A CONCEPTUAL FRAMEWORK AND APPROACH FOR ENHANCING TRANSPORTATION ASSET MANAGEMENT (TAM) IMPLEMENTATION FOR SUSTAINED TAM PROGRAMS

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A CONCEPTUAL FRAMEWORK AND APPROACH FOR ENHANCING TRANSPORTATION ASSET MANAGEMENT (TAM) IMPLEMENTATION FOR SUSTAINED TAM PROGRAMS

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To Nii Anyetei:

For always watching over me.

Fly high with the angels.

Love,

Your baby sister.

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"If you have the courage and determination to knock on enough doors, you will find the right one"

- Dr. Anthony Fernando

It has been a long five years and I have knocked on many doors to get to this point. I have to start by expressing my gratitude to my nuclear and extended family who have constantly shown love and support, and have encouraged me throughout this process. I am ambitious because my parents taught me never to settle for less - and it is that ambition that has led me here. To my big brother, Akofio, thank you for being a rock even when you didn't know that you were. And to the many other brothers and sisters I have adopted along the way in Atlanta and in other parts of the world, thank you all for helping me maintain a balanced lifestyle, for providing support, and for indulging me in those moments when I prioritized my work over everything else.

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Lastly, but certainly not least, all glory goes to God, who holds the pencil of my life in His hands.

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LIST OF ABBREVIATIONS

AADT	Annual Average Daily Traffic
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADKAR	Awareness, Desire, Knowledge, Ability, and Reinforcement
ASCE	American Society of Civil Engineers
BMS	Bridge Management System
CAM-CI	Capital Asset Management-Capital Investment
CDOT	Colorado Department of Transportation
CIMO	Context, Intervention, Mechanisms, Outcomes
CMAQ	Congestion Mitigation and Air Quality
COPACES	Computerized Pavement Condition Evaluation System
CPDC	Capital Program Delivery Committee
CPT	Comprehensive Program Team
DOT	Department of Transportation
EAMP	Enterprise Asset Management Program
EBDM	Evidence-Based Decision Making
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GAO	Government Accounting Office
GASB	Governmental Accounting Standards Board
GIS	Geographic Information Systems

GLACEAR	Guidance, Leadership, Applications, Culture, Employees, Alignment, Resources
GPRA	Government Performance and Results Act
GDOT	Georgia Department of Transportation
HRB	Highway Research Board
ISO	International Organization for Standardization
ISTEA	Intermodal Surface Transportation Efficiency Act
LOS	Levels of Service
MAP-21	Moving Ahead for Progress in the 21st Century
MPO	Metropolitan Planning Organization
NBI	National Bridge Inventory
NBIS	National Bride Inventory System
NCHRP	National Cooperative Highway Research Program
NHI	National Highway Institute
NHS	National Highway System
NHSDA	National Highway System Designation Act
NYSDOT	New York State Department of Transportation
NYSTA	New York State Thruway Authority
OFMB	Office of Financial Management and Budget
OPM	Organizational Performance Management
PDCA	Plan, Do, Check, Act
PICO	Patient or Problem, Intervention, Comparison, Outcomes
PICMO	Problem, Intervention, Context, Mechanism, Outcome)

PMS	Pavement Management System
P/PMIS	Project and Program Management Information System
PRWORA	Personal Responsibility and Work Opportunity Reconciliation Act
RAMT	Regional Asset Management Teams
RBAMP	Risk-Based Asset Management Plan
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users
SAMT	Statewide Asset Management Team
SMS	Safety Management Systems
SOP	Standard Operating Procedure
STIP	Statewide Transportation Improvement Plan
TAM	Transportation Asset Management
TAMP	Transportation Asset Management Plan
TEA-21	Transportation Equity Act of the 21st Century
TIRF	TAM Implementation Review Framework
TPM	Transportation Performance Management
TRB	Transportation Research Board
USDOT	United States Department of Transportation

SUMMARY

The history of national policy development for the formal management of transportation assets in the U.S. has shown that successful policy implementation for program sustainment is not easily achieved. In 2012, legislation reauthorizing national surface transportation programs introduced a requirement for formal transportation asset management (TAM) in state and local agencies. The law specifically requires agencies to develop TAM plans and implement TAM programs in their decision-making processes. Policy implementation and organizational theory research have shown that often, agencies can respond to this kind of legislative mandate with ineffective efforts to achieve legitimacy that reduce the likelihood for the program to be sustained in the long-term. This presents a challenge because without sustainment, the benefits of TAM, which are mostly long-term, may not be fully realized. The objective of this work was to develop a conceptual framework and tool to guide transportation agencies to review their TAM implementation approaches and identify opportunities to enhance long-term program sustainment.

The conceptual basis for the framework comes from a synthesis of transportation, policy and program implementation, and change management literature, supported by insight from a panel of practitioner and academic experts working on TAM and its implementation. The literature synthesis and expert panel results led to seven categories of factors that can influence the success of TAM implementation in terms of sustaining the program in the long-term. These categories emphasize the social and organizational aspects of implementation over the technical. By addressing the factors during the implementation phase, the likelihood of TAM programs to be sustained in the long-term

can be enhanced. This formed the foundation of the TAM Implementation Review Framework (TIRF), which incorporates the evidence-based principle of a systematic approach to documentation of experiences to generate evidence for specific actions. The TIRF was applied in case studies to review the TAM implementation processes of three Departments of Transportation (DOTs) resulting in different kinds of information on how implementation activities address factors related to program sustainment. These results can steer future implementation activities in DOTs towards increased probabilities of achieving long-term program sustainment. The TIRF output is being proposed as a foundational element in the development of an evidence-based catalog of TAM implementation strategies that can serve as a useful knowledge base to guide agencies as they implement the legislative requirements for TAM.

The primary contributions of this work lie in the development of a conceptual framework and review approach to enhance TAM implementation by emphasizing the people and organizational elements of agencies, alongside with the technical. In practice, the TIRF offers agencies a review and planning tool to support TAM implementation decision making and to promote program sustainment. The tool can facilitate inter-agency knowledge sharing by providing a platform for systematic information gathering. This can be used to build a catalog of implementation experiences with practitioner-documented evidence to support broader adoption of strategies that can contribute to increased program sustainment.

CHAPTER 1: INTRODUCTION

1.1 Research Topic: Transportation Asset Management (TAM)

Transportation asset management (TAM) has become an increasingly popular concept in the transportation industry, growing out of the practice of bridge and pavement management in the 1960s and 1970s. With growing demands on transportation infrastructure in the face of deterioration and budget shortfalls, there is a greater need for strategies to more efficiently allocate resources to maintain infrastructure performance at or above acceptable levels for longer periods of time. Over the years, many state Departments of Transportation (DOTs) and other local and regional transportation organizations have continued to adopt the principles of performance-based TAM in their business processes. In particular, the use of infrastructure condition data in making performance-based investment decisions has greatly evolved, resulting in the emergence of performance measurement and asset management as topics of interest in the transportation community. In July 2012, these concepts of TAM and performance-based planning were formally elevated to national policy issues when the surface transportation legislation, Moving Ahead for Progress in the 21st Century (MAP-21), was passed. MAP-21 introduced a formal shift to performance-based decision making in the industry, as well as a formal mandate for transportation agencies to develop and implement TAM plans.

Transportation Asset Management is "a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering

and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost" (U.S. Congress 2012). This definition, much like many others developed by different organizations around the world, applies the concept of asset management to physical assets, highlighting its basic principles which include: (i) a systematic evaluation of asset needs and available resources; (ii) consideration of the entire asset lifecycle; (iii) the combination of engineering and economic principles; (iv) investment decisions based on data; and (v) primary performance outcomes of efficiency and cost-effectiveness (Cambridge Systematics et al., 2002).

In recent years, TAM has become more popular with increases in the use of the term in describing agencies' efforts to distribute their limited financial resources towards infrastructure needs more efficiently and effectively; however, TAM principles have been used in the transportation industry for many years. The origination of asset management in transportation can be traced back to the American Association of State Highway Officials' (AASHO) Road Tests conducted in the late 1950s to determine the relationship between structural designs and expected loading over pavement life (FHWA 2011a). The experimental activity led to the introduction of performance measurement and prediction and, ultimately, pavement management systems (PMS). In the 1960s, the scope of infrastructure management extended to include bridges, after the collapse of the Silver Bridge between Ohio and West Virginia (LeRose 2001). This led to a number of federal mandates requiring that bridge infrastructure be monitored and maintained systematically, resulting in the genesis of bridge management systems (BMS).

Unlike pavement and bridge management, TAM is comprehensive, encompassing all classes or categories of infrastructure within an agency's jurisdiction. With the objective of upgrading, preserving and maintaining infrastructure over the lifecycle, TAM systems and the process of managing infrastructure assets can guide an agency in efficiently and effectively allocating resources. One of the most important components of a TAM system is the ongoing evaluation of progress towards an agency's performance goals with monitoring and feedback processes. Figure 1.1 shows the components of a generic asset management system, including this feedback element.

Since MAP-21 was passed, transportation agencies have initiated (but in many cases, continued) the process of implementing TAM in their agencies focusing primarily on the TAM plan. In fact, the FHWA conducted a pilot project with three states to develop TAM plans in order to set a precedent for other states. Essentially, it can be said that the TAM plan has been identified as the first major step in implementing a TAM program. According to the FHWA, the TAM plan is a "document that describes how a State DOT will carry out asset management….make risk-based decisions…as it relates to managing its physical assets and laying out a set of investment strategies to address the condition and system performance gaps" (FHWA 2015 p. 9249). It is important to note that while the language in MAP-21 suggests that the mandate is simply for a plan, the proposed rulemaking emphasizes not only creating, but also implementing the plan. All in all, while the industry is in the throes of implementing this policy to formally adopt TAM by developing and implementing TAM plans, it is important to note that TAM programs require more than the development of a plan.

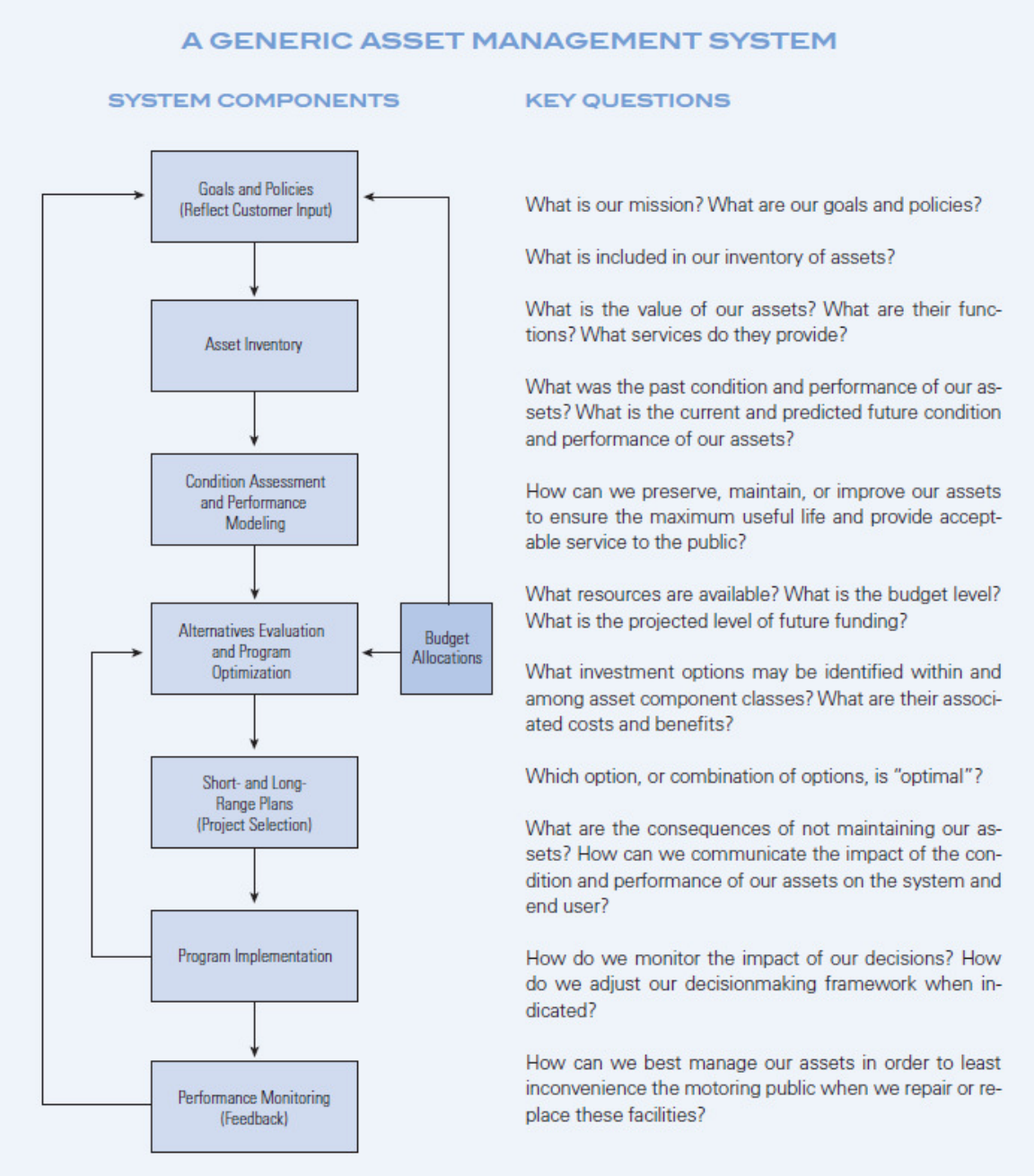

Figure 1.1 Generic asset management components (FHWA 2007)

This study addresses TAM implementation with a primary focus on three essential components of the implementation process: (i) the TAM plan and other guidance documents; (ii) the TAM governing structure and actors; and (iii) methods for

incorporating TAM into decision-making processes. This defined scope emerged based on the frequency of questions on these components of TAM implementation, at various industry conferences and other forums, from transportation professionals involved in the process of TAM implementation in their respective agencies.

1.1.1 Benefits of TAM

There are several benefits to applying TAM principles in agencies although, generally, the most important ones are only realized in the long-term. One of the primary benefits of TAM is the ability to devise well-informed, rational, data-driven, investment and resource allocation decisions (Haas and Hensing 2005; Kraus 2004). Especially in light of the ongoing transportation funding crisis, it is important to be able to justify investment decisions, applying an unprecedented level of transparency and agency accountability particularly for external stakeholders like the general public. TAM also provides the ability to understand the implications of different investment strategies based on the modeling and forecasting tools that are a central component (Kraus 2004; Mizusawa and McNeil 2009).

The management systems that support TAM programs enable an agency to determine how available funding can be allocated to the necessary investments or, on the other hand, to assess the funding needed to maintain a certain minimum level of performance. Where TAM programs incorporate different assets in integrated systems, trade-off analyses between investments in asset classes can be used to determine the most appropriate, and effective action at a given time resulting in increased agency efficiency and effectiveness (Haas and Hensing 2005; Mizusawa and McNeil 2009).

In the long run, TAM implemented and used correctly can lead to appropriate maintenance and management of infrastructure which improves asset performance over time while simultaneously reducing financial expenditure (Haas and Hensing 2005; Mizusawa and McNeil 2009). Overall, "more timely decisions and other efficiency improvements combine to reduce the costs of acquisition, maintenance, upgrade, and replacement of assets" (Haas and Hensing 2005 p. 3).

While these benefits are clear, it has been argued that "upper-level managers are interested in benefits that can be translated into monetary values" (Mizusawa and McNeil 2009 p. 232) indicating the importance of data that shows the quantitative benefits of TAM. There are challenges associated with quantifying the benefits of TAM and even the Federal Highway Administration (FHWA) admits limited data on the economic benefits (FHWA 2015). Nonetheless, international and other industry experiences show that TAM is an effective solution to the challenges of inadequate financial resources and the need for increases in funding to address infrastructure deterioration, as is evident in the incorporation of a related mandate in MAP-21.

1.2 Motivation

MAP-21 formally introduced a significant shift in the way business has been done in the transportation industry since the beginning of road building. As previously stated, the legislation mandates the use of performance-based planning and decision making in working towards specific national goals. It requires that transportation agencies develop and implement risk-based asset management programs as a tool for improving the performance of the transportation system. Although seemingly progressive, MAP-21 has been described as a five-year plan with only two-years of funding, raising concerns about

the sustainability of performance-based principles in the transportation industry, beyond the lifetime of the legislation.

In order for the long-term TAM program benefits to be realized, implementation must be handled carefully to ensure that the programs are effectively applied to accomplish the goals they are established to meet. While formal, federal, legislative mandates can be useful in ensuring the effectiveness of TAM implementation, a historical policy analysis of asset management principles in federal transportation legislation, and a study of institutional theories from the field of organizational theory and public policy (DiMaggio and Powell 1983; Edelman 1992; Meyer and Rowan 1977; Westphal et al. 1997) reveal a number of risks associated with legislative mandates of this nature. The motivation for this research is the risk of performance-based TAM becoming institutionalized as a legitimacy tool instead of serving its purpose as an innovative tool to increase efficiency and effectiveness and to improve infrastructure performance. Without careful implementation, state DOTs can start to view TAM as another tedious requirement to meet in order to remain in compliance with the law, increasing the risk of a short-lived existence of TAM programs. The federal mandate for TAM introduces a public policy perspective which brings in a unique set of challenges that have not been considered in the context of TAM or even in strategic program implementation in the transportation industry as a whole. This research addresses the concept of TAM program sustainment by examining the implementation of TAM programs in state DOTs, with a particular focus on those elements that are critical to program sustainment in the long term.

1.3 Objective

While MAP-21 encourages the relatively rapid adoption of TAM principles, care must be taken to ensure that TAM practices are implemented effectively and sustained in the long-term. A clear distinction must be made here between the effectiveness (or success) of TAM implementation and the effectiveness (or success) of TAM practices. Implementation has been defined as "a specified set of [actions] designed to put into practice an activity or program of known dimensions" (Fixsen et al. 2005). This means that implementing TAM refers to the process of putting the necessary components (plans, people, management systems, etc.) in place to make the application of TAM principles in agency decisions possible (i.e. to make "doing" TAM possible). In contrast, "doing" TAM (the application of TAM principles) refers to the process of applying engineering and economic factors to information gathered on asset performance, financial resources, etc. to inform decisions to systematically maintain infrastructure assets at a minimum condition over their lifecycle. While these are not entirely separate processes at all times, the primary focus of implementation is to put in place the necessary resources (technical, organizational, etc.) to make doing TAM on a routine basis possible. Proctor et al. (2011) suggest that implementation effectiveness, or implementation success is a necessary precondition for realizing the expected benefits of a program or policy. In other words, effective implementation is a prerequisite for positive program outcomes.

Proctor's ideas of this relationship between implementation effectiveness and program effectiveness inform the illustration in Figure 1.2 which defines four regions in which the outcomes of an implementation effort can fall, labeled A through D. Region A is where a program's greatest benefits are realized, when the program itself is effective,

and implementation is successful. In change management literature, Parry et al. (2014) support this idea, suggesting that the best outcome of a change effort is where the intended benefits of the effort are realized (implementation is successful) while improving business performance (positive outcomes are realized). In region B, the program is deployed as expected but is not effective in resolving the problem it was meant to address, which could indicate that the program is not fully appropriate for the setting or problem.

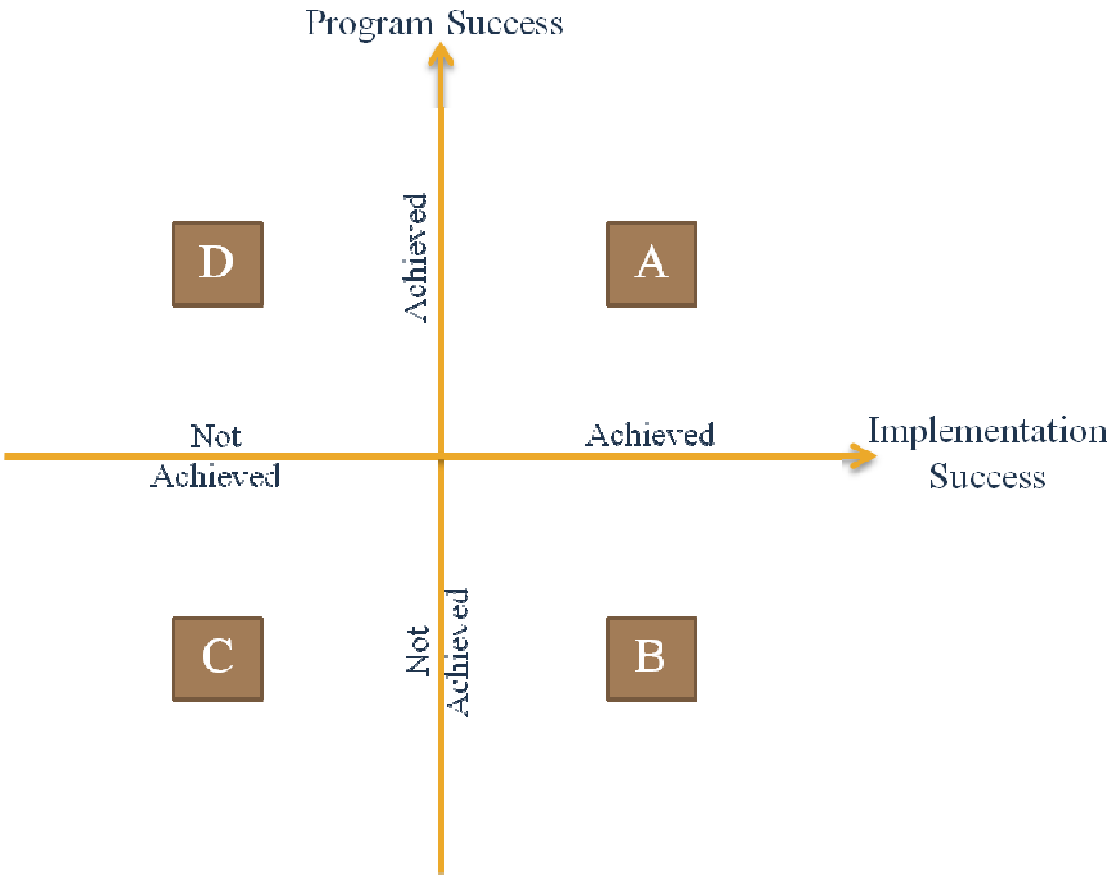

Figure 1.2 Illustration of a Conceptual Relationship between Program and Implementation Success

There are at least two possibilities for the program failure occurring in region C: either the wrong program is deployed incorrectly or the right program is deployed incorrectly leading to a failure to achieve program success. And finally, in region D, the program achieves success although implementation does not proceed as expected - this arguably rare instance could occur as a result of a number of factors such as an implementer's rescue efforts to address areas of implementation failure. While this conceptual relationship requires empirical testing, this work assumes that the outcome of TAM implementation in state DOTs can only fall in regions A, C (where the right program is deployed incorrectly), or D because the effectiveness or benefits of TAM programs are not under investigation. The history of TAM development and its organic evolution through the years have informed (and ultimately, strengthened) existing TAM programs and the MAP-21 requirements; therefore, it is assumed that the current design of TAM programs and the policy that supports them will achieve the desired benefits. While this may be arguable in practice, for this study, this assumption is made to introduce appropriate constraints and a scope for the research to support program sustainment. With this assumption, the chances of achieving the benefits of TAM are higher if programs are implemented successfully.

Based on the understanding that the most important benefit of TAM (improved infrastructure condition) is a long-term benefit, implementation effectiveness or success in this dissertation refers to the ability of the TAM program to be sustained because that is where the greatest benefit will be realized. This ability of a program to be sustained is captured in the implementation research outcome known as sustainment. Sustainment, also referred to as sustainability or longevity, is the extent to which an innovation is

maintained within stable operations of an organization, attaining long-term viability after the initial activity around implementation and programming has reached a steady state (Proctor et al. 2011). Sustainment can also be defined as the degree to which the intended benefits of a program are delivered over an extended period of time after external implementation support diminishes or is withdrawn (Rabin et al. 2008), or a measure of how the program at a single point in time reflects what it was initially intended to look like (Wiltsey Stirman et al. 2012).

The objective of this research study is to develop a conceptual framework and approach to guide a review of an agency's TAM implementation practices to identify opportunities for enhancing implementation towards long-term program sustainment and institutionalization. Similar to sustainment, the implementation outcome of institutionalization is also common in the multi-disciplinary field of implementation research, although different terms are sometimes used. Institutionalization, also referred to as penetration or reach, is a measure of the integration of a program within the service setting and within the culture of an organization (Glasgow 2007; Proctor et al. 2011; Rabin et al. 2008). Sustainment and institutionalization may actually be related conceptually because higher institutionalization can contribute to long-term sustainment; Rabin et al. (2008) actually define institutionalization as an operational indicator of sustainability, although Proctor et al. (2011) suggest that the specific relationships require further empirical testing. Finding clarity on that relationship is outside the scope of this work; however, this study focuses on sustainment with the assumption that it encompasses institutionalization.

While risk- and performance-based TAM implementation involves several elements, the scope of this study is limited to the TAM plan and other guidance documents, the governing structure and actors, and methods for incorporating TAM into decision-making processes related mainly to highway infrastructure. These three topics are areas with prominent knowledge gaps and little to no peer-reviewed literature as evident in general forums on TAM implementation where questions continue to be raised.

1.4 Methodology

This work falls in the continuum between quantitative and qualitative research, leaning more towards a qualitative approach. The lack of studies or published literature on implementing programs like TAM in state DOTs with an emphasis on program sustainment adds to the vagueness and nonexistence of a guiding framework for this study. This led to the need for an exploratory research design. While exploratory research design typically involves a qualitative phase followed by a quantitative phase (Creswell and Plano Clark 2007), the nascent nature of TAM program implementation and the concept of sustainment would not allow for a meaningful quantitative data collection process, resulting in the use of a more qualitative second phase. Thus, this research is heavily qualitative and includes very little quantitative data.

In qualitative research, more emphasis is placed on the contributions, opinions and perspectives of study participants, which reflects the idea of exploring the non-quantitative aspects of TAM implementation from an organizational perspective, that is, the people, strategies, and organizational and programmatic structures involved, instead of the analytical and technical tools. Qualitative research involves questions and

procedures that emerge as opposed to a pre-defined structure, strategies of inquiry such as case studies, and narrative research (Creswell 2009). This research methodology has characteristics that include the researcher as the key data collection instrument (instead of an inanimate object), data gathering from multiple sources but with some selectivity in determining subjects (or sites) and participants, and methods that include observations, interviews, document reviews, and the use of audio-visual materials usually guided by some protocol (Creswell 2009). Data analysis is inductive, involving data coding, identification of themes, or drawing patterns and generalizations, possibly guided by the use of a theoretical lens or perspective (Creswell 2009).

Figure 1.3 shows an illustration of the overall research design and the methodology used to address the stated objective, while Figure 1.4 shows the steps involved. As shown in Figure 1.4, the work involved two phases punctuated by the development of the framework for enhancing TAM implementation for program sustainment. In the first phase, a taxonomy for the approach was established based on an exploratory review of the literature on the following topics that formed the foundation of the approach: TAM implementation, policy and program implementation research, and change management. In the second step of phase one, a panel of TAM experts were consulted for their thoughts on factors or criteria their experience has shown to be important for successful TAM implementation, particularly for program sustainment. This TAM Implementation Expert Panel contributed to the refinement of the taxonomy first developed from a synthesis of the literature review findings, which eventually led to the development of the TAM Implementation Review Framework (TIRF).

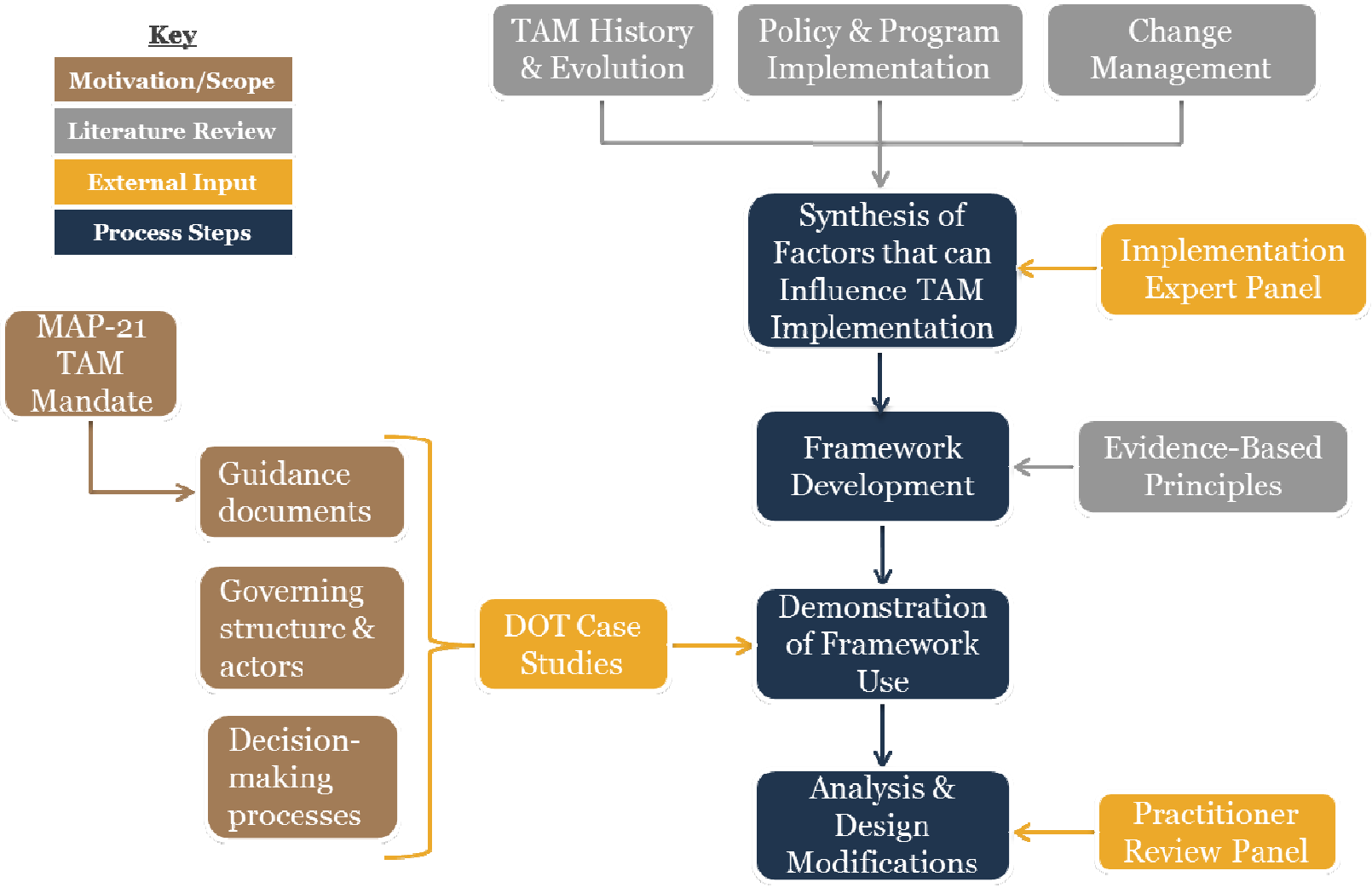

Figure 1.3 Overall Research Design

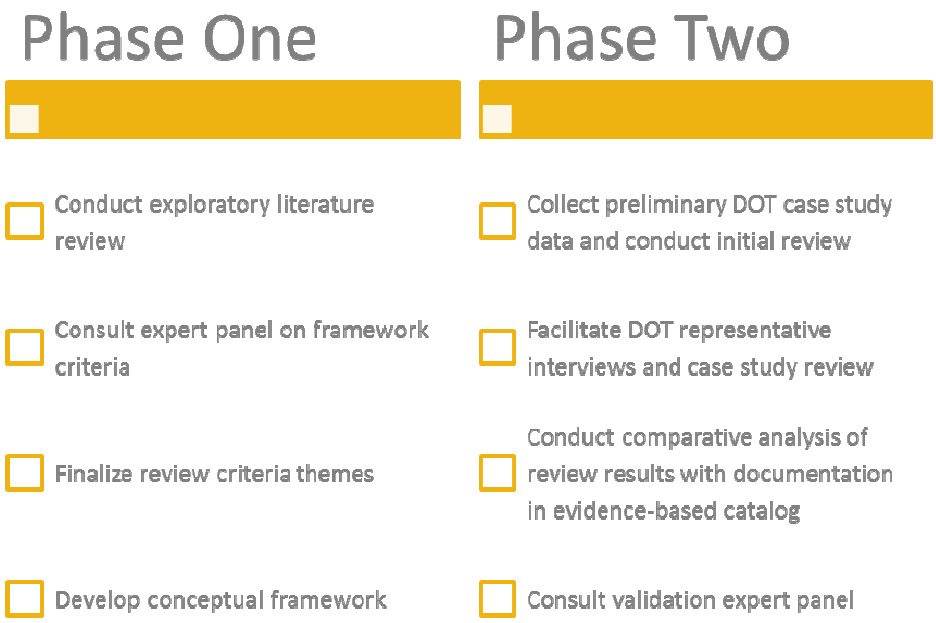

Figure 1.4 Steps Involved in the Methodology

The TIRF was tested in the second phase of the research and its applicability and usefulness in agencies were demonstrated using qualitative case studies from three DOTs at various levels of TAM program maturity. The case study and review results were validated by representatives of each agency, who also provided their general thoughts on the use of the review approach. The final steps of this study involved the use of evidence-based concepts to compile findings for a comparative analysis, and a second panel of practitioners to assess the applicability and usefulness of the review approach and the overall validity of the framework. Altogether, this work applied triangulation, member checking and external auditing as qualitative validation strategies. Triangulation of data in qualitative or mixed methods research involved data collection from several sources or several individuals to find convergence to confirm the findings. Similarly, member checking is a frequently used qualitative data validation approach where the

researcher provides summarized findings back to key participants to determine if the findings accurately reflect their experiences. In external auditing, individuals outside the research study are brought in to examine the study and its findings to provide a review and feedback on validity.

1.5 Organization of the Dissertation

This dissertation is organized into seven chapters. Chapter 2 presents the findings from the exploratory literature review, culminating in a discussion on the factors that influence TAM implementation especially where program sustainment is concerned. Chapter 3 presents a description of the review framework development including a summary of the implementation expert panel. In Chapter 4 the case study applications of the review approach are presented and the final design is presented in Chapter 5. A discussion of the major findings of this research study is offered in Chapter 6, and Chapter 7 concludes the dissertation with a summary of the work and discussion of the contributions and potential applications as well as possible future work.

CHAPTER 2: LITERATURE REVIEW

The exploratory literature review began with a detailed look at the evolution of TAM and its existence in transportation policy throughout the history of federal legislative participation in transportation. This process concluded with an understanding of the established standards for TAM implementation with particular focus on the components of guidance documents, governing structure and decision-making processes. In reviewing this literature, it became clear that TAM implementation has faced a number of challenges particularly when local or federal policy elements have been included. This created an interest in exploring the policy and program implementation research body of knowledge to uncover policy-related theories that could inform strategies for implementing a program like TAM for enhanced sustainment. Insights from policy and program implementation theories, and research and evaluation methods provided a context for the framing of this TAM implementation study in the policy space.

While much of the TAM implementation literature referred to the process as one of organizational change, policy and program implementation literature also highlighted the importance of considering implementation processes from the perspective of the organization. This pointed to the need to explore change management literature to identify drivers and factors that can lead to success and sustainment in program implementation. Change management definitions and models were explored in an effort to build an understanding of what it means to view TAM implementation as a process of change. The synthesis of findings from these three bodies of knowledge revealed a number of implementation factors that can influence TAM implementation success and

program sustainment. These factors formed the foundation for developing the conceptual framework and approach for enhancing TAM implementation for sustained programs. The exploratory literature review is summarized in Figure 2.1, illustrating the unprecedented intersections of the three bodies of knowledge that this work is grounded in.

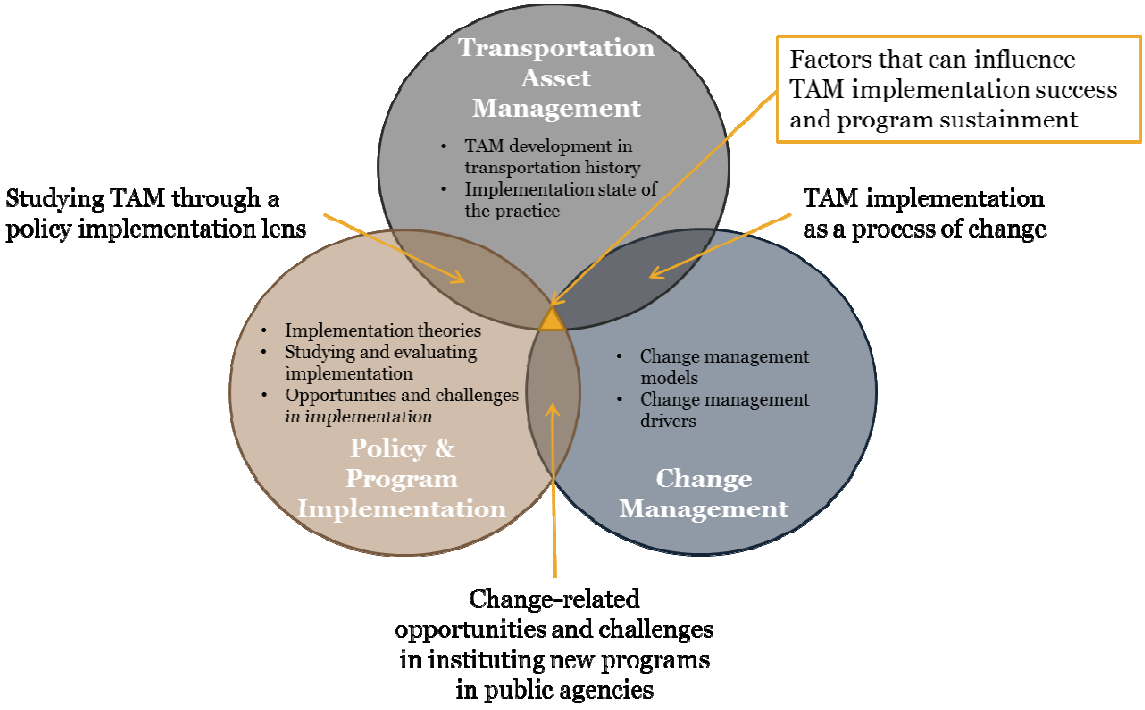

Figure 2.1 Exploratory Literature Map

2.1 TAM Development & Transportation Policy

The concept of strategic infrastructure maintenance was first raised in transportation legislation in a 1981 New Jersey law where the state provided funding for county road improvements requiring townships to "adopt a systematic plan for improving

the highways" (FHWA 1977; Weingroff 1996a). This legislation inspired a number of developments in state and federal actions in transportation, including the formation of a federal office (in 1893) dedicated to issues related to road transportation, which would eventually lead the first national road inventory in 1904 (FHWA 1977).

From the first Federal Aid Road Act in 1916 until the late 20th century, federal transportation policies were primarily focused on road building, authorizing funding to States according to an apportionment formula based on total state area, population and road mileage (Weingroff 1996a). During these years, the government allowed states to set their own standards of condition and performance through the American Association of State Highway Officials (AASHO) which was formed in 1914 (FHWA 1977; Weingroff 1996a). As highway construction continued to grow, especially in light of the Federal-Aid Highway Act of 1956 which introduced the National System of Interstate and Defense Highways, the condition of older roads began to fall to unacceptable levels. This increased the need for innovative ways to manage and maintain transportation infrastructure.

2.1.1 Pavement and Bridge Management

Towards the end of 1956, AASHO with sponsorship from the Highway Research Board (HRB) conducted a series of tests to study the factors that influence pavement and bridge performance (FHWA, 1977). The test results showed the importance of certain variables (like structural design) in pavement condition, leading to the development of a method to predict pavement performance from deflection and strain measurements (FHWA 1977, 2011a). The models developed based on these tests were able to link

pavement serviceability to distress data, one of the first elements of pavement management systems (PMS).

A PMS is defined in the American Association of State Highway and Transportation Officials (AASHTO) Pavement Management Guide as "a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time" (AASHTO 2001 p. 9). Pavement management increased in popularity over the years and, in many states, without any formal requirement to have a PMS. Throughout the 1970s and 1980s, workshops, research and experimentation encouraged more interest in PMS; however, there was cynicism due to a natural resistance to change, doubts about the reliability of prediction models, cost and time factors and the need for uniquely trained staff, among others (Finn 1998). Nonetheless, there was also increasing support for pavement management from organizations such as the Transportation Research Board (TRB), AASHTO, the World Bank, the National Highway Institute (NHI) and the American Society of Civil Engineers (ASCE) through published work or sponsored conferences (Finn 1998).

While pavement management was growing in the transportation industry, there was less emphasis on safety inspections and maintenance of bridges throughout the country (Ryan et al. 2006). This all changed in December 1967, when a two-lane, 1760-foot bridge across the Ohio River between West Virginia and Ohio, the Silver Bridge, collapsed during rush hour taking down 31 vehicles and killing 46 people (LeRose 2001). This infrastructure failure raised concerns about bridge condition and sparked a movement in bridge condition monitoring beginning almost immediately with the

Federal-Aid Highway Act of 1968 which created the first national bridge inspection program in U.S. history (Markow and Hyman 2009; Ryan et al. 2006; U.S. Congress 1968). This legislation mandated National Bridge Inspection Standards (NBIS) to set "national standards for the proper safety inspection and evaluation of all highway bridges" (FHWA 2013a), establishing a standard method of bridge data collection. The re-authorization of this legislation in 1970 went one step further, providing funding for bridge replacement based on priorities established by the Secretary of Transportation (USGAO 1975). This period marked the beginning of bridge management systems (BMS); however, a major concern was the lack of funding available for bridge and infrastructure repair and replacement.

During the twenty-year highway construction period from 1956 to the late 1970s, advances in PMSs and BMSs began to change the focus of the transportation industry from construction to maintenance, rehabilitation and repair (MR&R). While BMSs grew out of the 1968 legislation, the growth of pavement management and PMSs is noteworthy because there was no legislation or formal requirement and therefore no financial support (Schrag Lauver 1985). Between the 1970s and 1980s, federal reauthorizations allocated funding specifically for resurfacing and rehabilitating the Interstate System, and for bridge repairs (Civic Impulse n.d.). In particular, the Federal-Aid Highway Act of 1976 established the Interstate 3R (I-3R) Program, providing funding for resurfacing, restoration, and rehabilitation of non-toll segments of the Interstate Highway System (FHWA n.d.; Weingroff 1996b), while the Surface Transportation Assistance Act of 1978 authorized funding for the maintenance of public bridges with a span of over 20 feet (Ryan et al. 2006).

Over the years, federal legislation continued to expand and encourage pavement and bridge infrastructure maintenance as the federal share for these activities increased. Standards to extend highway service life, and minimum guidelines for the maintenance of the federal-aid highways were established in the Surface Transportation Assistance Act of 1982 (U.S. Congress 1983), and the Surface Transportation and Uniform Relocation Assistance Act of 1987 (U.S. Congress 1987), respectively. Nonetheless, it was not until the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 that pavement and bridge management systems became formal programs as part of federal legislation.

2.1.2 From Infrastructure Construction to Preservation

ISTEA broke significant new ground with explicit final funding authorizations for the construction of the highway system, in an effort to shift focus from expansion of the highway system to maintenance and preservation (Schweppe 2001). While previous legislation had introduced indicators for evaluating bridge condition, ISTEA identified pavement condition indicators for evaluating requests for maintenance funds and required states to implement a PMS within two years. State agencies were also required to implement five other management systems for bridges, highway safety, traffic congestion, public transportation facilities and equipment, and intermodal transportation facilities and systems (Lindquist 1999; Nemmers 1997; U.S. Congress 1991). Following the trend of BMSs and PMSs which were in use before this legislation, the goal of these management systems was to help states make investment decisions driven primarily by technical information as opposed to politics (Schweppe 2001). According to a 1997 National Cooperative Highway Research Program (NCHRP) survey, these management systems, and ISTEA in general, succeeded in instigating a “more dynamic decision-

making environment" (Markow and Hyman 2009 p. 25) illustrated by increased interest in performance and accountability measures and emphasis on system preservation, among other factors.

According to a 10-year review of this "landmark legislation", ISTEA drove organizational restructuring in transportation agencies by introducing programs like the Interstate Maintenance program, which established funding for maintenance projects on components of existing Interstate routes (U.S. Congress 1991). Even with this new programming specifically for maintenance and preservation, the policy lacked a clear national goal to direct investment decisions, and in the words of Shoup and Lang, "gave states and regions virtual carte blanche for use of the money" (Shoup and Lang 2011 p. 22). ISTEA also faced opposition from state governments because the management system mandate was unfunded and was not well aligned with systems that existed before 1991, which introduced the need to overhaul existing systems with the newly required ones (Schweppe 2001). At the same time, the specific guidelines which would translate a seemingly ambiguous legislation into specific rules were slow to be released, due to unfamiliarity and inexperience with the concept of asset management even among the federal staff writing the regulations (Lindquist 1999). In addition, many states complained that the mandate was too rigid to allow for customization - without this flexibility, states were faced with issues related to data collection requirements, organizational capacity in terms of employee expertise, and even issues related to their organizational structure (Lindquist 1999).

After about four years, the mandates for these six management systems were removed with the National Highway System Designation Act (NHSDA) in 1995

(Lindquist 1999; Markow and Hyman 2009; U.S. Congress 1995); however many states continued to use the systems they had developed and implemented (Markow and Hyman 2009; Ryan et al. 2006). An NCHRP survey found that even after BMSs and PMSs were made voluntary, 55 to 75 percent of agencies still used them to develop goals for desired system condition or service levels and for project prioritization, while 15 to 45 percent used them to establish funding levels (Markow and Hyman 2009). In removing the mandates for these management systems, the 1995 NHSDA legislation still maintained some aspect of the management system concept, by specifying that preventative maintenance would be eligible for federal assistance if the activity was shown to be a cost-effective means of preserving a federal-aid highway and extending its useful life (U.S. Congress 1995). Some reports have claimed that while ISTEA presented a timely shift in focus for the U.S. transportation system, it was considerably underfunded (Kassoff 1998).

2.1.3 Asset and Performance Management

ISTEA has been characterized as a milestone legislation due to the initial shift it provided towards a transition to a performance-based transportation industry. In 1993, further encouragement was provided in this direction through the Government Performance and Results Act (GPRA) which introduced requirements for performance plans and reports (U.S. Congress 1993). These requirements and many similar to this before 1995 were mainly driven by a desire to address demands for accountability in the government. Until this period, performance measures had been introduced haphazardly, to address specific concerns mainly related to infrastructure preservation like the

measures introduced in the NBIS (Amekudzi et al. 2012; Bremmer et al. 2005; Reed et al. 1993).

While ISTEA required states to implement six separate management systems, asset management as a concept had already been very successful in private industry, which interested some transportation professionals (Nemmers 1997). In 1996, the FHWA and AASHTO jointly sponsored the first Executive Seminar to explore asset management and its applications in the transportation industry - the 1st National Conference on Asset Management (Cambridge Systematics et al. 2002; Nemmers 1997). Following the discussions held at this meeting, AASHTO created a Task Force on TAM that developed a 10-year Strategic Plan, outlining goals, strategies and tasks needed for effective implementation of TAM (Cambridge Systematics et al. 2002).

In 1997, surface transportation legislation was reauthorized in the Transportation Equity Act of the 21st Century (TEA-21) which kept and extended all the major concepts and programs from ISTEA, providing funding at about a 40 percent increase, for the first time matching the financial need estimated to address the transportation system's declining service levels (Kassoff 1998). In particular, TEA-21 maintained the voluntary status of management system development instituted by the 1995 NHSDA but provided funding to support states in these efforts, if they chose to continue with establishing management systems. TEA-21 introduced additional requirements for an infrastructure investment needs report to estimate future highway and bridge needs, and a recommendation for life-cycle cost analyses (FHWA 2011b), which are both components of asset management programs. The new law further supported the general shift towards performance management encouraging a process that incorporated performance measures

that addressed an agency's strategic goal areas. The results of a Washington State DOT survey informed the characterization of this time period from 1995 to 2000 as the second generation of performance management with measures linked to strategic goals and business plans but often very complex and difficult to communicate (Amekudzi et al. 2012; Bremmer et al. 2005; Cambridge Systematics et al. 2010).

After TEA-21 was enacted, a one-year anniversary study showed improvements in bridge and pavement condition, specifically, as more funding was made available to the states (FHWA 2011b). From this report, the percentage of deficient bridges on the National Highway System had declined by 2.6 percentage points, the percentage of deficient bridges on all roads had declined by 2.9 percentage points, and pavement smoothness on the National Highway System had increased with the percentage with acceptable ride quality increasing by 1.2 percentage points. In 1999, the FHWA created an Office of Asset Management to provide leadership in the emerging field and to serve as an advocate and resource for TAM (Bloom 1999; Cambridge Systematics et al. 2002). By the end of that year, they released an Asset Management Primer (FHWA 1999) establishing a formal and clear definition of TAM.

Throughout the 2000s, TAM continued to grow fueled by the recurring National Conferences on TAM and other activities such as an NCHRP project to develop an Asset Management Guide (Cambridge Systematics et al. 2002), several research and implementation projects like the domestic and international scans on TAM (Cambridge Systematics and Meyer 2007; Geiger et al. 2005), and some continuing higher education courses. In the same vein, performance measurement in state DOTs continued to evolve in the industry with increased interest from the major players. A national survey

conducted by Washington State DOT determined that by 2003, a third generation of performance-based practices had emerged (Cambridge Systematics et al. 2010). During these years a more holistic approach to this performance management concept began to surface building on previous performance measurement practices (Amekudzi et al. 2012).

The Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU) was passed in 2005, refining the programs introduced in previous legislation, and expanding their scope to include systematic, preventative maintenance (Civic Impulse n.d.; FHWA n.d.; Shoup and Lang 2011). Although performance was becoming more important for investment decisions, SAFETEA-LU continued the use of funding formulas. A Government Accounting Office (GAO) analysis in 2008 revealed that these funding formulas had only an indirect relationship to real funding needs, and in many cases, no relationship to performance or outcomes (Shoup and Lang 2011). In 2009, as SAFETEA-LU was set to expire, the American Society of Civil Engineers (ASCE) released an infrastructure report card estimating a $3.6 trillion shortfall on infrastructure spending (ASCE 2013). The report card contributed to an increased awareness of the country's deteriorating infrastructure and the significant financial investment needed to solve the problem.

Over time, the importance of performance measures and performance management, and the practice of asset management became increasingly evident throughout the industry. Amekudzi et al. (2012) proposed a post-2007 emerging era (or a fourth generation) of performance measurement/management, driven by the need to make performance-based decisions, based on the results of a Georgia DOT survey conducted from 2009-2010. Ultimately, the transportation industry has welcomed performance

management as a concept much broader than performance measurement and asset management, incorporating the linking of the latter practices to more general strategic management. The growth of asset and performance management in the industry has been endorsed by the government, first through the introduction of an Office of Transportation Performance Management in the FHWA (FHWA n.d.), followed by the passing of the 2012 federal surface transportation legislation, Moving Ahead for Progress in the 21st Century (MAP-21), which has a heavy focus on performance-based principles and processes.

2.1.4 State of the Practice/Existing Standards

From the beginning of federal government involvement in transportation planning and operations, infrastructure maintenance and management has existed in some form, whether formally or informally. The first official workshop on asset management in 1996 is arguably the beginning of the formalization of transportation asset management. Since then, a number of guiding documents have been drawn up with the goal of establishing an understanding of the concept and providing assistance to agencies who wish to incorporate TAM principles in their business practices. These include the AASHTO 10-year Strategic Plan for TAM, the NCHRP domestic and international scans on TAM, and the FHWA Asset Management Primer. Over the years, the state of TAM practice has come to be particularly informed by the two volumes of the AASHTO TAM Guides, and more recently by MAP-21. This section discusses the standards presented in these three resources and the implementation processes or frameworks they recommend.

2.1.4.1 AASHTO TAM Guide Volume I

In 2002, AASHTO released a Transportation Asset Management Guide designed to assist transportation agencies in adopting the concept of systematically managing their physical transportation infrastructure for improved performance. This first TAM Guide has a significant emphasis on explaining asset management and identifying the concepts and elements that constitute TAM in an agency. In addition, it presents some guidance on strategies for implementing TAM, albeit with relatively limited detail. A resource allocation and utilization process in asset management is defined to include the following elements: (i) identifying policy goals, objectives and performance measures; (ii) planning and programming with alternative tradeoff analyses; (iii) program delivery; and (iv) systems monitoring and performance results. The guide proposes strategies for building the foundation of asset management in an agency with the discussion of these concepts that ultimately contribute to the agency's plan for asset management. In each of the four areas, the guide describes where TAM principles can be applied in existing agency processes. While there is little emphasis on a strategy for making the transition to incorporate TAM principles in these processes, there are some general recommendations that can be useful.

One of the first ideas presented is the use of an agency's existing resources – the people, tools and data that already exists. Very often, TAM is viewed as a daunting task requiring significant investments; however, the guide suggests beginning with the existing resources and then conducting a self-assessment to investigate where the need for additional investment is. The recommended self-assessment process is very specifically explained in the guide even down to the questions to consider, with the

objectives of enhancing agency-wide understanding of the status of TAM, assessing agency asset management readiness, and identifying the agency's priority areas for management. This diagnostic tool is very useful for providing the agency with a foundation for beginning the asset management process.

In establishing a foundation for practicing TAM, the guide presents recommendations for developing an asset management business approach which includes defining the scope, establishing roles and responsibilities and developing an implementation strategy and plan. Defining the scope means identifying which assets will be included, which actions (preservation, capital improvement, etc.) and business processes (planning, budgeting, etc.) will be included, and which asset management concepts will be emphasized. In establishing roles, the TAM Guide I recommends assigning the lead responsibility for asset management to one person to allow for continuity and clear accountability. This lead role can then be supported by cross-disciplinary teams such as an executive steering committee to guide and oversee program development, a technical committee of experts in IT and in the major asset classes included, and individual "owners" of each implementation task or activity who will be responsible for ensuring that the activity is completed. The final step in setting the foundation for TAM as recommended by this guide is building the implementation/action plan which requires identifying areas of improvement (based on the self-assessment), formulating the necessary tasks to close the gaps, defining a timeframe for each task, and documenting the findings in an implementation plan. An example provided for illustrative purposes is shown in Figure 2.2.

An important element of TAM implementation discussed in this guide is the development of a data strategy and data improvement model to support asset management. While data plays an important role in supporting the asset management processes, many agencies view data itself as an asset to be included in TAM processes (Akofio-Sowah et al. 2014). TAM cannot exist without the presence of good data. The data improvement model recommended centers on improving asset inventories and condition data, data quality, data integration and agency-wide data accessibility.

Objective	Activity	Intended Benefits	Timing
1. ESTABLISH ASSET MANAGEMENT OWNERSHIP	1.1 Assign lead for asset management coordination	• Clear accountability for asset management • Ensure that activities that are related to each one another are performed in a logical sequence	Near Term
	1.2 Form asset management steering committee with representatives from across the agency	• Cross-disciplinary support • Coordination of asset management activities throughout agency	Near Term
2. CLEARLY DEFINE SCOPE OF ASSET MANAGEMENT	2.1 Define which assets and activities to be included (e.g., all capital and maintenance activities on state-owned pavements and bridges)	• Clear focus for the effort • An effort that is appropriately scaled	Near Term
	2.2 Agree on the types of investments (e.g., preservation, capital, operational, etc.) to be considered in the asset management plan	• Clear focus for the effort	Near Term
	2.3 Agree on common principles and approaches to be applied to infrastructure decisions (e.g., life-cycle investment strategies, program-level tradeoffs, asset valuation methods, etc.)	• Basic direction for both process and information systems initiatives	Near Term
3. IMPROVE PUBLIC AND INTERNAL UNDERSTANDING OF ASSET MANAGEMENT	3.1 Hold periodic departmental workshops to discuss asset management and its implications for department activities	• More informed and committed staff	Near to Mid Term
	3.2 Develop and distribute public information describing asset management and its importance	• Increased public awareness and support	Mid Term

Figure 2.2 Screenshot of Sample Implementation Plan provided in TAM Guide I (Cambridge Systematics 2002)

Another key insight provided in this guide is the example first steps for transitioning an agency to a TAM way of thinking. The entry mechanisms suggested in this guide include:

- Internal vision workshops to initiate discussion, build knowledge and promote TAM team-building
- TAM marketing package to educate employees and external stakeholders of the benefits of TAM
- Supporting legislative proposals to institutionalize TAM in state transportation agencies
- Project-level TAM prototypes
- Comprehensive TAM project or plan to review the full range of assets and document steps for TAM
- National Highway Institute (NHI) Training Course in TAM

While these are recommendations for an agency to get started in TAM, the guide also presents some ideas for maintaining TAM practice in the long term, briefly discussing change management principles with a particular emphasis on communication plans as a major tool for enhancing sustainment. Overall, Volume I of the AASHTO TAM Guide presents a useful, albeit general, foundation for agencies to begin thinking about TAM and the implementation of TAM programs. The guide addresses program sustainment briefly, discussing ideas of how to "look to the long-term" with TAM, but in an unstructured way.

2.1.4.2 AASHTO TAM Guide Volume II: A Focus on Implementation

The second AASHTO TAM Guide (also referred to as the TAM Implementation Guide) was released in January 2011 in an effort to move the thinking beyond the foundational nature of the first guide. This resource was developed to add to the first guide by providing guidelines to help agencies "enhance and integrate TAM thinking and culture within their organizations" (AASHTO, 2011, p. 1–5). With the view of implementation as a policy-driven process of continuous improvement, the guide details a recommended approach to TAM implementation centered on four main implementation steps: (i) set the direction; (ii) align the organization; (iii) develop the TAM plan; (iv) strengthen information systems and data. The structure of the guide follows 14 key management steps within these four broader categories as shown in Figure 2.3.

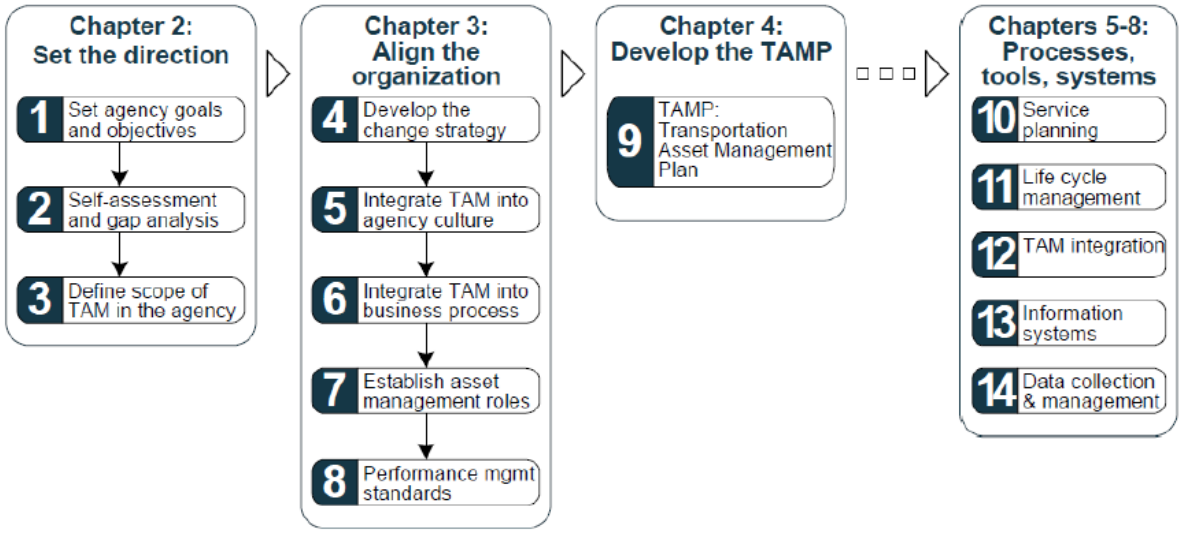

Figure 2.3 TAM Guide 2 Key Management Steps for Implementation (AASHTO 2011)

The first implementation task, setting the direction for TAM, draws from the foundation in the AASHTO TAM Guide I to meet some fundamental needs of TAM implementation. This step first involves setting goals and objectives to provide the agency with a sense of purpose and direction. This first task is an opportunity to link TAM to the agency's organizational planning, strategy, and policy, and is also an opportunity to improve communication between management and staff especially to obtain organizational commitment with respect to TAM. The TAM Implementation Guide provides a number of enterprise management frameworks to facilitate the goal setting process, which must be accompanied by performance measurement in order to be effective.

Once the direction for TAM in the agency is set, the next task is a self-assessment and a gap analysis. The self-assessment here is based on the tool described in the AASHTO TAM Guide I which gives the agency a high level picture of the current status of TAM. The Implementation Guide then introduces the gap analysis, which is meant to help agencies move "from a general action plan to hands-on implementation" (AASHTO 2011 pp. 2–25). The results of the gap analysis allow agencies to place themselves on an AASHTO TAM Maturity Scale (Table 2.1) that describes five levels of achievement, which then helps the agency determine what specific steps are necessary to move from one level of maturity to another. The self-assessment/gap-analysis task helps agencies identify strengths, weaknesses, constraints, and opportunities and identify critical areas and priorities to build a foundation for developing an improvement strategy for the TAM program.

Table 2.1 AASHTO TAM Maturity Scale (AASHTO 2011)

TAM Maturity Scale Level	Generalized Description
Initial	No effective support from strategy, processes, or tools. There can be lack of motivation to improve.
Awakening	Recognition of a need and basic data collection. There is often reliance on heroic effort of individuals.
Structured	Shared understanding, motivation, and coordination. Development of processes and tools.
Proficient	Expectations and accountability drawn from asset management strategy, processes, and tools.
Best Practice	Asset management strategies, processes, and tools are routinely evaluated and improved.

The final task in the first implementation step is to define the scope of TAM in the agency to be able to identify the boundaries of improvement actions. This involves answering questions of which assets, which decisions, and which business processes should be affected by TAM programming. In addition, it is important to also determine which asset management capabilities are feasible for the agency, and what data is necessary to achieve the goals.

The second implementation step in the framework presented by the AASHTO TAM Implementation Guide is aligning the organization which involves five specific tasks to ensure that the entire agency moves towards the direction established in the first step. The first task in this step is developing a change strategy that identifies what needs to be done and how it can be done. Here, the importance of change management in TAM implementation is emphasized with the understanding that TAM alignment requires leadership, communication, collaboration, and a constant awareness of the relationship between goals, policies and procedures. To that end, the guide describes the characteristics of successful change and change management towards transformational

change which "implies a greater intrusion into day-to-day activities and a significant shift in culture or behavior" (AASHTO, 2011, p. 3–3). After developing the change strategy, the next tasks are integrating TAM into agency culture and into business processes. Integrating TAM into agency culture requires continual, honest communication, efforts to gain buy-in throughout the agency, and monitoring progress and rewarding success. Similarly, integrating TAM into business processes refers to efforts to embed TAM into the agency's day-to-day practice by linking operational objectives on all levels and building mechanisms for formal and informal communication and review. Tasks seven and eight in the framework provided by this guide (Figure 2.3) are establishing TAM roles within the agency and establishing performance management standards. The guide recommends initial dependence on one person with teambuilding (managerial) skills which can lead into a mature team as the agency's TAM programming matures. Given that performance-based decision making is a core principle of TAM, the step of establishing performance management standards is useful to enable the agency to demonstrate progress towards achieving the goals and objectives established in the earlier steps. The guide recommends a performance management approach that can be applied across multiple asset categories, levels of operation, and stages of asset management.

The third implementation step, and task nine in the overall framework, is developing the asset management plan. According to the AASHTO Implementation Guide, the TAM plan should be viewed as a planning and communication tool that formalizes and documents key information on the TAM program. The process of developing the plan is cyclic with the expectation that the plan will be continuously updated and refined on a two- to four-year schedule. Furthermore, the plan can be

developed with a top-down approach (beginning with goals and objectives, based on existing data) or a bottom-up approach (beginning with data collection to improve the comprehensiveness of the plan). Either way, the AASHTO TAM Implementation Guide recommends that the plan includes information on levels of service (performance measures and metrics), life-cycle management (life-cycle and risk analyses), growth and demand information (forecasting models), a financial summary, a description of the current TAM practices, and an improvement or implementation plan.

The fourth and final implementation step is strengthening information systems and data by using processes and tools related to service planning, life-cycle management, and data collection and management. These final tasks seem to go toward improving a TAM program's maturity by considering the specific tools and processes that take asset management beyond data collection and monitoring towards actually making performance-based decisions. These processes include establishing performance measures and linking them to levels of service, forecasting growth and demand needs, risk assessment and management, selecting and prioritizing assets, and life-cycle analysis and modeling. Finally, the guide emphasizes the importance of TAM system integration and data management towards improvements in project evaluation and prioritization, trade-off analyses, resource allocation, budget integration, and program delivery. These final tasks are more specific steps in moving TAM implementation forward but are just as important as building the foundation. Generally, the TAM Implementation Guide refines and builds on the standards for implementing TAM established in the first volume towards improved and effective TAM programming.

2.1.4.3 MAP-21 TAM Legislation & Proposed Rules

In 2012, federal surface transportation legislation, MAP-21, introduced a momentous change in the way transportation authorizations were previously made by creating explicit, streamlined, performance-based and multimodal funding programs (FHWA n.d.). With respect to transportation infrastructure condition and performance in particular, MAP-21 presents three new components: (i) seven national goals that all agencies must work towards; (ii) a performance planning and reporting process to track progress towards those goals; and (iii) a risk-based asset management plan. Together, these additions to transportation legislation have the potential to improve infrastructure performance while increasing the effectiveness of investments in infrastructure performance.

Whereas previous legislation may have lacked direct and clear goals, MAP-21 specifies seven national surface transportation goals that agencies are to work towards, increasing accountability and transparency, and making way for more efficient investments and decision making through performance-based planning and programming (FHWA n.d.; Shoup and Lang 2011). The national goals are summarized in Table 2.2.

After enactment of the legislation, the U.S. Secretary of Transportation was required to establish performance measures aligned with the national goals, and all public transportation agencies (state and local) were given an allotted amount of time to determine targets for each performance measure which gives a quantifiable aim to work towards. MAP-21 requires a number of transportation plans to be developed by agencies with the intent to meet the targets set and the national goals.

Table 2.2 Seven National Goals Defined in MAP-21 (FHWA n.d.; U.S. Congress 2012)

National Goal Area	Description
Safety	To achieve a significant reduction in traffic fatalities and serious injuries on all public roads
Infrastructure Condition	To maintain the highway infrastructure asset system in a state of good repair
Congestion Reduction	To achieve a significant reduction in congestion on the NHS
System Reliability	To improve the efficiency of the surface transportation system
Freight Movement and Economic Vitality	To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development
Environmental Sustainability	To enhance the performance of the transportation system while protecting and enhancing the natural environment
Reduced Project Delivery Delays	To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices

These include the Metropolitan Transportation Plan, Statewide Transportation Plan, Strategic Highway Safety Plan, Congestion Mitigation and Air Quality (CMAQ) Performance Plan, State Freight Plan, Transportation Improvement Program and a Risk-Based Asset Management Plan. Together, these plans are to link investment priorities to system performance by describing how program and project selection will help states achieve their transportation performance goals and targets.

Performance monitoring, reporting, and feedback are critical elements of asset and performance management programs, demonstrating progress towards the program goals (AASHTO 2006; Cambridge Systematics and High Street Consulting Group 2010). MAP-21 also required the U.S. Department of Transportation (USDOT) to determine

criteria to evaluate the effectiveness of the performance-based planning process that states establish, based on a number of factors including the appropriateness of and progress towards their targets. The legislation detailed a timeline for states to report on their progress through the plans listed previously on an average of two to five years. Furthermore, the USDOT was required to submit a number of reports to the United States Congress within five years on the effectiveness of the performance-based planning process, illustrated in Figure 2.4.

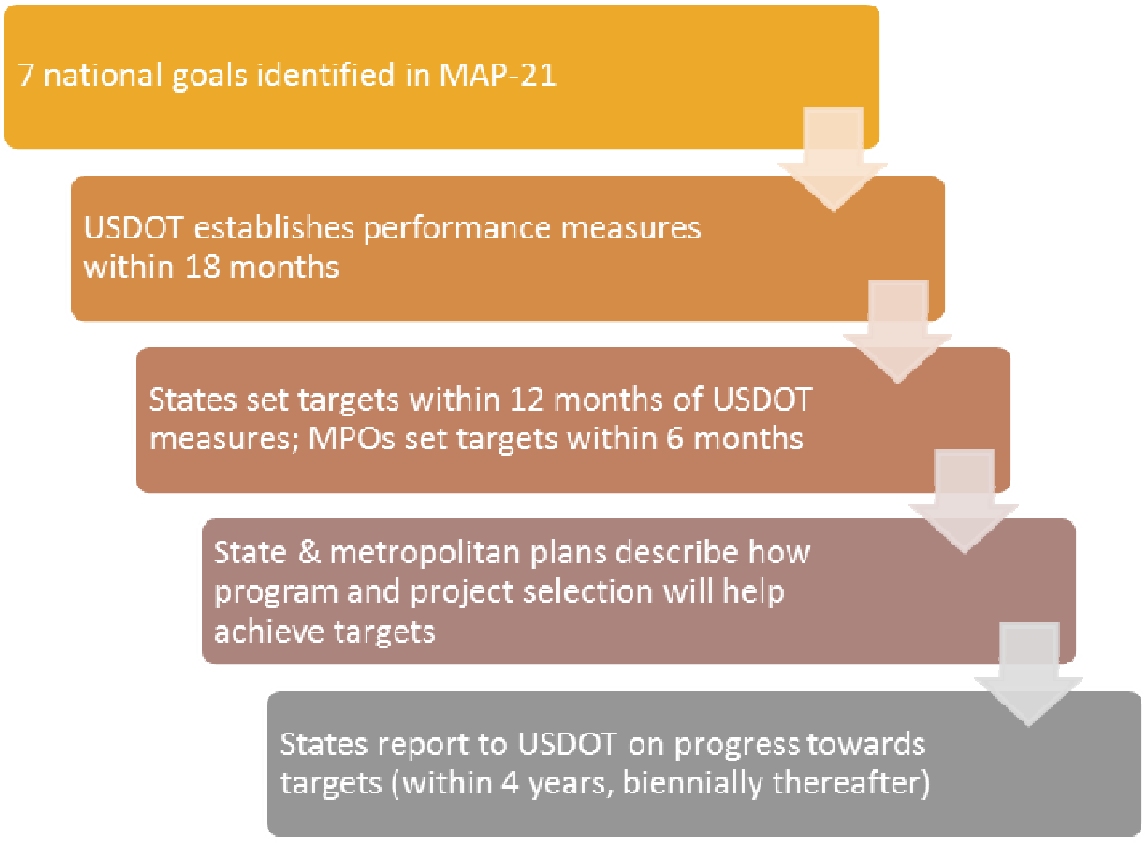

Figure 2.4 Performance-based planning process outlined in MAP-21

If a state or metropolitan planning organization (MPO) fails to develop a performance-based program, using asset management and performance measurement principles, according to the provisions in MAP-21, the consequences include a reduction in federal funding for transportation projects (Civic Impulse n.d.; FHWA n.d.).

MAP-21 is the first legislation to specifically mention and require the development of a risk- and performance-based asset management plan for all aspects of transportation, including public transportation and freight. With funding provided for implementing asset management programs, the requirements in MAP-21 are very clear, even down to the specific contents of a TAM plan. The plan is required to include "strategies leading to a program of projects that would make progress toward achievement of the State targets for asset condition and performance…and supporting the progress toward the achievement of the national goals" (U.S. Congress, 2012).

For the National Highway System, the legislation encourages states to include all assets within the right of way and to develop the plan in consultation with the USDOT. As specified in the law, these plans must include pavement and bridge inventory and condition data, objectives and measures, identified performance gaps, life-cycle cost and risk management analyses, a financial plan, and investment strategies. On its own, MAP-21 does not specify a process for implementing TAM in agencies beyond the development of an asset management plan; however, the proposed rulemaking issued by the FHWA provides more specific details, defining a framework for developing and implementing TAM plans.

The rulemaking serves five distinct purposes: (i) to establish a process for state DOTs to develop their risk-based TAM plans; (ii) to establish the minimum requirements

for the development of a TAM plan; (iii) to set minimum standards for states to use in developing and operating asset management systems; (iv) to describe penalties for failure to comply; and (v) to establish requirements for periodic evaluations to determine if reasonable alternatives exist for infrastructure that repeatedly requires maintenance (FHWA 2015). To develop the TAM plan, the proposed rule establishes a three-step process that includes defining processes to develop the required contents of the plan (gap analysis, life-cycle cost analysis, risk management analysis, financial plan, and investment strategies), using management systems to develop treatment recommendations, and obtaining approval from the head of the agency. The proposed rules provide general details on the expectations for each of these stages in the process without being fully prescriptive, presumably to allow for some flexibility. In addition, the proposed rule establishes a process to phase-in the development of the TAM plan (that is, phase in TAM implementation) particularly for those agencies that are much lower on the TAM program maturity scale to avoid facing the penalties associated with non-compliance in the allowable timeframes established in the original legislation. According to the rulemaking, the FHWA will certify each state DOT's TAM plan development process, before applying penalties if and when necessary.

One section of the proposed rulemaking describes how a state DOT can integrate TAM into its organizational culture, by establishing strategic goals with explanations of how TAM can assist in achieving the goals, and by conducting periodic self-assessments of the agency's TAM readiness with some emphasis on the implementation efforts. In general, the proposed rulemaking provides much detail to supplement the mandate established in MAP-21, and provides a clearer framework for implementing this policy.

2.1.5 Discussion

With transportation asset management now a formal part of the transportation planning and maintenance processes, there is a greater need for guidance on implementing and operating asset management programs and on making the necessary changes towards performance-based planning. The two AASHTO TAM Guides demonstrate the industry's growing interest and commitment to doing business more efficiently with asset and performance-based principles; in the same way, MAP-21 demonstrates policy-makers' commitment to better stewardship of resources especially where transportation assets are concerned – indeed there is some linkage between these two efforts. These resources provide useful guidance on asset management programs, and generally complement each other; however, there are some differences.

Ultimately, the AASHTO Guides are more useful than the federal legislation in terms of laying out steps for TAM implementation. MAP-21 places more emphasis on performance-based planning and decision-making with TAM required as a tool to help achieve the established goals. The legislation requires a risk- and performance-based asset management plan and infers its use in the planning process, but does not include a clear requirement for an actual asset management program or any detailed recommendations on how to implement and operate such a program. Here, the proposed rulemaking provides some recommendations that are seemingly pulled from the AASHTO TAM Guides. On the other hand, AASHTO's TAM Guide I provides an introduction to TAM and recommended steps for establishing a foundation for TAM in transportation agencies, and the TAM Implementation Guide builds on this foundation with a stronger focus on some actual implementation steps. These two guides

complement each other in discussions on determining where to start with TAM in the agency, determining the scope of TAM in agency practice, assigning roles and responsibilities for the governance of the TAM program, and considerations of TAM through a change management lens; however, they differ in their usefulness for incorporating TAM in an agency's business processes, especially where the sustainment of TAM programs is concerned. To establish the state of the practice and the standards that exist for TAM implementation, this discussion will focus on the three components of guidance documents, governing structure, and decision-making processes that define the scope of this work.

2.1.5.1 Guidance Documents: The TAM Plan

One key thing the existing resources have in common is stressing the importance of a plan to guide TAM development in the agency. In the TAM Guide I, the plan proposed is a basic action plan (Figure 2.2) that defines what needs to be done and by whom in building the asset management foundation. The plan is based on the results of the self-assessment, which identifies areas that need improvement, and defines the steps to take to make those improvements within a given timeframe. In contrast, the TAM Implementation Guide and MAP-21 propose a TAM plan that is more comprehensive and embeds the type of action plan found in the TAM Guide I. Even so, the TAM Implementation Guide and MAP-21 differ slightly in the proposed contents of their respective plans. On one hand, the TAM Implementation Guide recommends that the TAM plan should include information on levels of service (performance measures and metrics), life-cycle management (life-cycle and risk analyses), growth and demand information (forecasting models), a financial summary, a description of the current TAM

practices, and an improvement or implementation plan. On the other hand, MAP-21 requires that these plans must include pavement and bridge inventory and condition data, objectives and measures, performance gap identification, life-cycle cost and risk management analyses, a financial plan, and investment strategies. Ultimately, MAP-21 which was undoubtedly informed by TAM practices that existed prior to 2012 which includes the two guides. Between these three resources, there is ample information available to transportation agencies on how to develop a TAM plan towards implementing an asset management program in their agencies' business practices.

2.1.5.2 Governing Structure & Actors

Establishing the governing structure and responsibilities for implementing and operating a TAM program is an essential step in the process; however, less guidance is provided on this element compared to the TAM plan. While MAP-21 makes no recommendations or requirements for establishing roles and responsibilities, the two AASHTO guides present discussions and recommendations that are somewhat similar. The TAM Guide I recommends assigning the lead responsibility for asset management to one person to allow for continuity and clear accountability, supported by cross-disciplinary teams such as an executive steering committee to guide and oversee program development, a technical committee of experts in IT and in divisions with responsibility for the different asset classes, and individual "owners" of each implementation task or activity who will be responsible for ensuring that the task/activity is completed. Similarly, the TAM Implementation Guide recommends initial dependence on one person with a background in engineering, economics, or planning, but most importantly with teambuilding and managerial skills who can bring others together to govern the

implementation process. Although it is clearly stated that the specific roles and relationships of the TAM governance team will depend on each individual agency's organizational chart, this guide is more detailed in recommendations for a steering committee of senior managers to oversee the individual TAM leader and other teams to provide support in different areas. But even with this level of detail, the available guidance on developing a governing structure and determining the necessary actors for TAM implementation pushes the caveat that there is no one way to achieve success in this area. Ultimately, it depends on each individual agency and its particular context.

2.1.5.3 Decision-Making Processes

With a TAM plan developed and a governing structure established, an agency cannot claim success in implementing TAM without evidence of asset management principles incorporated into its business processes. Yet still, the guidance provided in this area is relatively vague. Here again, MAP-21 infers the use and consideration of TAM principles in planning and investment decisions without clear and specific guidance on how to accomplish this; the subsequent rulemaking on the TAM implementation aspect of MAP-21 also provides minimal guidance on how to implement TAM in decision-making processes. With the diverse nature of transportation agencies, it is understandable that the guidance provided in federal legislation does not go into such details. In the same way, the TAM Guide I does not provide recommendations or much detail on how to "do" TAM, although there is some discussion on processes such as tradeoff analyses that are related to applying TAM principles. In enhancing understanding of how to implement TAM principles in decision-making processes, the TAM Implementation Guide is superior, presenting detailed discussions on the processes

and tools for actually doing TAM. There are four specific steps in the TAM Implementation Guide framework for implementation (Figure 2.3) that are directly related to incorporating TAM in decision-making practices: (i) develop the change strategy; (ii) integrate TAM into agency culture; (iii) integrate TAM into business process; and (iv) develop performance management standards. Each of these steps is important for embedding TAM into the agency's day-to-day practice and the guide provides somewhat detailed recommendations for accomplishing them. Even with this guidance, it is evident that there are growth opportunities for the industry, to improve standards of doing asset management in terms of changes to the way we do business.

2.1.5.4 Summary

In general, the existing resources for TAM development and implementation provide very useful guidance on planning and operating TAM programs. Each resource builds on what existed before resulting in MAP-21 which, in many ways, is a culmination of the historical development of TAM informed by established standards and the continuously evolving practice. Ultimately, there is an inherent assumption that once TAM plans are developed and roles are assigned, they will be adopted by agencies and fully utilized towards improved infrastructure performance with cost-effective maintenance and management. With a financially supported federal mandate with a performance reporting structure, and with what seems to be an increased general industry interest in TAM principles, it is certainly probable that TAM and performance-based planning and decision making is here to stay. Nonetheless, the history of TAM in the transportation industry since the very beginning tells a tale of caution with respect to sustaining asset and performance management programs in a formal way in the long-

term. Furthermore, MAP-21 has turned this into a policy implementation process which carries a unique set of challenges. Ultimately the question is, will the implementation processes adopted by agencies and the resulting TAM program structure translate into the actual and sustained use of asset management principles in the long term? To help answer this question, the next two sections discusses policy and program implementation and what it means to study TAM implementation through an implementation research lens, as well as concepts of change management and what it means to consider TAM implementation as a process of change.

2.2 Policy and Program Implementation

With the introduction of a TAM mandate in federal legislation, studying TAM implementation has evolved from a largely and more basic study of program implementation in state DOTs into a slightly more complicated study of policy implementation. One key difference here is that a failure to implement a program driven by policy has the potential for more significant repercussions. Implementation that is not driven by policy (whether governmental or organizational) can and probably will develop and progress in a way that is different from policy-driven implementation. Policy and program implementation is a very important stage in the policy process because the success of any particular program can depend significantly on the success of the implementation process.

2.2.1 Characterizing Implementation: Theories & Models

Public policy can be defined as a purposive course of action taken by the government to address societal problems through some authoritative decision (Anderson 1997). These actions are usually communicated in the form of legislation, statutes,

regulations, judicial rulings or administrative action. The policy process involves a number of different stages from the formulation or design of the policy to implementation and finally, evaluation. In the medical field, Rabin et al. (2008) define implementation as "the process of putting to use or integrating evidence-based interventions within a setting" (Rabin et al. 2008 p. 118), while Peters et al. (2014) further explain it to be simply the act of carrying an intention into effect. Implementation is important because it is the process through which the goals and parameters set are brought to realization by putting in place the tools and resources needed to achieve those goals. It is during the implementation process that the characteristics of a policy or program are tested for their strength; challenges faced during implementation highlight the weaker areas of program design and can shed light on potential opportunities for improvement. Studies of policy implementation and administration contribute to useful understanding of the implementation process, and ultimately promote conceptualization and application of policy implementation theories.

"Any major policy innovation is an experiment" (Selker 2014 p. 1). While this statement and idea could provoke strong sentiments where policy processes affect real lives, there is much truth to the idea that many innovative programs are designed with the simple hope (as opposed to strong confidence) that they will result in a certain solution. When this form of pioneering legislation is enacted, significant uncertainty remains in the planning and processes, and as such, many in-course adjustments may occur. The Affordable Care Act (ACA) is one example of innovative policy that can be viewed as an experiment. In the words of Roosevelt et al., the legislation was "designed to be a flexible instrument that allows learning from and responding to experience" (Roosevelt

Jr. et al. 2014 p. 14). Brian Rosman (2014) discusses the idea that states are laboratories of democracy where many programs have been implemented, observed and later translated to the national level. In the same way, the ACA takes its inspiration from the Massachusetts healthcare legislation, Chapter 58, which has reportedly seen positive results (Bigby 2014). This view of policy implementation as an experiment and the inability to confidently predict results is undeniably a contributing factor to the resistance to novel policy implementation because while change itself is scary, change with an uncertain outcome is even scarier.

A second theory of policy implementation is that the process can take different forms based on the particular policy being implemented because different requirements call for different processes. Even for the same policy, different scenarios and environments can call for a variety of implementation strategies. Church and Nakamura (1993) illustrate this difference using the Superfund policy as an example, where the environment, scenario, and major actors and decision makers in different Environmental Protection Agency (EPA) regions influenced the way the policy was implemented. Their observations support a theory of policy implementation which subjects the achievement of the goals of any policy to the "constraints" of the environment and the specific scenarios in which the policy is to be implemented. This also speaks to the necessary versatility of the policy implementation process and the theory that one size does not automatically fit all, supporting the need for public policies to be flexible enough to allow the tailoring of implementation strategies to specific scenarios.

In addition to influences from the internal and external environments, policy implementation is also dependent on the specific parties involved in the process. In

particular, implementation can be influenced by the disciplinary background and approaches of relevant actors. In the same experience of the Superfund, changes in the EPA leadership were reflected in the most prominent approaches to implementing the Superfund cleanup policy. For example, Administrator Anne Burford pushed a more lenient approach dubbed "accommodation" by Church and Nakamura (1993) during her term, promoting settlements between the EPA Regional offices and the parties responsible for cleaning up the sites. In contrast, her successor William Ruckelshaus emphasized a more prosecutorial approach with increased referrals to the Department of Justice. In the late 1980s, EPA Administrator Winston Porter, with an engineering background, had an implementation approach that placed more emphasis on getting sites cleaned up before resolving liability disputes. Generally, the actors that have the most significant role and control over a policy implementation process, whether at the top of the implementing organization or at the frontlines, have the most potential to fine-tune the policy along the way at their discretion. A study of welfare reform policy, the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) of 1996, shows this theory in action; case workers implemented the policy in different ways as illustrated in their interactions with clients which varied depending on the investigation site (Lennon and Corbett 2003). Policies like PRWORA that allow for discretion at the frontlines can result in much variety in the implementation process which can then complicate evaluation of successful implementation.

While theories of implementation can establish a foundation for looking more closely at implementation research, implementation models that can further explain the process of implementation tend to be more useful for evaluating implementation success

and for knowing how to identify opportunities for improvement. Roger's Innovation-Decision process model, designed to illustrate individual adoption of an innovation, identifies the stages of knowledge, persuasion, decision, implementation, and confirmation (Rogers 2003). While this model is meant to focus on the individual, it has been widely used as a theoretical framework for implementation research in various disciplines. Glasgow's RE-AIM model was designed to broaden the criteria used to evaluate health programs and guide the development of adequate multistage and multilevel indicators when evaluating implementation efforts (Glasgow 2007; Rabin et al. 2008). He identifies the stages in program implementation processes as reach, adoption, implementation, and maintenance. In consolidating health implementation research, Rabin et al. (2008) identify the stages of program diffusion and implementation as dissemination, adoption, implementation, and sustainability. Similarly, Maurer et al. identify four stages in a DOT's process for implementing an initiative, for sustainability in transportation planning as branding, integration, communication and maintenance/monitoring (Maurer et al. 2013). One final implementation stage model also developed to guide the conceptualization of factors that influence implementation is the Exploration, Preparation, Implementation, Sustainment (EPIS) framework by Aarons et al. (2014). Although these and other implementation models vary in the number of stages and the terminology used, it is clear that the process of integrating an innovation, program or policy extends beyond the initial adoption phase to include some level of monitoring, maintenance, confirmation, or sustainment, emphasizing the importance of efforts to ensure that long-term program existence and viability is achieved.

2.2.2 Implementation Research

A study of the Affordable Care Act (ACA) promulgates the idea of a policy implementation study as a snapshot in time (Selker and Wasser 2014). The study, published only a few years after the legislation was passed, provides an early snapshot of the implementation process, which results in a discussion that is relatively heavily focused on the policymaking process and the factors that came into play during that developmental process that can influence the subsequent implementation. Studying the ACA at that stage of implementation revealed that the early snapshot can provide lessons on barriers or sources of resistance to program implementation to proactively determine how those challenges may be addressed (Holcomb and Nightingale 2003). Similarly, policy implementation studies at later times during the process can have a variety of emphasis areas and outcomes. For example, studies conducted after a program has reached a steady-state level of operations can provide much more insight on whether or not a program has been implemented as intended (Holcomb and Nightingale 2003). Ultimately, the policy implementation process can be described as a dynamic continuum with valuable insights to be discovered at whichever point the implementation research and analysis study is conducted.

Implementation research and analysis refers broadly to studies that aim to build an understanding of whether and, if so, how programs actually reflect what was originally intended in their conception. According to Rabin et al. (2008) "implementation research assesses whether the core components of the original intervention were faithfully transported to the real-world setting" (Rabin et al. 2008 p. 119). The goal is to describe how these policies and programs are translated into operation by developing or

characterizing typologies, generalizing conditions and experiences, and pulling out strategies that could be considered "best practices" that can have influences on future iterations or versions of the program (Holcomb and Nightingale 2003). In general, implementation research is mostly dependent on inductive reasoning, creating a generalized theory based on observations of a sample (Lennon and Corbett 2003) by investigating key aspects of the program and its implementation process. Accordingly, Church and Nakamura (1993) propose that studying various implementation strategies can lead to characterizations of implementation approaches, with the "hope that detailed, analytical case studies of the use of different approaches to implementation would advance understanding of how the program operates in the real world" (Church and Nakamura 1993 p. 8).

There is often confusion between implementation analyses and impact studies; however, there are some fundamental differences. Impact studies are designed to examine whether or not a policy or program has met its goal and achieved the results it set out to achieve while implementation analyses investigate if the program was implemented as intended (Corbett and Lennon 2003). Impact studies are similar to effectiveness research in healthcare defined by Rabin et al. (2008) as research that "determines the impact of an intervention with demonstrated efficacy when it is delivered under 'real-world' conditions" (Rabin et al. 2008 p. 119). It is said that policymakers prefer impact analyses because it provides them with a clear understanding of whether or not the policy works, while program managers prefer implementation analyses because they are concerned with those issues of process that determine how well they are doing their jobs. Nonetheless, implementation research is important in the context of impact

research because whether or not an impact is observed can depend on whether or not the implementation has been carried out successfully. When a program or policy fails to achieve the expected outcome, the performance could be attributed to either the ineffectiveness of the program or policy itself, or its incorrect deployment (Proctor et al. 2011). In this way, it is important to conduct studies of both the intervention and its implementation process.

Implementation research has evolved through three generations defined by the questions being asked and the research methods being used (Kaplan and Corbett 2003; Paudel 2009). Generally, no single disciplinary approach dominates the field; conceptual frameworks are developed from combinations of disciplines (Holcomb and Nightingale 2003). Nonetheless, most well-designed implementation studies have common features that frame the methodology and provide added structure. In general, the goal is to improve the industry's understanding of the program's existence in practice (as opposed to as a policy on paper), identifying similarities and differences across the various settings in which the program exists (Holcomb and Nightingale 2003). Furthermore, implementation studies are dynamic, with a constantly changing theoretical foundation based on accumulated findings. Implementation research can employ a combination of qualitative and quantitative analysis methods with various data collection strategies typically (but not always) with an institutional perspective (Holcomb and Nightingale 2003). Finally, due to the nature of these types of studies, conscious efforts must be made to ensure that quality research, in terms of objectivity and validity for example, is conducted. Guiding questions for implementation research are commonly focused on: (i) the major goals and assumptions of the policy or program; (ii) the organizational and

service delivery structure and context in which the program is implemented; (iii) how key management functions are carried out; and (iv) how contextual factors affect the program and its implementation (Holcomb and Nightingale 2003).

Implementation research is multidisciplinary; theories, methodologies, and concepts are built from a variety of experiences in different fields (Holcomb and Nightingale 2003). As a result, literature is published in journals scattered across different disciplines and consequently is rarely cross-referenced (Proctor et al. 2011). In transportation specifically, literature on policy or program implementation research is relatively limited; however ideas around studying policy implementation from other fields are very much applicable. Two formal methods of implementation research that are applicable to transportation and to TAM are field network studies and street-level research. While field network studies focus on the structure of a program resulting from a policy directive, street-level research provides a view of the program's actual delivery. These present two different perspectives that are both important for evaluating the success of a program's implementation.

2.2.2.1 Field Network Studies (Lurie 2003)

Field network studies are comparative case studies whose purpose is to gain a comprehensive understanding of the responses of institutions that are responsible for implementing large, non-incremental federal policy changes. Essentially, the goal is to uncover how those institutions undergo a process of change to account for the requirements of the policy and to execute the programs. Field network studies adopt a top-down view of policy implementation, focusing more on the structure of the program than the actual delivery of the service, or the client processing – the unit of analysis is the

institution. With this focus on institutional responses, multiple comparative case studies are designed and analyzed to develop a comprehensive report that answers specific research questions.

There are two groups of personnel involved in field research studies: the field researchers (observers/investigators) and the central (administrative) staff. Field researchers are knowledgeable observers chosen to directly investigate the institutions and their response to policy reform. They are typically academics physically located close to the institution and with some familiarity of the institution's processes. Researchers are equipped with a report form with descriptive and analytical questions constituting a standard protocol to examine the institution and develop the case study. These documented observations are then sent to the central staff personnel who analyze reports from the various institutions to produce a comparative analysis that generalizes the responses of institutions in an inductive manner. The interpretation of data collected is found to be biased towards the discipline or background of the personnel (whether field researcher or central staff) conducting the analysis: while political scientists may view and interpret some information in a theoretical way, engineers would probably view the scenario through a more technical lens. In field network studies, the use of a common protocol in data collection allows for construct validity (i.e. the ability to show why and how the operational measures of the analysis reflect the concept) and easier replication of the implementation research process.

2.2.2.2 Street-Level Research (Brodkin 2003)

When policy processes are left flexible enough for the frontline implementing staff to be able to use their discretion in addressing specific cases, more differences can

arise in the way the policy is implemented making implementation studies at a more disaggregate level important. Street-level research investigates this frontline policymaking to explore how the program is actually administered, combining theory and interviewing to study the relationship between the structure of the program at the institutional level and the actual delivery of the policy. Referred to by Brodkin as "deep-dish analysis" (Brodkin 2003 p. 145), this policy implementation research method uses an iterative process of interviews and observation to explore the possibilities of how a program is actually administered on a day to day basis. As described, street-level research provides a strategy for "separating policy fact [what actually happens] from policy fiction [the intent of the policy]" (Brodkin 2003 p. 151) and enables analysts to describe agency practice using data collected from assessments of work conditions and the content of practice, as well as observations of agency representatives in their work environment. This method of implementation analysis is most valuable when policy implementation requires significant changes in organization practice, complex decision making in a context of policy ambiguity and uncertainty, and discretion at the point of service delivery especially when the activities of those frontline staff cannot be fully monitored.

Similar to field network studies, street-level analysis also uses case studies to search for patterns in implementation and to inductively construct explanations for why implementation processes occur as they do. The case study method provides in-depth explanations of the complexities associated with program implementation while allowing for exploration of other factors that may not have initially been considered and would therefore not show up in a structured survey. In street-level research, cases are selected

based on the particular question under consideration (for example, selecting an urban agency to investigate implementation in an urban context) and data is collected using a combination of interviews and ethnographic observation. Since the unit of analysis in this method of implementation study is the frontline staff person delivering the service, comparisons can be made across individuals and departments to gain more insight on service delivery patterns and to expose more details of the policy implementation process. This method of in-depth research into the service delivery at the street-level has the advantage of creating a more accurate picture of the actual operation of policy since there may be discrepancies between the goals of the federal legislation and the service delivery. A disadvantage of street-level implementation research is that it is labor intensive, requiring significant time investments into the data collection process. Furthermore, this method adopts many of the limitations of the case study method such as observer bias. With such a close view on the implementation of a policy or program, street-level research allows analysts to make very specific discoveries related to the successes and challenges of the policy for the particular situation being investigated.

2.2.3 Evaluating Implementation

Regardless of the method in use, an important aspect of studying policy or program implementation is assessing the results. As previously stated, achieving the desired impact of a program or policy can, and more than likely, will depend on whether or not the implementation has been carried out successfully; effective implementation, ultimately, is a necessary precondition for realizing the expected benefits of a program or policy (Proctor et al. 2011). This is not to say that effective (or successful) implementation is the only condition for positive program outcomes. Nonetheless,

efforts to conceptualize and evaluate implementation success are still in development even in the field of medicine, where implementation research is comparatively well established.

2.2.3.1 Implementation Research Outcomes

As previously discussed, Church and Nakamura (1993) suggest that public policy implementation and the successes or challenges involved are very dependent on the specific environment and scenario in which the policy is being implemented and on the actors involved in implementation. Effectively, the success or failure of any policy or program and its implementation can be viewed from a number of different, but possibly equally important perspectives based on the industry and the particular scenario. In medical research, implementation success has been inferred by measuring treatment outcomes at the client or patient level leaning on the assumption that the intervention impact is correlated with implementation impact, while others measure more direct implementation targets such as desired provider behavior, that is, how the program is implemented at the frontlines (Proctor et al. 2011). As shown in Figure 2.5, a distinction can be made between implementation outcomes, which can be intermediate, short-term wins, and service and client outcomes, which are more specifically related to the intervention, and are directly impacted by the implementation outcomes.

In the environmental policy example of the Superfund, it is suggested that implementation evaluation can be simplified by defining measures of success that are based on the goals of the policy; however, given that policy goals are often not specific and measurable (Church and Nakamura 1993), this method of evaluation faces its own set of challenges.

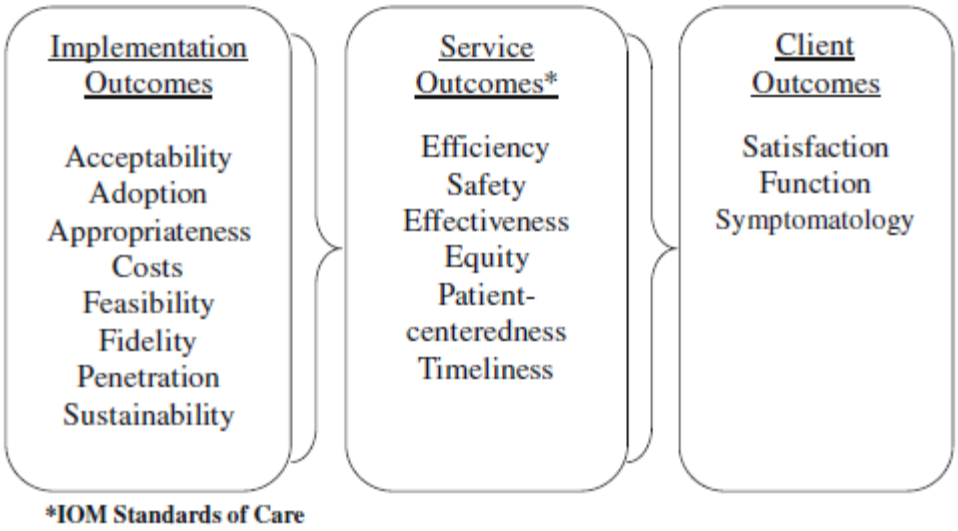

Figure 2.5 Types of Outcomes in Implementation Research (Proctor et al. 2011)

In either scenario, it is clear that establishing implementation assessment measures and criteria is important especially because measuring specific outcomes can help identify causal relationships within implementation processes to identify strategies that are more likely to lead to success or effectiveness of the program or policy.

When it comes to identifying implementation research outcomes, few studies outside the medical field, have established specific and proven outcome measures. Rabin et al. (2008) define three components in measuring or evaluating the implementation process: (i) *outcome variables* are measures of the impact of a program or intervention; (ii) *mediators* are process variables - factors that lie in the causal pathway between an independent variable (e.g. exposure to the intervention/program) and a dependent variable (e.g. the organizational change that results); and (iii) *moderators* are those factors that can alter the previously mentioned causal effect to influence the speed or extent of implementation. Rabin et al.'s outcome variables are essentially what Proctor

refers to as service outcomes – measuring the end result or impact of the program. Similarly, Proctor's implementation outcomes can be related to measuring Rabin et al.'s mediators and moderators which can help identify the factors and processes that lead to the success or failure of implementation. With a focus on the process of implementing TAM as opposed to "doing" TAM as discussed in Section 1.3, this work is only concerned with those outcomes associated with the implementation process, which will be referred to as implementation outcomes.

2.2.3.2 Sustainment/Sustainability as an Implementation Research Outcome

When specifying implementation outcomes, it is important to note that some can be more important at certain phases of the implementation process versus others, and similarly, some may be more important to certain stakeholders versus others, depending on their roles (Proctor et al. 2011). Three specific outcome measures that are applicable to sustaining TAM programs in state DOTs are fidelity, penetration (institutionalization), and sustainment (sustainability). Fidelity can be defined as the degree or extent to which a program is implemented as prescribed (Proctor et al. 2011; Rabin et al. 2008), while penetration, or institutionalization, is a measure of the integration of the program within the service setting, similar to Glasgow's element of Reach in the RE-AIM model (Glasgow 2007; Proctor et al. 2011; Rabin et al. 2008). Sustainment, the most important of these three outcomes for this work, is the extent to which a program is maintained within stable operations or the degree to which the intended benefits of the program are delivered over an extended period of time after external implementation support diminishes or is withdrawn (Proctor et al. 2011; Rabin et al. 2008). Wiltsey Stirman et al. (2012) define program sustainability as a measure of how the program at any single point

in time reflects what it was initially intended to look like. This definition closely associates program sustainment with high fidelity (quality of implementation).

To further understand sustainment as an implementation outcome measure, Rabin et al. (2008) highlight three operational indicators: maintenance, capacity building, and institutionalization. Maintenance refers to the ability of the implementing agency to continuously observe the benefits at a relatively constant level. Capacity building refers to activities that build durable resources to enable continued implementation and use of an intervention after support from the initial implementation drivers is removed. Institutionalization describes the extent to which the implemented program is integrated in the culture through policies and practice. Rabin et al. (2008) further describe three stages that determine the extent of institutionalization: (i) passage – a single event causes a significant change in structure and procedures; (ii) cycle or routine – repetitive reinforcement through inclusion in procedures; and (iii) niche saturation – the extent of integration into all sub-systems of the organization. Evidently, there is some relationship between institutionalization and sustainment since higher institutionalization can contribute to longer-term sustainment. However, Proctor et al. (2011) suggest that the specific relationship requires further empirical testing.

Ultimately, this study focuses primarily on the implementation outcome of sustainment with the understanding that it encompasses fidelity and institutionalization. According to Peterson et al. (2014), sustainability research is the study of a program's continuation beyond the implementation phase. While studies specific to program or innovation sustainment are not very well developed in any single field (Aarons et al. 2014; Wiltsey Stirman et al. 2012), research that identifies factors across system,

organization, and at individual levels that can influence or lead to a program's survival after implementation is needed (Aarons et al. 2014; Peterson et al. 2014). In many fields, even when initial implementation is successful, there is a risk of programs not continuing as originally implemented or becoming institutionalized as legitimacy tools especially where formal policy is involved (DiMaggio and Powell 1983; Edelman 1992; Meyer and Rowan 1977; Westphal et al. 1997; Wiltsey Stirman et al. 2012). Furthermore, Aarons et al. (2014) suggest that for some programs, the benefits may not be fully realized unless the program is sustained and without sustainment, investments may be diminished or wasted with a failure to realize cost-effectiveness and/or return on investment. The literature suggests that studying those factors that lead to program sustainment and planning for sustainability during the implementation phase can promote program longevity to eventually avoid falling from the standards of practice that will be associated with positive program outcomes (Aarons et al. 2014; Peterson et al. 2014).

Common methods of measuring the sustainment outcome reported in literature include self-reporting measures, individual and group interviews (structured or otherwise), observation, document and record reviews, or assessment of program integrity (Aarons et al. 2014; Proctor et al. 2011; Wiltsey Stirman et al. 2012). In a study protocol, Aarons et al. (2014) propose quantitative data analyses based on survey data. In addition, there are a few models developed towards measuring sustainment. (Wiltsey Stirman et al. 2012). One of the most common is a Level of Institutionalization Scale (Goodman et al. 1993) developed to address health promotion program implementation. This model assigns scores based on answers to yes/no and Likert scale questions in four sub-systems of organizations - production (program setup), managerial (leadership),

maintenance (long-term implementation staff), and support (financial and non-financial resources). Mancini and Marek (2004) developed a Program Sustainability Index which measures the sustainability of community-based programs for families based on seven elements that include leadership competence, effective collaboration, understanding the community, demonstrating program results, strategic funding, staff involvement and integration, and program responsivity. Glasgow's RE-AIM model for conceptualizing implementation can also be applied to evaluate implementation, with "maintenance" being the element most applicable to program sustainment. Maintenance is defined as the extent of discontinuation, modification or sustainability of the program (Glasgow 2007). In all these cases, measuring program sustainment after implementation is viewed as a retrospective process that occurs after implementation has progressed for a considerable amount of time.

However, there is one final model which, unlike most of the others, was designed to be used prospectively in the planning and early stages of implementation. This is the National Health Service Institute for Innovation and Improvements Health Service Sustainability Model. This model measures program sustainability based on ten factors categorized in three implementation domains that "increase the likelihood of sustainability and continuous improvement" (Doyle et al. 2013 p. 2). The measures are shown in Figure 2.6 below.

Domain	Factor	Issues being explored
Process	Factor 1: Benefits beyond helping patient	Whether in addition to helping patients there are other benefits that will make a difference to daily working lives or make things run more smoothly such as reduced waste or duplication.
Process	Factor 2: Credibility of the benefits	Whether benefits to patients, staff and the organisation are visible, are believed by staff and can be described clearly.
Process	Factor 3: Adaptability of improved process	Whether changed processes will continue to meet the need of the organisations and can be maintained when an individual or group of people who initiated it are no longer there.
Process	Factor 4: Effectiveness of the system to monitor progress	Whether data are easily available to monitor progress or assess improvement and whether there are systems to communicate this in the organisation.
Staff	Factor 5: Staff involvement and training to sustain the process	Whether staff play a part in the implementation of changes to processes and the extent of training and development of staff to help sustain these changes
Staff	Factor 6: Staff attitudes towards sustaining the change	Whether staff ideas are taken on board, the opportunity they are given to test these ideas and their belief that this is a better way of doing things that should be preserved.
Staff	Factor 7: Senior leadership engagement	Whether credible and respected senior leaders are seen as promoting and investing their own time in changes.
Staff	Factor 8: Clinical leadership engagement	Whether credible and respected clinical leaders are seen as promoting and investing their own time in changes.
Organization	Factor 9: Fit with the organisation's strategic aims and culture	Whether the changes being made are seen as an important contribution to the overall organisational aims.
Organization	Factor 10: Infrastructure for sustainability	Whether staff, facilities, equipment and policies and procedures are adequate to sustain new processes.

Figure 2.6 Screenshot of National Health Service Factors Proposed to Affect Likelihood of Program Sustainability (Doyle et al. 2013)

2.2.4 Studying TAM through an Implementation Research Lens

These findings from policy and program implementation literature have much to contribute to understanding TAM program implementation and the implications of the legislative backing for TAM programs in MAP-21. These findings have provided some context for studying TAM through a policy and program implementation lens. First of all, it is clear that the implementation process, and therefore studying this phase, is necessary to ensure that TAM programs are successful in the end. It is important to keep in mind that in applying this implementation research perspective, the goal is typically to investigate how agencies are responding to the policy that supports TAM implementation and how they are translating TAM programs from what is expected in the established guidelines into practice. In the context of this dissertation, the goal of implementation research is extended to include the identification of ways to leverage the implementation process to ensure that TAM programs are sustained. An understanding of implementation in terms of the theories and models that characterize the concept informs how the results of this TAM implementation research study can be interpreted. In particular, the models discussed establish the importance of a sustainment aspect to the implementation process.

Between the two implementation research methods discussed, the characteristics of this TAM implementation research study have more in common with field network studies than street-level research. While both of these methods use case studies of implementation scenarios, they focus on different aspects of implementation; the main differences are summarized in Table 2.3.

Table 2.3 Summary of the Differences between Field Network Studies and Street-Level Research

Field Network Studies	Street-Level Research
Understanding the response of institutions responsible for implementation	Exploring how policy is actually implemented on a day to day basis
Can be accomplished in the short-term	Longer-term study
Focus on program structure	Focus on frontline service delivery
Top-down view of policy implementation	Bottom-up view of policy implementation
Unit of analysis: institution	Unit of analysis: frontline staff

There are several reasons why this TAM implementation study has more in common with field network studies. First of all, the increased activity around TAM implementation that has resulted from MAP-21 is still in the fairly early stages of the implementation process. This means that this research is more of a short-term study, focusing on the program structure instead of the application of TAM at the frontlines. With the objective of enhancing TAM implementation in DOTs, the unit of analysis of this study is the institution responsible for implementing the program (the DOT) and this work investigates the implementation process with a top-down view.

Ultimately, achieving the objective of this study will rely on an understanding of the response of DOTs to the policy mandates for TAM implementation. All the same, there is an important discrepancy between field network studies and this research study because the former are said to be useful for studying non-incremental policy (Lurie 2003). Since MAP-21 essentially builds on past TAM-related policy and the structure of TAM programs outside of any policy mandates, it is difficult to argue that it is a non-incremental policy. Based on all of this information, the methodology adopted for this

research study adopts some of the features of a field network study, particularly the researcher-involved data collection, and the framework for comparative data analysis, but is certainly not a comprehensive field network study.

As the literature shows, evaluating implementation is an important aspect of implementation research. The proactive nature of this work, investigating TAM implementation at this relatively early stage limits the extent of evaluation particularly where measuring outcomes are concerned. In the same way the ability to measure the sustainment of TAM programs, which as described is typically a retrospective process, is limited due to the fact that formal TAM implementation is in the relatively early stages in most agencies. As such, the National Health Service model is most applicable to this work of the sustainment evaluation models presented. Since measuring TAM program sustainment is a next step for this work, this model and these implementation research ideas in general, will be used to inform the factors that can influence TAM implementation for program sustainment.

2.3 TAM Implementation as a Process of Change

For most of the past 50 years, transportation agencies have managed infrastructure assets on a worst first basis – the road that has the most damage or the bridge that seems to be worse off receives attention before any others. The introduction of TAM principles presents a new way of doing business and a new way of thinking about infrastructure maintenance and other decision making. More generally, TAM implementation is about changing the way agencies have made investment decisions, "improving the way certain existing functions are carried out, in order that the various participating units of an agency can work together more effectively to accomplish broad agency goals of asset

performance" (AASHTO 2011 pp. 3–13). A study describes risk management implementation as an organizational innovation because it involves a new way of working and/or thinking which can present more of an organizational challenge than a technical challenge (van Staveren 2014). Similarly, TAM is an organizational innovation which involves greater intrusion into the day-to-day activities of agency employees, promoting a significant shift in culture and behavior (AASHTO, 2011, p. 3–3). This type of transformational change has not been widely studied in transportation research at the organizational level. In fact, the process of organizational change in public agencies, in general, and the management of implementation processes have received little attention in academic research (van der Voet 2014).

Other studies in change management (of non-transportation fields and non-public agencies) have shown that the majority of organizational change initiatives eventually fail or are not sustained as expected (Xerri et al. 2014). Ultimately, organizational change is not a linear, straightforward process; it is "iterative and complex, with unintended as well as intended outcomes" (Whelan-Berry and Somerville 2010 p. 188). As such, the ability to manage any type of change has essentially become a core competency for organizations and their leaders (Parry et al. 2014; Whelan-Berry and Somerville 2010). In fact, Parry et al. (2014) suggest that appropriately managing change will lead to success in the change effort, but can also impact the overall performance of the organization; the best outcome is where the intended benefits of the change effort are realized while improving business performance. Nonetheless, there seems to be a need for "reliable, valid, robust, data-based information" (Parry et al. 2014 p. 100) on change

efforts to help determine the potential for success or failure, and to identify steps that can be taken to ensure success (Parry et al. 2014).

2.3.1 Defining Change & Change Management

Organizational change can simply be defined as the process of introducing an innovation (something new that does not already exist) into the setting of an organization whether in terms of structure, processes or resources. Todnem By (2005) presents three ways to define change: (i) by the rate of occurrence; (ii) by the scale or scope of change; and (iii) by how it comes about. Change defined by rate of occurrence can be discontinuous - involving rapid shifts or one-time events followed by periods of stillness; continuous – as an ongoing process; or incremental – with successive limited and negotiated shifts that do not occur at a steady state (Todnem By 2005). In looking at the scale or scope, convergent change, also known as fine-tuning, describes an ongoing process to find alignment with an organization's strategy, processes, people, and structure, while incremental adjustment refers to distinct modifications to specific management processes and strategies, without drastic action (Todnem By 2005). Two other characterizations of change by scale or scope are modular transformation, which involves major shifts in at least one division of an organization, and corporate transformation which involves drastic agency-wide alterations in business strategy (Todnem By 2005). Arguably, the most common way to characterize change is by how it comes about. Planned change occurs through rational goal-setting where "objectives are formulated in advance and implemented in a top-down fashion" (van der Voet 2014 p. 375), formally departing from the previous methods before adopting new approaches (Todnem By 2005). On the other hand, emergent change is a process of continuous and

open-ended adaptation driven from the bottom up where employees have active roles in the change process instead of passively receiving it (Todnem By 2005; van der Voet 2014). Todnem By (2005) also identifies a third characterization of change which involves strategies varied according to the particular organization – this is defined as contingency or situational change. Figure 2.7 shows a summary of these different characterizations of change found in literature, indicating a range of permutations of ways in which change can occur.

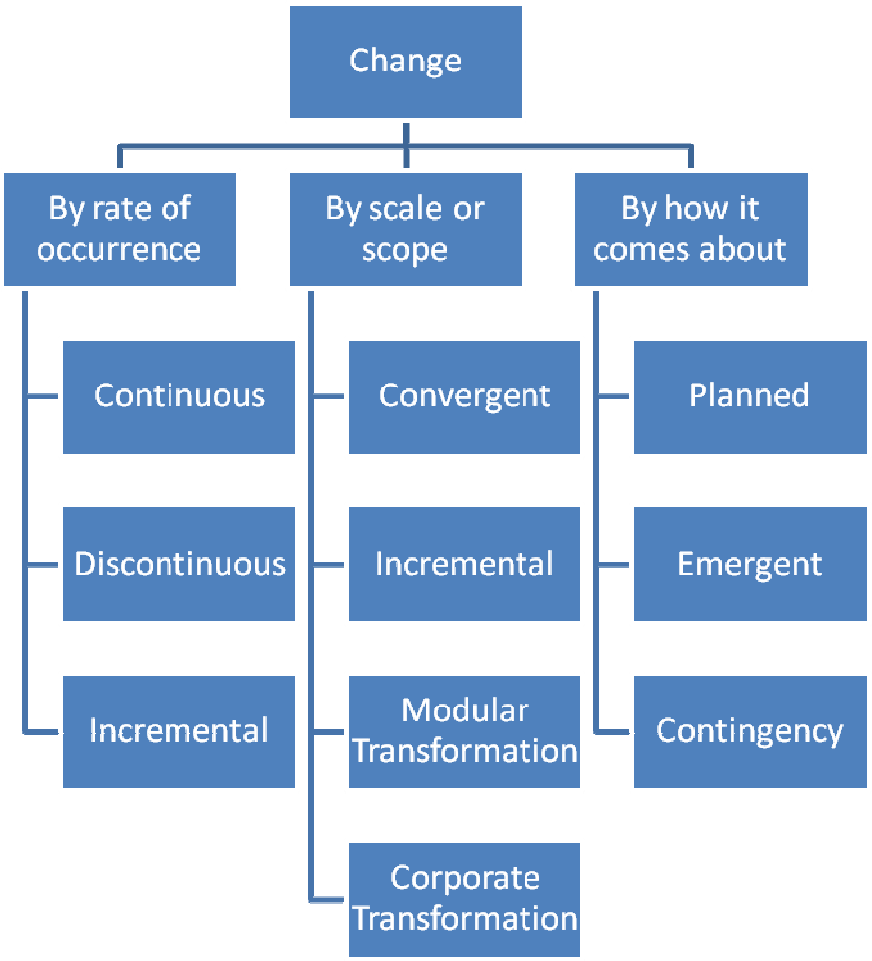

Figure 2.7 Characterizations of Change

Parry et al. (2014) provide a definition of organizational change that ties it to its management: "a complex, chaotic process that can be managed on an ongoing basis as it unfolds with interventions and actions based on the current stage and state of the project and aimed at providing ongoing course corrections, steering it towards a successful outcome" (Parry et al. 2014 p. 101). Van der Voet's definition states that change management involves "the planning, coordinating, organizing and directing of the processes through which change is implemented" (van der Voet 2014 p. 375). Certainly, this ability to adapt and coordinate an effort to implement change in an organization is important; however, there may not be one specific way to manage change - approaches should consider aspects of the internal and external environment (Parry et al. 2014; Todnem By 2005). This idea that change requires ongoing measurement, feedback and renewing especially to identify factors that can impact the success of the change effort, is supported by models of change that follow a general process of planning, launching, implementing, and sustaining change (Parry et al. 2014; Todnem By 2005; Whelan-Berry and Somerville 2010).

2.3.2 Organizational Change Models

For many years, researchers and experts have designed and put forward a number of change models that establish strategies or steps to be followed in order to achieve effective change. In general, the steps involved in these models tend to include some combination of the following five stages summarized by Whelan-Berry and Somerville (2010): (i) developing a clear, compelling vision; (ii) moving the change vision to the group level; (iii) individual employees' adoption of the change; (iv) sustaining the momentum of the change implementation; and (v) institutionalizing the change. Elrod

and Tippett (2002) observe that most change models also tend to follow Lewin's 1952 three-phase model which involves three simple steps: (i) unfreezing; (ii) moving; and (iii) refreezing. Lewin's model suggests that for change to be successful in an organization, current behavior has to be unlearnt or "unfrozen", after which movement to the new behavior can occur, followed by the final step of refreezing to ensure institutionalization (Brandt and Sommer 2013; Elrod and Tippett 2002). Parry et al. (2014) distinguish between types of change models, differentiating "processual" models that outline the steps involved in change processes from descriptive models that outline factors and variables that can lead to change implementation success.

In either case, organizational models should be based on reliable performance indicators and relevant characteristics of change efforts that can influence and be used to assess the success or failure of a change implementation project (Parry et al. 2014). Table 2.4 presents a sample of commonly cited organizational change models in the change management and organizational innovation literature developed from the mid-1980s to the early 2000s. As shown in the table, while there are differences in the number of stages presented in each model, they all follow a similar path which ends with some effort to integrate, anchor, reinforce or institutionalize the change similar to Lewin's refreezing stage. This bolsters the importance of efforts to ensure that change that is implemented in an organization will be sustained.

Table 2.4 Commonly cited organizational change models

Bullock and Batten's 4-Phase Model (1985)[1]	Kanter et al.'s 10 Commandments for Executing Change (1992)[2]	Kotter's 8-Stage Process for Successful Organizational Transformation (1996)[3]	Mento's 12-Step Model (2002)[4]	Luecke's 7 Steps (2003)[5]
1. Exploration	1. Analyze the organization and it's need for change	1. Establish a sense of urgency	1. The idea and its context	1. Mobilize energy and commitment through joint identification of business problems and their solutions
2. Planning	2. Create a vision and a common direction	2. Create a guiding coalition	2. Define the change initiative	2. Develop a shared vision of how to organize and manage for competitiveness
3. Action	3. Separate from the past	3. Develop a vision and strategy	3. Evaluate the climate for change	3. Identify the leadership
4. Integration	4. Create a sense of urgency	4. Communicate the vision	4. Develop a change plan	4. Focus on results, not on activities
	5. Support a strong leader role	5. Empower broad-based action	5. Find and cultivate a sponsor	5. Start change at the periphery, then let it spread to other units without pushing it from the top
	6. Line up political sponsorship	6. Generate short-term wins	6. Prepare your target audience, the recipients of change	6. Institutionalize success through formal policies, systems, and structures
	7. Craft an implementation plan	7. Consolidate gains and produce more change	7. Create a cultural fit	7. Monitor and adjust strategies in response to problems in the change process
	8. Develop enabling structures	8. Anchor new approaches in the culture (institutionalize)	8. Develop and choose a change leader team	
	9. Communicate, involve people and be honest		9. Create small wins for motivation	
	10. Reinforce and institutionalize change		10. Constantly and strategically communicate change	
			11. Measure progress of the change effort	
			12. Integrate lessons learned	

2.3.3 Implications of Applying Change Management Principles to TAM Implementation

The impetus for applying change management principles to TAM implementation stems from understanding TAM as a process of change. The different definitions and characterizations of change, or the way that the TAM implementation change process occurs is important for understanding how implementation outcomes can be influenced. For example, it may be relatively easier for an agency's leadership to make real-time adjustments to a change process that is planned than to alter the way emergent change is occurring. This implies that it may be easier for agency leadership to influence the outcomes of TAM implementation if the change occurs in a planned way in one agency, versus in another agency where TAM has been evolving in an emergent way. Similarly, different implementation factors affect can affect implementation outcomes based on the type of change. For example, continuous change can become routine in a way that makes it expected which would result in less employee resistance, compared to frequent, but discontinuous change efforts that could seem overwhelming and stir up resistance in agencies. Ultimately, the type of change that characterizes TAM implementation in different agencies is important for understanding how to enhance programs for sustainment.

The review of organizational change models has emphasized the importance of intentional efforts to institutionalize and sustain change in transportation agencies as part of the TAM implementation process. The existing guidelines for TAM implementation in the resources discussed in Section 2.1.4 seem to be lacking in their inclusion of a "freezing" step (adopting Lewin's terminology). The AASHTO TAM Guide I makes

mention of the need for a long-term focus and the AASHTO TAM Implementation Guide offers added detail in discussing change management principles. MAP-21 and the associated proposed rulemaking do not emphasize program sustainment beyond what is already in the guides. Altogether, the guidance provided on the necessary sustainment or integration step of TAM implementation is minimal and could benefit from added discussion of specific factors to consider during the implementation phase. While this does not imply that state DOT efforts to implement TAM will not result in sustained programs, there are several change drivers pulled from the literature that agencies can utilize to enhance the process for program sustainment. These change drivers are synthesized with the challenges and opportunities identified from the historical analysis of TAM development as well as the implementation factors identified in the policy and program implementation research to form the conceptual basis for the work that follows.

2.4 Synthesis of Implementation Factors that Can Influence TAM Program Sustainment

Since the very beginning of federal transportation policy development, asset management principles have been embedded in the general concepts of infrastructure maintenance, but with no explicit mandates until ISTEA in 1991. Throughout that time, TAM was implemented in various forms and at different levels, but it can be argued that this way of doing business has not been sustained in most agencies. While MAP-21 is an improvement on past TAM policy in several different ways, there are still a number of factors that can hinder the sustainment of TAM principles in transportation agencies' decision making. Viewing TAM implementation through the combined lenses of policy/program implementation and change management encourages a strategy that goes

beyond recognizing historical implementation opportunities and challenges, to identifying those factors that have been found to present similar opportunities and challenges in other contexts and relating them to the transportation planning and decision-making context in order to take preemptive action. In this section, a discussion is presented on those factors that can influence TAM implementation as it relates to program sustainment, identified from the three bodies of literature in the exploratory research phase. The factors identified have been summarized into the ten themes shown in Table 2.5.

Table 2.5 Summary of implementation factors that can influence TAM program sustainment

Factor Themes	TAM Practice/Experience	Policy/Program Implementation Research	Change Management
Goals, Expectations, Guidance	X	X	X
General Resistance to Change	X	X	
Change Implementation Process	X		X
Characteristics of the Innovation	X		X
Program Flexibility and Customizability	X	X	X
Leadership and Management		X	X
Other Agency Characteristics	X	X	X
Financial Resources	X	X	
Human Capital & Other Resources	X	X	X
External Factors	X	X	X

As illustrated, each theme is supported by references in at least two of the three main bodies of knowledge that have framed this exploratory literature review. Each factor is discussed below with some inferences offered for how they can be related to the TAM implementation context.

2.4.1 Goals, Expectations, & Guidance

One of the most important factors that can influence TAM implementation which is crucial from the outset of a program is the existence of clear, specific goals (AASHTO 2011; Church and Nakamura 1993; Kaplan and Corbett 2003b; Parry et al. 2014; van Staveren 2014; Whelan-Berry and Somerville 2010). Program goals and a clear vision of the way forward, at the national and agency levels, set the standard for what is to be achieved with the implementation effort. A flawed understanding of the goals of an innovation will result in failure to address the problem the innovation was established to address. Church and Nakamura (1993) argue that many public policy programs have unclear goals that are "too broad and amorphous to be of much help in guiding day-to-day activity" (Church and Nakamura 1993 p. 36).

With the establishment of seven national goals, performance measures and eventually targets, TAM policy at the national level is not susceptible to the challenge of unclear goals. However, the same generalization cannot be made at the agency level where implementation is concerned. Without specific, measurable implementation goals, there is no real standard for agencies to measure the success of their implementation process and this leads to the frontline employees responsible for using TAM having to use their discretion in defining implementation success. While this flexibility in program implementation could be beneficial (Maurer et al. 2013; Wiltsey Stirman et al. 2012), a

lack of understanding, knowledge or familiarity with TAM can cause the discretion in implementation to be a challenge. Furthermore, the goals of the policy may not be directly and completely met, if discretion is applied insufficiently and inconsistently across the board. As such, it is important that clear goals are reinforced with accountability, role clarity, and clear targets throughout the process (Parry et al. 2014).

Beyond establishing the goals, clear and regular communication of the vision is necessary to ensure that employees can see the way forward (AASHTO 2011; Parry et al. 2014; Whelan-Berry and Somerville 2010). Implementation success can often depend on all (internal and external) stakeholders' understanding of the vision, and agreement that the change is positive for the organization (Parry et al. 2014; Whelan-Berry and Somerville 2010) in order to encourage actions that are consistent and meet the expectations. For programs that give organizations responsibilities and authority that they have not previously held, clear communication of appropriate use of the program is also necessary. This is in order to avoid inconsistent implementation among other repercussions (Church and Nakamura 1993; Lennon and Corbett 2003).

2.4.2 General Resistance to Change

Without a clear understanding of the goals or necessity for change, there can be general resistance from employees particularly for policies and program implements that attempt to create a shift in human attitude or behavior (Lennon & Corbett, 2003; Selker & Wasser, 2014). According to Hanna et al. (2008), it is natural for employees to feel some apprehension when the standard way of doing business changes. TAM implementation faces this challenge because it presents a new way of making decisions that have typically been made based on engineering judgment and as a result of political influences

in the transportation industry. One of the common barriers to implementing PMSs and BMSs before they were mandated was a general resistance to changing the existing decision-making structure by introducing some dependence on data and other technical details (Finn 1998; Markow and Hyman 2009). A similar resistance was observed in agencies when implementing design-build delivery systems on transportation projects (Hanna et al. 2008). This challenge to an agency's standard operating procedures (SOPs) can cause "cultural resistance in the form of libertarian opposition to mandates" (McDonough 2014 p. 144).

At the end of the day, incentives towards change may not always be successful and usually require additional efforts to create general cultural change that go beyond simply establishing a policy and expecting employees or clients (where applicable) to comply. The difficulty of behavioral or attitudinal change can be further aggravated by the experimental nature of innovative policy implementation due to the fact that results are not always guaranteed and are more than likely not immediate (Selker 2014). Typical of human nature, results that are not immediate can often be viewed as no results, which can reduce morale and the will to continue steadfastly in the implementation process. Rabin et al. (2008) refer to this factor as the "observability" of a change which is the extent to which outcomes can be seen. Since change inherently occurs at the individual level in employees' behaviors, values or frameworks (Whelan-Berry and Somerville 2010), it is important to convince employees of the benefit of the change to gain their support (AASHTO 2011; van der Voet 2014). Employees' attitudes and behaviors (Rabin et al. 2008) and their emotional energy or emotional response to the change process (Parry et al. 2014) influences their willingness to change, which has been defined

as “a positive behavioral intention towards the implementation of modifications in an organization’s structure, or work and administrative processes, resulting in efforts from the organization member’s side to support or enhance the change process” (Metselaar 1997 p. 42 cited in van der Voet 2014 p. 375).

2.4.3 The Change Implementation Process

One way to counteract a general resistance to change is in the actual implementation process itself. On the individual employee level, allowing input, participation, and self-definition or empowerment in the change process, as opposed to imposing in a top-down manner has been found to positively impact the success of implementation (AASHTO 2011; Maurer et al. 2013; Parry et al. 2014; Whelan-Berry and Somerville 2010). This seems to suggest that a planned implementation change process can be less effective than an emergent process.

Other important factors related to the change implementation process are the ease of integrating the change into existing processes, whether using incremental enhancements or allowing for an organic evolution of the program (AASHTO 2011; Maurer et al. 2013). When ISTEA was enacted in 1991, the requirements for the new management systems did not align very well with the management systems that already existed (PMSs and BMSs) causing agencies to have to consider significant changes in their existing practice (Lindquist 1999). PMS and TAM policy grew out of movements that had been occurring for years, where these systems already existed in different agencies. Creating a mandate established a standard for these systems which existed in various form; however, completely ignoring the previously existing practices in order to create a uniform standard does not allow for effective implementation as was observed.

The requirements in MAP-21 are seemingly drawn from the development of TAM practice and understanding over the years, creating some level of alignment with agencies that already had TAM programs in place or in development prior to the legislation. While this may minimize the type and amount of change taking place, which is also important for implementation success (Parry et al. 2014), it can create a false belief about the ease of implementation, which would be disadvantageous to the process (Peterson et al. 2014).

2.4.4 Characteristics of the Innovation

During the implementation process, one factor that can bolster success and influence sustainment is the existence of short-term successes, benefits, and effects that are relatively easy to monitor (AASHTO 2011; van Staveren 2014; Wiltsey Stirman et al. 2012). Unfortunately, although there is general agreement on the benefits of TAM, most of the benefits are only realized in the long-term (Akofio-Sowah and Amekudzi 2013), reducing the "observability" (extent to which outcomes can be seen) of this change.

There are a number of other factors related to program characteristics that are important for the success of the implementation process. First of all, the program must be perceived to be compatible, or fit the agency and present an effective and cost-efficient solution to the problem being addressed (Rabin et al. 2008; Wiltsey Stirman et al. 2012). If the effectiveness of the program is not clear, its "trialability", or the possibility of running a trial before full implementation, can be important (Rabin et al. 2008). TAM implementation has been shown to have some trialability as evident in the Oregon DOT pilot study where TAM principles were applied to preservation and maintenance activity on a section of the highway system (Wipper 2007). Finally, the

program's complexity and the overall amount of change taking place can affect the implementation process, which can be countered by a clear and comprehensive presentation of the program in a way that leads to an improved understanding by all parties involved (Glasgow 2007; Parry et al. 2014; Rabin et al. 2008). With the different new tools (life-cycle cost analysis, risk management, tradeoff analysis, etc.) that are part of TAM applications, the implementation process can be perceived to be complex; however, the way the program is presented, and the general understanding of TAM in the workforce are factors that can help alleviate the perceived complexity.

2.4.5 Program Flexibility & Customizability

A factor related to program characteristics that is particularly common in places like the United States (where federal policy implementation in states is concerned) is related to the idea that different environments require different implementation processes (Church and Nakamura 1993; Selker and Wasser 2014). When the same program is to be implemented in regions with different contexts (e.g. urban versus rural), demographics, economic features, or even governing structures, the implementation process can become complicated, requiring several different sets of strategies as opposed to one that can be streamlined. Mandating a process that does not allow for flexibility may address those issues related to having too many varied implementation strategies; however, it will introduce other challenges of its own. In general, increased program flexibility, customizability, and the general ability for a program to be modified, is a factor that can promote implementation success (Glasgow 2007; Maurer et al. 2013; Wiltsey Stirman et al. 2012).

An NCHRP report on bridge management practices (Markow and Hyman 2009) discovered that after the mandates in ISTEA were repealed, the agencies that continued to operate BMSs did so very differently. This was driven by differences in the operating philosophies, approaches to planning programming and budgeting, the characteristics of the agency, their total transportation system and the infrastructure itself, and differences in the political, financial, technical and institutional environments. This observation points back to the long-standing argument that state agencies, specifically state DOTs, have innate differences that dictate the way they operate. Contingency theory supports this argument proposing that the best way to manage an organization and its performance is significantly dependent on the internal and external environment that the organization and its subunits have to operate in (Burns and Stalker 1994; Lawrence and Lorsch 1967). Allowing for flexibility in the implementation process contributes to the success and effectiveness of implementation; whether this is in terms of the data collection methods, software used or even performance thresholds, some level of flexibility in the mandates in order to address the various needs of each state has been shown to be a useful strategy for success (Bloom 1999; Lindquist 1999; Markow and Hyman 2009). Although, MAP-21 standardizes some aspects of TAM implementation, DOTs are generally able to customize their programs to some extent. While this reduces the opportunity for this factor to be a challenge to TAM implementation, there are still aspects that are mandated (the contents of the plan, the performance measures, etc.) that can work against successful program implementation for sustainment.

2.4.6 Leadership and Management Support

One of the most common factors that can influence the success of a change implementation process is the concept of a champion or change leader, preferably at a senior position in the organization who is able to motivate other employees (Aarons et al. 2014; Hanna et al. 2008; Maurer et al. 2013; Peterson et al. 2014; Wiltsey Stirman et al. 2012). Dedicated leadership and commitment from an organization's management can be crucial for programs that can easily become checkbox exercises in the agency (van Staveren 2014). It has been argued that while senior managers often initiate the change process, implementation relies on lower level leadership (van der Voet 2014) and as such, support from other leaders throughout the agency is just as, if not more critical than top leadership support (Whelan-Berry and Somerville 2010). Either way, the strength and manner of a leader's engagement at different levels of the agency is important and leaders should demonstrate the action they expect from employees in the implementation process (Parry et al. 2014; Whelan-Berry and Somerville 2010).

While most of the literature in both implementation research and change management support the importance of leadership and management support and commitment to the success of the implementation process, a recent study by van der Voet (2014) found that transformational leadership is not as important in situations of highly planned change, but can be important in highly emergent change scenarios in agencies with lower bureaucracy. Similarly, a study in Australia found that employee attitudes towards organizational change is influenced more by their relationship with the organization, than their relationship with supervisors; if employees perceive that they are well supported by the organization in general, it is likely they will contribute positively

toward organizational change (Xerri et al. 2014). On the other hand, another recent study by Peterson et al. (2014) found that leadership turnover foreshadowed later discontinuation of programs that were previously implemented. All in all, it is clear that leadership is an important factor in change implementation.

2.4.7 Other Agency Characteristics

One of the most important agency characteristics that can influence the success of an implementation program is the organizational structure. Van der Voet (2014) highlights organizational structure as a determinant of how change occurs; while prior research showed that classic, rigid, top-down structures benefit more from planned change and decentralized, flexible management benefits more from emergent change, the author found that both planned and emergent change approaches can be successful in agencies with high bureaucracy. Ultimately, it is clear that organizational structure should be aligned to the proposed change for an increased chance of success (Rabin et al. 2008; Whelan-Berry and Somerville 2010; Wiltsey Stirman et al. 2012). An example of this in the transportation context is found in TAM implementation during the ISTEA period, which introduced difficulties related to organizational structure in scenarios where different divisions within an agency were required to communicate with each other, which had never occurred before (Lindquist 1999); this was an important factor that contributed to the failure of that mandate for management systems to last.

Besides organizational structure, other characteristics that have been found to be important for change implementation success include agency size and an organizational culture that is oriented towards the practice to contribute to an agency's readiness for change (Peterson et al. 2014; Rabin et al. 2008; Wiltsey Stirman et al. 2012). In addition,

it is important that the agency does not have policies or regulations that oppose the change, or existing practices that present a conflict or are competing priorities to the change that is being introduced (Glasgow 2007; Wiltsey Stirman et al. 2012). In general, the organization should have a positive climate that supports adoption of the change – in school-based programs, implementation success was found to be a function of the climate in terms of the quality of relationships of the service providers with the recipients, and academic community partnerships (Aarons et al. 2014; Wiltsey Stirman et al. 2012). This is a potentially significant challenge for TAM implementation since it introduces data-informed decisions, which challenge the way that decisions in most agencies have been made previously, based on expert judgment or on a worst-first basis.

2.4.8 Financial Resources

One of the most important factors relevant to the success of implementation is the availability of resources to support the program (Aarons et al. 2014; Glasgow 2007; Hanna et al. 2008; Peterson et al. 2014; Wiltsey Stirman et al. 2012). Although federal mandates like the TAM plan requirements in MAP-21 are not required to come with funding, the lack of a clear financing structure can present a major challenge making implementation completely impossible. In the Superfund experience, Church and Nakamura conclude that the "enormity of the statutory goal…was unforeseen by the architects of the legislation" (Church & Nakamura, 1993, p. 117) in terms of the costs of implementing the program to clean up infected sites. Similarly, implementing TAM requires some significant financial investment from agencies for different components of the implementation process, and to sustain the program beyond implementation. The limited success of the management systems mandated in ISTEA has in many cases been

attributed to the lack of adequate funding to support the development of those systems (Schweppe 2001). Federal funding reduces the pressure on a state or local agency to divert funds from other agency business into a concept that they may not necessarily have completely bought into yet. One of the main benefits of TAM is the cost savings associated with preventive maintenance which leads to the avoidance of infrastructure failure and the avoidance of higher maintenance costs (Mizusawa and McNeil 2009); however, this cost savings is a long-term benefit that is not immediately realized. In some cases, agencies may simply not have the resources to implement a required mandate without diverting resources from other aspects of their operations. Financial assistance offsets the gap between initial capital investment and the return that will be realized in the long-term as a result of strategic management practices (Finn 1998). MAP-21 implementation should not be subject to this particular challenge since funding has been made available to support the requirement to have TAM plans and report on performance.

2.4.9 Human Capital & Other Resources

While funding is arguably the most important factor related to availability of resources to support a change implementation process, other internal resources such as human capital and time demand are also essential factors for successful program implementation (Glasgow 2007; Parry et al. 2014; Peterson et al. 2014; Whelan-Berry and Somerville 2010; Wiltsey Stirman et al. 2012). Any uncertainty in the availability of resources can cause much contention and delay in the implementation process, which is susceptible to these and other internal and external pressures that must be pacified at different stages and to different extents. In general, it is important to develop those new processes and systems that are necessary to support the innovation to achieve the

objectives (Hanna et al. 2008; Parry et al. 2014). Once resources are set in place, however, it is also essential to ensure that human capital and organizational capital are developed alongside the technical resources.

In the historical development of TAM, organizational capacity issues related specifically to the level of expertise and familiarity with asset management systems emerged within the state and local agencies, and to some extent, even the USDOT (Lindquist 1999). The AASHO road tests in the 1950s helped to accomplish industry-wide ownership of PMSs by contributing to the overall understanding of the underlying concepts (FHWA 2011a). Without improved understanding and ownership of TAM, agency implementation incorporating these necessary changes in their standard operating procedures (SOPs) and organizational processes will not be effective. Implementation and change management research supports this, highlighting the importance of training and education to increase understanding and enhance the capabilities of employees to perform with the change (Hanna et al. 2008; Parry et al. 2014; Whelan-Berry and Somerville 2010; Wiltsey Stirman et al. 2012).

2.4.10 External Factors

While change implementation occurs within the boundaries of an organization, contextual factors such as the political, social, and organizational setting, inter-organizational networks and collaborations, and stakeholder involvement have been found to be important to the success of the implementation process (Aarons et al. 2014; Peterson et al. 2014; Rabin et al. 2008; van Staveren 2014; Wiltsey Stirman et al. 2012). Generally, some level of cooperation between agencies can enhance effectiveness especially for programs mandated at a national scale. Furthermore, outside counsel can

be used to overcome potential challenges like the general resistance to changing standard operating procedures (Hanna et al. 2008). In fact, van Staveren (2014) goes as far as proposing that in change implementation, limited transparency towards stakeholders can be an indicator of ineffective and inefficient implementation.

Certain actions by external stakeholders also have the potential to influence implementation processes. During the highway boom, as road maintenance started to become a more important issue, a national Office of Maintenance was formed (FHWA 1977). Similarly, the emergence of asset management in the 1990s led to the formation of the FHWA Office of Asset Management even without a federal mandate to operate asset management programs (Bloom 1999). More recently, the FHWA introduced an Office of Transportation Performance Management in response to advances in performance-based planning even before MAP-21 was passed (this could also have been in anticipation of the legislation). These institutional changes by the administrative arm of the government reflect a commitment to performance management and TAM, encouraging states and local agencies in their implementation of management systems. Besides setting an example, a specific office becomes directly responsible for all things related to the program and is able to provide support to agencies, whether technical or otherwise. In the same vein, industry organizations such as TRB and AASHTO have shown support for asset and performance management through the Task Forces and Committees they established to host conferences, webinars or training sessions or to simply conduct research that advances the state of the practice. These offices and committees contribute to the success of implementation by creating an environment to facilitate discussion on the topic, providing resources to guide operation and assist in

building expertise within the agencies. Essentially, these organizations become advocates for TAM, communicating the importance of these practices to the stakeholders of the transportation industry, especially the public and the legislative arm of the government and in some cases, driving the policy development process.

2.4.11 Summary

Throughout the historical development of TAM, the initial focus was on creating the tools and methods to actually "do" asset management, with minimal focus on adapting the organizations or their employees to do this. A study of risk management implementation (van Staveren 2014) identifies a similar primary focus on the technical aspects as opposed to comparable attention on developing the organization and the users of risk management processes. The study's author developed a toolbox with a three-dimensional implementation model that places the organization and the frontline employees who would actually use and "do" risk management at equal priority to the actual risk management methods. According to this three-dimensional implementation model, organizational conditions should motivate users and should enable them to apply the methods, and the methods and tools should stimulate application instead of frustrating users (van Staveren 2014). In a similar fashion, the ten factors discussed seem to place more emphasis on the social and organizational aspects of implementation, as opposed to the technical aspects.

In the change management literature, the types of factors discussed here are referred to as change drivers – they facilitate the implementation of change and adoption of new programs (Whelan-Berry and Somerville 2010). Generally, change drivers have different influences at the different stages of the implementation and change models

previously presented (Aarons et al. 2014; Parry et al. 2014), but it is important to have a mix of factors at each stage that will leverage the key aspects of each stage (Whelan-Berry and Somerville 2010). In the same way, different organizational characteristics (setting and maturity) and different types of change can be influenced by the factors in different ways (Whelan-Berry and Somerville 2010). According to Parry et al. (2014), increases or decreases in implementation/change success are not linear – improvement (or decline) is more easily achieved in organizations with initially low performance with further improvements becoming increasingly challenging in more mature organizations (Parry et al. 2014). This idea of diminishing returns essentially means that the consideration of these factors should carefully regard the stage of implementation that an agency is at. Furthermore, a degree of thoughtfulness should be employed in building an understanding of these factors because they are correlated to a degree and even have complex interrelationships between them (Parry et al. 2014).

Ultimately, this literature review has found that in implementing any type of change like TAM in a public agency there are several factors that should be considered in order to enhance the chances of implementation success and the potential for program sustainment in the long-term. These findings have formed the foundation for the development of the conceptual framework to review and offer guidance to agencies' TAM implementation practices for program sustainment.

CHAPTER 3: DESIGNING THE FRAMEWORK

In the foundational part of this research study documented in the previous chapter, a number of factors that have been shown to (positively or negatively) contribute to program implementation success in terms of sustainment were identified out of the three bodies of knowledge of TAM development, implementation research and change management. Based on the understanding that the implementation phase of a program and the success of the implementation process can ultimately influence the effectiveness of the program itself, addressing the factors identified should be an important step during implementation in order to enhance the likelihood of program sustainment. For DOTs implementing TAM, one way to address these factors is to review what has already been accomplished to identify where the general implementation approach or specific implementation strategies address the various factors. In that way, opportunities for increasing the likelihood of program sustainment will be revealed.

The ten factors presented in the previous chapter are grounded in the literature offering the foundation of a conceptual basis for a framework to facilitate such a review of agency TAM implementation strategies for their potential influence on program sustainment. In order to strengthen the validity of the review criteria that would be developed from these factors for the transportation field and for TAM itself, experts in the field were invited to participate in a panel towards the refinement of a taxonomy that the review framework would be based on.

3.1 TAM Implementation Expert Panel

The TAM Implementation Expert Panel was conducted as a series of webinars held in June 2014 to gather ideas from asset management experts in the transportation industry on criteria to use in reviewing State DOT's TAM implementation processes for contributions to program sustainment. The goal was to use insight from the panelists to refine the factors identified from the literature review in order to advance the process of developing a conceptual framework. There were a total of nine panelists representing the federal government, private consulting firms, and academic institutions, as well as the FHWA Expert Task Group (ETG) on TAM, the TRB Standing Committee on TAM (ABC40) and the International Road Federation (IRF) Committee on Asset Management. Each panelist has at least ten years of experience in transportation, transportation policy or TAM. They were recruited based on this experience as well as their prominence in TAM forums such as those sponsored by TRB. The names and affiliations of the panelists are listed in Table 3.1.

Representatives from state DOTs were purposefully kept off the panel in order to avoid any bias that could result from including representatives from the primary audience of the approach in the initial development. If DOTs were involved in the initial framework development process, they could unknowingly suggest factors they are already addressing in their agencies as criteria especially if they have confidence in their implementation approach. This would decrease the credibility of the tool for use in DOTs. Instead, the non-DOT affiliated expert panelists were expected to provide their views on factors to address based on their personal experiences with TAM and its

implementation in various agencies of the same or different type (for example, DOT versus MPO, etc.).

Table 3.1 TAM Implementation Expert Panelists

NAME	AFFILIATION	POSITION	CATEGORY
Joe Guerre	Cambridge Systematics	Principal Consultant	ABC40; Consultant
Hugh Louch	Cambridge Systematics	Principal Consultant	Consultant
Alan Lubliner	Parsons Brinckerhoff	Principal Consultant	Consultant
Sue McNeil	University of Delaware	Professor	ABC40; Academic
David Rose	Parsons Brinckerhoff	Vice President, Strategic Consulting	Consultant
Francine Shaw-Whitson	Federal Highway Administration	Transportation Manager; Policy & Guidance Team Lead, FHWA Office of Transportation Performance Management	ETG; Federal
Omar Smadi	Iowa State University	Associate Professor	ABC 40; Academic; ETG; IRF
Butch Wlaschin	Federal Highway Administration	Associate Administrator, FHWA Office of Infrastructure	ABC40; ETG; Federal
Kathryn Zimmerman	Applied Pavement Technologies	President	ABC40; Consultant; ETG

The format for the webinar was a guided discussion based on four main questions that led to follow-up questions based on how the conversation progressed. In order to reduce external influence from the initial findings of the research, a brief introduction to the webinar simply explained the purpose of the discussion without revealing the factors that were identified from the literature. The questions were designed to elicit panelists' views on what state DOTs should incorporate in TAM implementation in order to

establish a successful and sustained program. Essentially, the discussion questions were centered on the general question which guided the literature review: what factors are important in TAM implementation to ensure successful implementation and sustained programming. The four questions posed are as follows:

1. What are the characteristics of a successful TAM program in a State DOT?
2. What needs to be done to ensure that performance-based TAM will last and/or become institutionalized in an agency's business processes?
3. What are unique and/or important factors that can encourage TAM longevity in State DOTs? Provide one factor for each of the following:
    a. Guidance documents - TAM plan or other documents
    b. Governing structure - roles & responsibilities
    c. Decision-making processes - how to incorporate TAM into decision making
4. How can agencies know that they are doing a good job with TAM implementation in the short term?

Overall, the panelists expressed a number of different views with some consistency in their responses to these questions. The responses and points raised in the general discussion were distilled into seven thematic categories of characteristics of successful and sustainable TAM implementation approaches. The themes are listed below and are described as they were discussed, in order of popularity. Note that prior to this discussion the panelists were not made aware of the ten factors identified from the literature review.

3.1.1 TAM Guidelines and Agency Guidance Documents

TAM implementation relies particularly on good documentation to show how TAM should fit into an agency's programming processes and how TAM principles can be incorporated into decision making. Agencies must have some minimum level and quality of guidance documents from the very beginning. Policy that establishes TAM as the basis for investment decision making, with other guidance documents that include explanations of forecasting, risk analysis, and other relatively newer concepts, can promote buy-in at all levels of the agency by enhancing understanding of the broader goal of TAM. Ultimately, the TAM plan should be a living document, but other operating guidance is needed, for example, short- to medium-term improvement plans to further manage the implementation process.

3.1.2 Leadership and Executive-Level Support

It is important for upper management to support TAM implementation with particular commitment from top-level executives; however, middle-management supporting top leadership efforts is also essential. For agencies that rely on a TAM leadership committee structure, it is important to have total cross-disciplinary agency representation with accountability. Capacity-building activities for committee members are particularly important to ensure that members should know what their role is on the committee but also throughout the agency as a whole.

3.1.3 Employee Awareness and Understanding of TAM

Ultimately, TAM cannot simply be an agency leader's way of doing business; there must be buy-in from throughout the agency. Employees at all levels must have some ownership and understanding of TAM, see why the principles work, and understand

what the benefits are. Most importantly, employees should understand the long-term effects of their decisions and how their roles are expected to change to incorporate TAM. Essentially, this means that agencies should create workforce capacity for TAM and, where possible, develop a succession plan.

3.1.4 Applying TAM in Decision Making

Probably the most important aspect of TAM implementation is clarifying how decision-making strategies and processes can be expected to change. Implementation should provide an explanation of how TAM principles will be integrated into investment decisions (that is, how to "do" TAM), with clear connections to agency planning and programming processes. Two ways of accomplishing this are the use of good, performance-based practices using performance measures, metrics, and outcomes, and using management systems that are connected to decision-making processes. Nonetheless, it is important to consider the distinction between data-driven decisions, and data-informed decisions, where the former allows metrics to primarily dictate the decision with little input from elsewhere. On the other hand, data-informed decisions are made based on a balance between expertise and information, acknowledging the inherent limitations of the data.

3.1.5 Comprehensive Agency Alignment

Ultimately, if TAM principles are driving decision making in an agency, decisions at all stages should be aligned with TAM goals, from the strategic-level to program- and project-level applications. Generally, there tends to be TAM implementation on capital-side programming without the same level on the maintenance-side. Successful TAM implementation should include strategies that create clear links to

outcomes and performance measures that matter to employees' day-to-day work. Furthermore, TAM should be connected to customer service creating alignment from the agency's strategic goals, through to service delivery.

3.1.6 Reflection on Agency Culture

One of the most accurate ways of knowing whether an agency has successfully implemented TAM is by examining agency culture. Implementation strategies that address agency culture can be more effective than any changes to legislation or agency policy. TAM implementation strategies should promote clarity of communication throughout the agency at all levels to ensure that all employees speak the same language and that the whole organization is "marching to the same beat" with respect to TAM.

3.1.7 Committed Resources

There should be evidence of financial resources committed. It is important to show commitment in other ways but if investment is being made at the top level financially, the gravity of the commitment to TAM can be felt throughout the agency and employees will be able to appreciate that their agency is moving towards a TAM way of doing business.

3.1.8 Expert Panel Summary

Throughout the discussion, the panelists expressed the importance of considering how to sustain programs in agencies, acknowledging the timeliness of this research study. The results and notes from the expert panel were summarized and compared with the factors identified from the literature review, revealing a number of intersections. The factors at the intersection of the two overlapping sets (from the literature and from the

panel) were combined to form the foundation of the TAM Implementation Review Framework. The panel discussion summary and the taxonomy of (combined) factors which formed the foundation of the framework were provided to panelists for review, to ensure that their views had been captured appropriately.

3.2 TAM Implementation Review Framework (TIRF)

The Transportation Asset Management (TAM) Implementation Review Framework (TIRF) is a diagnostic tool that can guide transportation agencies in conducting a systematic review of their TAM implementation approach to produce descriptive results on how the approach leans the implementation process toward sustaining TAM programs in the long-term. The tool is based on a conceptual framework that can help identify where opportunities exist to address factors that can enhance implementation for sustained programs. The most important feature of the framework is the criteria developed to guide the systematic review based on the factors that can influence program implementation identified in the literature. The goal of the TIRF design is to assist agencies in answering the question "how does our method of implementation address those factors that can influence the likelihood of our TAM program to be sustained by becoming ingrained in our agency culture?"

3.2.1 Conceptual Framework Design

As previously stated, findings from the literature review and expert panel processes informed the initial design of the conceptual framework. Although panelists were not exposed to the factors identified from the literature review, there was some clear overlap between those results and the themes discussed during the panel process. The themes identified from the expert panel process are all generally reflected in the results of

the literature review, although the reverse is not true. Figure 3.1 shows an illustration of these connections between the ten factors identified from the literature review (top and bottom rows) and the seven themes from the expert panel discussion (middle row).

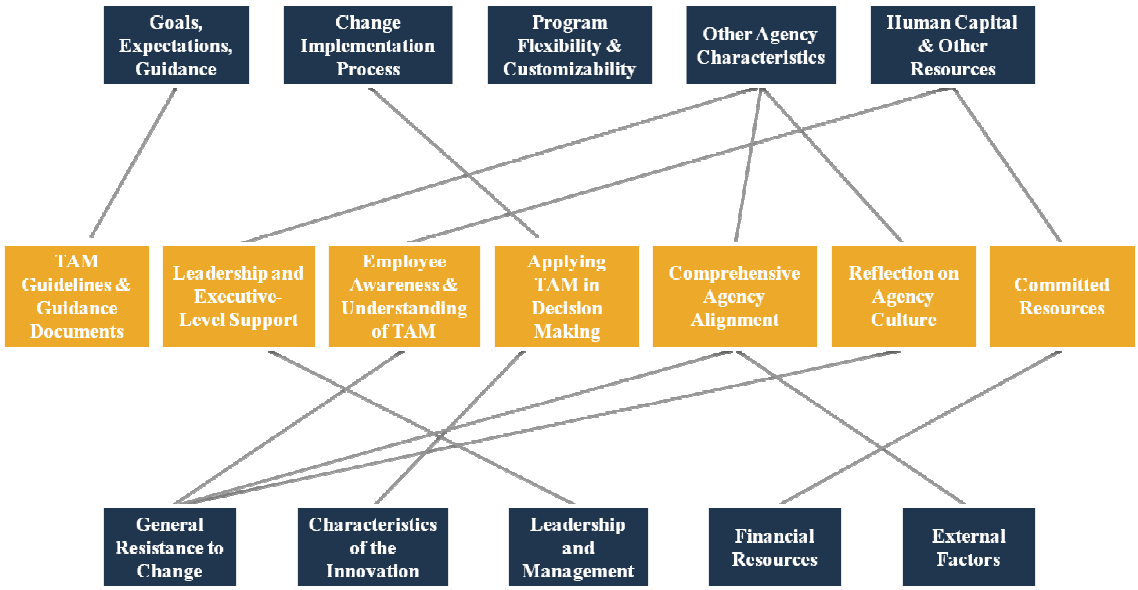

Figure 3.1 Links between Implementation Factors from the Expert Panel (Middle Row) and Literature Review (Top and Bottom Rows)

As shown, there are several links between most of the factors. Each theme from the expert panel has at least one link to a factor from the literature review. The program flexibility and customizability factor from the literature review is the only one that does not have a corresponding theme discussed in the expert panel. Based on these connections, seven categories of criteria that can be addressed in order to influence program implementation for sustainment are defined. Note that while the specific category names are pulled from the expert panel themes, the criteria that an implementation approach can address are also informed by literature.

To reiterate a point by Church and Nakamura (1993), one way to evaluate whether or not program implementation has achieved the desired result is by establishing a set of goals against which the implementation approach or strategies can be assessed. In this conceptual framework, the goal is program sustainment which can be achieved by addressing the criteria in each category. This framework proposes that if an agency's TAM implementation approach addresses the criteria category, the likelihood of their program to be sustained is increased. The categories and associated criteria are described below.

Category 1: Guidance and Expectations

Guidance documents are important for creating a clear and streamlined perception of TAM for each agency and for making sure that expectations are understood in the same way throughout the agency. Implementation strategies that address this category should:

1.1 Ensure that TAM is reflected in major agency policy documents

1.2 Explain where TAM fits in agency programming

1.3 Provide clarity on how standard operating procedures (SOPs) should change to incorporate TAM

1.4 Provide clear guidelines on how decision making should change, including explanations of risk analysis

Category 2: Leadership and Executive-Level Support

TAM leadership from the top has been found to be very effective in ensuring that the agency as a whole prioritizes TAM. Implementation strategies that address this category should:

2.1 Illustrate support and commitment from upper-level employees, management, and executives

2.2 Ensure total agency representation in the TAM governing structure

2.3 Promote accountability for the TAM governing structure

2.4 Reduce chances of diminishing support due to leadership changes

Category 3: Applications in Decision Making

A common gap in TAM implementation is a lack of clarity on how asset management is actually done, for example, what does it mean to make good decisions based on asset management? Implementation strategies that address this category should:

3.1 Introduce TAM into established decision-making processes

3.2 Incorporate clear metrics and expected outcomes (goals/targets)

3.3 Utilize decision-making questions that require reference to data

3.4 Promote decisions based on management systems

Category 4: Reflection in Agency Culture and Language

Agency cultural change is, arguably, the clearest indication of successful TAM implementation. Implementation strategies that address this category should:

4.1 Clearly communicate TAM goals and applications throughout the agency

4.2 Promote a uniform TAM language

4.3 Promote a long-term agency focus

Category 5: Employee Awareness and Understanding

In order for TAM principles to work and last in an agency, employees must have an understanding of what TAM is, how it works and what it means for their roles in the agency. Implementation strategies that address this category should:

5.1 Expand workforce capacity with respect to TAM

5.2 Promote employee understanding of their role in using TAM or how their job changes to incorporate TAM

5.3 Clarify expected outcomes or benefits of TAM to employees

Category 6: Comprehensive Agency Alignment

This category emphasizes a comprehensive understanding of TAM throughout the whole agency with alignment from the agency's strategic goals down to customer service delivery. Implementation strategies that address this category should:

6.1 Create clear links between TAM and agency outcomes/goals

6.2 Incorporate TAM into all aspects of programming (capital-side, maintenance, etc.)

6.3 Create connections to customer service

Category 7: Resources Committed to TAM Development

Implementing TAM is a consuming process which requires resources of all kinds. Implementation strategies that address this category should:

7.1 Allocate financial resources to TAM development and implementation

7.2 Commit human resources efficiently towards TAM programming

7.3 Prioritize and enhance data management

It is important to note that no weighting is applied to the categories or criteria. Weights could be assigned in a number of ways, using expert opinion and data (e.g. data on the agency's organizational and infrastructure capital); however, this framework will be more useful for each agency, if the importance of categories is considered in a context-sensitive way. As has previously been emphasized, contingency theory supports the idea

that different agencies may need to approach the same innovation in a different way based on their internal and external environments, the level of maturity of their existing TAM program, and possibly even based on the period of time during which implementation is taking place. As such, applying a weighting structure should not be generalized, but should be specific to each agency that uses this framework, and based on the particular scenario.

3.2.2 Incorporating Evidence-Based Principles

The conceptual framework design and the systematic review it is meant to guide are pulled from theories on evidence-based principles that are commonly used in the fields of healthcare, education, and social policy; while there is some use in transportation this is relatively rarer and fairly recent (Bones et al. 2013; Smith-Colin et al. 2014). Evidence-based approaches refer to methods that use quality evidence of past successes or failures to influence a decision or action. There are various definitions for evidence-based approaches in the different fields. In healthcare, evidence-based practice is a "conscientious, explicit, judicious use of current best evidence in making decisions…integrating clinical expertise with the best available external clinical evidence from systematic research" (Sackett et al. 1996 p. 1). The Institute of Education Sciences defines evidence-based decision making (EBDM) as "routinely seeking out best available research and data before adopting programs or practices that will affect significant numbers of students" (Whitehurst 2004 p. 5). Evidence-based management is defined as "integrating managerial expertise with the deliberate and prudent use of best evidence in making decisions while taking into account the perspective of those who may be affected by them" (Collins et al. 2008 p. 2). From these definitions, it is clear that the main

components of an evidence based approach are the evidence itself and the systematic review or evaluation of research or other studies used to identify that evidence.

A systematic review refers to the use of a rigorous and well-defined approach to select experiences as evidence towards a particular goal or outcome based on strict criteria (Stetler 2001). In social policy, the systematic review is the method by which evidence is located, appraised, synthesized, and reported, guided by questions that serve to identify the studies or experiences that will be included as evidence, the search strategy for identifying those studies or experiences, and the specific data to be extracted from the study (Briner et al. 2009). The importance of systematic reviews is also echoed in evidence-based management, where Rowley describes them as "summaries of previous research constructed according to a specific protocol, which includes clear aims and objectives and selection criteria….using an explicit analytic framework" (Rowley 2012 p. 527). This idea of a systematic review is applied in the TIRF to help agencies think critically about their TAM implementation approach, identifying where strategies address the criteria in the seven categories, to highlight areas where opportunities may exist for improvement.

In evidence-based design, the systematic review requires criteria that can lead to documentation facilitated using specific decision questions. In medical science, the PICO - Patient or Problem, Intervention, Comparison, Outcomes - approach is common; in social sciences, this is reformulated into CIMO - Context, Intervention, Mechanisms, Outcomes (Briner et al. 2009). Similarly, Smith-Colin et al. (2014) formulated the PICMO (Problem, Intervention, Context, Mechanism, Outcome) framework to support evidence-based decision making in TAM. For the TIRF, the concept of a systematic

review is adopted to facilitate the review of an agency's implementation approach, and documented using the seven categories as the guiding principles that can be abbreviated into the acronym GLACEAR – Guidance, Leadership, Applications, Culture, Employees, Alignment, and Resources. Using this framework, specific implementation strategies or aspects of an agency's implementation approach are reviewed based on the guiding question "does this strategy address criteria in the X category?" where X refers to each of the seven categories. To help trigger the determination of which criteria or categories are addressed, the documentation framework also requires a short sentence describing the primary observed or expected impact of the strategy. Note that in this work, an implementation "strategy" refers to a specific, key activity or action taken to adjust the agency's orientation towards TAM implementation, while an implementation "approach" refers to the compilation of all those activities which would define the agency's general plan of action towards implementing TAM.

In applying evidence-based approaches, the second important component is how evidence is defined, but more specifically how to determine evidence quality; the different fields that apply evidence-based approaches also define quality differently. In healthcare, evidence is generated from research studies and quality increases with increased rigor of the study. Multiple experimental studies like randomized controlled trials (RCT) with the same result indicate high quality evidence, while descriptive research, case studies, and other non-experimental methods are ranked at the lowest levels (Stetler 2001). In contrast, social policy applications of evidence-based approaches place a greater emphasis on quasi-experimental studies (Cooney et al. 2007). In education, evidence quality is defined differently, emphasizing the context

(educational setting) of, and range of participants (e.g. diversity of students) involved in the study, where the highest quality evidence demonstrates that a practice can be generalized (Shanahan et al. 2010). Ultimately, practices with low quality evidence have simply not been tested in a large number of settings; with accumulation of additional implementation efforts with similar documented results, evidence quality for the same practice could improve over time (Smith-Colin et al. 2014). Similarly, in evidence-based management, high quality evidence refers to those practices with an accumulation of case studies, with the caveat that the variables used to validate case study experiences must be carefully identified since different organizations exist in different internal and external contexts (Smith-Colin et al. 2014).

Amekudzi and Smith-Colin (2012) offer definitions of evidence levels (or evidence quality) in TAM experiences based on a review of the literature in other fields. Strong evidence refers to consistently performing evidence that can be translated to a range of DOTs and settings. Moderate evidence offers clear demonstration of improvement or strong proof of generalization but not both. Minimal evidence is based on strong theories and findings with supporting research, but without identified impacts. Much like in education and in management, generating evidence and defining evidence quality for TAM implementation in DOTs is a less rigorous process than in other fields where controlled environments can be created more readily. This approach, therefore, adopts the case study methodology, generating evidence for whether or not practitioners report that an implementation strategy addresses a factor category. As individual DOT TAM implementation experiences are documented using the TIRF, trends will evolve, revealing the program sustainment factors that implementation strategies are reported to

address. With the TIRF, it is important to note that evidence quality becomes important when an agency is looking to learn from the experiences of others. While state DOTs and other agencies have the history of learning from one another through various forums, the TIRF offers a basis for developing a structured environment in which agencies can progressively learn about program implementation from one another, and contribute to a growing practitioner knowledge base.

3.3 Applying the TAM Implementation Review Framework (TIRF)

As previously stated, the TIRF is designed to facilitate a systematic review of an agency's TAM implementation approach, whether specific strategies or more general methods. Using the established criteria, this process results in an informative illustration of how the implementation approach can contribute to program sustainment. An Excel worksheet has been developed to implement the conceptual framework as described in the previous sections; specific implementation strategies or aspects of the approach are listed, the primary observed or expected impact or outcome is specified, and the criteria category addressed is indicated with a simple syntax – when a strategy addresses at least one criteria in a category, the letter "Y" is entered into the appropriate cell.

3.3.1 A Generic Example

Figure 3.2 shows a view of the TIRF applied to an Example DOT. The strategies used in this example review are taken from implementation activities suggested in the FHWA TAM Expert Task Group report on *A Strategic Framework to Support the Implementation of TAM in State Transportation Agencies* (FHWA TAM Expert Task Group 2012).

Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	Guidance and Expectations	Leadership and Executive-Level Support	Applications in Decision Making	Reflection in Agency Culture and Language	Employee Awareness & Understanding	Comprehensive Agency Alignment	Resources Committed to TAM Development
Peer Exchanges		Y				Y		Y
NHI Training		Y		Y	Y	Y	Y	Y
Expert technical assistance		Y		Y	Y	Y		Y
Handbooks and guides		Y	Y	Y	Y	Y	Y	Y
Budgeting templates		Y		Y	Y		Y	Y
Software programs implemented				Y				Y

Figure 3.2 TAM Implementation Review Framework Example

As shown, this sample of implementation strategies (and therefore the approach suggested by the sample) for Example DOT shows commitment to TAM development with resources, and an emphasis on addressing TAM applications in decision making, with less emphasis on Leadership and Executive-Level Support. This presents a picture of possible gaps in the agency's TAM implementation approach which can be addressed based on the agency's priorities and/or ability to address the gaps.

There are a number of things that are important to note with respect to the output of this framework. First, it is necessary that each strategy meets at least one criterion, otherwise the benefit of the strategy for program sustainment is questionable. The output from this tool shows how the implementation approach leans with respect to the criteria categories and where opportunities for improvement may exist, if desired. Since the TIRF does not provide an assessment of the agency's approach to TAM implementation, the number of categories addressed (that is, the number of cells filled with a 'Y') is not as important as where cells are filled. The goal here is not to fill all the spaces, but rather to demonstrate where opportunities may exist to make additional improvements to increase the prospect of sustaining TAM practice and principles in business processes and decision-making.

While the TIRF facilitates a systematic review of an agency's TAM implementation approach, it can also be useful for demonstrating how improvements to a TAM implementation process can be made by one agency based on another's experience. Along the lines of evidence-based decision making, this will be more apparent as more agencies conduct their reviews and make their experiences widely available for use. In this situation, the number of categories that a strategy addresses can be an indicator of the strength or usefulness of the strategy to justify adoption by another agency. For an agency looking to invest in a different TAM implementation strategy, the experience of Example DOT suggests that handbooks and guides may be more useful than peer exchanges, at least initially, because more benefit can be gained from that investment in terms of contributions to the program sustainment factors (or in simpler terms, the number of categories addressed). In the same way, if another agency sought specifically to improve employee awareness and understanding of TAM, the experience of Example DOT suggests that they should consider peer exchanges, NHI training, expert technical assistance or handbooks and guides as alternative strategies.

In this initial version of the TIRF, when an indication is made that a strategy addresses a category, the format of the tool does not make allowance for further indication of how exactly or to what extent the strategy addresses the category. A strategy addresses a category whether it addresses only one criterion in the category or all the criteria in the category; this level of disaggregation has been traded for increased simplicity and ease of use of the tool. Even where two strategies address the same criteria within a category, their effectiveness at addressing the criteria is a more complex relationship that can only be defined with empirical study. Ultimately, a strategy that

addresses only one category, but does so super-effectively, may be better than a strategy that addresses three categories superficially. Given the nascent state of this conceptual framework, understanding the relationships between strategies and categories and clear definitions of levels to which strategies can address categories requires additional empirical studies that are outside the scope of this work. As a first-order approximation for this initial version of the TIRF, the number of categories that each strategy addresses can be treated, at the surface level, as an indicator of the strength of the strategy for influencing program sustainment.

3.3.2 Context-Sensitive Considerations

There are two important factors to consider when making decisions based on the TIRF, either from an agency's own experience or from learning from others' experiences. First of all, as discussed from the literature, internal and external environments are important determinants of whether or not an implementation strategy will successfully address a category. For example, it could be argued that since leadership and executive-level support has been found to be a stronger determinant of the success of organizational change in public agencies (van der Voet 2014), it is important that an agency adopts implementation strategies that ensure that executives are visibly supportive of the movement towards TAM or that the TAM governing structure is held accountable in clear ways. However, if the agency's internal environment is such that tension between frontline staff and management results in ineffective relationships, or if most successful innovations have begun with the frontline employees, that is, the agency operates better with a bottom-up structure, it may be less beneficial to address leadership and more beneficial to address those factors can enhance employee action without involvement

from leadership. Ultimately, while each category can influence program sustainment, the extent to which this is possible will depend on the agency's context.

Secondly, it is useful to consider implementation strategies or improvement actions in the context of an agency's TAM program maturity; some criteria may be more important at one level of maturity versus another. The AASHTO TAM Implementation Guide (AASHTO 2011) defines five levels of program maturity on a scale that describes where agencies stand in terms of their use of TAM principles. Agencies can place themselves on this scale based on the results of a gap analysis and depending on where the agency lies on this maturity scale, the implementation approach is likely to take a different direction. Table 3.2 suggests the categories in the TIRF that may be important at each maturity level.

Table 3.2 Addressing TAM Implementation in the Context of Program Maturity (Adapted from AASHTO 2011)

AASHTO TAM Maturity Scale Level	Generalized Description	Recommended Focus
Initial	No effective support from strategy, processes, or tools. There can be lack of motivation to improve.	Employees Leadership Resources
Awakening	Recognition of a need and basic data collection. There is often reliance on heroic effort of individuals.	Guidance Alignment Resources
Structured	Shared understanding, motivation, and coordination. Development of processes, and tools.	Applications Resources
Proficient	Expectations and accountability drawn from asset management strategy, processes, and tools.	Culture Resources
Best Practice	Asset management strategies, processes, and tools are routinely evaluated and improved	ALL

At the initial level, it may be more important to focus on employee awareness and understanding of TAM and leadership and executive-level support to build buy-in and generate the motivation needed to develop the TAM program. At the awakening level, developing clear guidance and expectations while fostering comprehensive agency alignment will be important to move from a state of acknowledging the use and need for TAM towards actually applying TAM principles. At the structured level, the need to improve clarity on how asset management is actually done will be most important. At the proficient level, efforts to improve TAM reflection in agency culture and language will solidify the progress made in implementing TAM and enhance the opportunity for sustainment. Once an agency has achieved the level of best practice, the determination of which category to focus on will be dependent on other factors besides maturity. This should be at agency's discretion based on self-determined opportunities for improvement. Finally, efforts that address the Resources category are important at all stages of maturity to demonstrate commitment to the concept.

3.4 Summary

This chapter has presented a description of the conceptual framework and approach developed for enhancing TAM implementation to increase the likelihood of sustained programs in the long-term. The basis of the framework is grounded in literature from TAM development, program and policy implementation, and change management research, further supported by insight from a panel of experts in the transportation field involved in TAM program development and implementation. The conceptual framework can be applied to review an agency's TAM implementation practices with the use of the TIRF tool developed as a basic Microsoft Excel spreadsheet.

The value and contribution of this work will be better appreciated with demonstrations of its use which will illustrate the useful output that can be obtained from applying this framework.

CHAPTER 4: CASE STUDY APPLICATIONS

In the first phase of this research study, a conceptual framework for helping transportation agencies review their TAM implementation process towards enhancing the likelihood of program sustainment was designed based on information gathered through an exploratory literature review and a panel of experts in the field. The second phase involves a proof of concept of the TAM Implementation Review Framework (TIRF) using case studies of three Departments of Transportation (DOTs).

4.1 Study Methods

From the beginning, this work was approached as a policy and program implementation study particularly since much of the motivation was strengthened by the TAM implementation requirements in the 2012 MAP-21 legislation. As discussed in the literature review (Chapter 2), implementation research is an evolving, multidisciplinary field with theories and methodologies built from a variety of experiences in different fields. This means that unlike strict scientific research, implementation research study methods tend not to be standardized following a specific protocol, although there are some common typologies. The design of the case study demonstration of the TIRF was influenced by an implementation research study method known as field network studies in terms of the unit of analysis and the purpose of the study.

As previously discussed (in Section 2.2.2.1), field network studies are comparative case studies whose purpose is to gain a comprehensive understanding of the responses of institutions that are responsible for implementing large, non-incremental

federal policy changes (Lurie 2003). In applying this method to the TAM implementation study, the implementing institution is the unit of analysis, which in this case is the DOT, and the focus is on the structure of the program, than the actual delivery of the service. Multiple case studies are developed and analyzed, answering specific questions to generate a comprehensive report. The case studies are built based on data collected by a researcher who has some familiarity with the institution, using a common protocol to examine material and in some cases conduct observations. Data from the selected case study sites are then examined to produce a comparative analysis. Generally, the interpretation of data collected can be biased towards the discipline or background of the researcher. The use of a common data collection protocol allows for construct validity and easier replication of the implementation research process.

The case studies to demonstrate application of the TIRF also reflect general qualitative strategies of inquiry, exploring programs in depth, but bounded by time (i.e. limited to the current status of implementation). Data collection is also bounded by the scope of the research which includes those three elements of guidance documents, governing structure, and decision-making processes. Qualitative data collection in the form of case studies involves a small number of purposefully selected participant sites with data gathered from multiple sources (Creswell and Plano Clark 2007; Creswell 2009). The three agencies selected for this study were chosen due to their record of TAM development and implementation which increases the likelihood of data availability for this work, compared to an agency that either has no TAM program or is very recently beginning the process. In addition, the case study sites were selected for differences in their geographical location, size, and climate – most, if not all, of these characteristics can

have some influence on the practice of TAM. The range of agency characteristics is to ensure usability of the tool in different settings. Table 4.1 provides some basic information on the states selected.

Table 4.1 Case Study States' Basic Information

	Colorado	New York	Georgia
Census Region/Division*	West/Mountain	Northeast/Middle Atlantic	South/South Atlantic
Climate**	Cold/Very Cold	Cold	Hot-/Mixed-Humid
Total Population (2010)*	5,029,196	19,378,102	9,687,653
Land Area (2010)*	103,641.89 mi^2	47,126.4 mi^2	57,313.49 mi^2
Population per Square Mile (2010)*	48.5	411.2	168.4
DOT-Owned Centerline Miles***	9061 miles	15034 miles	17926 miles
DOT-Owned Bridges***	3444	7487	6652
Agency Head (per Org Chart)	11-member Transportation Commission (& Executive Director)	Commissioner	13-member Transportation Board (& Commissioner)
Formal TAM Start	2001 – TAM Plan	1997 – Internal Task Force	2009 – TAM Director

*(U.S. Census Bureau n.d.)
**(Pacific Northwest National Laboratory 2013)
*** FHWA Highway Statistics (FHWA 2013b)

This method of sample selection, known as purposive sampling, is a nonprobability sampling method that is based on the judgment of the researcher to focus on particular units that will address the research question in the best way, without much concern for proportionality but based on a variety of criteria such as which participants

would be most likely to contribute relevant and in-depth data (Lund Research Ltd 2012; SAGE Publications and Oliver 2006; Trochim 2006). While statistical generalizations cannot be made with this sampling method, reasonable, logical generalizations are possible and acceptable.

The data collection protocol used in gathering information from these states was a three-step process that involved initial information gathering with validation by state DOT representatives. First, agency TAM implementation profiles were developed based on data collected from multiple sources: agency TAM-related documents (including all versions of TAM plans), agency websites, agency-related public presentations on TAM implementation (conference and webinar), and other research studies on TAM implementation that involved the agencies under study. Information to build this "implementation story" was focused within the defined scope of this work - the general implementation approach, guidance documents, governing structure, and decision-making processes. After this initial data gathering step, interviews were conducted with the person identified as the lead in TAM implementation to fill any gaps. Based on the implementation story, a list of implementation strategies was compiled and the initial review using the TIRF was conducted. In order to reduce researcher bias in the initial review output, all compiled information was provided to the interviewee to review the case study write-up for accuracy, and validate the initial application of the TIRF. It was requested that three to five people in the agency who are familiar with the TAM implementation process conduct an assessment of the TIRF review to determine if it reflects their experience with the agency, making modifications as necessary. Responses were then combined into the final review output. The data collection and case study

methodology employed both triangulation (collecting data from different sources) and member checking (obtaining participant agreement) which are qualitative validation strategies.

4.2 Case Study 1: Colorado Department of Transportation (CDOT)

The Colorado Department of Transportation (CDOT) has been known to stay ahead of the curve when it comes to TAM. The state of Colorado covers about 104,100 square miles and has the highest average elevation of any state at about 6800ft above sea level (FHWA 2004). CDOT manages the state's transportation system under the direction of the State Transportation Commission (TC), a statutorily authorized board of 11 commissioners representing specific districts who are appointed by the Governor and confirmed by the state Senate (CDOT 2014a; FHWA 2004; Markow and Racosky 2001). The TC formulates policy and provides guidance on construction, maintenance and management of the state's highways and transportation system in five defined transportation regions (CDOT 2014b; FHWA 2004; Markow and Racosky 2001).

CDOT's vision, according to their website, is "to enhance the quality of life and the environment of the citizens of Colorado by creating an integrated transportation system that focuses on safely moving people and goods by offering convenient linkages among modal choices" (CDOT 2014b). The department is responsible for about 9100 centerline-miles of highway and over 3000 bridges (Cambridge Systematics and Redd 2013; FHWA 2004) and is led by an Executive Director as shown in the organizational chart in Figure 4.1.

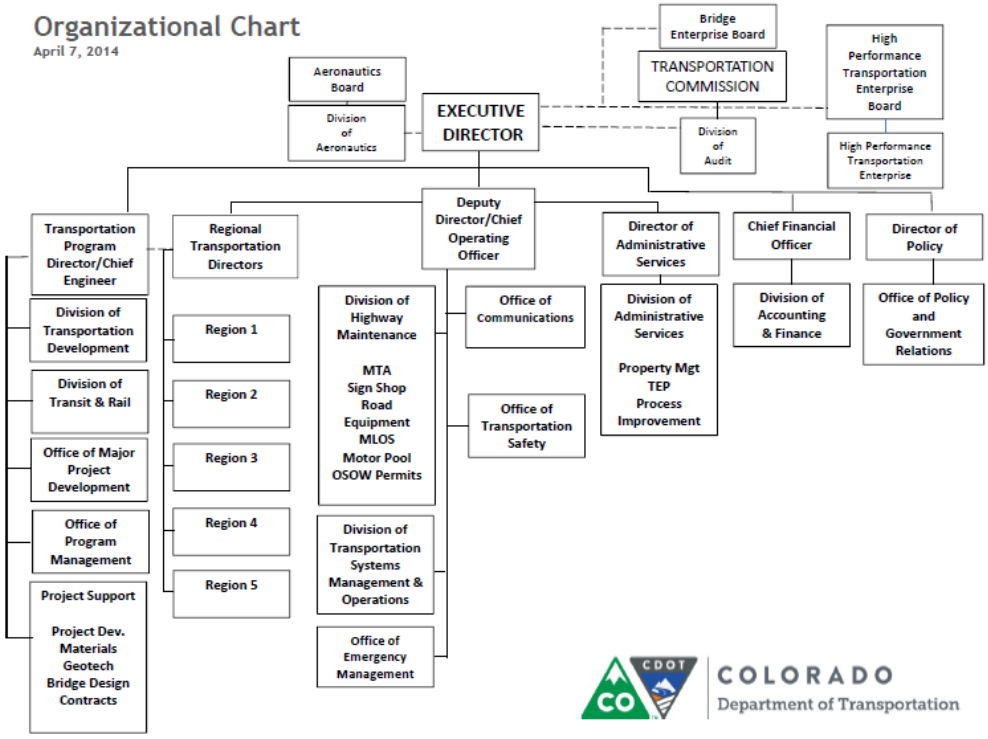

Figure 4.1 CDOT Organizational Chart (CDOT 2014b)

4.2.1 TAM Implementation Approach

The practice of asset management at CDOT began long before the federal mandate in MAP-21 existed. In fact, CDOT had some form of a TAM plan as early as 2001 (Markow and Racosky 2001). The *CDOT Asset Management Implementation Plan and Tiered System* was created as part of a study to review the agency's TAM practice and the use of TAM principles in other "leading" departments of transportation. A major accomplishment documented in this research report was the development of investment categories in the 1990s which organized program investments within a policy-oriented framework identifying performance measures and facilitating tradeoffs between different priorities (FHWA 2004; Markow and Racosky 2001). The 2001 plan was important for

communicating a vision for TAM and provided examples of how to translate the vision into specific recommendations for the different asset categories. One key aspect of this document was the detailed implementation plan for a series of objectives and tasks identified as "near-term" which referred to a period of one year after the plan was developed. These objectives were categorized in four key areas recognized as important to the development of a TAM program: policy and institutional factors, planning and program development, program delivery, and information and analytical tools. As shown in Figure 4.2, the TAM Implementation Plan even went as far as identifying implementation roles and assigning responsible units for each objective and task.

From the figure, one of the recommended tasks was for CDOT to create a task force to guide the implementation of the asset management plan. In 2001, the Asset Management Task Force was established, headed by the Deputy Director and including 10 representatives from across the department, to provide leadership and guide TAM implementation in the agency (FHWA 2013c). While the asset management plan was being developed, the agency implemented stand-alone management systems for pavements, bridges, and maintenance.

Following the release of the AASHTO Asset Management Guide in 2002, CDOT implemented a number of strategies towards developing their asset management program. This included a "book club" of employees to review the guide chapter by chapter (Park and Robert 2012), conducting of a self-assessment based on the process recommended in the guide (Park and Robert 2012), and the development of a draft asset management work plan in 2003 (CDOT 2014c).

Policy and Institutional Recommendations

Asset Management Objective *CDOT Unit Responsible*	Task	Timing and Cost
A. Designate a departmental task force under the Deputy Director to guide implementation of the asset management plan. *Director*	1. Designate the task force, building upon the experience of the Project Panel for Asset Management Plan development.	Near-term
B. Complete and refine Investment Category goals, targets, and performance measures *DTD*	1. Complete definition of statewide goals, targets, and performance measures for all programs.	Near-term
	2. Discuss the completed approach with local and regional planning agencies.	Near-term
C. Fold the performance measurement of all programs, including future strategic ("7th pot") projects, within the Mobility, Safety, and System Quality Categories *DTD*	1. Apply established performance measures to identify impacts of all projects, including strategic projects.	Near-term
	2. Implement procedures on a trial basis, assess results, discuss with Transportation Commission, and finalize.	Near-term

Figure 4.2 Excerpt from CDOT TAM Implementation Plan (Markow and Racosky 2001)

CDOT also saw many advances in data collection, management and eventually integration for a number of assets (including high-quantity, low-cost, ancillary assets) strengthening the asset management program (Akofio-Sowah 2011; CDOT 2014c). An NCHRP survey on the use of TAM principles in state highway agencies found that some of CDOT's advances in TAM, particularly for bridges, may have been driven by legislation in 2009 requiring the repair or reconstruction of bridges in poor condition through the Bridge Transportation Enterprise (Hawkins and Smadi 2013). This survey

also found that CDOT had identified a TAM champion, supported by efforts led by mid-level management (Hawkins and Smadi 2013). A 2010 Colorado state mandate that all state agencies use a performance-based budgeting process boosted CDOT's commitment to asset management and moved the agency towards integrating the management systems (AASHTO 2011).

Since the release of the AASHTO TAM Implementation Guide and the introduction of the TAM federal mandate in MAP-21, CDOT has continued to make significant advances towards implementing asset management throughout the agency. These steps toward implementation have included a Risk Evaluation Workshop to consider the risks for the agency in TAM, and National Highway Institute (NHI) Training Sessions which both contributed to a gap assessment process to uncover specific enhancement opportunities in TAM (Cambridge Systematics and Redd 2013). The gap assessment identified 10 priority areas which were further vetted in workshops with CDOT staff, and eventually fed into the Risk-Based Asset Management Plan (RBAMP). The RBAMP is the current CDOT TAM guidance document which meets MAP-21 requirements, and prioritizes the gap assessment recommendations based on their importance to the agency's TAM mission, the urgency to fill the gap, and the ease of implementing the steps to fill the gap (Cambridge Systematics and Redd 2013).

While CDOT did employ the services of consultants to guide the development of the RBAMP, a unique strategy they used was to employ a Program Leader in change management services who utilize the ADKAR model for change management. ADKAR stands for Awareness, Desire, Knowledge, Ability, and Reinforcement and is a goal-oriented tool that prioritizes the "people dimension" of change (Prosci n.d.). This model

for change management emphasizes communication with staff, focusing on the people aspect of the change process. The Program Leader communicates with change agents, change leads and sponsors spread throughout the agency.

4.2.2 TAM Governing Structure

CDOT's TAM implementation efforts are led by the manager of the Transportation Performance Branch in the Division of Transportation Development (see Figure 4.1) who heads the TAM Working Committee. Figure 4.3 shows the CDOT TAM Governing Structure. The TAM Working Committee is made up of representatives from all six transportation regions and from other agency divisions, with specific "asset managers" assigned for the different asset classes (Cambridge Systematics and Redd 2013). CDOT's asset managers synthesize information from the Working Committee to deliver to change agents in applicable parts of the agency, who then ensure that communication reaches the front line staff. While this is an informal structure, it is essential for making sure that communication is clear and effective. The TAM Working Committee meets monthly to ensure consistent and timely input from the agency-wide representatives and reports to a TAM Oversight Committee which consists of the Chief Engineer, the Chief Financial Officer, and Division and Regional Directors (Cambridge Systematics and Redd 2013). Out of the TAM Working Committee, a number of Task Forces lead the more specific TAM functions, like risk management.

Generally, CDOT's employees are involved in the process implementation at many levels. For example, the risk management process began with queries to staff to develop an initial list of risks that would impede CDOT from fulfilling its mission. This was followed by the Risk Task Force identifying a set of priority assets to develop a more

comprehensive list of risks and a workshop with subject matter experts to score those risks resulting in a risk register. Finally, the results of the risk register were presented to staff at a Risk Workshop to finalize the risks identified.

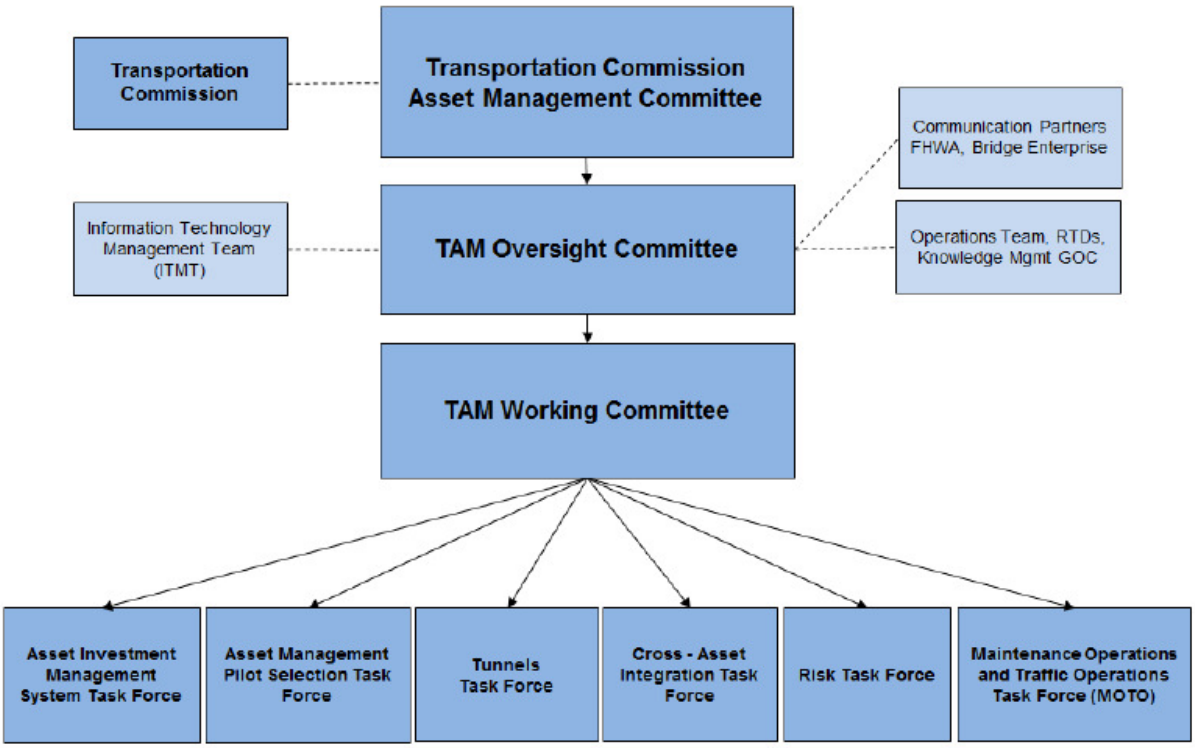

Figure 4.3 CDOT TAM Governing Structure (Cambridge Systematics and Redd 2013)

CDOT's TAM governing structure incorporates both the centralized and decentralized model with asset managers throughout the agency, reporting to a centralized committee that has final responsibility for TAM and TAM implementation. While specific asset managers have been hired, many of the employees in these roles were assigned based on their previously existing roles.

4.2.3 Guidance Documents

As previously stated, CDOT's first TAM plan (Markow and Racosky 2001) was developed in 2001, long before the requirement to have TAM plans in MAP-21 was introduced. This plan, developed as part of a research study on TAM, provides information on the very general ways in which TAM principles had been used in CDOT business processes and also discusses other states' experiences with asset management. This document presented an initial vision for CDOT's asset management program with examples of how to translate the vision into specific recommendations for each asset type. Arguably, the most important part of this document, for asset management implementation was the "Implementation Plan for Near-Term Items" which detailed the necessary steps for advancing the CDOT TAM program.

Twelve years later, CDOT has developed a new Risk-Based Asset Management Plan (RBAMP), with assistance from consultants, adapted to meet the requirements detailed in MAP-21 (Cambridge Systematics and Redd 2013). The development of the RBAMP was coordinated by the Transportation Performance Branch within the Division of Transportation Development with input from Staff Services. The Transportation Commission TAM Committee (see Figure 4.3) is the owner of this document, responsible for ongoing efforts to maintain and update it every two years (Cambridge Systematics and Redd 2013).

This current plan begins by clearly establishing the purpose which is stated "to provide a framework for staff to carry out the direction of the Transportation Commission and Executive Director" (Cambridge Systematics and Redd 2013 p. ES–3), with respect to asset management. The plan also clearly presents the goal of the asset management

program “to minimize life-cycle costs for managing and maintaining the department’s assets subject to acceptable levels of risks” (Cambridge Systematics and Redd 2013 pp. 1–2), and establishes clear links to the agency’s overall goals (particularly safety and maintenance). The RBAMP meets all MAP-21 guidelines for assets to be included, and adds maintenance (ancillary) assets, buildings, intelligent transportation system (ITS) equipment, fleet vehicles (road equipment), tunnels, culverts, and rock fall mitigation sites. CDOT’s RBAMP is presented in two parts with the first outlining the department’s ten-year plan for managing assets, and the second presenting the intended steps for improving the TAM program. Some unique features of the plan include a section establishing why TAM is important for the state by identifying problem areas that can be addressed by TAM (e.g. managing infrastructure to accommodate projected population growth), measurable objectives with associated performance targets categorized into aspirational and fiscally constrained targets, performance curves showing expected asset performance based on projected funding scenarios (for bridges and pavements), and a list of specific budgeting processes relevant or related to TAM with the role of the asset manager identified.

Part II of the RBAMP focuses on the advancement of CDOT’s TAM program, identifying gaps between the current and desired state of TAM at CDOT and the proposed action to achieve the desired state. An implementation plan is presented with a prioritized list of the ten project areas identified from the gap assessment, detailing what should be done to address the gaps, along with assigned staff responsibility and an implementation schedule for these near-term actions. The assigned project leads are responsible for developing the approach the department should take to address each of

the gaps with the given timeline. Images of the CDOT TAM Implementation Plan for the ten gaps identified are shown in Figure 4.4 and

Figure 4.5.

No.	Gap	Gap Dependencies (Prerequisites, etc.)	Resources Required	Project Lead	Begin Date	Deliver Date
1	Budget Distribution Process (FY 2017)	This capability will be improved by each asset documenting their process and tracking the status	Each asset manager is responsible for documenting how needs are assessed (incorporating risk) and funds are distributed for their asset.	Laurie Freedle/Kevin Henry	Aug 2014	Nov 2015
2	Risk Analysis	None	Staff time to identify, understand and rank risks to CDOT, and identify mitigation strategies	John Vetterling	Jan 2014	Oct 2014
3	Project and Program Delivery Risks	This capability will support the Strategic Management Framework	Managing delivery risks. This is part of the project pipeline and project portfolio management projects.	Richard Zamora	Jun 2014	Oct 2014
4	Establish Risk Framework	This capability will provide context for risk analysis	Staff time to suggest alternatives and SMT time to select and communicate chosen methodologies.	John Vetterling	Ongoing	Jun 2014
5	Analyze Budget Tradeoffs	Follows life cycle; this capability will support the asset budgeting process	CDOT is working towards cross-asset optimization, to better understand how to prioritize spending limited funds for the best overall ROI.	JoAnn Mattson/Laurie Freedle	Apr 2014	Nov 2014
6	Improve Project Scoping and Optimization	None – put this into place ASAP	Staff time to digest asset mgmt. concepts and determine how to apply them at every level, in a holistic manner to programs and projects.	Scott McDaniel/William Johnson	Ongoing	June 2014
7	Incorporate Life-Cycle Analysis	None – do ASAP, since this feeds other capabilities	Each asset manager must incorporate life cycle analysis into their asset management system and improve their understanding of how maintenance activities extend the life cycle of their assets.	JoAnn Mattson	Ongoing	Aug 2014
8	Target-Setting for RB AMP Update	Follows Tradeoff Analysis and supports Budgeting; Adjusted periodically	DTD and Staff Branches will work to make sure they understand direction from the TC and the SMT on this, and document accordingly.	DTD Planning: TBD	Oct 2014	Apr 2015
9	Strategic Management Framework	None – put this into place ASAP	Staff time from asset managers, regions, DTD, OFMB and Staff Branches, address the items listed in the Plan, Do, Check and Act framework.	Maria Sobota	Aug 2013	June 2015
10	TAM Benefits Communication	None – plan to provide communication regularly	Staff time to communicate change; and on the receiving side staff time to understand and implement the changes.	William Johnson	Aug 2013	Jun 2014

Figure 4.4 Screenshot of CDOT Risk-Based TAM Implementation Plan (Cambridge Systematics and Redd 2013)

Evidently, this RBAMP is the primary guidance document for TAM implementation at CDOT; however, one key question to consider is where the plan fits in with other planning and guidance documents and specifically how it can be used to leverage the business processes to ensure that TAM is actually being done. A strategic management framework dubbed "Plan, Do, Check, Act" (PDCA) is established in the RBAMP towards this purpose. The framework is described in detail in the next section.

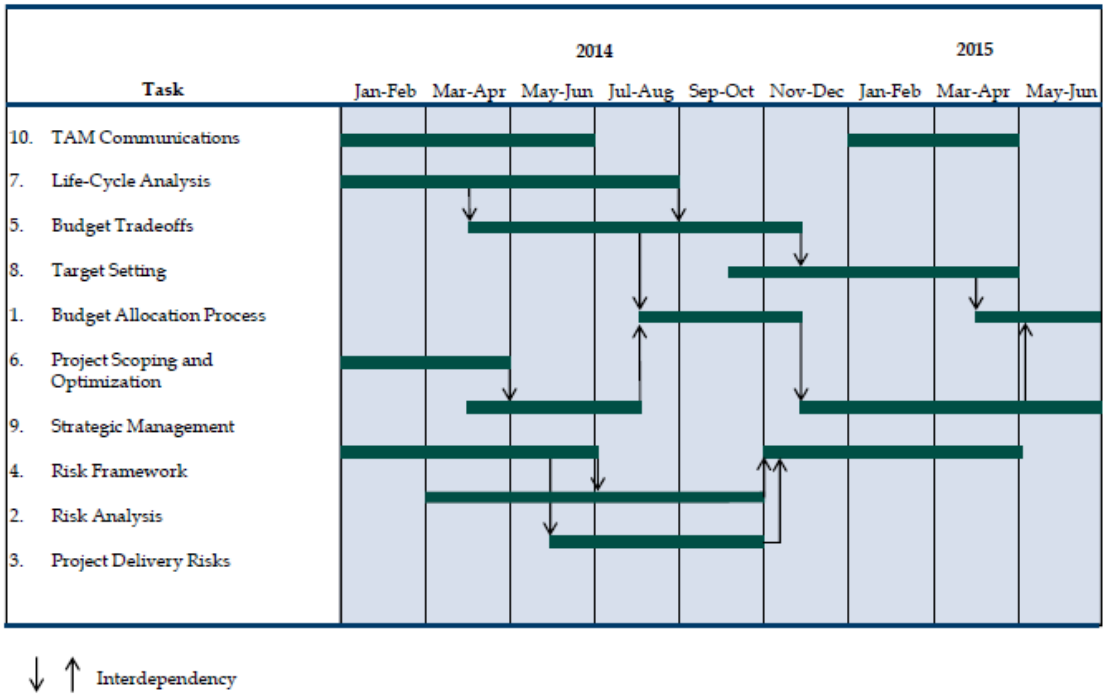

Figure 4.5 CDOT Risk-Based TAM Implementation Schedule (Cambridge Systematics and Redd 2013)

The Appendix of the RBAMP contains a *CDOT Guidance for Asset Management* which essentially is a summary of most of the key details in the RBAMP providing "direction regarding the risk-based asset management process as formal asset management structure, policies, and procedures are developed" (Cambridge Systematics and Redd 2013 pp. C–1). This four-page document includes brief descriptions of the governing structure for TAM, the assets and budget programs that are included in the TAM program, and explains the expected use of TAM principles in funding distribution and project selection. This provided interim guidance mainly for the asset managers, until the RBAMP was updated. After the release of the RBAMP, a workshop was held

for all employees to discuss the development and contents of the plan in an effort to increase the spread and understanding for the entire department.

4.2.4 TAM Decision Making

The CDOT RBAMP contains a section describing the asset management processes that were in place during the development of the plan. Here, the ways in which TAM programming is expected to be incorporated into the business processes of the department are clearly established beginning with the identification of existing processes that are relevant to TAM. One important part of TAM implementation at CDOT is the establishment of an organizing framework for asset management, the "Plan, Do, Check, Act" (PDCA) strategic management framework (Cambridge Systematics and Redd 2013). This framework, shown in Figure 4.6, also serves to align and incorporate all the agency's planning processes, including long-range planning and Statewide Transportation Improvement Plan (STIP) development.

While this is a cyclical process, the framework "begins" with the Plan phase where budgeting and project selection based on TAM principles and the use of the management systems occur. In the Do phase, projects are incorporated into the STIP, designed and implemented. The Check phase is where monitoring and accountability come into play to ensure that the process is working and proceeding as expected, and in the Act phase, feedback from the Check phase is considered in the agency's strategic and long-range planning processes to restart the cycle.

This framework provides a high-level view of how TAM is being implemented in decision making in CDOT; however, the RBAMP also provides additional details on the specific processes that come together to form this cycle.

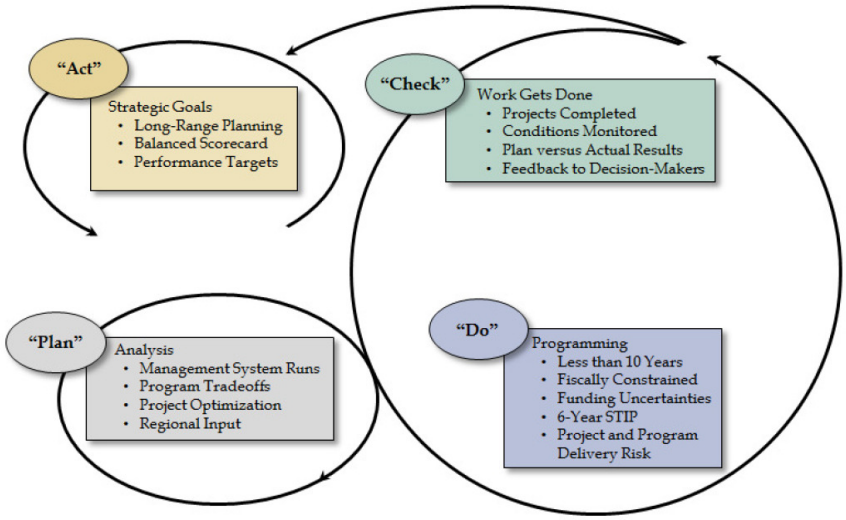

Figure 4.6 CDOT TAM Strategic Management Framework (Cambridge Systematics and Redd 2013)

Budgeting is achieved through the use of the Delphi process in a workshop attended by asset managers, budget staff, senior management, and regional staff. To receive funding, asset managers develop a 20-year performance curve based on budget scenarios and must demonstrate that their TAM systems, analysis tools and techniques have shown or are showing improvements. Staff present at the workshop vote on funding distributions in iterative rounds until consensus is achieved. Recommendations from the workshop are then presented to the Transportation Commission who makes the final budget decisions.

The RBAMP also provides guidance on project selection in the Plan phase of the PDCA framework for the asset managers and region staff who select projects recommended to the Office of Financial Management and Budget (OFMB) to be included in the STIP. Investment strategies define the type, location, and timing of TAM activities, providing general goals for process improvements and guidelines for the types

of activities to consider. CDOT employees who are responsible for selecting projects are given ample guidance based on the investment strategies and the expectations for TAM principles to consider recommended in the RBAMP.

4.2.5 Systematic Review of CDOT's Implementation Approach

As previously stated, the TIRF demonstration began with the identification of specific implementation strategies that characterize the approach used by CDOT. Essentially, this meant compiling a list of specific aspects of the implementation process that are either unique to CDOT or that can be attributed to a specific outcome or impact. About 24 strategies were identified and entered into the TIRF as shown in Figure 4.7. In this figure, the strategies shown on the left are sorted vertically according to the number of categories they address. At the same time, the categories across the top are sorted horizontally according to the number of strategies that address each one. Filled cells indicate where two or more contributors agreed that a strategy addresses the category. The purpose of the figure is to illustrate the general feedback from the output – the actual table output is provided in the catalog in Appendix A, where details are more visible.

From the output shown in Figure 4.7, it is clear that CDOT's implementation approach indicates a strong commitment to TAM development with significant investments in financial and human resources and an emphasis on data management. CDOT's implementation approach addresses the other categories in the following order: Employee Awareness & Understanding of TAM, Leadership and Executive-Level Support, Guidance and Expectations, Reflection in Agency Culture and Language, Comprehensive Agency Alignment, and Applications in Decision Making. Essentially, the analysis shows that there may be opportunities to improve the change implementation

process by focusing on strategies that can provide clarity on how TAM is actually done (Applications in Decision Making) and encourage a more comprehensive understanding of TAM throughout the whole agency with alignment from the strategic goals to customer service delivery (Comprehensive Agency Alignment). Since this framework does not suggest that one criterion matters more than any other for implementation effectiveness and longevity of change, there is no recommendation that CDOT needs to do more to address those last two criteria. However, if the agency has the desire to improve their TAM implementation, they might consider focusing on additional strategies that target improvements in those theme categories.

For an agency looking to learn from the CDOT experience, it appears that assigning "asset managers" in all divisions and identifying a point person or TAM champion were the most useful for CDOT in terms of improving TAM implementation in the agency, for enhanced program sustainment. On the other hand, according to the CDOT experience, the 2001 implementation plan, employing consultants and the 2003 draft AM work plan, while still useful in other regards, did not address many of the factors that are important for sustained change in the agency.

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	Resources Committed to TAM Development	Employee Awareness & Understanding	Leadership and Executive-Level Support	Guidance and Expectations	Reflection in Agency Culture and Language	Comprehensive Agency Alignment	Applications in Decision Making
14	Use "asset managers" in all related divisions	Staff accountability for implementation.The term asset manager became part of the culture	Y	Y	Y	Y	Y	Y	Y
6	Implemented integrated TAM system (AIMS)	Development of quantitative tool to perform trade-off analysis and cross-asset optimization. Continues to provide informed decision making.Data driven decision making; providing tools for budget setting to decision makers in consistent manner.	Y	Y	Y		Y	Y	Y
16	Agency-wide mid-level management represented on TAM Working Committee	Staff accountability for implementation. Maintains deadlines and prepares for delivery of content to Commission.Provide a forum for discussion and way to communicate change on a monthly basis.	Y	Y	Y	Y	Y	Y	
7	Identified TAM champion/point person	Staff accountability. Vital to success to have one individual as recognized authority for the department. Organizational change to elevate Transportation Performance to its own branch, and have the branch manager be the primary contact for asset mgmt.	Y	Y	Y	Y	Y		
10	NHI Training sessions	Gain staff knowledge of TAM. Beneficial from a standpoint of sharing best practices from other DOTs and of locking a large agency group in a room for two days to focus on TAM.Awareness to staff at HQ and regions; education and sharing of ideas.	Y	Y	Y	Y	Y		
24	Guidance for AM document	Interim instructions on AM process pending completion of implementation plan.	Y	Y		Y	Y		Y
8	Efforts supported by senior-level management via Oversight Committee	Facilitate staff-level decision making and support Transportation Commission TAM Committee direction and decisions. Important for Oversight Committee to exert influence but more vital for Executive Director and Transportation Commission to demand monthly public meetings on TAM. Alignment between asset mgrs/planners/budget staff with higher organizational concerns.	Y		Y		Y	Y	
13	Employed Program Leader in change management services	Leverage CM for TAM implementation and awareness. Helped streamline communication and push new information to regions in a manner consistent with other agency initiatives.Asset Management highlighted as one of many key changes within CDOT.	Y	Y	Y		Y		
17	RBAMP clearly establishes agency direction wrt TAM	Documentation of goals.Documents the as-is condition of asset mgmt at CDOT, and outlines a plan for improvement.		Y		Y	Y	Y	
22	Plan, Do, Check, Act framework	Use standard change management techniques.Emphasizes the need to go back and check how we did and compare it to what we planned to do		Y		Y		Y	Y
23	Delphi budgeting workshop	Interim investment programming activity that is in place until better analytical tools in the form of cross-asset optimization are developed. This is the key link to TAM and investment decisions. This turns TAM from an academic exercise to a practical one. Increase awareness among staff of how limited funds are and improves communication related to financial need	Y	Y		Y			Y
9	Risk evaluation workshop open to interested staff	Document risk factors for TAM. Helped provoke new thoughts and bring together many varied ideas on Risk.Begin to discuss what is risk and how does it impact CDOT's operations.	Y		Y	Y			
11	Gap assessment process identifying 10 priority areas	Identify priority action items for TAM implementation. Keeps the RB AMP dynamic and at the forefront of continued progress. Surveys highlighted areas to work on next.	Y		Y	Y			
21	Implementation plan projects have leads assigned with deadlines	Staff accountability for implementation.Emphasizes the need for accountability	Y	Y	Y				
2	2001 TAM Task Force	Staff awareness	Y	Y	Y				
3	TAM Guide Book Club	Formed framework for CDOT RB AMP. Staff gained knowledge of TAM; Staff education and discussion on next steps	Y	Y					
4	Initial self-assessment (based on TAM Guide 1)	Supported strategy for focusing on certain areas within TAM in building RB AMP. Identify current vs desired state. Identify gaps and next steps	Y			Y			
15	Transportation Commission AM Committee heads TAM program	Provide organizational policy for investment decisions. Generates a lot of additional staff work but stresses importance of TAM to those that might not otherwise feel compelled to contribute. Policy makers drive the change to CDOT's culture from capital projects to maintaining what we have.	Y		Y				
18	RBAMP describes value to citizens	Description of benefits of TAM to customers.Emphasizes CDOT's role as stewards of the system and the need for wise investment of limited dollars.		Y				Y	
19	Aspirational and fiscally constrained measures and targets described	Describe and document TAM goals. Helpful in understanding funding deficits.Generates discussion of targets and measures for assets that did not have them prior to the RB AMP. This is still evolving for smaller asset groups.			Y				Y
20	Implementation plan includes prioritized list of recommended projects	Describe action item where agency would develop new methods to optimize investment through quantitative and qualitative data.Project selection processes and the generation of a 4 year rolling program are in progress.		Y		Y			
1	2001 Implementation Plan	Documentation of initial asset management effort and needs; staff awareness	Y						
12	Employed consultants to develop RBAMP	Leverage industry professionals to accelerate development of plan and tools. Added credibility to RB AMP and brought insight from their work in other DOTs.Staff worked with consultants and benefitted from their perspective.	Y						
5	2003 Draft AM Work Plan	Staff awareness	Y						

Figure 4.7 CDOT TIRF Output

4.3 Case Study 2: New York State Department of Transportation (NYSDOT)

The New York State Department of Transportation (NYSDOT) is one of the three states that were selected to participate in an FHWA pilot project to develop TAM plans before the federal rulemaking was released (FHWA 2014). NYSDOT is led by a Commissioner of Transportation and an Executive Deputy Commissioner with five main divisions for statewide policy and program oversight. As shown in Figure 4.8, the agency also has 11 regional offices that are responsible for program delivery and operations and 68 county maintenance facilities (FHWA n.d.).

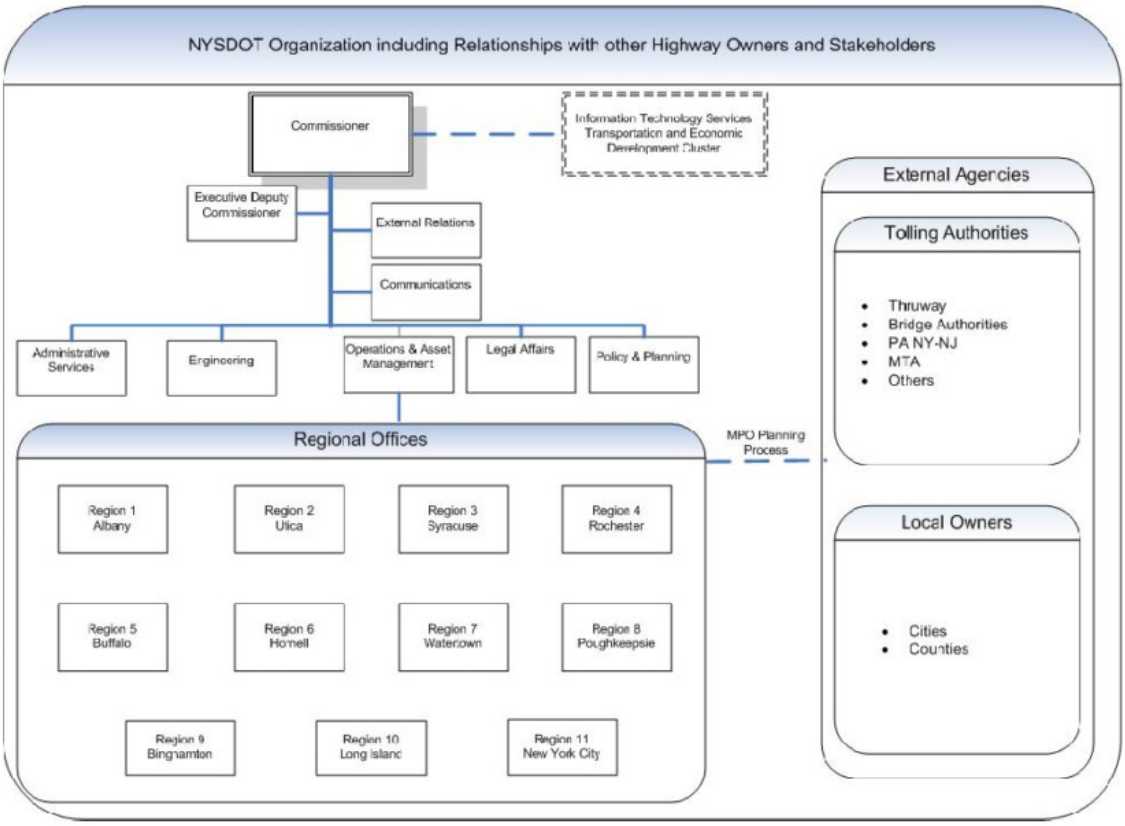

Figure 4.8 NYSDOT Organizational Chart (NYSDOT 2014)

The department is organized by functional programs (structures, planning, operations, etc.) in the central office as well as the regional offices (Clash and Delaney 2000). NYSDOT has about 8,000 employees statewide, managing an inventory of over 38,000 pavement lane miles and about 7500 bridges (NYSDOT 2014). While the department's inventory includes pavement markings, guiderails, sidewalks, culverts, traffic signals and traffic signs (Akofio-Sowah 2011), the current TAM effort is only concerned with bridges and pavements. Of all the NHS assets in New York State, only about 73% is owned and managed by NYSDOT; the remainder is owned and managed by municipalities and authorities such as New York City and the New York State Thruway Authority (NYSTA), with each owning approximately 10% of the NHS lane-miles. As such, NYSDOT's TAM efforts must include some collaboration with these two autonomous agencies.

4.3.1 TAM Implementation Approach

NYSDOT was among the first agencies to create electronic highway information systems (in the 1960s) and apply economic analysis to highway investments, putting TAM principles to use well before the concept began to increase in popularity in the industry (Clash and Delaney 2000; FHWA n.d.; Shufon and Adams 2003). These efforts were very much tied to organizational structure and decision making from the beginning, clarifying regional and main office roles, implementing goal-oriented programming, and improving and integrating management information systems through the 1980s and 1990s (FHWA n.d.). The Project and Program Management Information System (P/PMIS) was developed in 1990 to link those individual information systems. During that time, NYSDOT developed a formal, goal-driven business structure for decision making to

establish program and project priorities to be funded over a defined period of time, known as the Program Update Process (Clash and Delaney 2000; FHWA n.d.). The Program Update Process involves the following three stages: (i) establishing a statewide strategic direction (statewide goals and annual allocations distributed to each region with comprehensive instructions); (ii) regional program development including a detailed 12-year project selection; and (iii) program review and approval by the central office (Clash and Delaney 2000). Thus it can be said that by the late 1990s, NYSDOT had most of the major components of a TAM program, illustrated together in the flowchart in Figure 4.9.

In 1997, an internal task force was created to prepare a blueprint for advancing TAM implementation within the agency (Clash and Delaney 2000; FHWA n.d.). In the final report released a year later, the task force emphasized the need to enhance NYSDOT's approach to TAM by incorporating economic tradeoffs between individual asset classes. This led to a 2002 prototype TAM Tradeoff Model that employs economic tradeoff analysis, ranking candidate projects by rate of return on investment (FHWA n.d.; Shufon and Adams 2003). Currently, the tradeoff model is not used in program development.

In a 2002 NCHRP document, it was reported that NYSDOT had instituted a Capital Program Management Team made up of the First Deputy Commissioner, Chief of Staff, Chief Engineer, managers from planning, communications, budget and finance and the chief counsel for contracting and procurement (Cambridge Systematics et al. 2002). This executive-level body provided a review of the transportation program including forecasts, program targets, and recommendations.

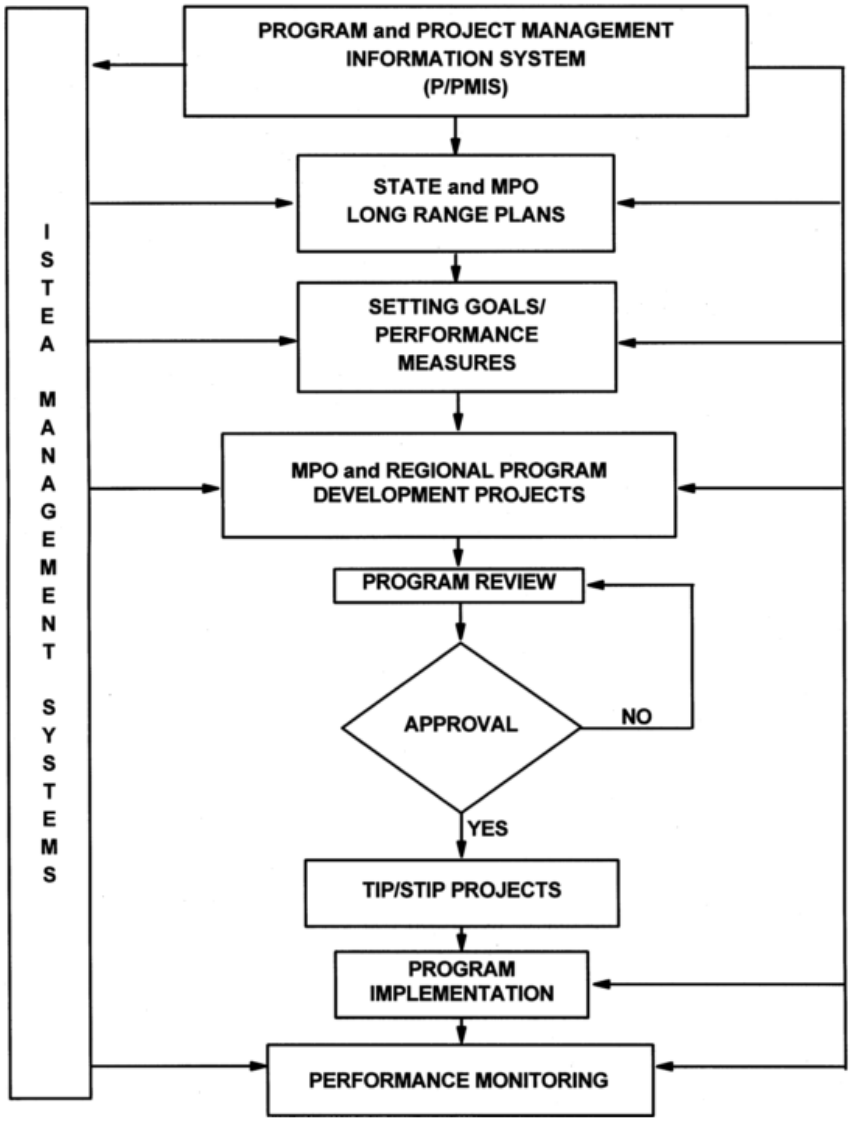

Figure 4.9 NYSDOT's early TAM system (Clash and Delaney 2000; Shufon and Adams 2003)

In May 2003, TAM program implementation was formalized with an announcement and direction from executive management that TAM principles should guide all infrastructure investment decisions (FHWA n.d.; Park and Robert 2012). However, there was a drop in momentum between 2003 and 2010 due to the loss of key

staff members in different parts of the organization. Stalled TAM implementation during this time has been attributed to failed efforts to reorganize, the narrow focus of the TAM program, and the decentralization of the agency's management and decision-making processes (Park and Robert 2012).

By 2011, NYSDOT had some asset management efforts for seven asset classes: earth retaining structures, traffic signs, guardrails, traffic signals, culverts, mitigation features, and sidewalks and ADA ramps (Akofio-Sowah and Amekudzi 2013). While the department had inventories for all these assets, there was no consistent data integration. The main use of this data was to estimate the capital improvements needed to achieve a state of good repair for those assets, based on investment needs. Since then, the agency has implemented a new asset management framework led by a Capital Asset Management-Capital Investment (CAM-CI) team to address a number of goals towards improved implementation (Park and Robert 2012). As shown in Figure 4.10, the framework considers action in two categories: preservation and beyond preservation.

By 2013, the NYSDOT implementation approach had evolved to emphasize four main aspects: an enterprise performance management framework, a robust inventory system, supported by comprehensive asset data collection, and a TAMP developed in accordance to MAP-21 (Park et al. 2013). Implementation is guided by four principles known as the "Forward Four" (Mcdonald 2014; Park et al. 2013) shown in Figure 4.11. NYSDOT's approach has a focus on improving investment quality, leveraging existing data and tools, minimizing initial investment and implementation time, working collaboratively across the agency, and employing TAM principles in a systems approach, implementing the Enterprise Asset Management Program (EAMP) from Agile Assets (Park et al. 2013).

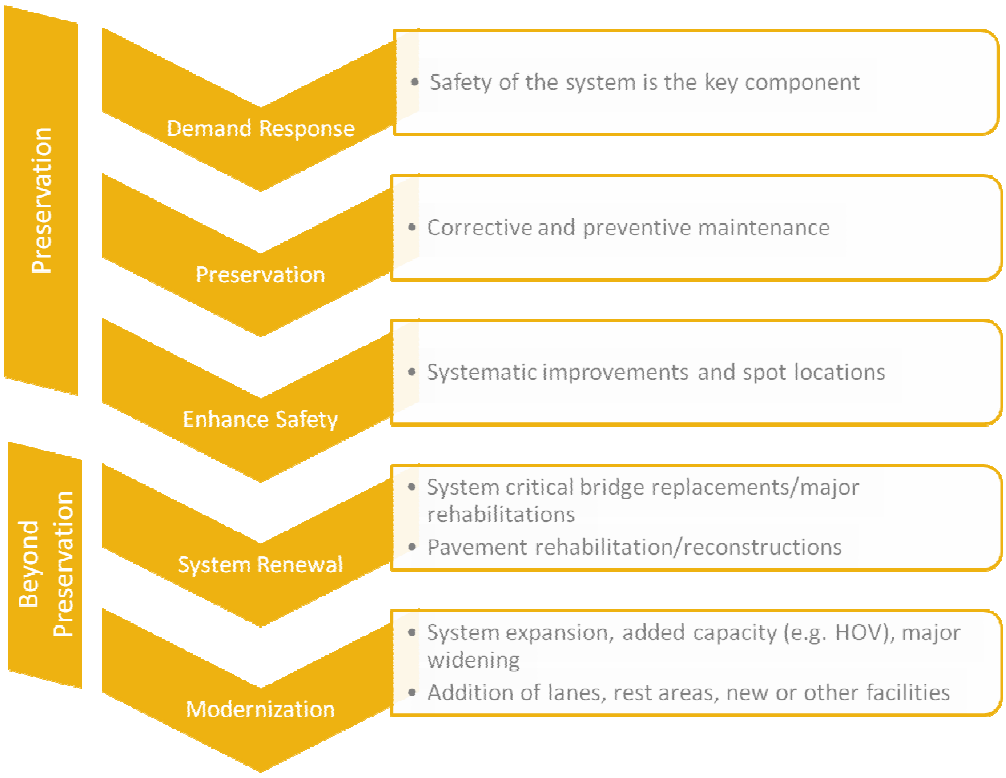

Figure 4.10 NYSDOT CAM-CI TAM Framework (adapted from Park and Robert 2012)

Figure 4.11 NYSDOT Forward Four Guiding Principles (NYSDOT 2014; Park et al. 2013)

4.3.2 TAM Governing Structure

NYSDOT's TAM governing structure has evolved over time from the 1997 internal task force to the early 2000s Capital Program Management Team, to the more recent Comprehensive Asset Management-Capital Investment Team. In 2011, recommendations from the CAM-CI Team led NYSDOT to create a new business structure for TAM, with the goals of: (i) improving the quality of investment decisions; (ii) leveraging existing data and tools; (iii) establishing collaborative relationships across the department; (iv) employing AASHTO TAM guidance; and (v) adopting a systems approach to TAM. The internal structure, shown in Figure 4.12, is made up of groups of staff across program areas in the main office and in regional offices and is built to be functional, not organizational (Mcdonald 2014; Park et al. 2014). In this structure, TAM efforts are led by the Comprehensive Program Team (CPT) with oversight from the Capital Program Delivery Committee (CPDC).

The CPDC is headed by the Commissioner of Transportation and is made up of other executive-level officials, as well as key staff such as the Director of Regional Planning and Program Management. This high-level committee provides the strategic vision and executive leadership for asset management implementation in NYSDOT and provides oversight to the CPT. The CPT is co-chaired by the TAM Champion and the Program and Project Management Champion, providing statewide leadership on TAM policies, practices, tools, and investments. This team has some common membership with the CPDC, including at least one Regional Director and the co-chairs of the Statewide Asset Management Teams (SAMT). There is one SAMT for each asset class and function considered to be of high priority.

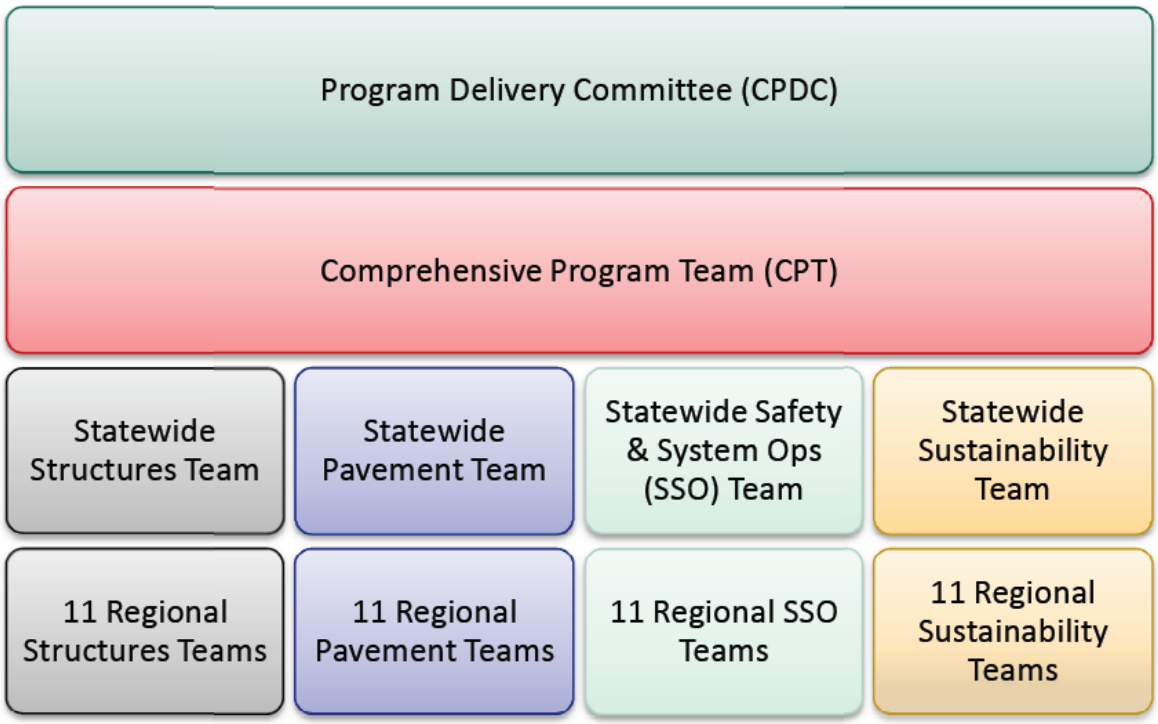

Figure 4.12 NYSDOT TAM Governing Structure/Internal TAM business structure (Mcdonald 2014; Park et al. 2013)

Each SAMT comprises of managers and experts from different functional areas (e.g. planning, engineering, geographic information systems support, etc.) and is responsible for establishing how their asset class is managed from a statewide perspective. The Regional Asset Management Teams (RAMT) make programming decisions to work towards the achievement of targets within their asset class or function area. While these teams receive some goals and guidance from the SAMTs, they operate under a Regional Program Committee for each region (Figure 4.13) which also dictates the specific make-up of each RAMT.

Figure 4.13 Regional Program Committee and Regional TAM Teams (Mcdonald 2014)

Outside of this structure, a Working Group was formed within NYSDOT to develop the TAMP, led by the TAM Executive Champion, a project lead and a project manager with representation from regions and units across the agency (Park et al. 2013). This team of technical experts also included external stakeholders such as a FHWA Division liaison, and MPO representative, and consultants hired to help in developing the TAMP (AASHTO 2014).

4.3.3 Guidance Documents

As previously stated NYSDOT is one of three states selected by the FHWA to develop TAM plans as part of a pilot project conducted prior to the release of the TAM plan rulemaking. As such, NYSDOT's plan development kicked off in 2013 with the work plan completion in June 2013, and a final draft in November 2013 (Park et al. 2013). With a view of the TAMP as a link between short-term programming and long-term planning (Park et al. 2013), the DOT Commissioner was involved with the development process from the beginning, making it easier to bypass step-by-step approvals (AASHTO 2014).

As part of the pilot project, NYSDOT's TAMP Working Group developed the Work Plan at a workshop in collaboration with the FHWA and consultants with clear staff assignments and deadlines for specific steps to take in order to develop the TAMP (AMEC Environment & Infrastructure and Cambridge Systematics 2013). With a focus on bridges and pavements, the TAMP is aligned to meet MAP-21 requirements, providing a link between strategic investment decisions and program development practices in the agency (Mcdonald 2014).

NYSDOT's TAMP provides "a window into its asset management practices" and "a forum to codify current practices…and identify gaps" (NYSDOT 2014 p. ES–3) to be addressed in the future. In ten chapters, the document addresses the objectives of (i) institutionalizing TAM practices; (ii) communicating TAM policy and strategy; and (iii) documenting and prioritizing opportunities for improvement of business practices (NYSDOT 2014). The TAMP is designed to be a living document updated on a biennial cycle which is to be initiated by the CPT but carried out by a Working Group following the TAM policy development process which involves internal and external reviews before final approval (Mcdonald 2014). In terms of guiding TAM implementation, NYSDOT's TAMP clearly explains the processes that are important, including whole life management strategies, risk management and creating and updating the risk register, investment strategies, and performance target setting. One unique feature of NYSDOT's plan is the illustration of the connection between risk management and asset management, which clearly shows how both processes are expected to influence each other (Figure 4.14).

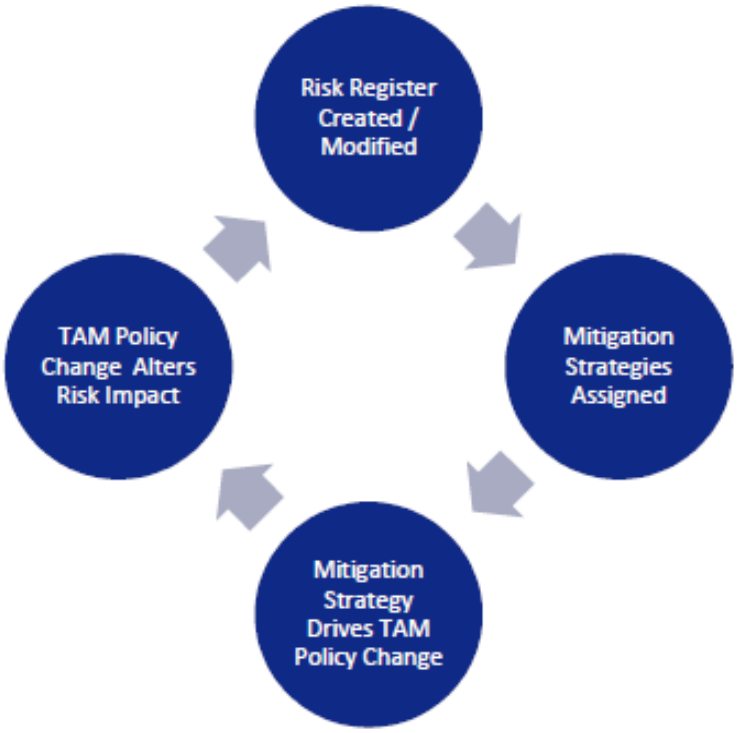

Figure 4.14 NYSDOT Risk & Asset Management (Mcdonald 2014)

In addition, the NYSDOT TAMP specifies performance targets for pavements and bridges, listing factors to consider in setting targets, and lists the steps to be followed in the iterative target-setting process. Furthermore, performance gaps are identified based on scenario analysis to illustrate the agency's need. The last part of NYSDOT's TAMP identifies internal and external challenges and opportunities that the agency faces with respect to future revisions of the document at both state and national levels, and lays out an agenda for improving TAM policy and the TAMP itself. After brief descriptions of the next steps for improving the TAM program, the document also includes an improvement plan listing major short-term (defined as one- to three-year) improvement initiatives with estimated timeframes and expected outcomes, shown in Figure 4.15.

Program improvements are generated from a number of sources including external regulatory audits, government policy, and internal reviews and assessments.

Driver	Response	Timeframe	Expected Outcome(s)
NYWorks - A comprehensive strategy for all NYS Capital Infrastructure Investments	Develop measures or methodologies to account for economic benefits of a proposed capital transportation investment.	< 2 years	Better tie transportation capital investment strategies to NYWorks and Economic Development Council(s) strategies.
MAP-21 Performance Based Planning	Work with MPOs to develop performance based plans that complement the TAMP.	< 2 years	A consistent set of performance measures that allow NYSDOT and MPOs to understand each stakeholder's responsibility and impact on Statewide goals.
	Establish a consistent set of performance measures for NYSDOT and MPOs.	2 – 4 years	
	Implement Portfolio Management Software to track accomplishments and performance.	< 1 year	An enterprise tool for planning and tracking project and program goals and accomplishments.
Tie TAMP to Long-Range Master Plan and Strategic Highway Safety Plan	Re-affirm or change the existing DOT Mission and Key Result Areas	< 1 year	Ensure that CPDC, CPT, and all Department program managers and staff clearly understand the overall mission and goals for the Agency.
	Use CPU 2014 to expand the "systems not projects" approach to include safety and mobility needs.	< 1 year	Better integrate safety and optimization into our asset management principles (the Forward Four) and asset management business structure.
	Expand CPU 2014 reporting to account for "pavement" and "bridge" funding that delivers accomplishments other than improving core infrastructure conditions.	< 1 year	Ensure funding stovepipes do not negatively impact the need to deliver safety and mobility
Integrate program modeling into a common enterprise TAM system that	Implement Enterprise Asset Management Program (EAMP) with at least the following modules including necessary inventory and condition assessment capabilities by December 2016.	< 3 years	Integrate program modeling into a common enterprise TAM system that allows for objective cross-program investment optimization

Figure 4.15 Screenshot of NYSDOT TAM Improvement Plan (NYSDOT 2014)

4.3.4 TAM Decision Making

As clearly stated in the TAMP, the main focus of TAM at NYSDOT is preservation and safety of infrastructure assets with the approach to TAM guided by four principles known as the "Forward Four" (Figure 4.11). These principles prioritize the preservation of existing infrastructure functionality and safety (Preservation First), then the consideration of investments in a larger context (System Not Projects), followed by

efforts to invest in a way that produces the greatest possible return (Maximize Return on Investment), and finally programming that "considers the relative and cumulative value of assets as they benefit the public, economy, and environment" (Make It Sustainable) (Mcdonald 2014 pp. 1–5).

With these principles forming the foundation, NYSDOT still makes use of the Comprehensive Program Update Process to select and prioritize projects for implementation. However, since the early development of this process, a number of other key processes have come to be involved to bolster the applications of TAM in decision making. For example, under the concept of "whole life management", windows of opportunity have been defined as that time period where a particular treatment is most effective or appropriate for a particular asset at a certain age. Specific treatments have been determined for specific windows of opportunity, identifying the cost effectiveness or relative costs of treatments in one stage versus the next. Computer models have been developed to determine these windows of opportunity, summarized in a Comprehensive Program Summary which includes all assets. This idea of whole life management looks at making program decisions for entire asset classes, distinguished from life-cycle cost analysis which, at NYSDOT, refers to a process used at the project level for individual assets.

Risk management is another process clearly defined and explained in the NYSDOT TAMP to improve understanding of applications of TAM in decision making. NYSDOT manages risk at the system level following a five step process to establish the context, identify, analyze, evaluate, and finally, treat the risks. This process is adopted from the International Organization for Standardization (ISO) Risk Management

Framework (ISO 31000:2009). Group brainstorming exercises that use facilitated discussions in statewide business units establish the context for risk management and identify the risks, which are then analyzed and prioritized by TAM business units before being assembled into a risk register presented to the CPT. After final approval from the CPDC, evaluation and treatment of risks is the responsibility of the TAM business units. The TAMP details this risk management process and presents the risk register, illustrating the connection between risk and asset management using the graphic shown in Figure 4.14.

NYSDOT has established three TAM investment strategies to help in decision making with a TAM perspective. As previously stated, the agency considers preservation first, prioritizing activities that extend or maximize service life over infrastructure expansion. Projects for investment at this level are selected on a regional basis, with planning targets established from management systems that are constant across the regions. Investments for assets that are beyond preservation, that is, those assets that have deteriorated beyond a state in which they can be preserved, are limited to projects initiated by MPOs or regions, ranked by statewide TAM teams with recommendations and a final project list developed by the CPT and CPDC respectively. The final investment strategy, demand recovery, addresses projects where the window of opportunity has been missed. These are then considered as part of the preservation priority lists. These investment strategies also define funding categories where the annual financial need is based on condition-based measures. Generally, while preservation decisions are made at the local and regional levels, the most important renewal and strategic improvement decisions are centralized.

An important aspect of the TAM process is target setting. At NYSDOT, scenario analysis is used employing in-house developed analysis software: the Pavement Model and the Bridge Needs Tool (NYSDOT 2014), which helps to identify performance gaps based on the targets set. An additional measure to help NYSDOT understand the gaps is the Asset Sustainability Index which is a ratio between the amount of money budgeted that directly impacts asset condition and the actual funding need to improve the asset to a given state.

One final process explained in the TAMP which is useful for applying TAM to agency decision making is the Policy Development Process which is the established process for development, review, and acceptance of all TAM policy including the TAMP, the comprehensive program, and STIP updates. With this process, a policy proposal is drafted by the initiating group which then undergoes internal review by the CPT and any other internal stakeholders deemed important by the CPT. For policies with external impacts, an external review and comment period follows, before resubmission to the CPT and CPDC for final approval. Generally, detailing these processes out in the TAMP is important to achieve consistency throughout the agency in applying TAM principles to make investment decisions.

4.3.5 Systematic Review of NYSDOT's Implementation Approach

For the NYSDOT demonstration, 24 implementation strategies that characterize the approach used were identified and entered into the TIRF, but after review by agency representatives, 21 strategies emerged as shown in Figure 4.16. Similar to the CDOT output, the strategies shown on the left are sorted vertically according to the number of categories they address, while the categories are sorted horizontally according to the

number of strategies that address each one. Filled cells indicate where a strategy addresses the category.

From the output shown, it is clear that NYSDOT's implementation approach indicates a strong commitment to setting clear guidance and expectations by creating a clear and streamlined perception of TAM throughout the agency, and providing direction on how TAM should actually be done. NYSDOT's implementation approach addresses the other categories in the following order: Leadership and Executive-Level Support, Resources Committed to TAM Development, Comprehensive Agency Alignment, Reflection in Agency Culture and Language, and Employee Awareness & Understanding of TAM. Generally, the analysis shows that there may be opportunities to improve the change implementation process by focusing on strategies that can promote cultural change and increase employee awareness and understanding of TAM. Here again, there is no suggestion that one criterion or category matters more than any other for program sustainment, however, the output gives NYSDOT a view of what could be addressed to improve TAM implementation to enhance program sustainment.

For an agency looking to learn from the NYSDOT experience, it appears that implementing regional performance targets in the comprehensive program update guidance, which ensured a minimum investment in preservation work in the regions, in addition to the use of the Forward Four principles, were the most useful for NYSDOT in terms of improving the state of TAM implementation in the agency, for enhanced program sustainment. On the other hand, according to the NYSDOT experience, employing consultants and gaining the Commissioner's approval of the TAMP Work Plan, while still useful in other regards, did not address many of the factors that are

important for sustained change in the agency. The details of NYSDOT's review are more visible in the catalog in Appendix A.

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	Guidance and Expectations	Applications in Decision Making	Leadership and Executive-Level Support	Resources Committed to TAM Development	Comprehensive Agency Alignment	Reflection in Agency Culture and Language	Employee Awareness & Understanding of TAM
24	Implemented regional performance targets in comprehensive program update gudiance (2011, 2013, 2014)	Regions given "preservation targets" to drive ensure at least a minimum investment in preservation work	Y	Y	Y		Y	Y	Y
9	Institution of "Forward Four" principles		Y				Y	Y	Y
2	(Comprehensive) Program Update Process	A unitified programmign process to align agency thinking, communications and objectives.	Y	Y			Y		
8	CAM-CI TAM Framework (Preservation & Beyond Preservation)		Y				Y	Y	
11	Created four-level internal business structure (2011)				Y	Y	Y		
13	TAMP Work Plan developed with clear staff assignments & deadlines				Y	Y			Y
16	TAMP illustrates how risk management and TAM are connected	The TAMP exists, but it is not widely understood by employees in general.	Y	Y				Y	
17	TAMP specifies performance targets for pavements and bridges and lists steps in target-setting process	The TAMP exists, but it is not widely understood by employees in general.	Y	Y				Y	
22	Scenario analysis using in-house software for performance gap identification		Y	Y		Y			
23	Established Policy Development Process		Y		Y	Y			
10	Implemented Agile Assets Enterprise Asset Management Program			Y		Y			
18	TAM Improvement plan with estimated timeframes and expected outcomes	The TAMP exists, but it is not widely understood by employees in general.			Y	Y			
19	Comprehensive Program Summary highlights treatment windows of opportunity		Y	Y					
20	Five-step risk management process detailed in TAMP	The TAMP exists, but it is not widely understood by employees in general.	Y	Y					
21	Three specific investment strategies outlined in TAMP	The TAMP exists, but it is not widely understood by employees in general.	Y	Y					
1	Project and Program Management Information System (P/PMIS)	Provides consistent data and reporting practices		Y					
3	Created the 1997 TAM Internal Task Force				Y				
7	May 2003 formal announcement of TAM implementation from executive management	Largely cerimonial			Y				
12	Formed TAMP Working Group					Y			
14	Consultants employed to assist with TAMP development					Y			
15	Commissioner approval of TAMP Work Plan				Y				

Figure 4.16 NYSDOT TIRF Output

4.4 Case Study 3: Georgia Department of Transportation (GDOT)

The mission of the Georgia Department of Transportation (GDOT) is to provide a "safe, connected, and environmentally sensitive transportation system that enhances Georgia's economic competitiveness by working efficiently and communicating effectively to create strong partnerships" (GDOT 2015). A 14-member State Transportation Board, representing each of Georgia's 14 congressional districts, oversees the operations of the department through an appointed Commissioner with a relatively extensive organizational chart as shown in Figure 4.17 (GDOT 2011, 2015). The agency is made up of several divisions and offices, seven districts that share responsibility for field services throughout the state and 32 area offices (GDOT 2011). One unique aspect of the GDOT organizational chart is that the Division of Planning reports directly to the Governor instead of going through the Commissioner. This essentially means that there could be added challenges for GDOT in implementing and applying TAM to investment decisions due to the potential for added political pressure in developing transportation plans.

GDOT's TAM plan only includes pavements, bridges, and highway sign assets. There are 123,456 miles of roadway in the state with only about 17,900 centerline miles on the state highway system that are maintained by GDOT (GDOT 2014). In addition, there are 14,700 bridges throughout the state, with about 6,600 managed by GDOT and approximately 3 million highway signs on state facilities (GDOT 2014).

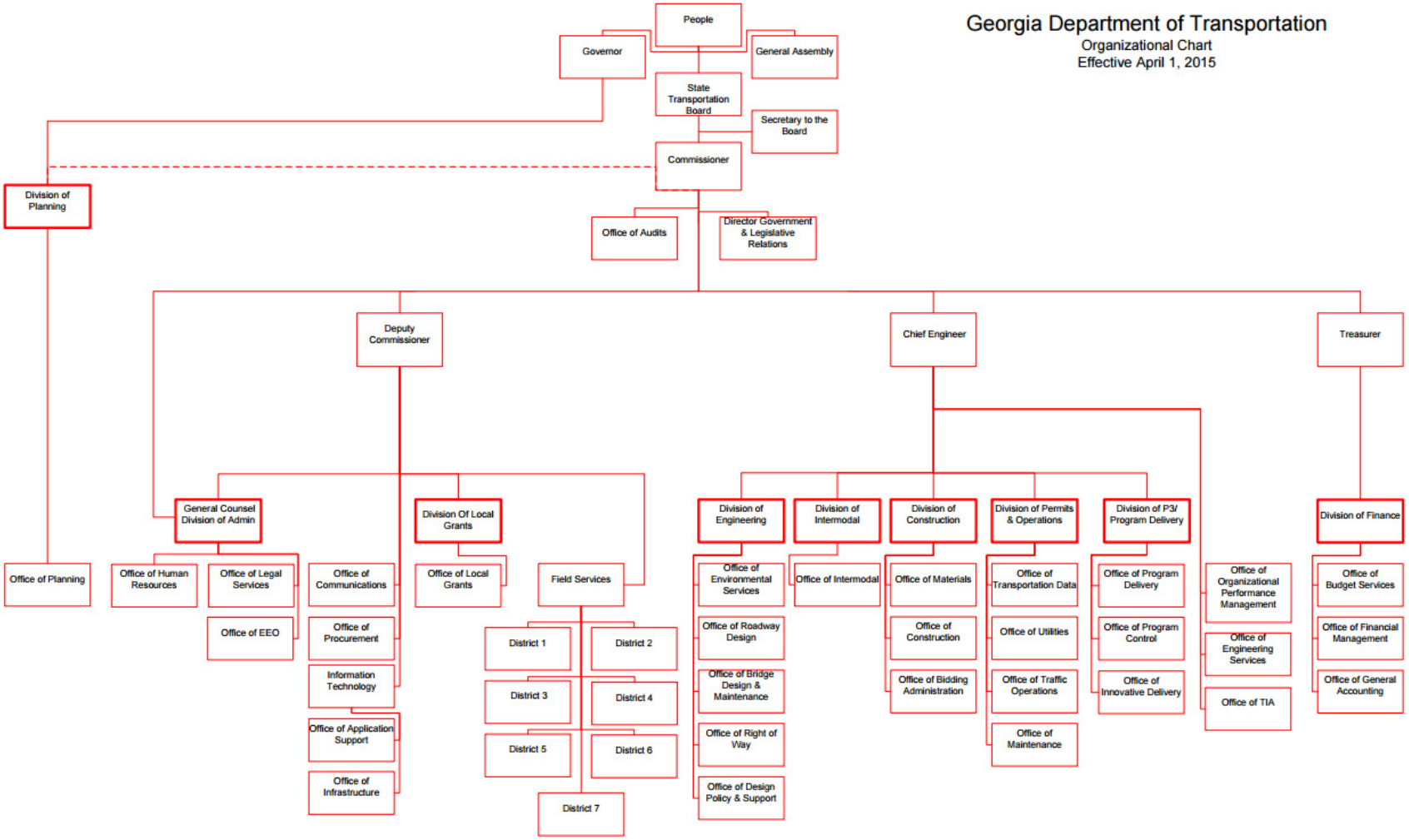

Figure 4.17 GDOT Organizational Chart (GDOT 2015)

4.4.1 TAM Implementation Approach

Historically, investments at GDOT were made in isolated groups of asset categories, before TAM principles were formally embraced in the last few years. The move towards TAM began in 2009 with the appointment of a TAM Director to champion efforts; however, prior information suggests that a shift towards TAM had already began in GDOT's maintenance division (GDOT 2014; Park and Robert 2012; Park et al. 2014). TAM principles were formally adopted in 2010 with an announcement from the Commissioner, providing an informal description of TAM (GDOT 2011, 2014). Around that time, the Office of Organizational Performance Management (OPM) was formed and tasked with TAM, performance management, and strategic development responsibilities; communication to District Engineers with information about TAM following the Commissioner's announcement came from OPM (GDOT 2011; Hawkins and Smadi 2013).

In 2011, a TAM Task Force was formed with representatives from each department that was deemed important for TAM implementation (GDOT 2011, 2014). The Task Force conducted a self-assessment of the agency's readiness for TAM using the AASHTO TAM Guide with higher level assessments performed by the Deputy Commissioner/Chief Engineer as well as the FHWA Assistant Division Administrator. As a result, a number of gaps were identified such as resource allocations that were not guided by a performance-based approach using consistent criteria, or data that was not fully accessible or integrated (GDOT 2014). Ultimately, the need for accurate data emerged as the number one priority area and continuing work resulted in the TAM Task

Force transitioning into an Executive Data Governance Committee with the purpose of ensuring data integration and availability.

While a FY2011 Strategic Plan Update was developed to reflect the agency's new focus on TAM principles, a Strategic Direction for TAM was also developed serving as an initial TAM plan (GDOT 2011, 2014). A series of "lunch and learns" were held after the Strategic Direction was published to communicate TAM objectives and concepts to employees to increase their understanding of TAM implementation (Park et al. 2014). At the same time, Asset Management Policy was formalized and published by the agency in order to adopt TAM as the "official, institutional approach in managing infrastructure assets and making capital investment decisions" (GDOT 2012 p. 1).

Since then GDOT has developed two versions of a TAM Plan with the most recent in 2014, formed a TAM Steering Committee to guide TAM implementation, and developed a comparative tradeoff analysis tool (GDOT 2014). In addition, two members of leadership have attended a national TAM Scanning Tour, and a web-based Performance Dashboard has been developed providing updates on maintenance, safety investments and preservation projects (Park and Robert 2012). Furthermore, the agency is in the process of developing a new Asset Management and Reporting System to integrate asset inventory data, and a geographic information systems (GIS) Data Visualization tool with Videolog technology for data collection (GDOT 2014).

4.4.2 TAM Governing Structure

As previously stated, the GDOT Office of Organizational Performance Management (OPM) was created specifically for the purpose of streamlining strategic planning, performance management, and asset management (Hawkins and Smadi 2013).

This unit is directly responsible for implementing and administering the TAM program and developing the TAM plan, and facilitates implementation efforts across other divisions (GDOT 2014; Park et al. 2014).

As previously stated, a TAM Task Force was formed in 2011 which eventually transitioned into an Executive Data Governance Committee (GDOT 2014). Other units within the agency that have been highlighted as essential for TAM implementation are the Office of Bridges and Structures (formed out of a merger between the bridge design and maintenance units), the Office of Transportation Data, which supports data integration and management, and Information Technology, which provides technical support.

More recently in 2012, a TAM Steering Committee was formed to guide direction and implementation of TAM principles throughout the agency, as previously stated (GDOT 2014). The TAM Steering Committee consists of key agency leaders such as the Director of OPM, the Director of Field Services, the Director of Permits and Operations, the Chief Engineer, and the Director of IT. The TAM Steering Committee meets monthly to discuss past or current activities as well as the agency's future needs related to TAM (GDOT 2014). While this Committee is the main TAM governing structure for GDOT, its operations are managed through OPM.

4.4.3 Guidance Documents

GDOT's first TAM-related guidance document was the 2011 Strategic Direction which presented an initial overview of the agency's approach to TAM and essentially represents a first attempt at a TAM plan (GDOT 2011; Park et al. 2014). This document

contained much of the same information that is updated in the 2014 GDOT TAM Plan and was the foundation for that plan.

Prior to MAP-21, GDOT was in the process of developing a formal policy statement that would adopt TAM as "the official, institutional approach in managing infrastructure assets and making capital investment decisions" (GDOT 2011, 2012). The policy establishes two main components of the TAM program, a TAM plan and an improvement strategy, and establishes OPM responsibility for TAM implementation, while also instituting the TAM Steering Committee for oversight (GDOT 2012). Additional unique recommendations in this policy are the emphasis on a data governance program, the requirement for all divisions to develop TAM Plans for assets under their jurisdiction to be included in the agency-wide TAM Plan, and a requirement for all contracts related to physical assets to be reviewed by the TAM Steering Committee.

Arguably, the most important guidance document for GDOT's TAM program is the current TAM Plan designed to comply with MAP-21 guidelines. The plan describes pavement, bridge, and highway sign management at GDOT, discussing levels of service based on the agency's strategic goals, department-wide performance measures, and customer feedback (GDOT 2014). In addition, the plan provides an overview of GDOT's funding sources, identifies key issues and general improvement strategies for each asset class, and addresses asset risk and ways to manage risk. Furthermore, the TAM plan includes an implementation plan, a performance management implementation plan, and a communications plan for TAM.

The GDOT TAM Implementation Plan is based on a framework that consists of four key TAM objectives: (i) a comprehensive data inventory; (ii) consistently managed

data; (iii) data-driven investment decisions; and (iv) TAM institutionalized within the agency (GDOT 2014). The implementation plan identifies objectives and strategies based on this framework and developed from the key findings of the AASHTO self-assessment conducted by the TAM Task Force and reviews of other states' approaches to TAM implementation. After detailing the state of the practice of TAM at GDOT and identifying specific TAM tools in the agency, an action plan with specific proposed steps towards TAM implementation is presented. The action plan has three levels – objectives, strategies, and action items – with a defined timeframe (near term, mid-term, long-term), identified unit responsible, resources needed, and expected outcome/output for each action item. In order to maintain some clarity, the roles of different agency departments for TAM implementation are described in this implementation plan. Figure 4.18 shows an excerpt from the implementation plan.

Objective 1: Develop a Comprehensive Asset Inventory

Strategy 1.1 Identify Critical Assets for Performance Measurement and Inventory

Action Item	Timeframe	Unit Responsible	Resources Needed	Expected Output/Outcome
1.1.1 Identify critical and supporting assets that are responsive to GDOT's organizational goals	Ongoing	Divisions/Offices responsible for individual asset types in coordination with Organizational Performance Management	• GDOT Strategic Plan • GDOT Asset Management Plan • Georgia Tech CTAMS report	• Documentation of critical and supporting assets to support overall asset management approach
1.1.2 Identify performance measures* to evaluate critical assets that support GDOT's mission and goals	Complete	Organizational Performance Management	• GDOT Strategic Plan • GDOT Asset Management Plan	• System performance measures established by OPM in conjunction with other offices
1.1.3 Determine roles, responsibilities, and costs for maintenance and improvement of these assets.	Mid to Long	Multiple Divisions and Offices depending on asset owners	• Documentation from Action 1.1.1	• Comprehensive list of assets that support GDOT goals

**GDOT's system performance measures are established by the Office of Organizational Performance Management in conjunction with all of GDOT's offices and divisions to support the evaluation of GDOT's goals. They can be found at http://www.dot.ga.gov/statistics/performance/Pages/default.aspx*

Figure 4.18 Screenshot of Excerpt from the GDOT TAM Implementation Plan (GDOT 2014)

As previously stated, the GDOT TAM Plan also includes a Performance Management Implementation Plan to provide guidelines and outline performance management procedures with respect to TAM implementation, and a Communications Plan that identifies strategies for presenting TAM to the department's internal and external audiences (GDOT 2014). The Performance Management Implementation Plan presents brief discussions on performance management principles, the roles and responsibilities for performance management implementation, and general steps for establishing performance measures, the use of scorecards and a performance dashboard, and methods of managing and reporting performance in the agency. Similarly, the Communications Plan identifies target audiences and includes the key messages to be communicated, methods of measuring communication success, and most importantly a list of communication strategies for different audiences, specifying the responsible party and the expected timeframe for communication as shown in Figure 4.19.

4.4.4 TAM Decision Making

At GDOT, performance management, TAM and strategic planning form a three-legged stool that supports the agency's primary function (GDOT 2014). In this way, the GDOT Strategic Plan drives TAM decision making particularly through the levels of service (LOS) which are "a qualitative measure of the public's perception of an asset's condition or of the services provided by an agency" (GDOT 2014 p. 5). For each asset category, LOS is measured using previously available tools through a life-cycle management approach to prolong assets' remaining useful life.

Audience		Strategies	Timeframe
Internal	State Transportation Board	▪ Communication with key Board Members – in contexts of maintenance efforts, fiscal responsibility and information we will be sharing with legislators and local government officials ○ Include information on TAM in Board orientation presentation ▪ One-on-one meetings with some or all Board members regarding TAM priorities in their respective districts. ▪ Powerpoint presentations and talking points prepared on TAM for each Board member to use in his/her district community meetings.	Near
Internal	Senior Managers	▪ Create TAM Steering Committee of key Champions (Director of Organizational Performance Management, Director of Engineering,	Complete

Figure 4.19 Screenshot of the GDOT TAM Communication Plan (GDOT 2014)

For pavements, a Computerized Pavement Condition Evaluation System (COPACES) is used to determine condition with risks managed on a project level (GDOT 2014). Treatment and investment decisions are based on the COPACES rating with risks incorporated by considering the functional classification of the route, the Annual average daily traffic (AADT), percent truck traffic, and county population. Bridge management and decision making is conducted following NBIS requirements with a standard method for optimizing decisions for maintenance strategies in development (GDOT 2014). A bridge prioritization ranking formula based on structural capacity and user demand is used to develop schedules for bridge rehabilitation and replacement, assigning the greatest risk to those bridges that carry higher traffic volumes and have the longest "detour length". The bridge prioritization formula has been used in the development of GDOT's STIP since 2011. Finally, traffic sign management is

conducted using the Sign Inventory Maintenance System II with inspections conducted as part of the Highway Maintenance Management System (GDOT 2014). Sign levels of service are determined based on the minimum retro-reflectivity levels from the Manual on Uniform Traffic Control Devices, with useful service life defined as the length of time a manufacturer will warrant the sign.

In order to make investment decisions, asset subject matter experts evaluate the risks associated with each asset in order to establish funding scenarios for various assets and programs; however, GDOT faces a significant challenge to TAM implementation and use in the form of a Congressional District funding balancing legislation which requires the department to distribute a percentage of federal transportation improvement funds (minus earmarks) equally among congressional districts over a five year period (GDOT 2014). Ultimately, this limits the agency's ability to apply TAM principles comprehensively.

4.4.5 Systematic Review of GDOT's Implementation Approach

For the GDOT demonstration, 27 implementation strategies that characterize the approach used were identified and entered into the TIRF as shown in Figure 4.20. Here again, the strategies shown on the left are sorted vertically according to the number of categories they address, while the categories are sorted horizontally according to the number of strategies that address each one. Filled cells indicate where a strategy addresses the category.

From the output shown, it is clear that GDOT's implementation approach indicates a strong commitment to TAM development with significant investments in financial and human resources and an emphasis on data management, with a similar

emphasis on implementation strategies that promote strong leadership and effective TAM governance. GDOT's implementation approach addresses the other categories in the following order: Employee Awareness & Understanding of TAM, Guidance and Expectations, Applications in Decision Making, Reflection in Agency Culture and Language, and Comprehensive Agency Alignment. There may be opportunities for GDOT to improve the change implementation process for an increased chance of program sustainment by focusing on strategies that can promote cultural change and encourage a more comprehensive understanding of TAM throughout the whole agency with alignment from the strategic goals to customer service delivery. Again, there is no suggestion that one category matters more than any other for program sustainment, however, the output gives GDOT a view of what could be addressed to improve TAM implementation, if desired.

For an agency looking to learn from the GDOT experience, a formalized TAM policy and a performance management implementation plan that described employee responsibilities with respect to performance management and steps for establishing performance measures, with the use of scorecards, a performance dashboard, and methods of managing and reporting performance, were reportedly the most useful in terms of TAM implementation for enhanced program sustainment. Here, it can be argued that breaking down the performance management strategy (ID 24 in Figure 4.20 or GDOT24 in Table A.3 in the Appendix for a clearer view) into a number of steps can decrease the perceived usefulness of the strategy for program sustainment in terms of the number of categories addressed. This speaks to the fact that it is important to consider how aggregated or disaggregate the strategies entered into the TIRF are. In terms of

strategies least useful for program enhancement, the GDOT experience shows that merging the bridge design and maintenance units, and using Levels of Service to tie strategic goals, performance measures, and customer feedback together, while still useful in other regards, did not address many of the factors that are important for sustained change in the agency.

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	Resources Committed to TAM Development	Leadership and Executive-Level Support	Employee Awareness & Understanding of TAM	Guidance and Expectations	Applications in Decision Making	Reflection in Agency Culture and Language	Comprehensive Agency Alignment
12	Formalized Asset Management Policy			Y	Y	Y		Y	Y
24	Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance	Evaluating performance will help to make adjustments to goals/objectives and targets.	Y	Y	Y		Y		Y
2	Commissioner announces adoption of TAM principles			Y	Y	Y		Y	
9	Developed 2011 Strategic Direction for TAM				Y	Y		Y	Y
10	FY2011 Strategic Plan Update reflected new focus on TAM				Y	Y		Y	Y
25	Communications Plan lists strategies for delivering key messages to internal and external audiences with expected timeframe and responsible party	Internal/external audiences will have a basic understanding of the need and purpose for asset management.	Y	Y	Y			Y	
4	Initial OPM communication to District Engineers				Y	Y		Y	
15	Leadership attended national TAM Scanning Tour		Y	Y	Y				
20	Requirement for all physical asset contracts to be reviewed by TAM Steering Committee			Y		Y	Y		
22	TAM Implementation Plan has specific list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes	Goals/objectives are clear and targets for specific action items are met.	Y	Y	Y				
1	Appointed TAM Director		Y	Y					
3	Formed Office of Organizational Performance Management		Y	Y					
5	Formed TAM Task Force		Y	Y					
7	Higher-level self-assessment conducted by Chief Engineer and FHWA Assistant Division Administrator		Y	Y					
8	Formed Executive Data Governance Committee		Y	Y					
11	TAM "lunch and learn"		Y		Y				
13	Formed TAM Steering Committee, reporting to Commissioner		Y	Y					
14	Developed comparative tradeoff analysis tool		Y				Y		
16	Developed web-based Performance Dashboard		Y				Y		
17	Developed and implemented enterprise-based TAM system (GAMS)		Y				Y		
18	Developing GIS Data Visualization tool		Y				Y		
23	TAM Implementation Plan defines department roles in implementation	Business Units will understand how their work fits into the bigger TAM framework.		Y	Y				
26	Asset "champions" (subject matter experts) evaluate risks to establish funding scenarios	Prioritized risks will help to achieve efficient funds allocation.	Y	Y					
27	TAMP describes how risk is factored into pavement and bridge decision-making tools	Understanding that factors other than asset condition are considered to make decisions.				Y	Y		
6	Conducted TAM self-assessment		Y			Y			
19	Merged bridge design and maintenance units		Y						
21	Levels of Service tied to strategic goals, performance measures and customer feedback								Y

Figure 4.20 GDOT TIRF Output

4.5 Insights from the Case Study Data

While the information documented using the TIRF in these three case studies is limited for drawing generalizations on the agency's general response to TAM implementation mandates, an analysis of the output reveals some useful insights that essentially provide a precursor to a larger database of implementation experiences accumulated over time. There are two main ways that the information gathered can be analyzed. First of all, there are trends with respect to which criteria and categories are well-represented by the TAM implementation approaches and which ones are not that can be distilled from the data. Secondly, the strategies can be compared to see which ones are common between the case studies, and of those, whether their perceived (and agency-reported) usefulness is similar, and where they fall in terms of usefulness for program sustainment compared to each agency's other strategies. Furthermore, the expected or observed outcome or impact of those common strategies can also be compared which would illustrate some of the differences in the reported effectiveness of strategies. Possible differences could be due to different contexts (internal and external environments), how long the strategy has been in place, or the maturity of the agency's program, among other variables.

4.5.1 Implementation Approach-TIRF Category Trends

The primary output that the TIRF was designed to produce was an idea of how each agency's TAM implementation approach leans with respect to program sustainment in terms of the seven categories of criteria that can enhance program sustainment. The framework also allows for the identification of sustainment-heavy strategies which hit at

multiple categories and so offer agencies a potentially wider range of impacts that are considered to influence program sustainment. While the case study results show some relatively different emphases from each of the agencies studied, it is possible to pull out some specific trends.

Table 4.2 shows the ranking of each TIRF category that emerged based on the case studies. As shown, CDOT's implementation approach has the greatest emphasis on Resources and the least emphasis on Applications. In the same way, NYSDOT's approach has the greatest emphasis on Guidance and the least emphasis on Employees. Finally, GDOT's analysis has the greatest emphasis on Resources and the least emphasis on Alignment. When these rankings are combined by computing an average (mean), it is clear that the TAM implementation approach taken by this specific group of agencies places a stronger emphasis on committing resources to TAM development and establishing TAM program leadership with executive-level support. However, there is less action towards creating comprehensive agency alignment and ensuring that TAM is reflected in agency culture. The rankings also very closely reflect the context-sensitive considerations discussion presented in Section 3.3.2 on which categories are more important at different levels of the AASHTO TAM Maturity Scale. The last column in Table 4.2 indicates the AASHTO maturity level that was aligned with each category in Section 3.3.2. As shown, if the categories were to be ranked based on that discussion and interpreted into a set of steps for implementation or even to assign weighting, the only differences with the observed average rank of these three agencies are that the Employee category would rise above the Guidance category, and Alignment would rise above Applications.

Table 4.2 Ranking of TIRF Categories based on Case Study Implementation Approaches

	CDOT	NYSDOT	GDOT	Avg Rank	AASHTO Maturity
Resources Committed to TAM Development	1	4	1	2	1
Leadership and Executive-Level Support	3	3	2	2.67	1
Guidance and Expectations	4	1	4	3	2
Employee Awareness & Understanding of TAM	2	7	3	4	1
Applications in Decision Making	7	2	5	4.67	3
Reflection in Agency Culture and Language	5	6	6	5.67	4
Comprehensive Agency Alignment	6	5	7	6	2

These observations could be interpreted to mean different things. First of all, committing resources towards a program is arguably one of the simplest and most straightforward steps in implementation. Whether an agency establishes a new department, appoints a new position, or purchases assisting technology, an investment is made in the implementation of the program illustrating a basic level of commitment that can send a message to employees that the organization is committed to the innovation. At the same time, this emphasis on committing resources means that the resources are available to be committed to TAM implementation which is a positive factor for enhancing program sustainment. Furthermore, it is clear that many implementation strategies will demonstrate resources committed, even if that is not the initial intention. Similarly, an emphasis on leadership and executive-level support is no surprise since

many agencies consider appointing governance positions as one of the first steps to be taken in implementing TAM. Again, implementation strategies that address this category are arguably some of the relatively simpler and more straightforward steps.

At the bottom of the list, strategies that will encourage a reflection of TAM in agency culture and language and create more comprehensive agency alignment being least emphasized by the three agencies could be attributed to different factors. With respect to institutionalizing TAM in agency culture, one could argue that this is a long-term goal, and thus, at this relatively early point in TAM implementation, most agencies are not taking steps to invest in this area. However, a counterargument is that it is important to clearly communicate TAM goals and applications throughout the agency, promote a uniform TAM language, and promote a long-term agency focus right from the very beginning (these are the three criteria which make up the Culture category – see Section 3.1.6). Alternatively, having the Culture and Alignment categories ranked at the bottom could be an indication that there are gaps in the industry's understanding of how exactly to create comprehensive agency alignment with respect to TAM, and how to ensure that the principles are engrained in agency culture.

To an agency looking from the outside, the ranking of the categories shown in Table 4.2 could very well illustrate or inform some sort of weighting to assign to the TIRF categories. The thinking here would be "if these agencies seem to have emphasized leadership and executive-level support and my agency has not, it may be a good idea for me to invest in that area." Similarly, the ranking could reflect an order of steps for an agency that is just starting out in TAM implementation to take, suggesting that the first thing to do is ensure that financial and other resources are available (which

includes data collection and management), before appointing some governance or leadership for the effort. While this data is only for three agencies, it is clear that the TIRF can enable a broader story of TAM implementation to emerge in terms of trends and emphasis areas among agencies. As agencies document their experiences using the TIRF and contribute it to a common knowledge base for TAM implementation strategies, the ability to generalize will increase, and the value of the knowledge base for informing others' investment decisions will be higher.

4.5.2 Common Implementation Strategies-TIRF Category Trends

In looking at the specific strategies that emerged from the case studies, it is clear that each agency has a different approach to TAM implementation. All the same, some strategies are common between the agencies and some simply follow the same theme. There are a total of nine strategies that are (or were) used by more than one agency. Out of those, only two are common among all three agencies: (i) implementing an integrated software system to support TAM; and (ii) including an implementation plan with specific time bound tasks and staff assigned to those tasks.

Figure 4.21 shows the combined systematic review of the integrated TAM system strategy by the three agencies. As shown, while NYSDOT and GDOT's experiences align in terms of perceived usefulness of this strategy for addressing the categories, CDOT shows a different experience with many more categories addressed. This difference is likely due to the type of systems implemented and their capabilities or the maturity of the different programs (that is, how long the systems have been in place). Ultimately, this output begins to show that the integrated TAM system strategy is

reported to address the Applications and Resources categories; additional documentation of experiences will strengthen this.

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT06	Implemented integrated TAM system (AIMS)	Development of quantitative tool to perform trade-off analysis and cross-asset optimization. Continues to provide informed decision making.Data driven decision making; providing tools for budget setting to decision makers in consistent manner.		Y	Y	Y	Y	Y	Y
NYSD10	Implemented Agile Assets Enterprise Asset Management Program				Y				Y
GDOT17	Developed and implemented enterprise-based TAM system (GAMS)				Y				Y

Figure 4.21 Screenshot of combined systematic review of "integrated TAM system" strategy

In the same way, Figure 4.22 shows the combined systematic review of the strategy of "having time bound implementation tasks with specific staff assigned to move the implementation process forward." Here, each agency indicated similar contributions to program sustainment; this would lead other agencies to consider this a potentially useful strategy for addressing the three categories of Leadership, Employees, and Resources. In Figure 4.22, NYSDOT has two rows that refer to the same general strategy of time bound implementation tasks with staff assigned. They are listed as "TAMP Work Plan developed with clear staff assignments & deadlines" and "TAM Improvement plan with estimated timeframes and expected outcomes". This situation results from the way in which strategies are entered into the framework.

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT21	Implementation plan projects have leads assigned with deadlines	Staff accountability for implementation.Emphasizes the need for accountability		Y			Y		Y
NYSD13	TAMP Work Plan developed with clear staff assignments & deadlines			Y			Y		Y
NYSD18	TAM Improvement plan with estimated timeframes and expected outcomes	The TAMP exists, but it is not widely understood by employees in general.		Y					Y
GDOT22	TAM Implementation Plan has specific list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes	Goals/objectives are clear and targets for specific action items are met.		Y			Y		Y

Figure 4.22 Screenshot of combined systematic review of "time-bound implementation tasks with staff assigned" strategy

Ultimately, this further demonstrates that the strategy aggregation discussed previously where the wording used to reflect an implementation strategy can affect the interpretation of its contributions to enhanced program sustainment. This is also illustrated in Figure 4.23 below which shows a combined systematic review of the multi-level governing structure implemented at two of the agencies. As shown, one agency has three items listed that relate to the same strategy simply based on the specificity of wording used. While CDOT lists "agency-wide mid-level management representation on TAM Working Committee", "efforts supported by senior-level management through the Oversight Committee", and "TAM program directed by Transportation Commission AM Committee", NYSDOT simply lists a "four-level internal business structure" which is also made up of an executive-level body (CPDC), senior-level management (CPT), and mid-level managers in the statewide and regional asset teams.

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT08	Efforts supported by senior-level management via Oversight Committee	Facilitate staff-level decision making and support Transportation Commission TAM Committee direction and decisions. Important for Oversight Committee to exert influence but more vital for Executive Director and Transportation Commission to demand monthly public meetings on TAM. Alignment between asset mgrs/planners/budget staff with higher organizational concerns.		Y		Y		Y	Y
CDOT15	Transportation Commission AM Committee heads TAM program	Provide organizational policy for investment decisions. Generates a lot of additional staff work but stresses importance of TAM to those that might not otherwise feel compelled to contribute. Policy makers drive the change to CDOT's culture from capital projects to maintaining what we have.		Y					Y
CDOT16	Agency-wide mid-level management represented on TAM Working Committee	Staff accountability for implementation. Maintains deadlines and prepares for delivery of content to Commission.Provide a forum for discussion and way to communicate change on a monthly basis.	Y	Y		Y	Y	Y	Y
NYSD11	Created four-level internal business structure (2011)			Y				Y	Y

Figure 4.23 Screenshot of combined systematic review of "multi-level governing structure with executive, senior, and mid-level management representation" strategy

This strategy aggregation issue can potentially be addressed as the tool matures to the point where a standard set of strategies can be offered to agencies as a departure point in using the TIRF, allowing them to also add their own strategies where none reflect their activity. All the same, this strategy of a multi-level governing structure also has some alignment between these two agencies in terms of which categories are addressed, with stronger evidence for some categories than others. Essentially, this data shows that a

multi-level governing structure is more likely to successfully address Leadership, Alignment, and Resources, than any of the other categories.

These observations of alignment in the TIRF categories addressed are similar for four other strategies with more distinct differences for the last two. The complete list of common implementation strategies reviewed in the TIRF is provided in Appendix B. Where alignment occurs, practitioner report that a strategy addresses a category may be distilled with accumulated documentation of experiences in different agencies. Implementation strategies reported by more agencies with alignment in the categories selected offer potentially more useful starting points to other agencies than cases where there is little or no alignment.

CHAPTER 5: MODEL REVIEW & REFINEMENT

The TAM Implementation Review Framework was continuously refined from the initial development stages through the case study demonstrations and analyses presented in the previous chapter. When asked about their general experience using the tool and whether it would be useful as they continue in their TAM implementation, the DOT representatives who participated in the case study responded positively, saying that the TIRF was straightforward, simple to use, and a good method to gauge their DOT's implementation of TAM. One practitioner mentioned his intent to have a wider range of coworkers complete the survey as part of their gap analysis for updating the TAMP. The most important feedback for refinement came from a practitioner review panel which is discussed below. While no substantive modifications were made to the tool itself, its applications and the interpretation of its output have evolved over time. This chapter presents the final design of the TIRF with guidelines for its implementation in practitioner settings, enhancing the possible utility of the tool in the transportation industry.

5.1 Practitioner Review Panel

In order to strengthen the applicability of the TIRF in practice, a practitioner review panel was conducted in May 2015 in the form of a structured webinar discussion. The objective of the TIRF Practitioner Review Panel was to obtain an evaluation and useful feedback on the TIRF criteria categories and the potential usefulness of the tool in practice. The panel consisted of eight professionals who are currently involved in TAM

implementation in state DOTs and other transportation agencies – there were two DOT representatives, five consultants from firms that are known for their work in TAM and TAM implementation, and one academic. The panelists, listed in Table 5.1, represent the FHWA TAM Expert Task Group (ETG), the AASHTO Subcommittee on Asset Management, as well as the TRB Sections and Standing Committees on TAM (ABC40), Pavement Management (AFD00), and Bridge Management (AHD35). Several of the panelists have also participated in NCHRP projects on various topics related to TAM.

Table 5.1 TIRF Practitioner Review Panelists

NAME	AFFILIATION	POSITION	CATEGORY
Abhishek Bhargava	Agile Assets	Product Manager	Consultant
Jason Bittner	Cambridge Systematics	Senior Associate Consultant	ABC40; Consultant
Jonathan Groeger	Amec Foster Wheeler	Principal Consultant	AFD00; Consultant
Tim Henkel	Minnesota DOT	Division Director, Modal Planning and Program Management	AASHTO; DOT; ETG
Sam Labi	Purdue University	Associate Professor	ABC40; Academic; AHD35
David Lee	Florida DOT	Administrator, Statewide Planning and Policy Analysis	DOT
J.P. O'Har	Parsons Brinckerhoff	Consultant	ABC40; Consultant
Charles Pilson	Agile Assets	Senior Principal Consultant	Consultant

The online webinar began with a presentation on the overall research study including a detailed explanation of the TIRF and the results of the case study demonstrations. Following the presentation, panelists had the opportunity to ask

questions and provide comments on their initial reaction to the tool. In general, this initial response was positive with comments offering suggestions for refining the TIRF and enhancing its practicality; there were no major issues raised regarding the criteria categories or the usefulness of the tool. After the webinar, a brief online survey was distributed for the panelists to further corroborate the TIRF to capture their feedback in a more accurate and permanent way. The four-question survey began with a matrix of ten statements that panelists were asked to indicate their agreement with from "strongly disagree" to "strongly agree". Their ratings were assigned scores from one (1) to five (5) with five being the highest (i.e. "strongly agree"). The survey, which was completed anonymously, had a 75% response rate with no response from two of the panelists.

Table 5.2 shows the ten statements posed to panelists in this first matrix rating question with the responses summarized. As shown, panelists agreed and strongly agreed that the TIRF is *suitable* for DOTs and that the seven criteria categories are *important* for TAM implementation and are *comprehensive*. In addition, panelists mostly agreed that the TIRF is *useful* for reviewing TAM implementation, that it will be *effective* for improving TAM implementation, that it is *applicable* in DOTs, and that it is *complete*. Panelists were mostly neutral on whether or not *additional criteria* could be included, and disagreed or strongly disagreed that the *output is misleading*. Statement nine on the use of the TIRF in other transportation agencies was the only statement with some recorded difference in opinion. While five of the six responding panelists (83%) agreed that the TIRF could be used in other transportation agencies, one panelist disagreed. The reason for this disagreement is not evident from the panelist's responses to the last three survey questions; however, other panelists' responses provide some insight.

Table 5.2 TIRF Practitioner Expert Panel Survey Question 1 (Matrix) Results

Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Weighted Average
1. The TIRF is useful for reviewing TAM implementation	0 (0%)	0 (0%)	1 (16.67%)	1 (16.67%)	4 (66.67%)	**4.50**
2. The TIRF is suitable for DOTs	0 (0%)	0 (0%)	0 (0%)	3 (50%)	3 (50%)	**4.50**
3. The TIRF is effective for improving TAM implementation	0 (0%)	0 (0%)	1 (17%)	2 (33%)	3 (50%)	**4.33**
4. The seven criteria categories are important for TAM implementation.	0 (0%)	0 (0%)	0 (0%)	1 (17%)	5 (83%)	**4.83**
5. The seven criteria categories are comprehensive.	0 (0%)	0 (0%)	0 (0%)	4 (67%)	2 (33%)	**4.33**
6. There are some additional criteria that could be included.	0 (0%)	2 (33%)	4 (67%)	0 (0%)	0 (0%)	**2.67**
7. The TIRF output provides misleading information	1 (17%)	5 (83%)	0 (0%)	0 (0%)	0 (0%)	**1.83**
8. I can see the TIRF in use in DOTs	0 (0%)	0 (0%)	1 (17%)	4 (67%)	1 (17%)	**4.00**
9. I can see the TIRF in use in other transportation agencies	0 (0%)	1 (17%)	0 (0%)	5 (83%)	0 (0%)	**3.67**
10. The TIRF is complete	0 (0%)	0 (0%)	2 (33%)	3 (50%)	1 (17%)	**3.83**

The second survey question asked panelists: "what do you see as a strength of this framework and tool?" Here, the general opinion was that the framework can be useful for reviewing agency implementation progress and can help an agency determine how to improve their TAM implementation. The comments collected were as follows:

"Could potentially serve as an objective beacon that agencies can use to measure the extent to which each different approach can help them reach TAM maturity. And therefore can help guide them on which ones to emphasize for their unique situations. By TAM maturity, I mean the situation where TAM actually becomes applied in a manner that is meaningful and perpetual."

"I really like your categories and the fact that you went outside the immediate area of TAM and looked at Change Management and other areas like the medical profession."

"The framework touches on the main topics I see with DOTs. It is useful to assess overall TAM strategies, especially the "soft" side of TAM including dedicating resources, changing culture, etc. This can be a very useful tool"

"Snapshot look at judging implementation progress or likelihood of success."

"Useful in review DOT TAM implementation; DOT's are developing TAM's and implementation processes. As DOT's update their TAM's and implementation

process they can critically assess the status and needs to enable focused improvement in areas of need."

"Appears to be very detailed."

Similarly, the next survey question asked panelists: "what do you see as a weakness of this framework and tool?" Here, no major weaknesses were identified; however, panelists gave useful suggestions for improving the use of the TIRF output to enhance its applicability. The refinement issues raised included making a clear distinction from the existing TAM-related tools, specifically the AASHTO Self-Assessment and the Gap Analysis tool, identifying recommended strategies to address each of the TIRF criteria categories, and providing some direction on how to prioritize the category areas for improving TAM implementation.

An important point raised in a comment was that agencies may be able to successfully implement TAM (and presumably sustain their program) even if the factors that form the foundation of the TIRF are not all addressed. Ultimately, the TIRF as it currently exists is not meant to be evaluative, in a way that tells agencies to what extent their implementation will be successful. Furthermore, the number of categories addressed cannot be interpreted into a measure of implementation success without further research and development of the tool. As such, there is no suggestion that implementation success will be hindered by a lower number of categories addressed. The TIRF simply highlights areas where improvements can be made, if desired. However, based on the findings from the literature review, it is fairly unlikely that a change

implementation process like TAM program implementation will be successful, in terms of program sustainment, without addressing at least one of the social capital factors included in the conceptual framework.

Another substantive issue raised in response to the question on weaknesses had to do with the applicability of the TIRF to other non-highway transportation assets. While this comment was not made by the same panelist who disagreed with the use of the TIRF in other transportation agencies in the matrix question, this comment provides further insight on the types of agencies that the framework may not apply to. Ultimately, since the scope of this work was limited to DOT highway assets, this particular comment was not incorporated in the refinement process. However, all other issues raised were addressed in the final design of the TIRF. The comments collected on weaknesses of the TIRF were as follows:

> *"No major weakness. One minor thing is that: I think that this is actually a HIRF not so much a TIRF. In other words, what you have may not be readily applicable to the management of other transportation assets (transit, marine, aviation, etc.) ... but might be applicable to TAM in those modes after a few tweaks."*

> *"I think that you need to firmly distinguish it from the existing gap analysis and self-assessment tools by emphasizing that it is focused on sustainability within the organization. I do think that based on your research, you could probably really contribute by giving specific recommendations for each of your categories so that*

when/if a state sees that they are lacking in any or the categories, they can look to your work to get concise recommendations about how to address these areas."

"The framework is solid. However, today's DOT TAM Asset Managers are usually new to their jobs and come from different departments of the agency with varying levels of knowledge WRT TAM. They are usually overwhelmed with educating themselves on TAM as well as starting to organize the DOT to implement TAM. Therefore, it would be very useful if there were some strategies to address the shortcomings that are identified through the TIRF process. What does the agency do next once presented with the results?"

"Variation in state DOTs -- some will be able to fully implement even if they don't have all of the elements in place."

"The research would be improved if it could study and document "the alignment of TIRF strategies and the AASHTO Maturity Scale." Also, the research could benefit from a description of category "priority" or "ranking" to aid DOT efforts to plan for improvements in TAM implementation process"

The final survey question simply asked panelists to provide any additional comments they may have. Here again, comments provided were mainly towards ways to refine the TIRF, reiterating previous suggestions to make clear distinctions from existing tools and to provide a list of recommended strategies to address each category. Again,

panelist feedback supported the usefulness and applicability of this work and the resulting framework and tool. The comments collected were as follows:

"Glad that you explained clearly the difference between TAM and TAM implementation, particularly with regard to AASHTO's self-assessment tool and TIRF. Would be useful to identify any parallels or inconsistencies between the two even though they serve different functions. Also, any synergies between the two could be identified and exploited in your framework so that the agency would avoid duplication of its self-evaluation efforts with regard to TAM elements and TAM implementation. Keep up the good work. We look forward to seeing and using your final product."

"I like the idea of a publicly available list of Strategies and information as to how each does or does not contribute to the categories. That way a state can go and look for strategies to address specific categories."

"This is very good work and should be useful to DOTs."

"Thanks for your work to improve TAM implementation."

"Great presentation in a short time period and obviously a significant work effort."

Overall, this feedback from professionals who have the practical experience of implementing TAM programs in state DOTs and in other transportation agencies strongly supports the conceptual basis of this research study and the framework developed to guide a review of strategies that can enhance TAM program implementation for sustainment in the business processes of state DOTs. This very relevant response from practitioners corroborates the TIRF, while suggesting some useful opportunities for refinement to improve its applicability and usefulness.

5.2 Final TIRF Design & Guidelines for Use

5.2.1 Summary of the TIRF Tool

The Transportation Asset Management Implementation Review Framework (TAM-IRF or TIRF) is a diagnostic tool that guides state transportation agencies in conducting a systematic review of their TAM implementation approach to produce descriptive results on how the approach leans the implementation process toward sustaining TAM programs in the long-term. The final design of the tool is a Microsoft Excel worksheet, shown in Figure 5.1, in which specific implementation strategies are identified with their observed or expected impact, and are then systematically reviewed using the GLACEAR methodology. An implementation "strategy" refers to a specific activity or action taken towards TAM implementation, while the implementation "approach" is the compilation of all those activities which would define the agency's general plan of action towards implementing TAM. The GLACEAR methodology asks the question "does the implementation strategy address the criteria in the X category?"

where X = **G**uidance, **L**eadership, **A**pplications, **C**ulture, **E**mployees, **A**lignment, or **R**esources.

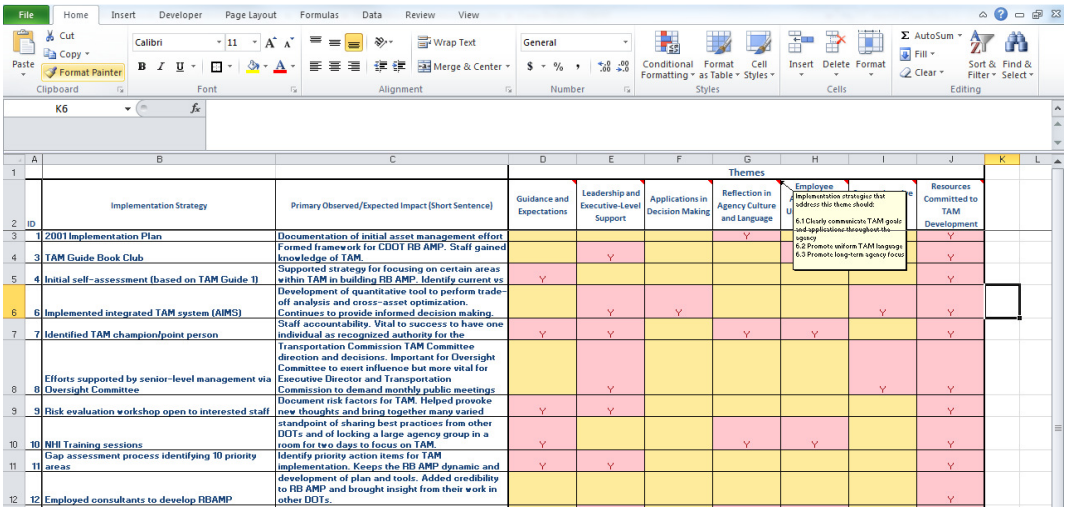

Figure 5.1 Screenshot of TIRF Excel Tool

The primary observed or expected impact of each strategy can help trigger the determination of which criteria or categories are addressed by each strategy. For a strategy to address any single category, it must meet at least one of the criteria as described in Figure 5.2. These criteria are coded into the spreadsheet as comment boxes, as shown in the screenshot in Figure 5.1, which appear when the corresponding category title is selected. To indicate a "yes" response, respondents enter the letter "Y" in the appropriate box which then turns red.

Strategies that meet the **Guidance** category...	...ensure that TAM is reflected in major agency policy documents.
	...explain where TAM fits in agency programming.
	...provide clarity on how standard operating procedures (SOPs) should change to incorporate TAM.
	...provide clear guidelines on how decision making should change, including explanations of risk analysis.
Strategies that meet the **Leadership** category...	...illustrate support and commitment from upper-level employees, management, and executives.
	...ensure total agency representation in the TAM governing structure.
	...promote accountability for the TAM governing structure.
	...reduce chances of diminishing support due to leadership changes.
Strategies that meet the **Applications** category...	...introduce TAM into established decision-making processes.
	...incorporate clear metrics and expected outcomes (goals/targets).
	...utilize decision-making questions that require reference to data.
	...promote decisions based on management systems.
Strategies that meet the **Culture** category...	...clearly communicate TAM goals and applications throughout the agency.
	...promote a uniform TAM language.
	...promote a long-term agency focus.
Strategies that meet the **Employee** category...	...expand workforce capacity with respect to TAM.
	...promote employee understanding of their role in using TAM or how their job changes to incorporate TAM.
	...clarify expected outcomes or benefits of TAM to employees.
Strategies that meet the **Alignment** category...	...create clear links between TAM and agency outcomes/goals.
	...incorporate TAM into all aspects of programming (capital-side, maintenance, etc).
	...create connections to customer service.
Strategies that meet the **Resources** category...	...allocate financial resources to TAM development and implementation.
	...commit human resources efficiently towards TAM programming.
	...prioritize and enhance data management.

Figure 5.2 TIRF Systematic Review Criteria

5.2.2 Guidelines to Use the TIRF in an Agency

Prior to using the TIRF, the agency must determine whether the purpose of the review is to look back on the implementation approach, or plan for future implementation. In either case, the general process steps will remain the same but the output should be interpreted in a forward- or backward-looking way (i.e. this is what our implementation approach does, or this is what it can do).

While the TIRF spreadsheet can be completed by one person in the agency, it is recommended that a group of employees that are closely involved in the management of the TAM implementation process gather to complete the review in order to reduce the possibility of bias or over/under reporting. In addition, some participants should have had a relatively long tenure in the agency, where possible, to be able to capture the impacts of any earlier efforts of TAM implementation particularly for those agencies that formally adopted TAM prior to 2010. The review should be conducted in the form of a three-session workshop where methods are employed to obtain consensus on a valid representation of the agency's TAM implementation approach. The sessions can be conducted at once on the same day, or broken up into different days. The flowchart in Figure 5.3 below illustrates the workshop format and process.

The workshop facilitator should be well-versed in the TIRF and its use as they will be responsible for leading the group to use the tool in the most effective way. Before the workshop begins, its purpose should be explained, and background information on the TIRF similar to the summary in Section 5.2.1 should be provided to the participants. After questions are clarified, the workshop should begin with the initial group session which involves three steps.

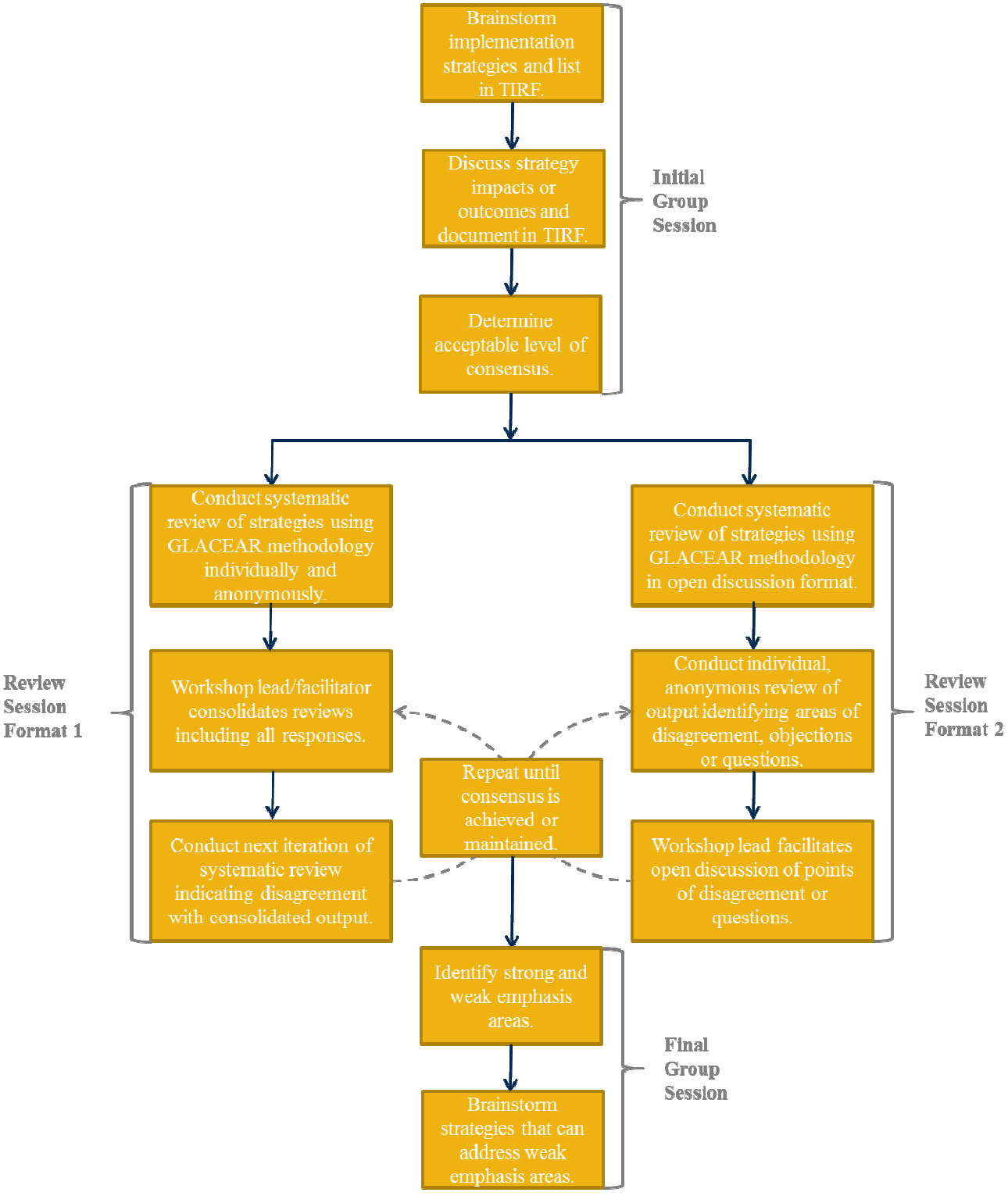

Figure 5.3 TIRF Workshop Format and Process Flow

The first step is to brainstorm implementation strategies (past or desired – depending on the focus of the review) to be entered into the first entry column in the Excel worksheet. As these entries are made, an identification number will be automatically generated in the tool and the TIRF category cells that correspond with the strategy row should become yellow. When the list is complete, the workshop lead should facilitate an open discussion to determine the observed or expected impacts and outcomes for each strategy. Where multiple impacts exist for a single strategy, the primary outcome should be documented. The third step in this initial group session is to determine how consensus will be defined for the workshop. The minimum requirement for consensus is 51% of the workshop participants. However, agencies may decide to apply a higher level of consensus either by using a minimum number of people who find agreement, or by using a higher percentage of the workshop participants who find agreement.

The second workshop session is the review session which can take two formats. In the first format, individual participants conduct the systematic review of the strategies listed in the first session using the GLACEAR methodology, and indicate their responses for each strategy and each TIRF category using the correct syntax. Anonymous results are submitted to the workshop facilitator who then consolidates the reviews into one worksheet, including all "yes" responses and indicating those where consensus was not achieved. Participants then use this consolidated output to conduct a second iteration of the individual, anonymous systematic review indicating if and how their initial review changes. This process of iterations should be repeated until consensus is maintained, that is, until the consolidated output remains the same for two iterations.

The second format for the review session involves a group-based systematic review using the GLACEAR methodology but in an open discussion format. The workshop facilitator leads this step, posing the review question to all participants for each strategy and each TIRF category. Once the initial review is complete, each participant conducts an individual review of the output, anonymously identifying areas of disagreement and/or posing questions on the review to the group. The workshop lead then facilitates an open discussion of these points of disagreement and questions, making changes to the initial review output as necessary to produce a new systematic review output. Individual reviews are then repeated to identify any further questions or objections, and the cycle is repeated until consensus is maintained, that is, until the output remains the same for two iterations, or until there are no disagreements or questions raised. To manage group dynamics in this second format, the workshop facilitator may use a system of voting during the open discussions and group reviews, where majority is the level of consensus that was initially determined.

In the third and final workshop session, the systematic review output should be provided to all participants with strong and weak emphasis areas identified. In viewing the output, workshop participants should brainstorm implementation strategies that can address the weaker emphasis areas to generate recommended areas to focus the implementation effort. However, it is recommended that this brainstorm session should not include any prioritization of the strategies, unless additional insight is available from a self-assessment or gap analysis of the TAM program, or from other evaluative methods. Ultimately, the workshop will allow the agency to have a more comprehensive view of

their TAM implementation approach, and provides the opportunity to enhance the approach by considering strategies that can influence program sustainment.

5.3 Evidence-Based Database or Catalog of Implementation Strategies

So far, the extent of incorporating the evidence-based principles that were discussed in Section 3.2.2 has been limited to the use of the systematic review that is the central concept behind the TIRF. As previously mentioned, the second important component of evidence-based design is evidence quality. Using the TIRF in transportation agencies for the TAM implementation process, evidence of whether or not an implementation strategy addresses a factor category is based on self-reported descriptions of an agency's experience; the TIRF framework and the GLACEAR methodology facilitate the documentation of this. Applying Amekudzi and Smith-Colin's (2012) definitions of strong, moderate, and minimal evidence to the TIRF, quality evidence (or evidence level) is defined based on the accumulation of experiences from different agencies. In other words, where multiple agencies employ the same or a similar implementation strategy and indicate similar output in the review, evidence that practitioners believe that the strategy addresses the categories indicated is stronger. Alternatively, if a strategy is used by multiple agencies with different results in the review, evidence that practitioners believe that the strategy addresses the categories is moderate. Finally, where an experience with an implementation strategy is documented only by one agency or where multiple agencies produce different review output, evidence that practitioners believe that the strategy can address the categories indicated is lower. In any of these cases, the experiences of different agencies must be consolidated in order

to understand how implementation strategies can address the program sustainment factors.

Compiling the experiences of different agencies documented in the TIRF will result in a catalog or database that includes the universe of TAM implementation strategies that have been used in the transportation agencies that apply the tool. This type of repository will hold a significant wealth of information which will be highly valued among transportation agencies. Generally, agencies learn from each other formally and informally, for example, over informal conversations based on the catalog, or through a formal peer exchange. A TIRF catalog of implementation strategies will provide a central location for documented implementation experiences that agencies can access to facilitate effective knowledge sharing and possible technology transfer. Ultimately, the catalog can be indexed by agency, by strategy keywords, and by the TIRF categories addressed. With this type of information and over time as more experiences are accumulated, clearer indications of which strategies are reported to address the specific categories can be mined which can then assist in the final brainstorming step at the end of the workshop recommended in the implementation guidelines (Section 5.2.2). While this catalog requires further development of an interface, the current study has provided a foundation based on the three case studies conducted. This foundational catalog is provided in Appendix A.

CHAPTER 6: DISCUSSION OF RESEARCH FINDINGS

The previous three chapters described the core of this research study which is the design and development of the TAM Implementation Review Framework (TIRF) based on the findings from the exploratory literature review and the results of a demonstration of its use in three case studies. This section discusses the major findings of this research project from the conceptual research, TIRF development and design, and the application demonstrations.

6.1 Findings from the Exploratory Literature Review

In the exploratory literature review effort, the main goal was to distill those factors that can influence the likelihood of TAM implementation processes achieving high penetration and program sustainment in an agency. This was in order to develop a taxonomy that would form the foundation of the framework to guide the review of implementation strategies. In reviewing the three bodies of literature, the following ten factors were identified: (i) goals, expectations, and guidance; (ii) general resistance to change; (iii) change implementation process; (iv) characteristics of the innovation; (v) program flexibility and customizability; (vi) leadership and management; (vii) other agency characteristics; (viii) financial resources; (ix) human capital and other resources; (x) external factors. These factors can be organized into three categories, according to the domain of implementation that they address. A domain, adopted from Doyle's work in healthcare implementation research (Doyle et al. 2013) is an aspect of the implementation process that will contribute to a comprehensive implementation of the

program. The ten factors identified that can influence program sustainment mainly address three implementation domains: the organization, the people, and the program.

The organization domain includes everything that has to do with the organization as a whole, including its physical and non-physical infrastructure, strategic goals, and other corporate characteristics. The people domain has to do with the individual employees regardless of their level in the agency, but especially those at the frontlines of TAM implementation. Finally, the program or innovation domain considers aspects of the implementation process specifically related to TAM programs. For some of the factors, it is difficult to make a clear-cut determination of the applicable domain because they touch on multiple aspects of the different domains. For example, while the "General Resistance to Change" factor concerns the overall response of the organization, it also has to do with individual employee response, which in summation, makes up the overall response. In the same way, while the "Change Implementation Process" factor sits primarily in the program domain, it also has to do with employee participation in that change process (i.e. the people domain). Figure 6.1 illustrates the general groupings determined, with intersections showing where factors are applicable to more than one implementation domain. Those factors that lie in the intersection space are indicated with an asterisk.

This domain concept makes it clear that the TAM paradigm that has been applied in transportation thus far can benefit from an expansion to include and elevate the social and organizational capital elements to the level of importance that has been accorded to the physical and technical capital elements of TAM.

Figure 6.1 Factors Categorized in Implementation Domains

While much attention has been focused on the technical aspects of TAM implementation, that is, the management system or software development and applications and the technical methods for incorporating performance-based TAM into decision making, state DOTs can and should begin to focus on developing the social capital that would contribute to TAM implementation success in terms of program sustainment. Generally, social and organizational capital should be formally considered along with technical and physical capital in implementing TAM programs. The AASHTO TAM guides suggest general implementation strategies related to social and

organizational capital with minimal detail; the TIRF presents implementation factors that are important for considering these concepts in a more structured way.

6.2 Findings from the TIRF development

The process of designing the TIRF combined the taxonomy developed in the literature review with the results of the implementation expert panel. Ultimately, the intersection of the results obtained from both of these steps provide mutually reinforcing criteria that form the foundation for the TIRF; not only does the literature propose those factors that can influence program sustainment in the implementation process, experts in practice identify them as well, based on their experiences in the field.

6.2.1 TIRF Category Weighting

What still requires clarification is an understanding of which factors are more or less important, that is, a prioritization scheme. As previously discussed, an agency's context can significantly influence the implementation process and can dictate what implementation processes are likely to have more successful outcomes in terms of program sustainment. In the same way, an agency's context may influence which of these TIRF criteria categories may be more important than others. Different organizational characteristics (size, structure, etc.), different organizational settings (political climate, external networks, etc.) and also different types of change (planned, emergent, etc.) can influence how the factors contribute to more or less successful outcomes with respect to TAM sustainment. Similarly, the temporal context of the agency will be important for determining the relative weighting for the TIRF categories: factors that could be important at one time (for example, at the end of the fiscal year

when agencies are tying loose ends) may not be as important when the agency is at a relatively "steady state" in its operations. A more distinct example of this temporal influence on weighting relates to where the agency sits in terms of their TAM program maturity. These context-sensitive considerations are discussed in Section 3.3.2 with recommendations on which categories are relatively more important at the different stages of the AASHTO TAM Maturity Scale.

In light of these considerations, it is clear that there is no generic formula for weighting the TIRF criteria categories. To assign weights, agencies can consider what would be most appropriate for their maturity and their internal and external environments. Assigning importance to change drivers or specific implementation factors has been explored in the literature with the use of broad surveys and statistical regression or factor loading analyses. Xerri et al. (2014) examined the importance of workplace relationships on attitudes toward organizational change in engineering asset management organizations in Australia. Their work used an online survey and structural equation modeling analysis to determine correlations and significance of factor relationships. Similarly, van der Voet (2014) looked at the extent to which transformational leadership, organizational structure and the type of change in question can contribute to the effectiveness and specificity of change management in public organizations. This work studied an organizational change that was occurring in the Dutch public organization Urban Development Rotterdam also using a survey but with linear regression analyses to determine the relationships between the factors and the effectiveness of implementation for that particular context.

The concepts in these studies can be extended to the TIRF categories and applied in a broader way to determine weights. This can be based on an agency-wide survey with data analyses to determine how important each category is for driving change or influencing implementation success relative to program sustainment. The weighting rationale should also involve the dynamics of the agency's TAM maturity – conducting additional case studies of agencies at different TAM maturity levels (for the short-term) or conducting a series of TIRF reviews, as in a longitudinal study, of agency implementation approaches at different stages (for the long term). Such an effort can reveal trends related to which factors are emphasized at different stages of maturity to inform weights assigned depending on an agency's TAM program maturity. Ultimately, the rationale used to assign weights should not be generalized, but should be specific to each agency based on their particular context and needs.

6.2.2 Parallels and Synergies with Existing Tools

As described, the framework and tool provide some structure for a state DOT to conduct a systematic review of their TAM implementation process paying particular attention to how their efforts can increase the likelihood for program sustainment in the long-term. Ultimately, the TIRF output provides descriptive results that illustrate how the agency's efforts lean with respect to program sustainment, in terms of the implementation factors addressed. While this clear and systematic illustration of the implementation approach can support future decisions on implementation investments, it is not meant to be prescriptive, in the sense that the framework does not recommend action in any one direction. In order to pull specific recommendations, the output from the TIRF must be considered in addition to other existing resources such as the AASHTO

self-assessment and gap analysis tools. For example, strategies that have been identified in the literature and practice as influencing program sustainment that also have other functions identified in the self-assessment and gap analysis tools may fall out as priority strategies for agencies that want to address these TAM gaps while increasing the likelihood of program sustainment.

The AASHTO Self-Assessment was first introduced in the 2002 TAM Guide Volume I (Cambridge Systematics 2002) as a tool and exercise to help an agency characterize its TAM practices and identify specific opportunities for improvement. Focusing on the actual TAM program, the exercise was designed to help organize thinking and develop consensus among top-level managers on how the agency can structure an agenda for planning for TAM with the goal of working towards "good asset management" (Cambridge Systematics 2002 pp. 3–8). In the 2011 TAM Guide II - A Focus on Implementation (AASHTO 2011), a Gap Analysis tool is introduced which goes one step beyond the Self-Assessment by providing a step-by-step method for moving from a general action plan to hands-on implementation. The purpose of the gap analysis is to determine the areas of the agency's TAM program that require improvement and how they should be prioritized. The main distinction between these two tools and the TIRF is that the former address improvements to doing TAM with a focus on the processes involved in applying asset management principles to decision making, while the latter addresses the TAM implementation process, that is the activities that set the stage for TAM principles to be applied to decision making. Furthermore, the TIRF has a greater emphasis on the social and organizational aspects of asset

management, as opposed to the technical processes involved, which are emphasized by the two AASHTO tools.

The Self-Assessment tool is organized around the four key areas of TAM identified in the AASHTO TAM Guide I: (i) policy, goals and objectives; (ii) planning and programming; (iii) program delivery; (iv) information and analysis. A total of 55 declarative statements are categorized in these four functions to which respondents indicate whether they strongly disagree - assigned a value of one (1) - or strongly agree – assigned a value of four (4) – and everything in between. According to the TAM Guide, top-level managers should complete the assessment individually with responses compiled and discussed. In this way, the results present an indication of how these managers view the agency's performance of each function.

Along the same lines, the Gap Analysis tool consolidates scores for over 250 individual questions that can be aggregated by assessment area, category or element. The six key assessment areas include the same four from the self-assessment in addition to life-cycle management and TAM, and legislative compliance. According to the TAM Implementation Guide, the Gap Analysis can be conducted by anyone with some level of understanding of TAM. Results from this tool are scores of the actual performance of the agency in the six assessment areas compared to a target performance that is also assigned a score, using a scale of one (1) to ten (10) and aligned with the TAM Maturity Scale from initial to best practice. With a weighting protocol as an input to the tool, the Gap Analysis allows for the prioritization of identified areas of improvement.

Similar to the Self-Assessment, the TIRF illustrates a view of the agency's performance towards each implementation factor category that is important for program

sustainment, but with a different syntax for completing the exercise. Unlike the Gap Assessment, however, the tool does not incorporate a weighting protocol. In contrast with both AASHTO tools, the use of the TIRF need not be limited to top-level management or even to one person, but can, and should, include all employees who have played significant roles in the implementation process (for example, any who are part of the governing structure). In this way, consensus can be achieved based on a consolidation of individual views.

Ultimately, all of these tools are diagnostic, generating an overall impression of an aspect of an agency's TAM program and providing a foundation for further implementation of TAM by identifying priority areas for improvement. However, while the TIRF provides a snapshot of the agency's TAM implementation process and how it leans with respect to longer-term program sustainment, the other two provide an understanding of the agency's TAM program. The key assessment areas in the AASHTO tools do not directly incorporate the social and organizational capital elements that are reflected in the TIRF, however, many of the questions (also referred to as criteria) in the Gap Analysis inherently reflect and ultimately, incorporate ratings of, the more social and organizational aspects of TAM programming as they relate to the processes and tools for applying TAM principles in decision making.

6.3 Findings from the Case Studies

The case study reviews provided demonstrations of the application of the TIRF and the type of output that can be obtained from its use. A brief analysis comparing the results of each case study was discussed in Section 4.5; this section extends the discussion by applying the concept of an evidence-based database or catalog of strategies presented in

as discussed in Section 5.3. The findings discussed here are examples of the type of analysis that can be conducted when the TIRF is used in more agencies. Altogether, the three case studies compiled 72 strategies for the agencies; there were two strategies common to all three agencies and seven common to two agencies. Out of those nine, there was alignment in the TIRF categories (that is, the same categories were indicated) for five of those strategies (see Appendix B). Note that for this discussion, those common strategies were kept separate since they are entries from different agencies. Nonetheless, from all 72 strategies, each of the TIRF categories was addressed by at least one strategy. The distribution shown in Figure 6.2 illustrates that the lowest number of strategies addressing a category is 17 for the Alignment category.

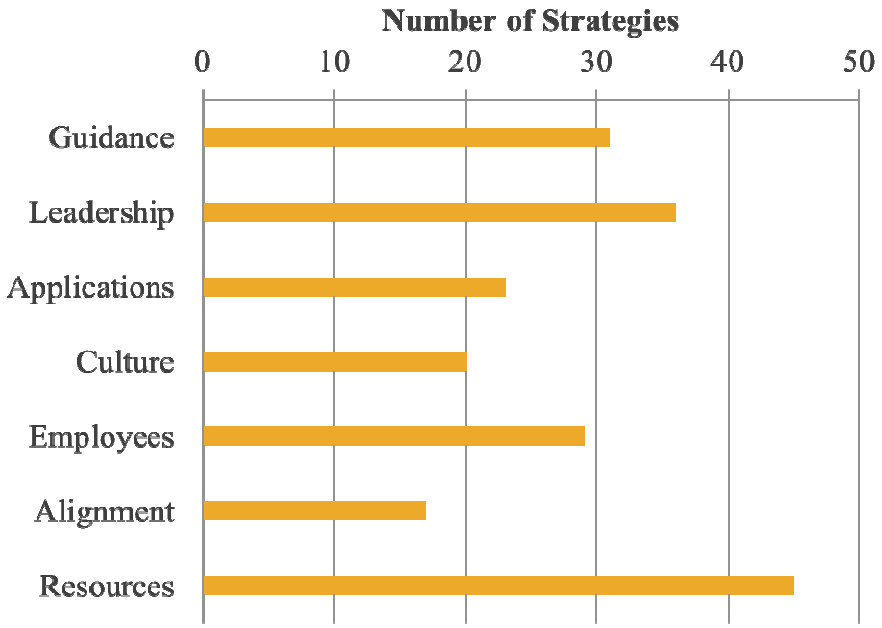

Figure 6.2 Number of strategies addressing each TIRF category from all case studies

Similarly, the highest number of strategies addressing a category is 45 for the Resources category. The strong emphasis on committing resources and establishing leadership with the least emphasis on comprehensive alignment and reflection in culture illustrated here is reflective of Table 4.2 where categories were ranked. This information could be interpreted to mean that these agencies have unknowingly prioritized certain categories above others in the implementation approaches or that they simply are better informed of how to incorporate strategies for some categories over others. In either case, this type of data and analysis has the potential to illustrate how the industry is approaching implementation, once a mass of similar data is collected from all agencies.

Out of the 72 implementation strategies listed for the three agencies studied, about 49% address more than two of the TIRF categories. The histogram in Figure 6.3 shows the distribution of the number of categories addressed by the strategies identified in the case studies. As shown, while only one strategy addresses all seven categories, the greatest number of strategies (26) addresses two categories. This shows that many of the implementation strategies employed by these agencies do well to address those factors that have been identified as important to ensure that the TAM program is sustained in the long-term.

As previously stated, the use of this database of implementation strategies can assist in identifying specific strategies to address the different TIRF categories if an agency wishes to do so. That is to say, agencies can uncover additional strategies to use in addressing any one category by exploring the information from other agencies documented using the TIRF. It can also help agencies in identifying strategies that hit at

multiple categories, i.e., sustainment-heavy strategies in the implementation process. This listing of strategies to address each category is provided in Appendix C.

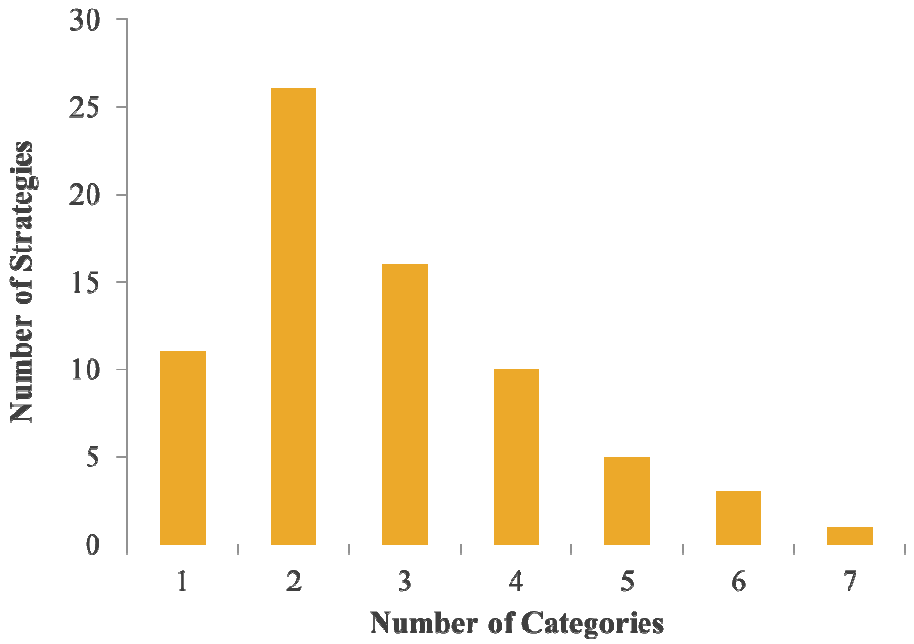

Figure 6.3 Histogram of number of TIRF categories addressed by implementation strategies from case studies

If this relationship between agency implementation strategies and categories addressed is taken a step further, it is possible to align the output from each agency with a certain level of TAM program maturity according to the AASHTO TAM Maturity Scale. For the three agencies studied, conclusions can be drawn linking their maturity to their output; however, generalizing this information may be misleading since the data is limited. In addition, representatives indicated that they have not measured their maturity against the AASHTO scale. Once a significant number of agency experiences at different levels of

measured maturity are collected, this type of analysis will become meaningful, possibly linking the levels on the AASHTO maturity scale to the implementation categories.

6.3.1 Generalizability vs Transferability

At this point, it is important to address the generalizability and/or transferability of this research study and particularly the case study demonstrations. Generalizability refers to the ability to extend findings and conclusions from a sample to the entire population (Barnes et al. 2012) or the external validity of applying results to new settings, people, or samples (Creswell 2009). Burchett et al. (2011) further define external validity as the "potential for a study's findings to be generalized from one sample or setting to others" (Burchett et al. 2011 p. 238), or the "likelihood that a study's findings could be generalized to other (unspecified or more general) samples or settings" (Burchett et al. 2011 p. 239). These definitions place emphasis on the extension of research findings or evidence to a generic population or sample. This is the main distinction with transferability, which emphasizes the extension of findings of a research study or evidence generated to a specific population or setting. Transferability is defined as the "likelihood that the study's findings could be replicated in a new, specific setting (i.e. that its effectiveness would remain the same)" (Burchett et al. 2011 p. 239). Unlike generalizability, transferability does not involve broad claims, but invites the audience or reader to make connections between the research and their experience in order to make extensions (Barnes et al. 2012). In most literature, transferability is often linked with applicability, which is the likelihood of successfully implementing research findings in a new, specific setting (Burchett et al. 2011).

Ultimately, while both generalizability and transferability allow for comparisons between different scenarios and situations, their implications are different. Burchett (2011) argues that while policy decisions are commonly informed by looking at research conducted in other settings, decision makers are typically more concerned with the applicability and transferability of a study to their specific population or setting, than generalizability to a broader context or wider setting. Transferability suggests that individual, context-based practices can be developed for a new setting based on the findings in the initial setting. For studies that involve social components, transferability may be more applicable due to the unique and unpredictable nature of social outcomes, however the degree of generalizability or transferability is ultimately a direct function of the similarities between contexts (Finfgeld-Connett 2010).

Understanding a study's generalizability or transferability is essential for evidence-informed practice. While the foundational concepts in this work may be generalizable based on the extent of the prior supporting research, the application of the TIRF and the case study demonstration outputs are simply transferable. The size of the sample of DOTs studied does not allow for making broad claims about TAM implementation; however, the TIRF could be applied in other agencies which could eventually inform valid generalizations - research has proposed that case study results can be generalized to some broader theory with the addition of more cases (Creswell 2009). Outside of making those eventual generalizations, it is true that in some fields, qualitative research is viewed as weak in terms of transferability (Misco 2007); however, there is much to be said for allowing a reader to find relevant patterns and similarities that can help explain their experiences.

6.3.2 Potential TIRF Applications in Practice

While this study began mainly on a theoretical notion, the conceptual framework developed out of the findings of the literature review and the resulting tool have some very important applications in the practice of asset management in the transportation industry. With transportation agencies in the midst of responding to the TAM implementation requirements mandated in the MAP-21 federal legislation, it is important for them to identify how to leverage and improve the implementation process to increase their likelihood of developing sustained TAM programs, in order for many of the long-term benefits to be realized. There are three main existing platforms that have been identified to facilitate the use of the TIRF to improve TAM implementation.

According to the FHWA Proposed Rules (FHWA 2015), State agencies are expected to update and resubmit their plan development processes and statewide infrastructure evaluation every four years from the initial submissions. Two of the agencies studied in Chapter 4 indicated their choice to update their TAM plans on a biennial cycle. In either case, these scheduled updates provide an opportunity to use the TIRF tool to illustrate an agency's implementation approach with respect to the social and organizational aspects of implementation, identify how the program is leaning with respect to long-term sustainment, and further identify where improvements can be made. Viewed in context with any self-assessment or gap analysis efforts that are conducted and updated regularly, this bundle of tools will provide a more comprehensive illustration of the state of an agency's TAM program, identifying areas of strength, possible weaknesses, and opportunities for improvement. In this way, the TIRF is useful for reviewing, but also for planning the progression of an agency's implementation approach.

As previously stated, continued use of the TIRF will result in an accumulation of experiences in TAM implementation as it relates to program sustainment. The importance of such a database cannot be understated. The AASHTO TAM Portal (AASHTO 2015) is a similar catalog that organizes a wide range of resources related to TAM in order to provide practitioners with easier access to information from multiple sources. The Portal houses a wealth of information on research and literature, agencies TAM plans from around the country, and even events related to TAM that are all indexed by type of resource, asset class, resource topic, and agency type. As a resource that exists to enhance TAM implementation efforts, the TAM Portal will benefit from the type of evidence-based database that can be developed with continued use of the TIRF. The database would house descriptions of agency strategies to implement TAM with indications of how those strategies have addressed the factors that are important to program sustainment summarized in the TIRF categories (see Appendix A), increasing the extensiveness of information shared between practitioners on TAM implementation.

In the application of evidence-based practice, the TIRF methodology applies the use of a systematic review dubbed GLACEAR to distill and document evidence that practitioners believe that implementation strategies used by an agency can enhance the likelihood for TAM program sustainment by addressing those factors that can influence program sustainment. Accumulation of similar experiences will begin to reveal strategies that are believed to more likely enhance the implementation process by addressing the program sustainment factors captured in the TIRF categories. In this way, agencies can learn from the experiences of others and, in an evidence-based way, consider applications of similar strategies in their own contexts. At the end of the day, the documentation of all

evidence regardless of how many agencies have similar experiences provides a platform to facilitate an exchange of information between agencies. AASHTO- and FHWA-sponsored Asset Management Peer Exchanges (Park and Robert 2012; Park et al. 2013, 2014) have provided an opportunity for agencies to share their practices in TAM, while learning from others, allowing for feedback as well as brainstorming on future action. In this setting, the TIRF has the ability to enhance the knowledge-sharing process, providing a standard structure and format to review an agency's implementation process.

6.4 Findings related to the Research Goals and Scope

From the beginning, the goal of this exploratory research study was to examine TAM implementation in state DOTs, paying close attention to how specific actions in the implementation phase could contribute to program sustainment in the long-term. The scope was focused on implementation as it relates to the TAM plan and other guidance documents, the governing structure and actors, and methods of incorporating TAM into decision-making processes, which are topics with prominent knowledge gaps and little to no peer-reviewed literature as evident in general forums on TAM implementation where questions continue to be raised. While the objective of the dissertation was to develop an approach to guide a review of strategies or interventions that can enhance TAM program implementation for sustainment in the business processes of state DOTs (which has been accomplished in the previous chapters), it is still necessary to address those questions that explain the knowledge gaps with respect to guidance documents, governing structure, and decision-making processes. These findings are examples of the broader and more generalizable conclusions that can be drawn when the TIRF is used in more agencies.

6.4.1 Guidance Documents

The TAM mandate in MAP-21 is for the development and implementation of a risk-based asset management plan which is a document detailing "strategies leading to a program of projects" (U.S. Congress 2012 p. 30) that would make progress toward the national goals. The legislation specifies and lists the minimum contents of a TAM plan which are further explained in the FHWA proposed rulemaking. Before MAP-21, however, a number of agencies had already developed TAM plans based on guidance from the published AASHTO TAM Guides (AASHTO 2011; Cambridge Systematics 2002). Although these resources for developing TAM plans lay out similar guidelines, a brief review of the plans from those agencies that were pro-active in adopting TAM prior to MAP-21 revealed several differences in their design.

Even with MAP-21 as the rule of the land, agency plans that are currently being developed or have been developed over the past few years maintain unique differences as seen in the cases studied. One key observation is the ambiguity between a TAM plan and a TAM implementation plan. Agencies like the three studied have TAM guidance documents that have evolved over time, reflecting variations of an implementation (or action) plan and a distinct, comprehensive, foundational plan that may incorporate the action plan. Some agencies also include additional documents like GDOT's TAM communications plan or CDOT's Policy Directive 14. Ultimately, it is clear that there is a distinction between these documents, and agencies are choosing to use them in different ways.

From the case study reviews, there were 26 strategies related to guidance documents. As shown in Figure 6.4, most of these strategies address the Employee

Awareness and Understanding category, with the least number addressing the Comprehensive Agency Alignment category. This suggests that for these agencies, the TAM implementation approach as it relates to guidance documents leans more towards addressing employee understanding of TAM, compared to comprehensive agency alignment. The fact that the Guidance and Expectations category, which directly refers to documentation, is not the highest represented category here suggests that these agencies could perhaps do more with their guidance documents to create a clear and streamlined perception of TAM, clarifying that expectations related to standard operating procedures, changes to decision making, and the other criteria in the category are documented in the agency's guidance documents.

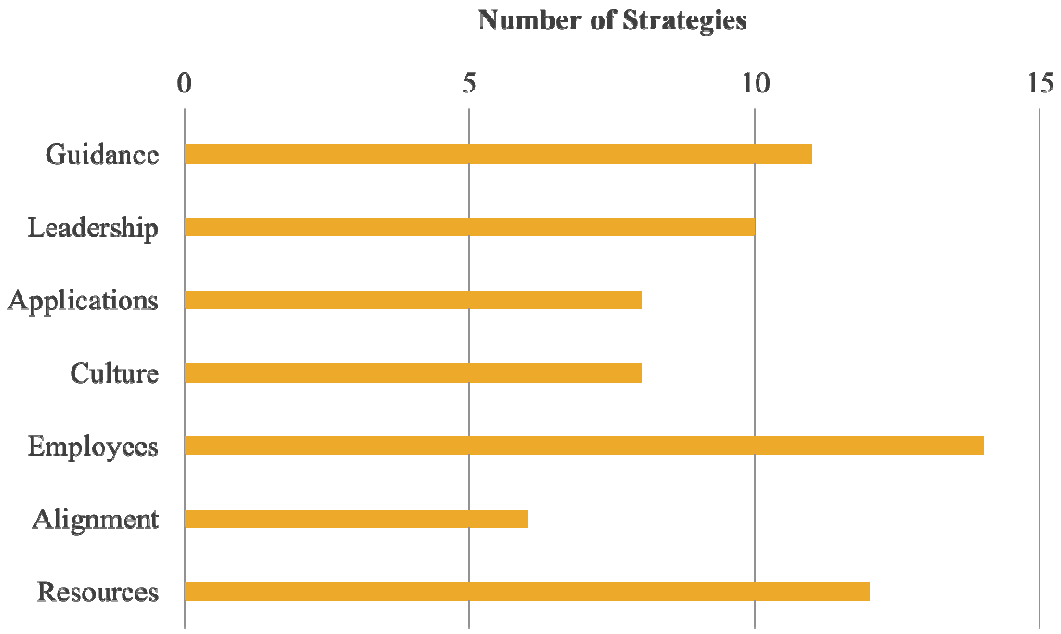

Figure 6.4 Number of guidance document-related strategies addressing each TIRF category from case studies

From these reviews, additional observations can be made on which specific strategies address the most factors related to program sustainment. Figure 6.5 presents a histogram of the number of TIRF categories addressed by guidance-related strategies; most of the strategies (9 or 35%) address only two of the categories, while the lowest number (3 or 12%) address five categories, which is the maximum number addressed.

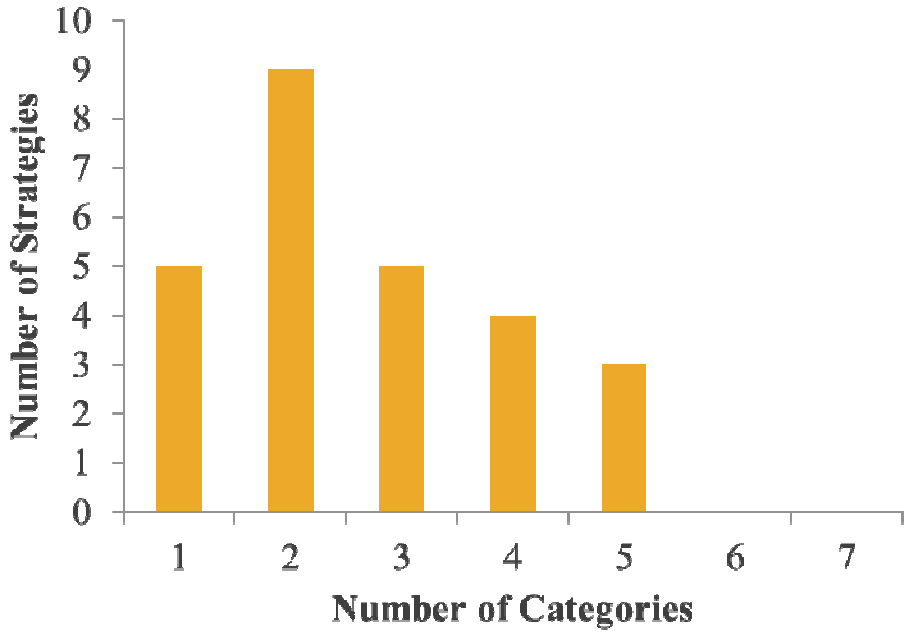

Figure 6.5 Histogram of number of TIRF categories addressed by guidance document-related strategies from case studies

The three strategies that address five categories are: (i) an interim TAM guidance document prepared while the final plan was in development; (ii) the use of formalized TAM policy; and (iii) the use of a performance management implementation plan describing steps for establishing performance measures. An agency looking to enhance

their implementation process, especially where guidance documents are concerned, may be better off considering one of these options, as opposed to other strategies that only address one category in order to increase their program's likelihood for sustainment.

6.4.2 Governing Structure

MAP-21 makes no recommendation or generalization of how an agency should adapt its organizational characteristics or create a governing structure for TAM implementation. In fact, there is a general understanding that TAM programs and their related structure should be adaptable and should complement the characteristics of individual agencies (AASHTO 2011; Cambridge Systematics 2002). This is understandable given the variety in the structure, culture and business processes of different state DOTs. From the case studies, there were 22 strategies identified related to the TAM governing structure. As shown in Figure 6.6, all but one (95.5%) address the Leadership category while only two (9%) address the Applications category.

This suggests that the strategies these agencies have adopted towards establishing a governing structure for TAM address those factors related to leadership that can influence implementation for program sustainment such as executive-level support, accountability for leadership, total agency representation, and reduced opportunities for diminished support with changing leadership. Figure 6.7 is a histogram depicting how the implementation strategies related to governing structure address the TIRF categories and showing that nine of the 22 strategies (41%) address only two of the categories. About 40% of the strategies address three or more categories, and in fact, only one is reported to address all five, six, or seven TIRF categories.

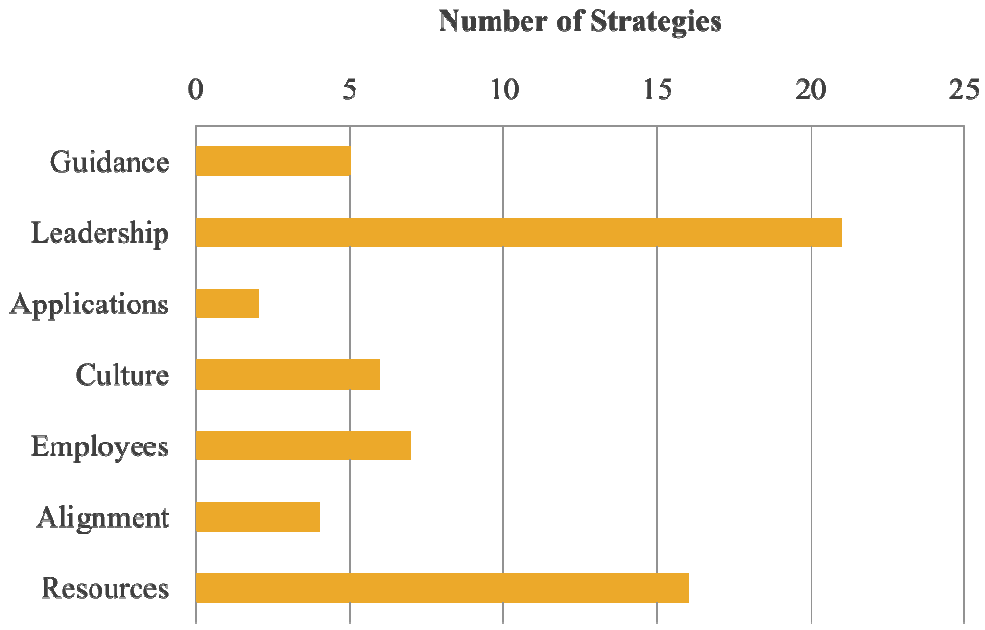

Figure 6.6 Number of governing structure-related strategies addressing each TIRF category from case studies

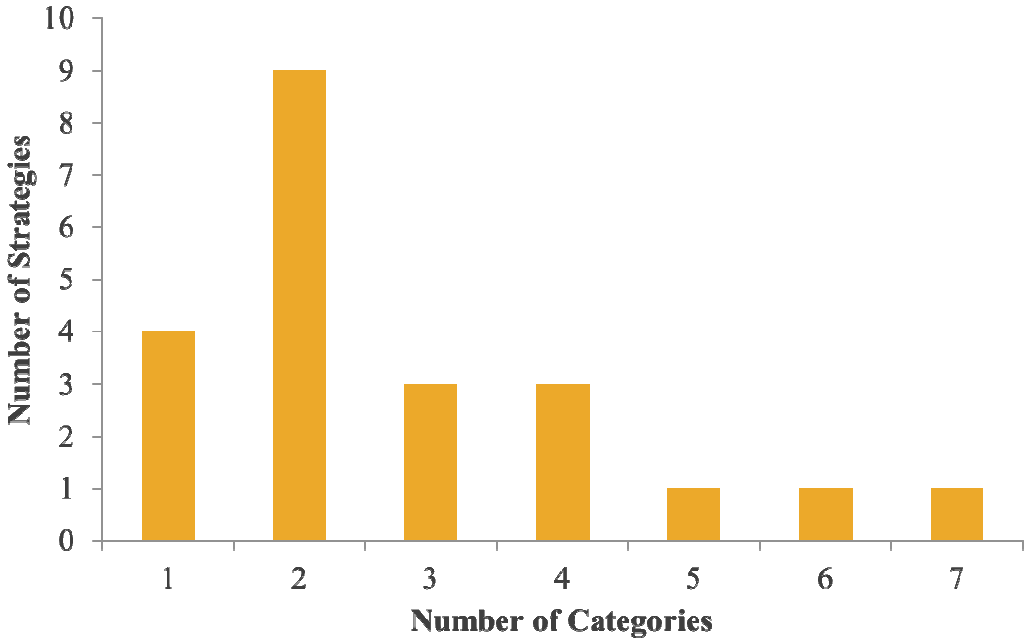

Figure 6.7 Histogram of number of TIRF categories addressed by governing structure-related strategies from case studies

The one strategy that addresses all seven is CDOT's use of asset managers in all pertinent agency divisions. This use of individual subject matter experts in all relevant divisions is similar to a strategy also adopted by GDOT; however, their review identifies only two categories as being addressed. While this discrepancy seems to highlight a limitation in the application of the TIRF related to differences in interpretation of the factors or simply human bias, there are a number of valid reasons. First of all, the GDOT strategy is listed as "asset 'champions' (subject matter experts) evaluate risks to establish funding scenarios" while the CDOT strategy is listed as "use 'asset managers' in all divisions"; if the GDOT use of champions is strictly limited to their evaluation of risks, the strategies are effectively not the same. Secondly, if the strategies are determined to generally be the same, there could be differences in their relative effectiveness in the agency. In either case, this would present an example of minimal evidence that practitioners believe that this strategy addresses the factor categories selected. This can inform the adoption of this particular strategy in any other agency that does not already use this governing structure.

There are two other governing structure formats revealed in the TIRF application that combine the guidance from the AASHTO guides and MAP-21. Both TAM guides recommend assigning the overall lead responsibility of TAM program development and implementation to one person to allow for continuity and clear accountability with supporting group structures. The most prevalent opposite option to this is to assign a group of employees with responsibility for implementing TAM. While all three case study agencies utilize some form of team leadership in managing the TAM program, whether a Task Force, Working Group, or Committee, two of them also have champions

appointed for TAM implementation. In addition, one agency has a department specifically established to facilitate TAM implementation and programming. For all three, their TAM governing structure reflects a combination of these four formats – an overall champion, a specifically appointed department, an inter-division team leadership structure, or individual asset champions. With the number of cases studied, no generalizations can be made on which structure has a greater influence on program sustainment. Here again, with accumulation of experiences in using the different strategies, the evidence that practitioners believe that a strategy addresses particular categories will begin to show.

6.4.3 Decision-Making Processes

What is arguably the most important element of TAM implementation is the actual incorporation of TAM into decision-making processes. Even with a TAM plan developed and a governing structure established, an agency cannot claim success in implementing TAM without evidence of TAM principles in its business processes. Nevertheless, out of the three existing sources of guidance for TAM, only the second AASHTO guide provides detailed discussions on the processes and tools for "doing" TAM. All the same, there were 26 strategies identified from the case study reviews for implementing TAM in the agencies' decision-making processes. As shown in Figure 6.8, the majority of these (21 or 81%) address the Applications in Decision Making category of factors, as would be expected. This means that most of the strategies implemented that have to do with decision-making processes promote decisions based on management systems, utilize decision-making questions that require reference to data, incorporate

clear metrics and expected outcomes (goals/targets), or somehow introduce TAM into established processes. These are the criteria in the Applications category.

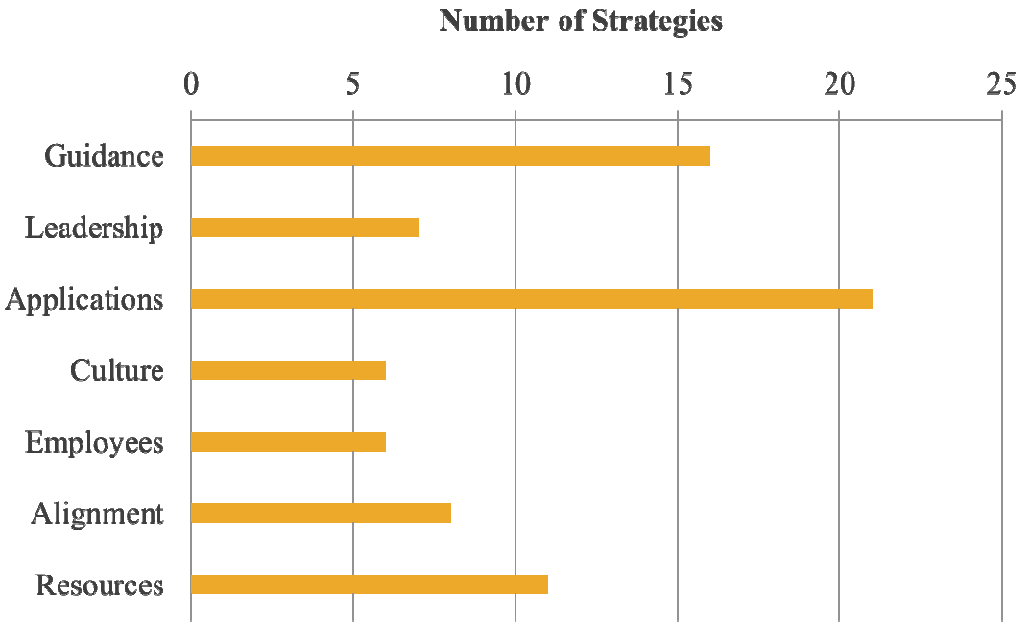

Figure 6.8 Number of decision-making implementation strategies addressing each TIRF category from case studies

Similar to the strategies related to guidance documents and governing structure, a closer look at those implementation strategies related to decision-making processes generates the histogram presented in Figure 6.9, showing that most of the strategies (10 or 38%) address two categories, while eight of them (31%) address three categories. Altogether, just over 50% of the strategies related to decision-making processes address three or more categories, but none address all seven categories. The two strategies that address six categories (which is the maximum for this set of strategies) are: (i) CDOT's integrated TAM system; and (ii) NYSDOT's use of regional performance targets. An agency

looking to enhance their implementation process especially where decision-making processes are concerned may be better off considering one of these options. However, as previously discussed, the lack of alignment in categories addressed by the integrated system strategy which is common to all three case study agencies indicates a lower level of evidence that practitioners believe that the strategy addresses those categories. This information should inform an outside agency's decision to make an investment into this strategy.

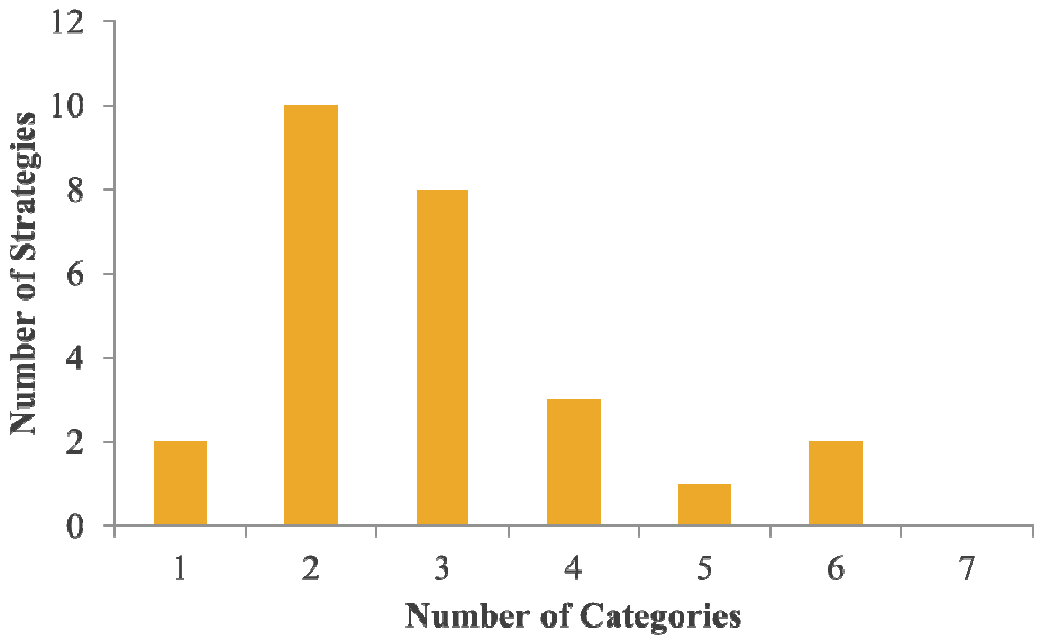

Figure 6.9 Histogram of number of TIRF categories addressed by decision-making implementation strategies from case studies

6.4.4 Summary

In general, while these discussions have focused on the total database of strategies for all the case studies, similar analyses of the three elements of implementation that

make up this research study's scope (guidance documents, governing structure, and decision-making processes) could be performed for the individual agencies. When a critical mass of agency data is collected, the analysis can be extended to uncover strategies with stronger evidence of the factor categories practitioners believe they address for any agencies whose experiences can be grouped to draw significant conclusions (e.g. for peer agencies, or agencies at similar levels of program maturity). This will provide further insight on how their strategies and overall implementation approaches are able to address the factors that can influence program sustainment in the long term, or alternatively, what strategies they can consider to address those factors.

All things considered, this discussion has demonstrated that the TIRF is a useful tool for uncovering trends related to agency TAM implementation, for understanding the nature of strategies through the lens of the factors identified as influencing program sustainment, and for understanding how implementation approaches can address implementation factors to enhance program sustainment. All in all, there is value in the transportation industry adopting this framework to facilitate the collection of data on agency TAM implementation experiences which will lead to the generation of a valuable repository of implementation strategies with agency-reported influences on TAM program sustainment. The conceptual framework developed from the first phase of the research and the resulting review approach have been shown to be useful for informing the future of TAM implementation to enhance the process for increased chances of program sustainment in the business processes of state DOTs.

CHAPTER 7: RESEARCH CONTRIBUTIONS, LIMITATIONS, AND FUTURE WORK

7.1 Contributions

This work makes three main contributions to the current conceptual understanding of, the research related to, and the industry practice of TAM implementation. First of all, the research undertaken here extends the body of knowledge on TAM program implementation specifically by applying program and policy implementation research as well as change management theories. While there is ample literature on asset management in general and some limited resources on asset management implementation, the effort in this work to study TAM implementation specifically through the lenses of policy and program implementation and change management theories takes a less common angle. Ultimately, the current TAM driver (MAP-21) and the resulting emphasis on changing the way transportation organizations make decisions related to their physical infrastructure makes studying TAM implementation in this way rational, and the useful results illustrate that. In particular, the identification of specific factors that can influence the implementation process and contribute to an enhanced likelihood of program sustainment, and the development of a taxonomy for those influence factors is a major contribution of this work. These factors and taxonomy form the basis of a conceptual framework for reviewing and planning for TAM program development in a manner that increases the likelihood of program sustainment. While the AASHTO TAM Guides suggest general implementation strategies related to social and

organizational capital with minimal detail, the conceptual framework developed here presents social and organizational implementation factors in a more structured way. This provides a step into research on the less technical aspects of TAM implementation, which is essentially an atypical approach that emphasizes the organizational and social facets.

The second main contribution that this research study makes is that it provides a tool for applying the conceptual contributions and framework previously described in practice. The TAM Implementation Review Framework (TIRF) can assist agencies in understanding how their TAM implementation approach addresses factors that increase the likelihood of sustained TAM programming. Effectively, it enables agencies to determine how their approach formally considers organizational aspects of implementation, which are critically important for program sustainment. The TIRF provides a tool that agencies can use to "take the temperature" of their TAM implementation process as it relates to program sustainment in order to make more informed decisions to improve the process, particularly when they schedule updates to their TAM plans and programs as required by the legislation. Since the framework and the tool only review implementation in the light of program sustainment, decisions on how to improve should not be based solely on the output – the output should inform those decisions in addition to other existing sources of information, such as the self-assessment and gap analysis tools. The TIRF and the incorporated GLACEAR review methodology also contribute to TAM research by expanding and adding on to the introduction of evidence-based practice in TAM that was initiated by Bones et al. (2013) and continued by Smith-Colin et al. (2014). Evidence-based approaches have seen much success in the medical and social science fields and hold much promise for transportation especially

since agencies value highly the ability to learn from others' experiences. This framework with the resulting database of information demonstrates how evidence-based practice can benefit the transportation industry.

The third and final contribution that this work makes comes out of the results of applying the TIRF. Ultimately, the information from the three case study agencies has formed the foundation of a catalog of systematically reviewed implementation strategies and approaches with additional information on how those strategies address the different factors related to program sustainment. In many ways, this catalog is an evidence-based repository of information that can inform or support the decision of an agency looking to learn from the experiences of others. When more fully developed, or in other words, when additional experiences have been recorded, the catalog can facilitate industry-wide learning in the form of peer exchanges, which currently occur around TAM and other subjects. Using this framework, agencies could find it relatively easier to understand how a specific practice at other agencies could potentially affect their implementation process. Even without the adoption of this framework for use during peer exchanges, at a minimum, the dense information on TAM implementation that agencies report through the TIRF can be housed on the existing TAM Knowledge Portal for wider access. In this way, knowledge-sharing is still possible but in a less formal way.

Generally, this dissertation pushes forward the concept of TAM program sustainment by uncovering those factors that are important and can positively or negatively influence program sustainment during the implementation phase. This work creates and introduces a pathway to address how TAM programs can be sustained in DOTs which can be extended to other transportation agencies with further study.

7.2 Limitations

There are a number of limitations to the research process and the framework developed that should be addressed, even though they do not take away from the broader impacts of this work. First, there are two main limitations related to the research process. Although the agencies for the case study demonstration were purposefully selected, the three agencies do not make up a sample size that is significant enough to draw generalizations about the state of TAM implementation in the wider industry with respect to program sustainment. Ultimately, the purpose of the case studies was not to draw these types of generalizations on the state of TAM implementation, but to demonstrate the use of the TIRF and show how that can eventually lead to induced characterizations of the implementation process once a representative sample of cases are studied. The case study methodology and results can be transferred to and applied in other agencies to eventually build the representative sample that will allow broad generalizations.

The second limitation of the research process is also related to the case studies. As described in Section 5.2.2, the actual application of the TIRF should involve multiple people in a workshop setting who can contribute to a consensus of the agency's implementation strategies and how they address the TIRF categories. Resource constraints prevented this full-scale simulation of the review process in the case study demonstrations. Instead, the data collection process was similar to a qualitative field network study, which is an existing policy implementation research method, where the researcher initiated the review process validated with feedback from agency representatives. From two of the agencies, feedback was obtained from only one representative increasing the possibility of bias in the results and potentially reducing the

accuracy of the review. At the end of the day, when the TIRF is properly implemented, it will produce the same type of output as was obtained here, making the same analysis illustrated in this document possible.

For the TIRF itself, there are three main limitations. First of all, the aggregation of criteria into seven broad categories presents a limitation because when a strategy is said to address a category, it may not necessarily address all the criteria in the category. This means that if a single criterion is not addressed by the implementation approach there is no direct way to tell especially if other criteria in that category are addressed. Ultimately, this opportunity cost of having a less complex and more practical tool does not present a substantial limitation, unless further research is able to show priority levels for the criteria in a single category. The criteria are simply different ways that a factor category can be addressed, thus there is not necessarily a need to address each criterion in order to address the factor category.

Similarly, the TIRF allows for an open-ended identification of implementation strategies with no guidelines on how to phrase the strategies. The case study demonstrations showed that similar strategies can be reviewed in different ways based on the level of aggregation of the strategy for reporting. This limitation can potentially be addressed as the tool matures to the point where a standard set of strategies can be offered to agencies as a departure point in using the TIRF, allowing them to also add their own strategies where none reflect their activity.

Finally, this research did not study ways to measure how much or how effectively a strategy addresses each factor. As discussed, the GLACEAR review methodology simply asks if a strategy addresses a factor without quantifying the level at which the

factor is addressed. Defining a metric to measure the extent to which a factor is addressed, and linking it to program sustainment, would enhance the understanding of which strategies are likely to be more effective in addressing the implementation factors; however, that would require more detailed study of the individual factor categories and the individual criteria as well as a deeper understanding of how the strategies address the factors, and how the factors in turn affect program longevity. Developing such a measure could involve quantitative models that define the relationships between strategies and factors which would then have to be tested broadly enough for validation. While this level of detail would enhance the TIRF, it is not essential for painting a general picture of how an agency's implementation approach leans with respect to program sustainment, and is outside the scope of this research study. Ultimately, interpretation of the output should consider the fact that while the strategies have the ability to address the factors they are reported to address, the extent to which they do so could vary in ways that would lead to different results in different contexts.

Generally, each of the limitations identified here, whether related to the research approach or to the TIRF tool, uncovers several opportunities for future work all of which are discussed in the next section of this dissertation.

7.3 Future Work

Possibly the most significant topic for furthering the concepts and applications addressed in this dissertation is that of assigning priority weights to the implementation factors that can influence program sustainment. While prior research has investigated specific factors and their contribution to implementation success, this recommendation is to study how the combination of factors identified in this work can influence

implementation success defined by program sustainment. This will also involve developing an understanding of the interrelationships between the implementation factor categories themselves. As discussed in Section 6.2.1, a method for assigning weights should not be generalized but should be specific to each agency based on their particular context and needs. All the same, a research study to explore different methods for assigning weights could result in a flexible model or framework that provides guidance for determining how the factors can be prioritized in a context-sensitive way. This could also then be extended to the criteria in each TIRF category, to determine their importance for concluding that the category has been addressed. As previously discussed, a context-sensitive factor/criteria prioritization process should consider the characteristics of the agency, the maturity of its TAM program, and other possible temporal influences.

A second opportunity for future research to further enhance the accuracy of the TIRF is to explore the options for measuring and modeling the possible relationships between implementation strategies or a general implementation approach and the factor categories. This type of work will allow more detailed and possibly quantitative measurement of how an agency's implementation process is contributing or can contribute to the sustainment of the TAM program by developing quantitative measures for the extent to which a strategy addresses the factor categories. The scope of this research would have to be carefully defined to limit the number of permutations of strategy and factor combinations which could potentially be plentiful.

A longer-term opportunity for future work has to do with validating the factor categories and their contributions to implementation success in terms of program sustainment. The state of these formally-mandated TAM programs after being in

operation for a number of years will be a clear indication of whether or not the programs have been sustained. At that point in time, more straight-forward inferences can be made on the factors addressed during the implementation process and how the programs have been sustained. While the TIRF factor categories are grounded in literature where validation in other fields has been illustrated, and while the methods applied in this study provided validation for the applicability of the factors in TAM, this future research opportunity can further corroborate these concepts to bolster the findings presented here.

Besides research that would improve understanding of the concepts that form the foundation of the TIRF, additional practice-oriented improvements can also be made to improve the appearance of the current tool. First of all, while the current Excel format is simple and practical with a user guide provided in Chapter 5, a more user-friendly, innovative interface can be designed. It is also possible to include a web-based version of the TIRF that would increase its accessibility and make the transition of review output from individual agencies into the evidence-based catalog of strategies easier. Future research can also include the development of the platform for this evidence-based catalog in order to make it widely accessible to realize the expected benefits. Finally, to continue populating the database to be able to draw broader conclusions on TAM implementation and accumulate that information that would lead to high qualities of evidence, the TIRF should be applied to review the implementation approach of additional DOTs in order to achieve at least a statistically significant sample, but ultimately, a complete review of all DOTs.

Finally, to enhance the contribution of this dissertation to the wider transportation industry, efforts can be considered to scale this work down to apply the TIRF to other

types of highway transportation agencies such as MPOs but also to agencies that manage other modes of transportation assets such as railway, transit or even air transportation assets.

7.4 Summary

The transportation industry in the United States is currently riding a wave of transportation asset management (TAM) program development and implementation as a result of the inclusion of performance-based TAM mandates in the 2012 federal surface transportation legislation, Moving Ahead for Progress in the 21st Century (MAP-21). Historically, principles of TAM have been introduced into agency programming, but never in a sustained way. But in order for some of the main benefits of TAM to be realized fully, TAM programs must exist and be applied effectively for a long period of time. The ability of a program to be sustained in the long term is most effectively addressed either during its design or its implementation phase. This research study has tackled the concept of TAM program sustainment in state DOTs by identifying key categories of factors for program sustainment, and developing an approach to guide a review of implementation strategies or interventions using a selection of factors that can influence the ability of a program to be sustained.

A TAM Implementation Review Framework (TIRF) has been developed as a result of the initial research conducted in this study. The TIRF is a diagnostic tool that facilitates the review of an agency's implementation approach based on seven categories of factors that can influence program sustainment during the implementation phase. The use of the TIRF has been demonstrated in case studies of three state DOTs, revealing the important types of useful information that can be gleaned about the implementation

approach that an agency or a group of agencies have employed, and how their approach addresses those factors that can influence whether or not their program is sustained. Furthermore, the output obtained from the demonstration of the use of the TIRF has formed the foundation for an evidence-based database or a catalog of TAM implementation strategies with reports of how those strategies can inform program sustainment by the implementation factors they address.

Generally, the TIRF complements the two main tools that exist for assessing agency TAM programs: the AASHTO self-assessment and gap analysis tools. While the existing tools allow agencies to see where their TAM programs stand relative to defined best practices, the TIRF allows agencies to see how their TAM implementation process can lead to a sustained program. Nonetheless, the combination of these tools provides a wealth of information that agencies can consider when making plans to improve their TAM implementation and programming. Ultimately, the results of this research study cannot necessarily inform broad claims on the status of TAM implementation, but can be applied in DOTs to help develop an understanding of their implementation approach as it relates to program sustainment, and leverage this understanding in future TAM program implementation and refinement.

APPENDIX A.

TAM Implementation Review Framework Catalog

Table A.1 Colorado DOT January 2015 TIRF Review

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT01	**2001 Implementation Plan**	Documentation of initial asset management effort and needs; staff awareness							Y
CDOT02	**2001 TAM Task Force**	Staff awareness		Y			Y		Y
CDOT03	**TAM Guide Book Club**	Formed framework for CDOT RB AMP. Staff gained knowledge of TAM; Staff education and discussion on next steps					Y		Y
CDOT04	**Initial self-assessment (based on TAM Guide 1)**	Supported strategy for focusing on certain areas within TAM in building RB AMP. Identify current vs desired state. Identify gaps and next steps	Y						Y
CDOT05	**2003 Draft AM Work Plan**	Staff awareness							Y
CDOT06	**Implemented integrated TAM system (AIMS)**	Development of quantitative tool to perform trade-off analysis and cross-asset optimization. Continues to provide informed decision making. Data driven decision making; providing tools for budget setting to decision makers in consistent manner.		Y	Y	Y	Y	Y	Y
CDOT07	**Identified TAM champion/point person**	Staff accountability. Vital to success to have one individual as recognized authority for the department. Organizational change to elevate Transportation Performance to its own branch, and have the branch manager be	Y	Y		Y	Y		Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
		the primary contact for asset mgmt.							
CDOT08	**Efforts supported by senior-level management via Oversight Committee**	Facilitate staff-level decision making and support Transportation Commission TAM Committee direction and decisions. Important for Oversight Committee to exert influence but more vital for Executive Director and Transportation Commission to demand monthly public meetings on TAM. Alignment between asset mgrs/planners/budget staff with higher organizational concerns.		Y		Y		Y	Y
CDOT09	**Risk evaluation workshop open to interested staff**	Document risk factors for TAM. Helped provoke new thoughts and bring together many varied ideas on Risk. Begin to discuss what is risk and how does it impact CDOT's operations.	Y	y					Y
CDOT10	**NHI Training sessions**	Gain staff knowledge of TAM. Beneficial from a standpoint of sharing best practices from other DOTs and of locking a large agency group in a room for two days to focus on TAM. Awareness to staff at HQ and regions; education and sharing of ideas.	Y	Y		Y	Y		Y
CDOT11	**Gap assessment process identifying 10 priority areas**	Identify priority action items for TAM implementation. Keeps the RB AMP dynamic and at the forefront of continued progress. Surveys highlighted areas to work on next.	Y	Y					Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT12	**Employed consultants to develop RBAMP**	Leverage industry professionals to accelerate development of plan and tools. Added credibility to RB AMP and brought insight from their work in other DOTs. Staff worked with consultants and benefitted from their perspective.							Y
CDOT13	**Employed Program Leader in change management services**	Leverage CM for TAM implementation and awareness. Helped streamline communication and push new information to regions in a manner consistent with other agency initiatives. Asset Management highlighted as one of many key changes within CDOT.		Y		Y	Y		Y
CDOT14	**Use "asset managers" in all related divisions**	Staff accountability for implementation. The term asset manager became part of the culture	Y	Y	Y	Y	Y	Y	Y
CDOT15	**Transportation Commission AM Committee heads TAM program**	Provide organizational policy for investment decisions. Generates a lot of additional staff work but stresses importance of TAM to those that might not otherwise feel compelled to contribute. Policy makers drive the change to CDOT's culture from capital projects to maintaining what we have.		Y					Y
CDOT16	**Agency-wide mid-level management represented on TAM Working Committee**	Staff accountability for implementation. Maintains deadlines and prepares for delivery of content to Commission. Provide a forum for discussion and way to communicate change on a monthly basis.	Y	Y		Y	Y	Y	Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT17	**RBAMP clearly establishes agency direction wrt TAM**	Documentation of goals. Documents the as-is condition of asset mgmt at CDOT, and outlines a plan for improvement.	Y			Y	Y	Y	
CDOT18	**RBAMP describes value to citizens**	Description of benefits of TAM to customers. Emphasizes CDOT's role as stewards of the system and the need for wise investment of limited dollars.					Y	Y	
CDOT19	**Aspirational and fiscally constrained measures and targets described**	Describe and document TAM goals. Helpful in understanding funding deficits. Generates discussion of targets and measures for assets that did not have them prior to the RB AMP. This is still evolving for smaller asset groups.		Y	Y				
CDOT20	**Implementation plan includes prioritized list of recommended projects**	Describe action item where agency would develop new methods to optimize investment through quantitative and qualitative data. Project selection processes and the generation of a 4 year rolling program are in progress.	Y				Y		
CDOT21	**Implementation plan projects have leads assigned with deadlines**	Staff accountability for implementation. Emphasizes the need for accountability		Y			Y		Y
CDOT22	**Plan, Do, Check, Act framework**	Use standard change management techniques. Emphasizes the need to go back and check how we did and compare it to what we planned to do	Y		Y		Y	Y	

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT23	**Delphi budgeting workshop**	Interim investment programming activity that is in place until better analytical tools in the form of cross-asset optimization are developed. This is the key link to TAM and investment decisions. This turns TAM from an academic exercise to a practical one. Increase awareness among staff of how limited funds are and improves communication related to financial need	Y		Y		Y		Y
CDOT24	**Guidance for AM document**	Interim instructions on AM process pending completion of implementation plan.	Y		Y	Y	Y		Y

Table A.2 New York State DOT March 2015 TIRF Review

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
NYSD01	**Project and Program Management Information System (P/PMIS)**	Provides consistent data and reporting practices			Y				
NYSD02	**(Comprehensive) Program Update Process**	A unified programming process to align agency thinking, communications and objectives.	Y		Y			Y	
NYSD03	**Created the 1997 TAM Internal Task Force**			Y					
NYSD07	**May 2003 formal announcement of TAM implementation from executive management**	Largely ceremonial		Y					
NYSD08	**CAM-CI TAM Framework (Preservation & Beyond Preservation)**		Y			Y		Y	
NYSD09	**Institution of "Forward Four" principles**		Y			Y	Y	Y	

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
NYSD10	**Implemented Agile Assets Enterprise Asset Management Program**				Y				Y
NYSD11	**Created four-level internal business structure (2011)**			Y				Y	Y
NYSD12	**Formed TAMP Working Group**								Y
NYSD13	**TAMP Work Plan developed with clear staff assignments & deadlines**			Y			Y		Y
NYSD14	**Consultants employed to assist with TAMP development**								Y
NYSD15	**Commissioner approval of TAMP Work Plan**			Y					
NYSD16	**TAMP illustrates how risk management and TAM are connected**	The TAMP exists, but it is not widely understood by employees in general.	Y		Y	Y			

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
NYSD17	**TAMP specifies performance targets for pavements and bridges and lists steps in target-setting process**	The TAMP exists, but it is not widely understood by employees in general.	Y		Y	Y			
NYSD18	**TAM Improvement plan with estimated timeframes and expected outcomes**	The TAMP exists, but it is not widely understood by employees in general.		Y					Y
NYSD19	**Comprehensive Program Summary highlights treatment windows of opportunity**		Y		Y				
NYSD20	**Five-step risk management process detailed in TAMP**	The TAMP exists, but it is not widely understood by employees in general.	Y		Y				
NYSD21	**Three specific investment strategies outlined in TAMP**	The TAMP exists, but it is not widely understood by employees in general.	Y		Y				
NYSD22	**Scenario analysis using in-house software for**		Y		Y				Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
	performance gap identification								
NYSD23	**Established Policy Development Process**		Y	Y					Y
NYSD24	**Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)**	Regions given "preservation targets" to drive ensure at least a minimum investment in preservation work	Y	Y	Y	Y	Y	Y	

Table A.3 Georgia DOT May 2015 TIRF Review

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
GDOT01	Appointed TAM Director			Y					Y
GDOT02	Commissioner announces adoption of TAM principles		Y	Y		Y	Y		
GDOT03	Formed Office of Organizational Performance Management			Y					Y
GDOT04	Initial OPM communication to District Engineers		Y			Y	Y		
GDOT05	Formed TAM Task Force			Y					Y
GDOT06	Conducted TAM self-assessment		Y						Y
GDOT07	Higher-level self-assessment conducted by Chief Engineer and FHWA Assistant Division			Y					Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
	Administrator								
GDOT08	**Formed Executive Data Governance Committee**			Y					Y
GDOT09	**Developed 2011 Strategic Direction for TAM**		Y			Y	Y	Y	
GDOT10	**FY2011 Strategic Plan Update reflected new focus on TAM**		Y			Y	Y	Y	
GDOT11	**TAM "lunch and learn"**						Y		Y
GDOT12	**Formalized Asset Management Policy**		Y	Y		Y	Y	Y	
GDOT13	**Formed TAM Steering Committee, reporting to Commissioner**			Y					Y
GDOT14	**Developed comparative tradeoff analysis tool**				Y				Y
GDOT15	**Leadership attended national TAM Scanning Tour**			Y			Y		Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
GDOT16	**Developed web-based Performance Dashboard**				Y				Y
GDOT17	**Developed and implemented enterprise-based TAM system (GAMS)**				Y				Y
GDOT18	**Developing GIS Data Visualization tool**				Y				Y
GDOT19	**Merged bridge design and maintenance units**								Y
GDOT20	**Requirement for all physical asset contracts to be reviewed by TAM Steering Committee**		Y	Y	Y				
GDOT21	**Levels of Service tied to strategic goals, performance measures and customer feedback**							Y	
GDOT22	**TAM Implementation Plan has specific**	Goals/objectives are clear and targets for specific action items are met.		Y			Y		Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
	list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes								
GDOT23	**TAM Implementation Plan defines department roles in implementation**	Business Units will understand how their work fits into the bigger TAM framework.		Y			Y		
GDOT24	**Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance**	Evaluating performance will help to make adjustments to goals/objectives and targets.		Y	Y		Y	Y	Y
GDOT25	**Communications Plan lists**	Internal/external audiences will have a basic understanding of the need and		Y		Y	Y		Y

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
	strategies for delivering key messages to internal and external audiences with expected timeframe and responsible party	purpose for asset management.							
GDOT26	**Asset "champions" (subject matter experts) evaluate risks to establish funding scenarios**	Prioritized risks will help to achieve efficient funds allocation.		Y					Y
GDOT27	**TAMP describes how risk is factored into pavement and bridge decision-making tools**	Understanding that factors other than asset condition are considered to make decisions.	Y		Y				

APPENDIX B.

TIRF Reviews of Implementation Strategies Common to More than One Agency

Table B.1 Combined systematic review of "employed consultants to develop TAM plan" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT12	**Employed consultants to develop RBAMP**	Leverage industry professionals to accelerate development of plan and tools. Added credibility to RB AMP and brought insight from their work in other DOTs. Staff worked with consultants and benefitted from their perspective.							Y
NYSD14	**Consultants employed to assist with TAMP development**								Y

Table B.2 Combined systematic review of "AASHTO self-assessment" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT04	**Initial self-assessment (based on TAM Guide 1)**	Supported strategy for focusing on certain areas within TAM in building RB AMP. Identify current vs desired state. Identify gaps and next steps	Y						Y
GDOT06	**Conducted TAM self-assessment**		Y						Y

Table B.3 Combined systematic review of "time-bound implementation tasks with staff assigned" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT21	**Implementation plan projects have leads assigned with deadlines**	Staff accountability for implementation. Emphasizes the need for accountability		Y			Y		Y
NYSD13	**TAMP Work Plan developed with clear staff assignments & deadlines**			Y			Y		Y
NYSD18	**TAM Improvement plan with estimated timeframes and expected outcomes**	The TAMP exists, but it is not widely understood by employees in general.		Y					Y
GDOT22	**TAM Implementation Plan has specific list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes**	Goals/objectives are clear and targets for specific action items are met.		Y			Y		Y

Table B.4 Combined systematic review of "TAM champion" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT07	**Identified TAM champion/point person**	Staff accountability. Vital to success to have one individual as recognized authority for the department. Organizational change to elevate Transportation Performance to its own branch, and have the branch manager be the primary contact for asset mgmt.	Y	Y		Y	Y		Y
GDOT01	**Appointed TAM Director**			Y					Y

Table B.5 Combined systematic review of "asset managers in all related divisions" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT14	**Use "asset managers" in all related divisions**	Staff accountability for implementation. The term asset manager became part of the culture	Y	Y	Y	Y	Y	Y	Y
GDOT26	**Asset "champions" (subject matter experts) evaluate risks to establish funding scenarios**	Prioritized risks will help to achieve efficient funds allocation.		Y					Y

Table B.6 Combined systematic review of "multi-level governing structure with executive, senior, and mid-level management representation" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT08	**Efforts supported by senior-level management via Oversight Committee**	Facilitate staff-level decision making and support Transportation Commission TAM Committee direction and decisions. Important for Oversight Committee to exert influence but more vital for Executive Director and Transportation Commission to demand monthly public meetings on TAM. Alignment between asset mgrs/planners/budget staff with higher organizational concerns.		Y		Y		Y	Y
CDOT15	**Transportation Commission AM Committee heads TAM program**	Provide organizational policy for investment decisions. Generates a lot of additional staff work but stresses importance of TAM to those that might not otherwise feel compelled to contribute. Policy makers drive the change to CDOT's culture from capital projects to maintaining what we have.		Y					Y
CDOT16	**Agency-wide mid-level management represented on TAM Working Committee**	Staff accountability for implementation. Maintains deadlines and prepares for delivery of content to Commission. Provide a forum for discussion and way to communicate change on a monthly basis.	Y	Y		Y	Y	Y	Y
NYSD11	**Created four-level internal business structure (2011)**			Y				Y	Y

Table B.7 Combined systematic review of "integrated TAM software system" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
CDOT06	**Implemented integrated TAM system (AIMS)**	Development of quantitative tool to perform trade-off analysis and cross-asset optimization. Continues to provide informed decision making. Data driven decision making; providing tools for budget setting to decision makers in consistent manner.		Y	Y	Y	Y	Y	Y
NYSD10	**Implemented Agile Assets Enterprise Asset Management Program**				Y				Y
GDOT17	**Developed and implemented enterprise-based TAM system (GAMS)**				Y				Y

Table B.8 Combined systematic review of "Formal TAM announcement" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
NYSD07	**May 2003 formal announcement of TAM implementation from executive management**	Largely ceremonial		Y					
GDOT02	**Commissioner announces adoption of TAM principles**		Y	Y		Y	Y		
GDOT04	**Initial OPM communication to District Engineers**		Y			Y	Y		

Table B.9 Combined systematic review of "risk management explanation" strategy

ID	Implementation Strategy	Primary Observed/Expected Impact (Short Sentence)	G	L	A	C	E	A	R
NYSD20	**Five-step risk management process detailed in TAMP**	The TAMP exists, but it is not widely understood by employees in general.	Y		Y				
GDOT27	**TAMP describes how risk is factored into pavement and bridge decision-making tools**	Understanding that factors other than asset condition are considered to make decisions.	Y		Y				

APPENDIX C.

Implementation Strategies That Address Each TIRF Category

Table C.1 Guidance & Expectations Implementation Strategies

ID	Implementation Strategy
CDOT04	Initial self-assessment (based on TAM Guide 1)
CDOT07	Identified TAM champion/point person
CDOT09	Risk evaluation workshop open to interested staff
CDOT10	NHI Training sessions
CDOT11	Gap assessment process identifying 10 priority areas
CDOT14	Use "asset managers" in all related divisions
CDOT16	Agency-wide mid-level management represented on TAM Working Committee
CDOT17	RBAMP clearly establishes agency direction wrt TAM
CDOT20	Implementation plan includes prioritized list of recommended projects
CDOT22	Plan, Do, Check, Act framework
CDOT23	Delphi budgeting workshop
CDOT24	Guidance for AM document
NYSD02	(Comprehensive) Program Update Process
NYSD08	CAM-CI TAM Framework (Preservation & Beyond Preservation)
NYSD09	Institution of "Forward Four" principles
NYSD16	TAMP illustrates how risk management and TAM are connected
NYSD17	TAMP specifies performance targets for pavements and bridges and lists steps in target-setting process
NYSD19	Comprehensive Program Summary highlights treatment windows of opportunity
NYSD20	Five-step risk management process detailed in TAMP
NYSD21	Three specific investment strategies outlined in TAMP
NYSD22	Scenario analysis using in-house software for performance gap identification
NYSD23	Established Policy Development Process
NYSD24	Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)
GDOT02	Commissioner announces adoption of TAM principles
GDOT04	Initial OPM communication to District Engineers
GDOT06	Conducted TAM self-assessment
GDOT09	Developed 2011 Strategic Direction for TAM
GDOT10	FY2011 Strategic Plan Update reflected new focus on TAM
GDOT12	Formalized Asset Management Policy
GDOT20	Requirement for all physical asset contracts to be reviewed by TAM Steering Committee
GDOT27	TAMP describes how risk is factored into pavement and bridge decision-making tools

Table C.2 Leadership and Executive-Level Support Implementation Strategies

ID	Implementation Strategy
CDOT07	Identified TAM champion/point person
CDOT09	Risk evaluation workshop open to interested staff
CDOT10	NHI Training sessions
CDOT11	Gap assessment process identifying 10 priority areas
CDOT14	Use "asset managers" in all related divisions
CDOT16	Agency-wide mid-level management represented on TAM Working Committee
NYSD23	Established Policy Development Process
NYSD24	Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)
GDOT02	Commissioner announces adoption of TAM principles
GDOT12	Formalized Asset Management Policy
GDOT20	Requirement for all physical asset contracts to be reviewed by TAM Steering Committee
CDOT02	2001 TAM Task Force
CDOT06	Implemented integrated TAM system (AIMS)
CDOT08	Efforts supported by senior-level management via Oversight Committee
CDOT13	Employed Program Leader in change management services
CDOT15	Transportation Commission AM Committee heads TAM program
CDOT19	Aspirational and fiscally constrained measures and targets described
CDOT21	Implementation plan projects have leads assigned with deadlines
NYSD03	Created the 1997 TAM Internal Task Force
NYSD07	May 2003 formal announcement of TAM implementation from executive management
NYSD11	Created four-level internal business structure (2011)
NYSD13	TAMP Work Plan developed with clear staff assignments & deadlines
NYSD15	Commissioner approval of TAMP Work Plan
NYSD18	TAM Improvement plan with estimated timeframes and expected outcomes
GDOT01	Appointed TAM Director
GDOT03	Formed Office of Organizational Performance Management
GDOT05	Formed TAM Task Force
GDOT07	Higher-level self-assessment conducted by Chief Engineer and FHWA Assistant Division Administrator
GDOT08	Formed Executive Data Governance Committee
GDOT13	Formed TAM Steering Committee, reporting to Commissioner
GDOT15	Leadership attended national TAM Scanning Tour
GDOT22	TAM Implementation Plan has specific list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes

Table C.2 (continued)

ID	Implementation Strategy
GDOT23	TAM Implementation Plan defines department roles in implementation
GDOT24	Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance
GDOT25	Communications Plan lists strategies for delivering key messages to internal and external audiences with expected timeframe and responsible party
GDOT26	Asset "champions" (subject matter experts) evaluate risks to establish funding scenarios

Table C.3 Applications in Decision Making Implementation Strategies

ID	Implementation Strategy
CDOT14	Use "asset managers" in all related divisions
CDOT22	Plan, Do, Check, Act framework
CDOT23	Delphi budgeting workshop
CDOT24	Guidance for AM document
NYSD02	(Comprehensive) Program Update Process
NYSD16	TAMP illustrates how risk management and TAM are connected
NYSD17	TAMP specifies performance targets for pavements and bridges and lists steps in target-setting process
NYSD19	Comprehensive Program Summary highlights treatment windows of opportunity
NYSD20	Five-step risk management process detailed in TAMP
NYSD21	Three specific investment strategies outlined in TAMP
NYSD22	Scenario analysis using in-house software for performance gap identification
NYSD24	Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)
GDOT20	Requirement for all physical asset contracts to be reviewed by TAM Steering Committee
GDOT27	TAMP describes how risk is factored into pavement and bridge decision-making tools
CDOT06	Implemented integrated TAM system (AIMS)
CDOT19	Aspirational and fiscally constrained measures and targets described
NYSD01	Project and Program Management Information System (P/PMIS)
NYSD10	Implemented Agile Assets Enterprise Asset Management Program
GDOT14	Developed comparative tradeoff analysis tool
GDOT16	Developed web-based Performance Dashboard
GDOT17	Developed and implemented enterprise-based TAM system (GAMS)
GDOT18	Developing GIS Data Visualization tool
GDOT24	Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance

Table C.4 Reflection in Agency Culture and Language Implementation Strategies

ID	Implementation Strategy
CDOT07	Identified TAM champion/point person
CDOT10	NHI Training sessions
CDOT14	Use "asset managers" in all related divisions
CDOT16	Agency-wide mid-level management represented on TAM Working Committee
CDOT17	RBAMP clearly establishes agency direction wrt TAM
CDOT24	Guidance for AM document
NYSD08	CAM-CI TAM Framework (Preservation & Beyond Preservation)
NYSD09	Institution of "Forward Four" principles
NYSD16	TAMP illustrates how risk management and TAM are connected
NYSD17	TAMP specifies performance targets for pavements and bridges and lists steps in target-setting process
NYSD24	Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)
GDOT02	Commissioner announces adoption of TAM principles
GDOT04	Initial OPM communication to District Engineers
GDOT09	Developed 2011 Strategic Direction for TAM
GDOT10	FY2011 Strategic Plan Update reflected new focus on TAM
GDOT12	Formalized Asset Management Policy
CDOT06	Implemented integrated TAM system (AIMS)
CDOT08	Efforts supported by senior-level management via Oversight Committee
CDOT13	Employed Program Leader in change management services
GDOT25	Communications Plan lists strategies for delivering key messages to internal and external audiences with expected timeframe and responsible party

Table C.5 Employee Awareness and Understanding Implementation Strategies

ID	Implementation Strategy
CDOT07	Identified TAM champion/point person
CDOT10	NHI Training sessions
CDOT14	Use "asset managers" in all related divisions
CDOT16	Agency-wide mid-level management represented on TAM Working Committee
CDOT17	RBAMP clearly establishes agency direction wrt TAM
CDOT20	Implementation plan includes prioritized list of recommended projects
CDOT22	Plan, Do, Check, Act framework
CDOT23	Delphi budgeting workshop
CDOT24	Guidance for AM document
NYSD09	Institution of "Forward Four" principles
NYSD24	Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)
GDOT02	Commissioner announces adoption of TAM principles
GDOT04	Initial OPM communication to District Engineers
GDOT09	Developed 2011 Strategic Direction for TAM
GDOT10	FY2011 Strategic Plan Update reflected new focus on TAM
GDOT12	Formalized Asset Management Policy
CDOT02	2001 TAM Task Force
CDOT03	TAM Guide Book Club
CDOT06	Implemented integrated TAM system (AIMS)
CDOT13	Employed Program Leader in change management services
CDOT18	RBAMP describes value to citizens
CDOT21	Implementation plan projects have leads assigned with deadlines
NYSD13	TAMP Work Plan developed with clear staff assignments & deadlines
GDOT11	TAM "lunch and learn"
GDOT15	Leadership attended national TAM Scanning Tour
GDOT22	TAM Implementation Plan has specific list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes
GDOT23	TAM Implementation Plan defines department roles in implementation
GDOT24	Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance
GDOT25	Communications Plan lists strategies for delivering key messages to internal and external audiences with expected timeframe and responsible party

Table C.6 Comprehensive Agency Alignment Implementation Strategies

ID	Implementation Strategy
CDOT14	Use "asset managers" in all related divisions
CDOT16	Agency-wide mid-level management represented on TAM Working Committee
CDOT17	RBAMP clearly establishes agency direction wrt TAM
CDOT22	Plan, Do, Check, Act framework
NYSD02	(Comprehensive) Program Update Process
NYSD08	CAM-CI TAM Framework (Preservation & Beyond Preservation)
NYSD09	Institution of "Forward Four" principles
NYSD24	Implemented regional performance targets in comprehensive program update guidance (2011, 2013, 2014)
GDOT09	Developed 2011 Strategic Direction for TAM
GDOT10	FY2011 Strategic Plan Update reflected new focus on TAM
GDOT12	Formalized Asset Management Policy
CDOT06	Implemented integrated TAM system (AIMS)
CDOT08	Efforts supported by senior-level management via Oversight Committee
CDOT18	RBAMP describes value to citizens
NYSD11	Created four-level internal business structure (2011)
GDOT21	Levels of Service tied to strategic goals, performance measures and customer feedback
GDOT24	Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance

Table C.7 Resources Committed to TAM Development Implementation Strategies

ID	Implementation Strategy
CDOT04	Initial self-assessment (based on TAM Guide 1)
CDOT07	Identified TAM champion/point person
CDOT09	Risk evaluation workshop open to interested staff
CDOT10	NHI Training sessions
CDOT11	Gap assessment process identifying 10 priority areas
CDOT14	Use "asset managers" in all related divisions
CDOT16	Agency-wide mid-level management represented on TAM Working Committee
CDOT23	Delphi budgeting workshop
CDOT24	Guidance for AM document
NYSD22	Scenario analysis using in-house software for performance gap identification
NYSD23	Established Policy Development Process
GDOT06	Conducted TAM self-assessment
CDOT01	2001 Implementation Plan
CDOT02	2001 TAM Task Force
CDOT03	TAM Guide Book Club
CDOT05	2003 Draft AM Work Plan
CDOT06	Implemented integrated TAM system (AIMS)
CDOT08	Efforts supported by senior-level management via Oversight Committee
CDOT12	Employed consultants to develop RBAMP
CDOT13	Employed Program Leader in change management services
CDOT15	Transportation Commission AM Committee heads TAM program
CDOT21	Implementation plan projects have leads assigned with deadlines
NYSD10	Implemented Agile Assets Enterprise Asset Management Program
NYSD11	Created four-level internal business structure (2011)
NYSD12	Formed TAMP Working Group
NYSD13	TAMP Work Plan developed with clear staff assignments & deadlines
NYSD14	Consultants employed to assist with TAMP development
NYSD18	TAM Improvement plan with estimated timeframes and expected outcomes
GDOT01	Appointed TAM Director
GDOT03	Formed Office of Organizational Performance Management
GDOT05	Formed TAM Task Force
GDOT07	Higher-level self-assessment conducted by Chief Engineer and FHWA Assistant Division Administrator
GDOT08	Formed Executive Data Governance Committee
GDOT11	TAM "lunch and learn"
GDOT13	Formed TAM Steering Committee, reporting to Commissioner

Table C.7 (continued)

ID	Implementation Strategy
GDOT14	Developed comparative tradeoff analysis tool
GDOT15	Leadership attended national TAM Scanning Tour
GDOT16	Developed web-based Performance Dashboard
GDOT17	Developed and implemented enterprise-based TAM system (GAMS)
GDOT18	Developing GIS Data Visualization tool
GDOT19	Merged bridge design and maintenance units
GDOT22	TAM Implementation Plan has specific list of action items with defined timeframe, unit responsible, resources needed, and expected outcomes
GDOT24	Performance Management Implementation Plan describes responsibilities and steps for establishing performance measures, use of scorecards and performance dashboard, and methods of managing and reporting performance
GDOT25	Communications Plan lists strategies for delivering key messages to internal and external audiences with expected timeframe and responsible party
GDOT26	Asset "champions" (subject matter experts) evaluate risks to establish funding scenarios

APPENDIX D.

Panelist and Participant Biographies

Abhishek Bhargava

Abhishek Bhargava, Ph.D., is a Product Manager with AgileAssets Inc. He has over five years of experience in implementing asset management software in transportation agencies, providing project management and oversight of implementation projects and working with clients to analyze existing and develop improved business processes, policies, and procedures, and providing consulting services for the implementation of asset management software applications. He has a Bachelor's degree and a Doctorate in civil engineering from the Indian Institute of Technology, Bombay, and Purdue University, respectively.

Jason Bittner

Jason Bittner, MPA, is a Senior Associate/Senior Transportation Analyst-Asset Management with Cambridge Systematics. He has an extensive research background in asset management, performance management, maintenance quality assurance, mobility, and technology policy with over 17 years of transportation analysis experience. Mr. Bittner is managing and has previously contributed to several state DOT asset management plans including Florida, South Carolina, New Hampshire and Massachusetts. He also played a key role in the FHWA Asset Management Gap Analysis and Outreach Support for evaluating gaps in asset management at the state level. He is active with the TRB, serving as a member of the Committee on Transportation Asset Management, co-Chair of the Committee on Conduct of Research, and Chair of the 10th National Conference on Transportation Asset Management Planning Committee. Mr. Bittner has coordinated the TRB Committee on Transportation Asset Management

paper review process for the last decade and has served on multiple NCHRP project panels. He received a Master's degree in Public Administration, Energy Analysis and Policy from the University of Wisconsin – Madison and a Bachelor's degree in Political Science from The American University.

Jonathan Groeger

Mr. Groeger is involved with asset management and planning at all levels of Government. For example, he was the project manager and lead technical analyst on a project to develop the first three MAP-21 compliant TAMPs for the New York, Minnesota, and Louisiana Departments of Transportation (DOT). He also has led the development of TAMPs for the South Carolina and New Hampshire DOTs. He has led the TAM Gap Analysis of ten states for the FHWA. He has over 25 years' experience in asset management and planning, pavement and asset management system development, as well as and extensive experience and direct responsibilities managing programs for FHWA, State and local DOTs. Mr. Groeger earned his B.S. in Civil Engineering from the University of Maryland at College Park, and received an MBA from the University of Maryland University College.

Joe Guerre

Joseph A. Guerre, P.E., PMP has over 10 years of experience, including expertise in the areas of asset management, investment analysis, performance measures, and maintenance management. Since joining Cambridge Systematics in 2000, Mr. Guerre has worked on several pivotal NCHRP projects focused on asset management, including development of

the AASHTO Transportation Asset Management Guide, Performance Measures and Targets for Transportation Asset Management, and Analytical Tools for Transportation Asset Management. Mr. Guerre is a member of the TRB Management and Productivity Committee. He is a licensed Professional Engineer and a certified Project Management Professional.

Tim Henkel

Timothy A. Henkel is a MnDOT Assistant Commissioner and directs the Modal Planning and Program Management Division at the Minnesota Department of Transportation (MnDOT). Mr. Henkel's 30+ year transportation career includes working with local government, the private sector and numerous MnDOT responsibilities including executive leadership of multimodal planning, program management, and project development & delivery. He currently Chairs the FHWA Transportation Asset Management Expert Task Group, is a member of the Transportation Research Board (TRB) Research and Technology Coordinating Committee, is a member of the Planning Committee for the Eleventh National Conference on Transportation Asset Management and is Vice Chair of the AASHTO Standing Committee on Planning and the Transportation Asset Management Subcommittee. He received a Bachelor of Science degree from Bemidji State University and a Certificate in Civil Engineering and Land Surveying from Dunwoody College.

Sam Labi

Dr. Samuel Labi is an Associate Professor of transportation and infrastructure systems engineering at the School of Civil Engineering at Purdue University. He received a B.S. from the Kwame Nkrumah University of Science and Technology, Ghana; and a M.S. and Ph.D. from Purdue University. Dr. Labi's expertise includes transportation asset management, infrastructure project appraisal and systems evaluation, and transportation economics and finance. He has authored books civil engineering systems, transportation project evaluation and decision making, and highway asset management. Dr. Labi has served as principal investigator for several research projects related to asset management, sponsored by the USDOT and the National Academy of Sciences. He is an editor of the ASCE Journal of Risk and Uncertainty in Engineering Systems, editorial board member for the ASCE Journal of Infrastructure Systems, and chairman of the ASCE subcommittee on planning, finance, and economics. Dr. Labi's numerous research awards include ASCE's Frank Masters Award for outstanding and innovative work in advancing the area of transportation infrastructure asset management systems, the Bryant Mather Award for best paper in concrete materials awarded by the American Society of Testing and Materials (ASTM), and the Transportation Research Board's K.B. Woods prize for outstanding journal paper in design/construction.

David Lee

David Lee is an administrator for Statewide Planning and Policy Analysis in the Florida DOT Office of Policy Planning.

Hugh Louch

Hugh Louch is a Senior Associate for Alta Planning + Design. Hugh has worked extensively on performance management, asset management, and long range transportation planning as a Principal Consultant for 13 years with Cambridge Systematics. He helped the FHWA develop a framework for performance management that is being implemented through MAP-21 and has worked extensively on capacity building, training, and technical analysis to support implementation.

Alan Lubliner

Alan Lubliner is a strategic management and organizational development specialist in Parsons Brinckerhoff's asset management consulting practice, in which capacity, his knowledge bridges asset management and managing institutional change. As a project manager, management consultant and advisor to local, state and federal government transportation agencies in the US and internationally, he has led engagements in asset management, strategic planning, management reviews and organizational development, business process improvement, governance and organizational structuring, and performance management. Mr. Lubliner joined Parsons Brinckerhoff following an earlier successful career as chief of transportation planning and transportation and public utilities assistant to two mayors of the City and County of San Francisco. In the leadership positions he has held in both the public and private sectors, Mr. Lubliner's responsibilities have included management of multi-agency transportation programs, policy development, institutional development and capacity building, design of decision-making frameworks, transportation funding, legislation, regulatory compliance, fiscal

oversight, information/technology transfer and training, stakeholder involvement and public affairs. With a keen understanding of government processes and the political environment, Mr. Lubliner's career has focused on identifying and overcoming institutional and societal barriers to effective implementation and management.

Sue McNeil

Sue McNeil, Ph.D., P.E., is a professor of civil and environmental engineering and urban affairs and public policy at the University of Delaware. Her research and teaching interests focus on transportation infrastructure management with an emphasis on the application of advanced technologies, economic analysis, analytical methods, and computer applications. McNeil has been a member of the Executive Committee of the Transportation Research Board (TRB) and the Board on Infrastructure and the Constructed Environment. She chairs the TRB Committee on Asset Management. From 1988 to 1993 she was chair of the ASCE Urban Transportation Division Committee on Transportation Facilities Management and is a founding associate editor for the ASCE Journal of Infrastructure Systems. McNeil was a professor of civil and environmental engineering, and engineering and public policy, at Carnegie Mellon University, where she earned her doctorate. She then moved on to the University of Illinois at Chicago where she served as director of the Urban Transportation Center and was a professor in the College of Urban Planning and Public Affairs and the Department of Civil and Materials Engineering.

John Patrick O'Har

Dr. O'Har is a consultant with Parsons Brinckerhoff who assists clients with asset management analysis, strategy and implementation. His project experience includes the development and implementation of strategic asset management programs in the roadway, transit, and aviation sectors, the identification of best practices in the asset management of ancillary transportation infrastructure assets, and the development of a performance measurement framework for a regional roadway agency in Canada. Prior to joining Parsons Brinckerhoff, Dr. O'Har completed theoretical and practical research on asset management in transportation, namely in the areas of risk management as it relates to climate change, emerging technologies and transportation infrastructure needs. He was a Mirzayan Science and Technology Policy Fellow for the National Academy of Sciences and is a published author and co-author of industry leading research supported by the Transportation Research Board (TRB) as well as a member of TRB's Asset Management Committee. He earned his B.S, M.S., and Ph.D. in Civil Engineering from the Georgia Institute of Technology.

Charles Pilson

Charles has 25 years' experience in transportation related civil engineering. He graduated from the University of Cape Town in South Africa and got his Masters and PhD at the University of Texas in Austin. He is currently a Senior Principal Consultant with AgileAssets Inc.

David Rose

David Rose, Ph.D., is the Vice President of Parson Brinckerhoff's Strategic Consulting Services. His experience covers project development and finance, asset management, business improvement, policy, economics, climate change, among others. His specialties include highway and transit asset management, transportation finance, organizational transformation, performance management and more. He has over 20 years of experience in the transportation field and is a nationally regarded industry expert. He received his Bachelor's and Master's degrees in economics from the London School of Economics and Political Science, and his Ph.D. in policy and planning from Rutgers University.

Francine Shaw-Whitson

Ms. Shaw-Whitson has worked as a Transportation Manager with the Federal Highway Administration for several years, developing policy and guidance for Transportation Performance Management and most recently, executing performance measures rulemaking to implement federal legislation requirements through the FHWA Office of Transportation Performance Management. She is a member of the TRB Standing Committee on Strategic Management and a member of the FHWA Expert Task Group on TAM. She has also participated on NCHRP projects related to asset management plan development. She received her Bachelor of Science in Civil Engineering from the University of Maryland at College Park.

Omar Smadi

Dr. Smadi has over 20 years of experience in the area of infrastructure and asset management ranging from pavements, bridges, safety, pavement marking, signs and other infrastructure assets. Dr. Smadi is an associate professor with the department of Civil, Construction, and Environmental Engineering at Iowa State University. He is also the Director of RIMOS (Roadway Information Management Information Systems) program at InTrans. He is currently serving as PI for several research projects for the Iowa Department of Transportation, the Iowa Highway Research Board, the federally funded Midwest Transportation Consortium (MTC), NCHRP, SHRP 2, and FHWA. He is a member of the TRB Committee on Pavement Monitoring and Evaluation, Pavement Management and Asset Management committees. Dr. Smadi earned his B.S. in Civil Engineering from Jami'at Al-Yarmouk and his Ph.D. in Transportation Engineering from Iowa State University.

Butch Wlaschin

Mr. Butch Wlaschin, has several years of experience working with the FHWA, most recently as the Director, of the FHWA Office of Asset Management, Pavements and Construction. In that role, he led a team of engineers and transportation specialists in developing policy, guidance and technical assistance for state and local transportation officials in those areas. Mr. Wlaschin has more than 42 years of service in the transportation arena, having been the Deputy Director and Chief Engineer of the FHWA Federal Lands Highway Program from 1997 to 2007. He holds a MSCE in Geotechnical

Engineering from Georgia Tech and a BSCE from Lamar University. He is a Life Member of ASCE and a Registered Professional Engineer.

Kathryn Zimmerman

Ms. Katie Zimmerman, President and founder of Applied Pavement Technology, Inc. (APTech), has earned a national reputation for her work in the use of asset management programs for pavements, bridges, and ancillary assets to improve decisions in transportation agencies. She led the development of Transportation Asset Management Plans (TAMPs) for the Minnesota, Nevada, and Ohio Departments of Transportation (DOTs) and recently served as the Principal Investigator for National Cooperative Highway Research Program (NCHRP) Project 08-90 to develop a Gap Analysis Tool to help agencies identify asset management enhancement areas. She also recently updated the two National Highway Institute (NHI) training courses on asset management to address the requirements outlined in Moving Ahead for Progress in the 21st Century Act (MAP-21) and serves as the lead instructor for these courses. In addition, she facilitates meetings of the Federal Highway Administration (FHWA)-sponsored Transportation Asset Management (TAM) Expert Task Group (ETG) and authored the group's strategic plan to advance the use of asset management principles in state agencies. Ms. Zimmerman serves as the Chair of the Transportation Research Board Committee on Transportation Asset Management and participates on several Technical Panels for NCHRP projects. She earned her B.S. and M.S. degrees in Civil Engineering from the University of Illinois.

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