NATIONAL SPATIAL DATA INFRASTRUCTURE PROGRAMS

A LITTORAL DISCUSSION

The recent tragedy in the Gulf of Mexico has thrust issues related to coastal zone management into the spotlight once again. In the United States and most nations, coastal zone maps that are key to many activities—including oil spill response—are outdated and inaccurate. For this reason, the littoral zone must be an integral part of any national spatial data infrastructure.

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Governments around the world are under increasing pressure to implement strategies and policies in the interest of long-term sustainability, particularly in dynamic environments such as the littoral zone—often defined as a 100-kilometer-wide area divided equally by the coastline, which is also defined as the mean sea level (MSL). In the United States, for example, there are a growing number of coastal and marine spatial planning (CMSP) initiatives being implemented to study coastal environments and identify areas best suited for various types of human use. These initiatives require an accurate and reliable national spatial data infrastructure (NSDI) to be effective.

Littoral Zone Details

Historically, the development of NSDI programs has been divided between onshore and offshore activities. Some government agencies are responsible for the onshore side of things while other, separate agencies may be responsible for the offshore component.

For example, consider a standard topographic map. Relevant information in the offshore areas (the "blue" areas) is nonexistent. Although topographic maps show soundings, they don't contain any bathymetric contours, shoals or descriptions of habitat such as sea grass beds and coral reefs—important data to support infrastructure and resource management programs. Similarly, navigation charts contain few topographic details except for perhaps the highest point within 50 kilometers of the shoreline or the odd road or urban area. The only thing topographic maps and navigation charts have in common is that the coastline separates them. Indeed, there's often disagreement about coastline delineation and definition.

The coast is home to 60 percent of the politically significant urban areas around the world. Consistent cloud cover, dense vegetation, rugged terrain and shallow waters—especially in equatorial regions—can make these areas difficult to map.

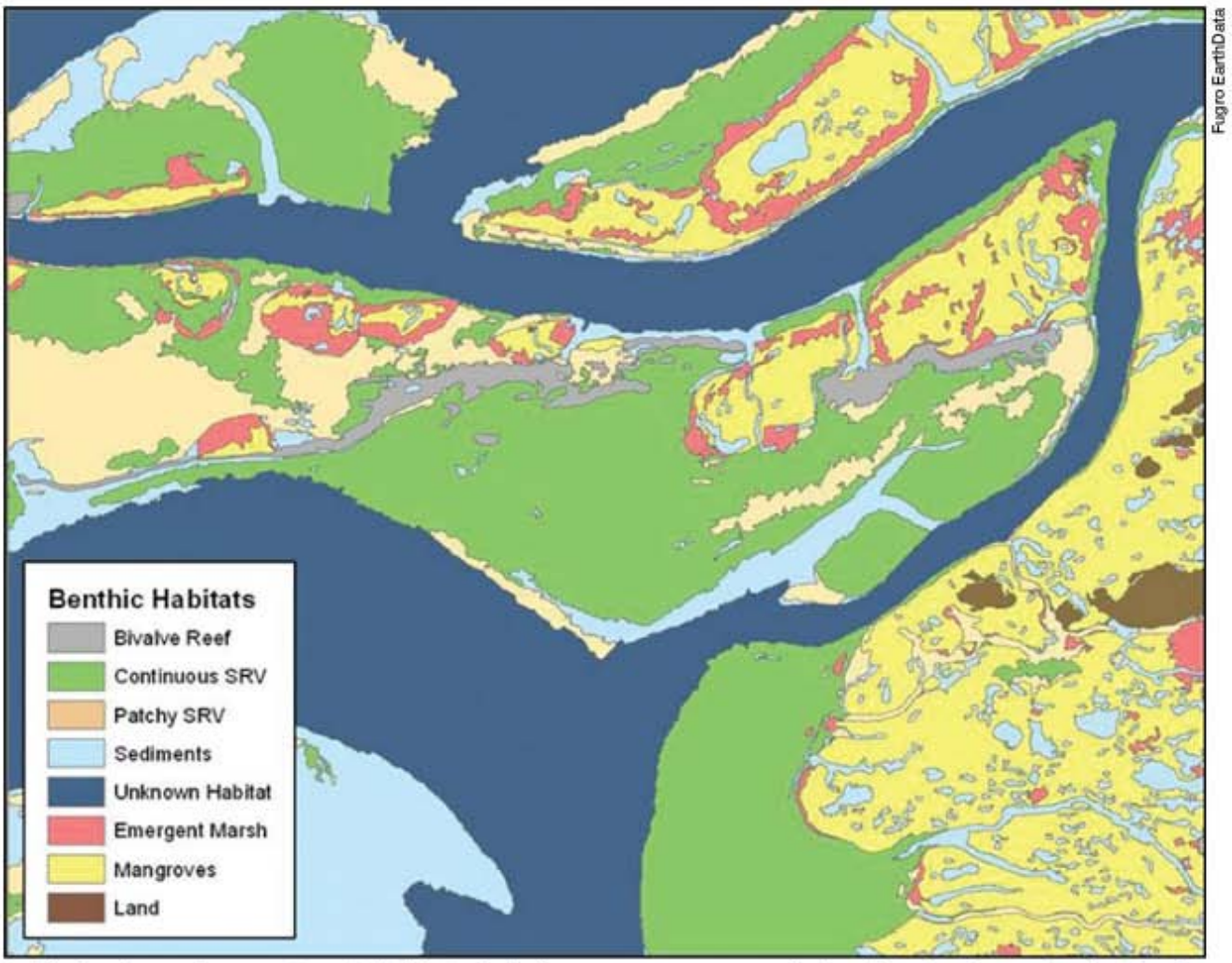
The littoral zone is important for several reasons. Statistics show 60 percent of the politically significant urban areas around the world are located within 40 kilometers of the coastline and 75 percent are located within 250 kilometers. If you take a closer look, four out of five world capitals are within 500 kilometers of the coast. This comes as no surprise, considering the littoral domain represents areas of economic importance, especially in the world's developing countries. In many cases, the lack of improved roads, railroads and harsh terrain make coastal areas and inland waterways vital to the transportation of raw materials and goods throughout the country. In fact, more than 90 percent of the world's trade by volume transits through ports.

NSDI Development

The global drive to exploit resources both onshore and offshore requires a country's NSDI to provide littoral zone information and knowledge. Building an accurate, up-to-date base map of the coast allows private and public stakeholders to make informed and effective decisions related to infrastructure development and coastal resources management. Such a map also provides critical information for a broad range of other applications, such as navigation safety, sea level rise analysis, coastal erosion, and disaster preparedness and response.

In most countries, the standard base mapping scale is 1:50,000. Typically mapping needs can be met by combining satellite and airborne technologies. Airborne, dual-band interferometric synthetic aperture radar (IfSAR) systems have proven to be a valuable technology to produce base mapping in areas of persistent cloud cover and dense vegetation. If the area to be mapped is cloud free and sparsely vegetated, then the area can be mapped effectively using high-altitude aerial imaging or even satellite imagery. The requirements of the mapping program simply need to match the characteristics of the area in terms of the nature of the information required—e.g., tundra in high-latitude areas and mangroves in tropical regions.

Three-dimensional framework data layers were developed for the Port of Tampa, Fla., from a combination of aerial mapping and terrestrial surveying methods.



Detailed and accurate maps of coastal habitats—including mangroves, seagrass beds and coral reefs—can be developed from airborne digital imagery using object-oriented image classification methods.

However, the dynamic nature of the littoral zone and the diversity of features and habitats require a finer level of detail than is typically required in most NSDI to accurately characterize and monitor this environment. Fortunately, recent advances in geospatial technology now allow users to develop comprehensive baseline maps over large portions of the littoral zone that are cost-effective and timely. This wasn't possible until recently, primarily because of the operational limitations of the various sensors used. Also, data storage and computer power no longer is the issue it once was, and geographic information system (GIS) software has made great strides to manage, deploy and support raster map products from a variety of sources and not just vector data. All this means

that advancements in sensor technology, as well as in commercially available hardware and software, now make it possible to acquire and process data into required maps in months rather than years.

More importantly, global organizations exist and are willing to help guide the development of such mapping efforts. Along with the maturity of the various remote sensing technologies, early agreements have been reached on the definition, positioning and portrayal of the coastline to help define and promote the need to develop a defined littoral zone. Such agreements, although a good start, only scratch the surface of what's possible from a technological and a financial investment point of view. Clearly, the more questions geospatial data answer, both onshore and offshore, the more value such comprehensive data sets provide.

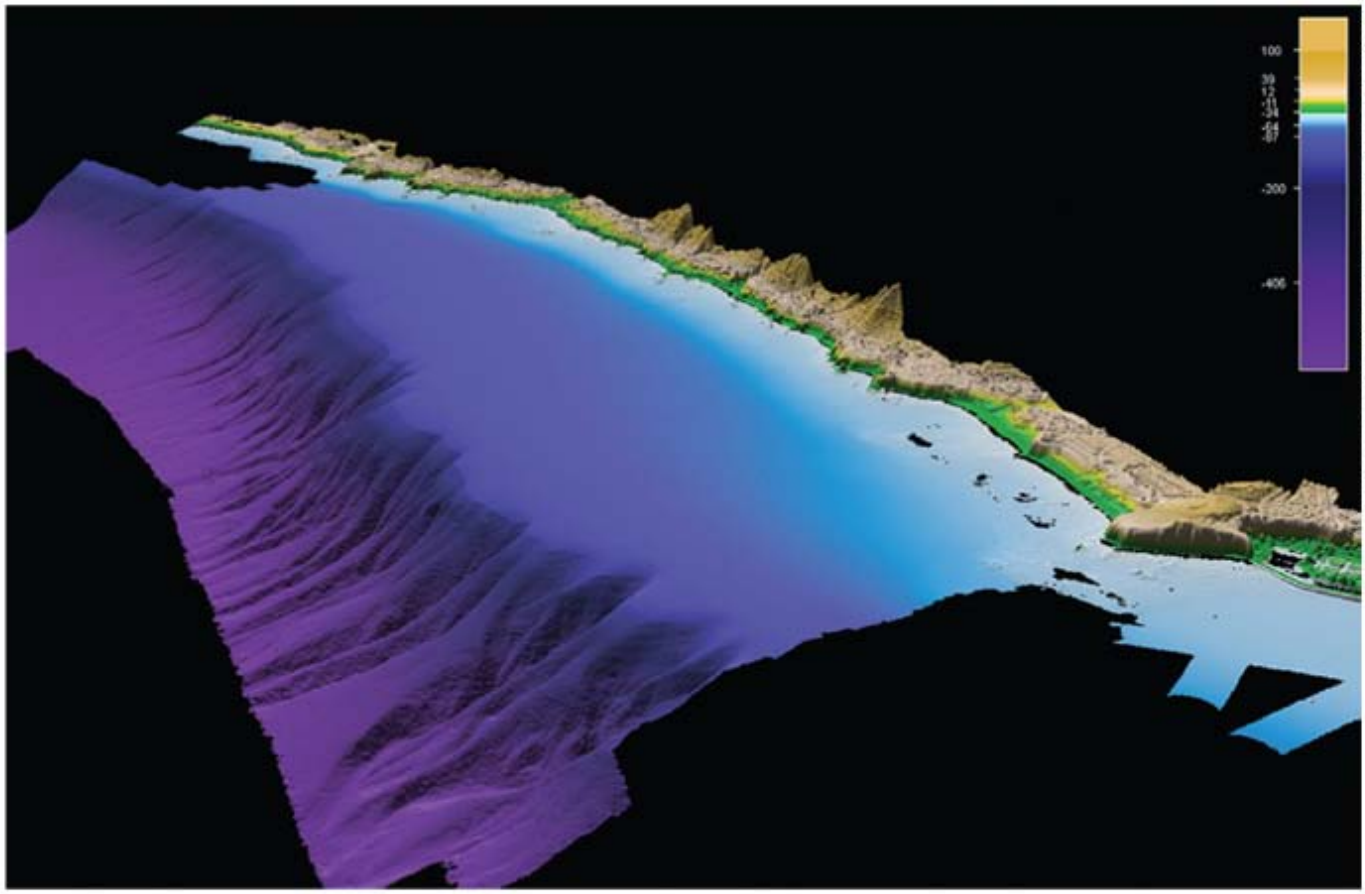
Fugro's GeoSAR airborne radar mapping system is used to accurately map littoral features and topography in equatorial regions that are difficult to map due to persistent cloud cover.

Mapping Solutions

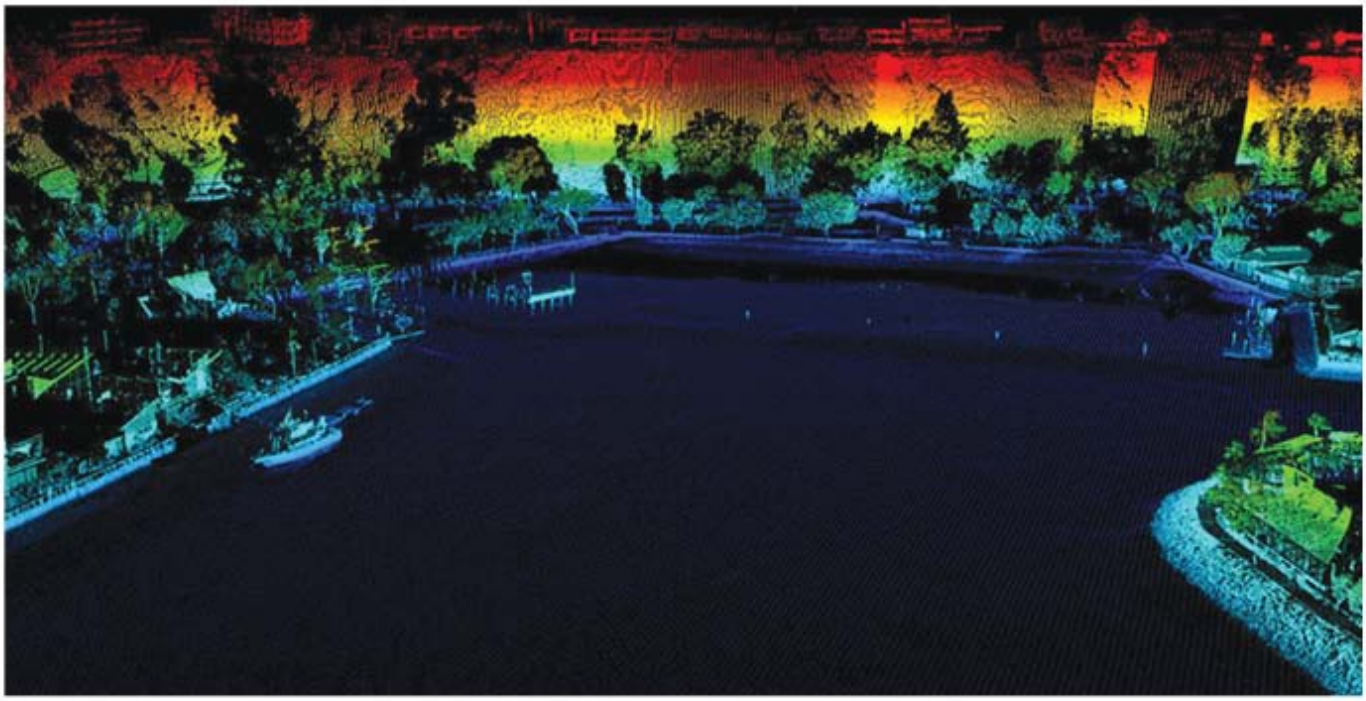
To map the near-shore side of the littoral zone, accurate, detailed geospatial data are developed using a combination of light detection and ranging (LiDAR) bathymetry and multibeam echo sounders. Each system also delivers, respectively, intensity and backscatter imagery used to identify benthic habitats. The MSL is determined from a variety of sources, including digital tide gauges, tide models and historical information. It's critical at this stage that both sides of the coastline see the coastline as the

"zero" contour. Complementing this effort is the need to ensure the respective data densities of each technology are reviewed and consistent once combined.

As for the onshore side of the littoral zone, mapping solutions have been well-documented in this publication and typically involve a combination of airborne, terrestrial and spaceborne technologies. Certainly, there's a primary need for 3-D and thematic information. On the airborne side, high-accuracy, high-density topographic LiDAR data, when combined with foliage-penetrating IfSAR and high-resolution color oblique and nadir imagery, provide a comprehensive data set that will set up a framework within which all the other "terrestrial" data will reside. Dynamic data derived from vehicle- or vessel-mounted LiDAR and digital imaging systems are attracting the interest of many planners as a better way to understand the existing infrastructure and how it may be impacted by further construction and development.



Mapping a littoral zone requires onshore and offshore mapping solutions. Hydrographic LiDAR overflights are beneficial for covering zones that are dangerous to a survey boat.



Point-cloud data of a harbor entrance were collected from a vessel-mounted LiDAR system.

Finally, satellite-sourced data sets can provide multispectral information and multitemporal data to monitor dynamic processes, such as ground subsidence or beach erosion. Although the resolutions and accuracies differ, data can provide value when defined within the framework of the most accurate data sets.

By simultaneously combining airborne LiDAR mapping, digital imagery, and marine and terrestrial surveying technologies, new methods have been developed to deliver accurate, seamless topography across the land-sea interface, as well as detailed information on habitats, geology and geomorphology. This approach is currently being implemented along the entire West Coast in a landmark Fugro EarthData project. Project details, including how the resultant mapping is benefiting multiple stakeholders, will be

highlighted in future issues of Earth Imaging Journal.

Geospatial technology has witnessed tremendous growth in the last few years, delivering immense benefits to public and private organizations by allowing users to develop comprehensive and reliable NSDI programs. The technology will continue to evolve through the development of new sensors and software, as well as the integration of real-time data, to deliver increasingly relevant geodata of the littoral zone to GIS users and nonspecialists alike. This trend will enhance decision making and increase efficiencies to address a broad range of coastal resources management issues.