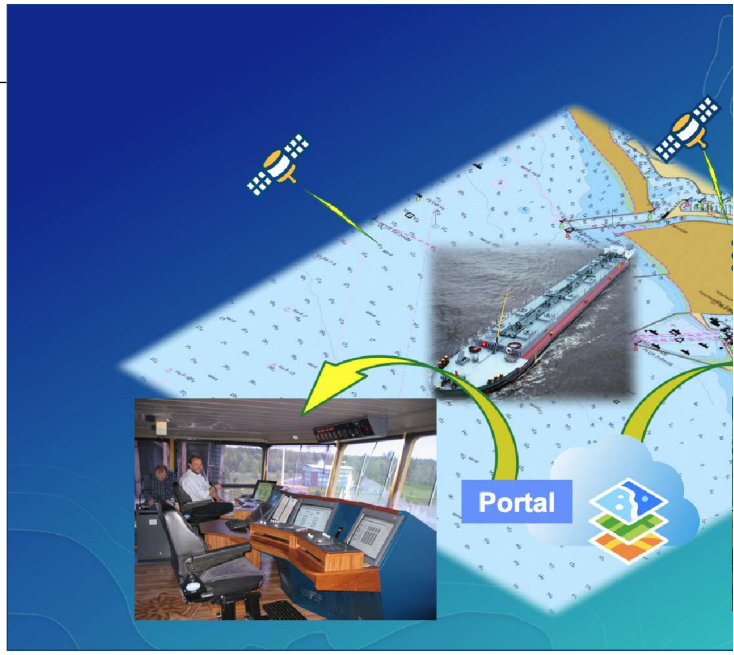
The Maritime World Enters The Fourth Industrial Revolution

New Era Requires Revolution of Data Processing, Analysis and Use

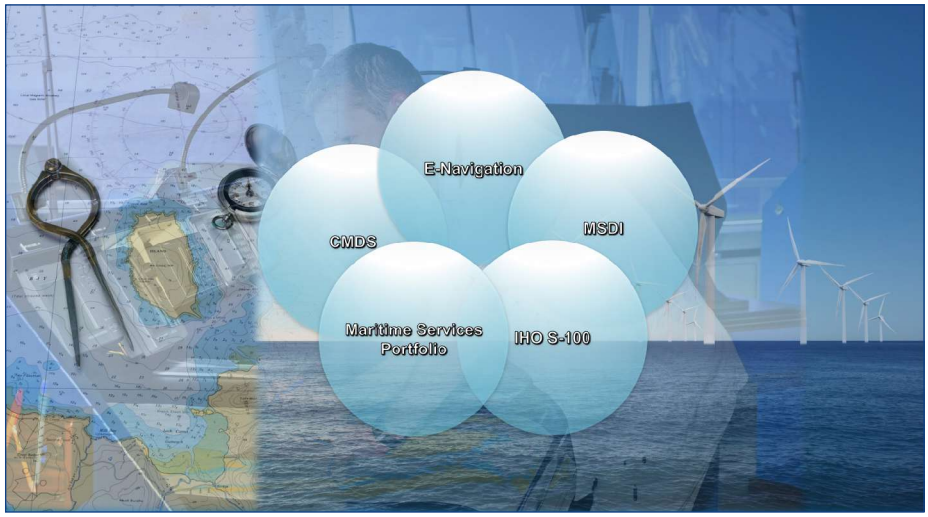
By Rafael Ponce



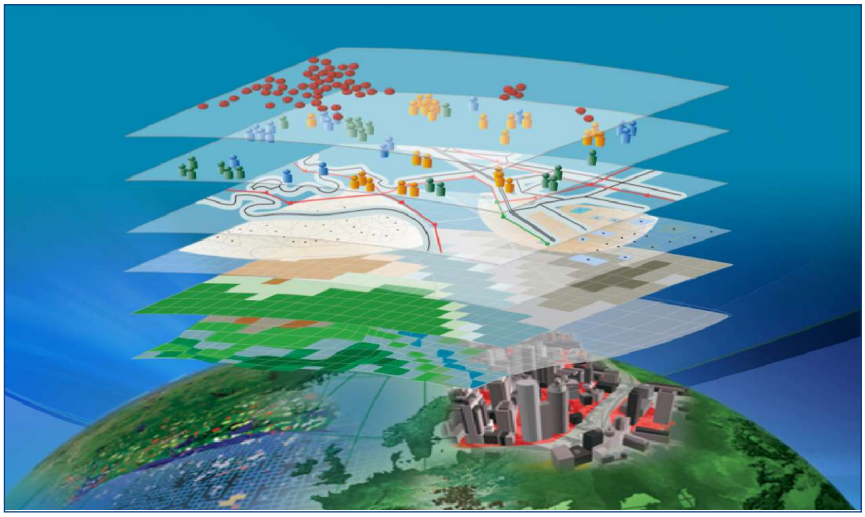
People around the world are calling our times the beginning of a new industrial revolution, one where the physical, biological and artificial aspects of technology are combining to alter our lives fundamentally in a way never before experienced.

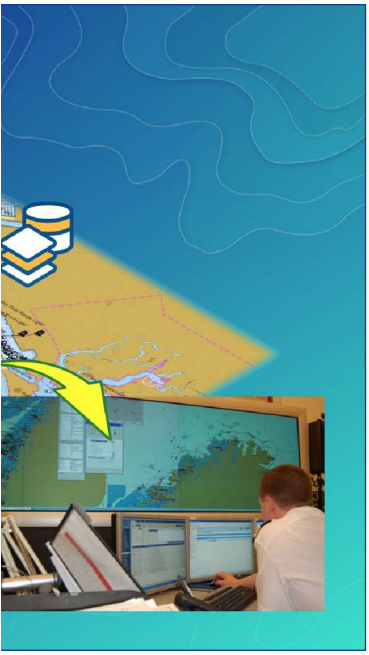
The first industrial revolution started with mechanization and the use of water and steam power; the second industrial revolution used electricity and created mass production and assembly lines; the third industrial revolution saw the advent of electronics, computers and automation; and the fourth one is building on top of the third to create cyber-physical systems, where physical and software components are intertwined and controlled by computer-based algorithms, integrated with the Internet and users. In this new industrial revolution, growth that used to be linear is now exponential, happening very fast to the point that we can no longer use the past to predict the future.

Change in general is accelerating; the technological and cultural changes that we will see in the next 50 years are going to happen faster than the changes that happened in the past few hundred years. And this has meaningful consequences; it is disrupting almost every industry, and the maritime industry is no exception. Emerging technologies and new concepts such as artificial intelligence (AI), robotics, the Internet of Things (IoT), big data, unmanned vehicles and augmented reality are already affecting the maritime world. We can see some hints of that in the economics of the shipping industry; for instance, GDP and cargo volumes have become decoupled.



Some experts in the field call this a new "Seaconomics" era. Technology and a new generation (millennials) are changing the economic dynamics. The focus is no longer on the lowest price, the most profitable thing or the best cost-benefit balance; the focus now is on sustain-





(From top to bottom) An illustration of the GIS concept. The e-navigation concept. Maritime initiatives for the fourth industrial revolution.

ability, environmental friendliness, added value, efficiency and resiliency.

These fast changes create new challenges and new opportunities for everyone. In light of the new technologies, a "digital vision" is necessary, powered by data, in space and time.

In the maritime world, autonomous ships and autonomous/remotely operated port terminals are not science fiction; they are happening right now and require handling geospatial data in new ways. The key is not getting more data, but getting the right data at the right time and processing data on the fly for decision-making by human or machine.

Maritime Needs

What would be required to enable and process all this information? We need four basic components: people, standards, technology and, of course, data. In the maritime domain, a good starting point is the shipping industry, where cargo transported by liner shipping represents about two-thirds of the value of total global trade, according to the World Shipping Council. This industry is constantly looking for ways to improve efficiency, so it's no surprise to see it embrace new technology faster than other fields.

Starting from the basics, a set of standards and governance rules for safety and efficiency of navigation must be established that favors environmental protection and sustainable growth—and I'm not just talking about the shipping industry's growth, but the related growth of ports, coastal areas and entire countries. Here, the International Maritime Organization (IMO) e-navigation initiative is an attempt to ensure safe berth-to-berth navigation. To enable this, a series of maritime services portfolios (MSPs) are being developed as part of the improved provision of services to vessels. MSPs are the means of providing electronic information in a harmonized way. Currently, there are 16 MSPs being considered, including VTS information services, maritime safety information services, pilotage services, nautical chart services and real-time hydrographic and environmental services. In order to enable these services, a common infrastructure is required, referred to as common maritime data structures (CMDS), the desired infrastructure supporting e-navigation.

CMDS would include and organize parameters for priority, source and ownership information, for example. In essence, CMDS are very similar to spatial data infrastructures (SDI), "the relevant collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data," according to the accepted definition. CMDS could be a subset of a marine SDI. We can consider CMDS as the binding blocks between and within all MSPs and with users. In that sense, we can conclude that CMDS constitutes a geographic information system (GIS), where data need to be organized in databases and models with well-defined feature classes and attributes that can be converted into information products to be used under the e-navigation concept, ashore and on board, through a series of services (MSPs) by any GIS type of application, including but not limited to ECDIS and ECS (on board) and VTS (ashore).

For overcoming the challenges of data harmonization, there is an important new International Hydrographic Organization (IHO) series of standards development, based on a new universal hydrographic data model, S-100. This is motivated not only because of the need to replace the old S-57 Electronic Navigational Chart (ENC) standard but also to provide support to a much larger set of GIS-based standards beyond traditional navigational products demanded today in anticipation of the effects of the fourth industrial revolution. The S-100 is a GIS based on the ISO TC 211/ISO 19100 series, providing a framework for developing product specifications in several maritime domains. For instance, the S-101 to S-199 series

are under the hydrographic domain for developing product specifications such as S-101 ENC, S-102 bathymetry surface, S-103 subsurface navigation and so on; the S-201 to S-299 is the IALA domain for products such as aids to navigation, inter-VTS exchange format and application-specific messages, among others. There are two other domains so far: S-301 to S-399 for the IOC and a "various" domain with an S-40x series for inland ENCs, ice information, weather overlay and other things that would be developed as necessary. There is actually an initiative through the IMO-IHO Harmonization Group to harmonize S-100 with an IALA Universal Maritime Data Model (UMDM).

The Role of GIS

As we can see, GIS is an important technology player in this new industrial revolution. It brings together the science of where things are and where things should be for the maximum benefit of everyone. Important examples of its use are projects such as the NOAA Physical Oceanographic Real-Time System (PORTS), https://arcg.is/1v14Dn, that takes advantage of some of the concepts and technologies described above to build a system that provides situational awareness of the operating environment. The system gives environmental observations of oceanographic and meteorological conditions and decision support tools to users in more than 25 major U.S. ports for the benefit of maritime commerce and coastal resource management.

Seaports are vital in the shipping industry; they represent the connection with the mainland and a hub in the multimodal transportation network. The Port of Rotterdam is one of the few port organizations that understands the critical role that GIS plays in this new industrial revolution era and has implemented this technology in its broadest sense, enabling the port to grow not in physical extent but in efficiency. It has become one of the most efficient and forward-thinking ports in the world. With approximately 30,000 seagoing and 110,000 inland vessels a year, the port needed an efficient, up-to-date and reliable port map that is not only essential for vessels but for all parties in the port to conduct their business. Based on GIS, and taking advantage of technological developments mentioned above, the Port of Rotterdam has established the new Portmap system, an interactive, complete, current and clear online map of the port, with detailed views of the terminals, jetties, dolphins, berths, water depths, etc. An example of the public view of the Portmap system can be seen at http://arcg.is/2kT2nW3.

Another important initiative is the Ecological Marine Units (EMUs) project, a public-private partnership between Esri and the U.S. Geological Survey that uses ocean-based environmental data to create a three-dimensional map of the world's oceans (https://arcg.is/00WTXn).

Under the Group on Earth Observations, as part of the GEOSS Task EC-01-C1 (2014)/GI-14 GECO (2016), the EMUs are a standardized, robust and practical global ecosystems classification and map of the planet, where Esri is engaged in producing and hosting the content. This initiative has put in practice the marine SDI concepts to create an information product that is proving to be very useful for monitoring ocean health, ecosystems valuation, conservation planning, marine data management, fishing management, risk reduction and many other activities that directly and indirectly support coastal and port development, as well as Exclusive Economic Zone and Extended Continental Shelf resources management.

Perhaps one of the largest and most ambitious projects regarding SDI is the Esri Living Atlas of the World, https://livingatlas.arcgis.com, a collection of geographic information from Esri and its partners that is a community-based effort of thousands of contributors sharing their best maps, apps and data with the rest of the world. Anybody can use and contribute to the Living At-

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las. For example, the U.S. Marine Cadastre at www.marinecadastre.gov is a comprehensive marine information system providing spatial data, tools and support for the U.S. coastal and ocean management community. This information product was created by cooperation between NOAA and the U.S. Bureau of Ocean Energy Management (BOEM). You can find an entertaining story map at http://arcg.is/1ziDun explaining its benefits.

Conclusions

In a nutshell, we have reviewed five important initiatives—e-navigation, CMDS, MSPs, marine SDI and S-100—benefited by the revolutionary technological developments of AI, IoT, big data and augmented reality that are having an impact on the maritime world. I have chosen the shipping industry as the center of this analysis because I consider it very influential for the rest of the maritime domains due to its extensive economic impact. But renewable energy, marine protected areas, deep-sea exploration (mining, petroleum), climate change and security are equally important.

The new industrial revolution will determine our lives in the near future. We not only have to acknowledge it but need to be part of the change as well. The UN Sustainable Development Goals (SDG) illustrate what should be a focus in the new industrial revolution. These 17 goals are in the areas of greatest impact to humanity, and all of them are interrelated. We live on a planet where roughly 70 percent is covered by oceans, so it is not hard to imagine how important the oceans are for everything in our lives. SDG 14 addresses the oceans, specifically conservation and sustainable use and development of the oceans, seas and marine resources. Our oceans play a critical role in weather and climate change, and accomplishing SDG 14 will help in accomplishing SDG 13, which aims to combat climate change and its impacts. For both these SDGs, shipping regulations will be important; technology will help in making shipping routes and travel more efficient to reduce greenhouse gas emissions; and efficient maritime services portfolios and implementation of e-navigation concepts will increase safety of navigation and reduce risks of accidents and pollution. Accurate and timely oceanographic and meteorological data and EMUs (as well as coastal marine units in the near future) will support better resources management, enabling "responsible consumption and production" (SDG 12) from the sea. We could easily go on making connections between the SDGs.

What I want to emphasize is that the core of humanity's sustainable development resides in the oceans. We are creating the technology to achieve sustainable development goals, but we also need to create consciousness to be part of the change for a sustainable future that will support the coming generations. **ST**

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