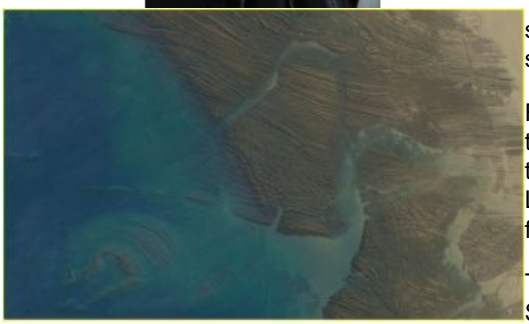
FRENCH COASTAL SURVEY USING ALB

From Concept to Feasibility in Aerial Mapping



Starting in 2005, the French Naval Hydrographic and Oceanographic Office (Service hydrographique et océanographique de la marine [Shom]) and the French National Geographic Institute (Institut National de l'Information Géographique et Forestière [IGN]) began conducting, as part of the national project Litto3D, a series of coastal surveys of metropolitan France and some overseas territories. This article provides insight into the evolution of Shom's expertise in airborne Lidar bathymetry (ALB).

The coastal areas were poorly described in 2005; airborne bathymetric Lidar data was used to create a continuous altimetric dataset of the coastal zone. The purpose of this project was to produce better risk management prevention plans for floods, landslides and earthquakes, and to support economic development strategies, environmental protection policies and scientific studies that require the knowledge of the near shore topography and bathymetry.

From 2007 to 2015, Shom built a strong expertise in the Airborne Lidar Bathymetry (ALB) technical field by subcontracting data acquisition to survey companies. In February 2016, the French Ministry of Environment officially decided to finalise the maritime part of the Litto3D programme; up to half of the cost of a regional ALB survey could be directly funded.

This decision opened a new perspective; instead of subcontracting survey companies Shom could run and operate its own ALB capacity with the guarantee to be financially supported. It was decided to launch a call for proposals on a three-year ALB full service. The selected company would have to provide the bathymetric Lidar system as well as the aircraft and its pilots, the training of the laser operators, take care of the maintenances/calibrations and deal with the administrative support (flight permits, insurance policy, etc.).

Planning the Mapping Mission

Leica Geosystems and CAE Aviation, who won the tender, mobilised their efforts to offer a comprehensive theoretical and practical training to Shom's team on the use of Lidar and the associated software with this technology.

The first survey conducted in Normandy and North of France used the Leica HawkEye III, an airborne multi-sensor deep water bathymetric and topographic Lidar system, mounted on a Cessna Grand Caravan.

During the data acquisition in Cherbourg in September 2016, the HawkEye III captured full waveform in a rather favourable environmental condition; the wind was relatively calm with flat seas and without fog in the survey area. In addition, the Leica MissionPro software with the 3D virtual globe view helped in the preparation and planning for the flights, and the Leica FlightPro flight management and sensor control system assisted in the data collection.

Figure 1: The SHOM operating team in the field.

The results of this first topo-bathymetric survey exceeded Shom's expectations, as the water column in The English Channel is globally

turbid, the goal was to reach the 5 metres isobaths. On many areas, the laser penetration overtook the 10m depth. The achieved work on morpho-sedimentary cells was impressive; for this first deployment, Shom only planned to survey the western part of Cotentin peninsula. After 4 weeks, the northern and half of the eastern parts were also covered (more than 300km of coastline). Leica Geosystems Lidar technology worked perfectly; no failures occurred during the first mission.

The Challenge

Given these positive findings, Shom continues in 2017 the Normandy and North of France survey, a major operation along ‘La Manche’ coastline, from Baie du Mont-Saint-Michel (western Normandy) to the Belgian border. Two more topo-bathymetric surveys will take place (in May-June and August-September 2017) and will enable Shom to generate a complete geographical product by mid-2018. The expected coverage goes down to 5 metres isobaths and up to 400m inland.

These coming deployments include real challenges for Shom; Mont-Saint-Michel is known for the highest tides in Europe (more than 14 metres between lowest and highest astronomical tides!). If the flights are correctly scheduled during low tides, the Shom team can benefit from them. The inclement weather might be another obstacle to overcome as well. But the main difficulty will remain the turbid coastal waters of The English Channel. Shom will again take advantage of the HawkEye III to provide high resolution and accurate deep bathy, shallow bathy and topography data.

An important goal in this kind of survey is indeed to have a smooth transition between topographic and bathymetric data, but this interface between land and sea is not easily measured. Due to tides, currents and wind, the clouds of turbidity have a tendency to accumulate near the shore. Rivers mouths and more generally rains can also bring a lot of sediments, which partially obstruct the optical path of an airborne Lidar. Breaking waves can even generate ‘white waters’, which are impenetrable by laser. Hence, the most challenging environmental conditions are often faced in these very coastal areas, between 0-10m depths. However, the topo-bathymetric Lidars, launched by equipment providers since 2012, have offered a major technological breakthrough: they are not as powerful as usual bathy Lidar, but their higher Pulse Repetition Frequency offers denser bathymetric point clouds (3-4 points per square metre) to surveyors. Even in turbid waters and with the help of dedicated software, it becomes achievable to detect the sea floor.

Figure 2: Area of interest in Normandie and Hauts-de-France.

The HawkEye III includes a Leica Chiroptera topo-bathymetric system and can achieve perfect earth-sea continuity thanks to its various sensors (3 channels: topo, topo-bathy also called ‘shallow’, and pure bathy also called ‘deep’). This technology ensures Shom there will be no gaps in the Digital Terrain Model (DTM), which is essential for the end product. The Litto3D geographical reference frame is used for many purposes in metropolitan France and French overseas territories: as listed in introduction, shoreline management, economic development, environmental protection and risk prevention. It is especially used to model maritime flooding, due to storms, tsunami or long-term sea-level rise. Wrong data could completely bias the conclusions of such studies, which is of course not acceptable for scientists, but also for stakeholders. Litto3D intends to enlighten decision making on the littoral.

On the software side, Leica Geosystems also provides the Leica Lidar Survey Studio (Leica LSS) to pre-process the waveform and position data to create classified point clouds. An important feature of LSS is the ‘Turbid Water Enhancement’ algorithm, which is obviously helpful in complex areas. The Shom team can also review the deep bathymetry, the shallow and the topographic Lidar data at the same time, including reviewing the images taken at the same location as the point cloud data.

Figure 3: The HawkEye III system on board the Cesna 208 grand caravan.

From a cost-effective approach, comparing with shipborne survey’s in the past, topo and bathy survey had to take place separately and Shom had to launch a complex merging data process. With Leica Geosystems technology, this step is not necessary anymore.

An Innovative Solution

Shom has the responsibility to conduct surveys in difficult areas and our partnership with Leica Geosystems gives us peace of mind by dealing with all the other aspects of the project, such as system installation, calibration, technical and aeronautical maintenance, among other tasks.

The Lidar technology has been widely used in monitoring various natural hazards. Due to the high accuracy of the captured data (if one considers a Lidar point expressed in the French legal geodetic system RGF93, its coordinates absolute precision is less than 20cm for topo dataset and less than 40cm for bathy dataset), the technology is today used in the field of oceanic sciences, including a DTM and bathymetric mapping. The HawkEye III is a simple-to-use sensor optimised for the most demanding survey requirements: ‘full sea floor search’ is of course not yet reached, but Shom commonly labels airborne bathymetric Lidar datasets in CATZOC B (IHO S-57).

Figure 4: Final DTM West of Granville (Normandy).

Figure 5: Final DTM West Bretteville-sur-Mer (Normandy) slightly textured by orthophoto.