Lidar Survey Report Partenavia P68C

Tampa Bay Nearshore Survey
Lidar Survey | Florida, USA

P040085_Report_of_Survey (01) | 30 September 2022

For Review

Center for Ocean Mapping & Integrative Technologies, University of South Florida

Document Control

Document Information

Project Title	Tampa Bay Nearshore Survey
Document Title	Lidar Survey Report Partenavia P68C
Fugro Project No.	P040085
Fugro Document No.	P040085_Report_of_Survey
Issue Number	(01)
Issue Status	For Review

Client Information

Client	Center for Ocean Mapping & Integrative Technologies, University of South Florida
Client Address	830 1st Street SE, St. Petersburg, Florida, USA
Client Contact	Steve Murawski

Revision History

Issue	Date	Status	Comments on Content	Prepared By	Checked By	Approved By
01	30 Sept. 2022	For Review	Awaiting client comments	MB	AM	

Project Team

Initials	Name	Role
AM	Arjan Mooij	Operations Manager
RG	Richard Goosen	Charge Surveyor
TM	Tiziana Munene	LiDAR Operator
JM	Jose Martinez	Data Processing and Analysis
MB	Marshall Blackbourn	Data Processing and Analysis
DD	David Dietzler	System Engineer

FUGRO
Fugro USA Marine, Inc.
6100 Hillcroft Avenue
Houston, Texas 77081
USA

USF College of Marine Science
830 1st Street SE
St. Petersburg, Florida, USA

30 September 2022

Dear Sir/Madam,

We have the pleasure of submitting the 'Lidar Survey Report Partenavia P68C' for the 'Tampa Bay Nearshore Survey'. This report has been compiled by Marshall Blackbourn and presents the details of lidar operations and processing results.

We hope that you find this report to your satisfaction; should you have any queries, please do not hesitate to contact us.

Yours faithfully,

Marshall Blackbourn
Fugro USA Marine Senior Hydrographer

Executive Summary

This Lidar project took place between 6 January and 10 January 2022. This period encompassed the mobilisation of the Partenavia P68C Aircraft, full system calibration and seven acquisition flights to ensure that specifications were met. On completion of operations, post processing commenced, concluding on 14 April 2022.

Contents

Figures in the Main Text

Tables in the Main Text

Abbreviations

ALB	Airborne Lidar Bathymetry
AGL	Above Ground Level
ANPD	Aggregate nominal pulse density
ANPS	Aggregate Nominal Pulse spacing
AOI	Areas of interest
CMG	Course made good
GCP	Ground Control Point
IMU	Inertial measurement unit
ITRF	International Terrestrial Reference Frame
Lidar	Light Detection and Ranging
MBES	Multibeam echosounder
RAMMS	Rapid Airborne Multibeam Mapping System
RTK	Real time kinematic
UTM	Universal Transverse Mercator

1. Introduction

1.1 Objective

Fugro was tasked by USF with completing a high-resolution shallow bathymetric survey for the western shoreline of Florida in the vicinity of St. Petersburg between Madeira Beach and Bean Point Beach within the specified area of interest (AOI). The task was to acquire the sounding density requirements from the shoreline to an approximate 5m contour, with survey extents of approximately 185km^2. To achieve the requirements of the survey, Fugro mobilised their RAMMS bathymetric multibeam lidar system to survey the shoreline from the water edge limit to the specified offshore project extents. Additionally, a Riegl 680i topographic lidar system was mounted to collect elevation data between the waterline and the inshore survey limits. Fugro achieved acceptable results to meet the scope of this survey, with depths of in excess of 10 m collected over the course of multiple acquisition attempts. For the final deliverables, topographic data within the client-provided survey limits are being provided.

1.2 Survey Overview

The tables below outline the parameters for bathymetry (Table 1-1) and topography (Table 1-2)

Table 1-1: Bathymetric survey parameters overview

Description	Proposed
Nominal flying altitude	325m
Ground speed	110kt
Distance between flight lines	240m
Overlap between swaths	50%
Swath width	290m
ANPS	0.7m
ANPD	≥1/m^2

Table 1-2: Topographic survey parameters overview

Description	Proposed
Nominal flying altitude	325m
Ground speed	110kt
Distance between flight lines	350m
Overlap between swaths	>100%
Swath width	375m
ANPD	>10points/m^2

1.3 Survey Location

Nearshore survey efforts took place as specified by USF, along the western coastline of Florida in the vicinity of St. Petersburg between Madeira Beach and Bean Point Beach. The AOI encompassed approximately 185km².

Figure 1-1 presents a project location overview map.

Figure 1-1: Area of Interest, Tampa Bay/Atlantic Ocean, Florida, USA

1.4 Geodetic Parameters

The project geodetic and projection parameters are summarized in Table 1-3.

Table 1-3: Project Geodetic and Projection Parameters

Project Global Positioning System Geodetic Parameters	
Datum:	NAD83 2011 (epoch 2010)
EPSG code:	26917
Semi major axis:	6 378 137.000 m
Semi minor axis:	6 356 752.314 m
Reciprocal flattening:	298.257222101
Project Projection Parameters	
Grid Projection:	NAD83 UTM Zone 17N
Central Meridian:	081° 00′ 00.000″ West
Latitude of Origin:	00° 00′ 00.000″ North
False Easting:	500 000 m
False Northing:	0 m
Scale Factor at Central Meridian:	0.9996
Units:	Metre

1.5 Vertical Datum

All data is being delivered relative to NAD83 2011 (epoch 2010) based on the GRS80 ellipsoid.

2. Operations

2.1 Summary of Events

A summary of key events is provided in Table 2-1.

Table 2-1: Summary of Key Events

Date	Location	Event
Wed, 5 January 2022	St. Petersburg, FL	Aircraft arrival onsite
Thu, 6 January 2022	St. Petersburg, FL	Two RAMMS acquisition flights conducted
Fri, 7 January 2022	St. Petersburg, FL	One RAMMS acquisition flight conducted
Sat, 8 January 2022	St. Petersburg, FL	Two Riegl acquisition flights conducted
Sun, 9 January 2022	St. Petersburg, FL	One RAMMS acquisition flight conducted
Mon, 10 January 2022	St. Petersburg, FL	One RAMMS acquisition flight conducted
Tue, 11 January 2022	St. Petersburg, FL	Aircraft and equipment departure

2.2 Key Personnel

The key survey, management and processing personnel involved in the Lidar survey are outlined in Table 2-2.

Table 2-2: Key Personnel

Position	Name
Fugro Operations Manager	Arjan Mooij
Fugro Charge Surveyor	Richard Goosen
Fugro Lidar Operator	Tiziana Munene
Fugro Data Processor	Jose Martinez
Fugro Data Processor	Charles Lapointe
Fugro Data Processor	Marshall Blackbourn
Fugro System Engineer	David Dietzler

2.3 Equipment

All equipment was mounted on a single base plate in the Partenavia P68C aircraft.

Table 2-3: Equipment List

Requirement	Equipment
Primary GNSS	Applanix PosAV 510 V6
GNSS Post-Processing	POSPac MMS 8.7
MRU and heading sensor	PosAV
Bathymetric Lidar	RAMMS 1
Topographic Lidar	Riegl 680i

2.4 Aircraft Details

An Aspen Helicopters' Partenavia P68C-6 was used as the acquisition platform for this survey. It is a low speed capable, high wing aircraft with large cargo/seating area that made it ideal for this project.

Figure 2-1: Partenavia P68C as used in this survey

2.5 Mobilisation & Calibrations

The Aircraft mobilisation was conducted in Oxnard, CA on 26 October 2021 at Aspen Helicopters' facility. All equipment installation and testing were completed in just a matter of hours. All final system checks and calibration flights were conducted in the vicinity of Oxnard, Ventura and Catalina Island, CA.

The system was calibrated in accordance with the Mobilisation Report following two calibration flights (one for the RAMMS system, one for the Riegl 680i system) over the calibration sites.

2.6 Survey Operations

The operation strategy called for four days to acquire data over the survey site at optimal weather states with sufficient standby time awarded to await a suitable survey window. Climatology suggested that January would be an appropriate time to collect bathymetric data, provided conditions were favourable.

Upon arrival of the aircraft in St. Petersburg it was determined that weather conditions allowed for immediate collection of RAMMS data. Three RAMMS acquisition flights were conducted over two days, provisionally completing acquisition in the entirety of the AOI.

Following the initial RAMMS data collection, and while assessment of the dataset took place, the Riegl 680i sensor was installed in the aircraft and two acquisition flights conducted, completing topographic acquisition in one day within the AOI.

It was then decided that additional “reflights” should take place using the RAMMS sensor to attempt to achieve better depth penetration in certain spots throughout the AOI. The RAMMS system was reinstalled and another two acquisition flights conducted over two days, with improved results achieved.

3. Field Procedures

3.1 Aircraft Offsets

In accordance with standard procedure and the work plan for this survey, offsets were determined between the IMU, the GNSS antenna and the lidar and camera sensors' reference centres from the design drawings of the equipment and the mounting plate. The GNSS to IMU lever arm was measured and then verified with the post-processing of the inertial navigation system trajectories in Applanix POSPac MMS survey suite. The GNSS/IMU lever arm values are checked with each trajectory processed to ensure that the values are consistent. Below are the offset results from dimensional control and post processing.

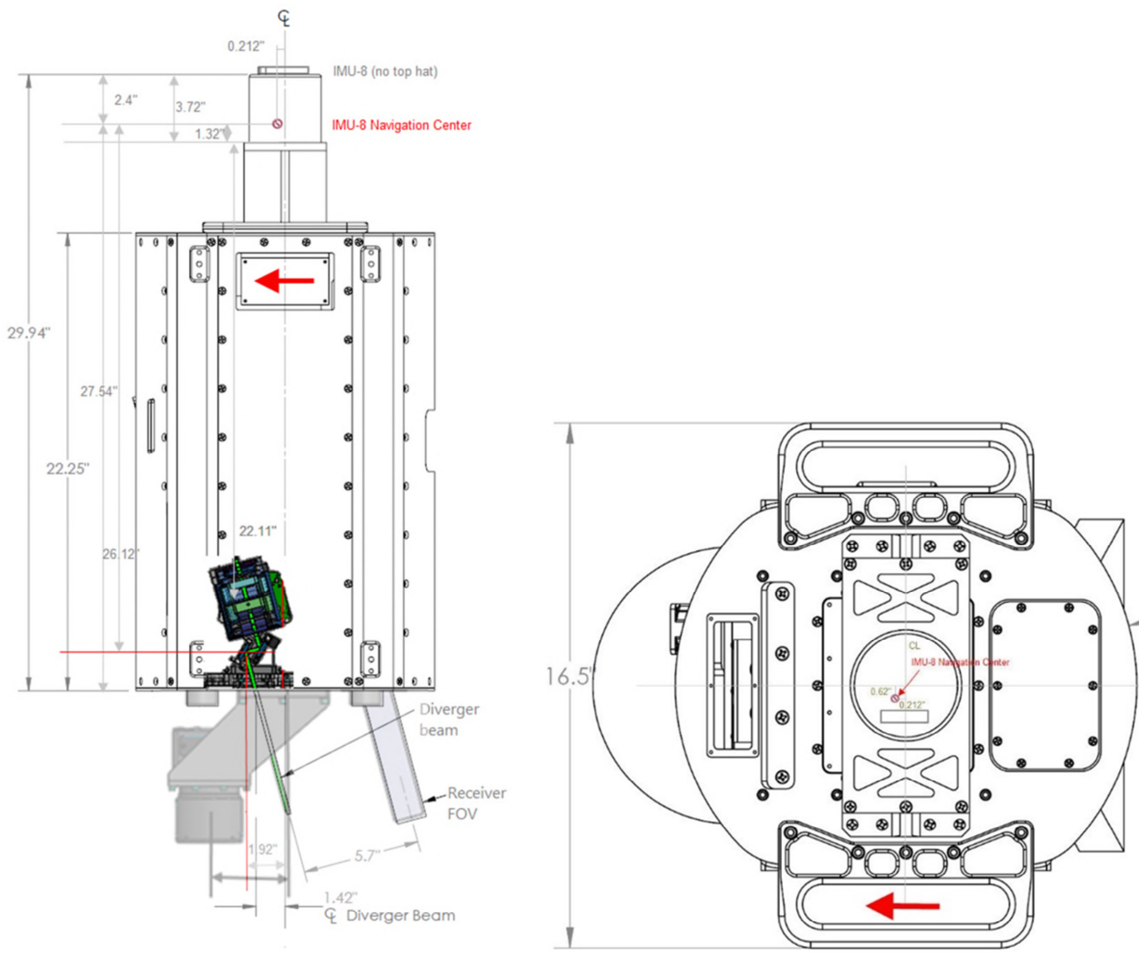

Figure 3-1: RAMMS sensor with IMU and PhaseOne cameras (sideways, left; top view, right). Red arrow points forward on the X-axis. Dimensions are in inches.

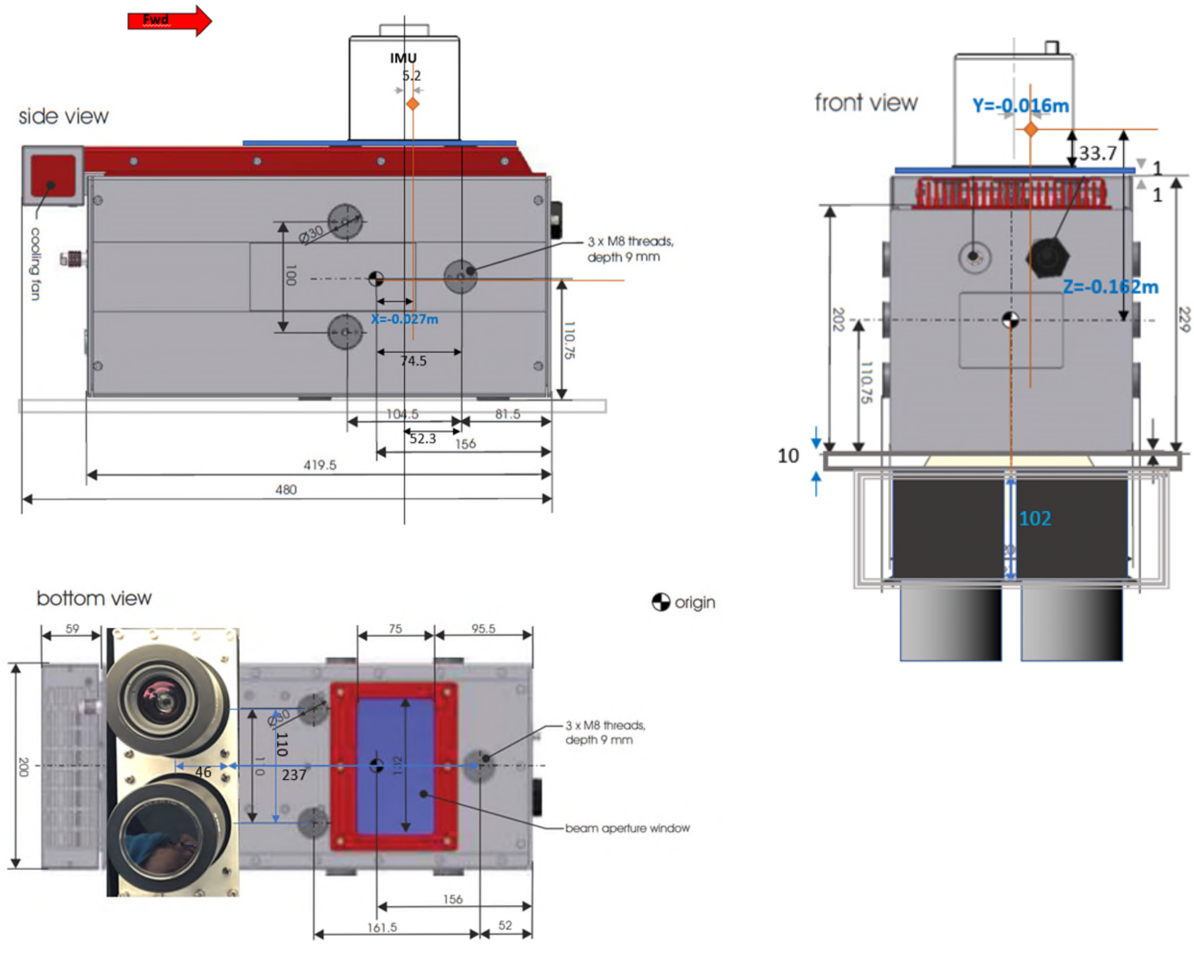

Figure 3-2: Q680i sensor with IMU and PhaseOne cameras (clockwise views: side; front;, bottom) Red arrow points forward on the X-axis. Dimensions in millimetres.

Table 3-1 RAMMS installation lever arms offsets (in meters)

POS AV Reference to:	X	Y	Z
IMU	0.000	0.000	0.000
RAMMS	0.043	0.016	0.663
PhaseOne stdb	0.118	0.067	0.824
PhaseOne port	0.118	-0.035	0.824
GNSS Antenna	-0.916	-0.182	-0.655

Table 3-2 Riegl Q680i installation lever arms offsets (in meters)

POS AV Reference to:	X	Y	Z
IMU	0.000	0.000	0.000
Riegl Q680i	-0.027	0.016	0.163
PhaseOne stdb	-0.206	0.071	0.386
PhaseOne port	-0.206	-0.039	0.386
GNSS Antenna	-0.980	-0.179	-0.988

4. Data Processing

4.1 General Processing

Data processing was performed via a hybrid approach of back-up and preliminary processing in the field, and final processing and deliverable generation in the Fugro office.

In general, the project's data processing workflow is summarised in the list below and represented in the diagram in Figure 4.1. These are in summary, the steps completed to produce the data deliverables:

- Transfer of raw acquired data to office server along with POS AV via solid state drives;
- Back-up of field data;
- Post-Processed trajectories from POS AV data are produced (SBET);
- SBET is produced in project's horizontal and vertical datum;
- RAMMS is synced with SBET and processed in RAMMS Processing Module (RPM) to produce point clouds in LAS format;
- Q680i is merged with SBET and processed in RiProcess to produce point clouds in LAS format
- RAMMS and Riegl data are imported into Global Mapper for cleaning, integration, validation and production of point cloud deliverables;
- Global Mapper Point Clouds are exported to ASCII XYZ, gridded surface (geotiff).
- Global Mapper is used to create full resolution and generalized surface contouring; polylines are exported to shapefile.
- Final deliverables are copied and delivered to client.

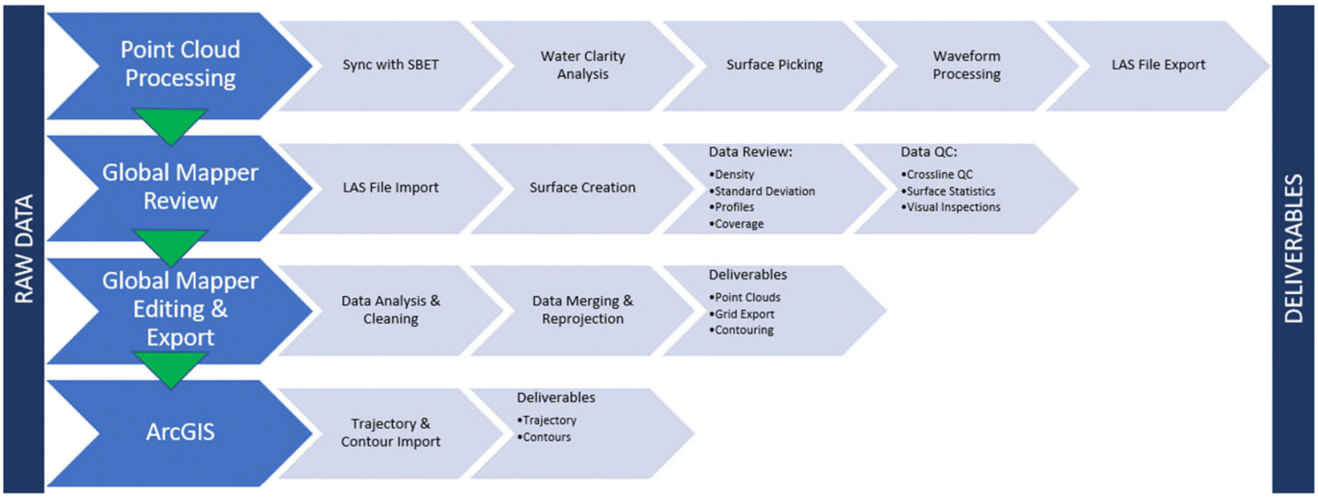

Figure 4-1: Data Processing Workflow

4.2 Aircraft Navigation

All navigation was post-processed in POSPAC MMS, using a local network of base stations to tie in to NAD83 in the UTM projection, Zone 17N. Using the post processed GNSS solution, a Smoothed Best Estimate of Trajectory is computed. This is synchronised with the RAMMS and

Riegl raw data during initial processing, using the common time stamp from the POSAV system.

SBET solutions were routinely reviewed to qualify positional accuracy through a complete report of the inertial processing results in POSPac. Specifically, the forward/backward processing results were compared, and differences plotted. This was compared the achieved accuracies from POSPAC.

Additionally, RAMMS and Riegl data was compared against each other and itself to ensure that the navigation solution was correct.

4.3 RAMMS

RAMMS data was processed in accordance with Fugro standards and protocols.

RAMMS data was of acceptable quality in all areas of interest given the conditions, with depths achieved beyond 10m.

4.4 Riegl

RIEGL data was of good quality in all areas of interest, with no gaps present in the point cloud.

5. Quality, Health, Safety and Environment

As an ISO 9001 compliant organization, Fugro applies due care to assuring the quality of the performance of our survey through several checks throughout the project.

5.1 Coverage

Coverage of the area was achieved using both airborne sensors. The surface below is gridded to 1m resolution and shows good overall representation of the coastline despite some gaps in coverage due to extremely shallow water or isolated turbidity.

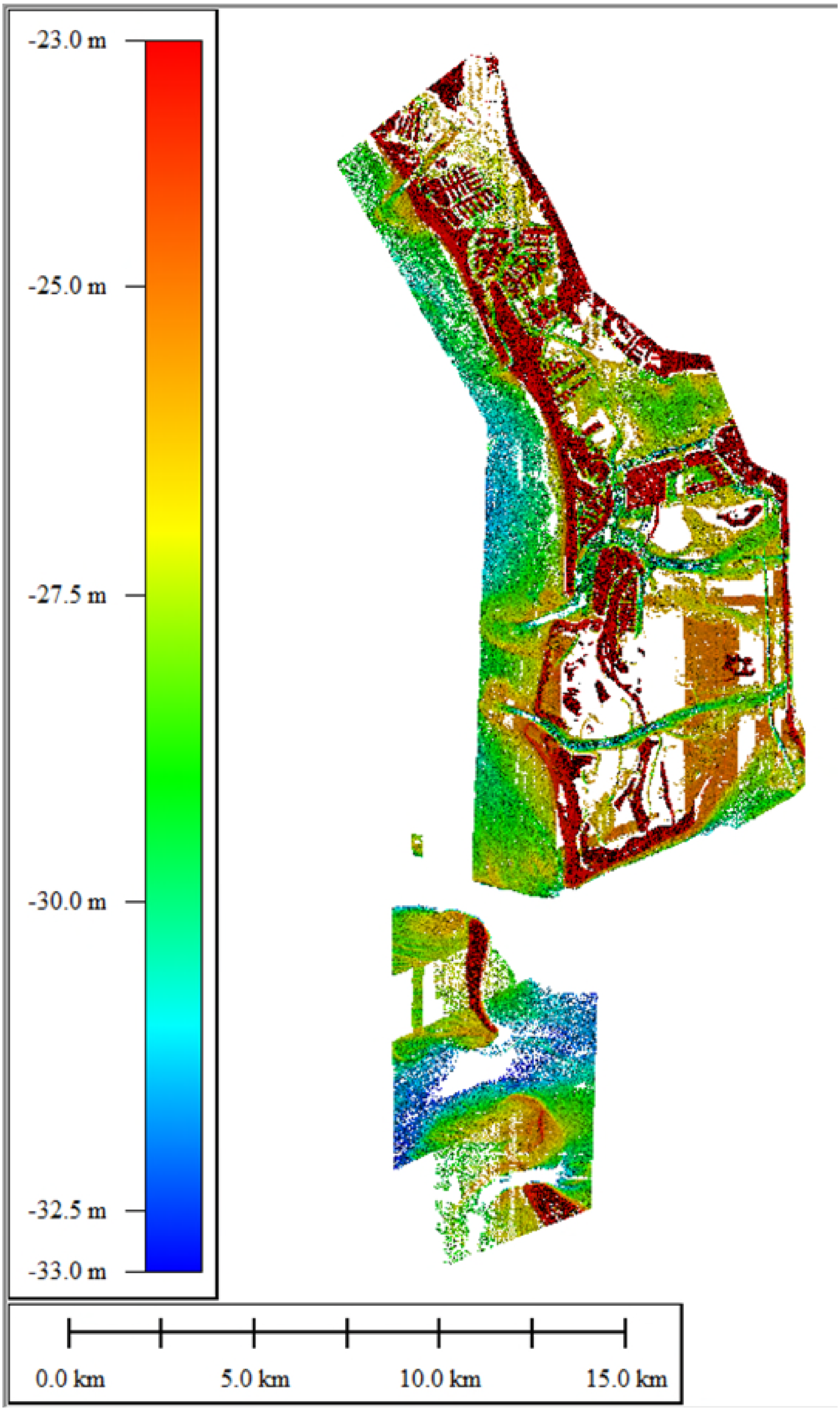

Figure 5-1 Tampa Bay Nearshore Survey Coverage

5.2 Density

In the graphic below, any cell failing 2 points/1m grid has either been plotted in red or is simply left empty, while passing cells are plotted in green. As can be expected, areas with high slope/rugosity or with breaking waves/white water experienced a reduction in density.

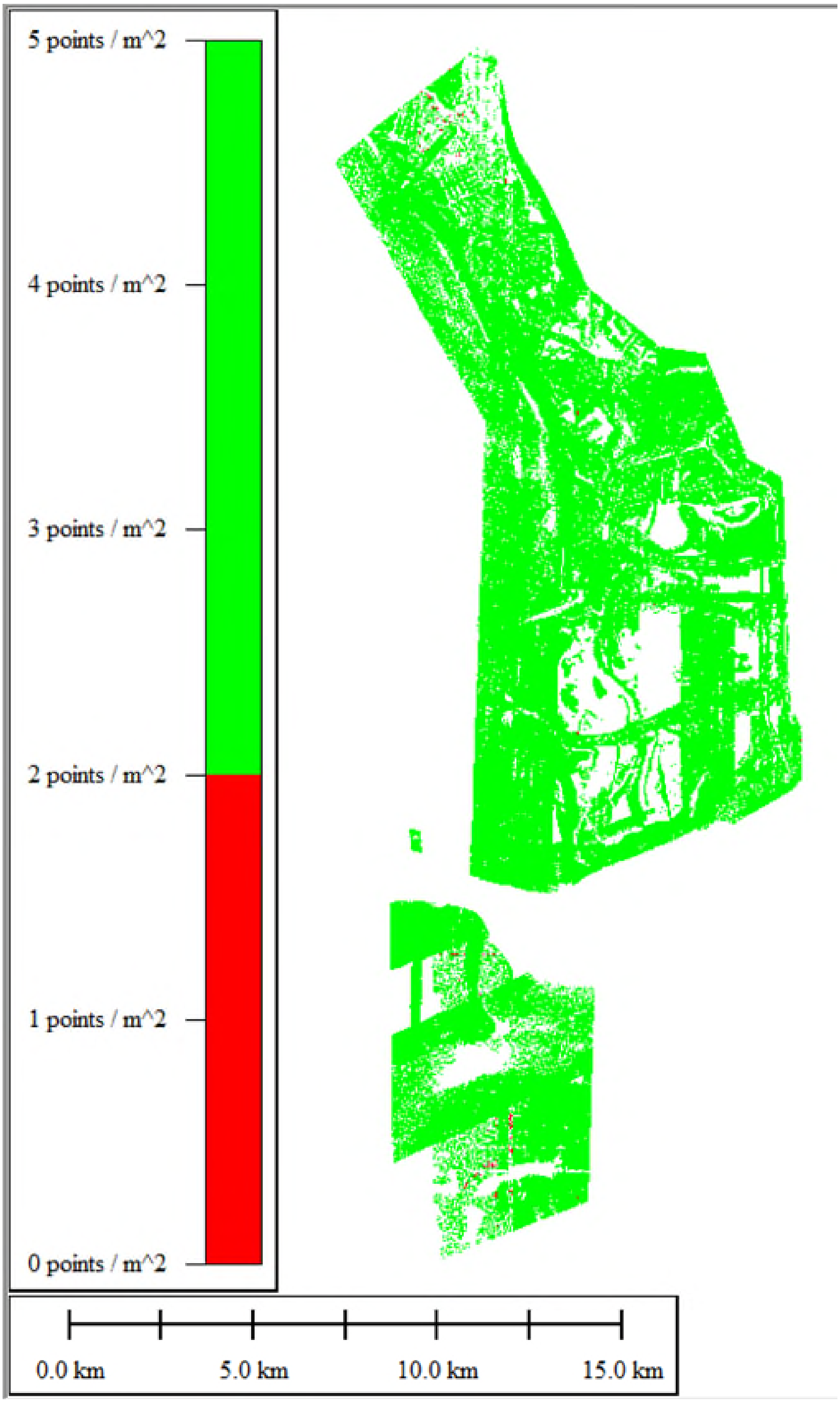

Figure 5-2 Tampa Bay Nearshore Survey Density Grid

5.3 Standard Deviation

Uncertainty of the combined dataset is shown below, with data falling well within 0.5m for most of the area, the only exceptions being in areas where the slope is significant enough to represent a >0.5m change in the bin size of the dataset (1m) such as in the surf zone, the dune line and any trees or manmade objects.

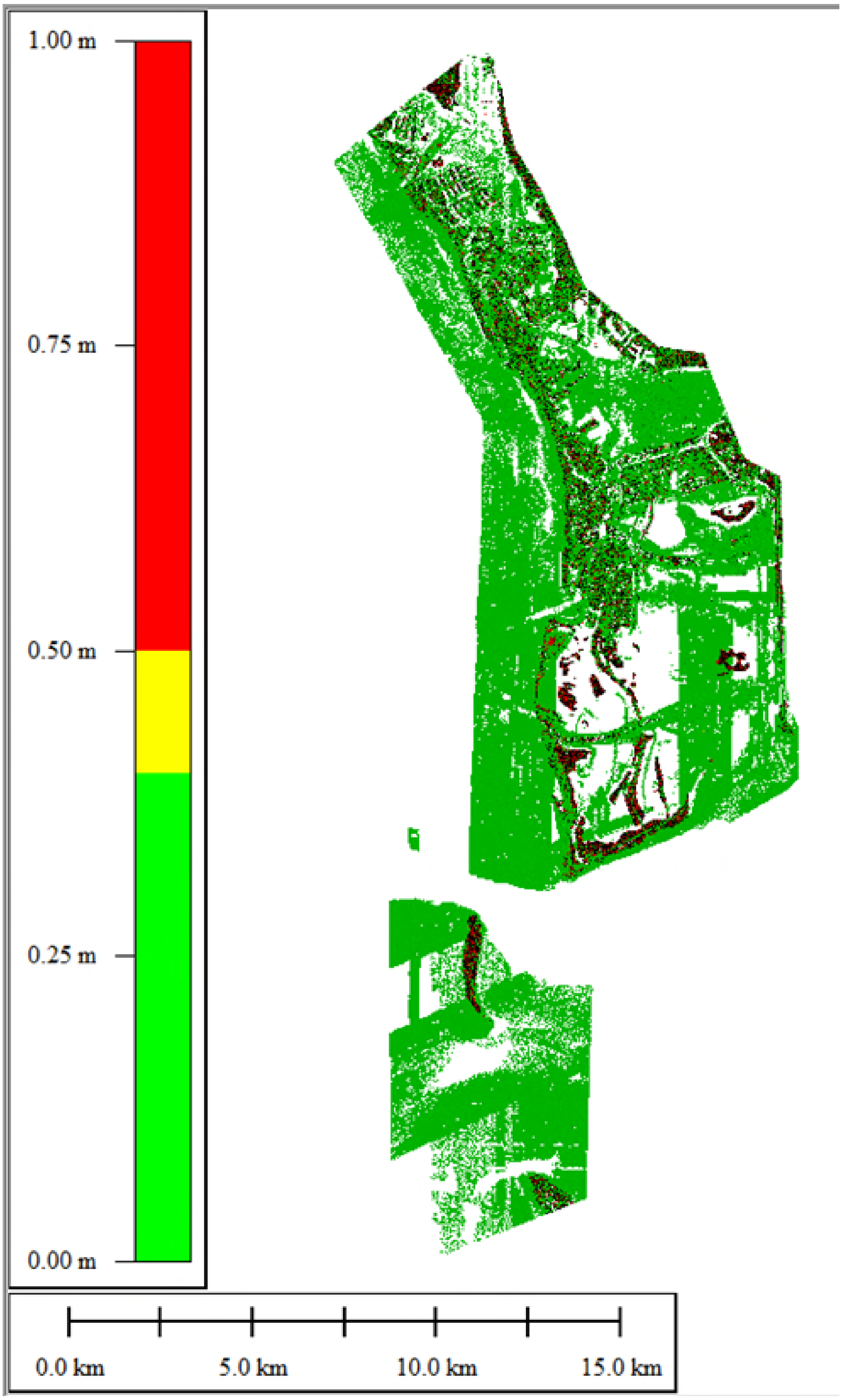

Figure 5-3 Tampa Bay Nearshore Survey Standard Deviation

5.4 Overall Point Cloud Inspection

The point cloud generated from datasets on every mission flight was inspected in Global Mapper for general coverage results, overlap matching, gaps and artifacts. Data was reviewed in the field to ensure completeness of the survey. In post processing, field cleaning was refined and data points classified to represent ground, seabed, water surface, noise or No Bottom Detected.

5.5 LiDAR Dynamic Height Check

Verification of the RAMMS and LMS-Q680i sensors' absolute vertical accuracy was checked during calibration flights by flying over a series of ground control points (GCP) located near the survey area. GCPs were accurately surveyed by using RTK (Real Time kinematic) GNSS techniques by Fugro staff over flat road surfaces. The RAMMS and LMS-Q680i point clouds were compared to the coordinates and z values of the independently surveyed GCPs.

5.6 Health, Safety and Environment

Fugro performed the survey operations with high regard for health and safety and the environment. A health, safety and environmental plan was completed prior to the start of the survey. This was produced in accordance with the company's Health Safety and Environmental Management System. All survey and crew members were required to read and sign this plan, to ensure they understood the work to be performed and the mitigating measures employed to minimise the identified risks.

During mobilisation and at regular intervals thereafter, safety briefings and toolbox talks were conducted to reiterate the risks relating to survey operations and steps taken to minimise these risks.

During operations a Hazard Observation Card (HOC) system was operated allowing crew to report unsafe acts, unsafe conditions, safe acts, or make HSE suggestions. No HOC cards were raised relating to any unsafe conditions associated with this particular project.