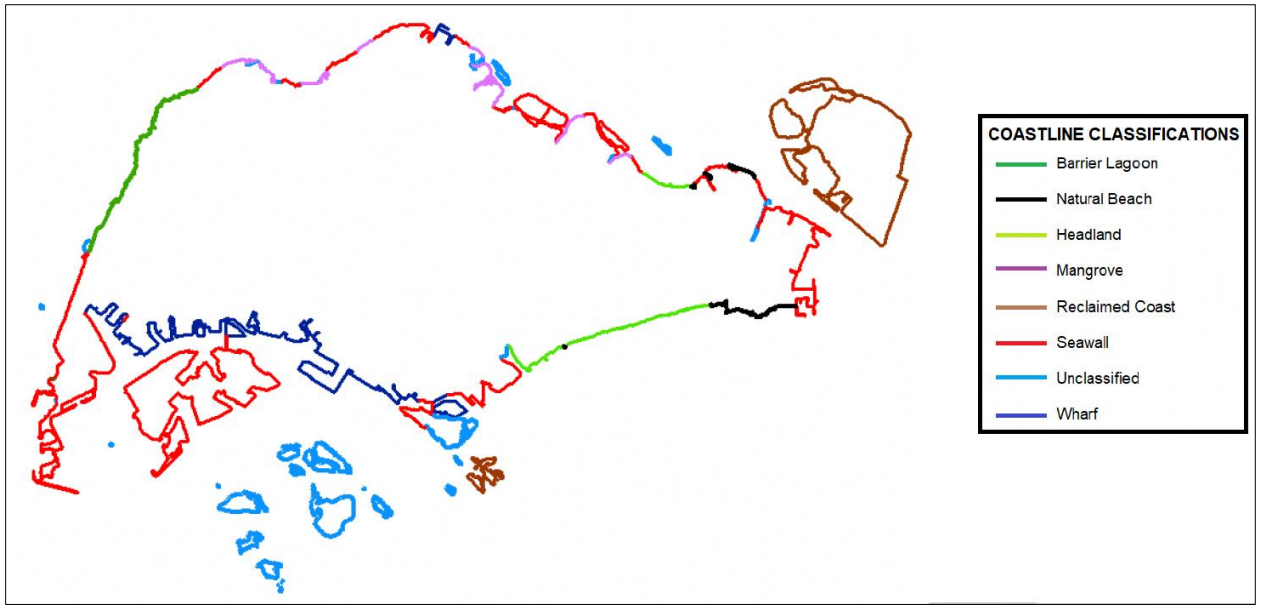
A Sponsor Perspective

SOON Kean Huat (SLA) and Lawrence CHEW (MPA)

Singapore Land Authority (SLA) and Maritime and Port Authority of Singapore (MPA)

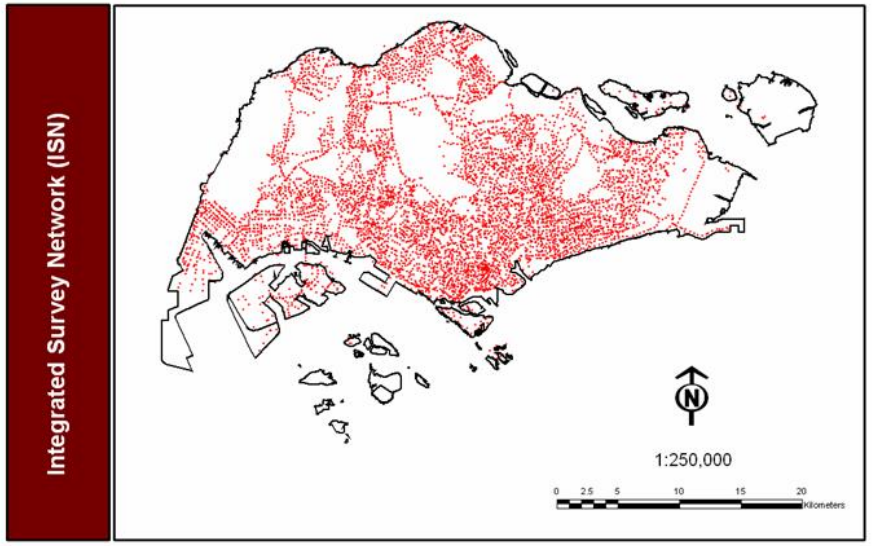
Spatial Context

- Singapore as an island nation with an industrialised coastline of 131km.
- Ongoing escalation of climate change as a significant challenge for Singapore.
- Threats include rising sea levels and increasing frequency of extreme weather events.
- Integrating land and sea data is required to assess potential risks

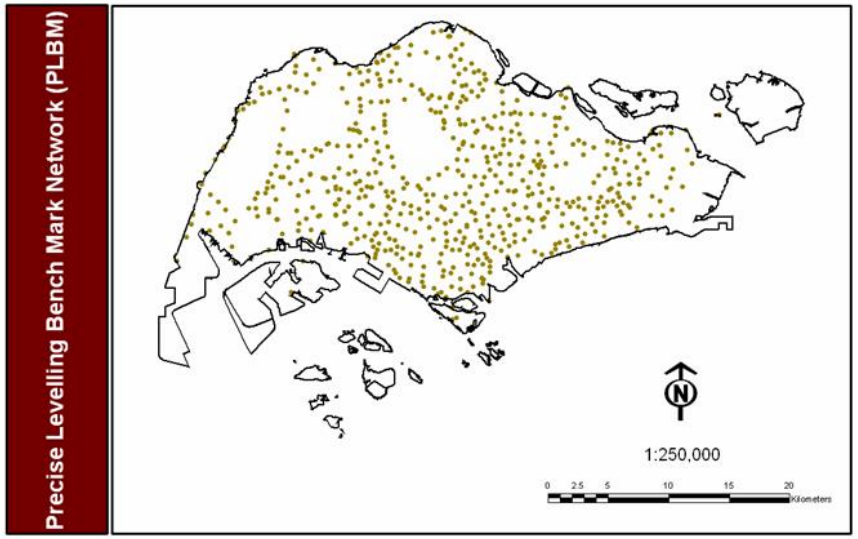


National Reference Infrastructure

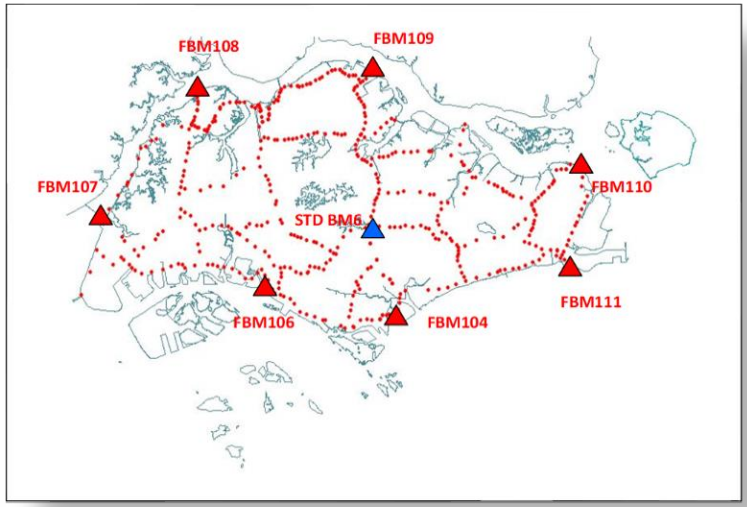
Integrated Survey Network (ISN)



Vertical Control Point Network (VCP)

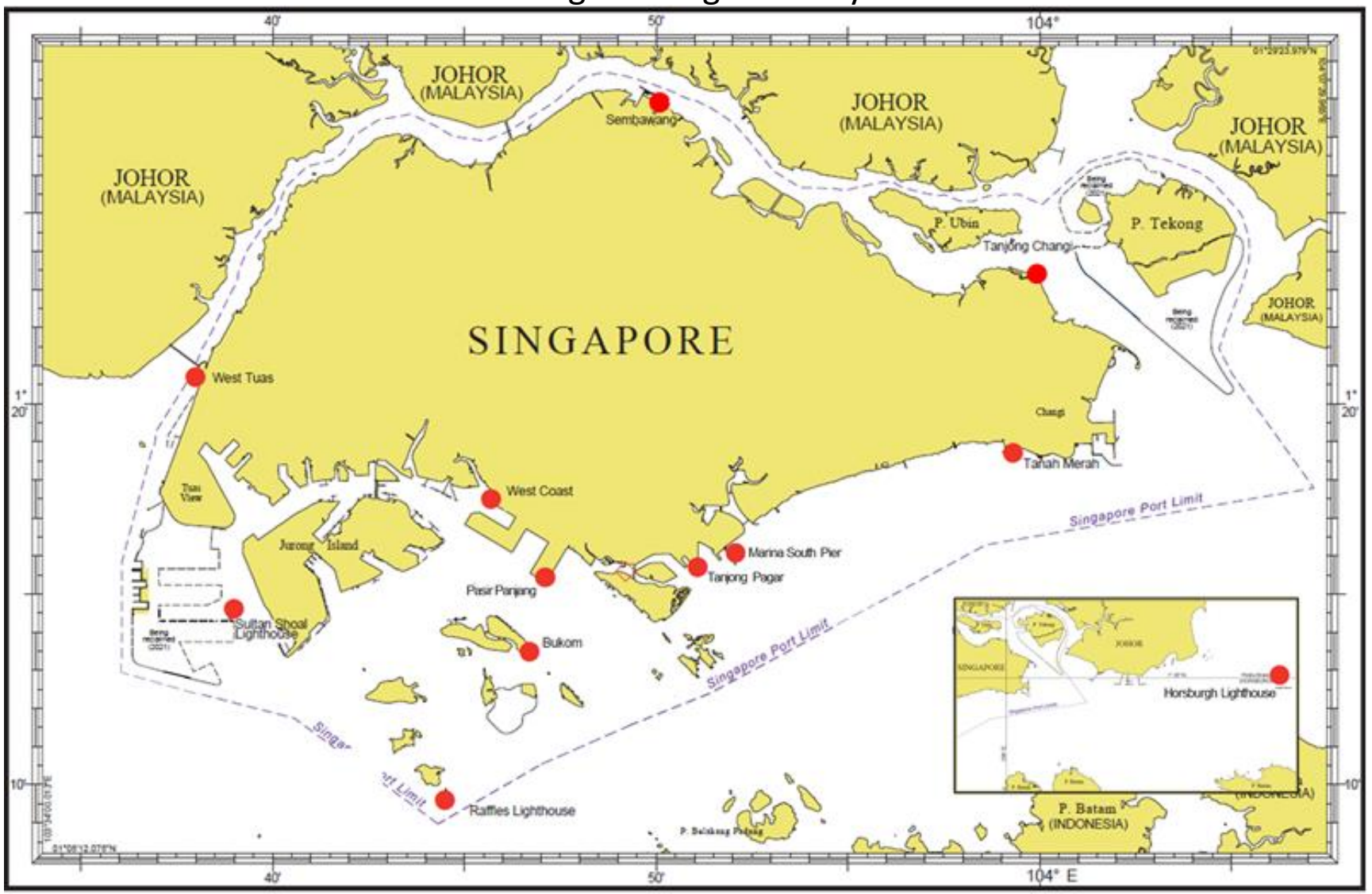


Fundamental Benchmarks



Tide Gauges

Tide Gauge Management System



Precise GNSS Positioning

National Infrastructure - Singapore Satellite Positioning Reference Network (SiReNT)

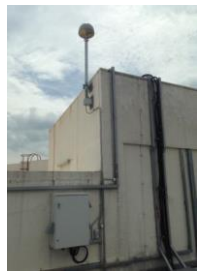
- **National Reference System** for Surveying, Mapping and GIS
- Adopt **Global Navigation Satellite Systems (GNSS)** technology
- Support up to **cm level real-time positioning** and navigation

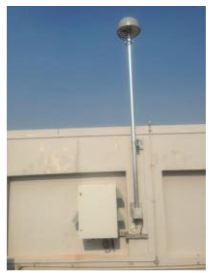
SiReNT provides:

Real-Time Kinematics (RTK)
– *3-5cm accuracy (real-time)*

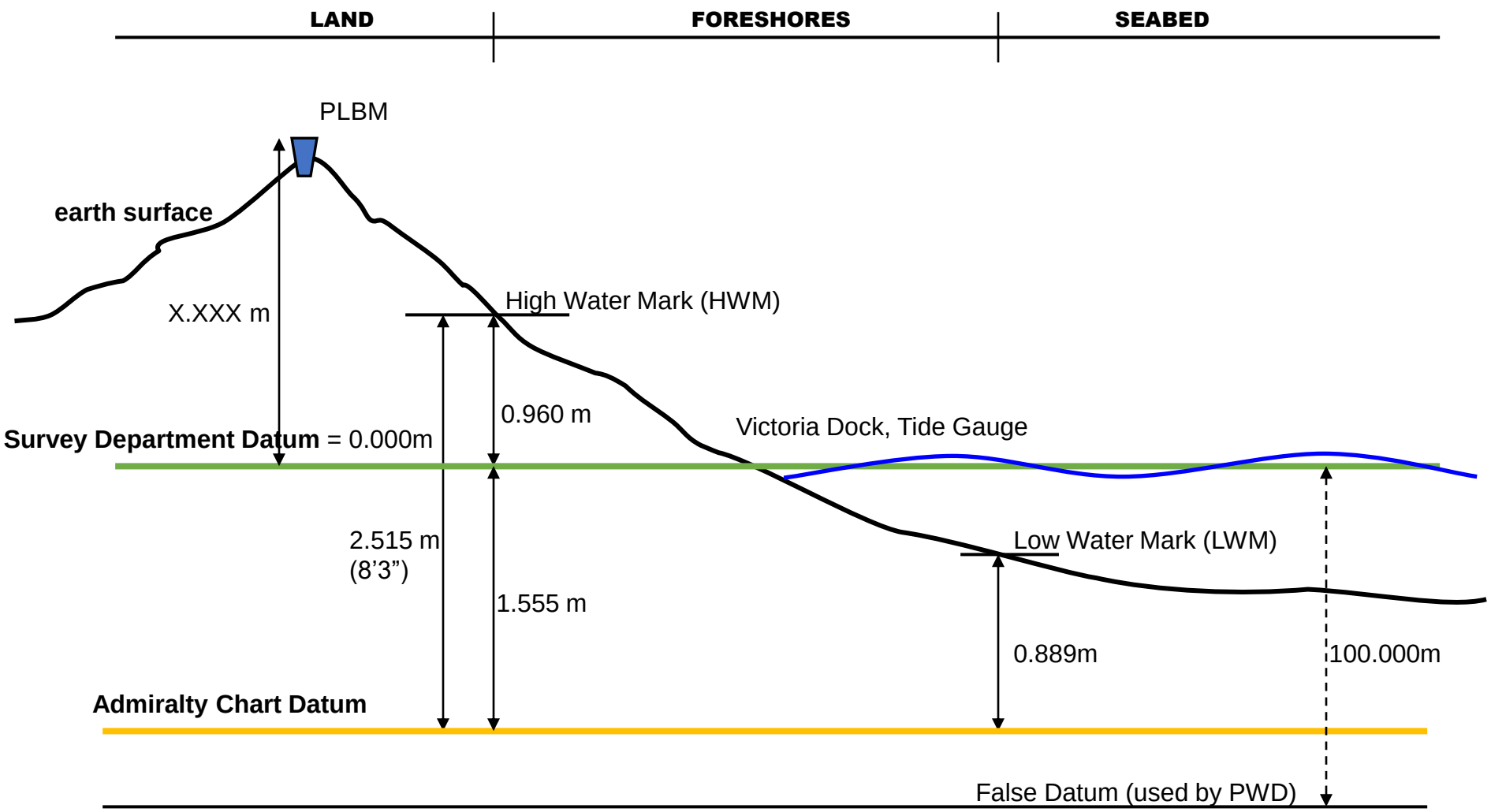
Differential GNSS (DGNSS)
– *sub-meter accuracy (real-time)*

Post Process On Demand (PP On-Demand)
– *5 millimeters accuracy*

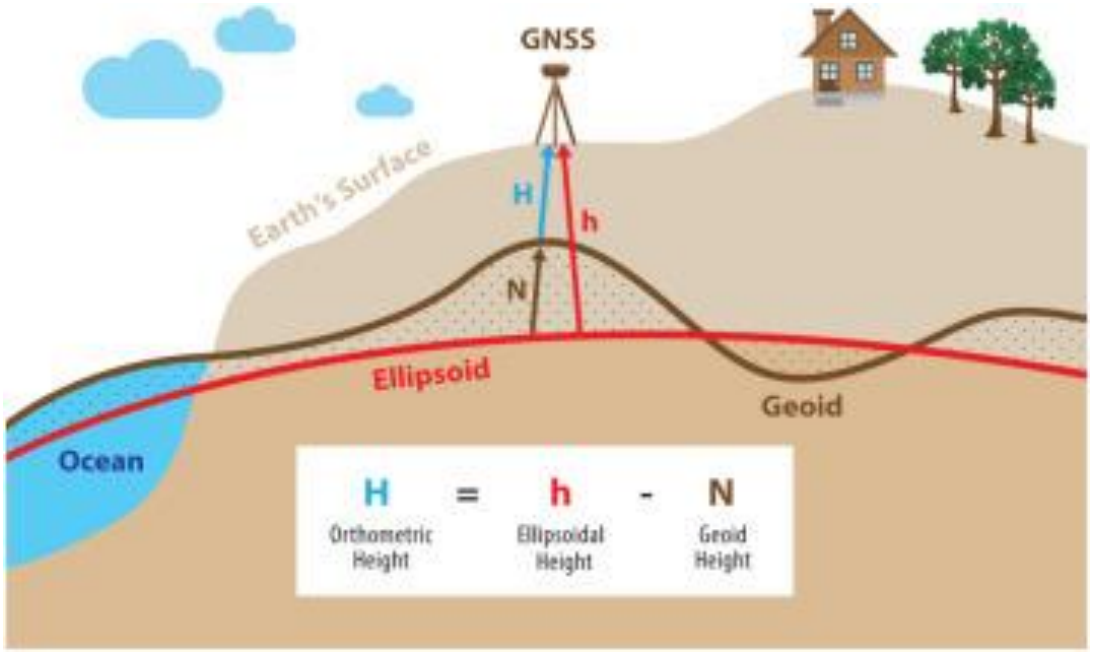




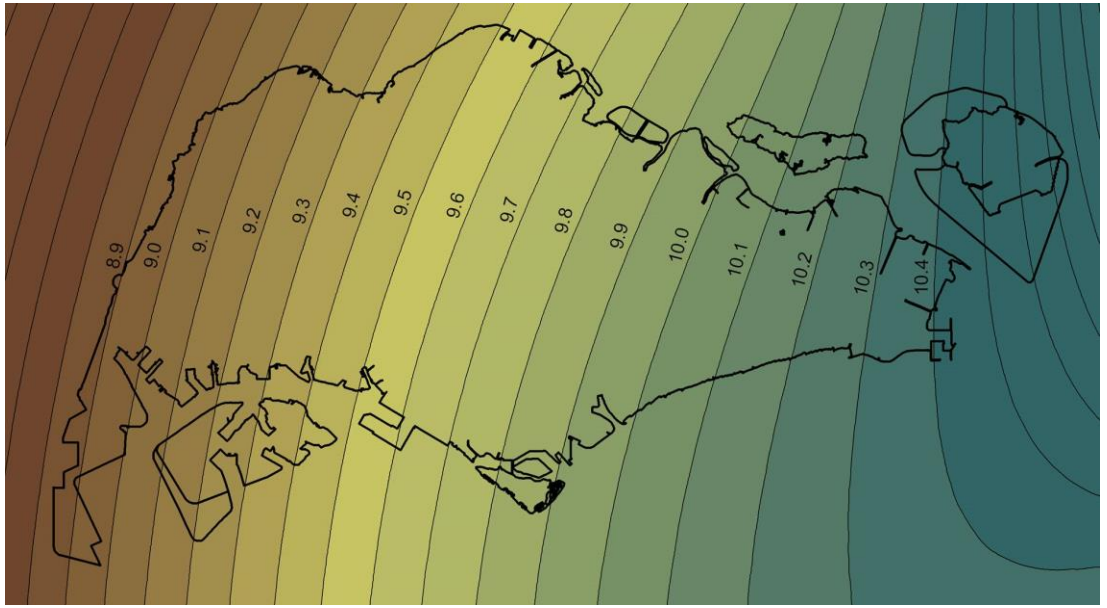
Datum Relationships



Different Heights



Relationships between **Orthometric Height** (H) and **Ellipsoidal Height** (h)



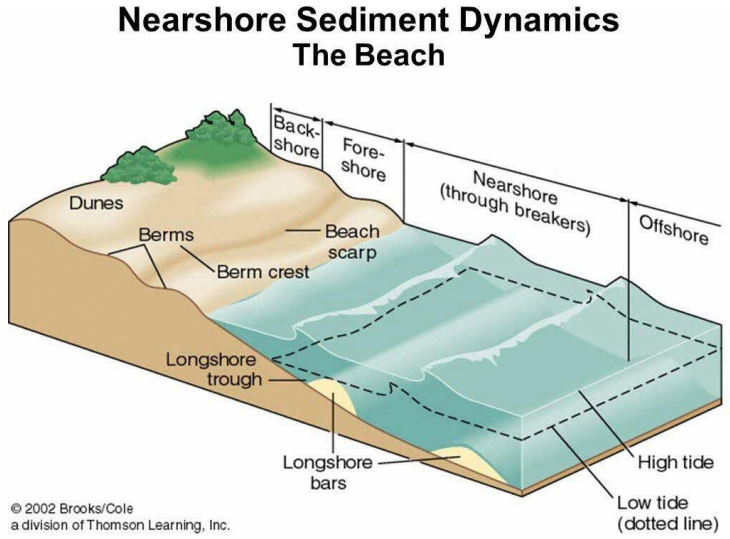
Geometric **Geoid** Model (N) of Singapore

Feasibility Study on Nearshore Mapping

Aims: To propose survey method to collect reliable topographic and bathymetric data at nearshore inter-tidal zone in a single operation.

- Conventional survey method to collect inter-tidal zone survey data is time consuming and labor intensive.
- Inter-tidal zone survey data is a key parameter to:
  i. evaluate nearshore wave evolution;
  ii. design coastal protection structures
- The project also proposes framework for harmonising Singapore Height Datum and Chart Datums to develop an Integrated Land-sea map

Selected 3 locations



Vertical Land Motion Monitoring

Singapore is **low-lying** (>30% of land area <5m from MSL) and is **surrounded by sea**

- Any increase in sea levels is an immediate treat
- By 2100, it is predicted that the **sea level will rise by up to 1.15m** (4-5m when coupled with extreme events etc.)

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)

2 components:
- Sea Level Motion (**SLR**)
- Vertical Land Motion (**VLM**)

} directly linked →

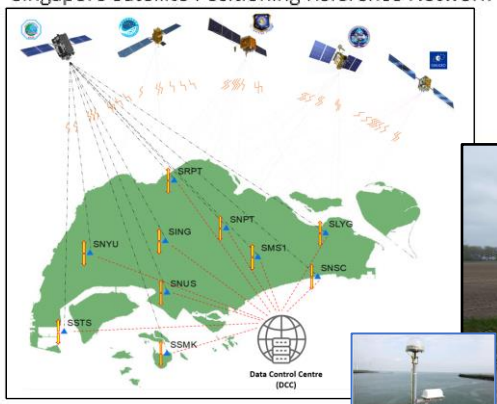
How to get this information?
-Sea → MPA, PUB, CCRS, EOS
-Land → **SLA**

Vertical Land Motion and Sea Level Rise

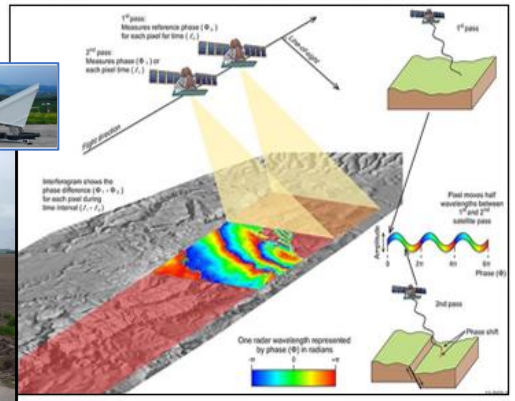
Vertical Land Motion Monitoring (VLM)

- Using GNSS (SiReNT), InSAR and Geodetic instrumentation -

Singapore Satellite Positioning Reference Network

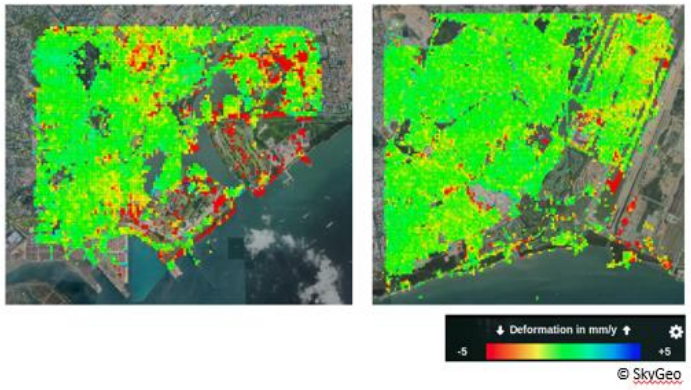


Interferometric Synthetic Aperture Radar



Patent # 2019103.21, June 2017, Patent Cooperation Treaty (PCT)

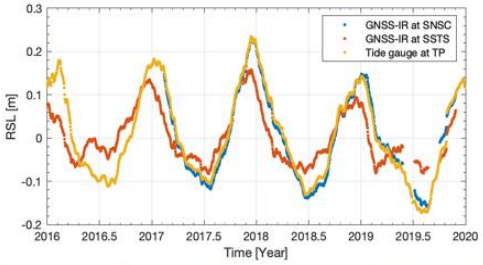
Geodetic Instrumentation

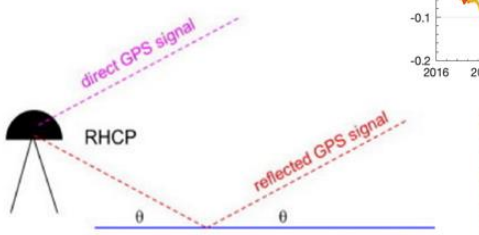


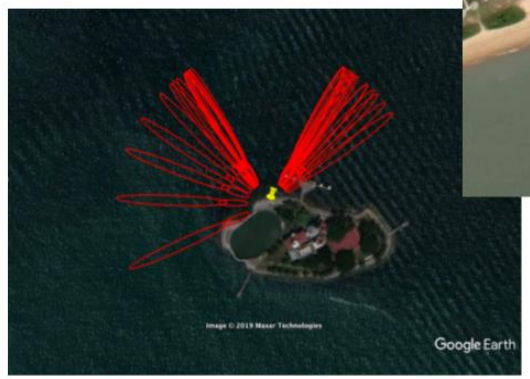
Nationwide VLM information product, absolute, referenced and validated

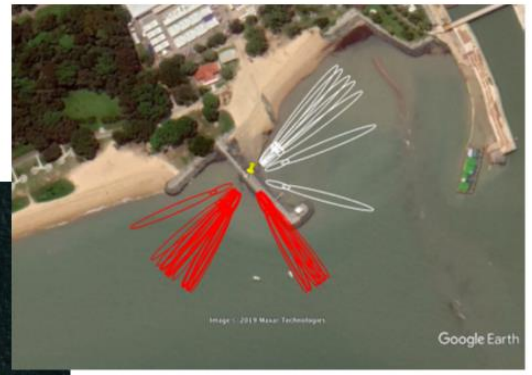
Sea Level Rise Monitoring (SLR)

- Using SiReNT-









- Simultaneously monitoring VLM and SLR
- Direct signals vs. reflected signals

→ ***Actionable information*** *that enables informed decision making for climate change adaption and mitigation.*

UN Expert Group on Land Administration and Management

Decision 13/109

(e) Also noted the intended considerations on the **integration of terrestrial, maritime, built and cadastral domains**, and encouraged the expert group to collaborate with relevant international organizations as well as functional groups of the Committee of Experts, including the working group on marine geospatial information, and to include consideration for the land/sea interface and its technical complexities;

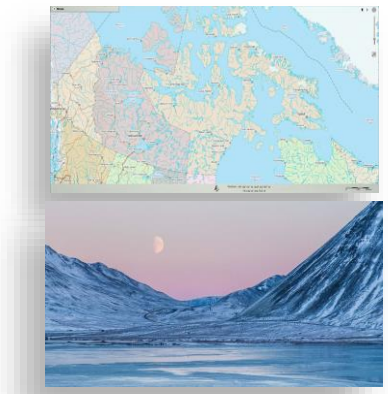
UN Working Group on Marine Geospatial Information

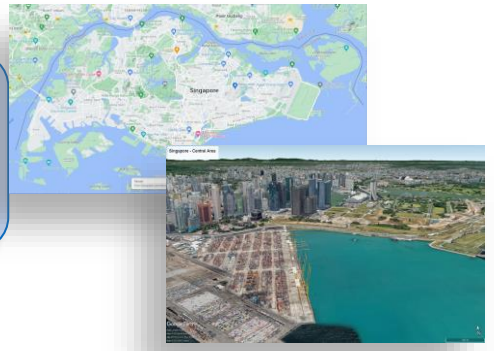
Decision 3/111

(e) Welcomed the updated workplan for the period 2023–2024, encouraged the working group to raise awareness and promote the implementation of the Operational Framework for Integrated Marine Geospatial Information Management at the country level and ensure that the Framework remains relevant through regular review and updates as necessary, and noted the action to work with the expert group on land administration and management and the Singapore-International Hydrographic Organization Innovation and Technology Laboratory **to advance the work of integrating activities related to the terrestrial and marine domains**;

Federated Marine Spatial Data Infrastructure 2023

3 Threads
3 Locations
5 Sponsors
10 Participants





Thread 1: Digital Twin of Land & Sea Interfaces in Singapore

Compusult Limited (Canada)
Ecere Corporation (Canada)
Geomatys (France)
Wuhan University (China)

Scenario Development | FMSDI Model | Demonstrator

Central Standards-based Catalog
Compusult Limited

FAIR Data & Services | Standards & APIs | FMSDI Model

Thread 2: Digital Arctic Connecting Land & Sea in the Canadian Arctic

Compusult Limited
ESRI Canada
Health Solutions Research, Inc.
Pelagis Data Solutions

Scenario Development | FMSDI Model | Demonstrator

Thread 3: Various Use Cases to Integrate Land & Sea Interfaces in the Caribbean

Compusult Limited
Global Geo-Intelligence Solutions Ltd.
Health Solutions Research, Inc.
IIC Technologies
OceanWise Ltd.

Scenario Development | FMSDI Model | Demonstrator

Natural Resources Canada / Ressources naturelles Canada

National Oceanic and Atmospheric Administration (NOAA)

UK Hydrographic Office

https://www.ogc.org/initiatives/fmsdi4/

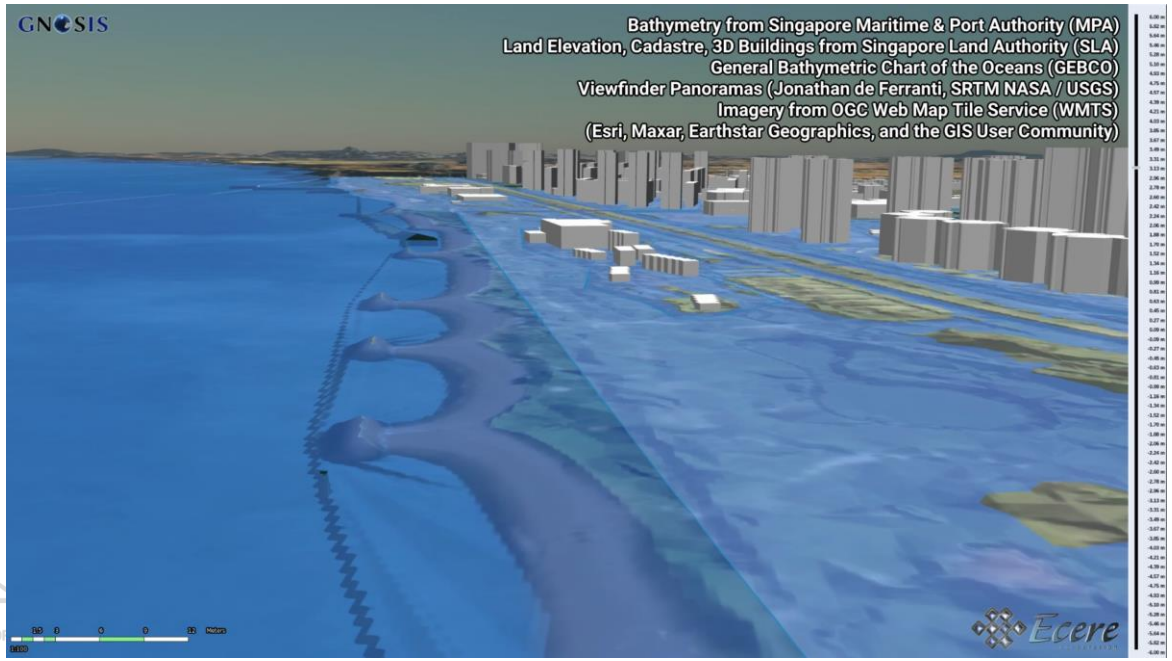
Thread 1: Digital Twin of Land and Sea in Singapore

Objective:

- ❑ Demonstrate interoperability between land and marine data that is necessary to understand coastal environments and land-sea interactions.

Requirements:

- ❑ A 3D visualisation to illustrate the integration with a storm surge scenario.
- ❑ Overcome the chart datum and height datum gaps



Provided Datasets:

- Bathymetry Data (MPA)
- Cadastre, 3D Building and Topography DTM (SLA)
- Open source datasets

Study Area:

East Coast of Singapore

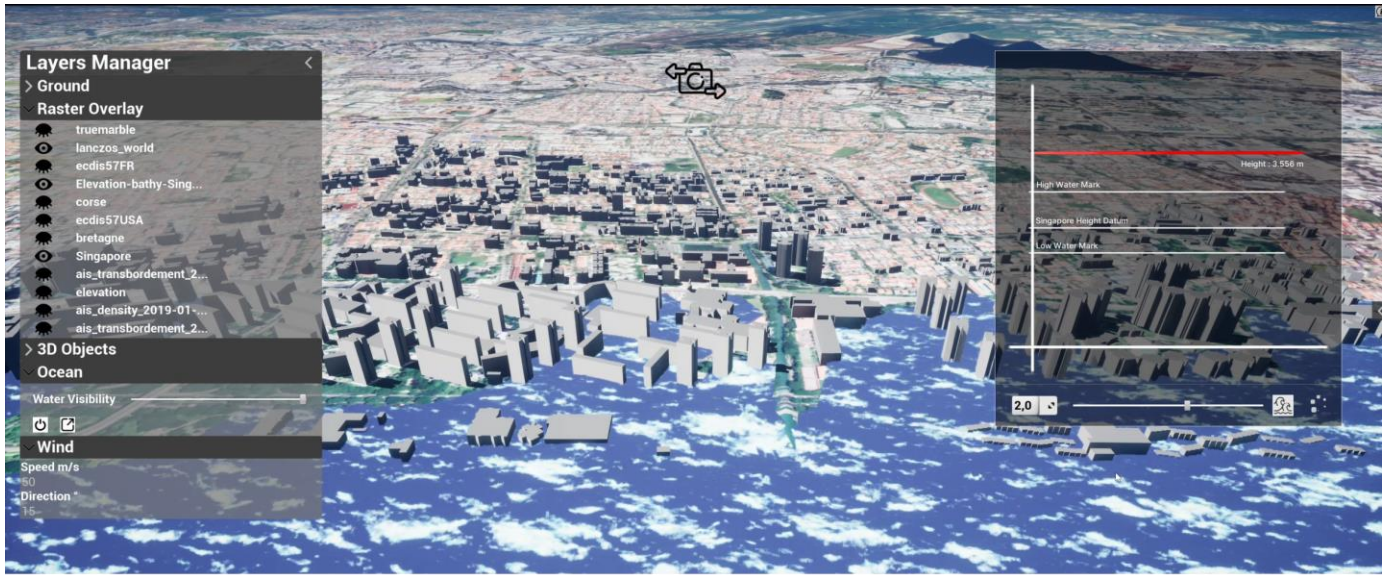
Tight Timeline

Milestone	Date	Event
M01	March 3, 2023	Release of Call for Participation
M02	March 23 & March 24	Bidders Q&A Webinar to be held 10:00-11:00 EST
M03	April 14, 2023	Close of Call for Participation and Responses Due
M04	April 21 - May 3, 2023	Proposal Evaluation and all Participation Agreements Signed.
M05	May 3 & 4, 2023	Kick-off Workshop (virtual)
M06	May 8 - Aug 30 , 2023	**Implementation Period:** Technology Integration Experiment (TIE) Testing, Draft ER and Initial Demonstration
M07	May 15, 2023	Initial ER Due
M08	July 27, 2023	Intermediate Virtual Workshop (Initial ER and Demonstration) to develop a shared implementation plan (Outreach activity: Presenting Draft ER in the OGC Member Meeting June 5-9, Huntsville, AL)
M09	Sep 15, 2023	Final Demo Videos Due
M10	Sep 29, 2023	Final Engineering Report Due
M11	Sep 25-29, 2023	Outreach activity: Presenting Final ER and Demos in the OGC Member Meeting (Singapore Sep 25)
M12	Oct 24-25,2023 (Tentative)	Final In-person Workshop in Canada (Demonstration of ER and Demo Videos) to ensure sustainability of project results.

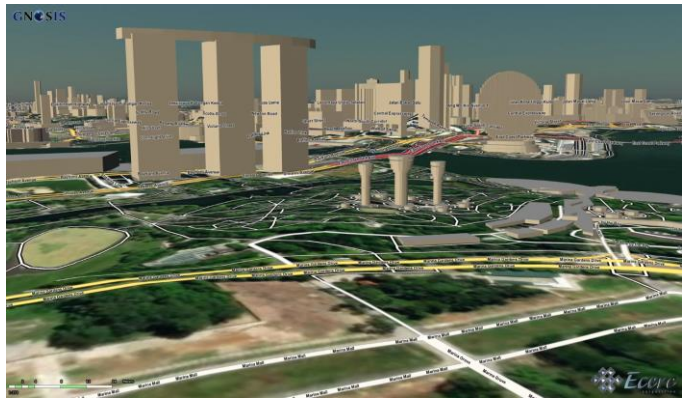
Outcomes

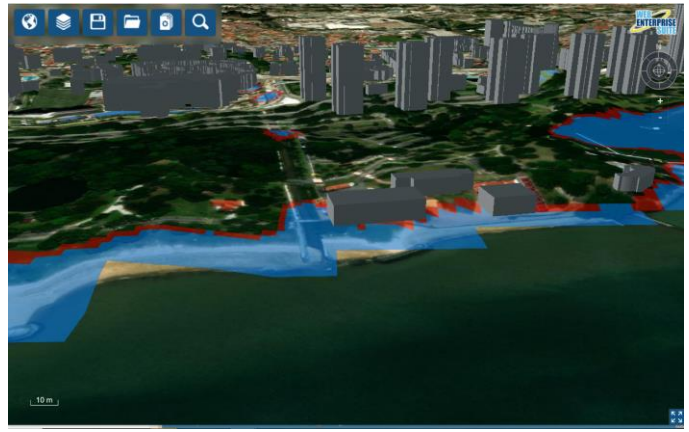
Good Discussions and Learning Experience

Demonstrators



Engineering Report: ogc.pages.ogc.org/FMSDI2023/





Key Takeaways

Benefits

- Profiling Singapore as thought leader in geospatial information
- Potential utilisation of prototypes for operations
- Lesson learnt through the engineering report for Singapore and other Small Island Developing States
- Experience on working with OGC, learn from the global experts
- Experience on collaboration with international stakeholders

Challenges

- Harmonisation of land and sea datums
- Low and different resolution of datasets
- Inherently large dataset sizes
- Short project timeline (6 months)
- Inclusion of OGC API open standards for 3D access, storage and visualisation

Technical Advancements and Standardisation

- Resolution enhancement of datasets
- Big data management of DEM and bathymetry datasets
- Future exploration of datum harmonisation for whole of Singapore

Enhance collaboration and Knowledge Sharing

- Adoption of Agile Project Framework
- Better incorporation and utilisation of OGC API standards


Thank You
Asante
Shukria
Dhanyavadagalu
Vinaka
Kiitos
Maake
Manana
Dankon
Kam Sah Hammida
Matondo
Dank Je
Mauruuru
Biyan
Blagodaram
Dziekuje
Chokrane
Arigato
Grazie
Juspaxar
Gracias
Mochchakkeram
Grazas
cảm ơn ban
Gratias Tibi
Ua Tsaug Rau Koj
Obrigado
Děkuji
Nirringrazzjak
Kop Khun Khap
ありがとう
Suksama
Hvala
Welalin
Djiere Dieuf
Danke
Go Raibh Maith Agat
Eskerrik Asko
Merci
Salamat
Tuke
Najis