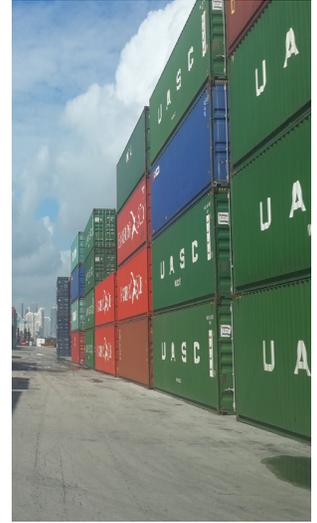


Port Planning and Investment Toolkit

Module 2: ITS Projects



U.S. Department of Transportation

Maritime Administration



Alliance of the Ports of Canada, the Caribbean, Latin America and the United States



Intelligent Transportation System Projects Module Contributors

Numerous port industry volunteers assisted in the creation and refinement of this Intelligent Transportation System (ITS) Projects Module of the Port Planning and Investment Toolkit. Thank you to the contributors from the following ports and organizations for your time, consideration and invaluable input.

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Port of San Diego, CA
Virginia Port Authority
Volpe National Transportation Systems Center
<i>WSP</i>

WSP was the primary author of the PP&IT ITS Module.

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This Toolkit module was developed through a cooperative agreement between the United States Department of Transportation (USDOT), Maritime Administration and the American Association of Port Authorities. [DTMA-91-H-2013-0004]. Opinions or points of view expressed in this document are those of the authors and do not necessarily reflect the official position of, or a position that is endorsed by, the United States (U.S.) Government, USDOT, or any sub-agency thereof. Likewise, references to non-Federal entities and to various methods of infrastructure funding or financing in this document are included for illustrative purposes only and do not imply U.S. Government, USDOT, or sub-agency endorsement of or preference for such entities and funding methods.



Preface

The American Association of Port Authorities (AAPA) and the USDOT Maritime Administration (MARAD) signed a cooperative agreement to develop an easy-to-read, easy-to-understand, and easy-to-execute Port Planning and Investment Toolkit (PP&IT). The goal of the project is to provide U.S. ports with a common framework and examples of best practices when planning, evaluating and funding/financing freight transportation, facility and other port-related improvement projects.

The analytical tools and guidance contained in this comprehensive resource are designed to aid ports in developing “investment-grade” project plans and obtain capital for their projects in a variety of ways, including: (1) improve the chances of getting port infrastructure projects into Metropolitan Planning Organization (MPO) and state transportation plans to qualify for formula funding; (2) better position port projects for federal aid; and (3) assist ports in obtaining private sector investment.

Since each ITS project is unique with its own set of objectives, methods, strengths and obstacles, the material in this module is not intended to address specific requirements of any single project, user or port; it is a resource for a diverse group of users to become familiar with planning, assessing feasibility and financing ITS projects and to highlight opportunities for engagement and coordination throughout the project definition process. This module is not a replacement of existing policies or consultation handbooks and does not constitute a standard, specification or regulation. The exhibits, processes, methods and techniques described herein may or may not comply with specific national, state, regional and local regulatory requirements.

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This module of the Toolkit will be updated periodically as new regulations and policies are developed affecting ITS planning, feasibility and investment requirements related to the applicable laws discussed in the document. Additional information, updates, and resources of the Toolkit are available on the AAPA website at <http://www.aapa-ports.org/PPIT> and the MARAD website at <https://www.maritime.dot.gov/ports/port-planning-and-investment-toolkit>.

For all other queries regarding the PP&IT, please contact Aaron Ellis, Public Affairs Director, AAPA at 703-684-5700.



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List of Acronyms

AAPA	American Association of Port Authorities
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment Grant Program
ATMS	Advanced Traffic Management Software
B/C	Benefit/Cost
BCO	Beneficial Cargo Owner
BTS	Bureau of Transportation Statistics
BUILD	Better Utilizing Investments to Leverage Development
CapEx	Capital Expenditure
CAV	Connected and Automated Vehicles
CMAQ	Congestion Mitigation and Air Quality Improvement
ConOps	Concept of Operations
DBFOM	Design-Build-Finance-Operate-Maintain
DBMS	Database Management System
DGPS	Differential Global Positioning System
DOTs	Departments of Transportation
DSRC	Dedicated Short Range Communication
EDI	Electronic Data Interchange
EEIR	Electronic Equipment Interchange Receipt
EFM	Electronic Freight Management
ELD	Electronic Logging Device
ETS	Equipment Tracking System
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FOTs	Field Operational Tests
FRATIS	Freight Advanced Traveler Information System
FSP	Freight Signal Priority
FTA	Federal Transit Administration
FY	Fiscal Years
GHG	Greenhouse Gas
GIS	Geographic Information System
GoPort!	Global Opportunities Port of Oakland
GOS	Gate Operating System
GPS	Global Positioning System
ICM	Integrated Corridor Management
IMO	International Maritime Organization
INFRA	Instructure for Rebuilding America
IoT	Internet of Things
IRIS	Intelligent Recognition and Imaging Software
ISO	International Standardization Organization
ITS	Intelligent Transportation Systems



JPO	Joint Program Office
LIDAR	Light Detection and Ranging
LPR	License Plate Recognition
MARAD	Maritime Administration
MPO	Metropolitan Planning Organization
NHFN	National Highway Freight Network
NHFP	National Highway Freight Program
NSHFP	National Significant Highway and Freight Projects Program
NHTSA	National Highway Traffic Safety Administration
OCR	Optical Character Recognition
OpEx	Operational Expenditure
OTR	Over-the-Road
P3	Public-Private Partnerships
PAB	Private Activity Bond
PATN	Port Area Transportation Network
PCS	Port Community System
POLA	Port of Los Angeles
POLB	Port of Long Beach
RADAR	Radio Detection and Ranging
RFID	Radio Frequency Identification
RFP	Request for Proposal
ROI	Return on Investment
RRIF	Railroad Rehabilitation and Improvement Financing
SAE	Society of Automotive Engineers
SE	Systems Engineering
STBG	Surface Transportation Block Grant
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIGER	Transportation Investment Generating Economic Recovery
TIP	Transportation Improvement Plan
TOS	Terminal Operating System
TPIMS	Truck Parking Information Management System
TRS	Truck Reservation System
V2D	Vehicle-to-Device
V2I	Vehicle-to-Infrastructure
V2Iot	Vehicle-to-Internet of Things
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
WIM	Weigh-in-motion



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INTRODUCTION



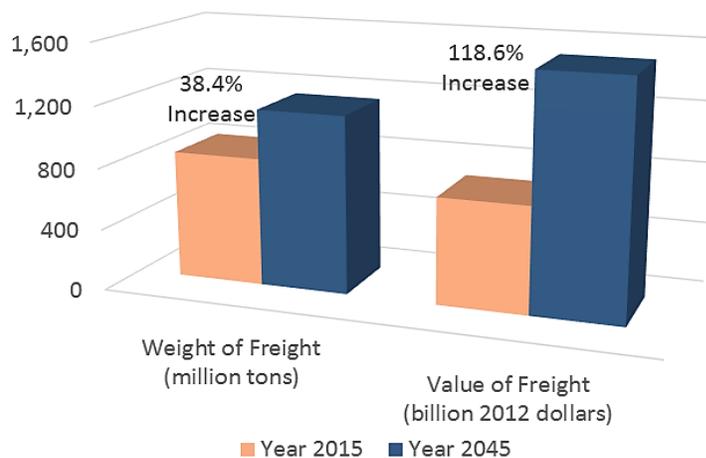
Introduction

The American Association of Port Authorities (AAPA), the USDOT Maritime Administration (MARAD) and the Volpe National Transportation Systems Center (Volpe) organized a team of U.S. port industry experts to assist in the development of this module of the Port Planning & Investment Toolkit (PP&IT). The module provides an overview of *Intelligent Transportation System* (ITS) and serves as a guide to facilitate the expansion of U.S. *port* participation in the development, implementation and operation of ITS projects regionally, and in a port environment.

Purpose & Need

The efficient and reliable movement of goods is critical to the U.S. economy. Analysis by the USDOT's Bureau of Transportation Statistics (BTS) and Federal Highway Administration (FHWA) indicate that freight tons moving on the nation's transportation network will increase by 40 percent in the next three decades while the value of the freight will almost double, increasing by 92 percent.¹

Exhibit 1: Projected Increases in Marine Freight Volumes



Source: USDOT BTS

Exhibit 1 illustrates the projected increase in the weight and value of freight moved through U.S. ports by 2045. In response to this sustained growth in freight movements through their facilities, many ports have increased operational capacities without greatly changing landside boundaries or regional transportation connections. This has led to increased levels of congestion on the surrounding inland distribution network, impacting the safety and efficiency of freight and passenger movements, as well as overall mobility for all travelers.

Along with building additional road and rail supporting infrastructure, at significant cost, *port owners* have opportunities to use their transportation resources more intelligently and efficiently through the application of ITS. Intelligence-based and dynamic technologies can improve the safety, efficiency, reliability and resiliency of port operations and the surrounding transportation network.

ITS is an engineering discipline that encompasses research, engineering, planning, design, integration, policy analysis and development, and deployment of systems and applications to maximize the efficiency of surface transportation systems. It includes *strategic planning*; *systems engineering*; multimodal and multijurisdictional integration of technologies, data sharing, communications *interoperability*; *real-time data monitoring*; and distribution of timely and accurate user information.²

ITS has traditionally focused on moving vehicles on an open public network, without commercial exchanges, in a lightly-regulated environment. By contrast, ports are origins and destinations for truck- and rail-based goods movement. Port

¹ <https://www.transportation.gov/briefing-room/dot-releases-30-year-freight-projections>

² <https://www.pcb.its.dot.gov/eprimer/module1.aspx#overview>



transport systems are bound, typically dead ends or local circulatory loops. Trucks and trains visit ports only for freight exchanges. Ports are tightly regulated spaces where private and public entities both cooperate and compete. Thus, implementation of ITS in a port environment requires consideration of a range of factors not typically considered for traditional ITS locations.

This module of the Toolkit assists users with the planning, evaluation, financing and deployment of ITS [projects](#) that address congestion and other transportation network challenges experienced by U.S. ports.

Context

The audience for this module includes port owners; [Metropolitan Planning Organizations \(MPOs\)](#); state, regional and local transportation service providers, [carriers](#), [beneficial cargo owners \(BCOs\)](#) and other port partners needing to advance the implementation of a port ITS project.

Since ports have complex interactions with an amalgam of public and private entities, each with varying interests in the application of technologies, this module addresses the implementation of ITS projects from three perspectives:

- **Local/regional**– Applications of ITS for the surrounding road and rail network that indirectly impact port operations. This could include the provision of [freight signal priority \(FSP\)](#) on road and rail interchanges in proximity to a terminal.
- **Port specific**– Applications of ITS for the [port area transportation network \(PATN\)](#) and within the terminal, such as gate access management and reservation systems.
- **Combination**– Applications of ITS that address port operations, the PATN and the region. This could include a truck staging and parking application that provides staging information at the terminal, and detailed route information for efficient and timely access to the facility.



It is important to understand the distinction between these perspectives as the planning, feasibility, financing and deployment processes for each may have subtle differences. For example, activities for planning, developing and implementing a regional FSP would likely involve a cross-section of other stakeholders (e.g., state or local departments of transportation that operate the roadways, MPOs that plan and program funds). Whereas a gate access management and/or reservation system may only include involvement of the [port authority](#), [terminal operator](#) and the trucking companies operating at the port. The span of communication, collaboration and cooperation is driven by the proposed ITS project.

Outline

This module is not intended to provide step-by-step directions to be followed sequentially. Instead the module is organized around key elements that can be adapted to specific needs and circumstances, whether users are at the early stages of the project definition process, such as determining project goals, or further along and seeking financing opportunities for an existing ITS project.

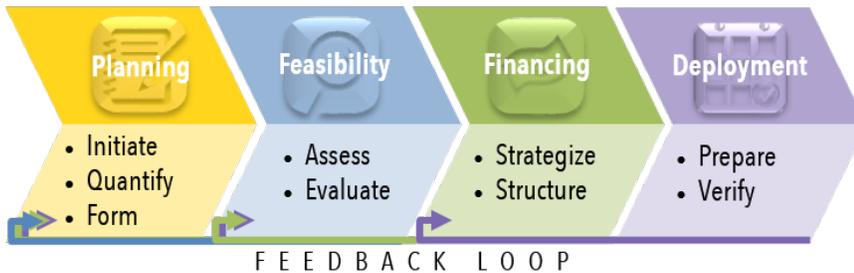
This module incorporates the three primary phases involved in project definition presented in *Module 1: General Projects*, accompanied by a fourth Deployment phase to support an integrated ITS implementation approach.

As shown in Exhibit 2, the nine elements that make up the primary phases provide a high-level structure for advancing ITS projects.



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Exhibit 2: Module Elements



PLANNING

Initiate the project by gaining an understanding of the goals and objectives, data to be collected and stakeholders that should be involved in the process.

Quantify the existing conditions and the operational drivers and user needs for ITS solutions.

Form alternatives of technology options and *concept of operations*, and make refinements based on architecture requirements and stakeholder input.

FEASIBILITY

Assess alternatives based on operational performance metrics, as well as institutional, economic and environmental impacts.

Evaluate each alternative based on qualitative and quantitative criteria to identify ITS applications that best meet the project needs.

FINANCING

Strategize the approach to secure the necessary financing for the ITS project and maximizing the return on investment.

Structure the financing to take advantage of the various available alternatives including federal, state and local funding sources, and private investment.

DEPLOYMENT

Prepare an operational action plan and supporting documentation that identifies procurement option(s), ITS standards and testing procedures, and training requirements.

Verify the functionality of the ITS project and its ability to meet project needs through testing and demonstrations prior to full implementation.

Within and between each phase, project definition activities may loop back to previous efforts to continually improve the planning, feasibility, financing and deployment strategy. The activities occurring at each stage can also be iterative and overlapping and might require reconsideration of previous conclusions if conditions change.

ITS

ITS has evolved to encompass applications, projects, and programs for different modes and facility types. A port system consists of various *transport modes* and facility types, including marine, intermodal, and inland terminals, container transfer facilities, and logistics depots. ITS applications can address this systemic complexity, supporting operational needs, as well as monitoring and managing the connecting surface transportation systems.

The advancement of ITS in the port industry has been enabled by:

- the rapid development and availability of cost effective technologies that maximize the use of existing transportation *assets*, and
- the need for service improvements to address a range of operational challenges that occur during (recurring) and disruptive (nonrecurring) conditions.

ENABLING TECHNOLOGIES

Technologies often support multiple functions, including data collection, network surveillance, asset tracking, communications, and information dissemination. Technologies that commonly enable ITS functions in ports are listed in Exhibit 3 and defined in *Appendix A – Glossary of Terms*. These technologies are grouped into the following classes that reflect their general role in the integrated implementation of ITS, port, and terminal functions:



- **PX:** Proximity and Detection Systems
- **ID:** Cargo and Vehicle Identification Systems
- **VI:** Vehicle Information Systems
- **LO:** Location Determination Systems
- **CO:** Wideband Communications Systems
- **LG:** Logistics Management Systems

Exhibit 3: Enabling Technologies and Their Use in Ports

Technology	Example of Use in Ports	Class
<u>Cameras and Sensors</u>	Cameras and sensors provide critical input not only for connected and automated vehicles (CAVs) on the road, but also for security and condition monitoring in the port. They also assist in gate transactions, improving efficiency by making the process faster.	PX
<u>Radio Detection and Ranging (RADAR) and Light Detection and Ranging (LIDAR)</u>	RADAR and LIDAR are heavily used for CAVs and will help in development of autonomous trucks for cargo hauling.	
<u>Optical Character Recognition (OCR)</u>	OCR is used for asset identification. For instance, OCR systems are used to identify incoming and outgoing containers based on their ISO numbers. OCR is also used to automate data transfer at port facilities by filtering, aggregating, and formatting data before presenting it to a host system.	ID
<u>License Plate Recognition (LPR)</u>	LPR systems use OCR to read and analyze the license plates of incoming and outgoing vehicles at the facility gate. The information gathered is matched with a database to help complete the gate transaction faster than a manual procedure.	
<u>Radio Frequency Identification (RFID)</u>	RFID is used to collect information from cargo vehicles entering or leaving a facility, cargo handling equipment, and to record where cargo is placed in the storage yard.	VI
<u>Weigh-in-motion (WIM)</u>	WIM devices are deployed in gate lanes along with other technologies, such as OCR and RFID, to connect vehicle and cargo weights with transaction data.	
<u>Vehicle Telematics</u>	Telematics devices provide information on a vehicle's or equipment's condition, find optimal delivery routes, monitor dangerous driving habits, track the location of drivers and cargo, and improve idle trailer allocation.	
<u>Electronic Logging Devices (ELD)</u>	An ELD is used to monitor a vehicle's or equipment's engine, capturing data on whether the engine is running, miles driven, and duration of operation.	LO
<u>Geographic Positioning System (GPS)</u>	GPS is the foundation of other ITS technologies such as Geographic Information Systems (GIS), and ELDs used by the maritime community. GPS can additionally be used to track container handling equipment and the placement of containers.	
<u>Differential GPS (DGPS)</u>	DGPS is used for tracking cargo and equipment within the port, as well as equipment automation.	
<u>Bluetooth</u>	Bluetooth is used to track street truck movement in to, out of, and within a terminal. Bluetooth proximity beacons are used to track cargo movement through various nodes.	
<u>Cellular Communication</u>	Cellular communication technology, including 5G cellular, is used to track the location of vehicles and handling equipment, and associated cargo.	CO
<u>Dedicated Short Range Communications (DSRC)</u>	DSRC can be used to enable trucks carrying cargo to utilize adaptive cruise control, clear vehicles entering and exiting a maritime facility, and to issue vehicle warnings.	
<u>Electronic Data Interchange (EDI)</u>	EDI is used to securely transfer goods movement data between liners, BCOs, truckers, railroads and government agencies including Customs and Border Protection.	LG
<u>Internet of Things (IOT)</u>	IoT is used to connect multiple platforms such as TOS, Port Portals, autonomous vehicles, etc. to share real-time information, enabling better cargo routing decisions.	
<u>Cloud-Based Data Processing and Management</u>	Cloud-based data processing and management are used to make cargo data, such as vessel stowage plans, available on a controlled basis across the port user community.	
<u>Blockchain</u>	Blockchain technology can be used to track freight, streamline the bill of lading process, execute bookings, and to submit shipping instructions and trade compliance documentation.	

Source: WSP USA



INTRODUCTION

Exhibit 4: Port Interactions and ITS Technologies

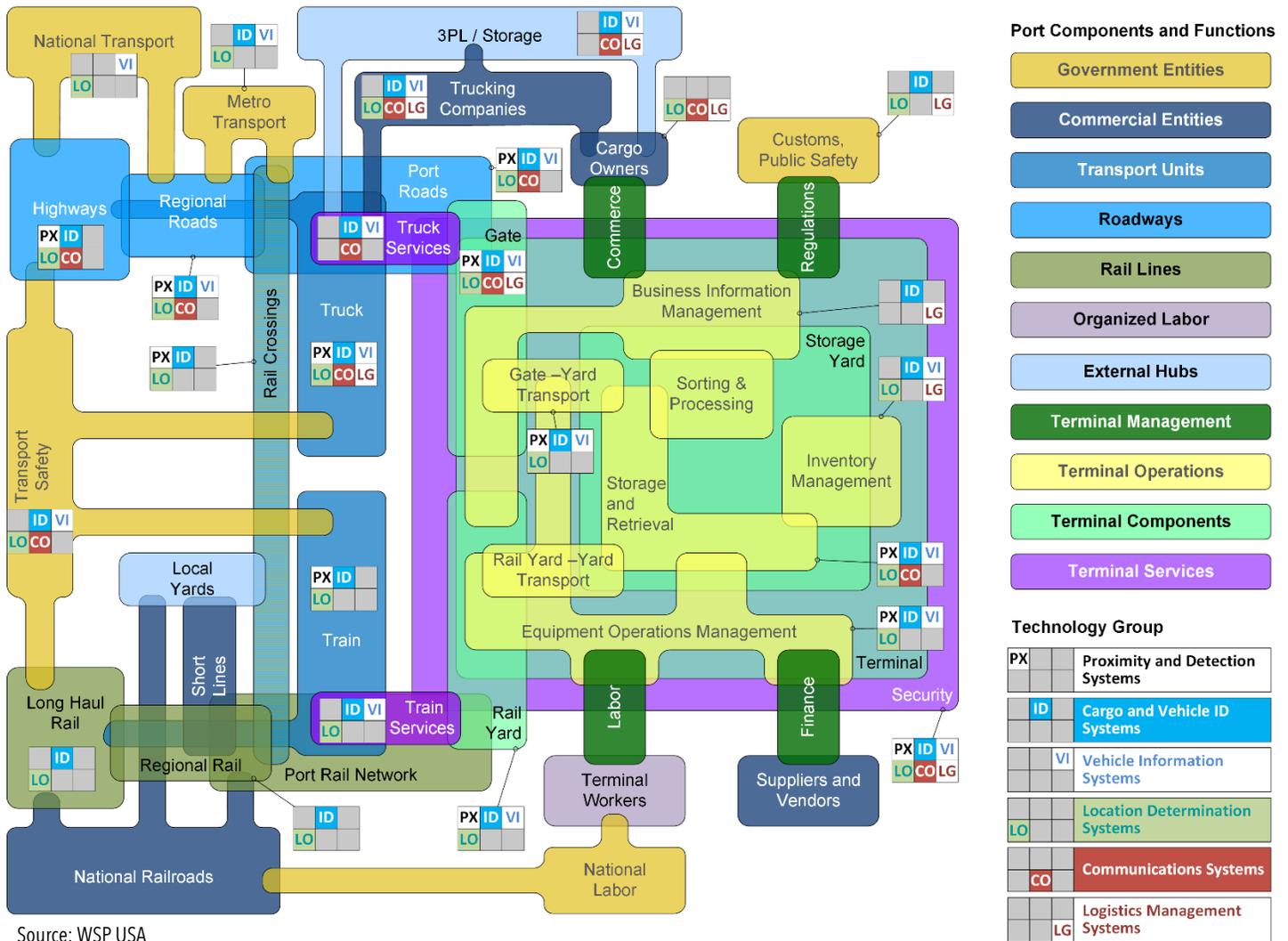


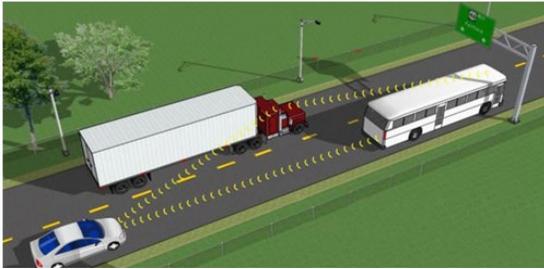
Exhibit 4 presents the logical relationship between the major elements of a port, its landside connectivity, its operating components, and the entities with which it interfaces. Shape overlaps reflect interactions between elements. Wherever ITS technologies might have a role or influence, an icon indicates those technology classes that are likely to be deployed in support of more efficient and safer operations.

VEHICLE TO EVERYTHING (V2X) COMMUNICATIONS

While ITS involves a variety of advanced applications that extend beyond vehicle systems,

Port ITS projects are primarily supported by the following bidirectional, real-time V2X technologies that allows vehicles to communicate with infrastructure, other vehicles, devices, and the Internet of Things (IoT).

Vehicle-to-Infrastructure (V2I) enables freight vehicles to communicate with roadway, rail and port infrastructure, such as traffic signals, railroad crossing, cargo terminal gate system, and priority lane systems. V2I service can use both DSRC and cellular network for communication.



Source: USDOT

Vehicle-to-Vehicle (V2V) enables freight vehicles (trucks, trains, and cargo handling equipment) to communicate with each other and other vehicles in the vicinity via advanced communication systems such as DSRC and 5G cellular. It allows the vehicles to share vehicle type, identity, position, speed, heading, transaction data and other information with each other.

Vehicle-to-Device (V2D) enables freight vehicles to communicate with receiving devices such as RFIDs, LPR, OCR, etc. V2D services can help streamline information flow for incoming and outgoing freight vehicles. V2D and V2V in

combination can help in safe transport of cargo on road and movement within a cargo terminal.

Vehicle-to-Internet of Things (V2IoT) enables freight vehicles to communicate to multiple technologies via IoT. Any type of information can be uploaded using cloud computing and can be retrieved to analyze and make informed decisions. V2IoT service can assist in V2I/I2V service as well.

IoT enables communication between supply chain instruments, connecting ports, carriers, warehouses and distribution centers, BCOs and customers. With further development and broad participation, IoT platforms can optimize the exchange of logistic information and offer holistic improvements to the supply chain network.

SERVICE IMPROVEMENTS

As shown in Exhibit 5, ITS can improve port performance by enhancing the safety, mobility, efficiency, and visibility of terminal assets, cargo and entities involved in the system.

Cybersecurity

While ITS provides opportunities to optimize port systems and improve operational performance, issues of security and privacy related to ITS can impact its potential benefits. Cybersecurity has risen out of the need to protect critical infrastructure and systems, and the information contained therein, from malicious attacks, unauthorized access, damage, and disruptions. The increasing use of ITS technologies exposes the U.S. maritime and freight sectors to cybersecurity vulnerabilities and highlights the need to safeguard ITS from cyberattacks.

A comprehensive approach to cybersecurity is needed to counteract the growing risks of cyberattacks on ITS. Various federal agencies have cybersecurity initiatives dedicated to maintaining a secure, connected, and resilient transportation system:

- **Vehicle**— The National Highway Traffic Safety Administration (NHTSA) has pursued a layered approach focusing on identifying solutions to harden the vehicle's electronic architecture against potential cyber-attacks and ensuring vehicle systems respond appropriately in the event of an attack. Resource: <https://www.nhtsa.gov/technology-innovation/vehicle-cybersecurity>
- **Infrastructure**— The National Institute of Standards and Technology (NIST) lays out a broad path for reducing cyber risk and improving resiliency in their Framework for Improving Critical Infrastructure Cybersecurity. The Framework's five Core Functions: Identify, Protect, Detect, Respond, and Recover provide a method to understand, evaluate, and reduce cyber risk. The USDOT had made it a priority to adopt and promote the use of the NIST Cybersecurity Framework within the transportation sector. Resource: <http://www.nist.gov/cyberframework/>
- **Integration**— The [USDOT ITS Joint Program Office \(ITS JPO\)](#) and its modal partners conduct research, development, and education activities on cybersecurity technical and policy mitigations. These efforts ensure that new technologies have security as an inherent part of their design and operations, providing a more unified approach to vehicle, device, and infrastructure security for the connected vehicle environment. Resource: <https://its.dot.gov/factsheets/cybersecurity.htm>



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Exhibit 5: Port Service Improvements from V2X and IoT Communications

Service Improvement	V2X and IoT Communications				
	Vehicle / Vehicle	Vehicle / Infrastructure	Vehicle / Device	Vehicle / IoT	IoT Platform
Safety and Reliability	Avoid port-area collisions, goods movement accident losses, hazardous material releases.				
	Port equipment position and routing.	Speed constraints, variant road conditions, construction areas, queue conditions, congestion, weights in motion.	Downstream congestion, speed reduction warnings, signal conditions, rail crossing condition, truck trailer basic safety message.	Trip timing or routing to avoid incidents, hazardous material conditions, expected rail movements and road blockages.	Vehicle maintenance tracking, inspection tracking and reporting, driver / vehicle qualifications.
Resilience	Mitigate the impact of disruptive events, such as extreme weather or geological events.				
	Engine conditions / flooding, mass vehicular stalls, emergency vehicle movements / warnings, utility vehicle proximity.	Road, rail, tunnel, and bridge closures; route damage; route reversals / alternatives.	Freezing / icing, stream conditions, power grid conditions, signal system disruption.	Relicensing directions, evacuation warnings, loss-of-service messages, emergency transport protocols.	Impact predictions, weather paths, flood surge modeling, seismic damage mapping.
Cargo Visibility, Reliability	Improve the reliability and timeliness of cargo transport, and improve the responsiveness of service providers.				
	Peloton / convoy, multi-shipment manifest coordination, trailer size/configuration.	Weights and weight limitations, construction areas, operational conditions that increase delays, truck parking tracking.	Vehicle characteristics, shipment location, transport unit location and condition, geofencing, net velocity, driver safety conditions, truck parking info. management system (TPIMS) availability.	Route recalculation, scheduled route interruptions, vehicle / signal synchronization, variable priority movements, TPIMS synchronization.	Congestion tracking and projection, route balancing and load sharing, dynamic proactive route optimization, TPIMS optimization.
Vehicle Efficiency and Mobility	Reduce travel time, reduce queuing and idling, maintain network fluidity, and improve transport workforce efficiency.				
	Peloton coordination, driver load splitting, driver team condition / coordination.	Signal pattern reporting, speed monitoring, geofence population tracking, dedicated lane / route indication.	Signal coordination conditions, speed enforcement, geofenced population management, dedicated lane / route utilization.	Queueing information, congestion reporting, priority path use, dynamic tolling, congestion pricing.	Dynamic modeling of transport space, movement optimization, congestion avoidance.
Gate Efficiency	Reduce queuing, improve accuracy, avoid transaction failure, gate transaction speed, extend hours, and optimize labor.				
	Multi-unit manifest coordination, team-wide transport monitoring and coordination.	Transaction-driven directional signage, queue entry/exit recording, queue-driven signal controls.	Vehicle / equipment ID OCR, RFID, LPR; dynamic tare + fuel for weighing; digital hazmat placard; digital seal; dead vehicle in queue; reefer temperature / condition.	Automatic transactions, off-terminal pre-processing, shift from "push" to "pull" processing, dynamic vehicle prioritization.	Align "pull" transactions to terminal resource availability, paperless liability controls, paperless manifest, transactions.
Terminal Yard Efficiency	Improve density and velocity, improve cargo handling equipment deployment, reduce cargo rehandling, reduce congestion.				
	Equipment queue management, report truck wait times, eliminate over-stows of moves in the queue.	Area closures, area restrictions, dynamic routing signage.	Mobile data terminal integration, geofenced density reporting, proximity to assigned equipment or location.	Dray-off yard areas for pre-lodged transactions, dynamic intra-terminal route management, internal queue management.	Equipment assignment optimization, awareness of upcoming moves to avoid over-stows, remote control operations.
Port Efficiency	Improve the efficiency of total port visit, balance load between resources, respond to congestion events.				
	Train positioning and routing, vessel-lift bridge coordination.	Equipment pool conditions, port-wide routing, terminal populations, rail crossing closures, train locations and movements.	Bridge deck weight sensors, rail crossing equipment, lift-bridge conditions, berth utilization, rail yard utilization.	Equipment inventories and demands, storage inventories, space available, transactions cleared for pickup, double-cycle opportunities.	Port wide chassis management, empty management, rail car management, train scheduling and vehicle move timing.



ITS APPLICATIONS

A range of ITS applications are under development or have been developed and implemented to enhance the movement of freight within the PATN and in the surrounding region.

Local/Regional

Platooning Systems: Platooning systems link vehicles in a convoy using connectivity technology and automated driving systems. Linked vehicles follow each other closely with the vehicle at the front of the platoon acting as its leader.

Vehicles behind the leader automatically react and adapt to changes in the lead truck's movement. This technology can be used at ports to improve traffic flows by consolidating vehicles heading to the same destinations. **Resource:** <https://www.itsknowledgeresources.its.dot.gov/its/bcllupdate/TruckPlatooning/>



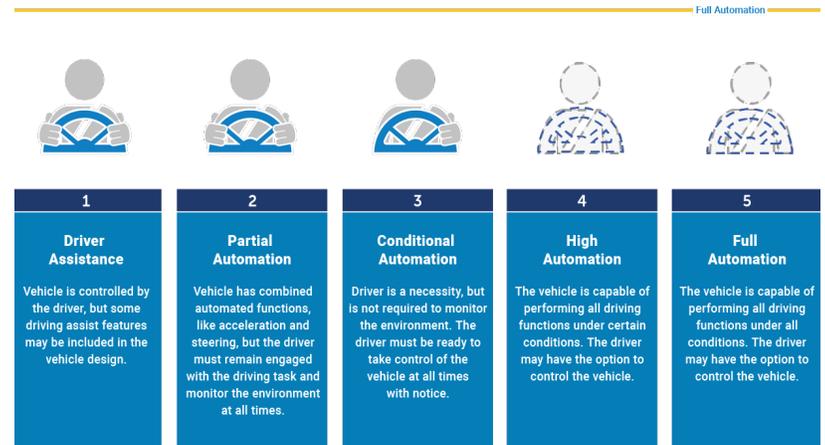
Source: USDOT

Connected, Automated and Autonomous Vehicles:

Incorporate connectivity and/or automation to allow vehicles to operate in some or all aspects without human assistance. The Society of Automotive Engineers (SAE) International Standard and National Highway Traffic Safety Administration (NHTSA) defines five levels of automation for CAVs as depicted in Exhibit 6.

CAVs can provide a path for ports to further explore automated terminal equipment and autonomous freight delivery. **Resources:** https://www.its.dot.gov/automated_vehicle/index.htm and <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>

Exhibit 6: Levels of Vehicle Automation



Source: SAE and NHTSA

Route Guidance: Navigation applications can identify the fastest path through the roadway network. If combined with terminal turn time reporting, a trucker could identify the optimal timing and route to their destination.

Port-Specific

Intelligent Recognition and Imaging Software (IRIS):

IRIS uses OCR and RFID to recognize and track containers, trains, trucks, and license plates through terminals and ports. IRIS is based on a neural network image processing algorithm that allows it to extract the relevant information from an asset, typically a container. Information that the system picks up includes container ID, ISO type, and size code. IRIS data is used to compile a library of traits and subsequently to extrapolate the systems recognition ability. **Resource:** http://iris.dot.state.mn.us/admin_guide.html

Equipment Tracking System (ETS):

An ETS keeps track of handling equipment thereby allowing more efficient deployment in response to competing demands. ETS can be comprised of DGPS, RFID, inertial and Bluetooth tracking systems. At port terminals, ETSs are used to track the movement of cargo handling equipment such as straddle carriers, gantry cranes, lift trucks, etc. **Resource:** https://ops.fhwa.dot.gov/freight/intermodal/freight_tech_story/sectiontwo.htm



INTRODUCTION

Terminal Operating System (TOS): A TOS manages the movement, processing and storage of cargo in and around a terminal or port, along with all the data required to satisfy all commercial, business, and regulatory requirements. A TOS typically includes a large database management system (DBMS) and integrates data flows with other technologies such as RFID, OCR, GPS, DGPS, WIM, etc.

Gate Operating System (GOS): A GOS is designed to manage the movement and processing of cargo through a port’s terminal gate. A GOS interfaces with multiple technologies such as OCRs, RFID,

WIM and LPR to process information for cargo arrival and departure. GOS has helped convert tedious and time consuming manual procedures into efficient and accurate automated and paperless gate processes.

Terminal Status Reporting: Terminals may offer data portals that report the condition of their facilities. These reports may include empty container availability, chassis availability, terminal area closures, expected service changes, special security requirements, and truck cycle times.

Gate Queue Reporting: Using technologies such as geo-fencing and automatic truck position reporting, business applications track and report truck populations in gate queues through smartphone applications that estimate wait times. Resource: <https://www.nap.edu/read/14536/chapter/7#52>

Truck Appointment Systems: An appointment system allows cargo owners and trucking companies to make appointments to carry out marine terminal transactions within given time windows. This allows drayage firms to make efficient dispatching plans and lets marine terminals control workloads. Also known as a Truck Reservation System (TRS). The *Port of Virginia’s TRS* at its Norfolk International Terminal and Virginia International Gateway has improved productivity at the facilities by reducing truck turn times up to 32 percent. Resource: <https://www.nap.edu/read/14536/chapter/7#50>

Street Exchange Systems: In a street exchange system, empty containers are transferred directly from the importer’s trucker to an exporter’s trucker. This is generally carried out through secure internet applications that integrate data and document commercial and liability transfer between liners, BCOs, and drayage operators.

Automated Work Flow: Automated work flow is currently used with EDI. At ports, automated work flow data models can be used to streamline inbound and outbound cargo processing. Automated work flow is also applied in automated gates to support faster transactions.

Port of Halifax Terminal Gate Metrics Module

The Port of Halifax’s Terminal Gate Metrics module provides vital information on the fluidity of truck gates at the facility by providing current and historic information on gate wait time, and truck service time. The Port makes this data publicly available and in doing so can reduce congestion and greenhouse gas emissions.

The Port gathers its data from the Halifax Harbor Bridges MacPass electronic tolling system. Most vehicles in the area have MacPass transponders that are detected by the Port’s MacPass readers as vehicles pass various checkpoints. Checkpoints are placed at terminal inbound and outbound gates, and certain upstream locations to create a holistic picture of vehicle movement. This data is subsequently analyzed to determine gate wait time, and truck service time.

The data gathered from the Port’s readers present a representative sample of trucks entering and exiting its marine container terminals. The data is color coded and presented in an understandable way.

TIME	THU	FRI	MON	TUE	WED	TODAY
07:00	-	-	-	-	-	-
08:00	16.3	43.8	22.8	30.6	64.8	12.6
09:00	13.6	15.1	9.2	14.1	24.8	15.0
10:00	9.5	13.0	7.9	8.5	21.5	12.0
11:00	13.2	11.8	12.6	19.1	14.9	12.6
12:00	-	-	-	-	-	-
13:00	21.3	21.3	22.4	20.8	24.7	19.9
14:00	14.2	11.3	17.1	12.2	17.7	11.9
15:00	12.9	10.0	29.9	13.1	13.7	17.4
16:00	6.0	6.0	11.0	0.0	3.0	6.0

Source: Port of Halifax



Combination

Geo-fencing: A geo-fence is a virtual geographic boundary that is created around a facility or area using GPS or other tracking technology. The geo-fence can track, record, and trigger a reaction when mobile devices, such as RFID tags or Bluetooth antennas, cross the boundary. Geo-fencing has several applications at port facilities, including determining truck turn times, gate or street queue populations and monitoring truck traffic within specific boundaries of the PATN.

Resource: http://www.dot.ca.gov/newtech/researchreports/reports/2015/CA16-2815_FinalReport.pdf

Freight Signal Priority: Signals at arterial road intersections and exit gates can be timed to control flow through the port and into gates, channeling queues and preventing blockages at signalized intersections. In some ports, FSP systems, combined with dedicated routing lanes, help channel truck flow and avoid adverse mixing with non-port traffic. Also known as Freight Vehicle Priority. **Resource:** https://www.its.dot.gov/infographs/eco_freight_signal.htm

Rail Yard Integration: Rail crossing controls can be integrated with roadway signals and port-wide monitoring systems to provide smoother movement of trucks and trains across the port's transportation networks. Rail operations management can be integrated with maritime and truck operations to allow intelligent scheduling of rail, truck, gate, and terminal resources.

Port Community System (PCS): Some ports have deployed applications that bring together all port, liner, drayage, BCO, terminal operator, and ITS streams. These portals are a central web site that helps users determine cargo availability and export booking status, and obtain information on terminal-specific operations, vessel schedules, and container locations. It also helps trucks by providing information regarding chassis and empty container availability. The Port of New York and New Jersey has deployed a "Terminal Information Portal System" (TIPS) as part of its PCS (see inset).

Port of New York/New Jersey (NY/NJ) Terminal Information Portal System (TIPS)

Launched in September 2015, the Port of NY/NJ TIPS is a single consolidated web portal that compiles information from all six container terminals and makes the data available to qualified users in real-time over the Internet. The system presents Port and terminal related information, container availability, booking status, vessel schedules, and empty container return locations.

The Port's TIPS is a part of its broader Port Community System, which integrates a range of operational information and customer support into its platform. The system has the following functions:

- Make information, e.g. booking inquiries and vessel schedules, readily available to stakeholders;
- Centralize the storage and dissemination of terminal information;
- Create 'watchlists' of containers regardless of what terminal they are being handled at;
- Notify stakeholders of container or booking status changes; and
- Meter truck arrival rates while keeping resources for all stakeholders operating at maximum levels.

The Port of Los Angeles (POLA) and GE Transportation have deployed a PCS, known as "Port Optimizer", which uses cloud-based technology to provide system wide information.

Freight Advanced Traveler Information System (FRATIS): FRATIS is a bundle of connected vehicle applications that provides freight-specific dynamic travel planning and performance information. FRATIS provides users with real-time data on congestion, travel times, and incidents along freight routes and at freight facilities, which allows vehicles to be optimally and dynamically routed. Refer to Section 6 for further details on the POLA and Port of Long Beach (POLB) initiative.

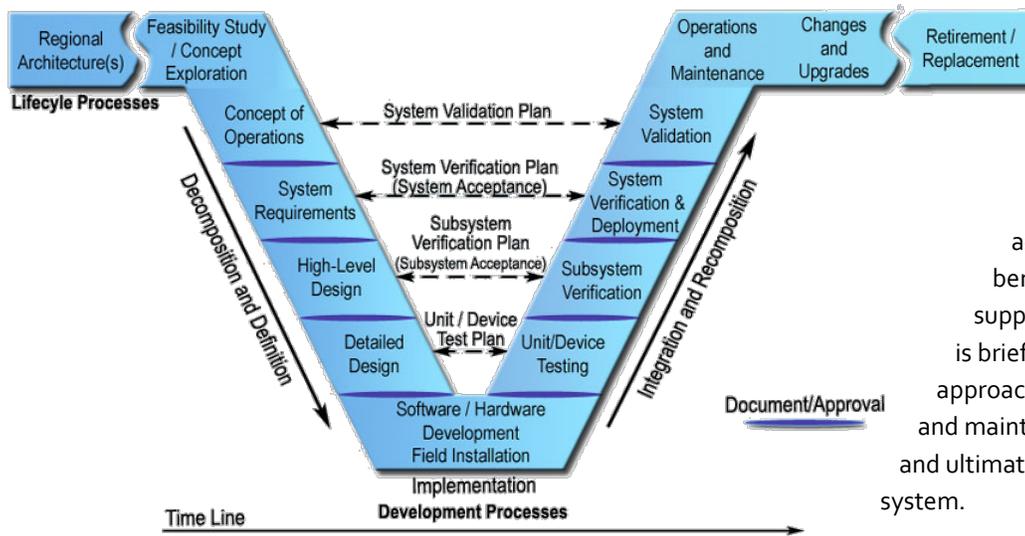
Resource: https://www.its.dot.gov/research_archives/dma/bundle/fratis_plan.htm

Traveler Information Reporting: Existing ITS systems report traffic, weather and parking conditions through mobile devices, in-vehicle systems, online services such as 511 and roadway infrastructure such as dynamic message signs (DMS). These applications can report traveler conditions along with information integrated from terminal status reporting and gate queue reporting applications. **Resource:** <https://ops.fhwa.dot.gov/publications/fhwahop14023/execsumm.htm>



INTRODUCTION

Exhibit 7: Systems Engineering “V-Diagram”



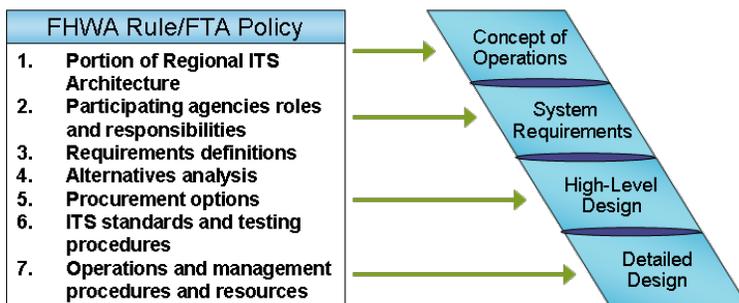
Systems Engineering
Systems Engineering (SE) is an interdisciplinary approach that enables the realization of successful systems development, including ITS. SE focuses on defining user needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem.³ Exhibit 7 provides a graphical representation of a systems development lifecycle and outlines the steps involved in the decomposition and definition, and document and approval lifecycle processes. The SE approach defines project requirements before technology choices are made and the system is implemented.

The project definition process described in this module aligns with the Decomposition and Definition task in the SE process. These early steps in the “V” diagram define the project scope and determine the feasibility and acceptability as well as the costs and benefits of the project. The latter steps support project implementation, which is briefly reviewed in this module. The SE approach then transitions into operations and maintenance, changes and upgrades, and ultimate retirement or replacement of the system.

The USDOT recognizes the benefits of applying the SE approach to the planning and development of ITS. Accordingly, an SE analysis is required for all ITS projects using Federal funds per the Final Rule/Policy on Architecture and Standards Conformity⁴. The ITS Architecture Implementation Program identifies seven minimum SE practices that must be included in the project, as shown in Exhibit 8.

Although the processes described in the module support the Final Rule/Policy, this module does not provide formal guidance on meeting the SE requirements in FHWA Rule 940 and the FTA National ITS Architecture Policy. Compliance with the Rule/Policy is established by each FHWA Division and FTA Regional Office. Contact your federal representative for the specific requirements in your state. Several states have established checklists that prompt project sponsors to consider the SE analysis requirements as part of the project definition process. For more information about SE for ITS, refer to https://ops.fhwa.dot.gov/int_its_deployment/sys_eng.htm and <https://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf>.

Exhibit 8: Rule/Policy SE Requirements



³ <https://ops.fhwa.dot.gov/publications/seitsguide/section3.htm>
⁴ In early 2001, the Final Rule on ITS Architecture and Standards Conformity (Final Rule) and the Final Policy on Architecture and Standards Conformity (Final Policy) were enacted by the FHWA and FTA respectively. The Final Rule/Final Policy ensures that ITS projects carried

out using funds from the Highway Trust Fund conform to the National ITS Architecture and applicable ITS standards. This will be accomplished through the development of regional ITS architectures and using a SE process for ITS project development.



ITS Architecture Integration

A regional ITS architecture supports the initial identification and scoping of an ITS project based on regional needs. The gap between the regional architecture(s) step and the other steps shown in Exhibit 7 signifies that the regional architecture is a broader product of the planning process that covers all ITS projects in the region. While it is important to ensure ITS projects are considered in the regional context, this module primarily focuses on the efforts identified in the SE approach “V” processes that apply to specific ITS projects.

Refer to the regional ITS architecture, typically managed by the MPO, or the applicable portions of the *ARC-IT* [National ITS Reference Architecture] to facilitate the integration and coordination of compatible ITS initiatives across a region, including those that involve port operations. The regional ITS architecture helps to ensure that related ITS projects are implemented more efficiently and travelers experience seamless transportation services as they travel across multiple jurisdictions.⁵

Developing a Regional ITS Architecture

Developing a regional ITS architecture helps to create a shared vision for ITS implementation among port stakeholders and advance regional transportation improvement programs and long-range transportation plans by defining goals and planning operations for regional ITS programs. Any region implementing ITS technologies is required to develop a regional ITS architecture if it is using Federal funds.

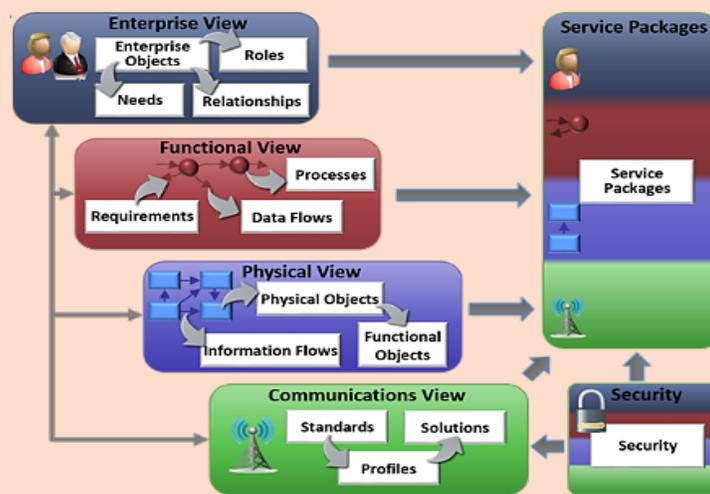
Ports should be an active participant in the development of regional ITS architectures to ensure that your needs, goals and objectives as they relate to ITS initiatives are addressed. Although a regional architecture may not include all subsystems or services within the National ITS Architecture, it should use the National ITS Architecture as a template for those programs and services it does include.

To help guide the development of regional ITS architectures, the USDOT has sponsored the development of the National ITS Reference Architecture, also known as the “Architecture Reference for Cooperative and Intelligent Transportation” (ARC-IT). As shown in Exhibit 9, ARC-IT provides a common framework for planning, defining, and integrating ITS. It was designed as a reference architecture for planners and engineers with differing concerns to conceive, design and implement systems using a common language as a basis for delivering ITS. ARC-IT does not mandate any implementation.

Whereas ARC-IT guides ITS programs at the national level and addresses all subsystems, technologies, and standards, regional ITS architectures are developed to:

- meet the specific needs of a region,
- define program goals,
- define a *Concept of Operations* (ConOps),
- develop institutional agreements, and
- focus on technical integration of ITS systems within the region.

Exhibit 9: ARC-IT



Regional ITS architectures are developed for regional deployments through the participation of regional stakeholders, including port authorities, highway and transit agencies, public safety agencies, motor carrier organizations, and other public transportation facility owners and managers.

⁵ https://ops.fhwa.dot.gov/publications/fhwahop12001/exec_sum.htm



PLANNING



- Initiate
- Quantify
- Form

Planning

Ports facilitate the movement of freight between different modes, and the improvement of connections between modes needs to be addressed when planning for ITS development and deployment. Opportunities to implement ITS solutions should be considered as early as possible, in both the more comprehensive strategic planning process and during the planning phase of project definition.

The following section presents the primary efforts involved in initiating and quantifying a potential port project and forming project alternatives. This approach can be refined and customized to accommodate project specific requirements necessary to identify ITS solutions that are practical and viable.

1.1 Initiate

The initiate stage involves developing a thorough understanding of the goals and objectives and information guiding the effort, as well as stakeholder perspectives that may affect the specifics of a potential project's direction.

1.1.1 Project Goals & Objectives

Defining the mission and vision are critical guiding principles that provide focus in the ITS planning process. It is likely that the goals and objectives may evolve and be revised over time as progress is made, but the mission and vision are likely to remain constant. The ITS mission and vision should describe what stakeholders can expect to see in the future. Include easy to read descriptions and infographics that address the needs of each of the major stakeholders. Exhibit 10 provides an example of a Port mission statement as it pertains to ITS programs.

Exhibit 10: Example Mission Statement

ITS Mission

- Provide the highest quality and most efficient intermodal freight services for economic prosperity
- Operate and manage an optimized, integrated transportation network by delivering high quality services for efficient and reliable movement of freight
- Provide high quality, adaptive, and integrated freight mobility technology solutions that meet the needs of all users

Goals and objectives serve as a path for achieving the overall mission and vision for ITS deployments. The project goals and objectives become the basis of the evaluation criteria in the Feasibility effort. Revisit project goals and objectives periodically to ensure the intent of the project definition process and strategies correspond with the mission and vision in view of evolving priorities.

ITS goals and objectives are centered on enhancing the safety, security, mobility, and environmental impact of transportation systems in and around the port community. Exhibit 11 provides example goals as they relate to port ITS applications in *integrated corridor management (ICM)* initiatives.⁶

The most critical factor in defining the mission, vision, goals and objectives is active engagement of stakeholders that will be impacted by or oversee the deployment and operation of ITS.

⁶ Leidos, and American Transportation Research Institute. Integrated Corridor Management and Freight Opportunities. USDOT – Federal Highway Administration. December 2015. Pp.13

Exhibit 11: Port ITS Goals Related to ICM

Goals	Importance to Ports
Facilitate On-Time Pick-Ups and Deliveries	<ul style="list-style-type: none"> Contracts for freight services often include very specific time windows for pick-ups and deliveries. Commercial drivers are regulated by Federal hours-of-service rules which limit the hours each day that drivers can be on-duty and driving, and any delays in a driver's schedule can impact their availability to work later in the day or week.
Improve Travel Reliability	<ul style="list-style-type: none"> Reliable travel times allow ports to accurately manage loads and equipment, schedule pick-up and delivery times and plan for mandated driver rest breaks.
Reduce Fuel Consumption	<ul style="list-style-type: none"> Medium- and heavy-duty trucks account for 22 percent of transportation-related Greenhouse Gas (GHG) emissions, which equates to roughly 6 percent of total U.S. GHG emissions.³ Idling trucks can consume anywhere from 1/2 to 1 gallon per hour.²
Reduce Non-Revenue Generating Labor Hours and Vehicle Maintenance Costs	<ul style="list-style-type: none"> The trucking industry faces a significant driver shortage. The driver shortage is pushing driver wages higher, making the non-revenue-generating labor hours that drivers spend stuck in traffic costlier. The highest industry costs per mile for vehicle repair and maintenance are experienced by less-than-truckload carriers whose operations are often focused on pick-up and delivery in congested urban areas.
Increase Safety	<ul style="list-style-type: none"> Research that compared crash involvement rates for medium-duty (10,001 - 26,000 lbs.) and heavy-duty (26,001 lbs. and greater) trucks found the highest crash rate index for medium-duty trucks in the central counties of metropolitan areas with populations over 1 million.

Source: Integrated Corridor Management and Freight Opportunities, <https://ops.fhwa.dot.gov/publications/fhwahop15018/index.htm>

1.1.2 Data Collection

Identifying the optimal ITS solution requires an understanding of the existing conditions. Conduct extensive data collection to ensure that decision makers have sufficient information about port and local/regional transportation performance, operations, and community priorities.

At this point, hold off on identifying possible solutions as technologies often advance during the project definition process. Apply the SE approach, which focuses on fully defining the problem, identifying user needs and documenting requirements prior to forming alternatives.

Exhibit 12: Sample Types of Project Data

Strategic	Infrastructure	Operational	System Performance	Financial
Regional ITS Architectures	ITS Infrastructure Inventory	ITS Field Devices and Equipment Inventory	Historical and Forecasted Port and Inland Transport Carrier Volumes	Congestion Costs
Port Planning Documents	Site Boundaries and Adjacencies	Truck and Rail Carrier Schedules and Operational Patterns	Historical and Forecasted Traffic Forecasts on Identified ITS Corridor(s) (Freight Movement on Interstate)	Lifecycle Costs
MPO Transportation Plans and TIP	Maps and Aerials of Existing Sites, Facilities and Infrastructure	Port Facilities Operating Schedules, Requirements and Patterns	Port Performance Statistics (Truck and Rail Turn Times, Gate Processing)	Financial Assistance Requirements
Statewide Transportation Improvement Program Documents	Truck and Rail Access in PATN, Inland Rail and Highway and Arterial Networks	Terminal Equipment Deployment Patterns	Mobility Statistics (Travel Speeds, Delay Times, Levels of Service)	Contracting Requirements
State/Local Freight Plans	Local Designated Truck Routes and Weight Limits	Transaction and Resource Supply Data	Reliability Statistics (Travel-Time Index, Planning-Time Index)	Tariffs, Tolls and Other Transportation Fees
Land Use Studies	Environmental Site Assessment Reports	Labor Deployment Rules	Safety Statistics (Accidents, Fatalities, Injuries, Locations and Contributing Factors)	Historical Transportation Infrastructure Capital Costs

Exhibit 12 provides a sample categorized list of data that could be needed for port ITS projects. Some of the data may be useful in presenting a case for the proposed project to stakeholders, supporting efforts to obtain federal funding, and/or developing alternatives. This data may be readily available from port and other local/regional agency staff, project stakeholders, or from secondary sources such as publications. The data collection effort presents an opportunity for multiple organizations to merge some, or all, their operations data, providing for a more thorough understanding of ITS system impacts on the port and surrounding region.

1.1.3 Stakeholder Engagement

The success of any ITS planning effort is facilitated by the successful engagement and involvement of all stakeholders that will be impacted by the deployment and operation of the given systems. Stakeholder input is crucial in defining the key goals, performance measures, and user needs for each ITS application. In the context of the port this includes all entities that are responsible for the safe, secure and efficient movement of goods and people.

Exhibit 13 shows the complex network of interaction between major project elements and stakeholders in the typical port. Stakeholders are grouped into government agencies, private

Exhibit 13: ITS Project Elements and Related Stakeholders

		Government Entities						Commercial Entities								Individuals							
		Port Authority	Customs & Border Patrol	Air Quality Regulator	Permitting Authority	MPO	Host City Government	State DOT	Vessel Liner	Port Terminal Operator	Rail Terminal Operator	Rail Switching Entity	Rail Class I Operator	Warehouse / DC Operator	Trucking Company	Chassis Pool Operator	Support Service Provider	Utility Company	Beneficial Cargo Owner	Longshore Labor	Rail Operating Labor	Truck Drivers	Residents / Workers
Terminal	Terminal Equipment	Modest		Modest	Modest				Modest	Strong				Modest	Modest	Modest	Modest		Modest	Modest	Modest	Modest	Modest
	Storage Yard Layout	Modest			Modest				Modest	Strong				Modest	Modest	Modest	Modest		Modest	Modest	Modest	Modest	Modest
	Gate	Modest	Modest						Modest	Strong				Modest	Modest	Modest	Modest		Modest	Modest	Modest	Modest	Modest
	Rail Working Yard	Modest			Modest				Modest	Strong	Modest									Modest	Modest	Modest	Modest
	Rail Storage Yard	Modest			Modest				Modest	Strong	Modest	Modest								Modest	Modest	Modest	Modest
	Telecomm Network	Modest	Modest						Modest	Strong	Modest	Modest			Modest	Modest	Modest	Modest		Modest	Modest	Modest	Modest
	Operating Systems	Modest							Modest	Strong	Modest	Modest		Modest	Modest	Modest	Modest	Modest		Modest	Modest	Modest	Modest
Port Area	Road Network	Modest			Modest	Modest	Modest	Modest	Modest	Strong				Modest	Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Rail Network	Modest			Modest	Modest	Modest	Modest	Modest	Strong	Modest	Modest			Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Access Roads	Modest			Modest	Modest	Modest	Modest	Modest	Strong				Modest	Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Rail Working Yard	Modest			Modest	Modest	Modest	Modest	Modest	Strong	Modest	Modest			Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Rail Storage Yard	Modest			Modest	Modest	Modest	Modest	Modest	Strong	Modest	Modest			Modest	Modest	Modest	Modest			Modest	Modest	Modest
Region	Road Network	Modest	Modest	Modest	Modest	Modest	Modest	Modest	Modest	Strong				Modest	Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Rail Network	Modest			Modest	Modest	Modest	Modest	Modest	Strong	Modest	Modest			Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Highways	Modest			Modest	Modest	Modest	Modest	Modest	Strong				Modest	Modest	Modest	Modest	Modest			Modest	Modest	Modest
	Distribution Centers	Modest	Modest				Modest	Modest	Modest	Strong				Modest	Modest	Modest	Modest	Modest			Modest	Modest	Modest

enterprise, and individuals. Project elements are grouped geographically: the terminal, the PATN, and the region in which the port is located. Dark-colored boxes represent strong interaction; light-colored boxes represent modest interaction.

The primary actors on the port's road and rail system include trucking companies, rail Class I operators, rail switching entities under "Private Enterprise", and truck drivers under "Individuals". These stakeholders' and users' needs will be central in preparing for any ITS deployment. Under Project Elements, the terminal's gate and rail yards, telecommunications network, and operating systems may be impacted by ITS, and the PATN will be the physical home of most ITS infrastructure. The figure highlights where the interests of the key ITS actors intersect with these project elements, and how these Project Elements are influenced by other stakeholders.

The PATN can come under the influence of the port authority, air quality regulators, permitting authorities, MPOs, the host city's government, and state Departments of Transportation (DOTs). These landside transportation project elements are also influenced by a range of private sector entities, including vessel lines, terminal operators, warehouses, trucking and rail companies, chassis pool operators, support service providers, utility companies, and, of course, BCOs, who generate truck and rail movement demands.

The separation between truck drivers and trucking companies is deliberate and essential commercial reality with far-ranging impacts. Most truck drivers are independent owner operators working under short- or long-term contracts with one or multiple trucking companies.

The terminal operator has the strongest influence over the working of the terminal elements. The truck driver must interface with the terminal operator's operating systems to process transactions, with the gate system to enter or leave, with the storage yard layout to get to the right storage spot, and with the terminal

equipment to receive or deliver the cargo. The port authority has a role in gate and storage yard design. U.S. Customs and Border Patrol has a strong role in the functioning of the gate, as it represents a bonded customs and transportation security boundary. The vessel liner is the terminal operator's primary customer, driving virtually all commercial decisions.

Active engagement with these stakeholders provides the opportunity for them to contribute throughout the scoping, planning and development process. This includes contributing to the ITS mission, vision, goals and objectives; the identification of user needs; and the review and concurrence on outputs of the planning process at critical decision points. Stakeholder engagement is also intended to provide visibility into the process, sustain participation in necessary data exchange, and foster ownership of the outcomes.

Engagement of stakeholders in this process may be facilitated through a range of activities, including:

- Surveys – Engage stakeholders with surveys that use focused questions to identify user needs and challenges, background on their operational roles and responsibilities, and their mission and vision for ITS deployments. A range of online tools can easily be used to support the survey process.
- One-on-One Meetings – Organize one-on-one meetings between a cross-section of port stakeholders to better understand each participants vision of successful ITS deployments, potential risks and opportunities, focus areas for moving forward, and roles and responsibilities.
- Workshops – Provide an ideal opportunity to review and discuss draft vision, goals and objectives derived through the stakeholder engagement process. They further provide an opportunity to gain feedback and formalize a shared vision that will help facilitate the planning and deployment of ITS.



PLANNING

Formalize the stakeholder engagement process in a plan that provides specific guidance through the initial stages of the planning activities, but also outlines stakeholder's engagement activities that need to be sustained throughout future development efforts. The plan should be designed to facilitate discussion among stakeholders while fostering collaboration and understanding that actively involves all impacted stakeholders in a timely manner, allowing for sufficient opportunity to voice needs, opinions and concerns.

Partnering

Engage private sector entities as partners in the ITS planning process to ensure that resulting plans meet the needs of shippers and merchants and are consistent with supplier's capabilities. The consumers should participate so that the plans meet their mobility needs.⁷ Involving private enterprise in port-ITS planning activities presents opportunities for funding. Examples of partnerships with private entities that have helped

facilitate the deployment of transportation technologies include:

- **Accelerating communications infrastructure deployment**– This could include fiber optic resource sharing agreements with private companies that allow installation of conduit and/or fiber optic cable right-of-way in exchange for the use of company-owned infrastructure in areas where the state does not have broadband infrastructure. With this type of arrangement, the private sector is granted access to Interstate and primary road right of way to deploy a commercial fiber optic network. In exchange, the transportation service provider receives telecommunications services necessary to support backhaul communications for transportation technologies.⁸
- **Traffic signal data sharing**– Companies are beginning to seek traffic signal data from public agencies for purposes of resale and/or utilization in an application meant for public consumption. One common approach is to “extract” signal data from a central advanced traffic management software (ATMS) platform most commonly provided by signal system vendors. Once extracted the data is transmitted over the internet to secure servers at one of the company locations where they can manipulate the data as needed.
- **Piloting new technologies**– Developers of advanced technologies sometimes enter partnerships with state and local jurisdictions to pilot emerging technologies. As an example, with this type of an arrangement a technology provider may provide a port owner with equipment to deploy on their fleets. This provides the port with the functionality of the technologies. This also allows the technology provider with opportunity to assess the operational performance and user acceptance of the equipment in a live operational environment.

Intelligent Transportation Society of America

The Intelligent Transportation Society of America (ITS America) advances the research and deployment of intelligent transportation technologies to save lives, improve mobility, promote sustainability, and increase efficiency and productivity.

The association convenes leaders from public agencies, private companies, academia, and research organizations to create an environment that fosters innovation; promotes a legislative and regulatory environment that supports investments in and the deployment of intelligent systems; and conducts research, educates stakeholders, and builds awareness of advancements in smart transportation technologies. ITS America members are united around a shared vision of a better future transformed by intelligent mobility that is safer, greener, and smarter.

ITS America works with ports and port authorities to demonstrate how connected and automated technologies and other advance transportation technologies can help them operate more efficiently and safely. For more information, visit www.itsa.org.

⁷ <https://www.fhwa.dot.gov/publications/research/operations/its/g804&/interimhb.pdf>

⁸ <https://www.fhwa.dot.gov/policy/otps/workplan.cfm>

1.2 Quantify

ITS provides the opportunity for ports to enhance their existing capabilities to meet future transportation needs with minimal infrastructure investment. Quantify the port’s capabilities, drivers, and needs that led to the identification of the potential ITS project. Capabilities are derived from close examination of the physical and operational aspects of each element in the port’s existing conditions. Port demands are derived from existing and forecasted traffic volumes, logistics and regulatory drivers. Project needs are derived by quantifying the gap between capabilities and drivers.

1.2.1 Existing Conditions

Prepare an inventory of existing and planned ITS infrastructure and other technologies to identify current conditions, resources available for regional integration, and constraints and opportunities for sharing of information with local and regional partners. Determine existing operational conditions along the PATN and the regional transportation network as they relate to safety, mobility, and reliability. This inventory also provides a baseline to gauge existing conditions against identified user needs.

Exhibit 14 provides an example of ITS-related elements that may be included in the inventory process. The inventory process is best facilitated through an interview process with port and terminal staff, DOTs, rail operators and other operational stakeholders.

1.2.2 Project Drivers and Needs

Identification and documentation of needs is derived from active engagement of stakeholders and is intended to identify the port’s operational challenges, their impacts on carriers serving the port and the traveling public, and potential strategies to overcome them. This process needs to be structured in a manner so that it does not just look at the operational challenges at the

Exhibit 14: Example ITS Inventory Elements

Element	Item
Technology	<ul style="list-style-type: none"> • Communications infrastructure • Freight traceability and security systems • Facility access security systems • Port logistics management systems • Traveler information systems
Institutional	<ul style="list-style-type: none"> • Organizational structure • Operational policies • Operational constraints • Funding sources
Operational	<ul style="list-style-type: none"> • Performance targets • Priority cargo and equipment movements • Systems integration • Security protocols
Cross-Sectional	<ul style="list-style-type: none"> • Port ITS System Architecture

surface, but rather examines the root causes to help derive the optimal ITS solution. Exhibit 15 provides an example of grouping of port operational challenges and user needs.

1.3 Form

Once the existing conditions, project drivers and needs have been identified, generate a range of practical, effective project alternatives and strategies that will fulfill the project goals and objectives. In forming project alternatives, provide sufficient detail to facilitate the measurement of impacts and performance of each alternative later in the project definition process. In many cases, the outcome of the Feasibility analysis will feed back into this Form stage, leading to iterative adjustments and refinements to the alternatives.

Exhibit 15: Analysis and Building of Needs

User Need	Underlying Cause	Potential ITS Solution
Improve travel time reliability in accessing port	<ul style="list-style-type: none"> • Traffic signals owned and operated by multiple jurisdictions • Outdated timing plans • Outdated controller and equipment 	FSP
Reduce queueing at port entrance	<ul style="list-style-type: none"> • Limited ability to manage truck flow at port 	TRS
Mitigate truck infringement on residential roads	<ul style="list-style-type: none"> • Limited ability to manage truck routing • Zoning ordinances vary by jurisdiction • Inadequate information for truckers 	ELDs and geofence



PLANNING

The goal of this process is to identify a small number of reasonable plan alternatives for feasibility assessment.

1.3.1 Alternatives Development and Analysis

The development of alternative ITS strategies provides the opportunity to connect operational needs to the most viable ITS solution. ITS alternatives should be documented as one- or two-page briefs so that they are available for future funding alternatives, including grants. ITS alternatives might include the following:

- Project description;
- Relation to the ITS mission and vision;
- System goals and objectives;
- System requirements;
- Data storage, generation and sharing activities;
- Earliest potential start date;
- Estimated duration of project development activities;
- Capital funding requirements;
- Lifecycle operational costs;
- Operational challenges to be addressed;
- Anticipated benefits;
- Potential risks;
- Impacts on the organizations;
- Interactions with other systems;
- Requirements and impacts on regional partners; and
- Operational responsibilities.

Review and assess each proposed project alternative with all team members and identify any alternatives that do not sufficiently align with the project goals and objectives and/or could potentially generate unacceptable impacts.

During this process, alternatives can be revised or new alternatives can be identified that provide a better balance of performance capabilities and impacts.

Incorporate stakeholder feedback and ideas where it is feasible and document all the engagement efforts that take place.

1.3.2 Refinement of Reasonable Alternatives

Refining ITS alternatives identified in the exploration of concepts to a point where they are ready to move forward to the design phase is primarily accomplished in the development of the Concept of Operations (ConOps), and the definition of requirements.

Concept of Operations

Develop or update a ConOps that provides an overview of the proposed project or system from the viewpoint of the user. The ConOps is part of the overall SE process and details:

- Goals and objectives of the project or system to be deployed;
- Current system or situation;
- Project or system to be deployed;
- Desired changes;
- Justification for changes;
- Proposed devices and system components;
- Institutional environment;
- Modes of operation;
- Operational policies and constraints;
- Roles, responsibilities, and relationship of the various stakeholders;
- Control and management protocols;
- Operational environment;
- Support environment;
- High-level requirements.

Defining a shared set of expectations is essential when planning, designing, or deploying an ITS project. The ConOps supports the development and documentation of these expectations to serve as the foundation for the project. The current *International Standard for Systems and Software Engineering -- Life Cycle Management* contains provisions for developing a ConOps document. The following resources provide a starting point as well as fundamental elements to include in a comprehensive ConOps:

- *ITS JPO Professional Capacity Building Program, ITS ePrimer, Module 2: Systems Engineering, Concept of Operations*

- *Developing and Using a ConOps in Transportation Management Systems. (FHWA-HOP-07-001 - 2005)*
- *Guide to the Preparation of Operational Concept Documents. (ANSI/AIAA G-043-2012). American National Standards Institute, 1992. This draft report gives guidelines for creating a ConOps document.*
- *Florida Department of Transportation (FDOT) ConOps Guidance Document and Template*
- *Virginia Department of Transportation (VDOT) ConOps Guidance Document and Template*

Definition of Requirements

The process of defining requirements entails reviewing user needs identified during the development of the ConOps, analyzing them and transforming them into verifiable requirements that define what the system will do. Key inputs into the definition of system requirements are:

- ConOps that clearly articulates user needs;
- Functional requirements, interfaces with other existing and planned systems, and applicable ITS standards;
- Applicable local, regional and statewide statutes, regulations, and policies; and
- Constraints, which may include integration with existing systems.

Key activities in the requirements definition process that move the overall concept closer to design are:

- Identification and documentation of and analysis of system requirements,
- Validation and management of system requirements,
- Development of a system verification plan, and
- Definition of a system acceptance plan.⁹

Designing a port ITS project typically involves preliminary engineering of infrastructure, environmental analysis, permitting, and ITS software and hardware design using a formal Systems

Engineering process as described in 23 CFR Part 940 – ITS Architecture and Standards (below) and presented in Exhibit 7. Guidance and resources for designing and implementing ITS projects are available at *FHWA’s ITS Architecture Implementation Program site*.

23 CFR Part 940 – ITS Architecture and Standards

Project implementation. (a) All ITS projects funded with highway trust funds shall be based on a systems engineering analysis. (b) The analysis should be on a scale commensurate with the project scope. (c) The systems engineering analysis shall include, at a minimum:

- (1) Identification of portions of the regional ITS architecture being implemented (or if a regional ITS architecture does not exist, the applicable portions of the National ITS Architecture);
- (2) Identification of participating agencies’ roles and responsibilities;
- (3) Requirements definitions;
- (4) Analysis of alternative system configurations and technology options to meet requirements;
- (5) Procurement options;
- (6) Identification of applicable ITS standards and testing procedures; and
- (7) Procedures and resources necessary for operations.

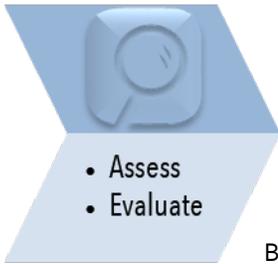
(d) Upon completion of the regional ITS architecture, the final design of all ITS projects funded with highway trust funds shall accommodate the interface requirements and information exchanges as specified in the regional ITS architecture. ... (e) ... Any major ITS project funded with highway trust funds that advances to final design shall have a project level ITS architecture that is coordinated with the development of the regional ITS architecture. ... (f) All ITS projects funded with highway trust funds shall use applicable ITS standards and interoperability tests that have been officially adopted through rulemaking by the DOT.

⁹ Iteris, Inc – National ITS Architecture Team. *System Engineering for Intelligent Transportation Systems*. FHWA-HOP-07-069. January 2007.

Pp. 33-39, Available online at <https://local.iteris.com/arc-it/documents/seguides/seguides.pdf>.



FEASIBILITY



Feasibility

Analyzing the feasibility of ITS alternatives should be initiated before project prioritization. Begin by assessing how all processes and resources would be impacted by the proposed applications. Evaluate the feasibility of ITS projects to objectively determine whether a project should be carried forward for further refinement, and consideration for selection and funding.

2.1 Assess

The feasibility assessment should consider a range of quantitative and qualitative factors including, but not limited to:

- Users' needs;
- Likely impacts on operational performance (both positive and negative);
- Port staffing requirements;
- Lifecycle costs;
- Technical advantages and limitations;
- Risks and security issues;
- User acceptance; and
- Technical maturity and limitations of the proposed ITS.

2.1.1 Operational Performance

The port industry is accustomed to gradual change that enhances performance without major disruptions to operations. Even when improvements to performance or efficiency are demonstrably clear, stakeholders often respond cautiously, recognizing the complexity, sophistication, and essential viability of the existing system.

The cargo handling paradigm can, and must, continue to evolve, through careful integration of new tools and techniques that improve performance without degrading the excellence that has already been achieved. Technology vendors from outside the maritime industry can

offer clever innovations, but these ideas must be subjected to robust feasibility analysis to avoid deployment failure.

A feasibility analysis on the deployment of ITS infrastructure should:

- Assess how ITS alternatives interact with stakeholders' resource and demand balance.
- Quantify existing and proposed performance of these resources in terms of effort, timeliness, and reliability. For example, an ITS project to improve access to the port's centralized chassis yard may impact truckers and terminal operators differently depending on their location within the port.
- Identify the current state of port and freight transportation operational practices, of commercial liability, of organized-labor deployment, and of existing positions of authority and responsibility for the specific area of concern.
- Determine whether any of these constraints will impact the operational efficiency or cost effectiveness of the ITS alternatives for the port.

2.1.2 Human Factors

Two human resource issues that need to be addressed during the assessment of potential port ITS projects are (1) the need for additional staff, and (2) the staff training that will be required to operate and maintain new systems. ITS provides the opportunity to expand operational capabilities of a port, but consideration must be given to whether these deployments will necessitate additional staff for routine operations and for preventative and emergency maintenance of the systems that are deployed.

Further, it is important to understand that the deployment, operation, and maintenance of ITS



may require skill sets that a port does not currently possess. The port owner will need to make investments in building the technical capacity of staff to not only ensure that the benefits of the deployed systems are maximized, but to ensure they are properly maintained to maximize the lifecycle of the systems.

2.1.3 Impacts

There are a wide-range of institutional, social (safety, mobility), environmental, and economic impacts that may result from the deployment and operation of a port ITS project. ITS can provide benefits to an existing system that successfully moves millions of containers and tons of cargo into and out of the nation's ports each year. Potential benefits for ports, terminal operators and freight transportation providers, include:

- Safety - Measured through changes in accident rates or other surrogate measures such as equipment interchange conflicts, or workers' compensation claims.
- Mobility - Measured in travel time or delay savings, as well as travel time savings, on-time performance, and travel-time reliability.
- Efficiency - Represented through increases in capacity or level of service within the port and terminal, as well as along existing road networks or freight rail systems.
- Productivity – Measured in terms of cost savings to transportation providers, terminal operators, or shippers.
- Energy and Environment - Typically documented through fuel savings and reduced pollutant emissions.

FHWA research indicates that benefit-to-cost ratios for EFM applications ranged from 1:1 to 7:1. Higher ratios were projected for companies with larger supply chains.

2.1.4 Risks and Mitigations

To understand how ITS can be successfully implemented in the port environment, it is useful to understand the potential risks and challenges that ITS applications might need to overcome.

Responsibility and Authority: The movement of cargo to, from and within port terminals requires a complex exchange of private and public agency authority and responsibility. There is usually no commercial relationship between the terminal operators and either the truck driver, the trucking company, or the BCO. The isolation between BCOs, who have the authority to schedule landside moves, terminal operators, who are responsible for serving those moves, and truckers, who perform the moves, will need to be addressed to leverage the interconnectivity of ITS.

Random Demand: The terminal operator is frequently faced with random demands for landside transport from the truck driver or BCO. The BCO's decision to deliver or retrieve cargo at the terminal is generally made without any communication with the terminal operator, and with no understanding of the terminal's current or expected state or service capability. On occasion, and sometimes with little warning, the terminal operator may need to constrain landside service to have capacity for waterside operational demand. This variability in terminal landside behavior can impact road/terminal ITS integration as truck movements in and out of the terminal are restricted. The increasing use of blockchain technology and digital platforms to connect port users and better manage supply chains should improve the visibility into landside cargo demand in the future.

Problem Resolution: Most terminal gates have "trouble service" areas where truck drivers can be removed from the stream to resolve transaction problems on their own time. Typically, trouble services are neither centrally monitored nor controlled, which can make them invisible to potential ITS solutions. Problem resolution areas



FEASIBILITY

will need be taken into account during the planning process for port ITS projects.

Waterfront Labor: Terminal operators employ trained stevedores to work ships and longshoremen to handle cargo in the terminal yard and gate. In most major ports, these workers are members of strong unions that have negotiated rigorous contracts with waterfront employers. These contracts reflect

the long history of labor relations on the waterfront, and are not easily changed.

Waterfront labor and their employer representatives should be jointly consulted during stakeholder engagement efforts to improve the viability or net effectiveness of ITS projects.

Freight Security: One of the primary goals of transporting cargo has always been maintaining freight security: preventing damage, theft, or pilfering. Container contents, and the logistics surrounding container movement, are closely protected data. An ITS information security program should be developed that provides guidance to those who will oversee the acquisition, installation, operation, and maintenance of ITS to ensure the ITS solution does not undermine freight security or confidentiality.

Transportation Security: Since September 11, 2001, transportation security has been a major driver of changes to port operating practices. In many ways, freight security and transportation security are in conflict because container secrecy reduces the odds of catching contraband or weapons. Over the years, a *modus vivendi* has been worked out that meets the needs of both freight and port security, and any new technologies or systems must work within the current security framework. Port ITS projects aimed to improve efficiency by improving transactional data visibility must take transportation security requirements into account.

Cyber Resiliency

The first step in fostering cyber resiliency is to understand the relationships and interdependencies of a port's business processes, networks, systems, and applications. This will help inform what redundancies and preparations are required to protect against a cyber-attack and enable a swifter recovery. The following organizations have published guidance and/or resources that will help ports facilitate cybersecurity and resiliency efforts.

The Coast Guard provides a variety of information and resources concerning maritime cybersecurity through *USCG Homeport - Cybersecurity*.

The American Bureau of Shipping (ABS) has provided a series of Guidance Notes on Cybersecurity and resiliency matters for vessel, ports, and other shore-side facilities. ABS provides an approach to measuring cyber risk - the FCI Cyber Risk™ equation, which can be found at *ABS Maritime Cyber Security*.

The International Maritime Organization (IMO)'s *Guidelines on Maritime Cyber Risk Management* provides high-level recommendations on maritime cyber risk management to safeguard shipping from current and emerging cyber threats and vulnerabilities, which includes functional elements that support effective cyber risk management.

The DHS US Computer Emergency Response Team (US-CERT) and Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) both have additional resources posted on their two websites concerning securing IT and operational technology (OT): *US-CERT Resources*, *ICS-CERT Resources*.

MARAD's *Office of Security* coordinates within the federal government to issue US Maritime Alerts and US Maritime Advisories, that may contain cyber elements.

2.2 Evaluate

There are various techniques and criteria that can be used to determine how the potential ITS alternatives can be used by stakeholders to solve the identified issues within the constraints.

2.2.1 Project Evaluation Approach and Recommended Project(s)

Although individual ports may have their own methodology for evaluating and recommending



projects, there are general steps that may be taken with regards to evaluating ITS projects:

- Screening – ITS projects should be screened to determine their basic feasibility. Key factors to be considered in the screening could include: user needs and functional requirements, user acceptance, consistency with mission and vision, potential deployment or operations challenges, and likelihood of having available funding.
- Technical evaluation and ordering – This process entails a qualitative and quantitative assessment of projects against criteria related to the goals and objectives, and agreed to by stakeholders. Based on the assessment projects would then be ordered per their score. Ideally high-priority projects will be those that:
 - Address the operational needs of the port and surrounding transportation network,
 - Are the most technologically feasible,
 - Provide the highest value in terms of performance and cost,
 - Have the least impacts on existing terminal operations,
 - Minimize additional staffing and training requirements,
 - Minimize additional operations and maintenance funding, and
 - Are sustainable by the port and their operational partners.
- Review – Technical advisory committee review and concurrence on the accuracy of the evaluation.
- Selection – Project selection is a critical step that entails concurrence from the technical review committee. This is the point at which the port owner will begin to try and secure adequate funding for the project(s).

The process of evaluating and recommending ITS projects will be well-served by the establishment and utilization of a technical review committee that is responsible for providing input into the criteria used for evaluating projects, and reviewing and concurring with the outcomes of the evaluation process.

2.2.2 Project Prioritization

It is possible that a port owner may not have the funding to deploy all the desired ITS solutions at one time. Therefore, it will be necessary to prioritize projects based on the overall ITS vision. Factors to be considered in the prioritization of projects include:

- Urgency of need for the project – Is the project replacing or supporting a critical system or function that is failing or near the end of its useful life?
- Benefit/cost (B/C) ratio of the project – What is the expected B/C ratio of the project?
- Sequencing as related to other projects – Is the project required to enable the functionality of other projects (e.g., communications infrastructure)?
- Portion of a project - Is the ITS application a component of a high priority project?
- Funding availability – Is there adequate funding to support the planning, development, operations, and maintenance of the desired project. Not accounting for adequate funding to maintain the deployment of technologies is a common mistake.¹⁰



¹⁰Integrating Intelligent Transportation Systems with them Transportation Planning Process: An Interim Handbook (Page 3-20). Prepared for: Federal Highway Administration Office of Traffic

Management and ITS Applications and Office of Environment and Planning. Prepared by: Transcore – An SAIC Company.



Financing

- Strategize
- Structure

Identifying and securing adequate funding for planning, development, implementation, and operations and maintenance is critical to the success of an ITS project. A range of traditional and innovative Federal, state, local, and private sector funding sources are available to project sponsors to support these activities.

3.1 Strategize

Funding for ITS has become an integral part of established transportation investments in the U.S., often augmenting the construction of hard transportation infrastructure. ITS projects are an affordable solution to enhance safety and mobility in comparison to building new roadways and bridges. The comparatively low-cost technology can offer investors a high return on investment (ROI) as measured in safety, travel time reliability, throughput and quality of life. The monetary benefits from ITS solutions continue to stimulate public and private investment in these technologies.

The broad array of public and private sector financing and funding options for ITS projects allows port owners to take advantage of multiple investment opportunities. To do so, port owners should perform the following:

- Review public funding mechanisms currently used for ITS projects, their institutional and legal framework, financing arrangements, requirements including timelines and procedures, and other key features.
- Identify multiple, alternative funding solutions and distinguish between near-term opportunities and long-term financial strategies to support the ITS project.
- Consider which strategies will offer the best solution in view of the port's mission and the specific ITS project objectives.

- Take into account how funding and financing options such as private activity bonds (PABs), lease agreements, and public private partnerships (P3) could impact the compatibility and continuity of the recommended ITS project.

3.2 Structure

After qualitatively evaluating the advantages and disadvantages of public, hybrid, and P3 financial alternatives, develop a financial plan and model to determine the most appropriate structure for the ITS project. The funding structure should include an assessment of the economic, social and operational value of the ITS project.

A detailed project finance and cash flow model should incorporate current and projected operating revenues, initial and maintenance capital expenses (CapEx), operating expenses (OpEx), and outstanding debt service. Ensure the model has the flexibility to consider incremental revenues, OpEx, and debt service associated with the project. Modeling OpEx are particularly important since the ongoing day-to-day costs for some ITS projects can exceed the funding necessary for the initial deployment. The pace of technological advancement and periodic staff training can further compound the ITS OpEx.

The financial plan should include:

- Financing and debt objectives;
- Debt profile including re-structuring/refunding opportunities for existing debt;
- Projected CapEx, OpEx, revenues and sources;
- Risk sensitivity analysis;
- Credit rating outlook and strategies; and
- Financing alternatives and P3 techniques that can be utilized in various combinations.

The overall result should be a comprehensive analysis and corresponding financing structure



that supports the development, deployment and sustainable operation of the port ITS project.

Module 1: General Projects includes a comprehensive discussion of the various debt alternatives and funding opportunities that can be applicable to port ITS projects. These products include various forms of PABs, commercial bank financings, bond alternatives, leasing programs, tax/fee revenue financing, *State Infrastructure Bank (SIB) loans*, and private equity, among others.

The following section focuses on select government funding programs available at the time of this module version that specifically facilitate the delivery of port ITS projects.

3.2.1 Federal Funding Sources

Federal funding change from year to year, as government revenue levels vary and federal appropriations fluctuate. There are various federal programs available to port owners at any given time. Exhibit 16 summarizes the availability of Federal funding to support ITS projects in the port environment. A brief summary of each program is

Exhibit 16: Federal Government Funding Programs

Govt. Program	Summary Description	Program and Project Size	Max. Federal Award	Key Eligibility Requirement for Ports/ITS
ATCMTD	Competitive grant for deployment of advanced transportation and congestion management technologies.	\$60M /yr. through 2020; Max. Size \$12M	50% of project cost	State or local government or political subdivision thereof; or multijurisdictional group
ITS	Funding for the development of ITS infrastructure, equipment, and systems; and ITS research initiatives, exploratory studies, and deployment support programs.	\$100M/yr. through 2020	80% of project cost	Enhancement of the national freight system and support national freight policy goals. Limits use of funds for the construction of physical surface transportation infrastructure.
BUILD	Competitive grant for enhancement of surface transportation infrastructure at local and regional level.	Variable – Yearly appropriation; Max. \$25M	80% of urban project, 100% of rural project	Freight rail transportation projects, port infrastructure investments, and intermodal projects.
INFRA	Competitive grant for highway and freight projects of national or regional significance.	Max. \$500M for freight through 2020; Min. \$25M large project, \$5M small project	60% of project cost	Acquisition of equipment, and operational improvements directly related to improving system performance.
STBG	Formula funding for States and MPOs for priority transportation projects.	≈\$12B/yr. through 2020	80% of project cost	Projects that facilitate direct intermodal interchange, transfer, and access of freight into and out of a port terminal. Includes installation of V2I communication equipment.
NHFP	Formula funding for States to improve movement of freight on National Highway Freight Network.	≈\$1.4B/yr. through 2020; Max. 10% freight	80% of project cost	Project must be identified in a freight investment plan included in the State’s freight plan
CMAQ	Formula funding for States, MPOs and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act.	≈\$2.45B/yr. through 2020	80% of project cost	Verified technologies for non-road vehicles and non-road engines that are used in port-related freight operations located in ozone, PM10, or PM2.5 nonattainment or maintenance areas.
TIFIA	Financing assistance for ITS and surface transportation projects, certain freight rail projects, intermodal freight transfer facilities, and certain projects inside a port terminal.	\$300M/yr. through 2020; \$15M ITS projects	49% of project cost (TIFIA max.)	Projects must be identified in the relevant State Transportation Improvement Program
RRIF	Financing assistance for railroad equipment, facilities and infrastructure including positive train control systems.	Up to \$35B in loans, up to \$7B for non-Class 1 carrier projects	100% of project cost	Loan recipients required to pay a credit risk premium
PABs	Tax-exempt financing issued through a public conduit for privately developed infrastructure.	\$15B in total allocation	100% of project cost	At least 95 percent of bond proceeds to be expended within a 5-year period



FINANCING

Virginia Port Authority TRS Expansion and Automated Data Model



Source: Port of Virginia

In 2017, the Virginia Port Authority was awarded a \$1.55 million ATCMTD grant to design, implement, and deploy a second-generation TRS at the Port. The project is comprised of three technological components:

- The installation of RFID readers at all entry and exit gates at the Richmond Marine Terminal, Portsmouth Marine Terminal, and Virginia Inland Port;
- A cloud based TRS that is integrated with the Inventory Management System and RFID readers at each facility; and
- A data model for standardizing and providing real-time status updates to truck dispatchers through their Truck Management Systems.

The TRS is based on a Data Subscription Model to get information from truckers to other supply chain stakeholders through a common cloud-based system across all the Port's marine terminals.

The project has a total investment cost of \$3.1 million, and engages a series of stakeholders including, but not limited to:

- Old Dominion University's Virginia Modelling Simulation Center;
- The Hampton Roads Transportation Planning Organization's Freight Technical Advisory Committee; and
- Virginia Maritime Association.

The project is expected to take four years to implement and will have the following impacts:

- Safer marine terminals – an estimated reduction of Virginia International Gateway's Risk Score from 560 to 168;
- Lower levels of regional traffic resulting from the reduction of peak period truck demand;
- Lower average truck trip times resulting from a decrease in idling time, turn time, and exit time; and
- Better air quality.

provided in the following section. Access further details by clicking on the title of the government funding program in Exhibit 16.

The majority of the programs fall under the Fixing America's Surface Transportation Act (FAST Act), which funds surface transportation programs at over \$305 billion for fiscal years (FY) 2016 through 2020. It is the first long-term surface transportation authorization enacted in a decade that provides long-term funding certainty for surface transportation. The FAST Act provides a range of new and existing funding opportunities to fund port-ITS initiatives.¹¹

Federal Discretionary Grant Programs

The Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

grant program is designed to facilitate the deployment of advanced technologies and related strategies to address issues and challenges in safety, mobility, sustainability, economic vitality, and air quality that are confronted by transportation systems owners and operators. It is envisioned that technologies deployed as part of this program will generate benefits by maximizing efficiencies based on the intelligent management of assets and the sharing of information using integrated technology solutions.

Eligible uses of the ATCMTD funds related to the planning, development and implementation of ITS to enhance port operations include:

- Advanced traveler information systems;
- Advanced transportation management technologies;
- Infrastructure maintenance, monitoring, and condition assessment;
- Transportation system performance data collection, analysis, and dissemination;



- 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; and
- Integration of ITS with the Smart Grid and other energy distribution and charging systems.

The Intelligent Transportation System program, which provides for the research, development, and operational testing of ITS aimed at solving congestion and safety problems, improving operating efficiencies in commercial vehicles, and reducing the environmental impact of growing travel demand. The ITS program is managed by the ITS JPO. Guided by the required five-year ITS Strategic Plan, the current ITS research program is focused on two key priorities: realizing connected vehicle implementation and advancing automation.¹²

The FAST Act stipulates that funds made available for tests of ITS under the ITS Program shall be used primarily for the development of ITS infrastructure, equipment, and systems. These funds may additionally be used to the maximum extent practicable, without being used for the construction of physical surface transportation infrastructure unless the construction is incidental and necessary to the implementation of an ITS project. Available funding opportunities are published throughout the year at the *Federal Register* website.

The Better Utilizing Investments to Leverage Development (BUILD) transportation Discretionary grant program provides competitive grants for the enhancement of surface transportation infrastructure, including roads, bridges, transit, rail, ports or intermodal transportation infrastructure, at a local or regional level.

BUILD grants are evaluated on merit criteria such as safety, economic competitiveness, quality of life, environmental protection, and innovation.¹³

Port ITS-oriented eligible projects for BUILD Transportation Discretionary Grants are capital projects that include, but are not limited to passenger and freight rail transportation projects, port infrastructure investments (including inland port infrastructure and land ports of entry), and intermodal projects.

The FY 2018 Appropriations Act allows up to \$15 million for the planning, preparation or design of projects eligible for BUILD transportation funding. Activities eligible for funding under BUILD Transportation Planning Grants are related to the planning, preparation, or design—including environmental analysis, feasibility studies, and other pre-construction activities—of surface transportation projects. Research, demonstration, or pilot projects are eligible only if they will result in long-term, permanent surface transportation infrastructure that has independent utility.¹⁴

Build America Bureau

The USDOT's *Build America Bureau* (the Bureau) assists project sponsors to develop, finance and deliver ITS and transportation infrastructure projects. The Bureau serves as the single point of contact to help identify and secure financing, and provides technical assistance for project sponsors. The Bureau houses certain USDOT grant and credit programs, including the INFRA grant program, the Transportation Infrastructure Finance and Innovation Act loan program, the Railroad Rehabilitation and Improvement Financing loan program, and PABs. The Bureau offers technical expertise in public-private partnerships, port oriented development, environmental review and permitting and other fields.

Project sponsors and their partners can benefit from the Bureau's ability to serve as the single point-of-contact to access the USDOT credit programs, to provide technical assistance and to investigate the viability of P3s in their transportation infrastructure projects.

Contact the Bureau at BuildAmerica@dot.gov, or call the Bureau at (202) 366-2300 for additional information or project assistance.

¹² <http://www.trb.org/ResearchFunding/FederalResearchPrograms.aspx>

¹³ <https://www.transportation.gov/BUILDgrants/about>

¹⁴ https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/build/114796/fed-reg-build-nofo-2018_o.pdf



The Infrastructure for Rebuilding America (INFRA) program, also known as the NSHFP, to provide Federal financial assistance, as competitive grants, to highway and freight projects of national or regional significance. The INFRA grant program creates opportunities for all levels of government and the private sector to fund infrastructure, using innovative approaches to improve the necessary processes for building significant projects, and increases accountability for the projects that are built.¹⁵

Eligible uses of the INFRA funds as they related to the planning, development and implementation of ITS to enhance port operations are:

- Development phase activities, including planning, feasibility analysis, revenue forecasting, environmental review, preliminary engineering and design work, and other preconstruction activities; and

Miami-Dade County/PortMiami Truck Gate



In 2018, Miami-Dade County was awarded a \$7 million INFRA grant to replace two cargo terminal gates at PortMiami with automated systems that use OCR to read data from trucks traveling towards Port Boulevard along the PortMiami tunnel. The real-time data will be electronically transferred to the gate, providing terminal operators advance notification of impending truck arrivals to terminal operators. The project will improve terminal fluidity, gate processing, and truck turn times.

- Construction, reconstruction, rehabilitation, acquisition of real property (including land related to the project and improvements to the land), environmental mitigation, construction contingencies, acquisition of equipment, and operational improvements directly related to improving system performance. [23 U.S.C. 117(f)].¹⁶

The INFRA grants program differs from the BUILD grants program, formerly known as the TIGER grants program, in two ways. First, the INFRA grants program has a different scale of awards. Typically, BUILD grant awards are between \$10M and \$20M whereas INFRA grants for large projects are at least \$25M for large projects and \$5M for small projects. Approximately 90 percent of INFRA funds are allocated to large projects. Second, unlike the BUILD program, the INFRA program is not subject to variability in yearly appropriations as it has a dedicated source of funding through to 2020.¹⁷

Federal-aid Grant Programs

The Surface Transportation Block Grant Program (STBG) has the most flexible eligibilities among all Federal-aid highway programs and aligning the program's name with how FHWA has historically administered it. The STBG promotes flexibility in State and local transportation decisions and provides flexible funding to best address State and local transportation needs. In general, STBG projects may not be on local roads or rural minor collectors. Exceptions to this requirement include port terminal modifications. The FAST Act also adds specific mention of the eligibility of installation of V2I communication equipment.¹⁸

The National Highway Freight Program (NHFP) was established under the FAST Act to improve the efficient movement of freight on the National Highway Freight Network (NHFN) while maintaining a focus on safety, efficiency, productivity, resiliency, and environmental

¹⁵ <https://www.transportation.gov/buildamerica/infragrants>

¹⁶ <https://www.fhwa.dot.gov/fastact/factsheets/fastlanegrantsfs.cfm>

¹⁷ <http://www.seneca-llc.com/funding-tools/fastlane-grants>

¹⁸ <https://www.fhwa.dot.gov/fastact/factsheets/stbgfs.cfm>



sustainability. Goals of the NHFP program, as they pertain to ITS, are to:

- Invest in infrastructure and operational improvements that strengthen economic competitiveness, reduce congestion, reduce the cost of freight transportation, improve reliability, and increase productivity;
- Improve the state of good repair of the NHFN; and
- Use innovation and advanced technology to improve NHFN safety, efficiency, and reliability.

Generally, NHFP funds must contribute to the efficient movement of freight on the NHFN and be identified in a freight investment plan included in the State's freight plan. Eligible uses of the NHFP funds as they are related to the planning, development and implementation of ITS to enhance port operations are:

- Development phase activities, including planning, feasibility analysis, revenue forecasting, environmental review, preliminary engineering and design work, and other preconstruction activities.
- Construction, reconstruction, rehabilitation, acquisition of real property (including land relating to the project and improvements to land), construction contingencies, acquisition of equipment, and operational improvements directly relating to improving system performance.
- ITS and other technology to improve the flow of freight, including intelligent freight transportation systems.
- Efforts to reduce the environmental impacts of freight movement.
- Environmental and community mitigation for freight movement.
- Truck parking facilities eligible for funding under section 1401 (Jason's Law) of MAP21.¹⁹

- Real-time traffic, truck parking, roadway condition, and multimodal transportation information systems.
- Electronic screening and credentialing systems for vehicles, including weigh-in-motion truck inspection technologies.
- Traffic signal optimization, including synchronized and adaptive signals.
- Work zone management and information systems.
- Electronic cargo and border security technologies that improve truck freight movement.
- ITS to increase truck freight efficiencies inside the boundaries of intermodal facilities.
- Any other surface transportation project to improve the flow of freight into and out of an eligible intermodal freight facility. [23 U.S.C. 167(i)(5)(C)].²⁰

The Congestion Mitigation and Air Quality

Improvement (CMAQ) program provides funding 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 for both non-attainment areas, and areas that are now in compliance. CMAQ Funds may be used for transportation initiatives that are likely to contribute to the attainment or maintenance of a national ambient air quality standard, with a high level of effectiveness in reducing air pollution. Projects must be included in the MPO's current transportation plan and Transportation Improvement Plan (TIP). The FAST Act added eligibility for verified technologies for non-road vehicles and non-road engines that are used in port-related freight operations located in ozone, PM₁₀, or PM_{2.5} nonattainment or maintenance

¹⁹The Moving Ahead for Progress in the 21st Century Act (MAP-21), was a funding and authorization bill to govern federal surface transportation spending. It was passed by Congress on June 29, 2012 and signed into law on July 6. The \$105 billion two-year bill does not significantly alter

total funding from the previous authorization, but does include many significant reforms.

²⁰<https://www.fhwa.dot.gov/fastact/factsheets/nhfpfs.cfm>



areas funded in whole or in part under 23 U.S.C. [23 U.S.C. 149(b)(8)(A)(ii)] or chapter 53 of 49 U.S.C.²¹

Federal Loan Programs

The Transportation Infrastructure Finance and Innovation Act (TIFIA) program provides Federal credit assistance to eligible surface transportation projects, including highway, transit, intercity passenger rail, certain freight rail projects, intermodal freight transfer facilities, and some modifications inside a port terminal. Three distinct types of financial assistance are available through the program:

- Secured loans are direct Federal loans to project sponsors offering flexible repayment terms and providing combined construction and permanent financing of capital costs.
- Loan guarantees provide full-faith-and-credit guarantees by the Federal Government to institutional investors, such as pension funds, that make loans for projects.
- Lines of credit are contingent sources of funding in the form of Federal loans that may be drawn upon to supplement project revenues, if needed, during the first 10 years of project operations. [23 U.S.C. 603 and 604].

TIFIA project terms include:

- Inclusion in the relevant State Transportation Improvement Program;
- Minimum capital costs of \$50 million, or \$15 million for ITS projects;
- Credit assistance limited to a maximum of 49 percent of the total eligible project costs;
- Senior debt rated as investment grade; and
- Project support from user charges or other non-Federal dedicated funding sources.

Historically, each dollar of funding has allowed TIFIA to provide approximately \$14 in credit assistance.

The Railroad Rehabilitation and Improvement

Financing (RRIF) program was established by the Transportation Equity Act for the 21st Century and was later amended by the Safe Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users, and the FAST Act. The RRIF program provides credit assistance for rail infrastructure by granting low-cost direct loans and loan guarantees to project sponsors.

Eligible recipients of RRIF program funds include railroads, state and local governments, government-sponsored corporations, and railroad joint ventures. Eligible uses of RRIF Program funds as they are related to the planning, development, and implementation of ITS to enhance railroad operations include:

- Acquiring, improving, or rehabilitating intermodal or rail equipment or facilities, track, track components, bridges, rail yards, buildings, and shops;
- Refinancing outstanding debt incurred for the purposes listed above;
- Pre-construction activities;
- Transit-oriented development projects; and
- Developing or establishing new intermodal or railroad facilities.

Under the RRIF program, USDOT is authorized to provide up to \$35 billion in direct loans and loan guarantees. A minimum of \$7 billion is reserved for projects benefiting freight railroads other than Class 1 operators. Direct loans can cover the entire cost of a railroad project with a repayment period of up to 35 years at an interest rate equal to the cost of borrowing money directly from the government.

The RRIF program differs from the TIFIA program in that it requires loan recipients to pay a credit risk premium, which offsets the risk of default. The risk premium helps the program comply with a congressional requirement, which states that the

²¹ <https://www.fhwa.dot.gov/fastact/factsheets/cmaqfs.cfm>

federal loan assistance program must operate at no cost to the federal government.²²

Private Activity Bonds (PABs)

PABs are issued by a government agency to provide debt financing for private projects that are developed for a public purpose and to provide opportunities for private sector investment and public-private partnerships (P3s). The program is geared towards increasing private sector investment in domestic transportation infrastructure. PABs funding is directed to nationally and regionally significant surface transportation projects including highway, transit and rail, and intermodal projects that receive federal assistance.²³ Providing private developers and operators with access to tax-exempt interest rates lowers the cost of capital significantly, enhancing investment prospects. Increasing the involvement of private investors in highway and freight projects generates new sources of money, ideas, and efficiency.

- The law limits the total amount of such bonds to \$15 billion and directs the Secretary of Transportation to allocate this amount among qualified facilities. The \$15 billion in exempt facility bonds is not subject to the state volume caps. Qualified highway or surface freight transfer facilities include:
 - Any surface transportation project which receives Federal assistance under Title 23, U.S. Code (as in effect on August 10, 2005, the date of the enactment of section 142(m))
 - Any project for an international bridge or tunnel for which an international entity authorized under Federal or State law is responsible and which receives Federal assistance under Title 23, U.S. Code (as so in effect)

- Any facility for the transfer of freight from truck to rail or rail to truck (including any temporary storage facilities directly related to such transfers) which receives Federal assistance under Title 23 or Title 49²⁴.

3.2.2 State and Local Funding Sources

Although port-related investments are often limited in terms of state or local appropriations, port owners should explore state and local budget allocation opportunities and land and grant programs for potential funding of a port ITS project. State and local finance and funding programs can be competitive and typically have monetary matching and other eligibility requirements.

Global Opportunities at the Port of Oakland (GoPort)

The Port of Oakland, City of Oakland, and Alameda County Transportation Commission have partnered to implement a series of landside transportation improvements within and near the Port. The project is geared towards using a suite of ITS to improve traffic flows, boost the efficiency of goods movement operations, and augment safety throughout the Port.

In 2017, the Alameda County Transportation Commission was awarded a \$9.72 million ATCMTD grant for GoPort project. The project was geared towards improving the existing integrated freight community system by developing a new port-specific traffic management center, advanced traveler information, traffic messaging, trucking information for mobile apps, rail-grade warnings, and terminal queue information. The project is scheduled to finish towards the end of 2021.

It is anticipated that the project will have the following impacts on the region:

- Safer, and more efficient and reliable truck and rail access to the Port of Oakland facility;
- Quicker dissemination of real-time traveler information to users;
- Better traffic and accident management within the Port and its associated access routes; and
- Less congestion, truck idling, and emissions.

²² <https://fas.org/sgp/crs/misc/R44028.pdf>

²³ <https://www.transportation.gov/buildamerica/programs-services/pab>

²⁴ <https://www.transportation.gov/buildamerica/programs-services/pab>



Discretionary allocations arising from state or local government budgets are specific to the relevant government of a port's locality and can come as the result of legislation authorizing the creation of local port districts with bonding and taxing power (e.g., Washington State), dedicated funding sources (e.g., Virginia), the collection of taxes and fees, and/or one-time funding appropriations.²⁵

3.2.3 Private Funding Sources

Some states lack legislation that gives assistance to ports – failing to either allocate state funds pursuant to a dedicated state program or empower local entities with the authority necessary to raise funds. One solution to this challenge may be P3s. While most P3 port initiatives involve design-build-finance-operate-maintain (DBFOM) or long-term lease concessions of new or existing facilities, there are instances of P3 arrangements for port ITS projects including:

- Digital Supply Chain Information Portal by POLA and GE
- Global Opportunities Port of Oakland (GoPort!) Freight Intelligent Transportation System Project by the Port of Oakland, Alameda County Transportation Commission, City of Oakland, California Department of Transportation, Union Pacific Railroad, BNSF Railway, San Francisco Bay Area Rapid Transit, Metropolitan Transportation Commission, and various utility entities
- Control and Communications Systems by Port of Miami and SICE (a systems integration technology company)

FHWA P3 Toolkit

The FHWA publishes a Public-Private Partnership (P3) Toolkit available at

<https://www.fhwa.dot.gov/ipd/p3/toolkit/>. The P3 Toolkit addresses Federal requirements and four key areas of P3 implementation:

- Legislation and Policy
- Planning and Evaluation
- Procurement
- Monitoring and Oversight

The P3 Toolkit includes fact sheets, publications, an analytical tool, a checklist of factors and analytical processes, webinars, training, and FAQs to assist in educating public sector policy-makers, legislative and executive staff, and transportation professionals in implementation of P3 projects. The Toolkit includes a summary of state P3 legislation that provides users with descriptions and hyperlinks to enabling statutes for implementing transportation-related P3 projects in 36 states, the District of Columbia and Puerto Rico.

²⁵ <https://www.infrastructurereportcard.org/ports/funding-future-need/>



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- Prepare
- Verify

Deployment

Deployment of ITS provides the opportunity to enhance the overall safety and mobility of operations, for both the port operators, and trucking and rail companies that operate at the port. A robust deployment process involves collaboration between stakeholders, verification of the program through demonstrations and operational testing, and consideration of the ITS program's operational implications.

4.1 Prepare

Preparing for the deployment of an ITS project is a critical step in the process. There are multiple approaches that can be employed to support ITS implementation, but the determining factors for selecting the appropriate approach should be driven by user needs, the nature of the ITS project and the way in which the ITS elements are expected to integrate with the region's broader architecture and with the port environment.

4.1.1 Procurement

The procurement of ITS equipment, software, and related services must strike a delicate balance between the technical and operational needs of the agency, while providing a competitive environment that provides the agency the best possible value.

Most ITS projects have different procurement processes than other port construction projects, with software and hardware component development provided by consultant services and construction by a contractor.

Cost Based

A common approach is to award contracts through a cost-only, or low-bid approach where overall bid price is the only factor considered when selecting a contractor. Although this method will give the port owner the lowest first cost for goods and

services, its feasibility to ITS procurements is questionable. A first cost based procurement may not allow for the flexibility that is necessary for emerging technologies, and the bidder that offers the best technical solution for the agency may not provide the lowest lifecycle cost. It also limits the bidder's ability to offer alternative and perhaps more feasible solutions. A cost based only procurement is most applicable when:

- The requirements of the project are well-defined and not likely to change,
- The technologies being bid on are relatively mature and present minimal risk, and
- Multiple suppliers bid on the proposed product or service.

Qualifications Based

With a qualification based procurement process, bidders submit qualifications to the port owner who selects the most qualified company, and then negotiates the scope of services, budget, fee and schedule. This approach has proven successful for ITS software and services, and other emerging transportation technologies. Variations of the qualifications based procurement approach include:

- Standard Request for Proposal (RFP)
- Competitive Design
- Demonstrations and/or Site Visits
- Requirements Checklists
- Sole Source

Qualifications/Cost Combination

With a Qualifications-Cost combination procurement approach, the qualifications of the proposers are considered in concert with proposed costs, and are weighted based on guidelines established by the procuring agency. Variations of the Qualifications-Cost approach include:



- Two-step Sealed Bids (Qualifications then Costs)
- Competitive Proposals
- Best Value
- Life-Cycle Costs
- Best and Final Offers
- Competitive Negotiations

Procuring based solely on qualifications can often result in a higher price in exchange for increased confidence in the quality of the result, especially in a field with a limited set of qualified suppliers. Combining qualifications and cost in the procurement process can often result in a lower price in exchange for reduced scope or quality, especially in a field with many competent suppliers.

4.1.2 Deployment Plan

Developing a deployment plan guides the implementation and integration of ITS applications. The ITS deployment plan typically focuses on a specified period (e.g., 5-years) and focuses primarily on implementation and integration. The ITS deployment plan should also be reviewed annually and amended as appropriate based on several factors that include, but are not limited to:

- Available budget,
- Emerging operational needs,
- Schedule and phasing,
- Advancements in technologies that are becoming increasingly pervasive in surface transportation operations such as CAVs,
- Performance of existing ITS deployments, and
- An assessment of the need for ITS expansion.

Annual reviews should also include deployment strategies for an additional year at each review cycle, so this document remains a plan moving forward. Although the exact structure and specific elements of the ITS deployment plan will vary by port, there are a range of topics that should be examined and covered in the document as described in the following section.



Lifecycle Costs

A commonly overlooked item in the deployment of ITS infrastructure is the total life-cycle costs for the technology and supporting infrastructure used. The cost of maintaining devices after initial acceptance can be a major factor in how much is deployed. The majority of ITS applications likewise contain an ongoing need for operational use on a daily basis. Lifecycle costs should be phased per the timeframe of the plan (e.g., 0-5 years).

Port environments are physically demanding, frequently contributing to accelerated instrument wear and premature failure. The total Operations and Maintenance (O&M) cost will likely depend on the number of devices and density in which they are deployed. The following costs are typically associated with the lifecycle costs including:

- Cost of Design - Design costs would be paid by the port authority to bring an ITS project from the planning phase to a biddable package of design plans and specifications. Generally, the costs are paid to an engineering consultant.
- Cost of Technical Support – Cost for a consultant to act as the port owner’s agent during development and deployment to oversee the technical elements of the ITS construction. Work typically includes review of shop drawing and submittal reviews, review of Requests for Information (RFI), review and



approval of equipment installation/ configuration plans, witness field installation, fiber splicing/testing, and assistance with acceptance testing oversight of the ITS system.

- Cost of Construction Engineering – Cost for a consultant to act as the port owner’s agent during ITS deployment to oversee the progress of the project.
- Construction Cost – Costs to furnish, install, test, and integrate all project elements. The cost for deployment varies based on the technology being deployed, existing site conditions, scope of the work and distance between locations. These factors can significantly impact the cost of deployment.
- Implementation Cost - Costs to furnish, install, test, and integrate all project elements. The cost for deployment varies based on the technology being deployed, existing site conditions, scope of the work and distance between locations. These factors can significantly impact the cost of deployment.
- O&M Costs
 - Maintenance – Maintenance of the ITS system can be handled with in-house staff, contracted with the technology provider or with a third party. The maintenance includes routine, preventative maintenance and non-routine, emergency services. The maintenance budget required for all ITS devices will vary based on the complexity of the system and the frequency of maintenance activities.
 - Capital maintenance – Instrument replacement will need to be planned and budgeted to take place before wear or failure leads to system degradation.
 - Power and Communication Costs – Costs include those for electrical services and communications with the new ITS field devices.

Maintenance and Operations Requirements

Establish appropriate maintenance and operational procedures and processes to maximize the functionality and lifecycle of the equipment. The main goal of an efficient, well-run maintenance program is fast response time with minimal additional cost to the port owner.

Risk Considerations

With any deployment of new technology or systems there are inherent risks that are present that must be addressed throughout the lifecycle of the project. Refer to Section 2.1.4 for further details on the potential risks and challenges of a port ITS project.

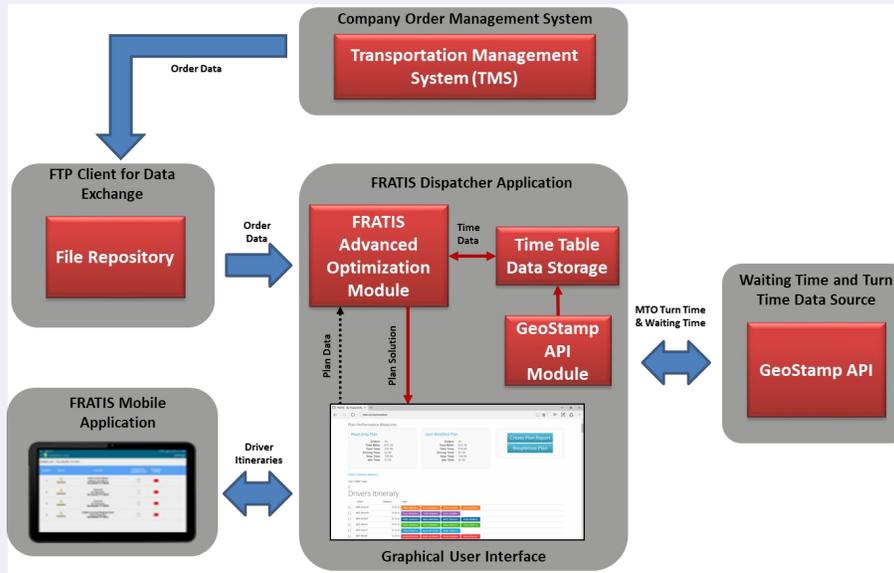
4.2 Verify

Demonstration projects and field operational tests (FOTs) have traditionally been used to help facilitate the development and adoption of ITS technologies. The focus of demonstration projects is typically to validate and promote innovative technologies such as ITS that enhance safety, mobility, and reliability. Information derived from the demonstration project is then gathered and shared with the user community – in this case, port operators and carriers.

FOTs are traditionally medium to large-scale testing programs designed to facilitate a comprehensive assessment of the given transportation technology solution. FOTs provide an opportunity to verify the operational and institutional impacts of large-scale introduction of a technological solution. This includes safety, mobility, efficiency and environment impacts. A key component of the FOT is to compare results of technology tests in different locations, and facilitate the exchange of knowledge within the transportation community.



Port of Los Angeles and Long Beach Freight Advanced Traveler Information System



Source: POLA

The POLA and POLB FRATIS is geared towards increasing cargo velocity through the two facilities. In 2016, the POLA and POLB commenced the first phase of FRATIS testing and implementation backed by funds from the State of California Energy Commission (CEC). This project, also termed Eco-FRATIS, was piloted over a one-year period and was comprised of the following technological components:

- FRATIS – software used by trucking company dispatchers to optimize the sequencing of truck movements to and from the POLA and POLB by using:
 - Real-time container terminal visit times and queue times from a third-party system called Geostamp; and
 - Real-time traffic data from regional transportation planning agencies.
- The University of California Riverside (UCR) Eco-Drive Application – audio and visual speed advisories provided to drivers wirelessly via tablet.

In 2017, the POLA and POLB completed a second phase of FRATIS testing with the USDOT, five trucking companies, and a total of 200 trucks. During this phase, the project leveraged software to optimize the sequencing of container movements to and from both port facilities. The FRATIS, Eco-Drive, and Geostamp elements of this project are the first of their kind to be demonstrated in a North American port complex. It is anticipated that this project will reduce truck miles travelled, truck-hours, emissions, and fuel use.

The project has a total investment cost of \$1,453,000 and was funded by grants from the CEC and the Los Angeles County Metropolitan Transportation Authority (LA METRO), as well as in-kind financial matching from the POLA and associated project consultants. For both phases of FRATIS development, the USDOT retained Productivity Apex Inc. (PAI) through a competitively solicited grant. The UCR Eco-Drive system was developed and tested via a United States Department of Energy competitively solicited grant. For these reasons, POLA chose to partner with PAI and UCR when submitting a CEC grant application.

The project was managed and administered by POLA. Stakeholders engaged during the project include the CEC, LA METRO, UCR, PAI, Infomagnus, the City of Los Angeles Department of Transportation, Southern Counties Express, and TTSI.



4.2.1 Demonstrations

Demonstrations and FOTs provide the port owner and carriers with an opportunity to understand how ITS deployment in the port environment will impact operations prior to wider-scale deployment. This process will assess ITS technologies over a pre-defined period to determine:

- Operational performance of the technologies,
- User acceptance of the new technologies, and
- Operational impacts of the technology, including safety, mobility, environmental impacts, and agency efficiency impacts.

The USDOT has historically used field operational tests to validate research, and justify wider-scale deployment of ITS technologies. As an example, in 2007 USDOT sponsored a successful field operational test in Columbus, Ohio which implemented “Freight Information Highway” components and 21 web services to support a Limited Brands international truck-air-truck supply chain. The Columbus Electronic Freight Management (EFM) field operational test featured an independent evaluation that examined quantified and non-quantifiable benefits that would result from implementation of EFM for all shipments in the host supply chain.²⁶ Similarly in 2017, the USDOT joined up with the Port of Los Angeles (POLA) and Port of Long Beach (POLB) to conduct testing of the FRATIS (see page 46).



Critical to the success of demonstrations and FOTs is a collaborative process that brings each of the involved partners together to cooperatively plan for and agree to specifics of the activities. Issues addressed in the process include:

- Goals – The criteria and standards to be considered, such as the technical readiness of a technology, or the likely impacts the technology will have on operations when deployed in a broader context.
- Objectives – The measurable steps to be taken during the activity such as testing and assessing the performance of a technology, examining the impact of technologies by users and impacted stakeholders, or examining and analyzing deployment issues that will advance future deployments of similar systems.
- Roles and responsibilities – The expectations for each of the participants including sponsor or funding source, participants, and perhaps independent evaluators.
- Scope – The range of variables involved in the activity including number of participants, geographic coverage, etc.
- Functionality – The functionality of the systems that are demonstrated and tested.
- Timeframe – The dates and length of time the field test or demonstration project will be conducted.
- Testing variables – The variables that will be examined as part of the demonstration or FOT, such as safety, mobility, agency efficiency, user acceptance.
- Approach for sharing outcomes – the method to share the outcomes or results of the evaluation with interested parties outside the core stakeholder group.

²⁶ Science Applications International Corporation. Columbus Electronic Freight Management Evaluation - Achieving Business Benefits with EFM Technologies. USDOT. March 2009.



4.2.2 Go-Live Checklist

This general checklist of actions should be taken into account prior to full deployment of port ITS technologies

- A complete inventory of all components has been developed including serial numbers, configuration, manuals, maintenance requirements and schedule, deployment location, etc. This is best achieved through an asset management system.
- The technology/system has been installed, configured, tested and accepted.
- The technology/system has been connected with the existing network. This has been checked, tested and approved.
- All data exchange protocols have been defined, discussed, and signed off by the key EDI users (trucking, agencies and shipping lines).
- Any data transfer between server(s) has been checked, tested and approved.
- Network management procedures have been defined.
- A firewall has been installed and tested.
- The technology/system communicates at functional level (EDI and other protocols) with workstations, handhelds, existing systems, and stakeholders' systems.
- Communications via internet with stakeholders have been checked, tested and approved.
- Wireless communications have been checked, tested and approved.
- All full cycle tests have been executed and were successful.
- The test list has been completed, accepted and signed off.
- Error list has been accepted and signed off.
- "Work-around" needs have been described.
- Any outstanding issues/errors have been resolved or a schedule has been established for resolution.
- All protocols have been documented, accepted and signed off by port management
- Distribution list for these documents has been defined, on paper and/or e-mail.
- Test and acceptance protocols have been signed off by port management.
- Training content and manuals have been defined and written.
- Stakeholders such as U.S. customs, the trucking community and rail companies have been briefed about the new technology/system.
- Port staff have been fully trained to manage the technology/system.
- Trouble shooting skills have been developed.
- System stop / restart and back-up procedures have been prepared.
- A first line support / helpdesk has been established and a contact list of experts with phone numbers, and e-mail addresses has been prepared and distributed.
- All documentation has been completed and is accessible electronically and on paper.



APPENDIX A Glossary of Terms

Alternative Minimum Tax (AMT) - Taxation based on an alternative method of calculating federal income tax under the Internal Revenue Code. Interest on certain private activity bonds is subject to the AMT.¹⁹

Architecture Flow - Information that is exchanged between physical objects, either subsystems and terminators, in the physical view of the Architecture Reference for Cooperative and Intelligent Transportation, also known as ARC-IT. Architecture flows are the primary tool that is used to define the Regional ITS Architecture interfaces. These architecture flows and their communication requirements define the interfaces which form the basis for much of the ongoing standards work in the national ITS program. The terms "information flow" and "architecture flow" are used interchangeably.¹

Asset - Any item of economic value, either physical in nature (such as land) or a right to ownership, expressed in cost or some other value, which an individual or entity owns.²

Automated Vehicle - Vehicle in which at least some aspect of a safety-critical control function (e.g., steering, throttle, or braking) occurs without direct driver input. Automated vehicles may be autonomous (i.e., use only vehicle sensors) or may be connected (i.e., use communications systems such as connected vehicle technology, in which cars and roadside infrastructure communicate wirelessly). Connectivity is an important input to realizing the full potential benefits and broad-scale implementation of automated vehicles.³

Baseline - Baseline is a frequently used term in systems engineering. A baseline is a reference point (e.g. specification or product) that has been

formally reviewed and agreed upon, that thereafter serves as the basis for further development, and that can be changed only through formal change control procedures.⁴

Beneficial Cargo Owner (BCO) - An importer that takes control of their cargo at the point of entry and does not utilize a third party such as a freight forwarder.⁵

Blockchain - A digital database or ledger that can be programmed to record interactions between and across multiple parties. Blockchain technology can be used to convert the documents, information, and commitments associated with international trade into a series of digital transactions based on permissions and secure encryption. The digitization of data makes it more visible to stakeholders, such as shipping carriers and trucking companies, thereby allowing them to efficiently plan their operations. Blockchain technology can be used to track freight, streamline the bill of lading process, execute bookings, and to submit shipping instructions and trade compliance documentation.⁶

Bluetooth - A technology that passively reads carrier signals from passing devices equipped with active Bluetooth hardware, such as smart phones.

Cameras and Sensors - A technology that uses cameras and sensors to capture images and other supporting input, extract application-specific information, generate descriptions, and make decisions as part of an intelligent system. Cameras and sensors provide critical input not only for autonomous vehicles on the road, but also for cargo handling equipment in the port.



Capital Expenditure (CapEx) - Expenditure on capital items either at the commencement of the project or the cost of their renewal and replacement (“R&R”) over the life of the project.

Carrier - A firm which transports goods or people via land, sea or air.⁸

Cellular Communications - A communications system that is composed of cell towers and cellular devices. By collecting radio signals from multiple cell towers, an approximate cellular device location can be established and data can be exchanged between vehicles, infrastructure and travelers.

Cloud-Based Data Processing and Management

- A data processing system that involves performing complex computing for massive amounts of data. It eliminates the need of expensive hardware and real estate space as data is saved and retrieved over the internet (“the cloud”). Using cloud-based computing, data processing can be performed in real-time and at a faster rate. Cloud-based data processing and management is used to make cargo data, such as vessel stowage plans, available to vessels in port and terminal operators. The technology is additionally used to automate electronic booking, the digital transmission of shipping instructions, and real-time container-status tracking.⁷

Concept of Operations (ConOps) – A foundation document that frames the overall system and sets the technical course for the project. The ConOps answers who, what, where, when, why, and how questions about the project from the viewpoint of each stakeholder.⁸

Dedicated Short Range Communication (DSRC)

- A wireless communications technology used for close-proximity communications between vehicles and the immediate infrastructure. It supports location-specific communications for ITS capabilities such as vehicle management, driver information, and automated commercial vehicle operations. One of the types of architecture interconnects defined in ARC-IT.¹ DSRC can be

used to enable trucks carrying cargo to utilize adaptive cruise control, clear vehicles entering and exiting a maritime facility, and to issue vehicle warnings.⁹

Differential GPS (DGPS) - A technology used to provide positional corrections to GPS signals. DGPS systems use a fixed, known position to adjust GPS calculations in real time. In doing so, DGPS systems improve the accuracy of position data provided to the user. DGPS is needed for equipment tracking and inventory control systems to safely operate with sufficient precision.¹⁰

Drayage - Transporting of rail or ocean freight by truck to an intermediate or final destination; typically, a charge for pickup/delivery of goods moving short distances (e.g., from marine terminal to warehouse).⁸

Electronic Data Interchange (EDI) - The automated transfer of information by computer systems using a standard format. EDI replaced postal mail and fax with email and databases to allow for faster and streamlined data exchange of all business documents. EDI allows participating organizations to generate, receive, and process data with little or no human intervention. EDI is used to cut freight waiting times, streamline administrative procedures, and to add visibility and traceability to the cargo exchange process.¹¹

Electronic Equipment Interchange Receipt (EEIR) – An electronic document required to transfer a cargo container from a ship to a marine terminal, or to another ship. EEIRs document details such as container number, vessel/voyage code, stacking position, and stowage position.

Electronic Logging Devices (ELD) – A monitoring technology that is attached to a commercial vehicle engine to record hours driven. An ELD is used to monitor a vehicle's engine, capturing data on whether the engine is running, miles driven, and duration of operation. This allows fleet managers to intelligently manage fleet utilization.¹²



Equity - A funding contribution to a project having an order of repayment occurring after debt holders in a flow of funds per the bond indenture securing such funding contribution.

Freight Signal Priority (FSP) - Technology that gives traffic signal priority to freight vehicles traveling on a signalized network. The systems decisions are based on real-time traffic and emissions data, and the vehicle's location, speed, type, and weight.³

Geographic Information Systems (GIS) – Tools used to gather, transform, manipulate, analyze, and produce information related to the surface of the Earth. This data may exist as maps, 3D virtual models, tables, and/or lists. GIS can be as complex as whole systems that use dedicated databases and workstations hooked up to a network, or as simple as "off-the-shelf" desktop software.¹³

Global Positioning System (GPS) - A satellite-based global navigation and positioning system that is composed of satellites, ground stations, and receivers. By collecting signals from at least three satellites, GPS receivers pinpoint a user's location within 10 to 15 feet. GPS is the foundation of other ITS technologies such as Geographic Information Systems, and ELDs used by the port and shipping community.^{14, 15}

Hazardous Material - A substance or material which the USDOT has determined to be capable of posing a risk to health, safety, and property when stored or transported in commerce.⁸

Intelligent Transportation System (ITS) - The integrated application of advanced computer, electronics, and information technologies that monitor, manage and/or enhance the connection between the transportation vehicle and infrastructure. ITS offers a complement or an alternative to traditional engineering methods to improve the safety, efficiency and mobility of inland surface transport modes.¹

Integrated Corridor Management (ICM) - An approach to improving transportation by taking

all elements in a corridor, including highways, arterial roads, and freight systems into account. The vision of ICM is that transportation networks will realize significant improvements in the efficient movement of people and goods through institutional collaboration and aggressive, proactive integration of existing infrastructure along major corridors. Through an ICM approach, transportation professionals manage the corridor as a multimodal system and make operational decisions for the benefit of the corridor as a whole.³

Internet of Things (IoT) - A network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. The IoT extends internet connectivity beyond traditional devices like desktop and laptop computers, smartphones and tablets to a diverse range of devices and everyday things that utilize embedded technology to communicate and interact with the external environment, all via the Internet.²³ In the port environment, IoT can be used to connect multiple platforms such as TOS, GOS, Port Portals, autonomous vehicles, etc. to share real-time information which enables better decision making for cargo flow.^{16, 17}

Interoperability - Interoperability focuses on enabling ITS devices and applications in vehicles and infrastructure to effectively communicate with other parts of the system as needed. It is useful to distinguish two degrees of interoperability, "pair-wise" and "end-to-end" interoperability. Pair-wise interoperability involves verifying that two systems are able to exchange data and that the data has the same meaning to each system and leads to the expected functionality. "End-to-end" interoperability involves verifying that the flow and use of data are consistent from initial input to final outcome.¹

ITS Architecture - An architecture of interrelated systems that work together to deliver



transportation services. An ITS architecture defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services. An architecture is functionally oriented and not technology-specific which allows the architecture to remain effective over time. It defines "what must be done," not "how it will be done."¹

License Plate Recognition (LPR) - A technology that uses OCR to read vehicle license plates and subsequently establish vehicle location at specific waypoints. LPR systems first look for the presence of a license plate, then extract its associated numbers and letters. Data extracted by a LPR system can be stored, linked to other applications, or compared to information in a database.¹⁸

Long Range Transportation Plan (LRTP) - A document resulting from regional or statewide collaboration and consensus on a region or state's transportation system, and serving as the defining vision for the region's or state's transportation systems and services. In metropolitan areas, the plan indicates all of the transportation improvements scheduled for funding over the next 20 years. The plan must conform to regional air quality implementation plans and be financially constrained.^{8,2}

Major Project Financial Plan - Under USDOT guidance, transportation projects are required to submit a Major Project Financial Plan if any of the following apply: 1) recipient of Federal financial assistance for a Title 23 project with a minimum cost of \$500 million, 2) identified by the USDOT Secretary as a major project and 3) applying for TIFIA assistance.

Metropolitan Planning Organization (MPO) - Every urbanized area with a population of 50,000 or more is federally mandated to have a MPO. MPOs are made up of representatives from local government and local transportation agencies. The purpose of the MPO is to plan transportation

within the region and to coordinate and collaborate with nearby regions. MPOs are responsible for distributing federal transportation funds to their regions.

National ITS Reference Architecture - Also known as the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT), this architecture provides a framework for planning, defining, and integrating ITS. It reflects the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, consultants, etc.). The architecture represents a national consensus on the course that ITS development should take in the U.S.¹

Net Revenue - The amount of money available after subtracting from gross revenues such costs and expenses as may be provided for in the bond contract. The costs and expenses most often deducted are O&M expenses.¹⁹

Operating Expenditure (OpEx) - Expenditure on operating and routine maintenance of facilities and equipment such as equipment maintenance, repairs and supplies, wages, rentals, general administrative expenses, etc.²².

Optical Character Recognition (OCR) - An electronic system that recognizes printed or written text characters in a digital image taken by intelligent / digital cameras. OCR systems allow users at a remotely located computer terminal to rapidly and accurately capture information that can be compared to a predefined list of targets. OCR is used for asset identification. For instance, OCR systems are used to identify incoming and outgoing containers based on their ISO numbers. The combination of a Gate Operating System (GOS), Terminal Operating System (TOS), and OCR at a port helps assign accurate work assignment to over-the-road (OTR) trucks entering the terminals for cargo delivery or receipt.²¹



Port - A single- or multiple-facility entity that facilitates the transfer of cargo and/or passengers between logistically-linked transport modes.

Port Authority - State or local government that owns, operates, or otherwise provides wharf, dock, and other investments at ports.⁸

Port Area Transportation Network (PATN) - A multi-modal network that supports the movement of freight and passengers within the operational boundaries of a port. PATNs can include roads, railways, pipelines, airports, rail yards, and marine and inland terminals.

Port Owner - Port authorities, terminal operators, private companies, and project sponsors that own and/or operate a port.

Private Activity Bonds (PABs) - A municipal security of which the proceeds are used by one or more private entities. A municipal security is considered a PAB if it meets two sets of conditions set out in Section 141 of the Internal Revenue Code. A municipal security is a PAB if, with certain exceptions, more than 10 percent of the proceeds of the issue are used for any private business use (the "private business use test") and the payment of the principal of or interest on more than 10 percent of the proceeds of such issue is secured by or payable from property used for a private business use (the "private security or payment test"). A municipal security also is a PAB if, with certain exceptions, the amount of proceeds of the issue used to make loans to non-governmental borrowers exceeds the lesser of 5 percent of the proceeds or \$5 million (the "private loan financing test"). Interest on private activity bonds is not excluded from gross income for federal income tax purposes unless the bonds fall within certain defined categories ("qualified bonds" or "qualified PABs"). Most categories of qualified PABs are subject to the AMT.¹

Project - A port owner's acquisition, development, expansion or renovation of an ITS infrastructure element or operational resource to meet an identified or emergent need.

Project Financing - A non-recourse or limited recourse financial structure where project debt and equity used to finance the project are paid back from the cash flow generated by the project. While the loan structure relies primarily on the project's cash flow for repayment; the project's assets, rights and interests are held as secondary security or collateral.²²

Project Funding - A financial structure where internal reserves, user charges and/or government investments are used to finance the project without a direct requirement for repayment.

Project ITS Architecture - High-level design specifications based on national and regional standards and regional ITS needs.¹

Project Revenues - All rates, rents, fees, assessments, charges, and other receipts derived by a project sponsor from a project.²

Project Sponsor - The entity that provides financial resources to support the project.

Public-Private Partnership (P3) - A generic term for a wide variety of financial arrangements whereby governmental entities agree to transfer any risk of, or substantial management control over, a governmental asset to the private entity. In the port sector this is typically in exchange for upfront or ongoing payments though those may only be sufficient to pay for the capital improvement.¹⁹

Radio Detection and Ranging (RADAR) and Light Detection and Ranging (LIDAR) – RADAR and LIDAR are distance determining technologies that work similarly except LIDAR emits pulses of light and RADAR emits pulses of radio waves. The signals bounce back from an obstacle and the instrument measures the return times and wavelengths. These technologies can also detect the angle and velocity of surrounding objects, and determine brake lights and changing road conditions. RADAR and LIDAR are heavily used



for CAVs and will help in development of autonomous trucks for cargo hauling.

Radio Frequency Identification (RFID) - A technology that uses radio waves to automatically identify and track information associated with objects. One method of object identification is to attach a microchip or “tag” equipped with memory and an antenna, holding a unique identity number and other information. RFID has helped convert manual processes to automated processes, such as gate operations, in which truck wait times are reduced.^{23, 24}

Railroad Rehabilitation & Improvement Financing (RRIF) - Under this program the USDOT is authorized to provide direct loans and loan guarantees up to \$35.0 billion to finance development of railroad infrastructure. Up to \$7.0 billion is reserved for projects benefiting freight railroads other than Class I carriers. The funding may be used to (a) acquire, improve, or rehabilitate intermodal or rail equipment or facilities, including track, components of track, bridges, yards, buildings and shops; (b) refinance outstanding debt incurred for the purposes listed above; and (c) develop or establish new intermodal or railroad facilities. Direct loans can fund up to 100 percent of a railroad project with repayment periods of up to 35 years and interest rates equal to the cost of borrowing to the government. Eligible borrowers include railroads, state and local governments, government-sponsored authorities and corporations, joint ventures that include at least one railroad, and limited option freight shippers who intend to construct a new rail connection.²⁵

Real-Time Data Monitoring (RTDM) - A process through which a data administrator can review, evaluate and modify the addition, deletion, modification and use of data on software, a database or a system. It enables administrators to review the overall processes and functions performed on the data in real time, or as it happens, through graphical charts and bars on a central interface/dashboard.²⁰

Regional ITS Architecture - A specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them.¹

Return on Investment (ROI) – A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. ROI measures the amount of return on an investment relative to the investment’s cost. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment, and the result is expressed as a percentage or a ratio.²²

State Infrastructure Bank (SIB) - A state or multi-state revolving fund that provides loans, credit enhancement, and other forms of financial assistance to transportation infrastructure projects.²

State Transportation Improvement Program (STIP) - A short-term transportation planning document covering at least a three-year period and updated at least every two years. The STIP includes a priority list of projects to be carried out in each of the three years. Projects included in the STIP must be consistent with the long-term transportation plan, must conform to regional air quality implementation plans, and must be financially constrained (achievable within existing or reasonably anticipated funding sources).²

Strategic Plan - A planning document that presents an organization’s strategy for a category of activity over a specified number of years. Depending on the organizational level at which the plan is produced, it may support the next higher organization’s strategic plan, and may mirror that plan’s structure. The strategic plan describes organizational and strategic goals and the strategies to be used in pursuing these goals. Elements included in the plan are anticipated funding levels, the desired outcomes



the initiating organization expects to obtain, and the overall benefit inherent in undertaking the activities described.³

Systems Engineering (SE) – An interdisciplinary, structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives and considers the total life-cycle of the project including not only the technical merits of potential solutions but also the costs and relative value of alternatives.⁴

Terminal Operator - A port authority or private company that operates a port facility and manages the movement of cargo and/or passengers.

Transport Modes – The movement of freight by type of conveyance: a. inland surface transport (rail, road, and inland waterway); b. sea transport (coastal and ocean); c. air transport; d. pipeline; and e. space transport. The majority of dry bulk and containerized freight moves via surface modes (truck, train and barge) to/from inland locations. Liquid bulk freight primarily moves via pipeline and high-value and/or time-sensitive freight is transported via air modes.

Transportation Improvement Program (TIP) - A short-term transportation planning document, approved at the local level, covering at least a four-year period for projects within the boundaries of a Metropolitan Planning Organization (MPO). The TIP must be developed in cooperation with state and public transit providers and must be financially constrained. The TIP includes a list of capital and non-capital surface transportation projects, bicycle and pedestrian facilities and other transportation enhancements. The TIP should include all regionally significant projects receiving FHWA or FTA funds, or for which FHWA or FTA approval is required, in addition to non-federally funded projects that are consistent with the MPO's LRTP.

Transportation Infrastructure Finance and Innovation Act (TIFIA) - The TIFIA authorized the

USDOT to provide three forms of credit assistance - secured (direct) loans, loan guarantees and standby lines of credit - to surface transportation projects of national or regional significance. A specific goal of TIFIA is to leverage private co-investment. Because the program offers credit assistance, rather than grant funding, potential projects must be capable of generating revenue streams via user charges or have access to other dedicated funding sources. In general, a project's eligible costs must be reasonably anticipated to total at least \$50 million, although lower dollar cost thresholds are available for ITS and other specific project categories. Credit assistance is available to: projects eligible for assistance under title 23 or chapter 53 of title 49; international bridges and tunnels; intercity passenger bus or rail facilities and vehicles, including those owned by Amtrak; public freight rail projects; private freight rail projects that provide public benefit for highway users by way of direct highway-rail freight interchange (a refinement of the SAFETEA-LU eligibility criterion); intermodal freight transfer facilities; projects providing access to, or improving the service of, the freight rail projects and transfer facilities described above; and surface transportation infrastructure modifications necessary to facilitate direct intermodal interchange, transfer and access into and out of a port. TIFIA credit assistance is limited to 49 percent of eligible project costs.⁸

USDOT ITS JPO - The USDOT ITS JPO was created in 1994 to streamline ITS development and deployment initiatives beginning in various USDOT agencies. In recognition of the interdisciplinary nature of ITS, the JPO was established to: (1) provide strategic leadership for ITS research, development, testing, and deployment, (2) guide policy coordination, and (3) ensure resource accountability. Responsibility for the actual implementation of ITS activities rests with individual program and modal administrations including MARAD, the Federal Railroad Administration (FRA), the Federal Motor



Carrier Safety Administration (FMCSA), the FHWA, and the NHTSA.¹

Vehicle Telematics - Embedded technology on a vehicle that combines information collection and processing with wireless and internet communications to send, receive and store vehicle information. Telematics devices are used to obtain information on the condition of a vehicle's mechanical components. This information helps fleet managers determine whether a vehicle requires maintenance or repair. Telematics systems can also help fleet managers find optimal delivery routes, monitor dangerous driving habits, track driver and container locations, and improve idle trailer allocation.^{26, 27}

Weigh-in-motion (WIM) - A sensor technology used to determine characteristics of a moving vehicle such as gross vehicle weight, wheel loads, axle loads and speed. WIM sensor devices are typically embedded in the pavement surface. At ports, WIM devices are deployed at gate lanes along with other technologies such as OCR and RFID. Cargo weight data helps enforce weight restrictions on roadways. In the case of container cargo, WIM helps enforce International Maritime Organization's (IMO) Safety of Life at Sea (SOLAS) container weight regulations.²⁸

Note: Sources for the glossary include (1) www.standards.its.dot.gov/LearnAboutStandards/Glossary, (2) <http://www.financingtransportation.org/global/glossary.aspx> (3) www.its.dot.gov, (4) www.sebokwiki.org, (5) <http://www.datamyne.com/whats-beneficial-cargo-owner/>, (6) https://www.dhs.gov/sites/default/files/publicatiopu/2018_AEP_Blockchain_and_Suitability_for_GoGovernme_Applications.pdf, (7) <https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublicatio> n800-145.pdf, (8) <https://ops.fhwa.dot.gov/freight/fpd/glossary>, (9) https://www.its.dot.gov/presentations/world_congress2016/Leonard_DSRC_Spectrum2016.pdf, (10) <https://www.fhwa.dot.gov/publications/research/operations/02072/index.cfm>, (11) https://www.hud.gov/sites/documents/20577_IMPLEMENT.PDF, (12) <https://www.fmcsa.dot.gov/faq/what-electronic-logging-device-eld>, (13) www.webopedia.com, (14) https://www.faa.gov/about/office_org/headquarterthea_offices/ato/service_units/techops/navservices/gnss/gps/, (15) https://www.fhwa.dot.gov/resourcecenter/teams/construction/cpm_5gps.pdf, (16) <https://dodcio.defense.gov/Portals/0/Documents/Announcement/DoD%20Policy%20Recommendations%20for%20Internet%20of%20Things%20-%20White%20Paper.pdf?ver=2017-01-26-152811-440>, (17) https://www.ntia.doc.gov/files/ntia/publications/iio_green_paper_01122017.pdf, (18) https://ops.fhwa.dot.gov/publications/fhwahop12026/sec_3.htm, (19) <http://msrb.org/Glossary>, (20) www.techopedia.com, (21) <https://www.faa.gov/about/initiatives/records/glossary/?key=gloss06>, (22) www.investopedia.com, (23) <https://www.dhs.gov/radio-frequency-identification-rfid-what-it>, (24) https://www.acq.osd.mil/log/sci/rfid_FAQs.html, (25) <https://www.transportation.gov/buildamerica/programs-services/rrif>, (26) <https://www.dhs.gov/science-and-technology/news/2018/05/15/snapshot-dhs-dot-partner-government-vehicle-telematics>, (27) <https://www.gao.gov/assets/670/663032.pdf>, and (28) [https://www.fhwa.dot.gov/policyinformation/knowledgecenter/wim_guide/wim_guidebook_part1_070918_\(508_compliant\).pdf](https://www.fhwa.dot.gov/policyinformation/knowledgecenter/wim_guide/wim_guidebook_part1_070918_(508_compliant).pdf)

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