Intelligent Transportation Systems Applications for Ports

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ITS Professional Capacity Building Program

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ITS Joint Program Office
U.S. Department of Transportation
ITS PCB Program Background

Part of USDOT ITS Joint Program Office (JPO)

- **1996**: Authorized by Congress
- **2010**: Reauthorized by MAP-21
- **2016**: Reaffirmed by FAST Act

The ITS PCB Program supports a variety of ITS learning opportunities to accelerate ITS deployments and encourage more efficient operations
Program Strategy

Vision: Prepare a dynamically knowledgeable community of transportation industry professionals for a connected automated transportation system.

Mission: Provide a multimodal and multi-disciplinary capacity building program for all levels of current and future transportation professionals to accelerate preparation for and the deployment of innovative ITS.
ITS PCB Program – Portfolio of Products
ITS PCB Program – Resources for Practitioners Tab
<table>
<thead>
<tr>
<th>Module 1</th>
<th>Module 2</th>
<th>Module 3</th>
<th>Module 4</th>
<th>Module 5</th>
<th>Module 6</th>
<th>Module 7</th>
<th>Module 8</th>
<th>Module 9</th>
<th>Module 10</th>
<th>Module 11</th>
<th>Module 12</th>
<th>Module 13</th>
<th>Module 14</th>
</tr>
</thead>
</table>

(https://www.pcb.its.dot.gov/eprimer/default.aspx)
MARAD seeks to increase cargo capacity and reliability of freight moving through ports

**Challenges & Issues**
- Marine terminal congestion is an ongoing challenge in the U.S.
- Economic growth driving cargo volume growth
- Exacerbated by larger container ships, infrastructure improvements — channel deepening, air draft clearance projects, Panama Canal expansion
- Complexity of multi-modal port operations

**Maritime Administration Strategic Plan (2017-2021) ... Strategic Goal #5: Maritime Innovation**

**ITS MARAD Truck Staging Study (joint project with ITS JPO, FHWA, and FMSCA) — Webinar available at**
American Association of Port Authorities

- The unified voice of the seaport industry in the Americas, representing more than 130 public port authorities in the U.S., Canada, the Caribbean and Latin America.

- AAPA events, resources and partnerships
  - connect, inform and unify seaport leaders and maritime professionals
  - promotes the common interests of the port community
  - provides advocacy and effective public outreach to influence seaports’ most urgent public policy issues

Information Technology Committee
The AAPA Information Technology Committee focuses on electronic data interchange, management information systems and other automation initiatives. The Committee is open to all members of the Association, including corporate (port) members and sustaining (port industry solution providers) members.

Information Technology Awards Program
The AAPA Information Technology Awards highlight port technology accomplishments in the areas of “Port Operations and Management Systems” and “Improvements in Intermodal Freight Transportation.” Participation is open to all corporate members of the association.
$66 Billion Investment Needed for Port Infrastructure - 44% Could Include ITS Solutions
Port Planning & Investment Toolkit (PPIT)

• Led by:
  • AAPA
  • MARAD
  • 64 Port Staff, PPM Candidates, Consultants

• Goal is to assist Ports:
  • Develop capital plans that clearly identify future needs;
  • Determine the most cost-effective, sustainable and efficient solutions to port challenges;
  • Position port projects for federal funding such as BUILD, INFRA and MPO grants;
  • Get port infrastructure projects into MPO and state transportation programs to qualify for other government funding; and
  • Obtain private sector funding to support their infrastructure projects.
PPIT and ePrimer Modules

• PPIT information, updates, and resources are available at:
  • AAPA website at http://www.aapa-ports.org/PPIT
  • MARAD website at https://www.maritime.dot.gov/ports/port-planning-and-investment-toolkit

• ITS Professional Capacity Building Program – ITS ePrimer Modules at https://www.pcb.its.dot.gov/eprimer/default.aspx

• PPIT and ePrimer ITS for Port Operations Module available June 2019
Intelligent Transportation Systems

• An engineering discipline that encompasses the research, planning, design, integration, and deployment of systems and applications to:
  • Manage traffic and transit,
  • Improve safety,
  • Provide environmental benefits, and
  • Maximize the efficiency of surface transportation systems.
ITS in the Port Context

Traditional Focus:

• Moving **vehicles**, on an **open** public network without **transactions** under limited **regulations** for **public** stakeholders

Port + ITS Focus:

• Moving **trucks** and **trains** on a **bounded** network, accessing **private** spaces, for **commercial** transactions under **tight** regulations for **private** stakeholders
ITS in the Port Context

- **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, such as terminal roadways, gate access management, and reservation systems.

- **Combination** – Applications of ITS that addresses port operations, the port area transportation network 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.
The Need for ITS in Ports

Demands and Constraints

• 52 M TEUs / year in 2017
  114 M by 2040: +118%

• Demand is spikier

• Port road and rail systems are static

Alternatives

• Build **new ports**
  • Flat Land + Deep Water: Rare and Constrained

• Build **more roads** in ports
  • Cities have expanded toward their ports, hemming them in

• **Shift** traffic off of roads
  • Intermodal rail has similar issues

• Build **smarter** roads

• Use resources more **efficiently**
# Potential Benefits for Ports

<table>
<thead>
<tr>
<th>Service Element</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety and Reliability</td>
<td>Avoid port-area collisions, goods movement accident losses, hazardous material releases.</td>
</tr>
<tr>
<td>Resilience</td>
<td>Mitigate the impact of disruptive events.</td>
</tr>
<tr>
<td>Cargo Visibility, Reliability</td>
<td>Improve the reliability and timeliness of cargo transport.</td>
</tr>
<tr>
<td></td>
<td>Improve the responsiveness of service providers.</td>
</tr>
<tr>
<td>Vehicle Efficiency and Mobility</td>
<td>Reduce travel time, queuing and idling.</td>
</tr>
<tr>
<td></td>
<td>Maintain network fluidity.</td>
</tr>
<tr>
<td></td>
<td>Improve transport workforce efficiency.</td>
</tr>
<tr>
<td>Gate Efficiency</td>
<td>Reduce queuing.</td>
</tr>
<tr>
<td></td>
<td>Improve accuracy, avoid transaction failure.</td>
</tr>
<tr>
<td></td>
<td>Improve gate transaction speed, extend hours, and optimize labor.</td>
</tr>
<tr>
<td>Terminal Yard Efficiency</td>
<td>Improve density and velocity.</td>
</tr>
<tr>
<td></td>
<td>Improve cargo handling equipment deployment.</td>
</tr>
<tr>
<td></td>
<td>Reduce cargo rehandling.</td>
</tr>
<tr>
<td>Port Efficiency</td>
<td>Balance load between terminals.</td>
</tr>
<tr>
<td></td>
<td>Respond to congestion events.</td>
</tr>
</tbody>
</table>
Not a Simple Playing Field - Terminals
Not a Simple Playing Field – Networks
Not a Simple Playing Field - Commerce
Not a Simple Playing Field - Transporters
Enabling Technologies

**Proximity and Detection Systems**

- Smart Cameras
- Laser / Infrared Scanners
- Radio Detection and Ranging (RADAR)
- Light Detection and Ranging (LIDAR)

**Cargo and Vehicle ID Systems**

- Optical Character Recognition (OCR)
- License Plate Recognition (LPR)
Enabling Technologies

- Weigh-in-motion - WIM
- Vehicle Telematics
- Electronic Logging Devices - ELD
- Radio Frequency Identification - RFID

- Geographic Positioning System - GPS
- Differential GPS
- Bluetooth Tracking
Enabling Technologies

**Communications Systems**
- Cellular Communication - 4GC, 5GC
- Dedicated Short Range Communications

**Logistics Management Systems**
- Electronic Data Interchange - EDI
- Internet of Things - IOT
- Cloud Data and Processing
- Blockchain
Technology Interactions
Technology Interactions – Road and Gate
ITS Applications

Local/Regional

• Connected, Automated and Autonomous Vehicles
• Platooning Systems
• Route Guidance

Combination

• Geo-Fencing
• Freight Signal Priority
• Rail Yard Integration
• Integrated Community Portal
• Freight Advanced Traveler Information System (FRATIS)
• Traveler Information Reporting

Port-Specific

• Intelligent Recognition and Imaging Software
• Equipment Tracking System
• Terminal Operating System
• Gate Operation System
• Terminal Status Reporting
• Gate Queue Reporting
• Truck Appointment Systems
• Street Exchange Systems
• Automated Work Flow
A Recent Example

- A port authority bought extra *bridge toll tag* (RFID) readers and placed them at:
  - Tail of entry gate queues
  - Entry into the container yards
  - Exit from the terminals

- Time stamp readings for each tag, and some filtering, produced *gate queue* and *truck service* times

- Mean results are dynamically updated, in public, on the port’s website
# Vehicle to Everything (V2X) and IoT Communications

<table>
<thead>
<tr>
<th>Service Improvement</th>
<th>Vehicle / Vehicle</th>
<th>V2X and IoT Communications Technology</th>
<th>Vehicle / Device</th>
<th>Vehicle / IoT</th>
<th>IoT Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety &amp; Reliability</td>
<td>Avoid port-area collisions, goods movement accident losses, hazardous material releases.</td>
<td>Port equipment position and routing.</td>
<td>Speed constraints, variant road conditions, construction areas, queue conditions, congestion, weights in motion.</td>
<td>Downstream congestion, speed reduction warnings, signal conditions, rail crossing condition, truck trailer basic safety message.</td>
<td>Trip timing or routing to avoid incidents, hazardous material conditions, expected rail movements and road blockages.</td>
</tr>
<tr>
<td>Resilience</td>
<td>Mitigate the impact of disruptive events, such as extreme weather or geological events.</td>
<td>Engine conditions / flooding, mass vehicular stalls, emergency vehicle movements / warnings, utility vehicle proximity.</td>
<td>Road, rail, tunnel, and bridge closures; route damage; route reversals / alternatives.</td>
<td>Freezing / icing, stream conditions, power grid conditions, signal system disruption.</td>
<td>Rerouting directions, evacuation warnings, loss-of-service messages, emergency transport protocols.</td>
</tr>
<tr>
<td>Cargo Visibility &amp; Reliability</td>
<td>Improve the reliability and timeliness of cargo transport, and improve the responsiveness of service providers.</td>
<td>Peloton / convoy, multi-shipment manifest coordination, trailer size / configuration.</td>
<td>Weights and weight limitations, construction areas, operational conditions that increase delays, truck parking tracking.</td>
<td>Vehicle characteristics, shipment location, transport unit location and condition, geofencing, net velocity, driver safety conditions, truck parking info. management system (TPIMS) availability.</td>
<td>Route recalculation, scheduled route interruptions, vehicle / signal synchronisation, variable priority movements, TPIMS synchronisation.</td>
</tr>
<tr>
<td>Gate Efficiency</td>
<td>Reduce queueing, multi-unit manifest coordination, trailer size / configuration.</td>
<td>Reduce queueing and maintain wheel traffic movements and vehicle proximity.</td>
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</tr>
<tr>
<td>Terminal Yard Efficiency</td>
<td>Improve density and vehicle proximity.</td>
<td>Equipment queue management, report truck wait times, over-stows of moves in and out.</td>
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<td>Equipment queue management, report truck wait times, over-stows of moves in and out.</td>
</tr>
<tr>
<td>Port Efficiency</td>
<td>Improve the efficiency of total port visit, balance load between resources, respond to congestion events.</td>
<td>Port equipment position and routing.</td>
<td>Speed constraints, variant road conditions, construction areas, queue conditions, congestion, weights in motion.</td>
<td>Downstream congestion, speed reduction warnings, signal conditions, rail crossing condition, truck trailer basic safety message.</td>
<td>Trip timing or routing to avoid incidents, hazardous material conditions, expected rail movements and road blockages.</td>
</tr>
</tbody>
</table>

## Improvement

### Cargo Visibility & Reliability

- Reliability, timeliness, responsiveness
- Vehicle characteristics, shipment location, transport unit location and condition, geofencing, net velocity, driver safety conditions, truck parking info. management system (TPIMS) availability.
## Stakeholder Matrix

<table>
<thead>
<tr>
<th>Legend</th>
<th>Government Entities</th>
<th>Commercial Entities</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Interaction</td>
<td>Port Authority</td>
<td>Vessel Liner</td>
<td>Longshore Labor</td>
</tr>
<tr>
<td>Modest Interaction</td>
<td>Customs &amp; Border Patrol</td>
<td>Port Terminal Operator</td>
<td>Rail Operating Labor</td>
</tr>
<tr>
<td>Strong Interaction</td>
<td>Air Quality Regulator</td>
<td>Rail Terminal Operator</td>
<td>Truck Drivers</td>
</tr>
<tr>
<td></td>
<td>Permitting Authority</td>
<td>Rail Switching Entity</td>
<td>Residents / Workers</td>
</tr>
<tr>
<td></td>
<td>MPO</td>
<td>Rail Class I Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Host City Government</td>
<td>Warehouse / DC Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>State DOT</td>
<td>Trucking Company</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chassis Pool Operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support Service Provider</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility Company</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beneficial Cargo Owner</td>
<td></td>
</tr>
</tbody>
</table>

### Terminal
- Terminal Equipment
- Storage Yard Layout
- Gate
- Rail Working Yard
- Rail Storage Yard
- Telecomm Network
- Operating Systems

### Port Area
- Road Network
- Rail Network
- Access Roads
- Rail Working Yard
- Rail Storage Yard

### Region
- Road Network
- Rail Network
- Highways
- Distribution Centers
A Systems Engineering Approach
Planning

• Initiate
  • Set Goals and Objectives
  • Collect Data
  • Engage Stakeholders

• Quantify
  • Map Existing Conditions
  • Identify Needs and Drivers

• Form
  • Develop and Refine Alternatives
  • Analyze and Compare
Cross-functional flow diagrams
# Feasibility

## Assess
- Potential Performance
- Human Resource Needs
- Impacts
- Risks

## Evaluate
- Criteria
- Prioritization
- Scoring & Selection

### B/C Ratio of Intermodal Projects @ 7%

<table>
<thead>
<tr>
<th>Account Element</th>
<th>Weight</th>
<th>Normalized/Assigned Scores</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational Performance</strong></td>
<td>32.0</td>
<td>283</td>
<td>268</td>
</tr>
<tr>
<td>Capacity at Site Buildout</td>
<td>8.5</td>
<td>85</td>
<td>68</td>
</tr>
<tr>
<td>Berth Productivity at Buildout</td>
<td>9.5</td>
<td>95</td>
<td>83</td>
</tr>
<tr>
<td>Gate Truck Cycle Time</td>
<td>7.0</td>
<td>56</td>
<td>70</td>
</tr>
<tr>
<td>Intermodal Service</td>
<td>7.0</td>
<td>44</td>
<td>47</td>
</tr>
<tr>
<td><strong>Development</strong></td>
<td>22.0</td>
<td>193</td>
<td>168</td>
</tr>
<tr>
<td>Suitability for Phased Implementation</td>
<td>7.0</td>
<td>63</td>
<td>56</td>
</tr>
<tr>
<td>Development Complexity</td>
<td>7.0</td>
<td>61</td>
<td>54</td>
</tr>
<tr>
<td>Risk of Delays</td>
<td>8.0</td>
<td>69</td>
<td>56</td>
</tr>
<tr>
<td><strong>Financial</strong></td>
<td>26.5</td>
<td>225</td>
<td>235</td>
</tr>
<tr>
<td>Net Present Value of Costs (SM)</td>
<td>9.0</td>
<td>74</td>
<td>84</td>
</tr>
<tr>
<td>Initial (5-year) Capital Outlay (SM)</td>
<td>9.5</td>
<td>95</td>
<td>81</td>
</tr>
<tr>
<td>Unit Operating Cost</td>
<td>8.0</td>
<td>56</td>
<td>70</td>
</tr>
<tr>
<td><strong>Workforce</strong></td>
<td>15.0</td>
<td>109</td>
<td>118</td>
</tr>
<tr>
<td>Worker Safety</td>
<td>8.0</td>
<td>51</td>
<td>67</td>
</tr>
<tr>
<td>Skilled Workforce Availability</td>
<td>7.0</td>
<td>56</td>
<td>51</td>
</tr>
<tr>
<td>Optimization of Workforce</td>
<td>7.5</td>
<td>75</td>
<td>56</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>30.5</td>
<td>217</td>
<td>259</td>
</tr>
<tr>
<td>Carbon Fuel Consumption</td>
<td>6.5</td>
<td>22</td>
<td>66</td>
</tr>
<tr>
<td>Noise Pollution</td>
<td>5.0</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td>Light Pollution</td>
<td>4.0</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>Total Energy Consumption</td>
<td>7.0</td>
<td>70</td>
<td>58</td>
</tr>
<tr>
<td>Land Utilization</td>
<td>8.0</td>
<td>80</td>
<td>64</td>
</tr>
</tbody>
</table>
Port ITS Considerations

• Responsibility & Authority
  • Many stakeholders
  • “Ownership” keeps shifting
  • Many drivers, few controls

• Random Demand
  • Ports serve the fickle sea
  • The landside isn’t much better

• Transactional Error
  • Freight moves neither faster nor better than its supporting data

• Labor
  • Bound by contract
  • Bound by tradition
  • Imbalances in power, control

• Freight Security
  • Avoid theft, damage, pilfering

• Transportation Security
  • Keep the Bad Guys out
  • Keep the Bad Stuff out
  • Find the Bad Stuff before it becomes Really Bad Stuff

• Cybernetics
  • Who ARE those Bad Guys?
Cybersecurity and Resiliency

• **Vehicle** – NHTSA
  - Harden the vehicle’s electronics against potential attacks and ensure appropriate response.

• **Infrastructure** – NIST + USDOT
  - *Framework for Improving Critical Infrastructure Cybersecurity*

• **Integration** – USDOT ITS JPO et al
  - Research, develop, and educate on cybersecurity technical and policy mitigations.
  - Pursue a unified approach to vehicle, device, and infrastructure security for connected vehicles

• **Navigation** – USCG
  - Information, resources concerning maritime cybersecurity: [USCG Homeport - Cybersecurity](#)

• **Vessels and Ports** – ABS
  - Guidance Notes on cybersecurity & resiliency matters.
  - FCI Cyber Risk™ algorithm at [ABS Maritime Cyber Security](#)

• **Ships at Sea** – IMO
  - Recommendations on maritime cyber risk management for shipping: [Guidelines on Maritime Cyber Risk Management](#)

• **Homeland** - DHS
  - US Computer Emergency Response Team (US-CERT)
  - Industrial Control Systems Cyber Emergency Response Team (ICS-CERT)
  - [US-CERT Resources, ICS-CERT Resources](#)

• **Maritime** - MARAD’s
  - Office of Security coordinates to issue US Maritime Alerts and US Maritime Advisories
Financing

• Strategize
  • Low cost, high return on investment
  • Identify funding opportunities and alternatives

• Structure
  • Federal funding sources
  • State and local sources
  • Private funding sources
External Funding Sources

• Federal Programs
  • Discretionary Grants
  • Federal-Aid Grants
  • Federal Loans
  • Private Activity Bonds (PAB)

• State, Regional, Local

• Private

<table>
<thead>
<tr>
<th>Govt. Program</th>
<th>Summary Description</th>
</tr>
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<tbody>
<tr>
<td>ATCMTD</td>
<td>Competitive grant for deployment of advanced transportation and congestion management technologies.</td>
</tr>
<tr>
<td>ITS</td>
<td>Funding for the development of ITS infrastructure, equipment, and systems; and ITS research initiatives, exploratory studies, and a deployment support programs.</td>
</tr>
<tr>
<td>BUILD</td>
<td>Competitive grant for enhancement of surface transportation infrastructure at local and regional level.</td>
</tr>
<tr>
<td>INFRA</td>
<td>Competitive grant or credit assistance for highway and freight projects of national or regional significance.</td>
</tr>
<tr>
<td>STBG</td>
<td>Formula funding for States and MPOs for priority transportation projects.</td>
</tr>
<tr>
<td>NHFP</td>
<td>Formula funding for States to improve movement of freight on National Highway Freight Network.</td>
</tr>
<tr>
<td>CMAQ</td>
<td>Formula funding for States, MPOs and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act.</td>
</tr>
<tr>
<td>TIFIA</td>
<td>Financing assistance for ITS and surface transportation projects, certain freight rail projects, intermodal freight transfer facilities, and certain projects inside a port terminal.</td>
</tr>
<tr>
<td>RRIF</td>
<td>Financing assistance for railroad equipment, facilities and infrastructure including positive train control systems.</td>
</tr>
<tr>
<td>PABs</td>
<td>Tax-exempt financing issued through a public conduit for privately developed infrastructure.</td>
</tr>
</tbody>
</table>
Deployment

• Prepare
  • Procurement Method
  • Deployment Plan

• Verify
  • Field Operational Tests
  • Key Performance Indicators
  • Demonstrations
  • Go-Live Checklist