Operational Aspects of GNSS CORS

What is a GNSS CORS system used for ?

Neil Ashcroft, Asia Pacific GNSS Reference Station Manager

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What is a GNSS CORS system used for ?

Basics…

What are Global Navigation Satellite Systems used for ?

- Positioning
- Navigation
- Timing

What about a Continuous Operating Reference Station ?

- **Characteristics**
  - Fixed location – Permanent power, remote communications
  - Taking observations every epoch (20Hz – 30 Second)
  - Complete Skyview (0 degrees – 15 degrees – 90 degrees)

What is a GNSS CORS system used for ?
Primary Purpose ?

Will be based upon most urgent need…

…and will be application specific.

Enabling a **Digital Reality** to support informed decisions

So, define the **primary purpose** of your CORS infrastructure.

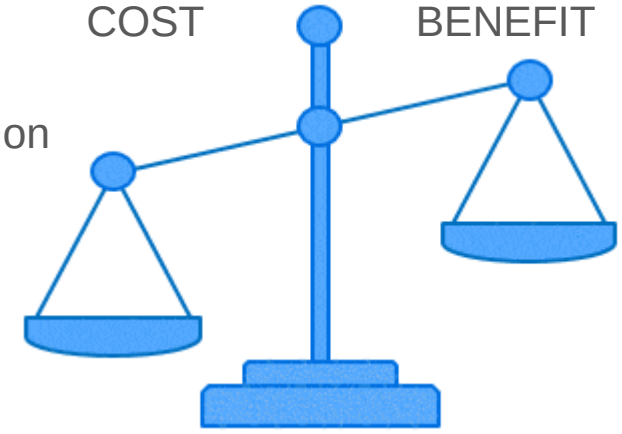
What is a GNSS CORS system used for ?
Applications

Science

- Geodynamics – Plate Tectonics
- Atmospherics – Weather
- Geodesy – Earth Shape, Reference Frame
- Climate Change – Sea Level Rise
- …

Positioning

- Mapping
- Cadastral – Land Management, Boundary determination
- Construction & Engineering, Machine Control
- Navigation
- Asset Collection
- Intelligent Transportation



What is a GNSS CORS system used for ?

CORS Data Products

Real Time

- RTCM Formats, v2.x, v3.x, MSM
- Messages, Single Base, Network Solution (VRS, FKP,MAC)

Post-Processing

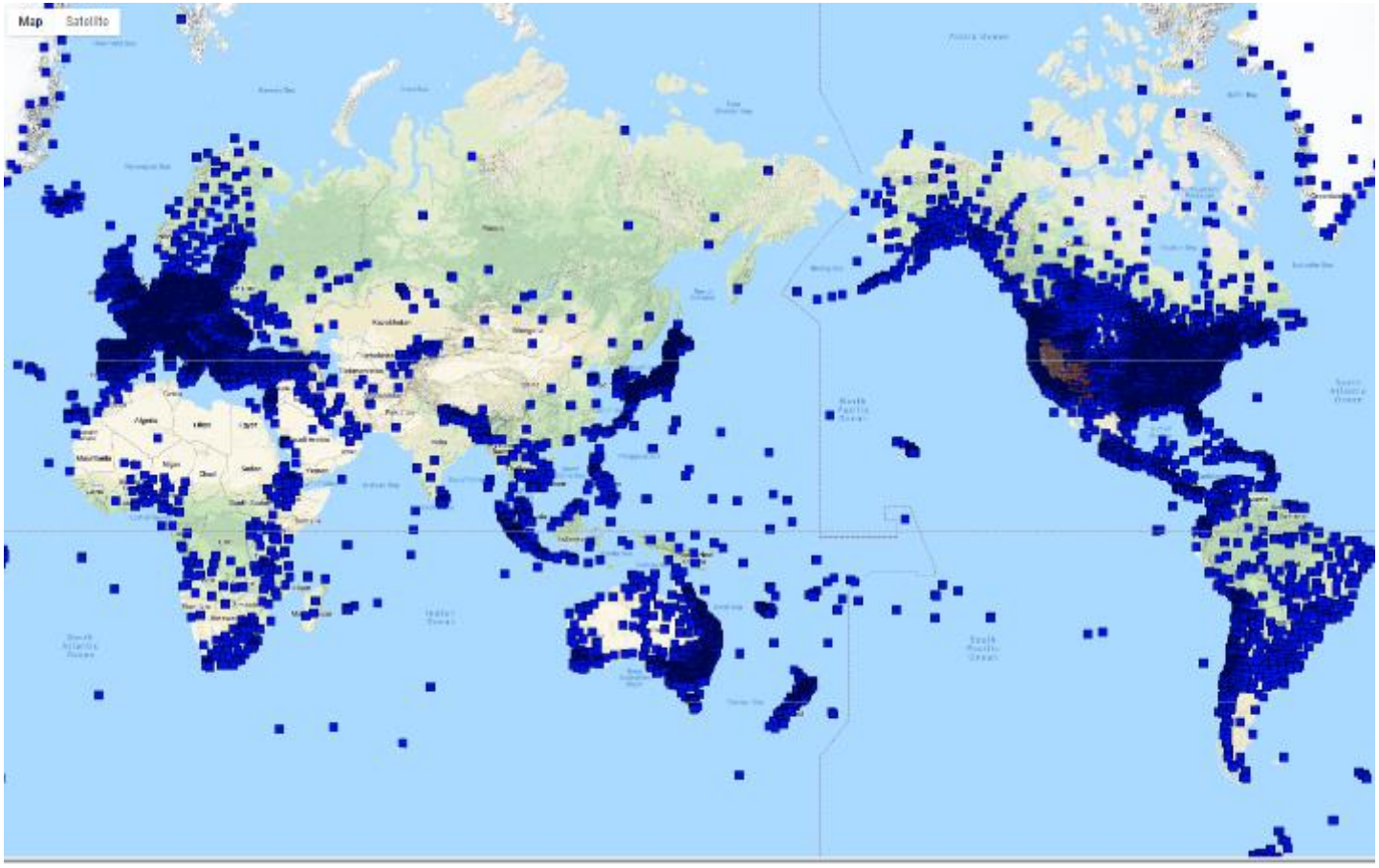
- RINEX Formats

Content

- Epoch Rates
- Elevation Mask
- Signals
- Auxiliary Sensors (Meteo, Tilt)

What is a GNSS CORS system used for ?

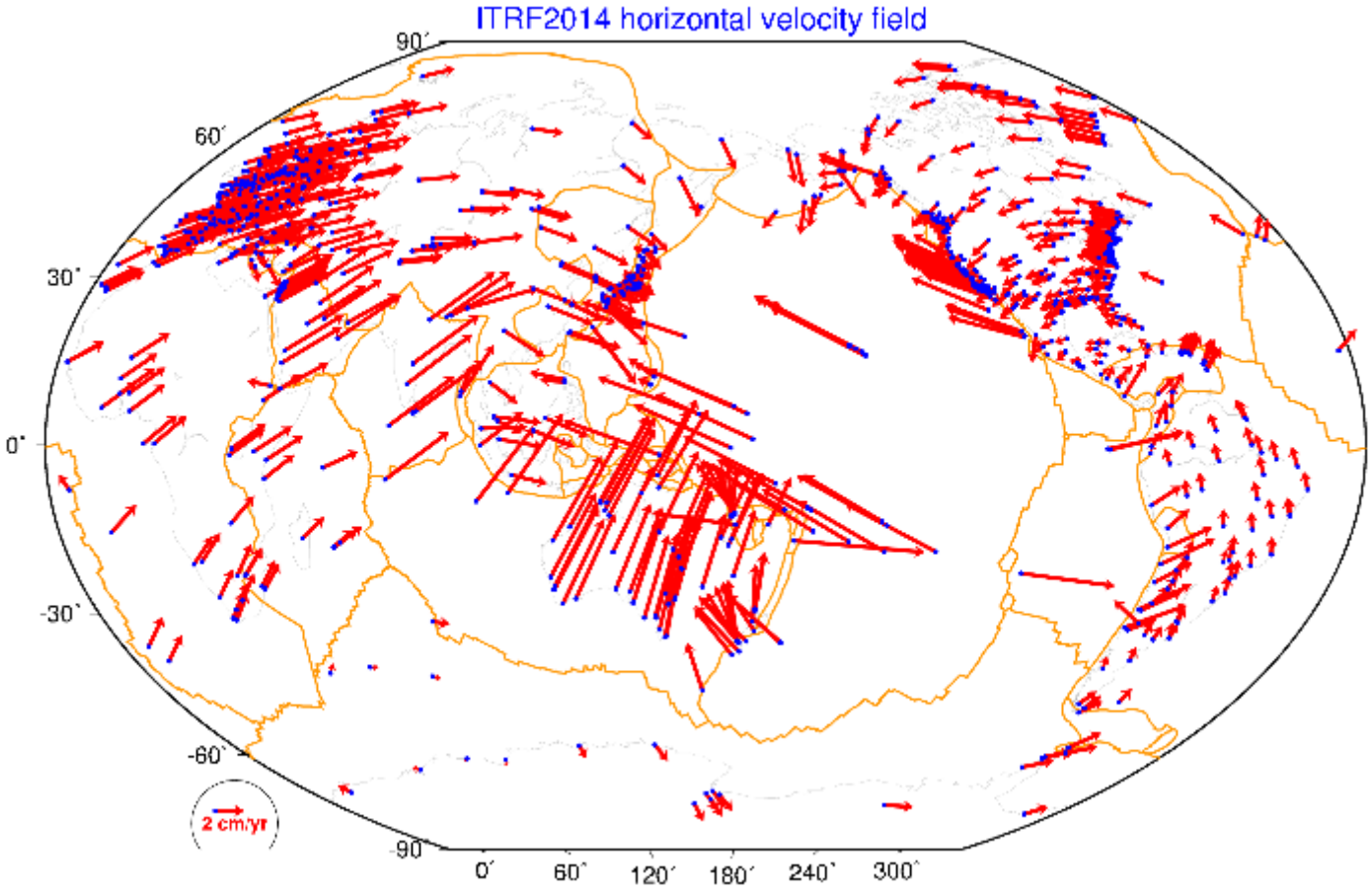
Worldwide CORS Sites



http://geodesy.unr.edu/NGLStationPages/gpsnetmap/GPSNetMap.html

Geodynamics

Computing Plate Velocities



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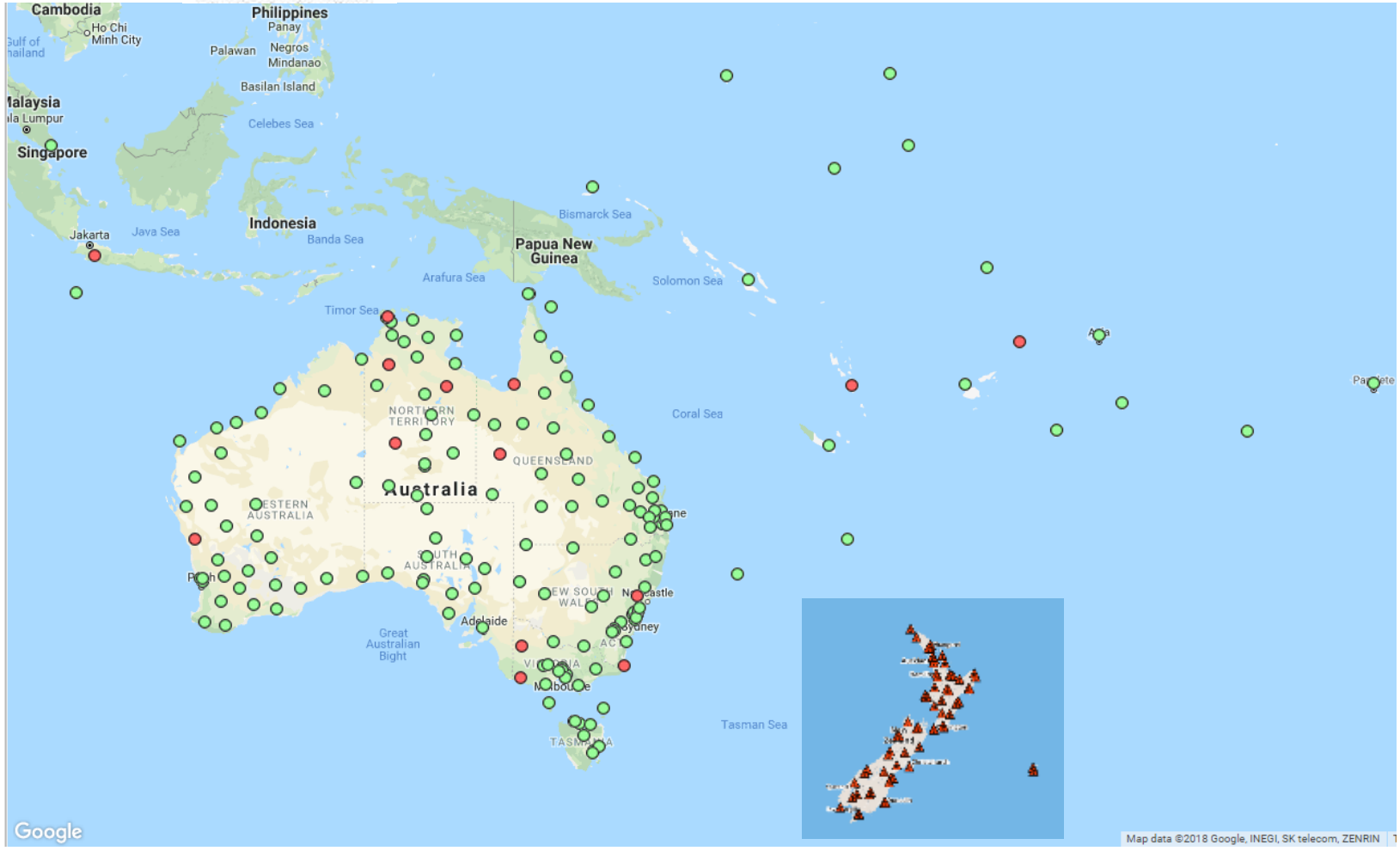
Australian Government
Geoscience Australia

GA Regional GNSS Datacentre



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PGSC
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Leica Geosystems

Geodynamics
Plate Velocities

HAZARD MAPPING

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FIG

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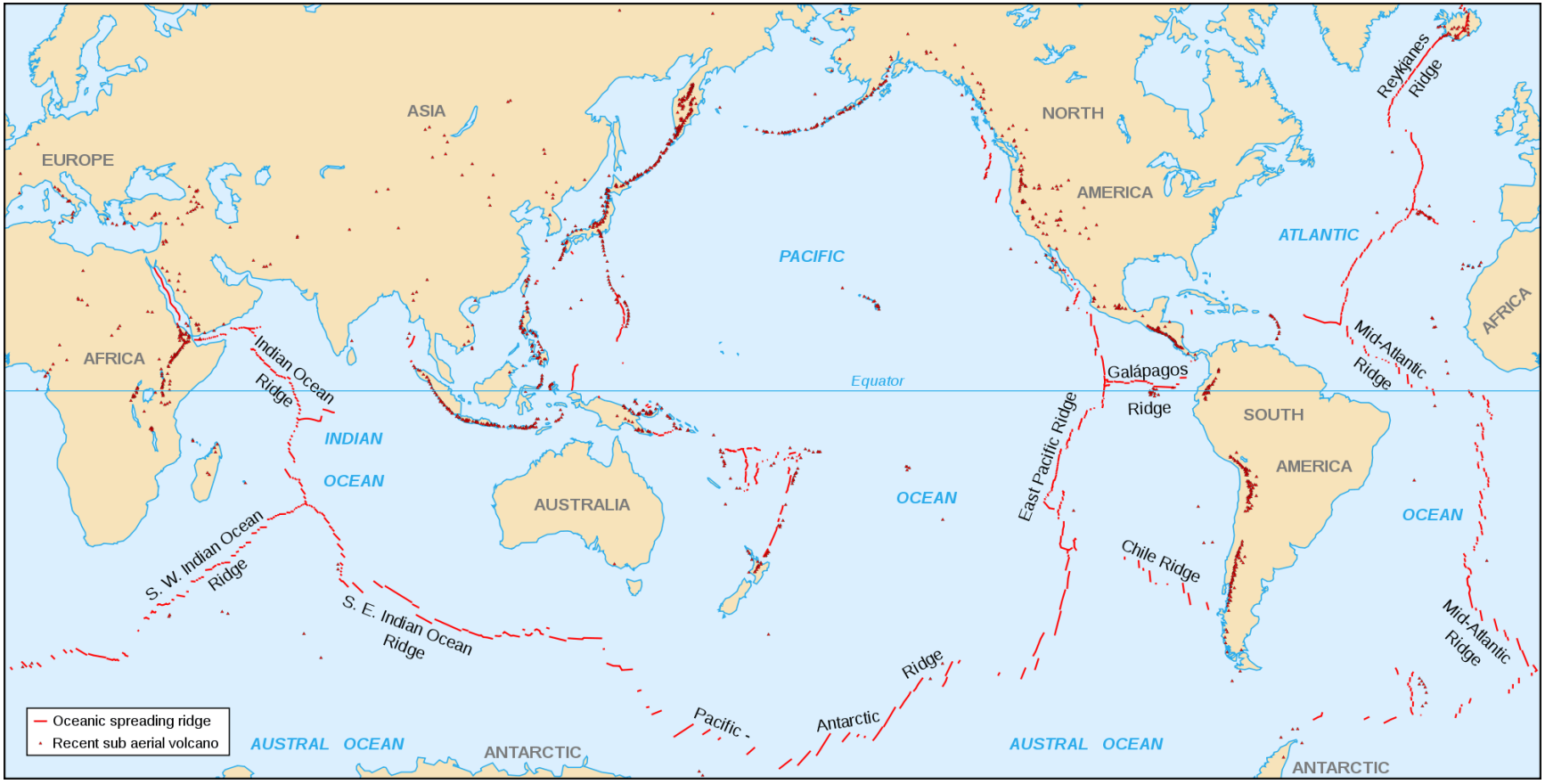
Leica Geosystems

Geodynamics
Active volcanos

HAZARD MAPPING



Hazard Mapping

Probabilistic Seismic Hazard Assessment for Pacific Island Countries

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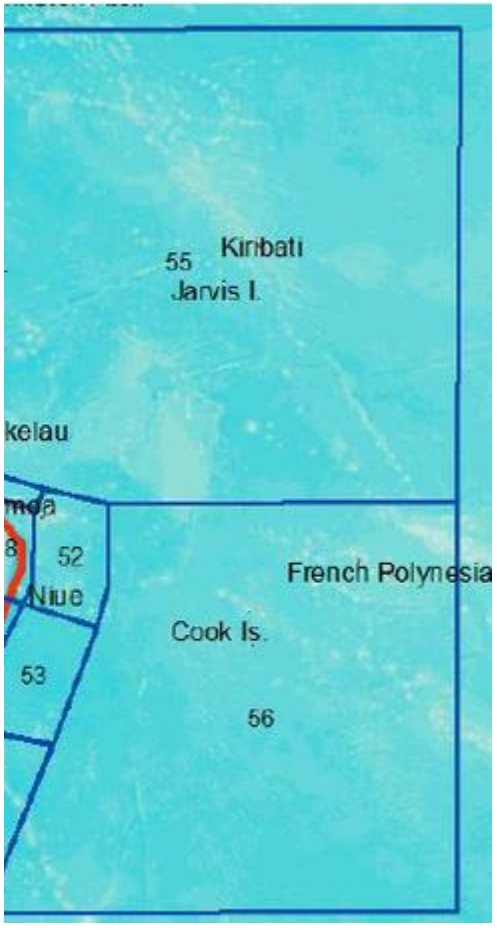
15 WCEE
LISBOA 2012

SUMMARY:
A fully probabilistic earthquake hazard assessment study was carried out for fifteen Pacific Island Countries (PICs): Cook Islands, Fiji, Kiribati, Republic of Marshall Islands, Federated States of Micronesia, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu and Vanuatu. A regional seismicity model was built based on historical and instrumental earthquake catalogs, subduction zone segmentation and plate motion information, geodetic data, and available data on crustal faults. We used different ground motion prediction equations to account for different types of earthquakes. The effect of site conditions on ground motion was modeled based on shear wave velocities derived from microzonation studies and high-resolution topographic slope data. A comparison of our findings with those of earlier studies, such as GSHAP, shows similarities, and in some cases, significant differences. The seismic hazard maps developed here have a spatial resolution that is adequate for local seismic risk studies and building code applications.

Keywords: Probabilistic seismic hazard assessment (PSHA), Pacific Islands, seismicity model, ground motion

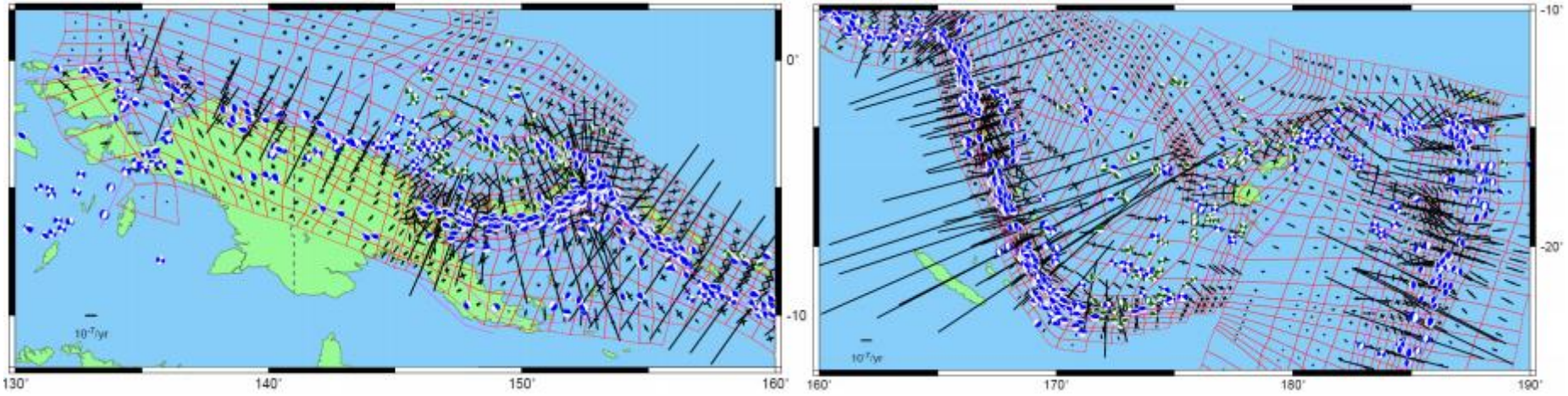
1. INTRODUCTION

Many of the PICs are located close to one of the most active subduction zones in the world and are prone to high seismic risk. Since the year 2000, fifteen earthquakes of moment magnitude (M_w) greater than or equal to 7.5 have occurred in the region, with four having M_w>8.0. The complicated tectonics and the high seismicity of the region are due mainly to the interaction of four major plates (Figure 1), the Pacific, Philippine Sea, Sunda, and Australia plates. The Philippine Sea plate subducts to the west under the Sunda plate at a rate of about 100 mm/year, and the Australia plate subducts to the north beneath the Sunda plate at a rate of about 70-80 mm/year. The convergence between the Australia and Pacific plates results in a shortening at the subduction plate boundaries along Papua New Guinea, the Solomon Islands, Vanuatu, Fiji and Tonga. The convergence rate is about 60-70 mm/year at the Tonga trench, and about 100 mm/year at other trenches.



Ref : Probabilistic Seismic Hazard Assessment for Pacific Island Countries

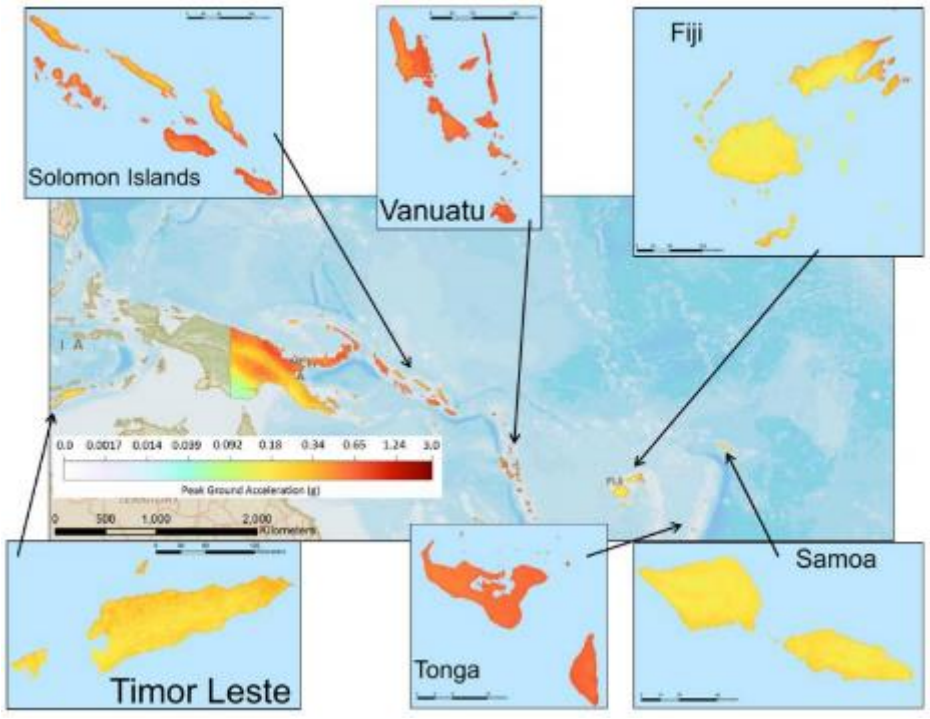
Hazard Mapping



Predicted strain rate field (black arrows) for Papua New Guinea and Solomon Islands region (left panel), and for the Vanuatu, Fiji, and Tonga region (right panel). The beach-balls show the focal mechanisms of historical earthquakes: green refers to earthquakes with , which are shown only for non-subduction areas; blue refers to earthquakes with 6.0. The red lines illustrate curvilinear grids and the thin pink lines illustrate the subduction zones and faults.

Ref : Probabilistic Seismic Hazard Assessment for Pacific Island Countries

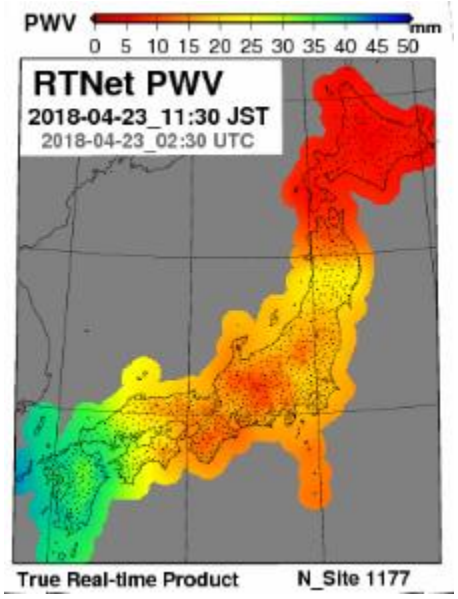
Hazard Mapping



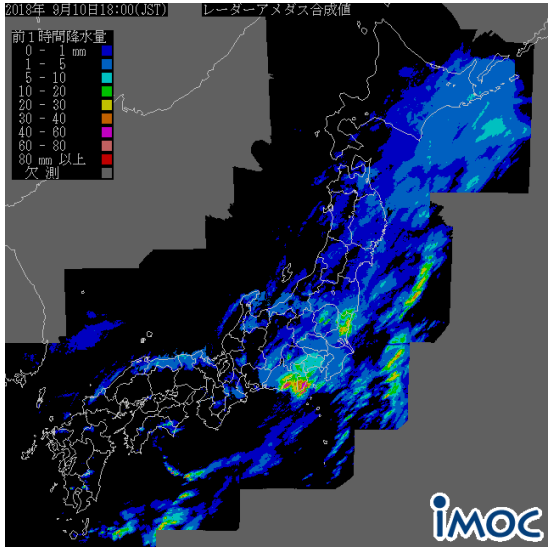
Hazard Map of free surface PGA, including site conditions, with 10% probability of exceedance in 50 years (475-year mean return period) for some of the Pacific Island Countries.

Ref : Probabilistic Seismic Hazard Assessment for Pacific Island Countries

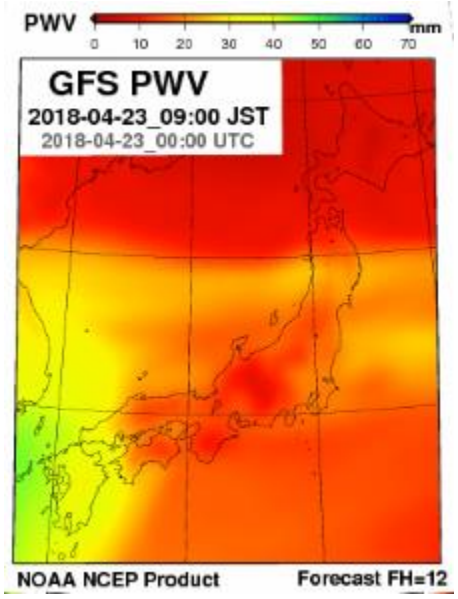
GNSS Meteorology



The real-time PWV (**with latency of 1~2 minutes**) product is used for **multiple organizations** for weather forecast service.



Shows analysis rainfall from https://www.imocwx.com/rdam/rd0_jp.htm



GNSS PWV products are compared with analysis/forecast field of PWV in numerical weather prediction system (NOAA NCEP GFS)

NOAA : National Oceanic and Atmospheric Administration
NCEP : National Centre for Environmental Prediction
GFS : Global Forecast System

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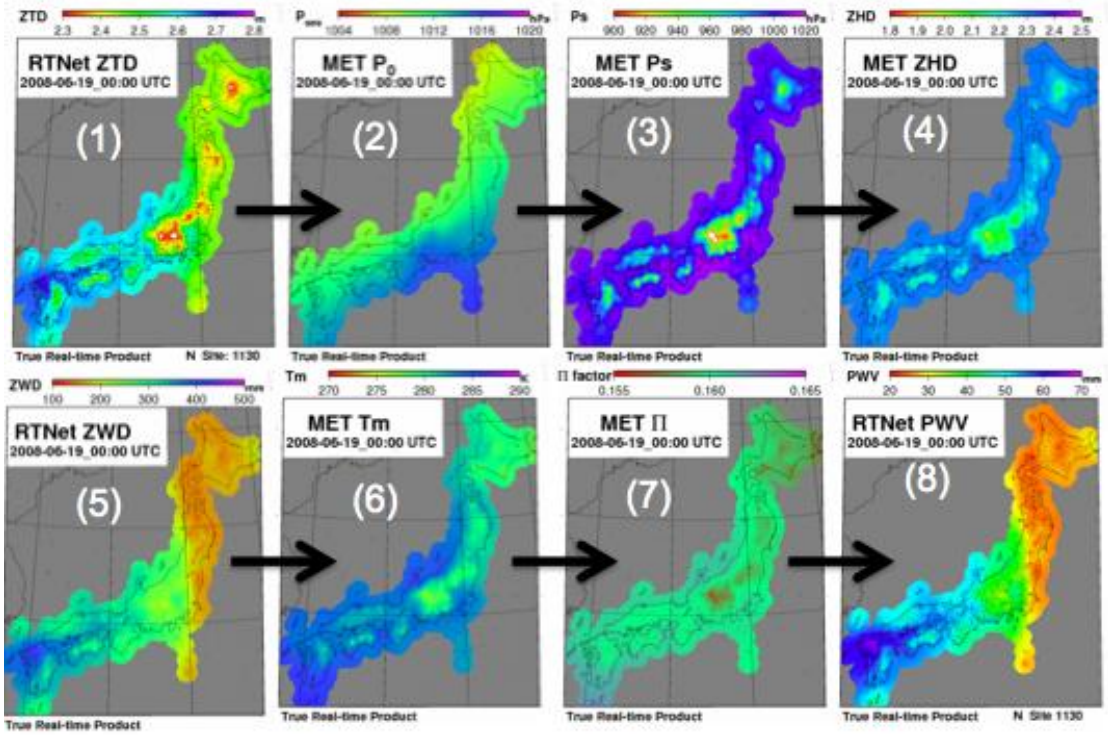
GNSS Meteorology



The maps show flow of conversion from GNSS ZTD (zenith tropospheric delay) to PWV (precipitable water vapor). ZTD has contribution from pressure and thus the map (1) has strong constrain with topography, while PWV map (8) has much less effect of altitude and has information on water vapor distribution.

Positioning
Support SBAS

Provide Correction Data for Satellite / Internet broadcast

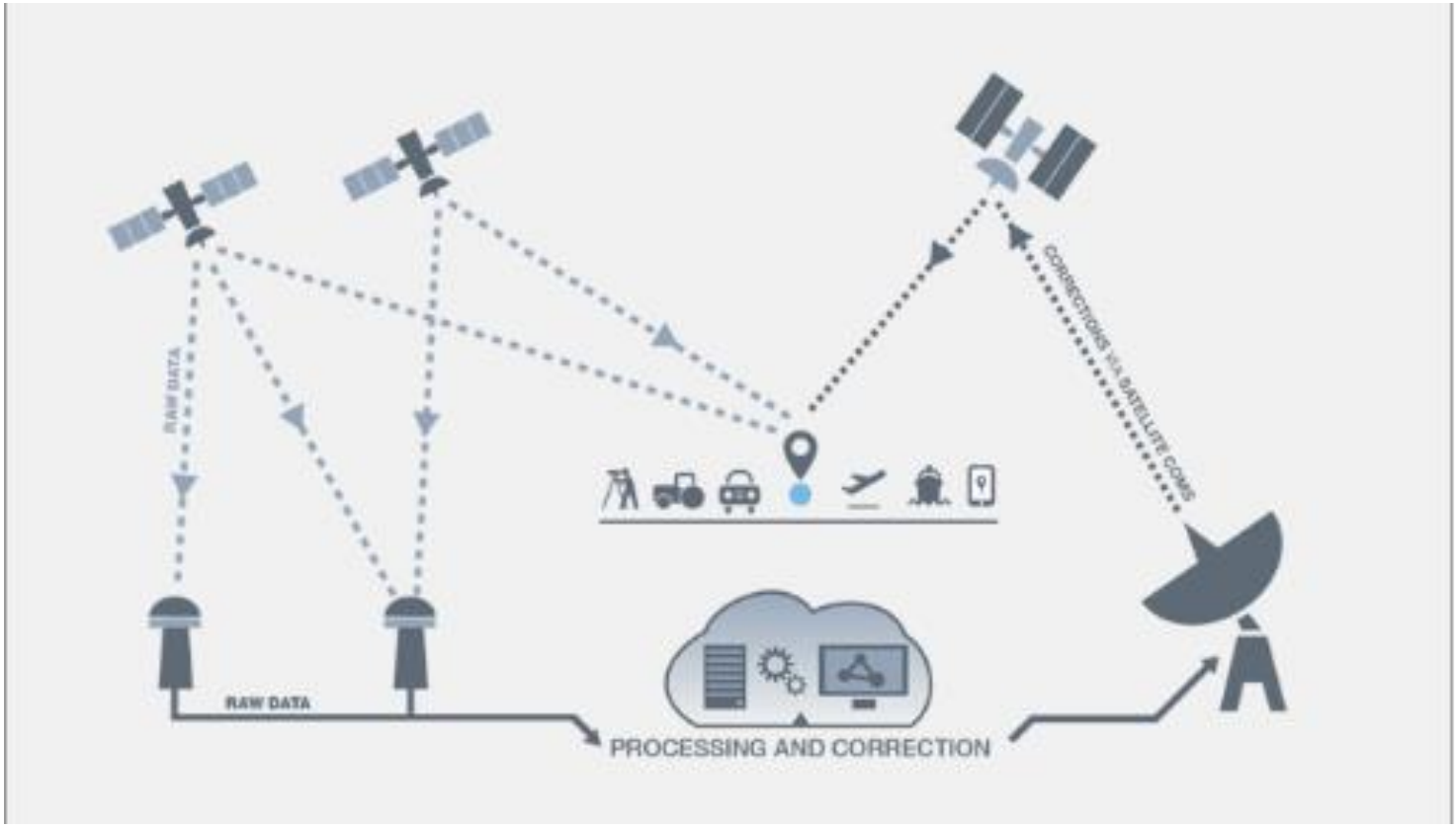


Image: Courtesy of Geoscience Australia

Positioning
Support SBAS

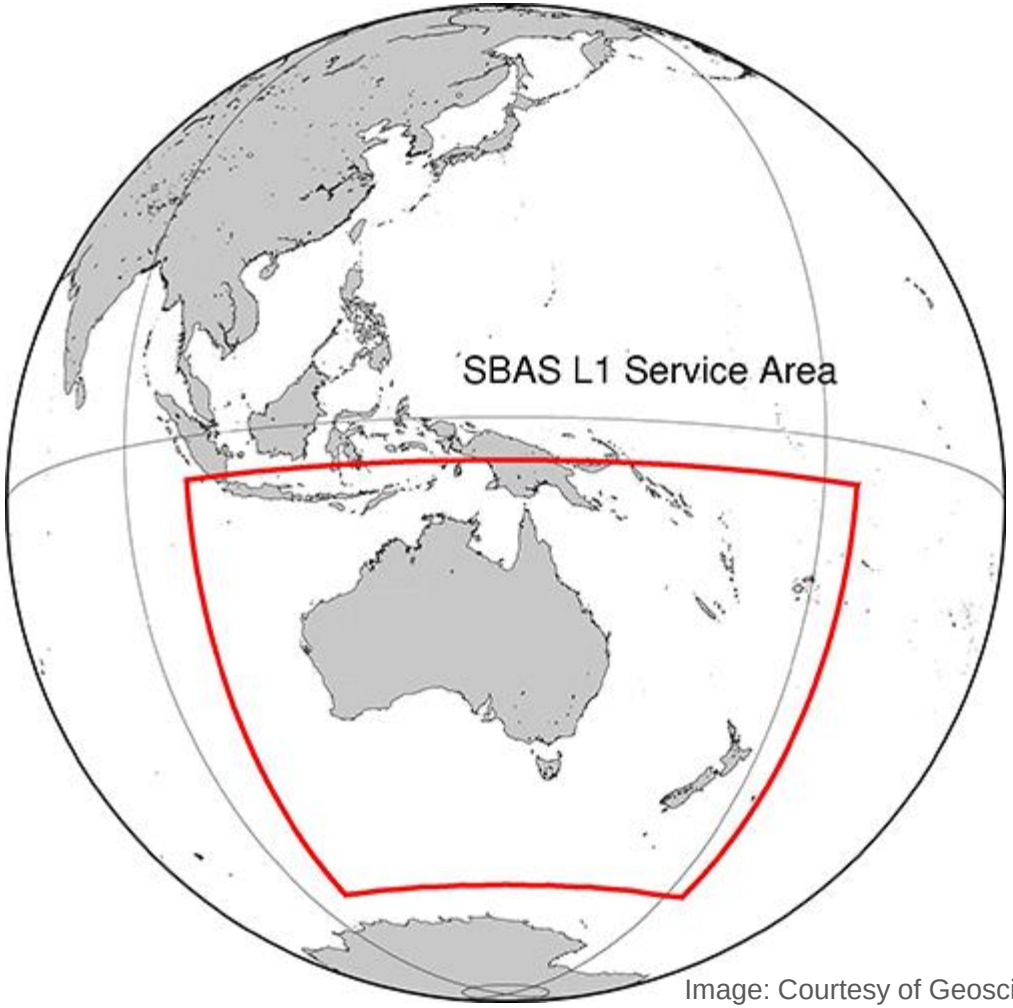


Image: Courtesy of Geoscience Australia

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Positioning
Support SBAS

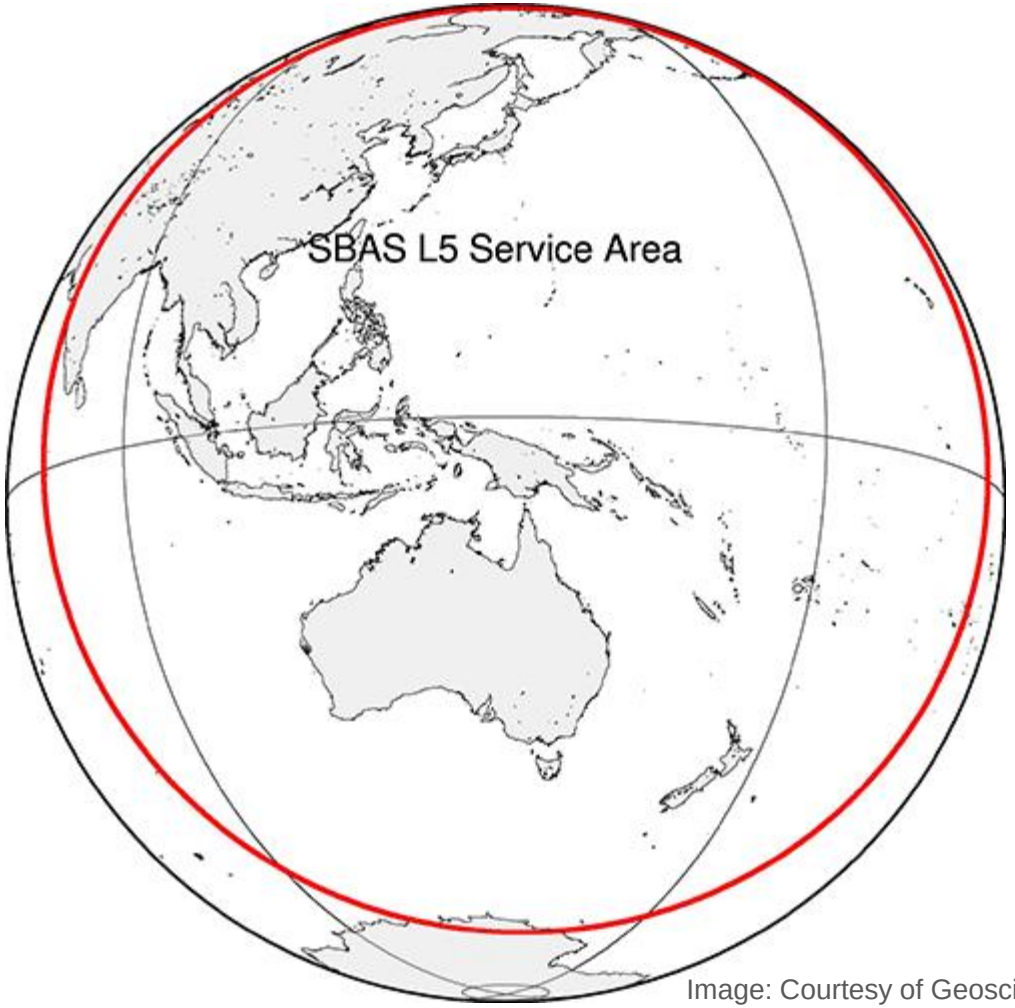
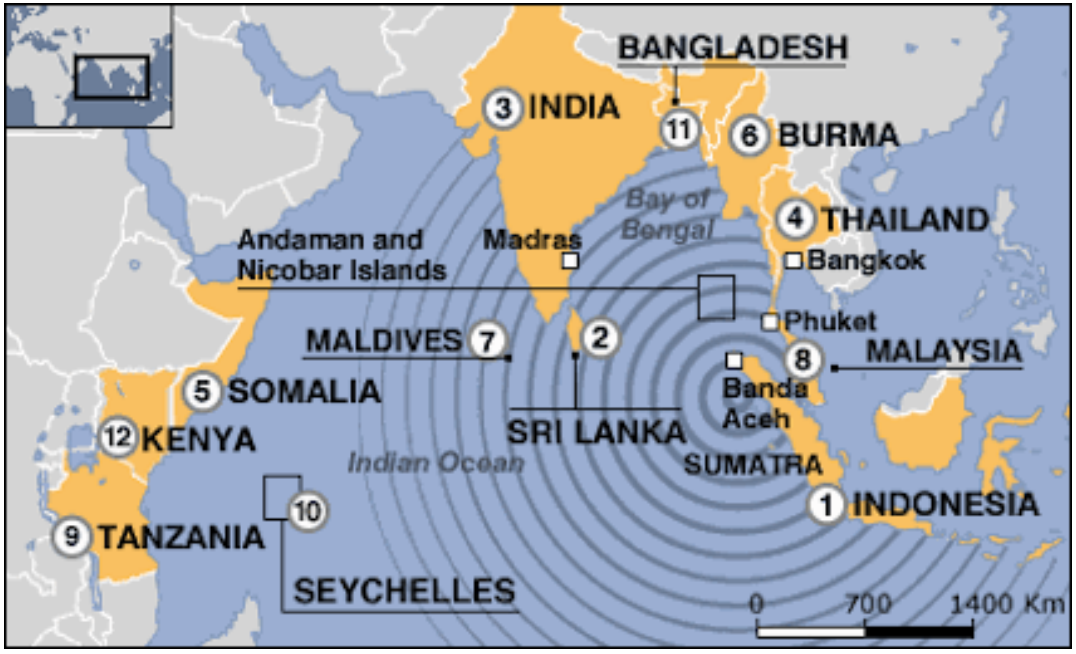


Image: Courtesy of Geoscience Australia

December 26, 2004: Tsunami Devastates Indonesia and Many Other Countries



Magnitude of Mw 9.1–9.3

Disaster Management

Before…

Disaster Management

…After

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…After

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…After

Disaster Management
Reinstatement begins

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…After

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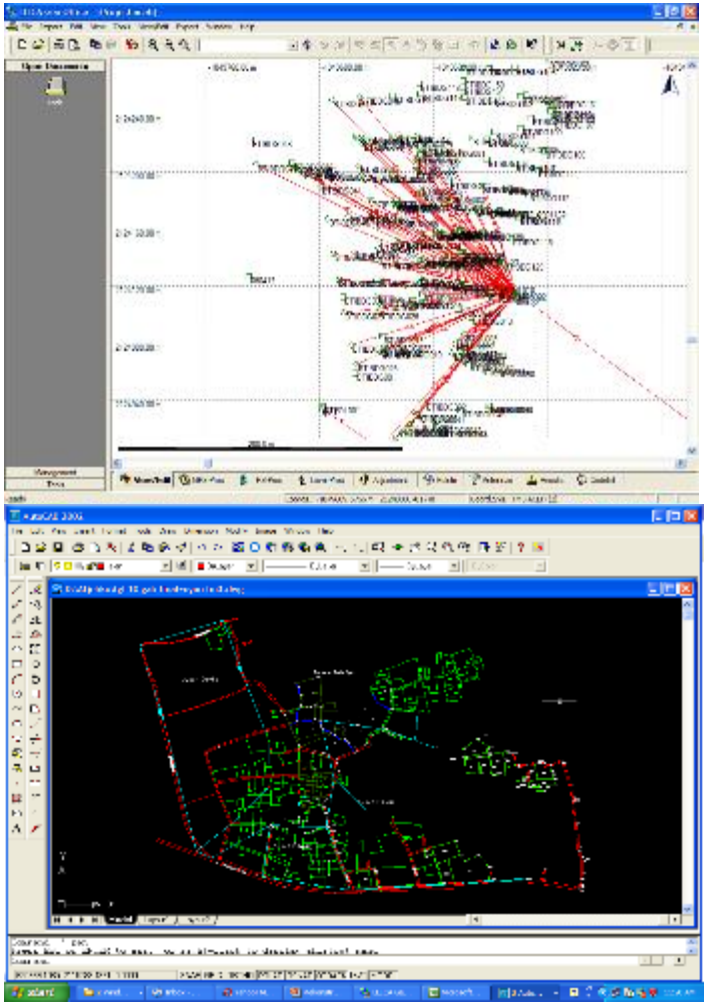
…After

Re-instating Ground Control Points

…to recover boundaries



Re-instating Boundaries

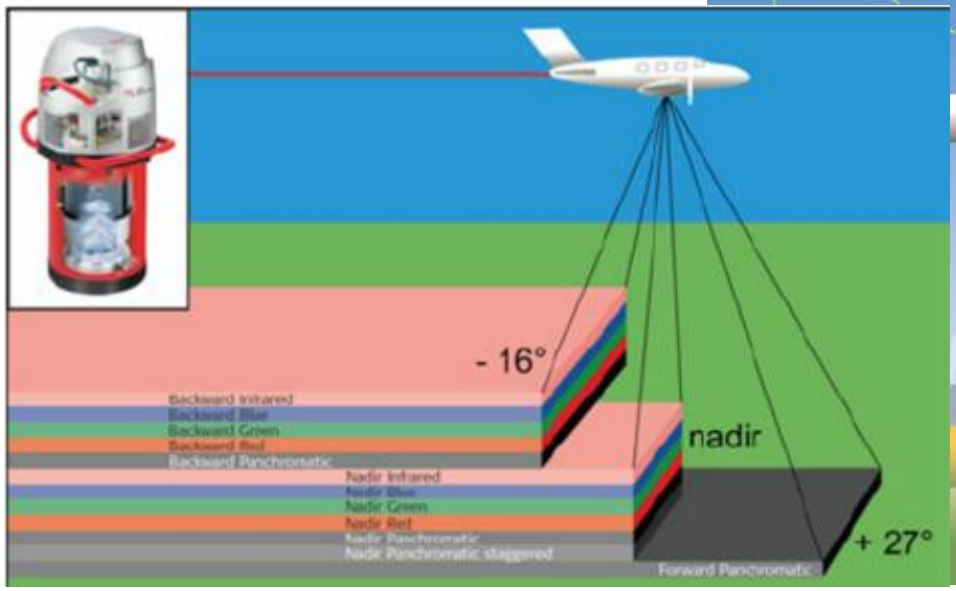
…Precision ?

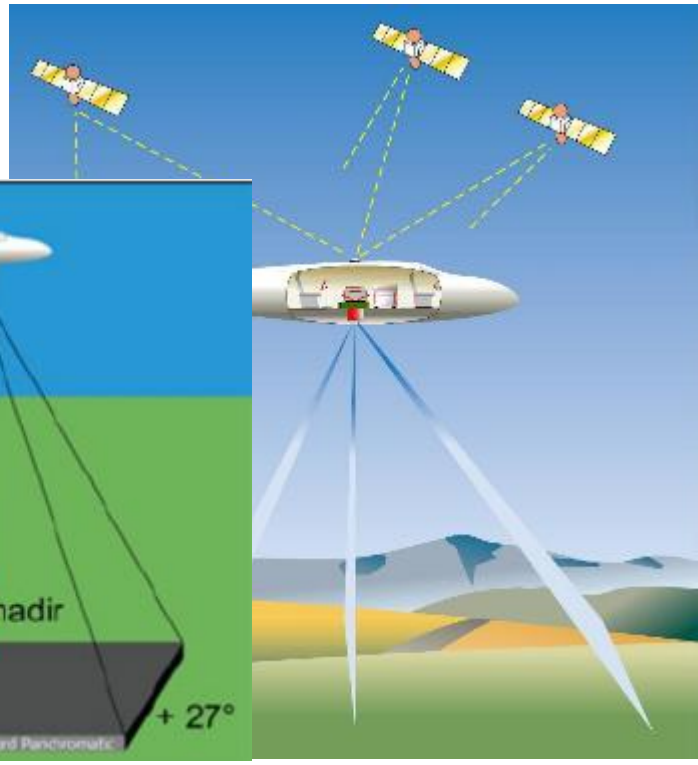
Pole on a tilt

Positioning

From the air…Fixed wing

- Digital
- Lidar
- Bathymetric
- Hybrid





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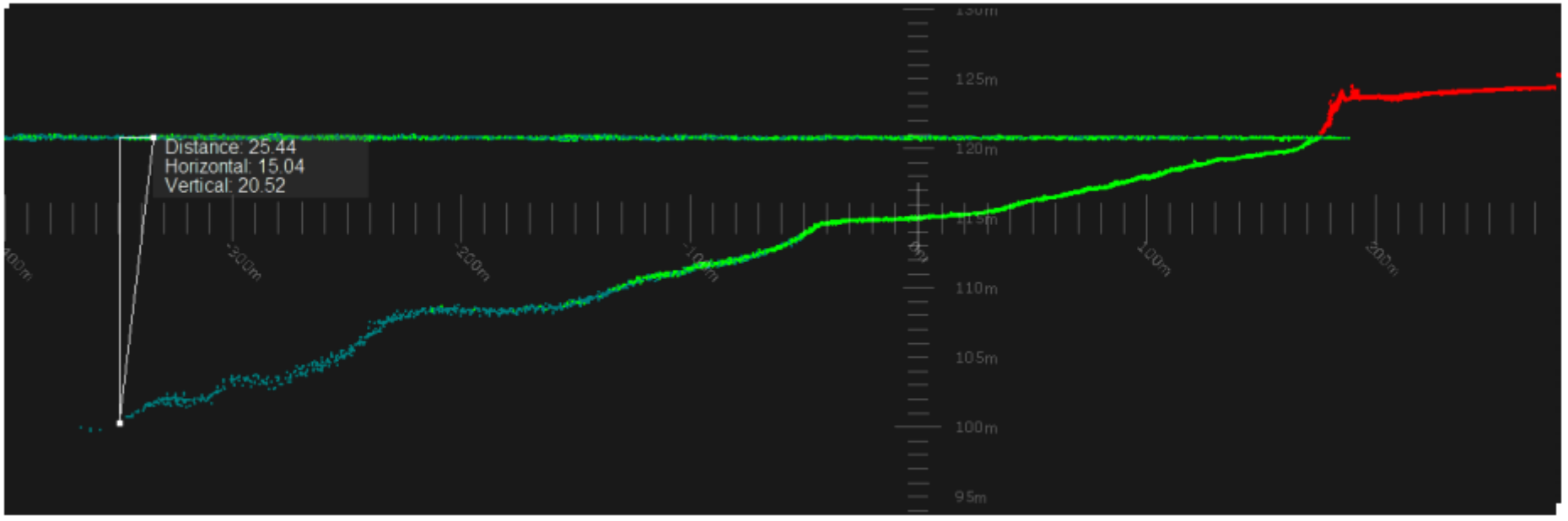
Positioning
Bathymetric Data



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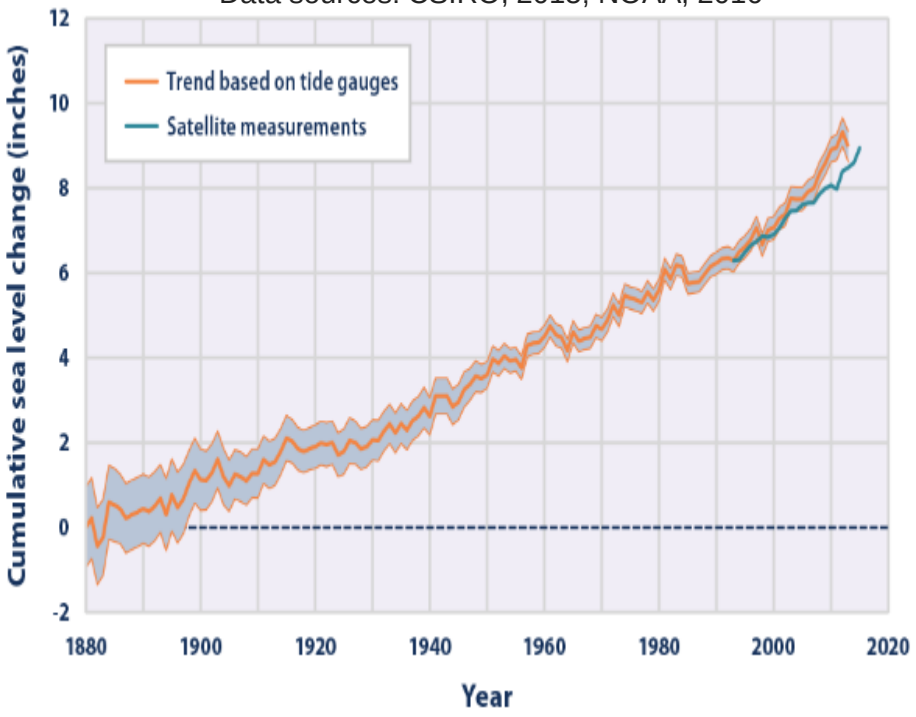
Positioning

Drivers (Benefits) - Sea Level rise & Coastal Change

- Global warming and sea-level rise
  - Average 2,3 cm annually
- Precipitation increases
- More and more intensive weather phenomena's
- Ground-water levels change (water supply, irrigation and salinity changes)
- National borders and territorial waters change as the sea-level rises

Data sources: CSIRO, 2015; NOAA, 2016



Need to continuously monitor land and environmental change in the coastal areas

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Positioning

Need a shallow water Bathy Chart ?

Positioning

From the air…UAV's

- Digital
- Lidar

Positioning
Mobile Mapping

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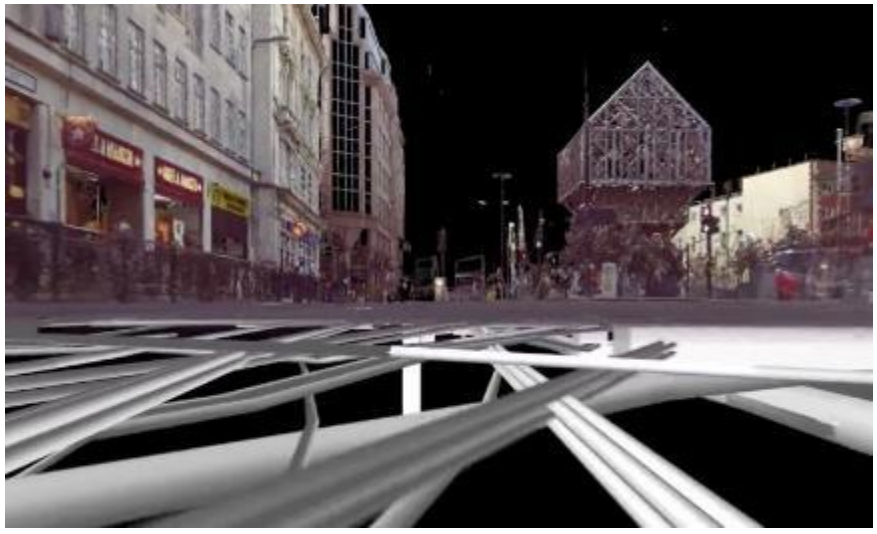
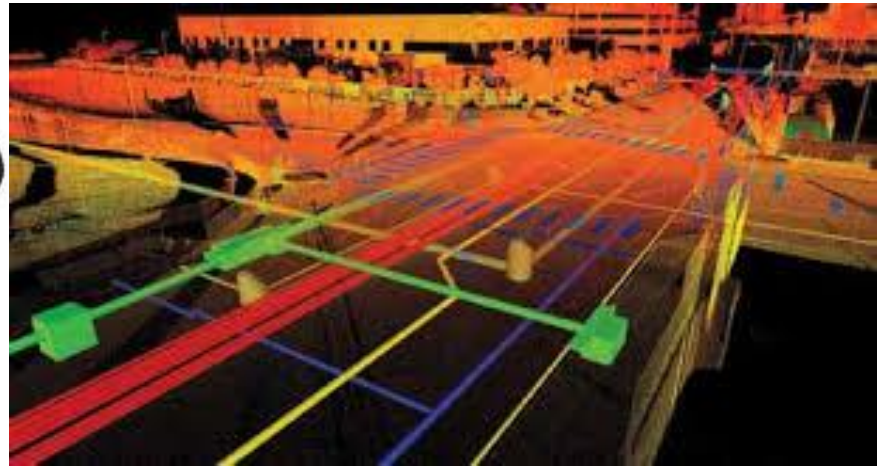
Positioning
Mobile Mapping





Positioning
Mobile Mapping

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Positioning
Machine Control

Excavators | Dozers | Graders | Drill Rigs | Paving

- when it has to be right

Positioning
Precision Agriculture

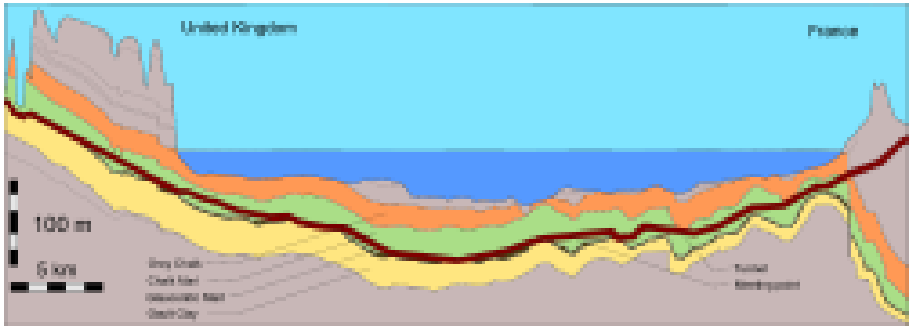
- when it has to be right

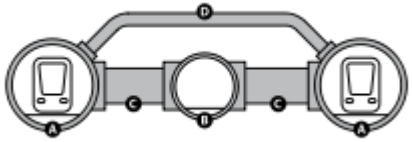
Positioning
Traditional Surveying

Positioning
Tunnelling

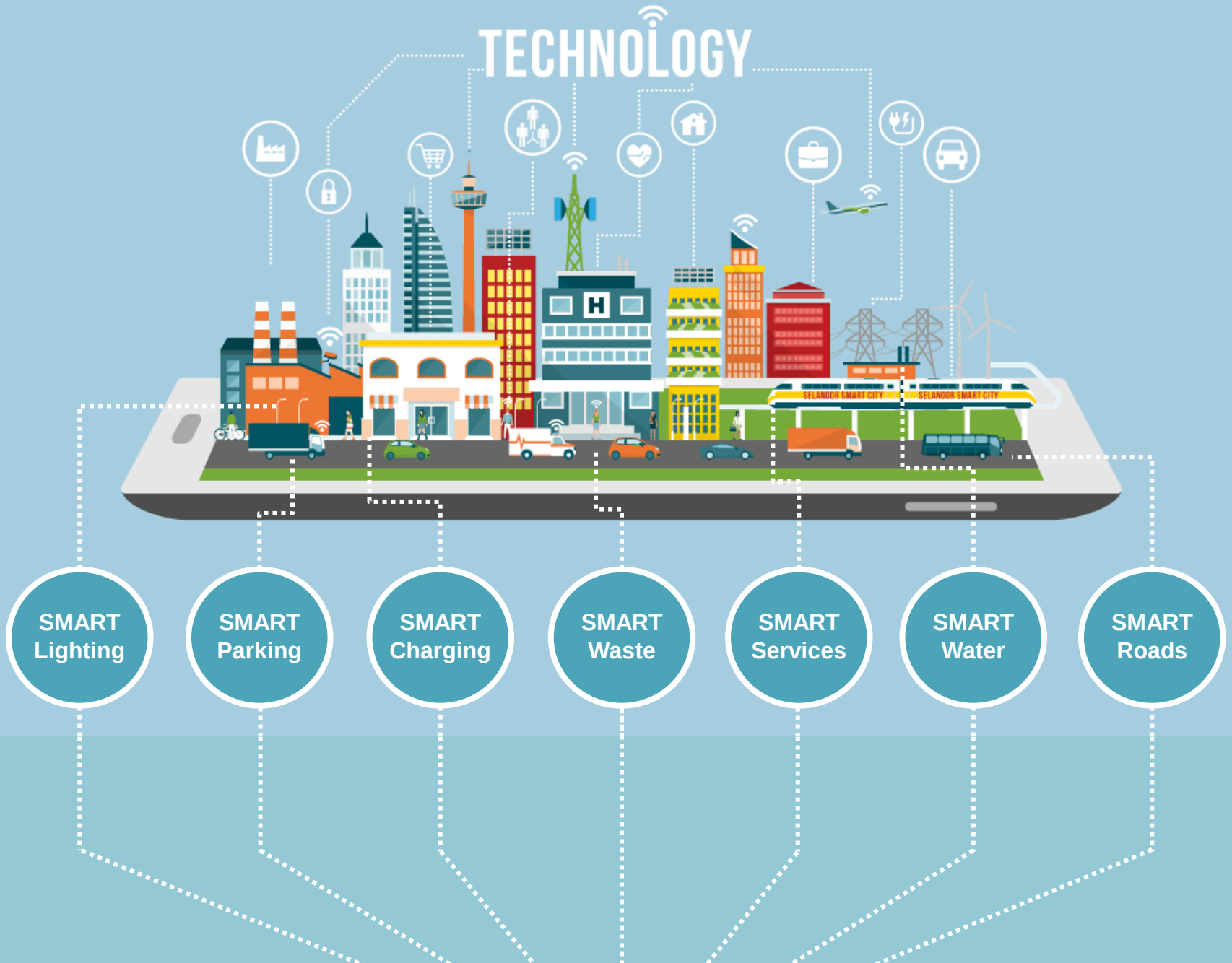
1986 : Used GPS to derive local Datum

Days of occupation





- **Total length: 57.8km**
- **Undersea tunnel length: 37.9km**
  - Misclosure : Horizontal 325mm Vertical 80mm


TECHNOLOGY
SELANGOR SMART CITY
SELANGOR SMART CITY
SMART Lighting
SMART Parking
SMART Charging
SMART Waste
SMART Services
SMART Water
SMART Roads

Intelligent Transport
Connected Vehicles

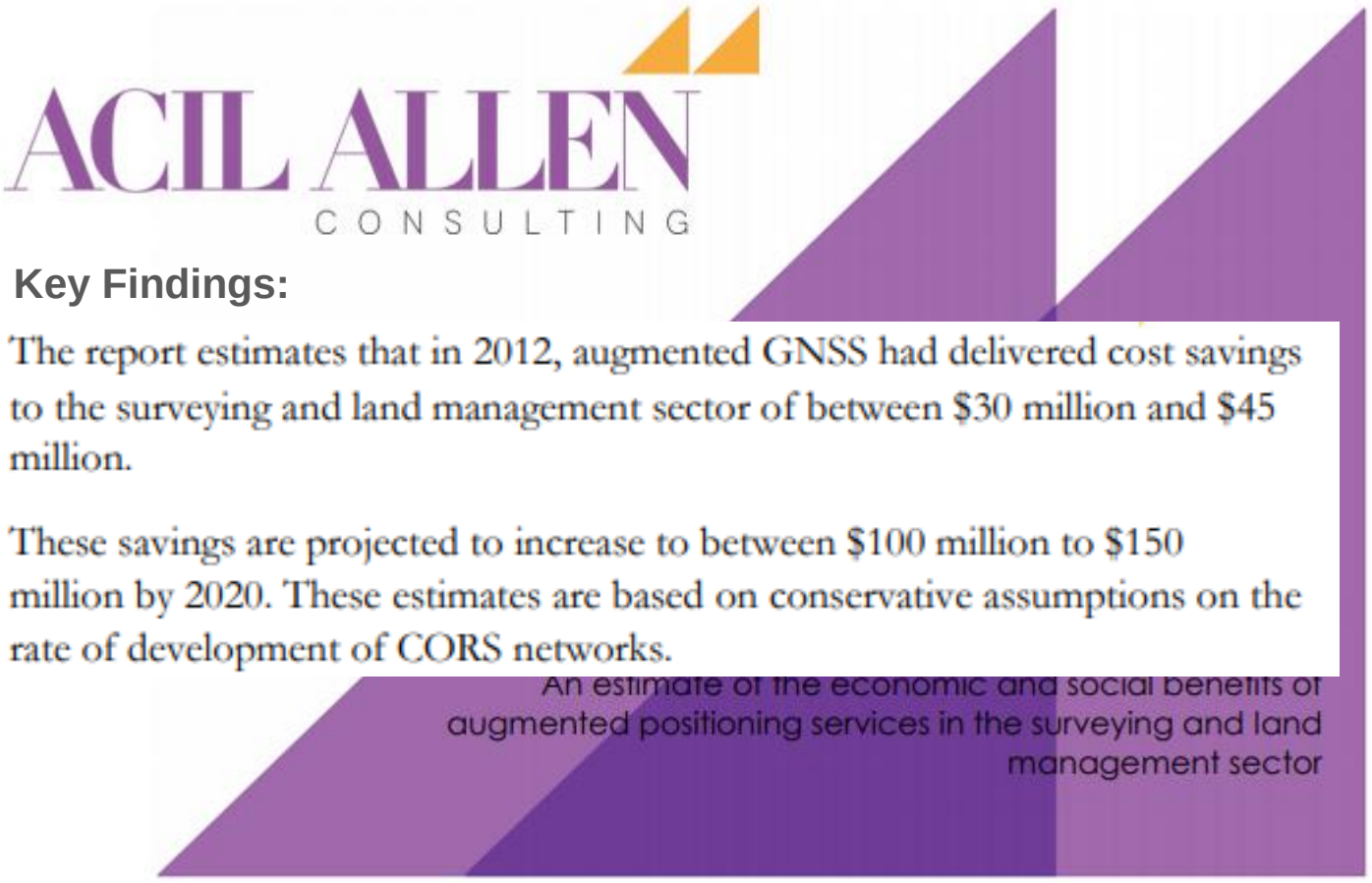
GNSS only ONE sensor in solution.

Provides overall Positional integrity

Cost Benefits

Economic Report by Allen Consulting

Link



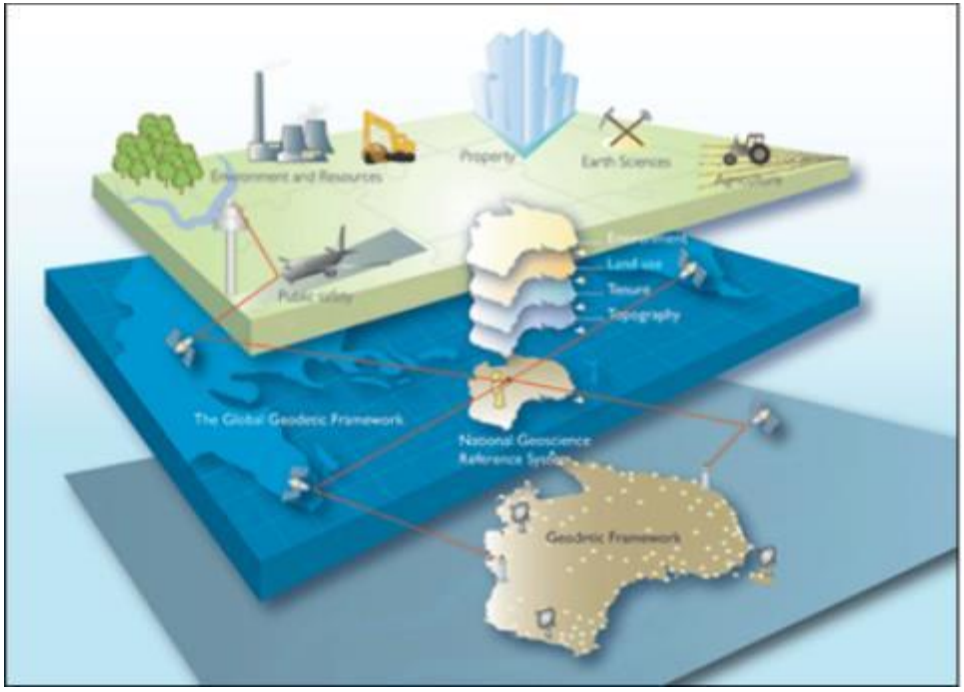
What is a GNSS CORS system used for ?

Summary…

A CORS system defines and monitors the National Reference Frame.

By accessing the derived products, realization of true National coordinates can be transferred into the field.

Everything is therefore positioned relative to a single reference.



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Building Monumentation

Building Monumentation

- Stake out
- Clearance
- Drilling
- …Drilling
- Installing Casing
- Inserting steel pipes
- Grouting
- Attaching adaptor

Building Monumentation

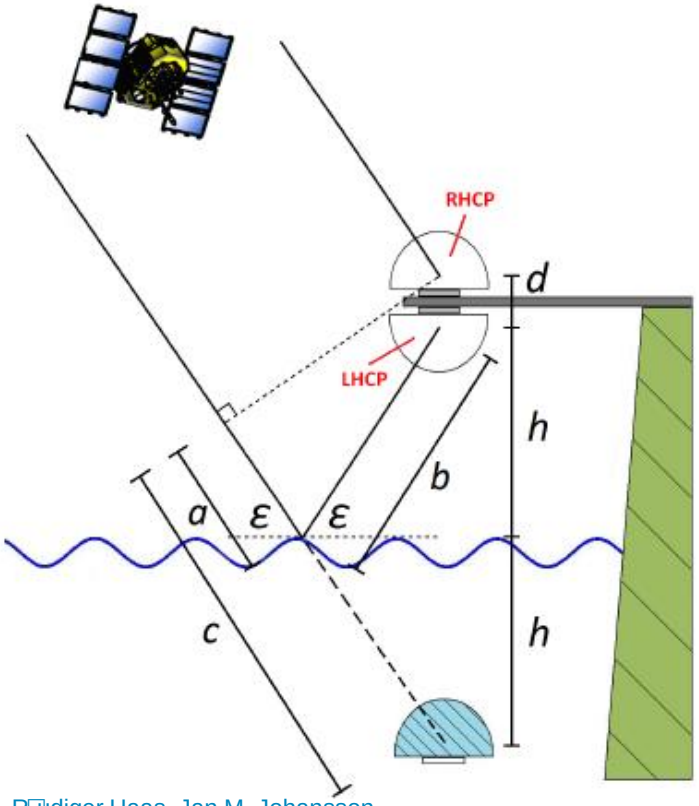
…finished product

Reference Station Antennae

LHCP AR20

The “left-handed“ antenna ➔ LHCP (left-hand-circular-polarised)

- **The idea*:**
  - Measurement of reflected signal
  - Determination of distance to reflective surface



* Reference: Monitoring Coastal Sea Level Using Reflected GNSS Signals; Johan S. L□fgren, R□diger Haas, Jan M. Johansson (2008 – 2011)

Thank You - Vinaka vaka levu

Any Questions ?

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