Benefits of GIS for Enterprise Asset Management in a Multi-modal Port

Presented by:
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Office of the Chief Operating Officer
The Port Authority of New York and New Jersey

July, 2015
Mission

Aviation Profile

- 5 Airports (2 International, 2 Domestic, 1 General Aviation)
- 17 terminals; average age of 30 years and over 220 gates
- 13 runways of over 100,000 feet combined and over 60 miles of taxiway
- Over 2 million square feet of cargo space
- 2 light rail systems
- 23 parking lots and 6 garages with over 45,000 spaces
- Fuel storage facilities, central heating and refrigeration plant, electrical substations

Peak Daily Activity*

- 230,000 air passengers
- 2,700 air traffic movements
- 4,500 tons air cargo
- 27,000 parked cars

* May 2014
PATH Profile

• 13 Stations

• 1 Transportation Center
  - including retail, office and parking space

• 11 buildings
  - including two maintenance facilities

Avg. Daily Activity*

250,000 passengers

* Nov 2014
TB&T Profile

4 Bridges
• George Washington Bridge
• Bayonne Bridge
• Goethals Bridge
• Outer Bridge Crossing
• 65 Toll lanes in 8 Toll Plazas

Over 90 lane miles of Roadway

2 Tunnels
• Holland Tunnel
• Lincoln Tunnel

2 Bus Depots
• George Washington Bridge Bus Station
• Port Authority Bus Terminal

Peak Daily Activity*
• 9,685 buses
• 25,800 trucks
• 286,000 automobiles
* May 2014
Port Commerce Profile
Seven Marine Terminals

New Jersey
- Port Newark
- Port Jersey
- Port Elizabeth
- Greenville Yard/65th Street

New York
- Brooklyn Marine Terminal
- Howland Hook
- Red Hook

Peak Daily Activity*
- 8,900 containers
- 1,150 automobiles

*May 2014

2,600 acres of property:

<table>
<thead>
<tr>
<th>Warehousing and other specialized facilities</th>
<th>Various equipment: Reach stackers, straddle carriers, top loaders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk cargo handling facilities</td>
<td>Rail Systems</td>
</tr>
<tr>
<td>Automobile processing</td>
<td>Various production plants</td>
</tr>
</tbody>
</table>
Port Authority in 2015

“The Port recognizes it must monitor the condition of its assets, know where to reinvest for the greatest good and improve its understanding and control of asset life cycle costs.”
“Systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purposes of achieving its organizational strategic plan.”

Source: PAS 55 Part 1 2008

Life Cycle Cost “Iceberg” (Source: Blanchard, 2008)
Asset Lifecycle Management involves understanding and accounting for the status and cost of an asset throughout its useful life in order to increase asset availability, reliability, reduce asset failure and reactive maintenance, and optimize agency investments. Asset Management is not “part” of the business, it is the business.
EAM Overview

Asset Management Process

- Strategic Vision
- Asset Inventory
- Asset Assessments
- Asset Valuations
- O&M/CIP Integration
- Strategic Decision Analysis
- Implementation

Existing Asset Assessment

Future Facilities Planning

Risks/Costs
Asset Management Objective

Know where to Reinvest for the Greatest Good

Risk

Not Recommended

Affordability

Bang for the Buck
Where is the Real ROI
Where is the Real ROI
Why Enterprise Asset Management?

• There is the opportunity with effective cross departmental collaboration to achieve results like this:
  - 5% improvement in equipment reliability
  - 15% improvement in asset utilization
  - 20% improvement in labor productivity
  - 20% reduction in inventory carrying costs
  - 20% reduction in energy consumption
  - 30% reduction in emergency repairs
  - 30% reduction in Service Level Agreement costs

(Source: “Reliability Centered Maintenance”, J. Moubray, 2010)

- 2000
  - New Jersey: 80%
  - Brooklyn: 10%
  - Staten Island: 10%

- 1987
  - New Jersey: 90%
  - Brooklyn: 5%
  - Manhattan: 5%
  - Staten Island: 0%

- 1959
  - New Jersey: 70%
  - Brooklyn: 30%
  - Manhattan: 0%
  - Staten Island: 0%
Asset Inventory

- Efforts to increase sensor use, leverage cognitive capabilities.
Asset Inventory
The “I” in GIS

GPS Satellites

ERP Systems
- SAP
- PeopleSoft
- DBMS

Geo Logistics System

EPC-RFID*
GPS and Cellular Updates

*Electronic Product Code – Radio Frequency Identification
Asset Hierarchy is Critical
Zones Enable Opportunistic Maintenance

A PM Routine

Is Applied to a Zone

Which Contains Locations

Which Contains Individual Assets

Torque & Clean Weekly

Maintenance Procedure Checklist

Reporting on What Work is Done at Each Location

Reporting on What Work is Done on Which Asset
What GIS Does
Figure 5 – Example of feature classes inheriting abstract class attributes. Source: Alexander Schultz (2012)
Connecting the Dots
What GIS Does

Data extract process:

- Select leaks and mains
- Remove unneeded attributes
- Assign ownership (linear referencing)
- Add attributes and calculate values
- Export tabular data to condition model (Excel)
What GIS Does

System-wide Leak History

- Sum of Leaks All Systems
- Sum of Age All Systems

Annual Leaks per 100 miles
Average System Age
What GIS Does

Cause of Leaks (system-wide)
Superstorm Sandy

October 29, 2012 Hurricane Sandy, a category 3 major hurricane, arrives in the Northeast United States

A winter storm met Hurricane Sandy, creating a Fujiwhara effect and bringing about the term “Superstorm”

Storm occurred during a full moon, resulting in 20% higher tides
Impacts of Superstorm Sandy

Estimated damages of $36.8 billion and $42 billion in New Jersey and New York, respectively

Port Authority facilities and operations were greatly impacted as the storm surge caused extensive flooding and damage, some of which are still being uncovered

Original Port Authority estimates of $2.2 billion in damage

The Port Authority is restoring infrastructure and building resiliency to prepare for future natural disasters
Effects of Salt Infiltration

Salt water intrusion caused a significant amount of latent damage to electrical systems affected by Sandy.

All the electrical equipment shown here needed to be replaced due to the effects of salt water.

The Port Authority continues to uncover the extent of this damage and changing projects costs to replace the necessary wiring and equipment.
Post-Sandy Protect: Resiliency Projects

LGA Flood Control and Resiliency Improvements:
West End Substation Protection

Reconstruction of unsuitable subgrade & replacement of drainage system

JFK Flood Control:
Tide Gates and Drainage Check Valves

LGA Flood Control and Resiliency Improvements:
West Field Lighting Vault

Howland Hook Container Terminal:
Upgrade Pavement Subgrade
Resiliency Efforts - Bungalows

Before

Interim 9/1 Protection

After
Port Assets: Challenges
## Asset Management Mission and Goals

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<tr>
<th>Impact</th>
<th>Likelihood</th>
<th>Assurance</th>
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</table>

Residual Index Score = 162
**Asset Management Mission and Goals**

**SUMMARY**
The Port Commerce Department is concerned about the structural impact marine borers cause to the infrastructure of the ports.

**INVASIVE SPECIES**

**AVERAGE RESIDUAL INDEX**

<table>
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<tr>
<th>PLAN NAME</th>
<th>TEND</th>
<th>RESIDUAL INDEX</th>
<th>IMPACT</th>
<th>LIKELIHOOD</th>
<th>ASSURANCE</th>
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<td>*</td>
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<td>5</td>
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<td>Brooklyn PA Marine Terminal/Red Hook</td>
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<td>320</td>
<td>8</td>
<td>10</td>
<td>4</td>
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<tr>
<td>Container Terminal</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Howland Hook Marine Terminal</td>
<td>↑</td>
<td>280</td>
<td>7</td>
<td>10</td>
<td>4</td>
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<tr>
<td>Port Newark/Elizabeth Marine Terminal</td>
<td>↓</td>
<td>260</td>
<td>10</td>
<td>7</td>
<td>4</td>
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</table>

**DEPARTMENT ASSESSMENTS**

**CONFIDENTIAL**

**FINANCIAL**

**INTERNAL BUSINESS PROCESS**

**TALENT MANAGEMENT**

**TREND**
QAD Defines Cyclical Structural Inspection Program

PCD approves workload for given year

PP issues charge code for QAD

QAD issues work order for condition survey

QAD coordinates with Facility to perform survey

QAD issues condition survey

PP inputs information into Structural Integrity Tracking Database

PP works with Facility Staff, PM, and EAD to determine how work will be accomplished

CMD manages repairs

QAD defines Cyclical Structural Inspection Program

PP issues memo to Facility Manager

Facility Maintenance Staff performs repairs

Facility Manager certifies completion of work to PP

PP forwards completion documents to QAD and EMSD

PP updates Structural Integrity Tracking Database Log

PP issues Work Order

PM requests EAD develop standard details and work plan

EAD provides standard details and work plan to PM

PM issues Work Order

CMD manages repairs

CMD certifies completion to Facility Manager, PM, and PP

PP forwards completion documents to QAD and EMSD

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EAD provides standard details and work plan to PM

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CMD manages repairs

CMD certifies completion to Facility Manager, PM, and PP

PP forwards completion documents to QAD and EMSD

PP forwards completion documents to QAD and EMSD

PP reviews condition survey repair performance with PCD, Deputy Director, Assistant Director, and Facility Managers bi-monthly

Repair Type:
- Immediate
- Safety
- Routine
- Priority

Repair types Immediate, Safety and Routine addressed under separate workflows

Facility Staff and PP review repairs identified and develop preliminary cost estimate

Priority Repairs

WHARF - Structural Integrity Condition Survey Priority Repair Workflow

PP reviews plan with PCD Capital Program Assistant Director
What Does GIS Provide
What Does GIS Provide
What Does GIS Provide
What Does GIS Provide

**What We Are Doing to Handle Growth – Waterside**

**Harbor Deepening Project**
- Deepening Key Channels to 50’ to accommodate larger ships
- Completion of all channels to 50’ by 2014

**Environmental Challenges**
- Air Quality
- Loss of Wetlands
- Managing Dredged Material
What Does GIS Provide

Chemical Coast North Connector - Development Program
What Does GIS Provide
What Does GIS Provide
## ROI of Geospatial Info (GIS, BIM, GPS, RFID)

<table>
<thead>
<tr>
<th>Project stage</th>
<th>Benefit area</th>
<th>Description</th>
<th>Benefits</th>
<th>Cost benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design team</td>
<td>animations, visualisations and virtual reality materials are produced as a by-product of the model. Simulations can help to improve health safety by considering aspects such as working at height – for construction and subsequent facilities management.</td>
<td>More effective promotion of a scheme and stakeholder awareness - A more effective and transparent design process - Improved health and safety management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main contractor</td>
<td>The virtual model provides an effective and efficient means of coordinating the design elements on a scheme. Although design teams claim to perform coordination and clash detection it is often left to second- and third-tier supply chain partners.</td>
<td>Clash-free, fully coordinated design model - Lower design cost (design is done once only, and done right) - Less burden on the design team during construction</td>
<td>5% saving in design cost</td>
</tr>
<tr>
<td></td>
<td>Sub contractor</td>
<td>Data from the 3D model can be exported quickly and easily to design analysis packages and the resultant design data can then be imported seamlessly back into the model.</td>
<td>Faster design analysis - Error free transfer of data between analysis and modelling packages - Lower design cost and the ability to consider more design options</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operator</td>
<td>Component and material schedules are generated automatically and accurately from the 3D model, and can be transferred easily to and from proprietary databases or spreadsheets to help estimators, purchasers and designers.</td>
<td>Quick production of error-free schedules - Smaller estimating teams - Better awareness of costs as the design develops</td>
<td>1% saving in design cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bills can be produced to any standard and format by exporting appropriate data from the model.</td>
<td>Quick production of correctly formatted bills with fewer errors - Lower cost of production</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2D drawings are extracted quickly, easily and efficiently from the model. As supply chains adopt a model centric approach, the need for drawings will diminish.</td>
<td>More cost effective drawing production, with fewer errors - Fully coordinated design deliverables</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The virtual model can be linked to project documents (such as specifications, risk assessments, etc) and to suppliers’ product information, either on or off the Web.</td>
<td>Easier access to project information for all stakeholders - Better management of component data - More efficient design process</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The virtual model is a powerful tool that helps to convey complicated design aspects to stakeholders, and information can be tailored easily to suit the audience.</td>
<td>Improved stakeholder awareness - Easier to secure buy-in earlier in a project - More likely to encourage a good response from potential tenderers</td>
<td>1% saving in design cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A model centric approach makes it more realistic for designers to 'do it right first time', and to consider more design options. It also enables more effective and better integrated decision making.</td>
<td>Greater design efficiency - Better value for the client - More profit for the designers and no erosion of margin in construction</td>
<td>3% saving in design cost</td>
</tr>
<tr>
<td>Procurement, construction &amp; commissioning</td>
<td>Trade packages</td>
<td>Construction planning</td>
<td>Buildability &amp; logistics</td>
<td>Clash management</td>
</tr>
<tr>
<td>----------------------------------------</td>
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<td>-----------------</td>
</tr>
<tr>
<td>1% reduction in build cost</td>
<td>- Easier compilation of tender information</td>
<td>- Improved project programming and better understanding of activities</td>
<td>- More efficient site activities leading to lower construction costs</td>
<td>- Clash free, fully coordinated design and construction</td>
</tr>
<tr>
<td>- Tenderers receive information that is correct, complete and consistent</td>
<td>- Better informed stakeholders</td>
<td>- Greater programme certainty</td>
<td>- Lower construction cost because of less waste and less disruption</td>
<td>- Quicker access to better design information by site teams</td>
</tr>
<tr>
<td>- Lower tender risk contingencies</td>
<td>- Improved health and safety training of site teams</td>
<td>- Improved planning of site laydown areas and materials logistics</td>
<td>- Less burden on the design team during construction</td>
<td>- Better certainty of project programme</td>
</tr>
<tr>
<td>0.25% reduction in build cost</td>
<td>- Easier compilation of tender information</td>
<td>- Improved project programming and better understanding of activities</td>
<td>- More efficient site activities leading to lower construction costs</td>
<td>- Clash free, fully coordinated design and construction</td>
</tr>
<tr>
<td>0.05% reduction in build cost</td>
<td>- Tenderers receive information that is correct, complete and consistent</td>
<td>- Better informed stakeholders</td>
<td>- Improved health and safety training of site teams</td>
<td>- Lower tender risk contingencies</td>
</tr>
</tbody>
</table>

### ROI of Geospatial Info (GIS, BIM, GPS, RFID)

- Using the virtual model, site teams can produce trade package information easily and accurately for tendering and managing subcontractors. Armed with a better understanding of the project, trade contractors are more likely to ‘get it right first time’.
- Virtual models can be linked to master and sub-project programmes using proprietary software tools, enabling the works (and changes) to be conveyed graphically via the model.
- Buildability and construction logistics checks are performed in the virtual world during the design phase to prevent problems from ever reaching site.
- Design coordination helps to prevent clashes reaching site, thereby eliminating both construction waste and the associated disruption. Fewer queries have to be referred back to the design team because there are fewer errors in the design and the construction team can interrogate the model to resolve queries.
- By monitoring planned and actual progress with a virtual model, payment mechanisms can be more accurate and more efficient.
- Site teams can produce drawings quickly and easily from the model if required, but the need to generate drawings on site is reduced.
- The virtual model can be used to convey elements of the project to stakeholders, and to simulate the impact of, for example, incidents that cause congestion on site. It can also help to clarify key interfaces between FM management and games operations.
ROI of Geospatial Info (GIS, BIM, GPS, RFID)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing operations</td>
<td>The model can be linked to an FM system to help manage space, assets, building maintenance, property and lease details, cable infrastructure and telecommunications. Model data can be loaded onto handheld devices for mobile audits and maintenance work.</td>
</tr>
<tr>
<td>Managing new works and change</td>
<td>Provision for maintenance can be built into the design more easily, building systems can be viewed using the model, and access by maintenance workers can be simulated.</td>
</tr>
<tr>
<td>Links to product information</td>
<td>The virtual building can be linked to project documents and to suppliers' product information, either on or off the Web.</td>
</tr>
<tr>
<td>Links to BMS systems</td>
<td>Environmental controls, sprinkler systems, lifts etc. can be linked to the model so that these can be managed graphically.</td>
</tr>
<tr>
<td>Links to security systems</td>
<td>The model can be linked to security systems to assist with access control, closed circuit TV and fire detection.</td>
</tr>
<tr>
<td>Links to stock control system</td>
<td>Stock control items, such as office partitions and furniture, can be managed by linking them to the model.</td>
</tr>
<tr>
<td>Building closure</td>
<td>The model contains all of the information needed to build and manage a facility, and it could be used to easily duplicate that facility (or parts of it) elsewhere.</td>
</tr>
<tr>
<td>Knowledge management</td>
<td>The model is a valuable repository of project knowledge, comprising data on design, construction and operation. Such data could be shared with potential purchasers of a facility, or used to assist with due diligence processes when it changes ownership.</td>
</tr>
<tr>
<td>Sustainability</td>
<td>The model contains data relating to sustainability, such as the location, quantity and quality of reusable materials.</td>
</tr>
<tr>
<td>Decommissioning</td>
<td>The virtual model contains important data about items such as structural walls that decommissioning contractors can use to minimize the risk of, for example, uncontrolled collapse.</td>
</tr>
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</table>
Risk Assessment with Modeling
Risk Assessment with Modeling
Network of Interactions for the Holland Tunnel and the Bus Terminal
## Resilience Assessment Workflow

<table>
<thead>
<tr>
<th>ID</th>
<th>Facility</th>
<th>Category</th>
<th>Consideration</th>
<th>Condition Rating</th>
<th>Importance Factor</th>
<th>Hypercritical Flag</th>
<th>Time to Recovery</th>
<th>Network Interaction</th>
</tr>
</thead>
</table>

### Abstract attributes for each consideration
- Robustness – controls, mitigations, barriers
- Resourcefulness - preparedness, responsiveness
- Recovery - returning to normal operations
- Redundancy - alternate options for functions

### Each R is scored based on it component’s
- Performance ratings
- Hypercriticality in facility operations
- Time to recovery
- Potential for cascading/domino effects

\[4R\text{\:s}\]

\[\text{Composite } R\]
Calculating Resilience

\[ R = f(W_{CR}^{CR}, W_{TTR}^{TTR}, W_{CEE}^{CEE}) \]

Main Variables:
- CR = Condition Rating
- TTR = Time To Recovery
- CEE = Cascading Effects Extent

Weighting on Variables depends on:
- Importance Factor
- Hypercriticality Index
The project “touches” assets beyond its construction zone, and its effect on resilience is magnified the larger the cascading chain.
Resilience is measured through its 4 attributes, per DHS methodology:
- Robustness
- Resilience
- Recovery
- Redundancy

Based on:
- Input of facility stakeholders
- Observations made by TB&T HQ staff
- Incorporates cascading effects (network consequences)

Major impactor on lower resilience score:
Lost utility power with no back-up power supply for mid-river pumps to remain operational

Major impactor on higher resilience score:
Higher elevation of facility makes it less susceptible to flooding.
Availability of emergency personnel and support staff.

Resilience Ratings (the 4 Rs) for a facility highlight:
- Performance levels for specific hazard
- Attributes towards which investment should be targeted
Project Prioritization
Workflow “Snapshots”

- **BENEFIT**
- **COST / BENEFIT**
- **COST**
- **PRIORITIZATION**

Projects Legend:
1. Replacement of Pier 9 and 204
2. Rehabilitation of Blower Ports for Ventilation
3. Supervisory Control System Replacement
4. Replacement/Rehab of NJAB Boiler and Hot Water Heater
5. NY River Vent Bldg Emergency Egress Stair Rehab
6. Replacement of Exhaust and Blower Duct Access Doors
### Result of Data Compilation = Dashboards

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<tr>
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<th>Feb-10</th>
<th>Mar-10</th>
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<tr>
<td>Reg. Insp. Issued and Closed</td>
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<td>93.7%</td>
<td>100.0%</td>
<td>99.1%</td>
<td>99.2%</td>
<td>1,643</td>
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### Graphs

- **Bar Chart**
- **Line Graph**
Port Authority of NY/NJ
Performance Management & Analysis
Key Performance Indicators - Preventive Maintenance
PANYNJ

PM Criticality 1 Percent Complete

PM Criticality 2 Percent Complete

PM Criticality 3 Percent Complete

PM Criticality 4 Percent Complete

Criticality 1: Life Safety / Critical Utility
Criticality 2: Mission Critical
Criticality 3: Mission Sensitive
Criticality 4: Non-Mission Critical
The Challenge: Operations & Resiliency Management

**Mission**

Enable maximum availability of physical assets for intended purpose

Make risk based determinations regarding ongoing financial investments

Ensure staff is trained, available and deployed to support strategies

Maximize asset life while minimizing asset costs.

**Mission**

Organize and manage resources and responsibilities for maximum effectiveness during natural or manmade disasters

Implement preparedness, response, and recovery plans and procedures to lessen the event impact

Reduce vulnerability to hazards to improve response and recovery times