



# LIDAR mapping and coastal water bathymetric surveys of the Maltese Islands

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## Structure

1. Malta is a special country
2. Four activities –the project
3. Data Merging
4. Conclusion and outlook

1. The project area - Malta is a special country
2. Four activities – the project in Malta
  - a. DSM and DTM of the islands using airborne Lidar data
  - b. oblique and nadir imagery of the islands (GSD 15 cm)
  - c. DSM of the seabed (depth 0-15 m) using airborne Bathymetric Lidar data
  - d. DSM of the seabed (depth 15-200 m, 1 nm) using acoustic and bathymetric scans from a vessel, ground truthing (grab sampling)
3. Data Merging
4. Conclusions and outlook



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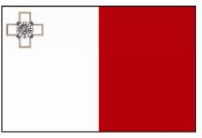
EUROPEAN REGIONAL DEVELOPMENT FUND  
MALTA 2007-2013



**PROJECT PART-FINANCED  
BY THE EUROPEAN UNION**  
**European Regional Development Fund**



**DEVELOPING NATIONAL ENVIRONMENTAL  
MONITORING INFRASTRUCTURE AND CAPACITY**



Operational Programme I – Cohesion Policy 2007-2013  
*Investing in Competitiveness for a Better Quality of Life*  
Equipment part-financed by the European Union  
European Regional Development Fund  
Co-financing rate: 85% EU Funds; 15% National Funds





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some hardly known facts:



Largest ship register in Europe  
(worldwide #7)



famous and award  
winning vineyards



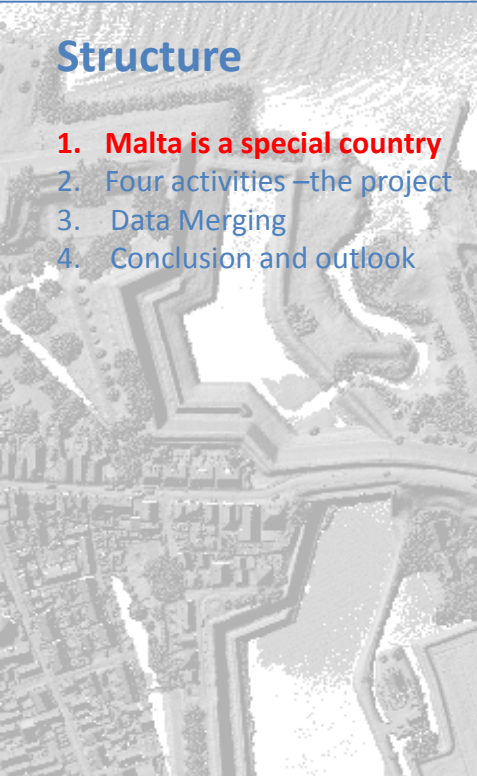
Number one in igaming with  
hundreds of companies





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Malta is very densely populated:  
with 1296 inhabitants/km<sup>2</sup> it is **number one of the most densely populated countries in Europe and worldwide number 2** after the Maldives  
(without considering city states like Monaco, Singapore, Vatikan)

for comparison:  
Netherlands (number 2 in Europe with 404 inhabitants per km<sup>2</sup>)  
Austria 98 inhabitants per km<sup>2</sup> # 80







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The dense population leads to high pressure on all resources of the islands, high demand for water, increased rate of urbanisation, pressure on transport and communication networks

Conclusion of the Maltese Environmental and Planning Authority:

We need a detailed and highly accurate geo data set in all dimensions in order to meet recent and future tasks

Background of the project:  
administer resources  
meet challenges of the future  
fulfill all reporting obligations for EU





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Main Aim of the project:

“Developing national environmental infrastructure and capacity “. It is funded under the 2007-2012 structural funds programme for Malta

Our project is part of a bigger programme that focuses on radically improving the national environmental capacity in five environmental themes

- 
- air**
- water**
- radiation**
- noise**
- and soil**



## Structure

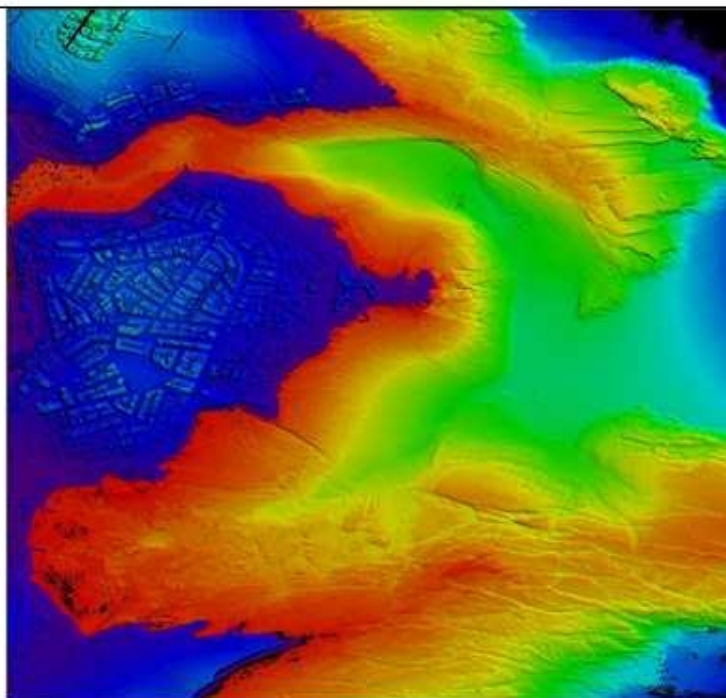
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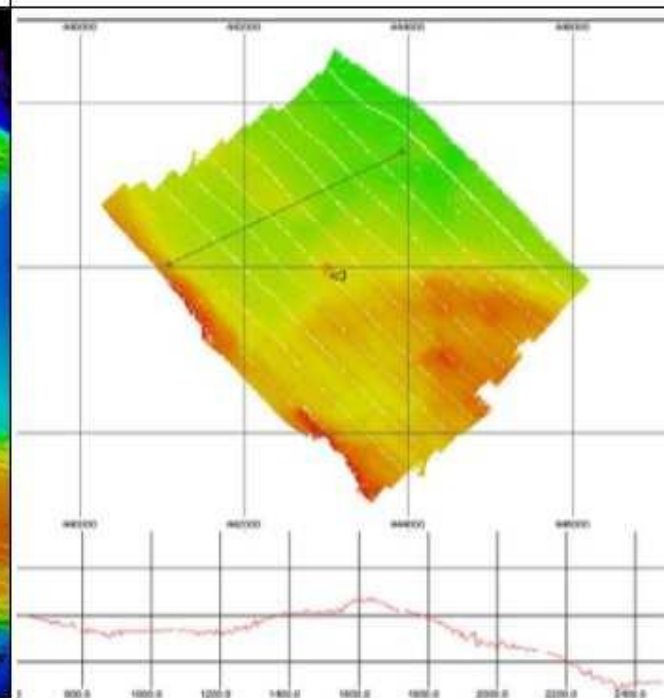
Activity 1- Lidar Survey and imagery



Activity 2- Oblique aerial imagery



Activity 3- Bathymetric Lidar survey



Activity 4 - Acoustic and bathymetric scans



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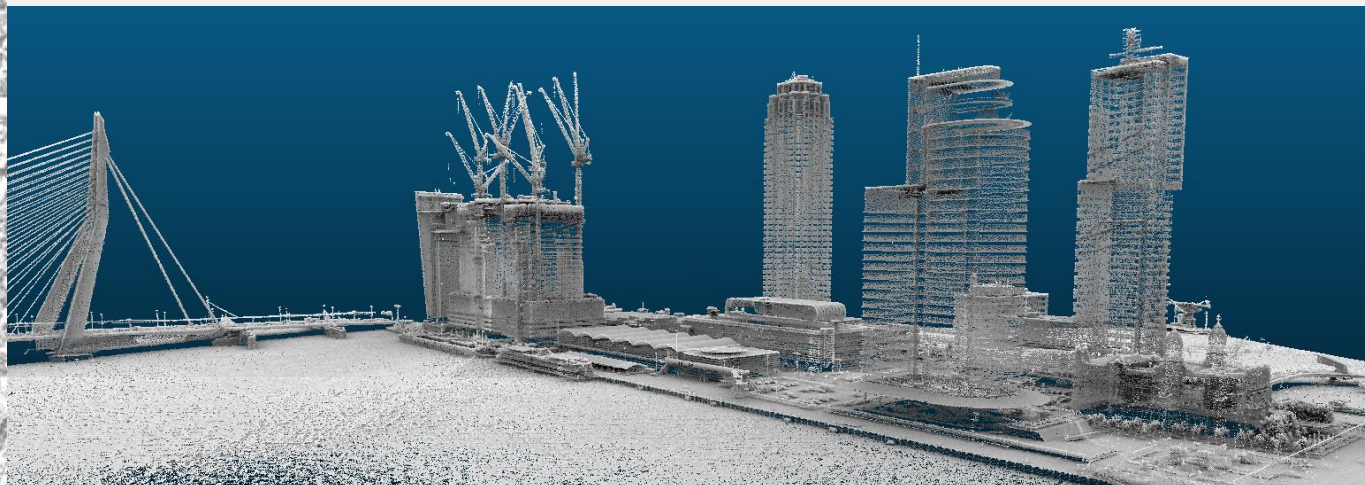
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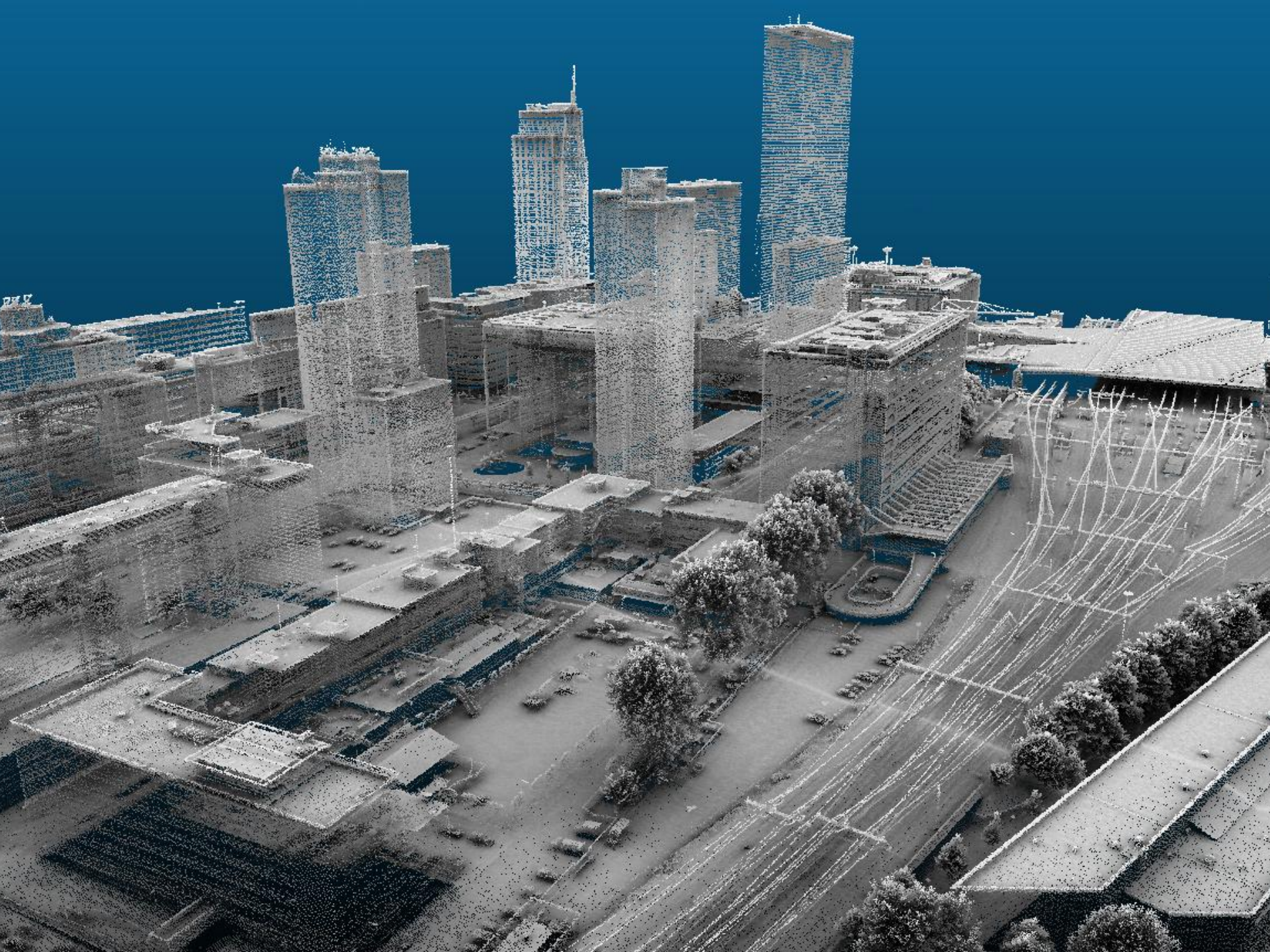
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**1996** Nationwide Elevation model of the Netherlands - 1 Pt./16 m<sup>2</sup> Z-accuracy 15 cm



**2012** Rotterdam 30-60 Pts/m<sup>2</sup> (airborne)  
z-accuracy: 5 cm



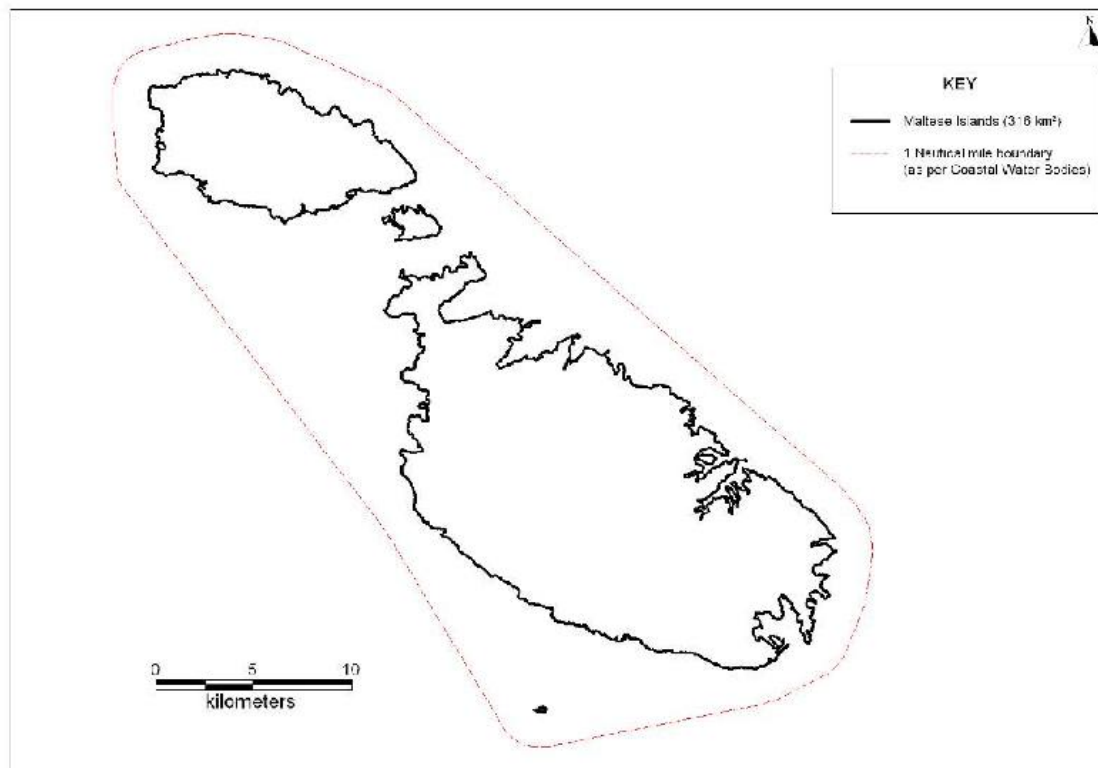




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## Activity 1 and 2: Lidar survey and imagery Oblique imagery

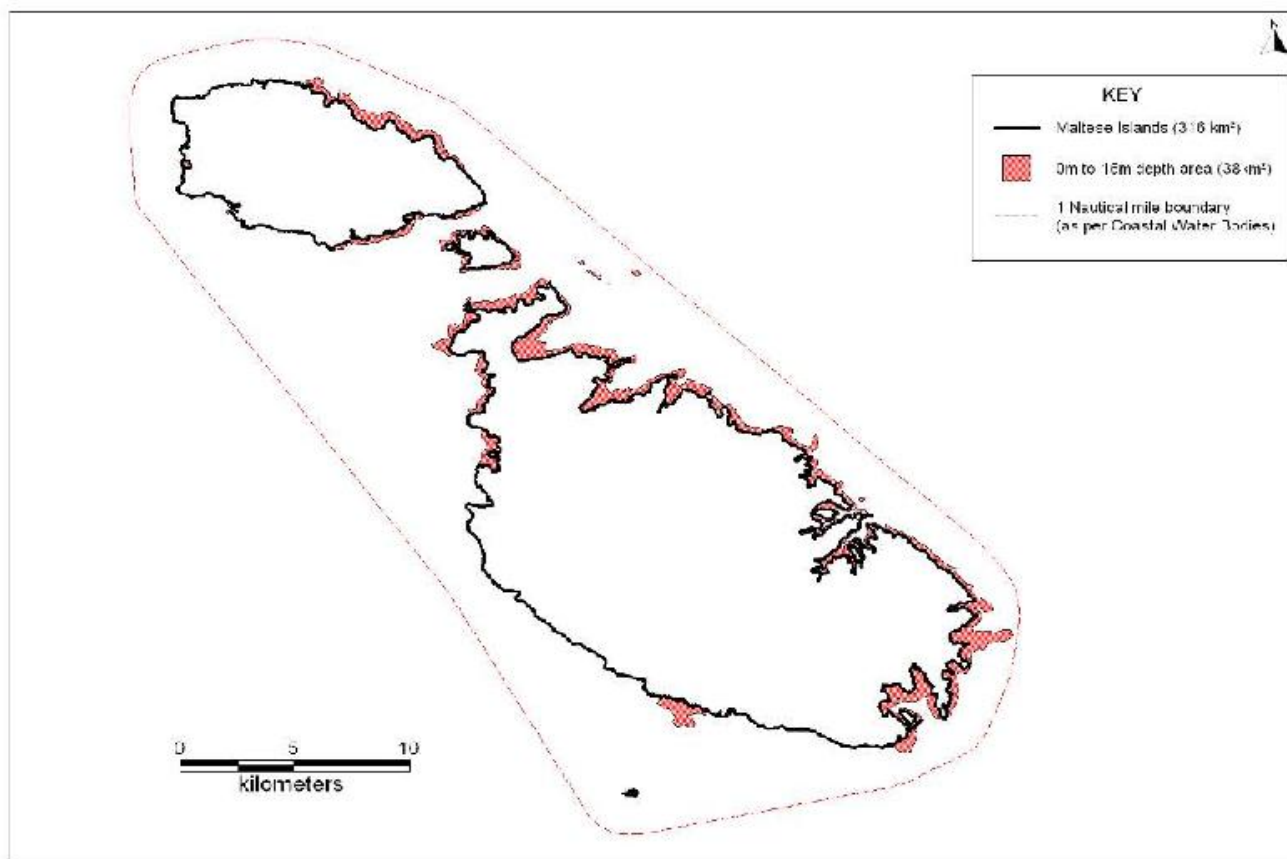




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## Activity 3: Bathymetric Lidar survey



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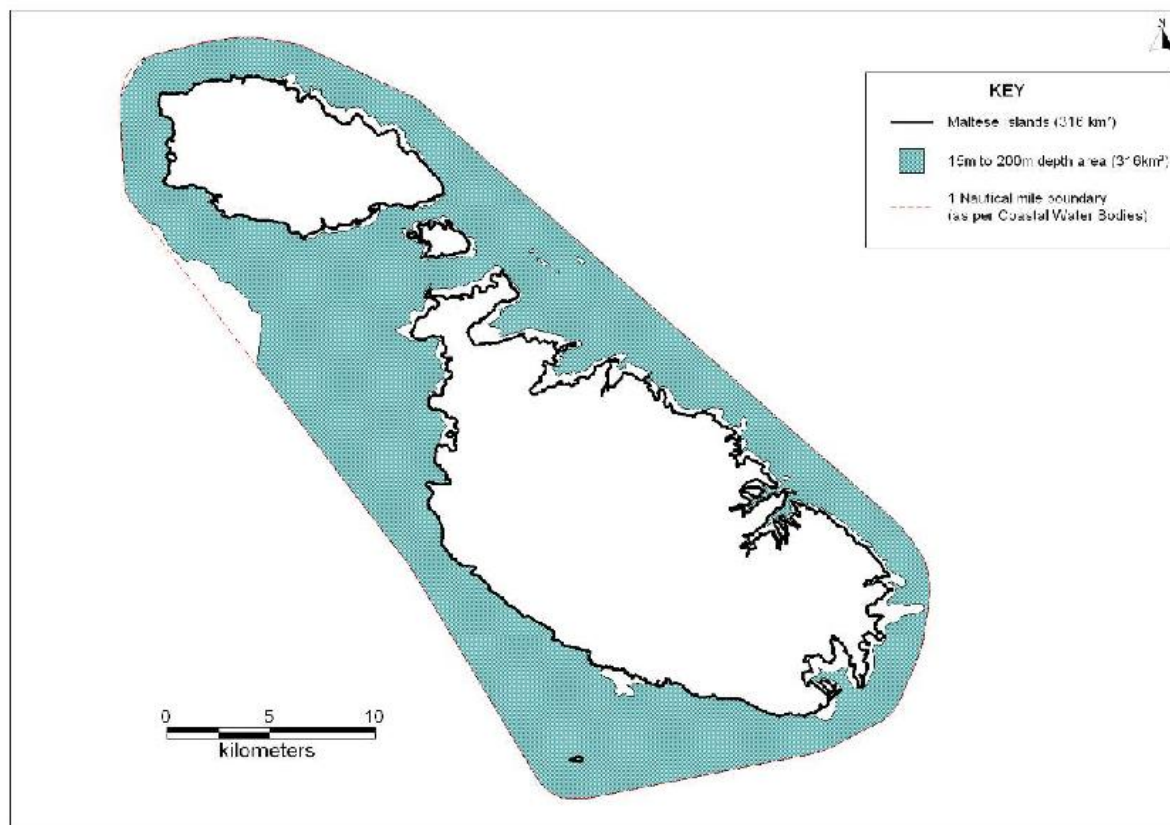
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## Activity 4: Bathymetric survey from Vessel





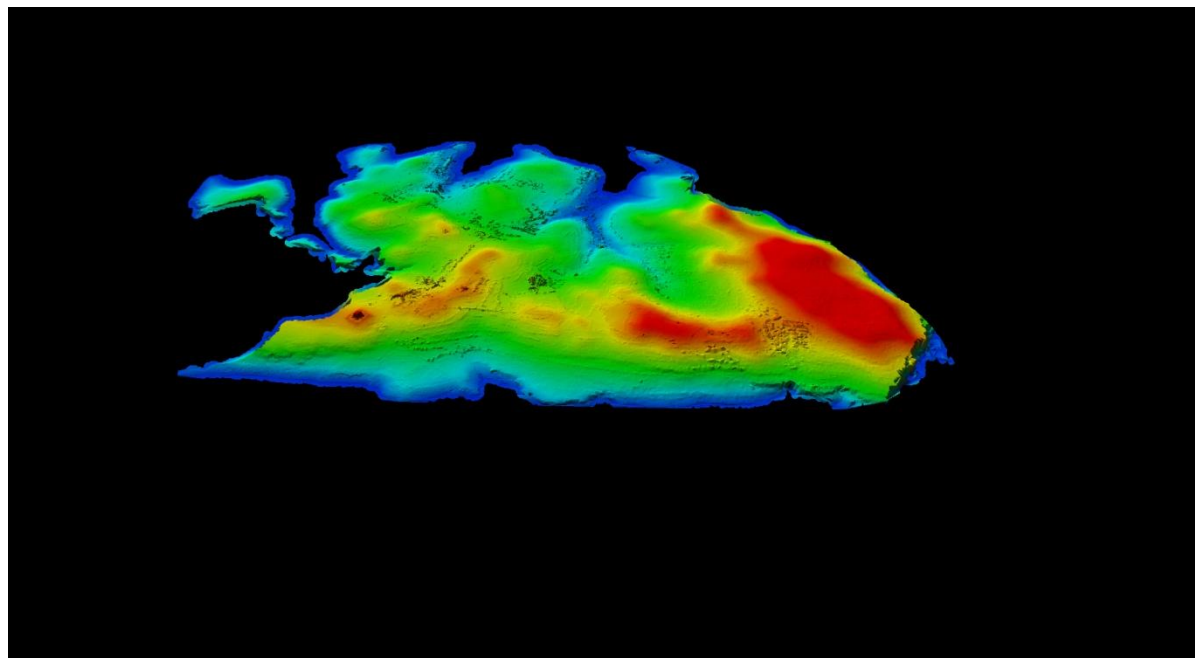


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## Tasks of Activity 1:

Lidar scan of the island, min 1 Pt/m<sup>2</sup>,  
classification in ground and nonground  
Simultaneous image acquisition, min. 25 cm GSD  
Final result: DSM and DTM of the islands



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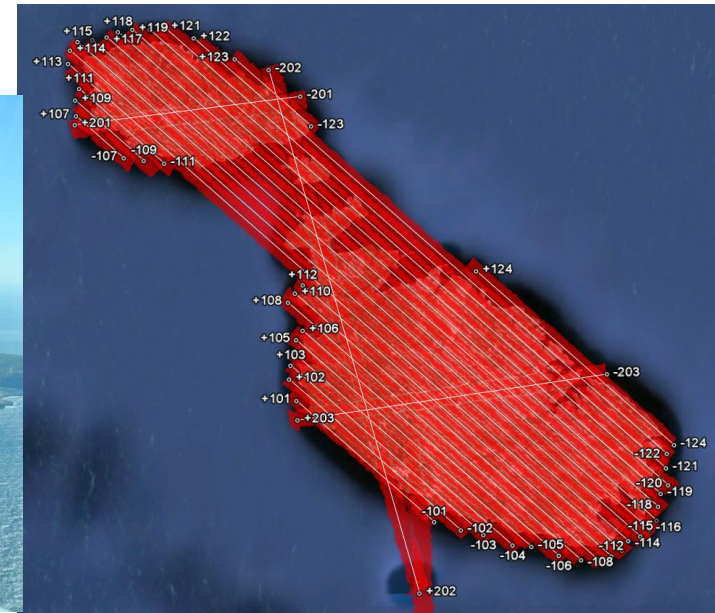


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Data acquisition was performed in February, Fh: 950 m AGL  
Sensor: IGI Litemapper 6800 (Riegl 680i)  
very good conditions; clear sky after long period of rain  
Image data was acquired simultaneously with the IGI Digicam

- 31 flight lines, 3 cross strips
- 100% coverage



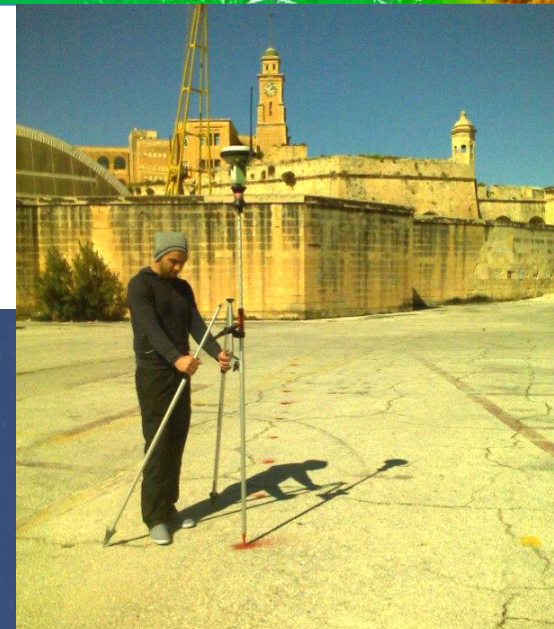
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- 2 GPS base stations
- 3 reference areas



## Trajectory



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Quality checks through all project phases:

Offer

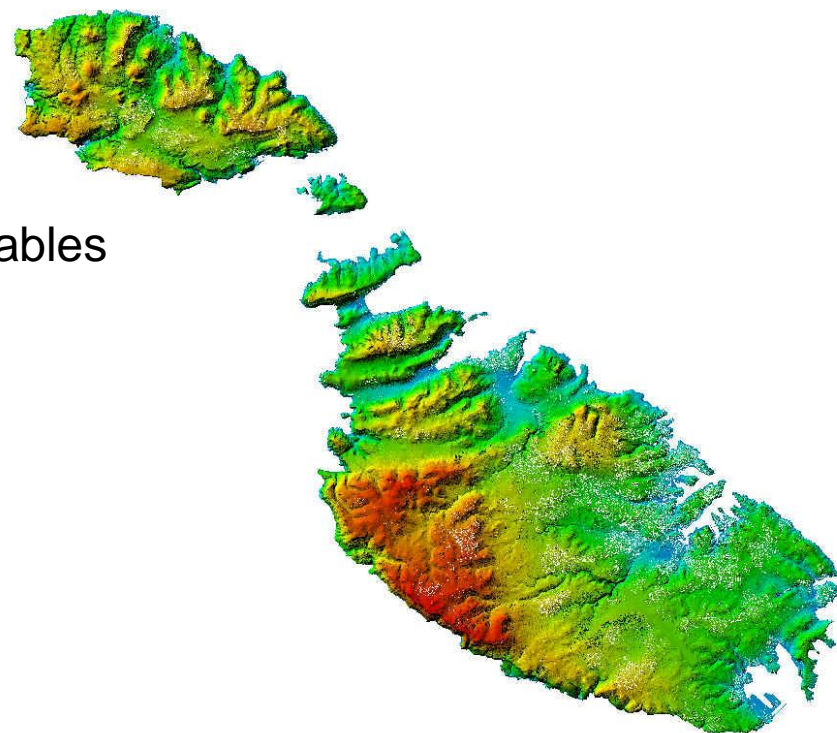
Mission planning

Data acquisition

Processing

Preparation of Deliverables

Delivery



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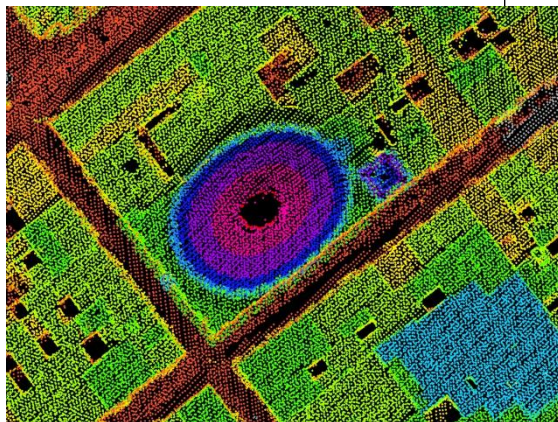
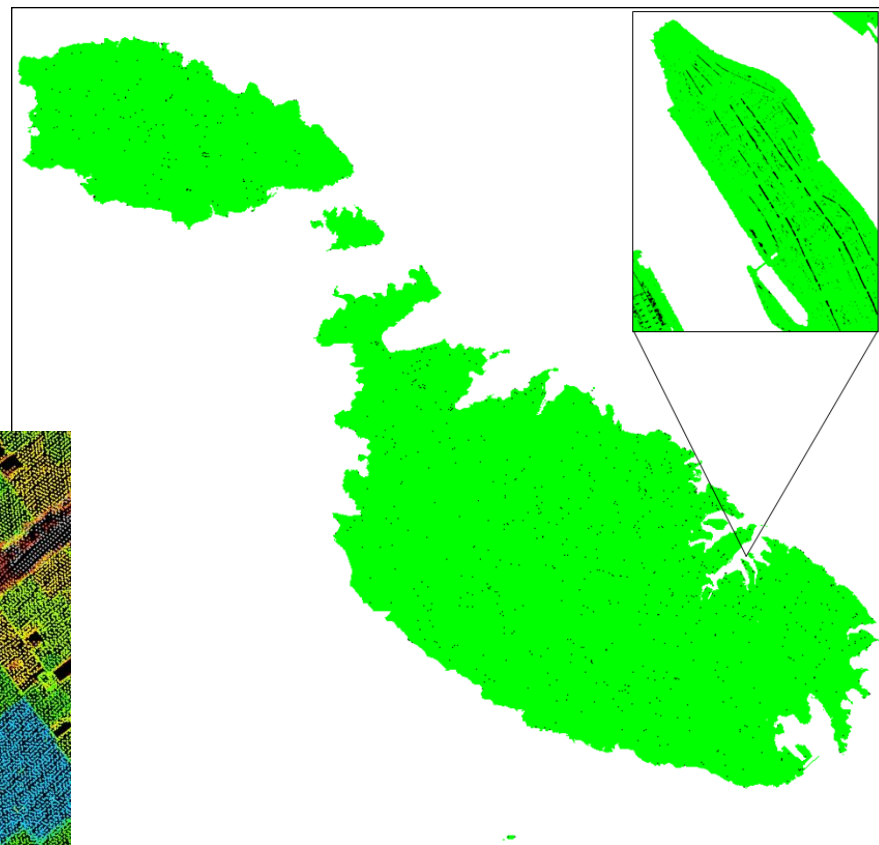
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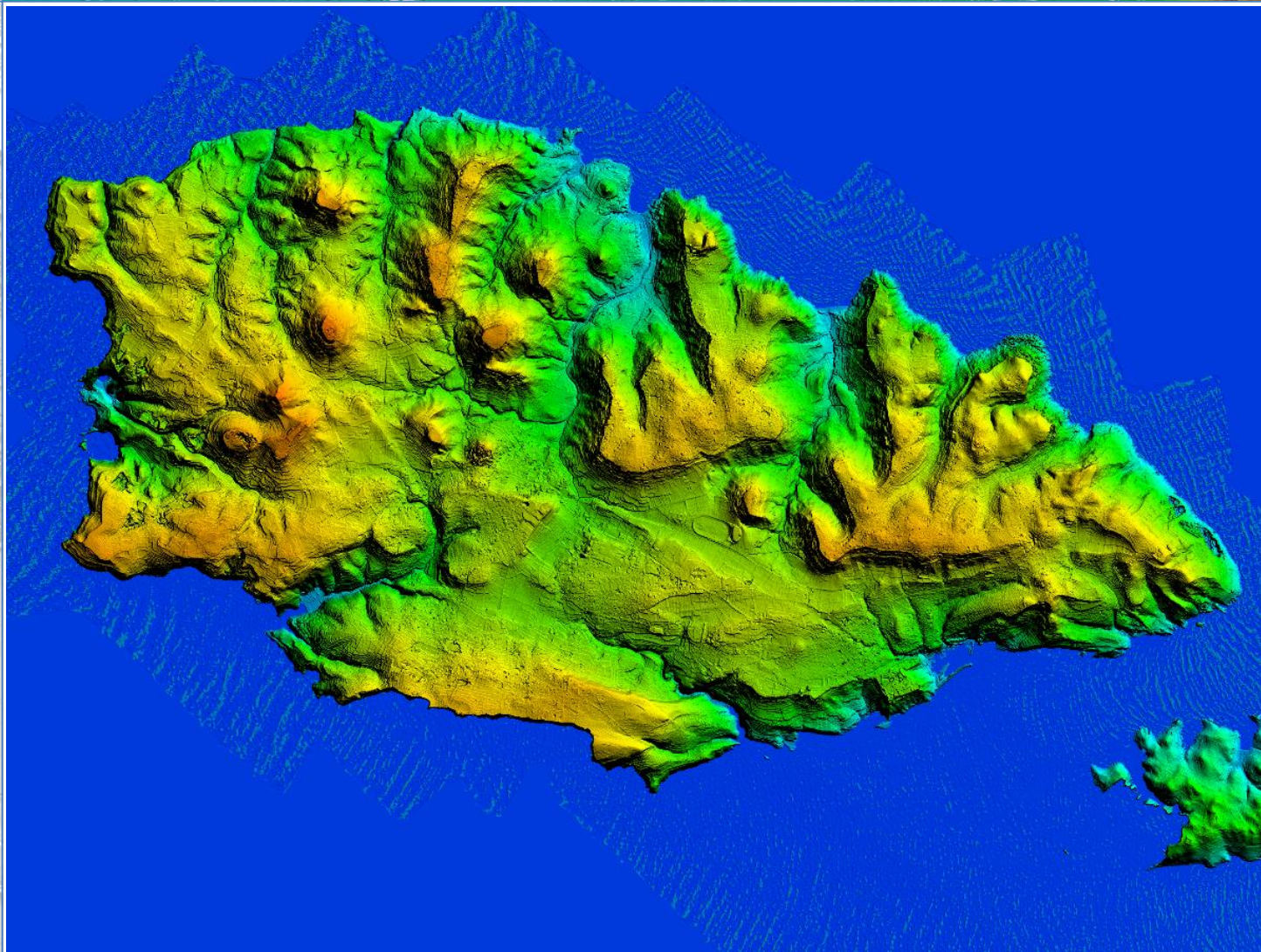
Average Point density : 4.3 pts/m<sup>2</sup>





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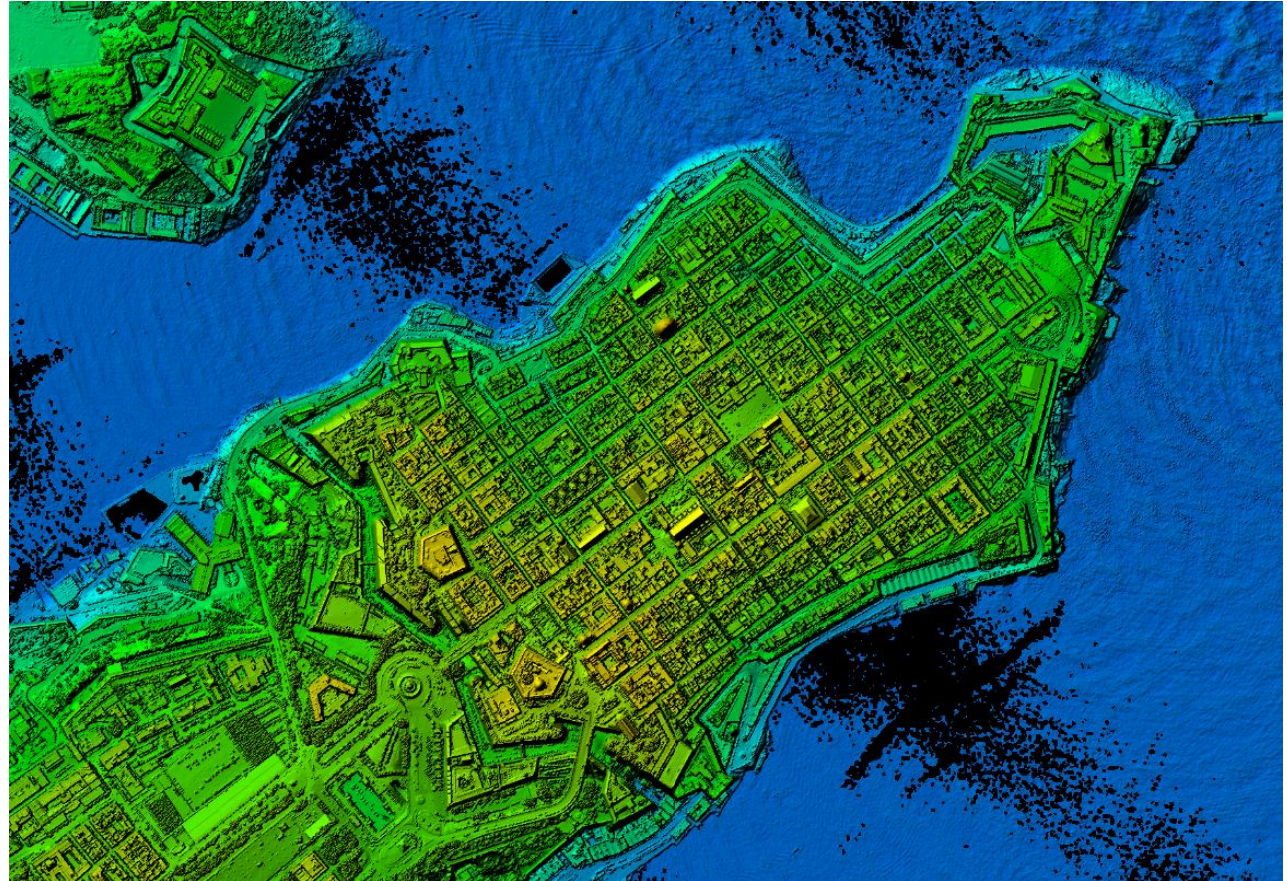
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DTM example: Gozo



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DSM example: Valetta

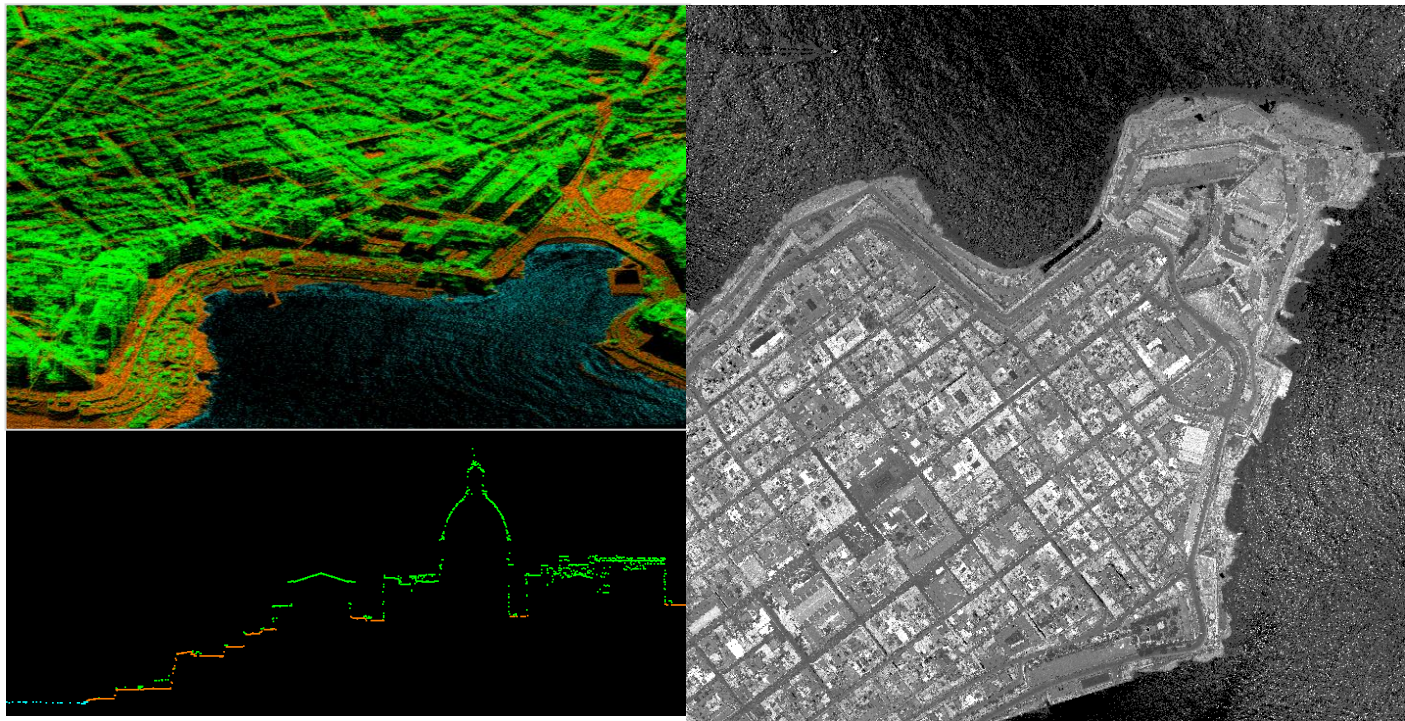


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Point cloud, profile, intensity data

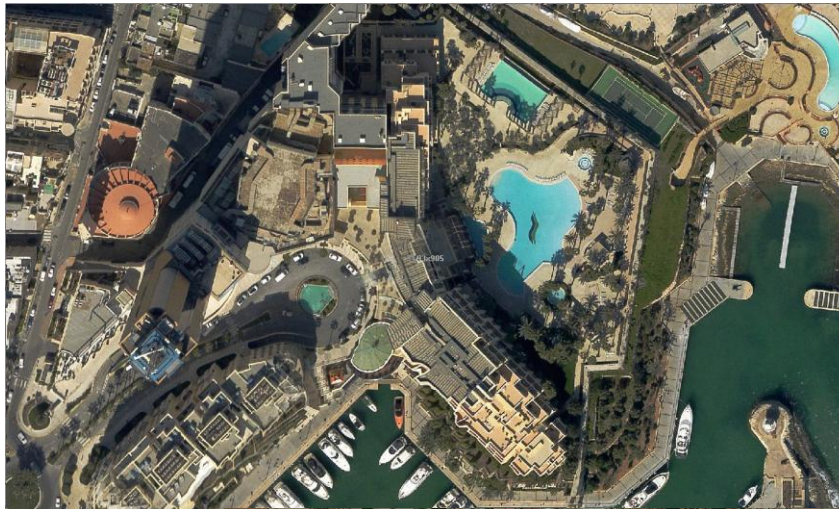






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IGI DigiCam:  
image mosaic  
with GSD of 16 cm



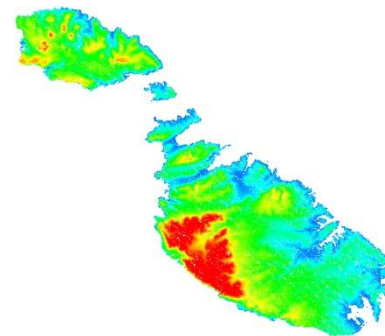
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### » Activity 1:

#### Delivered:

- DSM and DTM of the islands
- average point density 4.3 Pts./m<sup>2</sup>
- height accuracy > 5 cm
- orthoimage mosaic with a resolution of 16 cm
- absolute accuracy:  $\pm 11$ cm



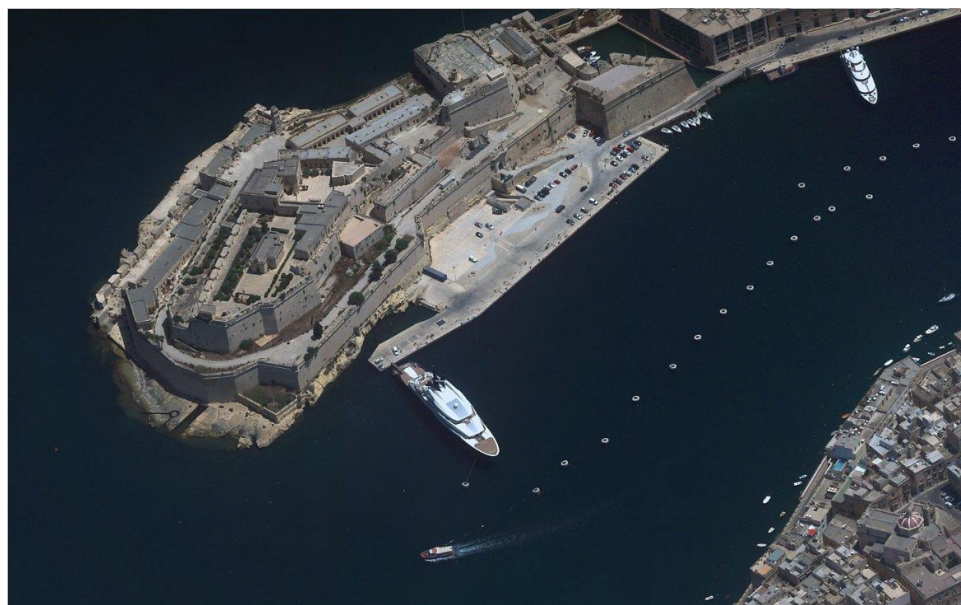
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## Activity 2: Oblique aerial imagery



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## Tasks of Activity 2:

- Aerial imagery survey over the entire Maltese Islands terrain by capturing images obliquely
- Both orthogonal and oblique angles using four neighbouring image views taken from opposing directions
- Imagery should have a spatial resolution of 15cm



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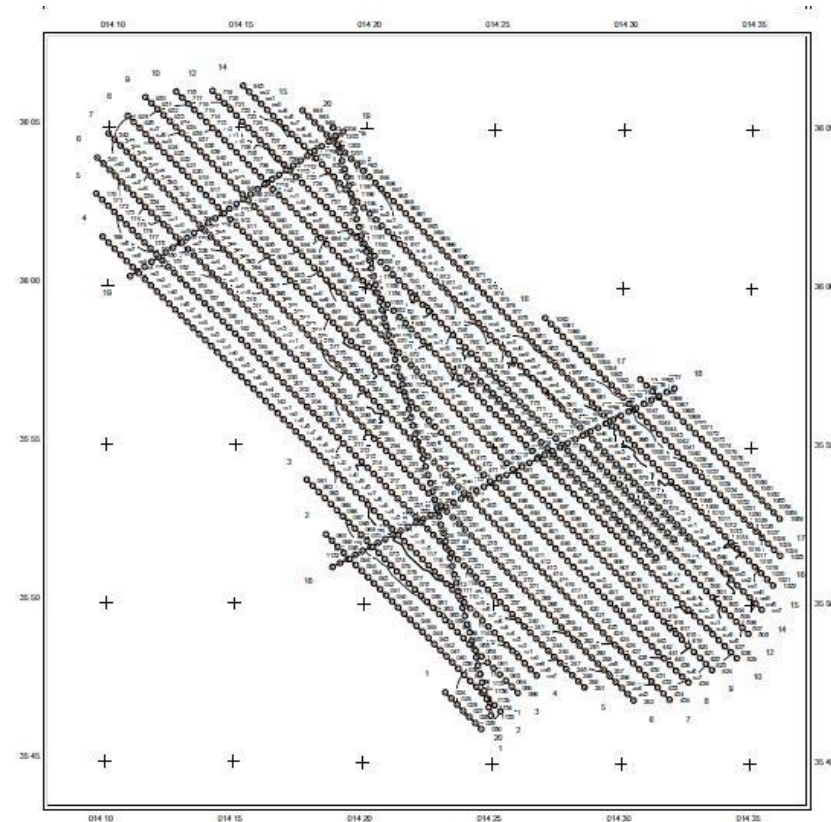
1. Malta is a special country
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Data acquisition: June 1<sup>st</sup> 2012

Camera: VisionMap A3

More than 2000 photos were taken to cover the islands

Fh 3000m.



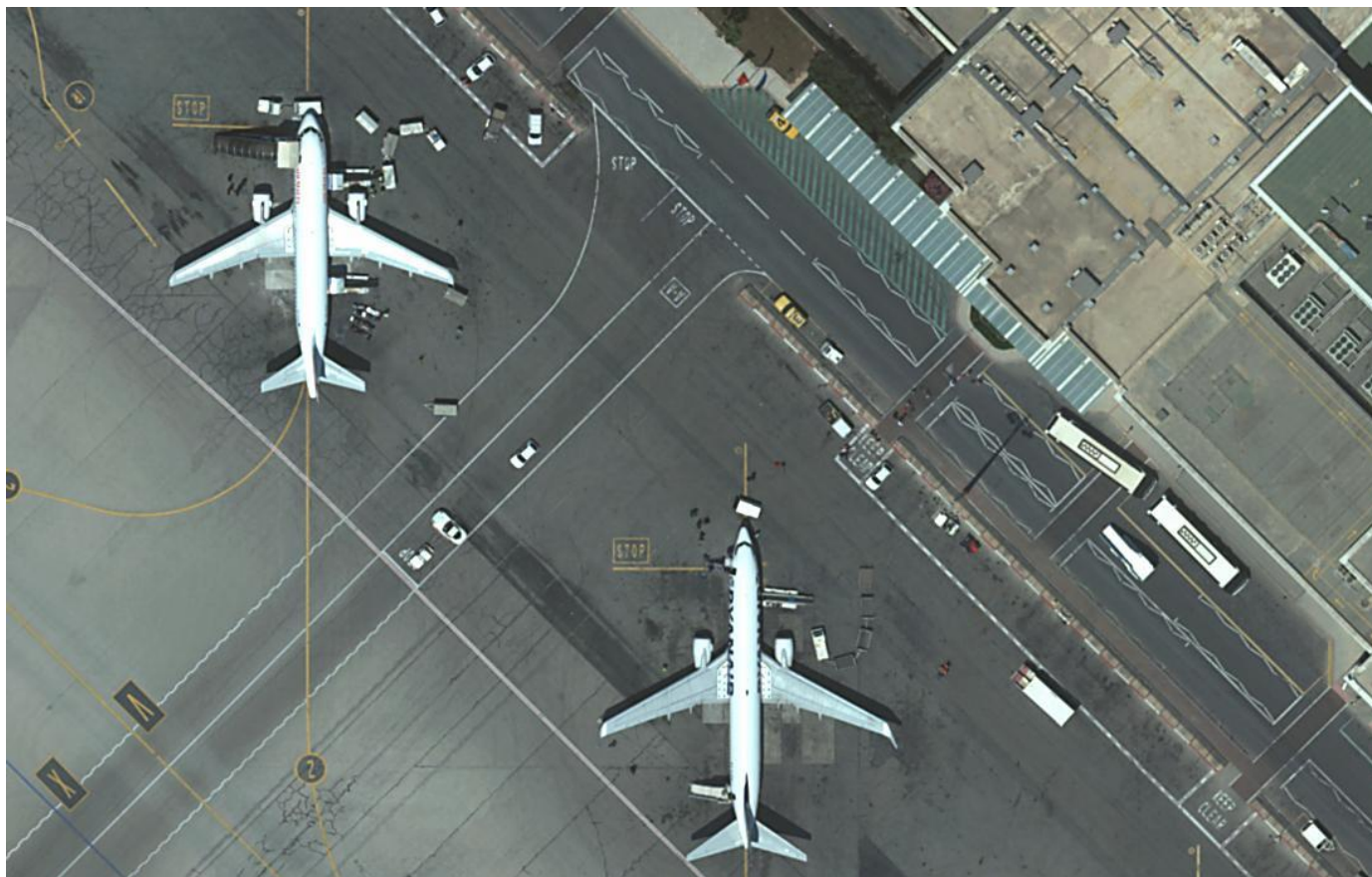
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## Structure

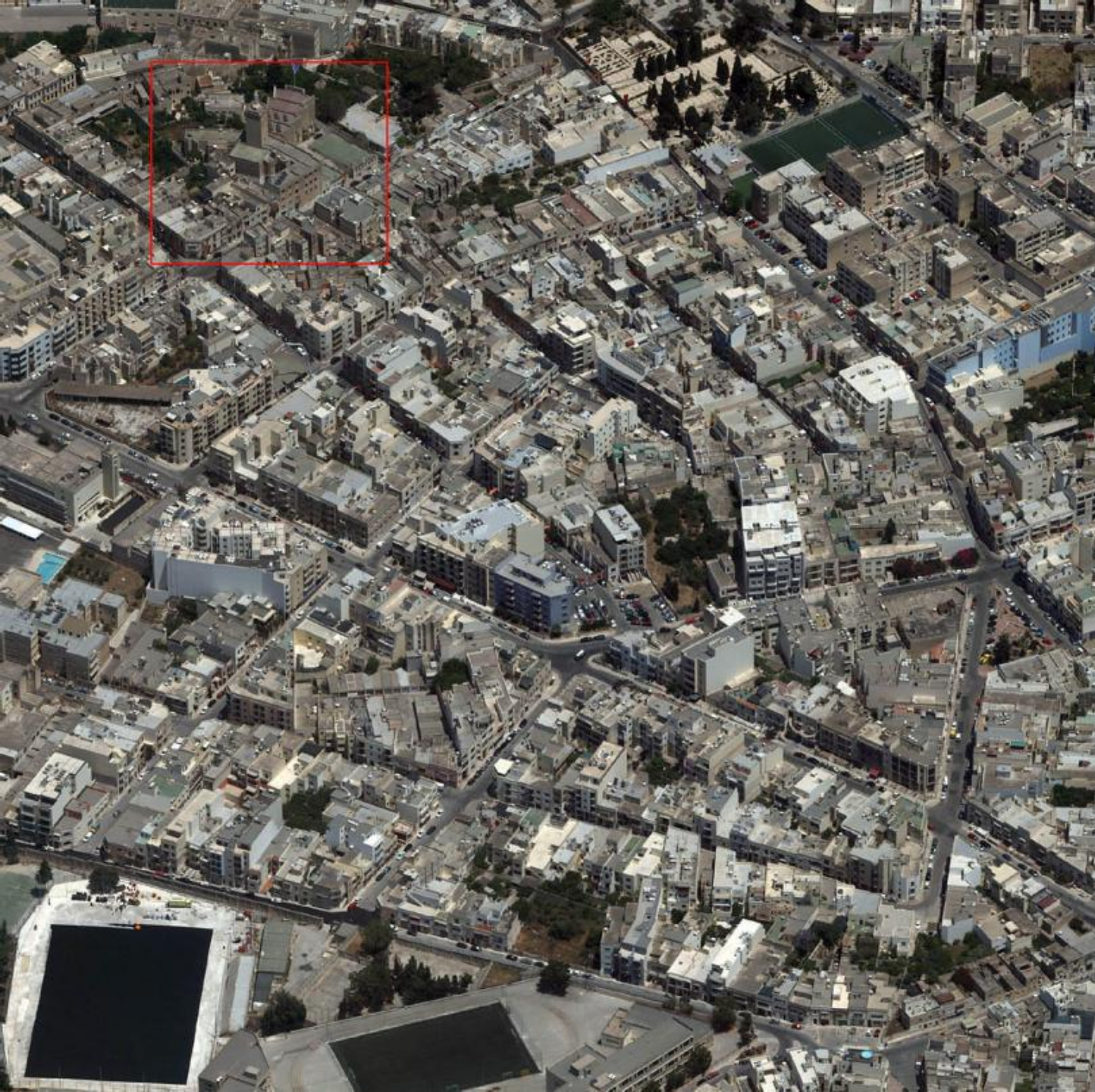
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Activity 2:  
Delivered: oblique imagery and an orthoimage mosaic  
with a resolution of 15 cm, accuracy +/- 1-2 pixel



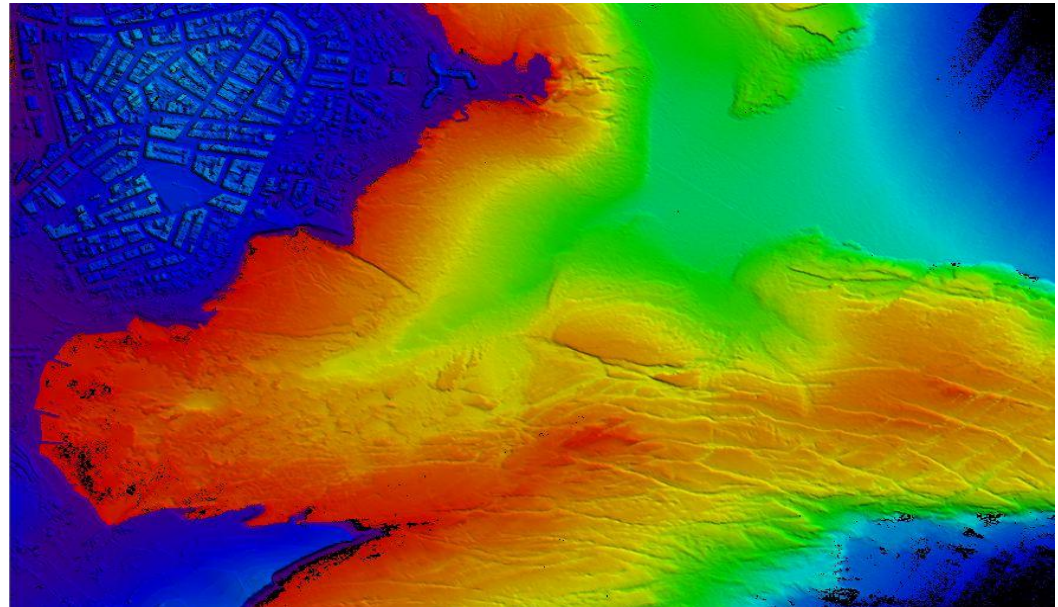
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## Activity 3: Bathymetric Lidar survey



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## Tasks of Activity 3:

Collection of bathymetric data of coastal waters at depths between 0m to 15 m

- Bathymetric data must be collected with a sounding **post-spacing of at least 2 m by 2 m**
- **Simultaneous topography and bathymetric data capture**, so as to include the coastal land area
- Include a **minimum 5m overlap** between bathymetric airborne LIDAR and the swath bathymetric survey for quality assurance purposes.
- Aircraft speed and swath width must be such as to enable the system to survey large areas quickly and provide rapid data collection
- Post-processed data must fulfill the **IHO requirements**
- Deliverables to consist of an ASCII XYZ format file and a Digital Surface Model

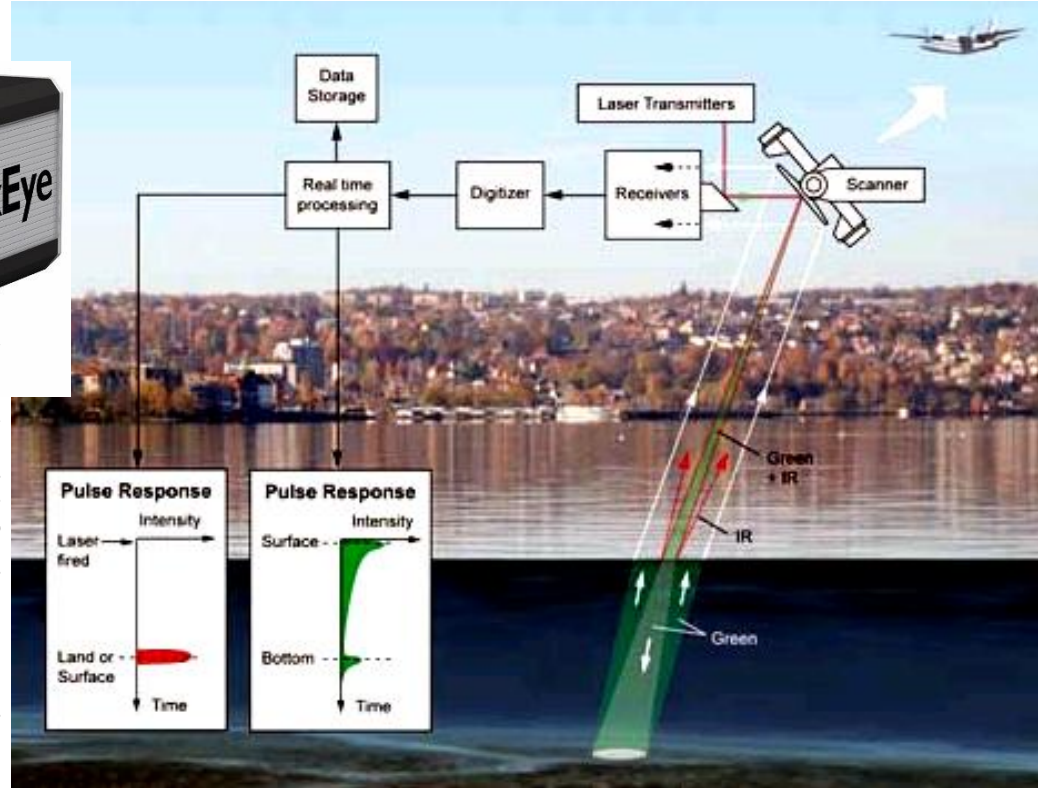


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- LiDAR used : HawkEye IIb (AHAB)
- Operating frequencies (kHz) : 1Khz (Bathymetric) 8Khz (Topographic)
- General water depth achieved : 15m (up to 50m)



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Courtesy of Airborne Hydrography AB ("AHAB")

## Data acquisition: Scan pattern



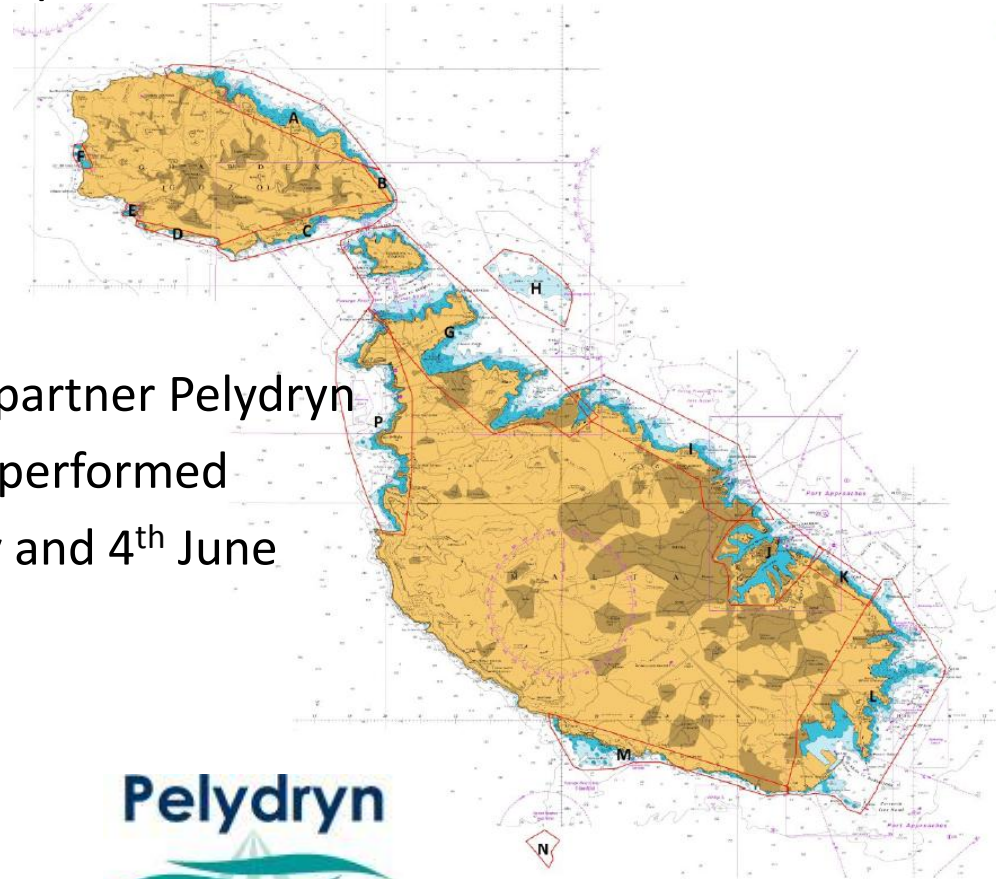
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## Activity 3: Data Acquisition

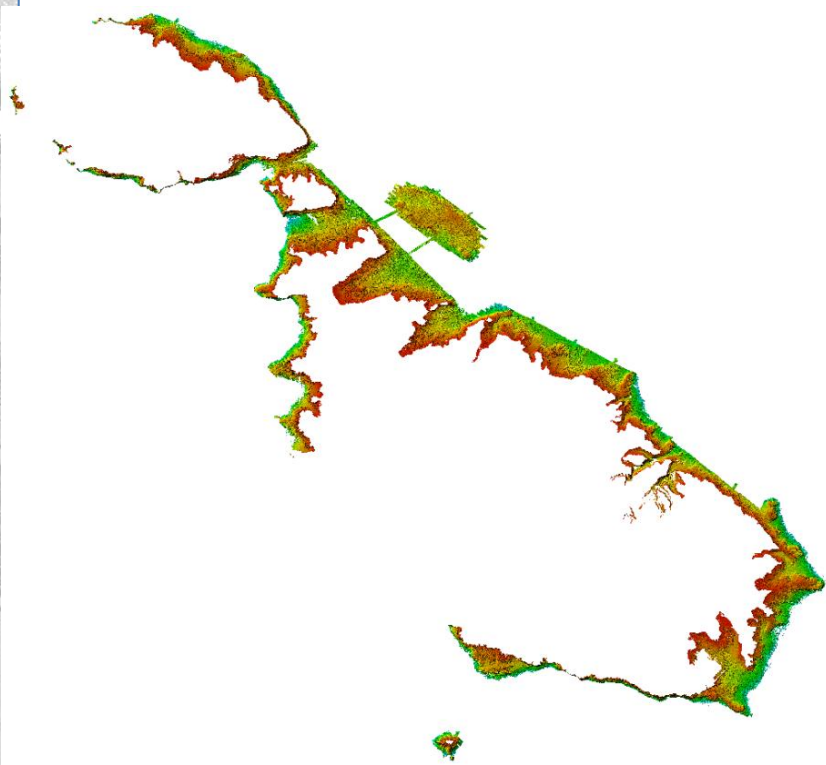
- Acquired by our partner Pelydryn
- Data acquisition performed between 8<sup>th</sup> May and 4<sup>th</sup> June
- 12 Survey areas
- 18 Survey days



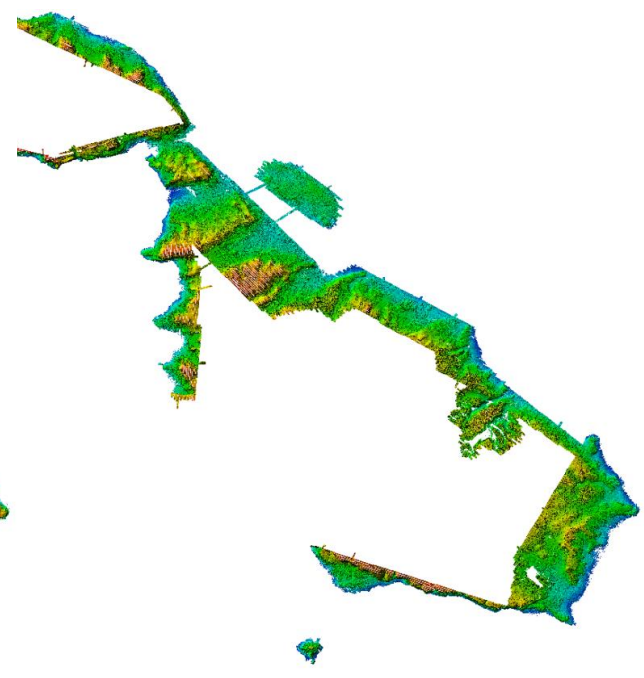


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Seabed



Seabed and topography

## LiDAR bathymetry: results



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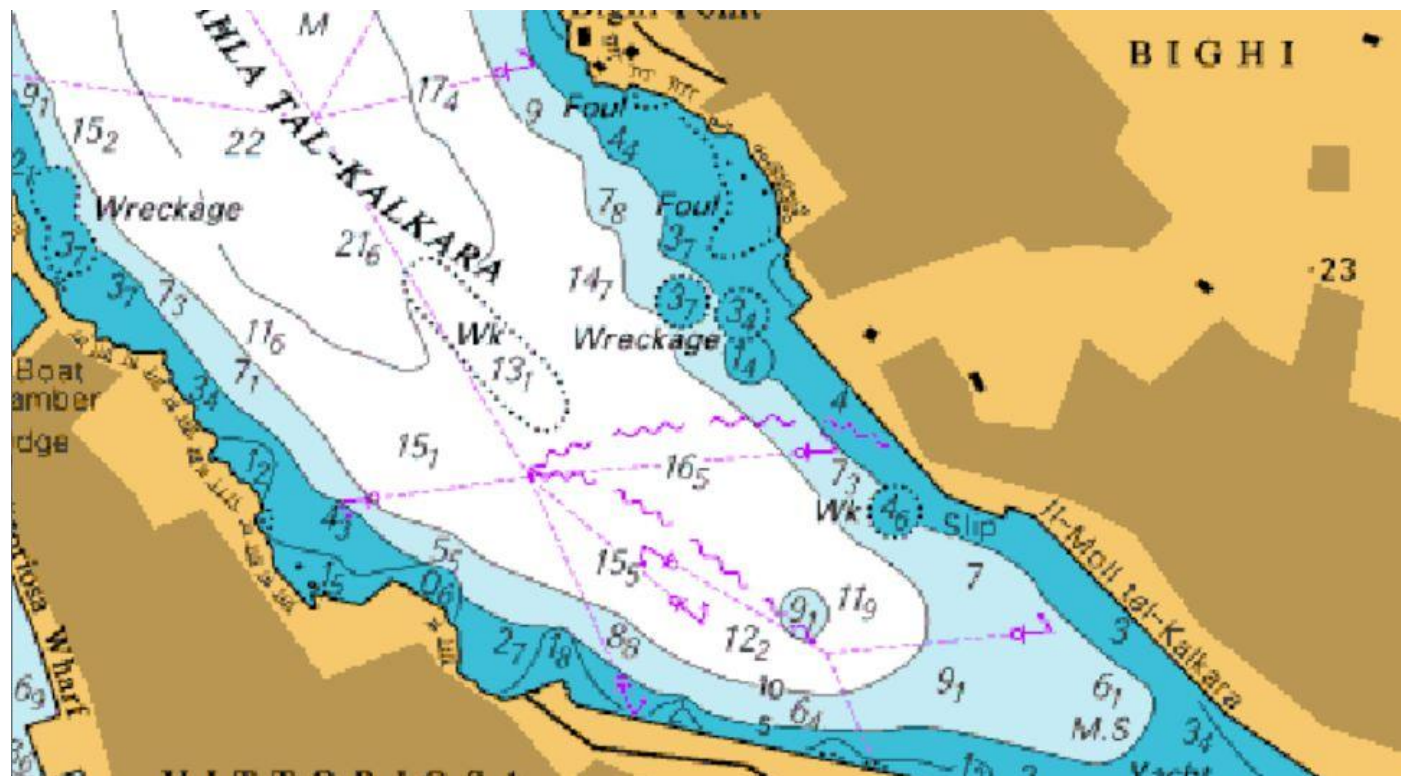
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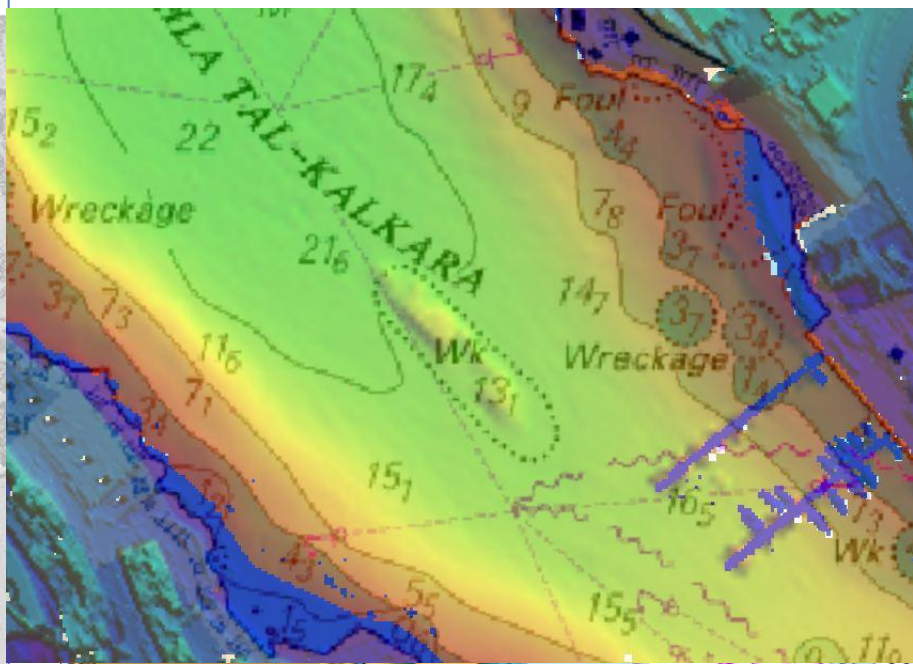


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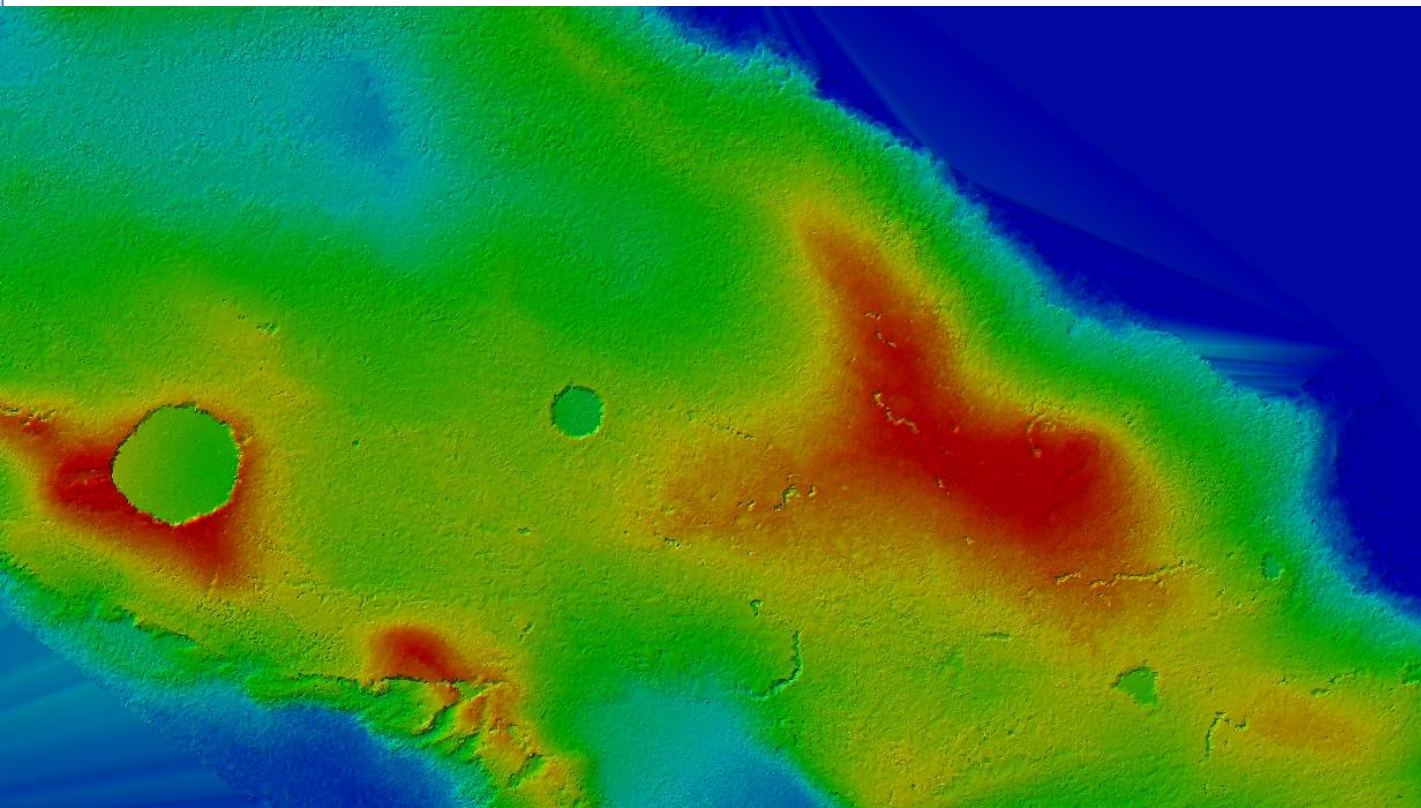


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Sea bed – details and unknown features

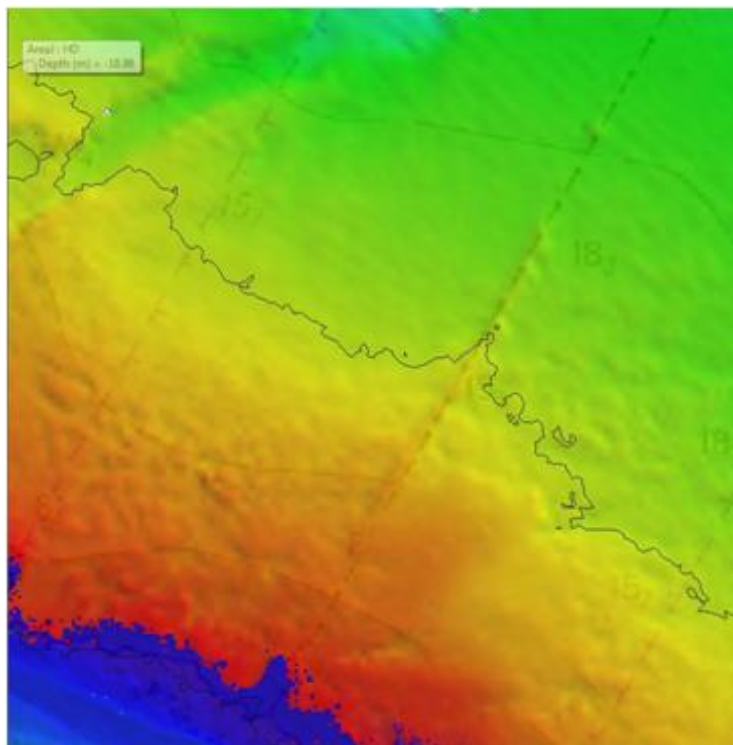


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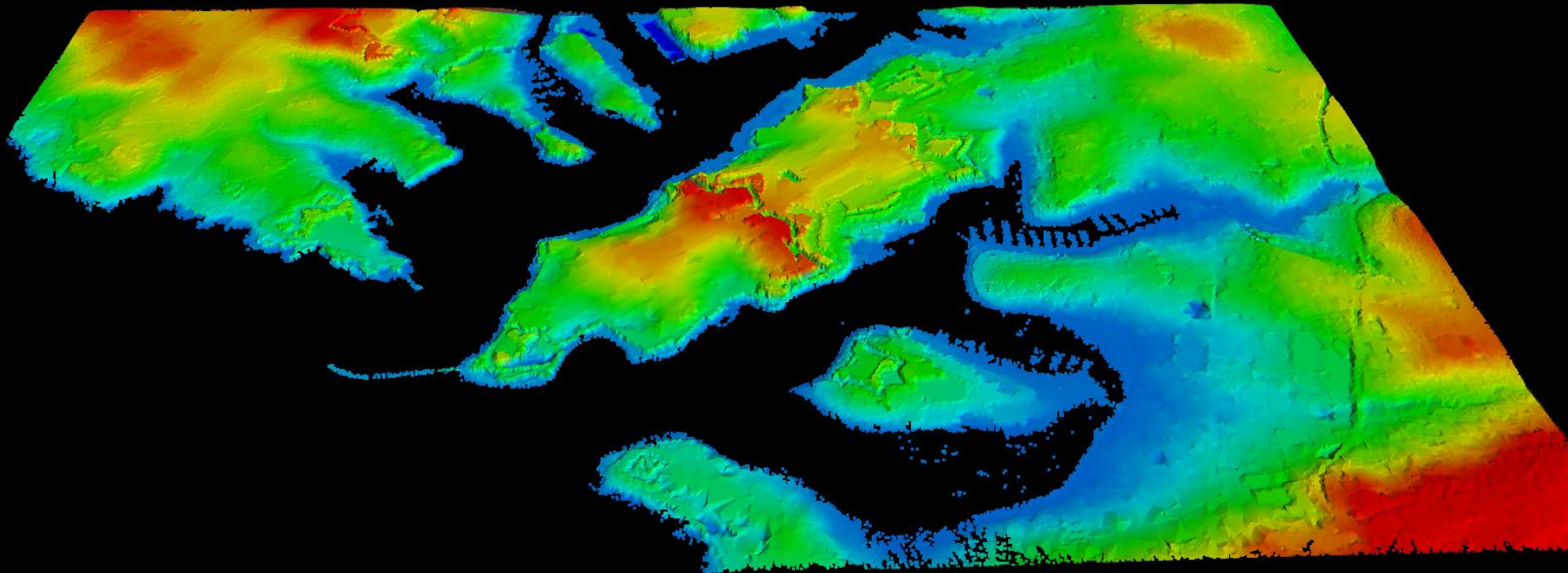
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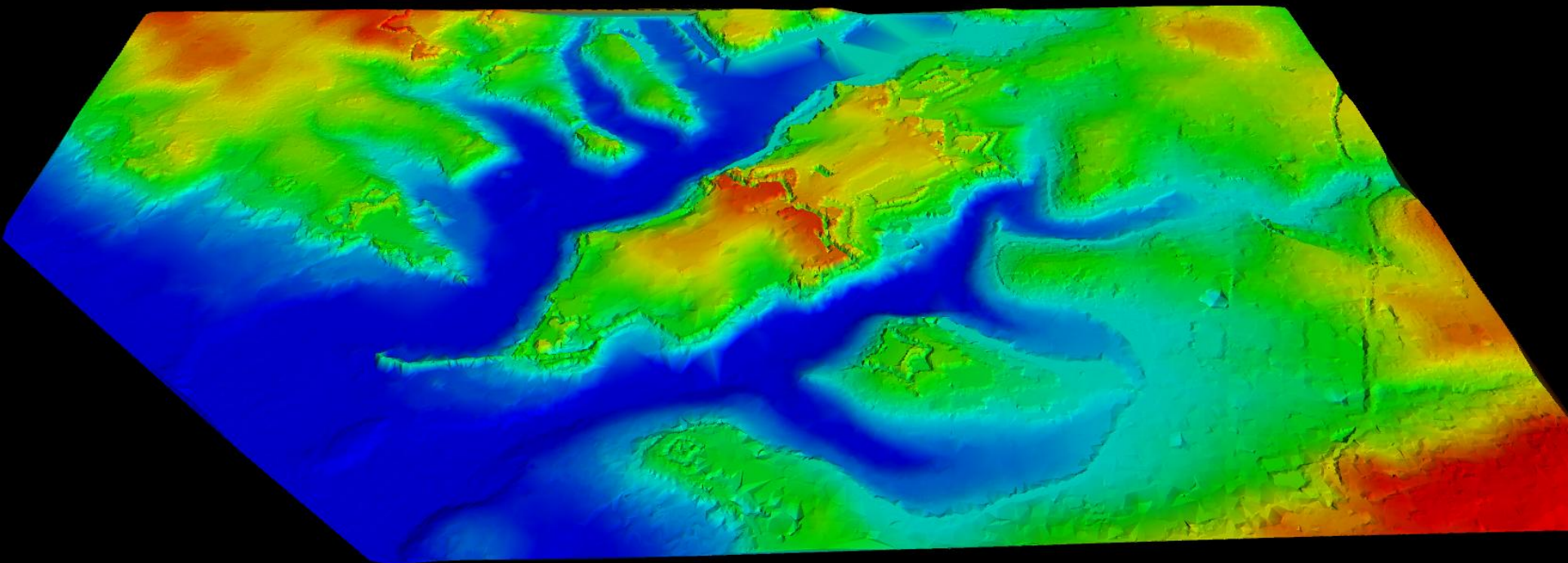
## Pipeline

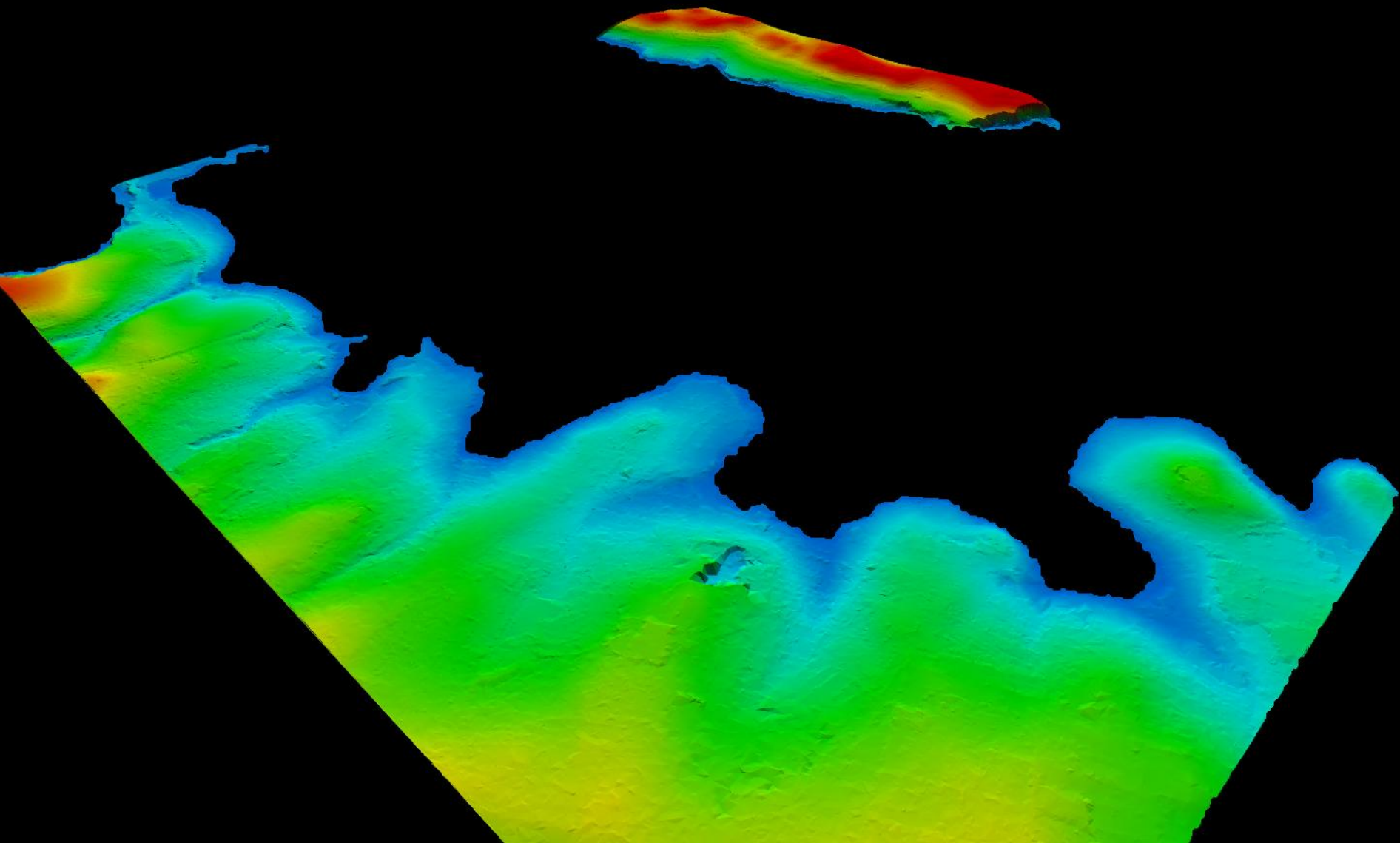


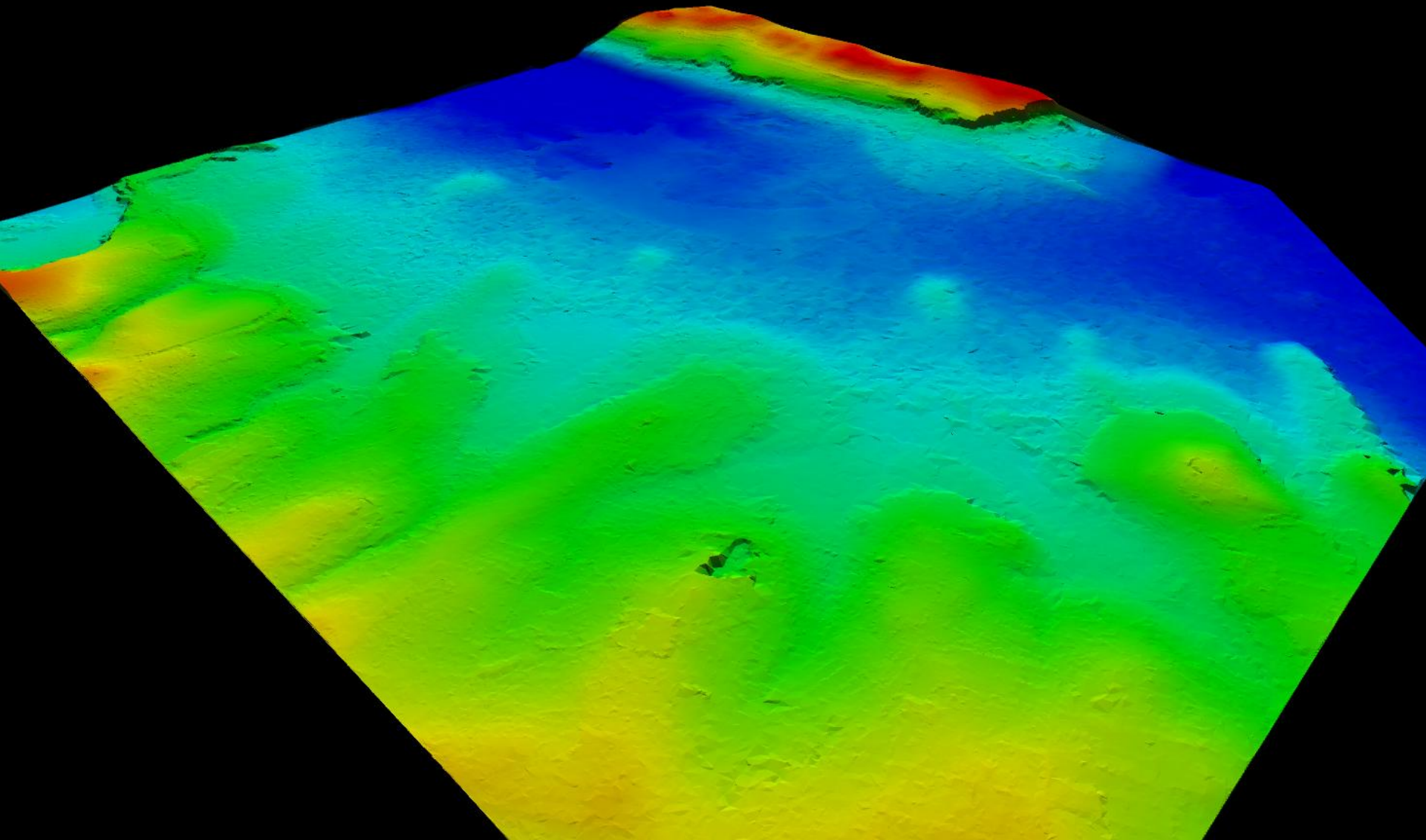
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## Land surface plus Sea bed









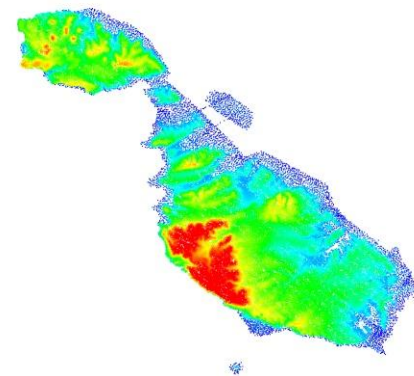


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## Activity 3

Delivered: DSM of the seabed up to 50 m depth  
postspacing 2 x 2 m  
accuracy: within IHO requirements

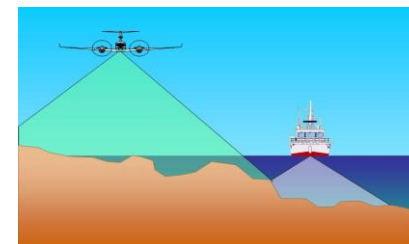
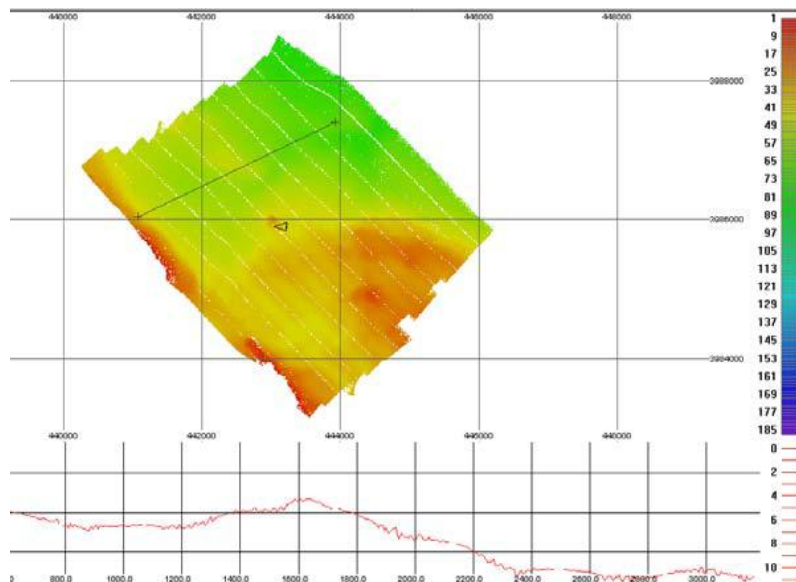




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# Activity 4: Acoustic and bathymetric scans



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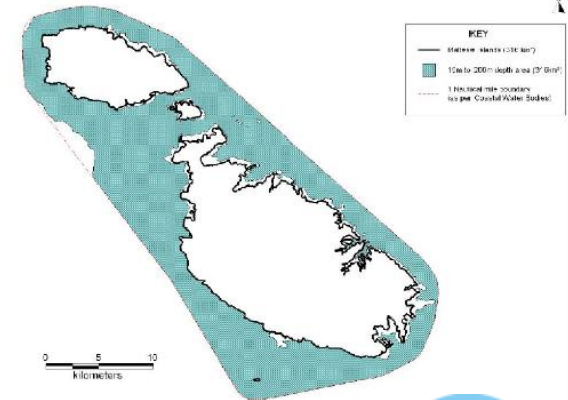
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- Tasks of Activity 4:
- Coastal water scans at 15m to 200m depths within 1 nautical mile from the Maltese baseline coastline
- production of a gridded map showing the x,y,z position of the seabed.
- Accuracies IHO survey requirements
- Ground Truthing of bathymetric surveys





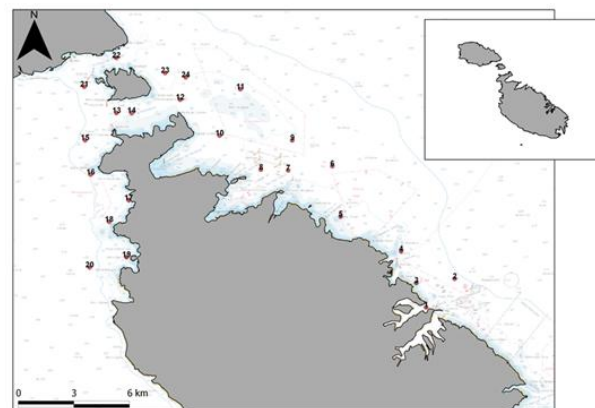


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- Ground Truthing of bathymetric surveys: determine type of sea bottom
- Grab sampling, Samples are taken where the ground changes



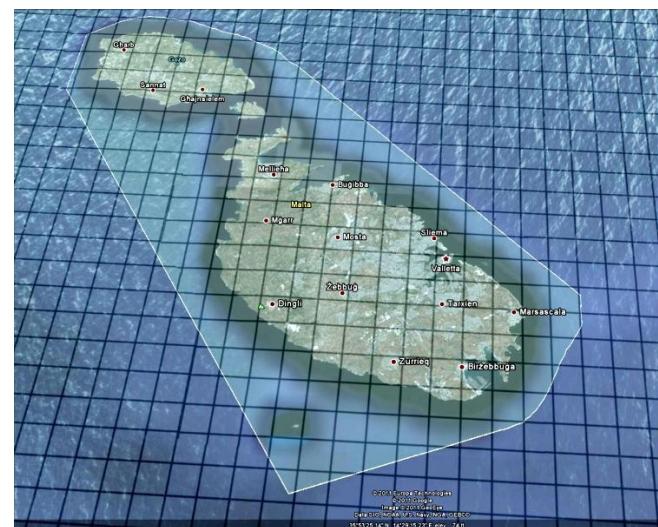


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Activity 4:  
Delivered: acoustic and bathymetric scans  
Samples from sea bed  
Accuracies following IHO requirements



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3. **Data Merging**
4. Conclusion and outlook

## » Merging the different elevation data sources

Topographic LiDAR data + Bathymetric LiDAR data +  
Vessel bathymetric data

### Challenges:

Varying coverage

>> data limits not clearly defined, overlap

Varying data accuracies

>> 5-50cm RMS, varying by depth

Varying acquisition times

>> February, May-June, April-December



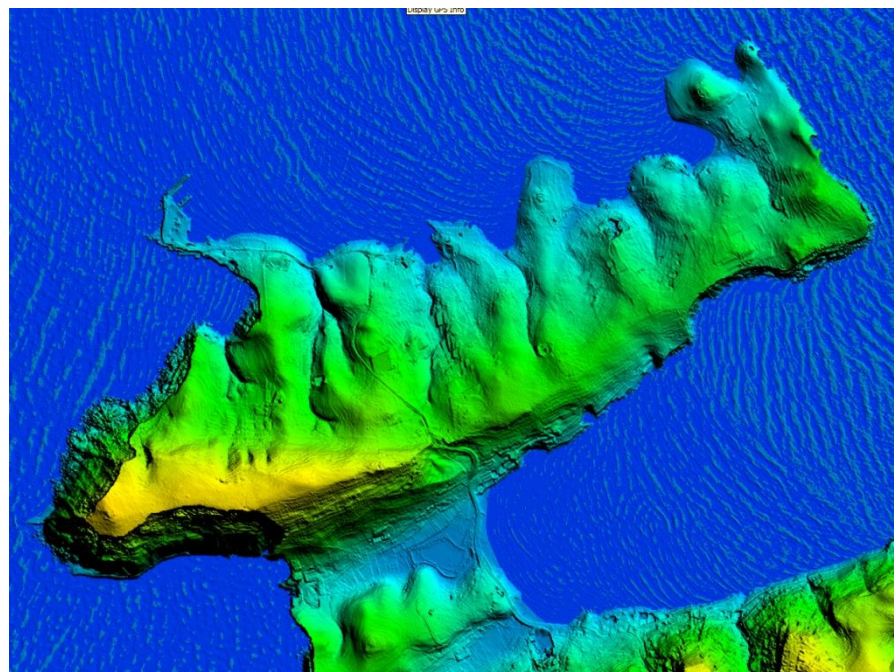


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## Methodology:

- We decided to use an advanced interpolation technique that allows to weigh the different properties of the data sets (e.g. accuracy, resolution)
- In shallow areas the data fitted very well (within 10 cm)
- Clear data boundaries of each data source were defined
- Systematic effects have been detected and corrected



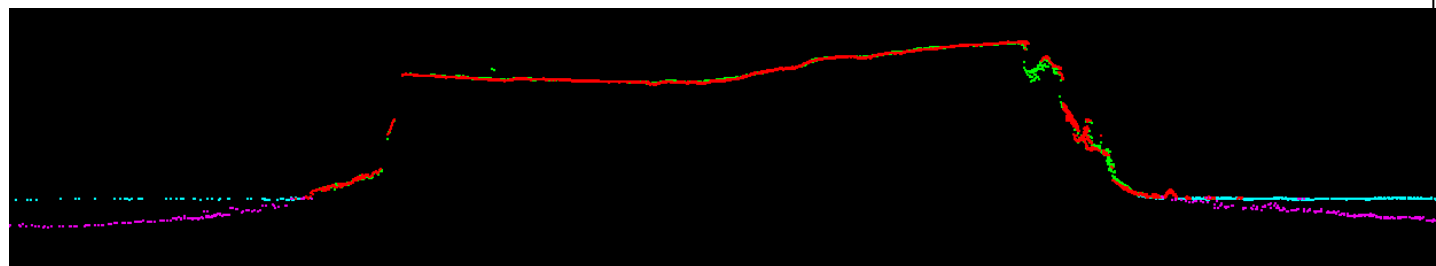
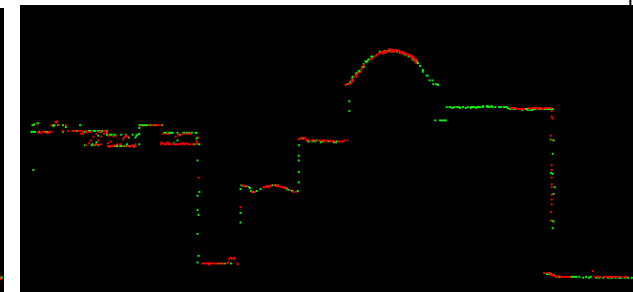
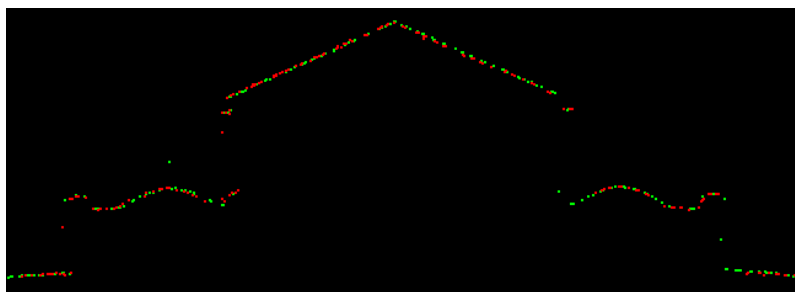




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## Example: Fit of Topographic LiDAR and LiDAR Bathymetry



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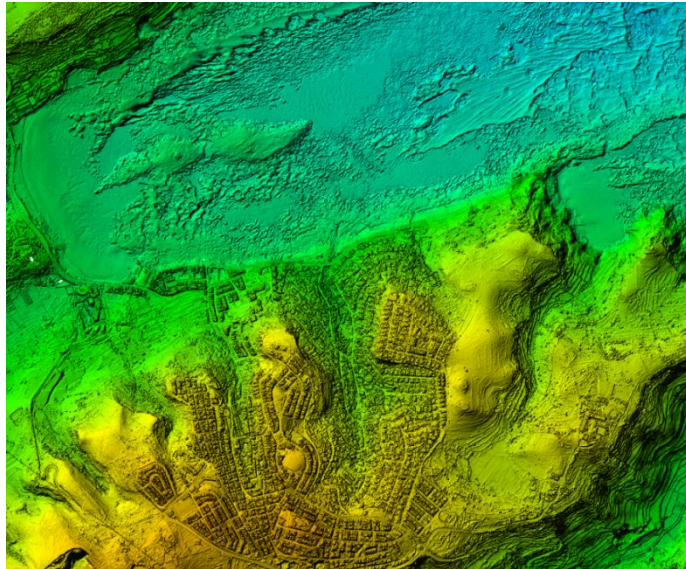
Dr. Andrea Hoffmann  
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- Seamless transition between the data sets



- Topographic part of LiDAR bathymetry not used
- Reflections on sea from topographic LiDAR not used



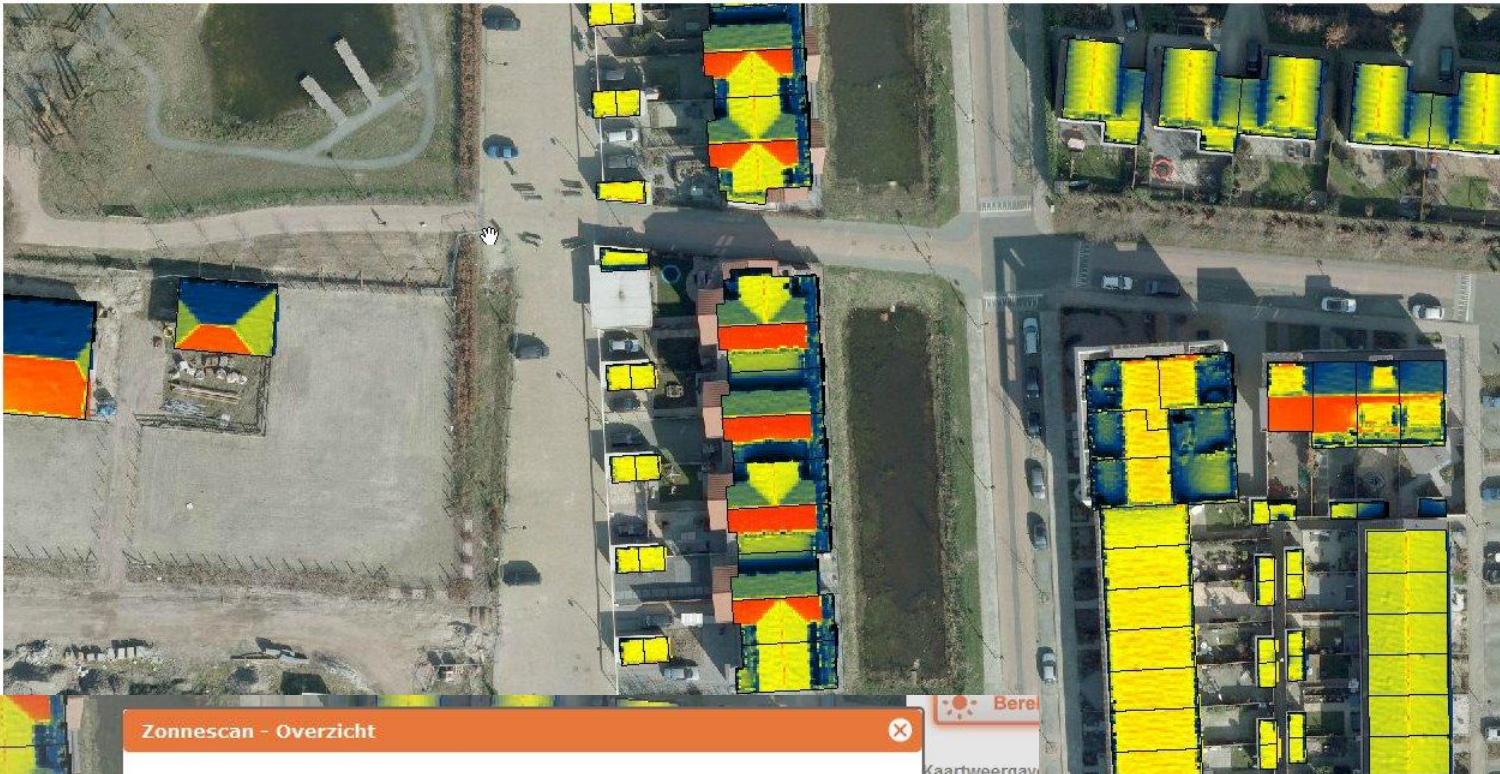
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## After the project is before the project...

- MEPA and all other public authorities are waiting in the wings and look forward to exploit the data
- One of the first applications will be flood risk monitoring. The islands are severely flooded after every heavy rain, a drainage system should solve this
- Mapping and maps will be transformed from analogue to digital
- First users will be the project partners: The Malta Resource Authority, the National Statistics Office, the Environmental Health Directorate and the University of Malta
- There will be a lot of users – this is special about the project – from next year on all data will be freely available for everybody via the internet. It can be displayed or downloaded





Selecteer gebouw ?

**Bereken**

Kaartweergave ?

- Gedetailleerde kaart
- Geschiktheid in zones

Legenda ?

(kWh/m<sup>2</sup>/jaar)

powered by Terra Imaging and Aerodata

**Zonnescan - Overzicht**

Aan de hand van de hellingshoek, richting en beschaduwing is het dak opgedeeld in vier zones.

Adres **Wageningseberg 41**

| Zone                | Oppervlak         | Instraling              |
|---------------------|-------------------|-------------------------|
| Plat dak, gunstig   | 0 m <sup>2</sup>  | 0 kWh/m <sup>2</sup>    |
| Schuin dak, gunstig | 57 m <sup>2</sup> | 1061 kWh/m <sup>2</sup> |
| Redelijk            | 8 m <sup>2</sup>  | 745 kWh/m <sup>2</sup>  |
| Ongunstig           | 10 m <sup>2</sup> | 340 kWh/m <sup>2</sup>  |

**Bereken opbrengst**

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# Solar potential

Malta also waits for the exploitation of one of their natural resources—the sun

samples from our Solar potential map of Amersfoort



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## Conclusion

# Combining data of different instruments in one project gives valuable new data esp. in the highly dynamic transition zone between land and sea

# In next future Malta will see various applications and models based on the data, starting with environmental analysis, flood monitoring and prevention, infrastructure management and much more

# Future will see more integrated projects using different sensors and technologies such as ground penetrating radar for infrastructural, heritage and tourism purposes.

# We will need to have new tools for the integrated analysis of these sources



**MEPA**



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there is so much more to tell and discuss....

Please contact us

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Thank you.



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