



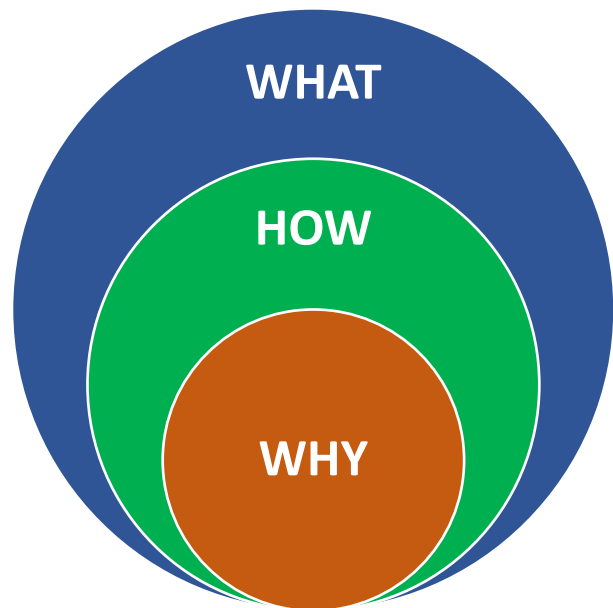
M P A
SINGAPORE



Integration of Terrestrial, Maritime and Cadastral Geospatial Information

Eric Foo

Maritime Port Authority of Singapore



SUSTAINABLE DEVELOPMENT GOALS

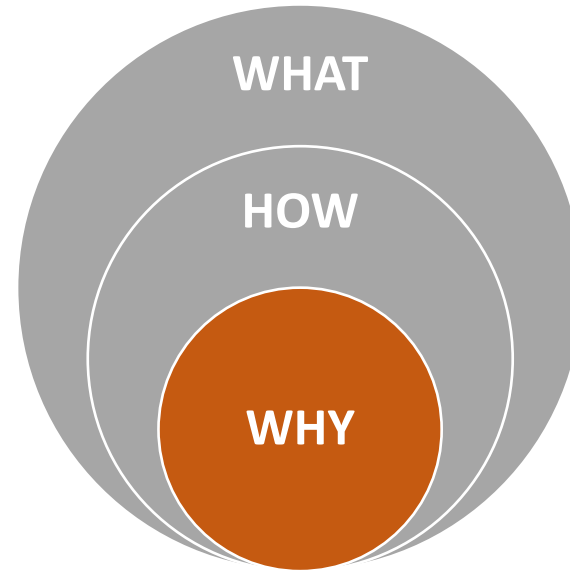
17 GOALS TO TRANSFORM OUR WORLD



(Source: wartsila.com)



Integrated Digital Twin



- ⚓ **Economic**
 - ⚓ Integrated Spatial Planning
 - ⚓ Coastal Economic Activities
- ⚓ **Social**
 - ⚓ Food Security
 - ⚓ Coastal Recreational Activities
- ⚓ **Environmental**
 - ⚓ Transition to Clean Energy Source
 - ⚓ Protection against Coastal Inundation
 - ⚓ Enhance Marine Habitats and Enrich Biodiversity



Economic



Social



Environmental





Technologies

Space-based



Aerial systems



Mobile Mapping Systems



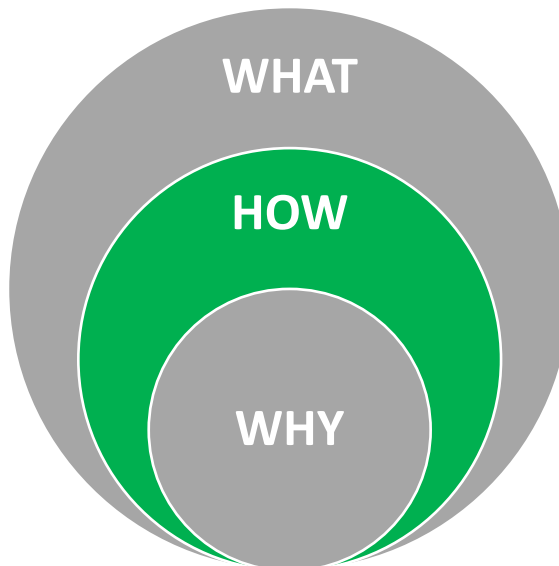
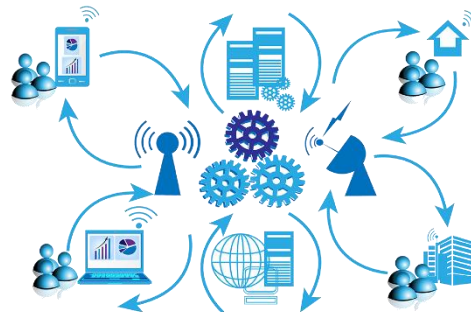
Ground based Systems



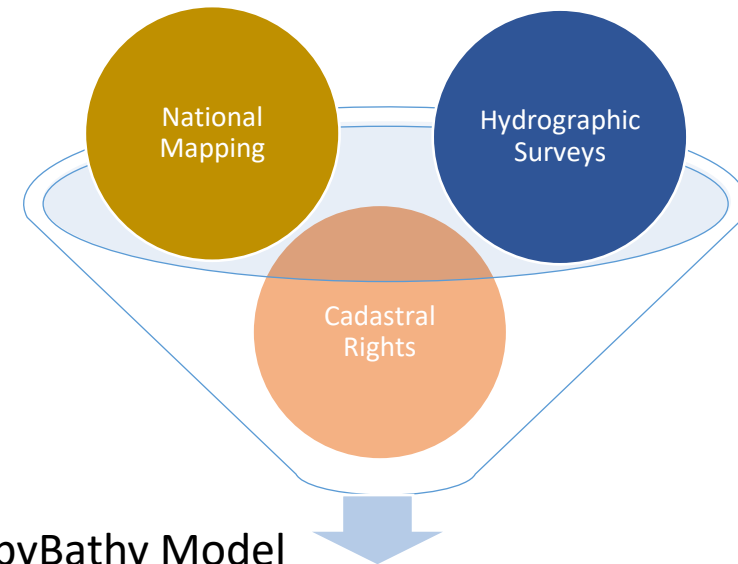
Hydrography



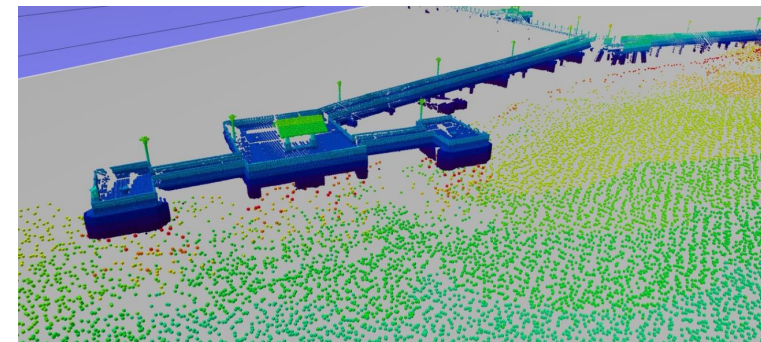
Systems



Datasets



TopyBathy Model





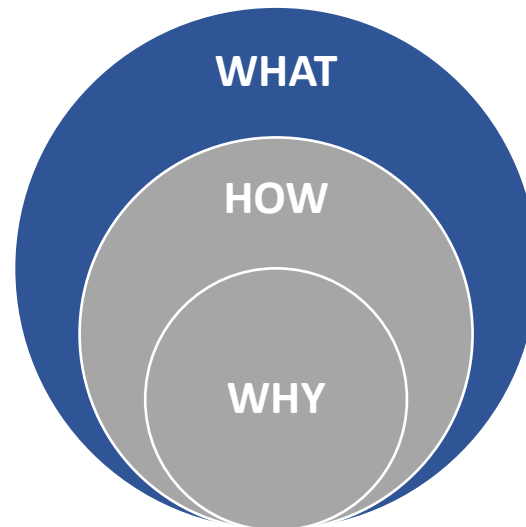
WHAT we do to overcome the Challenges

⚓ Current Challenges

- ⚓ Data Acquisition near coastline
- ⚓ Data Conversion or Harmonisation of Singapore Height and Chart Datum
- ⚓ Data Discovery and Sharing across systems

⚓ Future Challenge

- ⚓ Vertical Land Motion Monitoring for Coastal Adaptation Study



Why Do We Need to Integrate



Coastal Economic Activities



Economic



Port of Singapore
(Source: maritimegateway.com)



New floating fish farm off Changi aims to produce more seafood than traditional coastal farms



Social

Integrated Spatial Planning



Environmental



Youth Kayaking beside Sports Hub.
(Source: Today Online)



Singapore now home to one of the world's largest floating solar farms.
(Source: Straits Times)

Photo: Sunseap

Protection against Coastal Inundation



Environmental



High tide at East Coast Park Area B on 4 Feb, 2016
(Source: Straits Times)



Submerged boardwalk at Sungei Buloh Nature Reserve during a spring tide in January 2015 (Source: Straits Times)

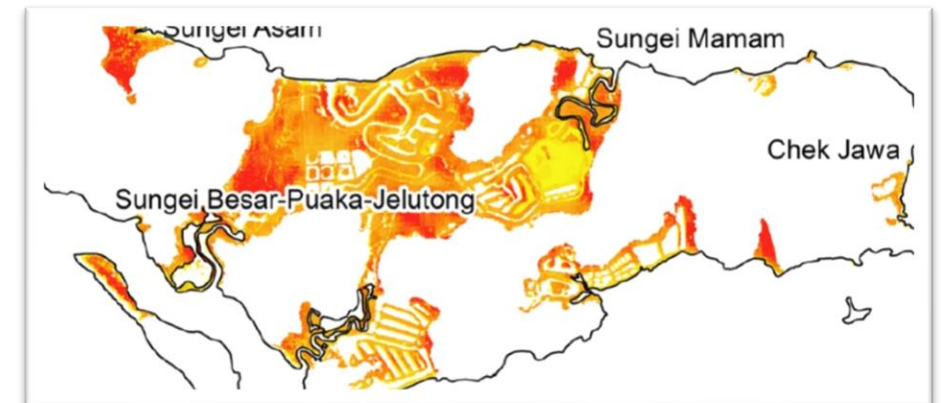
Protection of Biodiversity



The Coastal Protection and Restoration of Mangrove Biodiversity at Pulau Tekong conducted by NParks and HDB



Elevation mapping was conducted as part of the mangrove restoration program in Pulau Ubin



Mapping the mangrove sites to quantify the blue carbon stocks (Source: Mangrove Lab, NUS)



Environmental



Economic

Integrated Spatial Planning



Social



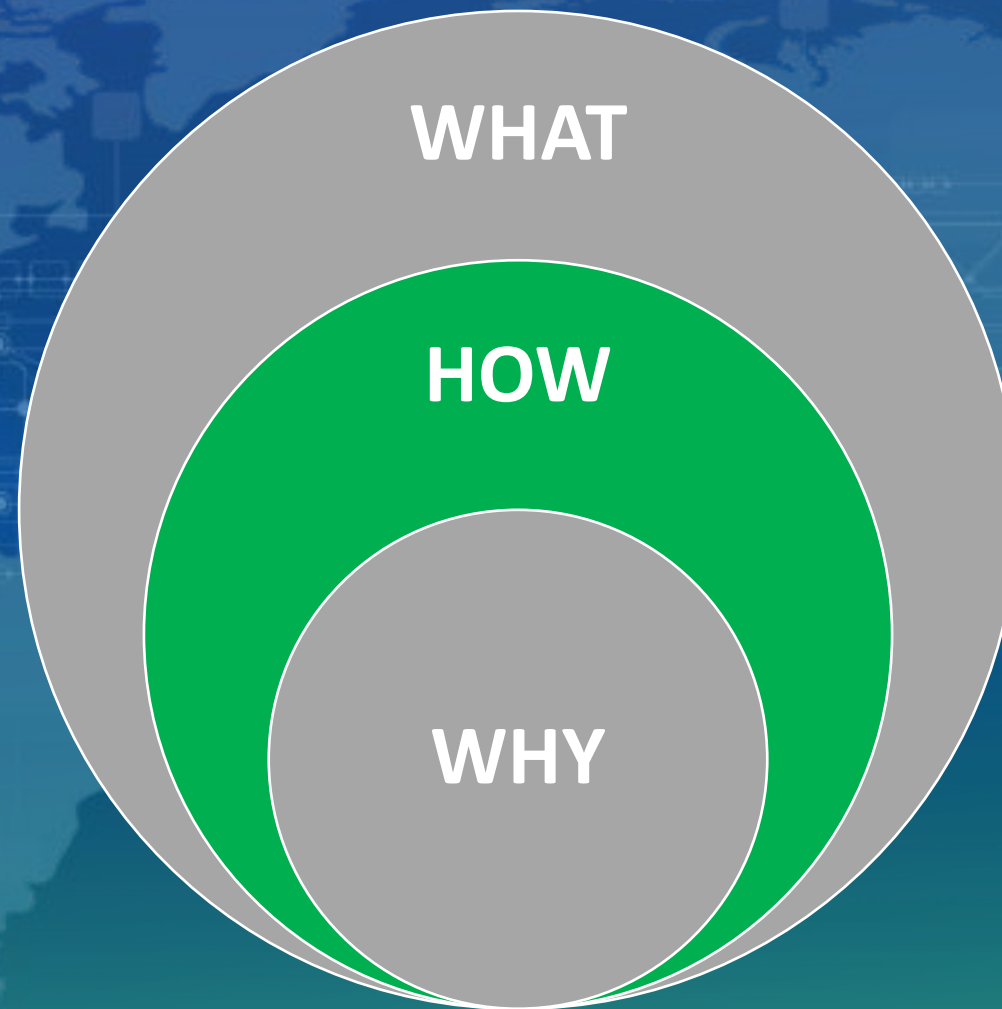
Environmental



The Greater Southern Waterfront will be redeveloped

For illustration only

How Do We Integrate



Adoption of Multi-Sensors and Technologies

Space-based



Aerial systems



Unmanned
Aerial Vehicle

Mobile Mapping Systems



Examples:

- ⚓ Remote Sensing
- ⚓ Photogrammetry
- ⚓ LASER Scanning
- ⚓ Global Positioning System (GPS) /
Global Navigation Satellite System (GNSS)
- ⚓ Total Station
- ⚓ Ground Penetrating RADAR
- ⚓ Multibeam Echo-sounder

Ground based Systems



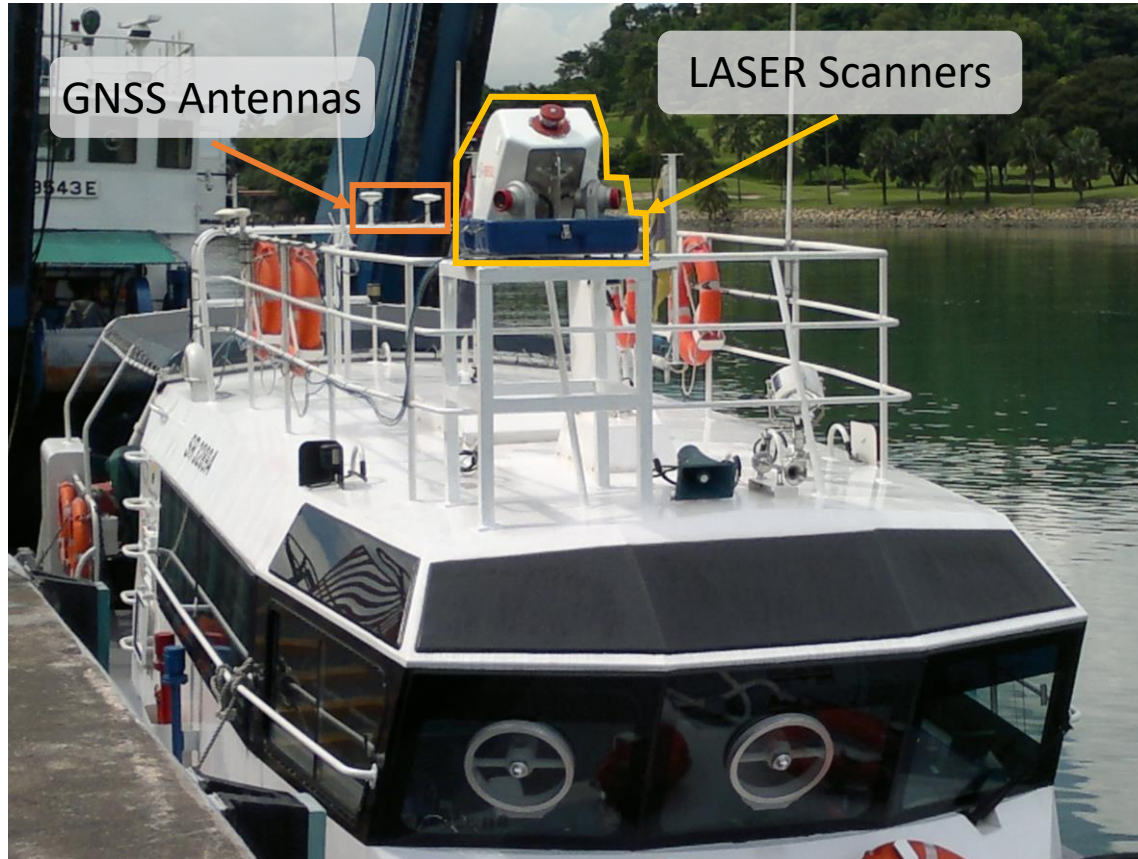
Subsurface



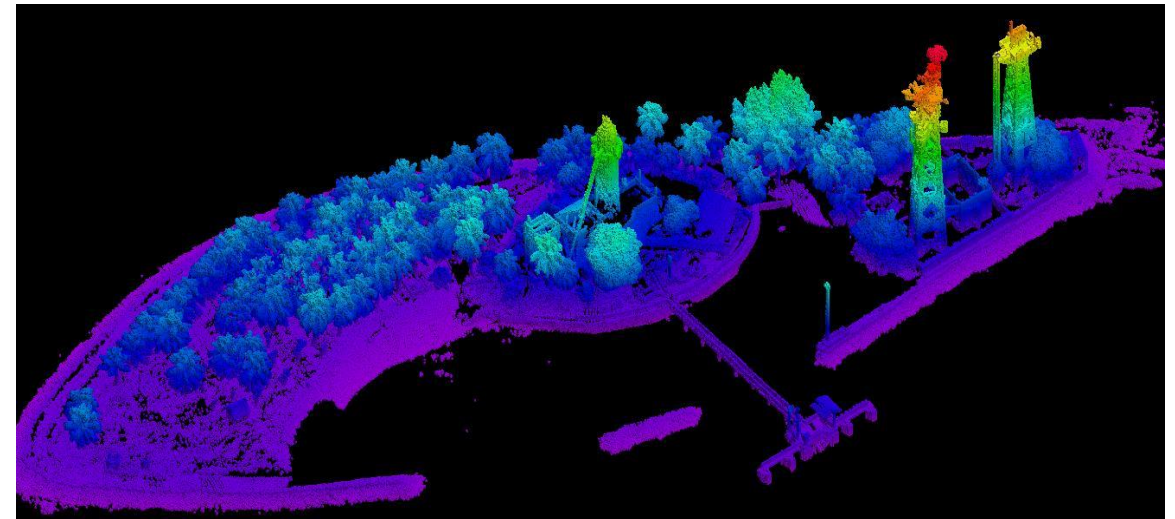
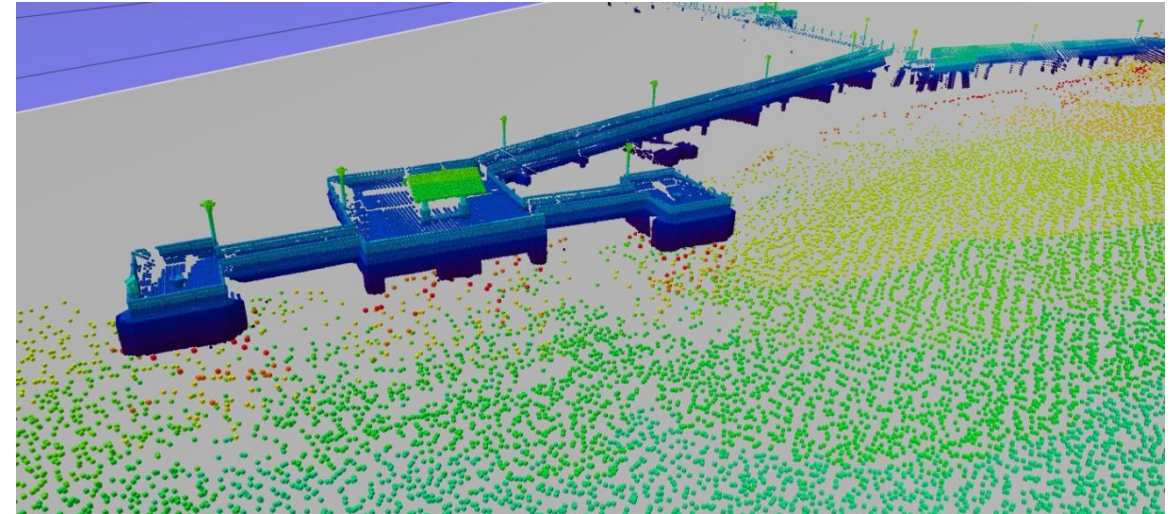
Hydrography



Simultaneous Survey with Multibeam Echo Sounder and Laser Scanner

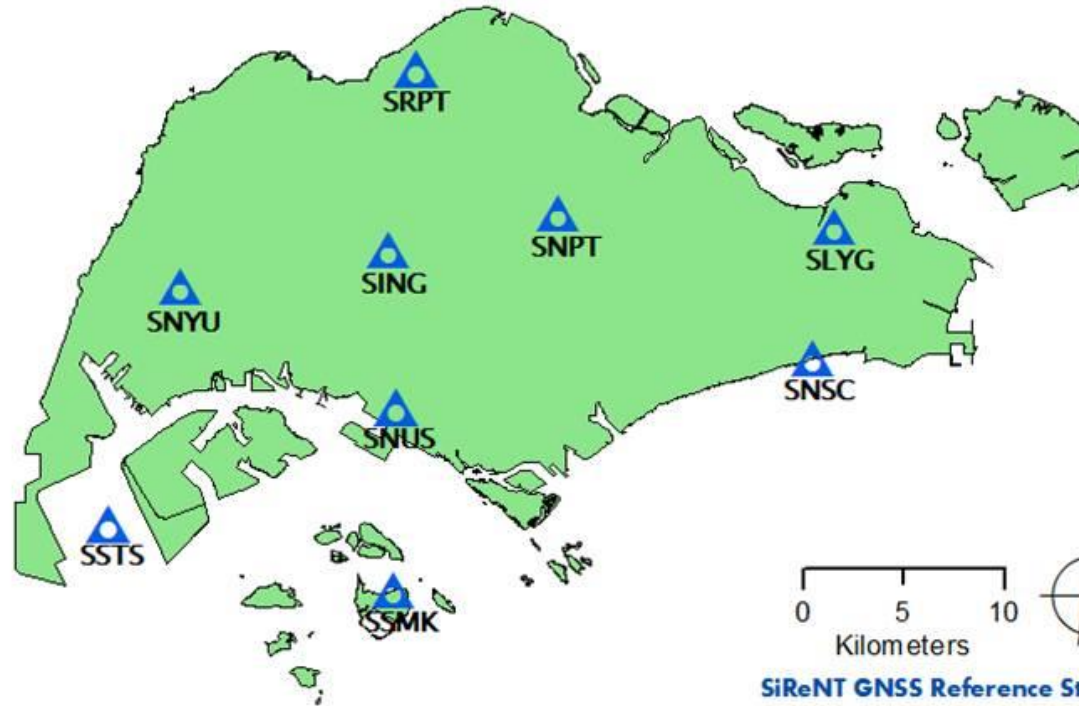


Simultaneous survey with Multibeam and
LASER Scanner System



Precise GNSS Positioning

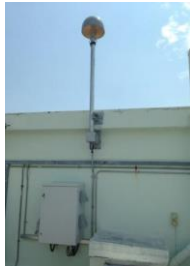
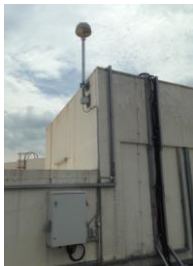
National Infrastructure - Singapore Satellite Positioning Reference Network (SiReNT)



- ⚓ **National Reference System** for Surveying, Mapping and GIS
- ⚓ Adopt **Global Navigation Satellite Systems (GNSS)** technology
- ⚓ Support up to **cm level real-time positioning** and navigation

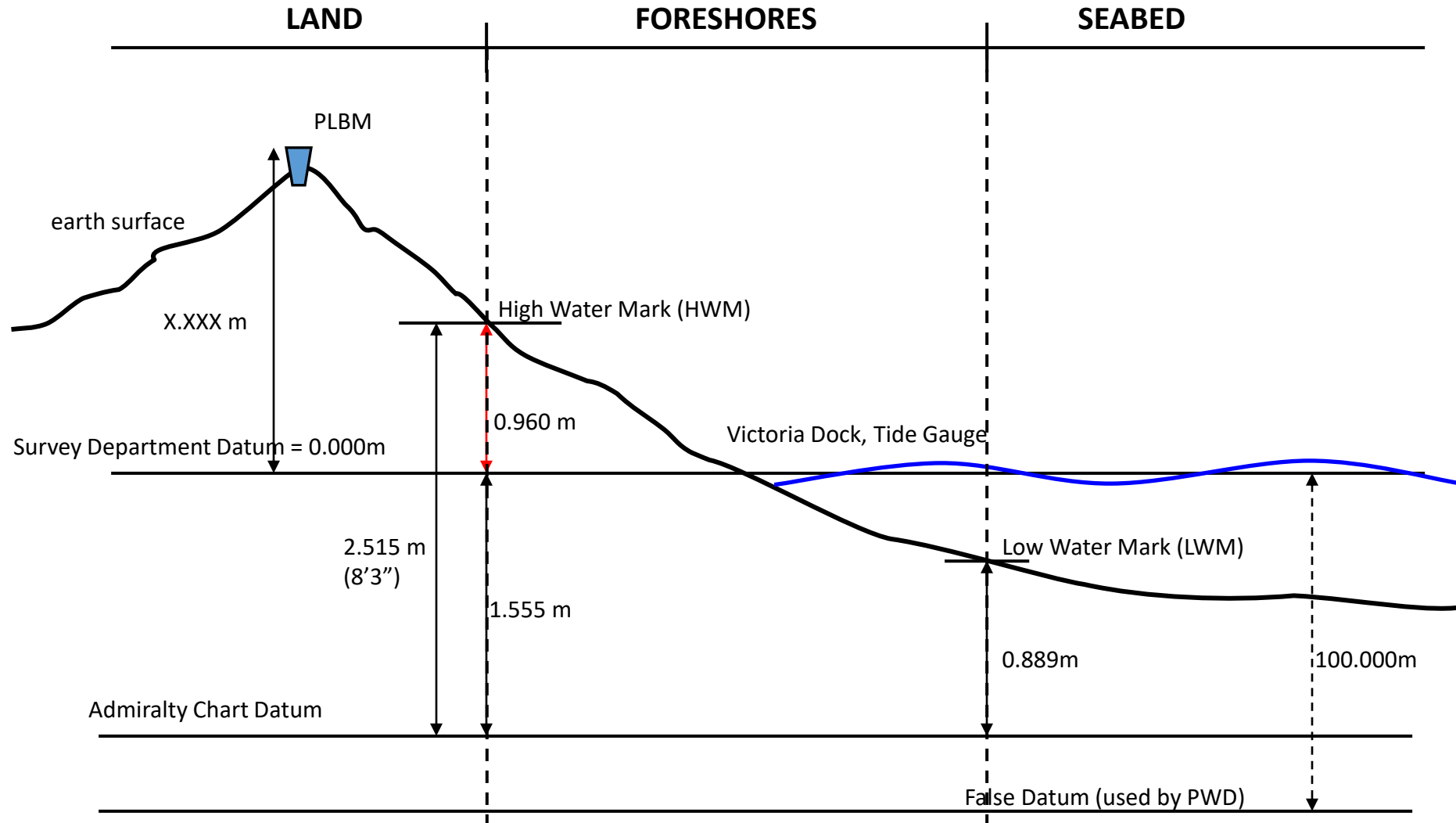
SiReNT
Singapore Satellite Positioning Reference Network

SLA
SINGAPORE
LAND AUTHORITY



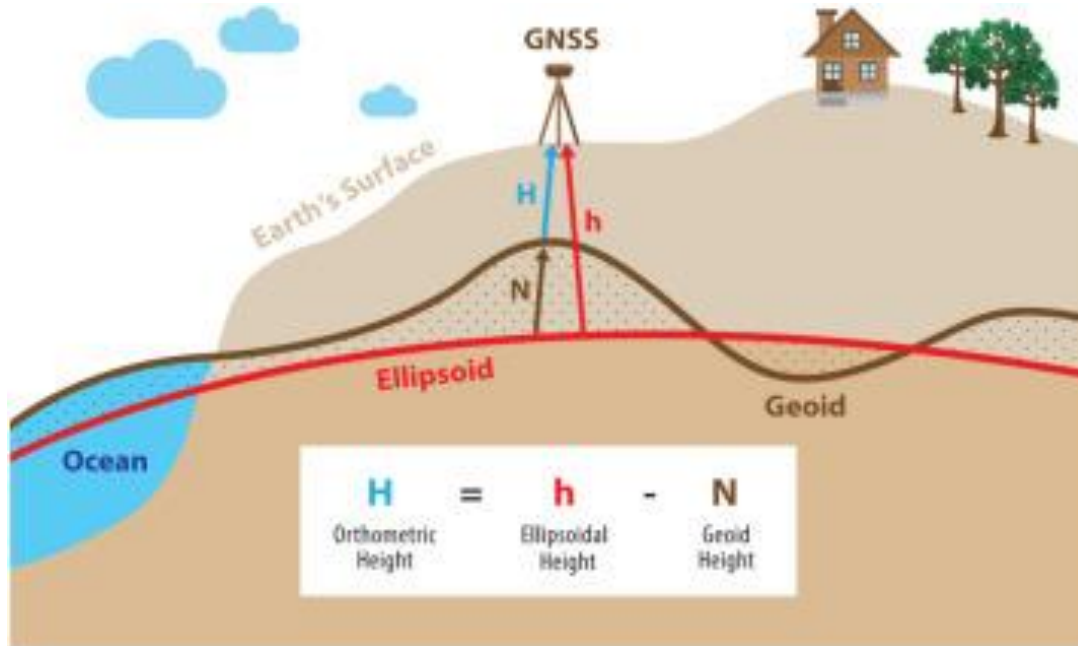


Datum Relationships

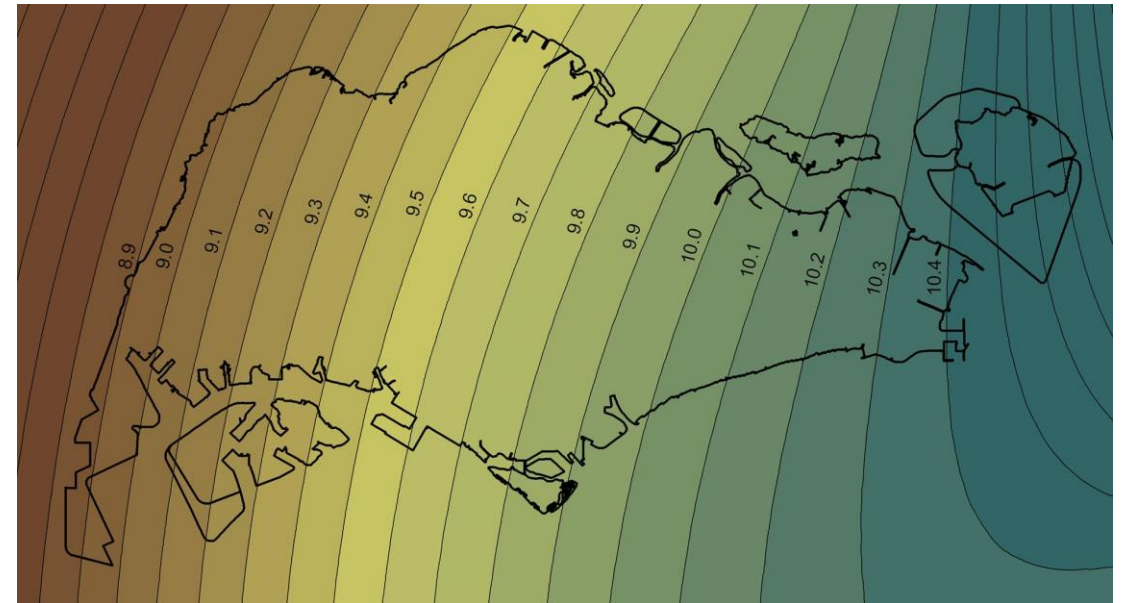




Development of Geoid Model



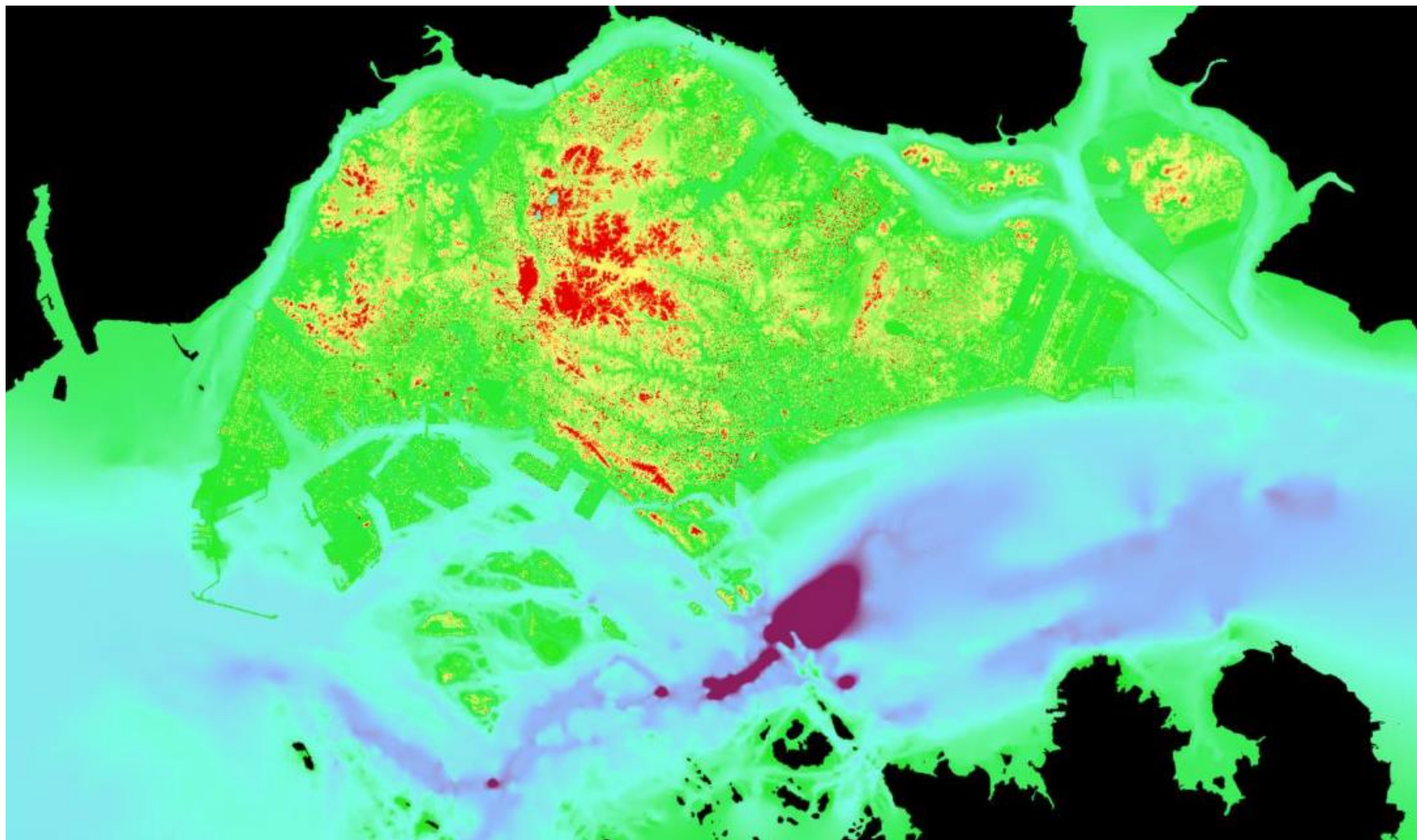
Relationship between Orthometric and Ellipsoidal Height



Geometric Geoid Model of Singapore



Integration of Topographic and Bathymetric Data

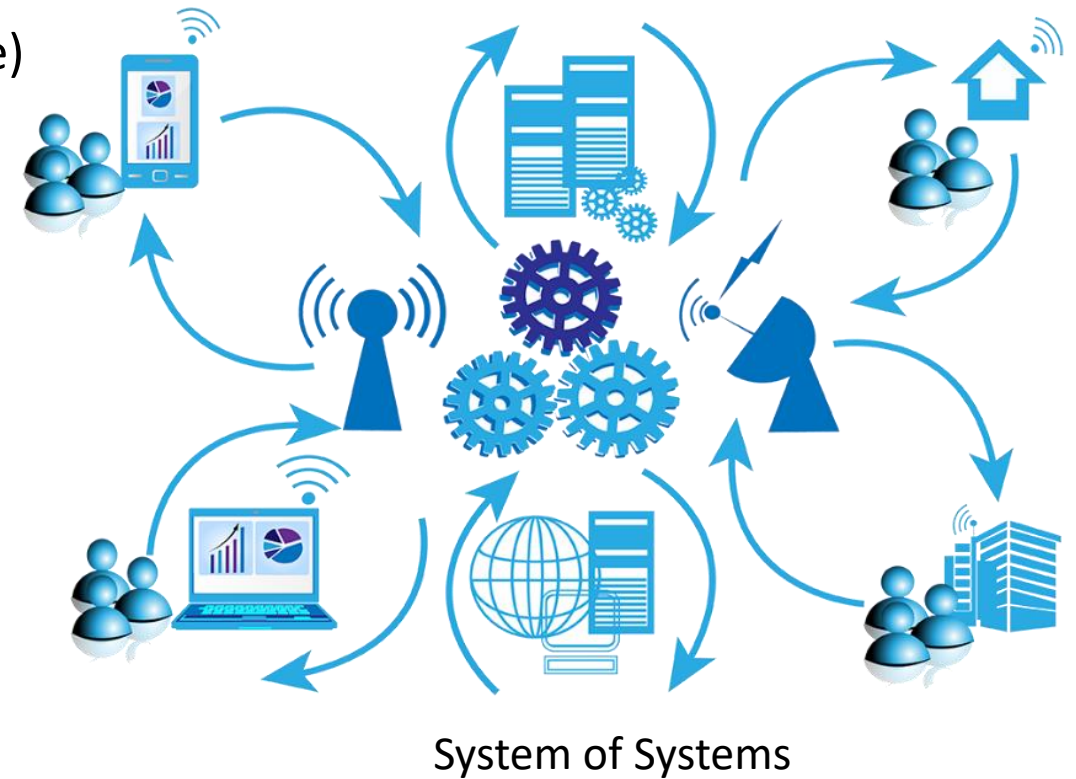


Singapore
ETH-Centre
Natural Capital

TopoBathy Map of
Singapore for
modelling
elevation
continuum in
Coastal Areas

System of Systems

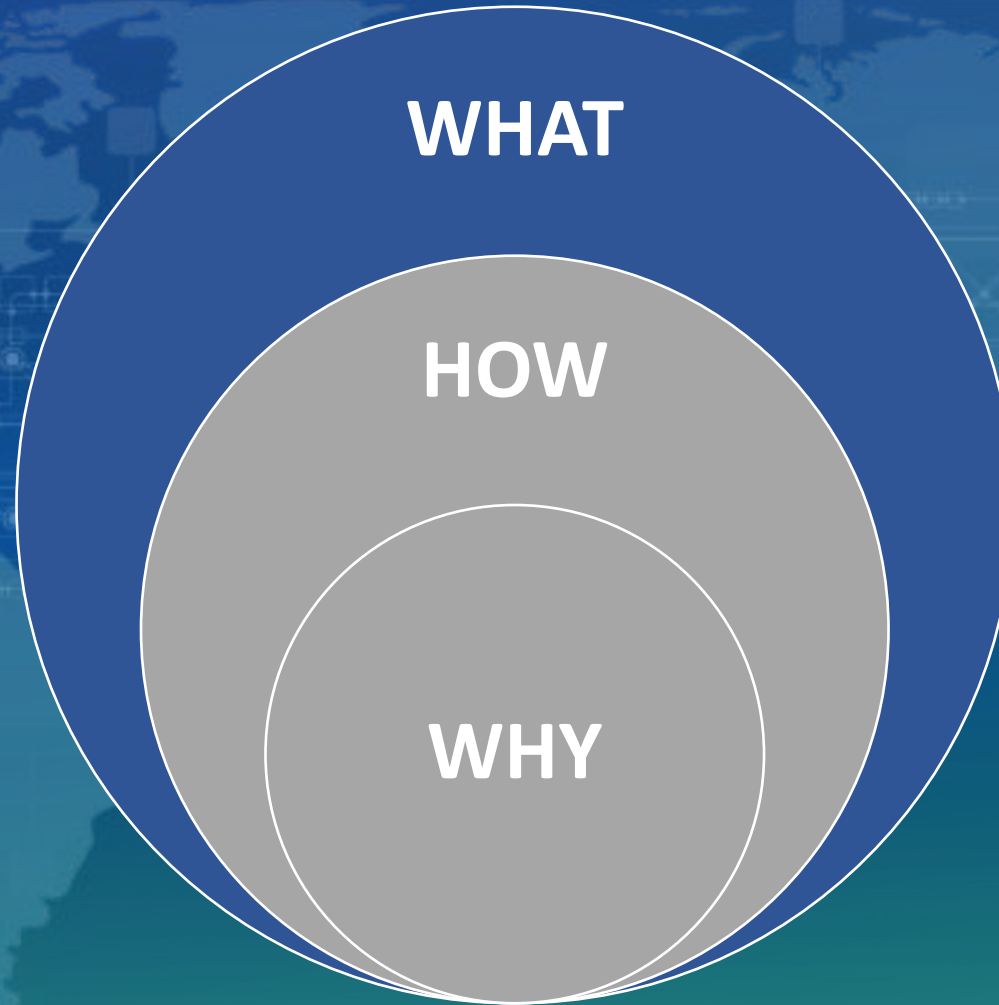
- ⚓ Nexus of multiple Spatial Data Infrastructures (SDIs) and Marine Spatial Data Infrastructures (MSDIs)
- ⚓ FAIR (**F**indable, **A**ccessible, **I**nteroperable and **R**eusable)
- ⚓ Open Geospatial Consortium (OGC) standards
- ⚓ International Organisation for Standardisation (ISO)
- ⚓ Web Services for Interoperability



Challenges

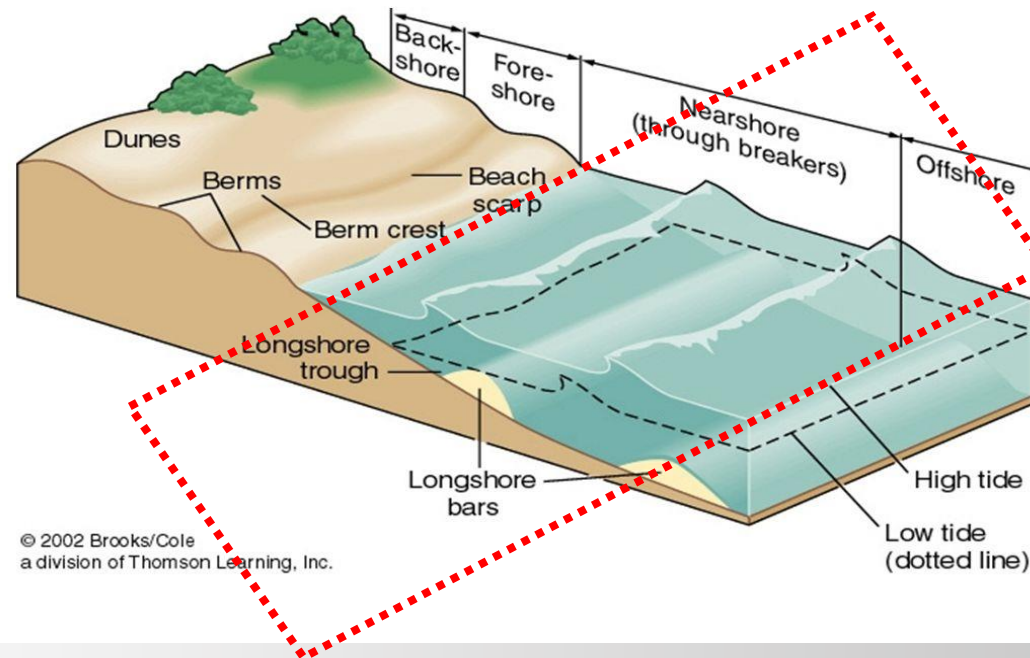
- ⚓ Data Acquisition “Gap”
 - ⚓ Coverage of Nearshore
- ⚓ Data Conversion or Harmonisation
 - ⚓ Horizontal Control
 - ⚓ Vertical Control
- ⚓ Data Sharing
 - ⚓ Platforms
 - ⚓ Standards

What We Do to Overcome the Challenges



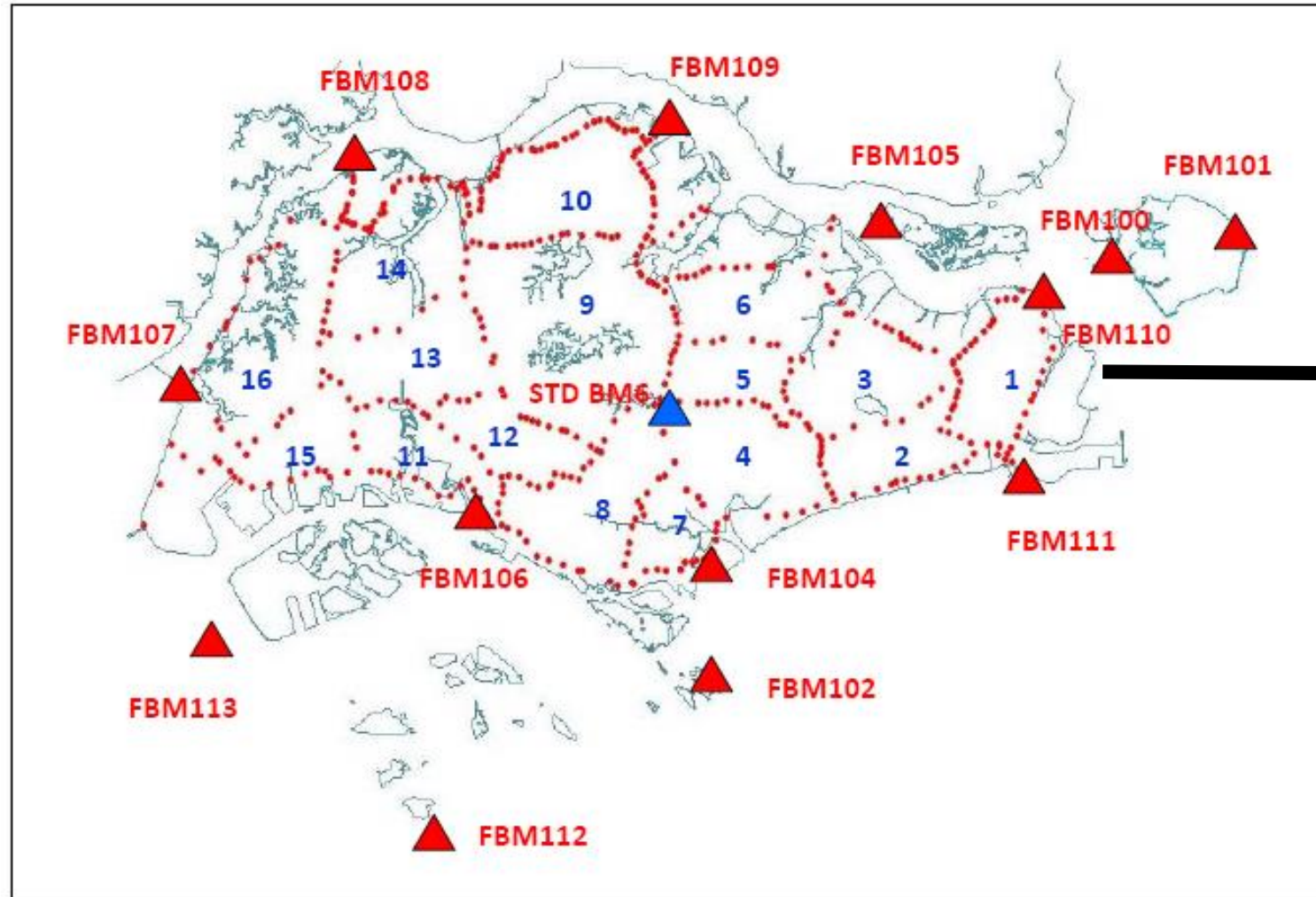
Feasibility Study on Nearshore Mapping with MPA and PUB (Ongoing)

- ⚓ No data available at nearshore due to challenges to acquire the data
- ⚓ Aims: To determine the best survey method to collect the topographic and bathymetric data at nearshore
- ⚓ To harmonise Singapore Height Datum and Chart Datums





New Vertical Control Infrastructure





geospace
sea



Basemaps



Administrative



Physical



Ecological



Human



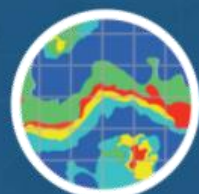
WHAT We Do

Featured Apps and Charts



Data Catalogue

Discover the data



2D Marine Viewer

Highlight spatial patterns and discover trends



3D Marine Viewer

Explore bathymetry and other spatial information in 3D



Data Dashboard

View all activities and key performance indicators

Driven by:



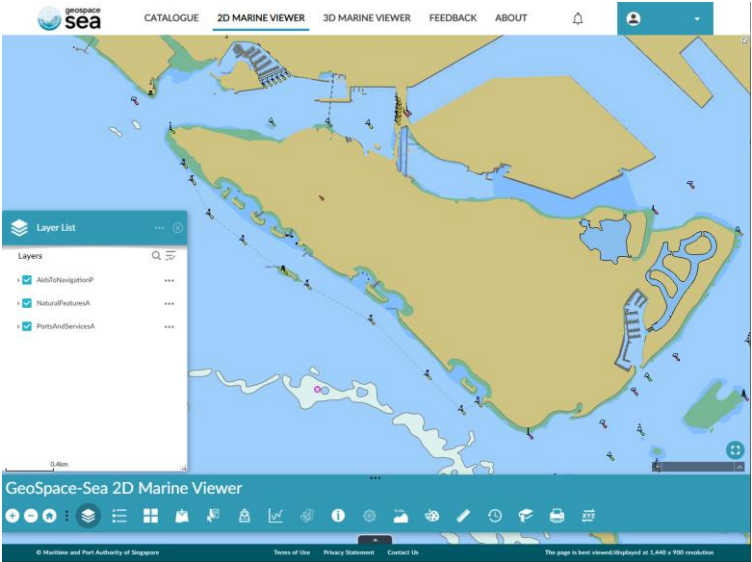
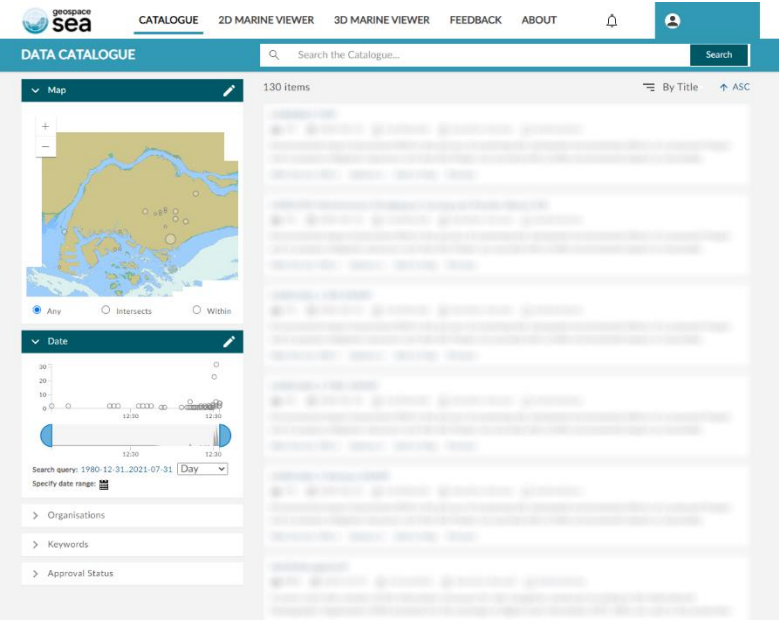
In joint collaboration with:



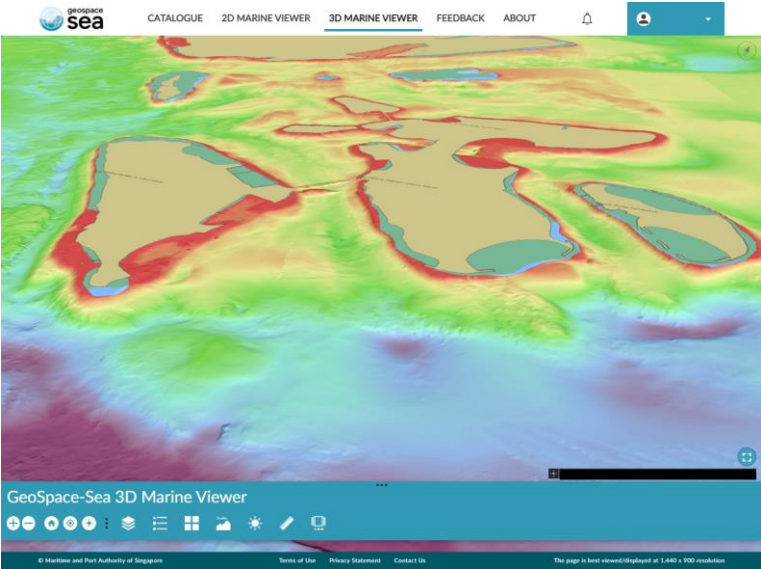
GeoSpace-Sea's Featured Applications



Data Catalogue



2D Marine Viewer



3D Marine Viewer



GeoSpace-Sea's Linkage with OGC

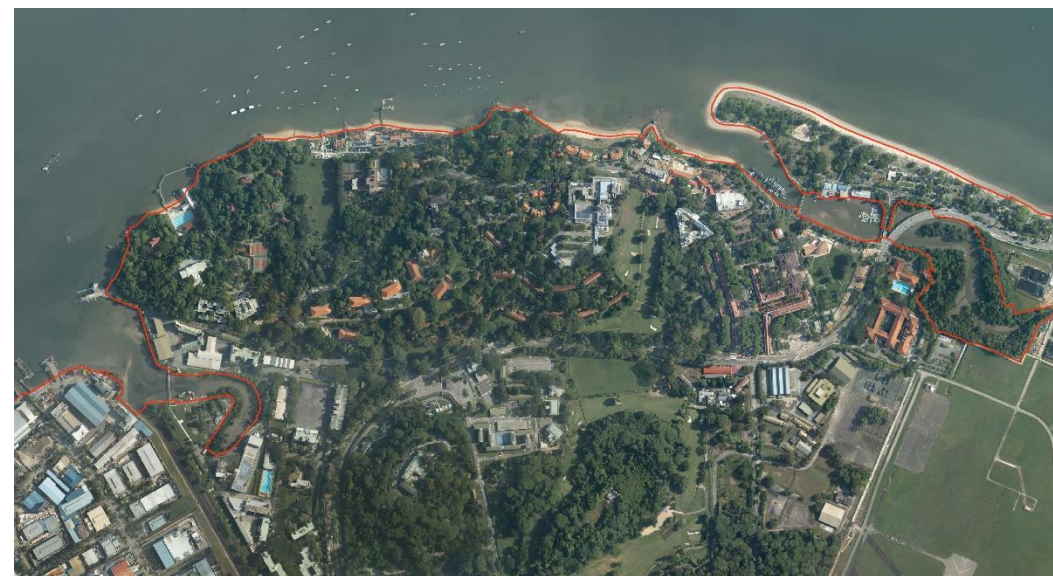
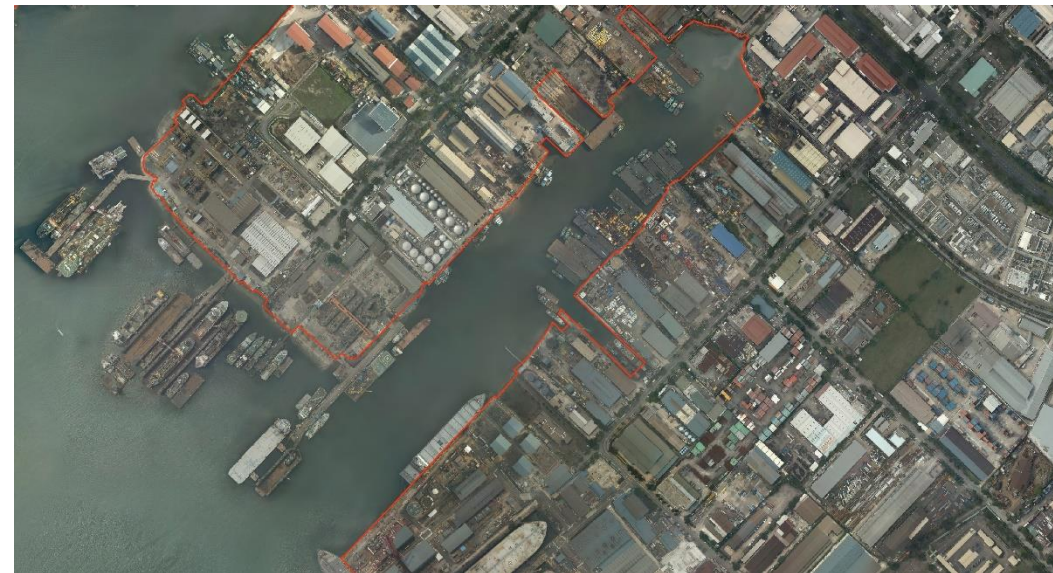
- ⚓ Ensuring that GeoSpace-Sea's data is FAIR (**F**indable, **A**ccessible, **I**nteroperable and **R**eusable).
- ⚓ Alignment with the publicly available geospatial standards in the form of web services, API, metadata etc.
- ⚓ Active participation in OGC Marine Domain Working Group.
- ⚓ Supporting the development of Marine Spatial Data Infrastructure (MSDI).



WHAT We Do

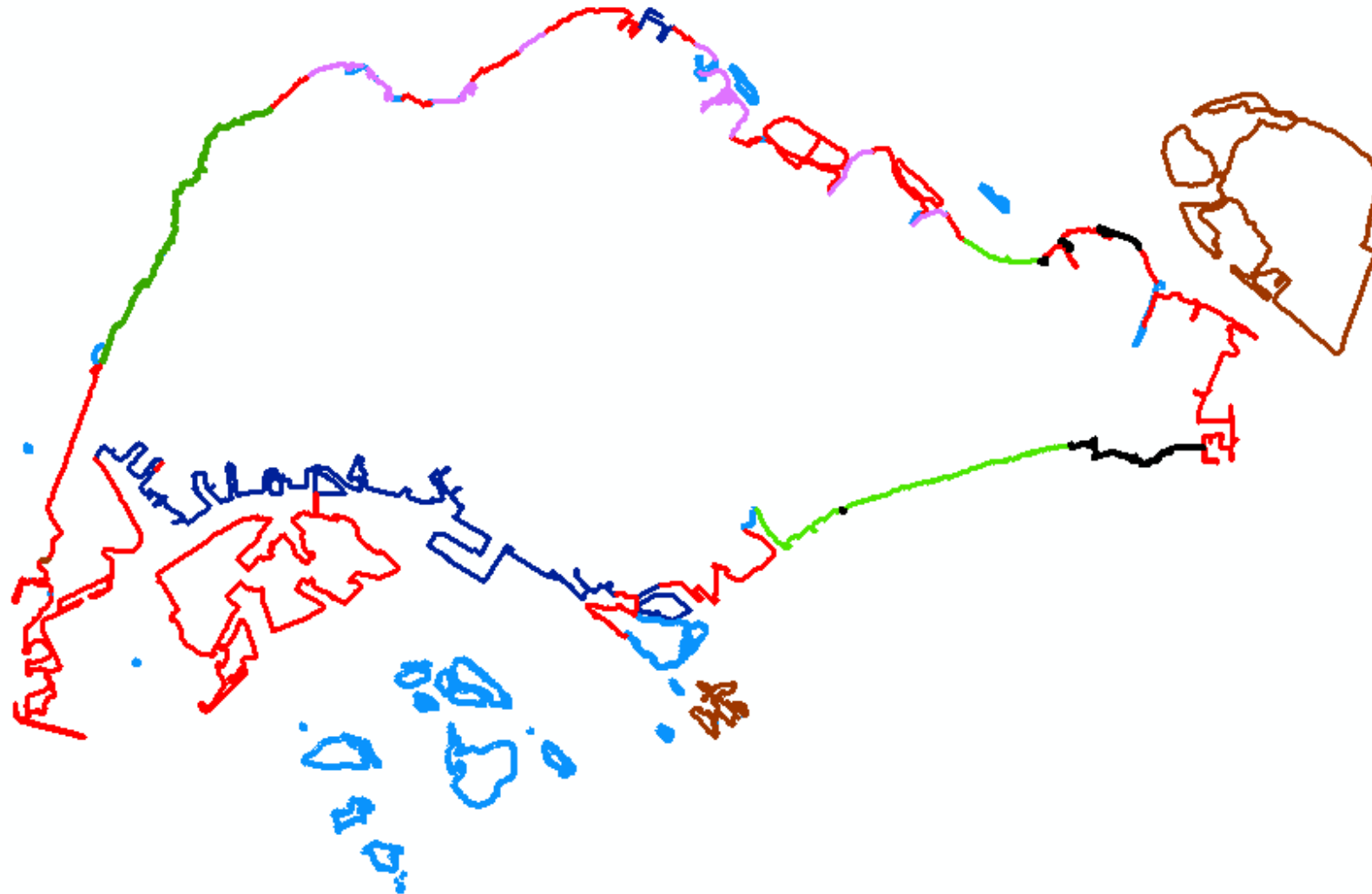
Coastal Protection Baseline Mapping

- ⚓ Determine Coastal Protection Baseline using combination of Aerial Images, Cadastral Survey Data and Terrain Model
- ⚓ Collaborate with BCA/PUB to demarcate and classify the Coastal Protection Baseline that will be used by WOG in 2018
- ⚓ In the process of setting up
 - ⚓ Authoritative database for the
 - ⚓ A workflow for updating through our Surveyors QP framework





Coastline Protection Baseline Mapping



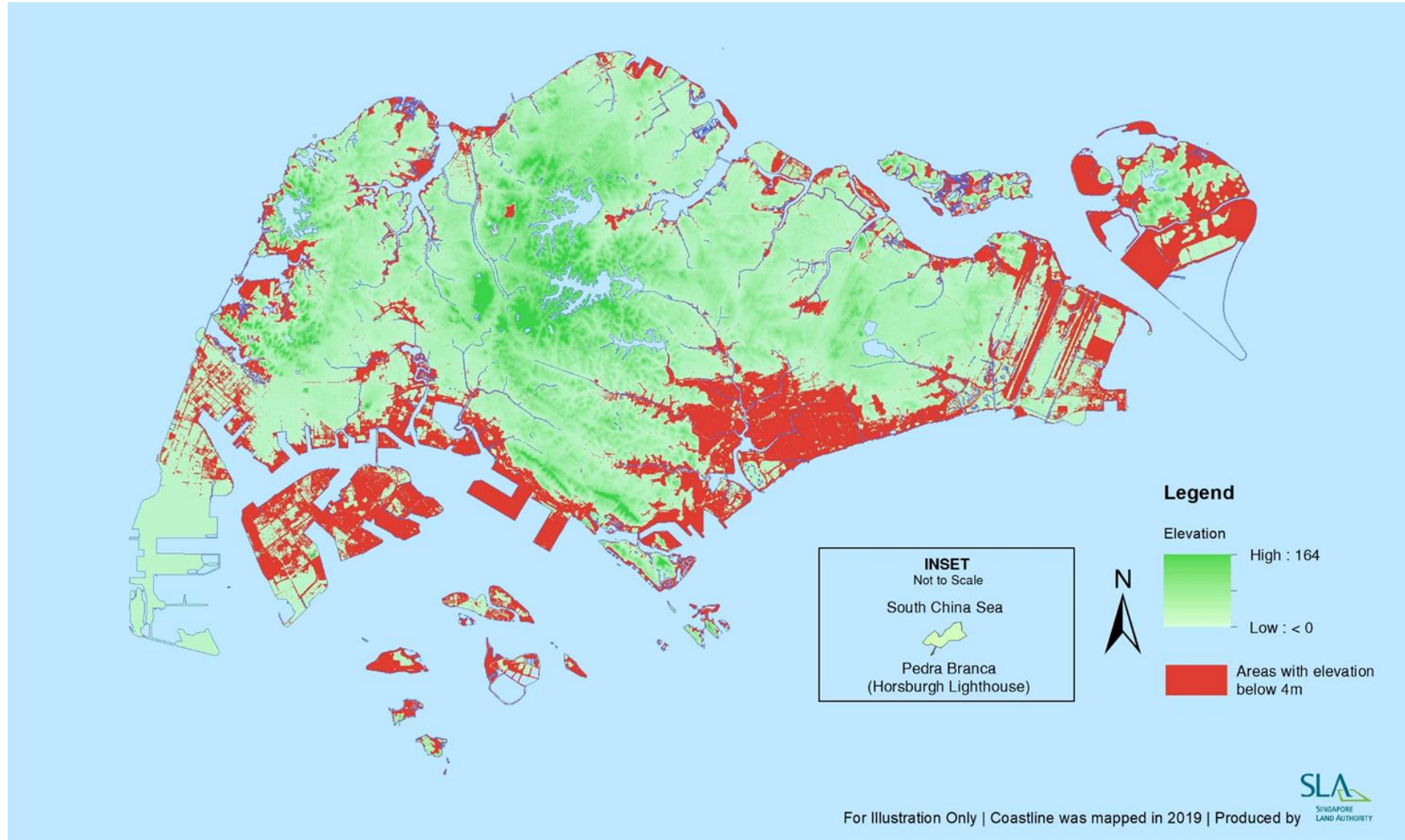
COASTLINE CLASSIFICATIONS

- Barrier Lagoon
- Natural Beach
- Headland
- Mangrove
- Reclaimed Coast
- Seawall
- Unclassified
- Wharf

Development of Terrain Model and Sea Level Rise Map

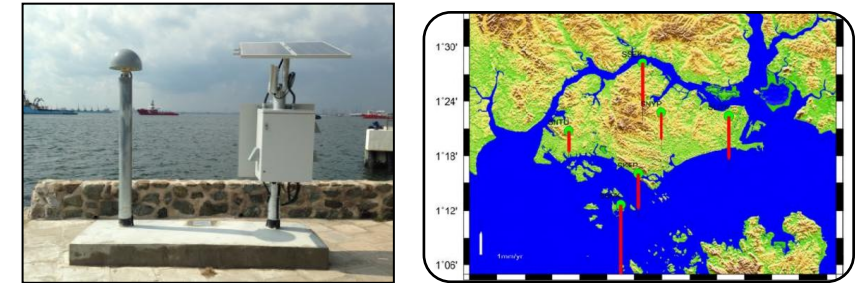


WHAT We Do



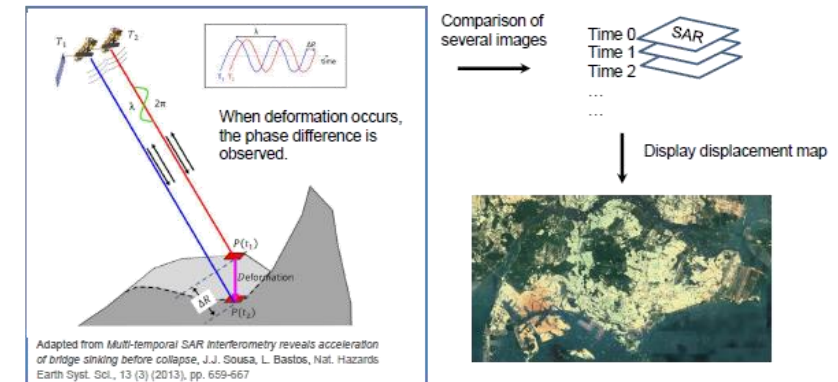
SLA to lead Vertical Land Motion (VLM) Monitoring

- ⚓ Support WOG national effort in adaptation and monitoring of sea level rise
 - ⚓ National Sea Level Research Programme
 - ⚓ IAC (Inter-agencies Adaptation Committee)
 - ⚓ RWG (Resilient Working Group)



SiReNT GNSS monitoring

- ⚓ Adopt integrated geodesy and mapping techniques in monitoring
 - ⚓ GNSS reference station long-term monitoring using SiReNT
 - ⚓ Vertical Control Network data from SGD
 - ⚓ Airborne laser scanning point cloud data from N3DMP
 - ⚓ Satellite data and InSAR technique



InSAR technique

Integration of Terrestrial, Maritime and Cadastral Geospatial Information





Thank You