

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MIT Center for Transportation & Logistics



Big Data & Innovation



Resilience in America's Ports

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 AAPA 2014 Port Security Seminar
 Baltimore, MD

James B. Rice, Jr.
 Deputy Director – MIT CTL












The Center for Secure and Resilient Maritime Commerce (CSR)

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Resilience in America's Ports

- Issues
- Big Data
- How to Create Port Resilience
- Innovation in Port Resilience



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Issues

- Security – Operational Efficiency Tradeoff → Balance
- Security – Resilience → what is the tradeoff/relationship?
- Do we all understand port resilience?
 - Many independent economic entities with different goals
- Planning for Port Resilience
 - Do we really know how to create Port Resilience?
 - Do we all have the same target for resilience outcomes?
- Big Data means big opportunities, big challenges



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Big Data: Big Opportunities, Big Challenges

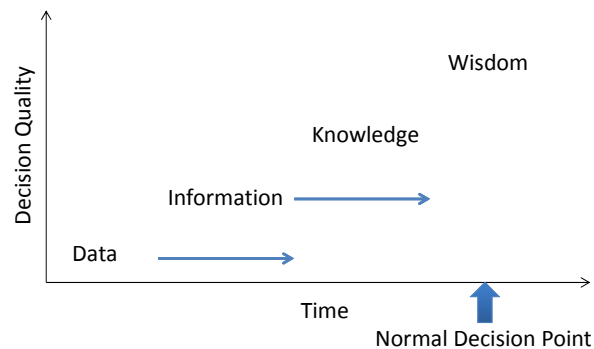


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Double-edged Sword of BIG DATA

- Great potential, great obstacles
 - Today: many new sources, minute detail, high volume, real-time, potential to leverage RT data for a common operational picture
 - But: data is static, not readily available, not integrated, not validated, not easily processed into → Information → Knowledge



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Data → Information → Knowledge → Wisdom

Situation	Data	Information	Knowledge
Port closure	Risk impacts if cargo does not reach destination	Economic risk to region	Priority for 1 st cargo permitted, Trade Resumption plan
Port closure	Alternate port capacities, expected delays	Validated options for cargo allocation	Priority for alternate port selection
Oil spill in waterway	Port conditions, currents, wind direction and speed	Anticipated migration and movement of spill	Optimal allocation of spill clean up resources and locales
Hurricane forecasted	Storm performance, wind strength, waterway structure	Prediction of storm surge	Port locations at most risk, requiring personnel and asset movement

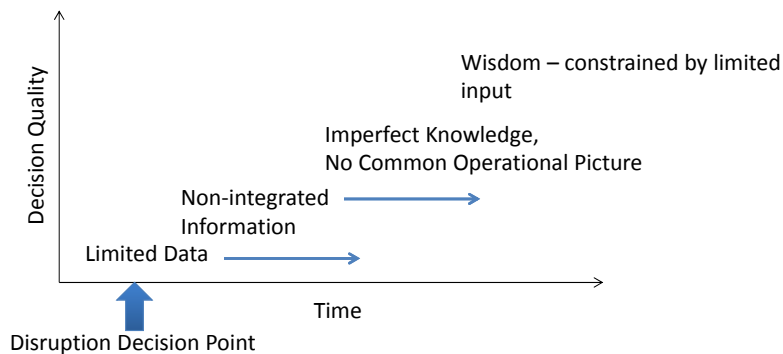


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Double-edged Sword of BIG DATA

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BIG DATA

Land Side

Facility
Contact DataFacility
Vulnerability
AssessmentsRoad, rail
data and
capacityImpact
Assessments
(1st & 2nd order)Intermodal
capacityEnvironmental
Factors

MSRAM

Commodity
typesShoreline
SensitivityCargo
handling
capacity

Water Side

Currents

Tides

Surface
temperatureWaterway
dataMDA
dataTerminal,
Facility DataVessel
locationIncident
information

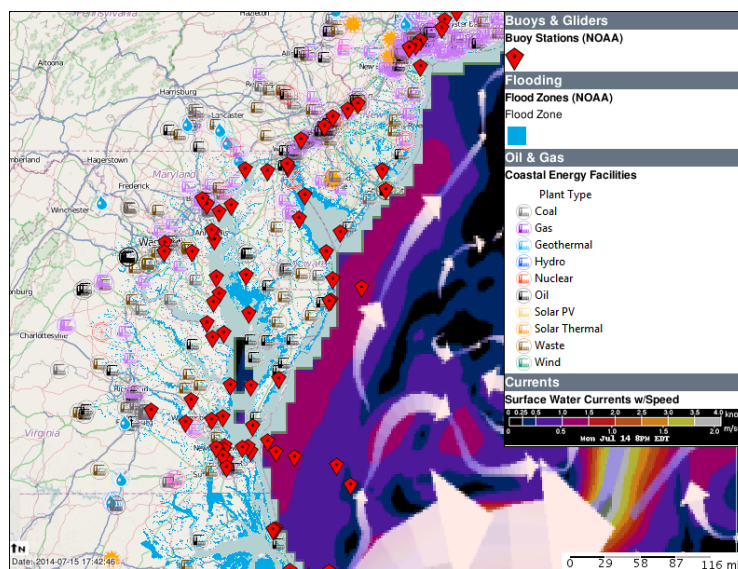
Salinity

Vessel call
history, crew
dataWind
strength &
vector

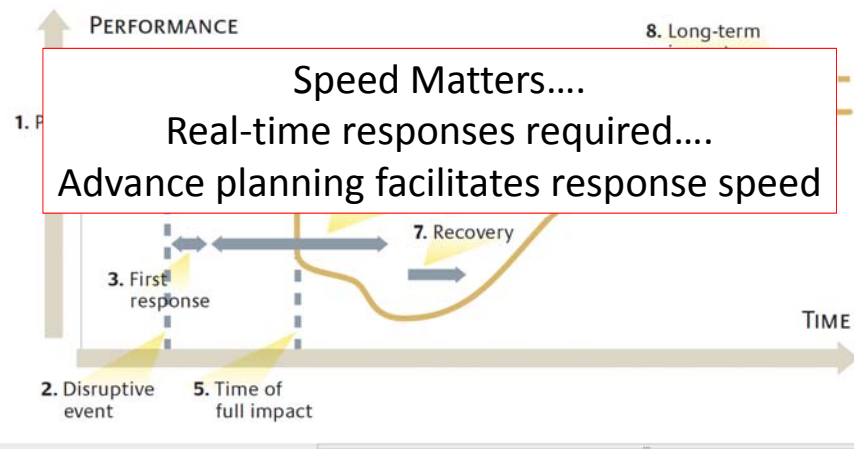
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ERMA Atlantic Bundles Data...some Data

US DOC | NOAA | NOS | NOAA Office of Response & Restoration
Email Comments: orr.erma@noaa.govCoastal Response Research Center
© 2007-2014 University of New HampshireERMA | Environmental Response Management Application
Atlantic

Decision Timing & the Life Cycle of a Disruption



Ref. – Sheffi, Rice, Supply Chain View of the Resilient Enterprise, Sloan Management Review 2005



Creating Port Resilience



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Supply Chain → Port Resilience

- Supply Chain Resilience:
 - In material science, resilience is the physical property of a material that can return to its original shape or position after a deformation that does not exceed its elastic limit.
 - In today's business environment, resilience is widely used to characterize an organization's ability to react to an unexpected disruption, such as one caused by a terrorist attack or natural disaster, and restore normal operations.
 - It's the ability to recreate supply chain capabilities, to 'bounce back' from variations and disruptions
- Examples of port resilience?

Source: "Building a Secure and Resilient Supply Network" by J. Rice, F. Caniato, SCMR Sept-Oct 2003

Risk Management Framework & ISO 31000

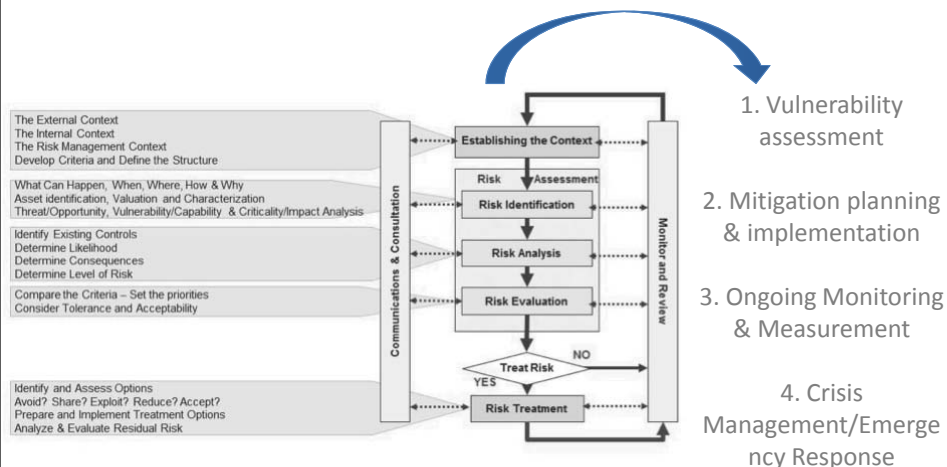


Figure 1: Risk Management Process (based on ISO 31000)

Creating Port Resilience

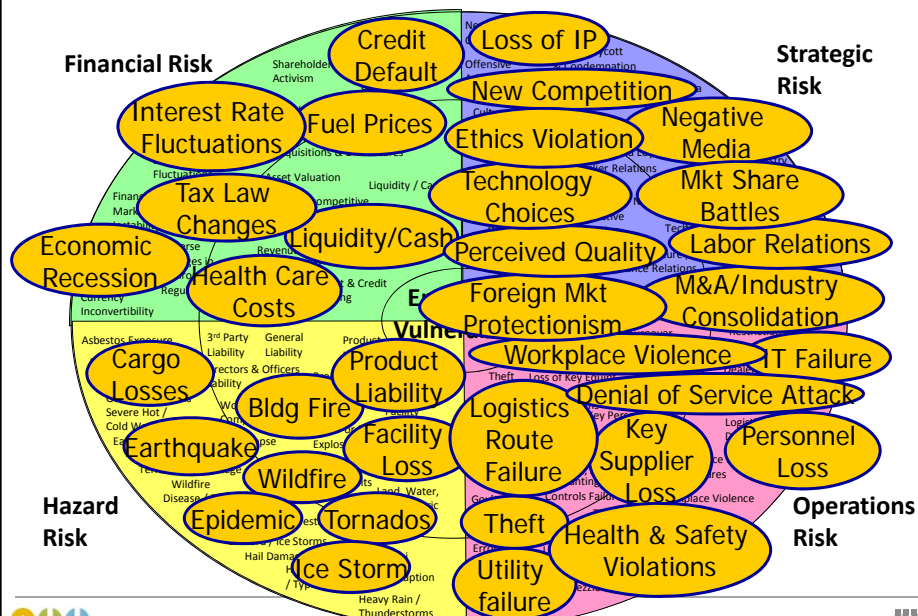
- Vulnerability and Response Assessment
 - Identify risk sources, response capabilities/capacities



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Nearly an Unlimited Source of Enterprise Risk



Ref: Dr. Debra Elkins, General Motors



Creating Port Resilience

- Vulnerability and Response Assessment
 - Identify risk sources, response capabilities/capacities

How capable are domestic US ports?



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Assessing Response Capabilities: Capacity Assessment Absorbing Volume Post-Disruption

Commodity/Conveyance Top 3 Ports for the commodity	Min Capacity Needed to Absorb Volume of Top Port
Container Top 3 Ports: Los Angeles, Long Beach, NY/NJ	26%
Chemicals Top 3 Ports: Houston, South Louisiana, Baton Rouge	23%
Coal Top 3 Ports: Mobile, Pittsburgh, Hampton Roads	16%
Food and Farm Products Top 3 Ports: So. Louisiana, New Orleans, Plaquemines	50%
Manufactured Equipment Top 3 Ports: Los Angeles, NY/NJ, Hampton Roads	18%
Petroleum Top 3 Ports: Houston, NY/NJ, South Louisiana	16%
Raw Materials Top 3 Ports: Duluth-Superior, NY/NJ, So. Louisiana	5%



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Creating Port Resilience

- Vulnerability and Response Assessment
 - Identify risk sources, response capabilities/capacities
- Ongoing Monitoring
 - To assess required response
 - ERMA available now – but scope is limited
- **All-hazards Continuity Plans**
 - Backup for critical infrastructure and systems (Port infrastructure, Intermodal, Waterways, Terminals)
 - For each failure mode/predictable outcome
 - Response plans, how will cargo in/out be processed?
 - Restarting operations/trade resumption
 - Do you have the governance to respond? Jones Act/Sandy



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Supply Chain Failure Modes – Predictable Outcomes

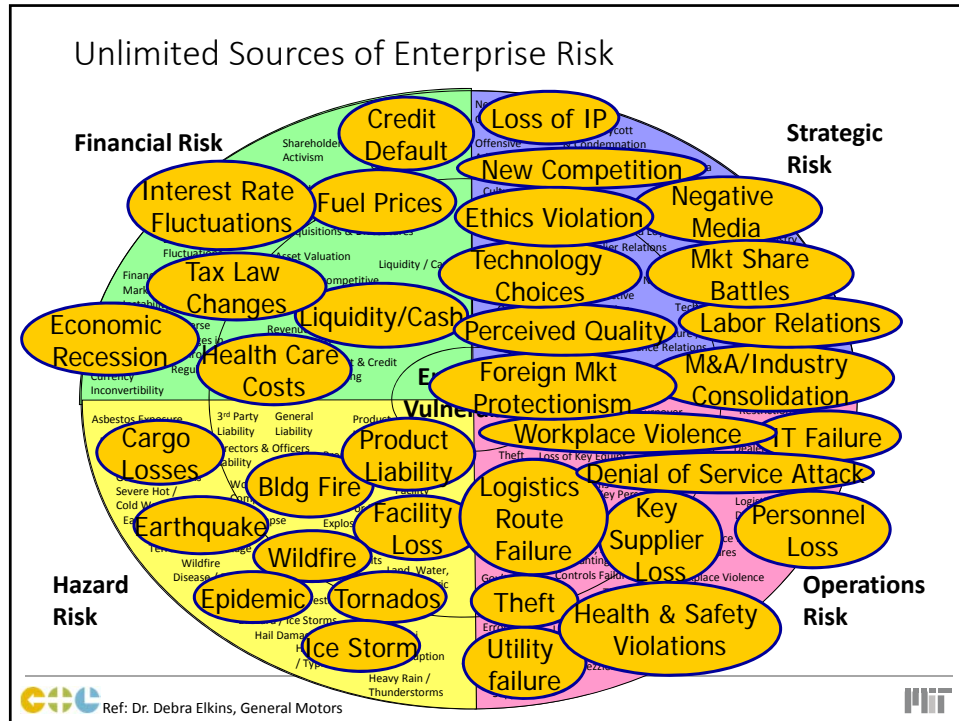
All disruptions result in a loss of one or more of these capacities:

- Capacity to acquire materials (supply)
- Capacity to ship/transport
- Capacity to communicate
- Capacity to convert (internal operations)
- Human resources (personnel)
- Financial flows



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Response Options by Failure Mode

Failure Mode	Resilience Action	Advantages	Disadvantages
Loss of supply / materials	Use multiple sources, multiple locations	Spread risk across firms, locations	Higher cost to qualify suppliers, lower volume leverage
	Use single source	Known supplier	Vulnerable to disruption w/o multi-site back ups
	Modify product to use standard parts	Reduces part invty cost, complexity	Costly to modify existing materials standards

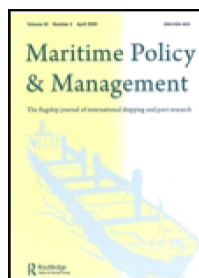
Continuity Plans



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Continuity Plans for Port Resilience



Maritime Policy & Management

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tmpm20>

Failure modes in the maritime transportation system: a functional approach to throughput vulnerability

Øyvind Berle ^a, James B. Rice Jr. ^b & Bjørn Egil Asbjørnslett ^a

^a Department of Marine Technology, Norwegian University of Science and Technology, Trondheim, Norway

^b Massachusetts Institute of Technology, Cambridge, MA, USA

Available online: 07 Oct 2011

MARIT. POL. MGMT., NOVEMBER 2011,
VOL. 38, NO. 6, 605–632



Table 4: Elaboration of failure modes for ports

Port	Failure mode: Loss of	Elements that may be backed up
Supply	Port supplies, utilities and infrastructure	Electricity, wastewater, water, roads, rail, land area, inventory, tugs, pilot boats
Transportation	The ability to move goods and people within and through the port	Transportation providers, trucks, lifts, stackers, gantry cranes, chassis
Communication	Communication, coordination and information systems across port players	Phone lines, mobile phone, data systems and networks, internet access
Internal operations / Capacity	The ability to move and position vessels, maintain safety and security, invest, develop and market port.	Berth spaces and lengths, support vehicles and vessels, business strategies
Human resources	Personnel operating port functions, supporting business	Port authority, pilots, managers, security, technicians

**Table 5: Elaboration of failure modes for terminals**

Terminal	Failure mode: Loss of	Elements that may be backed up
Supply	Terminal supplies, utilities and superstructure	Electricity, wastewater, water, land area, inventory, spare parts
Transportation	The ability to move goods and people within the terminal	Transportation providers, trucks, vans, lifts, stackers, gantry cranes, chassis,
Communication	Communication, coordination and information systems within terminal and to port	Phone lines, mobile phone, data systems and networks, internet access
Internal operations / Capacity	Loading / unloading, processing, documentation, Capacity	Storage space, cranes, conveyors, stackers, inventory
Human resources	Personnel operating terminal	Longshoremen, stevedores, drivers, managers, security, technicians



Table 7: Elaboration of failure modes for intermodal connections

Intermodal connections	Failure mode: loss of	Elements that may be backed up
Supply	Infrastructure leading to public infrastructure system, supplies for transportation and maintenance	Roads, rails, bridges channels, fuel, parts, chassis
Transportation	Equipment for moving and transloading goods for surface transportation Oversight and the ability to document and coordinate cargo shipment, communication between parties – stevedores, truckers, terminal operators	Trucks, lifts Routing systems, communication with providers, IT systems,
Internal operations / Capacity	The ability to transload goods between surface transportation and vessels, including processing and storage.	Inventory, spare chassis, storage and transloading space
Human resources	Personnel responsible for managing and performing transloading operations	Drivers, management, planners



Innovation in Port Resilience



Innovation in Port Resilience

- Port Mapper (CSR, MIT)
 - Cargo capacity, alternate port visualization and ID tool
- Magello (CSR, Stevens Institute of Technology)
 - Emergency response and management visualization tool
- Other....



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Port Mapper



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Port Disruption Response – Cargo Allocation

- What are the options for cargo allocation in the event of a disruption?
 - Need capacity
 - Proximity to disrupted port
 - Match cargo type – containers go to container terminals, dry bulk goes to dry bulk terminals, etc.
- While there are ~361 ports in the US
 - Not every port is an option
 - Concentration of commodity types reveals vulnerability
- Which port handles which cargo?
 - To date, we can only answer using intuition but not data
 - So we developed a tool to identify cargo allocation options

Cargo Allocation/Capacity Model

- Used 5 Years of annual port data (Army Corps of Engineers)
 - Segmented by commodity (SIC), port and cargo flow direction
- Augmented with port location information, water- and land-based distances between ports
- Created Excel-based model to understand port capacity in greater detail

Capabilities of Model/Tool

Cargo Allocation/Capacity Model Capability: The user can....

Fail single port and identify alternate port options for cargo

Fail multiple ports and identify alternate port options for cargo

But you need an analyst to use it...

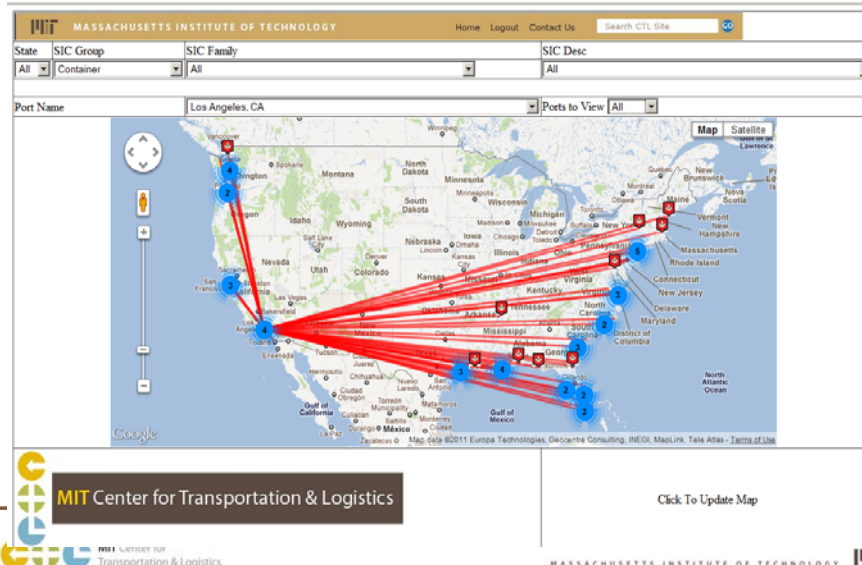
so we made a visual app called

Port Mapper

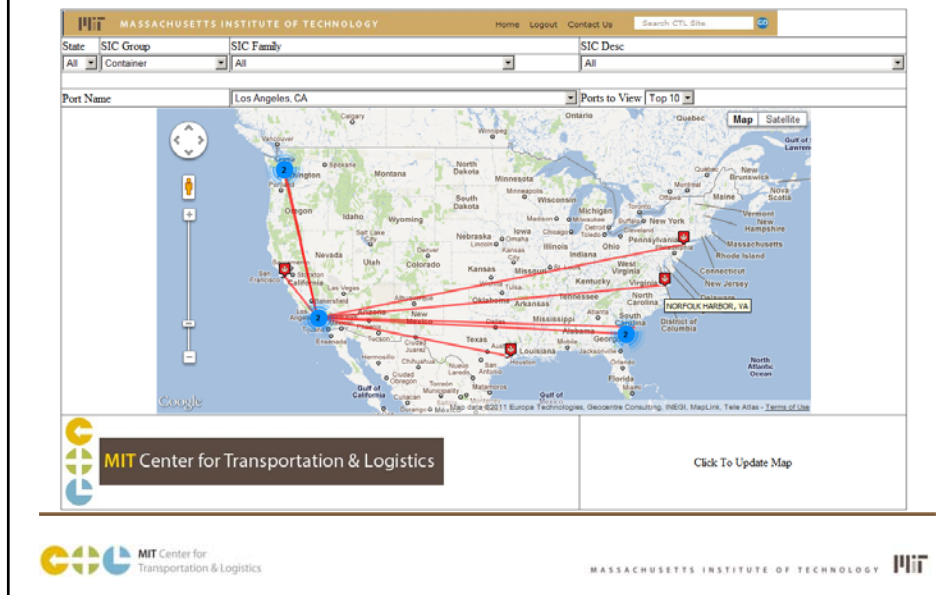
Fail port and allocate different amounts of cargo to different ports

Calculate port capacity requirements

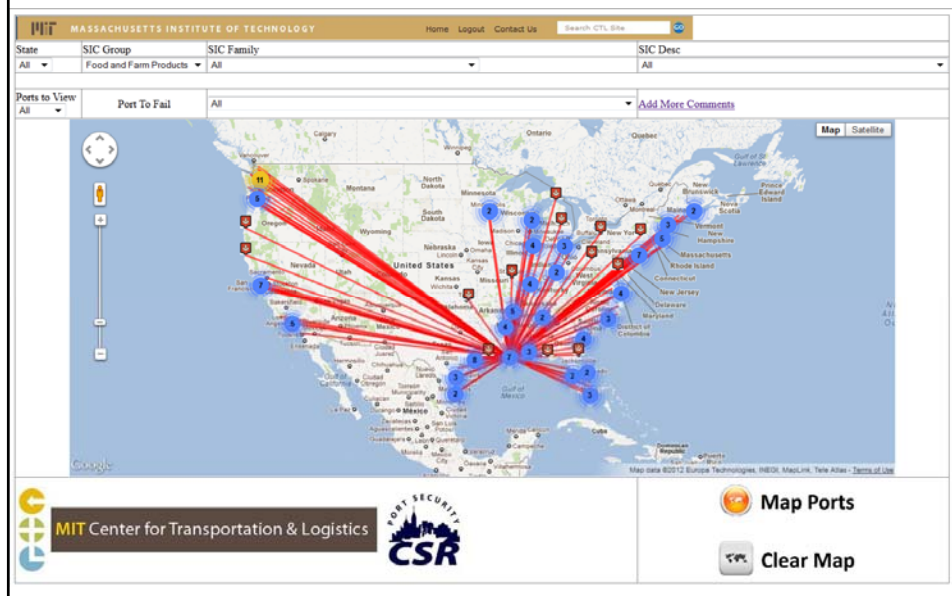
What would happen if Los Angeles could not handle containers? Where could the volume go?



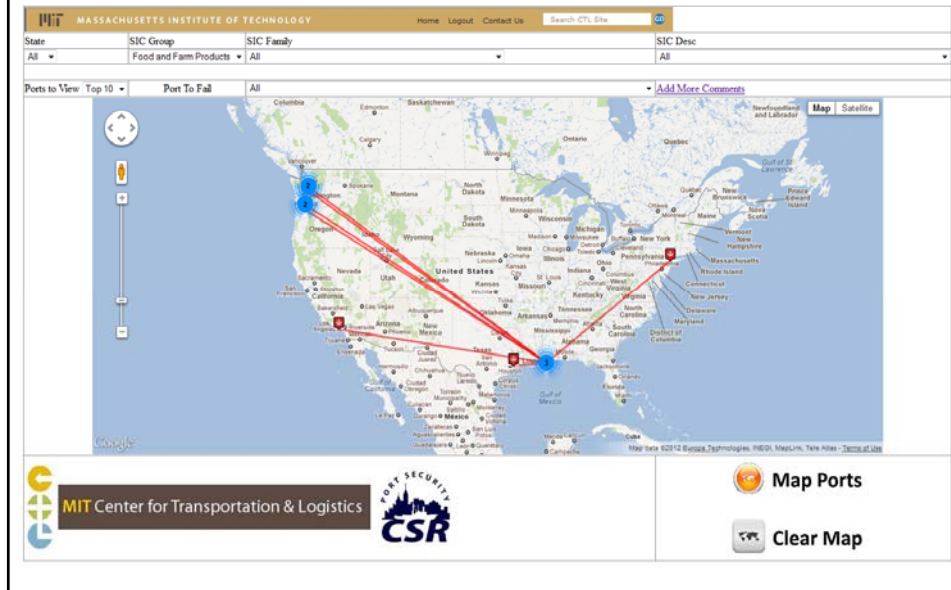
Continued: LA constraint. Where could the volume go if only the top 10 container ports were used?



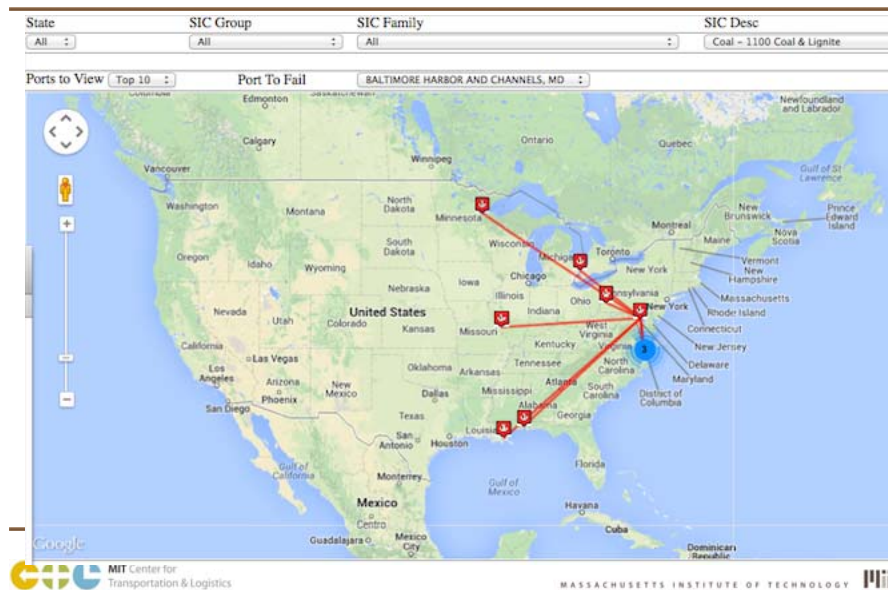
What if So. Louisiana could not handle Food & Farm Products? Where could the volume go?



Continued: So. Louisiana constraint. Where could the volume go if only the top 10 ports were used?



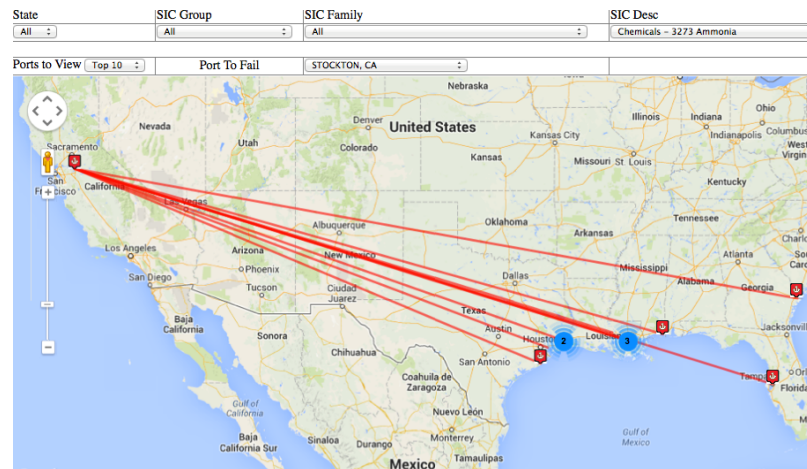
Baltimore – SIC Coal & Lignite



Baltimore – SIC Coal & Lignite Option Report

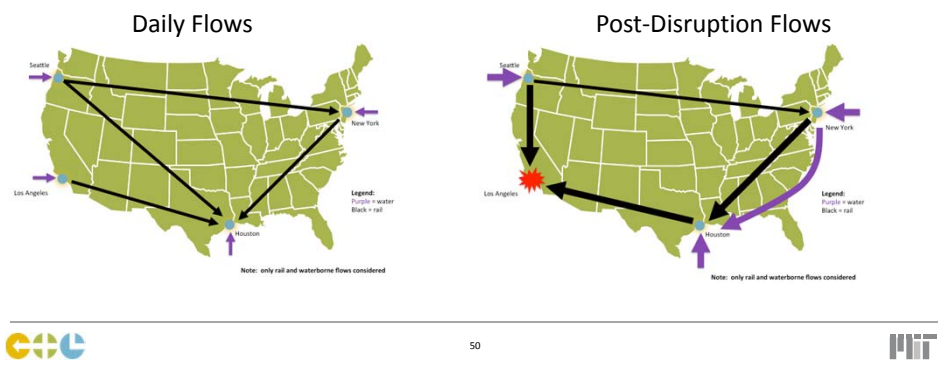
Port Name	Commodity Group	2009	2008	2007	Land
BALTIMORE, MD	Coal	14,244,900	16,407,300	11,401,400	0
WILMINGTON, DE	Coal	45	32,450	214	66
PHILADELPHIA, PA	Coal	116,831	30,639	432	90
CAMDEN-GLOUCESTER, NJ	Coal	254	43,040	0	93
RICHMOND, VA	Coal	0	0	1	134
NEWPORT NEWS, VA	Coal	13,618,400	21,809,300	17,501,000	158
HAMPTON ROADS, VA	Coal	27,751,500	41,032,900	34,799,900	162
NORFOLK HARBOR, VA	Coal	14,179,500	19,371,800	17,651,600	164
SUMMARY OF TRAFFIC TOTAL					
WATERBORNE COMMERCE OF THE PORT OF NEW YORK	Coal	2,468,760	2,267,670	1,981,820	174
PITTSBURGH, PA	Coal	27,779,300	31,350,000	24,769,700	196
BRIDGEPORT, CT	Coal	5,104,860	3,989,940	2,870,760	224
NEW HAVEN, CT	Coal	0	26,400	10,800	242
ERIE, PA	Coal	27,397	18,321	0	269
BUFFALO, NY	Coal	487,183	516,511	270,751	276
CONNEAUT, OH	Coal	1,163,040	646,300	8,475	278
NEW LONDON, CT	Coal	663,562	854,351	655,176	278
ASHTABULA, OH	Coal	2,793,640	2,485,040	1,768,970	283
FAIRPORT HARBOR, OH	Coal	13,688	16,681	0	295

Port of Stockton – Ammonia Options



Possible Future Developments

- Integrate with freight flows to hinterland, intermodal
- Integrate into a single environment for COP
- Scenario development: disruption changes land and port conveyances



Magello
 (CSR, Stevens Institute of Technology;
 Project Lead Investigator & Director of CSR,
 Dr. Julie Pullen)

Innovation in Port Resilience – Magello (CSR Stevens)

- Magello
 - Allows end user to visualize *ultra-high-resolution* port environment data on a Google Earth™ platform
 - Ongoing monitoring, situation assessment
 - Emergency response and management tool
- Data Capabilities
 - Urban: terrain, roads, AIS, ports
 - Ocean: surface temp, currents (direction, velocity, HF radar), acoustics, salinity
 - Air: temp, wind (velocity, vector), rain, air quality
 - Hazard: earthquake, contaminant release, explosion, oil spill
 - Coast: shoreline sensitivity, hydro lines, land use, AOR

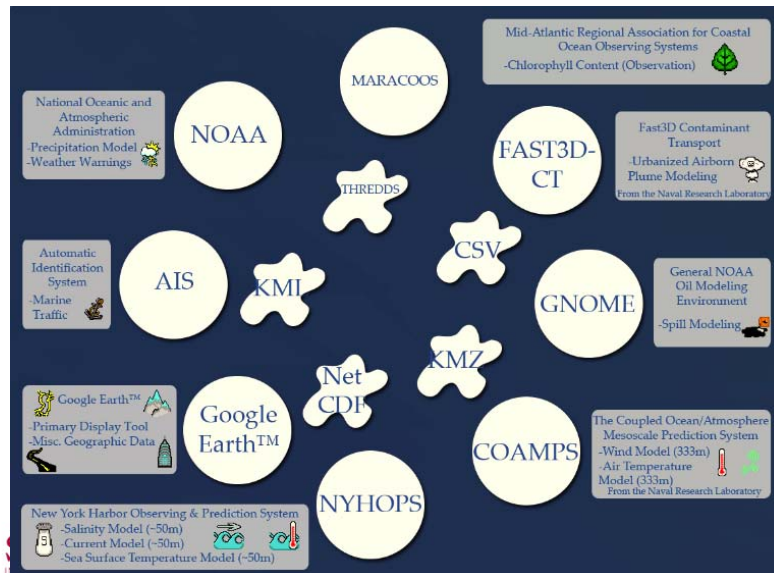


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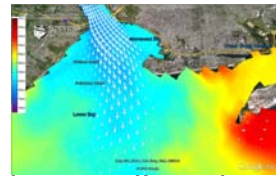
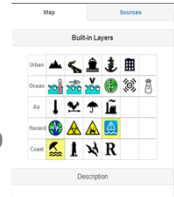
Magello Objective: Combine data in single tool to aid emergency response



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Magello

- Intuitive interface
- Real-time data, crowd-source info
- Platform change to enable mobile device access
- Ultra-high-resolution models
- Urban effects, multi-access levels
- Designed with broad range of apps to compliment, augment industry/gov't platforms (ERMA, SAROPS)



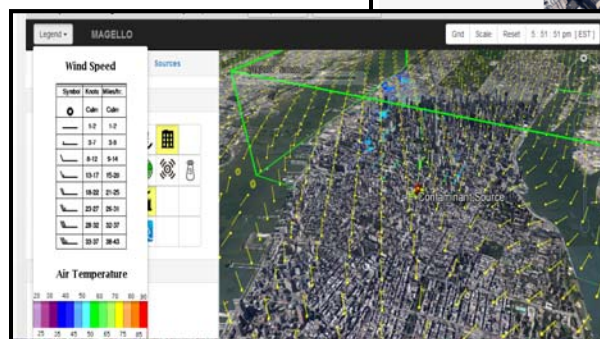
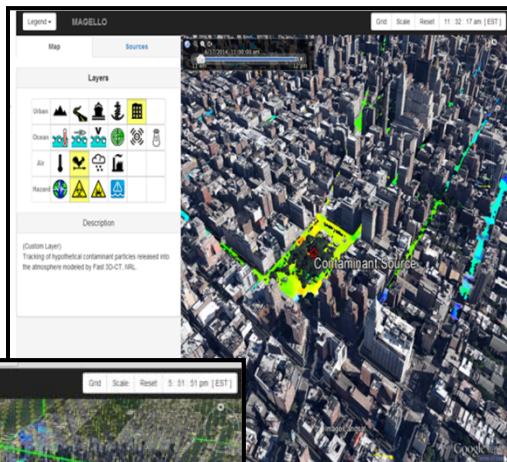
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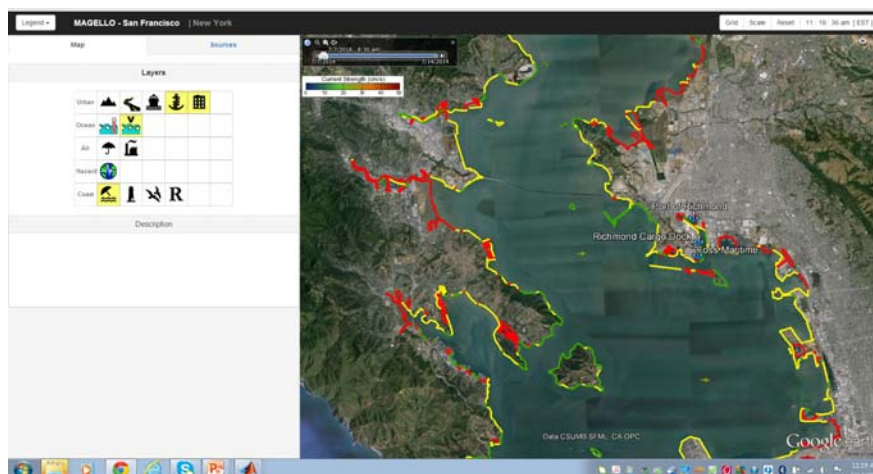
Magello Overview – AIS, Buildings, Surface Temps, Currents, Terrain, Roads, Winds

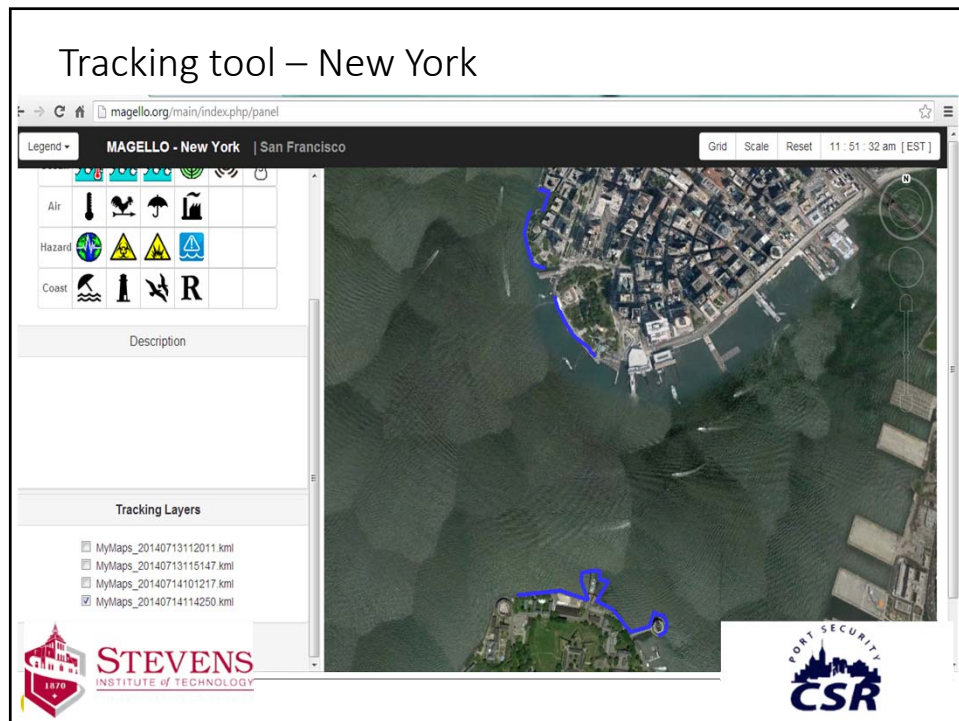
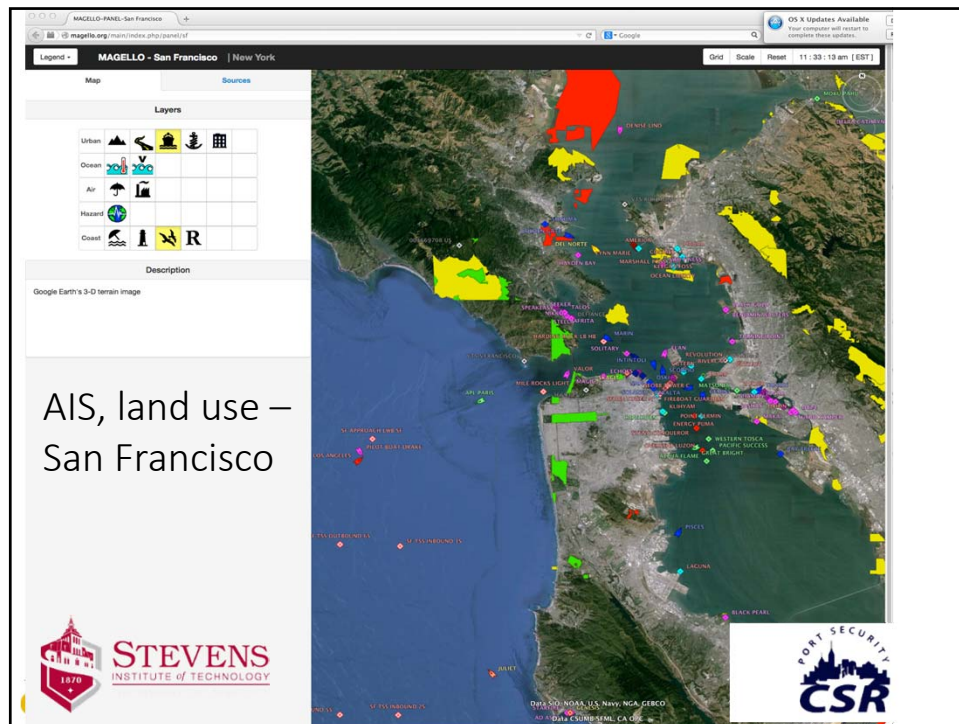


Contaminant source,
buildings, wind
vectors - NY

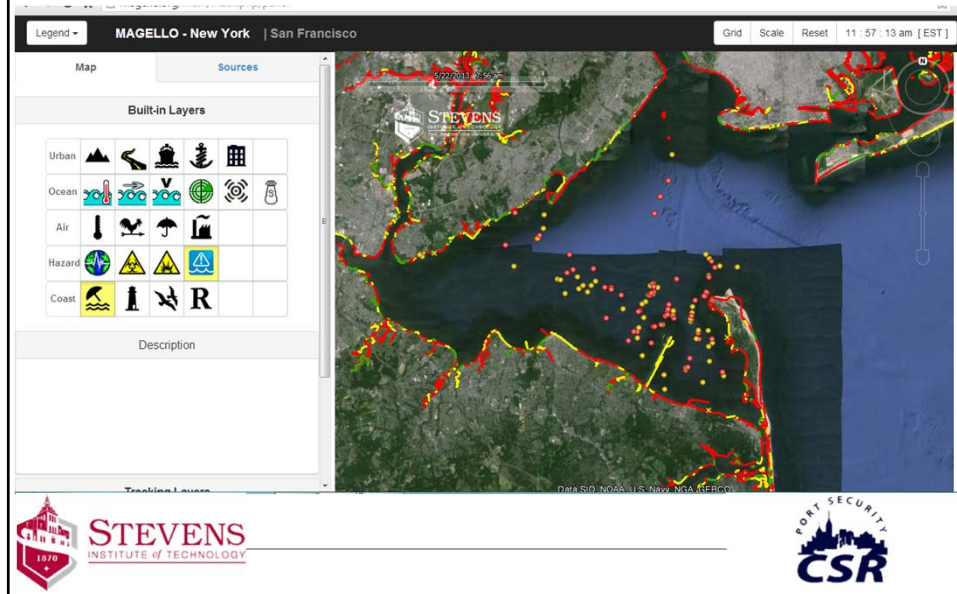


Shoreline sensitivity index, Ports – San Francisco



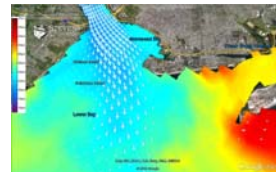
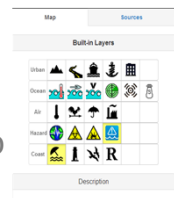


Oil Spill, Shoreline sensitivity index – New York



Innovation in Port Resilience – Magello (CSR Stevens)

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- Urban effects, multi-access levels
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And More....
CCICADA, CREATE, ADCIRC, VACCINE, Future



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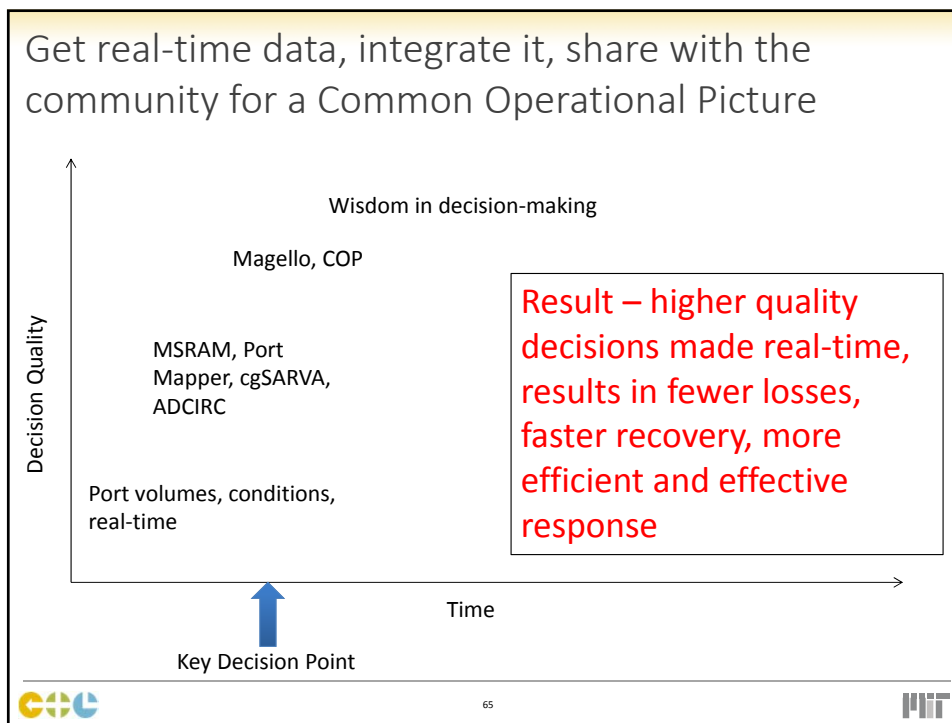
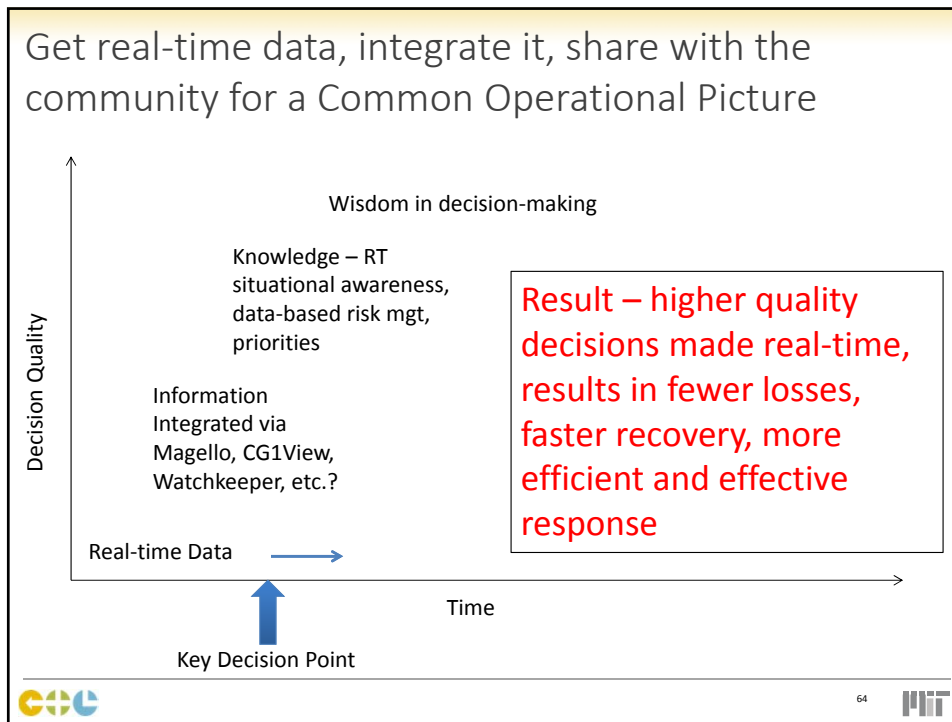
Future/Other Innovations in Port Resilience

- Other DHS COE contributors
 - CCICADA: Command, Control and Interoperability Center for Data Analysis (Rutgers)
 - CREATE: National Center for Risk and Economic Analysis of Terrorism Events (USC)
- cgSARVA (VACCINE, Purdue)
 - Search-and-rescue prediction visualization tool
- ADCIRC (Coastal Hazard Center, UNC-CH)
 - Storm surge modeling, dredging feasibility, modeling tides
- Future
 - Integrating/fusing all of these analytical tools into one system to provide a Common Operational Picture



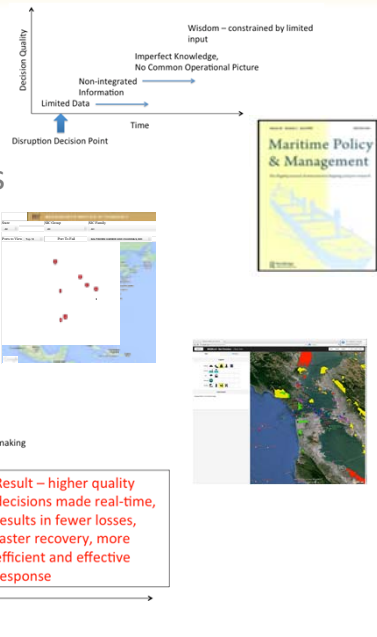
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Resilience in America's Ports

- Big Data
- Continuity Planning for Outcomes
- Innovation in Port Resilience
 - Port Mapper
 - Magello
 - Future – COP



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Thank you

Jim Rice

jrice@mit.edu

617.258.8584

<http://ctl.mit.edu>

<http://ctl.mit.edu/research/port-resilience>

http://portmap.mit.edu/port_mapper_g01.php