Real Time Data and ECDIS In A Web-Based Port Management Package

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***Abstract*-The web-based port management package recently developed for Port of San Diego by InterOcean and SevenCs companies offers harbour authorities new possibilities through real-time navigational and environmental data inputs and access to the land-based data bases for ECDIS presentation through the Internet. The data are presented on top of the Electronic Navigational Chart (ENC) in form of thematic overlays using ECDIS technology. The real-time information transmitted from the environmental sensors includes weather, currents and tidal heights. Tidal data are used also to provide the real-time, dynamic under-keel clearance information in the ship manoeuvring areas. The data are supported by the web-camera images with zooming and panning capability and, in near future, by the radar overlay and AIS information. Updated ship arrival and departure information is included together with static data showing relevant regulatory information, emergency response information, lists of facilities, fees, and marine events, etc. for the general public.**

The information can be accessed from any computer equipped with a Web browser, e.g. by Pilots navigating an approaching vessel, from the Port Authority offices, Coast Guard marine safety office, and by general public. The access is controlled by a multiple level password structure.

Unlike the navigational applications, there are no regulatory restrictions on the port or coastal information systems and variables can be dynamically presented. They can include meteorological and oceanographic data and depth adjusted for tides and surges. In addition to port management, practical applications can include presentation of coastal flooding predictions. ECDIS-type software may become a tool not only for port or coastal zone managers but also for insurance offices. Basing such systems on the web provides the general public with access to important information.

This paper describes the system and discusses the advantages it offers to port authorities not only in traffic management, but also in pollution control, safety, and public information. Future developments and enhancements are also proposed. Current trends indicate that this system, similar to PORTS and other CO-OPS initiatives of NOAA, will provide the basis for even more seamlessly-integrated and cost-effective real-time information systems for other ports. Ports and harbors similar to San Diego can be ideal candidates to benefit in many ways from the implementation and operation of the system described herein.

I. INTRODUCTION

The Port of San Diego is a large and important seaport with growing needs for a variety of users including Naval, commercial and recreational vessel traffic. Tourism, ecological awareness, and safety are of equal and fundamental concerns to the growth and future of the Port. As with many other ports of this size, it was apparent that the need existed for a centralized source of access to information without the burden, expense, and complexity of a traditional vessel traffic system (VTS). New technologies, and the internet, enabled the US Coast Guard, the Port of San Diego, and the Office of Oil Spill Prevention and Response (OSPR) of the Department of Fish and Game (State of California) to establish an integrated system approach for the access and management of information, navigation, environmental conditions, and emergency contingency planning for the Port of San Diego. The San Diego Marine Information System (SDMIS), developed by InterOcean Systems and administered by the Port of San Diego, is an internet-based system supporting the operational needs of the Coast Guard, Port District, Harbour Pilots, and recreational boaters. This system provides continuously-updated real-time information to the various users to facilitate access to resources and promote awareness in order to reduce the potential for - and facilitate the reporting of - incidents resulting in casualties and marine pollution.

The key technologies within San Diego's internet-based Integrated Marine Information System (IMIS) include real-time hydrographic sensors with wireless data transmission, real-time digital camera coverage of key areas, updated commercial vessel schedules with on-line vessel information database, and real-time access to the area response strategies including the harbour safety plan and the oil spill and marine casualty reporting system. A unique and central aspect of the system is an Electronic

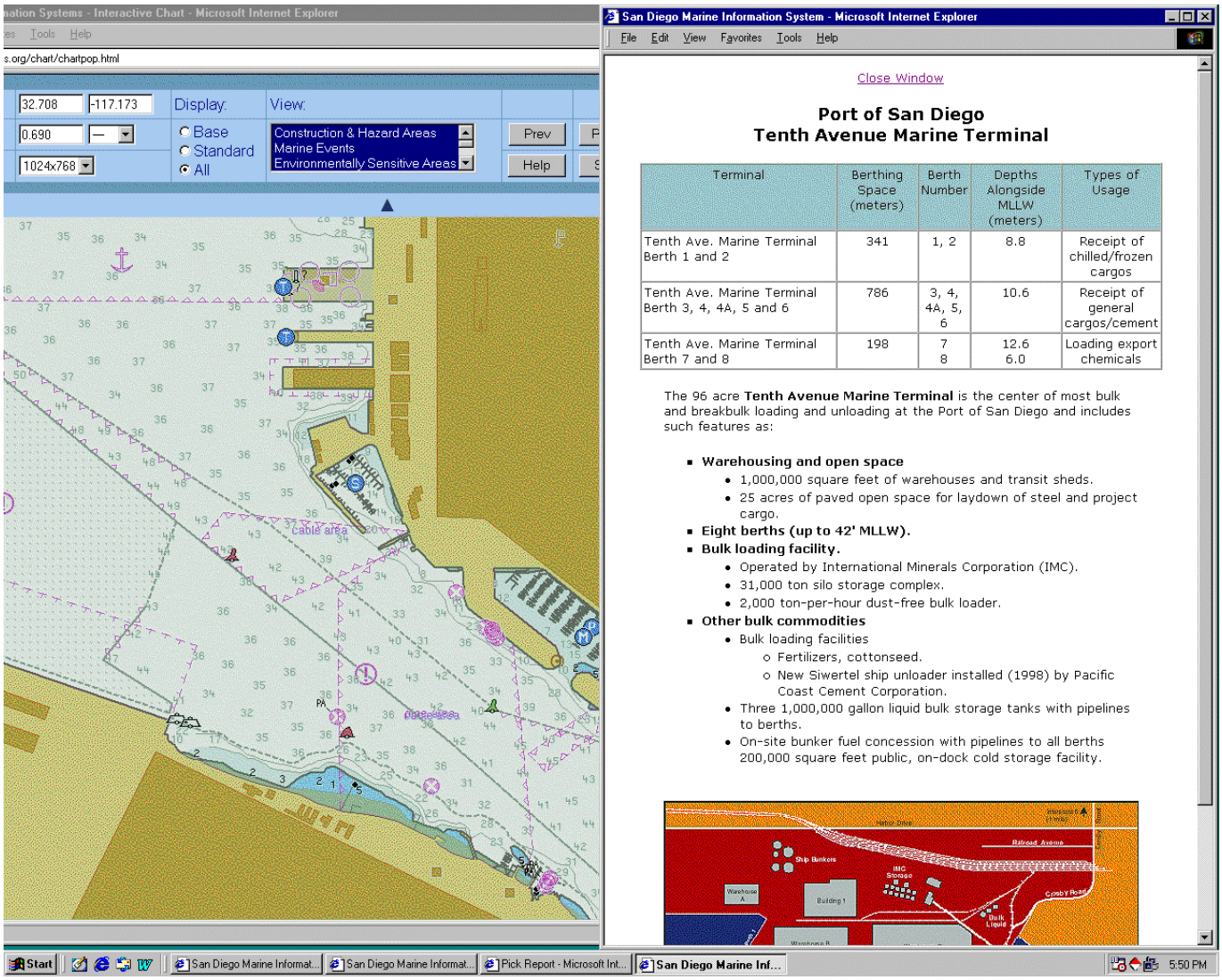

Fig. 1. ECDIS ENC internet display showing terminal approach, hazards, dynamic underkeel clearance (real-time tide), and associated report describing the selected chart feature (terminal berthing details).

Navigational Chart (ENC) using ECDIS-type technology with information overlays and interactive features for navigation, port services, public service announcements, identification of environmental areas, restricted security zones, and hazardous high-risk areas. This integrated marine information system and interactive electronic chart is accessed from the internet or by wireless link from a mobile unit (laptop computer). The data in SDMIS are presented on top of the appropriate corresponding Electronic Navigational Chart in the form of thematic overlays using ECDIS technology.

II. ECDIS

ECDIS, or Electronic Chart Display and Information System, has been developed for navigational purposes but is capable of serving as a central component of a fully integrated Marine Information System as demonstrated by the Port of San Diego. The ECDIS data structure makes it useful for standard Geographic Information System (GIS) functions, such as information and management for ports or coasts, and has the inherent capability to combine a wide range of four-dimensional navigational, meteorological, oceanographic/ coastal data adaptable to a wide range of uses; including planning, monitoring, and response scenarios. Because the data are in a vector format (i.e. each point of data is an object described by the relevant attributes and defined by a set of co-ordinates relative to the origin of the co-ordinate system), all objects on a chart or map can be interrogated for additional detailed information. Its technology can facilitate the reuse and transformation of data, and incorporate forecasting models, to create four-

dimensional GIS, enabling the use of knowledge-based methods to combine marine and terrestrial environmental data with process simulations. Selected variables can be overlaid on the bathymetry and topography, which are also temporally variable. Database tools such as XML tagging can be supported to allow easy accessibility to various data formats. The combination of XML and ECDIS technology provides seamless integration throughout various data bases without the need for proprietary tools, thereby facilitating use of different data groups for port management purposes.

ECDIS, like GIS, integrates spatial data with other information. However, as comparison, a GIS is generally static and not capable of handling the temporal variability of the objects. The main advantage of ECDIS over conventional GIS is the adaptive capability to display temporal variability, which is of key importance since, in reality, all objects that make up the electronic charts or maps, including coastlines and bathymetry, change with time at varying speed and frequency and with varying level of regularity and predictability.

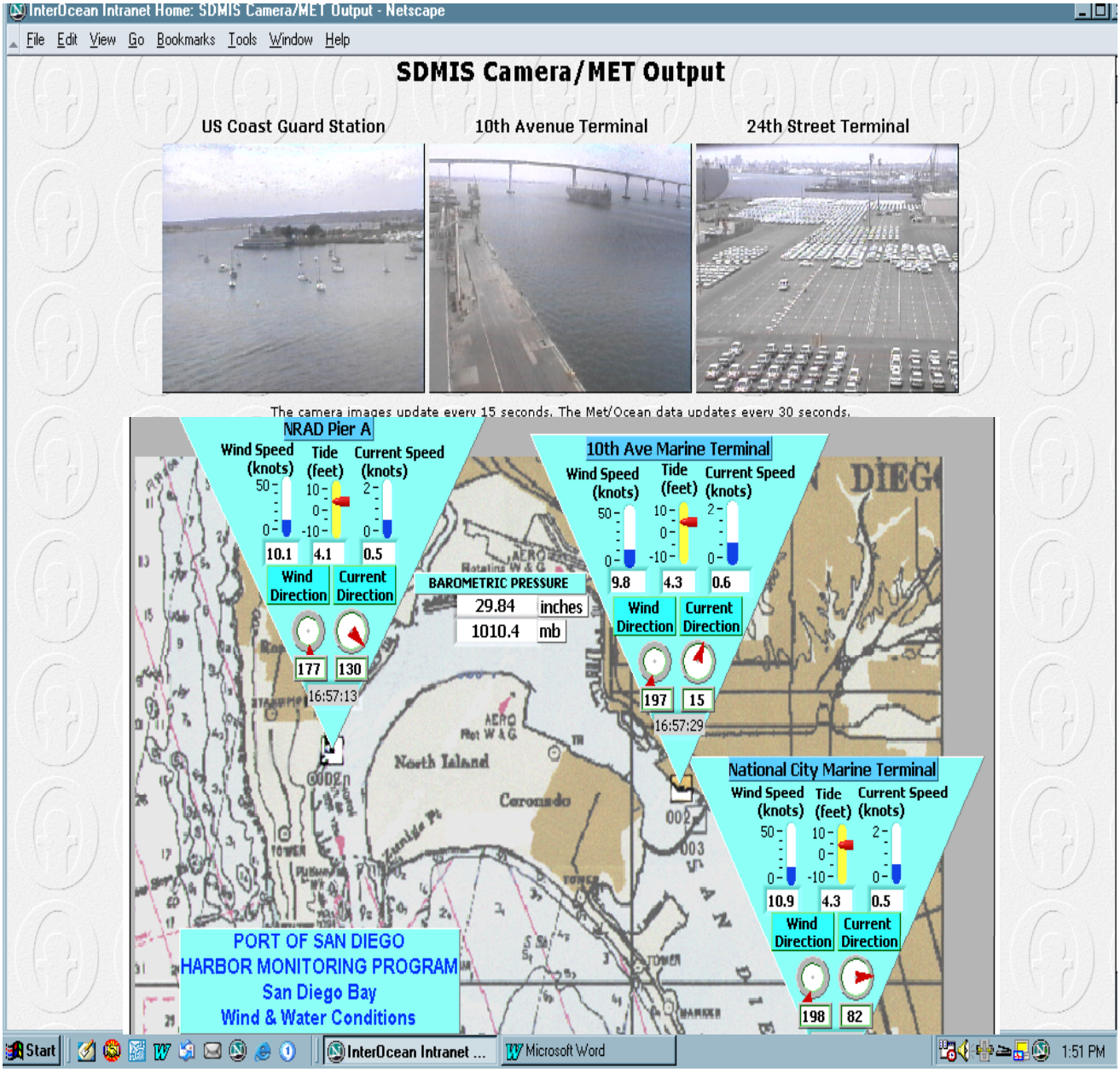

Fig. 2. .SDMIS internet link showing streaming video, and real-time wind, current, tide, and barometric pressure data at selected locations.

III. PORT OF SAN DIEGO INTEGRATED MARINE INFORMATION SYSTEM (SDMIS)

The SDMIS was an ambitious and successful undertaking involving many technical aspects that are unique yet common to many port requirements. This real-time information monitoring and management system goes well beyond the scope of a conventional VTS system in many regards, at a fraction of the cost. The basic scope of this project involved the following areas: i) in-situ oceanographic and meteorological instrumentation with autonomous power; ii) ruggedized internet-ready CCTV video equipment suitable for bayside installations, with incorporation of user control (pan/tilt/zoom) and real-time still and video images on the web-site; iii) high speed wide-bandwidth (T1) two-way radio telemetry throughout the Bay; iv) ECDIS IMO S57 & S52 compatible multi-layer vector chart created for San Diego Bay; v) dynamic depth chart soundings and safe manoeuvring areas in real time; vi) software compatible for Universal Automatic Vessel Identification system UAIS; vii) system software compatible with existing Port data bases and new data inputs; viii) creation of a Web Site to disseminate and distribute the SDMIS information to the various users; ix) optional telemetry-ready radar that can be easily displayed on the web; and x) local maintenance and training on a continuing basis. The hardware and technical expertise for all aspects of this system were managed, delivered, and commissioned by InterOcean Systems Inc, a San Diego company with a fifty-six year history of providing successful integrated hydrographic systems for coastal, oceanographic, and harbour applications.

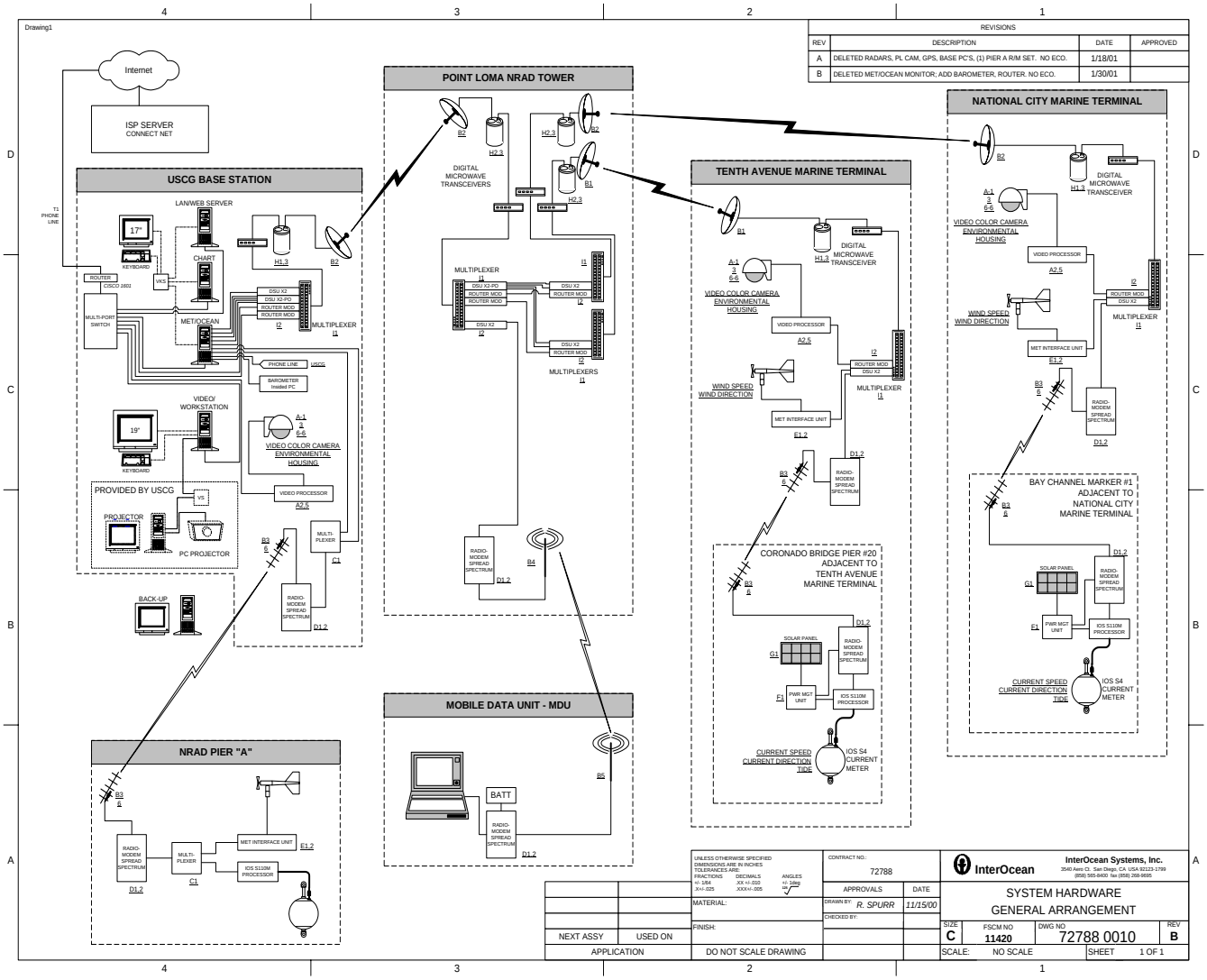

Fig. 3. A general overview of the SDMIS system architecture is for a unified system that is seamless in many regards and automated to basically operate itself.

There are currently three remote sites that are identical, containing S4A current and tide measuring instruments as well as two-way radio link and autonomous solar recharged power supplies. These monitoring sites are located at the National City Marine Terminal in San Diego's south bay, the Coronado Bridge adjacent to the 10th Avenue Marine Terminal, and within the Navy facilities at Point Loma near the entrance to the Harbor. This data is combined with the data from the wind sensors and video cameras located at these sites and sent by high speed T1 radio telemetry to a relay site at the tip of Point Loma and onward to the United States Coast Guard (USCG) base station on Harbor Drive.

All data are collected and processed on PC type computers in the situation room at the USCG Base. These computers are linked together on a local network with a Web server that permits authorized web users to access appropriate data over the Internet. The environmental data and video cameras each have their own PC controllers as will each of the optional radar sets to be installed in the future. The ECDIS system resides on a separate PC at this site and is also linked to the Web server. Personnel at this base station have real-time access to all electronic data and display of video, environmental, chart, vessel traffic, and radar images. Full or partial access to the same information is available through the internet for remote monitoring, security, and/or emergency response coordination from any location, including wireless access from Internet-enabled notebook computers, with the appropriate security passwords. A more typical remote user of this data are the harbour Pilots, who are equipped with portable laptop PC's containing the ECDIS charts and integrated wireless link to the radio repeater at Point Loma, to receive, display and monitor real-time conditions of wind, current, tide, channel depth, and position data, to assist planning and executing safe approach and manoeuvring at the berthing facilities prior to arrival.

All real-time data, including dynamic depth display and updated ship movement, together with static data showing relevant regulatory information, emergency response information, lists of facilities, fees and marine events, are available to each user group. The information can be accessed on **www.sdmis.org** from any computer equipped with a Web browser, e.g. by the navigators of the vessels approaching the harbor, from the Port authority or Coast Guard offices, and by general public. Access to additional information is controlled by a multiple-level password structure, allowing users such as Pilots unlimited access using their ruggedized mobile laptop units. Real-time conditions at selected locations are also available by synthesised voice system on a call-in basis.

IV. FUTURE DISPLAY METHODOLOGIES

For navigational purposes, the methodology of displaying information on the ECDIS screen is restricted by the S-52 standard. These restrictions do not apply to port and coastal zone applications. Since practically all objects shown by ECDIS (whether contained in the underlying map/chart, or in thematic overlays), can be considered as time variables, we must view the whole concept from a different point of view. Each object can be treated as having multiple dimensions for any given data point. Of course, the temporal variability adds an important dimension of its own, as does any data that varies with depth or height. Thus each vector point containing any data will have at least four dimensions: x, y, z and time, plus as many other dimensions as there are objects attached to this point. Multi-dimensional encoding will be necessary, as the present methods cannot effectively handle the expected amounts of time variable data - especially for real or near-real time data. The provision of multi-dimensionality, together with dynamic representation of variables, will make ECDIS a versatile tool for the future for both port and coastal zone management systems.

The most important aspect of the ECDIS data handling methodology is the separation of data and presentation. Databases contain only geo-referenced data without display information, and the display is handled separately by the so-called "presentation libraries". This makes any data modifications or updates faster, and inherently offers enormous flexibility in regards to display. This same information can be presented in a different way, depending on the user requirements. In this way, ECDIS can satisfy each unique user group with access to the same data, yet customize it to their own unique purposes and situational requirements. Various presentation libraries can be stored on the server, and users are able to download data specifically from their own presentation library for immediate display particular to any given circumstance, on demand.

Any thematic layer can be called from the selected source, including a computer simulation for practical or training purposes. ECDIS provides easy access to complex models and their resultant scenarios. It's standardised, open platform solution, can be adapted to all marine and coastal requirements, whether civilian or military, via a user-friendly interface which gives users a high-quality synthesised view of the simulated environment.

Most marine oceanographic and coastal variables are three-dimensional in their application and effect. Innovative techniques for marine data conversion, display and modelling in ECDIS are being developed to

accommodate the users' needs, e.g. three- or multi-dimensional displays. One promising display technique for navigational and port management applications is that of three dimensional presentation of bathymetry and topography for the narrow channels and passes using neural networks, which enable processing of the bathymetric data more efficiently than traditional methods. These are generic tools, which need to be trained for a particular area (or a set of data), and their accuracy is contingent on the density of the bathymetric data. Topography is handled by 3D digital terrain modelling, which today is a known, well-developed methodology encompassing many scientific, commercial, and military management applications. For example, an operational prototype of such a neural network based display has already been developed for the main channel in the Oder estuary, between the ports of Szczecin and Swinoujscie, in Poland.

V. NEXT STEPS

The San Diego project is only the first step toward development of much more sophisticated port management packages. Dynamic visual display and additional data types will also be introduced. Automatic AIS data acquisition and enhanced database tools are particularly useful functions of the IMIS, especially in view of the requirement for increased security in ports worldwide where circumstances warrant added vigilance. Environmentally, pollution control has been, and will continue to be, main concerns for any port management system, and an important addition is the real-time automated monitoring of oil spills. The next phase of scheduled implementation includes an early-warning detection system based on existing Slick Sleuth Oil Spill Monitor & Alarm technology, using an distributed array of remote above-water optical sensors, strategically located in areas of greatest environmental concern or highest likelihood of spill incidence. Key elements of this technology include the relative ease of integration, installation, and maintenance-friendly characteristics. The integration of this Slick Sleuth real-time oil pollution reporting system within the SDMIS provides a proactive approach aimed to demonstrate vigilance and insurance against spill-related environmental damage, casualties, costly cleanup, and navigational safety, by eliminating the chance that a spill could go undetected for any length of time. Additional dynamic meteorological and hydrographic variables, among others, have been included and, in addition to assisting vessel operations and enhancing safety with increased situational awareness, are also essential in tracking pollution spills and will inevitably be backed by on-line predictions and modeling. Presentation of dynamic variables is possible only with ECDIS-type technology. Long term goals include provision of high-density digital bathymetric data and determining the methodology of supplying internationally approved dynamic data by various scientific, government and commercial organizations. New data exchange formats, such as Marine XML, are presently being considered to improve interoperability of various databases and other data sources with the users. Interfaces with necessary real-time or near real-time information sources are already a reality.

ECDIS is not restricted to at-sea navigation. The system has already been adapted to the requirements of inland navigation, both in Europe and in North America. The US Army Corps of Engineers is developing the Inland Electronic Navigation Charts aimed at addressing the unique nature of inland navigation, while remaining consistent with data formats and electronic systems for deep-draft and SOLAS vessels. Additional objects and attributes, as well as a specialized set of symbols, have been created explicitly for this purpose. Inland waterways are of significant economic importance on all continents, and ECDIS is of vital importance to maintaining safety and efficiency of navigation on respective rivers, canals and lakes. The inland port requirements are different to those of the seaports, and the dynamic port management package can be easily adapted to accommodate the specifics of those requirements. For example, the use of locks is an important aspect of inland navigation, and lock management packages, already appearing on the market, may be incorporated as an integral component of ECDIS information systems. Like ports and harbors within the coastal zones, inland waterways are under constant redevelopment, and real-time ECDIS is the obvious choice for managing and monitoring these areas. In this instance, ECDIS technology again presents itself as an ideal tool, thanks in large part to it's ability to handle real-time navigational and environmental data with the ability to provide fully integrated display for total situational awareness and management.

The ECDIS-based harbor monitoring system recognizes it's potential to provide the basis for further development and integration within the National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS), which also collects and distributes observations and predictions of currents, water level, and flood warning at various sites to ensure safe and efficient, environmentally sound maritime commerce. The ECDIS-based SDMIS marine information systems, while providing similar information, may be more adaptable to site-specific requirements for individual ports such as San Diego, and is available as a very cost-effective alternative. At the same time, it is possible that data from SDMIS may enhance NOAA's ability to provide coverage and services in certain areas, and it's information can thereby apply to serve a broader understanding and management of our national marine resources, while facilitating safety, contingency planning, and port-related management issues.

VI. CONCLUSION

The IMO/IHO regulations restrict ECDIS with regard to dynamic data presentation for specific purposes, but there are no regulatory restrictions on port or coastal information systems for which dynamic variables can be employed as informational tools presented either in real-time or as predictions. These dynamic time-variables, presented within Electronic Navigational Charts, can include real-time navigational, meteorological and oceanographic data, real-time depth adjusted for tides and surges, video, radar, real-time ship position, among other static or dynamic time-variable information. ECDIS methodology for data encoding and display can be easily augmented from traditional or pure port management systems to cover coastal zone and hydrographic applications using the Internet and interactive functions tested and substantiated to provide much needed flexibility. ECDIS is a tested system which relies on international standards now proven to be capable of handling temporal variability of accepted defined objects, using recognized a standard set of symbols within an internationally recognized system. This has not been possible with traditional Geographical Information Systems (GIS). The need for this capability has been recognized early by the hydrographic community and the relevant methodology developed cooperatively during the last few years.

In the case of San Diego, the innovative and successful SDMIS concept was initiated by the Harbor Safety Committee, funded by the department of Oil Spill Prevention and Response, and managed by the Port of San Diego. Thus the ECDIS-based SDMIS integrated marine information system represents a true partnership between the various stakeholders and vested interests, that culminated in an installation and continued use of a modern on-line monitoring network that meets the varied operational interests and management requirements of the users, along with important expansion and enhancement opportunities. The project has met with large-scale success. As demonstrated, this system, and the further development of ECDIS technology for port management purposes will continue to have numerous important effects.

Development of this system has provided critical information to all key maritime interests, including vessel operators, vessel traffic management, port management, emergency planning and response, and public information. Further, it has empowered Pilots and ship operators by providing them with the latest navigation software displaying position of their own ship, integrated with shore-based radar pictures and other critical real-time information, all utilizing the full potential of ECDIS in a web-based port management package

Expansion is no longer the function of the initial steering committee, but is now the concern of these organizations who continue to recognise the importance of a web-based SDMIS system for navigational safety and incidence prevention in San Diego bay, giving them the opportunity to realize future enhancements such as the integration of AIS, active radar overlay, oil spill detection and alarm, additional environmental stations, and augmented ECDIS/ENC features in keeping with the parameters of the SDMIS system.

As demonstrated, this system, and the further development of ECDIS technology for port management purposes has numerous important effects. Authorities have a better overview and awareness of their respective areas of responsibility through real-time navigational and environmental data inputs and access to the land-based data bases. This in turn translates to greater awareness and manageability, fewer casualties, and higher efficiency for port operations.

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