



Acquiring 3D Samoa to Increase Climate Resilience

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Using Remote Sensing Technologies

CRCSI & Regional Activities

Setting the scene, hazards & risks in Samoa

Planning & Results of the Bathymetric & Topographic surveys

Next Steps

Conclusion + nautical charts

Acknowledgements



Samoan Govt– MNRE, DMO, PUMA, MoF, Survey/Tech & Project Management Team

UNDP – Samoa Office

CRCSI – Nathan Quadros

Fugro LADS - Luke Chamberlain, SW Pacific Campaign Project Director

LINZ – Data Service for downloading nautical charts

GEBCO

Open Street Map

World Bank

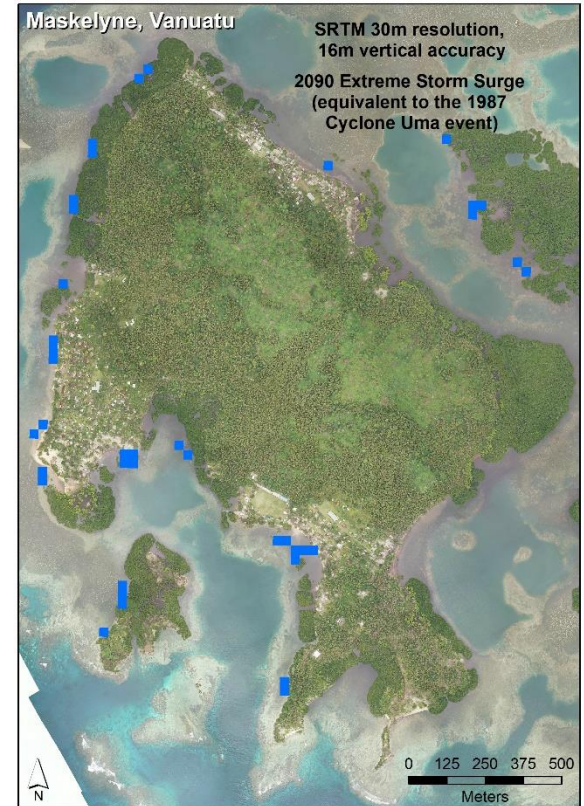
Asian Development Bank

PCRAFI

Why LiDAR for Pacific Island 3D Models?



Why LiDAR for Pacific Island 3D Models?

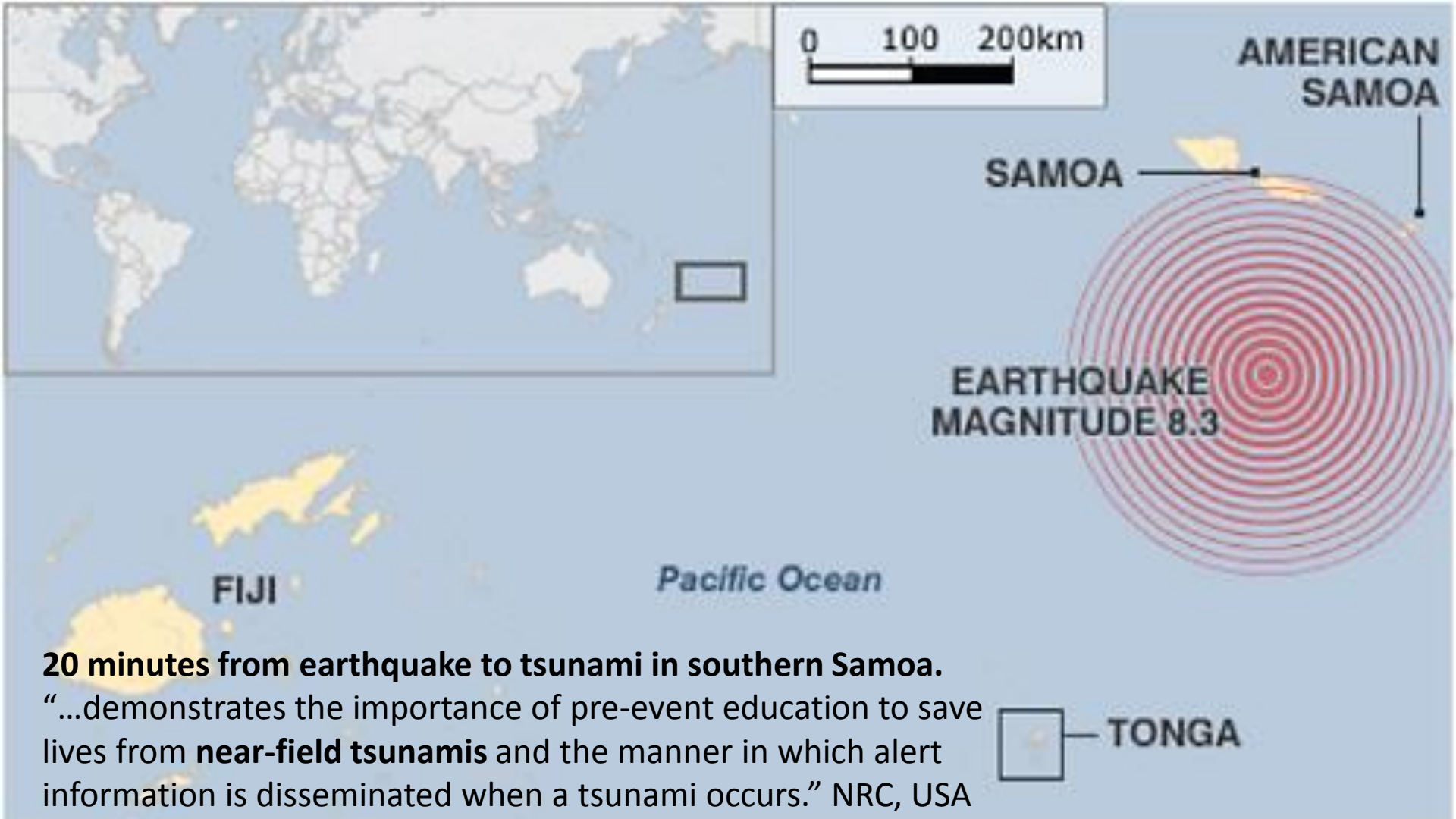


Hazards in Samoa



Hazard	Level of Risk
Cyclone	Extreme
Volcanic Eruption	Extreme
Tsunami	Extreme
Urban Fire (Apia)	Extreme
Public health crisis	Extreme
Environmental crisis – invasive species	Extreme
Flood	High
Earthquake	High
Landslide	High
Forest Fires	High
Aircraft emergency (airport)	High
Hazchem incident – marine	High

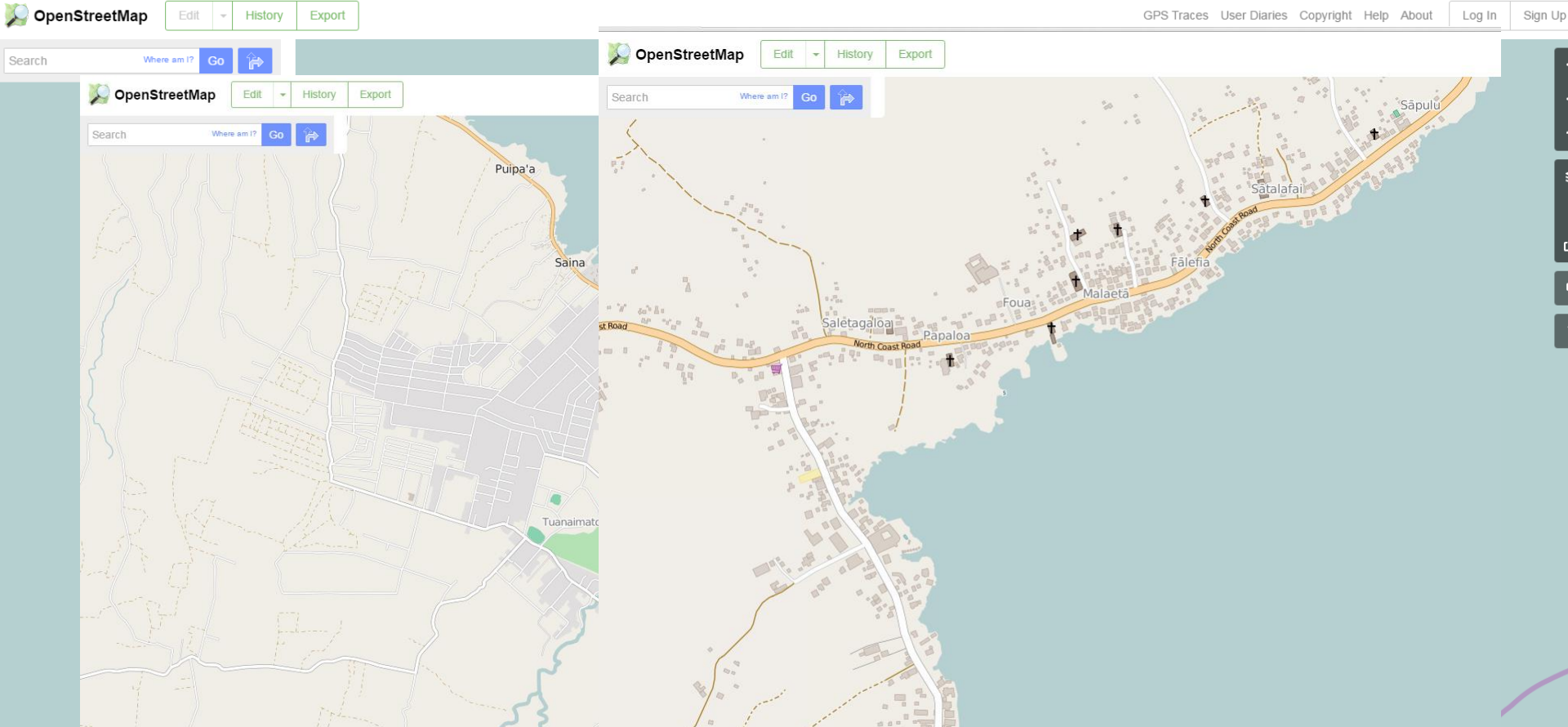
Hazard	Level of Risk
Lifeline Utility Failure – water	Mod
Agricultural crisis – animal or plant disease	Mod
Civil emergency – external	Mod
Lifeline Utility Failure – telecommunications	Low
Lifeline Utility Failure – electricity	Low
Single asset infrastructure failure – building collapse	Low
Single asset infrastructure failure – dam	Low
Drought	Low
Aircraft emergency (other location)	Low
Maritime vessel emergency	Low
Hazchem incident – land	Low
Terrorism	Low
Civil emergency – internal	Low



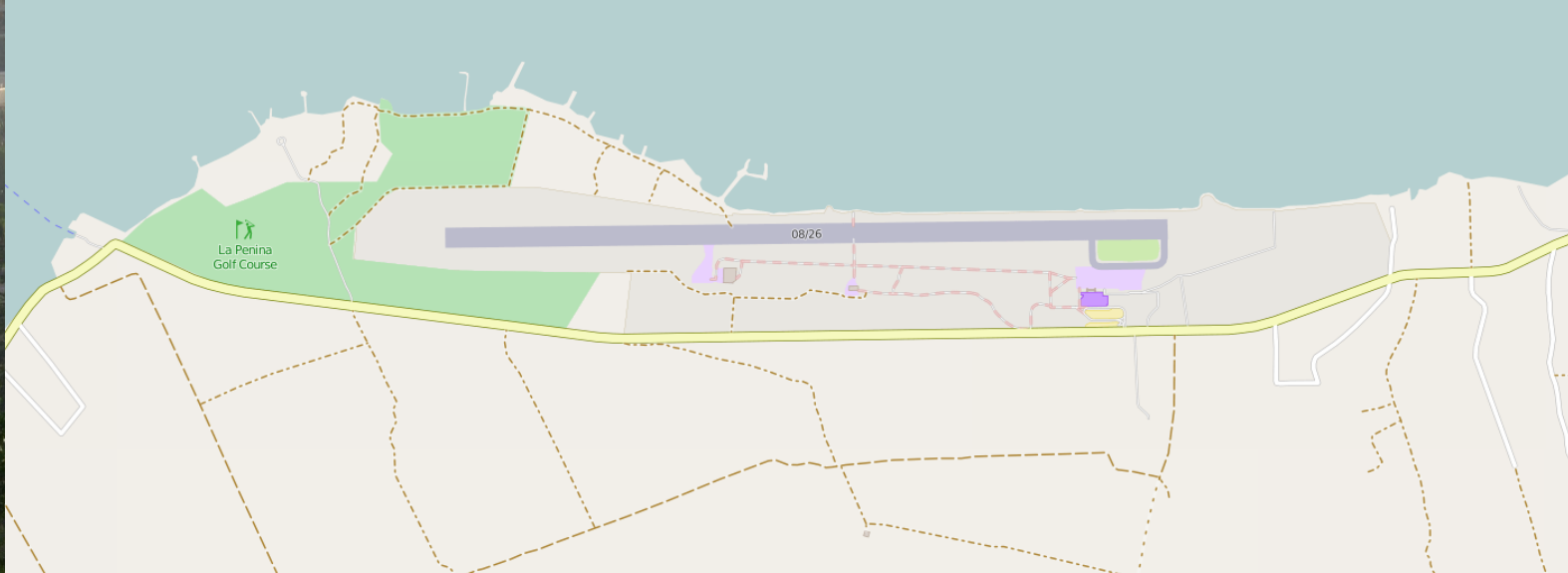
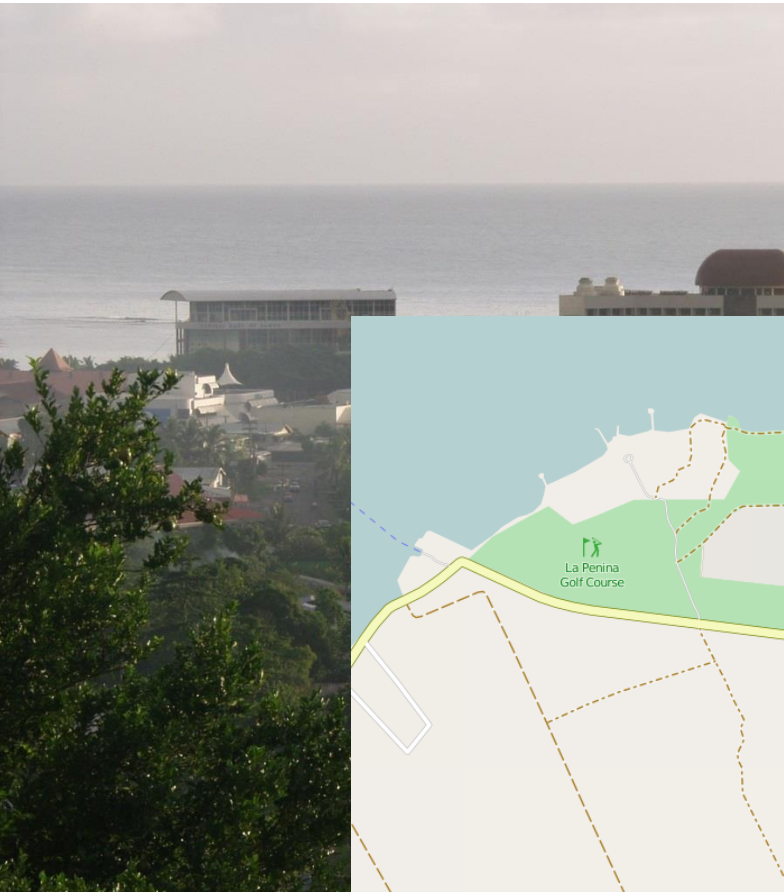
High demands near the coast



Over 70% of Samoans live within 1km of the coast



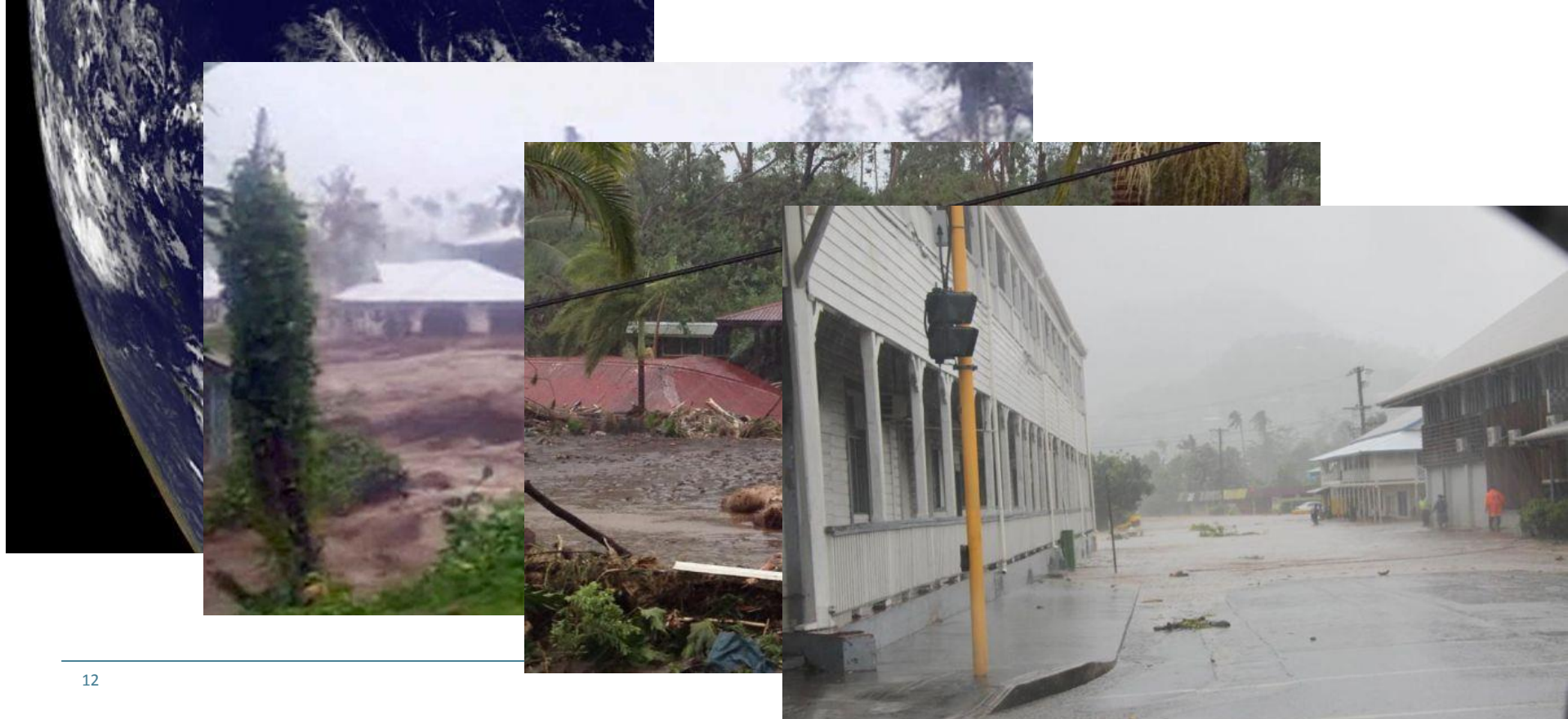
Critical infrastructure – on / near the coast



80% of the coastline is sensitive or highly sensitive to erosion



Modelling for multiple events



Harness & grow the blue economy



Other regional input to Samoa's DRM

- Tsunami models not aligning with actual Tsunami*

** GA 2009/02: Consultancy Report: A Probabilistic Tsunami Hazard Assessment of the SW Pacific Nations. "...Only more detailed modelling and analysis of each specific island could determine whether this (impacts from tsunami) indeed is the case for any of the countries covered by this report."*

- In 2011, cyclone disaster simulation was facilitated by Samoan Govt. Recommendation by HEAL 2012 was:

'the lack of available datasets means a lot of analysis could not be immediately provided. Also it is difficult for mapping experts to provide accurate descriptions of what is seen, as the base data is not current'.

- PCRAFI in 2013 anticipated that 'Samoa is expected to incur, on average over the long term, about US\$10 million per year in losses due to earthquakes and tropical cyclones.'

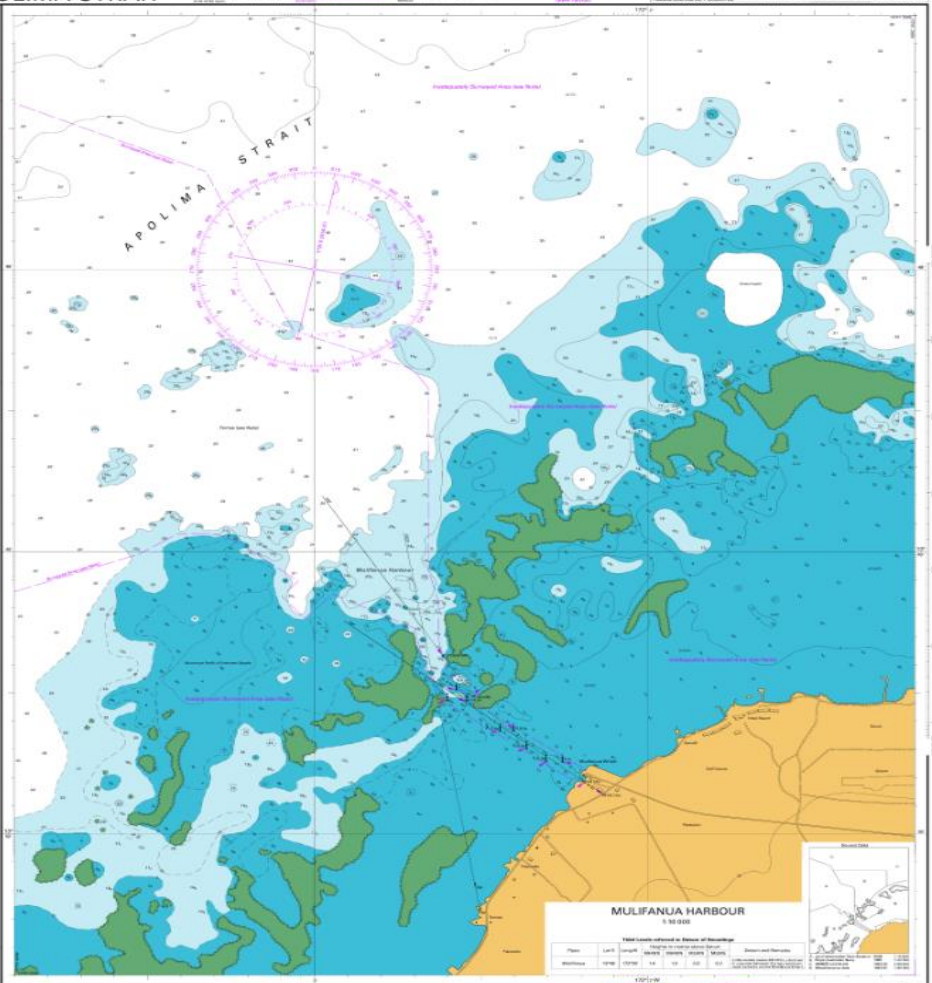
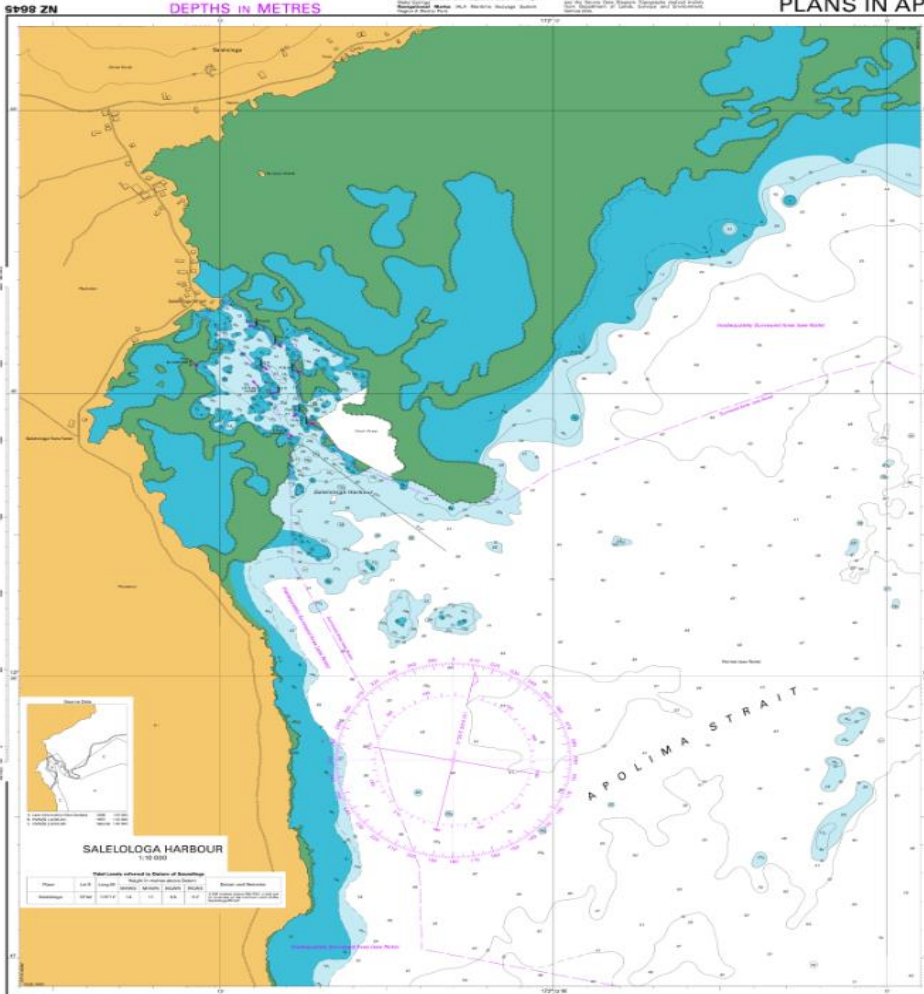
PACRFI's recommends that world bank funding can support remote sensing to supply the critical input to the first level of disaster risk management ."

- UNDP in 2014 stated that climate change is expected to result in losses to lives, livelihoods and assets for local communities in Samoa.

'Goal: vulnerable communities across Samoa are more resilient and government agencies have capacity to apply DRM'.

PLANS IN APOLIMA STRAIT

WGS 84 DATUM



In early 2015: What did the Samoan Government seek?

An up to date, accurate and detailed national wide record, from 30m depth contour to top of mountain (~1900m).

On receipt of this and in addition to risk assessment, the goals were to:

- Protect roads, public utilities, buildings, land & lives
- Protect coastal springs & conserve wetlands (better water management)
- Re-vegetate degraded areas & control sand mining
- Manage coastal reclamation (ie better engineered solutions)
- Regulate coastal land & outer reef use (ie palm trees, fishing, tourism etc)

What was provided?

Tender compilation & assistance with tender decision (CRCSI)

**Project Planning, Airborne Surveys, Ground Control,
Processing & Deliverables (FUGRO)**

Independent QC of all deliverables (CRCSI)

Training in data use (FUGRO & CRCSI)

Ongoing advice (FUGRO & CRCSI + others)

Tech Requirement:

- Coverage from top of Ridge to Outer Reef
 - Seamless dataset from the 1900m topo height to -30m depth
 - 100% coverage of topographic (2900 sqkm) &
 - 90% of bathymetric areas (1100sq km)

What we planned to satisfy the requirement:

LADS sensor: 5m x 5m point spacing (in water up to 40m)

Riegl Bathy Sensor: 4 points per sq m (along coastline & shallow water to 8m)

Riegl Topo Sensor: 4 points per sq m (Ridge to waterline coverage)

High Res Imagery: 15cm pixel (ridge to waterline coverage + overlap)

Incidental Mid Res Imagery: ~40cm pixel (reef/coastal coverage)

Staff

- Hydro Surveyors x 2
- Land Surveyor x 1
- Operators x 3
- Pilots x 3

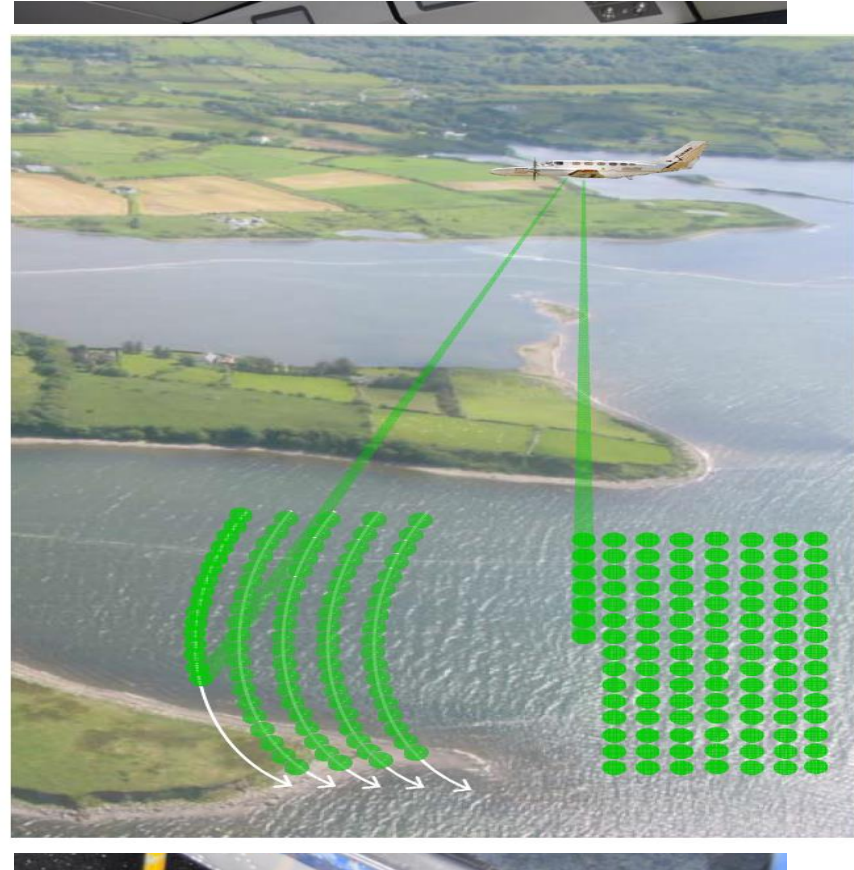
ICSM Guidelines for ALB capture, tendering, etc



Minimum Standard	IHO Order 1b – ~5m Horizontal accuracy , ~0.5m Vertical accuracy
Required Depth Coverage	5m drying to 30 metres depth,
Required Data Resolution	5m x 5m

Minimum Standard	ICSM Category 1 Standard – FVA \leq +/- 30cm. 95% confidence interval (1.96 x RMSE) FHA \leq +/- 80cm. 95% confidence interval (1.73 x RMSE) Level 2 classification
Data Resolution	4 pulses per square metre

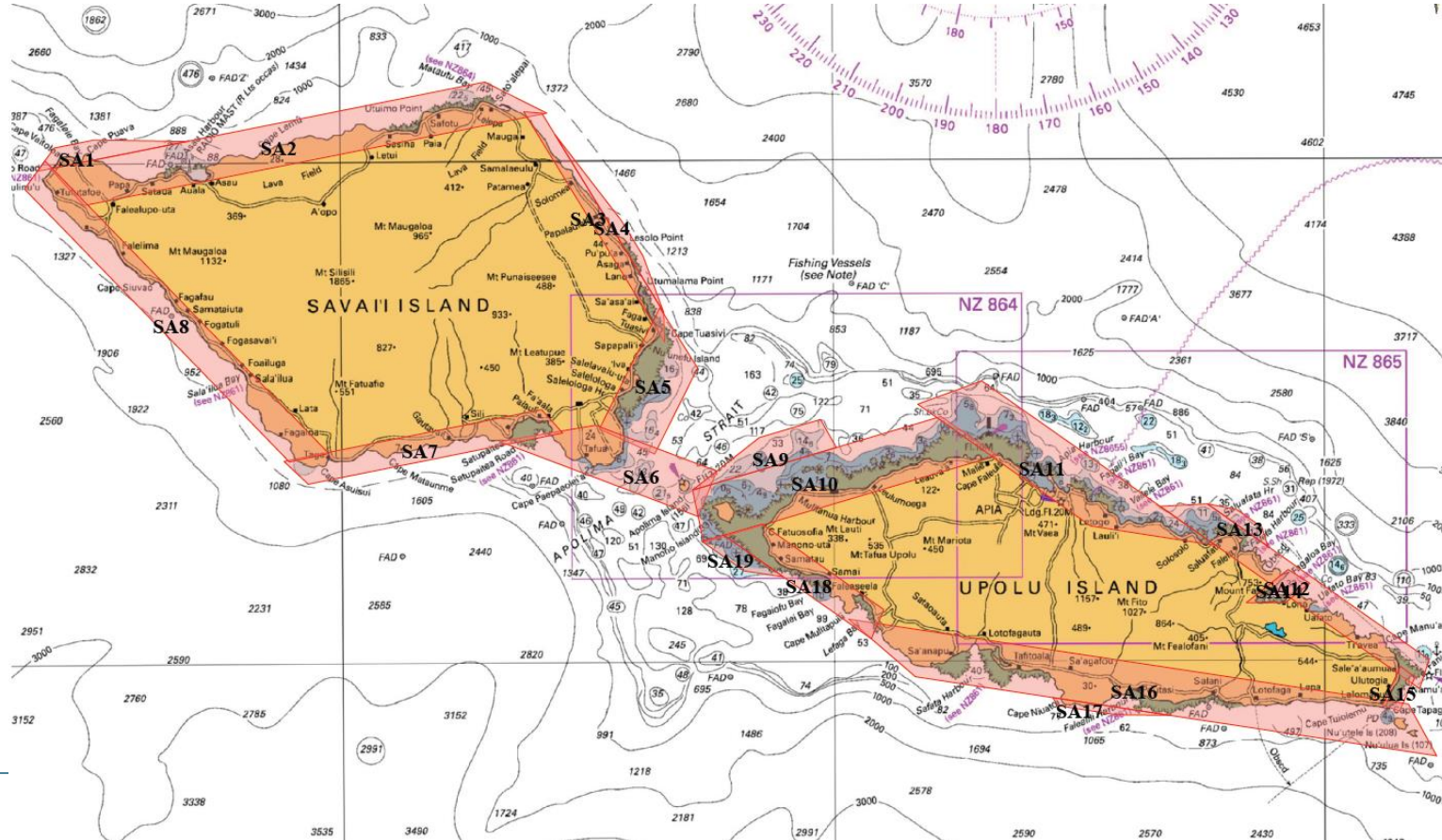
- Sensor:
 - LADS HD integrated with RIEGL VQ-820-G systems in the same aircraft
 - Both systems operate at 532nm
 - LADS system scans under the aircraft
 - RIEGL is angled 20 degrees fwd or aft
 - Systems complement each other providing coverage on the coast and offshore to deep water (LADS) and very high density coverage in very shallow water and on the beach and coast (RIEGL)



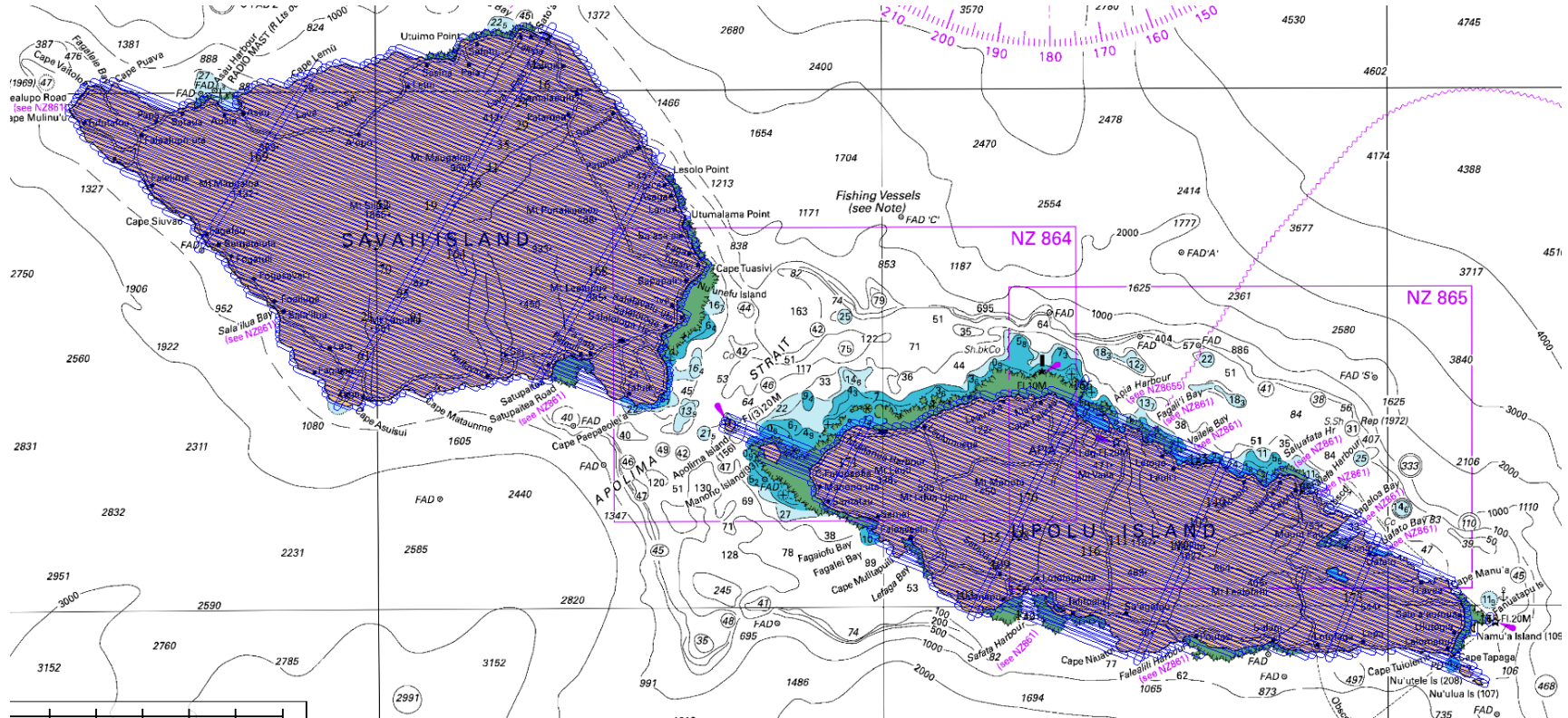




Ridge to Reef – Bathymetry survey ‘sub-areas’



Ridge to Reef – Topographic survey lines



Clear skies, low wave activity, crystal clear water

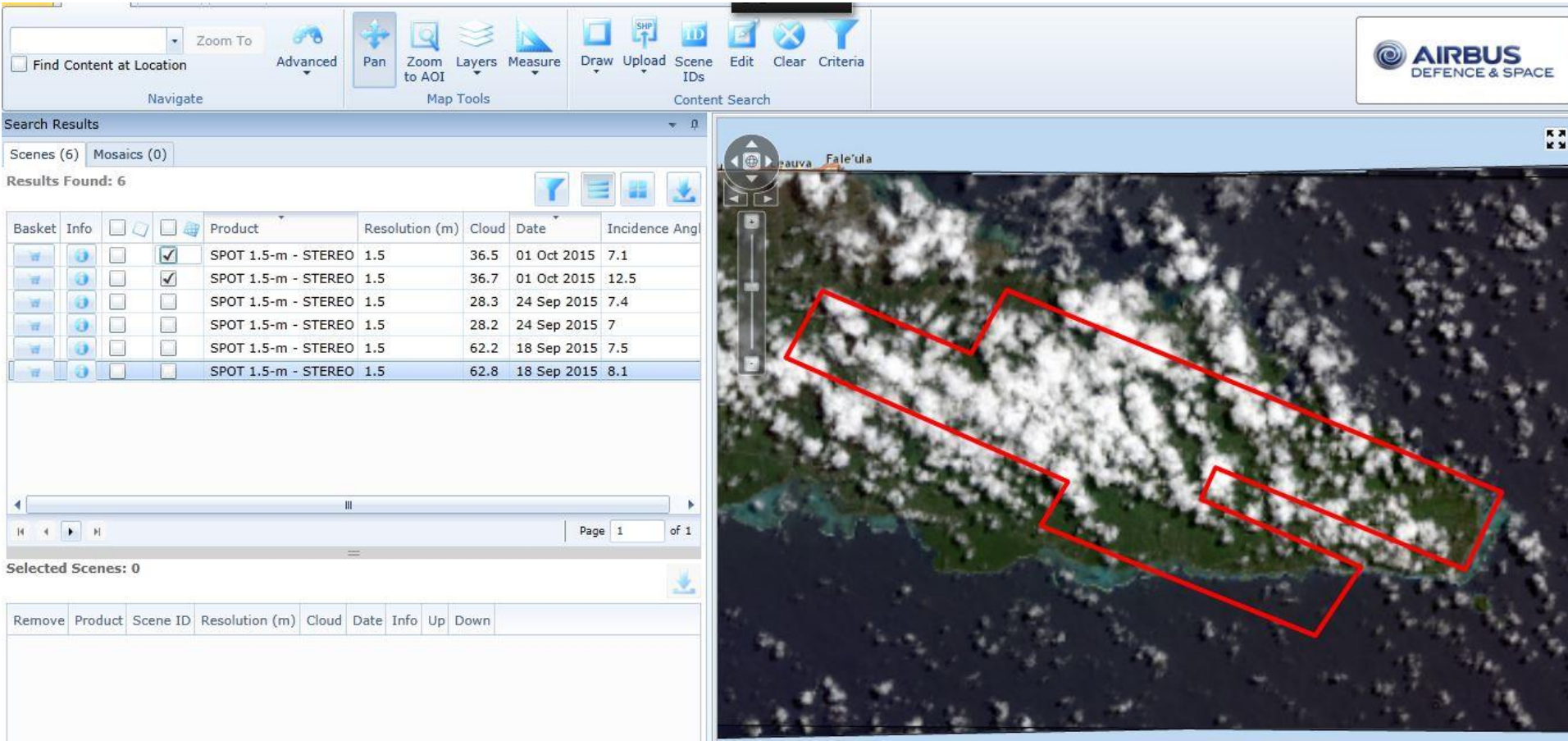




Cloud...



More clouds, as seen from Airbus SV



Find Content at Location

Zoom To

Advanced

Pan

Zoom to AOI

Layers

Measure

Draw

Upload

Scene IDs

Edit


Clear

Criteria

Navigate

Map Tools

Content Search



Search Results

Scenes (6) Mosaics (0)

Results Found: 6

Basket	Info	<input type="checkbox"/>	<input type="checkbox"/>	Product	Resolution (m)	Cloud	Date	Incidence Ang
		<input type="checkbox"/>	<input checked="" type="checkbox"/>	SPOT 1.5-m - STEREO	1.5	36.5	01 Oct 2015	7.1
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		<input type="checkbox"/>	<input type="checkbox"/>	SPOT 1.5-m - STEREO	1.5	28.3	24 Sep 2015	7.4
		<input type="checkbox"/>	<input type="checkbox"/>	SPOT 1.5-m - STEREO	1.5	28.2	24 Sep 2015	7
		<input type="checkbox"/>	<input type="checkbox"/>	SPOT 1.5-m - STEREO	1.5	62.2	18 Sep 2015	7.5
		<input type="checkbox"/>	<input type="checkbox"/>	SPOT 1.5-m - STEREO	1.5	62.8	18 Sep 2015	8.1

Selected Scenes: 0

Remove	Product	Scene ID	Resolution (m)	Cloud	Date	Info	Up	Down
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Maui Fale'ula

Results: Bathymetric Airborne Surveys

Airborne LiDAR Bathymetry - Accepted

- Requirement was above 95% coverage
- 3 calibration flights & 15 sorties completed in 25 days covering ~1100 sq km

Area	Number of 50x50m Grids (+5m drying to 30m depth)	Number of 50x50m Grids >50 soundings	Area % covered
Upolu	54030	53432	98.89%
Savaii	127952	123520	96.54%

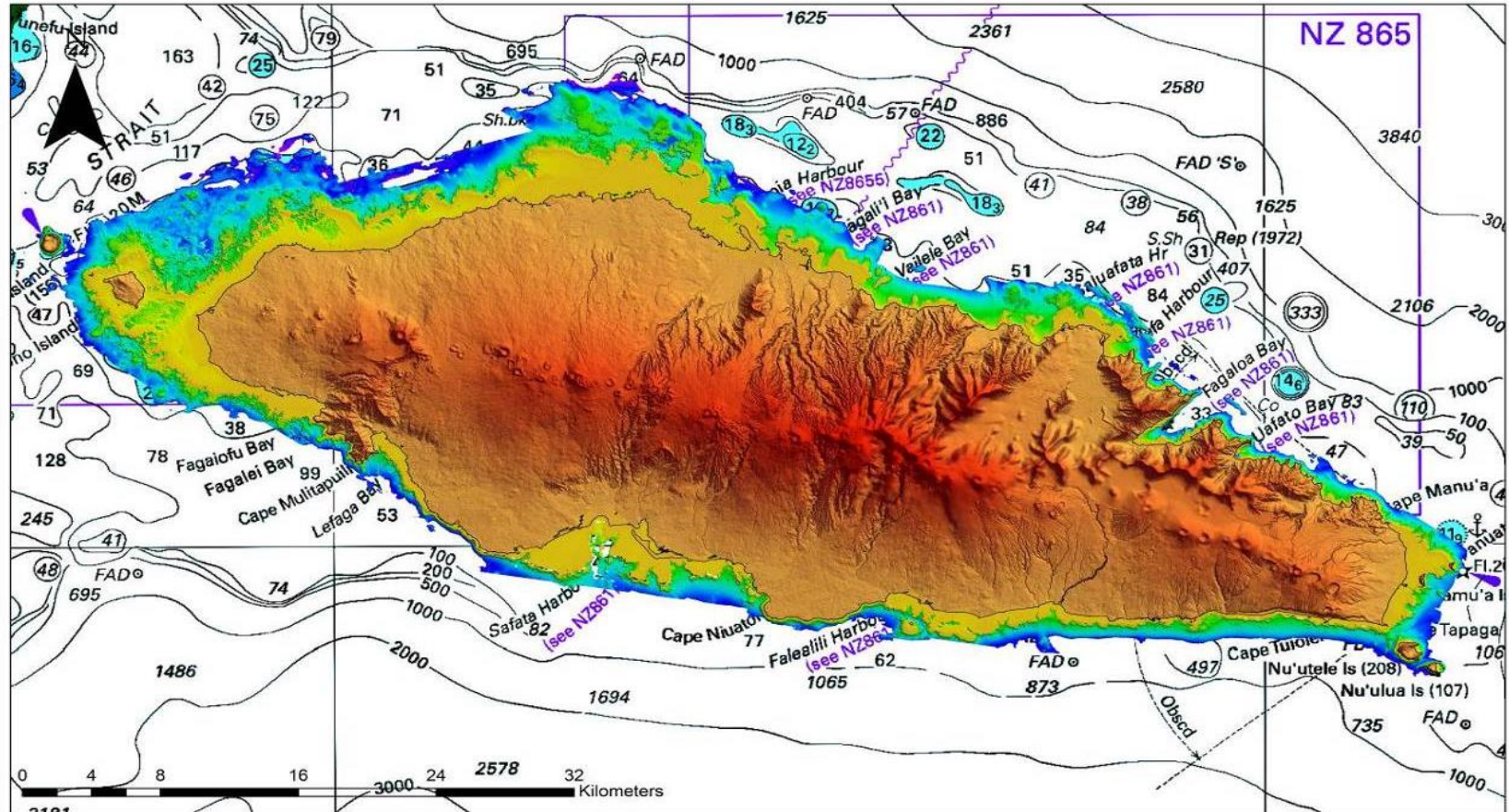
Results: Topographic Airborne Surveys

Aerial Imagery / Airborne LiDAR Topography

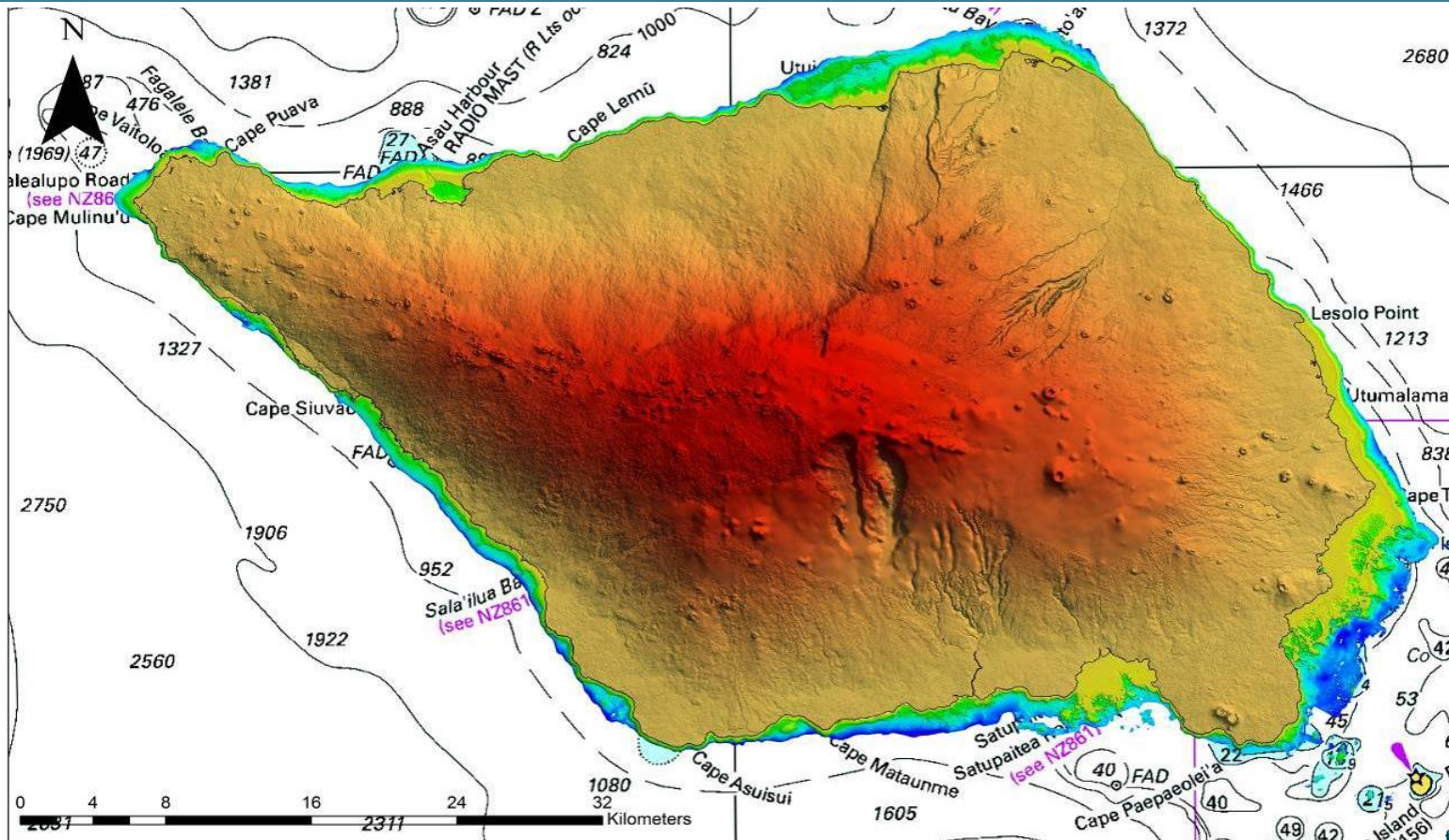
- Requirement was 100% coverage
- 2 calibration surveys & 38 sorties completed in 45 days covering ~2731sqkm
- 81% coverage achieved - **Leaving 19% needing another solution**

Area	Required SqKm	Achieved SqKm	Area percentage covered
Upolu – Total	1140	1310	115%
(Riegl LMS 780)		969	
(NextMap 10 Satellite)		341	
Savaii – Total	1713	1806	105%
(Riegl LMS 780)		1578	
Satellite RADAR		228	

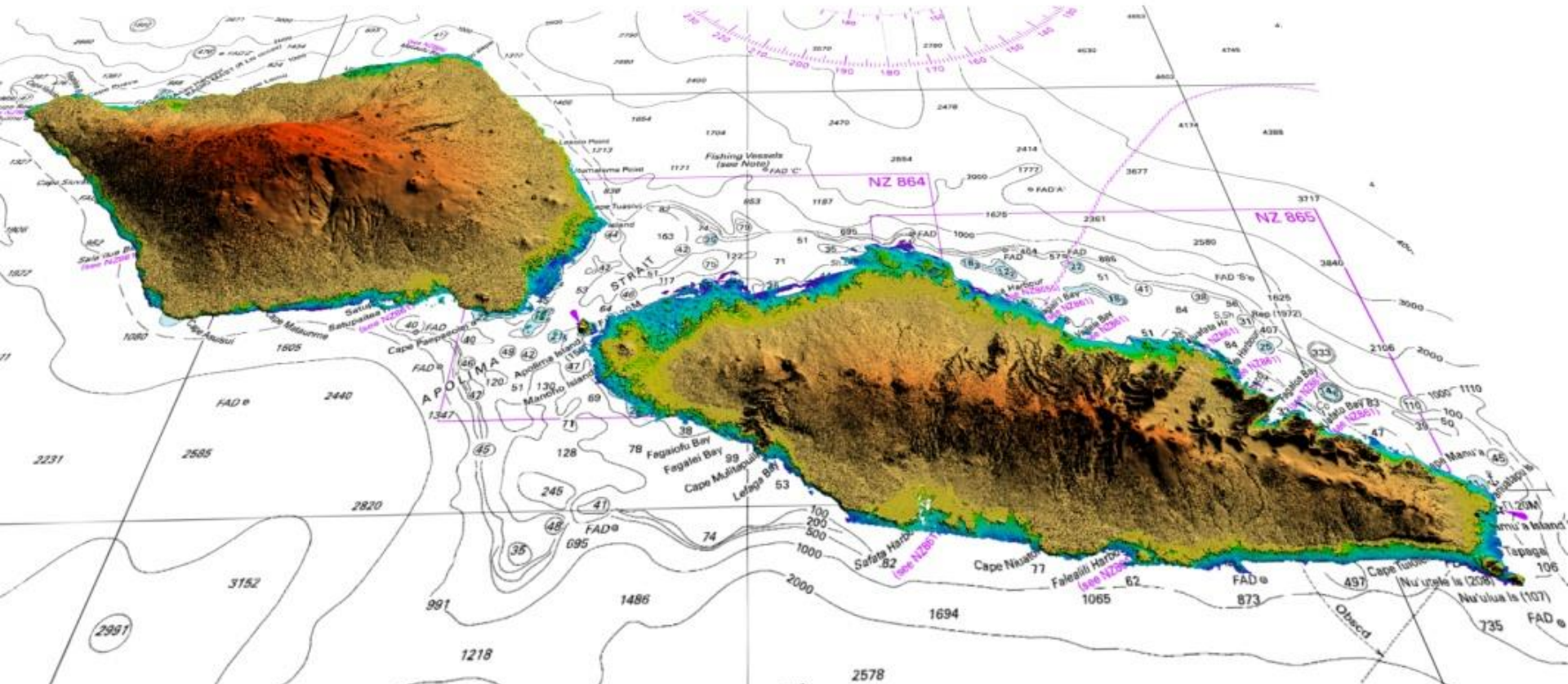
Upolu Seamless Terrain Model – Ridge to Reef



Savaii Seamless Terrain Model – Ridge to Reef



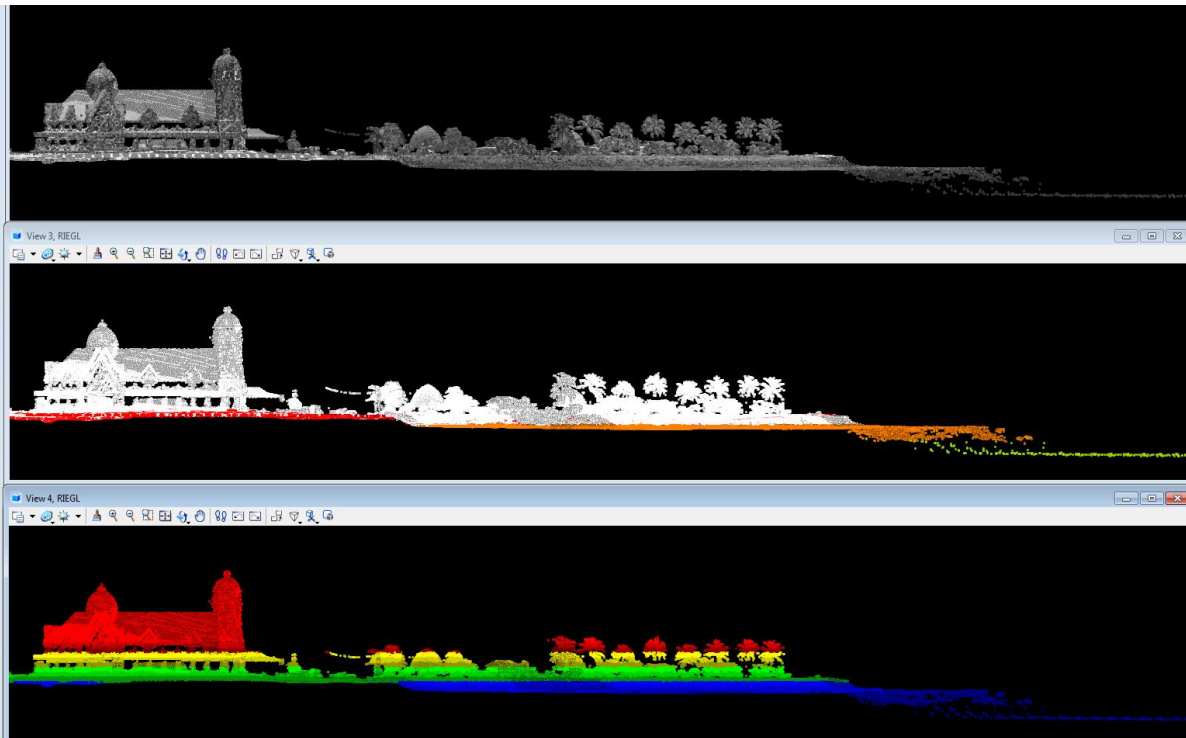
Upolu & Savaii Seamless Terrain Models – 3D Marketing Shot



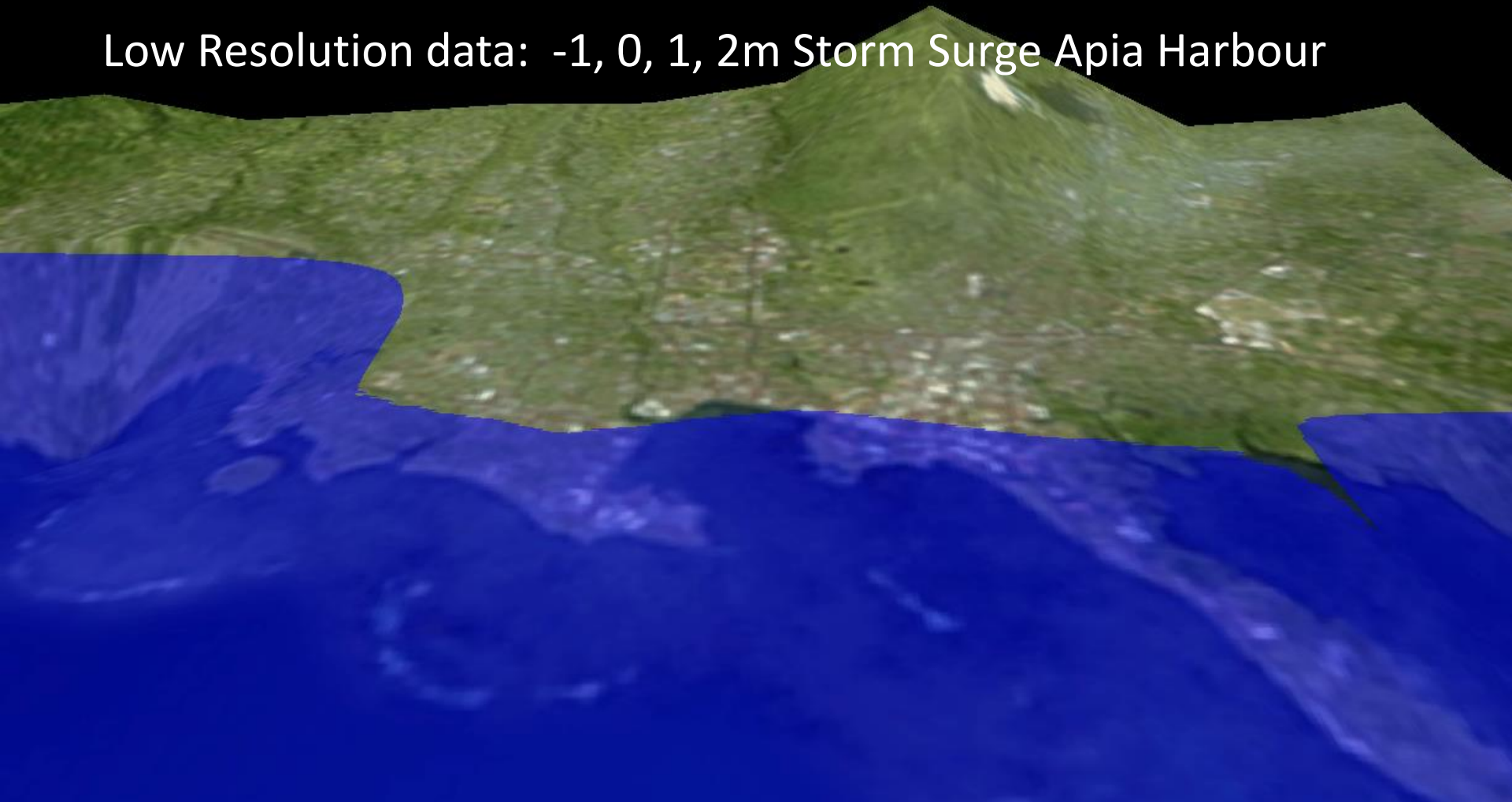
Upolu & Savaii Seamless Globe – 3D Marketing Shot



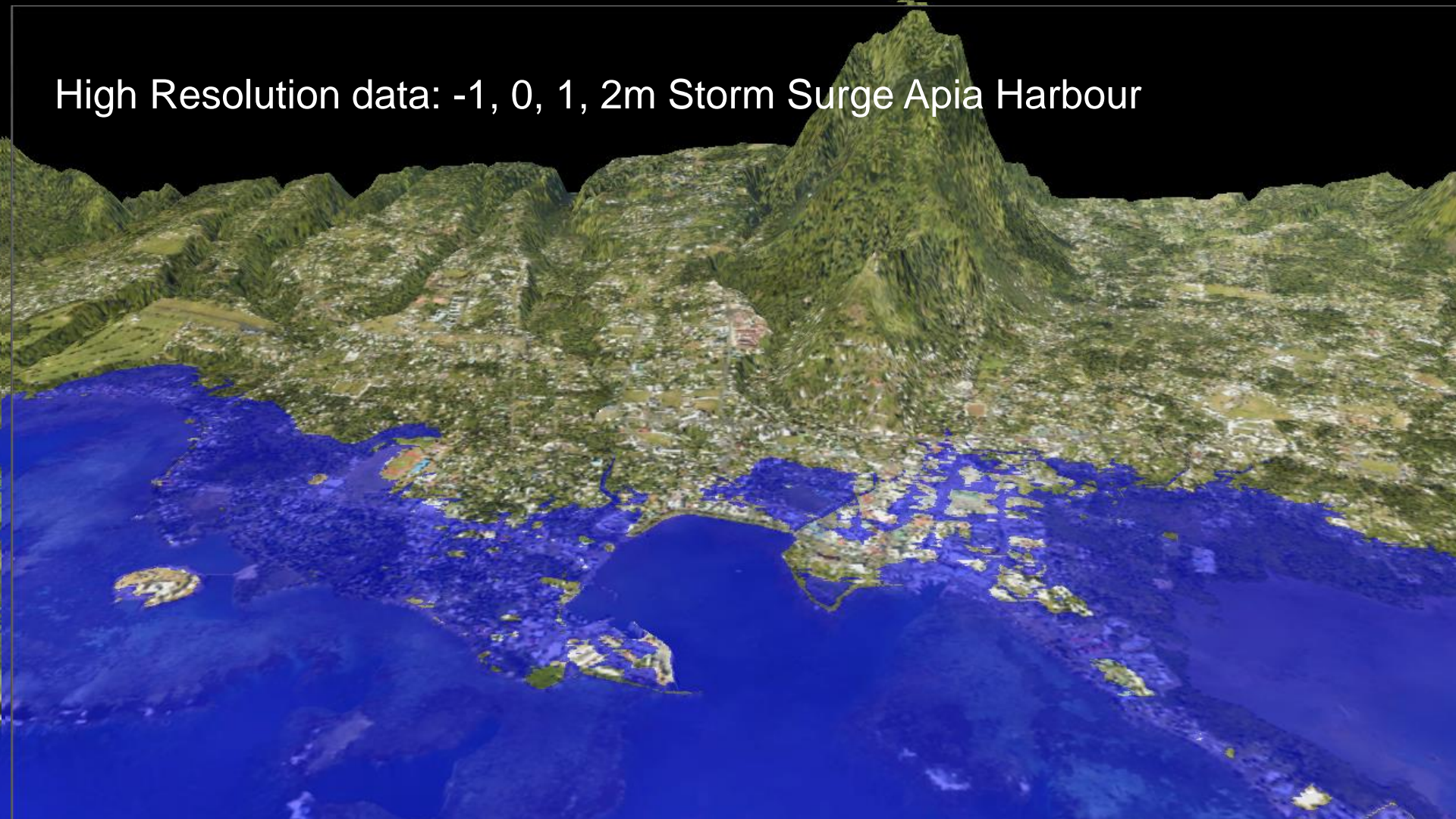
LAS file – Apia Church and Harbour area



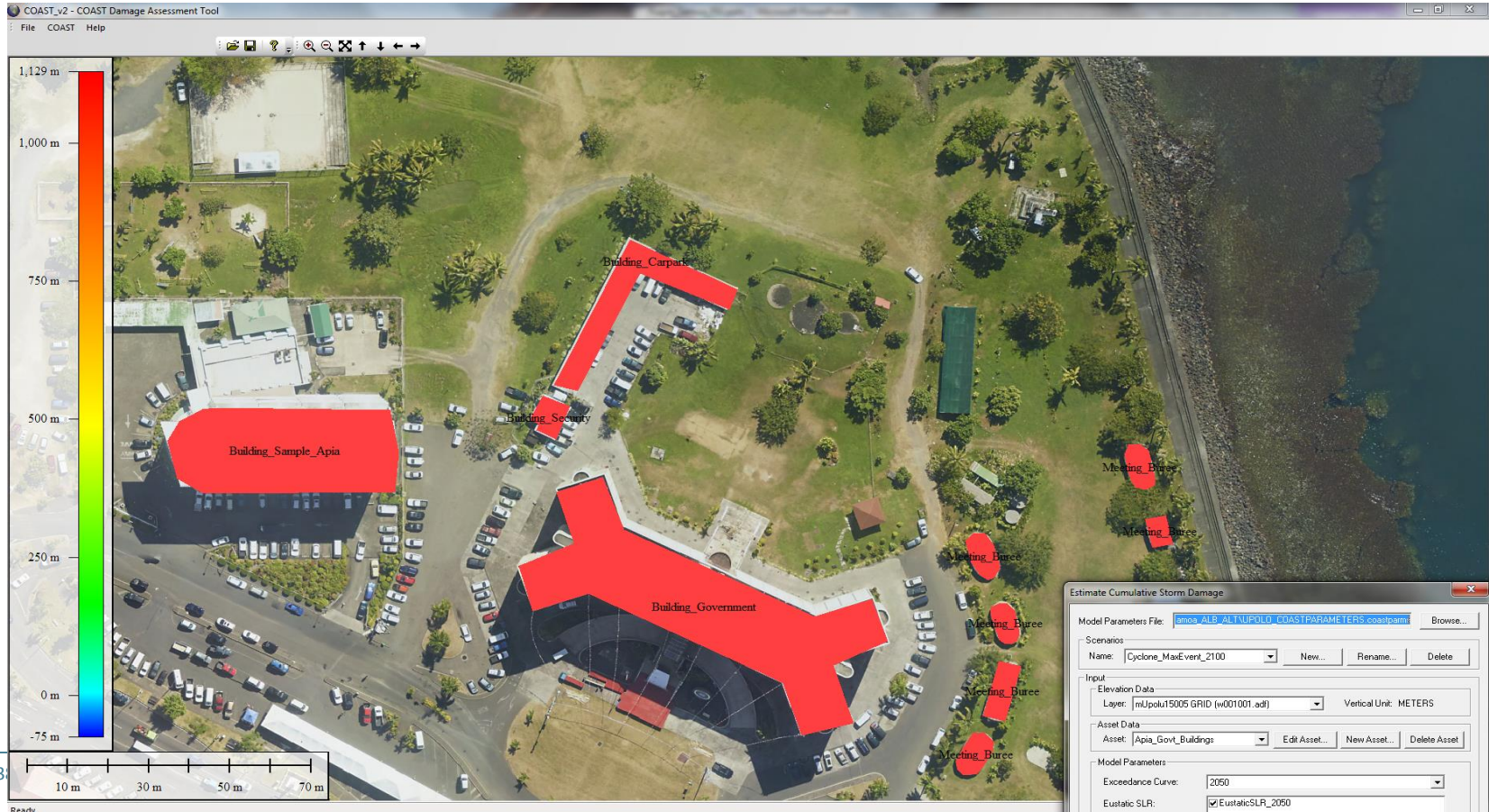
Low Resolution data: -1, 0, 1, 2m Storm Surge Apia Harbour



High Resolution data: -1, 0, 1, 2m Storm Surge Apia Harbour



Coastal Damage Assessment Tool



Next Steps for Samoan Government



Strategic Pillar	Activity One	Activity Two	Activity Three	Outcome
GIS Capacity Building	GIS training for MNRE	GIS training government stakeholders	LiDAR in universities and schools	Samoa has the skills to use LiDAR
IT Infrastructure	Acquire computing equipment	Store and distribute products		MNRE can store and access the LiDAR data
Data Licensing Framework	Creative Commons products	License templates		Data licensing framework created
Data Pricing Model	Samoa government access	Public , non-commercial pricing	Commercial pricing	Price for parties to access data
Value-Added Datasets and Services	Create and update map layers	Additional value-added products	Develop online web services	Additional datasets and services
Promotion	Promote the datasets to government	Promote the datasets broadly	Promote value-added prod & servs	People are aware of the data
Collaborate	Data custodians	Sharing between departments	Easy access for gov. agencies	Government easily shares

← → 📄 coastalrisk.com.au

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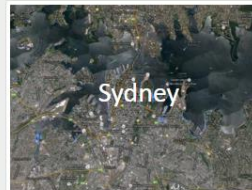
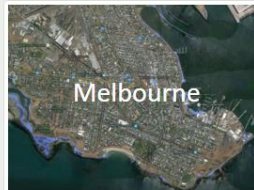
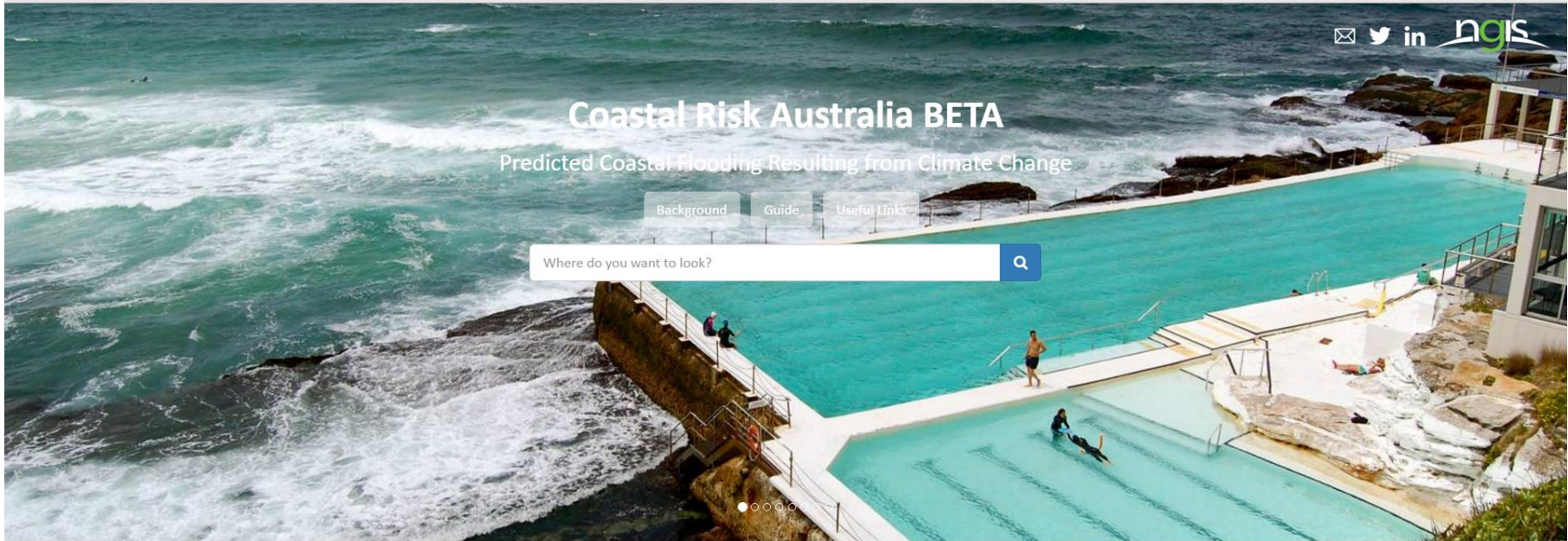
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Coastal Risk Australia BETA

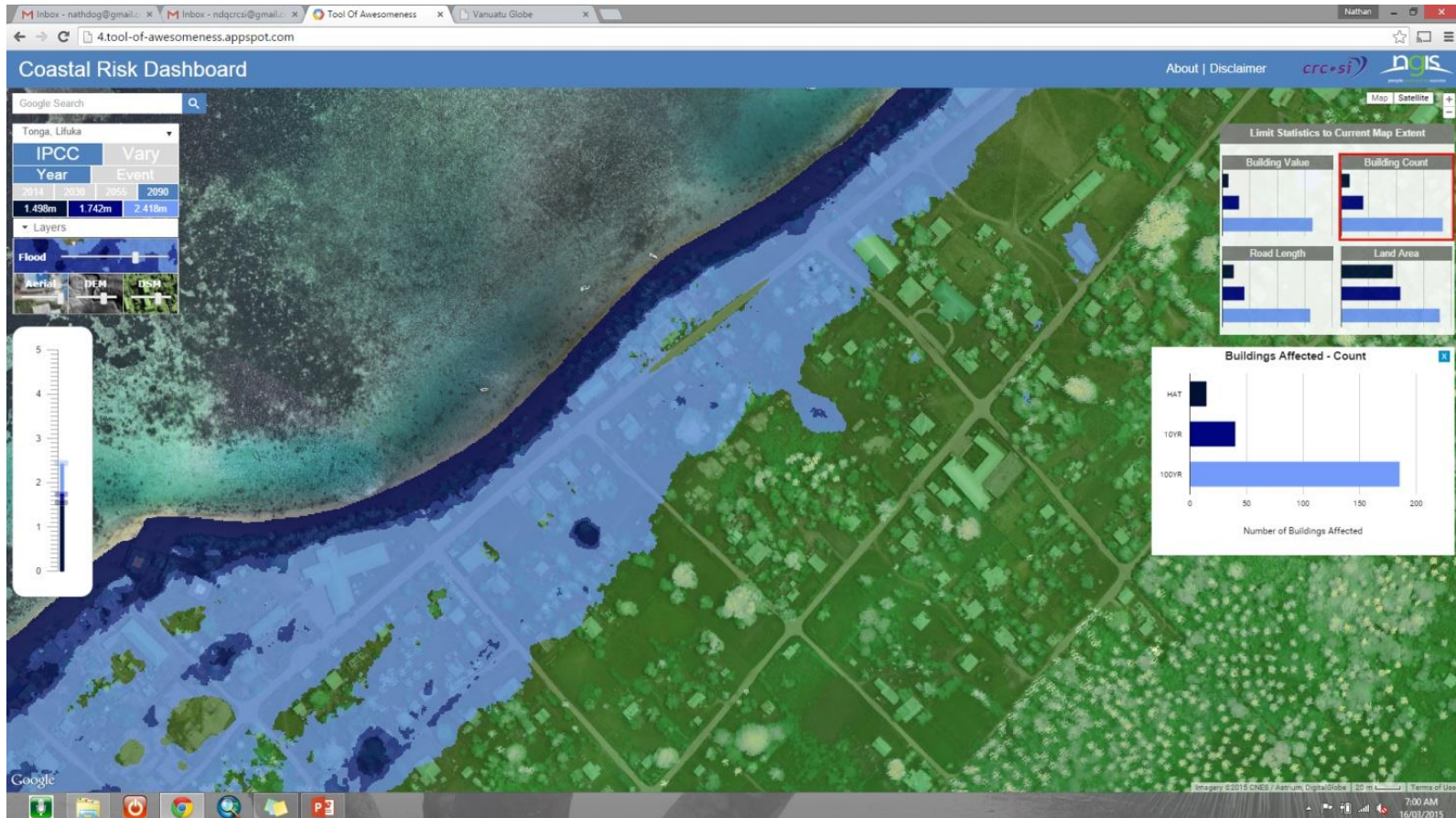
Predicted Coastal Flooding Resulting from Climate Change

Background Guide Useful Links

Where do you want to look? 🔍



Next Steps: Web Analytics - Coastal Risk Dashboard



- 46.5 billion points were captured
 - 37.1 billion topographic and 9.4 billion bathymetric
- 70% of topographic LiDAR points captured were high vegetation (trees >10m)
- 20% of bathymetric LiDAR points were classified as seabed
- Highest ground point in Samoa is 1858m above MSL
- Deepest bathymetric measurement was 75.2m below MSL
- Pulse density of 4.73 points per m² (required was 4 points per m²)
- The absolute vertical accuracy of the survey was 22cm at 95% confidence meeting the 30cm requirement.

- The World Bank recognises the importance of national, regional and local modelling in DRM and where remote sensing can help with this
- Remote sensing techniques of Aerial Imagery, Airborne LiDAR Bathymetry, Airborne LiDAR Topography & satellite datasets were combined to improve national to village hazard risk assessment
- Samoa is the best surveyed nation on earth, with a national deep reef to ridge dataset – before France, USA, England, Australia, New Zealand – with modelling taken to villages & towns to review historical events and potential future events to promote decisions for safer communities
- **What's the status of Nautical chart?**

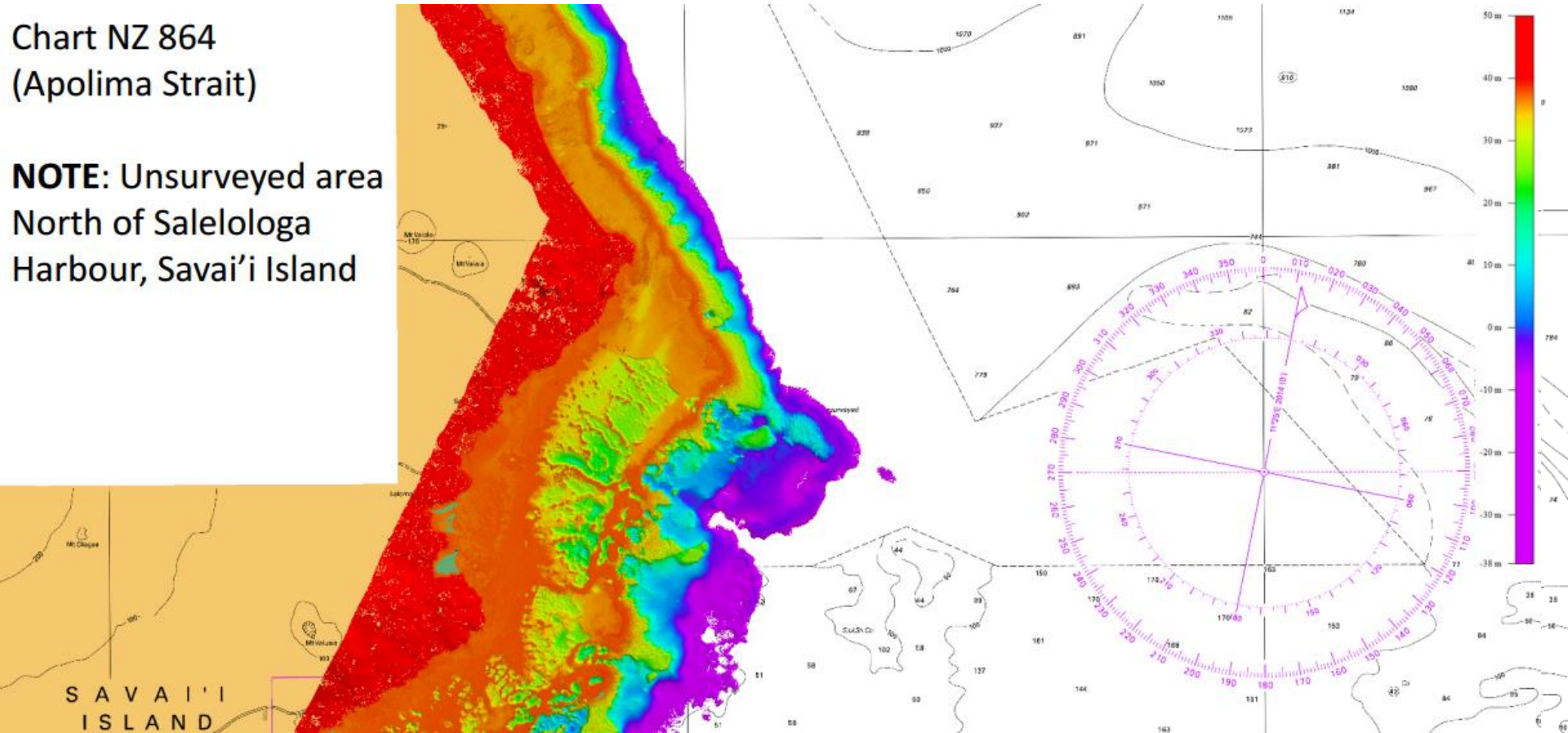
Country	Int_Reg	C_D	Last Update	Comments
Samoa	L	C	07/03/2014	Apolima Strait, Salelologa Harbour and Mulifanua Harbour have been recently surveyed by LINZ. This covers the route of the interisland ferry. Apia Harbour was recently surveyed by the RNZN. This data has been incorporated onto charts. Significant gaps in coverage: Numerous coastal routes and harbours are inadequately surveyed. These areas require surveying to modern standards to enable charting. Many small harbours are charted on an undetermined datum. These harbours require surveying to position them on WGS84 datum for modern charting. LINZ has a prioritised ENC production schedule that includes small, medium and large scale ENCs for the areas that are adequately charted. ENCs cannot be produced for areas that are charted on an undetermined datum until modern surveying and charting is completed.

Country	Region	0-200 Adequate	0-200 Resurvey	0-200 No-Survey	200+ Adequate	200+ Re-Survey	200+ No Survey	Comments
Samoa	L	5	95	0	0	20	80	1. Data provided by NZ. 2. Apolima Strait, Salelologa Harbour and Mulifanua Harbour have been recently surveyed by LINZ. This covers the route of the interisland ferry. 3. Apia Harbour was recently surveyed by the RNZN. Numerous harbours are inadequately surveyed. These harbours require surveying to modern standards to meet the needs of contemporary shipping. 4. Many harbours are on an undetermined datum and require modern survey to position them on WGS84 datum.

Improvements to Charts - Coastal

Chart NZ 864
(Apolima Strait)

NOTE: Unsurveyed area
North of Salelologa
Harbour, Savai'i Island



SAVAI'I
ISLAND

Improvements to Charts - Harbour

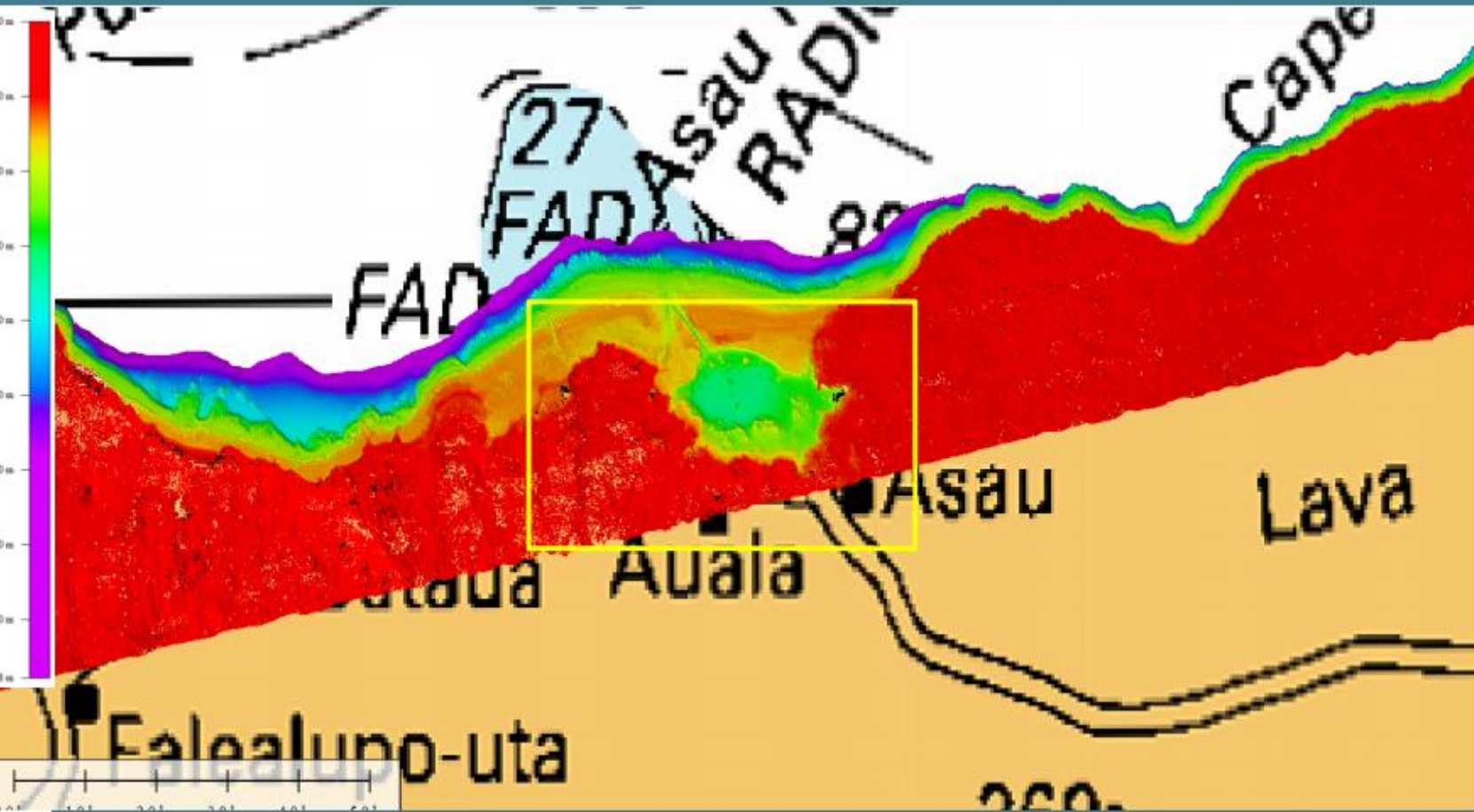


Chart NZ 86
(Samoa)

Only chart
for most of
island

NOTE: Asau
Harbour

Thank you

Questions?

