for about 20 minutes.
- ***Identification of Initiatives:*** If a workshop involved a "visioning" exercise after "evaluation," the participants were asked to identify specific initiatives the planning agency should take today to prepare for the scenario. For this qualitative exercise, the participants wrote their ideas on sticky notes and placed them on a large pad. The group and the scenario facilitator read the notes to identify the common themes for initiatives suggested by the group. The initiative identification exercise lasted for about 30 minutes.

The interactive workshops lasted from 1 hour and 45 minutes to 2 hours and 30 minutes. At the end of the workshop, the scenario group was asked to choose two representatives to share the results with the entire group of workshop participants in the "debrief and discussion session" (Section 4.2.3.4). The scenario representatives captured the insights from the group discussion, and the groups broke for lunch. A Facilitators Guide is part of the Scenario Planning Toolkit and is available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

4.2.3.3 Summary of the Breakout Sessions

During lunch, the facilitators tabulated the output of each scenario group (votes, initiatives, insights, etc.) in spreadsheets prepared for the analysis. The charts generated by these spreadsheets were linked into the presentation used for sharing the results of individual scenarios as well the cross-scenario analysis. MIT facilitators prepared the presentations to be shared with the group in the "debrief and discussion session" after lunch. The Excel file used to tabulate and generate results is part of the Scenario Planning Toolkit and is available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

4.2.3.4 Debrief and Discussion

After lunch, all scenario groups assembled together as one group, as they did for the introduction session (Section 4.2.3.1). In the first workshop (DVRPC), the debrief session was held over lunch and lasted for only one hour. It was realized that the debrief session needed much more time and focus. Therefore, the debrief and discussion sessions in all subsequent workshops were held after lunch and lasted from 1 hour and 30 minutes to 2 hours. This session typically had the following four components:

- ***Scenario Reveal:*** The debrief sessions began with the revealing of all the scenarios used in the workshop to the participants. Until this time, each participant had known one and only one scenario—the one he or she participated in. The reason for revealing all the scenarios for the debrief session was to ensure that all participants got to know the different scenarios so as to form a basis for discussion within the group. The scenario videos (Section 4.2.1.4) were used for this purpose. The scenarios summary video containing the overviews of each of the

four future scenarios is part of the Scenario Planning Toolkit and is available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

- ***Presentation of Individual Scenario Results:*** After revealing all scenarios, the cross-scenario facilitator (Section 4.2.1.1) invited the representatives from each scenario to present their group's results. The scenario representative used the presentation MIT facilitators had prepared during the lunch hour (Section 4.2.3.3). The cross-scenario facilitator encouraged the participants in other scenarios to compare their findings to the ones being presented. These often resulted into a lively exchange of ideas among the group.
- ***Presentation of Cross-Scenario Analysis:*** Following the presentation of results from individual scenarios, the cross-scenario facilitator presented the charts comparing the results from all scenarios. These charts were used to show the participants how different infrastructure segments can be classified into robust and contingent segments. The Excel and PowerPoint files for this debrief session are part of the Scenario Planning Toolkit and are available on the companion DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment"). The classification developed by MIT's Supply Chain 2020 research group was used for this analysis, as follows:
  - *No-brainer segments* are the ones found to be favorable for investment in all scenarios.
  - *No-gainer segments* are those that are unfavorable for investment in more than one scenario and not found to be favorable in any.
  - *No-regret segments* are those that are favorable in some, but not all, scenarios and are not unfavorable in any scenario. The above three types of segments are robust investments, that is, the decision to invest in them remains the same regardless of the scenario.
  - *Contingent segments* are those that are favorable in some scenario(s) and unfavorable in some others. The decisions to invest in these segments are contingent upon which scenario the world comes to be like. The strategy to invest in these segments involves making some "flexible" investments that can be adapted once the planning organization gets a better sense of which way the future may evolve.
- ***Sensors in the Ground:*** The cross-scenario analysis was followed by a presentation of "sensors in the ground." Sensors are those events in the business environment that change the assessment of the subjective likelihood of the future evolving in the direction of a particular scenario. Sensors provide indications for if and when flexible options in the contingent segment should be exercised. The lead facilitator always gave this presentation. After the discussion of sensors in the ground, the lead facilitator wrapped up the workshop.

4.2.4 Post-Workshop Activities

One day after the workshop, the workshop participants were sent a post-workshop survey via email. This survey had two parts. In the first part, the survey asked the workshop participants to assess the usefulness of investing in the freight infrastructure segments used in the workshop. These questions were identical to those in the pre-workshop survey. The reason for asking these questions again was to see if and how the participants' evaluations had changed after participating in the scenario planning workshop. In the second part, the participants were asked to rate the effectiveness of various parts of the workshop (described in Section 4.2.3) and the material used to describe the scenarios.

4.2.5 Summary

This section described the scenario planning process used at the six workshops. The section first presented the resources used in the workshop (Section 4.2.1). This was followed by a detailed account of the activities performed before (Section 4.2.2), during (Section 4.2.3), and after (Section 4.2.4) the workshop.

SECTION 5

Future Freight Flows Workshops: Results

The previous section compared the scenario planning process used across the six scenario planning workshops. In this section, we compare the results obtained from the six workshops. The workshops had different geographic focus areas (Northeast, Midwest, Northwest, Southwest, South, and the entire United States), region sizes (state, multi-state, national, etc.), strategic questions, and infrastructure segments. Additionally, each workshop used the scenarios developed for the Future Freight Flows project differently. In some workshops, the host organization evaluated the utility of investing in a set of pre-selected freight infrastructure segments. In some others, the scenarios were used to leverage the insights of the workshop participants to identify freight initiatives.

These results are compared in this section. Section 5.1 describes the method used for comparing the results across six disparate workshops. Following this, the results from infrastructure segments evaluation sessions are compared in Section 5.2. The comparison of initiatives from the "visioning" sessions across the workshops is presented in Section 5.3.

5.1 Method for Comparing Results Across Workshops

The scenarios in the six Future Freight Flows workshops were used for two purposes: evaluation of specific freight infrastructure segments and visioning of initiatives in the chosen region. The results of the evaluation session are quantitative; those of the visioning session are qualitative. These quantitative and qualitative results from the six workshops are summarized separately in Sections 5.2 and 5.3, respectively.

Five workshops (all except MNDOT) included an evaluation of infrastructure segments. The segments were physical components of the freight infrastructure specific to the regions in four of these workshops, and abstract concepts in the U.S.DOT workshop. In order to compare the results across these five workshops, the segments used in all workshops are first classified into one of the three types: gateways, corridors, and connectors. The three types are defined in Section 4.1.2.6. The number of segments of each type used in the five workshops is presented in Table 9 in the same section. For comparing the "evaluation" results from the five workshops, the positive votes and vetoes assigned to individual segments in each workshop are rolled up into the corresponding segment types. These results are discussed in Section 5.2.

Four of the six workshops (all except DVRPC and U.S.DOT) used a visioning session to identify initiatives the planning organization should consider. These are qualitative results; the themes are identified and compared across the four workshops. The comparison of results of the "visioning" sessions is presented in Section 5.3.

5.2 Comparison of Results from Evaluation Sessions

The results from voting in the evaluation sessions in five of the workshops are summarized by types of segments, and presented in Appendix E, Exhibits 8 through 12. Each exhibit has three sections: a, b, and c.

- **Section (a)** shows the number of individual segments of each type, followed by the total points (positive votes) and vetoes (negative votes) received in each scenario used in the workshop. For example, in the DVRPC workshop (Exhibit 8), the participants in the *Global Marketplace* scenario assigned a total of 1,360 points and 18 vetoes.
- **Section (b)** shows the proportion of total points and vetoes each segment type received in each scenario. Thus, in each scenario, the proportions of points for the three segment types add to 1. Similarly, in each scenario, the proportions of vetoes for the three segment types add to 1.
  - If the proportion of **points** received by a segment type in a scenario is greater than the proportion of **vetoes** received, then the former is shown in **blue** font. This suggests that the segment type, overall, was more often preferred than vetoed.
  - If the proportion of **vetoes** received by a segment type in a scenario is greater than the proportion of **points** received, then the former is shown in **red** font. This suggests that the segment type, overall, was more often vetoed than preferred.
- **Section (c)** shows the proportion of points and vetoes per segment. Thus, this section is section (b) normalized by the number of infrastructure segments in the segment type. For each scenario in a given workshop, the highest proportion of votes and vetoes per segment are shown using a bold font. The bold font highlights the most preferred and most vetoed segment types of the three, in each scenario.

Before delving into the results, we want to remind the reader about the number of segment types in each workshop. These results were presented in Table 9 by modes, and are reproduced here in Table 11 by combining all modes.

The results from individual workshops presented in Appendix E, Exhibit 8 through Exhibit 12, are summarized in one table (Table 12) for an easy, visual comparison of votes across the five workshops. However, because the information density of this table is high, it is described in detail first.

- Each column represents one of the five evaluation workshops (DVRPC, WSDOT, POLB, GDOT, U.S.DOT).
- Each workshop column has two sub-columns: one for positive points ("**votes**") and one for negative votes ("**vetoes**").
- The votes and vetoes are shown for gateways, corridors, and connectors for each scenario used in the workshop.
  - Remember that these workshops used four scenarios: *Global Marketplace* (GM), *Millions of Markets* (MM), *Naftástique!* (N!), and *One World Order* (OWO).

Table 11. Types of infrastructure segments used in evaluation workshops.

	DVRPC	MNDOT	WSDOT	POLB	GDOT	U.S.DOT
Gateways	2	-	3	2	3	6
Corridors	4	-	12	10	8	3
Connectors	2	-	1	3	2	3
Number of segments	**8**		**16**	**15**	**13**	**12**

Table 12. Summary of "evaluation" votes by segment types in all workshops.

		DVRPC		WSDOT		POLB		GDOT		U.S.DOT	
		votes	vetoes	votes	vetoes	votes	vetoes	votes	vetoes	votes	vetoes
Gateways	GM	0.36	0.17	0.21	0.00	0.25	0.15			0.47	0.29
		68%		100%		63%				62%	
	MM	0.21	0.47	0.20	0.05			0.26	0.36	0.45	0.57
		30%		81%				42%		44%	
	N!	0.25	0.20	0.15	0.23	0.08	0.54	0.21	0.21	0.42	0.89
		55%		40%		13%		50%		32%	
	OWO	0.17	0.47	0.15	0.44	0.26	0.22	0.25	0.50	0.35	0.83
		26%		25%		54%		33%		30%	
Corridors	GM	0.46	0.50	0.75	0.85	0.37	0.75			0.24	0.21
		48%		47%		33%				52%	
	MM	0.61	0.29	0.77	0.76			0.48	0.64	0.33	0.24
		67%		50%				43%		58%	
	N!	0.45	0.67	0.85	0.47	0.77	0.38	0.63	0.71	0.32	0.00
		40%		64%		67%		47%		100%	
	OWO	0.53	0.47	0.84	0.31	0.47	0.67	0.55	0.44	0.24	0.13
		53%		73%		41%		56%		65%	
Connectors	GM	0.19	0.33	0.03	0.15	0.38	0.10			0.30	0.50
		36%		19%		79%				37%	
	MM	0.19	0.24	0.03	0.19			0.26	0.00	0.22	0.19
		44%		15%				100%		54%	
	N!	0.31	0.13	0.00	0.30	0.15	0.08	0.15	0.07	0.26	0.11
		70%		0%		66%		68%		71%	
	OWO	0.30	0.05	0.02	0.25	0.28	0.11	0.20	0.06	0.41	0.04
		85%		7%		71%		76%		90%	

  - Scenario *Millions of Markets* was not used in POLB; scenario *Global Marketplace* was not used in GDOT. Therefore, the cells in the POLB and GDOT columns in rows MM and GM, respectively, are blank.
- In each scenario—for a given segment type in a particular scenario—the votes are shown in two rows.

The first row shows the percentage of all the votes (in sub-column "votes") and percentage of all the vetoes (in sub-column "vetoes") received by the type of segment in that scenario in that workshop. This data is taken from sections (b) in Appendix E, Exhibit 8 through Exhibit 12.

- The second row shows a bar-chart depicting the proportion of votes in the total proportion of votes and vetoes. Thus, the length of the bar is equal to votes/(votes + vetoes). Thus, the longer the bar, the more important the participants in that scenario in that workshop thought that segment to be.
- The bar charts in the scenarios are color-coded: *Global Marketplace* (blue), *Millions of Markets* (gray), *Naftástique!* (red), and *One World Order* (green).

Table 12 is shown above. Key observations from this table are presented in Section 5.2.1.

5.2.1 Observations from Comparison of Evaluations Across Workshops

The sections below describe the positive and negative voting results for the five evaluation workshops. The analysis combined the common infrastructure elements into three categories: gateway, corridor, or connector. Each is discussed in turn below.

Let us make three general comments on the combined results before discussing the details. First, these results and insights are limited in that they represent the opinions from only a small set of professionals from six different regions on a limited set of options presented by the host organizations. It is not meant to be conclusive or final.

Second, it is interesting to note that each scenario demonstrated slightly different priorities. No two workshops behaved quite the same across all segment types. This is probably due to the location at which each workshop was held as well as the particular economics of that area.

Third, we can get a rough sense of priority for the three different segment types by comparing the positive vote to negative veto ratio for each of the 18 scenario-workshop pairings. (A scenario-workshop pairing is simply one breakout group's results in one workshop. We ran five evaluation workshops with three using four scenarios and the other two using three scenarios. This gives us a total of 18: 4 GM, 4 MM, 5 OWO, and 5 N!). For gateways, only seven of 18 had more positive votes than negative vetoes, while for corridors this was reversed with 11 of 18 having more positive votes than negative vetoes. Connectors are a little more complicated since the WSDOT workshop had only a single segment that could be classified as a connector, which was heavily vetoed. Removing it, we can see that 11 of 14 scenario-workshop pairings had higher positive votes than negative vetoes. As a general insight, we can take away that connectors seem to be viewed as the most critical infrastructure elements to invest in followed by corridors. Gateways appear to be less valuable for further investment.

5.2.1.1 Gateways

The evaluation workshops had two (DVRPC, POLB), three (WSDOT, GDOT), or six (U.S.DOT) gateway segments. All five workshops had waterport and airport gateways. Only the U.S.DOT workshop had land gateways (i.e., border crossings with Mexico and Canada).

Gateways were found to be useful investments in all workshops in the Global Marketplace scenario. At least 62% of the total votes (including vetoes) received in the *Global Marketplace* scenario were in favor of investing in this segment type. In the remaining three scenarios, gateway segments, overall, were found to be useful to invest in at most one workshop in each of the remaining three scenarios, and found to be bad investments in the remaining workshops.

Of the four scenarios, *Global Marketplace* resembles the global world we live in today. This is the only scenario in which gateway segments are found to be useful to make investments in today. This suggests that, based on the results from all five workshops, *it makes sense to make investments into gateway segments only if we believe that the future will be similar to today*—that is, marked by global trade, which provides access to resources to anybody at any place in the world.

Actually, across all of the other scenarios, the general priority for gateway infrastructure is quite low; negative vetoes outweigh positive votes in 11 of 18 potential scenario-workshop pairings! Given that the official projections about the future often consider the continuation of the existing trends, there is a *real danger that infrastructure planning agencies will continue to invest in gateway segments* (because they are useful segment types in which to invest in *Global Marketplace*), *and these investments will turn out to be futile* if the official projections of the future are wrong. Therefore, investments in gateways must be done judiciously. The consensus of the other scenarios seems to be that there is sufficient gateway capacity for trade and further investment might not be needed.

5.2.1.2 Corridors

Corridors were the most common segments in each the Future Freight Flows workshops. With the exception of the U.S.DOT workshop, at least 50% of the segments evaluated in all workshops were corridors. WSDOT evaluated the most corridors, both by number (12) and by the percentage of total segments (75%). The most common corridors evaluated were highways, followed by rail lines.

Corridors were not found to be uniformly useful investments within any scenario across *all* five workshops. However, it was found to be generally useful to invest into corridor segments today to prepare for a *Naftástique!* or a *One World Order* scenario. The net proportion of votes received by corridor segments (including positive and negative votes) never fell below 40%, and was above 50% in seven out of 10 scenario sessions in the five workshops—reaching as high as 100% in *Naftástique!* in the U.S.DOT workshop and 73% in *One World Order* in the WSDOT workshop.

Corridor segments were also voted favorably in the *Millions of Markets* scenario in three of the four workshops where they were used. Only in the GDOT workshop was investing in corridors favored by less than 50% of the votes.

Corridor segments were found to be of the least use to invest to prepare for the *Global Marketplace* scenario. They received a higher proportion of vetoes than positive votes in three out of four workshops where they were evaluated for usefulness to prepare for a *Global Marketplace* world. Only in the U.S.DOT workshop was the proportion of positive invest points received by corridor segments slightly greater than the proportion of vetoes received. However, even in the scenarios for which corridor segments received a greater proportion of vetoes than invest points, the proportion of invest points was fairly high. One way to interpret this result is that the participants across all workshops felt that ***corridor segments were useful, but did not require additional investments at this time to prepare for a future similar to today.***

Overall, comparing the results of evaluation in four scenarios in five workshops, corridors stand out as fairly robust investments. However, these investments will be a lot more valuable if the future were to be significantly different from the world dominated by global trade. ***One way to invest in corridors today would be to prioritize investments in those corridor segments that urgently need to be invested in even to meet today's demands.*** Those investments will not only help us meet the present day needs, but also prepare us for a future quite different from today's fairly resourceful world of global trade.

5.2.1.3 Connectors

All five workshops evaluated one (WSDOT), two (DVRPC, GDOT), or three (POLB, U.S.DOT) connectors. The connectors consisted of local roads, short-line rails, or intermodal facilities.

The only connector evaluated in the WSDOT workshop was the "Grays Harbor to Chehalis Rail Line." This segment was heavily vetoed and received few positive invest points in all four scenarios used in the workshop. Because the results of evaluation of connectors in the WSDOT workshop are specific to one peculiar infrastructure segment only, they are omitted from the cross-workshop comparison presented below.

After discarding the evaluation from the WSDOT workshop, the connector segments emerge as highly useful investments to make to prepare for a *Naftástique!* or a *One World Order* scenario. Among the eight evaluations in these two scenarios from four workshops, the lowest proportion of positive points received by the connector segments is 66%. The connectors were also found to be useful investments in the *Millions of Markets* scenario in the GDOT and U.S.DOT workshops, and received 44% of the positive votes in DVRPC.

The connectors received mixed evaluations in the *Global Marketplace* scenario. They were found to be highly useful investments to make in the POLB workshop, but somewhat not useful investments in the DVRPC and U.S.DOT workshops. This suggests that connectors only in some specific regions or connectors only of specific types are useful investments to prepare for a business-as-usual future.

Overall, connectors emerge as useful to invest in to prepare for *Millions of Markets*, *Naftástique!,* or *One World Order*—any future in which the world looks different from today's *Global Marketplace.* Connectors are also found to be useful in some specific regions. Thus, ***one broad investment strategy for connectors would be to invest in those connector segments that urgently need to be invested in to meet today's demands.*** Those investments will help meet the present needs, and help prepare for a future quite different from today's *Global Marketplace* world.

5.3 Comparison of Results from Visioning Sessions

Four of the six Future Freight Flows workshops included a visioning session. The MNDOT workshop was a pure visioning workshop. The visioning sessions were conducted within individual scenarios, where the participants were asked to identify initiatives the planning organization should take today to be prepared for the corresponding scenario. The data collected in these visioning sessions is analyzed to identify similarities. Similar initiatives are grouped together under a category heading. Table 13 lists the most common initiatives across the four workshops. Only those initiatives are shown that were identified in at least two different scenarios in one workshop and in at least two different workshops. There are nine categories of initiatives, which are illustrated using the actual initiative identified by the workshop participants. An "x" next to the initiative indicates the workshop and the scenario in which it was identified. The rightmost column indicates the number of scenario groups across the four workshops in which the category of initiative was suggested.

5.3.1 Observations from Comparison of Initiatives Across Workshops

Of the four workshops with visioning sessions, two workshops used all four scenarios (MNDOT and WSDOT), and two workshops used three scenarios each (POLB and GDOT). Thus, the list of initiatives is generated in 14 scenario-workshop pairings.

By far, the most common group of initiatives was to "develop or improve intermodal connections." The initiatives in this category included increasing capacity of intermodal exchanges, improving interoperability among different modes at the intermodal facilities, and development of regional logistics hubs. These initiatives were identified in 11 out of 14 scenario sessions. They were identified in all four workshops and across all four scenarios used in the Future Freight Flows project. These initiatives are related to the "connector" type segments discussed in the previous section.

The next two most common initiatives were "creating freight-only lanes" and "making regulations and standards to facilitate freight." Each of these was identified by eight out of 14 scenario sessions, and across all four scenarios. While "freight lanes" was suggested in all four workshops, "regulatory initiatives" were suggested in three of the four workshops (except WSDOT). The initiatives in the "freight lanes" category suggested creation of dedicated truck lanes on highways, separating freight transportation from passenger transportation, and even taking the passenger traffic off the highways completely through improved transit! The motivating idea behind this initiative is to create "freight-only corridors" to facilitate goods flow in the country. The "regulatory initiatives" are also motivated by the need to improve the existing freight flows by eliminating regulations that hinder them. The common themes in this group of initiatives were

Table 13. Summary of initiatives from "visioning" session in all workshops.

		MNDOT	WSDOT	POLB	GDOT	#
Develop or improve intermodal connections: Improve capacity of intermodal exchanges, improve inter-operability via policy changes & technology, create regional logistics hubs, etc.	GM	x	x	x		11
	MM		x			
	N!	x	x	x	x	
	OWO	x	x		x	
Freight-only lanes: Create dedicated truck lanes on highways, separate passenger and freight transportation infrastructure, initiatives to take passenger traffic off highways, etc.	GM	x		x		8
	MM	x	x			
	N!	x			x	
	OWO	x		x		
Make regulations and standards to facilitate freight: National freight policy, repeal/revise Jones Act, improve goods flow across US-Mexico border, fast-track Environmental Impact Review process, standardize truck weights and sizes, etc.	GM	x		x		8
	MM				x	
	N!	x		x	x	
	OWO	x		x		
Increase highway capacity: Increase highway capacity, improve road conditions, streamline interchanges for commercial traffic, improve last-mile infrastructure, etc.	GM					7
	MM	x	x		x	
	N!	x	x			
	OWO		x		x	
Expand rail capacity: Increase capacity, double-track, separate freight from passenger traffic, improve operations (increase speed, reduce variability), etc.	GM		x			6
	MM		x			
	N!		x		x	
	OWO		x	x		
Reduce environmental impact of transportation: Incentivize use of greener modes of transportation, identify environmental initiatives, etc.	GM	x		x		6
	MM	x				
	N!	x				
	OWO	x		x		
Improve capacity of waterways: Dredge waterways, build new locks along waterways, build new barge facilities, etc.	GM	x				5
	MM					
	N!	x				
	OWO	x	x		x	
Land use: Reserve industrial land for industrial use, create multi-modal zones for industrial use and long-haul distribution, simplify zoning process, etc.	GM	x	x			5
	MM	x				
	N!	x				
	OWO	x				
Use information technology to improve freight flows: Implement demand management, implement technology to track and monitor cargo, use technology to charge for port usage, etc.	GM		x			3
	MM				x	
	N!					
	OWO				x	

having a national freight policy and funding to take freight planning out of regional provincial policies, developing policies to improve flow of goods across the U.S.-Mexico border, and repeal or revision of the Jones Act (Merchant Marine Act of 1920), which prohibits foreign shops from carrying cargo between U.S. ports.

The next three most commonly cited initiatives were related to improving the capacity of corridors—highways, rail lines, and waterways and ports. These initiatives were identified in seven, six, and five scenario sessions respectively. The initiatives related to adding new capacity (such as adding highway lanes or rail lines) or making the existing infrastructure carry more cargo (enabling double-stack transportation by rail, dredging ports, etc.). These initiatives were often mentioned in context of specific segments of the freight infrastructure (such as highway I-5, the Alameda Corridor, the Port of Savannah, etc.).

The other commonly identified initiatives included creating policies to reduce the environmental impact of freight transportation (six sessions), policies related to land use, specifically setting aside industrial land for creating long-haul distribution and multimodal facilities, and leveraging information technology to improve freight flows.

5.4 Summary

This section presented the results obtained in the six workshops, which used the Future Freight Flows scenarios project for evaluating different freight infrastructure segments and for identifying initiatives in different regions of the country. The six workshops had six different geographic focus areas: Northeast, Midwest, Northwest, Southwest, South, and the entire United States. To compare the results across the workshops with such diverse foci, some common themes had to be identified. Section 5.1 describes the method used for comparing the results across six disparate workshops. The actual comparison of results is presented in Sections 5.2 and 5.3. The former compares the results from evaluations of freight infrastructure segments and the latter summarizes the results from the visioning sessions used to identify freight infrastructure initiatives.

SECTION 6

Integration into Established Planning Process

Scenario planning workshops have been shown to be very engaging as well as effective in gathering input and feedback on freight transportation infrastructure investments from a diverse group of stakeholders. Clearly, running a workshop is not sufficient by itself to determine investment priorities and strategies. The scenario planning workshop is a simple and efficient method for collecting external feedback, uncovering unexpected insights, and "acid-testing" different strategies. Each state DOT has an established and (presumably) well-functioning process for freight investments. Transportation planners, however, are challenged with how to incorporate the workshop results (typically soft and qualitative) into their existing planning process (typically hard and quantitative).

While neither requested nor specified in the scope of the project initially, the integration of the workshops into traditional state planning processes has been a concern of the research team from the start of the project. The fact that each state follows its own process makes it more challenging for a standard or common process to be developed. We have addressed this through a separate Master's thesis (see Sánchez-Valero, M. A. 2011. *Merging Qualitative and Quantitative Criteria for Freight Investment Using Scenario Planning.* Massachusetts Institute of Technology, Cambridge, MA) that presents several case studies from WSDOT and makes recommendations on some potential methods. While this process is not adhered to by all states, it does serve as a starting point for states to consider how to incorporate a workshop into established processes.

The remainder of this section outlines the generic transportation planning process (mainly derived from WSDOT, but not completely) and then proposes three ways in which the results of a workshop can be incorporated.

6.1 The Generic Transportation Planning Process

Transportation planning is usually conducted at the state and metropolitan planning organization (MPO) levels. State departments of transportation are government agencies devoted to transportation, with official responsibilities for transportation planning, programming, and project implementation within their state or territory. MPOs are federally-funded transportation policy-making organizations made up of representatives from local government and governmental transportation authorities. Federal legislation requires the formation of an MPO for any urbanized area (UA) with a population greater than 50,000. In some states, planning for smaller communities and rural areas is conducted by their respective state DOTs, while others aggregate rural areas to form rural planning organizations. When developing transportation planning that includes Indian tribal lands, MPOs and state DOTs consult with the affected Indian tribal governments.

The transportation investment process is comprised of a large number of steps and involves many layers of multiple agencies, legislators, and jurisdictions. Its complexity is further enhanced by the lack of uniformity across regional administrations. For the purpose of simplification, and

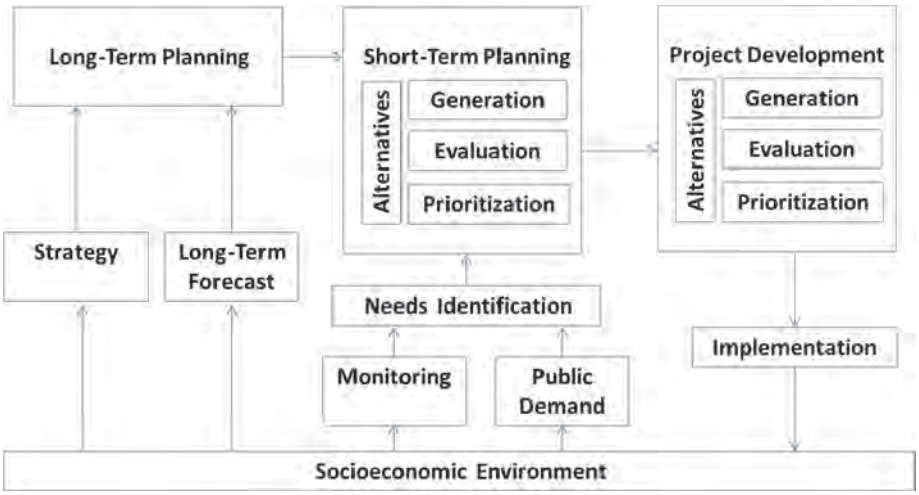


Figure 17. Transportation investment planning high-level components.

to help visualize which phases can be better served by scenario planning practices, we propose a simplified diagram, Figure 17, to summarize the relevant parts of the process.

Long-term transportation planning usually includes a vision, the desired condition of the region inside the expected future world. It defines broadly the strategic initiatives and priorities of the region, but usually provides little commitment to specific projects. Short-term transportation planning normally provides specific details and budget assignments for two years and leaves some flexibility for the second half of its time horizon. Based on the long-term strategic planning, the short-term planning includes projects to address the identified needs of the system. Those come from a variety of sources, including bottlenecks, safety hazards, unexpected maintenance, and requirements from local agencies or social pressure. Once a typical project study is budgeted, the first step is the development of high-level project option drafts that will be presented to different stakeholders for assessment. Subsequently, alternatives are evaluated and ranked, usually by a limited number of experts using simple multi-criteria analysis techniques. Their recommendations will lead to a final decision, and the implementation of the project.

We can further segment the statewide transportation planning process, as depicted in Figure 18. The figure shows on the outer loop the five phases that make up the process. The process starts with

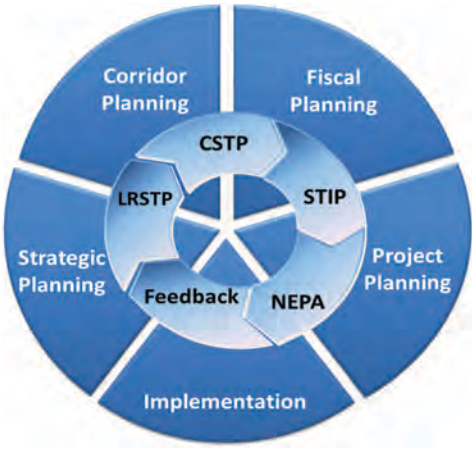


Figure 18. Transportation planning cycle with corresponding plan types.

the strategic planning phase and continues clockwise through corridor planning to fiscal planning, then financial planning and finally to implementation. Not all projects make it through all phases of the process. The inner circle shows the documents or plans that are handed off between the phases—these are explained in detail below.

In the strategic planning phase, a desired future state of the transportation system is produced. This is usually based on overall growth strategies for the region and a common vision developed through public outreach and stakeholder involvement, and derives into a final product, the long-range statewide transportation plan (LRSTP), which describes the strategic objectives to be reached and in varying degrees of detail, the specific actions and projects that will achieve them. Transportation scenario planning, as described later in this section, occurs in the strategic planning phase.

The corridor planning phase serves as a meeting point between the system-based view of the previous phase and the project-based approach of the next phases. In this phase, groups of possible investments are discussed and usually bundled into major multimodal corridors. This phase produces the corridor statewide transportation plan (CSTP), which describes specific projects in greater detail and ranks them in priority order for different corridors. Compared to the other documents in Figure 18, CSTPs are not required from the federal government, and therefore are not implemented in all planning organizations, especially when these decide to provide project-level details in their LRSTP, or have a previous planning system in place. But even if the name differs, the connecting phase between system-level and project-level thinking is always present, tying the LRSTP to the statewide transportation improvement program (STIP), and thus helping to reduce complexity and facilitate the transition from strategy to planning.

Fiscal planning, usually called programming, is the phase that produces the STIP, a formal document that lists all improvement projects planned for the next four years. A project must be included in the STIP to receive federal funding, and careful calculations of the estimated costs and benefits of each project are taken into account before submitting the projects and their priority ranking for funding allocation. It is interesting to note that priorities are allocated according to the current system data, forecasts, and perceived needs for each investment in each of the strategic goals of the planning agency (for example, in WSDOT these are mobility, safety, environmental enhancement, and economic vitality). Because funding needs always surpass available funding, if a clear and actionable strategic vision is not adequately stated and communicated from the LRSTP to the STIP (via the CSTP in some instances) so that the decision makers can use it as criteria to prioritize between similar ranking projects, the planning organization will always be in "firefighting mode," unable to implement its intended strategy and unable to react to emergent strategies to advance its goals.

Project planning is the phase in which a project is fully developed once it has received (or is expected to receive) funding for construction and preliminary studies. Based in the previous study at the corridor plan level, local planners produce an implementation plan. During this process, environmental permits and documentation must be obtained as required for federal and state funding. In some cases, environmental documentation can be prepared at the program-level in the corridor planning phase to ensure a faster implementation once funding is secured. The phase finishes with the approval of the National Environmental Policy Act (NEPA) documentation.

Implementation is the phase in which rights-of-way and real estate are acquired, a construction contract is released for bidding, and the project is finally built and becomes operational.

6.1.1 Key Documents for Transportation Planning

There are five key documents used for transportation planning: the unified planning work program (UPWP), the metropolitan transportation plan (MTP), the transportation improvement

	Who Develops?	Who Approves?	Time Horizon	Content	Update Requirements
UPWP	MPO	MPO	1 or 2 Years	Planning Studies and Tasks	Annually
MTP	MPO	MPO	20 Years	Future Goals, Strategies, and Projects	Every 5 Years 4 years for nonattainment and maintenance areas
TIP	MPO	MPO/ Governor	4 Years	Transportation Investments	Every 4 Years
LRSTP	State DOT	State DOT	20 Years	Future Goals, Strategies, and Projects	Not Specified
STIP	State DOT	US DOT	4 Years	Transportation Investments	Every 4 Years

Figure 19. Key documents for transportation planning (FHWA 2007).

program (TIP), the LRSTP, and the STIP. The key characteristics are described below and shown in Figure 19.

The ***UPWP*** lists the transportation planning activities that are to be undertaken by the MPO in support of the goals, objectives, and actions established in the LRSTP (for example, public outreach activities, planning workshops, etc.).

The ***MTP*** is a blueprint for transportation programs and spending in a specific metropolitan area. The *Code of Federal Regulations* requires the plan to "include both long-range and short-range program strategies/actions that lead to the development of an integrated intermodal transportation system that facilitates the efficient movement of people and goods" (CFR 450C, 2006). These plans usually follow a systems-level approach and are strategic in nature, proposing policies to deal with all aspects of transportation. They include projections for socioeconomic development, transportation demand, and cost estimates for operation, maintenance, and capital investments in the system over the next 20 years.

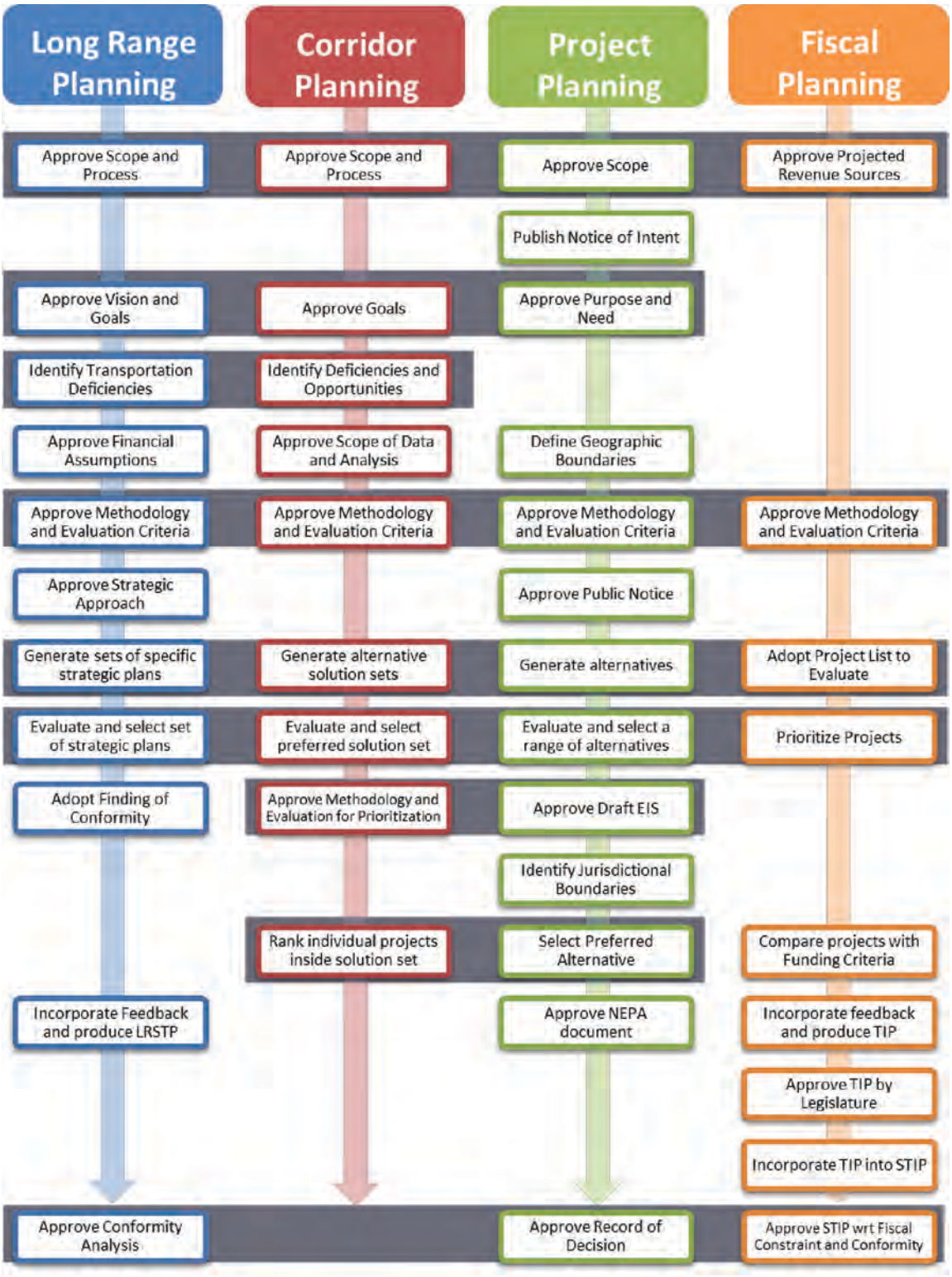
The ***TIP*** is a listing of all projects, project phases, and strategies scheduled to begin in the next four fiscal years in a metropolitan area. All projects that are candidates for federal funding must be documented in the TIP.

The ***LRSTP*** fulfills the same function as the MTP but at a statewide level. Both plans must be consistent with each other.

The ***STIP*** serves the same purpose as the TIP at a statewide level. All metropolitan TIPs are incorporated directly, without change, into their respective STIPs.

6.1.2 Transportation Planning Framework

Each of the planning phases described at the beginning of this section goes through a variety of steps. Figure 20 shows a transportation planning framework suggested by Transportation for Communities—Advancing Projects through Partnerships (TCAPP), a federal project to help



Note: wrt = with respect to.

Figure 20. Suggested planning framework (TCAPP 2011).

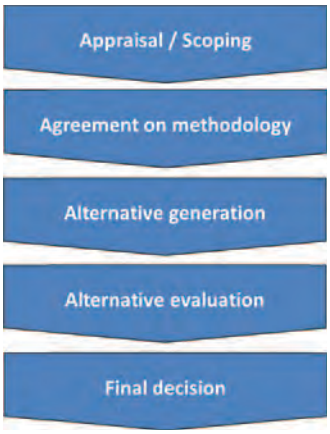


Figure 21. Common steps between all planning phases.

standardize planning steps and collaborative transportation decision-making processes across different states.

The description of each step is too lengthy to include here, but can be found online at *http://www.transportationforcommunities.com/shrpc01/*. Each phase can be conducted at the MPO or state DOT level, and all of them, except for corridor planning, involve more than one agency with decision-making authority, usually a federal agency (FHWA or a resource agency in the project phase) that decides whether to approve the final document or not. For this reason, all organizations with decision-making authority in any part of the process are usually engaged either in the scoping or in the alternative evaluation phases, to ensure their engagement and buy-in. The longitudinal areas shaded in gray in Figure 20 represent similar steps between all phases. These are depicted in Figure 21.

We can expect the use of exploratory scenario planning exercises to enhance the process in the scoping and alternative generation steps because of their ability to expose preconceptions and foster creativity and imagination. Normative scenario planning exercises can help in the alternative generation and final decision steps, assessing the robustness, the risk sensitivity, and the ability to capture unexpected opportunities for each alternative investment, as well as facilitating consensus among decision makers. The actual methodologies used in each of these steps vary among DOTs and even among projects, so no attempt to fully categorize them is made in this section.

6.2 Incorporating Scenario Planning into Transportation Planning

This section describes how the four scenarios created for the Future Freight Flows (FFF) project could be incorporated into the transportation planning process currently used by the state DOTs or MPOs.

6.2.1 When to Use Future Freight Flows Scenarios?

As discussed earlier, Future Freight Flows scenarios can be used in two general ways: visioning and evaluation.

- In "visioning," the FFF scenarios are used to stimulate thinking and facilitate discussion among the leadership team of the transportation planning agency to envision strategic objectives and/or

particular projects for the region. This is done by asking a participant to envision the region in one of the four scenarios and to identify corridors and/or strategies the region should have for the planning organization to best fulfill its overarching mission in that scenario.
- In "evaluation," the FFF scenarios are used to compare the usefulness of various projects previously identified by the leadership team under multiple scenarios. This is done by asking a participant to envision the region in one the four scenarios and then to vote on the set of projects chosen for the workshop.

In either case, the appropriate time for using scenarios is in the "strategic planning" phase. This means using the workshops to help develop the MTP for MPOs and to develop the LRSTP for state DOTs.

6.2.2 How to Use Future Freight Flows Scenarios for Visioning?

The FFF scenarios can be used for visioning exercises by the leadership team of the transportation planning agency to set the strategies for the transportation planning process. Here, the scenarios are used as *thinking devices* to help the leaders envision different future environments the region may experience. Using ideation methods—such as brainstorming—the scenario users identify the strategies, segments, and projects that would be useful in each scenario. These strategies, ideated across multiple scenarios, are compiled and are then evaluated *quantitatively* under multiple FFF scenarios using one of the "evaluation" methods as described in Section 6.2.3.

Additionally, the visioning exercise can also be used to identify the appropriate criteria for each scenario. Similar to the strategies, the criteria ideated under multiple scenarios are compiled and given appropriate weights for different scenarios (including the possibility of having weight zero on some criteria in some scenarios). A voting mechanism using non-negative points can be used to specify the relative importance of different criteria in multiple scenarios.

6.2.3 Three Approaches for Using FFF Scenarios for Evaluation

The Future Freight Flows scenarios can be incorporated into the existing evaluation structure either qualitatively or quantitatively—these are not mutually exclusive.

In the qualitative method, the workshop participants vote *individually* on the segments, and the scenario facilitator leads a discussion of the group's vote, asking the participants to explain why they voted as they did. This discussion uncovers values and insights of different stakeholders about how different segments would fare in their given scenario. These *qualitative insights* become the input to the transportation agency's planning process to help shape the MTP or the LRSTP for an MPO or state DOT, respectively. The planning agency would note these insights during the discussion and then incorporate them into strategic planning and/or corridor planning *subjectively* by adjusting the valuations of different projects.

To incorporate the quantitative results from the workshops, we assume that the existing transportation planning process evaluates the potential investments using multiple criteria. For example, each project or initiative might be evaluated along six criteria, as follows:

1. **Economic Growth**—Expected economic impact in the region, including direct and indirect effects.
2. **Freight Mobility**—Influence of each alternative on congestion levels; there is a set of projected data for each alternative and scenario.
3. **Environmental Impact**—Environmental damage of each alternative, including all viable attenuation measures.
4. **Economic Feasibility**—Net present value (NPV) projections including construction costs, revenue streams, and maintenance costs for each alternative.

5. **Development Impact**—Impact on land use and current long-term regional growth strategy.
6. **Safety**—Effect on a variety of safety metrics.

We assume that the planning agency has a vetted and established method for making trade-offs between these different dimensions. This could be as simple as ranking each project by individual criteria and weighting the results, or a more complicated multi-attribute optimization. In any case, the scenario results can be incorporated either by the following:

1. Evaluating each investment along its existing criteria within each scenario and then comparing across scenarios; or
2. Introducing a new dimension and adding it to the existing trade-off methodology.

The first method is discussed in great deal along with an example in Sánchez-Valero (2011). It is quite quantitative and incorporates mathematical expressions for reducing the regret, increasing the robustness, and minimizing the risk. While this is mathematically interesting, it would essentially require each workshop sub-group to apply its own multi-attribute evaluation. This is seen as being very time consuming and not very useful in a large-scale planning process.

In the second method, we create a new dimension that is populated based on the cross-scenario results. The workshop participants evaluate and vote on the different options as described earlier in the report. Each segment is then evaluated under all of the different scenarios. The votes on individual scenarios are combined in the cross-scenario analysis to compare the usefulness of investing in each segment under the multiple FFF scenarios. This exercise results in defining each segment as of one of the following four types:

- **No-brainer (NB):** Should be invested in all selected scenarios.
- **No-regret (NR):** Should be invested in some of the selected scenarios and not invested in none.
- **No-gainer (NG):** Should not be invested in any of the selected scenarios.
- **Contingent (C):** Should be invested in some of the selected scenarios and not invested in some other scenarios.

This qualification of each segment is added to the multi-criterion evaluation as described below:

- The NB and NR segments represent low-risk investments and should be promoted to the fiscal planning stage. Their cost-benefit estimation would be fairly straightforward and can be performed using traditional probabilistic decision-analysis methods. The scenarios should be considered equally probable for decision analysis.
- The NG segments also represent low-risk decisions, for *not* making investments. These segments should not be promoted to the fiscal planning stage.
- The C segments represent high-risk decisions and require a more extensive analysis during fiscal planning.
  - First, the planning agency should try to redefine the segment so that it consists of two parts: a base part that will be a NB and NR type investment, and a C part. Fiscal planning for the NB and NR part should be conducted as mentioned above.
  - The planning agency should identify *real options* to make the contingent part operational. A *real option* is a right, but not an obligation, to make an investment. A couple of examples of real options in transportation are as follows:
    (1) Acquiring land rights to build a four-lane road, but constructing only a two-lane road initially, or
    (2) Building a bridge with wide columns to add one more level, but constructing only a single level initially, and so forth.

    The agency should identify "sensors in the ground" to watch. The sensors are the environmental events that are used to update the likelihood of moving toward one of the scenarios, and are used to trigger the decision to exercise (or not) the real option.

In either method, the general approach is to add the results of the scenario planning workshop as one element within the decision-making process. Of course, by selecting investments one by one, we are ignoring system effects. Transportation investments are more effective if created as a "system" of transportation elements forming a corridor. Therefore, the evaluation process somehow needs to consider the value of forming a corridor. Additionally, transportation investments are budget constrained. The planning agency's goal is to maximize the utility of its investments that satisfy this constraint. The process we use evaluates each investment on its own merit, and does not take cost into account. The costs would be considered in the fiscal planning stage where cost-benefit analyses are performed.

This section was intended to summarize a generic transportation planning process and describe a potential method to incorporate the workshop results into that process. We understand that more research is required here to better integrate the workshops into the planning process.

SECTION 7

Conclusions and Future Research

This research project had two major objectives.

The first was to provide decision makers (at all levels and across all stakeholders) with a critical and comprehensive analysis of the driving forces and uncertainties that may affect the U.S. freight transportation system over the next 30 to 50 years. It is important to point out that this objective was *not* to develop the official version of the future for the U.S. freight transportation system to be used by all of the decision makers.

The second, and most important, was to create and disseminate a customized scenario planning methodology for these decision makers (primarily at the state DOT level) to use in creating a more flexible, adaptive, and responsive transportation management strategy on an ongoing basis. As a side benefit, this methodology was hoped to engender more productive interaction between the diverse stakeholders of the U.S. freight transportation system.

As the project progressed, a third (unofficial and out of scope) objective of the project arose. The need for integrating the scenario planning workshops into the established transportation planning process became apparent as we met and talked with different government planners at the MPO, state, and federal levels.

The remainder of this section is organized as follows. The first section recaps the analysis of future driving forces. The second section summarizes the scenario planning workshop methodology that was developed and presents some overall insights that were gathered. The third and final section briefly summarizes a potential method of integrating the scenario planning into the traditional existing planning process.

7.1 Future Driving Forces

The research team found a number of driving forces and critical uncertainties that we feel could influence future freight flows and thus freight infrastructure investment decisions. The conclusions were reached through a series of interactive exercises, surveys, and interviews with industry experts and practitioners. The forces were further classified and analyzed based on the probability of occurrence and the level of impact. The following conclusions were reached.

- The forces that appeared to both have the most impact and the most uncertainty were the level of global trade, potential re-domestication of manufacturing, and resource availability. These are all related in that they could signal a retreat from the global trading trends of the past half-century. These factors have tremendous impact on infrastructure investments and therefore were critical in the design of the four future scenarios.
- A number of important driving forces were seen to be present now and will continue to be important in the future with limited uncertainty. While important—the lack of uncertainty

limited their influence in infrastructure planning. Planners should assume that these trends will only increase. These included high and volatile fuel prices, increased use of battery vehicles, widespread use of "senseable" networks, and increased use of virtual working and online retailing.
- Several driving forces had very high levels of uncertainty—as measured across the industry surveys. The driving forces with the most variability in the probability of occurring are average age of 100, zero immigration, green customer demand, and reduction in global trade. The high variability indicates a lot of disagreement over the potential outcome and while these forces might not define the different scenarios, they were included.

Out of the analysis, several key elements arose. These helped to determine which forces and uncertainties should be used to define the scenarios, which to feather in, and which to ignore.

A number of the forces (aging population and increasing urbanization) were found to be so exceptionally certain to occur that they were classified as predetermined. This means that the trends are in effect and are exceptionally unlikely to deviate. These forces were deemed to be included in all of the scenarios. The only exception to this is that the specific geographies for the increased urbanization to occur were allowed to vary between mega-cities (New York City, Chicago, etc.) and second-tier cities (Madison, Burlington, Boise).

Another group of forces had high levels of uncertainty with two (or more) potential end points. These included the level of trade (ranging from global to blocs to regions to local only); resource availability (ranging from restricted and allocated to available); and manufacturing structure (ranging from highly centralized to decentralized). These structural forces became prime candidates for defining the four potential scenarios. Juxtaposing the two or three different forces can create a matrix of potential options. So, for example, using trade and resource availability would create a 2×2 matrix with the cells: Global Trade & Restricted Resources, Global Trade & Available Resources, Local Trade & Restricted Resources, and Local Trade & Available Resources. These are sometimes called "framing" forces since they form the framework or backbone of the set of scenarios.

7.2 Scenario Planning Workshops

The research team developed four scenarios to be used by government planning agencies to assist in long-term freight transportation infrastructure investment decisions. Rather than being developed for a single entity or location, the scenarios were designed to be usable at any level of government across any geography, and for a wide range of potential strategic questions.

The scenarios were tested in six workshops held at different levels of government (national, state, MPO, local) and different locations. The workshop design was tested and improved throughout the six workshops. Based on its experience through running these six workshops, the team created a Scenario Planning Toolkit for use by any planning organization. The toolkit includes guidebooks to assist in the planning and facilitation of the workshops as well as brochures, supporting videos, presentation slides, and spreadsheet templates to be used in the workshop itself. The complete Scenario Planning Toolkit can be found on the accompanying DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

Because each workshop was held in a different geography, under a different governmental organization, and evaluated different infrastructure investments, it was difficult to find any universal results. However, if we generalize to the *type* of infrastructure rather than a specific investment, we can glean a few insights. Specifically, any freight infrastructure (regardless of mode) can be classified into being a gateway (airport, sea port, etc.), a connector (intermodal connection, short-line rail, secondary road, etc.), or a corridor (highway, Class I rail line, etc.). We found some commonalities in the investment strategy for each of these infrastructure types.

7.2.1 Gateway Investments

Gateways were found to be useful investments in all workshops in the *Global Marketplace* scenario. Interestingly, of the four scenarios, *Global Marketplace* most closely resembles the global world we live in today. Because this is the only scenario in which gateway segments were found to be useful, it suggests that *it makes sense to make investments into gateway segments only if we believe that the future will be similar to today*—i.e., marked by global trade, which provides access to resources to anybody at any place in the world.

Given that the official projections about the future often consider the continuation of the existing trends, there is a *real danger that infrastructure planning agencies will continue to invest in gateway segments* (because they are useful segment types to invest in *Global Marketplace*), *and these investments will turn out to be futile* if the official projections of the future are wrong.

Therefore, investments in gateways must be done judiciously. The consensus of the other scenarios seems to be that there is sufficient gateway capacity for trade and further investment might not be needed.

7.2.2 Corridor Investments

Corridors were the most common segment type offered across the six workshops. They were found to be useful investments in three scenarios (*Naftástique!, One World Order,* and *Millions of Markets*) and only slightly useful in the *Global Marketplace* scenario. In no scenario were corridor investments considered detrimental.

One way to interpret these results is that the participants across all workshops felt that *corridor segments were useful, but did not require additional investments at this time to prepare for a future similar to today*.

Overall, corridors stand out as fairly robust investments. However, these investments will be a lot more valuable if the future were to be significantly different from the world dominated by global trade. *One way to invest in corridors today would be to prioritize investments in those corridor segments that urgently need to be invested in even to meet today's demands.* Those investments will not only help us meet the present day needs, but also prepare us for a future quite different from today's fairly resourceful world of global trade.

7.2.3 Connector Investments

Connector segments emerged as highly useful investments within three scenarios (*Naftástique!, One World Order,* and *Millions of Markets*) with mixed evaluations in the *Global Marketplace* scenario (depending on location). This suggests that connectors only in some specific regions or connectors only of specific types are useful investments to prepare for a business-as-usual future.

Connectors emerged as useful investments in those futures for which the world looks different from today's *Global Marketplace.* Connectors were also found to be useful in some specific regions. Thus, *one broad investment strategy for connectors would be to invest in those connector segments that urgently need to be invested in to meet today's demands.* Those investments will help meet the present needs, and help prepare for a future quite different from today's *Global Marketplace* world.

7.2.4 Common Initiatives Across Workshops

The workshops also collected qualitative suggestions and recommendations on potential initiatives. By far, the most common group of initiatives was to "develop or improve intermodal connections." The initiatives in this category included increasing capacity of intermodal

exchanges, improving interoperability among different modes at the intermodal facilities, and development of regional logistics hubs. These initiatives are related to the "connector" type segments discussed in the previous section.

The next two most common initiatives were "creating freight-only lanes" and "making regulations and standards to facilitate freight." The initiatives in the "freight-only lanes" category suggested creation of dedicated truck lanes on highways, separating freight transportation from passenger transportation, and even taking the passenger traffic off the highways completely through improved transit! The motivating idea behind this initiative is to create "freight-only corridors" to facilitate goods flow in the country. The "regulatory initiatives" are also motivated by the need to improve the existing freight flows by eliminating regulations that hinder them. The common themes in this group of initiatives were having a national freight policy and funding to take freight planning out of regional provincial policies, developing policies to improve flow of goods across the U.S.–Mexico border, and repealing or revision of the Jones Act (Merchant Marine Act of 1920), which prohibits foreign shops from carrying cargo between U.S. ports.

The next three most commonly cited initiatives were related to improving the capacity of corridors—highways, rail lines, and waterways/ports. The initiatives related to adding new capacity (such as adding highway lanes or rail lines) or making the existing infrastructure carry more cargo (enabling double-stack transportation by rail, dredging ports, etc.). These initiatives were often mentioned in context of specific segments of the freight infrastructure (such as highway I-5, the Alameda Corridor, the Port of Savannah, etc.).

The other commonly identified initiatives included creating policies to reduce the environmental impact of freight transportation, policies related to land use, the setting aside of industrial land for creating long-haul distribution and multimodal facilities, and leveraging information technology to improve freight flows.

7.3 Integration of Workshops into Existing Planning

The scenario planning workshops were well received as separate stand-alone events used to gather input and feedback from a wide set of stakeholders with different perspectives. The two challenges that state and MPO planners face are (1) the ability to run the workshops on their own and (2) the integration of the results into the established planning process.

The Scenario Planning Toolkit was designed to address the first challenge by providing a complete methodology as well as training materials required to run a workshop. The complete Scenario Planning Toolkit can be found on the accompanying DVD package or online at www.trb.org (search for "Scenario Planning for Freight Transportation Infrastructure Investment").

However, if a planning agency does not have sufficiently trained staff to facilitate or plan a workshop, it can always utilize a third party to assist. In fact, we found that there are many benefits to having a neutral third-party organization play an active role in facilitating the session. This third-party organization does not need to be the MIT research team. We recommend that the planning agency work with local university faculty and staff to identify qualified facilitators. It would also be worthwhile for the U.S.DOT to develop (or support) a training program to grow this strength across the various agencies and state DOTs.

The second challenge of integrating the workshop into an established planning process is more daunting. Each agency uses slightly (though sometimes dramatically) different methods for long-range planning of infrastructure investments. At a generic level, however, the workshops can be incorporated into the existing evaluation structure either qualitatively or quantitatively.

In the qualitative method, the suggestions and insights brought out by the workshop participants would become the input to help shape the MTP or the LRSTP for an MPO or state DOT,

respectively. The planning agency would note these insights during the discussion and then incorporate them into strategic planning and/or corridor planning *subjectively* by adjusting the valuations of different projects.

A more quantitative method would be to generate a robustness metric based on the cross-scenario voting results for the proposed infrastructure investments. This could then be categorized and ranked. The robustness metric could then be considered as another criteria in the existing multi-attribute evaluation system. The weighting could be adjusted accordingly to reflect the importance compared to the other established factors (e.g., economic growth, freight mobility, environmental impact, economic feasibility, development impact, safety, etc.).

Of course, by selecting investments one by one, we are ignoring system effects. Transportation investments are more effective if created as a "system" of transportation elements forming a corridor. Therefore, the evaluation process somehow needs to consider the value of forming a corridor. Additionally, transportation investments are budget constrained. The planning agency's goal is to maximize the utility of its investments that satisfy this constraint. The process we use evaluates each investment on its own merit, and does not take cost into account. The costs would be considered in the fiscal planning stage where cost-benefit analyses are performed.

SECTION 8

References

Caplice, C., and E. Blanco. 2006. *Freight Transportation Infrastructure Survey: Causes and Solutions to the Current Capacity Crisis,* MIT Center for Transportation and Logistics (CTL) Working Paper Series, Cambridge, MA.

CISCO and GBN. 2010. *The Evolving Internet: Driving Forces, Uncertainties, and Four Scenarios to 2025.*

Cousens, R., Steinberg, T., White, B., & Walton, S. (2002). Generic Scenarios: A Strategic Futures Paper. Strategic Futures.

De Jouvenel, Hugues. 2000. A Brief Methodological Guide to Scenario Building. *Technological Forecasting and Social Change* 65:37–48.

Deutsche Post AG. 2012. Delivering Tomorrow: Logistics 2050—A Scenario Study. Bonn, Germany: Deutsche Post AG.

De Wit, B., and Meyer, R. 2010. *Strategy: Process, Content, Context.* Cengage Learning EMEA Higher Education.

Federal Highway Administration. 2007. *The Transportation Planning Process: Key Issues. A Briefing Book for Transportation Decisionmakers, Officials, and Staff.* Retrieved 11/17/2010 from www.planning.dot.gov/documents/BriefingBook/BBook.htm.

Garvin, David A., and Lynne C. Levesque. 2006. *Strategic Planning at United Parcel Service.* Harvard Business School Case Study, 9-306-002.

Lempert, Robert J., Steven W. Popper, and Steven C. Bankes. 2003. *Shaping the Next One Hundred Years: New Methods for Quantitative Long-Term Policy Analysis.* Santa Monica, CA: RAND Corporation.

Lindgren, Matts, and Hans Bandhold. 2009. *Scenario Planning: The Link Between Future and Strategy.* Palgrave MacMillan.

Office of Freight Management and Operations. 2010. *Freight Facts and Figures 2010,* U.S. Department of Transportation, Federal Highway Administration.

Phadnis, Shardul. 2012. *Influencing Managerial Cognition and Decisions Using Scenarios for Long-Range Planning.* Unpublished Doctoral Dissertation, Massachusetts Institute of Technology, Cambridge, MA.

Ringland, G. 1998. Scenario planning: Managing for the Future. West Sussex, England: John Wiley & Sons.

Rogers, E. 2011. Global Strategy Manager, UPS, Conversation with authors.

Royal Dutch. 2005. *Shell Global Scenarios to 2025—The Future Business Environment: Trends, Trade-Offs, and Choices.* Shell International Limited.

Sánchez-Valero, Miguel Ángel. 2011. *Merging Qualitative and Quantitative Criteria for Freight Investment Using Scenario Planning.* Unpublished Master's Thesis, Massachusetts Institute of Technology, Cambridge, MA.

Scearce, Diana, and Katherine Fulton. 2004. *What if? The Art of Scenario Thinking for Non-Profits.* Global Business Network—Monitor Group. (www.gbn.com/articles/pdfs/GBN_What%20If.pdf).

Schoemaker, Paul J. H. 1993. Multiple Scenario Development: Its Conceptual and Behavioral Foundation. *Strategic Management Journal,* vol. 14, pp. 193–213.

Schoemaker, Paul J. H. 1995. Scenario Planning: A Tool for Strategic Thinking. *MIT Sloan Management Review,* vol. 36(2), pp. 25–40.

Schwartz, Peter. 1991. *The Art of the Long View.* New York, NY: Doubleday Currency.

Transportation for Communities Advancing Projects through Partnerships. 2011. Retrieved from http://www.transportationforcommunities.com/shrpc01/.

Wack, Pierre. 1985a. The Gentle Art of Re-Perceiving—Scenarios (Part 2): Uncharted Waters Ahead. *Harvard Business Review.* 85(5) pp. 72–89.

Wack, Pierre. 1985b. The Gentle Art of Re-Perceiving—Scenarios (Part 1): Shooting the Rapids. *Harvard Business Review.* 85(6) pp. 139–150.

Zegras, Chris, Joseph Sussman, and Christopher Conklin. 2004. Scenario Planning for Strategic Regional Transportation Planning. *Journal of Urban Planning and Development.* March, pp. 2–13.

SECTION 9

Appendices

Appendix A. Future Freight Flows Symposium

Agenda

Future Freight Flows Symposium

Thursday, March 11, 2010 – MIT MediaLab Extension Building, Room E14-633

8:30 *Registration & Continental Breakfast*

9:00 ***Welcome and Introduction***
Dr. Chris Caplice, MIT Center for Transportation & Logistics

9:15 ***A Nation of Floridas: Aging, Changing Lifestyles & the New Future of Freight***
Dr. Joseph Coughlin, MIT AgeLab

10:00 *Break*

10:30 ***After the Storm: New Challenges for the Global Economy in 2010-2030***
Sara Johnson, IHS Global Insight

11:15 ***Public Policy and Freight: History, Trends, and Issues***
Dr. David Luberoff, Harvard University Kennedy School of Government

12:00 ***Lunch***

1:00 ***Transporting Bits and Atoms***
Professor Neil Gershenfeld, MIT Center for Bits and Atoms

1:45 ***The New Age of Sensing***
Professor Sanjay Sarma, MIT Mechanical Engineering

2:30 *Break*

3:00 ***Wired for Innovation: How IT is Reshaping the Economy***
Professor Erik Brynjolfsson, MIT Sloan School of Management

3:45 ***Measuring and Managing Sustainability***
Professor Jonathan Johnson, The Sustainability Consortium

4:30 ***Wrap Up***
Dr. Chris Caplice

5:00 *Adjourn*

5:30 *Social and Light Hors d'Oeuvres*

Friday, March 12, 2010 – MIT Engineering Systems Division Building, Room E40-298

8:30 *Continental Breakfast*

9:00 ***Synthesis of Thursday's Expert Sessions***
Dr. Chris Caplice

9:30 ***Brainstorming Session: Key Driving Forces & Uncertainties***
All attendees and MIT facilitators

10:30 *Break*

10:45 ***Translation and Mapping to Freight Flows***
All attendees and MIT facilitators

11:30 ***Wrap Up and Preview of Next Steps***
Dr. Chris Caplice

12:00 *Lunch*

Attendee List

Future Freight Flows Symposium

March 11-12, 2010

AAFES
Maj. Gen. Keith Thurgood
Commander & Chief Executive Officer
Capt. DeShaunda Allen
CG Aide-de-Camp

adidas Group
Chris Peckham
Head of US Transportation

Anheuser-Busch InBev
Diana Orrego-Moore
Global Transport Manager

APL
Eric Mensing
President/CEO APL Maritime
VP Gov't Trade/Affairs APL

Arkansas Best Corp.
Judy McReynolds
President & Chief Executive Officer

Armada Supply Chain Solutions/LXP
Paul Newbourne
Vice President & General Manager

BNSF Railway
Dean Wise
VP Network Strategy

California DOT
Michele Fell-Casele
Senior Transportation Planner

Chiquita
Deverl Maserang
VP North America Logistics & Global Supply Chain Strategy

Con-way
Tom Nightingale
VP Communications & Chief Marketing Officer

Covidien
Robert Menard
Manager Global Transportation Contracts & Pricing

CSX
Dale Lewis
Strategic Analyst

D&M Holdings
Lalit Panda
CIO

Damco
Marc Heeren
Senior Director
Pyers Tucker
Global Head of Strategy

Dell
Bill Hutchinson
Director of Global Logistics and Fulfillment

EMC Corporation
Doug Deamaral
Senior Traffic Manager
John Manning
Project Manager - World Wide Logistics

Fairchild Semiconductor
Bob Scribner
Director of Global Logistics and Trade Compliance

FHWA
Tony Furst
Director of Freight Management & Operations Office

Fundacion LOGyCA
Rafael Florez
Director

Halcrow
Joe Bryan
Vice President

Heineken USA
Gregg Ramos
Senior Director of Supply Chain Management

Hewlett-Packard
Vincent Lafaix
HP Personal System Group Americas Logistics

Hutchison Port Holdings
Gary Gilbert
Senior Vice President

Illinois DOT
Keith Sherman
Bureau Chief, Urban Program Planning

J.B. Hunt Transport
Gary Whicker
Senior Vice President of Engineering Services

Kornegay & Co.
Tom Kornegay
President

Kraft Foods
Harry Haney
Associate Director of Transportation Planning

Limited Brands
Kurt Kravchuk
Assistant Vice President of Logistics

MeadWestvaco
Chris Osen
Vice President & General Manager

Michelin North America
William Jana
Director of Transportation & International Logistics

Michigan Technological University
Bruce Seely
Dean, College of Sciences and Arts

Minnesota DOT
Bill Gardner
Director of Freight, Rail & Waterways

Mississippi DOT
Juan Flores
Policy Manager

Mohawk Industries
Stan Brooks
Director of Transportation

Norfolk Southern Corporation
Michael Miller
General Manager

NxStage Medical
Judith Taylor
Vice President of Planning and Logistics

Orient Overseas Container Line
Rick Wen
Vice President of Business Development

Penske Logistics
Frank Hazeltine
Vice President of Global Markets

Pepsi Bottling Group
Jim Farrell
Vice President of Transport

Paul Hamilton
Vice President of Global Supply Chain Strategy

Port Authority of NY & NJ
Steve Brown
Manager, Freight Planning

RaceTrac Petroleum
Brett Connor
Logistics Manager

Schwan Food Company
Ron Siemers
Director of Supply Chain Operations

Starbucks
John Bauer
Director of Global Transportation & Supply Chain Operations

Target
Steve Carter
Director of Transportation Strategy & Planning

The TJX Companies
Brian Lawson
Vice President of Transportation

Transplace
Tom Sanderson
President and Chief Operating Officer

Transportation Research Board
Bill Rogers
Senior Program Officer

UPS
David Adams
Strategic Planning Manager

USDOT/Volpe
Dr. David Damm-Luhr
Domain Leader, Organizational Systems Performance

Mike Dinning
Director of Freight Logistics & Transportation Systems

USTRANSCOM
Marc Sukolsky
Military (Civilian) Senior Fellow

Walmart Transportation
Kelly Abney
Vice President of Corporate Transportation

Mike Bright
Senior Director of Transportation Strategy

Washington State DOT
Barbara Ivanov
Co-Director, Freight Systems Division

Working Knowledge
Andrea & Dana Meyer
Senior Partners

MIT

Bruce Arntzen, Ph.D.
Research Associate, CTL

Chris Caplice, Ph.D.
Executive Director, CTL

Ken Cottrill
Global Communications Consultant, CTL

Tony Craig
Ph.D. Candidate, Engineering Systems Division

Tara Faulkner
Director of Communications, CTL

Francisco Jauffred, Ph.D.
Research Affiliate, CTL

Stephanie Jernigan, Ph.D.
Research Associate, CTL

Loïc Lagarde
Research Associate, CTL

Roberto Perez-Franco
Ph.D. Candidate, Engineering Systems Division

Shardul Phadnis
Ph.D. Candidate, Engineering Systems Division

Jim Rice
Deputy Director, CTL

David Riquier
Director, Corporate Outreach, CTL

Prof. Yossi Sheffi
Director, Engineering Systems Division & CTL

Mahender Singh, Ph.D.
Research Director SC2020

Prof. Joe Sussman
JR East Professor, Department of
Civil & Environmental Engineering

Appendix B. Summaries of Thought Leader Presentations

This appendix contains detailed summaries of each of the thought leaders' presentations.

Symposium Introduction

Dr. Chris Caplice, Executive Director, MIT CTL

What should state-level transportation planners be thinking about 20 years from now? Dr. Chris Caplice, Executive Director of the MIT Center for Transportation and Logistics, opened the Future of Freight Flows Symposium with a question. How might future trends in the broader economy significantly change long-term future freight flows and thus affect the near-term patterns of investment in public and private transportation infrastructure? He illustrated this issue with an example from the past: how containerization affected sourcing, routing, and destinations of freight.

Containerization

Dr. Caplice described the history of an innovation – containerization – and its impact on freight. In the 1950s, Malcom McLean grew McLean Trucking into the second-largest trucking company in the US. McLean was trucking beer to Miami, but the cost of the transportation was eating into his profits. McClain thought, "What if I move beer by water instead of land?" In 1953, he developed plans to carry his trucks on ships. The trouble was, putting trucks on ships was inefficient because of the loss of potential cargo space. So, McLean originated the idea of simply loading the containers, not the chassis, on ships. The result: the cost per ton decreased from $6 per ton to 15 cents per ton in containers on ships.

Over time, containerization had significant second-order effects such as enabling offshore manufacturing and accelerating global trade. Ironically, containerization did not help McLean avoid congestion delays -- congestion simply concentrated in ports. In short, containerization greatly reduced costs, changed sourcing patterns (enabling offshore sourcing) and created congestion at ports.

The Role of Scenarios

Decision makers can use scenario planning to think about plausible future events and understand their impact before they occur. The goal of the scenarios is not to predict or forecast the future but to consider future outcomes or events and translate what their impacts would be on freight flows. Scenarios require stories to be plausible and relevant.

Their end goal is to enable a more robust planning strategy. This symposium is part of a 21-month project that is developing scenarios focused specifically on freight planning.

Symposium Goals: Divergent and Convergent Thinking

The Future of Freight Flows symposium, a day-and-a-half event, is divided into two parts to foster divergent and then convergent thinking about freight flow scenarios. The first day was devoted to divergent thinking – stimulating participants to think about a range of potential future events that might have significant direct or indirect effects on freight flows and stresses on logistics infrastructure. To do this, the first day featured seven talks by a range of thought leaders. The second day used breakout sessions for participants to discuss the adoption, implications, and stresses associated with 12 snapshot scenarios derived from the first day of the symposium.

A Nation of Floridas: Aging, Changing Lifestyles & the Future of Freight

Dr. Joseph Coughlin, Director, MIT AgeLab

Dr. Coughlin shared insights from the MIT AgeLab, of which he is the director. Whereas other presenters would talk about futures that may come to pass, Dr. Coughlin's message about the aging population was much more certain -- we are all getting older. And unless something drastic happens to death rates or immigration, the demographics of the US is readily predictable for the coming decades. Given the high predictability of the aging population, the questions Dr. Coughlin posed were: how will you live tomorrow? And what implications does that bring for the business of freight?

Demographic Trends

Demographic and economic trends will affect the composition of consumers and patterns of consumer demand that affect freight flows. Dr. Coughlin described four key trends that point toward these changes.

Aging in the US and Around the World

In the US, one person turns 64 years of age every 7 seconds. The fastest growing demographic in the US is the over-85 age group. We are all becoming a nation of "Floridas" and more like Europe, where one-quarter of the population today is already over age 60. Some states have markedly older populations as well. Not only Florida but also Iowa, Pennsylvania and West Virginia had 15% of their populations over age 65 in 2000, with New York, Massachusetts, and the Rust Belt close behind.

Looking globally, the percentage of the population over age 60 in the year 2000 was already 16.5% in the US and former USSR, 14.3% in Asia, and 19.8% in Europe. By 2025, those figures will be 25% in the US and former USSR, 25.3% in Asia, and 28.8% in Europe.

Women

The future is not about men, because women outlive men -- women outnumber men in nursing homes 8 to 1. Not only do women live longer, they also make a growing number of economic and consumer decisions. Women now are more educated than previous generations, and workforce participation by women is at an all-time high of 70 percent.

High Expectations of Activity

The boomers -- the generation that defined modern-day retailing -- are now getting older. The biggest challenge of meeting the needs of this group is brought by their expectations. Boomers have very different expectations of old age compared to their parents. Boomers expect to work, volunteer, stay productive and stay connected. They will not just be retiring and staying home. Indeed, 79% plan to volunteer and 62% will be working part-time. The most telling areas of the poll show that 79% of boomers expect no serious limits on their activity until over age 70, and 50% expect to be active and going strong at age 80. How? 83% of them expect treatments for the ills of aging to improve.

Improved Health: Ill But Not Sick

Boomers' expectations of good health into old age are not unfounded. There's been a decrease in disability among the "new elderly" in all income groups. People are enjoying longer periods of relative wellness into "old" age. That does not mean they are disease-free: 110 million Americans have a chronic illness, and 60 million have two or more chronic conditions. But they are managing these chronic conditions with medications and maintaining their lifestyles. Being ill no longer means being sick and disabled. These demographics of aging and health are already being disruptive. For example, the funeral industry is not meeting revenue projections because people are not dying fast enough – they are living longer.

New Opportunities

These trends in aging, expectations, and behavior lead to new or increased opportunities for commerce that will affect freight flows. Aging boomers represent a significant business opportunity. About 20% of the population controls over 40% of all disposable income. Additionally, older adults control 77% of all assets and have $1.6 trillion in buying power in the US. This is expected to increase by 29% over the next five years.

"Smart" Spending

Boomers are not looking just for prestige for the items they buy -- they want to get the good deal and show how smart they are. Costco parking lots have Porsches alongside Ford 150s as boomers look for ways to get brand-name products inexpensively. One issue yet in the early stages is: as boomers gray, will they also become more green? Boomers were the

generation that gave birth to the EPA. Green issues do resonate the most with them, and they are starting to think about their legacy and their personal footprint.

The fastest growing segment on the Internet is women 45+ who are seeking information on health, finance and auto purchases. They see the Internet and social media as a source of advice and to validate their choices. Women over age 59 are the fastest growing segment on Facebook. Whereas kids use social media to talk with people they already know, boomers use it as a way to meet new friends.

Higher Education

The number of older adults with four or more years of college has doubled in the last 20 years, and there's an increasing demand for non-traditional learning. The most popular places to retire are not golf courses but are college towns like Ann Arbor and Chapel Hill. Polls show that 89% of boomers expect to be learning, studying and traveling during their retirement years.

Women

Women manage the household and make 90% of the healthcare decisions, as companies like J&J and P&G already know. In fact, women make a surprising percentage of all purchasing decisions. Some 89% of consumer electronics sold per year -- $55 billion -- are sold to women. Even seemingly male-centric product categories have female-dominated purchasing patterns. For example, 80% of home improvement products and 80% of NFL products are sold to women. Women have made significant gains in affluence -- the number of women earning over $100,000 annually has tripled in the past 10 years, and 43% of people with assets over $500,000 are women. The point is that women are the Family CEO and are the primary caregivers for older adults.

Transportation & Caregiving

One in four families care for an older adult, and nearly 50% of US workers are more concerned about how they will care for a parent than a child. The oldest adult daughter typically guides the health and financial issues of older adults. Transportation is among the top five supports sought from friends and family. Just as boomers outsourced care of kids to daycare, their grown kids may outsource transportation and eldercare.

Four Future Scenarios

Dr. Coughlin enumerated four scenarios that are backed by current data.

Aging In Place

About 70% of Americans live in suburban and rural areas, and they plan to continue living there as they get older. Boomers are not likely to move to the city upon retirement. Their marriage and memories are tied to one place and most of them will be aging in place. The

implications for transport and freight are clear: mass transit is unavailable in most of these areas, which means that driving is the only viable alternative. Transportation plans need to be put in place now if they are to be ready when needed.

***Emerging Home Care Services*:** As people age in place rather than move into retirement homes, we'll see the emergence of virtual retirement communities like Beacon Hill Village. Community-based service providers will arrange for home delivery of food and medications. They will also provide contract home repair and maintenance.

***Intelligent Home Services*:** We'll see the integration of information technology (sensors) into clothing, appliances and bathroom fixtures. For example, next-generation toilets measure a person's weight, fat, heart rate, urine sugar, albumin and blood in urine, transmitting the information over the Internet to caregivers, doctors and pharmacists. This commode-and-communication combination is already a reality in Japan, where consumer electronics maker Panasonic has partnered with utility company Tokyo Electric Power to provide remote monitoring of older adults. These kinds of strategic partnerships will provide an array of branded home products combined with services. In the UK, a retailer is already using data from smart toilets to facilitate the food products you need based on your "output." In the US, Philips and Comcast have partnered on a product that reminds you to take your medications and enables video discussions with clinicians using broadband. Another product for the home is a teddy bear tiger that sits quietly on the sofa and detects motion.

In summary, intelligent home services link multiple sensors in the home (kitchen appliances, bathroom, clothing, entertainment platforms) with physicians, emergency response services, health and wellness monitoring systems, food and nutrition and pharmaceuticals. Leading-edge companies like Partners Telemedicine, ADT, Healthways, Bank of America, Stop & Shop and Walgreens are already providing these branded services.

Home Alone

Single-person households are among the fast growing in the US, and the oldest old will be women living alone. The implications for business are smaller homes, smaller package sizes and smaller format stores with shopping carts that are friendly to those with diminished physical capacity. Boomers are willing to spend more for convenience -- they have never short-changed themselves. Even in a downturn, they have more discretionary income than their parents had. Home delivery of groceries will see a resurgence.

Personalize Me

Boomers experiencing midlife aches and pains will look for customized products that let them continue their active lifestyle. Personalization is the design and marketing response

to older buyer needs and meeting their higher expectations. For example, boomers' disposable income lets them pay $20 more for a customized Nike ID shoe.

Wellness, Work & Older Workers

Older adults will work longer past retirement not only for the money but for the challenge, personal meaning and social benefits, an OECD study found. The implications for freight are a "graying" of the transportation workforce and an influx of women into the field. In the US, 56% of women 55-64 are in the workforce, an increase of nearly 10% in 10 years. This increased participation of older women in the workforce has implications for workplace design -- accommodating a 5'2" female driver rather than a 6' man.

Summary of the Implications of Aging on Business and Freight

Summary of Changes in Consumer-Side Logistics

- On-demand home logistics to meet personal needs will grow: store shelf to home shelf delivery.
- Overnight/day carriers blend as service operators (UPS meets Geek Squad).
- More home purchases made as needed rather than storing large quantities at home.
- More trips per household.

Summary of Changes in the Logistics Workplace

- Added focus on worker safety & health.
- Rethinking the current "big" packaging & big-box store format.
- The "Feminization of Freight," meaning redesigning the workplace from vehicle to warehouse to accommodate older female fragility and safety.

Key Finding: Our future looks to be gray, small and female.

After the Storm: New Challenges for the Global Economy in 2010-2030

Sara Johnson, IHS Global Insight

Sara Johnson, Managing Director of Global Macroeconomics at IHS Global Insight, presented forecasts for upcoming macroeconomic conditions. Work by IHS' Global Scenario Team tracks and forecasts a wide range of variables that affect freight flows. These factors include GDP, industrial production, trade, unemployment, interest rates, commodity prices, and currency exchange rates. Ms. Johnson offered a quick retrospective of the crisis, a commentary on near-term economic forces, and a discussion of longer-term trends in different regions of the globe.

Good News: No Depression 2.0

The good news is that the recent economic crisis was not another Great Depression. Although the world may have been staring into a financial abyss a year ago, resilience absorbed the shock. Concerted efforts by central bankers and governments prevented a deeper deflationary cycle, runs of banks, and other types of behaviors that contributed to the first Great Depression. Monetary stimulus stabilized the financial markets and fiscal stimulus limited the depths of the downturn. Now with the bottoming-out of the economic slide, people are becoming more confident or, at least, less fearful.

Globalization Continues

Despite some grumbling about greedy bankers, there was no significant backlash against free-market capitalism. By and large, governments rejected the siren call of protectionism that plagued the 1930s. Although world trade certainly suffered a big setback in 2009, trade is already rebounding. Although exports dropped 12% in 2009, they are expected to rebound 7% in 2010. In fact, charts of world imports as a fraction of GDP suggest that 2009 was more of a correction of over-exuberant levels of activity than a true setback. World imports were 24% of GDP in 2003, surged to 32% of GDP in 2008, retrenched to 27% in 2009, and are expected to climb back to 29% by 2011 and continue growing in the long-term to 37% by 2030.

Near-Term: Not a "V" Recovery

IHS does not expect a "V"-shaped recovery. Rather, growth will return slowly. Financial crises create more long-lasting economic damage than do normal business-cycle recessions. Banks still have more losses to absorb from commercial real estate; unemployment remains elevated; and many mortgages remain underwater. It takes time for banks, companies, and consumers to rebuild damaged balance sheets, access needed credit, and resume normal levels of economic activity.

Inventory Cycle Variations

Recent reports of very high growth (a 5.9% annual growth rate for the US in the last quarter of 2009) are not indicative of a sharp recovery. More than half of that growth figure reflects inventory cycle issues: companies ordered and produced extra goods at the end 2009 to replenish a year-long draw-down of inventories. Although this mini-surge of replenishment is unlikely to continue, it bodes well for the future. At the very least, companies are now regaining some confidence in holding inventory.

Pent-Up Demand, But Uneven Recovery Across Sectors

The next phase of the recovery will see a release of pent-up demand. In particular, IHS expects business equipment, especially high-tech, to lead the recovery. Consumers probably will not lead the recovery due to diminished appetites and capacities for borrowing and spending. Instead, consumers will be rebuilding decimated nest eggs by increasing their savings rates. Residential construction will rise from the extremely low current levels while non-resident construction will remain depressed due to aftermath of over-investment in construction during the last boom. The end of federal stimulus programs combined with budget pressures on state and local governments will mean low or negative growth in government spending. IHS expects healthy growth in exports as the US dollar weakens somewhat and world trade rebounds.

Prices and Currencies

Mostly Uninflated with a Chance of Price Bubbles

High unemployment and lingering financial damage should prevent any surge in inflation. Moreover, major central banks remain committed to controlling inflation. IHS expects an overall global rate of inflation of 2.5% annually over the next five years. That rate includes somewhat lower inflation in the advanced countries (less than 2%) and somewhat higher inflation in the emerging countries (4-5% inflation). Yet Ms. Johnson warned that the prevailing environment of ultra-low interest rates could spur speculation and over-investment in some areas. This might cause price bubbles in some assets or commodities.

The US Dollar Remains the Reserve Currency of World

Currency exchange rates affect the prices of imports vs. exports and thus affect the flow of international freight. During the crisis, the US dollar strengthened as investors sought safer refuge in the storm. IHS expects the US dollar to weaken slightly as the crisis unwinds.

As much as some might worry about the safety of the US dollar, no other currency seems capable of replacing it as a reserve currency used by many foreign exchange reserves and other global financial activities. The Euro's youth and the recent crisis with Greece (and similar debt issues with Portugal, Ireland, Italy, and Spain) make the European currency

unattractive. The Chinese Yuan is not freely inter-convertible and seems to be too much under the control of the Chinese government.

Future: A Multispeed World

Ms. Johnson's analysis of the various segments of the world economy revealed a multispeed future. Some economies will continue to grow quickly, while others will grow much more slowly. Whereas the advanced economies of the world will average about 2.5% annually over the next 10 years, emerging market economies will average 6% annual growth. Along with this spread of speeds is a further synchronization of business cycles and volatility. Greater globalization means increased tendencies for all economies to boom or bust at the same time, which means greater volatility of commodity prices and freight flow volumes.

Leading: Asian & Emerging Markets

Although the economic downturn certainly hit the export-dependent economies of Asia, they did not suffer as much damage to their financial systems as did Europe or the US. An earlier financial crisis in Asia in 1998 led to reforms that helped those countries avoid deeper damage. Asian banks held higher surpluses at the beginning of the crisis than did their Western counterparts. Thus, Asia rebounded faster than other countries.

In the coming years, China, India and other emerging market countries will lead global economic growth. China, in particular, will grow rapidly and become a far larger fraction of the world economy. By 2020, China will surpass the US in GDP. China has reached the point where it is buying more light vehicles than the US. China, with its large population and aggressive economic development policies, will become one-quarter of the world economy. India will also continue to grow quickly, as will a range of emerging markets countries in other parts of Asia. Emerging markets countries in Latin America (e.g., Brazil) and emerging Eastern European countries will enjoy somewhat lower rates of annual growth in the 3-4% range.

USA/NAFTA

The US and NAFTA countries will probably take a middle road in economic growth of between 2.5% and 3% per annum in the coming two decades. The expected gradual decline of the US dollar in the post-crisis years will lead to growing export volumes in capital goods and basic machinery. The US also enjoys low-cost natural gas, which translates into a persistent cost advantage in many chemicals.

Lagging: EU/Japan

Although the financial crisis was centered in the U.S., banks in Europe actually suffered greater damage. European banks had higher leverage than did American banks. European banks also had significant exposure to Eastern European countries. Moreover, the EU faces internal economic challenges with Portugal, Italy, Ireland, Greece, and Spain. Differences in

the competitiveness of different EU member countries will affect the rate of recovery of the region. Japan will also experience low rates of growth. Western Europe will average less that 2% annual GDP growth through 2030. The growth expectation for Japan averages less than 1% annually in the coming 20 years.

Long-Term Risks: Debts, Demographics, and Defaults

Despite the growing optimism, many risks remain on a variety of time horizons. The withdrawal of government stimulus spending and premature tightening of interest rates could jeopardize the nascent recovery. Home prices may fall further, and commercial real estate will almost certainly deteriorate. Price volatility from commodity and asset price bubbles could further hurt weakened businesses or reduce confidence.

Demographics are also affecting long-term economic forecasts. Western Europe and Japan, especially, have much older populations, which generally means both less domestic production and less consumption. Some countries are actually expected to shrink in population, which will reduce total GDP growth.

In the long-term, high deficits and growing government debts threaten the futures of many advanced countries, including the US. Current U.S. Congressional Budget Office projections for the federal deficit suggest that it will decline from $1.4 trillion now down to $700 billion before rising to $1 trillion by 2020. Europe's challenges with Portugal, Italy, Ireland, Greece, and Spain also stem from high deficits and debts. Research by Reinhart and Rogoff suggests that countries with government debt in excess of 90% of GDP suffer from slower growth. As government debt grows, more and more economic activity becomes absorbed by repayment of debt rather than investment in growth. These high and unsustainable debt levels also raise the specter of sovereign defaults that could further damage the banking system, hinder economic growth, and reduce trading with the affected countries.

Public Policy and Freight

David Luberoff, Harvard University Kennedy School of Government

David Luberoff explored the issue of the seeming silence of freight interests in government transportation policy -- the proverbial dog that does not bark in the night. Freight policy is clearly important, but it does not get much attention today. For example, in the Testimony on Current and Future Investment in Infrastructure May 2008, CBO Director Peter Orzag only mentioned the word "freight" nine times in 43 pages. Of these nine mentions, seven were on simple charts, one discussed changes to truck weights and travel distances to reduce highway wear, and the last mentioned freight in the context of public-private partnerships (PPPs) such as the Alameda Corridor.

Freight Policy in U.S. History

Historically, US transportation policy was dominated by freight. In the 1700s, ports were the key to the first American cities. In the early 1800s, the freight policy centered on internal improvements: waterways, railroads and some roads. Developing a rapidly-expanding frontier and mobilizing the natural resources of a nation meant an emphasis on moving goods from the hinterland to cities, factories, and markets. Later, the policy shifted to one of moving people more so than moving freight.

The Canal Era

The Erie Canal was built to move cargo, not people. Indeed, the Erie Canal cemented New York City as the dominant city because it was more freight-competitive than Philadelphia or Boston. Other localities also tried to build their own canals, but most of them failed economically. As a result, state governments began to put debt restrictions on such projects and put authorities in charge of them. The early 1800s also saw the first effort to have a federal plan for freight, but the idea failed.

The Railroad Era

In the mid- to late-1800s, freight policy focused on the promotion of transcontinental railroads. States provided free land to the railroads and city leaders vied to attract railroads to their areas. Railroad companies had the leverage to tell cities, "if you do not give us what we want, we'll go to a different city." Chicago leaders opened up their city to railroads and gained prominence.

Farm-to-Market Roads

Whereas the major federal policy of the late 1800s focused on the transcontinental railroad, in the early 1900s policy shifted toward creating a network of farm-to-market roads. Next, early aviation systems focused on airmail -- a low-volume, high-value product. Airplanes moved money between banks and documents between companies. Localities lobbied to get airports using federal government subsidies. When Atlanta became a

southern air hub over Birmingham, localities began to see the importance of aviation as part of their economic strategy.

From Interstate Highways to Suburban Congestion

The 1950s saw the emergence of trucking and the pressure to build highways. Freight was a big part of that, and the federal government created the Interstate highway system. A shift was beginning, however, because highways were also about moving people. The federal highway system represented a transitional moment in which moving people around became a priority at the national and state level. Although Interstate highways still primarily moved fright, highways in urban areas were about moving people. The rise of the suburbs brought the rise of commuters. Moreover, popular support came not from freight but from solving traffic problems.

Freight Policy Today

Today, few projects are freight-focused and high profile. The Alameda Corridor is the exception: a corridor to connect Long Beach and LA by means of a below-grade railroad. Only a handful of projects, such as the fast corridor in Seattle, focus on making freight flow better. Freight today faces the problem of conflicting uses: older working waterfronts are being redesigned into public spaces with restaurants -- but where is the freight? It disappears. Boston is one of the few cities to have a working port as well as a redevelopment project. In California, San Francisco focused on the tourist redesign and all the freight went to Oakland.

The Modern-Day Politics of Freight

Mr. Luberoff explored three hypotheses for the seeming absence of freight-related discussions in the government transportation policy discourse:

- freight is not important
- freight interests do affect policy but do so quietly
- freight interests do not affect policy due to some sort of strategic, political, or structural disadvantage

Is Freight Still Important?

Perhaps the reason why freight policy has disappeared from public discourse is due to the declining linkage of freight to the economies of most population centers. For example, consider the Port of New Orleans in the post-Katrina rebuilding effort. The number of people employed at the port is miniscule, thereby decoupling the importance of the port in the rebuilding. The declining cost of moving goods also reduces the salience of freight-related issues. The cost to move a ton of freight one mile has dropped dramatically. When

the cost of moving goods goes down, it is less important where the freight nodes are located. As a result, the economic fate of Boston is no longer tied to being a freight hub.

Yet other facts prove that freight still plays a key role in the US economy:

- The value of freight shipments was $14.9 billion in 2006 and $16.7 in 2008.
- The value of freight shipments is expected to rise in value by 3.1 to 3.5 percent a year.
- There were about 200,000 transportation and warehousing establishments in 2002.
- These establishments employed more than 3 million people.
- Total payroll was over $115 billion.

Is Public Policy Aligned with Freight Interests?

In terms of lobbying, freight interests do lobby. By sector, transportation spent $2.07 billion on lobbying from 1998-2009, compared to the highest spender (Finance, Insurance and Real Estate at $3.9 billion and Health at $3.8 billion). In comparison, Labor was a low spender at $392 million. [Source: OpenSecrets.org] This leads to the question of alignment of freight's use of transportation modes versus government spending on different modes. Looking at a pie chart of which modes freight uses, we see:

- Trucks: 65%
- Intermodal: 14%
- Pipeline and unknown: 10%
- Air, air & truck: 7%
- Rail: 3%
- Water: 1%

In comparison, the amount spent by private and public sources on transportation ($106 billion in 2004) was apportioned into the following infrastructure segments:

- Highways: 63%
- Mass Transit: 15%
- Aviation: 14%
- Freight/Railroads: 6%
- Water Transportation: 2%
- Passenger Railroads: 1%

Allocation of Government Spending by Mode

But the real test is the allocation of public spending to modes and how that compares to freight activity by mode. States spend more money than the federal government does on all modes (highways, mass transit, aviation, water transportation) except on freight railroads (which are all private spending) and passenger railroads, which is all federal (Amtrak). In general, the share of public spending on freight by mode aligns with the share of freight traveling by that mode, with some exceptions. For example, the share of freight (by value) traveling on trucks is 65% and the share of public spending on highways is 68%. The ratio for rail is 3% with zero public spending; water is 1% with 2% public spending; air and air/truck is 7% with 13% public spending; pipeline and unknown is 10% with zero public spending. Public spending on transit is 16% (which of course carries no freight). Thus, there is some variance but not large disparities in spending being allocated to the most-used freight modes.

Transportation Politics 101

Debates about how public spending will be allocated focus on four interrelated questions:

- how much will be spent
- who will pay for it
- what will it be spent on
- where will it be spent.

People want to know how much benefit will go to their state or district or how much their department will get from it. In the case of transportation, much of the money comes from the gas tax, which is paid by the public and truckers.

Transportation Politics 102

The deeper issues in the current debate require an understanding of the nature and importance of coalitions, government structures, funding mechanisms and regulatory politics. First, coalitions arise not because people all agree, but because if they work together they will get more things accomplished. In freight politics, weaker interests can block legislation but they cannot push any legislation through without help. Thus, powerful interests go to weaker interests to stop them from blocking, and weaker ones join stronger ones to get something that they want in return. In transportation, there's always a fight between mass transit interests and highway interests. Mass transit is important to a concentrated set of politically powerful cities. Even though transit only moves 2% of the population, it gets 20% of the funding.

Second, government structures evaluate issues based on what is in it for their geographies, which increases the focus on locally-targeted projects. That makes freight, which by definition spans geographies, weaker politically than highly local, city-focused

transportation projects. Third, funding mechanisms -- such as dedicated user fees and taxes -- generally change the political dynamics. Finally, regulatory politics may have a different structure and issues. Consider the Big Dig in Boston, which was funded by the 1987 Surface Transportation Act but vetoed by President Reagan as pork. It was tied to a jobs bill on regulation of billboards and speed limits on highways. Because of the speed limit issue, the state of Nevada voted with a coalition to override the veto.

Freight Politics in the 21st Century

Freight will have continued economic significance in the new century, and we need to ensure that freight interests are not ignored. Freight will, however, have a weaker connection to local economies, which weakens political clout. Conflicts with other uses and values, such as waterfront developments, may also weaken the political clout of freight interests. Finally, less visible regulatory policy makers may be more sensitive to freight issues.

In summary, freight is clearly important, but its influence on policy is less than its impact on the economy.

Transporting Bits and Atoms

Professor Neil Gershenfeld, MIT Center for Bits and Atoms

Prof. Neil Gershenfeld from the Center for Bits and Atoms (CBA) discussed the future of fabrication and the changing relationship between the world of physical goods and information. Research at CBA spans chemistry, biology, engineering, computer science, math, design, and many other disciplines. In many ways, the goal of CBA is to create a device similar to Star Trek's replicator that can be commanded to make any product at any time for anyone. Prof. Gershenfeld suggested that CBA is already one-third of the way to a replicator and that people can be inventing the future now, rather than waiting 20 years for it.

Goal: Generalize to All Scales

One of CBA's goals is to learn how to design and build anything of any size. That is, CBA would like to be able to design some object or functionality and then implement it in any scale. The problem is that it currently takes a lifetime to learn to use all the different tools. CBA is trying to change that. The work at CBA spans many orders of magnitude in scale, and Prof. Gershenfeld described three specific examples that span a range of scales.

Macroscopic Digital Fabrication

The macroscopic scale contains the familiar world of mechanical components, factory machine tools, and electronic circuit boards. Much of the work at CBA concerns a pivotal shift in macroscopic manufacturing technologies embodied in what CBA calls a FabLab. A FabLab is a collection of versatile computer-controlled tools that enable almost anyone to make almost anything. The goal is to both increase the capabilities of the tools and to broaden their use.

Microscopic Digital Fabrication

A range of technologies, such as those used in semiconductor chip-making, enable manufacturing on a microscopic scale. One crucial example of these devices is microfluidic systems. Etching tiny channels, pipes, chambers, etc. provides a small-scale environment for doing chemistry and chemical synthesis. One can even make microfluidic computer circuits in which bubbles in the pipes take the place of the information bits in a wire and specialized channel features automatically perform computer-logical operations with the bubbles.

Nanoscopic Digital Fabrication

Biology has already solved the problem of manufacturing shapes at the molecular level. Ribosomes are the tiny nanofactories that cells use to fabricate physical proteins and enzymes from information that is encoded in DNA and transcribed into RNA. Prof. Gershenfeld outlined DARPA research on growing engineered materials. He described the

workflow for designing a wrench that living cells could mass produce. The work starts with computational models that let one design a shape, convert that shape into an amino acid sequence, and then convert the amino acid sequence into a DNA sequence. Then one can confirm the quality of the work by simulating the folding of the DNA-encoded amino acid sequence back into the original goal design. Finally, one can upload the DNA into a bacteria, plant or animal that will mass produce copies of the design.

Goal: Embedded Computation in Objects and Materials

CBA is blurring the line between atoms and bits by trying to merge "it" with "bit." The result brings the advantage of digital systems to the normally analog world of atoms. The effort also radically increases the features and flexibility of physical systems.

The Digital Advantage

CBA seeks to make physical devices digital in the same the way that communications were made digital. Digital communications can be readily copied and transmitted without error. Whereas analog systems degrade over time, and noise steadily accumulates in the signal, digital systems can be robust to noise. Digital fabrication and digital objects could be more robust than their analog ancestors.

Microfabs

Prof. Gershenfeld provided an in-depth look at FabLabs, which are a network of small labs that let virtually anyone build virtually anything. The core of the FabLab is a set of computer-controlled fabrication tools for extremely high versatility. These tools include various computer-controlled machines such as a laser cutter, large milling machine, small precision milling machine, and a sign cutter. The combination lets people easily make a wide range of 2-D and 3-D parts in a wide range of materials including plastic, wood, metal, and even food. The FabLab also includes a programming toolkit for creating software for small RISC processor boards so that people's projects can respond to commands over a network, read sensor values, gather data, and control motors, valves, etc. Only a few years ago, these tools cost more than $100,000. Now a complete lab setup is half that price, and the prices continue to fall.

A Global Network of FabLabs

Although one FabLab is good, the key to changing the world is to get FabLabs located around the world. Thus, MIT and others have encouraged the deployment of local FabLabs worldwide. There are now more than 40 FabLabs located in countries such as Afghanistan, Iceland, Kenya, Ghana, Russia, and India. These labs not only provide an opportunity for more people to learn about the technology, but they also allow people to create low-cost solutions to suit local needs.

For example, the FabLab in Jalalabad, Afghanistan helps solve the city's telecommunications problems. Like many Third-World and war-torn areas, Jalalabad suffers from degraded infrastructure. The local FabLab designed a point-to-point wireless networking system called FabFi. They used the FabLab to build low-cost, high-gain antennas that would extend the range of simple WiFi routers over multiple miles in urban Jalalabad. Rather than import expensive telecommunications equipment from distant Western technology firms, the Afghanis could design, build, install, and maintain their own equipment at lower overall cost.

Other FabLabs have designed other low-cost products that can be replicated by a FabLab. For example, one lab created a disposable thermometer for healthcare applications. The device uses microfluidic design principles and only costs 1 cent. Another FabLab developed an Internet terminal that costs only $10.

Parallels in History

The development of low-cost tools such as those used in the FabLabs parallels the development of computers. As computers declined in cost, they transitioned from the mainframe, minicomputer, and PC eras. Each drop in cost led to an increase in adoption and an increase in the range of applications. And when computers became cheap enough for the home hobbyist, then applications and usage exploded and a massive new array of businesses was born. Inexpensive technology enables entrepreneurship by lowering the cost barriers to finding new applications and new businesses based on the technology.

Open-Source Model Leads to Viral Adoption

FabLab has an open-source mentality. People share ideas, problems, and solutions. People can see the interesting things that others can do with a FabLab and create their own new variants and new ideas. The result is a growing portfolio of ideas, solutions, and designs. Rather than re-invent the wheel, someone can download the design for a wheel off the network, add or remove features, and contribute their modified design to others. A national network of FabLabs could do for the US what Andrew Carnegie's network of public lending libraries did at the turn of the 20th century.

The result is a viral adoption model in which the more people that hear about FabLab, the more FabLabs get created. And the more people that can use the equipment, the more applications people will discover, design and create for the technology. And the more applications for a technology, the more valuable that technology becomes. And the more FabLabs that get created around the world, the more people hear about FabLab. Prof. Gershenfeld suggested that low-cost FabLabs could become a lightweight alternative to big costly National Labs in unlocking a new wave of creativity and discovery.

Implications for Economies and Freight

Example: Scream Body

Prof. Gershenfeld founded a course, "How to Make Almost Anything," with a twofold purpose: a) to teach students how to use these new fabrication technologies and b) to learn how people might use FabLab-style technologies. The star pupil of the first class, Kelly Dobson, illustrates what is possible. This non-engineering student designed and made a plush bag with shoulder straps that is worn on the chest like a backpack switched to the front. When the wearer becomes mad, frustrated, or just wants to blow off some steam, she (or he) can scream into the bag and be as loud and foul-mouthed as they want. The bag's circuitry both muffles the scream so no one else can hear it and also records the scream. Later, the wearer can replay the scream out loud. Needless to say, it is a very idiosyncratic product. No one expects the Scream Body to dominate the shelves of Walmart as the holiday's hottest product. Instead, the product illustrates how one non-technical individual can make one highly-individualized product that would have, in the recent past, required a team of engineers with a fat R&D budget.

Mass Production Still Has a Role

The technologies being developed by CBA and the FabLab network do not replace mass production. If a large number of people all want the same product with the same features, then traditional mass production may be more efficient. And some specialized manufacturing processes and products might well remain in the domain of mass production. But if some people want something special with added features, then a local FabLab-style lot size of one may be better. Or, if some people want a simple, stripped-down version of a product, then a local FabLab-style lot size of one may be better. Moreover, the expanding database of FabLab designs could easily provide the seeds for mass-produced products.

Reprogrammable Matter Means Less Reverse Logistics

The concept of programmable matter also implies that matter might be reprogrammed. Instead of discarding obsolete or damaged end-of-life objects, people would reprogram the material for other uses, reprogram it to self-degrade or feed the object back into the fabricator. The result is a reduced waste stream and less reverse logistics.

From Finished Goods to Finished Ideas and from Global Production to Local Production

The FabLab concept radically changes the flow of freight in two important ways. First, it replaces the flow of finished goods with a flow of information to microfabricators. Second, production of finished goods shifts from global to local. That is, the end-consumer or a local FabLab sources the design globally and downloads it over the Internet.

But FabLabs do not mean an end of freight. Instead of delivering finished goods, one delivers the raw commodity materials and components used by the FabLab for local or even home-based production. The materials include plastics, sheet materials, small RISC processors, MOSFETs, sensors, buttons, motors, etc. The point is that a relatively small number of high-tech consumable SKUs replace a virtually unlimited range of finished goods SKUs.

From Scarcity to Plenty in a Post-Industrial Digital Fabrication World

In the context of manufacturing, this trend overturns the economics of traditional industrial-era capitalism. The past was a time of scarcity in manufacturing. Only big companies had the capital needed for investing in the means of production. Companies controlled those factories and made products based on mass-produced economies of scale. But if anyone can buy a versatile FabLab-style microfactory for less than the price of car, then the means of production becomes extremely cheap. Any home hobbyist or small business can afford the equipment and make anything. The point is that the technology changes the manufacturing world from one of scarcity into a world of plenty.

The New Age of Sensing

Prof. Sanjay Sarma, MIT Mechanical Engineering

Dr. Sanjay Sarma, Associate Professor of Mechanical Engineering at MIT and cofounder of the Auto-ID Labs at MIT, spoke of the evolution of sensors. Prof. Sarma used the history of RFID tags and other sensor platforms as examples. As Prof. Sarma sees it, the world is changing from very sparse and expensive sensors to a world of mobs of ubiquitous sensors.

Technology Trends: Progression of Sensor Networks

In tracing the history of RFID, Prof. Sarma sees a common pattern in the progression of technologies. This pattern plays out in a 3-dimensional space composed of features, cost, and ubiquity.

Heavy

In the beginning, RFID chips were expensive and heavy. To justify their high cost, the chips needed to have a lot of functionality. High cost also meant low production volumes. This meant that one RFID tag design needed to serve many applications, which also meant lots of functionality. On a 3D cube -- with axes Features, Inexpensiveness, Ubiquity – early RFID occupied the high-features, high-cost, and low-ubiquity corner of 3D cube.

The world of sensors sees a similar pattern. Early sensors tend to be expensive and heavy. The cost motivates designers toward very rugged, long-lasting systems, but that further increases cost and mass. Such early-generation sensors are manufactured in very low volumes with stringent performance specs. These do-everything sensors and systems cost tens to hundreds of thousands of dollars. Only the military, government, and large corporations can afford these heavy sensors. Even then, they buy very few of them. Thus, early-generation sensors also tend to occupy the high-features, low-inexpensiveness, and low-ubiquity corner of the 3-D cube.

Medium

Over time, some people realize that certain applications only need a subset of features. Engineers design somewhat simpler, lower-performance versions that provide lower cost and expand the market for the technology. This creates a trend toward medium-performance, medium-inexpensiveness sensors that find increasing applications. This trend begins the movement of the technology out of the high-features, low-inexpensiveness, and low-ubiquity corner of the 3-D cube.

Mob

In the ultimate end-point of technology development, the sensors become so inexpensive that they become ubiquitous. That is, people can afford to deploy a mob of sensors. Each sensor may have limited functionality, limited performance, and limited life, but the ability to deploy hundreds or thousands of sensors compensates for the weakness of each sensor. Rather than insist on high reliability from a limited number of sensors, a mob of sensors can provide robust coverage even if some sensors fail.

In the RFID world, tags became simpler and simpler until the simplest only contain the minimum number of bits to uniquely identify the tag. All of the data that would have been stored in tags of yore are now stored in the network. This trend, which can be seen in the sensor world as well, is that as the sensor becomes cheaper, smaller, and dumber, the intelligence and functionality moves into the network.

The evolution of sensing is leading to mobile sensing. Lightweight sensors are just around the corner. Some organizations are using lightweight sensors for monitoring the temperature of food in transport, such as ice cream. One possible low-cost version of this could be simply two RFID tags stuck together with one of them having an antenna that melts if the temperature rises above freezing. If the tag is put on ice cream, it is easy to tell if the ice cream melted. Similar two-tag sensor designs could be used to detect moisture, physical shock, and even pests such as termites.

From Government to Corporate to Consumer Networks

Whereas early expensive sensors were the purview of the military, civilian government (e.g., weather satellites and oceanographic buoys) and high-end commercial applications, cheap sensors move into the realm of consumer devices. For example, iPhones and many smartphones contain a microphone, camera, accelerometer, and GPS and that enables them to sense sound, light, motion, and location.

Technology Trends: From Wired to Wireless

Another major technology trend concerns the connectivity of sensors. Decision makers must somehow get the data from the sensor so that they can process the data and act upon it. Over time, these connection technologies have changed to reduce the costs of connections, increase the flexibility of connections, and support increasing numbers of connections.

Wired Circuits

In the past, sensors were physically wired to data collection and information management systems. Wires suffer from three disadvantages. First, wire is expensive to install and run, especially over longer distances. Second, wires are prone to damage from errant backhoes and falling trees. Third, wires generally require forethought on placement and incur

additional high costs if they have to be moved. Prof. Sarma gave the example of controlling the lights in a room. With current technology, the light switch (which is a type of sensor that detects whether people want the light on or off) is physically wired to the light. Moving the lights or the switch requires significant expense in rewiring.

IP and Early Wireless

The next step in connection technology uses wired IP or wireless technologies in which sensors and other devices communicate to some type of home-base or central receiver. This technology eliminates the costs of routing long wires from point to point and makes it much easier to relocate systems. In wired IP networks, a simple reprogramming allows any switch to control any light without rewiring. People can easily modify wireless networks, as long as the sensors, controls, and devices remain in range of the home-base receiver. That central wireless receiver then becomes a limiting factor in the design, because each device must have enough power to provide the range to reach that receiver. The central receiver may also pose a reliability problem -- if the control center has a fault, then the entire system stops working.

Mesh Wireless

The latest in wireless technology, such as Zigbee, uses mesh networks in which each sensor or device in an area talks to its neighbors, and each neighbor steadily routes the data from neighbor to neighbor until it reaches the destination. Mesh networks have two major advantages. First, each device can have much lower power because it only needs to talk to other nearby devices (i.e., a range of dozens of feet rather than hundreds of feet). Second, the network is incredibly robust to damage. A temperature sensor can route data directly to a refrigeration unit or alarm without going through any central controller.

Wireless technologies continue to diminish in size and grow in ubiquity. Prof. Sarma asked if anyone was aware of the smallest cellphone in common use. The answer: the tiny circuit inside the Amazon's Kindle that lets Kindle users download books at anytime.

Example Sensor Networks

Prof. Sarma presented several examples of the evolution of sensors from heavy-sparse networks to mob-style networks.

Traffic Monitoring

The heavy-sensor version of traffic monitoring uses rugged traffic cameras and in-road loops to measure traffic flow and velocity at key locations. These sensors connect to Operations Centers via dedicated communications networks linking traffic monitoring to the operations centers. But these sensor networks are costly and cannot cover every road, intersection, or even every stretch of highway.

But, now, a mob of sensors does cover every road, intersection, and highway – it is the "mob" of cellphones that drivers carry. Cellphone-derived data potentially includes the motions of each phone from cell-tower to cell-tower, GPS data, and accelerometer data. Such data can detect velocity, stopped traffic, and even rapid braking. Moreover, cellphone-derived traffic data can be used to redirect traffic: people and freight can flow more smoothly through rapidly-changing traffic patterns by receiving updated route recommendations via their cellphone.

German Haus

In the past, energy consumption was not measured with fine granularity -- a single high-cost meter provided only monthly data on energy consumed for an entire facility. But low-cost sensors and connection technology now support much finer-grained, real-time monitoring of power consumption.

German Haus is freshman undergraduate dormitory that was instrumented with power strips that measured students' electricity consumption in every room. The goal was to monitor the levels of power use and transmit the data to a webserver over Zigbee. By viewing the power loads, experimenters could see whether some students left the lights on all the time, for example.

Implications

The move from heavy sensors to mob sensors provides significant opportunities for new applications and better decision making.

Creating Behavior Change

The traffic and power-strip examples raise the issue of behavior in future freight flow scenarios. Just because we have the capability to measure resource use does not imply that we have control over that use. Will people listen to the data and will they change their behavior?

The key issue is one of behavior change. Prof. Sarma cited the work of Dan Ariely and his recent book, *Predictably Irrational*. He summarized Ariely's point, which is that the right messaging is required to change human behavior. For example, a study by Arizona State Professor Robert Cialdini explored how to get occupants of a hotel room to agree to re-use their towels rather than getting new towels each day of their stay. Cialdini used four slightly different messages and tabulated the change in response. The first sign used the traditional motivation of "do it for the environment." The second sign asked guests to be the hotel's partner in this cause. (This sign had 12% less compliance than the environmental sign did.) The third sign stated that the majority of guests in the hotel reused towels at least once during their stay. (This message was 18% more effective than the traditional environmental one.) Finally, the fourth variation said that 85% of guests

"in this room" had reused their towels. This message produced a 33% increase in compliance over the traditional message.

Democratizing Sensors and Information

When sensors are inexpensive, consumers and start-up entrepreneurs can easily afford them. This leads to a wide range of personal, commercial, and public applications. Cheap sensors can help solve modern problems such as detecting automotive reliability problems such as Toyota's stuck accelerators, detecting mass movements of people such as stampedes, and mapping emissions from vehicles. The declining costs of sensors threaten specialized companies. For example, smartphones with embedded GPS (such as Google's Android) threaten specialized navigation device makers such as TomTom and Garmin.

Behind many of today's top stories is a growing role of cellphone video and cellphone networks. These range from the Iranian political demonstrations to the Chilean earthquake. The growing mobs of interconnected sensors of all types give more people more data for more applications.

Wired for Innovation: How IT is Reshaping the Economy

Prof. Erik Brynjolfsson, MIT Sloan

Prof. Erik Brynjolfsson is the Schussel Family Professor at the MIT Sloan School of Management, the Director of the MIT Center for Digital Business, and Research Associate at the National Bureau of Economic Research. An economist by training, Prof. Brynjolfsson presented research on the impact of information technology on productivity. In particular, his work found that companies must invest in much more than just hardware and software to gain the benefits of technology. In fact, investments in complementary organizational capital may need to be four to ten times higher than investments in technology in order to gain the full benefits of technology. Prof. Brynjolfsson's presentation summarized some of the ideas from his recent book, *Wired for Innovation*, which was included in the participants' conference materials.

Does IT Catalyze Productivity?

Prof. Brynjolfsson's research was driven by a productivity paradox. In the early decades of the computer revolution, economists could not find evidence they expected to find: that information technology was actually making companies more productive. Although it was easy to see why computers should help companies perform much better, the actual evidence did not show that IT was helping much. Then, after 1995, the data started to show increasing evidence that IT was actually helping. Prof. Brynjolfsson's work looked at explaining this change and why some companies benefit from IT and others do not.

IT Investment Does Help, But It Is Not the Whole Story

One analysis looked at the relative productivity of companies as a function of relative levels of IT investments. That is, were companies more productive than their peers if they invested in more IT than their peers? The answer was a modest yes, but there was a lot of scatter in the data -- some companies invested a lot but got little.

Leaders vs. Laggards

All industries have leaders and laggards -- the top 25% of firms enjoy higher profit margins than do the bottom 25% of firms. But how has this spread varied in time and among firms that use or do not use IT? Among companies that do not use much IT, the spread between the most profitable and least profitable firms has remained relatively constant for decades. But the picture for companies that intensively use IT (not just those that make IT) is quite different. In recent years since 1995, the gap is up 45% -- the leading firms have profit margins that are 50 points higher than lagging firms. This means that some companies are using IT effectiveness to out-compete and out-profit others.

Complements: The Other 90% of the IT Investment Story

Next, Prof. Brynjolfsson looked at why some companies enjoyed more productivity bang for their IT buck. He analyzed 1167 companies' financial statements and surveyed those companies to understand their practices and other investments. The result uncovered an interlocking set of investments and practices that create coherent performance from computerization.

Organizational Capital Investment

The first finding was that IT investments are only the tip of the iceberg in converting technology into productivity. Companies that gain the most from IT investments complement IT with very substantive investments in what Prof. Brynjolfsson calls *organizational capital*. That is, the leading firms invest heavily in people and processes, not just in computer hardware and software. In fact, for each $1 spent on IT, high-performing companies spend another $9 on these complements. Unfortunately, these complementary investments are not well measured by traditional accounting standards and economics. People may be a company's most important asset, but they appear nowhere on the company's balance sheets.

The Invisible Assets on an Empty Factory Floor

An anecdote serves to illustrate the power of these unmeasured complements. When Prof. Brynjolfsson visited Dell's Round Rock computer factory, he noticed that the factory was half empty. That seemed inefficient. His host explained that Dell had recently redesigned its manufacturing operations to reduce work-in-process, accelerate cycle times, and employ much more aggressive just-in-time practices with a 4-hour delivery lead-time. The result was the factory now churned out 30% more computers using 40% less floor space. Six months later, Dell had filled the factory and was producing twice as many computers as before the reorganization.

Another company, if faced with a potential doubling of production, would have bought another factory. Dell invested in reorganization instead. In essence, Dell got a free factory out of its investments in better processes. Working smarter meant that Dell could produce more without more factory space. That reorganization represented a very valuable asset that is equivalent to having another factory. And yet current-day accounting and economics does not recognize the tremendous value. This illustrates not only the value of investing in organizational capital but also how two companies might have similar levels of assets on their balance sheets (i.e., the same level of investment in physical plants, IT, etc.) and yet one company produces much more than the other.

Seven Practices of Digital Organizations

Overall, Prof. Brynjolfsson found seven key practices to what he calls digital organizations. Companies that invested in IT *and* used most of these seven practices had superior performance relative to companies that only invested in IT, that only used these practices, or that neither invested in IT nor used these practices. These practices complement IT investments in the sense that, together, they lead to significantly higher productivity and profits than they would if adopted individually. The seven practices are:

- Move from analog to digital processes
- Open information access
- Empower employees
- Use performance-based incentives
- Invest in corporate culture
- Recruit the right people
- Invest in human capital

Coherence is Key: Partial Adoption Is Worse than No Adoption

These seven practices also complement each other. The audience noticed an interesting dip in the plot of company performance as a function of IT investment and the adoption of digital organization practices. Companies that adopted some -- but not many -- of the digital organization practices did worse than those companies who did not adopt any digital organization practices. This dip speaks to the crucial role of complementarities -- some practices really need other practices to work well. This dip also illustrates the curse of best practices: just because some practice works really well in one leading organization does not mean it will work well in another company if the adopting organization does not copy all of the complementary practices of that leading organization.

Productivity Isn't Everything, But Almost

Productivity is the Future

Productivity defines future growth and future affluence. Over the long-term, productivity accumulates to make massive differences in economic activity and standards of living. A 1% rate productivity growth for 70 years means a doubling of the standard of living. In contrast, 4% productivity growth for 70 years means a 16 times higher standard of living. A 16-times increase takes a $2,500/year Third-World worker to a $40,000/year Western life style and takes a $40,000/year Western worker to $320,000 per year life of opulence. Concerns about how society might pay for healthcare disappear in the face of such long-term improvements in total earning power.

Total Factor Productivity: Measuring True Improvement

Prof. Brynjolfsson focuses on total factor productivity to control for all the tricks that might make productivity look higher than it really is. Productivity is defined by the total amount of all inputs needed to make some output. Questions from the audience led to a clarification of what does not count as a true productivity improvement. For example, productivity does not mean just working longer hours; longer hours mean more inputs. And finding cheap labor does not count because someone is still putting in the hours to make the product. Outsourcing does not always improve productivity -- substituting external purchased services for internal labor simply shifts the labor from the company to the contract manufacturer or service provider. Outsourcing only improves productivity if the service provider really does have better processes and methods that result in less labor and money to create the same or greater outputs. The point is that true productivity means working smarter, not just worker more, working for less, or having someone else do the work.

Productivity: More and Less Freight

Productivity improvements lead to both more and less freight for two reasons. First, productivity means doing more with less, which generally means more finished goods coming out per unit of raw material coming in. It also means a rising standard of living, which generally means more consumption and more freight. Productivity increases affluence, which enables consumers to buy more finished goods.

The Great Restructuring, not the Great Recession

The trends behind these studies go far beyond just economic effects; they also affect the futures of workers and companies. The past couple of years have not been too good for the economy as unemployment has risen sharply. Worse, six million people have been out of work for more than six months. Many of these six million people represent jobs that are gone and will not come back due to changing patterns of economic activity. For those reasons, Prof. Brynjolfsson said the Great Recession will ultimately become known as the Great Restructuring.

Measuring and Managing Sustainability

Prof. Jonathan Johnson, The Sustainability Consortium

Jonathan Johnson, Professor of Management at the Sam M. Walton College of Business, University of Arkansas, led the establishment of the Sustainability Consortium in July 2009. The Sustainability Consortium seeks practical solutions for improving the sustainability of corporate business practices. Consortium members include Walmart, Best Buy, Safeway, Dell, Clorox, Colgate, Disney, General Mills, Pepsi, P&G and Monsanto. Prof. Johnson is seeking some transportation companies to be members as well.

The Sustainability Consortium and Responsible Reporting

Managing the New Anthropocene Epoch

The Consortium represents a cross-industry effort to have sustainability reporting and to get people to think long-term about how to drive sustainability reporting. A primary driver for the Consortium is the evolution of earth history from the Holocene to Anthropocene epochs, namely the shift to an air, land, and sea environment dominated by a large human population and human activities. As the population increases and the levels of affluence increase around the world, we will see increased consumption that will stress ecosystems even more. The Consortium seeks to mitigate those impacts.

Multi-Metric Lifecycle Analysis

Prof. Johnson advocated a multidimensional, full lifecycle approach to sustainability. For example, incandescent lights have a smaller footprint at the store shelf when compared to CFLs but when one adds in the entire life, including the consumer's energy footprint in using the light, then CFLs beat incandescent. Some counter that CFLs represent a serious risk from toxic mercury during disposal, but mercury emissions from the coal fired electricity plants that make incandescent lamps are a more serious source of mercury. The point is that one needs to understand the entire lifecycle and all dimensions.

Avoiding Uni-dimensional Mandates

Prof. Johnson cautioned against simplistic approaches to sustainability, because they miss real opportunities to improve sustainability and can stifle innovation. For example many now advocate an "eat local" ethos on the basis that it reduces the footprint of transportation. But transportation may be a small fraction of the total footprint. An analysis of the CO2 emissions from US milk production found that only one-quarter (27%) of the footprint comes from transportation. Even if the cow were in the consumer's backyard, milk would still have a significant footprint. In fact, other factors such as inefficient production could make local milk less sustainable than milk transported from more efficient producers.

Multiple Interlocking Natural Cycles

The need for responsible metrics and reporting is due to the interrelated nature of nature. That is, we cannot look just at the carbon footprint impacts without also considering water and the nitrogen cycle. The different dimensions are all interrelated, and we cannot make decisions on just one dimension. We need rigorous information to drive innovations at every point -- not just in manufacturing but in consumer behavior as well. The information has to be at a sufficiently good level of granularity so that all decision makers -- both consumers and buyers -- can make informed decisions.

Social Dimensions

The Consortium's sustainability reporting metrics include an explicit social component. In contrast to the environmental movements of the past, modern sustainability takes a balanced approach to look not just at resource depletion in the environment but also the social and environmental aspects like human rights and safety. The quantification of social metrics is currently at an earlier stage compared to environmental impact metrics.

Guiding Principles

Science-Based and Outcome-Focused

The Consortium wants to combat a tower of ecobabble -- some 350 different possible green labels -- with solid information and consistent methods for assessing sustainability. The competing green labels, some of which are blatant frauds, contributed to distrust of certifications and labels. Objective and transparent analysis methods that are based in science rather than ideology will help companies, consumers, and policy makers understand the true impact of their choices and will motivate more sustainable decisions.

To accomplish its aim, the Consortium borrows technologies from the virtual world of the Internet. The technology of ontology mapping enables developers of online worlds to define the components and properties of an object such as a chair. That same approach lets one map the components of real-world objects and aggregate lifecycle sustainability properties to understand the net impacts of real-world objects.

Understand the Uncertainty

The Consortium also wants to avoid an artificial sense of certainty in sustainability assessment. Adding another digit after the decimal point to a rating does not necessarily imply the rating is more accurate. Acknowledging and tracking what we do not know about the sustainability of products and processes will help guide improvements in methods and data-gathering.

Use Information to Drive Innovation and Adoption

Although the tools are still in their infancy, Prof. Johnson advocates a much greater use of information technology to guide decision making. Without a clear understanding of why a product has the sustainability rating that it does, managers can have no basis for improving the product's sustainability. That is, the rating by itself is not very useful because managers need to understand the basis and components of the rating if they are to make changes to improve the rating. These tools are in development. For example, SAP announced the forthcoming release of a sustainability performance management module. Prof. Johnson noted that open-source teams are creating low-cost tools, too.

To be adopted by businesses, a sustainability methodology must provide value without excessive costs or risks. The four business imperatives for a good assessment include:

- integrated and interpretable decision tools
- credible, transparent metrics
- cost-effective reporting
- intellectual property protection (e.g., for proprietary formulas and methods)

Tools might also extend to the consumer. For example, GoodGuide is an iPhone app that lets consumers scan the bar code of a product, such as Cheerios. The service provides an overall product rating that combines some 15 dimensions related to health, environment, and society.

Benefits of Good Environmental Practices

Measuring and managing sustainability will bring benefits beyond the environment and social benefits. Prof. Michael Porter of the Harvard Business School examined the potential innovation benefits of companies who were leaders in environmental management in the mid-1990s. He looked at the country level: countries that regulated environmental externalities more strictly received innovation benefits. For example, regulating tailpipe emissions not only reduced the emissions but also enabled a host of other innovations.

Driving Adoption

The Sustainability Consortium is only eight months old as of March 2010, but symposium participants asked what will drive adoption of the reporting metrics. A range of forces will contribute to the growing adoption of sustainability.

Consumer Demand

Currently, consumers say they care about the environment, but they are not making those decisions at the transaction level. Some demographics will pay more for sustainable products, but due to greenwashing practices there's also a distrust in the claims. Consumers do not have enough information to make a sound decision. Young mothers and

millennials have shown a willingness to pay a premium for sustainable products, and all Whole Foods shoppers pay a premium, but most consumers are not making those decisions.

Sensible -- Not Premature -- Government Standards

Another participant asked about the role of government in mandating sustainability metrics. For example, France is mandating environmental labeling starting in 2011. The question remains, however, how to meaningfully measure the carbon footprint in a consistent way. And, it is important to look at the whole lifecycle and across dimensions. For example, the local-food movement reduces "food miles" of trucking, but misses the bigger costs, such as trying to grow lettuce in Arizona. We have to look at the bigger picture of total environmental cost.

Retailer and Producer Sensitivity

Retailers are becoming more interested in labeling. Retailers see labeling as an important new competitive space. And, their customers are expecting some level of prescreening before a product makes it onto store shelves. No one wants to discover that their store carries a product with 12% child labor. It is a portfolio of drivers among industry, consumers and perhaps government that will make this happen.

Attendee Comments and Discussions

At the end of day one, Dr. Caplice asked the audience to share its key takeaways from the presentations. He then asked people if they were certain about any particular future events on a 10-year timeframe and then a 20-year timeframe. Below are the participants' responses.

Participants' Key Takeaways

Technology

- We are on the verge of the next industrial revolution. The Star-Trek-like replicator (i.e., the personal fab) Prof. Gershenfeld mentioned is disruptive technology squared.
- Technology continues to be a driver across any topic -- analytics, sensing, computing, microelectronics. Computing power drives it all.
- Integrate technology with business processes to get productivity gains. (Do not just automate bad processes.) Evaluate carriers and help them get better.
- There's a digital gap between the creation of new technology and the adoption of it by organizations. For example, we have remote sensing technologies but truck drivers fill out paper logs.

Big Economic Changes

- Demographics are changing.
- The price and availability of commodities: there is volatility in prices, but the spikes up cannot be passed along to consumers.
- Geopolitical insight into China and India and the global economic shift: There'll be a change in the wealth patterns if China's population becomes wealthy.
- Will the current great recession affect future generations? The Great Depression affected a whole generation. Will we see changes in buying and saving patterns from those scarred by the current downturn?

Role of Government

- Government interest in infrastructure: what the government can/should do: the government has a role to play.
- There's a gap between government and business in managing disruptive technology. There are biologic products that the government does not understand.
- Sustainability and environmental concerns will be more important and will be driven by both consumers and government.

Changing Supply Chains

- Seeing more customization/personalization and a lot size of one.
- Freight/supply chain matters can make a significant difference in performance, sustainability, cost, etc.
- Safety and freight: using new technology to create a safer environment.

How to Learn About the Future

- The difference between individual insights and research-based insights.
- "Me guessing what is important to someone else is not as powerful as seeing what is important to them, watching them do it." (In reference to seeing the products which people have built using personal fabs.)

Participants' 10-Year, High-Confidence Predictions

Changing Citizenry and Consumers

- The numbers of older people will be increasing: aging demographics.
- Healthcare delivery will change: receiving more care through the home.
- The customer rules, and customization has good implications for reducing inventory. When we try to guess what the customer wants, we get it right 40% of the time. But with customization, we can get it right 100% of the

time. There will be a better focus on customers, which will bring increased efficiency.

- What are the chances of a welfare state, if 50% of the population pays no taxes and 20% of the population pays 80% of the taxes?

Overall Increase in Freight

- Equation: Population x Affluence = Greater Freight. This increase will bring a lot of implications (especially environmental impact) which may bring the shift to intermodal.
- Globalization will continue: trade barriers will not go up, and there will be more global freight. On the downside, the US will have network failures due to congestion.

Supply Chains in 10 Years

- Trucks will still move the majority of the freight because that mode is more time-definite than intermodal.
- We will not see an improvement in miles per gallon (MPG) in trucks. No significant breakthroughs appear to be on the horizon.
- We want to see a more efficient transportation system and we are spending a reasonable amount of money (based on David Luberoff's chart) but it is not clear how we can best influence the process to get that efficiency. Where should investment go? How do we go about the investment process as a group, to influence a comprehensive plan?
- The carbon footprint of air freight vs. ocean and rail vs. truck, as well as lower costs, will drive an increase toward those more socially-conscious modes.
- New Department of Transportation requirements, such as testing for sleep apnea, combined with aging of truck drivers, will force more intermodal use because of a lack of truck drivers.
- Public-Private Partnerships (PPP) will arrive given the reality of transportation funding. The partnerships could be a way for the private sector to get what they want and increase highway capacity.

Paradox of Better Decisions and More Uncertainty

- Disruptive technology will come faster, but almost certainly our predictions about what that technology is will be wrong. "Something disruptive this way comes."
- A lot of technological capacity depends on social, political and economic factors to be successful, as Prof. Brynjolfsson showed. We over-promise the near-term and underestimate the long-term impacts because of the unknown-unknowns. There's a deep-rooted enthusiasm about disruptive technology, but it is not likely in the 10-year window. (Do not be seduced by

the enthusiasm for the IT and sensing technologies we see now because it takes longer for the social pieces to evolve.)

- On-time decision making will improve. We'll have more real-time data, more sensing, and faster processing, which will help make better decisions.
- The rise of smart sensing is de-skilling and increasing access to what previously required an army of engineers to do (such as route planning for UPS). Now route planning can be done for free on the Internet, Google maps, etc. This is true not only of sensing and data: there is a proliferation of analytics that are becoming easy to use and widely available. (On the other hand, this can also increase information overload.)
- We need transparency and good science around sustainability.

Participants' 20-Year, High-Confidence Predictions

- An increasing focus on the environment.
- A shift in global wealth from developed markets to emerging markets (from west to east).
- Aging of the population.
- Adaptability: people will age, but their ability to keep working will increase, and their health will be better so they will not be idle.
- There will be wars and rumors of wars.

Appendix C. Snapshot Scenario Output

Out of the input collected during day one of the symposium, the following "single-shot" drivers were developed. These are meant to be individual critical driving forces that were to be analyzed in isolation. Twelve were selected and two were rejected for use at the symposium.

Each of the Snapshot Scenarios were discussed in a small group setting and the different participants evaluated the level of impact of the snapshot occurring across an extended timeline. In the charts below, the vertical axis represents the level of impact (or adoption in some contexts) and the horizontal axis represents the time frame in five buckets. Each participant had to place five poker chips (one for each time-horizon bucket) indicating their best estimate of the level of impact during that timeframe. We collected each participant's private and public (after discussion with the group) allocations.

Additionally, the flow implications for each snapshot scenario are listed (to the right of the adoption/impact matrix). These are the expected implications of that scenario on the flow of freight within the United States.

The best way to interpret these charts is by looking at the level and speed of adoption and evaluating the rate of impact for the specific flow implications. The analysis of these snapshot scenarios can be found in Section 2.6.3.

Aging of the US Population

The majority of the aging US population lives alone in non-urban settings and still has very specific product and service needs shared within their extended social network. Women tend to exhibit a willingness to remain involved in the workforce.

Aging of the US population

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%			25%	38%	50%
40-60%		25%	25%	38%	50%
20-40%	25%	13%	25%	25%	
0-20%	75%	63%	25%		

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%			13%	38%	63%
40-60%		13%	25%	38%	38%
20-40%	25%	38%	38%	25%	
0-20%	75%	50%	25%		

Flow Implications

Sourcing patterns
Minimal impact with some closer or localized sourcing

Flow destination
More frequent, smaller deliveries to more locations
Increased need for quality "last mile" distribution

Routing
Increased use of hubs and complex routing
Increased added value services - white and grey glove

Flow volume
More volume in the last mile
Minimal change on inbound moves

Value density
Much higher value density ratio
Smaller products due to miniaturization

Increase in Global Trade

Global trade has made the majority of the country strongly interdependent. This leads to higher volatility and extreme swings in GDP growth. Protectionism occurs but is only reactionary and is not permanent. The system is generally resilient with fluid trading blocks.

Increase in global trade

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				13%	25%
60-80%	13%	13%	25%	63%	63%
40-60%	25%	50%	75%	25%	13%
20-40%	50%	38%			
0-20%	13%				

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				0%	0%
60-80%				38%	50%
40-60%	13%	25%	63%	63%	50%
20-40%	75%	75%	38%		
0-20%	13%				

Flow Implications

Sourcing patterns
More points of entry due to large imports/exports
Flow destination
Minimal impact
Routing
Increased use of transload hubs from ports
Flow volume
Increase especially at ports and natural choke points
Value density
High value density imports
Exports might expand with lower value density ratio

Rising Power of Emerging Markets

The dollar and the Euro have weakened. Emerging markets gained in affluence and purchasing power as well as political stability and financial strength. They are less focused on exporting as a means to grow and thus, importing more.

Rising power of emerging markets

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%		13%	13%		25%
40-60%	13%			63%	63%
20-40%		13%	63%	38%	13%
0-20%	88%	75%	25%		

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%		13%	13%		13%
40-60%	13%			63%	75%
20-40%		13%	63%	38%	13%
0-20%	88%	75%	25%		

Flow Implications

Sourcing patterns
Balance in imports and exports
Increase in domestic sourcing from interior points (midwest)
Flow destination
Dramatic increase in exports
Ports as primary destinations
Increase in specialized ports
Routing
Increase in entry and exit points will be required
Rise of inland (dry) ports
More freight corridors to handle mix of import/exports
Flow volume
Potentially more air freight volume
Increased overall flow as trade increases
Value density
Value density goes down on exports but remains the same on imports

International Climate Regulation

Climate change proved to be a reality with rising sea levels and higher overall temperature. However, the major disruptions actually stemmed from the higher variability in weather systems leading to more extreme and abrupt manifestations. A sense of urgency shared across developing and developed countries led to the creation of a Global Environment Council redefining business rules and regulations globally in alignment with the WTO.

International climate regulation

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					14%
60-80%					14%
40-60%				57%	57%
20-40%			57%	43%	14%
0-20%	100%	100%	43%		

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					14%
60-80%					14%
40-60%				57%	57%
20-40%			57%	43%	14%
0-20%	100%	100%	43%		

Flow Implications

Sourcing patterns
Reduce sourcing options for greener suppliers
Increase in local sourcing (relative to international)
Flow destination
No changes
Routing
Significant impact on complexity of routing
More routing via greener options - intermodal, inland waterways
Flow volume
Limited volume in and out of region (national)
More shipment moves within region
Value density
Impacted to reduce wasted materials and miles

Rise of Protectionism

Following the COP15 debacle and a longer than anticipated recession, countries reacted by raising tariffs and duties to protect their own industries. While the US tried to save the WTO, internal debates between the states led to the US also adopting protectionist measures – sealing the fate of WTO.

Rise of protectionism

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%		13%	13%		13%
60-80%	13%		13%	50%	13%
40-60%	13%	38%	25%		
20-40%	75%	38%	38%	38%	38%
0-20%		13%	13%	13%	38%

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%		13%	13%		
60-80%	13%		13%	38%	13%
40-60%	13%	38%	25%	13%	13%
20-40%	75%	38%	38%	38%	38%
0-20%		13%	13%	13%	38%

Flow Impacts

Sourcing patterns
Reduction in both exports and imports
Revival of domestic sourcing
Flow destination
Significant drop in exports
More bi-national agreements and regional trading blocks
Reduction in US trade with Asia
Routing
More distributed routing with less port movements
Flow volume
Less in and out of region
Increase within region
Value density
Minimal impact

New Technology: Personal Fabrication

Fueled by the innovative high-tech tools, personal fabrication has become a reality. Open-source design and social network platforms empower people with creating the products that best reflect their personal universe and needs. Although more manufacturing will be done locally in the US, automation limits the number of jobs created.

New technology: personal fabrication

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				13%	38%
60-80%			13%		25%
40-60%				38%	13%
20-40%		38%	50%	38%	25%
0-20%	100%	63%	38%	13%	

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				13%	38%
60-80%			13%		13%
40-60%				25%	25%
20-40%		38%	50%	50%	25%
0-20%	100%	63%	38%	13%	

Flow Impacts

Sourcing patterns
Increase in raw material sourcing
Increase in local sourcing of components
Flow destination
Local or regional distribution will become more prevalent
Routing
More bulk routing of raw materials
Reduction in amount of last mile delivery
Flow volume
Overall reduction in shipments
Value density
Much lower value density ratio

New Technology: The Senseable Network

Cheap wireless technology enables ubiquitous presence of sensors on products, vehicles and the infrastructure. This allows collection, transmission and analysis of multiple attributes such as temperature, humidity, location, etc.

New technology: the Senseable Network

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				38%	75%
60-80%			38%	25%	25%
40-60%		50%	25%	38%	
20-40%	75%	25%	38%		
0-20%	25%	25%			

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				50%	75%
60-80%			50%	38%	25%
40-60%		63%	38%	13%	
20-40%	75%	25%	13%		
0-20%	25%	13%			

Flow Impacts

Sourcing patterns
Greater efficiencies can be gained with sensing
No major impacts
Flow destination
Greater efficiencies in deliveries
No major impacts
Routing
Dramatic efficiency improvements
Potential reduction in congestion
Flow volume
No dramatic overall change
Shift to off-peak times
Value density
No impact

Increase in Sustainability Regulations

Several layers of all-encompassing regulations at the international, federal and state level are enacted. These regulations cover at varying degrees social responsibility, environmental emissions, resource usage, and trade practices. This results in a patchwork of often conflicting rules and penalties.

Increase in sustainability regulations

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%			13%	25%	50%
60-80%		13%	38%	38%	13%
40-60%	25%	38%	25%	38%	25%
20-40%	13%	25%	25%		13%
0-20%	63%	25%			

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%			13%	25%	50%
60-80%		25%	25%	38%	13%
40-60%	13%	25%	38%	13%	25%
20-40%	25%	38%	38%		13%
0-20%	63%	25%			

Flow Impacts

Sourcing patterns
Increase in local or regional sourcing
Flow destination
Increased intermodal and water modes used
Increased restrictions and costs for urban delivery
Routing
Complex routing to reduce overall environmental footprint
Lower service levels due to consolidation
Flow volume
Reduction in truck and local delivery
Increase in greener modes
Value density
Increase in value density as waste is reduced
Cost of transport increases - driving value increase

Increase in Sustainability Customer Demand

Consumer demand for sustainable products is a reality led by different segments of the population including aging baby-boomers, young mothers, etc. This is further fueled by innovative technology that enables consumers to make real-time decision at the point of purchase.

Increase in sustainability customer demand

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				13%	13%
60-80%			13%		38%
40-60%			13%	50%	25%
20-40%	13%	38%	50%	25%	13%
0-20%	88%	63%	25%	13%	13%

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%				13%	13%
60-80%			13%		38%
40-60%			13%	38%	25%
20-40%	13%	38%	50%	13%	
0-20%	88%	63%	25%	25%	25%

Flow Impacts

Sourcing patterns
Increase in local and regional sourcing
Flow destination
Consumers demand more local distribution
Increase in last mile delivery
Routing
Increased complexity to reduce green footprint
Flow volume
Reduction in total miles
Value density
Increase in value density ratio as waste is removed

Rise in Global Security Concerns

Due to heightened security concerns, federal regulation now requires 100% scanning and tracking of all flows within and across the country. These procedures require state-of-the-art technology that is both time consuming and costly.

Rise in global security concerns

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%					20%
40-60%				20%	
20-40%			40%	20%	60%
0-20%	100%	100%	60%	60%	20%

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%					
40-60%					13%
20-40%			25%	38%	63%
0-20%	100%	100%	75%	63%	25%

Flow Impacts

Sourcing patterns
Increase regional sourcing
Concentrated port entry and exit points
Increase in NA trading blocks
Flow destination
Minimal impact
Routing
Significant impact as transit takes longer
Flow volume
Reduction in shipments in and out
More intra-regional moves
Value density
No significant change

Rise in Commodity Prices and Availability

Unreliable supply or unpredictable demand has led to dramatic increase in volatility and price of commodities to include oil, metals, grain, etc. Financial markets have further exacerbated the situation and new technologies have failed to solve the issue.

Rise in commodity prices and availability

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%		14%	14%	29%	29%
40-60%	43%	29%	43%	29%	43%
20-40%	14%	43%	14%	43%	29%
0-20%	43%	14%	29%		

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					
60-80%		14%	29%	29%	29%
40-60%	43%	29%	43%	57%	71%
20-40%	14%	57%	14%	29%	14%
0-20%	57%	14%	29%		

Flow Impacts

Sourcing patterns
Increase in near shoring
Commodity scarcity drives to more remote sourcing
Flow destination
Reduction in local delivery
Routing
More complex to reduce fuel usage
Shift to more efficient modes
Flow volume
Increase on more efficient modes
Value density
Higher value density as efficiency become critical

Additional Points of Entry Open Up

The Panama Canal is completed. The Northwest Passage is now open during summer. Manufacturing is no longer concentrated in the Pacific Rim as regions such as Africa have emerged as reliable suppliers for Europe and North America.

Additional points of entry open up

Adoption matrix - initial

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					14%
60-80%				14%	57%
40-60%				14%	14%
20-40%			57%	71%	14%
0-20%	100%	100%	43%		

Adoption matrix - final

	0-2yr	2-5yr	5-10yr	10-20yr	20-40yr
80-100%					14%
60-80%				14%	57%
40-60%				14%	14%
20-40%			57%	71%	14%
0-20%	100%	100%	43%		

Flow Impacts

Sourcing patterns
New points of entry into region
Balance of flow from various coasts
Flow destination
No significant changes
Routing
More complexity as sourcing entry points will change
More transhipments and other intermediate points
Flexibility in routing is critical
Flow volume
Increase in all volume of flows
Value density
No significant changes

Appendix D. Description of an Interactive Workshop Session

In order to get a feel for the dynamics of the interactive sessions, this Appendix summarizes the discussion and debate involved in one of the six breakout groups. It is important to remember that one of the objectives of this exercise was to test drive the hands-on process involving poker chips and playing boards.

Snapshot: New Technology: Personal Fabrication

The Scenario

In this scenario, low-cost, computer-controlled FabLab-style tools, open-source designs, and social networks let anyone create their own unique personal products locally. Although more manufacturing would be done in the US, the high level of automation means limited job creation. The group wondered about key aspects of this scenario, such as the cost of the personal fabricators and the skill-set. For purposes of the exercise, the devices were assumed to cost $2,000 - $3,000 and require no special skills. The groups also got clarification that the scenario did not include Prof. Gershenfeld's more futuristic notions of programmable matter.

Adoption Trends

Overall, the group expected no adoption for at least 2 years and then a steady increase in adoption. Yet even on the 20-40 year horizon, adoption might only be 50%. The group also varied in their adoption estimates, spanning the entire 0% to 100% adoption range in the 10-20 year time frame.

One issue was that some group members thought that many people would eschew the technology because they were too busy to want to spend time on personal fabrication. That is, people who are cash-rich and time-poor would not use the technology. This led to the discussions that local businesses or individuals might act as "Personal Fabricators" analogous to the notion of hiring a "Personal Shopper." This issue also implied that adoption might also have a strong generational component with both extremes of the age spectrum adopting the technology. On the youth-end, kids personalize everything and do not mind spending untold hours playing with technology. At the other end, the technology may find a following among retirees: grandpa could be puttering in the basement with his personal fabrication workshop.

Freight Flow Implications

The biggest change would be a shift in sourcing. More bulk commodities would be coming from countries that provide raw materials. And less sourcing would occur in low-cost labor countries. This is part of a larger trend of self-service that includes self-checkout in stores and IKEA assemble-it-yourself furniture. Developing world labor cannot compete with a customer who donates their labor for free to save money, ensure quality, or because they enjoy the do-it-yourself ethos.

In particular, the US would probably reroute more domestically-extracted raw materials to internal local production rather than export. The shift from concentrated centers of finished goods production and distribution would change routing from hierarchical paths to a mesh of cross-deliveries.

Stress Map

The decline in sourcing of finished goods from Asia would reduce freight flows on the West Coast. Rising local production and personal production would mean more flows and more stress on urban infrastructure and areas with high population density, such as the East Coast. The group recommended adding a 23rd bubble to the stress map – a bubble for Urban Congestion.

Snapshot: Rising Protectionism

The Scenario

What if the WTO dies under a rising tide of protectionism fueled by a longer than anticipated recession? Countries would enact higher tariffs and duties to protect local industries. The group saw this as a self-fulfilling prophecy in which countries progressively retaliate against each other. One group member with extensive experience in international trade noted that protectionists have an arsenal of techniques to manipulate international trade.

Adoption Trends

The group's aggregate voting patterns showed a rise and then fall of protectionism over time. Rather than see protectionism rise steadily into the future, the group expected a cyclic process tied to the broader macroeconomic challenges of the Great Recession. Governments might become more protectionist for several years, but then the cycle would reverse under pressures to take advantage of foreign trade opportunities, access inexpensive imports, and create reciprocal agreements to improve trade relations. Overall, the group expected protectionism to peak at 50% adoption in 10 years and then decline to 20% adoption in the 20-40 year time frame.

Freight Flow Implications

Overall, protectionism would mean a significant change in sourcing. Domestic sources would supplant foreign sources. Protectionism would also change destinations in the sense that lower exports mean less freight destined for seaports and land ports.

Stress Map

This would lead to a decline in seaport activity and a marked increase in domestic freight movements. In particular, the group voted strongly for high stresses on West Coast highways, East Coast highways, and the South route of the East-West highways. And yet, the group also anticipated much lower GDP due to economic damage of protectionism. Depressed imports, exports, and overall demand mean less total freight flows.

The group discussion revealed a second major type of economic stress for freight infrastructure. Whereas the most common type of stress comes from over-utilization, freight infrastructure can also suffer economic stress and demand for investment due to underutilization. In the case of rising protectionism, US seaports would experience significant declines in freight volume. The problem is that these asset-intensive entities often require some minimum volume of business to support high debt payments and labor. If freight volume drops, then the ports might suffer from debt defaults, bankruptcies, and massive layoffs that would disrupt the viability of the seaports. Ironically, a decline in freight volume may necessitate some form of investment or government support to maintain operations.

Appendix E. Six Workshops: Agendas, Facilitators' Scripts, Voting Results

Exhibit 1. Agendas for the Six Workshops

time from	DVRPC	MNDOT	WSDOT	POLB	GDOT	USDOT
7:45						
8:00	Registration	Registration	Registration			Registration
8:15						
8:30	Welcome	Welcome	Welcome			Welcome
8:45		Intro to ScenPlan	Segments			Intro to ScenPlan
9:00	Intro to ScenPlan			Registration		
9:15			Intro to ScenPlan			
9:30	Segments	FAB		Welcome	Registration	Segments
9:45		-break-	-break-	Intro to ScenPlan		-break-
10:00	-break-	Interactive workshop	Interactive workshop		Intro to ScenPlan	Interactive workshop
10:15	Interactive workshop			Segments		
10:30				-break-	Segments	
10:45				Interactive workshop	-break-	
11:00					Interactive workshop	
11:15						
11:30						
11:45						
12:00	Lunch; Workshop summary	Lunch	Lunch			Lunch
12:15						
12:30						
12:45						
13:00		Reveal, Team debrief, Discussion	Reveal, Team debrief	Lunch	Lunch	Reveal, Team debrief
13:15						
13:30						
13:45						
14:00			Discussion			
14:15				Reveal, Team debrief	Reveal, Team debrief	Cross-scenario comparison
14:30		Wrap up	Wrap up			
14:45						
15:00				Cross-scenario comparison	Cross-scenario comparison	Wrap up
15:15						
15:30						
15:45						
16:00				Wrap-up		
16:15				Technical tour of POLB	Wrap up	
16:30						
16:45						

Exhibit 2. DVRPC Workshop Facilitator Script

PHASE / TASKS	TIME
Before starting the workshop • DVRPC will have 2-3 note-takers per room. • Meet with the note-takers and introduce yourself. • Tell the note-takers the rules of the game: o You (the facilitator) will do all the facilitation and talking. o The note-takers will NOT interact with the group at all. o Emphasize to them that one of the most important outputs of the workshop are the insights of the participants. Tell them, your job is to get the participants talking and their (note-takers') job is to capture all of those insights. Tell them it can be difficult and they need to listen carefully. o Briefly describe the plan for the breakout session. o Tell them up front that they will have to listen very closely especially after the video, after the participants place bets on the map. o Suggest the note takers to divide the participants among themselves (e.g. first six sitting up front on the left side of the table, etc). They will be primarily responsible to capture what this group of people said. • Tell the note-takers how to take notes: o Write name or initials of the person and gist of what s/he is saying. o Ideally capture what is said verbatim.	9:45 – 10:00

PHASE / TASKS	TIME
Introduction • Introduce yourself (name and association) • Ask note takers to introduce themselves. Inform the group that one of the most important outputs of this workshop is the participants' insights and the note takers will be capturing those notes. • Tell which scenario this group is going to discuss and ask everyone to make sure they are in the right room	10:00 – 10:05
Immersion in the scenario • Inform that the audience needs to "live" in the <scenario name> in year 2037 for next 40 minutes. "I want you to describe the world in <scenario name>" • Ask if they have read the scenario. (Some heads will nod). Ask participants nodding heads to describe the key facets of the scenario. Go around the room and ask different people to describe the world. <u>There are two goals</u>: (1) get people talking and (2) start highlighting important aspects of the scenario. • **Before workshop:** Prepare a list of important facets of your scenario. **During "Immersion…"**: mentally cross items off this list as people bring them out. • After about 10 minutes, the audience should have hit most, if not all, of the major points. • Tell: "Now that we understand the world we are living in, let's check our news…" **Play the video**. • Ask what aspects of "our world" they saw in the video. The goal here is to reemphasize the key points. • If the participants have missed any key point, ask them "what do you think about…?"	10:05 – 10:35 (end by 10:20) (end by 10:25) (end by 10:30) (end by 10:35)
Scenario implications • Ask: "So, how does the freight environment of the US and the	10:35 – 10:55

PHASE / TASKS	TIME
Delaware Valley look like in this scenario?" (There are no right/wrong answers here. We are looking for individual insights. There are three goals: Make sure that (1) everyone gets to contribute, (2) no one is dominating the group, and (3) people are not talking nonsense.) • The group should be talking about some of the following things o Macro freight environment (global vs. local) o For the freight (i) originating from, (ii) coming into and (iii) passing through Delaware Valley region: volume, value density, origin, destination, and mode. o Change in the preference/demand for different modes (roads, rail, water, air) o Store-delivery versus home-delivery o Relative prices and availability of various energy sources; socio-political preferences for energy sources • This discussion should begin to create a sense of which routes and modes will experience higher demand, and which ones won't.	
Vote on candidate investment bundles • Inform the participants that now we want to understand which infrastructure investment bundles we want to invest in TODAY to prepare for the scenario in YEAR 2037 we have just described. • Place the big map of candidate investments on the table (if not already there). Inform the group that each one has to evaluate the attractiveness of eight investment bundles described in the morning. Tell them the map on the table shows those investment bundles. Give them a minute to view the map. Also inform them that each one has a copy of this map in their packet. • Give each participant a bag containing chips. Tell the group that we are going to use chips to indicate which projects we want to invest in NOW to be prepared for the world. • Tell them what the chips mean:	10:55 – 11:25 (end by 11:00) (end by 11:05)

PHASE / TASKS	TIME
o Tell them they have 1 chip (color?) worth 25 points, 5 chips worth 10 points each, and 5 chips worth 5 points each. Thus they have 100 points. These chips are used to indicate relative importance of the investment bundles DVRPC should invest in today to prepare for 2040.	(end by 11:07)
o They also have 3 black chips. One chip indicates which bundles to not invest in.	
• Ask everyone to pull out "**Individual Investment Decision**" form. Ask them to write down individually how they will assign the chips to each investment. Give the following instructions:	
o Each has at most 100 points to assign to bundles to invest in (one may use less than 100)	(end by 11:12)
o Each one has to choose at least one bundle and at most three bundles to NOT invest in.	(end by 11:17)
o They cannot assign investment points to a bundle and say do not invest (but okay if group does that)	
• Give about 3-5 minutes to think and write.	(end by 11:30)
• Once everyone seems to have written their answers, ask them to **place their chips on the map** as per their votes on the Individual Investment Decision form:	
o Ask the participants to create stacks for each investment by color	
• Facilitate the discussion based on the votes. The goal of the discussion is to capture the *insights behind the voting*. Here are **some pointers** for which investment bundles to discuss:	
o Bundles with both "Invest" and "Do not invest" chips	
o Bundles with maximum "Invest" points	
o Bundles with maximum "Do not invest" chips	
o Bundles that have no votes at all – either "Invest" or "Do not invest"	

PHASE / TASKS	TIME
o Bundles that have very little chips	
Discuss any "Other" projects • Ask if there are any "Other" bundles to invest in. • Ask participants if they have suggested any other projects, ask them to describe the investment. Ask if any other participants would vote on them.	11:30 – 11:35
Change in vote based on group discussion • Ask the participants if they would like to change the vote based on the discussion. If they do, let them and have discussion. • Ask them to circle any votes they changed on the form and write their new vote next to it – without erasing or crossing out the old vote.	11:35 – 11:48
Wrap up • Ask if the participants have any comments before they break. • Ask the group to submit the Individual Investment Decision form to you. • Break the group for a working lunch and scenario debrief in the main conference room starting at noon.	11:48 – 11:50
After the workshop • Write the number of chips of each of four types on the investment map on the table. • Ask the note-takers to give three to five important insights they captured. • Give the map with the number of votes to the main facilitator for the workshop. From the insights given by note-takers and the ones you captured, find top five or six. Pass these to the main facilitator to include in the presentation. • Main facilitator will have 10 minutes to enter data and prepare the presentation.	11:50 – 12:15 (end by 12:00) (end by 12:10) (end by 12:15) (end by 12:25)

Exhibit 3. MNDOT Workshop Facilitator Script

Time	Activity
8:00 – 8:30	Registration and Sign In
8:30 – 8:45	Welcome and Project Overview (Minnesota DOT)
8:45 – 9:15	Introduction to the Scenario Planning (Dr. Chris Caplice)
9:15 – 9:40	Overview of Freight Action Bundles (Minnesota DOT)
9:40 – 9:50	Directions for Exercise (Dr. Chris Caplice)
9:50 – 10:00	Break and report to breakout group
10:00 – 12:15 **Interactive workshop**	***Scenario immersion (~30 minutes)*** • Inform that the group needs to "live" in the <scenario name> in year 2037 for next 2 hours. • Ask if they have read the scenario. (Some heads will nod). Ask participants nodding heads to describe the key facets of the scenario. Go around the room and ask different people to describe the world. <u>There are two goals</u>: (1) get people talking and (2) start highlighting key aspects of the scenario. • Mentally cross items off the list of important facets of your scenario as people bring them out. After about 10 minutes, the audience should have hit most, if not all, of the major points. • Tell: "Now that we understand the world we are living in, let's check our news…" **Play the video**. • Ask what aspects of "our world" they saw in the video. The goal here is to reemphasize the key points. • If the participants have missed any key point, ask them "what do you think about…?" ***Scenario implications (~15 minutes)*** • Ask: "How does the freight environment of the US and Minnesota look like in this scenario?" (No right/wrong answers here. We are looking for individual insights. <u>There are three goals:</u> (1) everyone gets to

Time	Activity
	contribute, (2) no one is dominating the group, and (3) people are not talking nonsense • The group should be talking about some of the following things o Macro freight environment (global vs. local) o For the freight (i) originating from, (ii) coming into and (iii) passing through Minn: volume, value density, origin, destination, and mode. o Change in the preference for different modes (roads, rail, water, air) o Store-delivery versus home-delivery o Relative prices and availability of various energy sources; socio-political preferences for energy sources • Ask if the implications are any different within the ring, outside the ring but inside the county, and outside the county. ***Voting on FAB: (~15 minutes)*** • Hand out printout of the FAB to all participants. Ask if everyone understands the FABs. (If there are any questions, Minn DOT reps will be in each group.) • Assign 100 points to five FABs, representing the relative important of each FAB in a given scenario. (There are no vetoes) • Individuals vote on their vote sheet and place chips on a large board • After individual voting, ask if anyone wants to change the vote • Tally the votes for each FAB ***Optional break** (discretion of the facilitator while tallying the votes) ***Identify three initiatives in each FAB (~65 minutes)*** • Start with the FAB with the most votes (break any ties randomly) • Nominal group brainstorm with sticky notes and easel pad (~3 min per FAB) • Real group brainstorm based on sticky notes; summarize and identify three key initiatives for the FAB (~10 min per FAB) • Repeat for all FABs ***Real group brainstorm to identify sensors** in the ground for the scenario **(5 min)***

Time	Activity
	Appoint two representatives to present the group's results (one each from private and public sectors)
12:15 – 13:00	Lunch (During lunch, MIT facilitators summarize the results for all groups for cross-scenario analysis)
13:00 – 14:30 **Plenary session**	***Presentation of results for individual scenario*** (~10-12 min/group x 4 = 45 minutes) • Ranking of FAB and brief rationale • Three initiatives within each FAB • Sensors in the ground ***Cross-scenario discussion (~45 minutes)***, led by CTL facilitators • Show ranking of FABs across four scenarios (one slide) • For each FAB (starting with one with maximum total points in all four groups) o Present all initiatives identified by the participants from four groups o Identify the initiatives common across more than one scenario. For each such initiative ▪ Ask the groups that identified them, why they found it useful ▪ Ask the group(s) that did not identify them, if they are useful, hurtful, or benign (neither useful nor hurtful) in their scenario o For initiatives identified in only one scenario, ask if they are useful, hurtful, or benign each of the remaining scenarios • Present list of sensors identified by each scenario group
14:30 – 14:45	Wrap up

Exhibit 4. WSDOT Workshop Facilitator Script

Time	Activity
8:00 – 8:30	Registration and Sign In
8:30 – 8:50	Welcome and Project Overview (Washington DOT, WSDOT)
8:50 – 9:00	Overview of Freight Infrastructure Segments (WSDOT)
9:00 – 9:45	Introduction to the Scenario Planning (Dr. Chris Caplice)
9:45 – 10:00	Break and report to breakout group
10:00 – 12:30 **Interactive workshop**	***Scenario immersion (~30 minutes)*** • Tell the group that for next 2 hours they will be living in the <scenario name> world and that it is 2037. Ask if they have read the scenario. (Some heads will nod). • **Ask participants to describe the world**. Go around the room and ask different people to. The two goals are: (1) get people talking and (2) start highlighting key aspects/facets of that scenario. • Mentally cross items off the list of important facets of your scenario as people bring them out. After about 10 minutes, the audience should have hit most, if not all, of the major points. • Say, "Now that we understand the world we are living in, let's check our news…" Play the video. • Ask how the newscast changed or reinforced their thoughts on their scenario. The goal here is to reemphasize the key points. • If the participants have missed any key point, ask them "what do you think about…?" ***Scenario implications (~15 minutes)*** • **Ask: "How does the freight environment of the US and Washington state look like in this scenario?"** (No right/wrong answers here. We are looking for individual insights. There are three goals: (1) everyone gets to contribute, (2) no one is dominating the group, and (3) people are not talking nonsense

Time	Activity
	• The group should be talking about some of the following things o Macro freight environment (global vs. local) o For the freight (i) originating from, (ii) coming into and (iii) passing through Washington state: volume, value density, origin, destination, and mode. o Change in the preference for different modes (roads, rail, water, air) o Relative prices and availability of various energy sources; socio-political preferences for energy sources ***Individual voting: (~15 minutes)*** • **Ask "Does everyone understand the Freight Infrastructure Segments?"** Make sure everyone has the maps. (If there are any questions, WSDOT reps will be in each group.) • **Say, "Please pull out and fill in your Individual Investment Decision forms."** They will first vote privately (on paper) and then publically with chips. The rules: o Positive Votes - Assign 100 points across the 16 segments (in multiples of 5), representing the relative importance of each segment in the given scenario. More points = more importance o Veto Votes – they must veto at least one and up to three segments. o One cannot assign investment points and veto the same segment • After 3-5 minutes to think and write, tell them to place chips on the board • Tally the votes for each segment ***Group discussion of votes and real-group voting: (~30 minutes)*** • Facilitate the discussion based on the votes. Ask "Why did you vote this way?" or "What was your thinking for these segments?" • Prioritize the segment discussion by the more controversial ones first: o Segments with both "Invest" and "Veto" chips

Time	Activity
	○ Segments with maximum "Invest" points ○ Segments with maximum "Veto" chips ○ Segments with no or very few chips (either "Invest" or "Veto" chips) • **Ask, "Does anyone wants to change their vote?"** Allow people to change votes accordingly. Change chips and display the final score. ***Post-voting survey and brief break after survey (~15 minutes)*** • You will hand out a paper survey and ask them take a short break while they fill it out. • Also, tell them that after the break, "**You will be asked to combine these individual segments into Freight Corridors. Start thinking how you want to do this**." ***Forming Freight Corridors (~15 minutes)*** • Ask "**Now let's try to form a primary corridor for the State of Washington."** Have them identify which of the 16 segments to bundle into a contiguous corridor • A corridor is a multi-modal collection of segments put together as a "transportation system." Therefore, the individual segments may or may not appear in the final corridor despite its earlier vote. • Pick one of the maps and draw the corridor on it. ***Identifying Corridor Initiatives (~30 minutes)*** • Ask "**Now let's try to identify some initiatives that WSDOT should take to improve this Freight Corridor."** Have them brainstorm silently with sticky pads – one initiative per – and put them on the easels. • After 5-10 minutes ask, **"I need two volunteers to report out to the larger group."** Have the group brainstorm out loud to consolidate and identify up to five initiatives for this corridor.
12:30 – 13:15	Lunch (Show scenario videos)
13:15 – 14:30 **Plenary session**	***Cross-scenario summary (10 minutes)*** • Overview of all Scenarios – level setting • Show a few slides with invest & veto results for all 16 segments across the scenarios

Time	Activity
	Presentation of corridors and initiatives by scenario (~10 min. x 4 = 40 minutes) • Each scenario team will describe their corridors (including segments included and not) and the reason for the choice • Each scenario team will then describe the five initiatives they identified ***Cross-scenario discussion of initiatives (20 minutes)*** • Discussion facilitated by CTL
14:30 – 14:45	Wrap up

Exhibit 5. POLB Workshop Facilitator Script

Time	Activity
9:00 – 9:30	Registration and Sign In
9:30 – 10:30	Welcome, Project Overview, Overview of Freight Infrastructure Segments, Introduction to the Scenario Planning (Dr. Chris Caplice)
10:30 – 10:45	Break and report to breakout group
10:45 – 13:00 **Interactive workshop**	***Scenario immersion (~35 minutes)*** • Tell the group that for the next 45 minutes they will be living in the <scenario name> world in year 2037. Ask if they have read the scenario. (Some heads will nod). • **Ask participants to describe the world**. Go around the room and ask different people. The two goals are: (1) get people talking and (2) start highlighting key aspects/facets of that scenario. • Mentally cross items off the list of important facets of your scenario as people bring them out. After about 10 minutes, the audience should have hit most, if not all, of the major points. • Say, "Now that we understand the world we are living in, let's check our news…" Play the video. • Ask how the newscast changed or reinforced their thoughts on their scenario. The goal here is to reemphasize the key points.

Time	Activity
	• If the participants have missed any key point, ask them "what do you think about…?" ***Scenario implications (~20 minutes)*** • **Ask: "How does the <u>import/export environment of the US through Southern California</u> look like in this scenario?"** (No right/wrong answers here. We are looking for individual insights. There are three goals: (1) everyone gets to contribute, (2) no one is dominating the group, and (3) people are not talking nonsense • The group should be talking about some of the following things o Macro freight environment (global vs. local) o For the freight (i) originating from, (ii) coming into and (iii) passing through Southern California: volume, value density, origin, destination, and mode. o Change in the preference for different modes (roads, rail, water, air) o Relative prices and availability of various energy sources; socio-political preferences for energy sources. ***Individual voting: (~20 minutes)*** • **Ask "Pull out the letter-sized paper in your folder called "Freight Infrastructure Segments." This shows 15 segments chosen for today's exercise."** Make sure everyone has the maps. • Say, "Now, come back to Apr 13, 2011. Think about which of these segments we need to invest in TODAY to be ready for <scenario name> in year 2040." Give instructions to complete the Individual Investment Decision forms. The participants first vote privately on these forms and then publically with chips. Explain the following rules: o Positive Votes - Assign 100 points across the 15 segments (in multiples of 5), representing the <u>relative importance</u> of each segment in the given scenario. More points = more importance. The number of positive votes assigned to each segment refers to the importance of the segment – not budget! o Veto Votes – Each participant must veto at least one and up to three segments.

Time	Activity
	○ One cannot assign investment points and veto the same segment • After about 5 minutes to think and write, tell them to place chips on the board • Tally the votes for each segment ***Brief break (15 minutes) – count the chips*** • Display the group's vote to the entire group. Everyone should be able to see the number of invest points and vetoes assigned to each segment. ***Group discussion of votes and real-group voting: (~20 minutes)*** • Facilitate the discussion based on the votes. The goal is to understand the rationale behind the investment decisions made by the individuals. • Prioritize the segment discussion by the *interesting* segments, in the following order: ○ Segments with both "Invest" and "Veto" chips ○ Segments with maximum "Invest" points ○ Segments with maximum "Veto" chips ○ Segments with no or very few chips (either "Invest" or "Veto" chips) • **Ask, "Does anyone wants to change their vote"**. Allow people to change votes accordingly. Change chips and display the final score. ***Identifying initiatives (~35 minutes)*** • Ask "**Now let's try to identify some initiatives we need to take TODAY to prepare for this scenario."** Have the group brainstorm *nominally* with sticky pads – one initiative per sticky note. Ask the individuals to put the sticky notes on the poster pad. • After 5-10 minutes ask, **"I need two volunteers to report out to the larger group."** Have the group brainstorm out loud to consolidate and identify up to five initiatives for this corridor. ***Post-voting survey (~25 minutes)*** • Thank the group for participating in the exercise. **Inform them** that other two groups are engaged in a similar exercise. We will get to see the other

Time	Activity
	scenarios after lunch. Ask them what they thought about the scenario and the exercise. This is a 5-10 minute chitchat to bring them out of the scenario. • **Hand out the questionnaire. Say:** "Now you have seen one scenario. This may or may not have changed the way you think about the future. What I would like you to do next is to complete the questionnaire I am passing out. This is the same questionnaire that you completed online before the workshop. While filling this questionnaire, don't think about the scenario we lived in anymore… But, take a few minutes to think about the kind of world we may live in in year 2040… You may or may not believe in the scenario. Just answer the questions based on what comes to your mind easily." Thank the group for completing the questionnaire.
13:00 – 14:00	Lunch
14:00 – 15:30 **Plenary session**	***Cross-scenario summary (30 minutes)*** • Have everyone sit with his or her scenario teams. • Show scenario videos for all three scenarios used • Overview of all Scenarios – level setting ***Presentation of initiatives by scenario (~10 min. x 3 = 30 minutes)*** • Each scenario team will describe their corridors (including segments includes and not) and the reason for the choice • Each scenario team will then describe the five initiatives they identified • Encourage cross-discussion and questioning from other teams ***Cross-scenario discussion of initiatives (30 minutes)*** • Show a few slides with invest & veto results for all segments across the scenarios • Discuss robust and contingent investments • Have individuals vote for the segments (pick most robust) – vote by hand • Make a group vote for the priority segments • Show the Tech Savior video • Ask group how they would change their voting
15:30 – 16:00	Wrap up

Exhibit 6. GDOT Workshop Facilitator Script

Time	Activity
9:30 – 10:00	Registration and Sign In
10:00 – 10:45	Welcome, Project Overview, Overview of Freight Infrastructure Segments, Introduction to the Scenario Planning (Dr. Chris Caplice)
10:45 – 11:00	Break and report to breakout group rooms
11:00 – 13:15 **Interactive workshop** ***end @11:30***	***Scenario immersion (~30 minutes)*** ***MINDSTATE 1(Future/Known)*** • Tell the group "For the next 45 minutes they will be living in the <scenario name> world in year 2037". Ask "Have you read the scenario?" • Ask participants to **"describe the world"**. Go around the room and ask different people. The two goals are: (1) get people talking and (2) start highlighting key aspects/facets of that scenario. • Mentally cross items off the list of important facets of your scenario as people bring them out. After about 10 minutes, the audience should have hit most of the major points. • Say, "Now that we understand the world we are living in, let's check our news…" Play the video. • After the video, ask "How has the newscast changed or reinforced your thoughts on the scenario?" The goal here is to reemphasize the key points. • If the participants have missed any key point, ask them **"what do you think about…?"** ***Scenario implications (~15 minutes)*** ***MINDSTATE 1(Future/Known)*** • Ask**: "How does the freight environment for the State of Georgia and the Southeastern U.S. look like in this scenario?"** (No right/wrong answers here. We are looking for individual insights. There are three goals: (1) everyone gets to contribute, (2) no one is dominating the group, and (3) people are not talking nonsense • The group should be talking about some of the following things o Macro freight environment (global vs. local) o For the freight (i) originating from, (ii) coming into and (iii) passing

Time	Activity
	through Georgia state: volume, value density, origin, destination, and mode. o Change in the preference for different modes (roads, rail, water, air) o Relative prices and availability of various energy sources; socio-political preferences for energy sources
	Individual voting: (~20 minutes) MINDSTATE 2(Now/Known)
end @ 11:45	• Ask **"Pull out the letter-sized paper in your folder called "Freight Infrastructure Segments". This shows 13 segments chosen for today's exercise."** Make sure everyone has the maps. • Say, "Now, come back to May 9, 2011. Think about which of these segments we need to invest in TODAY to be ready for <scenario name> in year 2037." Give instructions to complete the Individual Investment Decision forms. The participants first vote privately on these forms and then publically with chips. Explain the following rules:
take break @ ~ 12:05	o Positive Votes - Assign 100 points across the 13 segments (in multiples of 5), representing the relative importance of each segment in the given scenario. More points = more importance. The number of positive votes assigned to each segment refers to the importance of the segment – not budget!
start up by 12:15	o Veto Votes – Each participant must veto at least one and up to three segments. o One cannot assign investment points and veto the same segment • After about 5 minutes to think and write, tell them to place chips on the board
end @12:35	***Brief break (10 minutes) – count the chips*** • Display the group's vote to the entire group. Everyone should be able to see the number of invest points and vetoes assigned to each segment. ***Group discussion and Consensus: (~20 minutes) MINDSTATE 2(Now/Known)*** • Facilitate the discussion based on the votes. The goal is to understand the rationale behind the investment decisions made by the individuals.

Time	Activity
end @13:10	• Prioritize the segment discussion by the *interesting* segments, in the following order: o Segments with both "Invest" and "Veto" chips o Segments with maximum "Invest" points o Segments with maximum "Veto" chips o Segments with no or very few chips (either "Invest" or "Veto" chips) • Ask**, "Does anyone want to change their vote"**. Allow people to change votes accordingly. Change chips and display the final score.
End No Later than 13:15	***Identifying initiatives (~35 minutes) MINDSTATE 2(Now/Known)*** • Ask "**Now let's try to identify some *actionable* initiatives we need to take TODAY to prepare for this scenario."** Have the group brainstorm *nominally* with sticky pads – one initiative per sticky note. Ask the individuals to put the sticky notes on the poster pad. • After 5-10 minutes ask, **"I need two volunteers to report out to the larger group."** Have the group brainstorm out loud to consolidate and identify **up to five** initiatives for the scenario. ***Distribute questionnaire and break for lunch MINDSTATE 3(Now/Unknown)*** • Thank the group for participating in the exercise. Hand out the questionnaire. • Say: **"Now you have seen one scenario. What I would like you to do next is to complete the questionnaire I am passing out. Turn it in before we start the next session after lunch….** • **This is the same questionnaire that you completed online before the workshop. While filling this questionnaire, assume the time is NOW and that the future is UNCERTAIN - it will not necessarily follow your scenario.** • **Also please write your name. Your responses are completely confidential."**
13:15 – 14:15	Lunch
14:15 – 16:00	Ask everyone to turn in their questionnaires.

Time	Activity
end @14:45	***Cross-scenario summary: Reveal videos of all scenarios used (30 minutes)*** • Have everyone sit with his or her scenario teams. Show scenario videos for all three scenarios used. Provide short overview of all Scenarios – level setting ***Presentation of results and initiatives by scenario (~10 min. x 3 = 30 minutes)*** • Each scenario team will then describe the five initiatives they identified • Encourage cross-discussion and questioning from other teams
end @15:15	***Cross-scenario discussion of initiatives (45 minutes)*** • Show the slide with invest & veto results for all segments across the scenarios • Discuss robust and contingent investments • Ask **"Please now pick one segment that is the most critical for the future"**
end @16:00	• Show the *Global Marketplace* video and ask **"How would you change Your votes?"**
16:00 – 16:30	Wrap up

Exhibit 7. USDOT Workshop Facilitator Script

Time	Activity
8:00 – 8:30	Registration and Sign In
8:30 – 8:45	Welcome & Introductions (Tony Furst, Polly Trottenberg, John Horsley)
8:45 – 9:45	Introduction to the Scenario Planning & Freight Segments (Dr. Chris Caplice)
9:45 – 10:00	Break and report to breakout group rooms
10:00 – 12:30 **Interactive workshop**	***Scenario immersion (~30 minutes)*** ***MINDSTATE 1(Future/Known)*** • Tell the group "For the next 45 minutes they will be living in the <scenario name> world in year 2037". Ask "Have you read the scenario?" • Ask participants to **"describe the world"**. Go around the room and ask different people. The two goals are: (1) get people talking and (2) start highlighting key aspects/facets of that scenario.

Time	Activity
	• Mentally cross items off the list of important facets of your scenario as people bring them out. After about 10 minutes, the audience should have hit most of the major points. • Say, "Now that we understand the world we are living in, let's check our news…" Play the video. • After the video, ask "How has the newscast changed or reinforced your thoughts on the scenario?" The goal here is to reemphasize the key points. • If the participants have missed any key point, ask them **"what do you think about…?"**
end @10:30	***Scenario implications (~15 minutes)*** ***MINDSTATE 1(Future/Known)*** • Ask**: "How does the <u>freight environment for the United States</u> look like in this scenario?"** (No right/wrong answers here. We are looking for individual insights. There are three goals: (1) everyone gets to contribute, (2) no one is dominating the group, and (3) people are not talking nonsense • The group should be talking about some of the following things o Macro freight environment (global vs. local) o For the freight (i) originating from, (ii) coming into and (iii) passing through US: volume, value density, origin, destination, and mode.
end @ 10:45	o Change in the preference for different modes (roads, rail, water, air) o Relative prices and availability of various energy sources; socio-political preferences for energy sources ***Q1 Priority of Components: (~15 minutes)*** ***MINDSTATE 2(Now/Known)*** • Ask **"Pull out the letter-sized paper in your folder called "Infrastructure Components". This shows the 12 infrastructure components chosen for today's exercise."** • Say, "Now, come back to JUNE 28th, 2011. Where should we prioritize federal funds NOW given that the future described in your scenario in 2037 is going to occur?"

Time	Activity
	• Tell them, "Remember, this is for federal funds (including the US Army Corps of Engineers). You should not feel constrained about silo-ed funding." • Hand out the Q1 Investment Programs individual voting sheets and put the 11x17 Group Voting sheets on a center table. • Ask them to first vote privately on these forms and then publically with chips. • Hand out the chips – each person gets 12 colored and three black chips. • Explain the following rules: o Positive Votes – Place your 12 chips across the 12 components to represent the relative importance of each component in the given scenario. More points = more importance. The number of positive votes assigned to each segment refers to the importance of the segment – not budget! Colors of chips are irrelevant. o Veto Votes – Each participant must veto at least one and up to three components. o One cannot assign investment points and veto the same segment • After about 5 minutes to think and write, tell them to place chips on the board
take break @ ~ 11:00	***Brief break (10 minutes) – count the chips*** • Write the number of chips and vetoes on the chart. Display the group's vote to the entire group. Everyone should be able to see the number of invest points and vetoes assigned to each segment.
start up by 11:10	***Group discussion and Consensus: (~15 minutes) MINDSTATE 2(Now/Known)*** • Facilitate the discussion based on the votes. The goal is to understand the rationale behind the investment decisions made by the individuals. • Prioritize the segment discussion by the *interesting* segments, in the following order:

Time	Activity
end @11:25	○ Segments with both "Invest" and "Veto" chips ○ Segments with maximum "Invest" points ○ Segments with maximum "Veto" chips ○ Segments with no or very few chips (either "Invest" or "Veto" chips)
end @11:55	• Ask**, "Does anyone wants to change their vote"**. Allow people to change votes accordingly. Change chips and display the final score.
end @12:15 ***FINISH NLT 12:30 and NET 12:20***	***Q2 - Level of Investment initiatives (~30 minutes) MINDSTATE 2(Now/Known)*** • Ask "**Now let's drill in a little deeper. We have combined the Gateways a little bit here by type. <u>What level of investment should the federal Government take for each type of infrastructure</u>? Choose between Maintain Existing, Improve Existing, and Add New."** • Explain the levels – refer to the Infrastructure Components sheet – on the back. • Hand out the Q2 Level of Investment Individual Voting Sheet and have them vote individually on the sheet – Only one check per row. • While they are filling out their sheets, hand each participant nine chips of any color and have them vote. • There are chip limits by investment level: ○ Maintain Existing– unlimited ○ Improve Existing – No More Than 3 ○ Add New – No More Than 2 • Quickly tally the votes, write it on the sheet, post it, and open discussion. ***Q3 – Policy & Funding (~20 minutes) MINDSTATE 2(Now/Known)*** • Ask "**Now let's look at where POLICY should be made and how FUNDING should be provided. For POLICY, check the level where it should be made for each component. For FUNDING, check where the PRIMARY funding should come from for each component."** • Hand out the Q3 Policy Level and Funding Source Individual voting sheets. • Have them vote individually where each person puts one check per row for POLICY and one per row for FUNDING. Thus, each row should have two and only two checks. • While they are voting, hand each person 18 chips (color does not

Time	Activity
	matter). Have them place them according to their individual votes. They must use all chips. • Quickly tally the votes, write it on the sheet, post it, and open discussion. ***Wrap Up and Final Comments (use remaining time)*** • Ask, **"I need two volunteers to report out to the larger group."** Tell them we will show their responses on the screen – they only need to explain their choices
12:30 – 13:30	Lunch
13:30 – 14:00 ***End @ 14:00*** ***End @14:45*** ***end @15:30***	***Cross-scenario summary: Reveal (30 minutes)*** • Have people sit in their groups. • Show scenario videos for all scenarios used. • Provide short overview of all Scenarios – level setting. • ELECTRONIC VOTING. – 1. Which scenario is most like TODAY? 2. Which scenario is MOST LIKELY to occur? 3. Which Scenario is MOST PREFERRED? ***Presentation of results and initiatives by scenario (~10 min. x 4 = 45 minutes)*** • Each scenario team will then describe the five initiatives they identified • Encourage cross-discussion and questioning from other teams ***Cross-scenario discussion of initiatives (45 minutes)*** • Show the slide with invest & veto results for all segments across the scenarios • Discuss robust and contingent investments • ELECTRONIC VOTING – 1. Which component is MOST critical? 2. Which component is LEAST critical? • Discuss Sensors in the Ground 1. Vote on specific sensors (which is the most likely direction)
15:30 – 16:00	Wrap up • ELECTRONIC VOTING – 1. What is the value of this type of workshop? (likert) 2. Likelihood that DOTs will use this process?

Exhibit 8. DVRPC Workshop Voting Summary

Delaware Valley Regional Planning Commission (DVRPC)

(a) sum of points and vetoes

		GM		MM		N!		OWO	
	nbr of segments	Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	2	485	3	275	8	290	3	235	9
Corridor	4	620	9	810	5	525	10	740	9
Connector	2	255	6	250	4	360	2	410	1
		1360	18	1335	17	1175	15	1385	19

(b) proportion of points and vetoes

		GM		MM		N!		OWO	
		Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	2	0.357	0.167	0.206	0.471	0.247	0.200	0.170	0.474
Corridor	4	0.456	0.500	0.607	0.294	0.447	0.667	0.534	0.474
Connector	2	0.188	0.333	0.187	0.235	0.306	0.133	0.296	0.053

(c) proportion of points and vetoes per segment

	GM		MM		N!		OWO	
	Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	**0.178**	0.083	0.103	**0.235**	0.123	0.100	0.085	**0.237**
Corridor	0.114	0.125	**0.152**	0.074	0.112	**0.167**	0.134	0.118
Connector	0.094	**0.167**	0.094	0.118	**0.153**	0.067	**0.148**	0.026

Exhibit 9. WSDOT Workshop Voting Summary

Washington State Department of Transportation (WSDOT)

(a) sum of points and vetoes

		GM		MM		N!		OWO	
	nbr of segments	Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	3	275	0	240	1	240	7	190	7
Corridor	12	980	17	925	16	1330	14	1095	5
Connector	1	45	3	40	4	0	9	25	4
		1300	20	1205	21	1570	30	1310	16

(b) proportion of points and vetoes

		GM		MM		N!		OWO	
		Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	3	0.212	0.000	0.199	0.048	0.153	0.233	0.145	0.438
Corridor	12	0.754	0.850	0.768	0.762	0.847	0.467	0.836	0.313
Connector	1	0.035	0.150	0.033	0.190	0.000	0.300	0.019	0.250

(c) proportion of points and vetoes per segment

	GM		MM		N!		OWO	
	Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	**0.071**	0.000	**0.066**	0.016	0.051	0.078	0.048	0.146
Corridor	0.063	0.071	0.064	0.063	**0.071**	0.039	**0.070**	0.026
Connector	0.035	**0.150**	0.033	**0.190**	0.000	**0.300**	0.019	**0.250**

Exhibit 10. POLB Workshop Voting Summary

Port of Long Beach (POLB)

(a) sum of points and vetoes

		GM		N!		OWO	
	nbr of segments	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	2	295	3	105	14	315	6
Corridor	10	430	15	1025	10	575	18
Connector	3	450	2	195	2	340	3
		1175	20	1325	26	1230	27

(b) proportion of points and vetoes

		GM		N!		OWO	
		Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	2	0.251	0.150	0.079	0.538	0.256	0.222
Corridor	10	0.366	0.750	0.774	0.385	0.467	0.667
Connector	3	0.383	0.100	0.147	0.077	0.276	0.111

(c) proportion of points and vetoes per segment

	GM		N!		OWO	
	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	0.126	**0.075**	0.040	**0.269**	**0.128**	**0.111**
Corridor	0.037	**0.075**	**0.077**	0.038	0.047	0.067
Connector	**0.128**	0.033	0.049	0.026	0.092	0.037

Exhibit 11. GDOT Workshop Voting Summary

Georgia Department of Transportation (GDOT)

(a) sum of points and vetoes

		MM		N!		OWO	
	nbr of segments	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	3	180	4	190	3	220	8
Corridor	8	325	7	565	10	480	7
Connector	2	175	0	135	1	175	1
		680	11	890	14	875	16

(b) proportion of points and vetoes

		MM		N!		OWO	
		Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	3	0.265	0.364	0.213	0.214	0.251	0.500
Corridor	8	0.478	0.636	0.635	0.714	0.549	0.438
Connector	2	0.257	0.000	0.152	0.071	0.200	0.063

(c) proportion of points and vetoes per segment

	MM		N!		OWO	
	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	0.088	**0.121**	0.071	0.071	0.084	**0.167**
Corridor	0.060	0.080	**0.079**	**0.089**	0.069	0.055
Connector	**0.129**	0.000	0.076	0.036	**0.100**	0.031

Exhibit 12. USDOT Workshop Voting Summary

United States Department of Transportation (USDOT)

(a) sum of points and vetoes

		GM		MM		N!		OWO	
	nbr of segments	Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	6	67	4	72	12	56	17	54	19
Corridor	3	34	3	52	5	42	0	38	3
Connector	3	43	7	35	4	34	2	64	1
		144	14	159	21	132	19	156	23

(b) proportion of points and vetoes

		GM		MM		N!		OWO	
		Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	6	0.465	0.286	0.453	0.571	0.424	0.895	0.346	0.826
Corridor	3	0.236	0.214	0.327	0.238	0.318	0.000	0.244	0.130
Connector	3	0.299	0.500	0.220	0.190	0.258	0.105	0.410	0.043

(c) proportion of points and vetoes per segment

	GM		MM		N!		OWO	
	Points	Vetoes	Points	Vetoes	Points	Vetoes	Points	Vetoes
Gateway	0.078	0.048	0.075	**0.095**	0.071	**0.149**	0.058	**0.138**
Corridor	0.079	0.071	**0.109**	0.079	**0.106**	0.000	0.081	0.043
Connector	**0.100**	**0.167**	0.073	0.063	0.086	0.035	**0.137**	0.014

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation