Mainstreaming Integrated Corridor Management

An Executive Level Primer

September 2019

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16. Abstract

The purpose of this primer is to provide executive level public sector decision-makers and transportation officials with an understanding of Integrated Corridor Management (ICM) and how to build off the previous experience, best practices, and lessons learned from the ICM Program. The intent is to further empower transportation officials to mainstream ICM practices in their transportation planning, project development, and operations practices to help address transportation problems and mobility issues. Mainstreaming ICM as a part of regional transportation systems management and operations (TSMO) activities is necessary for success over the long term. The primer also summarizes potential funding sources and resources to facilitate next steps for those agencies who decide to move forward with ICM implementation.

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LIST OF ACRONYMS

Acronym	Definition
AMS	Analysis, Modeling, and Simulation
ATCMTD	Advanced Transportation and Congestion Management Technology Deployment
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
BUILD	Better Utilizing Investments to Leverage Development (BUILD) Grant
CALTRANS	California Department of Transportation
CMM	Capability Maturity Model
CMAQ	Congestion Mitigation and Air Quality
ConOps	Concept of Operations
CV	Connected Vehicle
DOT	Department of Transportation
DMS	Dynamic Message Signs
DSS	Decision Support Systems
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
HOV	High Occupancy Vehicle
HSIP	Highway Safety Improvement Program
ICM	Integrated Corridor Management
ICMS	Integrated Corridor Management Systems
INFRA	Infrastructure for Rebuilding America
ITS	Intelligent Transportation Systems
MPO	Metropolitan Planning Organization
MWAA	Metropolitan Washington Airports Authority
NCHRP	National Cooperative Highway Research Program
NHPP	National Highway Performance Program
NHS	National Highway System
NITTEC	Niagara International Transportation Technology Coalition
NOVA	Northern Virginia
NJDOT	New Jersey Department of Transportation
NSFHP	Nationally Significant Freight and Highway Projects
O&M	Operations and Maintenance
SH	State Highway

SHSP	Strategic Highway Safety Plan
SR	State Route
STP	Surface Transportation Program
STPB	Surface Transportation Block Program
SyRS	System Requirements Specification
TIP	Transportation Improvement Program
TIGER	Transportation Investment Generating Economic Recovery
TMC	Transportation Management Center
TSMO	Transportation Systems Management & Operations
UDOT	Utah Department of Transportation
USDOT	United States Department of Transportation
UTA	Utah Transit Authority
VDOT	Virginia Department of Transportation
WMATA	Washington Metropolitan Area Transit Authority

EXECUTIVE SUMMARY

In contrast to the traditional approach of independently managing your own assets and systems, Integrated Corridor Management (ICM) represents a proactive, integrated approach for transportation operations agencies to manage the supply and demand in the presence of atypical events or conditions within a multimodal corridor. ICM improves regional and corridor response - by integrating existing Intelligent Transportation Systems (ITS) devices, systems, and assets controlled and operated by multiple agencies with multiple stakeholders, to create proactive solutions for managing demand and capacity across modes in each corridor. ICM is defined as "an approach designed to actively monitor, assess, and respond to atypical recurring and nonrecurring events that impact traffic on the most visibly congested highways or freeways that define a corridor."[1] ICM requires the institutional, operational, and technical integration of as many participating agencies as are available to combine their assets into one unified real-time response.

ICM is typically implemented through a system, called an integrated corridor management system (ICMS) with a decision support system (DSS) that monitors traffic conditions in the corridor, looking for atypical anomalies in traffic patterns or significant events that substantially change the traffic situation. When triggered by such conditions, the DSS will model alternative solutions (composed of multiple strategies that stakeholders have agreed could be implemented by the different agencies) as compared to the "do-nothing" alternative. If the alternative solutions are predicted to be significantly better than the "do-nothing" alternative, the solution with the best outcome is recommended for approval by an ICMS operator(s) or coordinator and instituted in real-time. The strategies that the DSS evaluates have been pre-approved and agreed to by the individual agencies and reflect the business rules that the DSS is programmed to evaluate. The DSS then continues to monitor network conditions after the response plan is implemented to determine if it is working or further adjustments are needed.

This primer provides background on the concept of ICM and discusses the characteristics of ICM as compared to traditional traffic management practices. The primer presents an overview of the federal ICM program as it evolved over the last decade and offers insight into the cities and agencies who participated in the program-sponsored ICM planning and deployment activities. The primer provides information on the motivation and business case to deploy ICM and offers readiness criteria for you to carefully consider prior to embarking on ICM implementation.

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[1] "What is Integrated Corridor Management?", USDOT Fact Sheet, FHWA-JPO-18-708, Nov 2018, https://rosap.ntl.bts.gov/view/dot/38816.

For candidate regions, mainstreaming ICM as a part of your transportation systems management and operations activities is necessary for success over the long term.

For agencies that are interested in implementing ICM, the primer presents material on how you can effectively integrate, or *mainstream*, ICM as part of your regional transportation business processes. For candidate regions, mainstreaming ICM as a part of the transportation systems management and operations (TSMO) activities is necessary for success over the long term.

Successful ICM within a region requires strong interagency and department commitment and involvement at all levels to incorporate ICM strategies and practices into regional operations and processes. Without an effort to mainstream ICM into today's transportation planning, system development, and operations practices, it will always remain a separate initiative within a region, not fully understood or supported, and underfunded. In addition, these separate ICM initiatives will likely lose momentum as staff changes occur and lack the necessary institutional and executive level support to fully realize the potential benefits.

Without an effort to mainstream ICM into today's transportation planning, system development, and operations practices, it will always remain a separate initiative within a region, not fully understood or supported, and underfunded.

Until recently, most ICM deployment and implementation planning activities were facilitated by federal grant money. Regardless of whether you secure grant money or other federal awards, further funding sources for operational improvements need to be applied to initiate, grow, and evolve your ICMS. The primer provides an overview of potential funding sources and offers resources for next steps if you want to find out more about ICM.

A listing of the best practices contained in this report for mainstreaming ICM are provided by topic in the table below. These best practices are expanded on in Chapter 4 of the primer.

Topic	Best Practices for Mainstreaming ICM
Working with Multiple Transportation Agencies	• Build on an existing collaborative group • Ensure that there is at least one committed champion • Establish lead coordinator • Organize and train staff • Achieve multiagency support • Gather support from elected or appointed officials and agency leadership • Engage participants
Transportation Planning Processes	• Adopt ICM-centric transportation goals • Use Federal Highway Administration (FHWA) Resources • Use Analysis, Modeling, and Simulation (AMS) tools to evaluate ICM • Incorporate ICM Strategies into Transportation Systems Management & Operations (TSMO) Plans • Integrate ICM into Planning Meetings • Consider ICM Strategies in planning studies and alternatives analyses • Make ICM part of standard regional processes
Transportation Programming Processes	• Include ICM in Transportation Improvement Programs (TIP) • Ensure that project selection procedures consider the impacts of ICM • Utilize federal funding opportunities for ICM projects
Project Development Processes	• Plan for incremental deployment of your ICMS • Use the system engineering process • Use and update your regional ITS architecture • Recognize that ICM projects are like other ITS projects
Operations and Maintenance Activities	• Include ICM components in ITS operations and maintenance contracts, technological refreshes, or equipment swap outs • Incorporate periodic ICM Management Systems (ICMS) into performance review meetings • Address ongoing ICMS operations and maintenance (O&M) roles and funding needs

Topic	Best Practices for Mainstreaming ICM
Considerations for Decision Support Systems (DSS)	• Develop your DSS incrementally • Consider the costs and resources needed for DSS • Harmonize the traffic modeling tools used • Consider new uses for enhanced traffic modeling capabilities • Use business rules agreed upon by stakeholders in the DSS • Use multimodal, corridor-level performance measures to drive decision-making
Funding ICM	• Integrate ICM into your regional TSMO, ITS, and State and local short and long-range transportation and strategic plans • Integrate ICM into your department's programmatic, TSMO, and ITS budgets • Add ICM to larger project proposals for United States Department of Transportation (USDOT) Discretionary Grant Programs • Remember to budget for long-term operations and maintenance

CHAPTER 1. INTRODUCTION

Consider all of the pre-planning that exists for special events like college and professional game days, parades, and protest marches. Often, weeks of planning occur, involving many agencies, contingencies, and mitigations. Secondary routes, modes, and messages are all enlisted to help defray the congestion. The event subsumes the better part of that day. Now imagine a similar, but *unplanned* event, like a truck-overturn, or a severe weather event, or phantom backup, that would otherwise occupy many hours' delay. In the latter case, ICM engages in real-time to diffuse the situation and mitigate the event.

Transportation operations in corridors are handled largely independently and siloed, often resulting in increased congestion and reduced returns on incident management and response. Integrated Corridor Management (ICM) incorporates the entire region (aka, the "travel shed," explained later) in responding to the incident or delay, instead of just the facility. Starting in 2006, to address growing congestion and reduced mobility along urban corridors, the United States Department of Transportation (USDOT) began research into the integration of the operations of all the transportation networks (e.g., freeway, arterial, transit, rail, etc.) within a corridor to maximize their effectiveness of incident management and reduce congestion, creating the ICM program. ICM is defined as "an approach designed to actively monitor, assess, and respond to atypical recurring and nonrecurring events that impact traffic on the most visibly congested highways or freeways that define a corridor."[2] Simply put, it is more than just a locational detour.

PURPOSE AND AUDIENCE

The purpose of this primer is to provide *executive* level public sector decision-makers and transportation officials with an understanding of ICM, how to build off the previous experience, best practices, and lessons learned from the ICM Program, and further empower transportation officials to mainstream ICM practices in their transportation planning, project development, and operations practices to help address transportation problems and mobility issues. The purpose is *not* to delve deeply into the Concept of Operations or mechanisms of ICM. The target audience for this primer are public sector and executive-level transportation officials wishing to implement mainstreamed ICM in their region.

ORGANIZATION AND HOW TO USE THIS PRIMER

The primer is organized as shown on the following page.

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[2] "What is Integrated Corridor Management?", USDOT Fact Sheet, FHWA-JPO-18-708, Nov 2018, https://rosap.ntl.bts.gov/view/dot/38816.

- Chapter 1 Introduction
- Chapter 2 Background on ICM
- Chapter 3 Motivation and Readiness for ICM
- Chapter 4 Mainstreaming ICM
- Chapter 5 Funding ICM
- Chapter 6 Resources for Next Steps

This chapter serves as the introduction. Chapter 2 provides the background on the concept of ICM and discusses the characteristics of ICM as compared to traditional traffic management practices. Chapter 2 also presents an overview of the federal ICM program as it evolved over the last decade and offers insight into the cities and agencies who participated in the program-sponsored ICM planning and deployment activities. Chapter 3 provides more information on the motivation and business case to deploy ICM and offers readiness criteria for you to carefully consider prior to embarking on ICM implementation. This will help you to know whether ICM is the right solution for your transportation corridor.

For agencies that are interested in implementing ICM, chapter 4 presents material on how you can effectively integrate ICM as part of your regional transportation business processes. Mainstreaming ICM as a part of regional transportation systems management and operations activities is necessary for success over the long term. Until recently, most ICM deployment and implementation planning activities were facilitated by federal grant money. Part of the mainstreaming message is that typical funding sources for operational improvements need to be applied to grow and evolve your ICM System (ICMS). Chapter 5 provides an overview of these funding sources and chapter 6 offers resources if you want to find out more about ICM.

It is hoped that this primer will be read by top officials (executives) within transportation agencies and then widely shared with management and other leaders within those agencies. Regarding how to use this document, the reader may wish to read the introduction in order to determine which chapters and sections are most relevant to their situation. For example, if you already have a solid understanding of ICM and the USDOT ICM program, you may wish to skip chapter 2. If your region has already decided to implement ICM in a specific corridor or corridors, you should consider jumping to chapter 4 to learn about mainstreaming best practices. In addition, key stakeholders in the region should be brought together to discuss these mainstreaming ideas during an appropriate meeting or venue.

CHAPTER 2. BACKGROUND ON ICM

This chapter provides the definition and defining characteristics of Integrated Corridor Management (ICM), offers an overview of the United States Department of Transportation (USDOT) ICM program, and provides a brief discussion of how ICM works.

WHAT IS ICM?

ICM follows the evolution of Intelligent Transportation Systems (ITS) technologies. Agencies first deployed individual devices, followed by separate modal systems, and ultimately integrating devices and systems into multimodal ICM. ICM improves regional response – not just corridor response - by integrating existing ITS devices, systems, and assets controlled and operated by multiple agencies with multiple stakeholders, to create proactive solutions to manage demand and capacity across modes in each corridor. ICM is only possible as a result of mining "big data," which was not available as recently as a decade or so ago.

ICM is an approach designed to actively monitor for the most severe atypical recurring and nonrecurring events that impact traffic on already congested trunk highways or freeways that define a corridor. Because of near constant congestion, even minor events on an anchor facility can have a huge impact, *even if* those facilities may already deploy highly advanced systems like ramp metering, high occupancy vehicle lanes, or peak hour enhancements. The latter strategies do their best to mitigate an already congested facility, but one which can instantly degrade into stop-and-go speeds due to even the most minor incident.

ICM requires the **institutional, operational, and technical integration** of as many participating agencies as are available to combine their assets into one unified real-time response. ICM is "regional" but is often defined by the major trunk highway. Therefore, a corridor-defined region is bounded by a "travel shed" of (mostly) commute and daily trips that are germane to the subject artery highway and the subordinate parallel and coexistent modes and routes that are also germane to that shed. Think of the travel shed as a "watershed," in that a common set of streams (of traffic) "drain" into a single larger body of collection (see Table 1). In an ICM context, the "corridor" is comprised of all the multimodal options and traffic systems that exist and can reasonably service trips within the travel shed. For example, a corridor may contain a freeway management system, several arterial signal systems, transit bus routes, and a commuter rail system. At various times, all of these systems may participate in an ICM response.

Table 1. Key Terms in ICM

Term	Definition
Corridor	(Also, the "region,") defined by the trunk highway, and bounded by a "travel shed" of (mostly) commute and daily trips that are germane to the subject artery highway and the subordinate parallel and coexistent modes and routes that are also germane to that shed.
Travel Shed	The boundary of all first- and last-mile trips that have a high feasibility of using the primary facility of a given corridor.
Integrated Corridor Management System (ICMS)	A system designed to implement ICM within a given area. The system monitors traffic, looks for unusual events or delays, assists with decision-making and communications, and generally operationalizes the ICM strategies for the corridor.
Decision Support System (DSS)	Software that assists or automates portions of the decision-making process needed as part of an ICMS. The DSS monitors traffic conditions, compares to typical trends, models alternative solutions and strategies consistent with expert rules that have been programmed in, predicts the impact of those solutions, and assists with implementation and evaluation of a given response.
Business Rules	The agreed-upon policies, procedures, and protocols of the participating agencies that govern the way in which individuals and agencies interact within the ICMS. The business rules reflect the operational strategies and constraints that have been pre-approved by the ICM stakeholders as suitable candidates for creating response plans within an ICMS.

Each unique travel shed, then, would have its own different ICM partners, including all proximate department of transportation regional transportation management centers, cities, or boroughs along that corridor as well as the agencies that operate in or oversee each individual shed. A neighboring travel shed of another, distinct ICM corridor would have a new mix of partner agencies and would be as different from the first one as it would be from a different region or State.

ICM goes beyond nominal (i.e., day-to-day) traffic management and traditional incident response (i.e., a detour) on a highway, as those operational practices are typically only reactive and do not include ICM's proactive engagement of other agencies' assets on parallel routes or alternate travel modes. ICM strategies are characterized by actively changing signal timings, promoting (and if need be, temporarily increasing) transit alternatives, providing bus bridges, modifying toll rates, changing ramp meters, and generally flexing the entire corridor

to absorb the congestion vent rather than merely responding only near the event on the subject anchor highway.

ICM combines two fundamental concepts: active management and integration. Active management involves real-time monitoring and assessing performance of the transportation system and dynamically implementing responses to fluctuations in demand. In ICM, all individual facilities are actively managed so that operational approaches can be taken in real-time in response to events anywhere in the system. Integration requires actively managing assets in a unified way so that corrective actions can be taken to benefit the *entire* corridor, and not just parts of it. Integration occurs in the following three dimensions:

- **Institutional Integration -** Involves the coordination and collaboration between multiple agencies across jurisdictions (i.e., transportation network owners) in support of ICM. This includes the distribution of specific operational responsibilities and the sharing of control functions that transcend institutional boundaries.
- **Operational Integration –** Involves the implementation of multi-agency transportation management strategies, often in real-time or planned, and promotes the sharing and coordination operations across the transportation networks in the corridor to facilitate the management of the total capacity of the corridor.
- **Technical Integration** – Provides the means (i.e., communication links, system interfaces, and associated standards between agencies) by which system information, operations and control functions are effectively shared and distributed across the transportation network. It also provides agencies and their respective transportation management systems with immediate information on the impacts of operational decisions, so that agencies can evaluate their impacts and take corresponding action.

Table 2 below describes the defining characteristics of ICM. As shown by the various dimensions, ICM can be characterized as multimodal, multijurisdictional, traveler/person-focused, integrated, proactive, comprehensive, and collaborative. In other words, agencies having an ICM mindset work collaboratively across modal and jurisdictional boundaries to integrate their systems for the benefit of people traveling in and through the corridor.

ICM can be characterized as multimodal, multijurisdictional, traveler/person-focused, integrated, proactive, comprehensive, and collaborative.

Table 2. Defining Characteristics of ICM

Dimension	ICM **is not**…	ICM **is** …
Facilities/Modes/ Networks	Primarily **unimodal**, such as a freeway network, arterial streets, and transit routes that simply co-exist	A **multi-modal** network encompassing the main transportation options within a corridor/travel shed
Integration of Transportation Systems	Separate systems (e.g., freeway management, arterial signal, incident management, or bus Automatic Vehicle Location (AVL) system)	Integrated, system of systems
Priority	Moving vehicles	Moving people (travelers) and goods
Jurisdictions	Optimizing for an individual jurisdiction	About solving travel problems across multiple jurisdictions
Traveler Information	Separate information for drivers and transit users	Updated information across all modes in a corridor, coordinated with the Integrated Corridor Management Systems (ICMS)
Operations decisions within the corridor	Independent, agency specific actions	Coordinated and communicated actions
Agencies and stakeholders	Optimizing an individual agency's system	Multi-agency collaboration and coordination
Performance monitoring	Vehicle-focused measures	Traveler focused, multimodal measures
Approach to response plans?	Reactive, ad-hoc	Proactive, pre-planned, predictive

BACKGROUND ON THE ICM PROGRAM

The USDOT initiated the ICM Program to research the integration of transportation networks within urban travel corridors. Starting in 2006, USDOT began research into ICM as an approach in congestion management, by optimizing the use of existing infrastructure and assets, and by leveraging unused capacity along our nation's corridors. The ICM Program Objectives are provided in the text box on the following page.

ICM Program Objectives:

- To demonstrate and evaluate pro-active integrated approaches, strategies, and technologies for efficient, productive, and reliable operations.
- Provide the institutional guidance, operational capabilities, and ITS technical methods needed for effective Integrated Corridor Management.

The ICM program consisted of four phases, as detailed in Figure 1. A brief description of these phases is provided below.

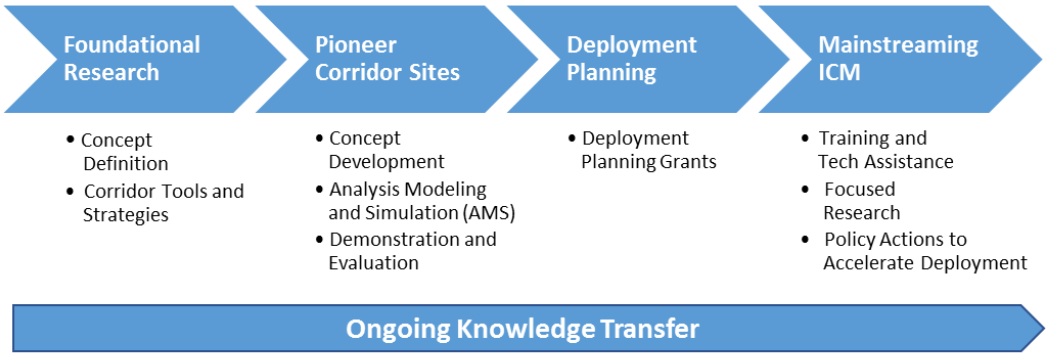

Figure 1. Chart. Major Phases of the USDOT ICM Research Program (Source: USDOT)

During Phase one, foundational research was performed to understand both the institutional, operational, and technical integration required of corridor management and the development mitigation strategies. Phase two solicited actual corridor stakeholders, termed the **Pioneer Sites**, via a competitive funding process to develop concepts for the integrated operation of corridor networks, to analyze the benefits of demonstrations, and then conduct two large-scale ICM demonstrations in San Diego, CA and Dallas, TX. The eight pioneer sites (noted in Table 3) were selected from across the U.S. and had representative configurations and characteristics of similar corridors across the country. The Pioneer Sites development process was divided into three stages. In Stage one, the eight pioneer sites developed concepts of operations (ConOps) and system requirements for implementing ICM in their corridors. Stage two involved analysis, modeling and simulation (AMS) of ICM strategies on three corridor networks (Dallas, San Diego, and Minneapolis). In Stage three, two large-scale ICM demonstrations (I-15 in San Diego, CA and US-75 in Dallas, TX) were implemented and evaluated.

Table 3. Pioneer Site Locations

Pioneer Site Locations (City and State)	
Dallas, TX	Minneapolis, MN
Houston, TX	Seattle, WA
San Antonio, TX	Montgomery
San Diego, CA	County, MD
Oakland, CA	

Phase three built off the success of Phase two's Pioneer Sites and provided competitive grant funding for an additional 13 sites across 10 States to develop "pre-implementation" documents and begin active planning for integrated corridor management systems. A total of 33 sites applied and 13 were selected in highly congested areas. See Table 4 for a list and Figure 2 for a map of the 13 selected corridor locations. The planning grants provided assistance in the development of pre-implementation documents, such as Concept of Operations (ConOps), System Requirements (SyRS), Analysis Modeling and Simulation Plans, and/or ICM Implementation Plans.

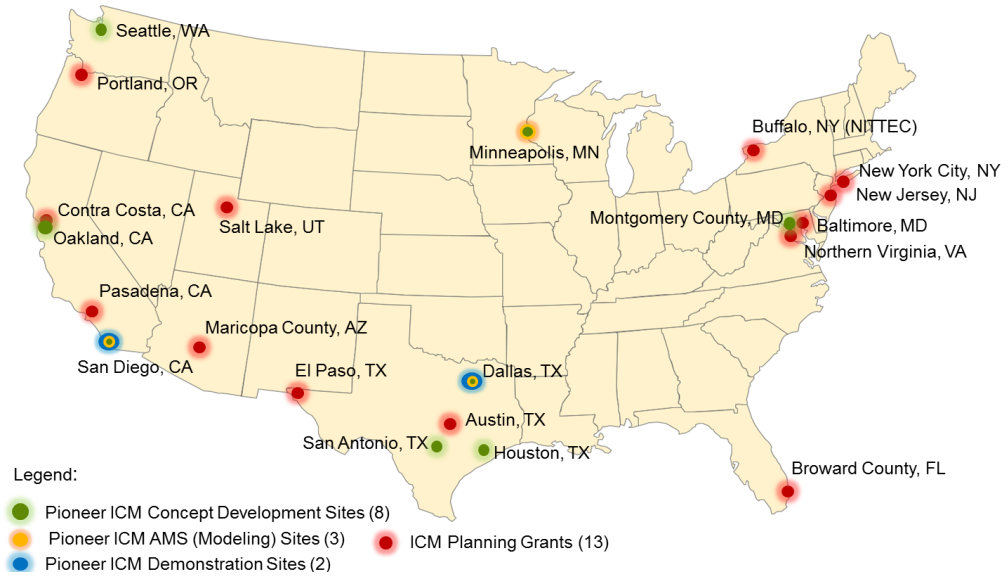

Figure 2. Chart. ICM Pioneer Site and Implementation Planning Grant Corridor Locations (Source: USDOT)

Table 4: ICM Planning Grant Recipients
(Source: USDOT)

State	Lead Agency or City	Corridor Description
Arizona	Maricopa County	I-10 through the Phoenix metro area and multiple east-west parallel routes.
California	California Department of Transportation (Caltrans)	I-210 on a 22-mile section from the 134/210 interchange near downtown Pasadena to the Foothill Boulevard Interchange in La Verne.
California	Contra Costa County	State Route (SR)-4 in the city of Hercules from I-80 to I-680.
Florida	Broward County	I-95 on a 25-mile section in Broward County. Commuter rail, transit bus service, inter-city rail (including Amtrak) park & ride lots and bike trails.
Maryland	Maryland State Highway Administration	Three corridors connecting Washington, DC and Baltimore: I-95, MD 295 (the Baltimore-Washington Parkway), and US 1 between MD 32 and I-695.
New Jersey	New Jersey Department of Transportation (NJDOT)	New Jersey Turnpike (I-95), Garden Parkway and US 1 and US 9 from Woodbridge (south) to the Holland Tunnel (north).
New York	City of New York	In the New York/New Jersey metro area, the corridor includes sections of Route 495 (the Long Island/Queens-Midtown Expressway) and crosses midtown Manhattan, the Lincoln Tunnel and the Queens-Midtown Tunnel.
New York	Niagara International Transportation Technology Coalition (NITTEC)	I-90 within the Buffalo-Niagara region, including the Peace Bridge and the I-190/I-90 interchange to the south and the I-190/I-290 interchange to the north.
Oregon	City of Portland	I-84 from downtown Portland encompassing over 45 square miles. Light rail and streetcar routes. Local streets. Bus and bike routes.
Texas	City of El Paso	IH-10 from US-54 to Loop 375, US-54/IH-110 from IH-1 to Loop 375. This project is 16 miles combined. Bus routes.
Texas	City of Austin	IH-35 between US 183 and State Highway (SH) 71
Utah	Utah Transit Authority (UTA) and Utah Department of Transportation (UDOT)	Major north-south roadways, representing approximately 25 miles, from downtown Salt Lake City to Lehi City, including I-15, State Street and Redwood Road. Commuter rail services.
Virginia	Virginia Department of Transportation (VDOT)	Northern Virginia east-west corridors including I-66, SR 7, US 29, US 50 and SR 267. The Virginia Railway Express Manassas line, Metro Silver and Orange lines, commuter bus routes, and commuter parking lots.

The fourth and final phase of the ICM research program is referred to as "Mainstreaming ICM" and focuses on mainstreaming ICM concepts and strategies, through efforts such as this primer, to encourage further adoption of ICM, and consists of the continued knowledge transfer of ICM concepts, methods, tools, and products, to encourage the adoption of ICM into everyday transportation planning, project development, and operations. Mainstreaming activities also include focused research to assist with deployment challenges and policies to encourage deployment, such as establishing ICM as an eligible or even preferred project type in various deployment grant programs. Note that knowledge transfer activities have been an ongoing part of every program phase, as shown by the continuous activity bar in Figure 1.

For additional information regarding the ICM Program, please see *Integrated Corridor Management (ICM) Program: Major Achievements, Key Findings, and Outlook.* See chapter 6 for more information on this resource.

HOW DOES ICM WORK?

Very briefly, ICM is implemented through a system, called an integrated corridor management system (ICMS) with a decision support system (DSS) that monitors traffic conditions in the corridor, looking for anomalies in traffic patterns or significant events that change the traffic situation enough that alternative approaches to managing the multimodal corridor should be evaluated for possible implementation. Once an atypical event triggers such an evaluation, then the DSS will model one or (often) more alternative solutions (composed of multiple strategies that stakeholders have agreed could be implemented by the different agencies) as compared to the "do nothing" alternative. If the alternative solutions are predicted to be significantly better than the "do-nothing" alternative, the solution with the best outcome is recommended for approval by an ICMS operator(s) or coordinator and instituted in real-time.

The DSS then continues to monitor network conditions after the response plan is implemented to determine if it is working or further adjustments are needed. The DSS can have varying levels of capability and support and may involve more or less human involvement in the process of evaluating and implementing the strategies. The strategies that the DSS evaluates have been pre-approved and agreed to by the individual agencies and are the ***business rules*** that the DSS is programmed to evaluate. The strategies can include providing pre-trip and en-route traveler information, recommending and guiding travelers to diversion routes or alternate modes, modifying the traffic signals or ramp meters to accommodate more traffic, temporarily adding capacity to transit modes, facilitating smooth transfers at network junctions, and many other options. Resources and more information on DSS can be found in chapter 6.

CHAPTER 3. MOTIVATION AND READINESS FOR INTEGRATED CORRIDOR MANAGMENT (ICM)

This chapter provides information on the benefits of integrated corridor management to assist with making the business case for Integrated Corridor Management (ICM) and offers suggestions on readiness criteria for sites wanting to move forward with implementation.

WHY SHOULD YOU INVEST IN ICM?

While the concept of ICM makes sense to most transportation professionals, the benefits of such systems need to be understood and quantified so that investments can be weighed in terms of their relative merits and costs along with other transportation improvements. To that end, an independent evaluation was conducted on the two Pioneer ICM demonstration sites; the I-15 corridor in San Diego, California, and the U.S. 75 corridor in Dallas, Texas, that began operations in 2013. This evaluation[3] found that the improved interagency cooperation and coordination brought about by going through the ICM process was a big success. Both San Diego and Dallas created a fundamental paradigm shift in the management of their respective corridors by creating strong multi-jurisdictional partnerships that set the foundation for a regional corridor management mindset – based on a platform of strong institutional, technical, and operational integration. Key findings that emerged from the evaluation of these demonstrations include the following benefits:

- Regional operations awareness of corridor congestion and incidents improved significantly through regional data sharing.
- Incident reporting details improved substantially in both regions.
- Corridor operators reported better situational awareness of corridor operating conditions, although there were opportunities to improve.
- Incident and congestion specific traveler information provision improved.
- While employing different levels of human involvement, the Decision Support System (DSS) at both sites proved to be valuable for better situational awareness, decision-making, and response coordination.
- Corridor mobility performance generally improved during ICM activations.
- Using the assumptions and modeling tools documented by the evaluators, the benefits estimated for San Diego's Integrated Corridor Management Systems (ICMS) easily exceeded costs (2:1 to 9:1), whereas the break-even point (1:1 ratio) for Dallas' ICMS was contained within the expected range for the benefit cost ratio.

[3] Battelle, Integrated Corridor Management Initiative: Demonstration Phase Evaluation, Final Report Draft, August 2017.

Agencies should understand the evaluation challenges associated with ICM, specifically that relatively infrequent large-scale incidents are not likely to occur at the exact same location, at the same time, and under the same conditions in the before and after periods for direct comparison. Traffic modeling and other Analysis, Modeling, and Simulation (AMS) tools and techniques will play a key role in understanding ICM benefits.

Findings from a survey of the 13 implementation planning grant sites confirmed that there were significant institutional benefits of improved interagency cooperation and coordination brought about by going through the ICM process. While these benefits are difficult to quantify, they are clearly important in making the business case for ICM in your region. Having a more detailed understanding of the operational considerations of various corridor stakeholders will ultimately lead to operational benefits. For more information, please see the resources section.

ARE YOU READY TO GET STARTED?

Before launching ahead (or further) into ICM deployment, it is first necessary to understand whether ICM is the right solution for your specific corridor or area. For example, if you do not have a congestion, incident, and travel time reliability issue or predicted problem to solve, then ICM may not be very beneficial to you. Likewise, network constraints, such as a lack of viable alternative routes or modes for a given corridor, may mean that there are not reasonable options for diverting travelers in case of an incident on the main freeway. Additionally, agencies should understand what they're getting into from an institutional perspective and decide whether or not they want to commit to those activities. A list of these attributes has been compiled below; a one-page handout of the same information is published for your reference and distribution at meetings.[4]

Prior to implementing ICM, local agencies and organizations need to address the following questions to ensure that they are properly prepared to address implementation and associated challenges and that ICM is the *right solution* to meet their transportation needs.

1. **Is there s*ignificant* congestion and unreliability along a corridor or travel shed?**
    - The impact of ICM is more noticeable in areas with significant congestion and delay, as improved traffic flow in these areas can be more attributable to ICM strategy implementation than in areas that experience inconsistent congestion. Keep in mind that ICM may be very beneficial to have in place for managing the traffic conditions associated with major construction activities or special events.

[4] "10 Attributes of a Successful ICM Site" published by the United States Department of Transportation (USDOT) can be accessed at https://rosap.ntl.bts.gov/view/dot/38815 .

2. **Is additional infrastructure available within the corridor?**
    - ICM requires additional infrastructure availability like parallel arterials, transit routes, and mode hubs, as transportation alternatives to the clogged freeway in the corridor/travel shed.
3. **Does your area have multimodal capabilities?**
    - A major feature of ICM is information sharing across modes, such as bus transit, rail transit, and freeway, from both an incident detection and management perspective and providing up-to-date traveler information. Traveler information allows users to make informed decisions about routing and mode used to get to their destination.
4. **Does your area use a centralized data hub, like a Transportation Management Center (TMC)?**
    - Real-time and historical data are vital to the simulation capabilities ICM and in developing scenarios (i.e., playbooks) for incidents management. A Transportation Management Center (TMC), or centralized data hub, makes it easier to organize and analyze data collected and come up with potential solutions.
5. **What procurement practices can we use?**
    - ICM is comprised of multiple systems, components, and Intelligent Transportation Systems (ITS). Procurement issues, contract type, or goods and services procured can cause cost overruns or project delays. It is important to use available resources and engage ITS experts and the ICM community who have experience in ICM implementation.
6. **Is transit readily available?**
    - Transit alternatives are an important component of ICM and assists in reducing congestion. Having reliable bus routes, bus rapid transit, high occupancy vehicle lanes, and commuter rail are all important transportation alternatives that can relieve a clogged highway.
7. **Are current systems optimized?**
    - Ensuring that transportation systems are optimized and that additional infrastructure improvements won't alleviate congestion assists in the solutions to be proposed as part of ICM.
8. **Are we ready to engage the public and gather feedback?**
    - Stakeholder and public engagement is vital for any successful transportation project. By engaging stakeholders and the public throughout the development and deployment of ICM, it provides them with a better understanding of the project, increases buy-in, assists in setting expectations, and limits potential "surprises."
9. **Is there open-mindedness for changes in travel behavior?**
    - A major component of ICM is getting travelers to change their behaviors to reduce congestion, like using transit, carpooling, or driving during non-peak times. Successful ICM Sites have been able to get travelers to use other

modes of transportation, such as public transportation (light rail, bus rapid transit, etc.), carpooling, or managed lanes.

10. Do we have organizational and institutional support?

- Interagency and institutional support are critical pieces of ICM. A strong ICM Champion, leadership, clear vision, and robust participation are vital to laying the foundation for success. Without the coordination of transportation agencies and organizations, multimodal communication and coordination is extremely difficult.

CHAPTER 4. MAINSTREAMING ICM

This chapter provides an overview of what mainstreaming Integrated Corridor Management (ICM) means, why mainstreaming ICM is important, and examples of mainstreaming efforts across the U.S. The chapter provides information on how to integrate ICM into the overall transportation business processes, including planning, programming, project development, and operations and maintenance activities. Additionally, special considerations for decision support systems within the context of ICM mainstreaming are offered.

WHAT IS MAINSTREAMING ICM?

As noted in Chapter 2 of this Primer, ICM is more than just a tool in addressing congestion and incident management. ICM attempts to help manage and control congestion on freeways and arterials by utilizing multimodal communication between transportation organizations and resulting in positive benefits and outcomes. *For this primer, we define mainstreaming ICM as promoting the incorporation of ICM goals, strategies, and concepts into the everyday, routine processes and practices of multi-agency planning, programming, developing and implementing projects, and operations and maintenance of the transportation system.*

Mainstreaming ICM goes beyond using ICM as a separate, standalone, congestion management strategy. Mainstreamed ICM incorporates ICM strategies and practices into department or agency operations, institutional frameworks, and processes. Successful ICM within a region requires strong interagency and department commitment and involvement at all levels. Without an effort to mainstream ICM into today's transportation planning and system development practices, it will always remain a separate initiative within a region, not fully understood or supported, and underfunded. In addition, these separate ICM initiatives will likely lose momentum as staff changes occur and lack the necessary institutional and executive level support to fully realize the potential benefits.

WHY IS MAINSTREAMING ICM IMPORTANT?

The time to consider ICM is now and understanding how to mainstream ICM will be the key to its overall success. We simply cannot afford to work in isolation when it comes to transportation operations - agencies must come together to address regional and corridor-specific transportation problems. New technologies provide opportunities to further integrate, communicate and collaborate across transportation modes and regions. Whereas previously, highways, surface streets, arterials, transit, and other modes of transportation were disjoint, the transportation system of today is evermore connected and interdependent, both physically and technologically. Today's traveler expects up-to-date traveler information so that they can make informed decisions on the mode of transportation used, route options, and travel times.

The same can be said for transportation officials, who, by having up-to-date information, can adequately identify incidents or congestion, collaborate on incident response plans, and execute them accordingly. ICM, when fully integrated and implemented, can provide this information and assist in better informed decision-making processes and mitigation plans.

Mainstreaming ICM doesn't happen immediately. The ICM deployment planning grantees identified both successes and challenges that will impact and potentially delay the mainstreaming effort. Building from the best practices and lessons learned documented by United States Department of Transportation (USDOT) and partners, localities can use these experiences to tailor their own ICM for their specific transportation needs. *ICM can be considered mainstreamed once it is considered and used as a part of a standardized process, where agencies routinely assess and use ICM strategies in combination with other improvements/alternatives to meet their corridor or region's transportation needs.* The same can be said from a project funding perspective. Once localities begin to utilize local/State funds possibly in combination with federal matching funds for ICM, ICM implementation can be considered mainstreamed.

HOW DO YOU MAINSTREAM ICM INTO YOUR TRANSPORTATION BUSINESS PROCESSES?

Transportation planning plays an important role in the development of both long-range and short-range transportation plans and is an input into an agency's strategic plan for future programs and projects. ICM represents the integration of multiple agencies and technologies to meet the ever-changing needs of transportation professionals and the cities they serve. This section discusses the importance of integrating ICM into the overall transportation planning and project development processes at a high-level.

Best Practices for Integrating ICM across Agencies

For Mainstreaming ICM to occur, it must be integrated both institutionally and culturally. Though this process may be different depending on the transportation agency organizational structure, the benefits would be similar. Below are best practices for integrating ICM across transportation agencies, adapted from the Federal Highway Administration (FHWA) Office of Operations, *Planning for Transportation Systems Management and Operations Within Corridors: A Desk Reference*.[5]

- **Build on an existing collaborative group**. Transportation agencies tend to have multiple operations groups or committees that handle multiple topics, such as Intelligent Transportation Systems (ITS) Architecture, emerging transportation technologies, Transportation Systems Management and Operations (TSMO), or a

[5] https://ops.fhwa.dot.gov/publications/fhwahop16037/ch1.htm

Metropolitan Planning Organization (MPO) committee system operations working group. Though these groups may seem disjoint, they all serve the same purpose, to improve transportation operations in their region. ICM would be best served by integrating with them, providing transportation professionals and stakeholders with an important medium to conduct planning in a proactive manner and enhance coordination and communication.

- **Ensure that there is at least one committed champion**. In locations where ICM has been the most successful, there was at least one "champion." This person, or persons understands the benefits of ICM, has a clear program vision, encourages engagement, and is committed to its implementation. They work from within their own organization and collaborate with others to ensure that ICM becomes a standardized and mainstreamed practice. Though important initially, the lead agency and champion's role changes over time. Through effective mainstreaming efforts, multiagency buy-in increases, and personnel from multiple agencies will be proponents of the ICM initiatives in the region and reduce the dependence of ICM on individual champions.

- **Establish lead coordinator**. The lead coordinator serves as the daily manager of operations, overseeing and inspecting the status of the ICM deployment and response plans. Additionally, this person is the main point of contact for questions regarding the ICM System operations. In some cases, the Lead Coordinator is an employee of the Lead Agency/Champion.

- **Organize and train staff**. By mainstreaming ICM, agencies have begun to recognize the importance of ICM and is becoming an ever-more important part of the Transportation Management Center (TMC) operator's responsibilities. Generally, agencies that have implemented ICM, follow two models: ICM responsibilities are added to current staff's job roles and responsibilities, or in some cases, a full-time equivalent employee was added and served as the ICM coordinator. Training TMC operators and maintenance personnel on ICM and day-to-day operations is also an important part of staffing. Specifically, training is needed on how to select, monitor and adjust response plans (playbooks), all of which can be dynamically determined or presented as option to choose from.
- **Achieve multiagency support.** ICM requires the coordination of multiple agencies to be effective. Without multiagency support and buy-in, ICM cannot succeed. Coordination and clear communication among participating agencies are key parts of ICM and are needed to achieve the desired outcomes.
- **Gather support from elected or appointed officials and agency leadership**. Identifying an executive-level ICM advocate, whether elected or appointed, early-on is key for the program to receive adequate resources from both funding and staffing perspectives. It will also assist with garnering participation from peer agencies and stakeholders.
- **Engage participants**. It is important to identify and engage the array of operating agencies and stakeholders that will play a role and be critical to the operations within the corridor. Typically, this includes local transportation agencies, a State department of transportation (DOT), transit agencies, and

representatives of local governments and community groups. Law enforcement, emergency responders, and major employers in a corridor also may be important participants. If some participants, such as emergency management agencies, are unable to attend project committee meetings, better success may be realized by taking the project to other established forums or meetings held by those stakeholders.

Incorporating ICM Into Transportation Planning Processes

Transportation planning and programming shape the way agencies handle congestion, plan infrastructure and technological investments, and their corresponding staffing and resources. Integrated ICM from both planning and programming perspectives bring increased value to these processes by increasing coordination and collaboration. ICM will be considered mainstreamed once it is considered standard operating procedure, fully integrated into agencies' transportation plans and considered a tool in congestion management. The list below provides considerations for integrating ICM into the planning phase.

- **Adopt ICM-centric transportation goals.** ICM strategies can improve mobility by reducing congestion and improving trip reliability during events, reduce incident response times, etc. By using regional goals that are consistent with ICM impacts, stakeholders can increase the likelihood that ICM projects will be planned and funded.
- **Use FHWA Resources.** ICM Strategies are primarily operations-oriented. Considered using information from FHWA's Organizing and Planning for Operations Program.
- **Use Analysis, Modeling, and Simulation (AMS) tools to evaluate ICM.** AMS tools can be helpful in selecting and designing the specific ICM strategies that you wish to implement. In addition, by tailoring the AMS tools to model your specific corridor situation, agencies can get an idea of the operational impacts of the ICMS. The topic of AMS received much attention under the Pioneer site process and guidance on AMS for ICM is available from the traffic analysis tools program. (See Chapter 6 for more information.)
- **Incorporate ICM Strategies into TSMO Plans.** Multiple areas across the U.S. are in the process of developing plans to address regional TSMO needs, such as TSMO Plans, ITS strategic plans, Long-Range Transportation Plans etc. In doing so, ICM is funded using primarily State and local resources (often with federal-aid program matching funds). ICM strategies should be considered and incorporated into these plans as appropriate. Since these plans tend to receive funding and are implemented, this increases the probability of ICM implementation.
- **Integrate ICM into Planning Meetings.** Initially, a region's ICM planning efforts might be handled through separate meetings to get momentum going for implementing ICM to help address transportation problems in a particular

corridor. Ultimately, ICM planning efforts needs to be integrated in the TSMO plans for the region and shouldn't be limited to separate meetings.

- **Consider ICM Strategies in planning studies and alternatives analyses.** ICM strategies should be considered along with other traditional transportation and other TSMO strategies.
- **Make ICM part of standard regional processes.** This would increase the probability to ICM becoming a multi-corridor and regional solution to congestion and incident management, further mainstreaming the practice.

Incorporating ICM Into Transportation Programming Processes

Incorporating ICM into an agency's transportation programming is key to the project's success. Doing so further integrates ICM from budgetary and business process perspectives. The list below provides considerations for integrating ICM into programming and funding allocation decisions (developing the transportation improvement program (TIP), prioritizing projects, or equivalent).

- **Include ICM in Transportation Improvement Programs (TIP).** For ICM to receive adequate funding and resources, related projects need to be included in the TIP, just as other projects are required to do so.
- **Ensure that project selection procedures consider the impacts of ICM.** The project prioritization process needs to be sensitive to their impacts on reliability and mobility. By not doing so, ICM deployment will not progress, and corridor reliability could falter, resulting in increased traffic variability.
- **Utilize federal funding opportunities for ICM projects.** Current federal funding mechanisms can be applied to ICM projects including: Surface Transportation Program (STP), Congestion Mitigation and Air Quality Improvement Program (CMAQ), and the Advanced Transportation and Congestion Management Technologies Deployment Program (ATCMTD). ICM projects can generally use funding sources used to implement ITS and TSMO projects. Additional information regarding funding programs can be found in Chapter 5 of this primer.

Incorporating ICM Into Project Development Processes

Once ICM is incorporated into transportation planning and programing, it must be included in the project development phase. ICM project best practices are similar other ITS project best practices but tend to include additional stakeholders and modes of transportation.

- **Plan for incremental deployment of your ICMS.** Given the reality of funding limitations and overall capabilities needed to implement your planned Integrated Corridor Management Systems (ICMS), incremental deployment of your ICMS is recommended. You should plan to deploy a sequence of projects that gradually

builds the capabilities you envision for your ICMS. In addition, you should implement ICM capabilities first on your highest priority, most congested and unreliable corridors prior to moving to less congested corridors. Note that an additional primer is available on the topic of incremental deployment (Build Smart, Build Steady). See Chapter 6 for more information on resources.

- **Use the system engineering process.** Like other ITS projects, ICM has the best outcome when systems engineering is used. Ultimately, if the project is using federal funds, its use is obligatory. Overall, System Engineering reduces the risk of schedule and cost overruns while increasing the chance that the end user's needs will be met.
- **Use and update your regional ITS architecture.** By referring to the applicable regional ITS architecture, you may find additional opportunities for integration that hadn't been considered. Also, the functionality and data sharing associated with your ICM project should be reflected in updates to the regional ITS architecture as part of the regional ITS architecture maintenance activity.
- **Recognize that ICM projects are like other ITS projects.** An ICMS is essentially a system of systems and represents advanced ITS. ICM includes traditional transportation technologies, such as variable message signs or ramp metering, but also addresses multimodal components, simultaneous implementation of multiple strategies, and an increased number of stakeholders.

Incorporating ICM Into Operations and Maintenance Activities

Once ICM becomes an established practice and is mainstreamed across a transportation agency, it is important to further the practice of ICM for operations and maintenance activities. Specifically, as equipment and infrastructure upgrades take place, combined with computer refreshes, opportunities to prepare the infrastructure for ICM should be considered. The list below provides information on how to incorporate ICM into operations and maintenance activities.

- **Include ICM components in ITS operations and maintenance contracts, technological refreshes, or equipment swap outs.** As new ITS equipment is installed or upgraded, it is important to evaluate components from an ICM context. Newer ITS equipment is often internet connected that provides value not only in traffic management but could bring additional value by being ICM-capable. Examples of equipment upgrades include communication system upgrades, DSS interfaces to signal control systems or ramp meters, information exchange networks, 511-system upgrades, and traffic monitoring map displays.
- **Incorporate ICM Management Systems (ICMS) into performance review meetings.** These performance reviews could be scheduled periodically or, as an after-action review, could also take place after certain major events, retrospectively. During such meetings, stakeholders evaluate chosen response plans, discuss if and how they met the needs of the event, and seek to understand the impacts the response plans had on corridor performance.

- **Address ongoing ICMS operations and maintenance (O&M) roles and funding needs.** Establish roles and responsibilities and funding levels in ITS or TSMO strategic plans as well as multiyear program budgets. By establishing clear roles and responsibilities and expected funding levels from the agencies participating in ICM, Operations and Maintenance (O&M) needs can be addressed, while further integrating ICM into ITS O&M budgets and contracts. Additional attention should be paid to who has the responsibility to upgrade the Decision Support System (DSS), and if in the long-term ICM components can be absorbed into broad ITS O&M contracts of the various participating agencies.

CONSIDERATIONS FOR DECISION SUPPORT SYSTEMS (DSS)

Decision Support Systems (DSS) are an integral component of ICM. A DSS is a computer-based information system that supports business or organizational decision-making activities, typically resulting in ranking, sorting, or choosing from among alternatives. This section provides background information on what a DSS is, why DSS are important, considerations for mainstreaming ICM, and offers references for more information.

In the context of ICM, a model-driven DSS is used to take data inputs and parameters provided by users or the traffic monitoring system to assist decision-makers in modeling a given situation. The DSS uses information to develop and model the performance of different "what if" scenarios that may be appropriate given the situation (e.g., in the case of a major incident on the main freeway, diverting a percentage of the traffic to an alternate arterial route and providing more green time for signals on that specific arterial). A transportation model of some sort is needed; a traffic simulation model may be used to predict the impacts of various alternatives.

When discussing DSS in the ICM context, business rules are a key. Business rules are rules or agreements that define or constrain some aspect of operations, decision-making, and strategy, among multiple organizations. Specifically, business rules establish the ways in which agencies communicate, coordinate, and share information. The business rules reflect the agreements between agencies or organizations on roles and responsibilities and operational practices given certain conditions or situations on the corridor. A DSS must be programmed to incorporate business rules and agreements with relevant entities when making recommendations.

Specifically, the role of the DSS in ICM is to receive data from an information exchange, evaluate multiple response plan options, and provide a recommended plan to the ICM coordinator, partner agencies, and an information exchange system. Utilizing this information, an ultimate decision is made by the coordinator and carried out by the agencies and stakeholder groups. Based on this decision, previously agreed upon strategies are implemented and system performance continues to be monitored to adjust if needed. Some

implementation considerations for DSS in the context of mainstreaming ICM efforts are provided below.

- **Develop your DSS incrementally.** Due to its complexity, agencies should consider incremental development of the DSS over the long-term. In fact, it may be wise for Transportation Management Center (TMC) operators to test some of the agreed-upon business rules under various conditions to see how they will work in practice, prior to programming them into the DSS. While human involvement in the decision-making and response strategy implementation process is needed during the initial stages of ICM, it is expected that the level of automation supported by the DSS can increase over time.
- **Consider the costs and resources needed for DSS.** DSS often require recalibrating a traffic model or other parameters and the associated costs and resources needed are an importation consideration that should not be overlooked.
- **Harmonize the traffic modeling tools used.** Traffic model feeds should be consistent with the modeling tool used by region in modeling and simulation efforts for an effective DSS. If possible, use the same tool. Doing so will increase stakeholder acceptance and facilitate staff's use of it as a tool.
- **Consider new uses for enhanced traffic modeling capabilities.** A DSS may require the use of enhanced traffic modeling capabilities in order to be effective. Utilize this opportunity to meet the modeling needs of other users or agencies. This will increase the overall impact of the ICM project as an effective and efficient project and serve as a long-term resource for the area.
- **Use business rules agreed upon by stakeholders in the DSS.** Incorporating business decision rules that have been agreed upon by stakeholders will enhance the stakeholder acceptance and effectiveness of the strategies proposed by the DSS and reduce uncertainties. If the business rules are unclear in certain circumstances, additional details need to be provided and decided upon.
- **Use multimodal, corridor-level performance measures to drive decision-making.** Using multimodal performance measures to drive decision-making for response plans provides a valuable way to evaluate the effectiveness of the DSS, from both a predictive and a retrospective viewpoint.

For more information on DSS in the context of ICM, see FHWA's Office of Operations, "Elements of Business Rules and Decision Support Systems within Integrated Corridor Management: Understanding the Intersection of These Three Components" (also referenced under resources in chapter 6). In addition, the ICM Program: Major Achievements report provides more information on the DSS implementation in the Dallas and San Diego Pioneer site deployments.

EXAMPLES OF MAINSTREAMING ICM EFFORTS

This section will provide case studies on localities that have implemented ICM and how they've mainstreamed ICM. As all the case studies noted below have either planned or implemented ICM, this section highlights themes from their projects as illustrative examples of mainstreaming ICM.

San Diego, CA – Mainstreaming ICM: Operations Integration and DSS Implementation[6]

The San Diego ICM Demonstration site corridor covered a 21-mile section of I-15 from just north of State Route (SR) 52 in the City of San Diego to SR 78 in the City of Escondido. The I-15 is one of two major freeways that connect commuters and interregional goods movement between San Diego, Orange and Riverside counties, and people traveling to and from Mexico. The I-15 is one of the busiest sections of freeway in the region. The Corridor study area included the freeway, ramp metered interchanges, 20 miles of continuous Express Lanes (otherwise known as managed lanes) – 16 miles which are reversible, a bus rapid transit (BRT) line that runs on the I-15 Express Lanes, BRT stations, direct access ramps, major arterial streets, and ITS technologies.

While the San Diego, CA region historically had inter-governmental cooperation, many of the real-time decisions were made independently by agencies for their specific facility. For example, two agencies operate buses; Caltrans manages the freeways, Express Lanes, and ramp meters; and the cities of San Diego, Poway, and Escondido each operate traffic signals on local streets. The ICM demonstration project addressed the need to collaborate across government agencies and effectively manage congestion along the I-15. Specifically, the DSS component of the ICM monitored for "atypical congestion" to alert "triggers" that invoke a DSS response(s). The DSS has the potential to provide over 1.5 billion response plans based on specific inputs and outputs, but only provides up to 15 response plans at any single time for the ICM manager to select. Predictions and recommendations are generated at 15-, 30-, and 60-minute horizons and are based on real-time and historical data. Using the selected response plans from the DSS by the ICM Manager, a coordinated response is carried out by the multiple agencies, including connected infrastructure, by synchronizing freeway ramp meters with traffic signals, and providing advanced traveler information via variable message signs or the 511 service. The public can receive information about different travel options and modes to avoid gridlock, instead of simply defaulting to using arterial routes based on past experience and knowledge of typical arterial travel times.

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[6] https://www.sandiego.gov/sites/default/files/legacy/planning/community/pdf/cpc/agendas/2013/icm.pdf

Northern Virginia (NOVA) – Mainstreaming ICM: Collaboration between governments, modes, and private companies[7]

The NOVA ICM site covered an East-West Corridor including I-66, Route 26, 50, 236, and 620, as well as the Greenway Toll Road. Specifically, this corridor has an array of project participants, including the Virginia Department of Transportation (VDOT), multiple counties, cities, and towns, the U.S. National Park Service, the Metropolitan Washington Transit Authority (WMATA), Metropolitan Washington Airports Authority (MWAA), and multiple private toll companies (Dulles Greenway, I-495 Express Lanes, and future I-66 Express Lanes). Involved agencies wanted to use ICM to manage incidents impacting travel in a clear, safe, efficient, and effective manner across all modes of transportation. Doing so required active participation from and collaboration with numerous project partners, including multiple levels of State and local government, transit modes, and private toll companies. Another component of this project was to establish evacuation plans and real-time awareness of emergency operations across the project partners and streamline communications technologies.

As a result of the project, coordinated responses plans to events were developed and a streamlined communications system was implemented. An enhanced traveler information system as well as a data warehouse were established, providing both real-time and archived data on roadway operations, signals, transit, parking, bikes and pedestrians, freight, and incidents, as well as probe and Connected Vehicle (CV)-generated data. Specifically, the data warehouse interfaces with the DSS, further augmenting the DSS modeling capabilities.

Austin, TX – Mainstreaming ICM: Technological Refresh and Integration of ICM into the Strategic Mobility Plan[8]

The Austin, TX ICM site covered a North-South running corridor that included the I-35, US 183, US 290, and State Highway 1 and 71. The primary motivation of the agencies was to address increasing congestion on the I-35, resulting from capacity deficiencies, as well as the congestion throughout the urban arterial system from freeway closures. The project's participants included local government agencies and departments of transportation, multimodal partners, research institutions, and the metropolitan planning organization. The project sought to better manage peak hour traffic, construction activities, special event surges, and crash and weather-related diversion, while increasing the efficiency of arterial, transit, and freeway networks.

ICM became part of Austin's "2014 TX Mobility Strategic Plan," which established a new regional traffic management center with advanced technologies. The ICM and incident

[7] http://itsmd.org/wp-content/uploads/2016-3B-NoVA-EW-ICMv3.pdf
[8] https://www.austintexas.gov/sites/default/files/files/AMP_Report_DrupalUpload.pdf

management systems were implemented as part of the larger Mobility35 capital program. These systems are overseen 24/7 and use ITS to manage and balance "load levels" across transportation modes. Improved integration, management and operations of regional traffic signals, dynamic message signs (DMS), traffic cameras, detection systems, travel time monitoring equipment, and volume count stations across jurisdictional boundaries were key components of this ICM. Specifically, new signals with connected capabilities were installed as older obsolete equipment was swapped out. Pre-trip and en-route traveler information was made available to travelers via mobile devices and dynamic message signs about up-to-date traffic conditions, roadway closures, and events.

The three examples given above are not the only good examples of mainstreaming ICM across the country. In fact, several areas have begun to plan and implement ICM with their own funding sources, in the absence of special grant funding from the USDOT. Some agencies are also targeting use of ICM to help manage the traffic around major construction activities. Some of these areas include Kansas City, Orlando, and several corridor areas in the States of North Carolina, Maryland, and California.

CHAPTER 5. FUNDING ICM

This chapter discusses potential Federal, State, regional, and local funding sources or opportunities that can be considered for deploying Integrated Corridor Management (ICM), including long-term operations and maintenance arrangements.

While understanding the benefits of ICM and mainstreaming its practices are important, funding remains one of the most-mentioned constraints to ICM implementation. Whereas the ICM pioneer sites and planning grantees were recipients of United States Department of Transportation (USDOT) grants with State and local funding matches, future ICM projects are not expected to receive ITS research program funding as stand-alone projects and will need to be funded with a mixture of State and local funding, Federal Aid, and potential USDOT grant opportunities. This further supports the mainstreaming theme in that potential ICM investments should stand on their own merits and compete for prioritization in the programming or project selection process.

USDOT conducted outreach to all of the ICM Planning Grantees in Spring 2018 and found that ICM sites that had integrated their ICM projects into their Transportation Systems Management and Operations (TSMO), Intelligent Transportation Systems (ITS), and State and local budgets were the most successful in securing funding for implementing ICM. Below are best practices in ICM funding.

- **Integrate ICM into your regional TSMO, ITS, and State and local short and long-range transportation and strategic plans.** Establishing the project's visions, benefits and outcomes early-on helps socialize ICM at an agency-wide perspective and removes a siloed approach to ICM.
- **Integrate ICM into your department's programmatic, TSMO, and ITS budgets.** Setting budgetary expectations are key to achieving success. Additionally, using a multifaceted approach for funding helps integrate the ICM into already mainstreamed practices and projects related to traffic and congestion monitoring that use similar transportation technologies.
- **Add ICM to larger project proposals for USDOT Discretionary Grant Programs.** Although project selection is not assured, integrating ICM into larger project proposals increases the proposed project's benefits, and can be used to establish project performance and benchmarking data collection and metrics.
- **Remember to budget for long-term operations and maintenance.** Plan for your funding needs to continue to enhance, fine tune and operate your Integrated Corridor Management Systems (ICMS). Early implementers of ICM have pointed out the need to identify each stakeholders' financial responsibility regarding funding long-term operations and maintenance activities.

FEDERAL-AID FUNDING PROGRAMS

Table 5 provides a listing of commonly used federal-aid funding programs for which ICM projects and other TSMO activities are likely to be eligible. Agencies should consider the possibility of using these programs for planning and implementation activities for ICM.

Table 5. Federal Funding Programs that May Support ICM and TSMO Project Activities (Source: FHWA)

Federal Funding Program	Purpose	Sample of Eligible Activities Related to ICM/TSMO
Congestion Mitigation and Air Quality (CMAQ)	Provides a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act. Funding is available to reduce congestion and improve air quality for areas that do not meet the National Ambient Air Quality Standards for ozone, carbon monoxide, or particulate matter (nonattainment areas) as well as former nonattainment areas that are now in compliance (maintenance areas).	• Projects that improve traffic flow, including projects to improve signalization, construct high occupancy vehicle (HOV) lanes, improve intersections, add turning lanes, improve TSMO strategies that mitigate congestion and improve air quality, and implement ITS and other CMAQ eligible projects, including projects to improve incident and emergency response or improve mobility, such as real–time traffic, transit, and multimodal traveler information.
Highway Safety Improvement Program (HSIP)	To achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non–State–owned public roads and roads on tribal lands. A highway safety improvement project is any strategy, activity or project on a public road that is consistent with the data–driven State Strategic Highway Safety Plan (SHSP) and corrects or improves a hazardous road location or feature or addresses a highway safety problem.	• Installation of a priority control system for emergency vehicles at signalized intersections. • Collection, analysis, and improvement of safety data. • Planning integrated, interoperable emergency communications equipment, operational activities, or traffic enforcement activities (including police assistance) relating to work zone safety.

Federal Funding Program	Purpose	Sample of Eligible Activities Related to ICM/TSMO
National Highway Performance Program (NHPP)	To support the condition and performance of the National Highway System (NHS), for the construction of new facilities on the NHS, and to ensure that investments of Federal–aid funds in highway construction are directed to support progress toward the achievement of performance targets established in an asset management plan of a State for the NHS.	• Operational improvements of NHS segments, including capital improvements for installation of traffic surveillance and control equipment, computerized signal systems, traveler information systems, integrated traffic control systems, incident management programs, and transportation demand management facilities, strategies, and programs. • Capital and operating costs for traffic and traveler information, monitoring and management programs, and infrastructure–based ITS capital projects.
Surface Transportation Program (STP)/ Surface Transportation Block Program (STPB)	Provides flexible funding that may be used by States and localities for projects to preserve and improve the conditions and performance on any Federal–aid highway, bridge and tunnel projects on any public road, pedestrian and bicycle infrastructure, and transit capital projects.	• Operational improvements for highways. • Capital and operating costs for traffic monitoring, management and control facilities and programs, including advanced truck stop electrification. • Infrastructure–based ITS capital improvements.
Metropolitan Planning	Establishes a cooperative, continuous, and comprehensive framework for making transportation investment decisions in metropolitan areas.	• Planning funds may provide MPO staff support for regional transportation operations coordination, regional operations guideline development, minor studies, and other staff activities to support regional TSMO or ICM programs.

Source: https://ops.fhwa.dot.gov/publications/fhwahop13050/index.htm
(Bond, Alex et al, *Programming for Operations: MPO Examples of Programming and Funding,* FHWA-HOP-13-050, 2013.)

USDOT DISCRETIONARY GRANT PROGRAMS

USDOT Discretionary Grant Programs are a great resource for potential ICM funding, particularly when paired with large infrastructure projects (depending on the specific criteria of the grant program). Table 6 provides examples and brief overview of a few applicable USDOT Discretionary Grant Programs. Please note that this section is for informational purposes only and project selection is not assured.

Table 6. USDOT Discretionary Grant Programs that May Support ICM Project Activities (Source: USDOT)

USDOT Discretionary Grant Program	Description
Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)[9]	The Fixing America's Surface Transportation (FAST) Act established the ATCMTD to make competitive grants for the development of model deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment.
Better Utilizing Investments to Leverage Development (BUILD) Grant (Formerly Transportation Investment Generating Economic Recovery (TIGER))[10]	The BUILD Transportation Discretionary Grant program provides a unique opportunity for the USDOT to invest in road, rail, transit and port projects that promise to achieve national objectives. Previously known as TIGER Discretionary Grants, Congress has dedicated nearly $7.1 billion for ten rounds of National Infrastructure Investments to fund projects that build and repair critical pieces of our freight and passenger transportation networks and have a significant local or regional impact.
Infrastructure for Rebuilding America (INFRA) [11]	The FAST Act established the Nationally Significant Freight and Highway Projects (NSFHP) program to provide financial assistance—competitive grants, known as INFRA grants, or credit assistance—to nationally and regionally significant freight and highway projects that align with the below-listed program goals. • Improve the safety, efficiency, and reliability of the movement of freight and people. • Generate national or regional economic benefits and an increase in global economic competitiveness.

[9] https://www.fhwa.dot.gov/fastact/factsheets/advtranscongmgmtfs.cfm
[10] https://www.transportation.gov/BUILDgrants/about
[11] https://www.fhwa.dot.gov/fastact/factsheets/infragrantsfs.cfm

USDOT Discretionary Grant Program	Description
	• Reduce highway congestion and bottlenecks. • Improve connectivity between modes of freight transportation. • Enhance the resiliency of critical highway infrastructure and help protect the environment. • Improve roadways vital to national energy security. • Address the impact of population growth on the movement of people and freight.

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

The Fixing America's Surface Transportation (FAST) Act established the Advanced Transportation and Congestion Management Technologies Deployment Program to make competitive grants for the development of model deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment.

Eligible Activities for ATCMTD funding include the following list:

- Advanced traveler information systems.
- Advanced transportation management technologies.
- Infrastructure maintenance, monitoring, and condition assessment.
- Advanced public transportation systems.
- Transportation system performance data collection, analysis, and dissemination systems.
- Advanced safety systems, including vehicle-to-vehicle and vehicle-to-infrastructure communications.
- Technologies associated with autonomous vehicles, and other collision avoidance technologies, including systems using cellular technology.
- Integration of intelligent transportation systems with the Smart Grid and other energy distribution and charging systems.
- Electronic pricing and payment systems.
- Advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly and disabled individuals. [23.U.S.C. 503(c)(4)(E)]

A grant recipient may use up to 5% of the funds awarded each fiscal year to carry out planning and reporting requirements under the program. [23 U.S.C. 503(c)(4)(L)]

Better Utilizing Investments to Leverage Development (BUILD) Grant

The Consolidated Appropriations Act, 2018 (Pub. L. 115– 141, March 23, 2018) (“FY 2018 Appropriations Act” or the “Act”) appropriated $1.5 billion to be awarded by the Department of Transportation (“DOT” or the “Department”) for National Infrastructure Investments. This appropriation stems from the program funded and implemented pursuant to the American Recovery and Reinvestment Act of 2009 (the “Recovery Act”). This program was previously known as the Transportation Investment Generating Economic Recovery, or “TIGER Discretionary Grants,” program and is now known as the Better Utilizing Investments to Leverage Development, or “BUILD Transportation Discretionary Grants,” program.

Infrastructure for Rebuilding America (INFRA)

INFRA is an opportunity to apply directly for financial assistance for highway and freight projects of national or regional significance. To maximize the value of FY 2019 INFRA funds for all Americans, the Department is focusing the competition on transportation infrastructure projects that support four key objectives: (1) Supporting economic vitality at the national and regional level; (2) Leveraging Federal funding to attract non-Federal sources of infrastructure investment; (3) Deploying innovative technology, encouraging innovative approaches to project delivery, and incentivizing the use of innovative financing; and (4) Holding grant recipients accountable for their performance.

STATE AND LOCAL FUNDING SOURCES

To successfully mainstream ICM, State and local funding sources ultimately need to be used. Most, if not all, federal programs that may support ICM implementation require State and local funding match. These sources may include county or regional, as well as State and local, funding categories. A wide variety of programs are may be available for ICM implementation depending on the specific criteria established for those programs and budget categories. Many areas also have funding categories specific to operations and maintenance expenses.

CHAPTER 6. ICM RESOURCES FOR NEXT STEPS

This chapter provides information to support further understanding of ICM implementation and additional resources for reference. See Table 7 for a list and description of key ICM resources that may be useful as you consider moving forward with ICM in your region.

Table 7. Key ICM Resources and Topics

Topic	Resource(s)	Description
Office of Operations program for ICM (Corridor Traffic Management)	Program Website. Accessed at https://ops.fhwa.dot.gov/program_areas/corridor_traffic_mgmt.htm	Provides a description of corridor management and links to lots of resources and related efforts (other primers, factsheets, etc.).
ICM Capability Maturity Model (CMM)	Advances in Strategies for Implementing ICM (National Cooperative Highway Research Program (NCHRP) Project 20-68A), Scan 12-02. Accessed at http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_12-02.pdf	Based on the levels of maturity of the different building blocks of ICM, the application of a CMM for ICM can help agencies evaluate their ability to deploy an ICM program, as well as identify areas for improvement.
Key Components of An Effective ICM Program	Advances in Strategies for Implementing ICM (NCHRP) Project 20-68A), Scan 12-02. Accessed at http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_12-02.pdf	Contains discussion of best practices in implementing ICM, from institutional, operational, and technical perspectives.
Decision Support Systems (DSS)	"Elements of Business Rules and Decision Support Systems within Integrated Corridor Management: Understanding the Intersection of These Three Components." Accessed at https://ops.fhwa.dot.gov/publications/fhwahop17027/index.htm	This document provides a fundamental explanation of the "decision support system" (DSS) concept and the relationship of DSS systems and business rules to the transportation community.

Topic	Resource(s)	Description
Implementation Guidance for ICM	"Integrated Corridor Management: Implementation Guide and Lessons Learned." Accessed at https://rosap.ntl.bts.gov/view/dot/30929	This guide is intended for use by adopters of ICM approaches and strategies to address congestion and travel time reliability issues within specific travel corridors. It introduces the concept of an integrated corridor management system (ICMS) and provides lessons learned based on Pioneer site experiences.
ICM Analysis, Modeling, and Simulation	Traffic Analysis Tools Volume XIII: Integrated Corridor Management Analysis, Modeling, and Simulation Guide (Updated 2017). Accessed at https://rosap.ntl.bts.gov/view/dot/32428	This guide was designed to help corridor stakeholders implement the ICM Analysis, Modeling, and Simulation (AMS) methodology successfully and effectively. It provides a step-by-step approach to implementation of the ICM AMS methodology and reflects lessons learned in its application to the three ICM Pioneer Sites and a test corridor.
Funding Categories	A Guide To Federal-Aid Programs And Projects. Accessed at https://www.fhwa.dot.gov/federalaid/projects.pdf	Comprehensive list and description of active and inactive federal-aid programs and projects.
Funding ICM	Bond, Alex et al, "Programming for Operations: MPO Examples of Programming and Funding", FHWA-HOP-13-050, 2013. Accessed at https://ops.fhwa.dot.gov/publications/fhwahop13050/index.htm	This document discusses how MPOs have incorporated TSMO projects into the programming phase of transportation investment decision-making in metropolitan areas, including nine case studies.
ICM Program Overview	Hardesty, D. and Hatcher, S.G., "Integrated Corridor Management (ICM) Program: Major Achievements, Key Findings, and Outlook", FHWA-HOP-19-016, 2019. Accessed at https://ops.fhwa.dot.gov/publications/fhwahop19016/index.htm	This document describes the USDOT ICM program in some detail, including a discussion of outcomes and findings from the Pioneer site demonstrations.

Topic	Resource(s)	Description
ICM Deployment	"Build Smart, Build Steady" Primer (under development) 2019, FHWA-HOP-19-039. After publication, accessed at https://ops.fhwa.dot.gov/program_areas/corridor_traffic_mgmt.htm	Available from corridor management website, this document describes the benefits of an incremental deployment strategy for improving and expanding your ICMS. *(Forthcoming)*
Executive video explaining ICM	After publication, available from corridor management website. After publication, accessed at https://ops.fhwa.dot.gov/program_areas/corridor_traffic_mgmt.htm	Short video that explains ICM in simple terms and motivates executives to pursue further. *(Forthcoming)*
ICM tutorial videos	After publication, available from corridor management website at https://ops.fhwa.dot.gov/program_areas/corridor_traffic_mgmt.htm	Short training videos on various ICM topics. *(Forthcoming)*
ICM Evaluation	Independent evaluation of Dallas' and San Diego's ICM Demonstration. After publication, accessed at https://ops.fhwa.dot.gov/program_areas/corridor_traffic_mgmt.htm	Final independent evaluation report. *(Forthcoming)*

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