



GEOSCIENCE AUSTRALIA

CHRISTMAS ISLAND AND COCOS (KEELING) ISLANDS LiDAR SURVEY

VOLUME 18141A02NOM

Summary

Project

AAM Pty Ltd was commissioned by Geoscience Australia to undertake a LiDAR survey over Christmas Island (approximately 151 km²) and Cocos Islands (approximately 160 km²). The LiDAR survey was undertaken by AAM using a fixed wing aircraft between 24th and 26th of August, 2011 on Christmas Island and between 8th and 16th of August, 2011 on Cocos Islands.

Data

The data in this volume consists of:

- ESRI Digital Surface Model (DSM).
- ESRI Digital Elevation Model (DEM).
- ESRI Canopy Height Model (CHM).
- ESRI Foliage Cover Model (FCM) 10m.
- ESRI Foliage Cover Model (FCM) 2m.
- Orthorectified Imagery in TIFF and ECW tiles plus overall ECW mosaics, GSD 0.15m.
- Survey control data.
- Check point comparisons.
- Flight Trajectories.

The LiDAR data capture and post processing of this project has been controlled to achieve 0.15m vertical accuracy (RMS).

The orthorectified imagery has been controlled to achieve a 0.30m horizontal accuracy (RMS).

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1. PROJECT REPORT

Safety: No safety Incidents were reported during the project.

Acquisition: Airborne Laser Scanning (ALS) data was acquired from a fixed wing aircraft between 8th and 16th of August, 2011 on Cocos Islands and between 24th and 26th of August, 2011 on Christmas Island.

Ground Support: GPS base station support was provided by Whelans without incident. Ground check points provided by Whelans allowed an assessment of the accuracy of the ALS data.

Data Processing: Reduction of the ALS data highlighted some datum problems. This will be discussed in more details in the data validation section. Laser strikes were classified into ground and non-ground points using a single algorithm across the project area. Manual checking and editing of the data classification further improved the quality of the terrain model.

Further Processing: Ground point data has been thinned by filtering superfluous points not contributing to the definition of the terrain.

Data Presentation: The data provided on this volume has been supplied in accordance with a specification agreed with the primary client. Subsequent users experiencing difficulties in handling the data should please contact AAM to arrange a more appropriate data presentation.

Project Contacts:

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2. DATA INSTALLATION

Data format : ESRI .shp, TIFF, ECW
Number & type of media : 1xHDD
Files on media : Data files, image files,
Readme_18141A02NOM.PDF,
, and metadata
Data formatted on : 30.11.2011
Disk volume : 18141A02NOM

README FILE

This document (Readme_18141A02NOM.PDF) is provided as an Acrobat file in this volume. To open the file, double click on the PDF file to activate Acrobat Reader Software.

Adobe Acrobat Reader may be downloaded from:
<http://www.adobe.com/products/acrobat/readstep2.html>

LOADING NOTES

Data may be copied using a file copy utility such as Windows Explorer or similar.

FILE SIZES AND NAMES

Data is provided as tiles 1km by 1km to the following filenames convention:

eg. e259n8688.las

- 259 - coordinate easting (in thousands) of south west tile corner
- 8688 - coordinate northing (in thousands) of south west tile corner
- *.las - Laser strikes classified as LAS 1.2
- *.tif - Geo-referenced intensity images

LiDAR data has been classified as follows:

Number	Point class	Description
0	Unclassified	Created, never classified
1	Default	Unclassified
2	Ground	Bare ground
3	Low vegetation	0 – 0.3m (essentially sensor 'noise')
4	Medium vegetation	0.3 – 2m
5	High vegetation	2m >
6	Buildings, structures	Buildings, houses, sheds, silos etc.
7	Low / high points	Spurious high/low point returns (unusable)
8	Model key points	Reserved for 'model key points' only
9	Water	Any point in water
10	Bridge	Any bridge or overpass
11	not used	Reserved for future definition
12	Overlap points	Flight line overlap points
13-31	not used	Reserved for future definition

3. ADDITIONAL SERVICES AND EXTRA DATA

Product Generation

AAM can perform the following additional services on the data contained on this volume if required:

Change horizontal datum	: to AMG or other local grid
Alter geoid modeling	: by transforming ALS data to fit orthometric survey heights
Improve data classification	: by tailoring parameters to suit regional variations
Further classification	: assist building identification by further classifying non-ground strikes
Data thinning	: to remove superfluous points not adding to the terrain definition
Data subset	: by dividing the data into different tiles or polygons
Data presentation	: by creating profiles, perspectives, flythroughs, colour-coded height plots etc.
Ground truthing	: by comparing the ALS terrain model with extra independent height data
Data gridding	: to convert the measured spot heights into a regular grid
Fly – Throughs / 3d Perspectives	Image draping /slope models

4. METADATA

SOURCE DATA

Item	Source	Description	Ref No	Date
Laser System	AAM	ORION with DiMAC camera	18141A	8-26.08.2011
Pulse Rate Frequency	AAM	150 kHz	18141A	8-26.08.2011
GPS Base Data	Whelans	Static GPS	18141A	8-26.08.2011
Base Stn Coords	Landgate	SSM	18141A	08.2011
Field Survey Data	Whelans	GPS RTK	18141A	9-14.08.2011

LASER DATA CHARACTERISTICS

Characteristic	Description
Format	Las 1.2, TIF (See Data Volume 18141A01NOP)
Captured terrain model	5.5 point/s per 1m ² .
Model key points	Points not contributing to the terrain definition within 0.10 m removed
Laser return	1 st , 2 nd 3 rd and last
Laser Intensity	Supplied on all pulse returns
Laser footprint size	0.15 m (approximate)
Laser mode	Single Pulse

REFERENCE SYSTEMS

	Horizontal	Vertical
Datum	GDA94	
Projection	MGA	N/A
Geoid Model	N/A	EGM08
Primary Survey control (Cocos Island, MGA47)	SSM15 263 649.145 E 8 652 117.503 N	2.791RL (CKIHD)
Primary Survey control (Christmas Island, MGA48)	SSM 6 575 554.367 E 8 844 686.779 N	259.897 RL (CIHD)
Control Points (Cocos Island, MGA47)	SSM101 270 775.997 E 8 659 677.904 N	1.601 RL (CKIHD)
Control Points (Christmas Island, MGA48)	SSM9 575 293.075 E 8 846 649.276 N	301.566 RL (CIHD)
	SSM102 570867.942 E 8 832 551.963 N	218.103 RL (CIHD) Whelans re-surveyed
	SSM129 569002.478 E 8 841 830.035 N	226.151 RL (CIHD) Whelans re-surveyed
	SSM274 573 823.603 E 8 848 309.809 N	17.822 RL (CIHD) Whelans re-surveyed
	SSM700 562 504.983 E 8 841 970.932 N	213.905 RL (CIHD) Whelans re-surveyed

Note: On 01-01-2000, Australia formally changed its reference spheroid from AGD to GDA94, and its map grid from AMG to MGA. MGA coordinates are approximately 200m different from AMG.



GDA This data is GDA-compliant

5. ACCURACY

PROJECT DESIGN ACCURACY

Project specifications and technical processes were designed to achieve data accuracies as follows:

Laser Data	Measured Point	Derived Point	Basis of Estimation
Vertical data Horizontal data	< 0.45m	0.15m	Project Design System specifications

Camera Data	Measured Point	Derived Point	Basis of Estimation
Horizontal data	0.30m		Project Design

Notes On Expected Accuracy

- Values shown represent standard error (68% confidence level or 1 sigma), in metres.
- “Derived points” are those interpolated from a terrain model.
- “Measured points” are those observed directly.
- Accuracy estimates for terrain modeling refer to the terrain definition on clear ground. Ground definition in vegetated terrain may contain localized areas with systematic errors or outliers which fall outside this accuracy estimate.
- Laser strikes have been classified into “ground” and “unclassified”, based upon algorithms tailored for major terrain/vegetation combinations existing in the project area. The definition of the ground may be less accurate in isolated pockets of dissimilar terrain/vegetation combinations.

LIMITATIONS OF DATA

- The definition of the ground under trees may be less accurate.

DATA VALIDATION

- **Cocos Islands**

Ground data in this volume has been compared to 462 test points obtained by field survey and assumed to be error-free. The test points were distributed in 5 groups across the mapping area and located on open clear ground. Comparison of the field test points with elevations interpolated from measured data resulted in:

Ref Point Site (Ref SSM)	No. of Points	Mean Difference (m)	Std Deviation (m)	RMS (m)
Site1 (PSM101)	101	-0.390	0.016	0.391
Site2 (PSM101)	94	-0.410	0.022	0.411
Site4 (PSM15)	94	-0.234	0.013	0.235
Site5 (PSM15)	75	-0.221	0.013	0.222
Site6 (PSM15)	98	-0.261	0.027	0.261

Test sites 1 and 2 were referenced to SSM101 on the Eastern Island (Home Island) and Sites 4, 5 and 6 were referenced to SSM15 on the Western Island. The difference of ~0.14 m between datums has been revealed. This was also confirmed by precise GPS surveys

conducted by Landgate, (refer to Linda Morgan, Landgate). As some of the difference could be attributed to the low resolution/low accuracy geoid model (EGM08), it is believed that this, rather than errors in leveling, could be responsible for the majority of the difference. It has been agreed between Landgate, Geoscience Australia and AAM to readjust SSM101 by -0.118m (Linda Morgan, Landgate) to bring the Home Island datum in line with the Western Island.

After re-adjusting Sites 1 and 2 the mean difference of -0.255 m has been calculated using all five sites. This mean difference has been removed from the data.

Final accuracy estimates after removing the mean offset yielded:

Ref Point Site (Ref SSM)	No. of Points	Mean Difference (m)	Std Deviation (m)	RMS (m)
Site1 (PSM101)	101	-0.014	0.016	0.021
Site2 (PSM101)	94	-0.029	0.022	0.036
Site4 (PSM15)	94	0.026	0.013	0.029
Site5 (PSM15)	75	0.039	0.013	0.041
Site6 (PSM15)	98	0.001	0.027	0.027

- **Christmas Island**

Ground data in this volume has been compared to 436 test points obtained by field survey and assumed to be error-free. The test points were distributed in 5 groups across the mapping area and located on open clear ground. Comparison of the field test points with elevations interpolated from measured data resulted in:

Ref Point Site (Ref SSM)	No. of Points	Mean Difference (m)	Std Deviation (m)	RMS (m)
Site1 (SSM274)	50	-0.180	0.021	0.181
Site3 (SSM9)	92	-0.197	0.014	0.197
Site4 (SSM102)	93	-0.259	0.015	0.260
Site5 (SM129)	75	-0.257	0.008	0.257
Site6 (SSM700)	102	-0.176	0.019	0.177

The mean difference of -0.214 m has been removed from the data. Final accuracy estimates after removing the mean offset yielded:

Ref Point Site (Ref SSM)	No. of Points	Mean Difference (m)	Std Deviation (m)	RMS (m)
Site1 (SSM274)	50	0.030	0.021	0.036
Site3 (SSM9)	92	0.013	0.014	0.019
Site4 (SSM102)	93	-0.049	0.015	0.052
Site5 (SM129)	75	-0.047	0.008	0.047
Site6 (SSM700)	102	0.034	0.019	0.039

As not all available SSM's have been spirit leveled, Whelans Survey Company has setup and solved a homogeneous GPS network that linked all SSM's. The new orthometric heights are based on GPS observations and the EGM08 geoid model. It has been noted that spirit leveled SSM274 (18.035) has a new derived orthometric height of 17.822m. As some of the difference could be attributed to the low resolution/low accuracy geoid model (EGM08), it is

believed that this, rather than errors in leveling, could be responsible for the majority of the difference.

- Data classification has been manually checked and edited against available ortho images.

Cocos Islands Landcover analysis

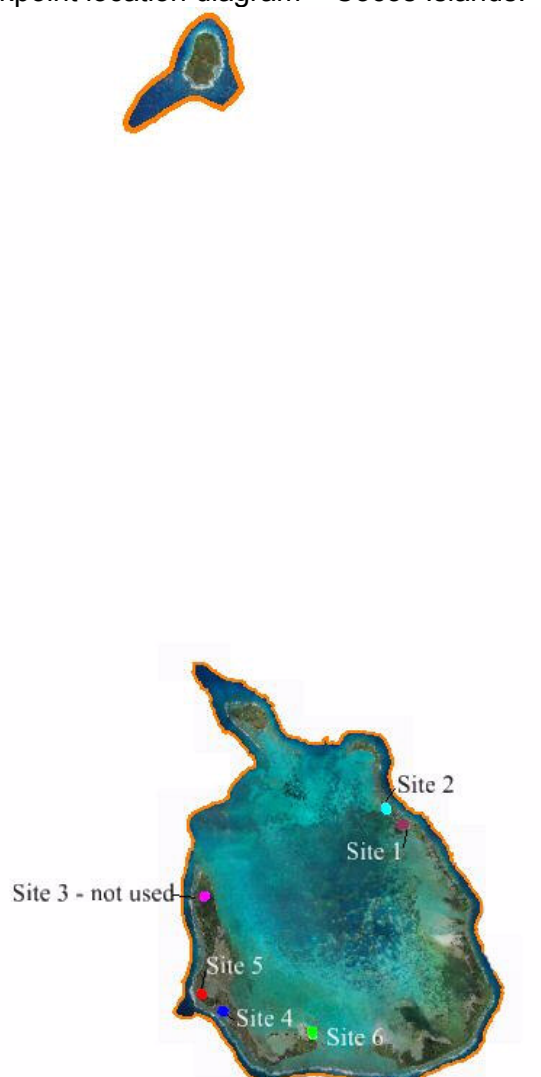
Vertical Accuracy – LiDAR Data

Landcover Class	No. of Points	Mean Difference (m)	Std Deviation (m)	RMS (m)
Open Cleared Areas (Class 2)	462	0.005	0.018	0.031
Dense Timber (Class 3)	131	0.107	0.087	0.144
Medium, Low Bushes (Class 4)	0	--	--	--
Grassed Areas (Class 5)	267	0.053	0.023	0.06

Vertical Accuracy Comparison with Data Specification– All Landcover Classes

Landcover Class	Within $\pm 0.15\text{m}$	Outside $\pm 0.15\text{m}$	Total	% Within $\pm 0.15\text{m}$	% Outside $\pm 0.15\text{m}$
Open Cleared Areas (Class 2)	462	0	462	100	0
Dense Timber (Class 3)	91	40	131	69	31
Medium, Low Bushes (Class 4)	--	--	0	--	--
Grassed Areas (Class 5)	267	0	267	100	0

Checkpoint location diagram – Cocos Islands.



Cocos Islands Checkpoint Site 1



Cocos Islands Checkpoint Site 2



Cocos Islands Checkpoint Site 4



Cocos Islands Checkpoint Site 5



Cocos Islands Checkpoint Site 6



Christmas Island Landcover analysis

Vertical Accuracy – LiDAR Data

Landcover Class	No. of Points	Mean Difference (m)	Std Deviation (m)	RMS (m)
Open Cleared Areas (Class 2)	436	-0.007	0.016	0.037
Dense Timber (Class 3)	77	0.021	0.034	0.05
Medium, Low Bushes (Class 4)	130	0.056	0.075	0.107
Grassed Areas (Class 5)	100	0.011	0.033	0.054

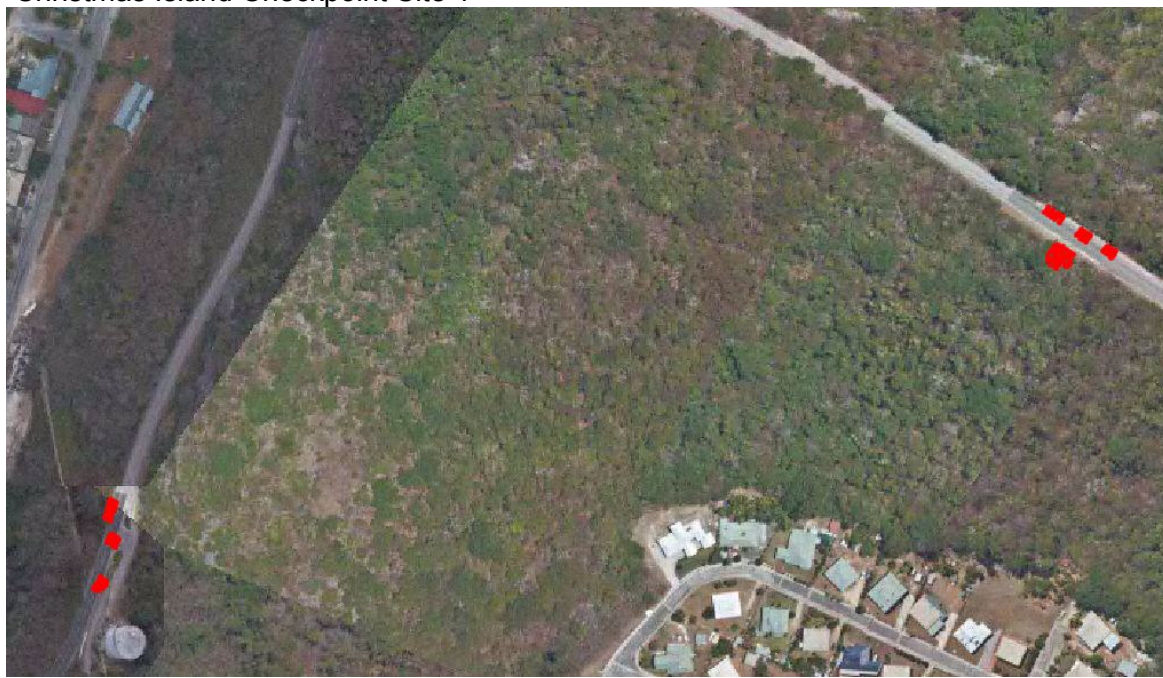
Vertical Accuracy Comparison with Data Specification – All Landcover Classes

Landcover Class	Within $\pm 0.15\text{m}$	Outside $\pm 0.15\text{m}$	Total	% Within $\pm 0.15\text{m}$	% Outside $\pm 0.15\text{m}$
Open Cleared Areas (Class 2)	436	0	436	100	0
Dense Timber (Class 3)	77	0	77	100	0
Medium, Low Bushes (Class 4)	109	21	130	84	16
Grassed Areas (Class 5)	100	0	100	100	0

Checkpoint location diagram – Christmas Island.



Christmas Island Checkpoint Site 1



Christmas Island Checkpoint Site 3



Christmas Island Checkpoint Site 4



Christmas Island Checkpoint Site 5



Christmas Island Checkpoint Site 6



USE OF DATA

- Intended use: Environmental management.
Infrastructure management.

6. CONDITIONS OF SUPPLY

The data in this volume has been commissioned by **GEOSCIENCE AUSTRALIA**.

The data in this volume is provided by AAM Pty Limited (AAM) to **GEOSCIENCE AUSTRALIA** under the client's Terms of Engagement, which allow **GEOSCIENCE AUSTRALIA** to full IP Ownership which resides with the Commonwealth of Australia and No IP for AAM is retained.

Any problems associated with the information in the data files contained in this volume should be reported to AAM Pty Limited. A complete list of project related contacts is listed on page 2 under the Project Report heading.

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7. VALIDATION PLOTS

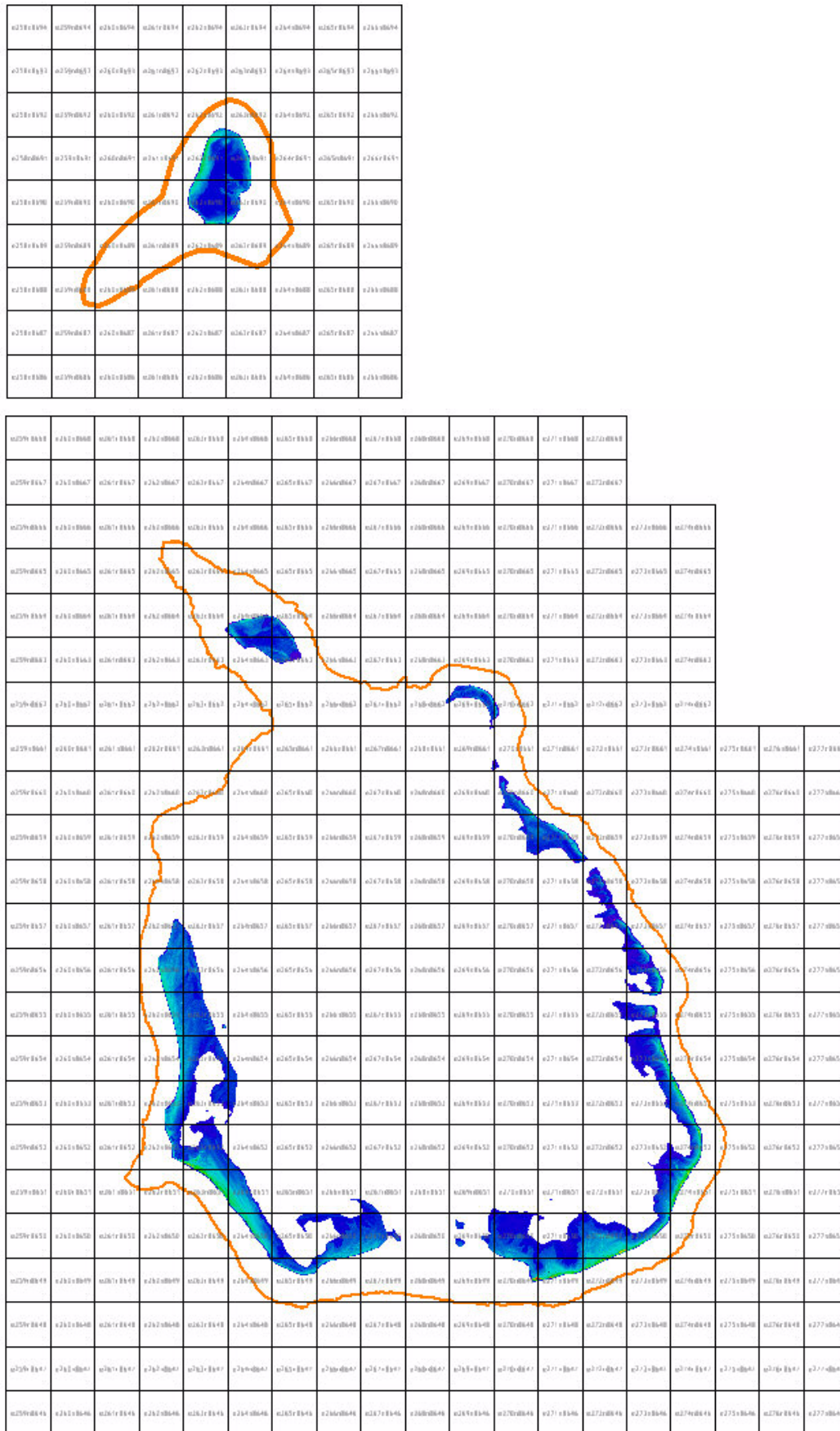


Figure 1 – Cocos Islands Digital Terrain Model

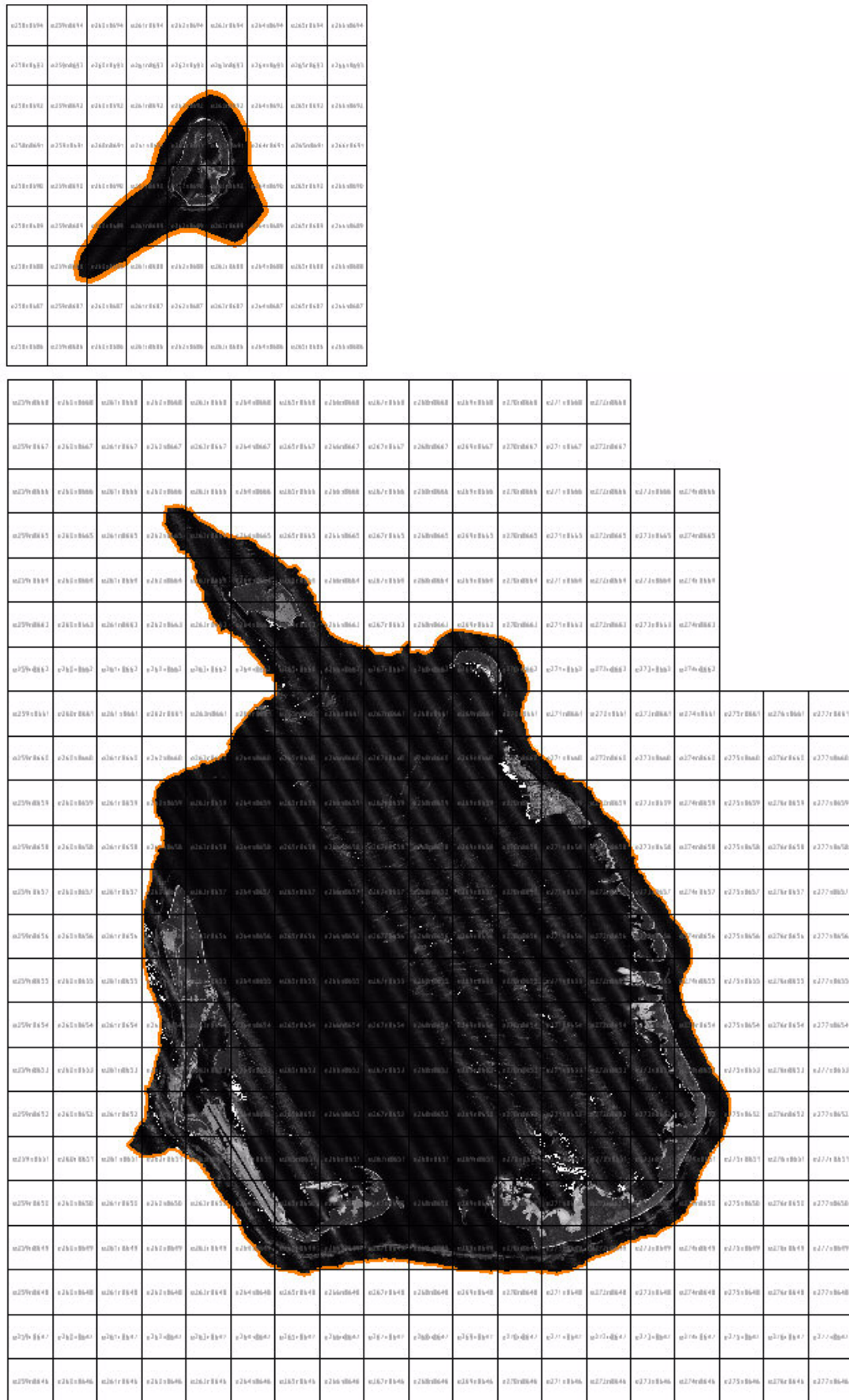


Figure 2 – Cocos Islands Intensity images

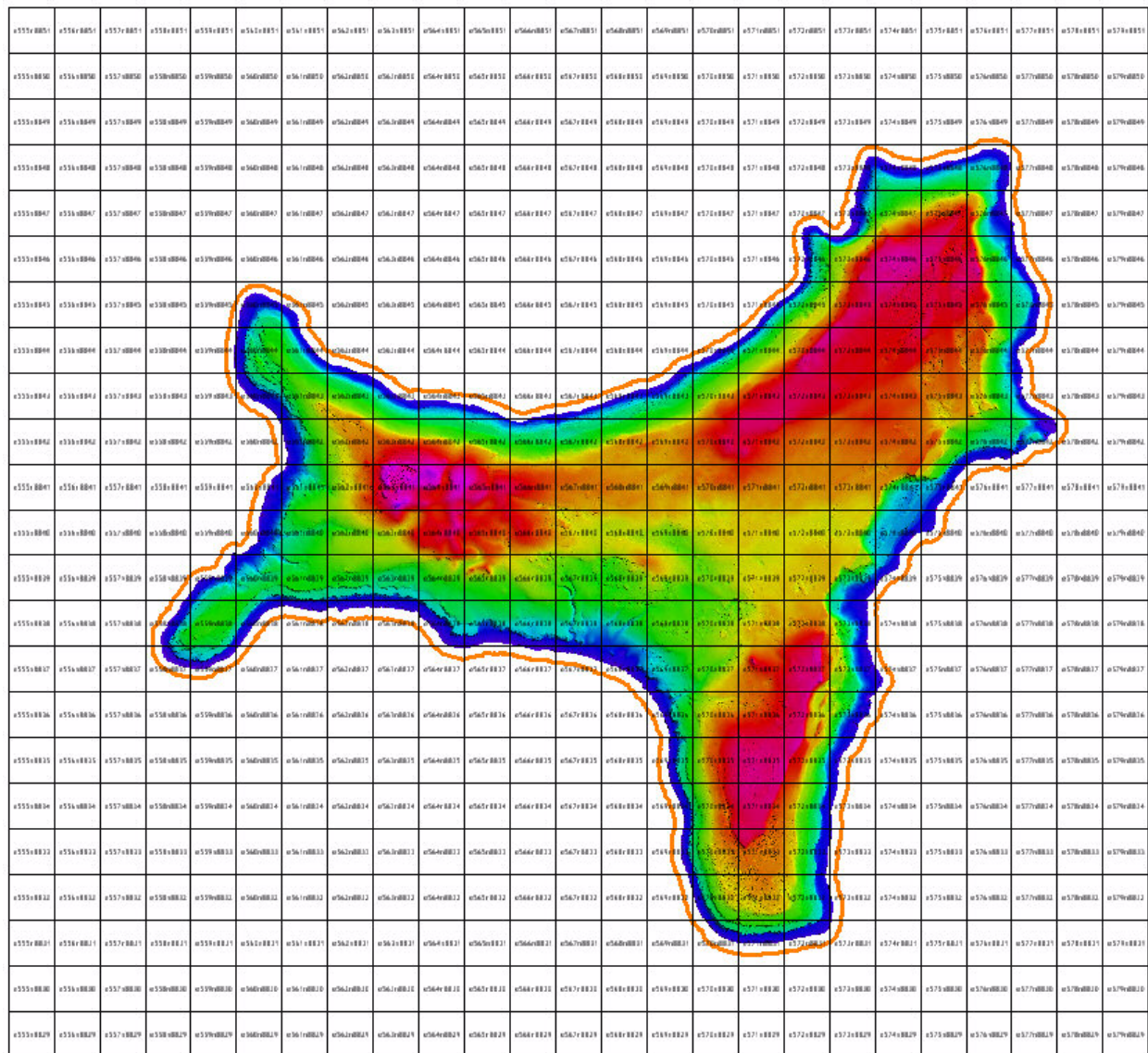


Figure 3 – Christmas Island Digital Terrain Model

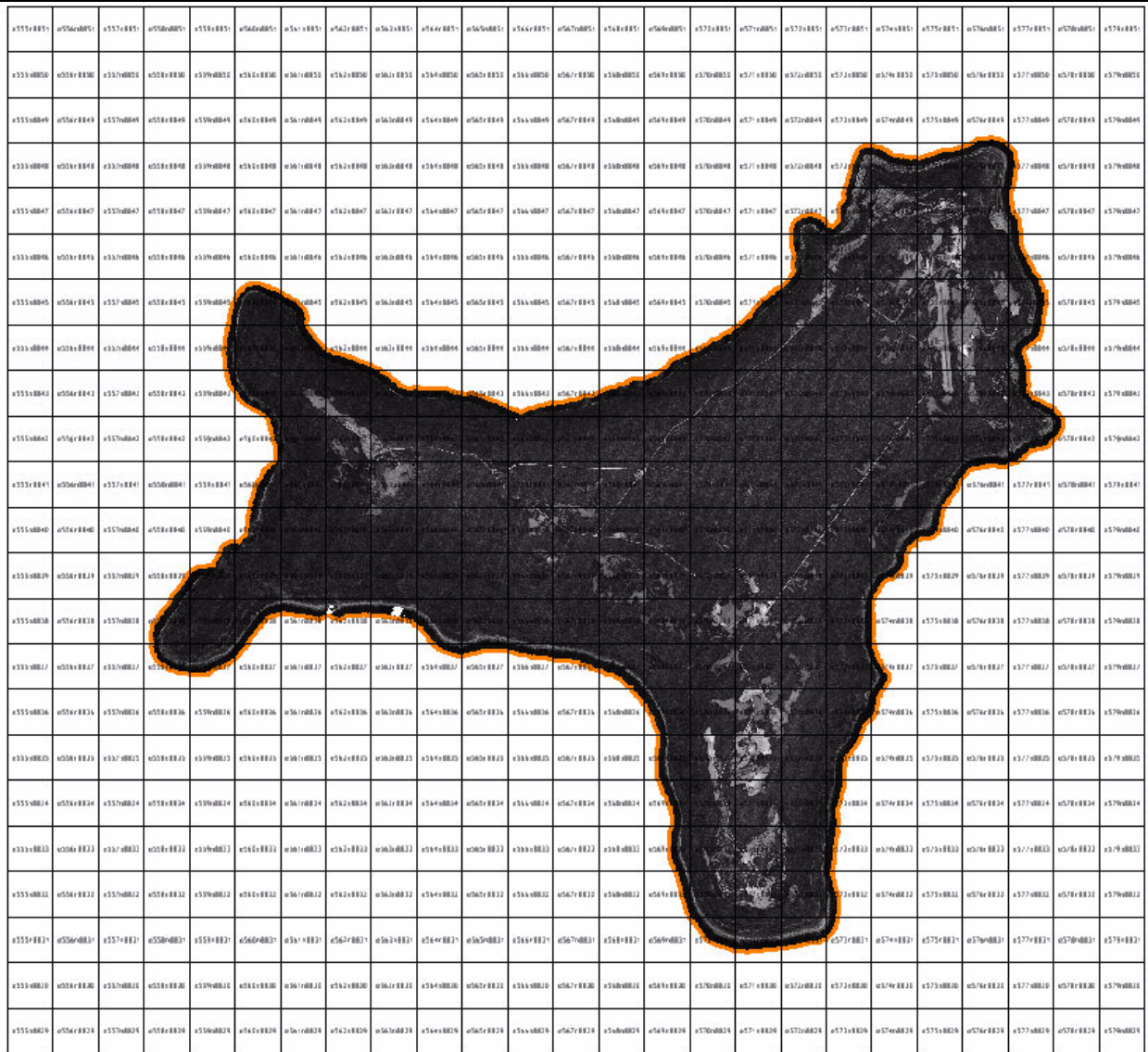


Figure 4 – Christmas Island Intensity images



Figure 5 – Cocos Islands Orthorectified Imagery



Figure 6 – Christmas Island Orthorectified Imagery