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MTS Resilience: eNavigation Best Practices

Transforming the Marine Transportation System: A Vision for R&D
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2C Panel: Safety and Security

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Presentation Focus

- MTS Resiliency Defined
- eNav in the context of MTS resiliency and MDA
- Corresponding eNav functions for Hazard Avoidance, Monitoring, and Response/Recovery
- Best Practices: E-Nav leveraged by GPS, VTS, AIS, and Satellite data
- Performance Gaps and R&D Needs

Resiliency Principles

Certain inherent attributes enable a system to withstand an extreme event with a tolerable level of losses, maintain its functions and structure, take actions to mitigate the consequences, and degrade gracefully when it must. The report on *Concept Development: An Operational Framework for Resilience,* Homeland Security Studies and Analysis Institute, August 2009, has identified these attributes as:

- Adaptability
- Robustness
- Hazard Containment
- Consequence Mitigation
- Risk-informed planning
- Risk-informed investment
- Harmonization of purposes
- Comprehensiveness of scope

Resiliency End state

A system capable of achieving three mutually-reinforcing objectives regarding the functions of a nation's Critical Infrastructure and Key Resources (CI/KR):

- ***Resistance***: Ability to limit the damage through interdiction, avoidance, and neutralization;
- ***Absorption***: Ability to mitigate the consequences of a damage-causing event: It bends but does not break;
- ***Restoration***: Capability of the system for being rapidly reconstituted and reset to pre-event status.

eNavigation Defined

Capability to access and integrate navigation data and sensor input within a single tool from an array of data sources to facilitate decision-making for:

- Voyage planning
- Vessel monitoring
- Collision avoidance
- Situational Awareness
- Incident Response, Search and Rescue (SAR)
- Capacity Optimization

E-Nav Applications in the Maritime Domain

E-Nav data flows enhance the Maritime Domain Awareness (MDA); MDA is the:

- Capability to anticipate, prevent, and respond to events through access to multiple sensor inputs and decision-support information in a centralized system; and the
- Effective understanding of anything associated with the global maritime domain that could impact the nation’s security, safety, economy or environment.

How E-Nav Contributes to the Resiliency of the Maritime Domain

E-Nav enhances the resiliency of the maritime domain by creating MDA and enabling:

- Hazard visibility and system adaptiveness;
- Hazard avoidance, resistance, and fault-tolerance;
- Hazard containment and redundancy;
- Risk Informed decision making for response, recovery, and mitigation.

Enhanced MDA through an Integrated Bridge System (IBS)

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IBS is a system of interconnected functionalities that integrates E-Nav capabilities in a single command-control-communication (C^3) workstation providing:

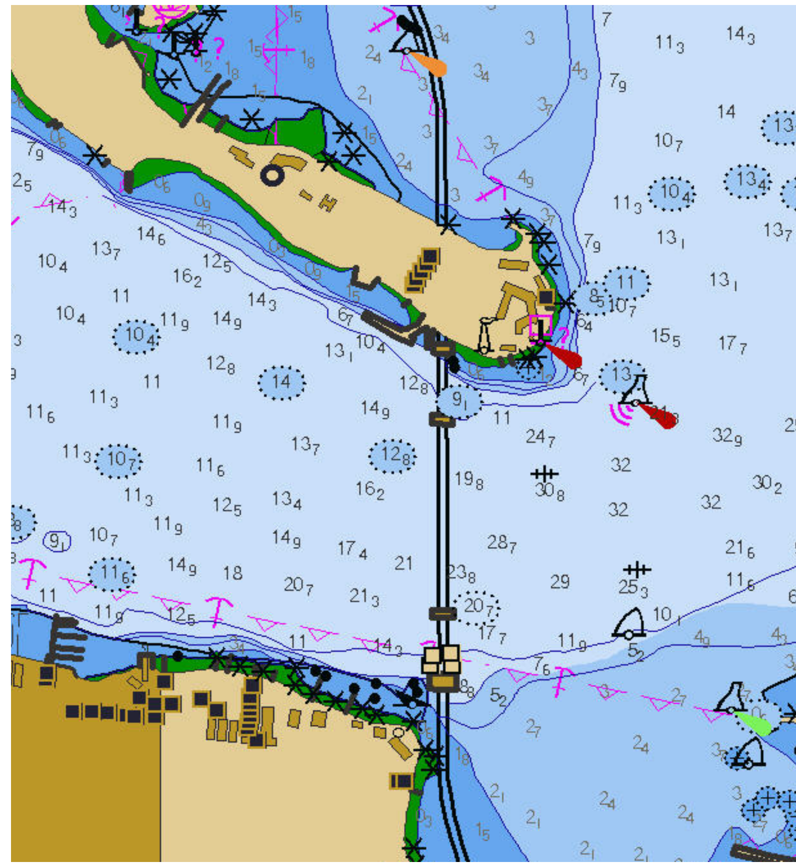
- ***Centralized Sensor Inputs*** form AIS, radar, GPS, Tide/Current Weather satellites, VTS,GNSS;
- ***Display Capability*** for static & dynamic data: ENC/ECDIS, ARPA, Tide charts, AIS marks;
- ***Decision Support Capability***: SAR, consequence mitigation, spill response, military defense.

Brilliance of the Seas

ENC Vector Charts Enable Hazard Identification and Visibility

A vector ENC is not the same as a paper- or raster-chart:

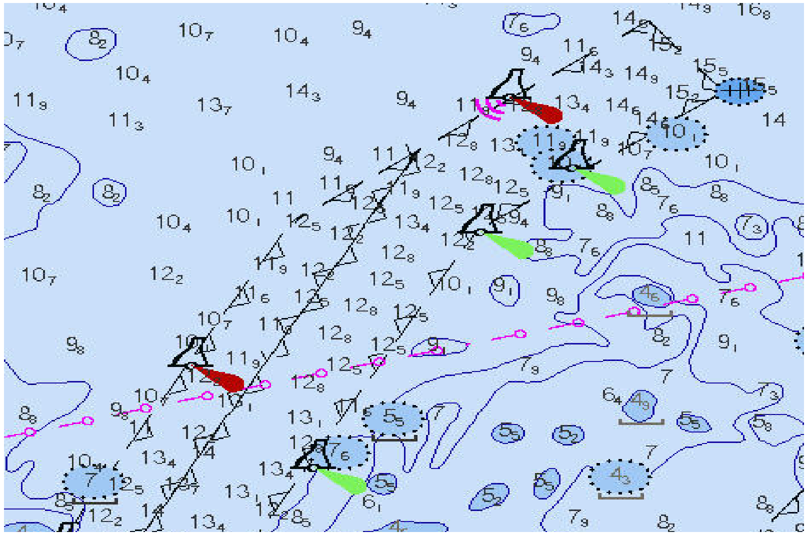
- ENC provides real-time data telling you where the ship is *now* and where it will be *next*;
- ENC is a “smart chart” because it enables navigator to “read ahead”; it alerts the mariner to impending hazards;
- International standards support global use and enhance waterway safety;
- A paper/raster chart tells you where you would be when the chart was mapped, not reflecting the bathymetric changes in the ocean floor.



E-Nav Real-Time Integration Capability Enables Hazard Avoidance

Access to digital vector ENC on the ship bridge, integrated with other E-Nav data, enables:

- Real-time chart data augmented with location precision obtained from GPS signals;
- Avoidance of weather-related hazards by integrating sensor data from Tide/Water level/ Wind/Weather Satellite signals;
- Hazard monitoring by integrating data received from AIS, VTS, radar, and other collision avoidance signals.



ECDIS Provides Visibility for the Maritime Domain

The IMO has made the carriage of an Electronic Chart Display Information System (ECDIS) mandatory for commercial vessels over certain size to establish consistency of standards and interoperability; ECDIS has the capability to integrate static input (from E-charts) and to provide display and decision-support capability for dynamic inputs:

- Automatic Identification System (AIS)
- Radar/Automatic Radar Plotting Aid (ARPA)
- GPS
- Tide/Current/Water level
- Ice Coverable
- Meteorological /Oceanographic signals
- Vessel Traffic Service (VTS)
- Wind sensors/ Echo Sensors
- Gyro
- Marine Habitable
- Ecologically Sensitive Areas.

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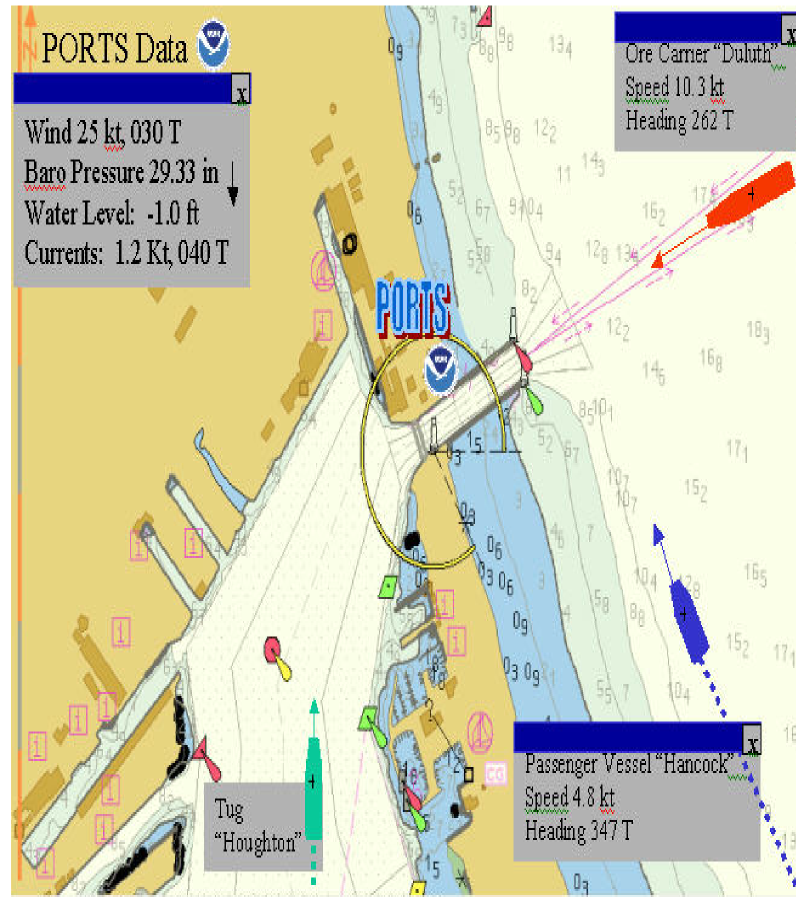
Hazard Avoidance Benefits: ECDIS Capability to Display Multiple Signals

ECDIS offers the capability to display an array of signals to avoid hazards:

- Integration of PORTS® Tides/Current data provides real-time situational awareness;
- Integration of radar and VTS data helps prevents collision;
- Enhances safety by incorporating the USCG Virtual AtoN;
- Assists port pilots and federal SAR in their response, rescue and recovery efforts.



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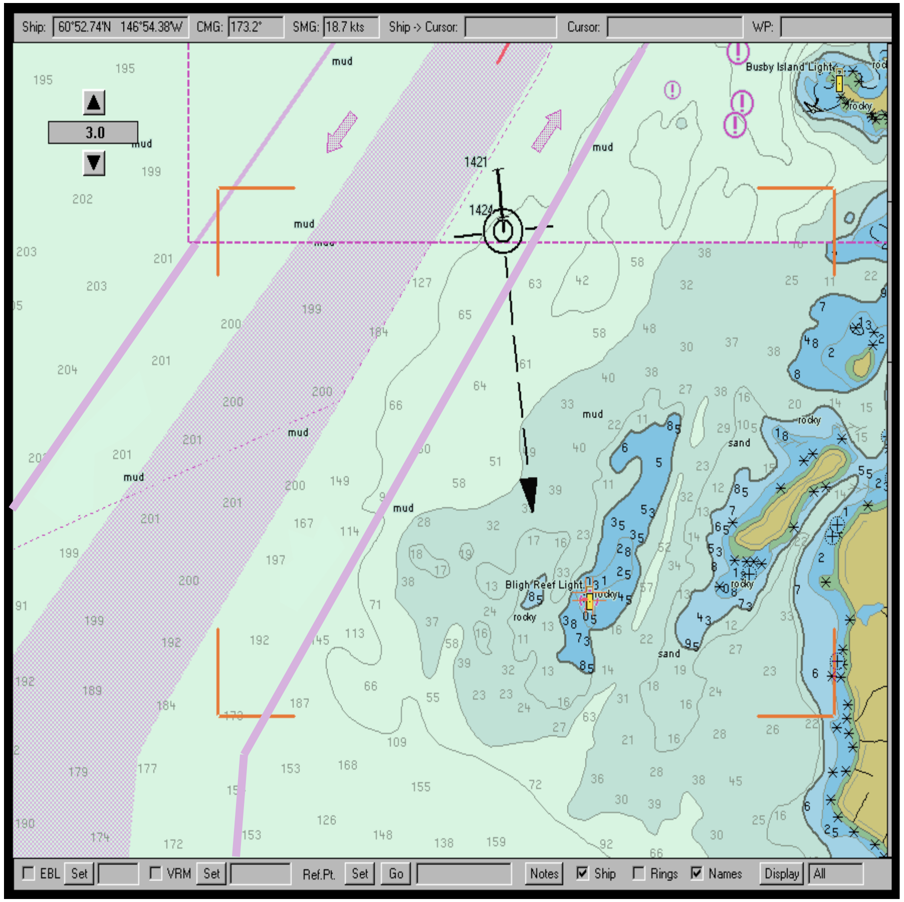
ENC Enables Hazard Avoidance by Creating Visibility for Submerged Marine Hazards

ENC vector charts provide real-time navigation information to avoid grounding by:

- Providing warnings of shoals and submerged objects;
- Preventing catastrophic spills;
- Protecting the marine environment by identifying coordinates for Sensitive or Protected Marine areas on the charts.



Best Practices: Tracking Oil Tankers to Avoid Spills

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Real-time ENC location data are used for hazard identification in:

- Vessel Tracking Information Systems (VTIS), designed to provide Nav Aid to protect narrow channels with heavy petroleum barge traffic;
- The Volpe Center has deployed the VTIS in the Buzzards Bay to reduce risks of barge groundings and oil spills in the Bay.

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Best Practices: Integration of VTS Data for Grounding Avoidance

Integration of VTS signals on a ship's IBS allows the USCG to enhance its MDA beyond the current collision-avoidance benefits of VTS:

- VTS capabilities are limited to monitoring ship movements through shore-side radar stations that identify and track the vessels at risk of collision;
- VTS has no capability to address collision or grounding risks in close quarters (e.g., ships docking or maneuvering in a bay or anchorage area);
- VTS is enhanced when integrated with ECDIS, helping vessels avoid grounding by showing real-time shoreline, harbor and channel alignment and obstructions with charts augmented with data on water level/tide/wind, and current velocity.

The Scope of the U.S. Vessel Traffic Service (VTS)

Best Practices: Hazard Containment and Informed Decision-Making through SAROPS

Search and Rescue Optimal Planning System (SAROPS), the USCG SAR risk model uses ENC and Tide/Current data as its core risk modeling capability for hazard containment, response, and recovery:

- SAROPS risk model is a GIS-based application used by USCG officers at over 50 Command Centers;
- SAROPS calculates the Probability of Success (POS) of SAR operations as a function of p of Containment (POC) and p of Detection (POD);
- Key to SAROPS decision-support capability is the availability of real-time ENC and Tide/Currents data to maximize the POS by computing two conditions in which: the search object is within the search area; <u>and</u> the search object is detected.
- By using the e-Nav data on vessel drift and wind speed, the officers can calculate the “containment area” to maximize POC; and maximize “detection” capability/POD by tracking the ship location signals.

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Hazard Detection and Response Best Practices: SARSAT

Search and Rescue Satellite Aided Tracking (SARSAT) is a NOAA supported international cooperative SAR system currently in use within EU and 38 nations:

- SARSAT detects and locates mariners, aviators, and land-based operators in distress;
- It relays distress signals from emergency beacons to a network of ground stations;
- SARSAT relies on signal data from the National Polar Orbiting Operational Environmental Satellite System (NPOESS) (part of the Global Earth Observation System of Systems or GEOSS), to monitor weather and climate change using the NOAA lower-earth and geostationary satellites.

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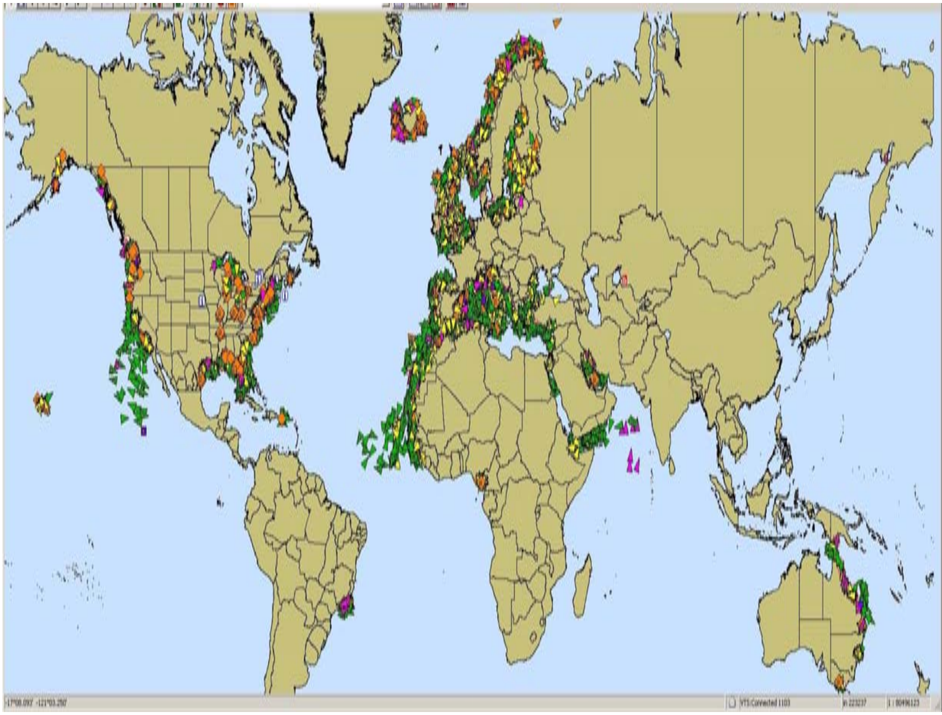
Hazard Monitoring Best Practices: MSSIS

The Maritime Safety and Security Information System (MSSIS):

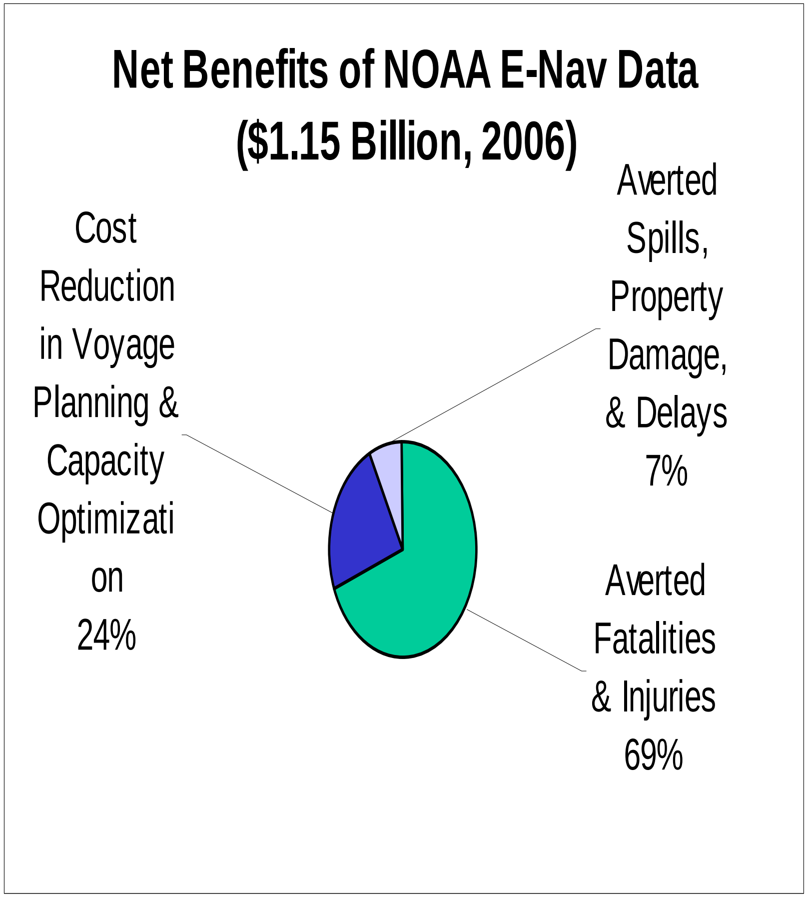
- Developed by the USDOT/Volpe Center to collect and display AIS data from multiple mobile and stationary platforms to provide real time MDA;
- MSSIS data allow regional partners access to a common operational picture (COP) to share information for monitoring the maritime domain;
- Vessel data are provided to participating nations through a secure, password-protected web-based system;
- Has been fully operational in Europe since 2006, with over 50 nations participating.



System Adaptiveness and Hazard Identification Best Practices: NOAA E-Nav Data

A Benefit-Cost Analysis Conducted at the Volpe Center on the Benefits of the NOAA ENC and Tides/Currents Data, available to all users for free downloads, showed:

- Net Benefits: $1.15 billion; reflecting a Benefit to Cost Ratio: 24:1
- Total Benefits: $1.2 billion compared to Government Costs $48,500,000 /year;
- Safety benefits from averted fatalities ($449 million) and averted injuries ($373 million) accounted for 69% of the benefits;
- Cost reduction benefits to navigators and vessel operators from voyage planning, reduced delays, and optimization of a vessel's load carrying capacity amounted to $286 million (24% of benefits);
- Averted spills and property damage from grounding amounted to $89 million (7% of benefits.)



R&D Priorities: Reducing Operator Error

A key gap in E-Nav capability is the ability to address Human Factors:

- Whereas modern technologies have improved MDA, SAR effectiveness, and system robustness, human operators have not become safer:
- Operator error accounts for about 80% of the causal factors contributing to marine accidents;
- "Technology Assisted Collision" is commonly used to refer to the paradoxical role of advanced navigation technologies in increasing accident risks;
- We have made the vessels and waterways safer, but we have not made people better operators;
- There is a tendency for "*conservation of risk*": evidence suggests that improved technology has encouraged more risky behavior in humans;
- The Moral Hazard involved in human response to technology is due to the false sense of protection generated that encourages mariners to go to sea without adequate training;
- Crew fatigue is another manifestation of operator error, caused by an array of factors relating to efforts to reduce vessel staffing costs as well as lack of adequate training and the moral hazard inherent in navigation.

Enhancing the Elements of "Soft" Resiliency

Resiliency is an inherently complex concept, with a broad range of applicability to physical assets, engineering systems, critical infrastructure, and human communities:

- The greatest gains so far have been from promoting "hard" resiliency: enhancing the structural and technological capabilities and functions of the CI/KR;
- "Soft" resiliency is harder to capture, given the vulnerabilities associated with maritime safety introduced by human operators;
- Gains can be made by combining mariner training and community preparedness efforts with better understanding of the human factors that contribute to both risky behavior and risk mitigation.
- Gains in hard resiliency can be leveraged by building on the potential synergies between hard and soft concepts.