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

Presented by:
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Mission

- “MEET THE CRITICAL TRANSPORTATION INFRASTRUCTURE NEEDS OF THE BI-STATE REGION'S PEOPLE, BUSINESSES, AND VISITORS BY PROVIDING THE HIGHEST QUALITY AND MOST EFFICIENT TRANSPORTATION AND PORT FACILITIES AND SERVICES TO MOVE PEOPLE AND GOODS WITHIN THE REGION, PROVIDE ACCESS TO THE NATION AND THE WORLD AND PROMOTE THE REGION’S ECONOMIC DEVELOPMENT.”

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:	
ü Warehousing and other specialized facilities	ü Various equipment: Reach stackers, straddle carriers, top loaders
ü Bulk cargo handling facilities	ü Rail Systems
ü Automobile processing	ü Various production plants

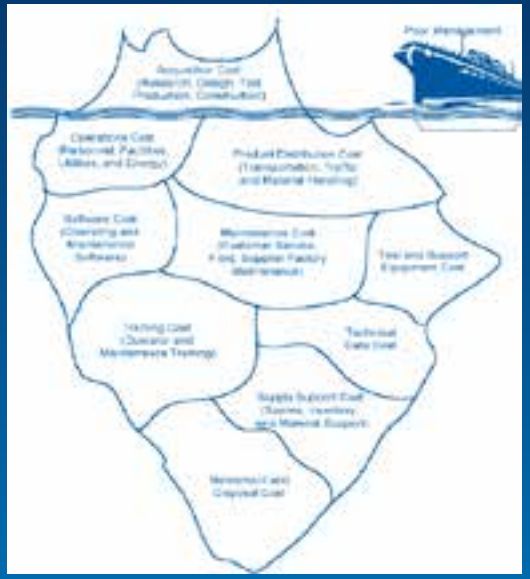
Port Authority in 2015

"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."

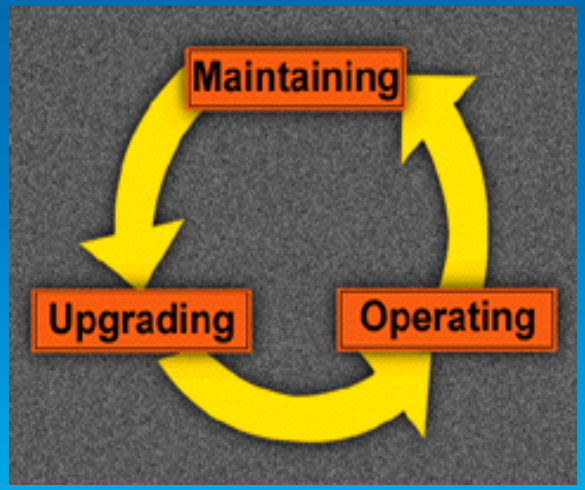
Enterprise Asset Management (EAM): Definition

- ***"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."***

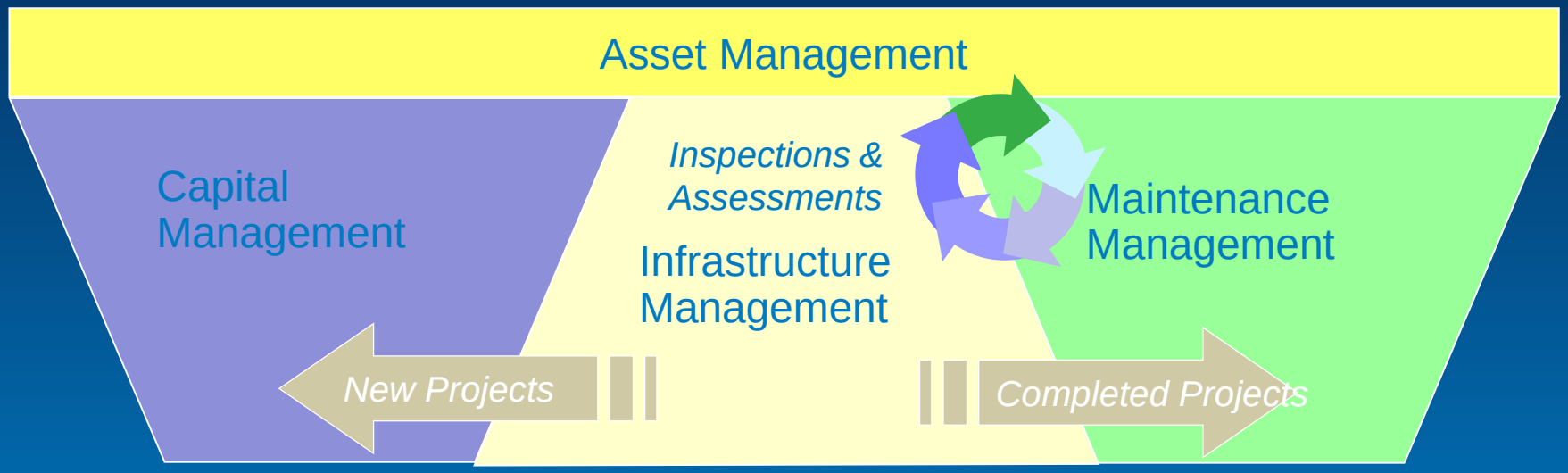
- **Source: PAS 55 Part 1 2008**



Life Cycle Cost "Iceberg"
(Source: Blanchard, 2008)

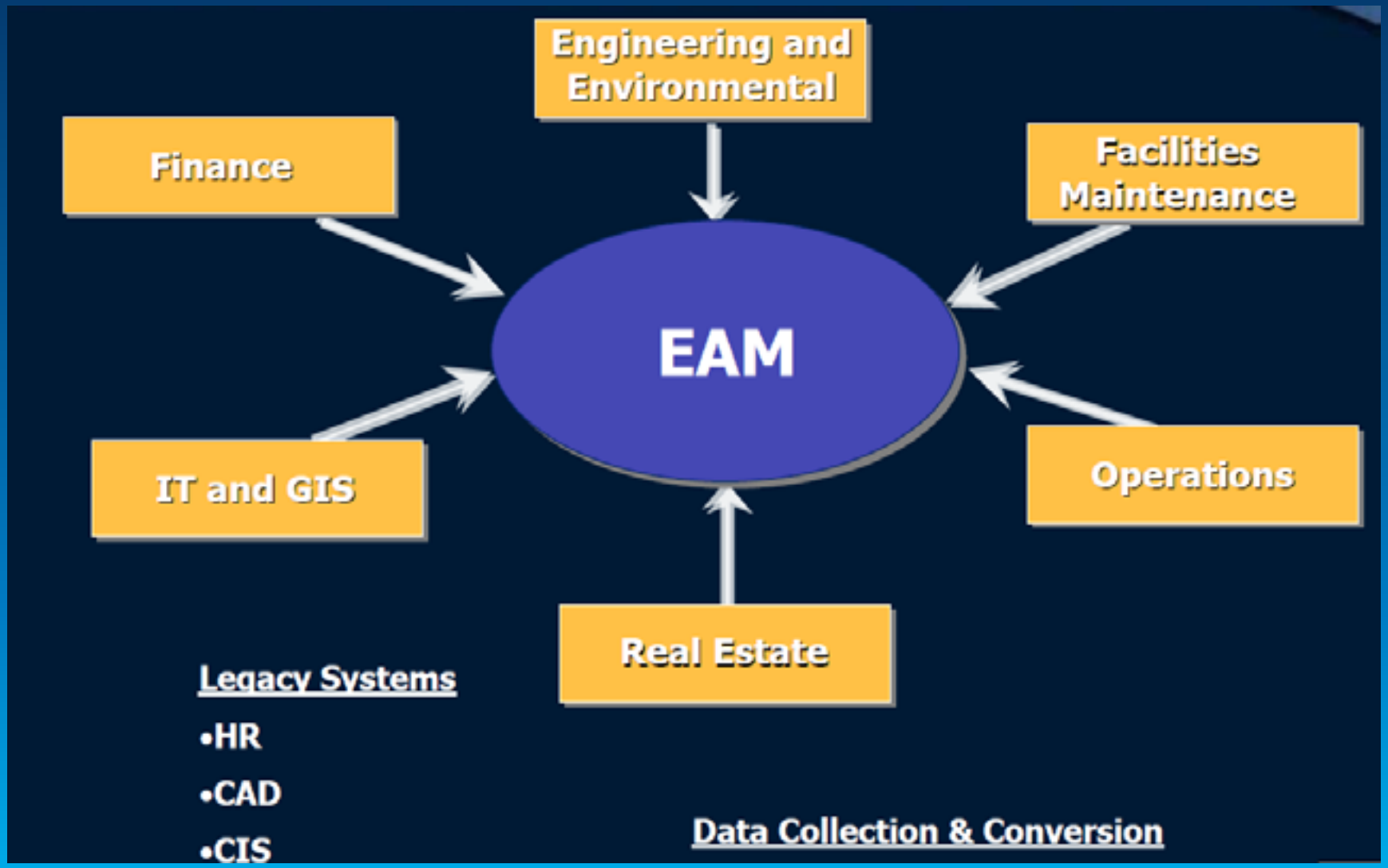


Asset Lifecycle Management

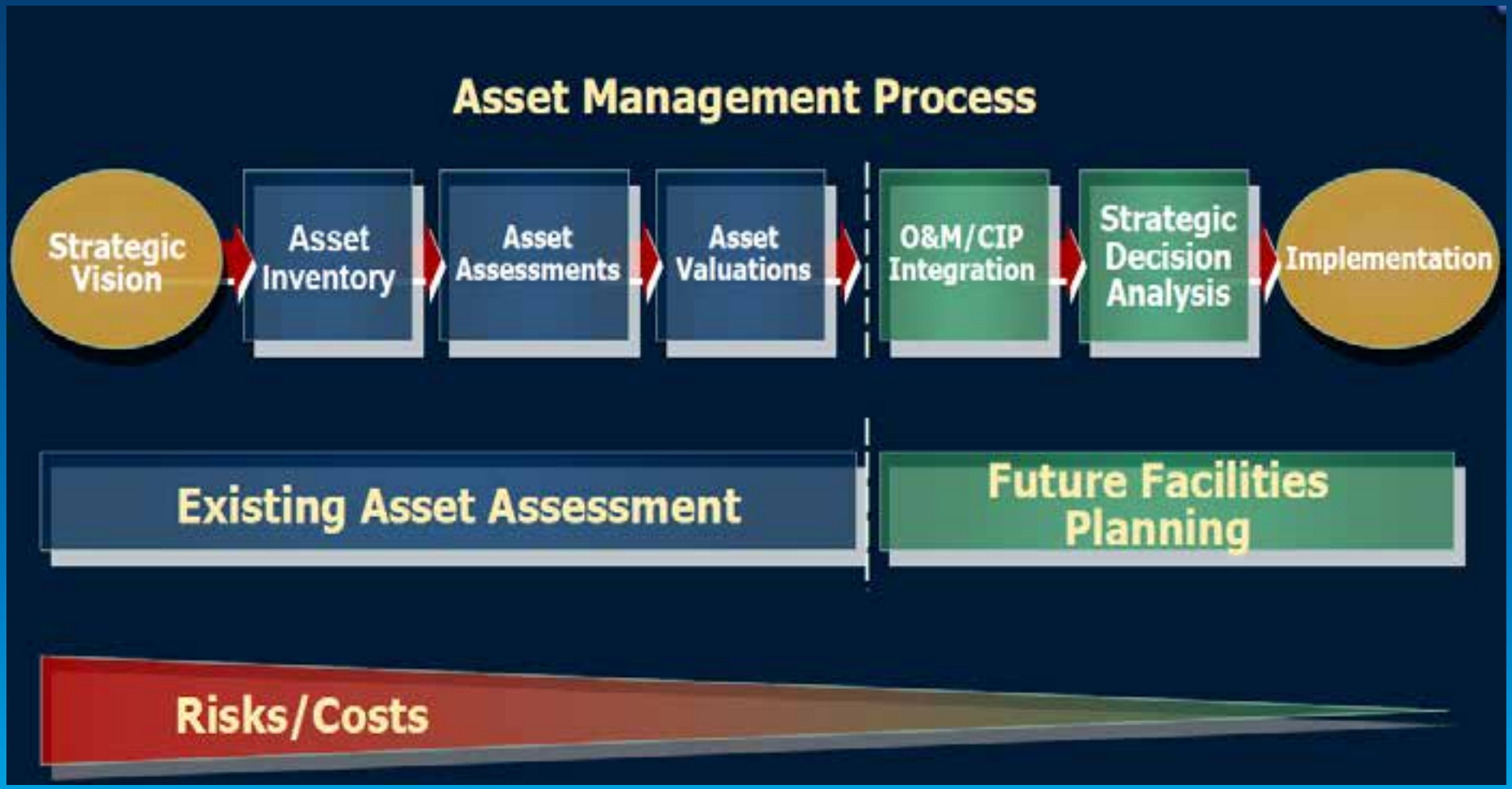


- **Asset Lifecycle Management involves understanding and accounting for the status and cost of an asset throughout its useful life in order to increase asset availability, reliability, reduce asset failure and reactive maintenance, and optimize agency investments. Asset Management is not "part" of the business, it *is* the business.**

EAM Touchpoints

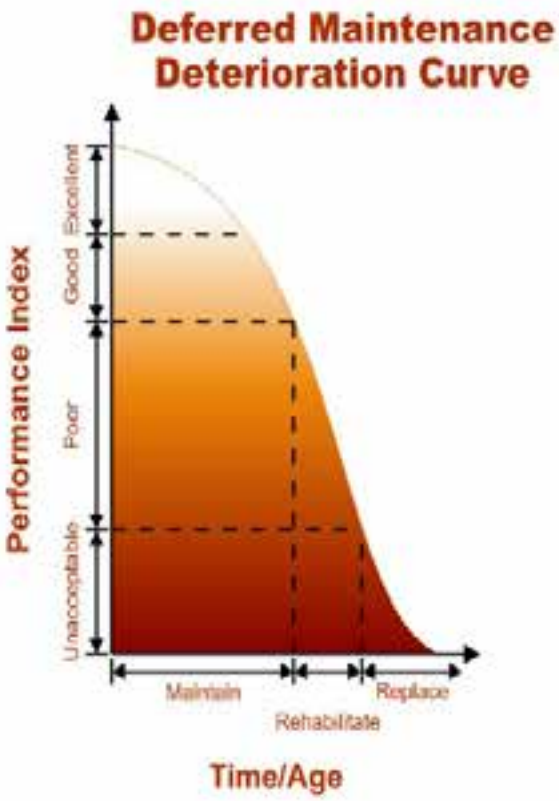


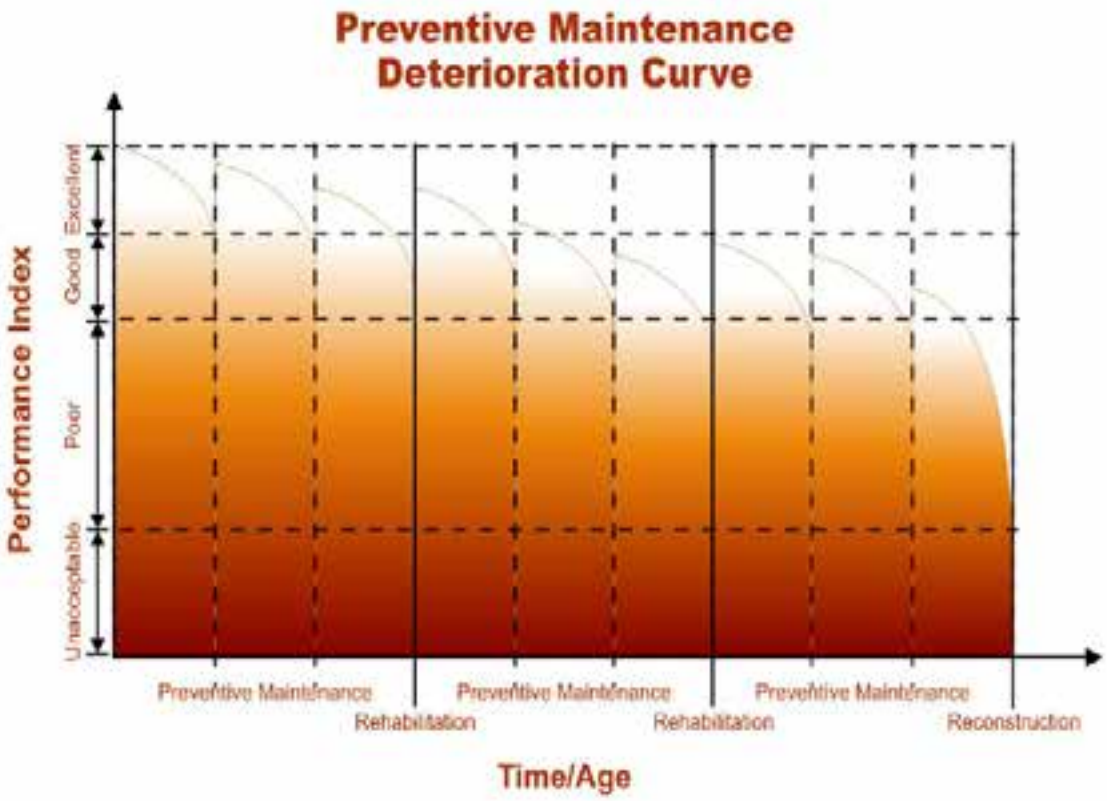
EAM Overview



Asset Management Objective

Where is the Real ROI





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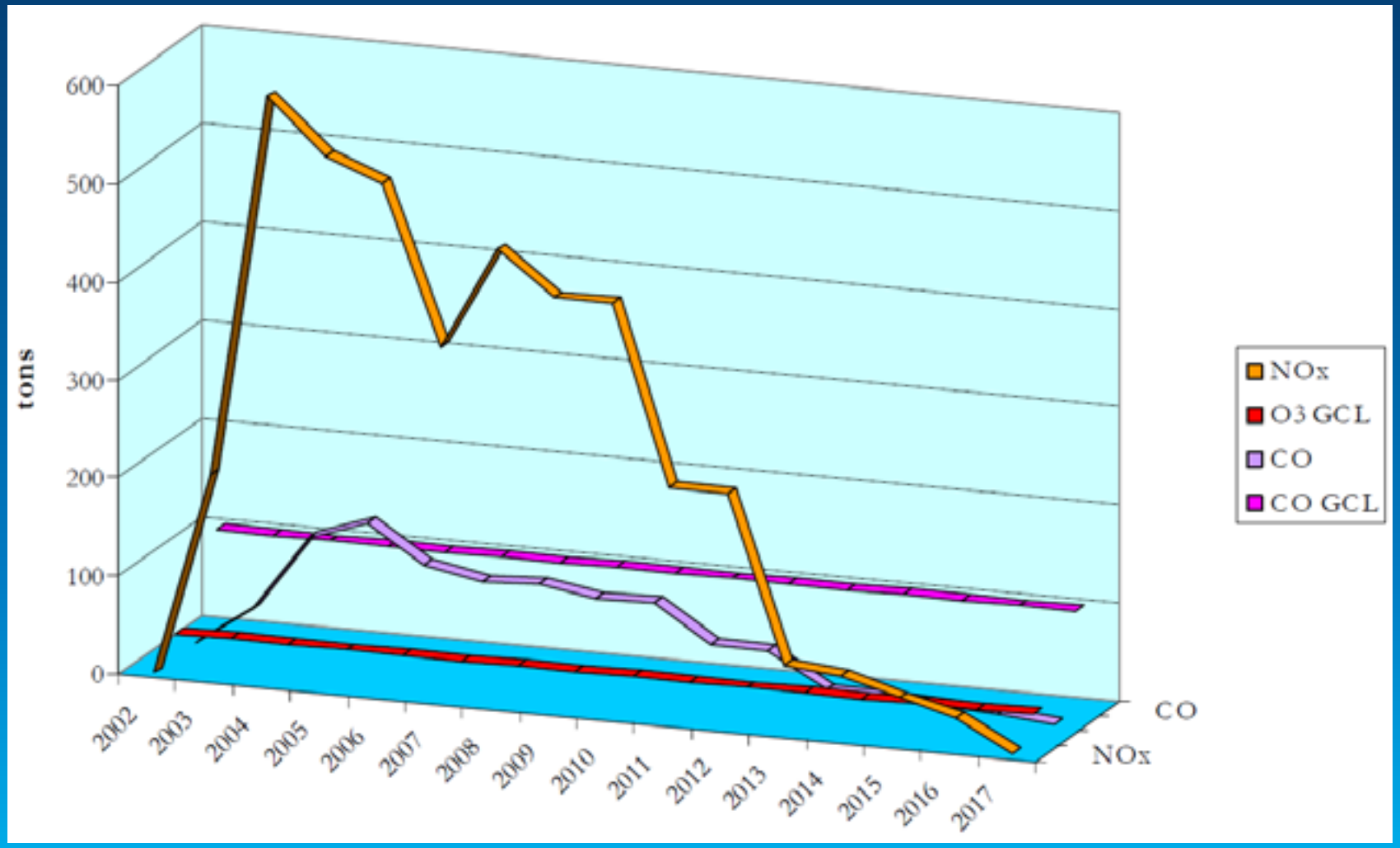
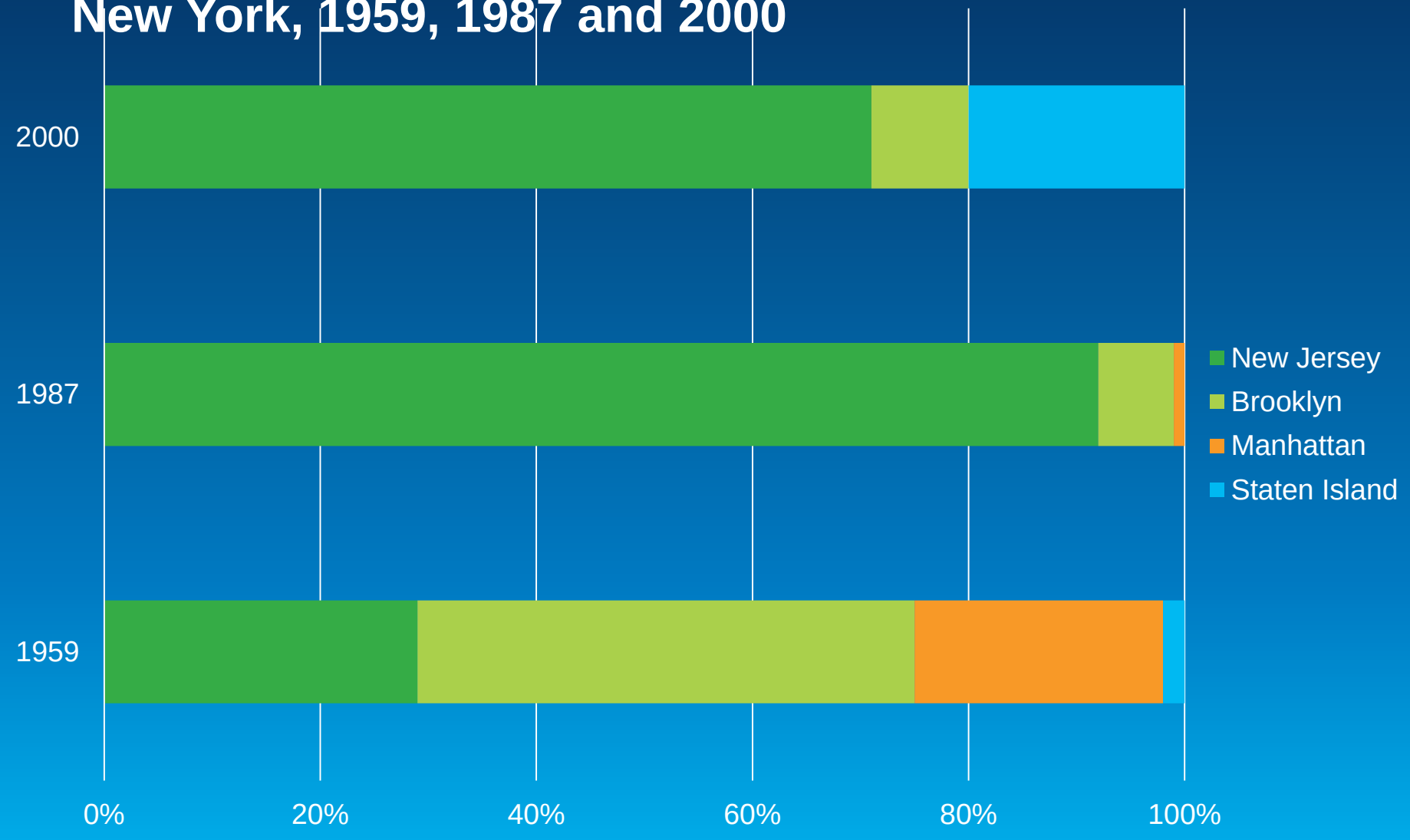


Why Enterprise Asset Management?

- **There is the opportunity with effective cross departmental collaboration to achieve results like this:**
  - **5% improvement is 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)***

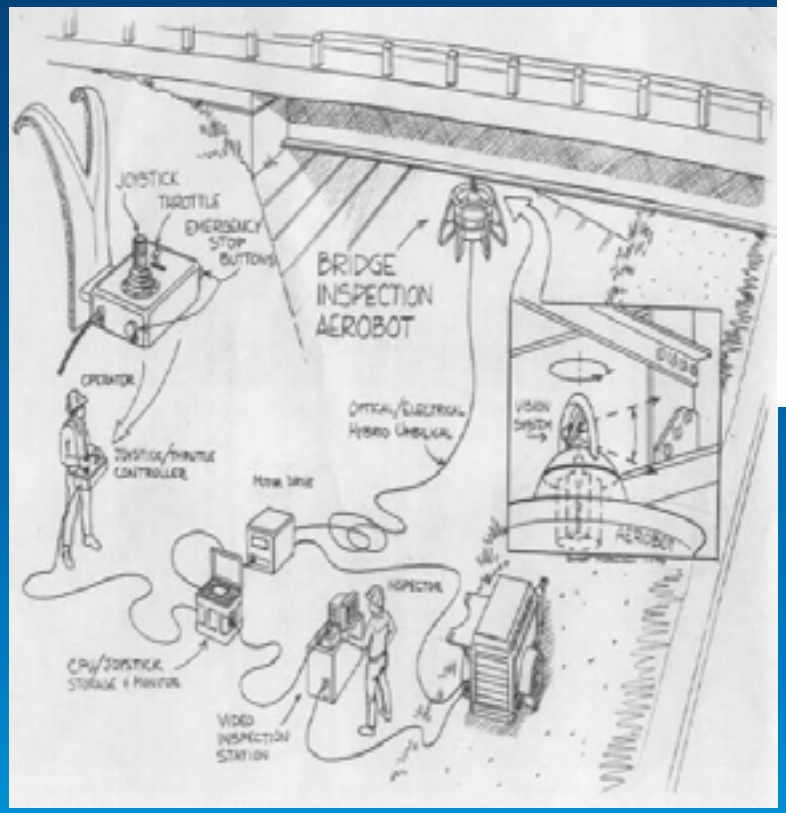
Distribution of General Cargo Operations, Port of New York, 1959, 1987 and 2000

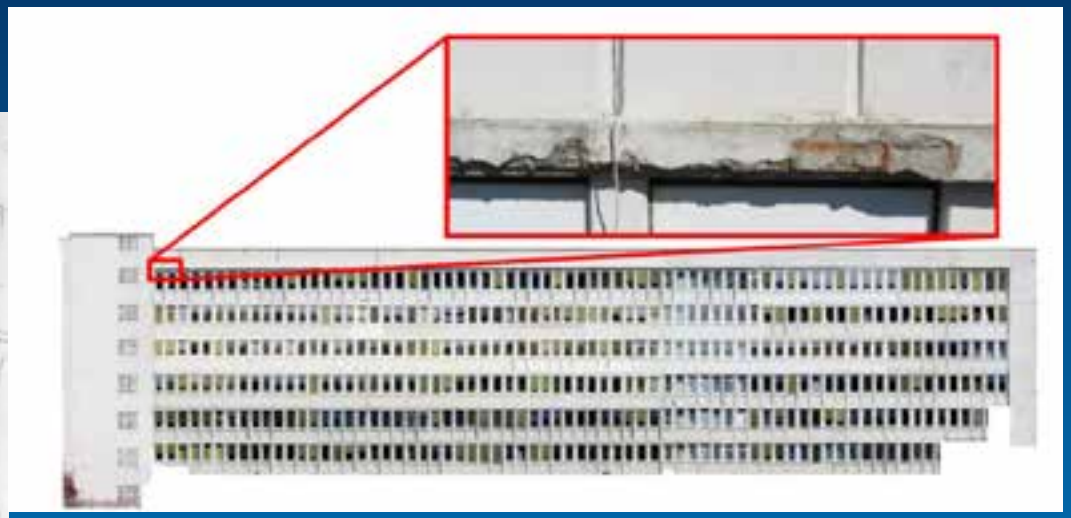


Asset Inventory

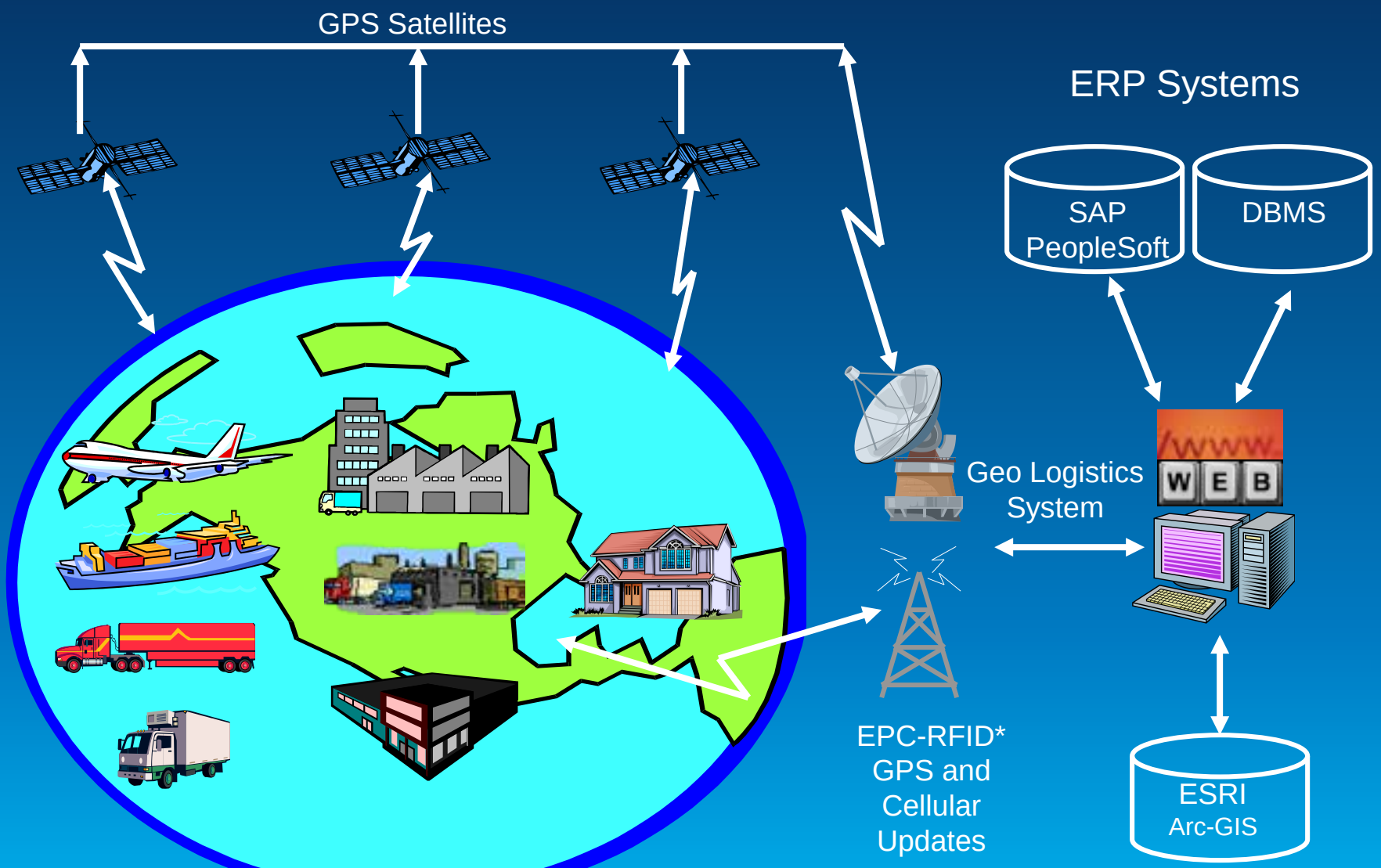
- Efforts to increase sensor use, leverage cognitive capabilities.

Asset Inventory



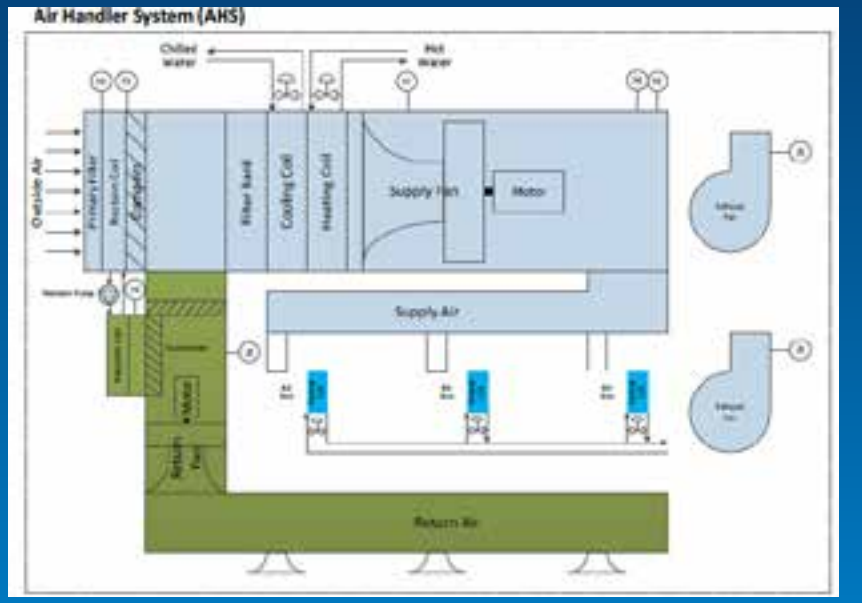


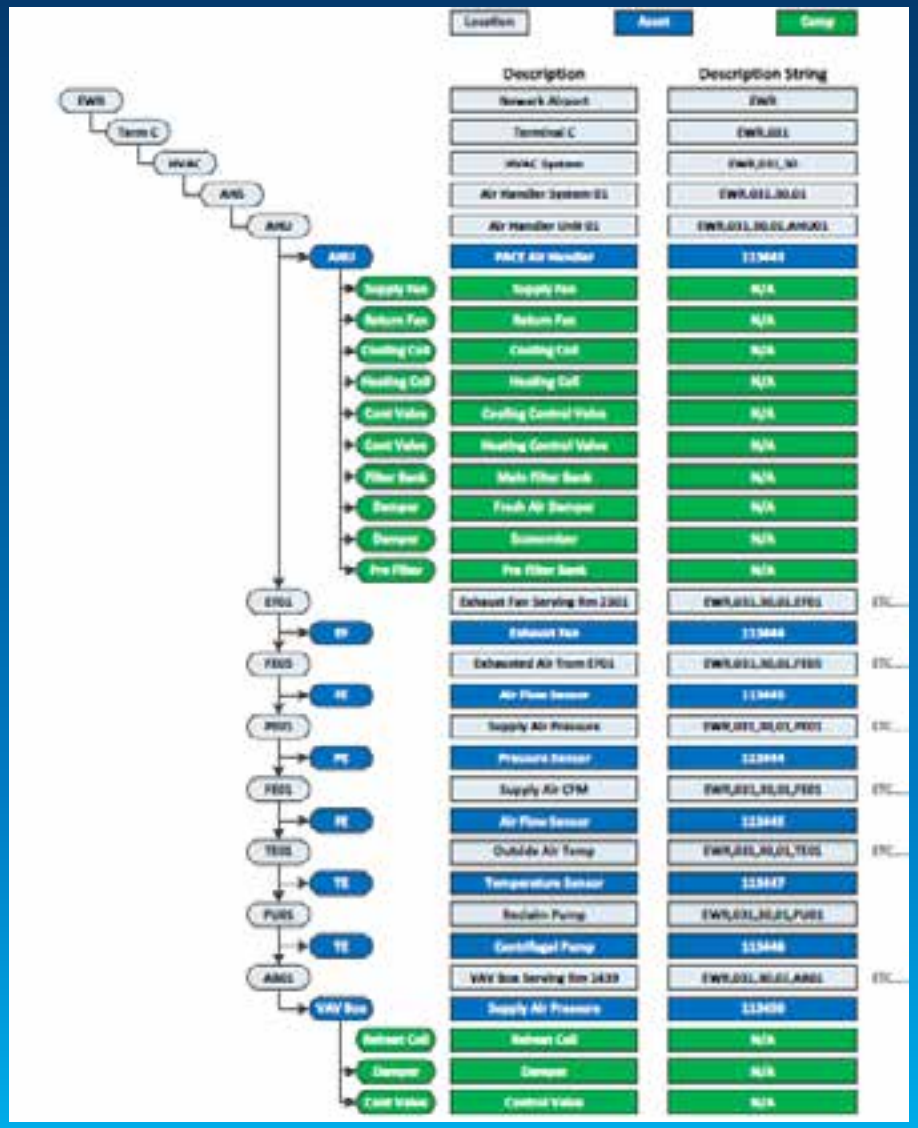
The “I” in GIS



*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

4

TW-G-TW-P:TW-P
TW-P-TW-E:TW-G
TW-P-TW-G:TW-G

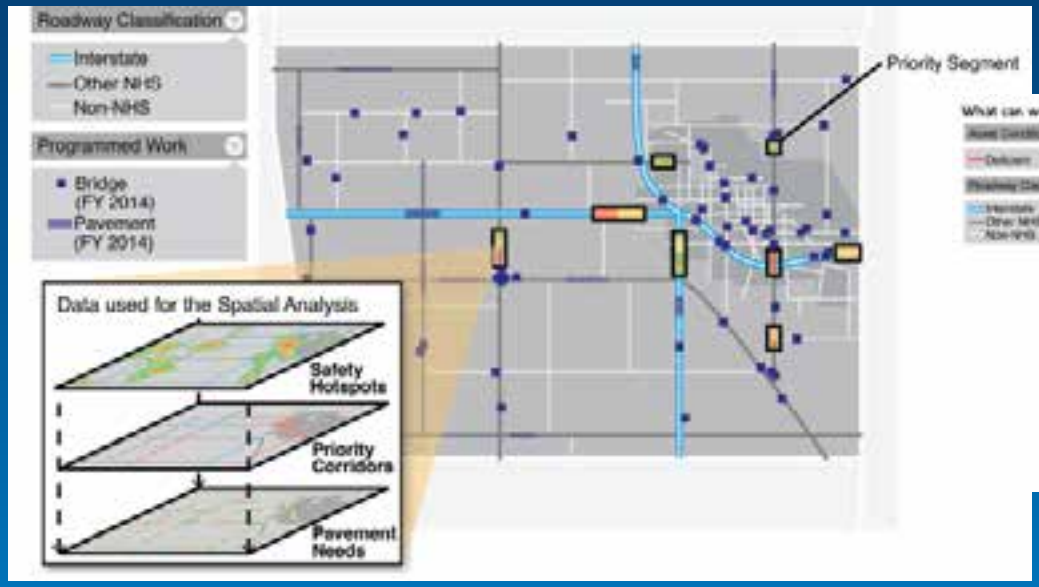
EWR-TW-P-TW-G:TW-G-LHB-P04S00

Maintenance Procedure Checklist

Reporting on What Work is Done at Each Location

Reporting on What Work is Done on Which Asset

What GIS Does



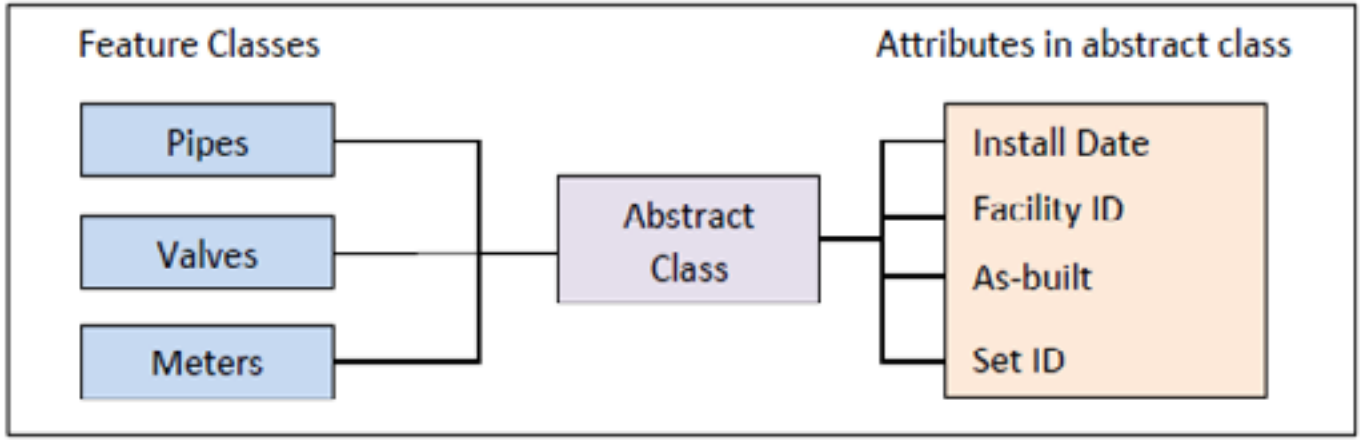
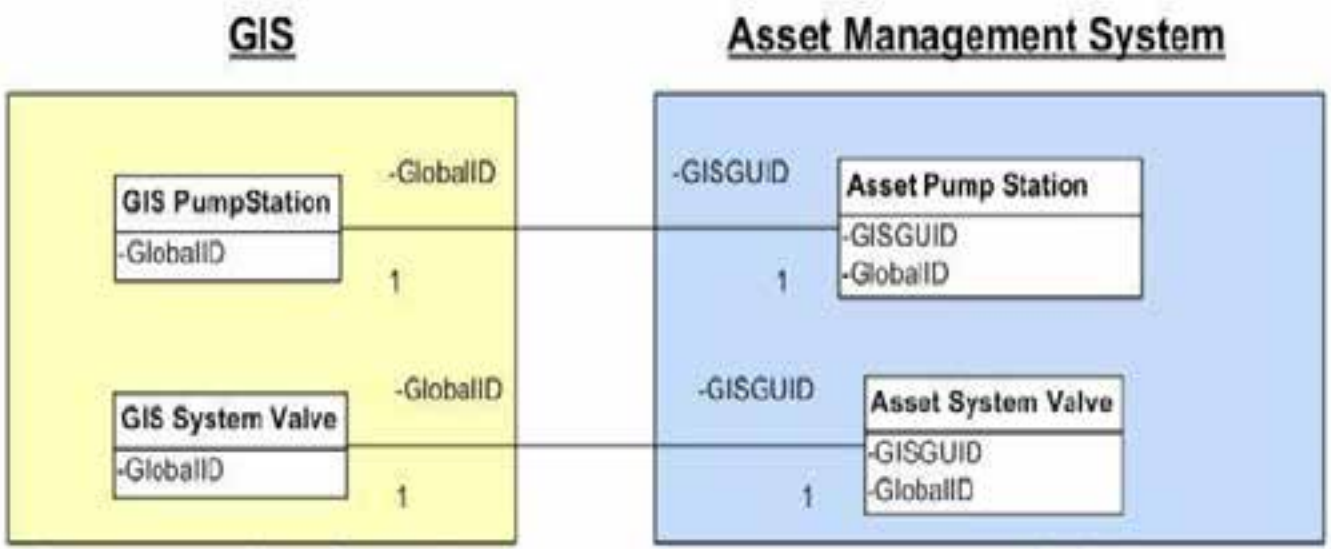
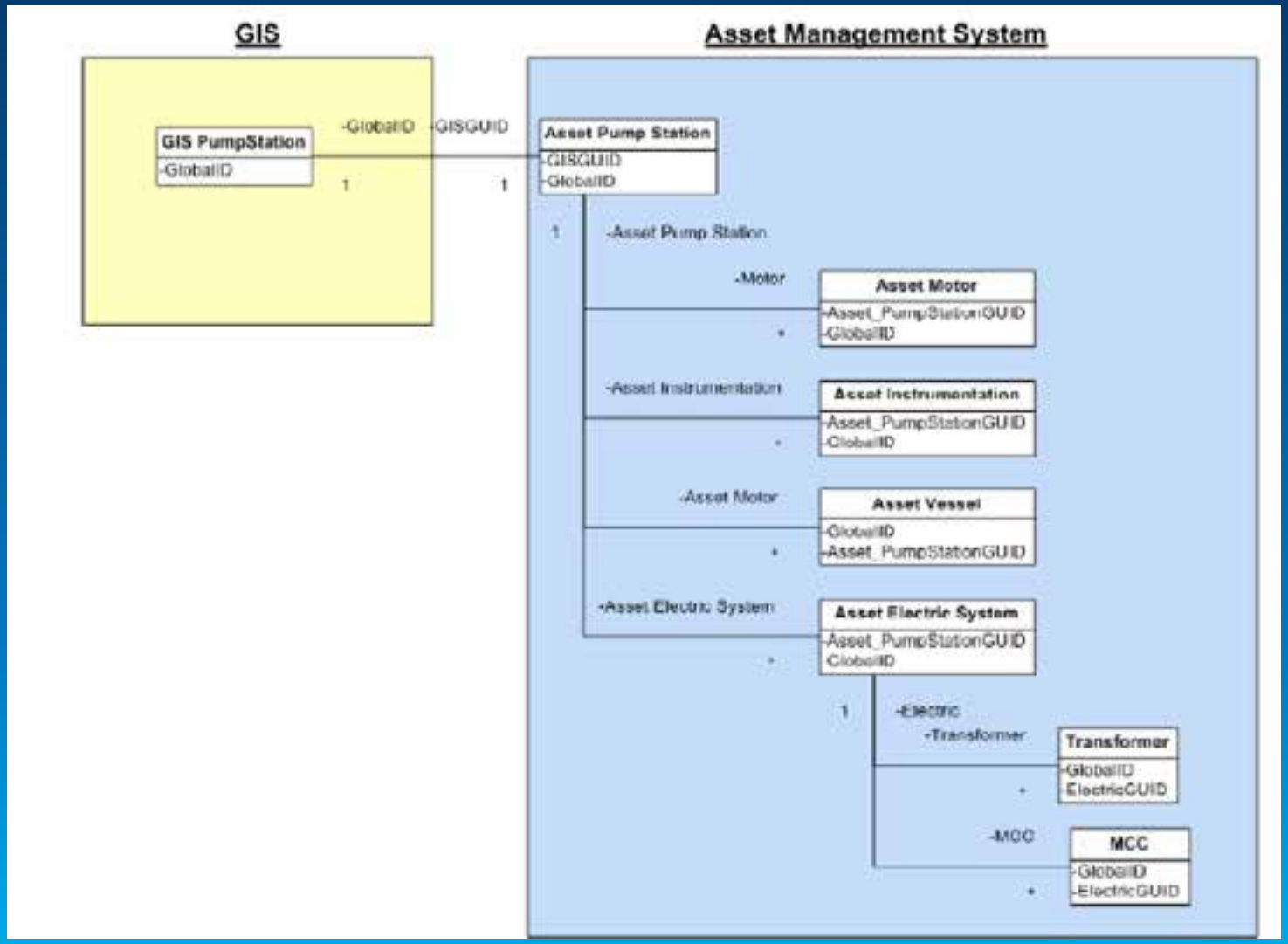


Figure 5 – Example of feature classes inheriting abstract class attributes. Source: Alexander Schultz (2012)



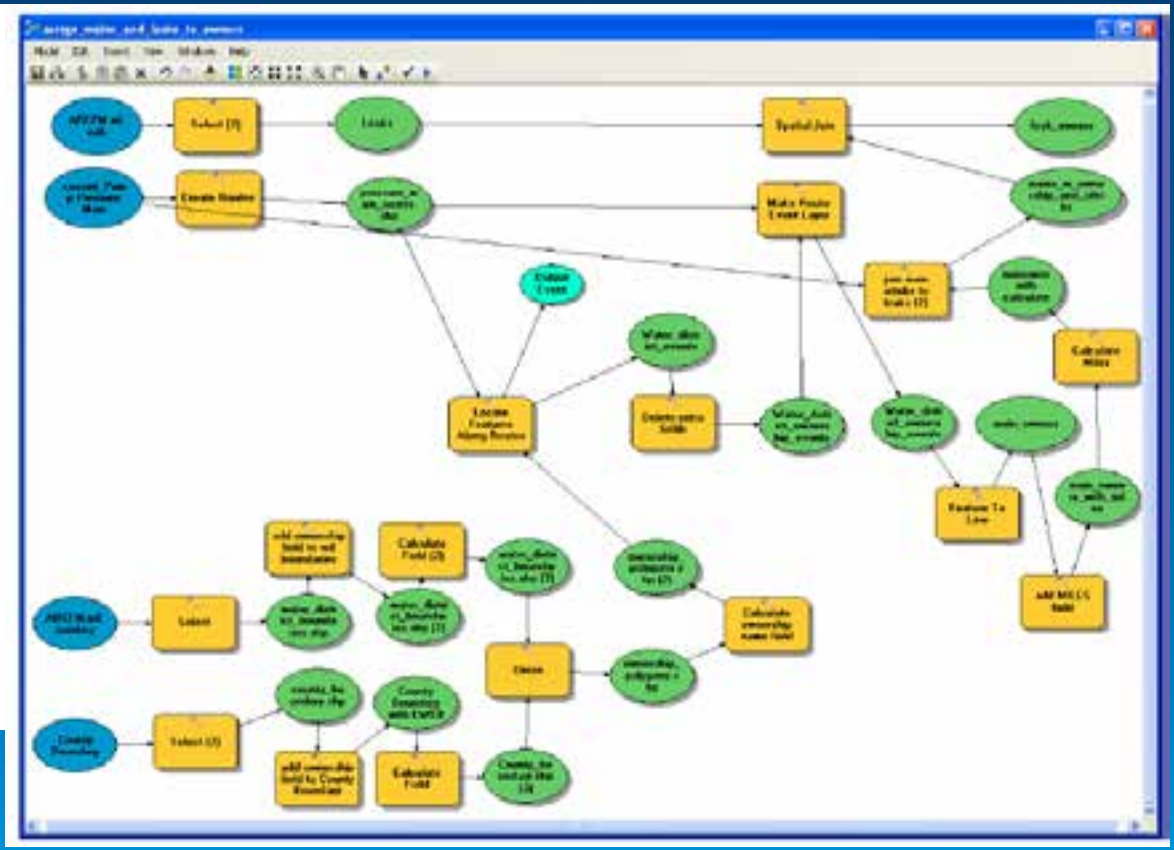
Connecting the Dots



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)



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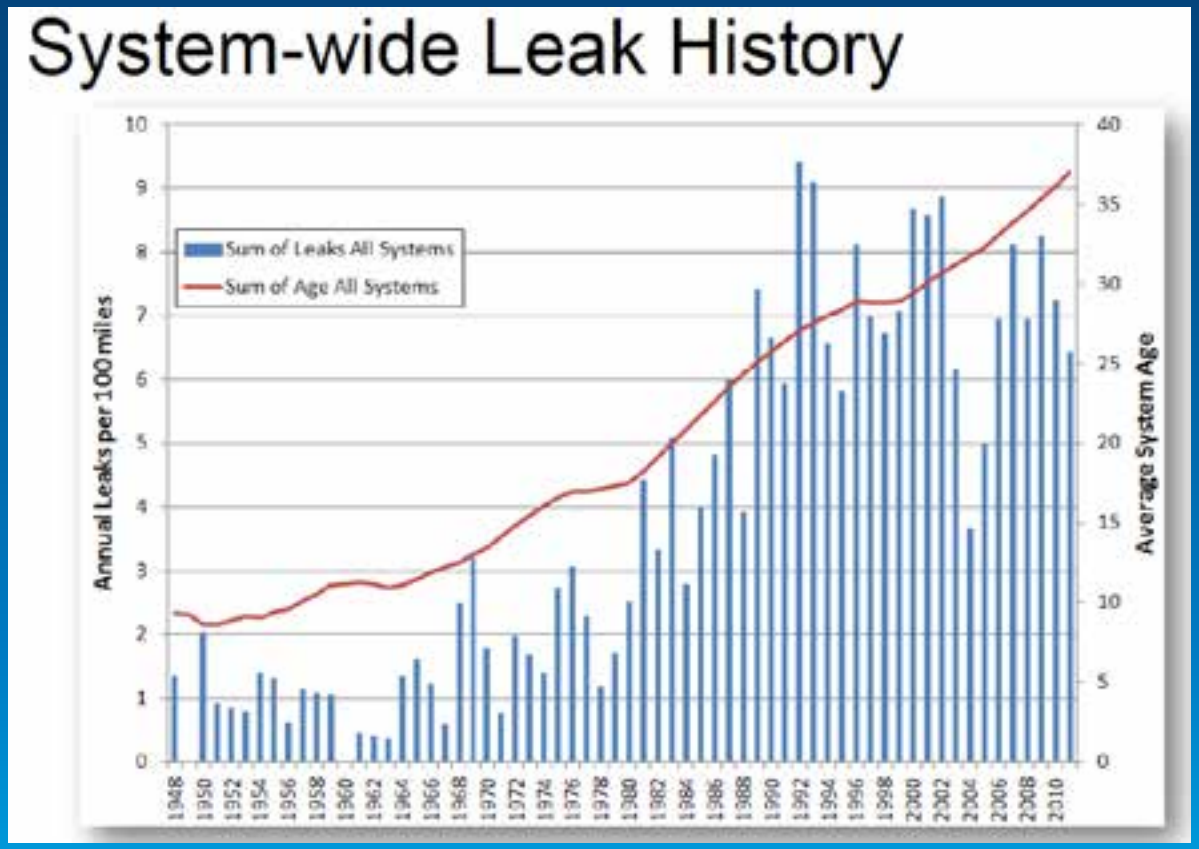

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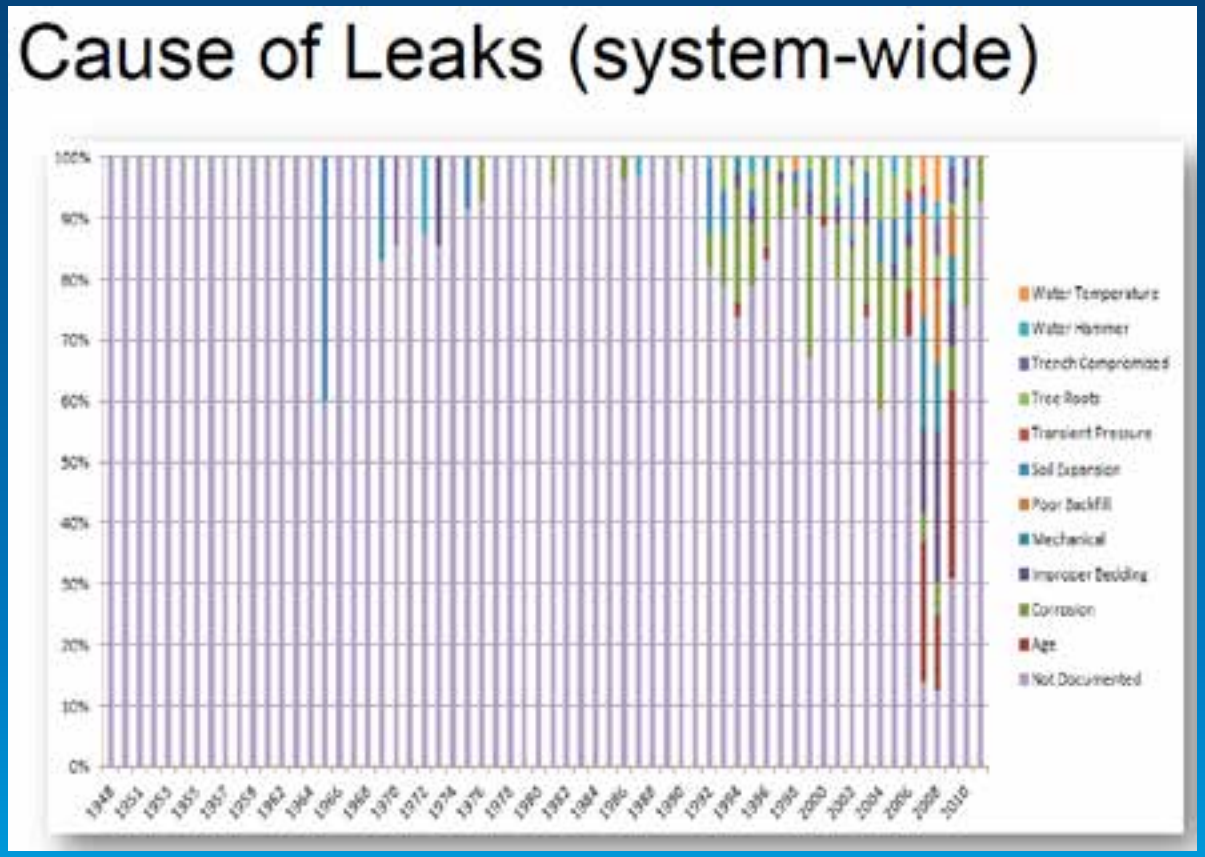


Superstorm Sandy

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 effected my 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







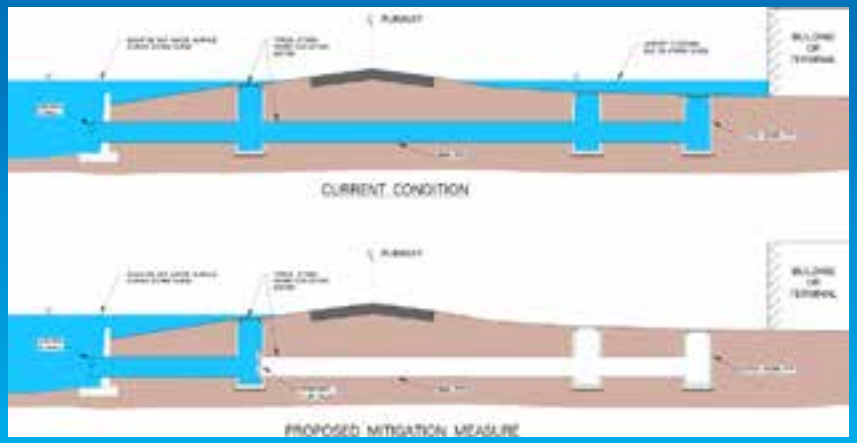


Post-Sandy Protect: Resiliency Projects

LGA Flood Control and Resiliency Improvements: West End Substation Protection

LGA Flood Control and Resiliency Improvements: West Field Lighting Vault

JFK Flood Control: Tide Gates and Drainage Check Valves



Howland Hook Container Terminal: Upgrade Pavement Subgrade

Reconstruction of unsuitable subgrade & replacement of drainage system

Resiliency Efforts - Bungalows

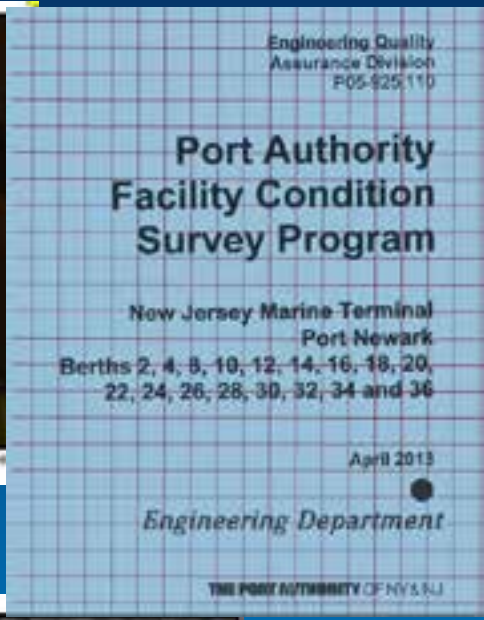
Before

Interim 9/1 Protection

After

Port Assets: Challenges

Bent 25, Pile CW Bat: Corrosion, pitting, and open weld on ste
with concrete fill exposed, rated Severe (Routine Repair)



Engineering Quality
Assurance Division
P05-925110

Port Authority
Facility Condition
Survey Program

New Jersey Marine Terminal
Port Newark
Berths 2, 4, 8, 10, 12, 14, 16, 18, 20,
22, 24, 26, 28, 30, 32, 34 and 36

April 2013

Engineering Department

THE PORT AUTHORITY OF NY & NJ

Photo 2-18: Berth 10, Bent 460, Pile 8: Timber pile with 25% evidence
severe marine borer deterioration (Routine Repair)

Photo 2-29: Be

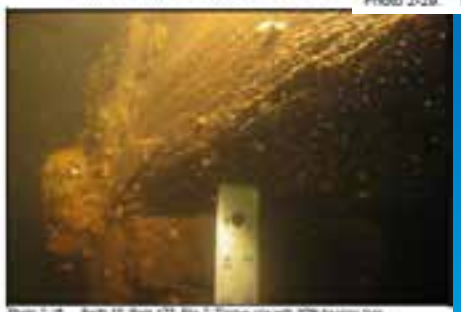


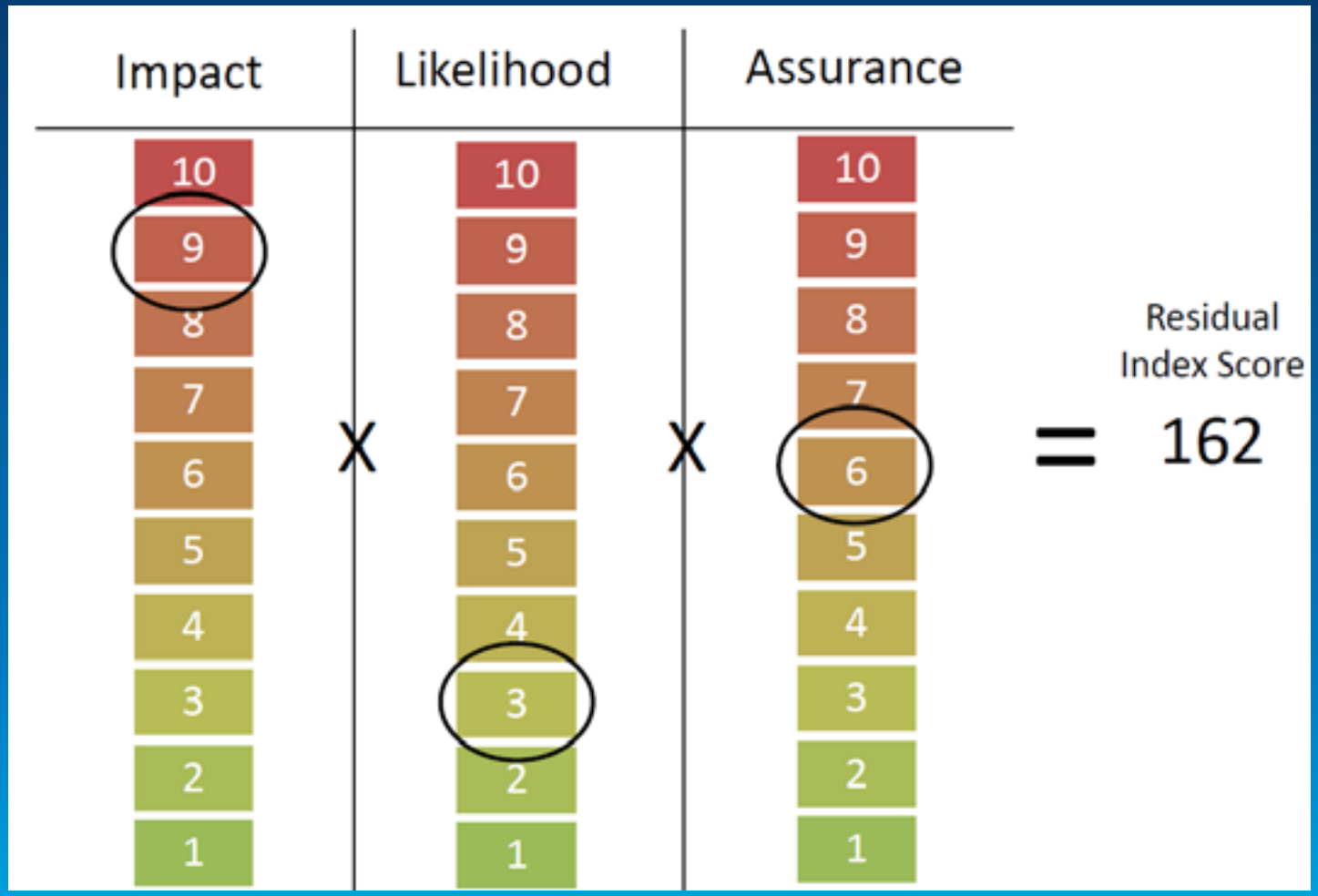
Photo 2-18: Berth 10, Bent 473, Pile 7: Timber pile with 80% bearing loss
(Routine Repair)

Photo 1: Port Newark Berth 10, Bent 460, Pile 8: Timber pile core sample where
surface with section loss due to insects and borer damage

Photo 2: Port Newark Berth 10, Bent 458, Pile 8: Timber pile core sample with
approximately 25% deterioration due to insects and borer damage (Routine

Photo 2-20: Berth 10, Bent 463: Timber pile cap with severe marine borer
deterioration (Routine Repair).

Asset Management Mission and Goals



Asset Management Mission and Goals

INVASIVE SPECIES

Confidential

SUMMARY

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

AVERAGE RESIDUAL INDEX **TREND**

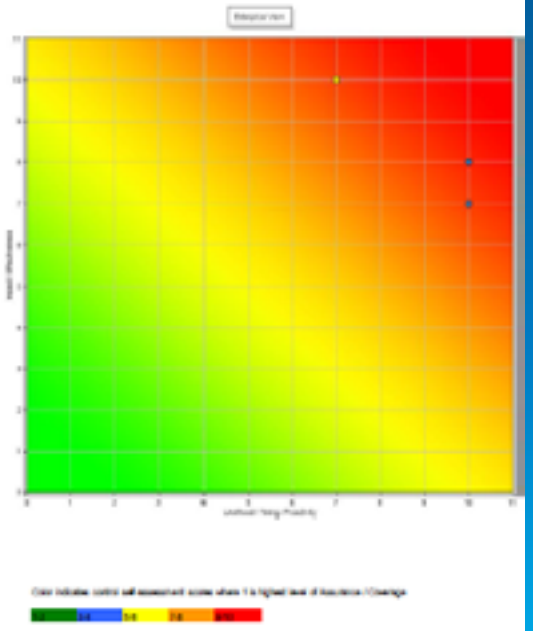
308 ↑

AGENCY OBJECTIVES

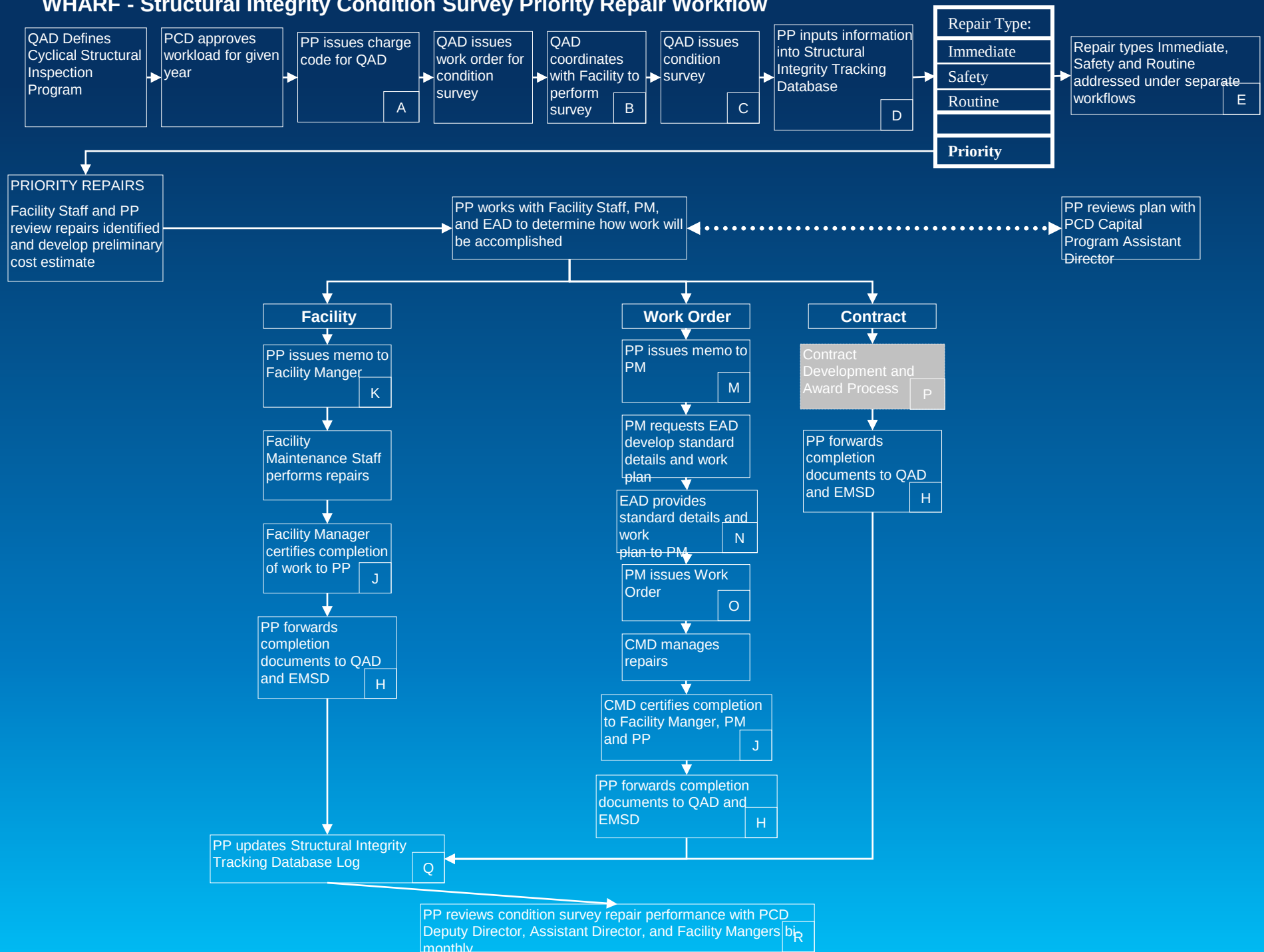
CUSTOMER	FINANCIAL	INTERNAL BUSINESS PROCESS	TALENT MANAGEMENT

DEPARTMENT ASSESSMENTS

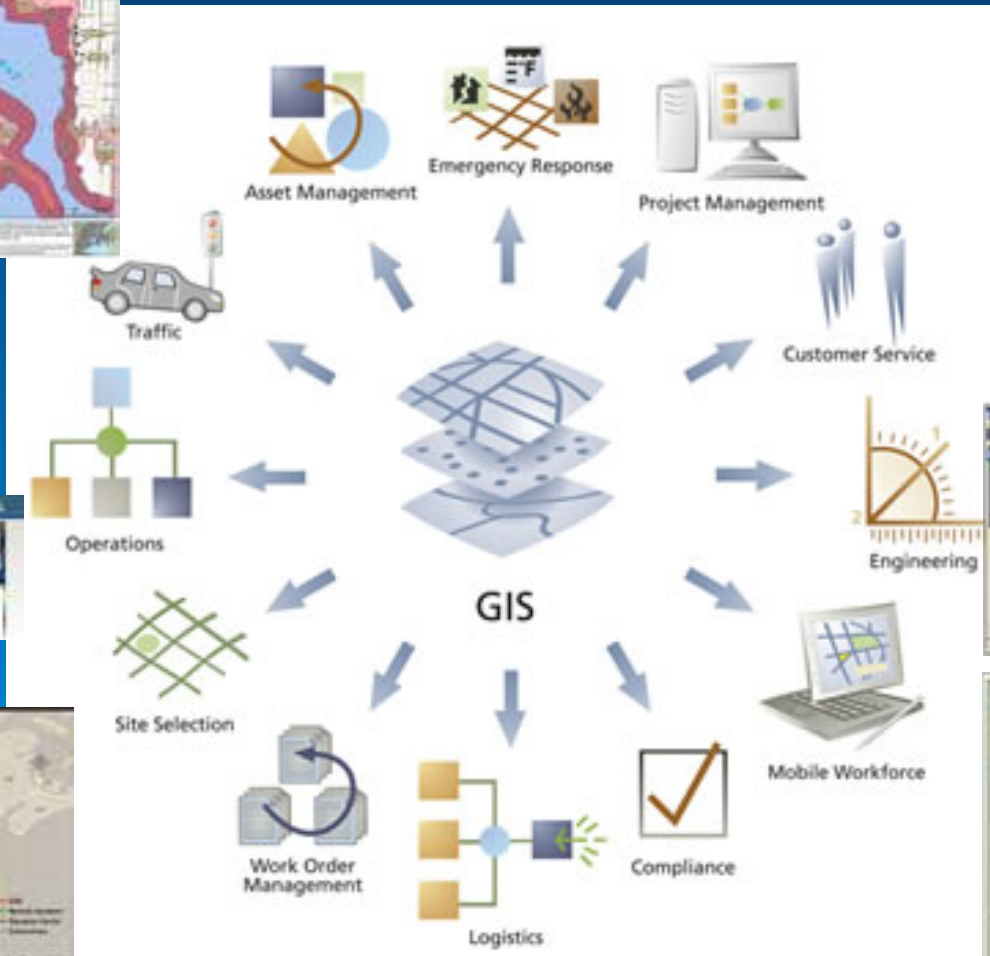
PLAN NAME	TREND	RESIDUAL INDEX	IMPACT	LIKELIHOOD	ASSURANCE
Port Jersey	*	350	10	7	5
Brooklyn PA Marine Terminal/Red Hook Container Terminal	↑	320	8	10	4
Howland Hook Marine Terminal	↑	280	7	10	4
Port Newark/Elizabeth Marine Terminal	↔	280	10	7	4



WHARF - Structural Integrity Condition Survey Priority Repair Workflow



What Does GIS Provide



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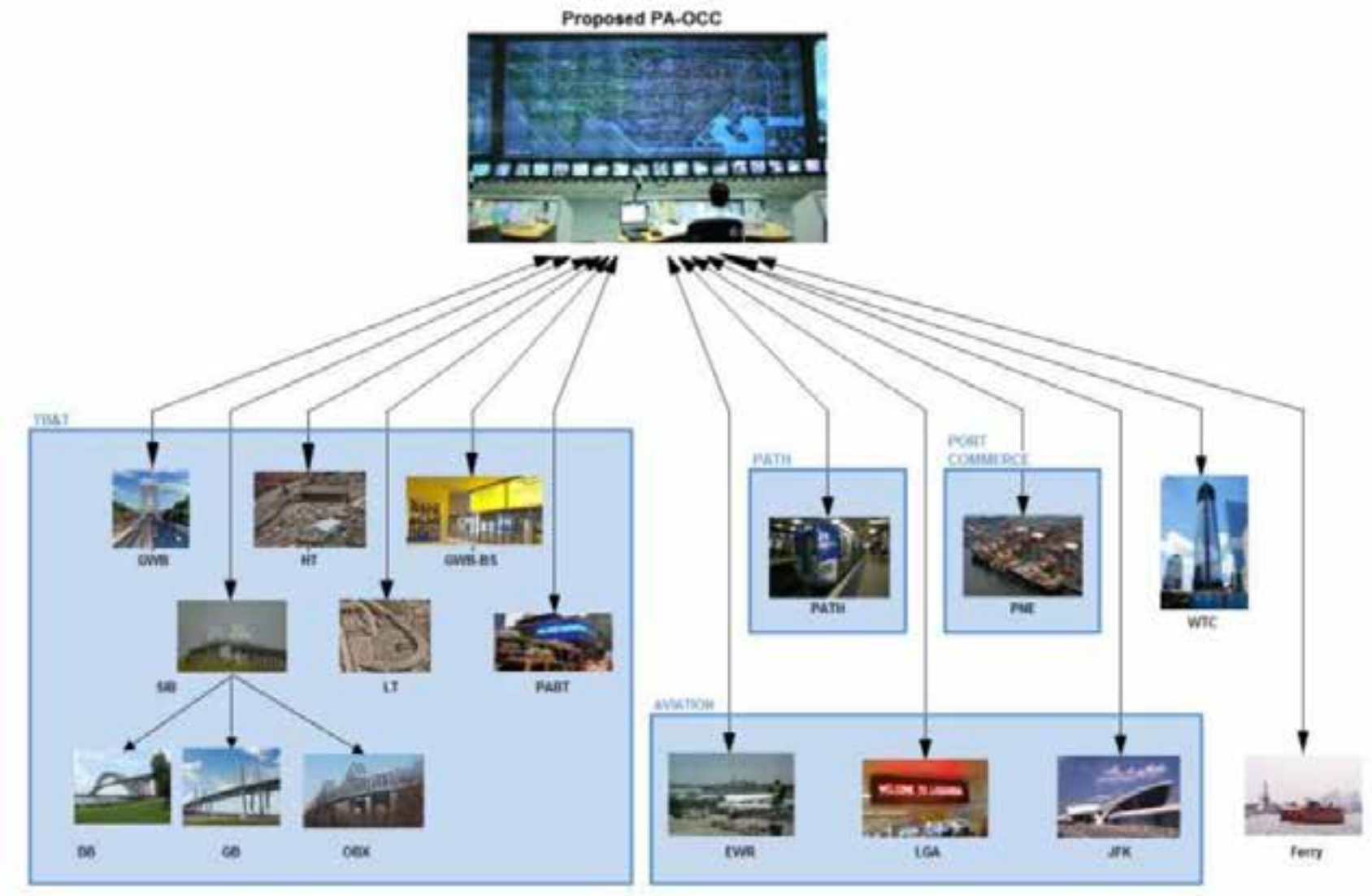

What Does GIS Provide

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

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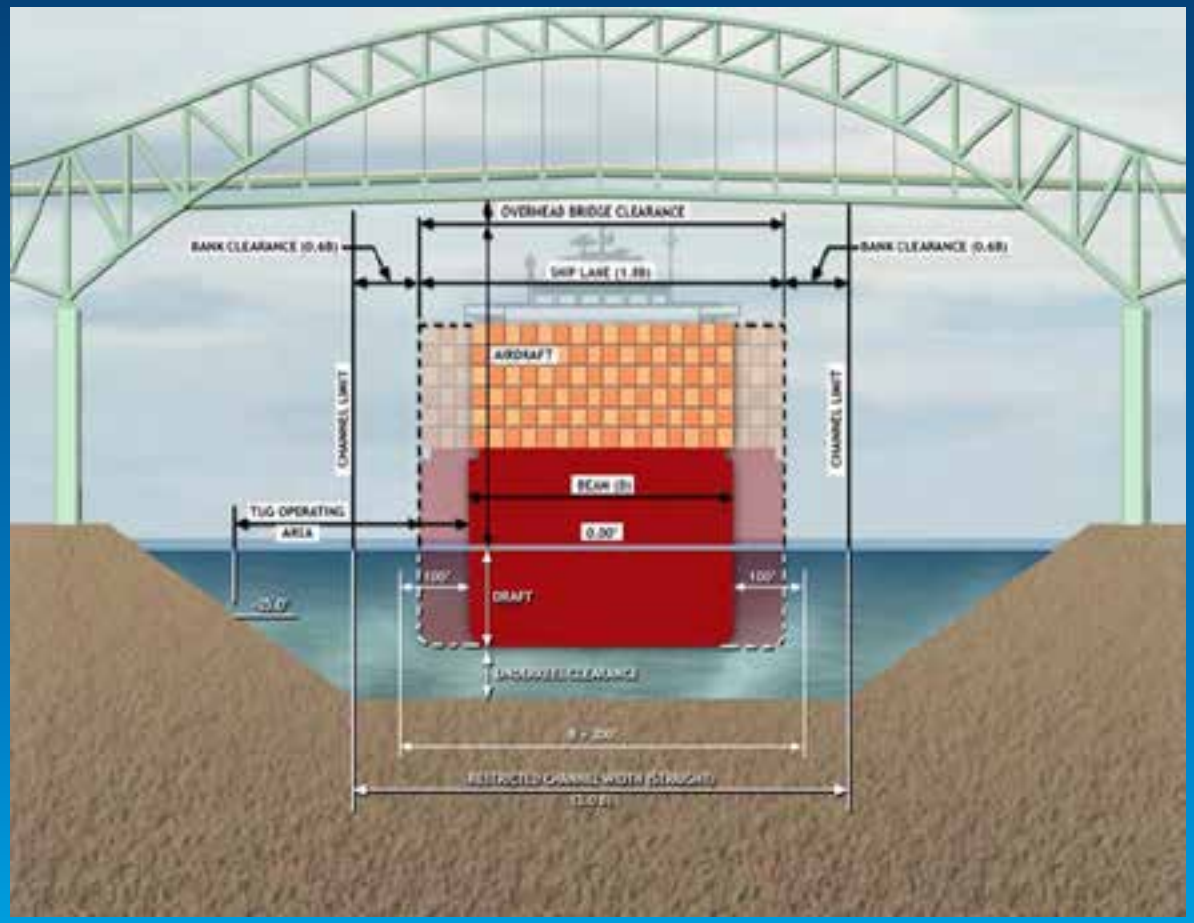

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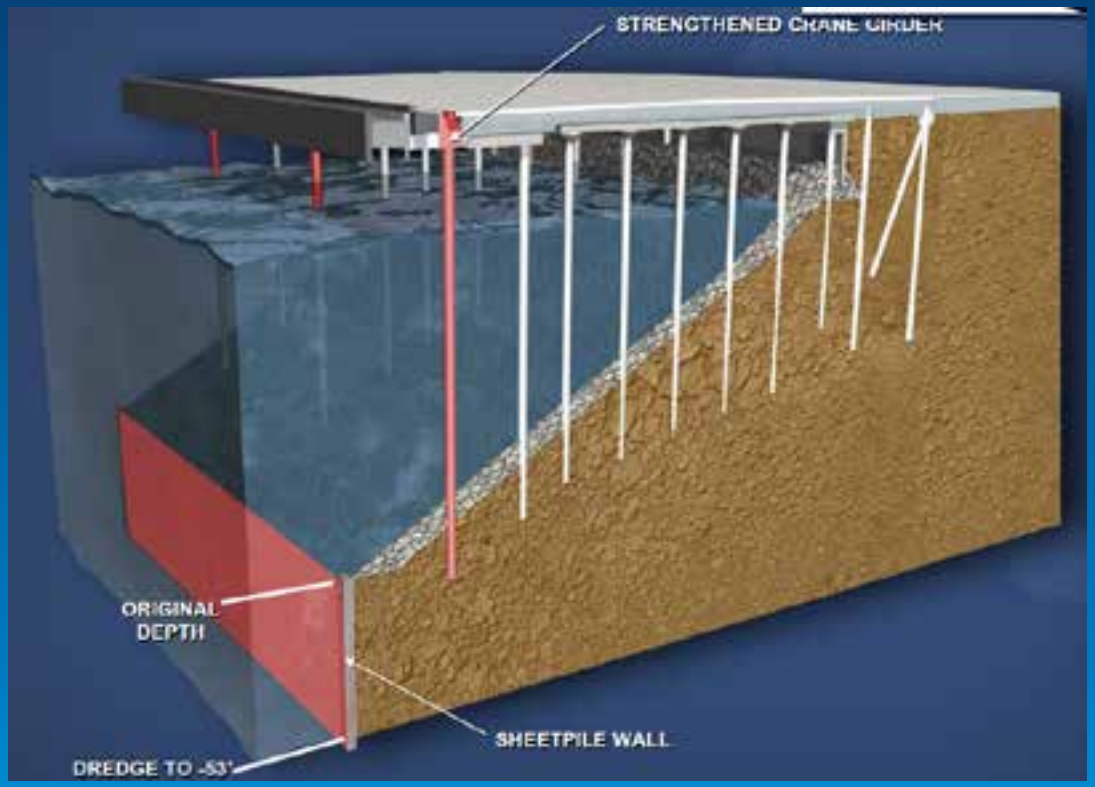


ROI of Geospatial Info (GIS, BIM, GPS, RFID)

Key
■ Principal beneficiary
□ Secondary beneficiary

Project stage	Benefit area	Design team	Main contractor	Sub contractor	Operator	Description	Benefits	Cost benefit
Preliminary, concept and detail design	Visualisations, animations, and virtual reality	■	■	□	□	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.	- More effective promotion of a scheme and stakeholder awareness - A more effective and transparent design process - Improved health and safety management	
	Coordination and clashing	■	■	□		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.	- 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	5% saving in design cost
	Design analysis	■				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.	- Faster design analysis - Error-free transfer of data between analysis and modelling packages - Lower design cost and the ability to consider more design options	
	Material schedules	■	■	□		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.	- Quick production of error-free schedules - Smaller estimating teams - Better awareness of costs as the design develops	1% saving in design cost
	Bills of quantities	■	□			Bills can be produced to any standard and format by exporting appropriate data from the model.	- Quick production of correctly formatted bills with fewer errors - Lower cost of production	
	2D drawings	■	□	□		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.	- More cost effective drawing production, with fewer errors - Fully coordinated design deliverables - Accurate and consistent plans, sections and elevation	
	Links to project documents	■	□	□	□	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.	- Easier access to project information for all stakeholders - Better management of component data - More efficient design process	
	Stakeholder awareness	■	■	□	□	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.	- Improved stakeholder awareness - Easier to secure buy-in earlier in a project - More likely to encourage a good response from potential tenderers	1% saving in design cost
	Design efficiency	■	□	□	□	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.	- Greater design efficiency - Better value for the client - More profit for the designers and no erosion of margin in construction	3% saving in design cost

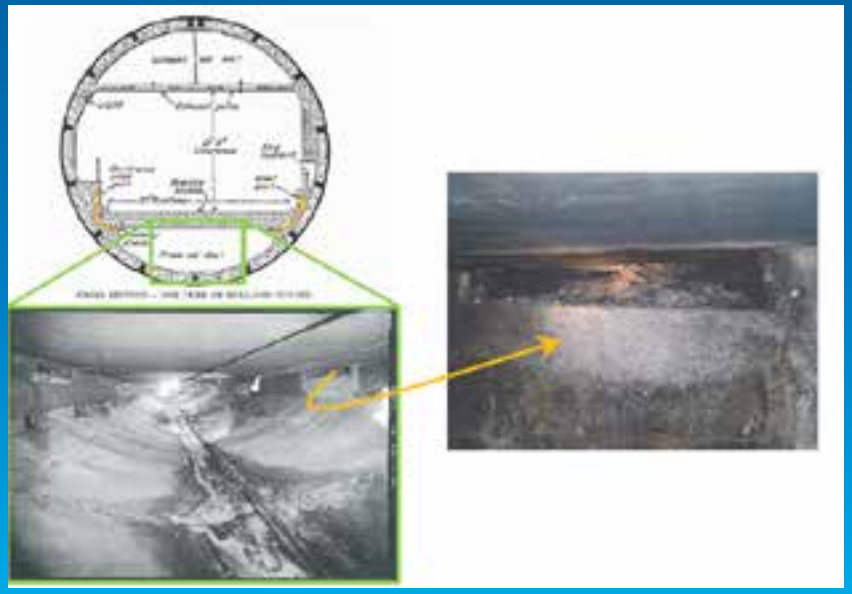
ROI of Geospatial Info (GIS, BIM, GPS, RFID)

Procurement, construction & commissioning	Trade packages		■	■		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'.	- Easier compilation of tender information - Tenderers receive information that is correct, complete and consistent - Lower tender risk contingencies	1% reduction in build cost
	Construction planning		■	□		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.	- Improved project programming and better understanding of activities - Better informed stakeholders - Improved health and safety training of site teams	0.25% reduction in build cost
	Buildability & logistics	□	■	■		Buildability and construction logistics checks are performed in the virtual world during the design phase to prevent problems from ever reaching site.	- More efficient site activities leading to lower construction costs - Greater programme certainty - Improved planning of site laydown areas and materials logistics	
	Clash management	■	■	■	□	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	- Clash free, fully coordinated design and construction - Lower construction cost because of less waste and less disruption - Less burden on the design team during construction - Better certainty of project programme	5% reduction in build cost
	Stage payment		■	□		By monitoring planned and actual progress with a virtual model, payment mechanisms can be more accurate and more efficient.	- Better payment mechanisms - Fewer contractual disputes - Improved transparency of processes	
	2D drawings	■	■	■		Site teams can produce drawings quickly and easily from the model if required, but the need to generate drawings on site is reduced.	- Less burden on the design team during construction - Quicker access to better design information by site teams - More effective interaction with specialist suppliers and subcontractors	
	Awareness of works		■	■	□	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 operatioes.	- Improved understanding of matters affecting health and safety on site - Greater transparency of site activities - Less disruption to programme	0.25% reduction in build costs
	As built information		■	□	■	As-built information can be produced easily and more accurately because the model is kept current through the construction period, ensuring that the facilities manager will receive high quality data.	- Easier to produce high quality as built data for handover - Lower cost of producing as built information	0.05% reduction in build costs

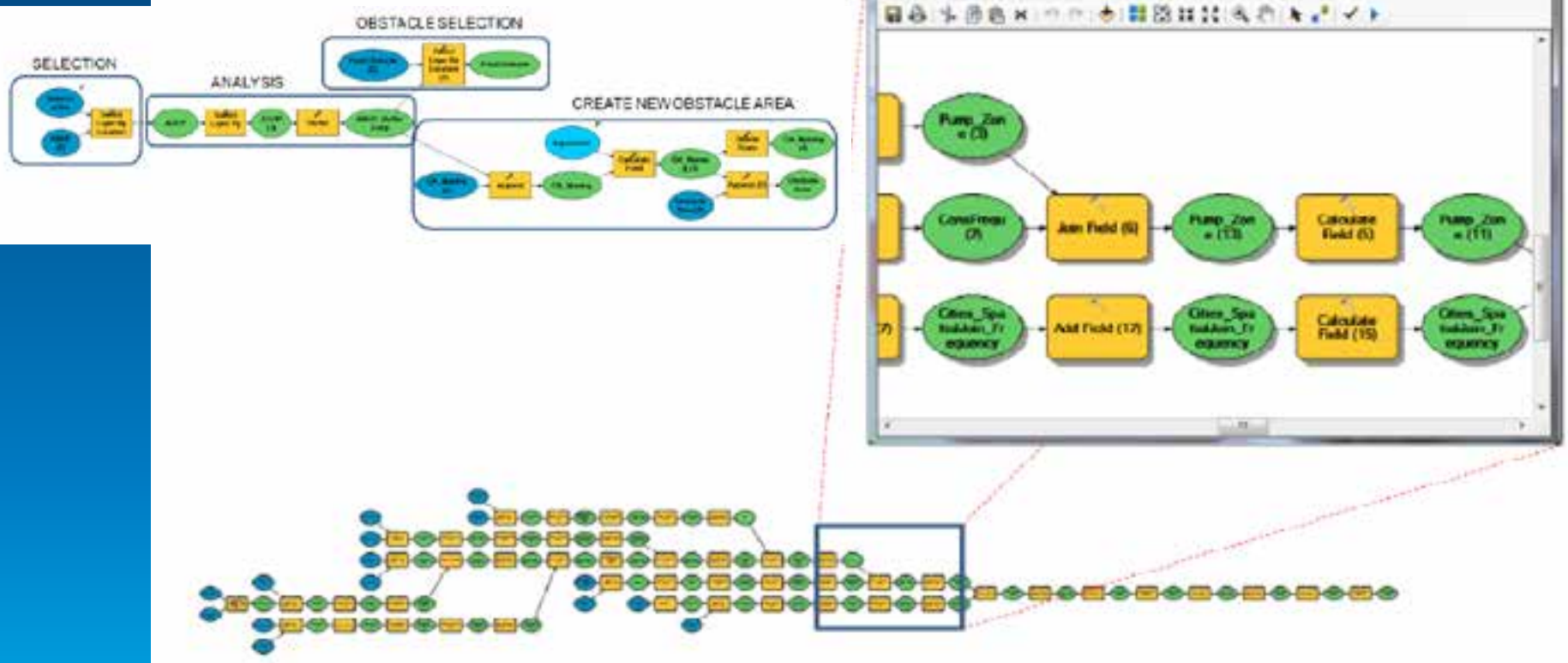
ROI of Geospatial Info (GIS, BIM, GPS, RFID)

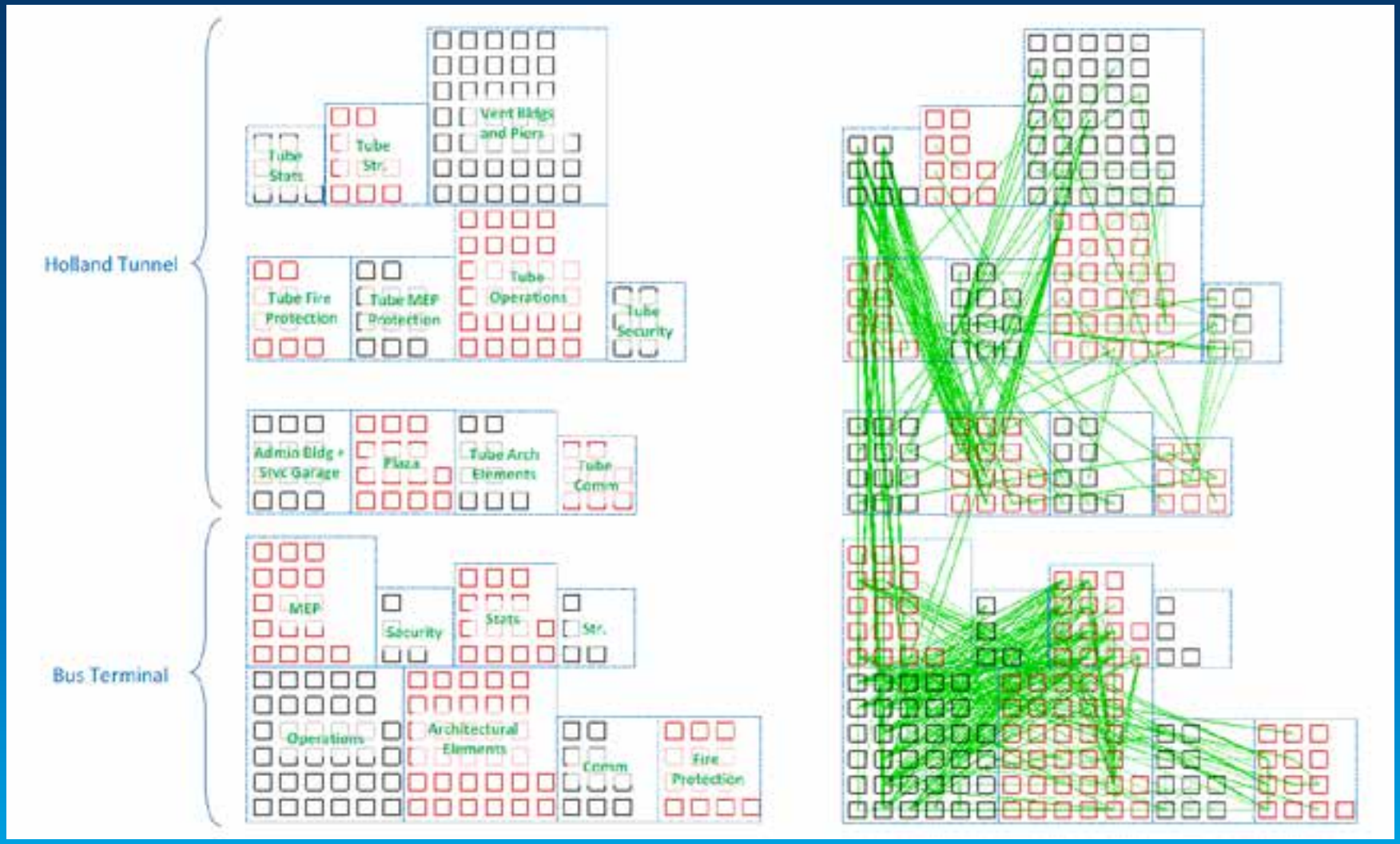
Operations, FM & legacy	Population of FM database		□		■	The virtual model can be used to automatically populate a facilities management asset database at the end of construction, generating a large saving in staff resources and cost.	· Swift, accurate population of the FM database with good quality data · Lower cost of establishing the FM system	Ok one-off saving
	Managing operations				■	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.	· More efficient facilities management · Staff have easy access to high quality record information · Lower cost of operations (including auditing, benchmarking, etc)	
	Managing new works and change	□	□		■	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.	· More efficient design and implementation of new works · Improved health and safety · Lower cost of managing the facility as it evolves over time	Annual saving
	Links to product information				■	The virtual building can be linked to project documents and to suppliers' product information, either on or off the Web.	· Easier and quicker access to product information · Lower cost of sourcing data	
	Links to BMS systems				■	Environmental controls, sprinkler systems, lifts etc. can be link to the model so that these can be managed graphically	· More effective facilities management	
	Links to security systems				■	The model can be linked to security systems to assist with access control, closed circuit TV and fire detection.	· More effective facilities management	
	Links to stock control system				■	Stock control items, such as office partitions and furniture, can be managed by linking them to the model.	· More effective facilities management	
	Hazardous material location	□	□	□	■	The construction industry does not use hazardous materials but if future legislation were to require, say, all glass fibre insulation to be located in a building, then the model could be interrogated to show its position.	· Lower cost of complying with legislation	
	Building cloning	■			□	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.	· Much reduced cost or providing similar facilities in future	
	Knowledge management	□			■	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.	· Easy referencing of project knowledge · Lower cost of due diligence activities	
	Sustainability	□			■	The model contains data relating to sustainability, such as the location, quantity and quality of reusable materials.	· Quick access to high quality sustainability data · Efficient sustainability reporting, auditing and management	
	Decommissioning	□	□	□	■	The virtual model contains important data about items such as structural walls that decommissioning contractors can use to minimise the risk of, for example, uncontrolled collapse.	· Safe decommissioning · Lower risk contingencies in decommissioning tenderers' quotations.	

Risk Assessment with Modeling



Risk Assessment with Modeling





Network of Interactions for the Holland Tunnel and the Bus Terminal

Resilience Assessment Workflow

ID	Facility	Category	Consideration	Condition Rating	Importance Factor	Hypercritical Flag	Time to Recovery	Network Interaction

- *Arch*
- *Structural*
- *Comm*
- *MEP*
- *Operations*
- *Security*
- *Fire/Life-safety*
- *Stats*

- *Parents*
- *Children*

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

Facility Rating

4**R**s

Composite **R**

Calculating Resilience

$$R = f(W_{CR}CR\ ,\ W_{TTR}TTR,\ W_{CE}CEE)$$

Main Variables:

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

Weighting on Variables depends on:

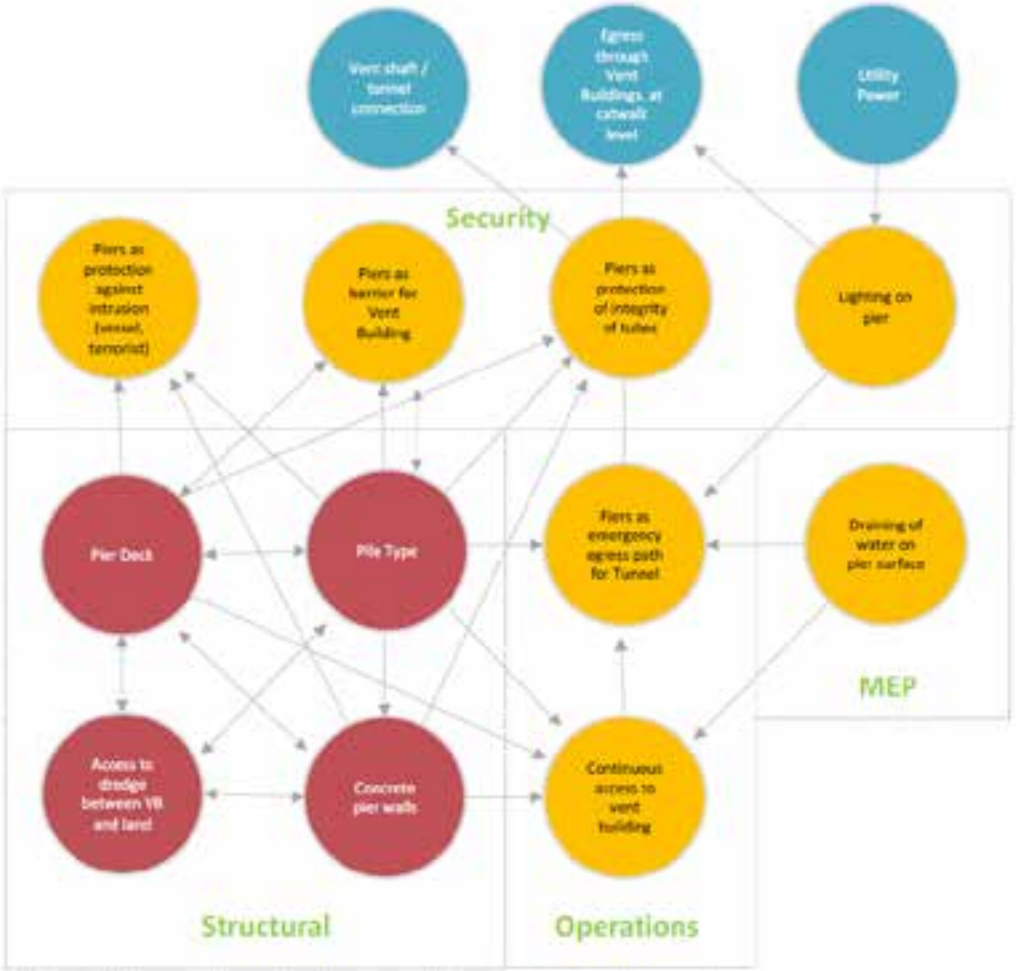
- Importance Factor
- Hypercriticality Index

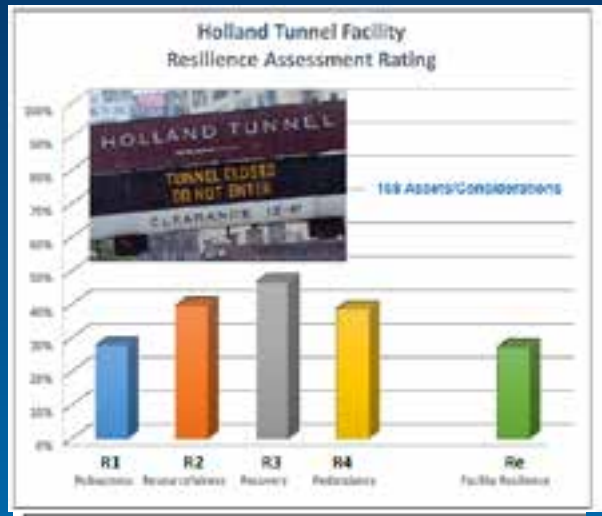
Example: Cascading Effects

Project #1: Pier 9 and Pier 204 Replacement

The project "touches" assets beyond its construction zone, and its effect on resilience is magnified the larger the cascading chain.

- Hypercritical
- Other Considerations
- Considerations Outside Project Scope





- Resilience is measured through its 4 attributes, per DHS methodology:
  - Robustness,
  - Resourcefulness,
  - Recovery and
  - 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

Resilience Ratings (the 4 **R**s) for a facility highlight:

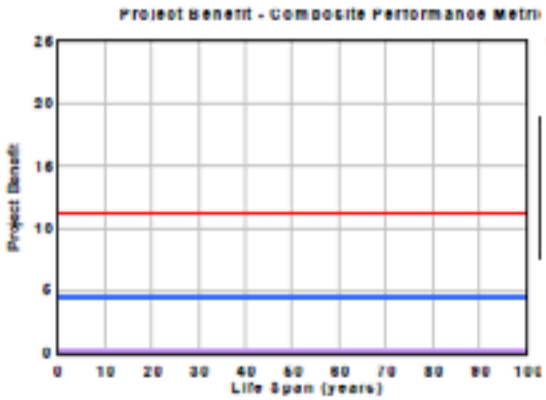
- Performance levels for specific hazard
- Attributes towards which investment should be targeted.

Major impactor on higher resilience score

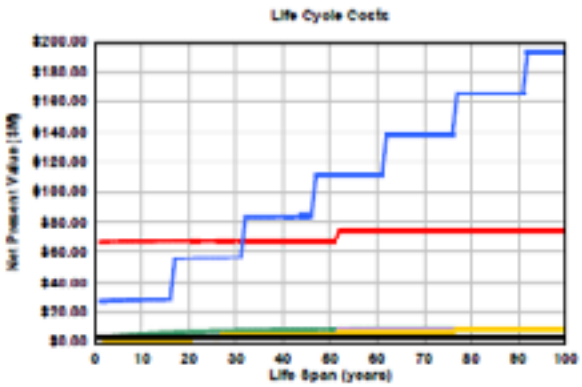
Higher elevation of facility makes it less susceptible to flooding.

Availability of emergency personnel and support staff.

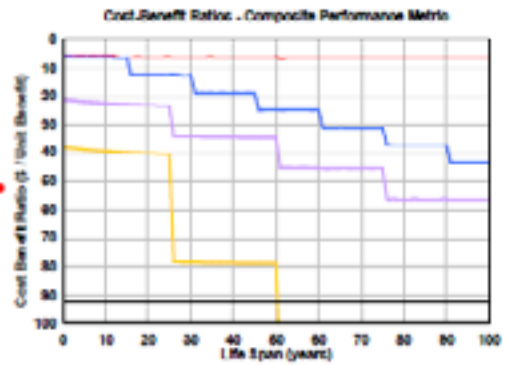
Project Prioritization
Workflow "Snapshots"



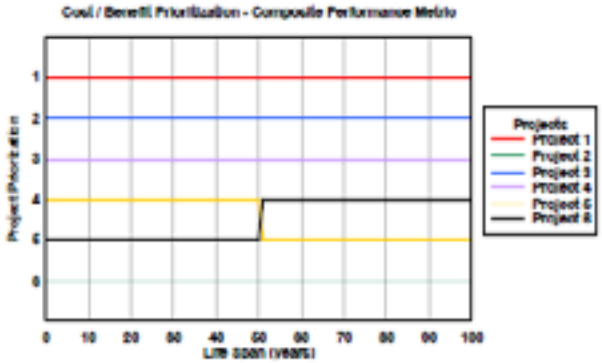
BENEFIT



COST



COST / BENEFIT



PRIORITIZATION

Projects Legend:

1. Replacement of Pier 9 and 204
2. Replacement (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

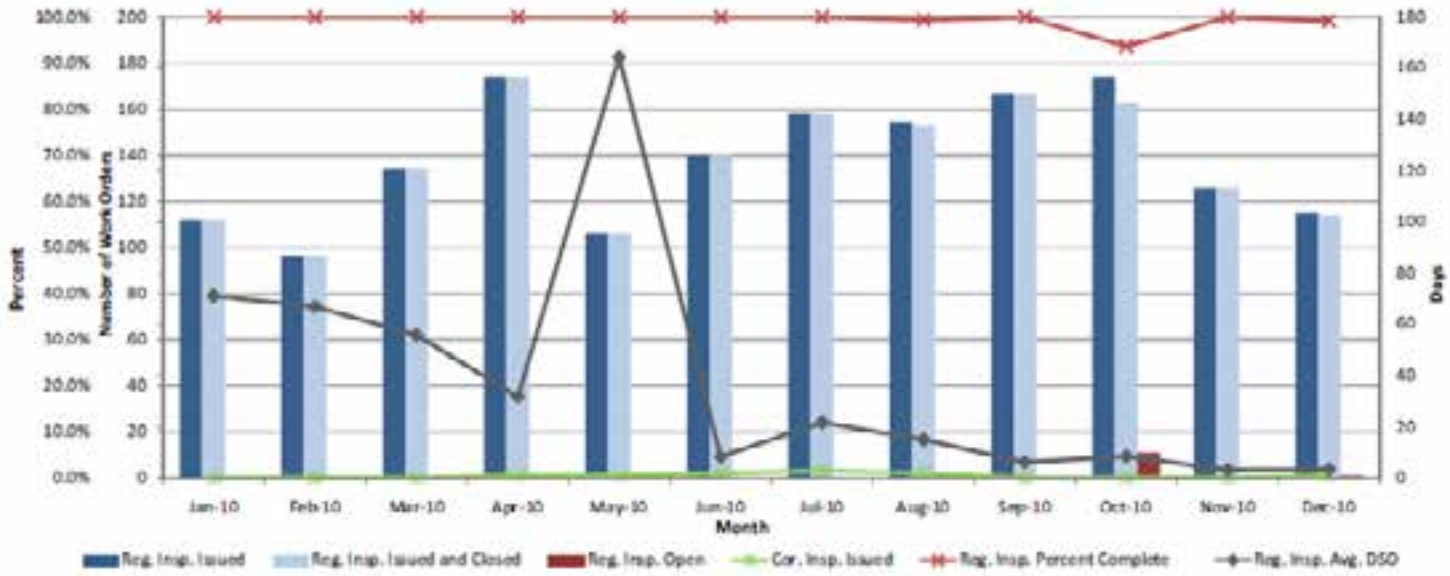
Port Authority of NY/NJ

Percent Complete Report

Regulatory Inspection Work Orders

Aviation Fire Pumps

Regulatory Work Order	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Total
Reg. Insp. Issued	112	96	134	174	106	140	158	154	167	174	126	115	**1,656**
Reg. Insp. Issued and Closed	112	96	134	174	106	140	158	153	167	163	126	114	**1,643**
Reg. Insp. Open	0	0	0	0	0	0	0	1	0	11	0	1	**13**
Reg. Insp. Avg. DSO	71	67	56	32	164	8	22	15	6	8	3	3	**456**
Reg. Insp. Percent Complete	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.4%	100.0%	93.7%	100.0%	99.1%	**99.2%**
Cor. Insp. Issued	0	0	0	1	1	2	3	2	0	0	0	1	**10**
Cor. Insp. Issued and Closed	0	0	0	1	0	1	3	2	0	0	0	0	**7**
Cor. Insp. Open	0	0	0	0	1	1	0	0	0	0	0	1	**3**
Cor. Insp. DSO	71	67	56	32	164	8	22	15	6	8	3	3	**456**



Key Performance Indicators

PANYNJ

Labor Utilization

Month | 12 Month

Regulatory Inspection Percent Complete

MIN = 98.4% (Aviation)

MAX = 99.6% (TB&T)

Month | 12 Month

Avg. DSO Regulatory Corrective

Month | 12 Month

Preventive Maintenance Percent Complete

Month | 12 Month

Percent PM Work Orders

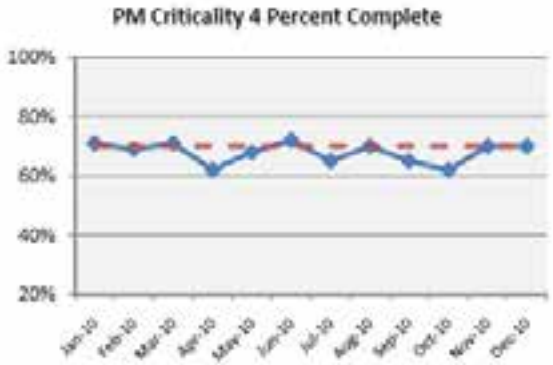
Month | 12 Month

Percent Emergency Work Orders

Month | 12 Month

Key Performance Indicators - Preventive Maintenance

PANYNJ



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 on-going 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