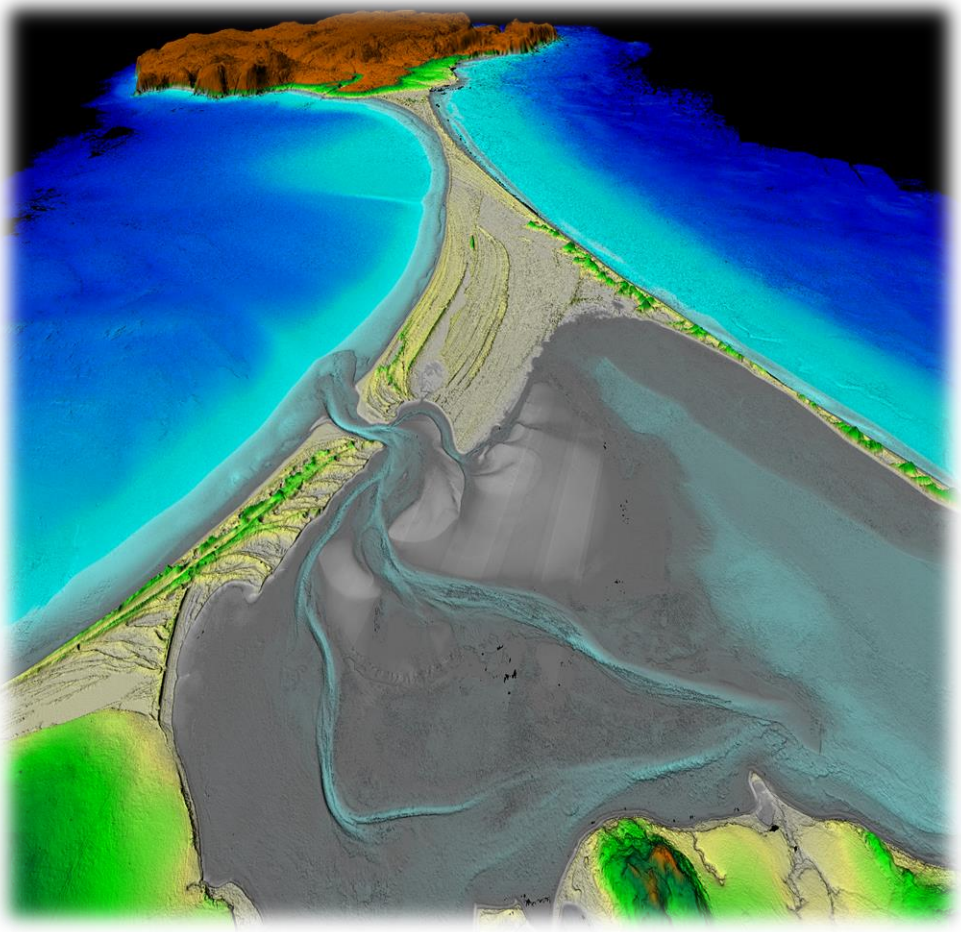
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

SHOM
L'océan en référence

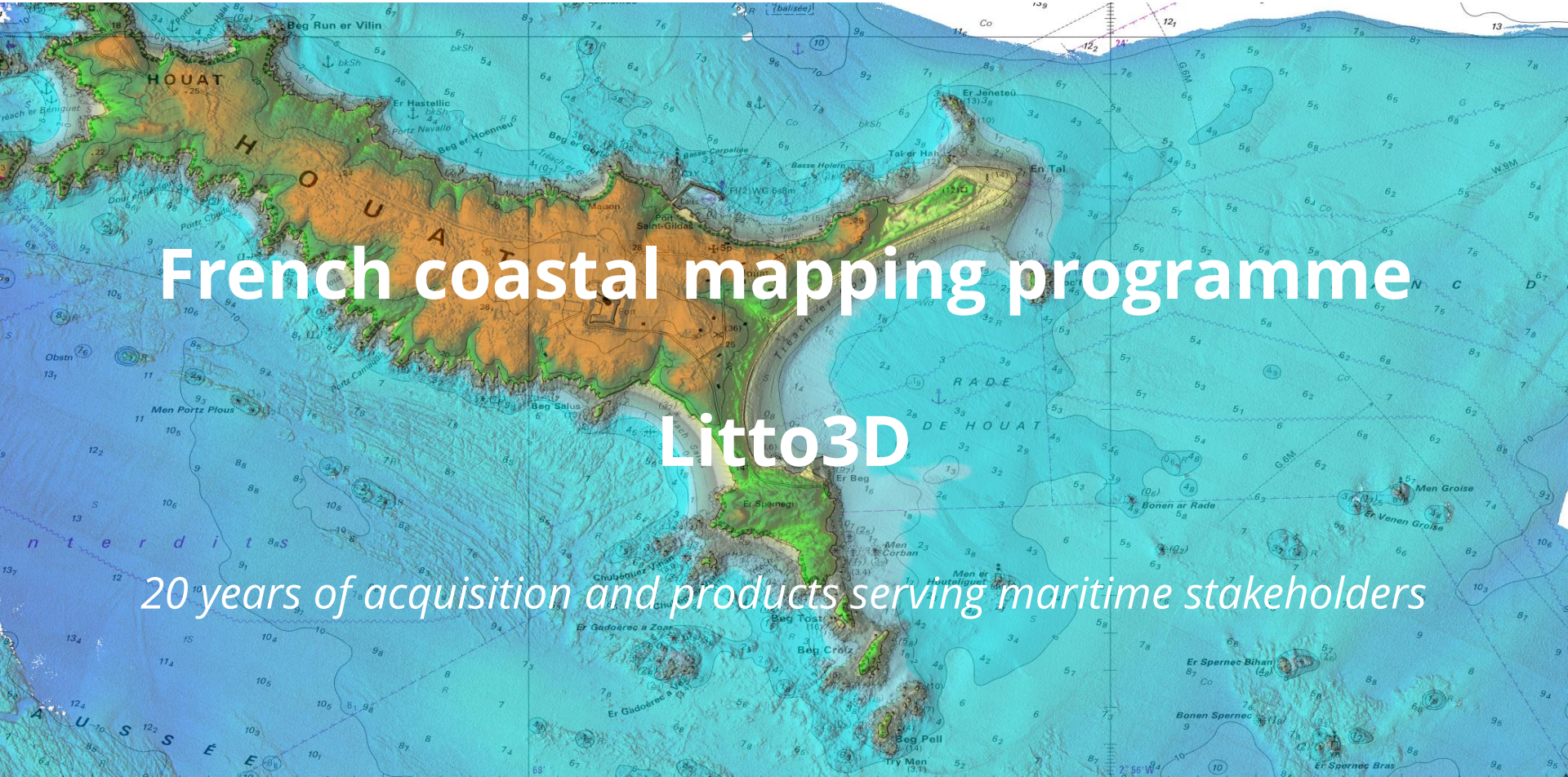
TWO DECADES OF TOPO-BATHYMETRIC LIDAR FOR THE FRENCH COASTAL MAPPING PROGRAMME

Litto3D®



Julien Smeeckaert [1], Coralie Monpert [1], Elizabeth Trancart [1]

[1] Shom

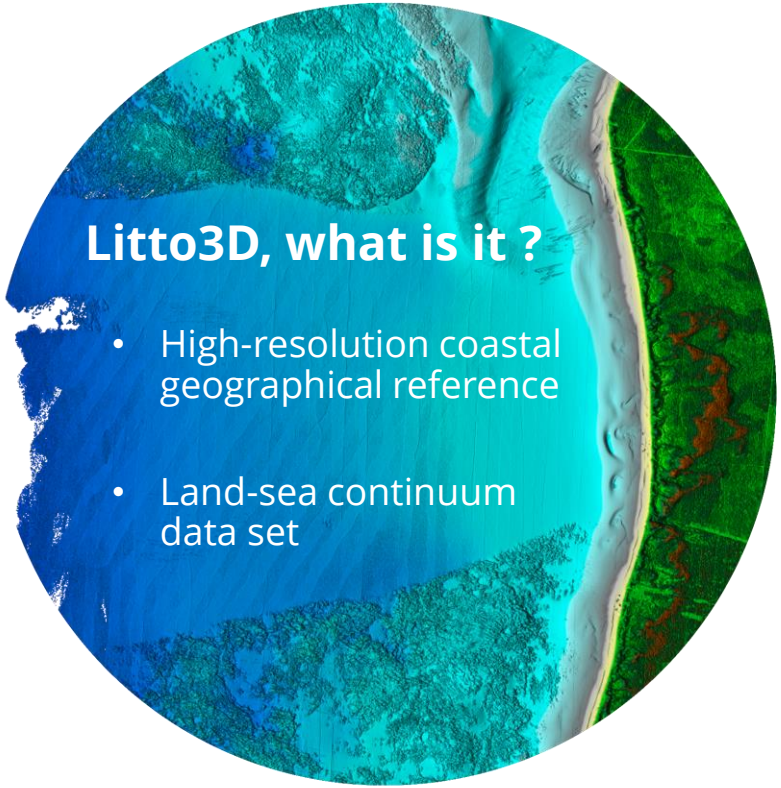


French coastal mapping programme

Litto3D

20 years of acquisition and products serving maritime stakeholders

Litto3D, a tool dedicated to integrated coastal management

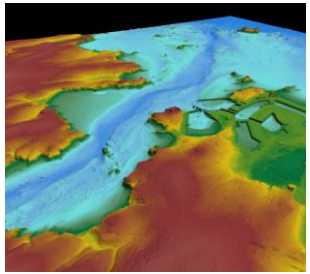


Who ?

- Shom (French hydrographic office)
- IGN (French geographical institute)

Why ?

- Coastline management
- Risk prevention
- Marine submersion modelling
- Land-use planning

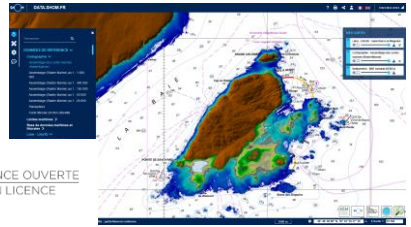


How ?

- Airborne topographic & bathymetric LiDAR technology
- Data processing & product generation

Where to get the products ?

- Online Shom portals
  - data.shom.fr
  - diffusion.shom.fr



Litto3D, support of public policies for integrated coastal management

2000 — **2010** — **2020** — **2030**

Erika (1999) and Prestige (2002) disasters

European and national policies promoting integrated coastal zone management
Development of the Litto3D programme

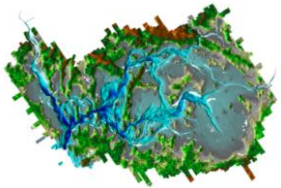
2003

Interministerial Committee for the Sea (CIMER)

Creation of programme Litto3D

2005

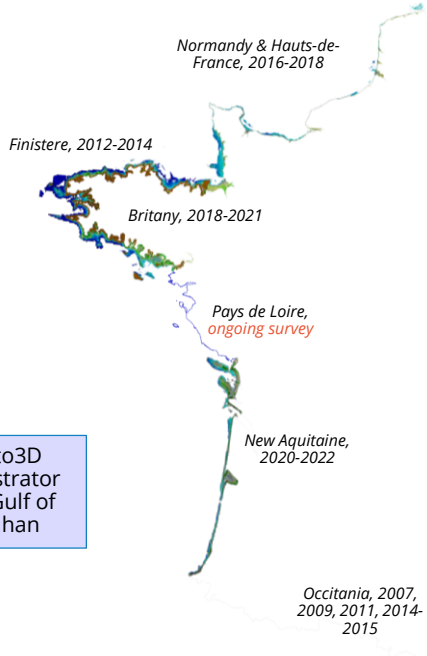
1st Litto3D demonstrator in the Gulf of Morbihan

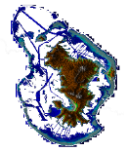


Gulf of Morbihan, 2005

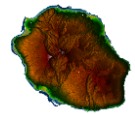
2009

LiDAR surveys & product generation (mainland + overseas territories)

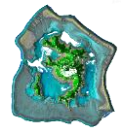




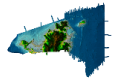
Mayotte, 2012



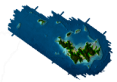
Reunion Island, 2016



Fr. Polynesia, 2015

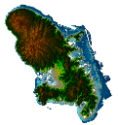


Saint-Martin, 2019



Saint-Barthelemy, 2019

Guadeloupe, 2016



Martinique, 2016

Corsica, 2017-2018

St-Pierre-et-Miquelon, 2023

Fr. Polynesia, 2025, ongoing processing

***New Caledonia**, Tender process underway, reviewing applications*

2025

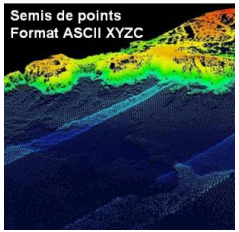
National Strategy for Integrated Coastal Zone Management, 2025–2030

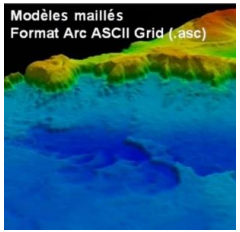
" Reflection on the opportunity for a national lidar topographic and bathymetric acquisition capacity "

Litto3D, open-licence multi-format products

Litto3D products include :

- Point clouds (floor/seafloor & over-ground)
- DTM 1m
- DTM 5m
- Open Licence ETALAB
- Viewing on data.shom.fr
- Downloading on diffusion.shom.fr

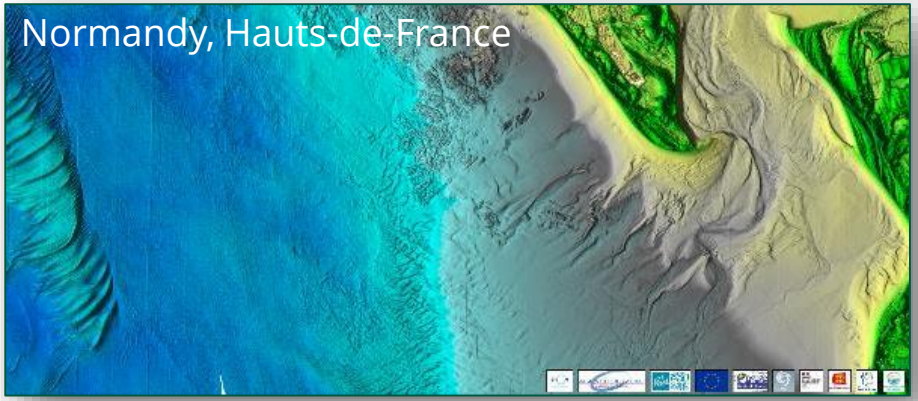


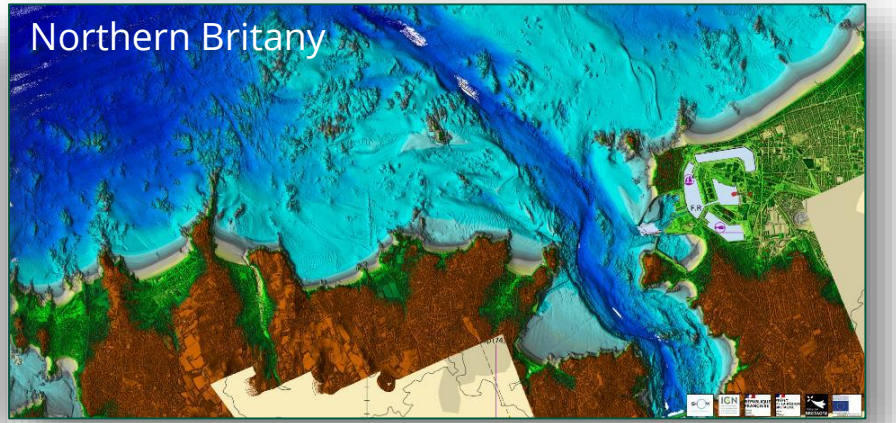


Specified uncertainties

	Horizontal uncertainties (95%)	Vertical uncertainties (95%)
Topo	20 cm	20 cm
Bathy	2.80 m	50 cm

Compliant with IHO S-44 order 1B

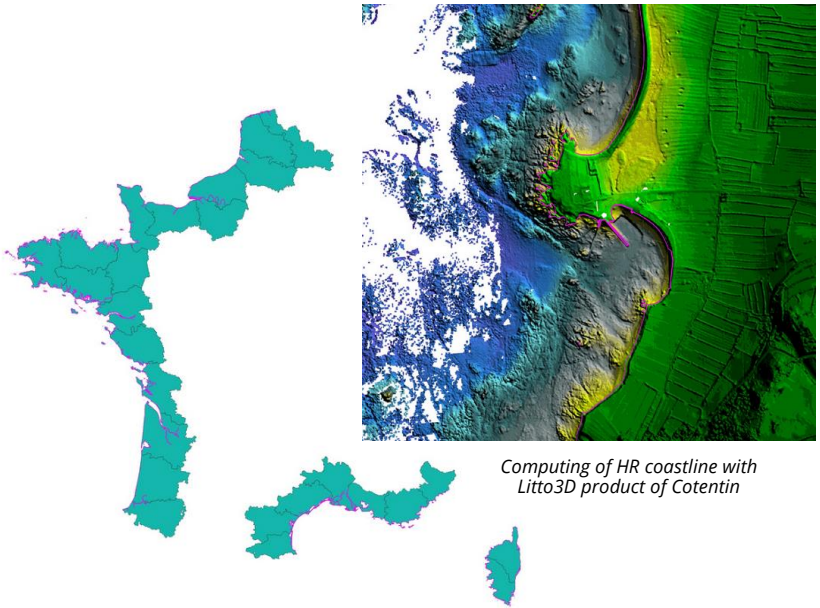




Litto3D, various uses for different stakeholders

Definition of an official high-resolution coastline

- Better resolution than the current product HISTOLLIT (TCHV2)



Computing of HR coastline with Litto3D product of Cotentin

Coastal Digital Twin Project

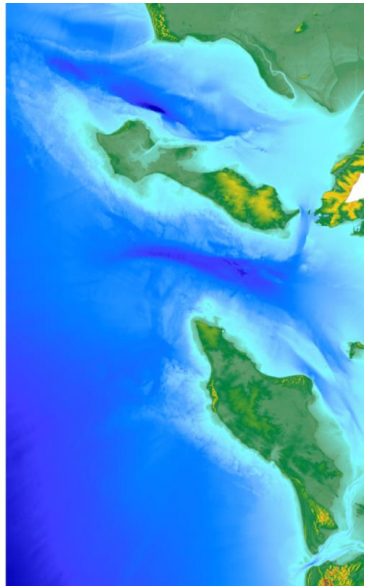
- Decision support for risk management
- Integration of multi-source data including Litto3D

Prototype of coastal digital twin viewer, Shom internal documentation 2025

Litto3D, various uses for different stakeholders

HOMONIM project

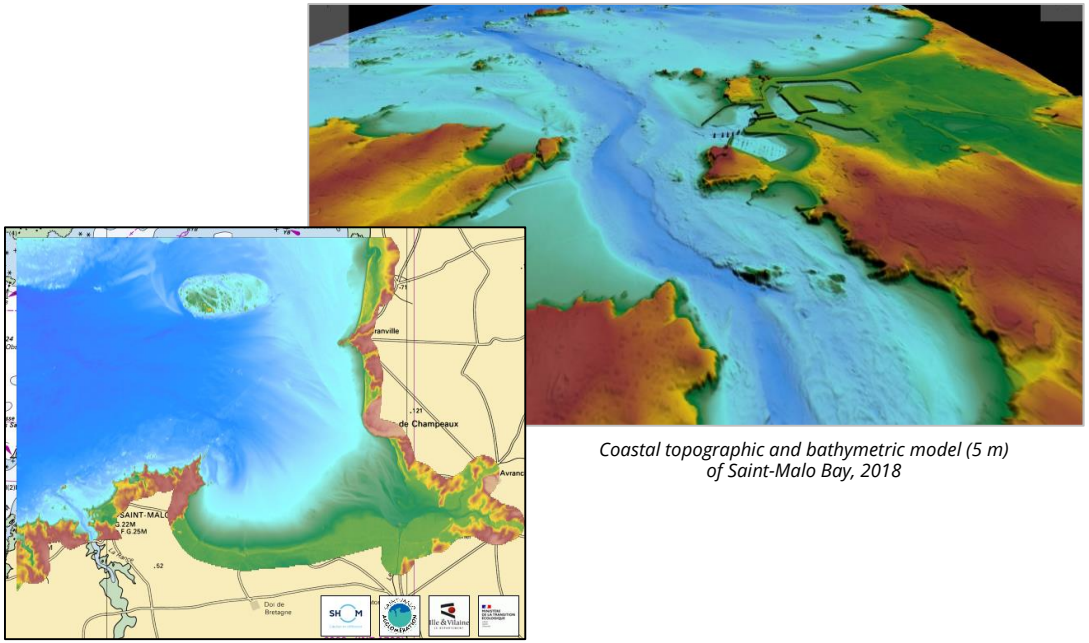
- Modelling and forecasting marine submersion risks for Wave-Submersion Vigilance
- Modelling currently realised with 20m DTMs
- Extra high resolution local prototyping (5m)



Coastal topographic and bathymetric product for the Charente straits with a resolution of 0.0002° (DTM 20m)

Flood Prevention Action Programme

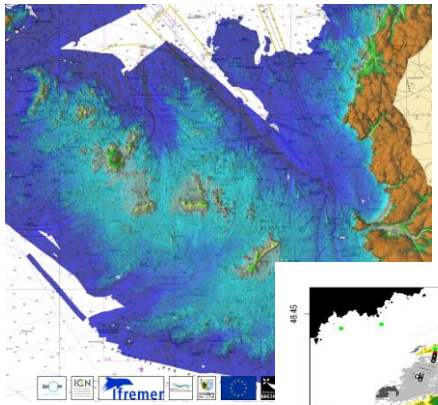
- Merging of Litto3D data and acoustic echosounders measures to create a 5m DTM
- Shom supporting Saint Malo city in defining a local flood monitoring service



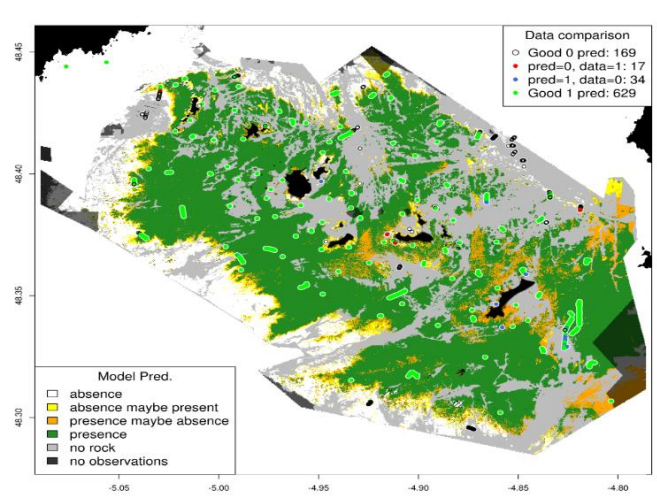
Coastal topographic and bathymetric model (5 m) of Saint-Malo Bay, 2018

Litto3D, various uses for different stakeholders

Predictive mapping of marine habitats



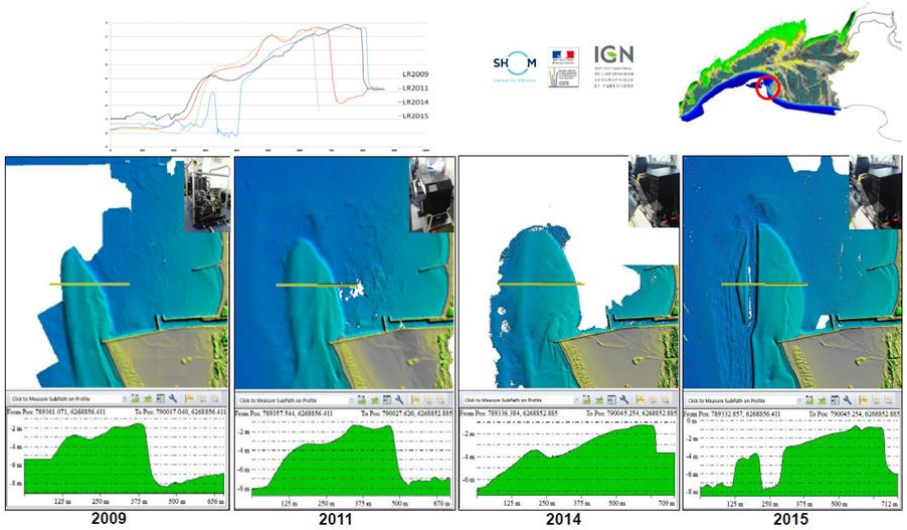
Molène Plateau with Litto3D Finistère data (2014), data.shom.fr



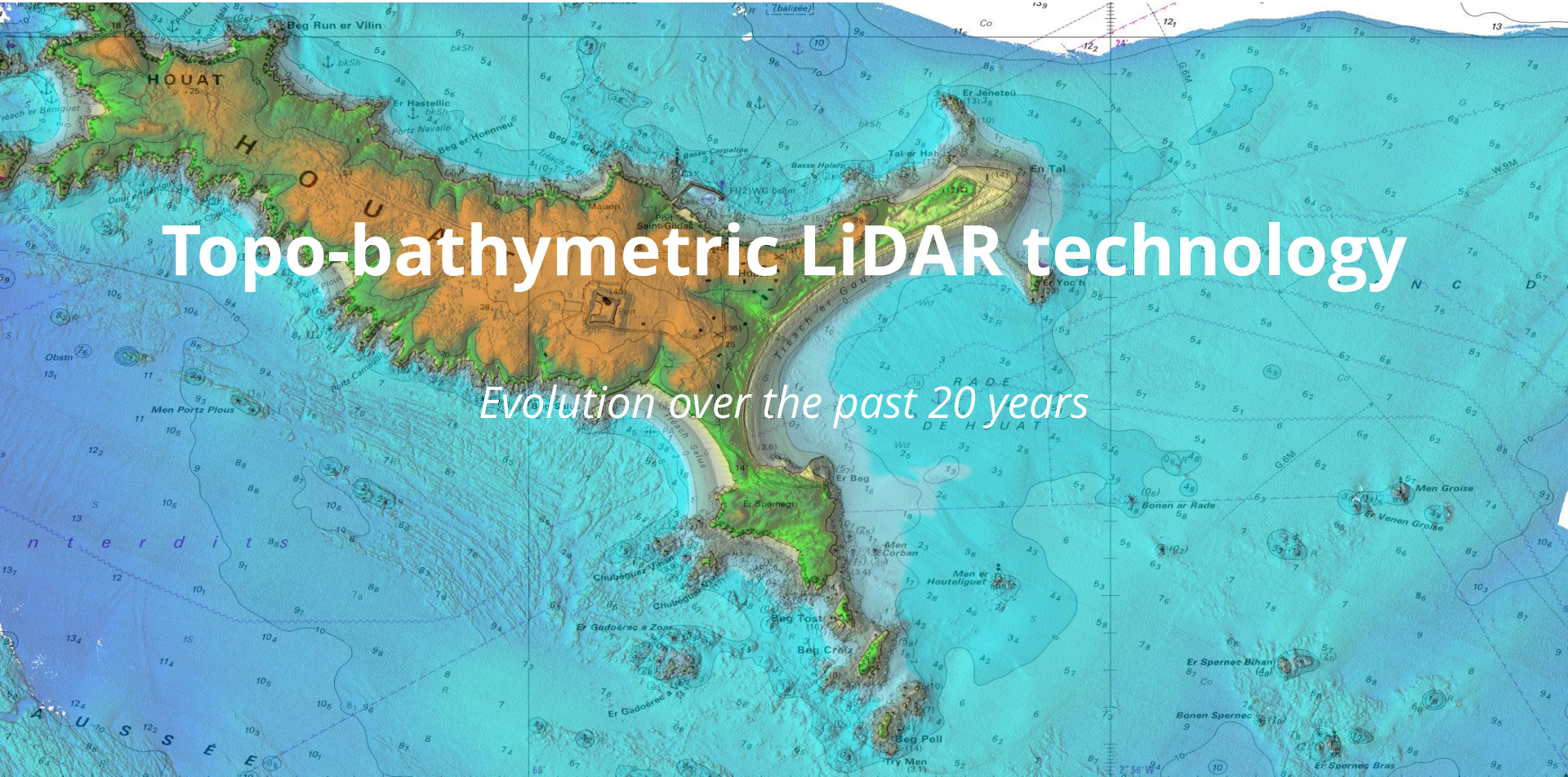
BAJJOUK T. et al, Predictive mapping of the kelp field on the Molène plateau based on physical and biological data, IFREMER, 2013

Monitoring of coastal sediment dynamics

- Requires regular surveys



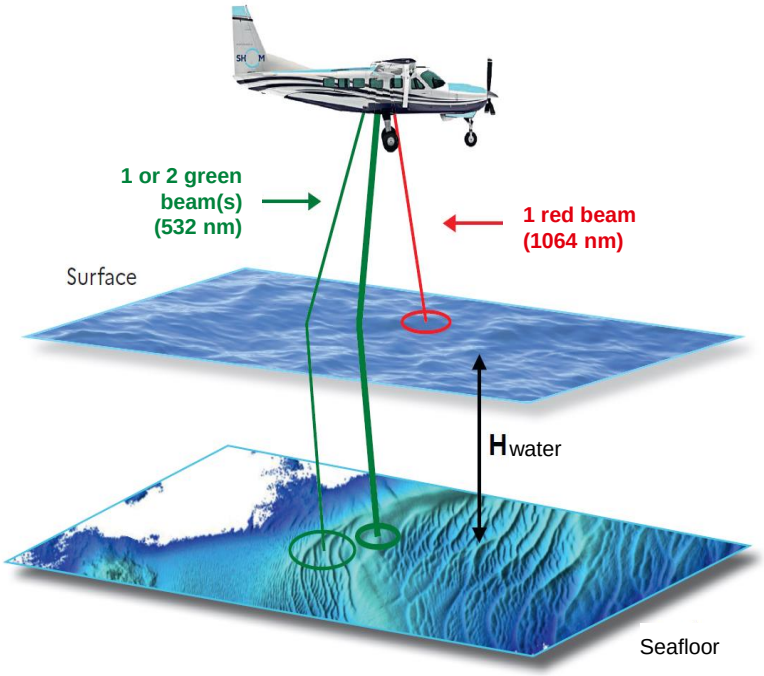
Evolution of sedimentary deposits at Pointe de l'Espiguette in Le Grau-Du-Roi

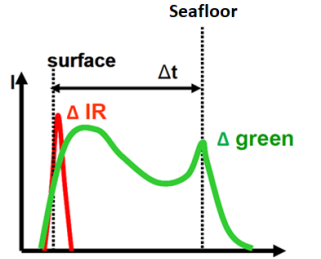


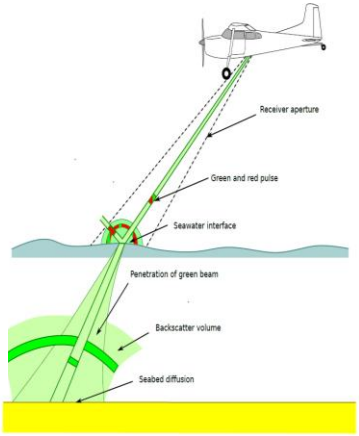
Topo-bathymetric LiDAR technology

Evolution over the past 20 years

Topographic & bathymetric LiDAR technology



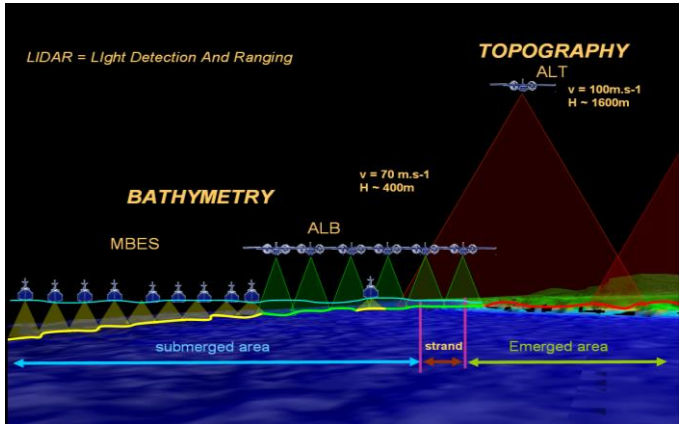




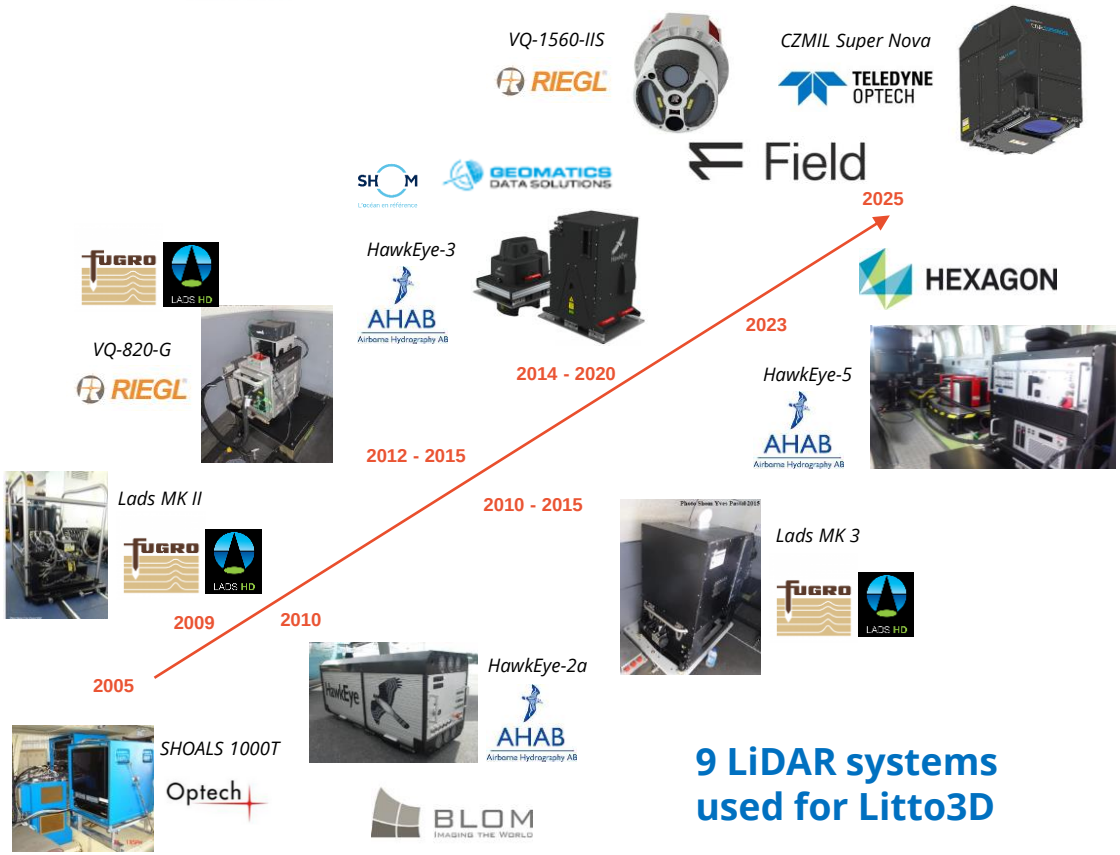
Airborne LiDAR – H : flight altitude, V : flight speed, A : Lateral angular aperture of the sensor

Illustration: Michel Legris (Ensta Bretane)

- Easy survey of very shallow waters
- Rapid coverage over large areas
- Lower operational costs compared to acoustic surveys conducted by ship
- Highly dependent on weather conditions, turbidity and vegetation



Systems implemented on the Litto3D programme

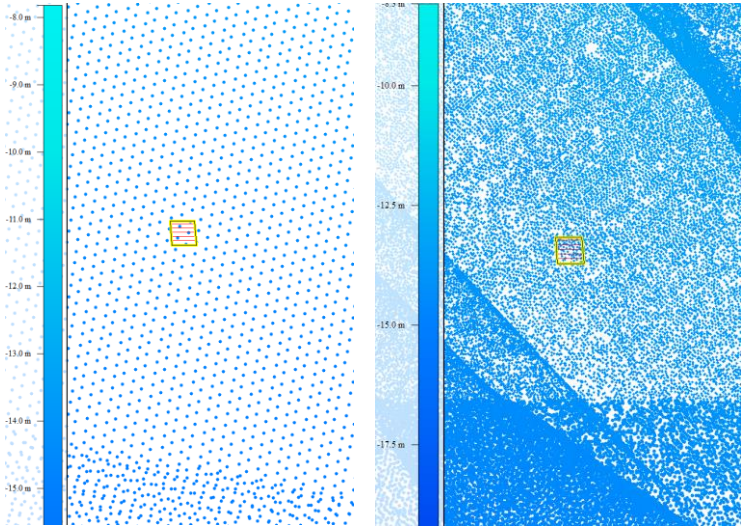


9 LiDAR systems used for Litto3D

Bathymetric LiDAR evolution :

DEEP (2010) ➔ SHALLOW/DEEP (2018…)

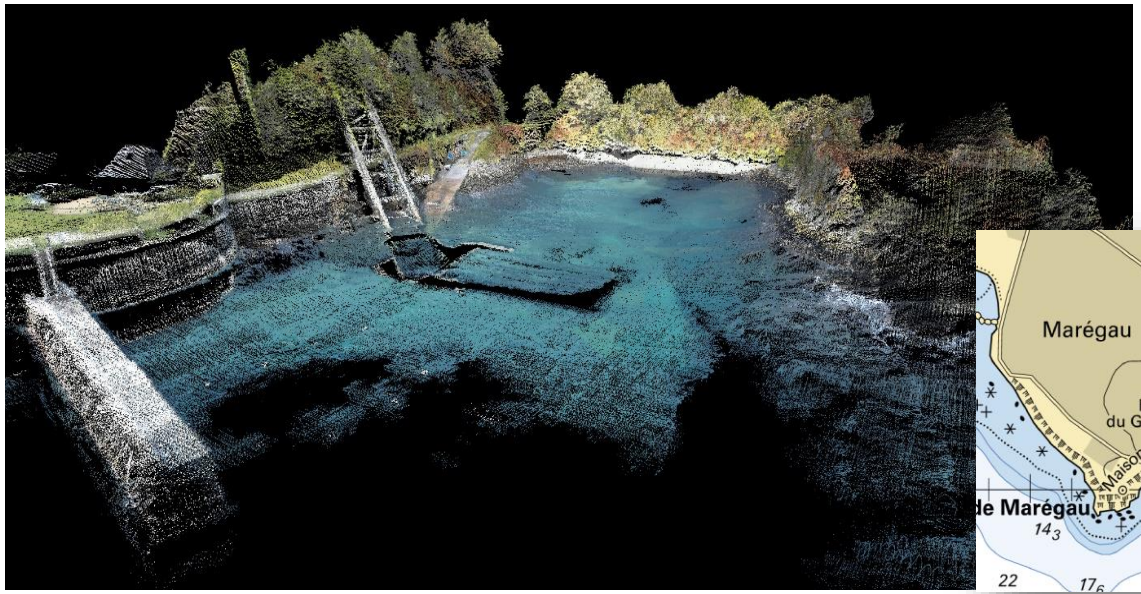
- Increased density & resolution
- Improvement of range detection



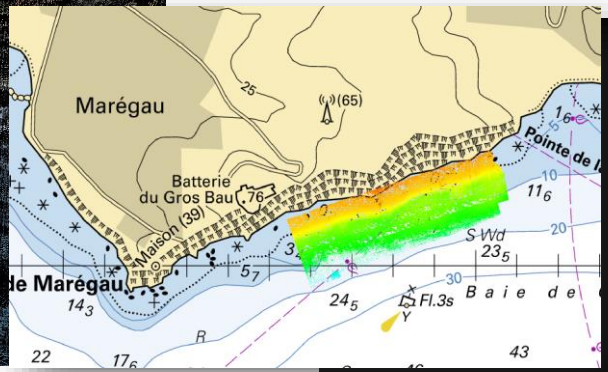
2012 : 0,2 pt/m² *2022 : 1 pt/m²*

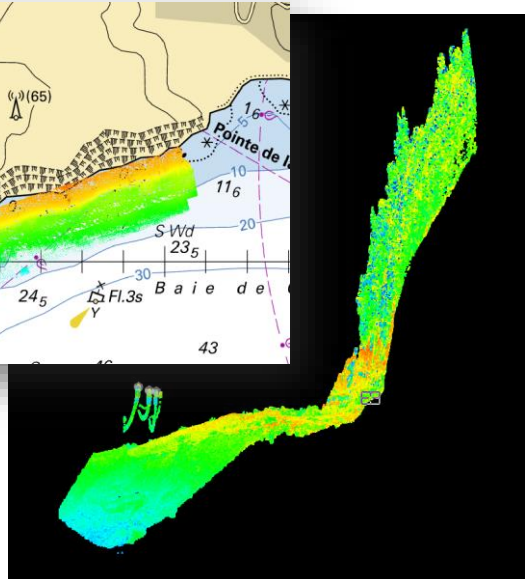
Comparison of bathymetric LiDAR density on Britany survey

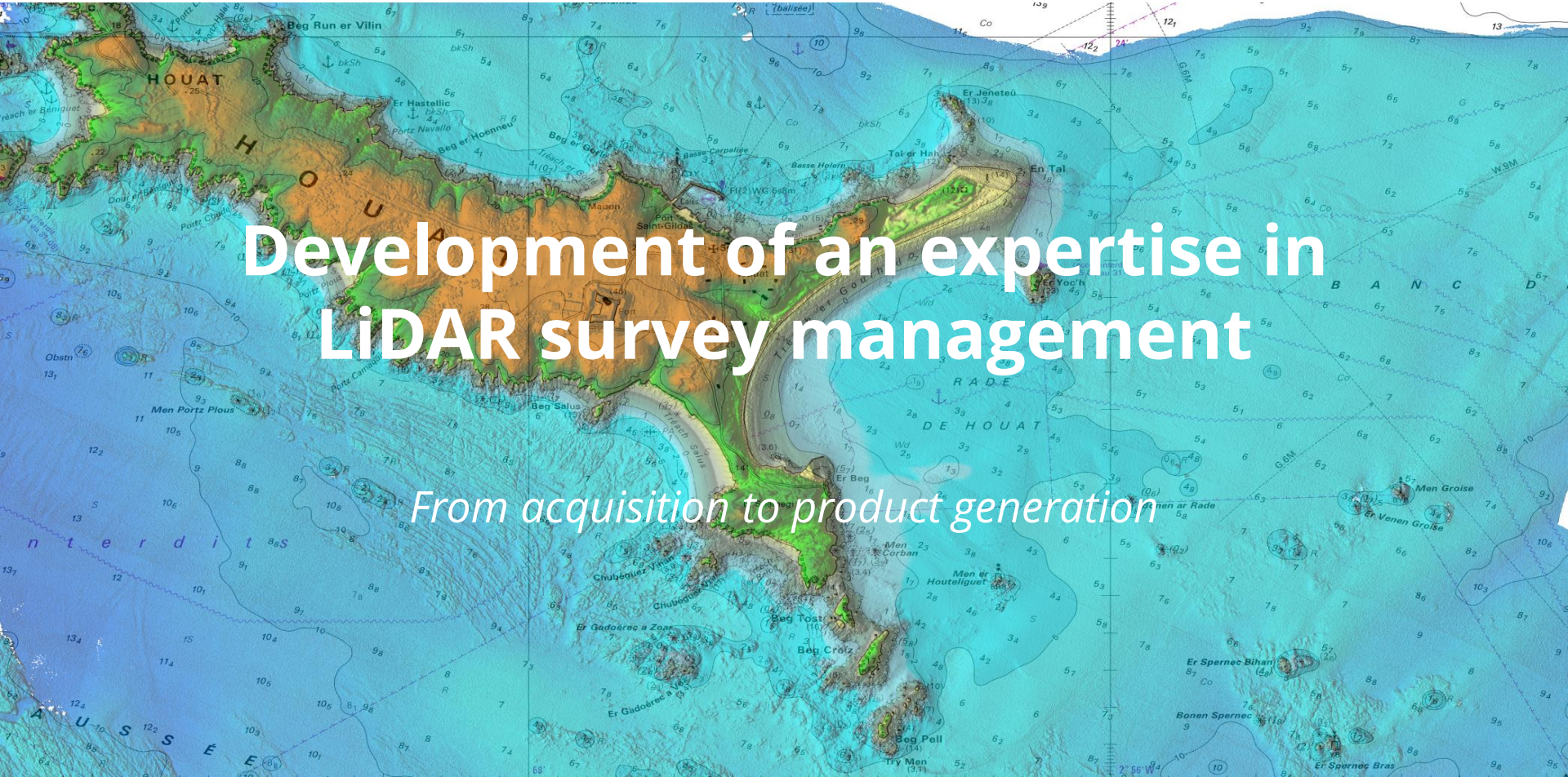
The prospect of dronisation with the miniaturisation of sensors



Ongoing and future experiments to evaluate system performance and compliance with hydrographic standards in the context of hydrographic surveys for the safety of navigation







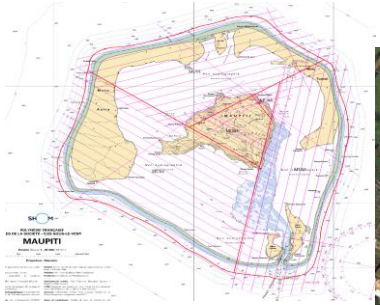
Development of an expertise in LiDAR survey management

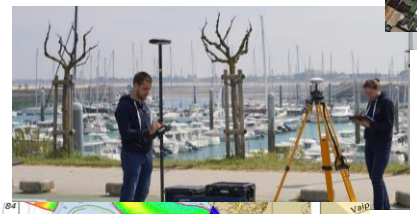
From acquisition to product generation

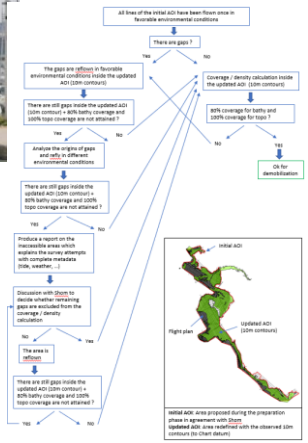
LiDAR acquisition monitoring

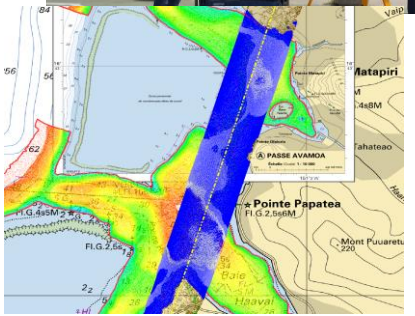
Shom support for the subcontractor in charge of surveying throughout the acquisition process

- Environment assessment / advices on flight plan
- Establishment of a field truth
  - ➢ Topography : measuring geodetic points + QC lines on remarkable features
  - ➢ Bathymetry : choice of recent multibeam surveys in Shom database
- Definition of QC lines (data control with ground truth)
- Daily monitoring : flight sheets sent by the subcontractor describing the operations realised
- Weekly monitoring : data coverages, density maps and QC lines transmitted by the subcontractor for Shom analysis
- Report of the meteorological conditions
- Supervision of the planification of re-flight lines
- Approval of demobilisation based on a decision tree







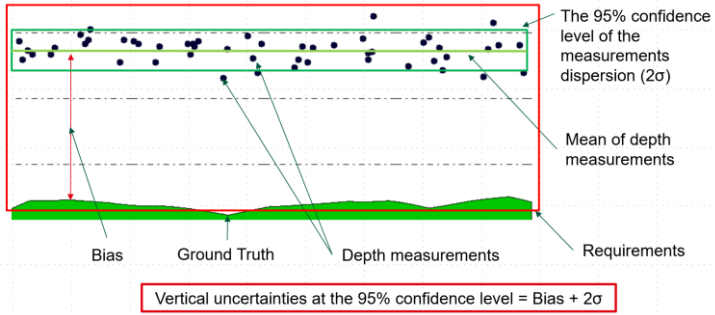


Win-win partnership between Shom and subcontractor: survey conducted in accordance with quality requirements and enriching experience

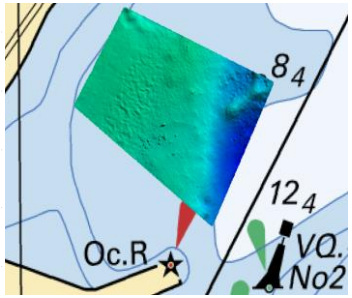
Quality control during acquisition

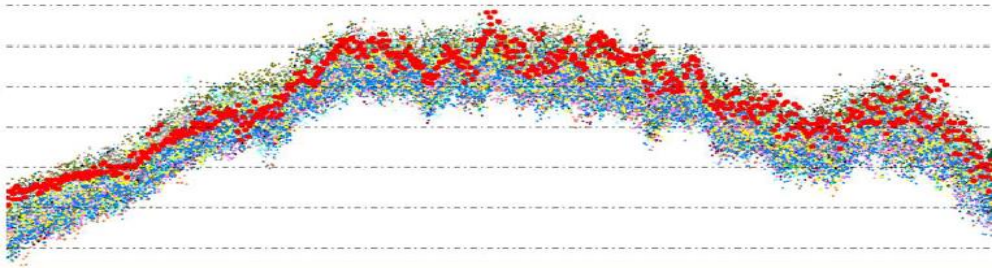
Controls on each QC line

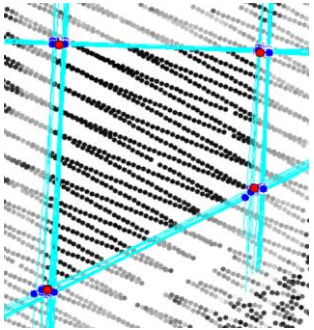
- Horizontal precision and uncertainty compared to ground truth (topographic survey)
- Consistency between the various laser sensors
- Vertical precision and uncertainty compared to ground truth (MBES surveys)

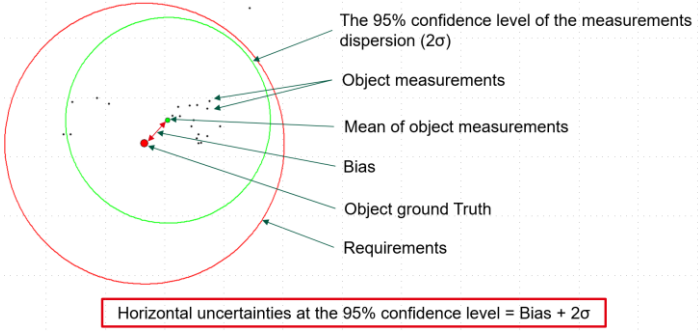


Vertical uncertainties at the 95% confidence level = Bias + 2σ





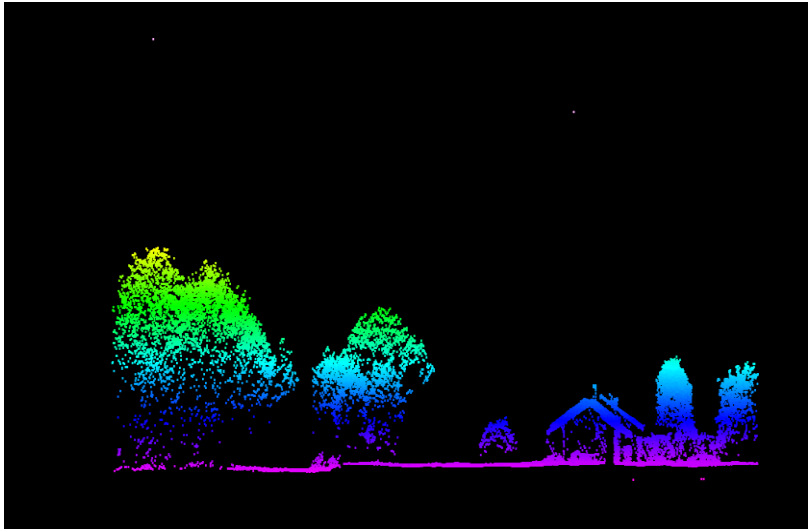




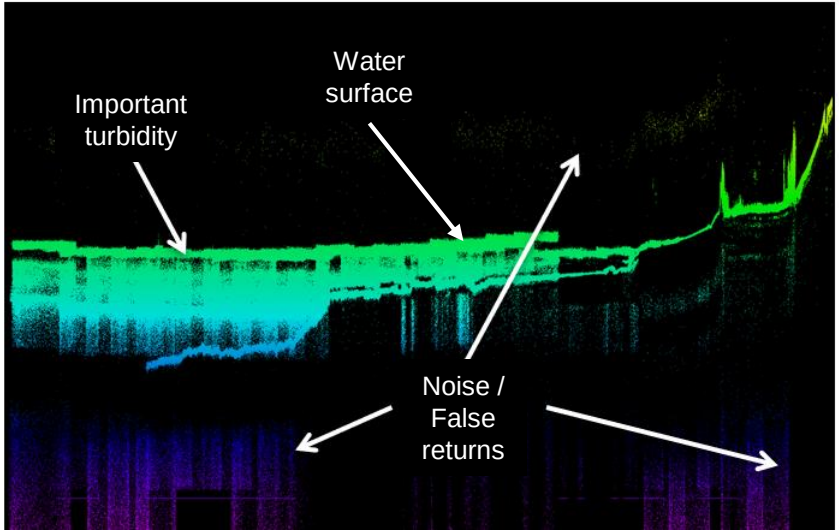
Horizontal uncertainties at the 95% confidence level = Bias + 2σ

LiDAR data processing

Topographic data



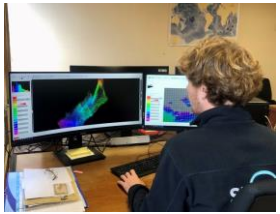
Bathymetric data

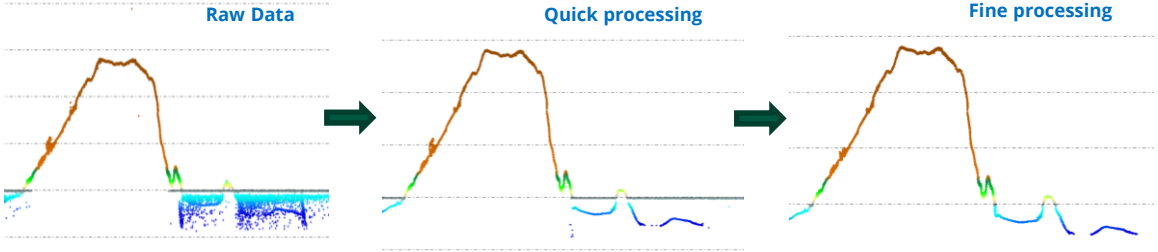


LiDAR data processing

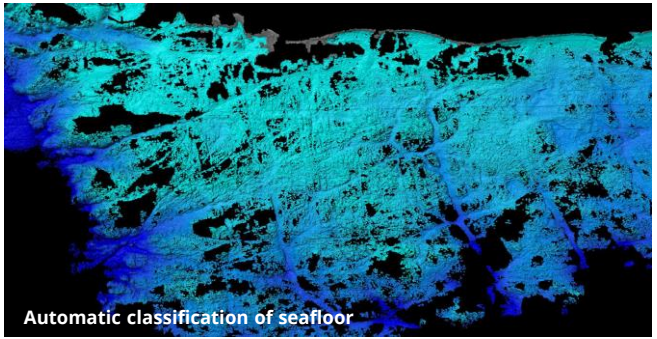
Shom processing

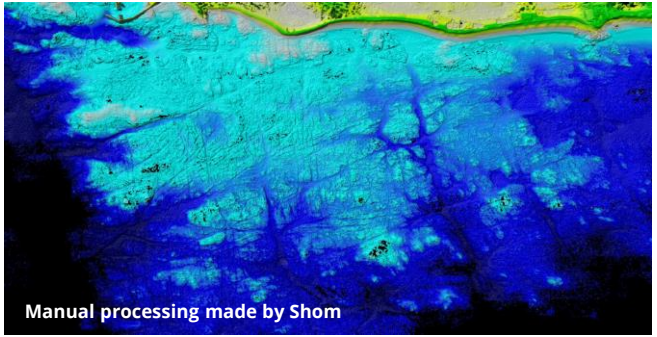
- Processing purpose : separation ground / non-ground for both emerged and submerged data (vegetation, buildings, vehicles, noise, water surface…)
- Quick processing done automatically with FME
- Final processing realised with software PFMABE manually done by the Shom processing team
- Quality control & uncertainty estimation





Automatic classification tools not well suited to LiDAR bathymetric data





Ongoing research into the use of AI to classify LiDAR data

- Building and consolidating the learning base
- Statistical analysis to highlight the best descriptors
- Better scaling of machine learning tools (Caen University / Scienteama) and deep learning tools (Shom)

Litto3D product generation

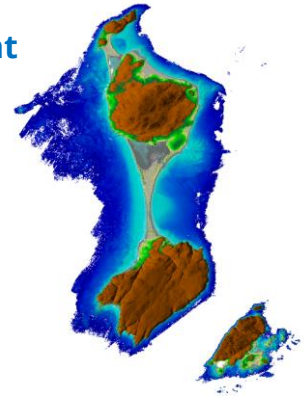
Creation of products on a large scale

- Conversion of processed point clouds
- Generation of surfaces with resolutions of 1m and 5m
- Merging of data acquired on behalf of Shom with IGN LiDAR data on the terrestrial portion
- Quality control of the products

The challenge of the big-data component

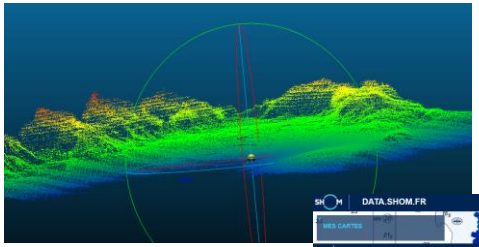
Example of Saint-Pierre-et-Miquelon project :

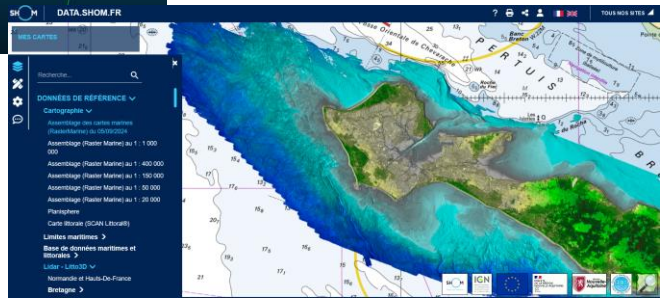
- Covered area : **715 km²**
- Raw data : **2,1 Tb**
- Validated points in final product : **20 389 361 820**
- Final product : **762 1-km² tiles / 691 Gb**



Constant improvement of the production process

- Automation of most of the steps and some controls
- Alignment of product tiles with processing tiles
  - ➢ the final product is generated and checked as the tiles are validated after treatment
  - ➢ Easier correction of the product by identification of the concerned tiles and control of corresponding data





Example of ongoing Pays-de-la-Loire project :

- Product : about **2100 1-km² tiles**

Simultaneous identification during processing and product creation of nautical information necessary for the safety of navigation

L'océan en référence

Thank you for your attention

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