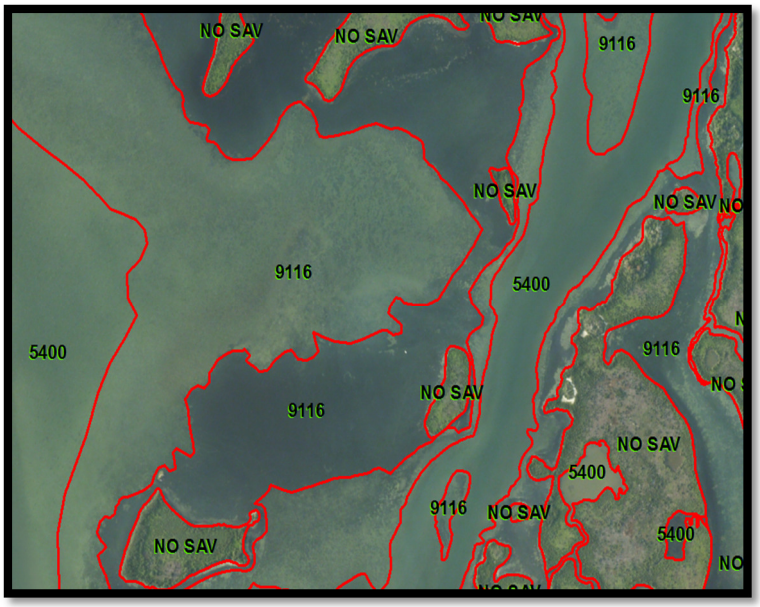
2015 Indian River Lagoon
Seagrass Mapping
Final Project Report



Project # 28172

Report Date: May 19, 2016

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Dewberry®

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1.0 Project Overview

Dewberry was contracted by the St. Johns River Water Management District (SJRWMD) to complete aerial imagery acquisition, orthophotography, field work, photointerpretation, and ArcGIS geodatabase delivery of seagrass maps within the Indian River Lagoon System (IRL). As a water resource manager, the SJRWMD requires geospatial technologies to help assess, monitor, analyze and manage water quality within the Indian River Lagoon. The many options surrounding geospatial technology today must be implemented strategically and cost effectively. The information derived from geospatial data can be instrumental only if the development of such data is designed to provide actionable information. The SJRWMD has made a significant investment in analyzing changes in seagrass distribution through the use of geospatial technology.

The mapping and trend analysis performed under this project provides quantifiable data vital to the assessment of water quality and the general health of the estuarine system. The resultant data provides an overall picture of the seagrass resource in the IRL over time. The maps serve as an important management tool for assessing distribution trends of the seagrass resource. They help identify healthy areas that may deserve special protection efforts along with potential problem areas that require further investigation.

This report describes the tasks and methodology used for the project along with the deliverables produced.

2.0 Project Area

The project area included the areas of Mosquito Lagoon north to Ponce de Leon Inlet, Banana River Lagoon, and Indian River Lagoon south to the Jupiter Inlet.

Figure 1 shows the extent of mapping performed for the project.

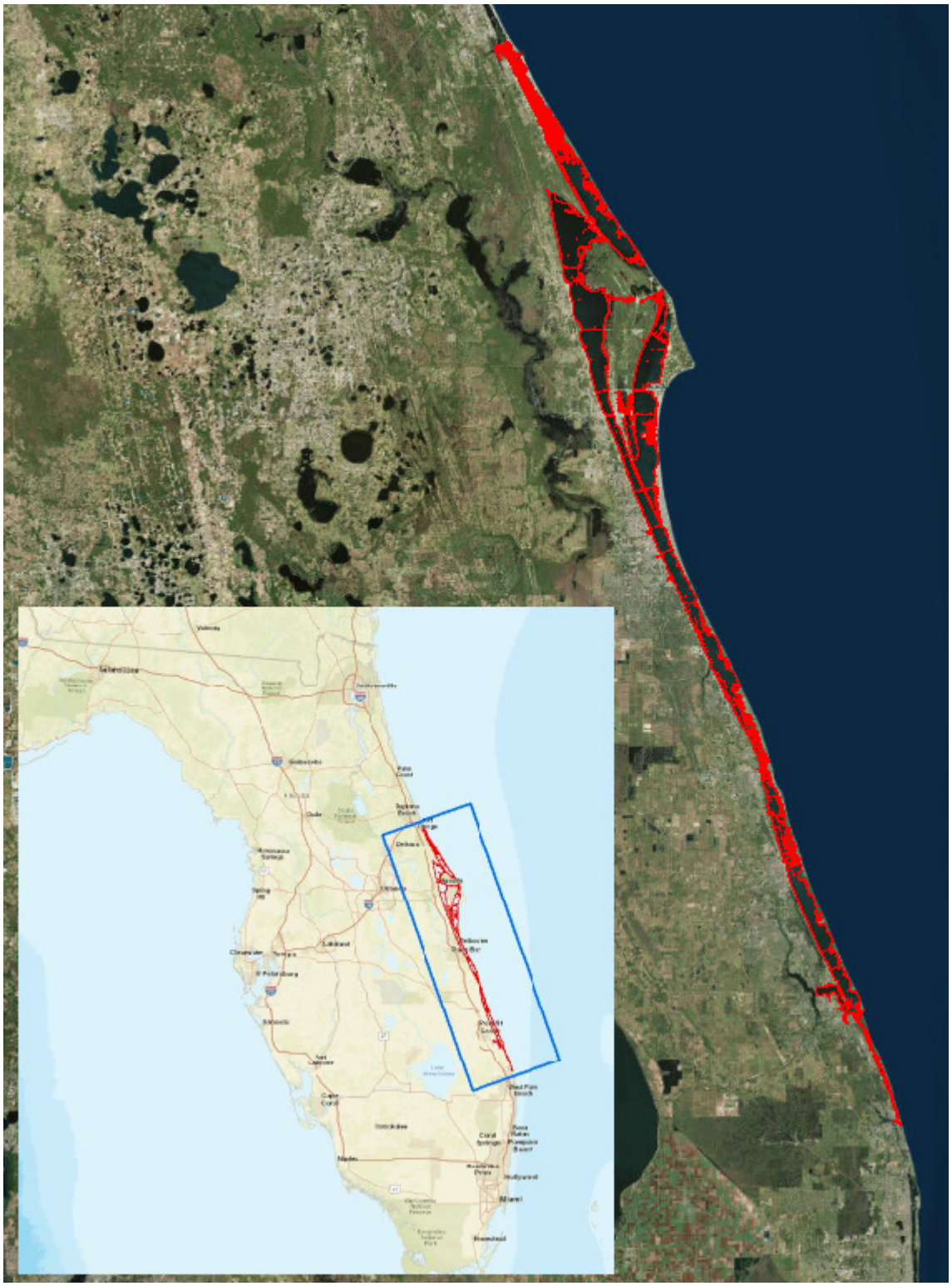

Figure 1 – Seagrass Mapping Project Boundary

3.0 Mapping Methodology

The following sections describe the methodology Dewberry used for the project.

3.1 Aerial Imagery Acquisition and Quality Control

Aerial imagery acquisition for the project required the careful design and constant evaluation of many parameters not normally associated with aerial imagery missions. These parameters included mobilization time, summer season weather patterns, sun angle, stereo overlap requirements, ground sample distance, ground control, base station location, virtual reference systems available for airborne GPS data, turbidity, local winds, tidal influences, controlled water releases within the watershed, localized anomalies, along with other parameters that made aerial imagery acquisition for the project complex.

In addition to the above parameters, access and flight clearance had to be authorized because the project area covers the Kennedy Space Center, Patrick AFB and other sensitive areas that possess a high level of security.

Imagery for the project was acquired using a Microsoft UltraCam Eagle frame-based sensor during multiple missions over the IRL. The imagery was collected free of smoke, clouds, shadows, haze, or sun glint under calm wind conditions. Imagery collection was accomplished during periods of high water clarity in order to capture the best exposure of submerged bottom features at a ground sampling distance (GSD) of 8.4 inches. Acquisition took place when the sun angle was between 15 and 30 degrees to reduce surface reflection from sun glint.

Attachment A contains the Imagery Acquisition Report delivered for the project and contains all the information associated with imagery acquisition.

Quality control was performed by both Dewberry and the SJRWMD on the raw imagery after collection. Imagery was collected over 12 days, May 8, 9, 12, 21, 22, 29, June 1, 5, 14, 18, 19, 26, 2015.

Upon acceptance of the raw imagery, aerotriangulation for the project was set up as a single image block of 13 adjacent and overlapping flight lines comprised of a total of 767 images. The imagery was controlled horizontally using a combination of airborne GPS/INS data and surveyed image-identifiable ground control points.

Attachment B contains the Aerotriangulation Report delivered for the project.

Dewberry then tested the accuracy of the aerotriangulation solution and produced orthophotography for the project. Spatial accuracy was tested using surveyed checkpoints. The project's specifications called for the spatial accuracy to conform to USGS National Map Accuracy Standards for 1:12,000 scale maps. The tested spatial accuracy was well within this specification.

Attachment C contains the Positional Accuracy Assessment Report delivered for the project.

Groundtruthing field work was completed throughout the project area in order to 1) ensure that signature identification was accomplished prior to photointerpretation; and 2) accomplish problem resolution and accuracy assessment groundtruthing during photo interpretation prior to map completion.

Before visiting the field, the photo interpreters reviewed signatures on the imagery. A field point feature class was created to catalog information obtained in the field. The fieldwork feature class was then taken to the field with the imagery displayed in ArcMap on a GPS-enabled ruggedized field laptop. The photo interpreters traveled to and located each field point accurately via GPS, compared the imagery to the seagrass, and documented the field information within ArcMap. This process was efficient and reliable and has been used by Dewberry's staff on many mapping assignments.

Additional field equipment included a digital snapshot camera that recorded coordinate location and bearing of the snapshot. The conditions occurring at each field point were photographed for inclusion within field documentation. Dewberry also used an underwater video drop camera to view bottom conditions at several sites and snorkeling was used at many sites.

All the information gathered in the field was incorporated within an ArcGIS feature class which was delivered for the project. The following information, relevant to photo interpretation, was documented within the feature class.

Issue – Details on why the point was placed by the photo interpreters.

Field Comments – Signature clarifications, site specific information and other information was recorded here.

Trip Date- Date of the fieldwork week

X and Y Coordinates – Spatial location

Figure 2 shows a portion of the field work feature class created for field work.

Table

Fieldpoints

OBJECTID_1 *	Shape *	OBJECTID	Issue	Field_Comm	Field_Date
40	Point	51	open water?	1406, looked bare	11/19/2015
41	Point	53	come back, fix polys	1359, cont syr, grass definitely present	11/19/2015
42	Point	55	grass?	1348, 4ft, looked like sparse hw	11/19/2015
43	Point	56	looks like grass or algae	1340, caul or dec?	11/19/2015
44	Point	57	grass?	1328, very soft mucky bottom sediment stirred up, almost no vis, drift	11/19/2015
45	Point	58	grass?	1321, looks like macro algae, hard to get camera too bottom	11/19/2015
46	Point	59	what is this?	1313, cont syr/hw, see vid	11/19/2015
47	Point	62	open water?	1304, crunchy bottom, but nice tall cont syr, some caul	11/19/2015
48	Point	64	looks like culerpa and syr - have Ryan look at	1318, no vis.	11/17/2015
49	Point	65	grass?	1312,cont syr med dense, check vid	11/17/2015
50	Point	66	bit of a dif sig, check	1308, looked like some hw or syr, strong winds and current	11/17/2015
51	Point	67	algae or grass?	1326, ripply bottom, mostly bare, few sprigs of syr	11/17/2015
52	Point	68	algae?	1334, cont decip, some drift	11/17/2015
53	Point	69	grass?	1340, looks like some syr, lot of bare bottom, ripply sand	11/17/2015
54	Point	70	more culerpa?	1348, hw/syr, and looks like dec	11/17/2015
55	Point	71	looks like nothing but culerpa	1405 looks mostly bare on point	11/17/2015
56	Point	72	mostly culerpa, plus some sparse syr	1354, syr and thal or caul, check vid	11/17/2015
57	Point	73	grass?	1417, spare syr and dec	11/17/2015
58	Point	74	grass?	1400, thal, some dec	11/17/2015

1 (0 out of 518 Selected)

Fieldpoints

Figure 2 – Field work shapefile attribute table

A significant amount of field work was accomplished for the project. A total of 679 field points were collected and documentation included 475 underwater video segments. Figure 3 is an example of the video clip with date and time stamp that is recorded in the field point attribute table.

Figure 3 – Field work underwater video of seagrass bed

Attachment D contains the Field Reports delivered for the project and details the dates, locations and field personnel who participated on field work.

3.2 Photo Interpretation Key

Dewberry and the SJRWMD collaboratively developed a Photo Interpretation Key that was used during photo interpretation to support decision-making and mapping consistency. The Photo Interpretation Key includes examples of seagrass delineated on aerial photographs and descriptions for each classification code used for the project. Delineation guidelines are also described.

Attachment E contains the Photo Interpretation Key delivered for the project.

3.3 Photo Interpretation

Seagrass mapping for the Indian River Lagoon Project was accomplished using stereo photo interpretation. Interpretation was accomplished using Dewberry's SOCET SET and SOCET GXP softcopy photogrammetry workstations interfaced with SOCET for ArcGIS software. This software allows photo interpreted data to be stored within the ArcGIS software environment. Using SOCET SET/GXP, Dewberry was able to capture the data using stereo imagery which allowed the photointerpreters to see texture and depth. Seeing depth is beneficial in helping to identify pockets in the substrate where drift algae may accumulate. Figure 4 shows the stereo workstation.

Figure 4- SOCET Stereo Workstation

During photo interpretation, the historical shapefiles and imagery from past Indian River Lagoon projects were utilized as ancillary sources to analyze changes and update seagrass polygons. This allowed for consistency with past 2013 photo interpretation when delineating seagrass changes. Photo interpreted polygons were either 1) newly delineated features which were not apparent on the prior 2013 imagery or 2) digitized edits to 2013 polygons according to changes occurring on the 2015 imagery.

In addition to using the 2013 data, the photo interpreters utilized field documentation during delineation and classification. The field work feature class was loaded within ArcGIS software and immediately accessible during the photo interpretation task.

In addition to the seagrass polygon map deliverable, a seagrass bed edge confidence was applied to all continuous (9116) seagrass beds for the first time in 2015. Edge Confidence is a process whereby the photo interpreters evaluate the overall confidence they have in the placement of a boundary line for a continuous seagrass bed (class 9116). The ability to see and delineate the precise edge of seagrass beds depends in large part on the water clarity, depth, wind conditions, illumination, localized anomalies and other factors existing on the aerial imagery at the time of capture. To quantify the confidence level

associated with photo interpretation and seagrass bed delineation, the photo interpreter assigned confidence levels within the GIS map data to edge-of-bed linework according to the following thresholds.

High Confidence: Imagery signatures and seagrass bed extent is very clear within this edge of bed section. Delineation is straightforward and seagrass presence can easily be distinguished from surrounding covertypes. Actual seagrass edge of bed distance within 10m from delineated edge.

Medium Confidence: Imagery signatures within this edge of bed section are less precise and require a higher level of judgment on the part of the photo interpreter. Delineation within this area is not as clear and straightforward as it is within sections of High Confidence linework. Expect actual seagrass edge of bed to be within 50m of delineated edge.

Lower Confidence: Imagery signatures within this edge of bed section are not precise and require a high level of judgment on the part of the photo interpreter. Delineation within this area is not as clear and straightforward as it is within sections of High and Moderate Confidence linework. Frequent use of collateral imagery and /or other information is often required to complete seagrass delineation. Expect actual seagrass edge of bed to be greater than 50m of delineated edge.

4.0 Accuracy Assessment

Accuracy assessment was completed by Dewberry for this task under a separate Scope of Work. Separate Dewberry employees other than the ones working on the seagrass maps were tasked to complete fieldwork consisting of visiting 270 sampling points provided by The District. The 2015 IRL Seagrass Maps were found to exceed accuracy specifications at 88% accurate and are acceptable.

The accuracy assessment field report is included as Attachment F.

The District supplied accuracy assessment report is included as Attachment G.

The maps were not revised using the field information documented during accuracy assessment field work.

5.0 Project Deliverables

The following table lists the tasks accomplished and the associated deliverables completed for the project.

TASK BREAKDOWN	DELIVERABLES
TASK 1: Preliminary Conference and Study Plan	Kick-off meeting Draft and final work plan
TASK 2: Acquisition of Digital Aerial Photos and Sample Imagery	Raw imagery, airborne GPS/IMU data Acquisition report Sample Imagery

TASK 3: Classification Accuracy Assessment	ArcGIS feature class containing accuracy assessment fieldwork documentation Accuracy assessment results
TASK 4: Pre-photointerpretation Groundtruthing Field Work	ArcGIS feature class containing during-interpretation fieldwork documentation A report including groundtruthing methodology and dates of field work
TASK 5: Photointerpretation Key	Photointerpretation key detailing examples each class
TASK 6: Triangulation and Orthophotography **SUBTASK 6.1: Aerial Triangulation** **SUBTASK 6.2: Digital Orthophotography**	An Aerial Triangulation Report AT files PSM report describing AT process and results 4-band digital orthophotography tiles FGDC compliant metadata
TASK 7: Positional Accuracy Assessment	Positional accuracy sampling strategy A positional accuracy assessment report The surveyor collected checkpoints
TASK 8: Photointerpretation	Monthly status reports and documentation of project progress Example photo interpretation prior to delivery of Draft Geodatabase
TASK 9: During Photointerpretation Groundtruthing Field Work	ArcGIS feature class containing during-interpretation fieldwork documentation A report including groundtruthing methodology and dates of field work
TASK 10: Seagrass Edge Confidence Analysis	Seagrass edge confidence linework as a feature class for the entire study area
TASK 11: Draft Map	Draft seagrass map ESRI geodatabase of the project
TASK 12: Final Map	Final seagrass map ESRI geodatabase of the project
TASK 13: Final Report	A draft and final report submitted electronically

6.0 Lessons Learned and Recommendations

The imagery was collected a little earlier than in the past but within the date range provided in the SOW. This earlier collect was approved by the District and helped to provide imagery with excellent water clarity. In addition, summer weather patterns were avoided which helped ensure that the imagery was collected with a short timeframe without weather delays. We recommend that the imagery continue to be collected as early as possible before summer weather patterns occur and while biomass is high.

The edge confidence deliverable was applied to the entire project for the first time in 2015. Every effort was made to identify the exact edge for seagrass beds during groundtruthing and during photointerpretation. Edge confidence is not solely based on the aerial imagery. It is highly influenced by the imagery but also evaluated based on ancillary data such as District supplied transect points and Dewberry's groundtruthing fieldwork. Edge confidence is also influenced by the clarity of the water and density/species of the seagrass bed. Nevertheless, it is evident that imagery acquired during optimal conditions increases overall map accuracy and edge confidence. We recommend that this combined evaluation effort for determining edge confidence is followed for future projects.

7.0 Conclusion

The 2015 Indian River Lagoon Seagrass Mapping Project was completed without any significant problems.

Fieldwork provided a valuable tool for identifying signatures before photo interpretation and for checking mapped data in the field for accuracy assessment and problem resolution.

Deliverables were submitted according to the project's schedule and map accuracy was checked and passed by the water management districts.

The project was a positive success and resulted in the generation of highly accurate GIS-based seagrass maps and field data that can be used for seagrass trend analysis and monitoring within the Indian River Lagoon system.

List of Attachments

The following attachments are included for report.

Attachment A: 2015 Imagery Acquisition Report

Attachment B: 2015 Aerotriangulation Report

Attachment C: 2015 Positional Accuracy Assessment Report

Attachment D: 2015 Field Reports

Attachment E: 2015 Photo Interpretation Key

Attachment F: 2015 Accuracy Assessment Field Report

Attachment G: 2015 Seagrass Accuracy Assessment Report

AERIAL IMAGERY ACQUISTION REPORT

FOR THE

INDIAN RIVER LAGOON 2015 SEAGRASS MAPPING PROJECT

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Dewberry®

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Report Date
August 20, 2015

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1 Overview

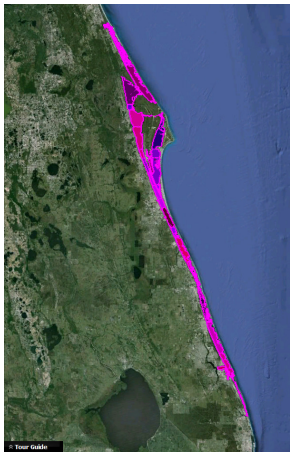
ACA was contracted by the Dewberry to acquire digital aerial photography for the Indian River Lagoon Seagrass Mapping Project. Project Boundary: Mosquito Lagoon north to Ponce de Leon Inlet; Banana River, including Newfound Harbor; Indian River proper, including Turnbull Creek up to the railroad bridge; the entire Banana Creek up to the Shuttle Crawlway; and south to Jupiter Inlet, including Hobe and Jupiter Sounds and Loxahatchee River to the 811 Bridge.

This report describes how the imagery was captured and details the parameters surrounding the acquisition process.

2 Project Area

The map displayed in Figure 1 shows the project boundary. Imagery acquisition was accomplished within this boundary.

Figure 1 Project Area



3 Acquisition Equipment

Dewberry tasked Aerial Cartographics of America, to acquire the digital imagery. All imagery was captured in 4-band (RGBIR) format.

The digital aerial photography was captured using the Microsoft UltraCam Eagle 100). A calibration certificate for the sensor used on the project is contained within Attachment A.

The following additional equipment and software was used for the acquisition.

GPS and IMU System

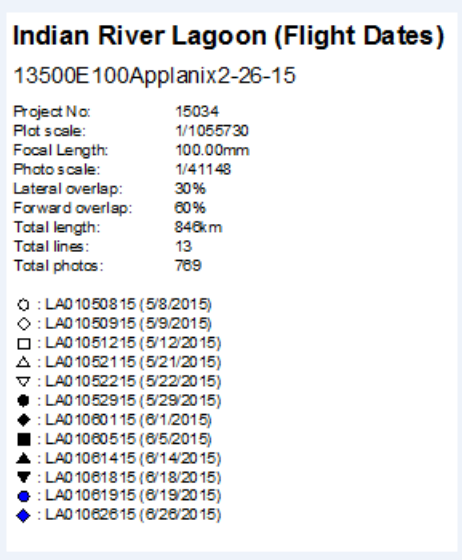
Applanix POS AV-510
System Version:
Product-Model: AV-510; Version: VER5; Serial Number: S/N3452;
Hardware Version: HW4.0-7;
Software Release Version-Date: SW04.70-Mar25/09;

ICD release version: ICD16.00;
Operating System Version: OS425B14;
IMU Type: IMU8; Primary GNSS Type: PGPS16; Secondary GNSS Type: SGPS0;
Primary GNSS Version: BD960 S/N:4828K32507 SW:03.65 OMNISTAR SN,32507;
Processed GPS and IMU blending:
Applanix POSPAC 6.3
Applanix Smartbase (ASB) GNSS processor

The digital sensor used for acquisition was mounted in a Cessna 206 single engine aircraft. The tail number of the aircraft is N9481T.

4 Acquisition Date

The aerial photography was acquired on May 8, 9, 12, 21, 22, 29, June 1, 5, 14, 18, 19, 26, 2015. Several flights were required due to weather conditions.



5 Flight Logs

Flight logs document the date, time, flight crew, weather, and flying height for the mission. The flight logs for the project are provided as separate attachments.

6 Flight Line Orientation

The flight lines for the project are oriented in a Northwest - Southeast direction as shown within Figure 3.

Figure 3 Flight Line Map

7 Sun Angle

The photography was taken during the time of day when the sun angle was greater than 15º but not more than 30º in order to minimize sun glare on the images.

8 Ground Sample Distance and Flight Line Overlap

Acquisition was completed at an altitude of approximately 13,500' above mean ground yielding a ground sample distance of 8.4".

The flight lines were spaced apart so as to yield a side image coverage overlap of approximately 30% between adjacent flight lines and a forward overlap of 60% between individual exposures.

The following table itemizes specific elements of the acquisition.

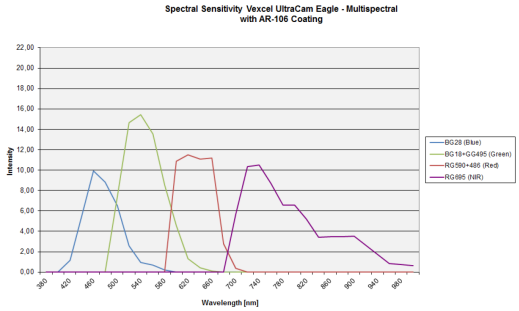
Project Area	Pixel Resolution	Flying Height	Flight Line Miles	Sidelap	Forward Overlap	Number of Lines
IRL	21.4 cm	13,500'	525	30	60	13

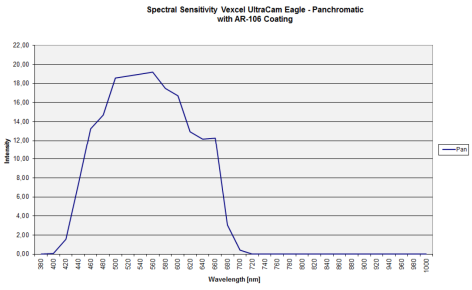
All flight lines were extended and increased in number sufficiently to provide stereo image coverage beyond the project area boundaries.

9 Imagery Specifications

The digital camera imagery was simultaneously captured in registered 12-bit panchromatic, RGB/color, and NIR (near infrared). Camera characteristics and spectral sensitivity information are as follows.

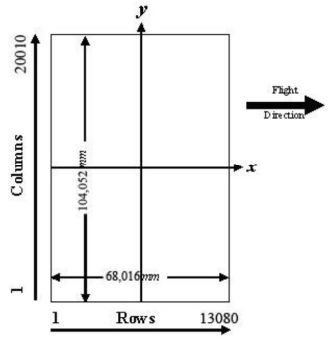
Detailed Specs:



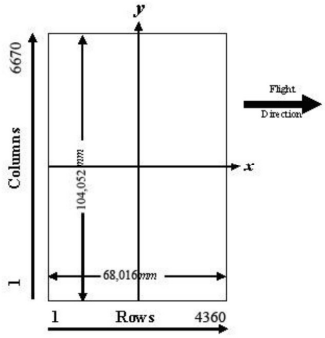


3) Level 3 Image Coordinate System:
(after rotation of 270° CW)

PAN 20010 pixel by 13080 pixel
MS 6670 pixel by 4360 pixel



Panchromatic Image Format



Multispectral Image Format

10 Airborne GPS Positioning

During acquisition, the project's control network consisted of accurate photo-center coordinates and orientations determined via airborne GPS/IMU equipment. Applanix' Single Base & Multi-single base post processing system was used in lieu of the placement of temporary GPS base stations on or near the site during the aerial photography mission.

Continuously Operating Reference Stations (CORS) were used as control during acquisition. Figure 5 shows a graph that provides the typical ABGPS sensor errors and position residuals for the flight missions. Maximum deviation is within 10cm which was well within the acceptable range for the project.

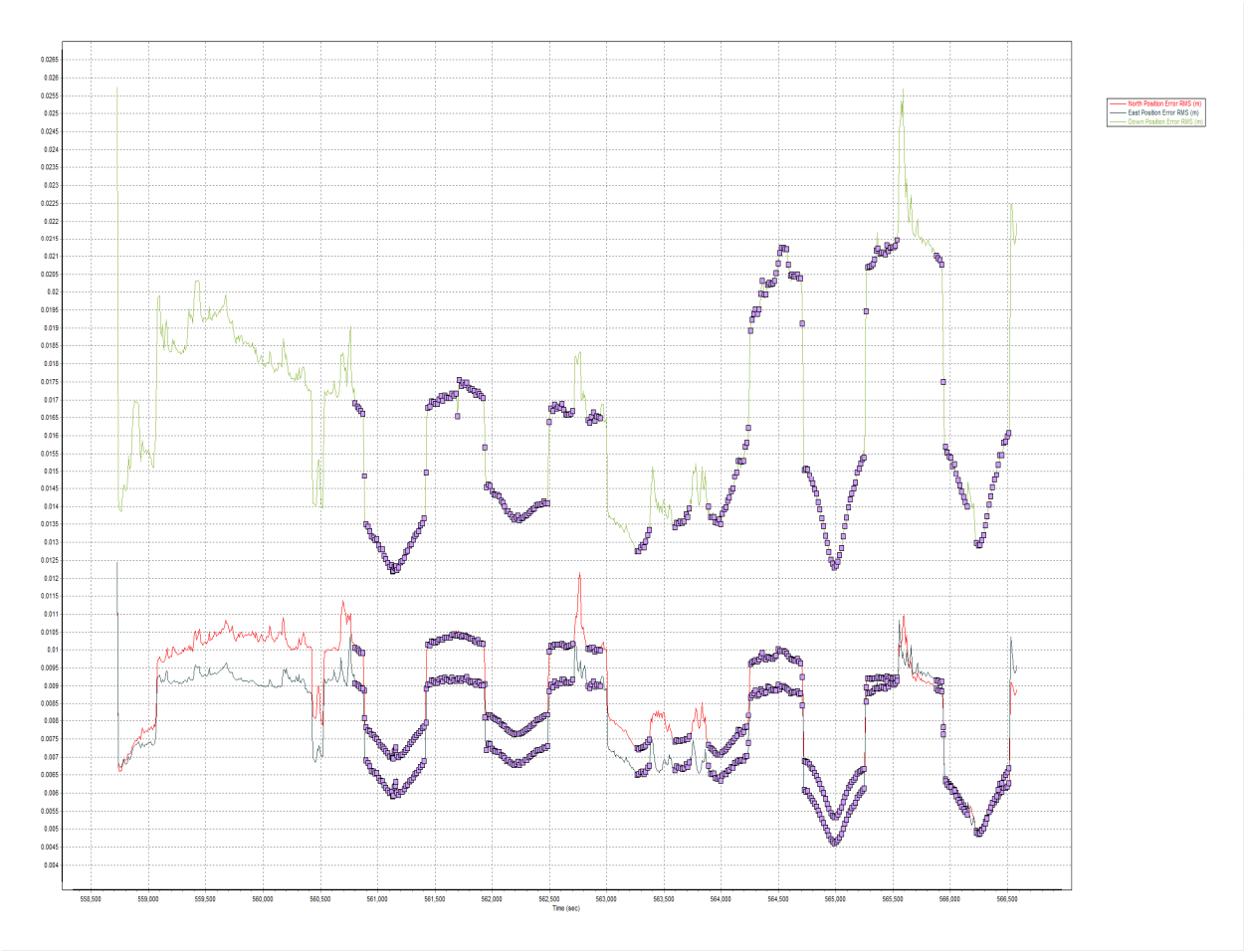


Figure 5 AGPS Sensor Errors

11 Summary

Imagery acquisition and related positional data was acquired successfully for the project from May 8, 2015 to June 27, 2015. The raw imagery and associated ABGPS/IMU data were quality inspected and supplied for use during aerial triangulation.

12.

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name			Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150508_S2_1	15034	Indian River Lagoon			05-08-2015	1	S2	UCE/100	N9481T	c206	M. Peterson	Hernandez
Flight Plan	**Line**	**Direction**	**Images or Record**	**Start UTC**	**Stop UTC**	**Sensor Settings**			**Remarks**			
13500E100Applanix2-26-15	8	340	001 - 019	11:48	11:53	13500E100Applanix2-26-15			POS Failure All needs to be reflown			
13500E100Applanix2-26-15	3	160	020 - 092	12:03	12:20							
13500E100Applanix2-26-15	4	339	093 - 153	12:25	12:42							
13500E100Applanix2-26-15	2	159	154 - 238	12:46	13:06							

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name			Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150509_S2_1	15034	Indian River Lagoon			05-09-2015	1	S2	UCE/100	N9481T	c206	M. Peterson	Hernandez
Flight Plan	**Line**	**Direction**	**Images or Record**	**Start UTC**	**Stop UTC**	**Sensor Settings**			**Remarks**			
13500E100Applanix2-26-15	9	159	001 - 119	11:46	12:18	13500E100Applanix2-26-15						
13500E100Applanix2-26-15	10	338	120 - 127	12:20	12:22							
13500E100Applanix2-26-15	12	339	128 - 135	12:27	12:29							
13500E100Applanix2-26-15	11	160	136 - 144	12:33	12:35							
13500E100Applanix2-26-15	2	340	145 - 253	12:38	13:05							
13500E100Applanix2-26-15	9	159	254 - 271	13:11	13:15							
13500E100Applanix2-26-15	2	160	272 - 290	13:17	13:21							

Aerial Cartographics of America, Inc.
Flight Acquisition Report Form

Mission	Job #	Job Name			Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150512_S2_1	15034	Indian River Lagoon			05-12-2015	1	S2	UCE/100	N682AC	206	K. Norup	Peterson
Flight Plan	**Line**	**Direction**	**Images or Record**	**Start UTC**	**Stop UTC**	**Sensor Settings**			**Remarks**			
	Static			11:10	11:15				Static: KISM			
	CORS			11:30	11:35				Titusville			
13500E100Applanix2-26-15	7	307	001 - 001	11:04	11:04	6.7 1/350			partial clouds			

Aerial Cartographics of America, Inc
Flight Acquisition Report Form

Mission	Job #	Job Name		Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150521_S2_1	15034	Indian River Lagoon		05-21-2015	1?1900	S2	UCE/100	N682AC	206	M. Peterson	E.Heranandez
Flight Plan	Line	Direction	Images or Record	Start UTC	Stop UTC	Sensor Settings		Remarks			
	Static			11:05	11:10			Static: KISM			
	CORS			11:30	11:35			Titusville			
13500E100Applanix2-26-15	0	307	001 - 001	11:04	11:04	13500ft E100					
13500E100Applanix2-26-15	0	319	002 - 002	11:05	11:05	13500ft E100					
13500E100Applanix2-26-15	0	314	003 - 003	11:05	11:05	13500ft E100					
13500E100Applanix2-26-15	8	338	294 - 312	11:51	11:56	13500ft E100					
13500E100Applanix2-26-15	1	159	314 - 389	12:04	12:23	13500ft E100					
13500E100Applanix2-26-15	2	338	390 - 416	12:25	12:33	13500ft E100		Clouds 414. UCE stopped taking images at frame 415 missed 3 images. Reflown lines that were missed.			
13500E100Applanix2-26-15	2	338	417 - 487	12:37	12:56	13500ft E100		Clouds 417-433. clouds 448- 450. Clouds 465- 472.			
	CORS			13:03	13:09			Titiusville			
	Static			13:31	13:36			Static: KISM			

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name		Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150522_S2_1	15034	Indian River Lagoon		05-22-2015	1	S2	UCE/100	N683AC	C206	M. Peterson	A. Bausola
Flight Plan	Line	Direction	Images or Record	Start UTC	Stop UTC	Sensor Settings		Remarks			
	POS			11:46	11:52			In Air: KTIX			
13500E100Applanix2-26-15	2	338	490 - 514	12:16	12:22	F6.7 1?350		Clouds			
	POS			13:32	13:37			Static: KISM			

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name		Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150529_S2_1	15034	Indian River Lagoon		05-29-2015	1	S2	UCE/100	N683AC	C206	M. Peterson	A. Bausola
Flight Plan	Line	Direction	Images or Record	Start UTC	Stop UTC	Sensor Settings		Remarks			
	POS			10:57	11:02			StaticL KISM			
	POS			11:24	11:30			In Air: KTIX			
13500E100Applanix2-26-15	7	159	517 - 553	11:40	11:50	F6.7 1/350					
13500E100Applanix2-26-15	6	340	554 - 610	11:53	12:08	F6.7 1/350		Clouds near image 595			
13500E100Applanix2-26-15	5	159	611 - 685	12:13	12:33	F6.7 1/350		Clouds near 635 654 661 and on south end			
13500E100Applanix2-26-15	2	340	686 - 743	12:36	12:50	F6.7 1/350		Clouds near 727 736			
	POS			13:56	14:01			Static: KISM			

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name			Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150601_S2_1	15034	Indian River Lagoon			06-01-2015	1	S2	UCE/100	N683AC	C206	M. Peterson	A. Bausola
Flight Plan	**Line**	**Direction**	**Images or Record**	**Start UTC**	**Stop UTC**	**Sensor Settings**			**Remarks**			
	POS			11:03	11:08				Static: KISM			
	POS			11:30	11:36				In Air: KTIX			
13500E100Applanix2-26-15	13	338	746 - 759	11:49	11:52	F6.7 1/350						
13500E100Applanix2-26-15	4	159	760 - 794	11:55	12:03	F6.7 1/350			Clouds 793 794			
13500E100Applanix2-26-15	5	340	795 - 817	12:06	12:12	F6.7 1/350			Clouds 798 799 800			
	POS			12:59	13:04				Static: KISM			

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name			Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
lift one	15034	Indian River Lagoon			06-05-2015	1	S2	UCE/100	N683AC	C206	M. Peterson	Peterson
Flight Plan	**Line**	**Direction**	**Images or Record**	**Start UTC**	**Stop UTC**	**Sensor Settings**			**Remarks**			
	POS			10:40	10:45				Static: KISM			
13500E100Applanix2-26-15	3	n		11:20		F6.7 1/350			some clouds in all lines.			
13500E100Applanix2-26-15	2	s				F6.7 1/350						
13500E100Applanix2-26-15	4	n				F6.7 1/350						
13500E100Applanix2-26-15	5	s			12:50	F6.7 1/350						
	pos			13:10	13:14				Static: KISM			

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name			Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
lift one	15034	Indian River Lagoon			06-14-2015	1	S2	UCE/100	N683AC	C206	M. Peterson	Peterson
Flight Plan	**Line**	**Direction**	**Images or Record**	**Start UTC**	**Stop UTC**	**Sensor Settings**			**Remarks**			
	POS			11:00	11:05				Static: KISM			
13500E100Applanix2-26-15	6	n	13.5 deg sun angle									
13500E100Applanix2-26-15	5	s				F6.7 1/350			some clouds in all lines. Hazy			
13500E100Applanix2-26-15	3	n				F6.7 1/350						
13500E100Applanix2-26-15	5	s				F6.7 1/350			partial nav conn failed			
13500E100Applanix2-26-15	6	n	32 deg sun angle			F6.7 1/350						
	pos			13:40	13:45				Static: KISM			

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name	Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150618_S2_1	15034	Indian River Lagoon	06-18-2015	1	S2	UCE/210	N682AC	C208	M. Peterson	E.Hernandez

Flight Plan	Line	Direction	Images or Record	Start UTC	Stop UTC	Sensor Settings	Remarks
Static				11:05	11:10		Static KISM
13500E100Applanix2-26-15	0	345	001 - 001	10:46	10:46		Clouds in some of the images
13500E100Applanix2-26-15	0	56	002 - 002	10:46	10:46		
13500E100Applanix2-26-15	0	69	003 - 003	10:46	10:46		
13500E100Applanix2-26-15	0	72	001 - 001	11:10	11:10		
13500E100Applanix2-26-15	3	341	820 - 892	11:23	11:42		
13500E100Applanix2-26-15	2	160	893 - 958	11:44	12:00		
13500E100Applanix2-26-15	4	340	959 - 1023	12:03	12:20		
13500E100Applanix2-26-15	5	160	1024 - 1080	12:22	12:36		
CORS				12:32	12:38		
Static				13:03	13:08		Static KISM

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name	Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150619_S2_1	15034	Indian River Lagoon	06-19-2015	1	S2	UCE/100	N9481T	C-T206H	M. Perterson	K. Norup

Flight Plan	Line	Direction	Images or Record	Start UTC	Stop UTC	Sensor Settings	Remarks
Static @ KISM				7:11	7:16		
In-air over KTIX				7:38	7:44		In climb
	6	N	18	7:48	7:52	F 6.7, 1/350	Message 20205 rejected! N/A in present state
	5	S	49	7:56	8:09		"
	3	N	61	8:17	8:32		"
In-air over KTIX				8:39	8:45		"

Aerial Cartographics of America, Inc.
Flight Acquisition Form

Mission	Job #	Job Name	Date	Lift	System	Sensors	Aircraft	Type	Pilot	Operator
15034_20150626_S2_1	15034	Indian River Lagoon	06-26-2015	1	S2	UCE/210	N683AC	C206	K. Norup	E.Hernandez

Flight Plan	Line	Direction	Images or Record	Start UTC	Stop UTC	Sensor Settings	Remarks
Static				11:25	11:30		Static KISM
In air alignment				11:53	11:59		In air alignment KTIX
13500E100Applanix2-26-15	4	339	1613-1706	12:09	12:33	13500 E100	
Static				14:00	14:05		Static KISM

IRL 2015 AT Summary

Contact Info

Fagerman Technologies, Inc.
56 Gilchrist Road
Somerville, AL 35670
Tel: (256)778-0521
Cel: (256)654-4884
web: www.LiDAR.com\photogrammetry
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Client:	Dewberry 1000 N. Ashley Dr., Suite 801 Tampa, FL 33602 www.dewberry.com
Phone:	Direct: 813.421.8622
Fax:	813.225.1385
Contacts:	Keith Patterson
email:	kpatterson@Dewberry.com
Project:	IRL 2015
Client Job #:	
Started:	August 8, 2015
Delivered:	August 17, 2015
Revised:	
Invoice #:	
Cost:	$

Contents

Project Summary

This project consisted of 13 strips for a total of 767 photos. Some of the images are entirely water but not too many.

The project is in meters. The average flying height was roughly 4100 meters and the average ground elevation was roughly 5 meters.

A typical set of rectangular image parameters were used for the adjustment to compensate for all image distortions.

The control point std devs were set to 0.4 meters. All points were used as full XYZ control points with the exceptions of Ctl_6_1773 and Acc_6_1767 (vertical, Z, only) and Acc_10_176c, Acc_13_1771, Acc_16_1775 (horizontal, XY, only). Point Acc_16_1775 could not be used at all as it was obstructed.

There was AGPS & IMU data. It was broken into eight (8) essential missions or groupings based upon time of collection. All the events were used except 2_0160 (it has a residual in X of 0.8 meters). Events for 2_507, 2_509, 2_510, or 2_0511 were not found. They are probably available but as these images were added in at the end the events were not included. It will not adversely affect the solution in any way. Line 2 was a very confusing strip. From the email sent earlier, here's just one segment of the line: 251, 252, 253, 417, 415, 419, 420, 507, 416, 509, 510, 954, 953, 952, 951, 686, 687, 432, 433…

Line 5 (dated 6/18/2015) was a short session with only 18 photos from lines 3 & 5 but it also had an unusually large Z shift of nearly 29 meters. Upon investigation the difference is… the output is in ellipsoidal height rather than orthometric height like all of the rest of the files. There were 11 missions in all but some were obviously not used at all.

The imagery was flown using a Vexcel digital camera (UltraCamEagle-SN1-220411214). The calibrated focal length of this camera is reported as 100.500 mm with a 5.2 micron square pixel and image format of 20010 x 13080 pixels.

It's worth noting that ISAT collected an abundance of points on the white caps/waves, floating debris, boats, etc. These were removed (and yet in each pass through more seemed to creep back in!!!).

The sigma per each adjustment is shown in the table below.

Adjustment	Lines / Block	Sigma (microns)
Controlled	All	1.29

The following table shows the AGPS & survey residual summary:

Block	Description	X	Y	Z m
All				
	RMS control point residuals:	0.138	0.068	0.148
	Maximum control point residuals:	0.276	0.151	0.425
	RMS GPS residuals:	0.118	0.104	0.121
	Maximum GPS residuals:	0.490	0.433	0.629
	RMS IMU residuals:	0.0131	0.0128	0.0129
	Maximum IMU residuals:	0.0389	0.0305	0.0901
	(Computed from real residuals)			

The survey control points were not overwritten. All data from BINGO has been imported (EO and XYZ points).

RO and AO solutions were computed for all models and resections for all photos. Earth curvature and atmospheric refraction were applied.

A file, tabularizedParameters.txt (and .csv), is also included as it contains many of the parameters from the photo file in comma delimited table format for easy use in Excel, Access, etc.

Additional report files are also provided with more detailed information for convenient reference. All files shown below have an "*" replacing a named adjustment. Usually this would be as simple as "Controlled" or "Free" but can be more complicated such as "NorthHalf", etc.

File	Description
antenna*.dat	AGPS/IMU data file.
Bingo*.lis	The adjustment report file.
Geoin*.dat	A setup parameter file for the adjustment.
Gpsresi*.dat	The AGPS/IMU residual file.
imresi.dat	The image residual file for all measurements adjusted.
Itera*.dat	The adjusted EO and point XYZ information.
Project*.dat	The project parameter file for the adjustment.
Reselli*.dat	The ground residual file.

Number of points measured in 2 photos: 1560
Number of points measured in 3 photos: 3892
Number of points measured in 4 photos: 205
Number of points measured in 5 photos: 144
Number of points measured in 6 photos: 461

Summary of photo data:

No. of used points	6262
No. of used photos	759
No. of used cameras	1
Max. photo rays per point	6
Max. photo measurements per point	6
Used points per photo - minimum	3
Used points per photo - median	25
Used points per photo - maximum	47
Max. photo index difference	198

No. of photo orientation data	759
No. of approximate coordinates	6262
No. of camera input statements	2

Free Network Adjustment

<Not Computed>

Controlled Adjustment

RESULTS OF ADJUSTMENT SIGMA 0 = 0.00129

Residuals of photo coordinates list limit = 4.0 * sigma

Point	Photo	Vx'	Vy'	Rx'%	Ry'%	Wx'	Wy'	Nabla x'	y'
		(1 / 1 0 0 0)						(1 / 1 0 0 0)	

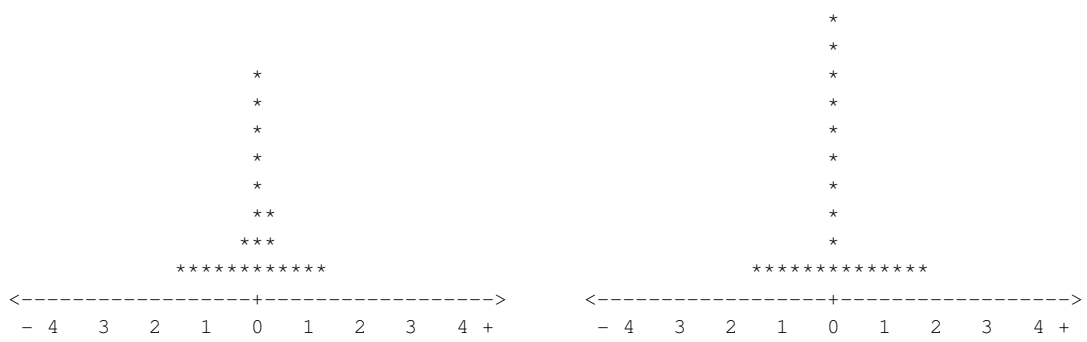
Residuals of photo measurements (x', y') in photo space: (1:1000)

RMS	0.9	0.8
MAX	7.5	8.8

RMS residuals of all other photo measurements transformed to object space:

RMS	0.035	0.033	0.012

Frequency of photo measurement residuals N(0,1) :



GPS shift and drift parameters

GPS-File	LINE-No.	Param.Name	Shift	Drift	+-S	Photos	Drift effects min, max	
1	2	s_X	-1.028		0.067	27		
1	2	s_Y	-1.036		0.060	27		
1	2	s_Z	-0.433		0.074	27		
1	2	d_X		0.000	0.002	27	-0.004	0.004
1	2	d_Y		0.003	0.002	27	-0.074	0.074
1	2	d_Z		0.016	0.003	27	-0.377	0.377
1	4	s_X	-0.045		0.050	94		
1	4	s_Y	-0.567		0.047	94		
1	4	s_Z	-0.202		0.061	94		
1	4	d_X		-0.010	0.004	94	0.114	-0.114
1	4	d_Y		0.003	0.003	94	-0.030	0.030
1	4	d_Z		-0.008	0.004	94	0.090	-0.090
1	5	s_X	-0.045		0.063	18		
1	5	s_Y	-0.768		0.061	18		
1	5	s_Z	-28.723		0.070	18		
1	5	d_X		0.032	0.010	18	-0.176	0.176
1	5	d_Y		0.048	0.010	18	-0.264	0.264
1	5	d_Z		-0.079	0.011	18	0.435	-0.435
1	6	s_X	-0.131		0.050	109		
1	6	s_Y	-0.674		0.047	109		
1	6	s_Z	-0.240		0.061	109		
1	6	d_X		0.014	0.002	109	-0.295	0.295
1	6	d_Y		0.009	0.001	109	-0.198	0.198
1	6	d_Z		-0.040	0.002	109	0.847	-0.847
1	7	s_X	-0.060		0.092	107		
1	7	s_Y	0.009		0.072	107		
1	7	s_Z	0.605		0.071	107		
1	7	d_X		-0.012	0.005	107	0.369	-0.369
1	7	d_Y		-0.001	0.003	107	0.035	-0.035
1	7	d_Z		-0.012	0.003	107	0.371	-0.371
1	8	s_X	0.687		0.098	135		
1	8	s_Y	0.194		0.063	135		
1	8	s_Z	-0.487		0.076	135		
1	8	d_X		-0.040	0.005	135	1.311	-1.311
1	8	d_Y		-0.015	0.003	135	0.489	-0.489
1	8	d_Z		-0.013	0.002	135	0.420	-0.420
1	9	s_X	0.077		0.088	250		
1	9	s_Y	-0.035		0.062	250		
1	9	s_Z	-0.189		0.086	250		
1	9	d_X		0.003	0.003	250	-0.147	0.147
1	9	d_Y		0.001	0.002	250	-0.042	0.042
1	9	d_Z		-0.005	0.002	250	0.222	-0.222
1	13	s_X	0.082		0.069	14		
1	13	s_Y	-0.548		0.065	14		
1	13	s_Z	0.012		0.092	14		
1	13	d_X		-0.084	0.046	14	0.146	-0.146
1	13	d_Y		0.014	0.040	14	-0.025	0.025
1	13	d_Z		0.360	0.039	14	-0.624	0.624

Camera data

Camera 1

Diff. angle of rotation delta : 0.0150 0.1239 0.0004
+-S : 0.0003 0.0002 0.0116

Additional parameters : Format factor = 2.087000

1	2	4	6	14	19
25	26				

-0.0014	-0.0002	-0.0002	-0.0024	-0.0005	-0.0004
0.0075	0.0176				

Radial symmetric lens distortion from additional radial parameters (1/1000)

Distortion values; First value for R = 5.0 (= Step width)

0.1	0.4	0.7	1.0	1.3	1.5	1.6	1.3	0.6	-0.6
-2.5	-5.3	-9.1	-14.1	-20.6					

```
*
*     Control point residuals for graphical output
*
*               <___Vx_Max__><___Vy_Max__><___Vz_Max__>
VMAX                   0.276        0.151        0.425
*
*<____Point_No__><_____Vx____><_____Vy____><_____Vz____>   Key
       Acc_2_1762        0.276       -0.052        0.086   XYZ  **
       Acc_6_1767        0.000        0.000       -0.156     Z  *
       Acc_8_1769       -0.001        0.085       -0.076   XYZ
       Acc_9_176b        0.240       -0.066       -0.100   XYZ  *
       Ctl_1_1760        0.049       -0.019       -0.020   XYZ
       Ctl_2_1766       -0.171        0.042        0.057   XYZ  *
       Ctl_4_176e       -0.175        0.009        0.307   XYZ  ***
       Ctl_5_1770       -0.176       -0.119       -0.012   XYZ  **
       Ctl_6_1773        0.000        0.000        0.004     Z
       Ctl_7_1778        0.135        0.077        0.036   XYZ  *
      Acc_10_176c       -0.083       -0.057       -0.425   XYZ  ****
      Acc_13_1771       -0.041        0.006        0.039   XYZ
      Acc_18_1777       -0.094        0.002        0.084   XYZ  **
      Acc_20_177a        0.001       -0.010        0.046   XYZ
      Acc_23_177d       -0.028        0.151        0.033   XYZ  *
      Acc_24_177f        0.067       -0.049        0.098   XYZ  *


     RMS control point residuals:            0.138   0.068   0.148
     Maximum control point residuals:        0.276   0.151   0.425

     RMS GPS residuals:                      0.118   0.104   0.121
     Maximum GPS residuals:                  0.490   0.433   0.629

     RMS IMU residuals:                     0.0131  0.0128  0.0129
     Maximum IMU residuals:                 0.0389  0.0305  0.0901
     (Computed from real residuals)



          A posteriori variance-component estimation

          Test value  = s(a posteriori) / s(a priori)

     Group                               Test Value    No. of Obs.   Redundancy
-------------------------------------------------------------------------------------------
     Photo coordinates                 :      0.27          38204     16289.10
     Coordinates of control points     :      0.54             44        14.71
        Control points in X            :      0.55             14         5.47
        Control points in Y            :      0.26             14         6.20
        Control points in Z            :      0.85             16         3.04
     Photo positions and orientations  :      0.15           2262      2070.23
        Photo orientation in phi       :      0.12            754       662.11
        Photo orientation in omega     :      0.23            754       655.16
        Photo orientation in kappa     :      0.01            754       752.96
     Exterior orientations incl. GPS   :      0.23           2262       998.96
        GPS position in X              :      0.23            754       268.11
        GPS position in Y              :      0.22            754       228.44
        GPS position in Z              :      0.24            754       502.41

     Sum of all observations           :      0.26          42772
```

Control Point Notes.

```
begin control_points sx=0.4 sy=0.4 sz=0.4 pc=XYZ pt=CONTROL

Acc_9_176b        528262.085    3145055.952    2.457
Ctl_4_176e        538572.243    3120107.269    1.323
Acc_24_177f       588191.015    2979932.929    1.386
Ctl_1_1760        502691.212    3218460.893    0.948
Ctl_2_1766        513750.177    3197251.957    2.7
Acc_8_1769        535947.958    3169822.429    1.62
Ctl_5_1770        547955.486    3093052.912    0.672
Ctl_6_1773        563059.13     3060760.747    3.614  /pc=Z /desc=not visible in flat black parking lot
Ctl_7_1778        576795.074    3014520.698    1.326

Acc_10_176c       539701.477    3142390.807    3.182
Acc_23_177d       589589.966    2986656.046    5.727
Acc_6_1767        522011.217    3180948.614    2.291  /pc=Z /desc=paint strip has been changed
Acc_13_1771       554003.423    3081296.375    1.572
Acc_16_1775       566950.648    3036402.88     1.819
Acc_18_1777       576487.859    3022077.813    1.345
Acc_2_1762        509803.786    3212733.97     2.809
Acc_20_177a       579896.848    3004881.943    1.259


end control_points
```

Image Notes.

The images were delivered on hard drive. The images required most of a day to process into a usable format.

AGPS Notes.

All stations were except as already noted above. Below is a listing of computed drift and shift parameters per mission followed by a listing the individual residuals.

GPS shift and drift parameters

GPS-File	LINE-No.	Param.Name	Shift	Drift	+-S	Photos	Drift effects min, max	
1	2	s_X	-1.028		0.067	27		
1	2	s_Y	-1.036		0.060	27		
1	2	s_Z	-0.433		0.074	27		
1	2	d_X		0.000	0.002	27	-0.004	0.004
1	2	d_Y		0.003	0.002	27	-0.074	0.074
1	2	d_Z		0.016	0.003	27	-0.377	0.377
1	4	s_X	-0.045		0.050	94		
1	4	s_Y	-0.567		0.047	94		
1	4	s_Z	-0.202		0.061	94		
1	4	d_X		-0.010	0.004	94	0.114	-0.114
1	4	d_Y		0.003	0.003	94	-0.030	0.030
1	4	d_Z		-0.008	0.004	94	0.090	-0.090
1	5	s_X	-0.045		0.063	18		
1	5	s_Y	-0.768		0.061	18		
1	5	s_Z	-28.723		0.070	18		
1	5	d_X		0.032	0.010	18	-0.176	0.176
1	5	d_Y		0.048	0.010	18	-0.264	0.264
1	5	d_Z		-0.079	0.011	18	0.435	-0.435
1	6	s_X	-0.131		0.050	109		
1	6	s_Y	-0.674		0.047	109		
1	6	s_Z	-0.240		0.061	109		
1	6	d_X		0.014	0.002	109	-0.295	0.295
1	6	d_Y		0.009	0.001	109	-0.198	0.198
1	6	d_Z		-0.040	0.002	109	0.847	-0.847
1	7	s_X	-0.060		0.092	107		
1	7	s_Y	0.009		0.072	107		
1	7	s_Z	0.605		0.071	107		
1	7	d_X		-0.012	0.005	107	0.369	-0.369
1	7	d_Y		-0.001	0.003	107	0.035	-0.035
1	7	d_Z		-0.012	0.003	107	0.371	-0.371
1	8	s_X	0.687		0.098	135		
1	8	s_Y	0.194		0.063	135		
1	8	s_Z	-0.487		0.076	135		
1	8	d_X		-0.040	0.005	135	1.311	-1.311
1	8	d_Y		-0.015	0.003	135	0.489	-0.489
1	8	d_Z		-0.013	0.002	135	0.420	-0.420
1	9	s_X	0.077		0.088	250		
1	9	s_Y	-0.035		0.062	250		
1	9	s_Z	-0.189		0.086	250		
1	9	d_X		0.003	0.003	250	-0.147	0.147
1	9	d_Y		0.001	0.002	250	-0.042	0.042
1	9	d_Z		-0.005	0.002	250	0.222	-0.222
1	13	s_X	0.082		0.069	14		
1	13	s_Y	-0.548		0.065	14		
1	13	s_Z	0.012		0.092	14		
1	13	d_X		-0.084	0.046	14	0.146	-0.146
1	13	d_Y		0.014	0.040	14	-0.025	0.025
1	13	d_Z		0.360	0.039	14	-0.624	0.624

*
* Residuals of GPS and IMU orientation data for graphical output
*
*   <___Vx_Max__><___Vy_Max__><___Vz_Max__>
VMAX   0.490   0.433   0.629
*   Key
*<____Photo_No__><_____Vx____><_____Vy____><_____Vz____>   <_>/<_><__Vphi__><_Vomega_><_Vkappa_>(1/1000)
*LINE   2
           2_0705   -0.275   -0.213   0.296   GPS/IMU   12.2   11.3   -12.3
           2_0904   -0.039   -0.008   -0.070   GPS/IMU   0.2   2.1   9.8
           2_0161   -0.037   -0.130   0.121   GPS/IMU   0.9   8.6   15.5
           2_0704   0.178   -0.073   0.629   GPS/IMU   20.0   11.4   -13.2
           2_0687   -0.213   -0.207   0.468   GPS/IMU   12.6   11.9   -8.9
*LINE   9
           9_0024   0.013   0.012   0.272   GPS/IMU   -14.4   15.4   -6.0
           9_0025   0.102   -0.021   -0.009   GPS/IMU   -13.7   14.8   -9.2
           9_0026   -0.066   -0.061   0.062   GPS/IMU   -16.3   12.5   -12.6
           9_0027   -0.045   -0.027   0.160   GPS/IMU   -15.8   14.0   -13.5
           9_0028   0.271   0.179   0.020   GPS/IMU   -7.5   9.3   -14.2
           9_0029   -0.002   -0.075   0.114   GPS/IMU   -11.9   16.6   -11.1
           9_0030   0.252   0.234   0.138   GPS/IMU   -6.6   9.1   -7.5
           9_0031   -0.114   -0.122   0.060   GPS/IMU   -12.9   18.1   -3.8
           9_0032   0.035   0.083   0.053   GPS/IMU   -10.0   15.3   -0.1
           9_0033   0.079   -0.120   0.098   GPS/IMU   -9.9   18.4   -2.6
           9_0034   0.098   0.023   -0.011   GPS/IMU   -11.6   16.1   -2.2
           9_0035   -0.066   -0.120   0.009   GPS/IMU   -13.4   17.0   -1.8
           9_0036   -0.152   -0.023   -0.064   GPS/IMU   -13.4   17.7   -9.1
           9_0037   0.021   0.173   0.006   GPS/IMU   -12.8   14.6   -10.5
           9_0038   0.075   -0.154   -0.001   GPS/IMU   -13.2   18.8   -7.5
           9_0039   0.040   0.121   0.004   GPS/IMU   -12.2   14.1   -7.4
           9_0040   -0.306   0.171   -0.024   GPS/IMU   -15.5   15.1   -7.2
           9_0041   0.021   0.024   0.095   GPS/IMU   -10.3   13.9   -7.7
           9_0042   0.037   -0.112   -0.080   GPS/IMU   -11.6   16.1   -8.8
           9_0043   -0.193   0.051   0.052   GPS/IMU   -14.6   14.2   -10.2
           9_0044   0.102   0.020   -0.236   GPS/IMU   -9.3   12.1   -10.9
           9_0045   0.002   0.054   -0.010   GPS/IMU   -11.2   12.8   -9.7
           9_0046   -0.033   -0.011   0.033   GPS/IMU   -9.1   15.4   -8.7
           9_0047   0.153   -0.031   0.012   GPS/IMU   -5.2   15.2   -10.8
           9_0048   0.082   0.043   0.070   GPS/IMU   -7.4   14.8   -6.5
           9_0049   0.044   -0.106   0.023   GPS/IMU   -7.4   16.2   -8.8
           9_0050   -0.153   0.018   0.020   GPS/IMU   -14.3   16.9   -10.1
           9_0051   -0.106   0.073   0.111   GPS/IMU   -13.8   16.9   -10.8
           9_0052   -0.048   0.103   0.063   GPS/IMU   -13.0   15.7   -12.4
           9_0053   -0.261   -0.151   0.036   GPS/IMU   -20.1   20.2   -12.8
           9_0054   0.443   0.198   0.052   GPS/IMU   -8.9   14.4   -15.3
           9_0055   -0.285   0.156   0.147   GPS/IMU   -21.8   13.3   -17.1
           9_0056   -0.121   0.107   0.059   GPS/IMU   -19.3   14.4   -19.5
           9_0057   0.050   0.054   -0.171   GPS/IMU   -15.2   11.5   -23.9
           9_0058   -0.234   0.071   -0.118   GPS/IMU   -22.4   9.4   -29.6
           9_0059   0.190   0.160   -0.112   GPS/IMU   -11.2   9.8   -26.9
           9_0060   -0.012   -0.200   -0.048   GPS/IMU   -13.7   13.9   -29.7
           9_0061   0.190   -0.076   0.103   GPS/IMU   -11.4   13.0   -29.4
           9_0062   -0.075   -0.156   -0.122   GPS/IMU   -13.4   14.0   -25.0
           9_0063   -0.228   0.094   -0.051   GPS/IMU   -16.3   14.9   -19.2
           9_0064   0.060   0.075   0.085   GPS/IMU   -11.4   15.5   -26.8
           9_0065   -0.013   0.143   -0.079   GPS/IMU   -11.1   13.3   -31.4
           9_0066   -0.060   -0.022   -0.113   GPS/IMU   -8.6   19.2   -36.0
           9_0067   -0.119   0.160   -0.061   GPS/IMU   -8.1   15.2   -39.8
           9_0068   0.062   0.057   0.367   GPS/IMU   -10.4   19.2   -25.8
           9_0069   -0.087   0.145   -0.247   GPS/IMU   -5.3   15.7   -21.0
           9_0070   -0.110   -0.039   -0.240   GPS/IMU   -8.9   17.7   -30.1
           9_0071   0.189   0.337   0.378   GPS/IMU   -4.5   14.3   -28.9
           9_0072   0.191   -0.071   0.079   GPS/IMU   -4.7   17.6   -31.7
           9_0073   0.061   -0.064   0.054   GPS/IMU   -7.9   17.7   -33.8
           9_0074   0.116   -0.106   -0.307   GPS/IMU   -9.7   18.9   -29.3
           9_0075   0.062   -0.145   -0.106   GPS/IMU   -10.9   15.3   -24.6
           9_0076   -0.011   -0.101   0.607   GPS/IMU   -15.6   11.3   -90.1
           9_0077   -0.068   0.121   -0.181   GPS/IMU   -12.1   18.4   -31.2
           9_0078   -0.156   0.059   -0.109   GPS/IMU   -13.3   16.4   -20.5
           9_0079   -0.045   -0.131   -0.304   GPS/IMU   -14.6   18.5   -27.4
           9_0080   0.173   0.066   -0.096   GPS/IMU   -10.6   17.3   -30.7

	9_0081	0.108	0.048	0.060	GPS/IMU	-13.2	15.4	-29.6
	9_0082	-0.076	0.020	0.095	GPS/IMU	-15.8	17.6	-27.4
	9_0083	-0.070	0.091	-0.069	GPS/IMU	-15.4	15.6	-31.6
	9_0084	-0.094	-0.051	-0.129	GPS/IMU	-14.3	17.4	-26.6
	9_0085	-0.073	-0.067	-0.156	GPS/IMU	-14.6	17.6	-29.6
	9_0086	-0.135	0.388	0.010	GPS/IMU	-17.5	9.6	-27.7
	9_0087	0.102	0.117	0.083	GPS/IMU	-15.8	14.4	-26.2
	9_0088	0.052	-0.002	0.004	GPS/IMU	-14.7	18.0	-26.0
	9_0089	-0.093	-0.066	0.012	GPS/IMU	-17.7	17.3	-26.8
	9_0090	0.010	0.169	0.037	GPS/IMU	-15.4	17.4	-28.4
	9_0091	-0.050	-0.007	0.001	GPS/IMU	-17.3	19.3	-29.2
	9_0092	0.051	-0.096	-0.056	GPS/IMU	-14.6	22.3	-29.5
	9_0093	-0.068	0.151	-0.111	GPS/IMU	-17.5	17.8	-27.5
	9_0094	-0.207	-0.052	0.185	GPS/IMU	-21.4	23.5	-25.0
	9_0095	-0.016	-0.034	-0.018	GPS/IMU	-17.8	20.5	-24.5
	9_0096	0.124	0.040	-0.091	GPS/IMU	-16.5	18.5	-22.7
	9_0097	0.011	0.155	0.029	GPS/IMU	-18.9	17.9	-21.9
	9_0098	0.156	-0.119	0.102	GPS/IMU	-18.0	19.4	-17.9
	9_0099	-0.151	-0.056	-0.017	GPS/IMU	-22.8	17.3	-21.2
	9_0100	-0.093	0.100	-0.197	GPS/IMU	-19.0	14.0	-24.3
	9_0101	0.047	-0.031	-0.066	GPS/IMU	-14.5	17.4	-22.7
	9_0102	0.154	0.025	-0.056	GPS/IMU	-15.0	16.7	-23.0
	9_0103	0.010	-0.090	0.014	GPS/IMU	-16.5	17.8	-23.8
	9_0104	-0.027	0.007	0.039	GPS/IMU	-14.7	15.4	-25.5
	9_0105	0.072	-0.007	-0.011	GPS/IMU	-11.8	15.6	-24.0
	9_0106	-0.037	0.059	-0.027	GPS/IMU	-14.3	15.1	-20.6
	9_0107	-0.090	-0.131	0.044	GPS/IMU	-16.3	18.8	-17.1
	9_0108	-0.007	-0.074	0.104	GPS/IMU	-14.1	20.1	-16.3
	9_0109	0.103	-0.030	0.096	GPS/IMU	-11.5	19.8	-14.5
	9_0110	0.047	0.092	-0.038	GPS/IMU	-16.5	17.5	-16.2
	9_0111	-0.210	-0.153	-0.032	GPS/IMU	-18.8	21.5	-15.0
	9_0112	0.026	-0.098	-0.102	GPS/IMU	-15.6	20.9	-12.6
	9_0113	-0.016	-0.135	-0.125	GPS/IMU	-17.1	21.1	-9.3
	9_0114	-0.338	0.023	-0.272	GPS/IMU	-21.3	20.3	-8.7
	9_0115	0.302	0.001	-0.081	GPS/IMU	-14.6	19.5	-12.4
	9_0116	-0.189	-0.056	-0.036	GPS/IMU	-22.4	21.8	-8.4
	9_0117	0.168	-0.045	0.017	GPS/IMU	-17.2	21.5	-9.2
	9_0118	-0.147	0.111	-0.084	GPS/IMU	-21.4	17.9	-8.2
	9_0119	0.041	-0.061	-0.045	GPS/IMU	-20.0	23.2	-8.9
	9_0254	-0.101	-0.038	-0.052	GPS/IMU	-13.9	16.7	1.5
	9_0255	0.158	0.012	0.101	GPS/IMU	-9.1	17.0	-1.5
	9_0256	-0.055	-0.077	-0.161	GPS/IMU	-13.1	19.8	1.9
	9_0257	-0.048	0.054	-0.025	GPS/IMU	-12.1	20.5	2.4
	9_0258	0.162	0.170	0.088	GPS/IMU	-11.3	18.4	1.3
*LINE	10							
	10_0125	-0.009	0.165	-0.092	GPS/IMU	2.0	2.2	1.3
	10_0126	-0.130	0.037	-0.149	GPS/IMU	2.7	6.6	0.4
	10_0127	0.120	-0.120	-0.068	GPS/IMU	5.1	7.2	-0.1
*LINE	11							
	11_0136	-0.054	0.020	-0.034	GPS/IMU	-14.7	16.5	-2.6
	11_0137	-0.137	0.045	-0.269	GPS/IMU	-14.3	16.1	0.2
	11_0138	-0.020	-0.063	-0.083	GPS/IMU	-13.8	20.7	1.7
	11_0139	0.119	-0.023	0.103	GPS/IMU	-15.5	20.9	-1.6
	11_0140	-0.035	0.070	0.057	GPS/IMU	-17.0	19.1	-5.1
*LINE	12							
	12_0133	0.267	-0.092	0.045	GPS/IMU	4.7	9.9	-10.4
	12_0134	0.170	-0.044	-0.021	GPS/IMU	1.4	10.6	-6.6
	12_0135	0.024	0.021	0.028	GPS/IMU	-2.3	9.7	-4.2
*LINE	13							
	13_0746	-0.017	0.010	0.013	GPS/IMU	1.0	0.0	-10.2
	13_0747	-0.022	0.021	-0.068	GPS/IMU	1.7	1.1	-8.5
	13_0748	0.041	-0.009	0.091	GPS/IMU	-1.4	0.3	-4.5
	13_0749	-0.009	-0.002	-0.018	GPS/IMU	0.1	1.7	-4.9
	13_0750	0.004	0.002	0.033	GPS/IMU	0.0	0.1	-1.5
*LINE	11							
	11_0141	0.029	-0.031	0.052	GPS/IMU	-15.7	19.0	-3.5
	11_0142	0.021	-0.010	0.003	GPS/IMU	-18.4	27.6	14.3
*LINE	12							
	12_0128	-0.099	0.034	0.106	GPS/IMU	3.5	6.3	-7.1
	12_0129	0.021	-0.286	0.064	GPS/IMU	2.5	10.7	-7.3
	12_0130	-0.009	0.133	0.111	GPS/IMU	2.9	5.3	-6.7

	12_0131	-0.163	0.073	0.144	GPS/IMU	-0.5	6.3	-8.1
	12_0132	-0.195	-0.044	0.030	GPS/IMU	-2.4	11.3	-8.4
*LINE	2							
	2_0145	-0.182	0.031	-0.161	GPS/IMU	0.8	8.1	5.9
	2_0146	0.258	-0.224	-0.030	GPS/IMU	5.5	10.2	10.0
	2_0147	0.160	0.181	-0.026	GPS/IMU	2.8	3.0	14.0
	2_0148	-0.115	-0.076	-0.086	GPS/IMU	0.5	6.8	12.6
	2_0149	0.254	-0.116	-0.076	GPS/IMU	8.0	6.5	11.5
	2_0150	-0.098	0.025	-0.054	GPS/IMU	3.1	4.2	9.3
	2_0151	-0.224	0.112	-0.076	GPS/IMU	0.9	2.7	10.2
	2_0152	-0.070	-0.229	-0.035	GPS/IMU	3.5	7.3	8.8
	2_0153	0.132	-0.175	0.019	GPS/IMU	6.2	6.5	10.3
	2_0154	0.151	-0.234	0.143	GPS/IMU	5.5	7.6	12.8
	2_0155	-0.217	0.091	0.042	GPS/IMU	-0.3	5.4	14.6
	2_0156	-0.045	0.122	0.030	GPS/IMU	3.0	4.6	11.6
	2_0157	-0.181	-0.235	-0.005	GPS/IMU	-0.4	12.1	9.8
	2_0158	0.202	-0.132	-0.017	GPS/IMU	5.2	10.0	14.9
	2_0159	-0.014	-0.104	0.156	GPS/IMU	1.0	9.5	14.9
	2_0162	0.048	-0.104	-0.151	GPS/IMU	2.8	6.7	18.6
	2_0163	-0.004	0.071	-0.100	GPS/IMU	4.5	3.9	23.3
	2_0164	-0.150	-0.177	-0.183	GPS/IMU	3.9	7.4	20.0
	2_0165	-0.049	0.187	-0.153	GPS/IMU	6.5	1.5	23.8
	2_0166	-0.215	0.121	-0.150	GPS/IMU	6.2	0.9	21.5
	2_0167	0.332	-0.122	-0.111	GPS/IMU	14.1	4.9	20.6
	2_0168	0.162	-0.037	-0.235	GPS/IMU	13.2	3.6	16.5
	2_0169	0.038	0.166	-0.258	GPS/IMU	12.9	1.7	14.2
	2_0170	-0.100	-0.152	-0.090	GPS/IMU	7.7	6.7	12.3
	2_0171	-0.024	0.162	-0.136	GPS/IMU	5.4	2.8	9.1
	2_0172	-0.037	0.013	0.180	GPS/IMU	4.0	5.5	8.6
	2_0173	0.015	-0.011	0.197	GPS/IMU	2.0	7.6	6.5
	2_0174	-0.100	-0.209	0.305	GPS/IMU	1.3	9.1	6.8
	2_0175	0.016	0.058	0.197	GPS/IMU	1.4	5.5	10.1
	2_0176	-0.045	-0.206	0.129	GPS/IMU	-1.8	10.0	11.7
	2_0177	-0.148	-0.079	0.026	GPS/IMU	-2.0	8.0	16.1
	2_0178	0.045	0.056	0.163	GPS/IMU	2.4	6.7	14.3
	2_0179	0.144	-0.115	-0.050	GPS/IMU	-1.2	7.0	12.9
	2_0180	0.194	0.101	0.032	GPS/IMU	0.9	4.3	16.0
	2_0181	-0.035	-0.167	-0.049	GPS/IMU	-2.8	6.2	18.9
	2_0182	0.101	-0.044	-0.054	GPS/IMU	-2.2	3.9	17.9
	2_0183	-0.104	-0.070	-0.149	GPS/IMU	-2.8	5.3	17.5
	2_0184	0.077	-0.004	-0.126	GPS/IMU	0.0	5.4	19.0
	2_0185	0.161	-0.126	-0.005	GPS/IMU	2.3	10.1	13.6
	2_0186	-0.058	0.116	-0.125	GPS/IMU	-1.0	5.3	14.5
	2_0187	0.198	-0.031	-0.003	GPS/IMU	4.5	6.4	16.8
	2_0188	0.022	-0.121	0.010	GPS/IMU	1.4	11.1	18.7
	2_0189	0.311	0.064	-0.214	GPS/IMU	2.4	7.7	20.4
	2_0190	-0.145	0.108	0.091	GPS/IMU	-4.2	5.0	24.9
	2_0191	-0.243	-0.092	0.184	GPS/IMU	-2.0	9.8	23.6
	2_0192	0.037	-0.026	-0.039	GPS/IMU	3.6	10.7	21.1
	2_0193	0.126	-0.059	-0.103	GPS/IMU	6.5	8.1	21.7
	2_0194	-0.133	0.132	-0.050	GPS/IMU	-0.3	4.8	22.9
	2_0195	0.216	-0.050	-0.001	GPS/IMU	4.9	6.1	23.2
	2_0196	-0.124	-0.025	0.194	GPS/IMU	2.0	7.2	22.7
	2_0197	0.056	0.057	0.011	GPS/IMU	3.7	5.9	22.4
	2_0198	0.119	-0.043	-0.083	GPS/IMU	4.7	5.6	23.7
	2_0199	0.223	-0.158	0.041	GPS/IMU	7.0	9.7	27.5
	2_0219	0.037	0.005	0.144	GPS/IMU	-1.8	7.4	16.1
	2_0220	-0.048	0.015	0.070	GPS/IMU	1.4	6.8	20.2
	2_0221	-0.104	0.049	0.051	GPS/IMU	0.6	6.3	18.7
	2_0222	-0.082	-0.137	0.131	GPS/IMU	5.7	7.2	17.8
	2_0223	-0.026	0.227	0.063	GPS/IMU	8.0	1.0	16.1
	2_0224	0.180	0.003	0.014	GPS/IMU	7.8	4.3	13.0
	2_0225	-0.004	-0.089	0.089	GPS/IMU	4.9	5.0	9.3
	2_0226	0.099	-0.117	0.189	GPS/IMU	6.5	7.4	11.9
	2_0227	-0.148	-0.237	0.138	GPS/IMU	2.9	9.0	10.3
	2_0228	0.279	0.148	0.092	GPS/IMU	8.1	5.3	6.7
	2_0229	-0.015	-0.178	0.283	GPS/IMU	4.2	10.4	2.0
	2_0230	0.009	-0.145	0.138	GPS/IMU	4.0	8.7	1.8
	2_0231	0.165	0.037	0.150	GPS/IMU	5.1	7.8	1.7
	2_0232	-0.021	0.055	0.244	GPS/IMU	4.7	7.3	2.9
	2_0233	-0.126	-0.070	0.134	GPS/IMU	3.4	9.6	5.3

	2_0234	-0.105	-0.057	0.176	GPS/IMU	2.2	9.0	2.5
	2_0235	0.082	-0.056	0.021	GPS/IMU	8.3	11.6	1.8
	2_0236	-0.104	0.224	0.070	GPS/IMU	-0.1	7.9	1.3
	2_0237	0.309	0.160	0.155	GPS/IMU	7.9	7.5	-0.1
	2_0238	0.165	0.188	0.198	GPS/IMU	5.0	7.1	-5.0
	2_0239	-0.067	0.318	0.152	GPS/IMU	-0.9	4.7	-5.7
	2_0240	0.112	-0.012	0.181	GPS/IMU	2.6	8.4	-3.2
	2_0241	-0.013	0.093	-0.053	GPS/IMU	0.5	6.9	0.1
	2_0242	-0.061	0.055	0.023	GPS/IMU	-0.5	8.1	1.9
	2_0243	0.123	0.039	0.058	GPS/IMU	4.2	10.4	-0.2
	2_0244	-0.161	0.138	-0.020	GPS/IMU	-1.4	8.3	-5.7
	2_0245	-0.076	0.051	-0.014	GPS/IMU	-2.3	9.1	-2.8
	2_0246	0.077	-0.098	-0.019	GPS/IMU	0.5	8.3	1.8
	2_0247	-0.007	0.025	0.210	GPS/IMU	0.2	8.4	-1.4
	2_0248	-0.052	-0.044	0.149	GPS/IMU	2.8	12.0	-2.1
	2_0249	-0.129	-0.059	-0.073	GPS/IMU	1.4	12.4	-1.5
	2_0250	0.274	-0.140	-0.066	GPS/IMU	6.0	12.5	-2.0
	2_0251	-0.017	0.164	-0.108	GPS/IMU	2.4	9.0	-2.8
	2_0252	-0.014	-0.102	0.112	GPS/IMU	1.7	9.6	-2.7
	2_0253	0.007	-0.044	-0.129	GPS/IMU	1.3	9.6	-2.1
	2_0272	-0.097	0.292	-0.224	GPS/IMU	-18.5	9.3	1.6
*LINE	9							
	9_0259	0.036	0.073	0.111	GPS/IMU	-13.2	18.2	3.0
	9_0260	-0.103	0.220	0.328	GPS/IMU	-17.2	16.0	3.1
	9_0261	-0.098	0.179	0.045	GPS/IMU	-15.0	15.1	3.3
	9_0262	-0.211	0.073	-0.331	GPS/IMU	-17.7	13.2	0.9
	9_0263	-0.155	0.089	-0.105	GPS/IMU	-17.2	13.2	0.2
	9_0264	-0.026	0.112	-0.261	GPS/IMU	-13.5	14.1	4.0
	9_0265	-0.073	-0.008	-0.145	GPS/IMU	-13.0	13.4	1.9
	9_0266	0.005	-0.036	-0.061	GPS/IMU	-11.0	14.7	1.7
	9_0267	0.010	-0.006	-0.031	GPS/IMU	-10.9	15.1	-0.6
	9_0268	0.019	-0.077	-0.056	GPS/IMU	-10.6	17.8	1.5
	9_0269	-0.112	-0.027	-0.066	GPS/IMU	-12.4	18.1	8.8
	9_0270	0.027	-0.036	0.037	GPS/IMU	-10.3	19.6	8.5
	9_0271	0.131	-0.052	-0.048	GPS/IMU	-12.8	16.4	9.1
*LINE	10							
	10_0120	-0.244	-0.182	0.124	GPS/IMU	-0.6	7.5	4.6
	10_0121	0.054	-0.115	0.152	GPS/IMU	4.1	7.3	6.0
	10_0122	0.105	0.141	-0.003	GPS/IMU	5.0	3.6	6.0
	10_0123	0.032	-0.199	0.065	GPS/IMU	2.5	8.5	4.1
	10_0124	-0.019	0.129	-0.102	GPS/IMU	2.6	5.0	3.8
*LINE	2							
	2_0273	0.035	-0.075	-0.026	GPS/IMU	-18.9	20.0	-0.6
	2_0274	0.156	0.171	-0.177	GPS/IMU	-19.7	13.9	-0.2
	2_0275	-0.084	0.060	-0.008	GPS/IMU	-23.3	17.5	-1.7
	2_0276	0.144	-0.137	-0.180	GPS/IMU	-18.0	20.1	-7.3
	2_0277	0.139	-0.209	-0.011	GPS/IMU	-19.0	23.4	-8.4
	2_0278	-0.051	0.082	-0.060	GPS/IMU	-20.6	16.5	-8.1
	2_0279	-0.046	0.033	0.029	GPS/IMU	-19.6	19.4	-11.2
	2_0280	-0.104	0.023	-0.164	GPS/IMU	-21.4	16.1	-10.1
	2_0281	0.266	0.006	0.027	GPS/IMU	-15.0	17.9	-10.4
	2_0282	-0.022	-0.122	-0.053	GPS/IMU	-18.2	20.5	-11.3
	2_0283	0.006	0.100	-0.163	GPS/IMU	-15.6	16.9	-12.4
	2_0284	0.082	0.166	-0.047	GPS/IMU	-13.6	17.0	-12.4
	2_0285	-0.381	0.026	0.051	GPS/IMU	-21.2	18.6	-12.2
	2_0286	-0.105	-0.001	0.098	GPS/IMU	-17.0	16.8	-12.4
	2_0287	-0.056	-0.157	-0.106	GPS/IMU	-15.4	20.7	-8.8
	2_0288	-0.031	-0.025	-0.054	GPS/IMU	-16.4	18.0	-8.3
	2_0289	0.044	0.025	0.019	GPS/IMU	-16.6	15.6	-9.7
	2_0290	-0.288	-0.001	0.042	GPS/IMU	-22.8	14.8	-8.5
	2_0415	0.268	0.108	-0.011	GPS/IMU	3.4	10.1	14.1
*LINE	8							
	8_0299	0.241	0.159	-0.121	GPS/IMU	-24.2	16.6	-1.5
	8_0300	-0.040	-0.113	-0.084	GPS/IMU	-29.4	20.2	-3.1
	8_0301	0.020	0.010	-0.105	GPS/IMU	-27.9	20.8	-6.1
	8_0302	0.045	-0.148	-0.053	GPS/IMU	-25.2	20.1	-2.3
	8_0303	0.095	-0.035	-0.010	GPS/IMU	-25.4	21.1	-3.3
	8_0304	-0.105	0.065	0.073	GPS/IMU	-26.5	18.2	-7.0
	8_0305	-0.193	0.184	-0.012	GPS/IMU	-29.9	16.4	-7.3
	8_0306	-0.050	0.061	-0.098	GPS/IMU	-27.1	16.9	-9.2
	8_0307	0.022	0.019	-0.010	GPS/IMU	-26.2	16.9	-16.3

	8_0308	0.055	0.077	-0.010	GPS/IMU	-25.0	17.3	-13.2
	8_0309	0.011	0.096	-0.110	GPS/IMU	-27.4	16.7	-7.5
	8_0310	-0.048	-0.149	-0.040	GPS/IMU	-29.2	20.0	-9.6
	8_0311	-0.051	-0.043	-0.104	GPS/IMU	-28.3	20.0	-6.6
	8_0312	0.025	0.029	0.008	GPS/IMU	-27.4	20.9	-3.8
*LINE	9							
	9_0019	-0.023	0.028	-0.202	GPS/IMU	-10.6	14.4	-0.8
	9_0020	-0.003	-0.093	-0.176	GPS/IMU	-10.4	17.0	-2.9
	9_0021	0.089	-0.096	0.096	GPS/IMU	-10.3	19.7	-5.9
	9_0022	0.039	-0.071	-0.010	GPS/IMU	-12.9	17.2	-7.2
	9_0023	-0.004	-0.076	-0.027	GPS/IMU	-14.5	16.3	-5.9
*LINE	1							
	1_0314	0.065	0.080	0.261	GPS/IMU	-31.5	28.5	-4.1
	1_0315	0.268	0.138	0.521	GPS/IMU	-29.3	24.6	-4.1
	1_0316	-0.101	-0.040	0.407	GPS/IMU	-34.6	27.5	-4.0
	1_0317	-0.018	-0.047	0.310	GPS/IMU	-33.6	27.5	-0.8
	1_0318	-0.010	0.118	0.356	GPS/IMU	-33.6	25.0	1.3
	1_0319	-0.331	-0.179	0.258	GPS/IMU	-38.7	28.6	2.2
	1_0320	-0.178	0.128	0.231	GPS/IMU	-35.1	24.6	2.0
	1_0321	-0.244	-0.056	0.203	GPS/IMU	-37.4	25.4	0.5
	1_0322	-0.145	0.101	0.349	GPS/IMU	-38.0	24.6	0.9
	1_0323	-0.311	-0.090	0.332	GPS/IMU	-38.9	26.2	-2.9
	1_0324	0.354	-0.192	0.238	GPS/IMU	-31.6	25.7	-5.2
	1_0325	0.044	-0.132	0.220	GPS/IMU	-35.0	27.3	-6.7
	1_0326	0.055	-0.013	0.106	GPS/IMU	-32.8	24.1	-5.0
	1_0327	-0.071	-0.058	0.317	GPS/IMU	-34.9	24.6	-2.3
	1_0328	-0.228	-0.112	0.006	GPS/IMU	-35.7	26.0	-1.4
	1_0329	0.062	-0.099	0.048	GPS/IMU	-30.8	26.0	-5.0
	1_0330	-0.146	0.038	-0.045	GPS/IMU	-34.0	22.5	-4.0
	1_0331	0.030	0.101	0.187	GPS/IMU	-28.7	21.9	-3.4
	1_0332	-0.142	0.022	-0.147	GPS/IMU	-31.2	19.9	-5.1
	1_0333	0.080	0.024	-0.011	GPS/IMU	-26.7	22.3	-5.8
	1_0334	0.165	-0.120	-0.050	GPS/IMU	-26.5	27.3	-3.4
	1_0335	-0.121	0.043	0.091	GPS/IMU	-28.0	23.5	1.2
	1_0336	0.102	-0.043	0.225	GPS/IMU	-26.2	24.6	-0.7
	1_0337	-0.118	0.033	-0.153	GPS/IMU	-29.8	19.0	-1.1
	1_0338	0.021	0.124	-0.006	GPS/IMU	-27.3	20.3	-2.8
	1_0339	0.108	0.016	-0.032	GPS/IMU	-27.8	22.1	-1.3
	1_0340	-0.172	-0.016	0.029	GPS/IMU	-31.9	22.4	-1.1
	1_0341	0.072	-0.039	0.034	GPS/IMU	-27.0	26.0	-6.6
	1_0342	0.183	0.107	-0.048	GPS/IMU	-27.2	22.0	-4.3
	1_0343	-0.017	0.002	0.018	GPS/IMU	-28.0	23.5	-1.9
	1_0344	-0.472	0.036	-0.100	GPS/IMU	-33.0	27.1	-0.4
	1_0345	0.273	-0.129	-0.008	GPS/IMU	-23.8	25.3	-2.9
	1_0346	0.233	-0.185	-0.062	GPS/IMU	-22.4	26.6	-5.0
	1_0347	0.009	-0.056	-0.076	GPS/IMU	-24.3	24.2	-1.4
	1_0348	0.078	-0.264	-0.127	GPS/IMU	-25.1	25.9	-1.4
	1_0349	0.047	-0.032	-0.103	GPS/IMU	-26.0	25.2	1.4
	1_0350	0.218	-0.159	-0.174	GPS/IMU	-25.8	27.0	7.2
	1_0351	0.103	-0.082	-0.169	GPS/IMU	-27.7	25.5	6.8
	1_0352	-0.132	0.066	-0.041	GPS/IMU	-31.2	22.3	2.1
	1_0353	0.490	0.214	0.001	GPS/IMU	-22.6	20.1	0.8
	1_0354	0.117	0.102	-0.030	GPS/IMU	-29.6	20.9	1.0
	1_0355	0.089	0.423	0.024	GPS/IMU	-27.1	17.2	3.5
	1_0356	-0.148	-0.285	0.080	GPS/IMU	-31.9	30.5	5.6
	1_0357	-0.420	0.007	-0.094	GPS/IMU	-31.8	24.5	-1.5
	1_0358	0.106	-0.007	0.020	GPS/IMU	-24.9	25.3	-6.0
	1_0359	0.138	0.030	-0.024	GPS/IMU	-21.6	24.7	-3.3
	1_0360	0.126	0.178	0.027	GPS/IMU	-22.8	24.9	-2.0
	1_0361	0.017	-0.097	-0.057	GPS/IMU	-24.7	26.9	1.9
	1_0362	-0.004	0.058	-0.132	GPS/IMU	-23.9	22.9	3.8
	1_0363	0.018	-0.015	0.059	GPS/IMU	-25.0	20.0	6.5
	1_0364	0.000	0.042	0.083	GPS/IMU	-23.1	17.4	5.7
	1_0365	-0.187	0.205	0.022	GPS/IMU	-29.9	15.4	6.9
	1_0366	0.055	-0.093	-0.103	GPS/IMU	-25.0	18.8	9.6
	1_0367	-0.111	0.134	-0.172	GPS/IMU	-27.4	16.6	9.8
	1_0368	0.099	0.026	-0.162	GPS/IMU	-22.8	19.8	9.5
	1_0369	-0.070	-0.034	-0.028	GPS/IMU	-28.3	19.4	9.2
	1_0370	-0.284	-0.065	0.081	GPS/IMU	-32.7	20.7	9.7
	1_0371	-0.011	-0.047	0.005	GPS/IMU	-29.0	20.5	3.6
	1_0372	0.175	0.065	0.007	GPS/IMU	-26.4	21.0	0.6

	1_0373	0.054	-0.141	0.023	GPS/IMU	-27.6	25.6	-0.6
	1_0374	-0.181	-0.007	-0.178	GPS/IMU	-29.7	23.4	-1.5
	1_0375	0.076	-0.117	0.091	GPS/IMU	-23.8	23.7	0.9
	1_0376	0.011	-0.017	0.130	GPS/IMU	-26.2	22.8	1.0
	1_0377	0.107	0.124	-0.037	GPS/IMU	-23.0	18.6	1.9
	1_0378	0.236	0.076	0.058	GPS/IMU	-23.0	19.8	3.6
	1_0379	0.005	-0.085	-0.031	GPS/IMU	-25.3	22.8	4.6
	1_0380	-0.063	0.031	0.064	GPS/IMU	-26.7	22.1	1.2
	1_0381	-0.020	0.023	-0.199	GPS/IMU	-24.5	22.6	-0.9
	1_0382	0.160	-0.089	-0.177	GPS/IMU	-22.9	24.3	-0.8
	1_0383	0.228	0.107	-0.280	GPS/IMU	-20.8	22.1	-1.5
	1_0384	-0.197	-0.102	-0.230	GPS/IMU	-26.1	24.6	-3.5
	1_0385	-0.173	-0.025	-0.020	GPS/IMU	-24.3	23.9	-3.7
	1_0386	0.143	-0.027	-0.329	GPS/IMU	-19.2	23.0	-3.3
	1_0387	-0.011	-0.216	-0.218	GPS/IMU	-20.8	26.3	-3.9
	1_0388	0.369	-0.112	-0.419	GPS/IMU	-15.0	26.7	-1.7
	1_0389	0.241	0.134	-0.306	GPS/IMU	-15.7	20.8	-2.6
*LINE	2							
	2_0416	0.208	-0.097	0.106	GPS/IMU	2.9	11.6	7.5
	2_0417	-0.029	-0.140	-0.078	GPS/IMU	2.8	11.6	19.8
	2_0419	-0.081	-0.003	0.025	GPS/IMU	2.3	9.2	20.0
	2_0420	0.198	-0.118	-0.132	GPS/IMU	9.1	13.2	16.7
	2_0432	0.330	-0.168	-0.074	GPS/IMU	9.4	9.7	19.1
	2_0433	0.142	-0.034	-0.116	GPS/IMU	6.5	6.6	15.3
	2_0434	0.275	0.216	-0.196	GPS/IMU	8.5	6.9	11.0
	2_0435	-0.123	0.018	-0.016	GPS/IMU	5.4	8.2	10.7
	2_0436	0.063	0.133	-0.155	GPS/IMU	6.5	5.8	10.3
	2_0437	-0.126	-0.134	-0.069	GPS/IMU	5.9	11.3	9.1
	2_0438	-0.131	0.164	0.046	GPS/IMU	6.1	6.3	12.9
	2_0439	-0.070	0.224	-0.092	GPS/IMU	5.6	4.4	14.0
	2_0440	0.002	-0.171	-0.012	GPS/IMU	5.6	10.9	15.9
	2_0441	0.089	-0.173	-0.140	GPS/IMU	7.4	9.0	15.6
	2_0442	-0.051	0.362	-0.048	GPS/IMU	6.9	1.4	13.8
	2_0443	-0.288	0.071	-0.211	GPS/IMU	1.1	7.1	13.2
	2_0444	0.182	-0.217	0.036	GPS/IMU	12.0	10.1	10.3
	2_0445	-0.026	0.085	-0.133	GPS/IMU	6.5	6.4	7.6
	2_0446	-0.131	0.309	0.104	GPS/IMU	5.4	5.2	2.9
	2_0447	0.377	-0.079	-0.324	GPS/IMU	14.2	9.3	8.0
	2_0450	-0.037	-0.001	0.083	GPS/IMU	12.2	5.7	1.8
	2_0451	-0.046	-0.105	-0.219	GPS/IMU	10.4	7.0	5.6
	2_0452	-0.269	-0.098	-0.065	GPS/IMU	8.9	8.6	2.4
	2_0453	-0.052	-0.040	0.125	GPS/IMU	12.0	12.2	-1.4
	2_0454	0.101	-0.047	-0.008	GPS/IMU	10.3	9.4	3.9
	2_0455	0.175	0.069	0.035	GPS/IMU	10.8	4.3	6.6
	2_0456	-0.131	-0.087	0.120	GPS/IMU	10.1	11.7	6.5
	2_0457	0.097	0.138	0.047	GPS/IMU	9.5	6.0	6.2
	2_0477	0.103	-0.433	-0.046	GPS/IMU	14.0	14.7	10.0
	2_0478	-0.386	-0.111	0.134	GPS/IMU	8.1	10.7	10.1
	2_0479	0.044	-0.224	0.089	GPS/IMU	14.3	10.7	12.9
	2_0480	-0.400	0.048	0.217	GPS/IMU	7.6	5.1	14.6
	2_0481	-0.236	-0.032	0.245	GPS/IMU	11.6	6.4	12.9
	2_0482	0.283	0.273	0.188	GPS/IMU	16.9	1.8	14.1
	2_0483	0.110	0.257	0.179	GPS/IMU	17.0	1.8	13.5
	2_0484	-0.018	0.127	0.138	GPS/IMU	18.3	3.4	13.8
	2_0485	-0.246	0.127	0.087	GPS/IMU	14.2	1.4	15.4
	2_0486	-0.148	0.063	0.143	GPS/IMU	19.4	3.9	15.0
	2_0487	-0.220	-0.096	0.252	GPS/IMU	18.2	4.1	16.7
	2_0686	0.241	0.244	0.598	GPS/IMU	18.5	4.5	-4.9
*LINE	7							
	7_0522	0.009	0.120	-0.099	GPS/IMU	-17.3	17.2	9.3
	7_0523	-0.040	-0.069	-0.128	GPS/IMU	-16.2	19.0	4.7
	7_0524	-0.040	0.032	-0.077	GPS/IMU	-18.4	17.8	3.3
	7_0525	0.053	-0.048	0.076	GPS/IMU	-19.5	14.3	4.2
	7_0526	-0.032	-0.009	-0.028	GPS/IMU	-16.3	15.6	9.1
	7_0527	0.032	-0.013	0.037	GPS/IMU	-15.0	18.1	11.7
	7_0528	0.043	0.024	0.124	GPS/IMU	-13.0	19.5	13.1
	7_0529	0.093	0.116	0.221	GPS/IMU	-15.1	17.0	10.9
	7_0530	-0.178	0.073	0.240	GPS/IMU	-18.5	18.1	10.0
	7_0531	0.014	-0.076	0.165	GPS/IMU	-16.1	19.2	7.7
	7_0532	0.072	-0.025	0.225	GPS/IMU	-16.7	19.2	8.4
	7_0533	-0.068	-0.304	0.097	GPS/IMU	-17.8	23.1	6.1

	7_0534	-0.241	0.041	0.116	GPS/IMU	-17.2	18.3	4.8
	7_0535	-0.028	0.084	0.178	GPS/IMU	-16.9	18.7	10.2
	7_0536	-0.013	-0.059	0.221	GPS/IMU	-15.3	22.1	9.9
	7_0537	0.069	0.152	0.192	GPS/IMU	-16.4	17.9	9.4
	7_0538	-0.230	-0.102	0.166	GPS/IMU	-18.8	22.5	8.6
	7_0539	-0.160	0.183	0.096	GPS/IMU	-20.1	19.8	7.8
	7_0540	0.155	0.004	0.087	GPS/IMU	-12.9	21.3	11.0
	7_0541	-0.157	0.169	0.103	GPS/IMU	-20.3	19.8	12.5
	7_0542	-0.161	-0.274	0.046	GPS/IMU	-20.0	25.5	15.1
	7_0543	0.068	-0.109	-0.002	GPS/IMU	-13.7	22.7	10.7
	7_0544	0.077	-0.124	-0.052	GPS/IMU	-17.2	21.3	10.2
	7_0545	0.026	0.108	0.082	GPS/IMU	-14.7	19.7	8.1
	7_0546	0.216	0.034	0.115	GPS/IMU	-13.6	20.4	7.4
	7_0547	-0.002	-0.283	-0.040	GPS/IMU	-14.4	21.7	5.1
	7_0548	0.218	0.222	0.011	GPS/IMU	-11.6	14.3	-2.1
	7_0549	0.127	-0.026	-0.090	GPS/IMU	-14.3	16.5	-0.7
	7_0550	-0.048	0.025	0.038	GPS/IMU	-15.2	16.0	-3.2
	7_0551	-0.368	0.247	-0.027	GPS/IMU	-18.9	12.3	4.0
	7_0552	0.166	-0.223	0.090	GPS/IMU	-7.7	19.6	9.0
	7_0553	-0.219	0.003	0.159	GPS/IMU	-16.3	20.1	12.4
*LINE	8							
	8_0294	-0.045	0.098	-0.120	GPS/IMU	-31.9	22.3	-2.1
	8_0295	-0.098	-0.006	-0.099	GPS/IMU	-30.8	21.7	1.1
	8_0296	-0.050	0.006	-0.126	GPS/IMU	-29.9	21.7	-0.6
	8_0297	-0.045	0.075	-0.133	GPS/IMU	-30.4	19.7	2.3
	8_0298	-0.389	0.001	-0.047	GPS/IMU	-33.0	20.1	1.9
*LINE	6							
	6_0560	-0.020	-0.029	-0.093	GPS/IMU	2.6	4.8	-1.8
	6_0561	0.220	-0.204	0.049	GPS/IMU	6.1	7.9	-1.5
	6_0562	-0.019	-0.377	-0.076	GPS/IMU	5.7	11.2	-1.0
	6_0563	0.026	-0.071	0.119	GPS/IMU	6.3	8.1	-3.0
	6_0564	0.046	0.072	0.183	GPS/IMU	3.4	6.4	-5.4
	6_0565	0.053	-0.388	-0.105	GPS/IMU	2.8	12.4	2.5
	6_0566	0.048	-0.154	-0.001	GPS/IMU	3.4	8.1	-1.7
	6_0567	0.078	-0.100	0.088	GPS/IMU	4.5	8.7	-0.2
	6_0568	0.100	-0.077	-0.011	GPS/IMU	4.2	9.6	0.3
	6_0569	-0.139	-0.040	-0.034	GPS/IMU	1.2	8.0	2.8
	6_0570	0.083	0.207	-0.003	GPS/IMU	1.7	6.1	2.5
	6_0571	-0.052	0.173	0.071	GPS/IMU	2.0	4.9	3.3
	6_0572	0.016	0.337	0.051	GPS/IMU	3.6	5.9	5.6
	6_0573	0.246	-0.197	0.108	GPS/IMU	6.5	11.5	9.4
	6_0574	0.200	-0.017	0.097	GPS/IMU	6.6	7.7	10.0
	6_0575	0.128	0.168	0.085	GPS/IMU	4.7	5.1	12.2
	6_0576	0.027	0.056	-0.021	GPS/IMU	4.4	8.1	10.1
	6_0577	-0.116	0.095	-0.003	GPS/IMU	4.4	10.2	13.0
	6_0578	0.418	0.144	-0.119	GPS/IMU	10.4	6.5	13.0
	6_0579	-0.039	0.080	0.003	GPS/IMU	4.5	8.4	8.6
	6_0580	-0.097	0.087	-0.055	GPS/IMU	1.9	7.0	8.5
	6_0581	0.085	0.004	-0.047	GPS/IMU	4.2	7.7	11.1
	6_0582	0.206	0.069	-0.002	GPS/IMU	7.2	8.6	12.8
	6_0583	0.113	0.291	-0.153	GPS/IMU	5.4	6.0	12.0
	6_0584	0.015	-0.102	-0.113	GPS/IMU	4.1	9.6	7.8
	6_0585	0.023	-0.166	-0.156	GPS/IMU	4.3	11.3	7.7
	6_0586	0.000	0.017	-0.039	GPS/IMU	4.4	7.5	12.9
	6_0587	0.029	-0.151	-0.030	GPS/IMU	5.2	11.7	13.3
	6_0588	-0.007	0.045	-0.056	GPS/IMU	4.1	4.5	10.1
	6_0601	0.032	0.239	-0.072	GPS/IMU	4.7	6.2	8.1
	6_0602	0.073	-0.065	-0.025	GPS/IMU	5.0	9.0	3.2
	6_0603	-0.040	0.012	-0.118	GPS/IMU	7.1	7.0	3.7
	6_0604	-0.049	-0.089	-0.245	GPS/IMU	3.8	9.3	2.3
	6_0605	0.027	0.106	-0.023	GPS/IMU	4.5	5.8	0.4
	6_0606	-0.009	-0.179	-0.095	GPS/IMU	1.9	10.4	-0.1
	6_0607	-0.081	0.030	-0.104	GPS/IMU	2.2	7.1	0.1
	6_0608	-0.079	-0.085	-0.344	GPS/IMU	1.5	10.2	2.8
	6_0609	-0.060	-0.067	-0.195	GPS/IMU	1.0	7.8	3.6
	6_0610	-0.031	-0.022	-0.060	GPS/IMU	0.8	7.6	6.2
	6_1486	-0.016	-0.022	0.031	GPS/IMU	0.1	0.6	2.5
	6_1487	0.018	-0.019	0.030	GPS/IMU	-0.8	0.5	6.0
	6_1488	0.017	-0.004	0.050	GPS/IMU	0.2	1.1	6.6
	6_1489	-0.038	-0.014	-0.081	GPS/IMU	0.1	2.3	7.6
	6_1490	0.025	0.030	-0.030	GPS/IMU	-0.7	1.9	5.5

*LINE	5							
	5_0616	-0.066	0.096	-0.065	GPS/IMU	-11.7	13.7	4.5
	5_0617	-0.010	0.149	0.076	GPS/IMU	-9.9	14.3	6.5
	5_0618	0.073	0.149	-0.050	GPS/IMU	-10.5	13.2	5.3
	5_0619	-0.155	0.255	0.034	GPS/IMU	-12.9	12.7	5.6
	5_0620	0.035	-0.061	-0.090	GPS/IMU	-8.3	17.2	8.1
	5_0621	-0.217	0.054	-0.130	GPS/IMU	-14.5	16.1	9.8
	5_0622	-0.141	-0.017	0.031	GPS/IMU	-13.0	16.7	8.0
	5_0623	0.064	0.261	-0.132	GPS/IMU	-11.7	12.5	10.2
	5_0624	0.065	-0.001	-0.144	GPS/IMU	-10.1	16.0	10.7
	5_0625	-0.036	0.152	-0.031	GPS/IMU	-13.6	12.6	10.4
	5_0626	0.026	0.125	-0.126	GPS/IMU	-14.1	14.1	13.0
	5_0627	-0.117	-0.237	-0.065	GPS/IMU	-14.1	15.5	9.6
	5_0628	0.270	-0.349	-0.270	GPS/IMU	-8.4	18.3	9.8
	5_0629	0.339	-0.077	-0.309	GPS/IMU	-8.4	15.6	10.1
	5_0630	-0.056	-0.015	-0.296	GPS/IMU	-13.7	14.4	10.0
	5_0672	-0.112	-0.045	-0.195	GPS/IMU	-8.1	16.1	20.4
	5_0673	0.005	-0.020	-0.084	GPS/IMU	-11.9	12.2	16.7
	5_1069	0.024	0.009	-0.038	GPS/IMU	-1.3	1.0	-20.2
	5_1070	-0.003	0.035	-0.049	GPS/IMU	0.4	1.5	-16.4
	5_1071	-0.015	-0.005	0.015	GPS/IMU	0.1	0.6	-14.5
	5_1072	-0.010	-0.024	0.066	GPS/IMU	-0.8	0.5	-13.4
	5_1401	0.017	0.003	-0.093	GPS/IMU	-0.3	0.6	-8.9
*LINE	2							
	2_0905	-0.003	0.015	0.026	GPS/IMU	0.8	1.7	17.2
	2_0906	0.011	-0.003	0.088	GPS/IMU	1.1	0.7	14.7
	2_0907	-0.002	0.011	0.009	GPS/IMU	0.1	0.6	15.0
	2_0908	-0.004	0.016	-0.025	GPS/IMU	-0.1	1.4	18.5
*LINE	13							
	13_0751	-0.005	-0.020	-0.021	GPS/IMU	0.7	0.5	-1.9
	13_0752	0.006	-0.010	-0.039	GPS/IMU	-0.2	-0.6	-5.1
	13_0753	0.026	-0.019	-0.056	GPS/IMU	1.0	0.3	-5.5
	13_0754	-0.019	0.000	0.095	GPS/IMU	-0.7	0.8	-7.8
	13_0755	0.015	-0.007	-0.074	GPS/IMU	-0.3	0.2	-9.8
	13_0756	-0.029	0.008	0.036	GPS/IMU	1.1	0.5	-5.2
	13_0757	0.015	0.024	-0.003	GPS/IMU	-0.2	1.0	-3.6
	13_0758	0.026	0.002	0.035	GPS/IMU	-1.7	0.7	0.1
	13_0759	-0.031	-0.001	-0.023	GPS/IMU	1.0	-0.1	2.4
*LINE	2							
	2_0909	0.019	0.041	-0.005	GPS/IMU	-0.2	2.5	19.3
	2_0910	0.039	0.032	0.026	GPS/IMU	-0.6	1.2	17.1
	2_0911	-0.041	0.006	0.005	GPS/IMU	1.4	1.2	15.7
	2_0912	-0.039	-0.041	-0.240	GPS/IMU	1.2	1.4	12.0
	2_0913	-0.019	-0.018	0.005	GPS/IMU	2.1	1.6	12.3
	2_0914	0.003	-0.030	-0.027	GPS/IMU	1.0	1.1	12.4
	2_0915	-0.029	-0.037	0.018	GPS/IMU	-0.5	1.3	16.8
	2_0916	0.042	0.006	0.152	GPS/IMU	-0.1	2.9	16.2
	2_0917	0.032	0.028	0.121	GPS/IMU	-0.2	2.4	16.0
	2_0918	0.010	-0.007	-0.032	GPS/IMU	-1.1	0.3	19.7
	2_0919	-0.023	0.054	0.019	GPS/IMU	1.4	2.4	25.0
	2_0920	-0.006	-0.001	-0.037	GPS/IMU	-0.4	0.8	21.0
	2_0921	0.024	-0.009	-0.009	GPS/IMU	-0.8	-0.2	15.8
	2_0922	0.036	-0.004	-0.027	GPS/IMU	-2.0	-0.2	14.7
	2_0951	-0.050	-0.014	-0.050	GPS/IMU	1.7	0.0	5.6
	2_0952	-0.023	-0.056	-0.057	GPS/IMU	0.6	-0.8	1.8
	2_0953	0.008	-0.006	0.077	GPS/IMU	-0.1	1.0	1.2
	2_0954	0.060	0.009	0.038	GPS/IMU	-1.3	0.8	1.9
*LINE	3							
	3_1409	0.003	-0.026	0.029	GPS/IMU	0.4	-1.0	9.1
	3_1410	0.001	0.017	0.012	GPS/IMU	0.3	0.5	8.5
	3_1411	0.016	-0.003	-0.010	GPS/IMU	-0.4	0.4	5.2
	3_1412	0.019	-0.027	-0.016	GPS/IMU	-0.5	-1.3	4.2
	3_1413	0.005	-0.001	-0.003	GPS/IMU	-0.4	0.3	3.9
*LINE	5							
	5_1402	0.024	-0.003	0.025	GPS/IMU	-1.0	1.3	-13.1
	5_1403	-0.017	-0.036	-0.007	GPS/IMU	0.2	0.5	-11.4
	5_1404	-0.006	-0.004	0.052	GPS/IMU	0.5	0.6	-7.3
	5_1405	-0.015	0.014	-0.004	GPS/IMU	0.2	1.3	-6.9
	5_1406	-0.013	0.035	0.030	GPS/IMU	1.2	1.7	-6.6
	5_1509	0.048	-0.011	-0.119	GPS/IMU	1.8	3.5	10.0
	5_1510	-0.053	-0.042	-0.039	GPS/IMU	2.0	1.4	8.2

	5_1511	-0.030	-0.034	-0.031	GPS/IMU	2.7	3.0	10.0
	5_1512	0.026	-0.027	0.011	GPS/IMU	0.5	2.7	12.5
	5_1513	0.040	-0.037	0.048	GPS/IMU	0.5	2.6	14.9
*LINE	3							
	3_1414	-0.008	0.013	-0.027	GPS/IMU	-0.4	1.0	2.9
	3_1415	-0.017	-0.007	0.037	GPS/IMU	0.5	0.5	1.9
	3_1416	0.000	0.031	-0.014	GPS/IMU	-0.3	1.9	2.8
	3_1417	0.031	0.015	-0.021	GPS/IMU	-1.4	0.8	2.4
	3_1418	-0.026	-0.006	0.070	GPS/IMU	0.5	-0.2	0.4
	3_1419	-0.004	-0.011	-0.027	GPS/IMU	0.6	-0.1	-2.5
	3_1420	-0.010	-0.003	-0.033	GPS/IMU	0.9	-0.2	0.4
	3_1550	-0.006	0.003	0.064	GPS/IMU	-0.6	0.7	7.9
	3_1551	0.010	-0.014	0.078	GPS/IMU	-1.3	1.1	10.2
	3_1552	0.025	-0.021	0.021	GPS/IMU	0.3	-0.6	12.4
	3_1553	-0.024	-0.019	0.027	GPS/IMU	1.3	0.5	11.5
	3_1554	-0.020	0.007	0.016	GPS/IMU	1.4	1.1	11.1
*LINE	6							
	6_1491	0.002	-0.009	0.023	GPS/IMU	0.6	0.3	5.8
	6_1492	-0.012	0.003	-0.011	GPS/IMU	0.8	0.8	4.4
	6_1493	0.003	-0.006	-0.044	GPS/IMU	0.5	0.5	4.8
	6_1494	-0.006	-0.003	0.002	GPS/IMU	0.4	0.3	2.7
	6_1495	-0.026	0.004	0.011	GPS/IMU	1.7	0.7	4.2
	6_1496	0.002	0.038	-0.032	GPS/IMU	-0.1	1.9	7.5
	6_1497	0.001	0.034	-0.067	GPS/IMU	-1.0	1.8	6.7
*LINE	7							
	7_0517	0.059	0.052	0.120	GPS/IMU	-8.9	20.9	15.9
	7_0518	0.143	-0.017	0.130	GPS/IMU	-10.0	21.3	15.8
	7_0519	-0.139	0.103	-0.485	GPS/IMU	-12.4	21.4	14.8
	7_0520	-0.079	-0.188	-0.185	GPS/IMU	-15.9	21.8	11.8
	7_0521	-0.039	-0.020	0.034	GPS/IMU	-17.1	21.1	11.5
*LINE	5							
	5_1514	-0.017	-0.041	0.083	GPS/IMU	0.5	2.6	12.8
	5_1515	-0.051	-0.020	0.092	GPS/IMU	0.1	2.3	14.8
	5_1516	0.001	0.004	0.020	GPS/IMU	0.7	2.1	15.6
	5_1517	0.015	-0.007	-0.072	GPS/IMU	1.3	1.5	16.9
	5_1518	0.004	0.025	0.053	GPS/IMU	1.3	2.0	16.7
	5_1519	-0.016	0.004	0.064	GPS/IMU	1.0	1.8	17.0
	5_1520	-0.011	0.025	-0.018	GPS/IMU	1.1	2.6	16.2
	5_1521	-0.007	0.031	0.017	GPS/IMU	1.5	2.0	18.4
	5_1522	-0.004	0.005	-0.078	GPS/IMU	0.1	2.7	20.3
	5_1523	0.028	-0.005	-0.135	GPS/IMU	0.5	2.3	21.1
	5_1524	0.025	-0.018	-0.008	GPS/IMU	0.0	1.9	23.4
	5_1525	-0.005	-0.028	0.044	GPS/IMU	0.2	4.3	23.3
	5_1526	-0.017	0.040	0.023	GPS/IMU	0.9	3.6	20.6
	5_1527	0.004	-0.025	0.035	GPS/IMU	1.7	3.1	20.3
	5_1528	-0.025	0.026	-0.094	GPS/IMU	2.7	3.9	21.1
	5_1529	-0.016	0.007	0.020	GPS/IMU	1.6	4.2	18.6
	5_1530	0.015	-0.004	-0.065	GPS/IMU	0.3	4.4	19.3
	5_1531	0.046	0.007	-0.009	GPS/IMU	0.7	4.3	21.1
	5_1532	0.022	-0.016	-0.014	GPS/IMU	1.0	4.2	22.8
	5_1533	0.009	-0.007	0.047	GPS/IMU	1.3	4.1	21.8
	5_1534	0.017	-0.005	0.055	GPS/IMU	1.6	3.7	21.4
	5_1535	0.002	-0.034	0.016	GPS/IMU	0.9	2.2	25.5
	5_1536	-0.017	-0.036	-0.135	GPS/IMU	1.1	3.6	27.0
	5_1537	0.000	0.015	-0.040	GPS/IMU	0.0	6.1	25.0
	5_1538	0.037	0.004	0.034	GPS/IMU	0.6	3.8	21.3
	5_1539	-0.017	0.031	-0.016	GPS/IMU	2.2	4.1	18.7
	5_1540	-0.026	0.011	-0.055	GPS/IMU	1.4	5.1	19.9
	5_1541	-0.005	0.018	0.013	GPS/IMU	1.5	5.4	18.9
	5_1542	0.025	-0.014	0.043	GPS/IMU	1.3	4.2	18.3
	5_1543	-0.005	-0.001	-0.095	GPS/IMU	1.1	5.1	17.6
	5_1544	-0.001	0.038	0.023	GPS/IMU	1.4	5.4	15.8
	5_1545	0.037	-0.013	0.055	GPS/IMU	0.3	3.1	17.0
	5_1546	-0.005	0.042	-0.021	GPS/IMU	-1.6	4.1	20.5
	5_1547	0.029	0.038	0.087	GPS/IMU	-0.6	3.5	21.8
	5_1548	0.037	0.047	0.093	GPS/IMU	1.1	3.8	22.7
	5_1549	-0.027	0.064	0.019	GPS/IMU	1.0	2.7	21.4
*LINE	6							
	6_0555	0.004	0.008	0.013	GPS/IMU	1.4	6.3	4.6
	6_0556	0.003	0.000	-0.081	GPS/IMU	3.3	4.8	5.4
	6_0557	-0.006	0.061	-0.057	GPS/IMU	3.0	4.9	2.7

	6_0558	-0.244	0.090	0.027	GPS/IMU	3.0	5.2	1.5
	6_0559	-0.265	0.033	-0.062	GPS/IMU	-0.2	6.3	-1.3
*LINE	3							
	3_1555	-0.027	0.015	-0.036	GPS/IMU	0.8	1.7	14.2
	3_1556	-0.021	0.026	-0.061	GPS/IMU	1.3	2.0	15.7
	3_1557	-0.006	-0.006	0.063	GPS/IMU	0.4	-0.2	17.3
	3_1558	0.016	-0.004	-0.051	GPS/IMU	-0.5	0.5	17.8
	3_1559	0.019	0.004	0.024	GPS/IMU	-0.3	0.0	16.8
	3_1560	-0.019	0.029	-0.005	GPS/IMU	0.7	1.9	18.2
	3_1561	-0.002	0.023	0.106	GPS/IMU	1.5	1.4	15.1
	3_1562	-0.014	-0.015	0.027	GPS/IMU	-0.4	0.8	11.6
	3_1563	0.012	-0.032	0.094	GPS/IMU	-0.2	-0.1	14.9
	3_1564	-0.009	-0.049	0.093	GPS/IMU	0.9	0.3	15.1
	3_1565	0.012	-0.020	0.102	GPS/IMU	-0.2	1.1	17.7
	3_1566	0.009	-0.008	0.082	GPS/IMU	-0.5	0.5	15.8
	3_1567	-0.050	-0.002	0.007	GPS/IMU	-0.3	1.7	13.3
	3_1568	0.008	0.012	0.021	GPS/IMU	0.6	1.4	10.6
	3_1569	-0.047	-0.011	0.010	GPS/IMU	1.4	0.6	8.7
	3_1570	-0.035	-0.028	0.067	GPS/IMU	1.2	-0.1	10.5
	3_1571	-0.008	-0.004	-0.016	GPS/IMU	1.0	1.2	12.7
	3_1572	0.020	-0.034	0.049	GPS/IMU	0.0	0.3	12.8
	3_1573	-0.003	-0.014	-0.070	GPS/IMU	-0.4	0.7	8.9
	3_1574	-0.008	-0.031	0.023	GPS/IMU	-0.2	0.4	7.4
	3_1575	0.011	-0.024	0.091	GPS/IMU	0.1	1.0	9.6
	3_1576	0.028	0.025	-0.103	GPS/IMU	-0.7	2.3	11.3
	3_1577	-0.007	0.023	-0.019	GPS/IMU	0.7	1.5	14.0
	3_1578	0.016	-0.013	-0.043	GPS/IMU	0.3	-0.2	12.9
	3_1579	-0.036	0.023	-0.029	GPS/IMU	2.2	1.0	15.8
	3_1582	0.029	0.036	0.021	GPS/IMU	-1.4	1.8	16.0
	3_1583	-0.005	0.017	0.041	GPS/IMU	-0.1	1.2	18.5
	3_1584	0.002	0.037	-0.046	GPS/IMU	0.8	1.9	16.8
	3_1585	-0.033	0.033	0.021	GPS/IMU	1.2	1.9	12.4
	3_1586	0.008	-0.004	0.068	GPS/IMU	1.3	0.3	14.2
	3_1587	-0.032	-0.012	-0.053	GPS/IMU	0.5	1.5	13.7
	3_1588	0.000	0.000	0.028	GPS/IMU	0.7	1.2	16.0
	3_1589	0.039	-0.023	-0.043	GPS/IMU	0.2	0.7	16.6
	3_1590	-0.016	-0.005	-0.143	GPS/IMU	0.7	0.9	15.1
	3_1591	0.002	-0.001	-0.065	GPS/IMU	0.4	0.4	15.8
	3_1592	0.011	0.023	0.010	GPS/IMU	-0.1	1.9	13.3
	3_1593	0.016	0.039	-0.025	GPS/IMU	0.0	1.6	16.8
	3_1594	0.010	0.016	-0.037	GPS/IMU	-0.4	1.1	15.9
	3_1595	-0.020	-0.002	-0.004	GPS/IMU	0.9	-0.1	11.6
	3_1599	0.041	0.018	0.092	GPS/IMU	-1.1	1.8	4.7
	3_1600	-0.023	-0.010	-0.042	GPS/IMU	0.5	1.2	2.8
	3_1601	0.021	-0.042	0.028	GPS/IMU	-1.0	0.6	2.5
	3_1602	0.001	-0.019	0.012	GPS/IMU	-0.9	1.0	4.2
	3_1603	0.012	-0.032	-0.012	GPS/IMU	-0.2	2.1	5.6
	3_1604	0.060	0.003	-0.078	GPS/IMU	0.7	2.2	10.0
	3_1605	-0.001	-0.017	0.011	GPS/IMU	0.6	1.1	8.2
	3_1606	-0.002	-0.025	-0.110	GPS/IMU	1.3	1.7	7.0
	3_1607	0.023	0.036	-0.054	GPS/IMU	-0.2	2.2	10.1
	3_1608	-0.014	0.037	0.002	GPS/IMU	1.5	1.5	13.7
	3_1609	-0.036	-0.012	-0.055	GPS/IMU	0.8	1.1	12.3
	3_1610	-0.024	-0.026	-0.033	GPS/IMU	1.2	-0.9	12.5
*LINE	4							
	4_1613	-0.024	-0.002	0.036	GPS/IMU	1.8	-0.1	-3.1
	4_1614	-0.025	-0.002	-0.058	GPS/IMU	0.2	1.0	-0.5
	4_1615	0.011	-0.012	0.009	GPS/IMU	-0.4	-0.2	-0.7
	4_1616	0.034	-0.002	0.014	GPS/IMU	-1.1	0.3	8.0
	4_1617	-0.007	0.006	-0.018	GPS/IMU	0.3	1.0	9.5
	4_1618	-0.008	0.023	-0.022	GPS/IMU	0.0	1.6	5.2
	4_1619	0.005	0.005	-0.011	GPS/IMU	-0.1	0.8	4.0
	4_1620	-0.009	0.000	-0.055	GPS/IMU	-0.5	0.4	2.4
	4_1621	-0.031	0.020	0.005	GPS/IMU	1.1	1.0	5.4
	4_1622	-0.006	0.003	0.045	GPS/IMU	0.2	1.2	5.5
	4_1623	0.016	-0.020	0.028	GPS/IMU	-0.9	0.0	1.8
	4_1624	0.020	-0.011	-0.061	GPS/IMU	-0.4	0.8	0.2
	4_1625	0.010	0.025	0.025	GPS/IMU	-0.8	1.0	-1.2
	4_1626	0.038	0.012	-0.039	GPS/IMU	-1.7	0.9	-2.5
	4_1627	0.014	0.018	0.045	GPS/IMU	-1.4	1.4	5.0
	4_1628	0.020	0.021	0.002	GPS/IMU	-0.4	1.4	3.7

4_1629	0.021	0.014	0.011	GPS/IMU	0.0	1.3	7.0
4_1630	-0.034	0.022	0.018	GPS/IMU	0.3	1.4	10.8
4_1631	-0.036	0.004	-0.021	GPS/IMU	1.2	0.9	13.2
4_1632	-0.043	-0.023	-0.095	GPS/IMU	0.5	1.0	12.2
4_1633	0.002	0.040	-0.066	GPS/IMU	-0.9	2.9	13.2
4_1634	0.019	0.006	-0.034	GPS/IMU	-0.8	1.3	11.2
4_1635	-0.047	-0.009	0.017	GPS/IMU	0.6	1.9	8.2
4_1636	-0.050	0.029	-0.044	GPS/IMU	2.4	2.0	12.3
4_1637	0.030	-0.042	-0.034	GPS/IMU	-1.8	0.4	12.6
4_1638	0.012	-0.037	0.021	GPS/IMU	-1.4	1.8	14.1
4_1639	0.036	0.033	0.054	GPS/IMU	-0.7	1.1	11.5
4_1640	0.038	0.005	-0.024	GPS/IMU	-1.2	1.5	13.4
4_1641	-0.013	-0.006	0.075	GPS/IMU	-0.4	0.8	17.2
4_1642	0.018	-0.056	-0.004	GPS/IMU	0.4	0.3	16.0
4_1643	0.023	0.030	0.081	GPS/IMU	-0.7	1.6	14.6
4_1644	0.001	-0.011	0.000	GPS/IMU	1.4	2.7	15.1
4_1645	-0.020	-0.021	-0.018	GPS/IMU	0.2	1.3	13.7
4_1646	-0.013	-0.020	-0.080	GPS/IMU	0.5	1.0	13.7
4_1647	-0.004	-0.038	-0.018	GPS/IMU	0.7	-0.5	9.6
4_1648	-0.004	0.033	0.010	GPS/IMU	0.0	1.6	9.6
4_1649	0.016	0.023	-0.018	GPS/IMU	-0.3	1.1	7.9
4_1650	-0.011	-0.001	0.082	GPS/IMU	0.2	0.7	11.7
4_1651	-0.017	0.007	0.055	GPS/IMU	1.2	0.9	12.1
4_1652	0.003	-0.028	-0.021	GPS/IMU	0.2	1.1	12.6
4_1653	-0.034	-0.039	0.091	GPS/IMU	1.5	0.3	11.2
4_1654	0.030	-0.022	0.002	GPS/IMU	0.9	0.3	12.2
4_1655	0.012	-0.039	0.004	GPS/IMU	0.5	-0.1	15.3
4_1656	-0.012	-0.023	-0.044	GPS/IMU	1.1	1.2	12.4
4_1657	0.006	-0.035	0.066	GPS/IMU	1.4	-0.4	9.8
4_1658	-0.035	-0.012	0.003	GPS/IMU	0.7	1.5	6.3
4_1659	0.020	-0.011	0.090	GPS/IMU	0.7	1.5	8.3
4_1660	0.012	-0.005	-0.049	GPS/IMU	-0.1	0.7	7.8
4_1661	-0.023	0.015	-0.100	GPS/IMU	1.3	1.5	4.9
4_1662	-0.054	0.026	0.022	GPS/IMU	2.9	1.1	4.3
4_1663	-0.004	-0.013	-0.016	GPS/IMU	-0.4	0.0	0.5
4_1664	-0.006	0.013	0.034	GPS/IMU	-0.2	1.1	0.3
4_1665	-0.011	0.020	0.054	GPS/IMU	-0.2	2.0	-0.3
4_1666	0.016	-0.021	0.085	GPS/IMU	0.3	0.1	1.4
4_1667	0.009	-0.046	0.049	GPS/IMU	0.2	-0.4	1.4
4_1668	0.023	-0.013	-0.022	GPS/IMU	-1.1	0.5	0.2
4_1669	0.051	-0.018	-0.040	GPS/IMU	-0.5	1.6	3.5
4_1670	-0.010	0.016	-0.003	GPS/IMU	0.2	1.2	0.6
4_1671	0.008	0.010	0.071	GPS/IMU	0.5	1.7	4.0
4_1672	0.037	0.043	0.064	GPS/IMU	-0.6	1.7	5.3
4_1673	0.030	0.054	-0.020	GPS/IMU	0.4	3.0	5.2
4_1674	-0.006	-0.002	-0.042	GPS/IMU	-0.2	1.5	3.5
4_1675	-0.019	0.015	-0.009	GPS/IMU	0.1	2.3	1.7
4_1676	0.027	0.028	-0.104	GPS/IMU	0.8	1.4	1.5
4_1677	-0.027	0.010	0.006	GPS/IMU	1.0	1.0	0.0
4_1678	0.003	0.021	-0.011	GPS/IMU	0.3	1.8	1.4
4_1679	-0.011	0.014	0.041	GPS/IMU	0.0	2.1	4.2
4_1680	0.020	-0.012	-0.017	GPS/IMU	-0.1	0.2	3.8
4_1681	0.021	-0.015	-0.033	GPS/IMU	-0.2	0.8	4.4
4_1682	-0.001	0.037	-0.016	GPS/IMU	0.4	1.7	5.1
4_1683	0.006	0.016	0.024	GPS/IMU	-0.1	1.8	4.7
4_1684	0.006	0.023	0.039	GPS/IMU	1.4	1.4	6.4
4_1685	-0.001	-0.029	-0.050	GPS/IMU	0.7	0.2	3.2
4_1686	-0.018	-0.014	0.018	GPS/IMU	0.3	0.7	5.8
4_1687	0.028	0.000	-0.009	GPS/IMU	0.2	0.9	1.9
4_1688	-0.045	-0.016	0.028	GPS/IMU	1.2	0.8	3.3
4_1689	0.014	0.001	0.018	GPS/IMU	0.0	0.7	4.6
4_1690	0.003	-0.036	-0.001	GPS/IMU	-0.4	-0.2	2.7
4_1691	-0.008	-0.034	0.017	GPS/IMU	0.7	0.7	5.0
4_1692	0.005	-0.009	-0.027	GPS/IMU	0.6	0.1	6.7
4_1693	0.038	0.015	-0.039	GPS/IMU	0.2	1.1	4.6
4_1694	-0.001	-0.012	0.019	GPS/IMU	-0.3	1.0	4.7
4_1695	-0.028	0.030	0.045	GPS/IMU	1.5	0.4	8.4
4_1696	-0.006	0.004	-0.002	GPS/IMU	1.5	0.0	6.4
4_1697	-0.042	-0.001	-0.008	GPS/IMU	0.8	1.6	3.9
4_1698	0.006	0.024	0.032	GPS/IMU	0.3	2.0	3.7
4_1699	0.012	0.022	-0.002	GPS/IMU	0.8	1.5	3.7

	4_1700	-0.003	-0.001	0.042	GPS/IMU	-0.1	0.8	0.9
	4_1701	-0.019	0.011	0.015	GPS/IMU	2.6	1.5	1.6
	4_1702	-0.008	-0.001	0.011	GPS/IMU	1.0	1.3	5.2
	4_1703	-0.005	-0.027	-0.085	GPS/IMU	-0.2	1.0	1.6
	4_1704	0.010	-0.010	-0.055	GPS/IMU	-0.7	0.1	0.5
	4_1705	-0.001	-0.026	-0.037	GPS/IMU	-0.1	-0.2	-2.3
	4_1706	-0.004	0.036	-0.038	GPS/IMU	-0.5	1.8	-5.7
*LINE	5							
	5_0611	-0.028	-0.116	-0.201	GPS/IMU	-17.1	17.6	-8.0
	5_0612	-0.075	0.391	-0.110	GPS/IMU	-15.1	9.4	-4.3
	5_0613	-0.026	-0.064	0.104	GPS/IMU	-14.7	13.3	-1.3
	5_0614	0.007	-0.105	0.027	GPS/IMU	-11.2	17.7	3.4
	5_0615	-0.117	0.057	-0.218	GPS/IMU	-11.1	14.3	7.4

*----------

Instrumentation and procedures.

All compilation was performed using the Intergraph (Z/I Imaging) ISAT (ImageStation Auto Triangulation) software product. BINGO 6.0 was used for the final bundle block adjustment.

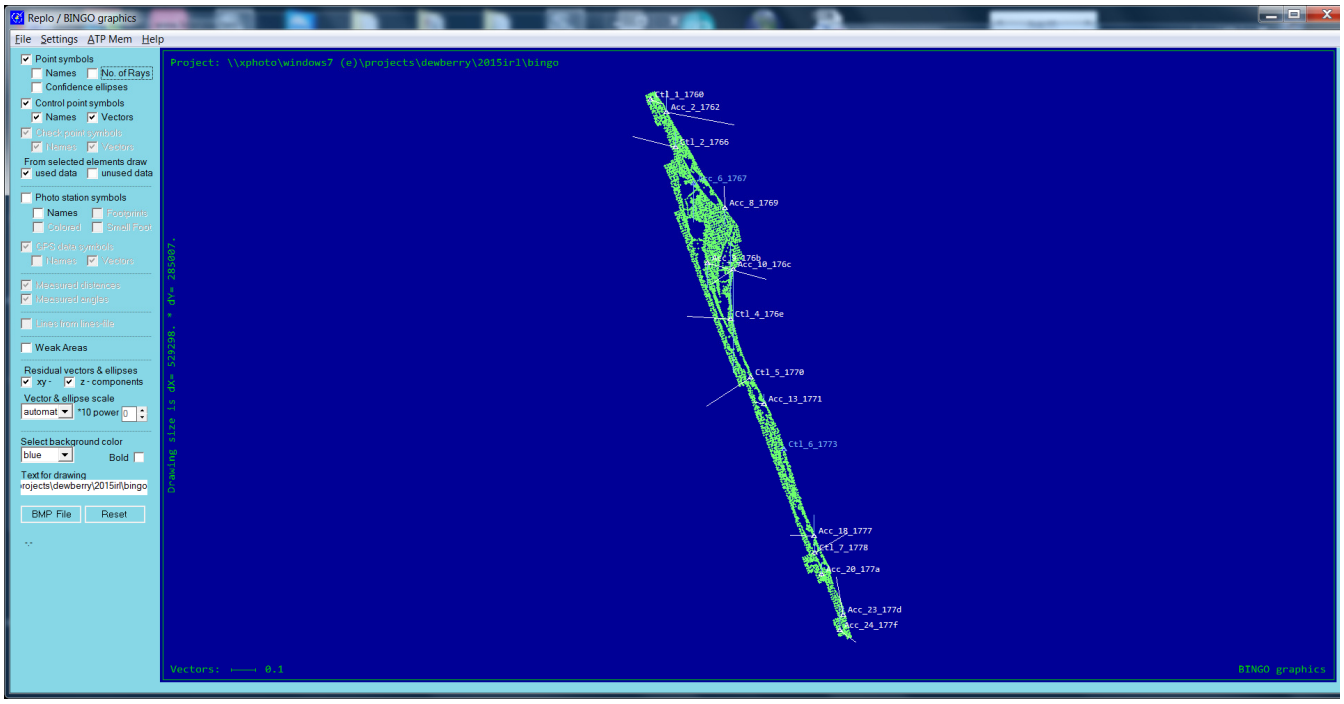
Image Files Supported
The raster file formats supported are the very same as Intergraph. This includes Intergraph's proprietary formats as well as the majority of the industry standards. The preference is for tiled tiff jpeg compressed imagery to keep file sizes to a minimum and maximize data access speeds.

The Measurement Process
Fully automated solutions are now being used on any and all data sets as possible. In all other cases an assisted measurement approach that guarantees very good results is employed. The number of tie points between strips is maximized in order that as many six (or more) ray points as possible are obtained to strengthen the block geometry. This cost additional time but definitely increases the reliability and helps guarantee a quality solution. Pass points are typically collected in a five-point pattern (i.e. ten per stereo model) and are generally points on the ground (not on roof tops, trees, etc.). This last part is important for three good reasons: 1) there is redundancy in each model solution reducing the likelihood of any remaining model parallax, 2) the data capture operator needs to be able to (vertically) index to the point, and 3) it allows for a good QC measure on the elevation data (by comparing the triangulated points to the elevation data).

The Adjustment
The triangulation or bundle adjustment usually includes a relative bundle adjustment (i.e. without control) to be certain that the photogrammetric ties are without defect. Projects with a lot of water or other occlusions may make a relative solution impractical. Once a relative solution is obtained within specifications the full bundle using ground control and AGPS/IMU (if available) is computed. This allows for delivery of the cleanest data possible and the isolation of problems with external data such as control and AGPS/IMU. Large projects or those using AGPS/IMU are solved using sophisticated algorithms as found and supported in BINGO.

Graphics.

Control Residuals



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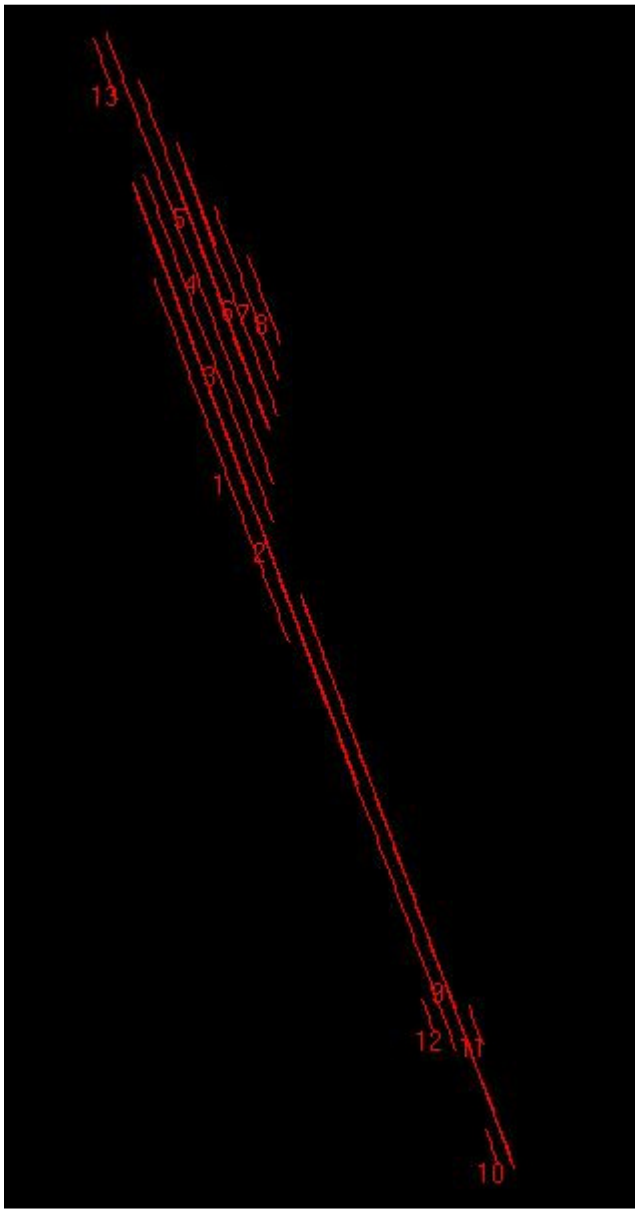
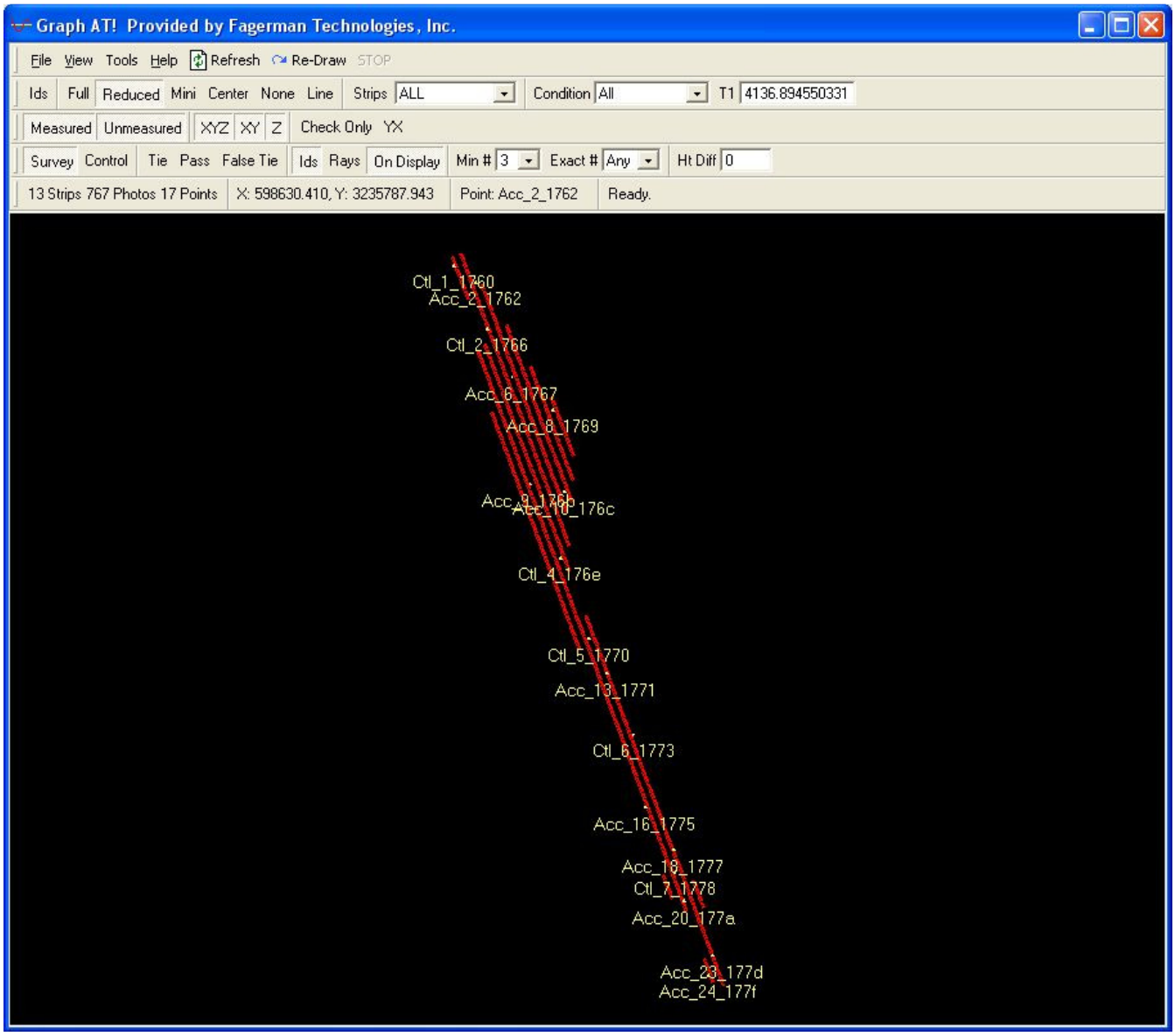


Layout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Survey Control Tie Pass False Tie Ids Rays On Display Min # 3 Exact # Any Ht Diff 0
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Acc_2_1762
Ctl_2_1766
Acc_6_1767
Acc_8_1769
Acc_10_176c
Ctl_4_176e
Ctl_5_1770
Acc_13_1771
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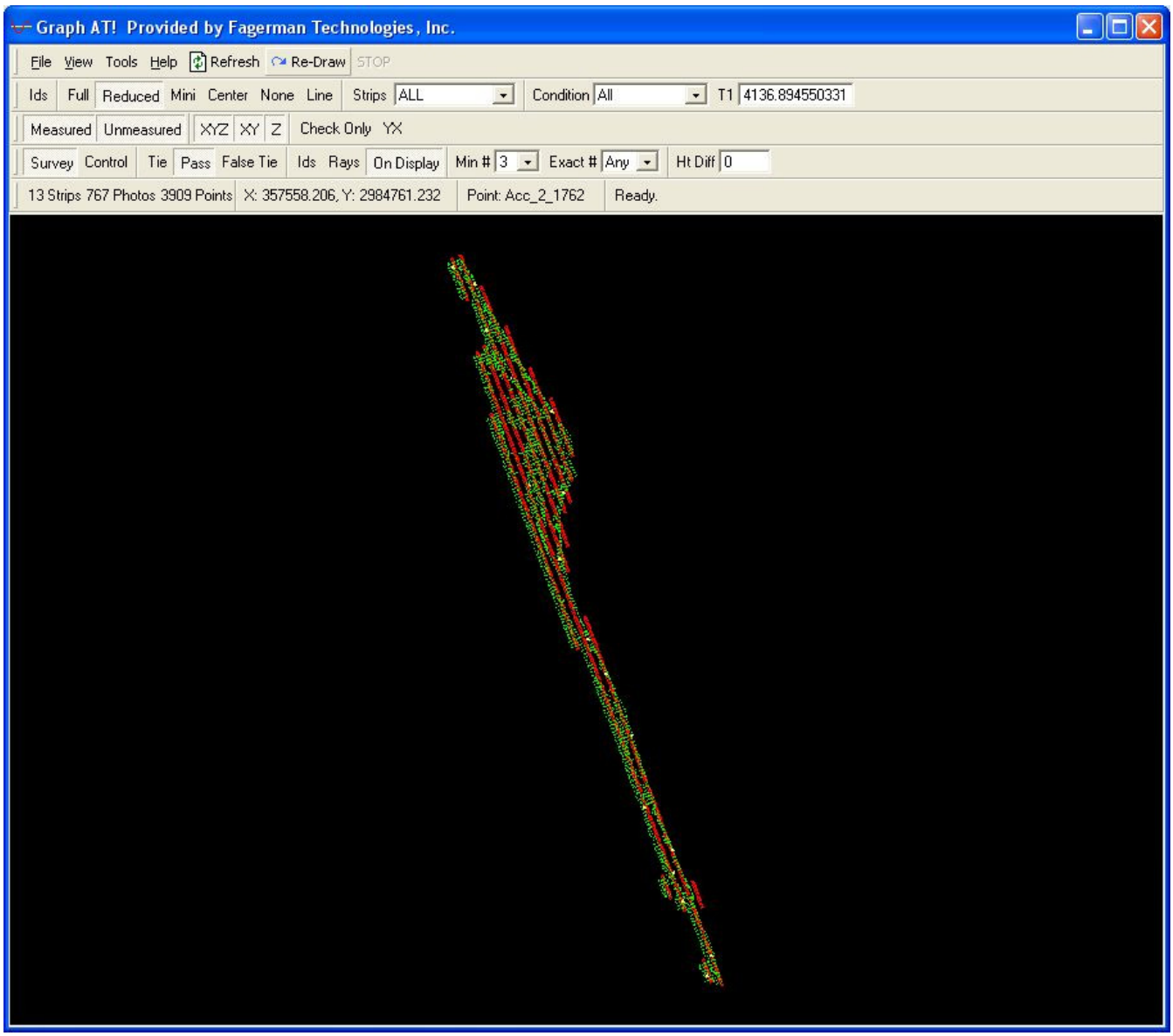
Acc_20_177a
Acc_23_177d
Acc_24_177f

Pass Points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Survey Control Tie Pass False Tie Ids Rays On Display Min # 3 Exact # Any Ht Diff 0
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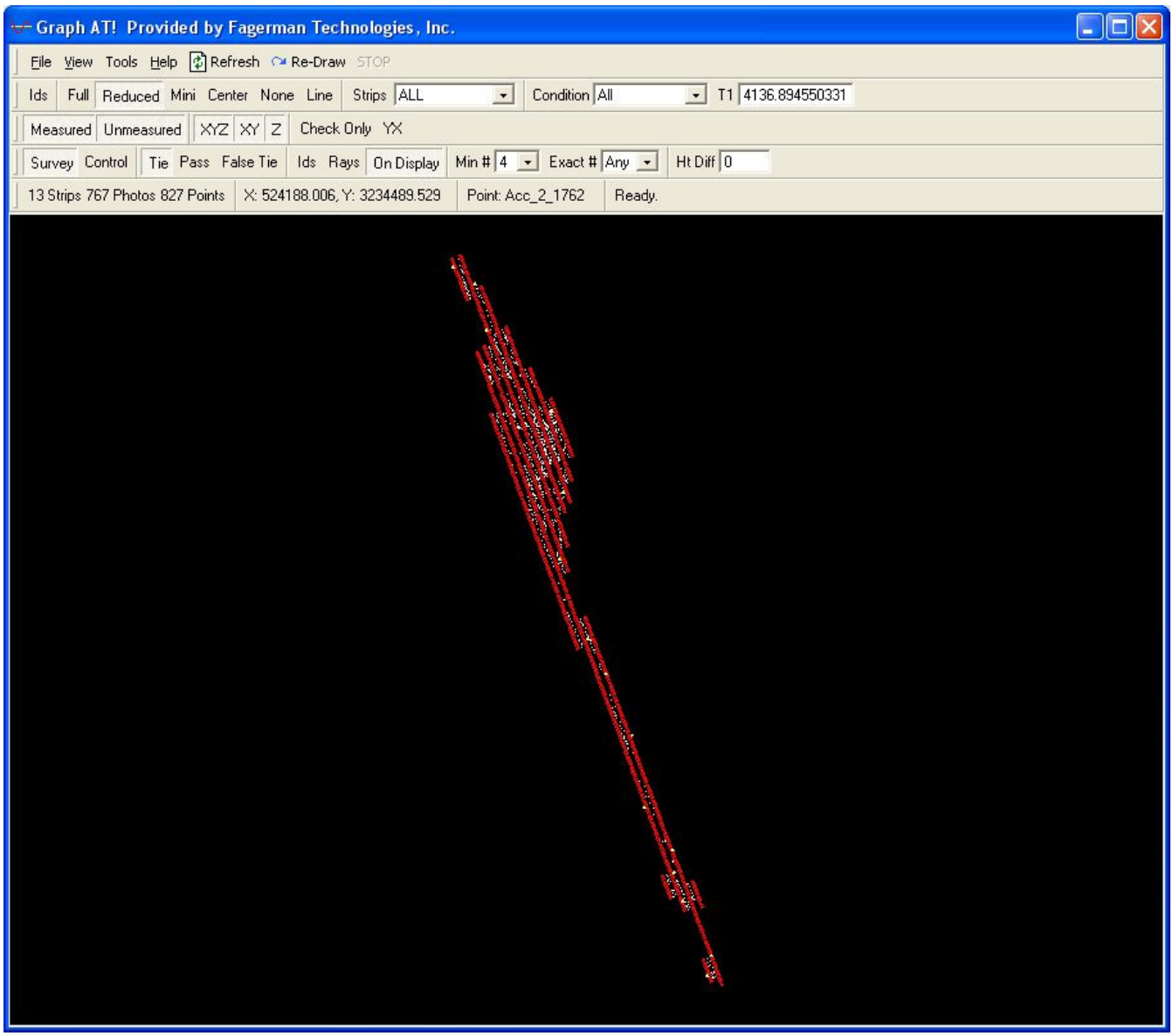
Ties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Survey Control Tie Pass False Tie Ids Rays On Display Min # 4 Exact # Any Ht Diff 0
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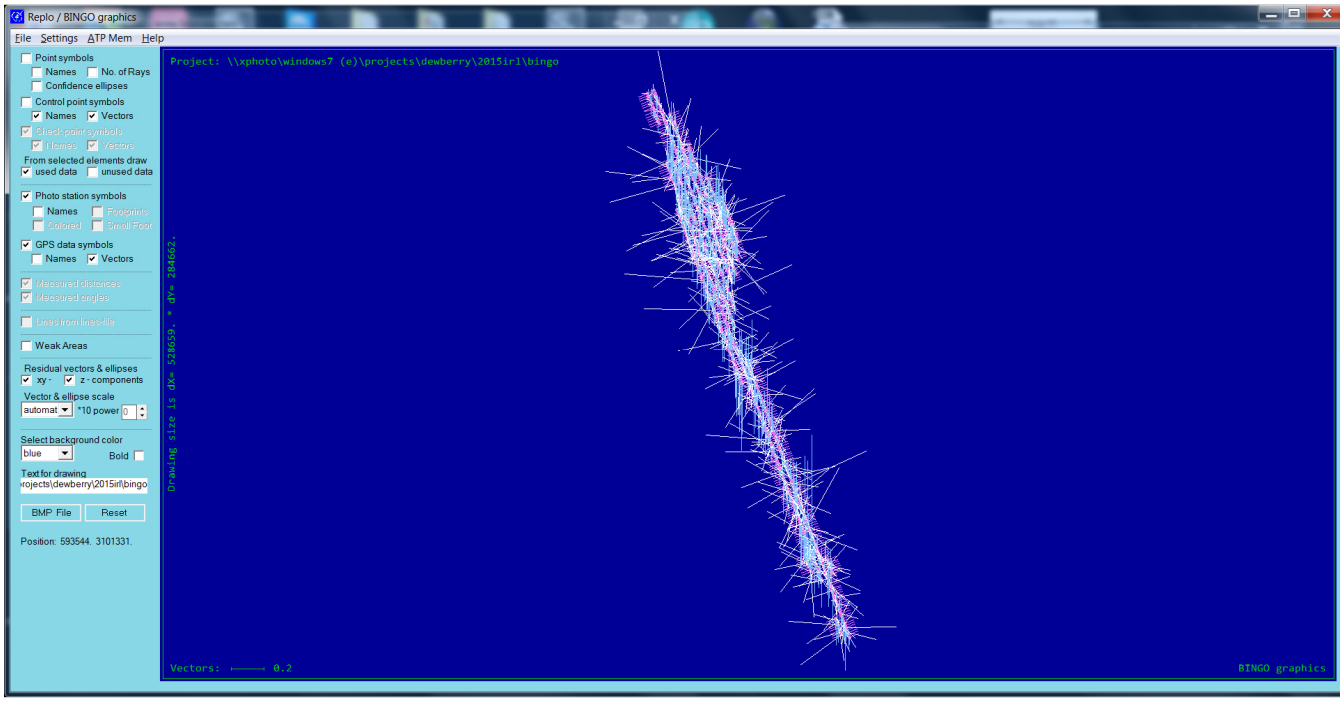
AGPS Residuals



Check Point Survey Report
Indian River Lagoon Seagrass Mapping 2015

Prepared By:
Dewberry Consultants LLC
1000 N Ashley Dr, Suite 801
Tampa, FL 33602

TABLE OF CONTENTS

1. INTRODUCTION

1.1 *Project Summary*

The St. Johns River Water Management District (SJRWMD) has contracted Dewberry for imagery acquisition and seagrass mapping for the Indian River Lagoon (IRL). The overall objective of this contract is to: A) acquire 2015 time appropriate aerial imagery of the entire IRL captured directly in digital format by a digital mapping camera; B) produce a complete 2015 seagrass map primarily by photo interpreting this newly acquired aerial imagery in soft-copy stereo along with ancillary ground truth data; and C) deliver the processed aerial imagery along with all files used in establishing the blocks in orthorectification and other processes described below in the Scope of Work. As part of this work Dewberry staff will complete check point surveys that will be used to evaluate horizontal accuracy.

Final horizontal coordinates are referenced to UTM Zone 17 North, WGS84, in meters. Final Vertical elevations are referenced to NAVD88 in meters. Geoid model 2009 (Geoid09).

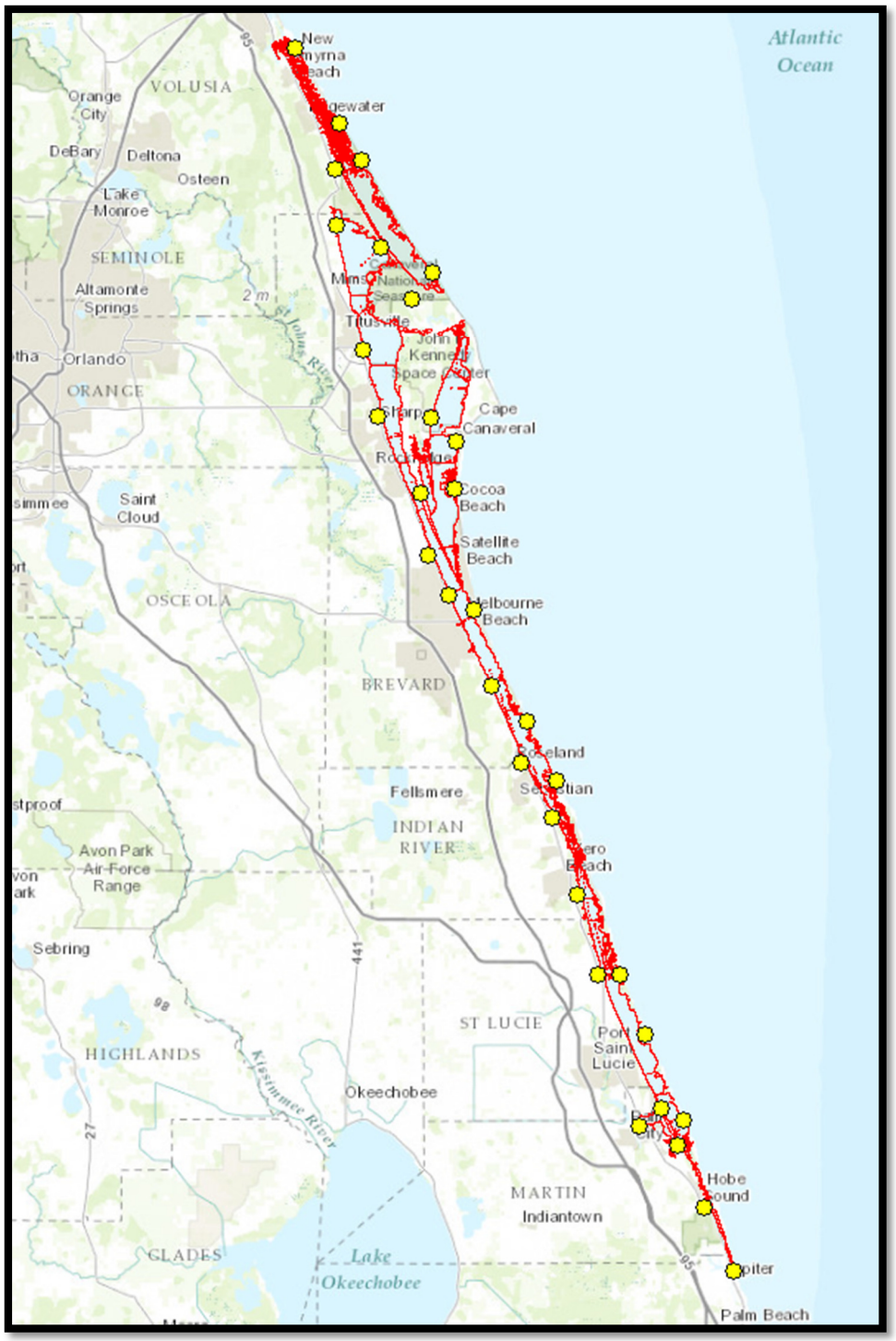
1.2 *Points of Contact*

Questions regarding the technical aspects of this report should be addressed to:

Dewberry Consultants LLC

Keith Patterson
Dewberry
1000 N Ashley Dr, Suite 801
Tampa, FL 33602
813-421-8635

1.3 *Project Area*



Indian River Lagoon

2. PROJECT DETAILS

2.1 *Survey Equipment*

In performing the GPS observations, Trimble R-8 GNSS receiver/antenna attached to a two meter fixed height pole was utilized.

2.2 *Survey Point Detail*

The 32 Check Points were well distributed throughout the project area.

A sketch was made for each location and photos taken to help identify the survey point in the aerial imagery. The Check Point locations are detailed on the "Ground Control Point Documentation Report" sheets that are included in the IRL_2015_Survey_photos_sheets report delivered with this report.

2.3 *Network Design*

The Trimble R8 receiver is a multi-channel, multi-frequency GNSS (Global Navigation Satellite System) receiver designed for use as a stand-alone reference station or as part of a GNSS infrastructure solution. Trimble R-Track technology in the R8 receiver supports the modernized GPS L2C and L5 signals as well as GLONASS L1/L2 signals.

2.4 *Field Survey Procedures and Analysis*

All locations utilizing the Florida Permanent Reference Network were occupied for at least 5 minutes.

All locations which utilized OPUS were occupied for 20 minutes.

Field GPS observations are detailed on the "Ground Control Point Documentation Reports" sheets that are included in the IRL_2015_Survey_photos_sheets report delivered with this report.

2.5 *Adjustment*

Adjusted using OPUS where necessary.

2.6 *Data Processing Procedures*

Downloaded data is run through OPUS to obtain the corrected coordinate information for the checkpoints.

After review of the point data a shapefile was exported from the collector to make a visual check of the point data (Pt. # and Coordinates,). The data can now be imported into the final product.

3. FINAL COORDINATES

Point ID		
	Easting X (m)	Northing Y (m)
irl_01	507058.0251	3216891.055
irl_17	520054.3108	3195243.538
irl_19	515569.6925	3202507.563
irl_08	514850.1705	3193508.137
irl_18	515062.1949	3182599.51
irl_30	529653.4094	3168479.615
irl_02	520074.6865	3158488.387
irl_21	523023.6005	3145774.009
irl_22	532664.905	3118949.156
irl_11	536885.1326	3110994.578
irl_28	544979.1461	3093424.442
irl_14	550866.3553	3078569.767
irl_06	556614.7108	3067907.353
irl_20	561511.5536	3053216.492
irl_04	565436.009	3037790.13
irl_26_2	569923.069	3037699.812
irl_12	574554.6986	3026068.675
irl_05	577848.8731	3011966.554
irl_32	573510.9898	3008506.869
irl_27	582178.464	3009571.394
irl_29	581035.9941	3004824.077
irl_13	586020.4037	2992751.907
irl_03	591704.4381	2980557.049
irl_31	551955.366	3086606.151
irl_16	533230.477	3145436.243
irl_09	523744.289	3178424.174
irl_23	541658.178	3108377.031
irl_24	557432.065	3075145.545
irl_10	538306.974	3140810.697
irl_15	537824.725	3131560.283
irl_07	531448.728	3130694.92
irl_25	533518.147	3173498.314

2015 IRL Seagrass Ortho Positional Accuracy Table			
	Δx^2	Δy^2	Totals
# of Points			32.000
Sums	2.679	1.772	
MSE	0.084	0.055	
RMSExy	0.289	0.235	
RMSEr			0.373
ACCURACYr			0.645
NMAS			0.566

Point ID	Survey Checkpoint Coordinates Provided by Surveyor		Ortho Imagery Coordinates Measured by Dewberry		Ortho Imagery minus Surveyed Coordinates		Discrepancies Squared as Required for RMSE Calculations	
	NAD83 UTM Zone 17N		NAD83 UTM Zone 17N		NAD83 UTM Zone 17N		Δx^2 (m^2)	Δy^2 (m^2)
	Easting X (m)	Northing Y (m)	Easting X (m)	Northing Y (m)	Δx (Easting)	Δy (Northing)		
irl_01	507058.0251	3216891.055	507057.823	3216891.331	-0.202	0.276	0.041	0.076
irl_17	520054.3108	3195243.538	520055.083	3195244.505	0.772	0.967	0.596	0.935
irl_19	515569.6925	3202507.563	515569.827	3202507.721	0.135	0.158	0.018	0.025
irl_08	514850.1705	3193508.137	514849.559	3193507.787	-0.612	-0.350	0.374	0.122
irl_18	515062.1949	3182599.51	515062.327	3182599.606	0.132	0.096	0.017	0.009
irl_30	529653.4094	3168479.615	529653.433	3168479.663	0.024	0.048	0.001	0.002
irl_02	520074.6865	3158488.387	520075.030	3158488.491	0.343	0.104	0.118	0.011
irl_21	523023.6005	3145774.009	523023.567	3145774.009	-0.033	0.000	0.001	0.000
irl_22	532664.905	3118949.156	532664.740	3118949.090	-0.165	-0.066	0.027	0.004
irl_11	536885.1326	3110994.578	536885.298	3110994.578	0.165	0.000	0.027	0.000
irl_28	544979.1461	3093424.442	544979.245	3093424.376	0.099	-0.066	0.010	0.004
irl_14	550866.3553	3078569.767	550866.587	3078569.701	0.232	-0.066	0.054	0.004
irl_06	556614.7108	3067907.353	556614.810	3067907.220	0.099	-0.133	0.010	0.018
irl_20	561511.5536	3053216.492	561511.454	3053216.690	-0.100	0.198	0.010	0.039
irl_04	565436.009	3037790.13	565435.976	3037790.197	-0.033	0.067	0.001	0.004
irl_26_2	569923.069	3037699.812	569922.970	3037699.547	-0.099	-0.265	0.010	0.070
irl_12	574554.6986	3026068.675	574554.599	3026068.675	-0.100	0.000	0.010	0.000
irl_05	577848.8731	3011966.554	577848.708	3011966.487	-0.165	-0.067	0.027	0.004
irl_32	573510.9898	3008506.869	573511.089	3008507.067	0.099	0.198	0.010	0.039
irl_27	582178.464	3009571.394	582178.695	3009571.592	0.231	0.198	0.053	0.039
irl_29	581035.9941	3004824.077	581035.630	3004824.341	-0.364	0.264	0.133	0.070
irl_13	586020.4037	2992751.907	586020.437	2992751.973	0.033	0.066	0.001	0.004
irl_03	591704.4381	2980557.049	591704.670	2980557.446	0.232	0.397	0.054	0.157
irl_31	551955.366	3086606.151	551955.201	3086606.085	-0.165	-0.066	0.027	0.004
irl_16	533230.477	3145436.243	533229.782	3145436.177	-0.695	-0.066	0.483	0.004
irl_09	523744.289	3178424.174	523744.454	3178424.042	0.165	-0.132	0.027	0.017
irl_23	541658.178	3108377.031	541658.112	3108377.163	-0.066	0.132	0.004	0.017
irl_24	557432.065	3075145.545	557432.171	3075145.552	0.106	0.007	0.011	0.000
irl_10	538306.974	3140810.697	538306.934	3140810.459	-0.040	-0.238	0.002	0.057
irl_15	537824.725	3131560.283	537824.209	3131560.442	-0.516	0.159	0.266	0.025
irl_07	531448.728	3130694.92	531448.371	3130694.999	-0.357	0.079	0.127	0.006
irl_25	533518.147	3173498.314	533517.790	3173498.314	-0.357	0.000	0.127	0.000

Ortho Horizontal Accuracy Results

# of Points	$RMSE_x$	$RMSE_y$	$RMSE_r$	$ACCURACY_r$ ($RMSE_r$ x 1.7308) Spec=1 m	NMAS (Horizontal Errors reported at the 90% Confidence Level)
32	0.289	0.235	0.373	0.645	**0.566**

Field Work Report for the 2015 Indian River Lagoon Seagrass Mapping Project

Report Date: 9/2/2015

The following summarizes field work conducted by Dewberry in support of the 2015 Seagrass Mapping Project. The field work process is designed to support accurate photo interpretation and is an integral part of the overall mapping process. Selected field points (i.e. field sites) were chosen prior to field deployment while viewing the imagery in stereo. Other field points were added while in the field during field work. All the field points will serve to assist photo interpretation so that accurate delineation and classification can be accomplished.

Dewberry's subcontractors, CSA Ocean Services and Seagrass Systems Analysts (SEA) provided watercraft along with seagrass habitat expertise during all the field trips.

Dewberry utilized GPS enabled ruggedized laptops equipped with ArcMap to document information at each location visited. The laptops are loaded with the aerial imagery used for the project and the 2013 seagrass map produced during the last mapping effort.

The field personnel travelled to and located field points via waypoints in the GPS. At each field point, the imagery was compared to seagrass occurrence and documentation was performed within ArcMap. The ArcMap field work feature class is a deliverable for the project and contains the specific information gathered for each field site.

TRIP 1 for Pre-Interpretation Field Work

Day 1: July 28, 2015

Personnel: Ryan Ligon and Brittany Isenberg, Dewberry; Jeff Riddle, CSA Ocean Services

Location: Jupiter, FL

Weather conditions: Mostly sunny, warm, light breeze. Temps around 90F and water temp around 85F.

Daily field activities: Launched from Burt Reynolds Park and moving north, stopping at A1A Causeway in Stuart, Florida. Collected several points below A1A Causeway on the western shore of IRL. Continued north to St Lucie inlet and the St Lucie River, then back to Burt Reynolds Park.

Observations: Medium visibility (less than 1 foot up to about 3 feet) required use of underwater video camera. The camera as well as personnel entering the water also used in order to ascertain both species type and density. Traversing the area for several points was required to identify or verify species in shallow areas. A lot of drift algae and similar looking bottom cover was found (grassilaria, chaetomorpha, zoobotryan), a few areas had sand ripples present.

Day 2: July 29, 2015

Personnel: Ryan Ligon and Brittany Isenberg, Dewberry; Jeff Riddle, CSA Ocean Services

Location: Stuart, FL

Weather conditions: Partly sunny, warm, calm in the morning but increasing wind and a few area thunderstorms in the afternoon. Temps around 90F, water temp around 85F.

Daily field activities: Launched from Sandsprit Park, went to the northeastern portion of the St. Lucie Inlet, worked north along the western shore to the St. Lucie Nuclear Power Plant powerlines and then returned to ramp working along the eastern shore as storms permitted.

Observations: Generally low water visibility (less than 1 foot). Good mix of thalassia, decipiens, syringodium, halodule, and some johnsonii. A lot of caulerpa and drift algae mixed with seagrasses. Quite a few points were checked within currently mapped beds or along edges to check for expansion/loss and accuracy of edge.

Day 3: July 30, 2015

Personnel: Ryan Ligon and Brittany Isenberg, Dewberry; Jeff Riddle, CSA Ocean Services

Location: Fort Pierce, FL

Weather conditions: Cloudy and light wind, warm. Temps around 90F, water temp around 83-85F.

Daily field activities: We launched from the Stan Blum boat ramp, proceeding south along the east shore of the IRL to St. Lucie Nuclear Powerplant, then north along the west shore of IRL towards Stan Blum Boat Ramp, then switched to east shore north of boat ramp to Vero Beach, then collected points along west shore and center of IRL back to Stan Blum Boat Ramp.

Observations: South of Stan Blum Boat Ramp towards the powerplant, syringodium is the predominate seagrass with some decipiens and drift algae intermixed. North of the ramp, syringodium and decipiens were also observed along with areas of shell hash and macro algae (zoobotryon and culerpa).

Day 4: July 31, 2015

Personnel: Ryan Ligon and Brittany Isenberg, Dewberry; Jeff Riddle, CSA Ocean Services

Location: Sebastian, FL

Weather conditions: Sunny and warm. Calm through the day, high of around 90F and water temp around 85 F.

Daily field activities: Launched at the Sebastian boat ramp. Started off going north along the west shore up to Grant Island Estates, then turned to the east shore working south down to the Pelican Island National Wildlife Refuge. Continued to the west shore, working north back to the ramp.

Observations: Great water visibility, halodule was the predominate seagrass species found in the area, mixed with some decipiens and johnsonii in a few areas. Areas of drift algae, shell hash and macro algae(caulerpa) present.

TRIP 2 for Pre-Interpretation Field Work

Day 1: August 18, 2015

Personnel: Ryan Ligon, Dewberry; Bob Virnstein, SEA

Location: Titusville, FL

Weather conditions: Sunny and hot, high of around 95. Water temp around 90. Light south winds.

Daily field activities: Launched from Haulover Canal boatramp. Proceeded east into mosquito lagoon and north to approximately ICW channel marker 24, then southeast and clockwise around back to Haulover canal. We then proceeded into northern Indian River Lagoon and southwest to the ICW "dog leg" then clockwise north and then east back to the boatramp.

Observations: Overall seagrass beds in the Mosquito Lagoon system have not changed much. A little sparser in places but with the decreased water clarity this year that is not surprising. In northern IRL it was found that several of the beds have gained some cover and the edges of the bed are further to water than they were in 2013. Several of the areas in north IRL had surprisingly clear water. There was however one area of a possible brown algae bloom near the old bombing target. This coordinate was provided to Lauren Hall for possible review as part of a water quality assessment project.

Day 2: August 19, 2015

Personnel: Ryan Ligon, Dewberry; Bob Virnstein, SEA; Lauren Hall, SJRWMD

Location: Titusville, FL

Weather: Sunny and hot. Temps around 95F, water temp around 90F. Afternoon storms forced us off the water a little early around 2pm.

Daily field activities: Launched from Parrish Park and proceeded north to the ICW "dog leg" and then back to the south along the west shore of the IRL to the Port St John power plant. We then worked our way back north along the east shore as we could between brief showers.

Observations: Overall the grass beds in the northern IRL area appear to be doing quite well and even increasing in size in several places. South of Max Brewer causeway and toward Port St John the changes were really a mix of add some grass coverage as well as take away coverage from the 2013 mapped beds. There were some localized algae blooms that have been going all summer that are effecting water clarity and O2 levels.

Day 3: August 20, 2015

Personnel: Ryan Ligon, Dewberry; Bob Virnstein, SEA

Location: Cocoa, FL

Weather: Sunny and hot. High temp around 95F with water temp around 90F.

Daily field activities: Launched from Riverside park in Cocoa and proceeded north toward Port St John power plant collecting points along the west shore then heading back south and collecting points along the eastern shore. We continued south to the Pineda Causeway then turned back to the north to return to the boat ramp.

Observations: A lot of caulerpa and sparser grass was found. Quite a few of the questions were just a darker sand mottled bottom.

Day 4: August 21, 2015

Personnel: Ryan Ligon, Dewberry; Bob Virnstein, SEA

Location: Merritt Island, FL

Weather: Sunny and hot. High temp around 95F, water temp around 90F.

Daily field activities: Launched from the Kelly Park boat ramp and proceeded north toward the NASA vessel restriction line in Banana River then worked our way south toward the Pineda

causeway. Just north of Patrick AFB we made our way toward Newfound Harbor for a few points and headed back to Kelly Park. A lot of the points back in the mangrove islands south of the 520 causeway were not observed due to the long amount of time it would take to idle to them since there are all in no wake/manatee zones. Some of these points can be visited if need be on future fieldwork trips.

Observations: A lot of the points to check for grass were drift algae and/or caulerpa. There were also several areas that do have some increasing density or area, probably due to good water clarity earlier in the summer.

The above July trip completes the pre-photointerpretation field work task for the project.

Field Work Report for the 2015 Indian River Lagoon Seagrass Mapping Project

Report Date: 1/18/2016

The following summarizes field work conducted by Dewberry in support of the 2015 Seagrass Mapping Project. The field work process is designed to support accurate photo interpretation and is an integral part of the overall mapping process. Selected field points (i.e. field sites) were chosen prior to field deployment while viewing the imagery in stereo. Other field points were added while in the field during field work. All the field points will serve to assist photo interpretation so that accurate delineation and classification can be accomplished.

Dewberry's subcontractors, CSA Ocean Services and Seagrass Systems Analysts (SEA) provided watercraft along with seagrass habitat expertise during all the field trips.

Dewberry utilized GPS enabled ruggedized laptops equipped with ArcMap to document information at each location visited. The laptops are loaded with the aerial imagery used for the project and the 2013 seagrass map produced during the last mapping effort.

The field personnel travelled to and located field points via waypoints in the GPS. At each field point, the imagery was compared to seagrass occurrence and documentation was performed within ArcMap. The ArcMap field work feature class is a deliverable for the project and contains the specific information gathered for each field site.

The following field work was accomplished primarily for ground truthing of completed mapping and to answer site-specific questions arising during photo interpretation.

TRIP 1 During Photointerpretation Field Work

Day 1: November 17, 2015

Personnel: Brittany Isenberg, Dewberry; Jeff Riddle, CSA

Location: Stuart, FL

Weather conditions: Partly cloudy in the morning, becoming mostly sunny in the afternoon, strong winds, high of 82F.

Daily field activities: Very windy, making water choppy and visibility in the water very low. Launched from Sandsprit boat ramp in Stuart, FL. Travelled south towards Hobe Sound National

Widlife Refuge, stopped at furthest point to the south and then continued to stop at points as we proceeded to head back to the north to the St Lucie Inlet. Visited points along the eastern shore north of the inlet to Nettle's Island, then proceeded to stop at points along the western shore heading south back towards the inlet/Sandsprit boat ramp.

Observations: Low Visibility, less than one foot. Required underwater video camera to ascertain presence of seagrasses. Bottom was very soft and stirred up very easily in almost all locations. Fair amounts of decipiens observed in points south of St. Lucie Inlet, Halodule wrightii, Syringodium, and Thalassia observed north of the inlet. Some drift algae and caulerpa's observed as well.

Day 2: November 18, 2015

Personnel: Brittany Isenberg, Dewberry; Jeff Riddle, CSA

Location: Ft. Pierce, FL

Weather conditions: Mostly Sunny, windy and very choppy water, high of 84F

Daily field activities: Very windy, making water choppy and visibility in the water very low. Launched from Stan Blum boat ramp in Ft. Pierce, FL. Travelled north along the western shore of IRL to about North Hutchinson Island then proceed to the eastern shore and worked south back to the Ft. Pierce Inlet and boat ramp.

Observations: Low Visibility, less than one foot. Bottom was very soft in most places especially along the western shore, sediment was stirred up very easily in almost all locations as well. Halodule wrightii, Syringodium were the predominate species observed with some decipiens. Caulerpa also present. Many points had soft dark sand.

Day 3: November 19, 2015

Personnel: Brittany Isenberg, Dewberry; Jeff Riddle, CSA

Location: Ft. Pierce, FL

Weather conditions: Mostly cloudy in the morning, rain showers in the afternoon, Temp high of 84F

Daily field activities: Launched from Stan Blum boat Ramp in Ft. Pierce. Started with points along the western shore south of the inlet. Collected points going south until just north of Nettle's Island. Proceeded to the eastern shore and worked north back towards the inlet and boat ramp.

Observations: Syringodium and decipiens were the predominate species observed. Some caulerpa along with zoobotryon and bryothamnion were also observed. Visibility was very poor, sediment stirred up very easily.

Day 4: November 20, 2015

Personnel: Brittany Isenberg, Dewberry; Jeff Riddle, CSA

Location: Sebastian, FL

Weather conditions: Overcast with a few rain showers in the morning, partly cloudy in the afternoon, high of 84.

Daily field activities: Launched from the Main Street Boat Ramp in Sebastian, FL. Proceeded to collect points along the western shore, working south to around the Hole In the Wall Island area, then travelled north, started collecting points on the eastern shore just past the 510 (Bridge Blvd) Causeway until just north of the boat ramp.

Observations: Haledule wrightii most predominate species observed. Lots of caulerpa as well, visibility a little better at some points compared to others. Soft bottom at most points as well. Sediment stirred easily.

TRIP 2 During Photointerpretation Field Work

Day 1: January 11, 2016

Personnel: Brittany Isenberg and Keith Patterson, Dewberry; Bob Virnstein, SEA

Location: Titusville, FL

Weather conditions: Sunshine all day, 46F in the AM with a high of 57F in the afternoon, 10-15mph winds from the North

Daily field activities: Launched from Haulover Canal Boat Ramp, headed east into Mosquito Lagoon. Travelled along the western shore towards the north until approximately the Oak Hill area, proceeded across the lagoon heading northeast to the Shipyard Island area, and then worked south collecting points along the eastern shore to the southern portion of Mosquito Lagoon. Then collected the remaining points along the western shore heading north back to the boat ramp.

Observations: Low Visibility, for the most part, less than two feet, required the underwater video camera to ascertain presence of seagrasses. Areas in the north had better clarity compared to

points in the southern portion of Mosquito Lagoon. Haledule wrightii was the predominate species observed along with bare bottom and shell/shell hash.

Day 2: January 12, 2016

Personnel: Brittany Isenberg and Keith Patterson, Dewberry; Bob Virnstein, SEA

Location: Titusville, FL

Weather conditions: Sunny all day with temps of 46F and a high of 66F, NNW wind approx. 10-15mph

Daily field activities: Launched from Parrish Park Boat Ramp, travelled across the lagoon to the eastern shore and collected points heading north to the top of Northern IRL. Then proceeded to collect points along the western shore heading south until Port St. John Boat ramp, from there we went across the lagoon again back to the eastern shore and collected points heading north back to Parrish Park Boat Ramp.

Observations: Haledule wrightii and Syringoduim were the two seagrass species observed. Caulerpa, algae, chaetomorpha and chaetocera were also observed a quite a few areas. Areas of shell and shell hash also in the area. Clarity was pretty terrible in this area, <1ft of visibility and the water was a brown/ yellowish color.

Day 3: January 13, 2016

Personnel: Brittany Isenberg and Keith Patterson, Dewberry; Bob Virnstein, SEA

Location: Port St. John, FL

Weather conditions: Cloudy in the AM, 47F, light wind NW 6mph, Partly cloudy in the afternoon, 61F, stronger winds from the NNE, 17mph

Daily field activities: Started off at Port St. John Boat Ramp, travelled along the western shore of IRL heading south to Front Street Boat Ramp (Front Street Civic Center), then proceeded across the lagoon to the eastern shore heading north back to Port St. John Boat Ramp.

Observations: Water clarity was still terrible, visibility < 1ft in this area as well. Observed no grass at any of the sites we went to. Most areas were nothing but sand and shell/shell hash. Observed areas with algae, caulerpa and some areas with sand ripples.

Day 4: January 14, 2016

Personnel: Brittany Isenberg and Keith Patterson, Dewberry; Bob Virnstein, SEA

Location: Melbourne, FL

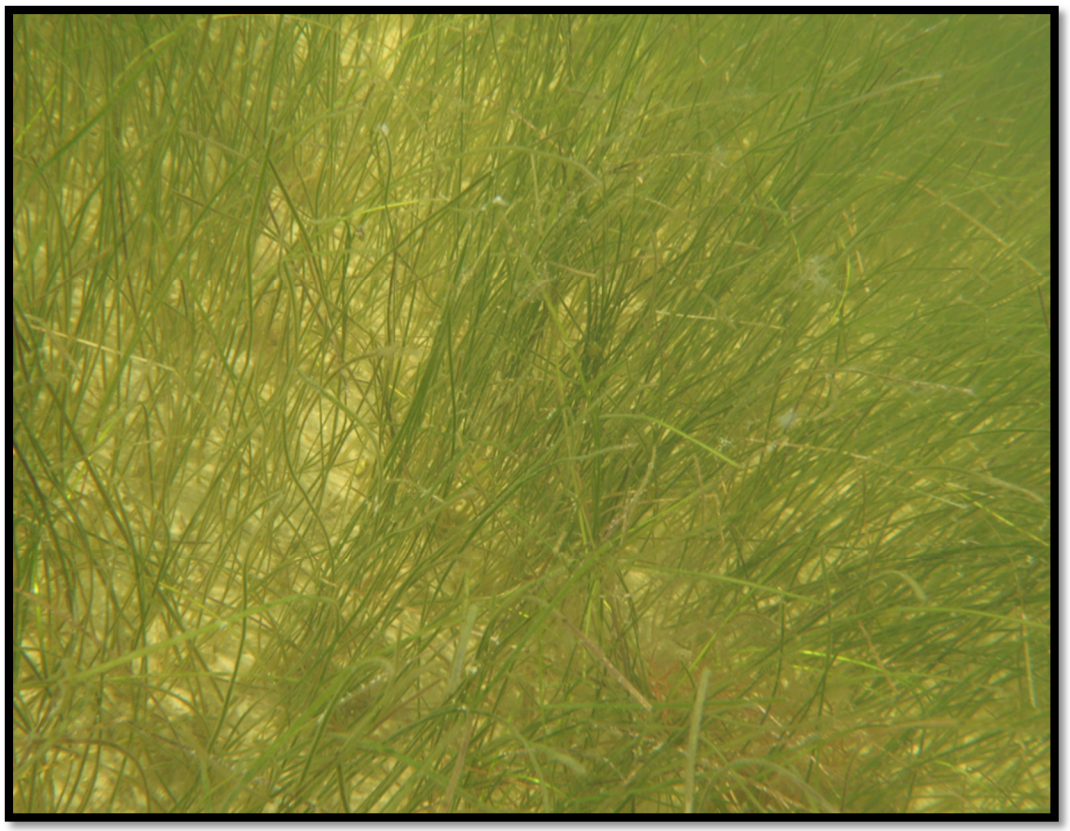
Weather conditions: Mostly cloudy all day low of 50F and a high of 66F, very light winds all day

Daily field activities: Launched from Front Street Civic Center Boat Ramp, proceeded south along the western shore to a little north of Sebastian Creek. Headed across the lagoon a bit north of the Sebastian Inlet, then collected points along the eastern shore of the lagoon going north back to the Civic Center Boat Ramp.

Observations: Water clarity was much better compared to the first three days of this trip some areas had >3ft of visibility. Haledule wrightii was the predominate species observed along with some Syringodium. There was a good amount of clam shells, shells/shell hash observed as well. Caulerpa and algae in a few areas, and some areas if ripples or mottled bottom.

The above January trip completes the photointerpretation field work task for the project.

PHOTOINTERPRETATION KEY
FOR THE
2015 INDIAN RIVER LAGOON SEAGRASS MAPPING PROJECT



January 28, 2016

Prepared by:

Dewberry

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Preface

The St. Johns River Water Management District (SJRWMD) contracted Dewberry for imagery acquisition and seagrass mapping for the Indian River Lagoon (IRL). The overall objective of this contract is to: A) acquire 2015 time appropriate aerial imagery of the entire IRL captured directly in digital format by a digital mapping camera; B) produce a complete 2015 seagrass map primarily by photo interpreting this newly acquired aerial imagery in soft-copy stereo along with ancillary ground truth data; and C) deliver the processed aerial imagery along with all files used in establishing the blocks in orthorectification and other processes.

The classification system used for this project consists of the Florida Land Use Land Cover and Forms Classification System (FLUCCS), which was originally compiled by the Florida Department of Transportation, State Topographic Bureau and modified for this project.

The following Photointerpretation Key was developed in order to document the decisions and mapping conventions applied during the photointerpretation process. The key was used to help ensure that the photointerpretation was consistent throughout the project. It was designed to provide descriptions of the visual and spatial distribution characteristics of the classification types used for the project and to document any special mapping conventions that were developed. The key also serves as metadata to provide insight for future users into the rationale for the delineation and classification of seagrass habitats appearing within the database.

Contents

The following describes the classification codes applied within the ArcGIS geodatabase constructed for the Indian River Lagoon 2015 Seagrass Mapping project.

CLASSIFICATION CODES

5400 **Unvegetated Bottom <10% cover**

9113 **Seagrass, Patchy**

9116 **Seagrass, Continuous ≥10% cover**

Continuous seagrass polygons are further classified according to the percent cover of seagrass (i.e. density) existing within each polygon.

0/100 - 0% Dense / 100% Sparse

20/80 - 20% Dense / 80% Sparse

40/60 - 40% Dense / 60% Sparse

60/40 - 60% Dense / 40% Sparse

80/20 - 80% Dense / 20% Sparse

100/0 - 100% Dense / 0% Sparse

NO SAV **Not Classified (land, islands, mangroves, etc.)**

<u>Edge Confidence Classification:</u>

HC **High Confidence**

MC **Moderate Confidence**

LC **Lower Confidence**

CLASSIFICATION SYSTEM

For each classification type listed herein, a definition is included along with a written description of the photo signature. The photo signature describes how each classification category appears on the digital natural color aerial photography from a photointerpretation perspective. Tone, color, shape, size, association, texture, and typical location are described. Also included are photographs taken in the field and an aerial photograph showing the photointerpretation delineations.

Unvegetated Bottom – 5400 Barren substrate with less than 10% seagrass coverage. Areas populated with algae and tidal flats are included within this class.

Description

The 5400 classification has many different photo signatures and will depend on the characteristics of the area where it is occurring. These signatures can be divided into two distinctly different categories, which are dependent on depth.

Deepwater 5400 is usually a smooth, bluish-green color, but can sometimes appear dark blue or brown depending on water depth and turbidity levels. It can usually be found on the deeper edges of seagrass beds and in residential canals. Sometimes a deep water 5400 polygon will be elongated and linear with straight edges, denoting a man-made channel dredged through a shallow water area (i.e. the Intracoastal Waterway and inlets).

The photo signature for the shallower water 5400 classification is usually very smooth. This signature can be many different colors depending on water depth and turbidity levels. If the water is relatively clear, the very shallow sandy areas will appear white as opposed to the light green or turquoise as seen within slightly deeper sandy areas. Murky or tannin-stained water will create a gray or light brown colored photo signature respectively.

Figures 1 through 3 show examples of Unvegetated Bottom.

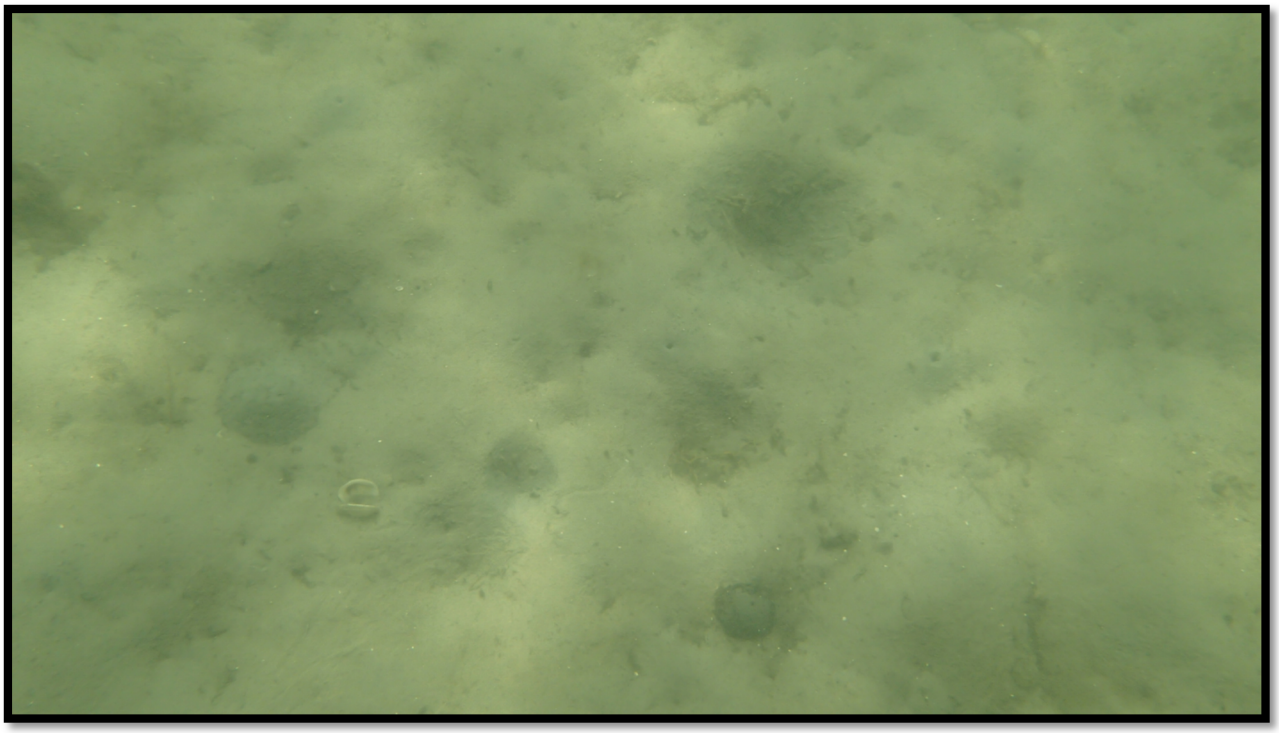


Figure 1. Unvegetated Bottom – 5400

Figure 2. Shallow Unvegetated tidal flat – 5400

Figure 3. Delineated aerial photograph showing 5400

Seagrass, Patchy – 9113 Areas 0.25 acre or greater in size that consist of primarily (greater than 50%) bare bottom in which many small patches (each less than 0.25 acre) of seagrass are scattered, and where the seagrass patches are not interconnected.

Description

The photo signature for the 9113 classification usually has a rough texture when viewed on a stereoscopic workstation and is bluish-gray to almost black depending on water depth and turbidity. Patchy seagrass polygons can be found on the deeper and shallower edges of continuous seagrass beds or can be large and expansive and cover the entire bed. The actual seagrass beds will look like small circular colonies that are close enough together to be combined into a seagrass polygon. These areas can occur because of new growth on a previously unvegetated substrate, or within areas of previously continuous seagrass that is deteriorating due to changing water conditions such as salinity, turbidity, and temperature or pollution levels.

Figures 4 and 5 show examples of Patchy Seagrass.

Figure 4. Patchy Seagrass – 9113

Figure 5. Delineated aerial photograph showing 9113

Seagrass, Continuous – 9116 The dominant feature of these seagrass beds is that they are continuous in nature, with interconnected areas of seagrass. These beds may contain many small interspersed patches of sparsely vegetated or unvegetated bottom. The dense aspect means that the area should contain more vegetated bottom than unvegetated bottom, and thus at least 50-60% of the area with this FLUCCS code should contain seagrass. Only sand patches greater than 0.25 acres should be distinguished within a continuous bed.

Description

The photo signature for 9116 is smoother than that of 9113 but it still has some texture. It also can be bluish-gray to almost black, but has only a few areas of open bottom showing through to interrupt the continuous signature. 9116 usually can be found in the center of large, healthy seagrass beds and sometimes runs parallel to the shoreline for hundreds of meters. These larger beds usually have some sparse growth between the continuous areas (i.e. they are not always composed of a uniform thickness, but are still considered continuous).

Figures 6 and 7 show examples of Continuous Seagrass.

Figure 6. Continuous Seagrass – 9116

Figure 7. Delineated aerial photograph showing FLUCCS 9116

Seagrass Density

Description

Areas mapped as Continuous seagrass (9116) are further classified according to the percent cover of seagrass (i.e. density) occurring within each polygon. Density percentages are assigned to Continuous seagrass polygons based on the best visual estimation by the photointerpreter according to the following rules.

9116 polygons less than 100 acres are assigned one density percentage which best describes the entire polygon.

9116 polygons greater than 100 acres that contain varying densities will be broken into smaller polygons with a minimum mapping unit of 50 acres.

Each density class is expressed as a ratio of Dense versus Sparse cover (Dense/Sparse). The density classes are listed below.

0/100 - 0% Dense / 100% Sparse

20/80 - 20% Dense / 80% Sparse

40/60 - 40% Dense / 60% Sparse

60/40 - 60% Dense / 40% Sparse

80/20 - 80% Dense / 20% Sparse

100/0 - 100% Dense / 0% Sparse

The geodatabase created for the mapping contains two separate fields which record the density percentages. One field is entitled Dense Seagrass (DSG) and lists the first percent shown above. The second field is entitled Sparse Seagrass (SSG) and lists the second percent shown above.

Seagrass Density Percentage Calculations

Figures 8 through 13 show examples of density percentages as applied to delineated Continuous Seagrass beds. These images should be used as a guide for assigning density percentages.

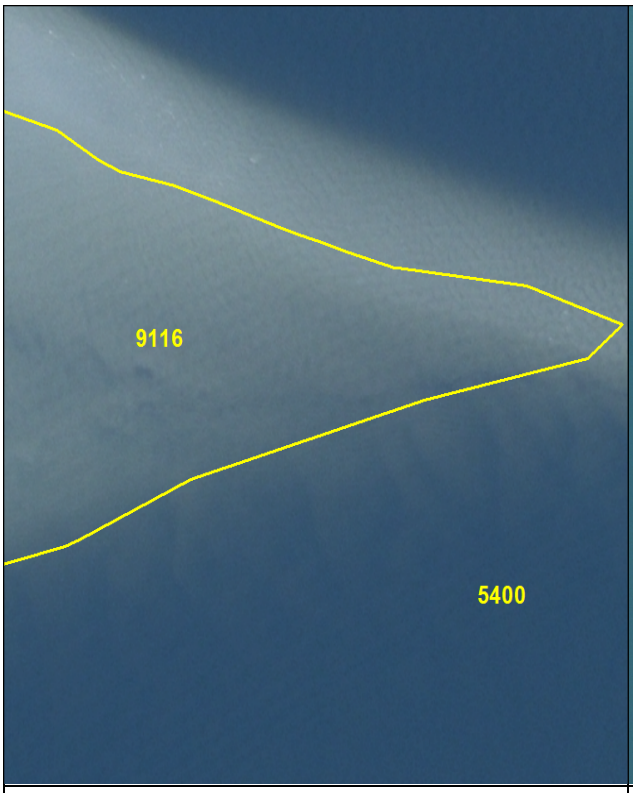


Figure 8. **0/100** - 0% Dense / 100% Sparse

Figure 9. **20/80** - 20% Dense / 80% Sparse

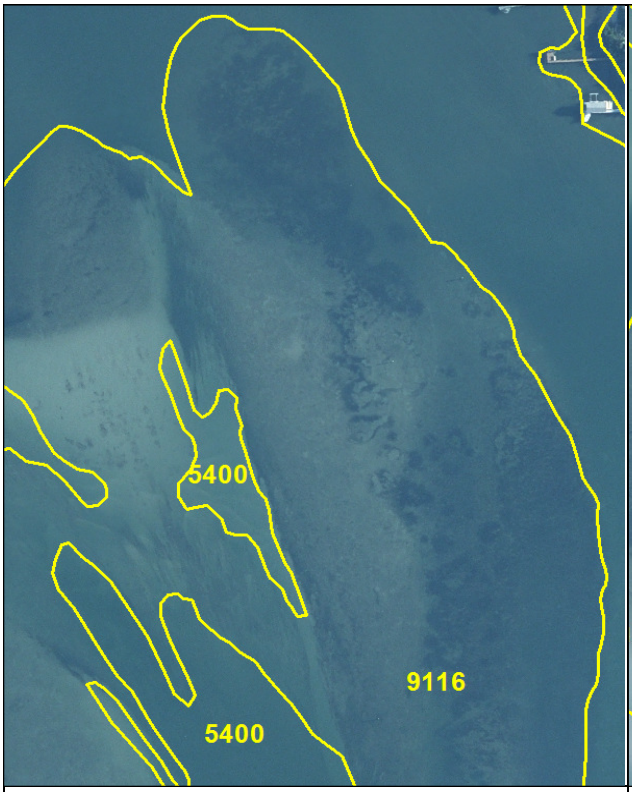


Figure 10. **40/60** - 40% Dense / 60% Sparse

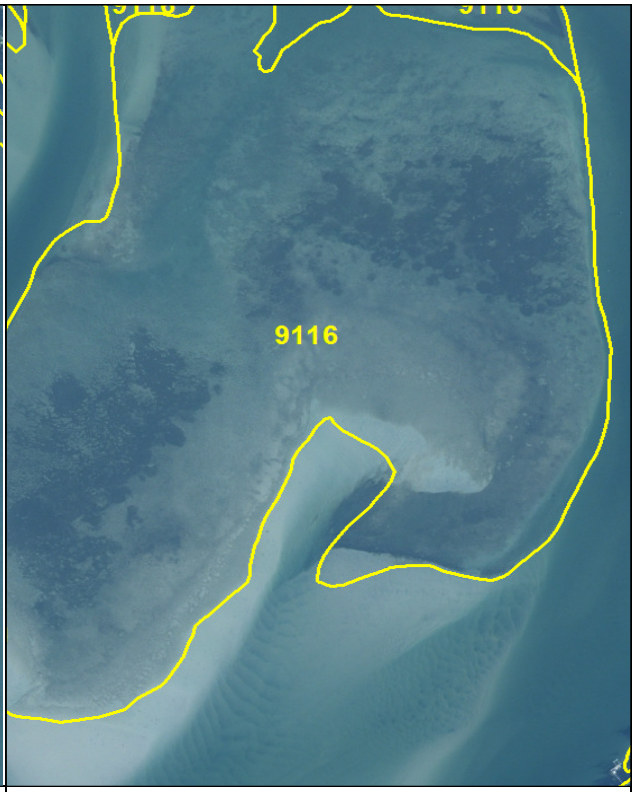


Figure 11. **60/40** - 60% Dense / 40% Sparse

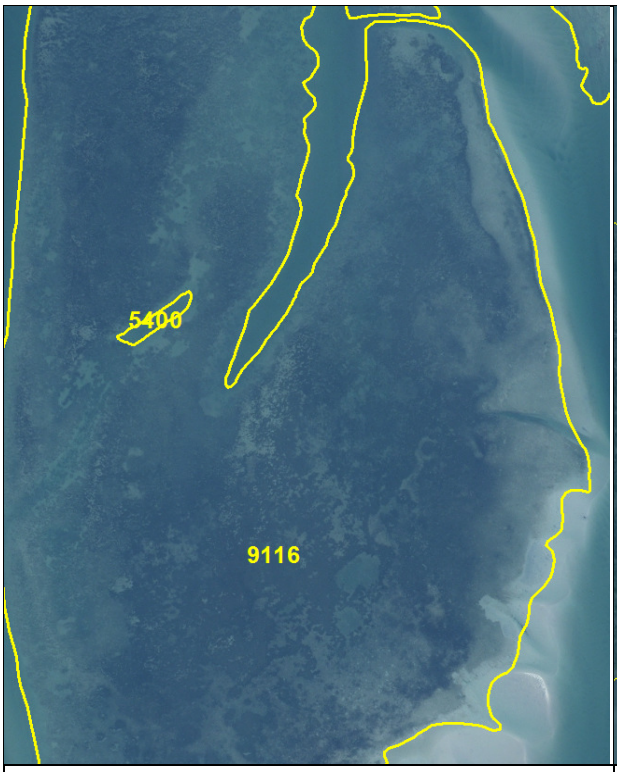


Figure 12. **80/20** - 80% Dense / 20% Sparse

Figure 13. **100/0** - 100% Dense / 0% Sparse

Not Classified - NO SAV This classification category includes all covertypes that are not included within the other covertype classifications. Examples include the mainland, islands, mangroves, wetland marshes, etc.

Figures 14 and 15 show examples of NO SAV areas.

Figure 14. Mangrove hammock – NO SAV

Figure 15. Delineated aerial photograph showing NO SAV

Seagrass Edge Confidence Analysis

The ability to see and delineate the precise edge of seagrass beds depends in large part on the water clarity, depth, wind conditions, illumination, localized anomalies and other factors existing on the aerial imagery at the time of capture. To help quantify the confidence level associated with photointerpretation and seagrass delineation, confidence levels are coded to edge-of-bed vector linework. The coding is completed only for 9116 Continuous Seagrass areas.

Seagrass Edge Confidence Analysis data is stored as line features within an ArcGIS feature class separate from the classified/attributed seagrass polygons within the project's geodatabase

The confidence levels will be attributed as described below.

> **High Confidence-HC**: Imagery signatures and seagrass bed extent is very clear within this edge of bed section. Delineation is straightforward and seagrass presence can easily be distinguished from surrounding covertypes. Actual seagrass edge of bed distance within 10m from delineated edge.

Moderate Confidence-MC: Imagery signatures within this edge of bed section are less precise and require a higher level of judgment on the part of the photo interpreter. Delineation within this area is not as clear and straightforward as it is within sections of High Confidence linework. Expect actual seagrass edge of bed to be within 50m of delineated edge.

Lower Confidence-LC: Imagery signatures within this edge of bed section are not precise and require a high level of judgment on the part of the photo interpreter. Delineation within this area is not as clear and straightforward as it is within sections of High and Moderate Confidence linework. Frequent use of collateral imagery and /or other information is often required to complete seagrass delineation. Expect actual seagrass edge of bed to be greater than 50m of delineated edge.

The following figures show examples of delineated aerial photographs that are attributed according to edge confidence.

High Confidence:

Moderate Confidence:

Low Confidence:

PHOTOINTERPRETATION DELINEATION GUIDELINES

The following guidelines are provided as a means of standardizing photo interpretation

A. The photo interpreter shall exercise extra care especially on the deep edge of seagrass beds. “Real” changes should be made regardless of the minimum mapping unit (MMU).

B. Outer boundaries of beds are more important than density categorization within beds.

C. The minimum mapping unit is 0.25 acre (0.1 ha). Only changes larger than the MMU of 0.25 acre (0.1 ha) are mapped, except where the changes less than the MMU either are completely new (not present in the previously mapped year) to the surrounding region, such as a spoil island, or have completely disappeared from the region. It is more important to map individual small isolated patches than similar sized patches that are part of a large matrix.

D. When deciding whether an area with patches of seagrass is one polygon of patchy seagrass or individual seagrass polygons, apply guideline C above with a MMU of 0.25 acre. Err on the side of lumping except in areas where small patches are the only seagrass present.

E. If an area has only a few patches, each <0.25 acre: include the polygon of patchy seagrass if the total seagrass area is >0.25 acre. Err on the side of including these rather than excluding them.

F. The existing 2013 shoreline shall be used unchanged during stereocompilation. The new 2015 line work shall be snapped to the shoreline where appropriate. If the shoreline bisects any of the photo-interpreted seagrass beds during this process, the District shall be consulted for problem resolution.

G. Significant change to be mapped shall follow similar criteria as mapping original seagrass polygons, only changes larger than the MMU of 0.25 acre (0.1 ha) are mapped except for changes in the deep edge of seagrass beds.

The new undelineated aerial photography shall be compared to the photography from previous mapped years and seagrass vector data to ensure changes are mapped accurately.

The photo interpreter shall ensure that differences between the 2013 and 2015 coverages represent only true seagrass changes and not positional inaccuracies (slivers) or photo interpreter differences.

The MMU unit for all categories is 0.25 acre (= 0.1 hectare).

Accuracy Assessment Field Work Report for the 2015 Indian River Lagoon Seagrass Mapping Project

Report Date: 9/03/2015

The following summarizes field work conducted by Dewberry's accuracy assessment team (AA team) in support of the 2015 Indian River Lagoon Seagrass Mapping Project. This field work process is designed to assess the accuracy of the photointerpretation and is an integral part of the overall mapping process. Selected accuracy assessment field points (270 points) were chosen prior to field deployment by the St. Johns River Water Management District (SJRWMD) using a slightly-stratified spatially-balanced sampling method. Some field points were inaccessible while in the field due to shallow water or navigational hazards and the point locations were moved accordingly. In most cases these adjusted points still fell within their original polygons. These adjusted points were noted in the attribute table along with the distance and direction moved from its original location. At the conclusion of photointerpretation, the accuracy assessment percentage will be calculated by Dewberry's AA team for each FLUCCS code recorded using the 270 classification field points.

Dewberry's subcontractor, Seagrass Ecosystems Analysts (SEA) provided watercraft along with seagrass habitat expertise during all the field trips.

Dewberry utilized GPS enabled ruggedized laptops equipped with ArcMap as well as a sub meter Trimble GPS to document information at each location visited. The laptops are loaded with the aerial imagery used for the project, the 2013 seagrass mapping linework, and an ArcMap feature class containing accuracy assessment fieldwork documentation.

The field personnel travelled to and located field points using a differential GPS set to sub-meter accuracy- Field points were either surveyed using a mask/snorkel or in shallow, clear water points were visually observed. All points visited covered an area of approximately 0.25acre and documentation was performed within ArcMap. The ArcMap feature class containing accuracy assessment fieldwork documentation is a deliverable for the project and contains the specific information gathered for each field point.

TRIP 1 for Accuracy Assessment Field Work

Day 1: June 1, 2015

Personnel: Melanie Masessa, Dan Bubser, Dewberry; Bob Virnstein, SEA

Location: Jupiter Sound, Hobe Sound, Peck Lake, South Indian River, Sewall's Point, FL

Left: Bob and Mel identifying seagrass at a point. Right: Starfish found at a location.

Weather conditions: Sunny and hot, high temp around 85°F.

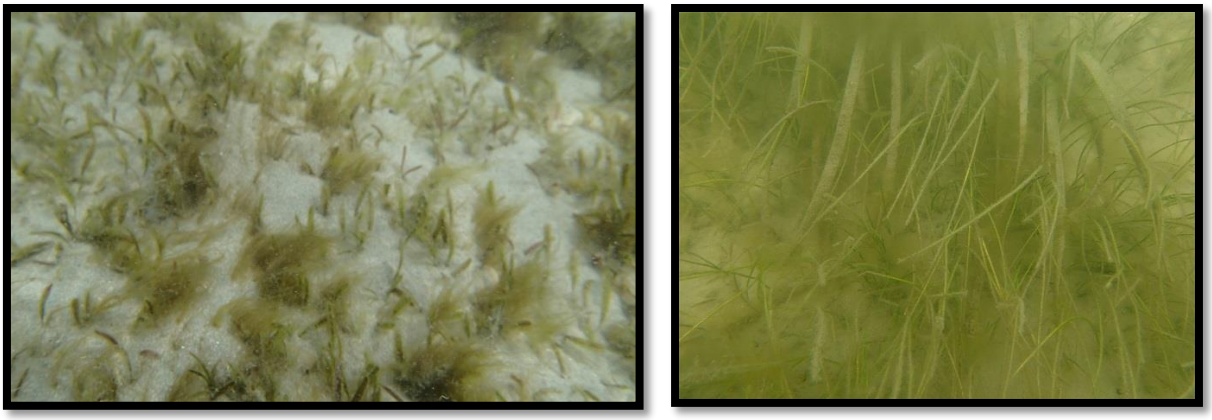
Daily field activities: Launched from Burt Reynolds Park in Jupiter around 10:30am and headed North through Jupiter Sound. One point was assessed in Jupiter Sound and contained Manatee grass (*Syringodium filiforme)* and Shoal grass (*Halodule wrightii*). Then we traveled north to assess one point in Hobe Sound where no seagrass was present. We continued to travel north and assessed one point in Peck Lake which also did not contain any seagrass. Once we got up to the St. Lucie Inlet near Hutchinson Island, we assessed three points located in the Indian River along the Southeast side of Sewall's Point and further into the open water of the Indian River. All three of these points contained Johnson's seagrass (*Halophila johnsonii*) and two had *Halodule wrightii*. To conclude the day, we traveled north of the Stuart Causeway on the Indian River and assessed two points on the east side of Sewall's Point. *Caulerpa* was present at one point and a thick layer of blue green slime algae was recorded at another. A total of eight points were completed for the accuracy assessment on this day. The weather was very sunny and hot with minimal wind and very calm water.

Day 2: June 2, 2015

Personnel: Melanie Masessa, Dan Bubser, Dewberry; Bob Virnstein, SEA

Location: Jensen Beach Causeway, Hutchinson Island, Fort Pierce Inlet State Park, Avalon State Park, FL

Weather conditions: Partly cloudy, breezy in the morning with variable winds and storms inland in the afternoon. High temp around 80°F with a cool start.



Left: *Halophila johnsonii.* Right*:* Dense bed of *Thalassia testudinum*.

Daily field activities: Launched from Jensen Beach Causeway ramp and worked our way north up the Indian River. Several points near Jensen Beach contained *Halodule wrightii* and some *Syringodium filiforme* as well. As we traveled north in the Indian River, many areas contained thick beds of *Syringodium filiforme*, especially near Hutchinson Island. Points around Fort Pierce Inlet State park had patchy *Halophila johnsonii* and various types of algae, while points west of the park had continuous *Syringodium filiforme*. Further north up the Indian River, near Avalon State Park, thick beds of Turtle grass (*Thalassia testudinum*) became more prominent. The day ended with points just north of Round Island Park. These points contained many types of seagrass in thick, continuous beds. Twenty four points total were assessed this day, extending from Jensen Beach Causeway all the way up to Florida Ridge between Round Island and Head Cove. The day ended earlier in the afternoon due to threatening storms along the coast and choppy water.

Day 3: June 3, 2015

Personnel: Melanie Masessa, Dan Bubser, Dewberry; Bob Virnstein, SEA

Location: Head Cove, Prang Island Conservation Area, Veterans Memorial Island, McCullers Cove, Gifford Island, Wabasso Island, Pelican Island National Wildlife Refuge, Sebastian Inlet State Park, FL

Weather conditions: Partly cloudy, breezy and brisk in the morning, clearing up mid-morning to be humid and sunny. Morning temp around 72°F. Afternoon temp around 80°F.

Dense bed of *Syringodium filiforme*.

Daily field activities: Launched from Riverside Park in Vero Beach, traveled south along the Indian River Lagoon toward Round Island Park. We assessed many points around Little Parks Cove and traveled north through Indian River Lagoon up to South Beach. Points in this area showed various types of seagrass present – *Syringodium filiforme*, *Halodule wrightii*, and *Thalassia testudinum*. North of South Beach were two points in Little Starvation Cove. The deeper point revealed no seagrass, while the more shallow point contained *Halodule wrightii*. A single point below Prang Island Conservation Area had a dense array of seagrass. Four points stretched from East Causeway Blvd up to Gifford Island. The only seagrass type observed at these point locations was *Halodule wrightii*. The two accuracy points near Wabasso Island were both bare with no seagrass. Continuing north up the Indian River Lagoon, many points were located around the Pelican Island National Wildlife Refuge, as well as near some spoil islands west of the refuge. These assessment points ranged from sand only to a presence of *Caulerpa* and continuous beds of *Halodule wrightii*. The three points north of the refuge near Melba Island all contained *Halodule wrightii* and drift algae, with one sighting of *Halophila johnsonii*. The day ended just southwest of Sebastian Inlet State Park. Two points were located in this area and neither contained dense nor continuous seagrass. A total of 30 points were assessed with calm and warm weather conditions in the afternoon.

Day 4: June 4, 2015

Personnel: Melanie Masessa, Dan Bubser, Dewberry; Bob Virnstein, SEA

Location: Sebastian Inlet State Park, Ballard Cove, Grant-Valkaria, Mullet Creek, Rocky Point, Palm Bay, Melbourne Causeway, FL

Weather conditions: Sunny and humid throughout the day. Morning temp around 75°F. Afternoon temp around 85°F.

***Caulerpa* and drift algae found at several point locations.**

Daily field activities: Launched from Memorial Park in Sebastian and traveled north up the Indian River Lagoon. The first seven accuracy assessment points were scattered around Sebastian Inlet State Rec Area. Only a few points had seagrass present (*Halodule wrightii*). The other points contained loose sand and drift algae. We then traveled north up the lagoon to assess each accuracy point from Micco up to Melbourne International Airport. We assessed points in the lagoon outside of Mullet Creek. Most of these point locations contained *Caulerpa* and drift algae with one area of dense *Halodule wrightii*. Of the five points we assessed in the areas of Valkaria, south of Hog Point, only one area contained continuous *Halodule wrightii*. This area was located right along the shoreline of Rocky Point. None of the six points near the Melbourne Causeway and the airport contained seagrass. Some areas had very dense patches of drift algae. On this day, we covered every point from Sebastian Inlet State Park to Indian Harbour Beach, with a total of 32 accuracy assessment points.

Day 5: June 5, 2015

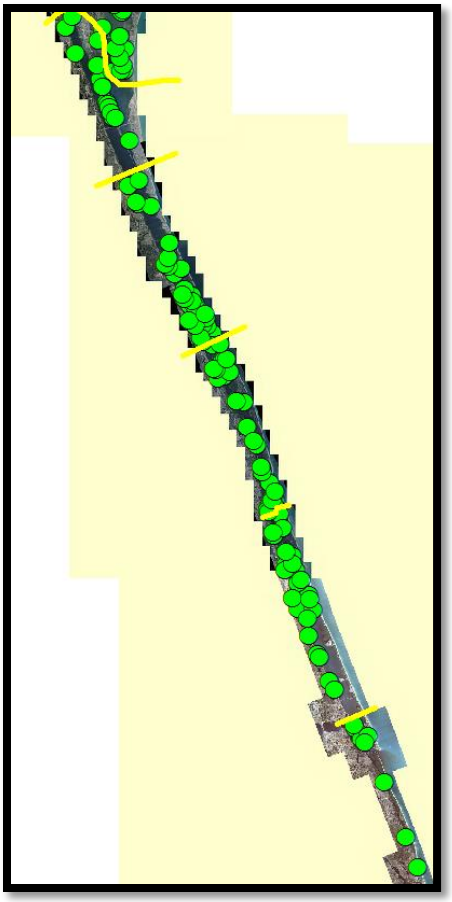
Personnel: Melanie Masessa, Dan Bubser, Dewberry; Bob Virnstein, SEA

Location: South Banana River, Merritt Island, Sykes Creek, Ulumay Wildlife Sanctuary, Indian River south of Martin Andersen Beachline Expy, FL

Weather conditions: Sunny and humid throughout the day. Morning temp around 77°F. Afternoon temp around 85°F.

Close-up view of *Halophila engelmannii*.

Daily field activities: Launched from POW/MIA Park in Melbourne and traveled south on the Indian River, around the point of Merritt Island, and north up the Banana River. The first point, located near Samsons Island Park, revealed no seagrass and a lot of loose, course sand. There were eight points north of the Pineda Causeway along the east coast of Merritt Island. Many of these accuracy assessment points contained *Caulerpa*. There was continuous *Halodule wrightii* and a lot of *Caulerpa* and drift algae mixed in at a few points. Two points contained Stargrass (*Halophila engelmannii*) and one had a few sprigs of Widgeon grass (*Ruppia maritima*). We headed north into Sykes Creek where two points were located. One had continuous *Halodule wrightii* with patches of *Halophila engelmannii*, while the other contained only a few sprigs of seagrass and many patches of drift algae. Once these points were completed, we headed north up the Sykes Creek and took the Canaveral Barge Canal back over to the Indian River. From here we headed south down the river. All four points that were located south of the Martin Andersen Beachline Expy on our trip back to POW/MIA Park contained a lot of drift algae and a soft, sandy bottom. On this day we covered 15 accuracy assessment points in weather that was clear, calm and sunny.



Location of Trip 1 Field Points. Separate days divided by yellow lines.

The first Accuracy Assessment trip (June 1st-5th) encompassed every point located from Jupiter up to Martin Andersen Beachline Expy, including areas of south Banana River and points located in Sykes Creek. There were a total of 109 accuracy points assessed and documented in the ArcMap feature class.

TRIP 2 for Accuracy Assessment Field Work

Day 1: July 6, 2015

Personnel: Melanie Masessa, Dewberry; Bob Virnstein, SEA

Location: Indian River north of Martin Andersen Beachline Expy, Stony Island, Cruickshank Trail, east coast of Mantonhurst, FL

Weather conditions: Sunny and hot with few clouds. Morning temp around 85°F. Afternoon temp around 90°F and a heavy afternoon storm with lightning.

Daily field activities: Launched from Port St. John Boat Ramp at 8:00am near Cocoa. We traveled south to complete points just north of Martin Andersen Beachline Expy. The two points closest to the bridge contained no seagrass. As we traveled north up the west coast of Merritt Island, all of the seven points leading up to NASA Causeway contained *Halodule wrightii*. Some points had drift algae and *Caulerpa*, while others contained *Syringodium filiforme* and some *Ruppia maritima*. As we continued to travel north up the Indian River near Stony Island, many points had to be relocated due to very shallow water levels. Almost all of the ten points in this location displayed very dense *Halodule wrightii* and *Syringodium filiforme*. Water clarity was poor and some small patches of *Caulerpa* were present. Three points were located on both sides of the Max Brewer Memorial Parkway. Two had to be moved due to shallow water levels, and two points had heavy amounts of drift algae and some *Caulerpa*. *Halodule wrightii* was found at the points surrounding the Cruickshank Trail with a lot of algae growing on the seagrass blades. As we completed points up the east coast of Mantonhurst, we noticed various types of algae in the point locations. Three different types of seagrass were also present – *Ruppia maritima*, *Halodule wrightii*, and *Syringodium filiforme*. On this day we covered 32 points in the Indian River, from the Martin Andersen Beachline Expressway all the way up to the east coast of Mantonhurst. While navigating back to the boat ramp, we were encompassed by an intense lightning storm on the water, making the day's wrap-up chaotic and stressful.

***Jania capillacea* seaweed found growing among seagrass in Indian River.**

Day 2: July 7, 2015

Personnel: Melanie Masessa, Dewberry; Bob Virnstein, SEA

Location: North section of Indian River, Cruickshank Trail, through Haulover Canal, Mosquito Lagoon near Pardon Island and Three Cabbage Island, FL

Weather conditions: Sunny, calm and hot with few clouds. Morning temp around 85°F. Afternoon temp around 93°F with storms building around 3pm.

Daily field activities: Launched from the Haulover Canal at 7:30am and headed into the Indian River. Once out of the canal, we proceeded to collect accuracy points along the perimeter of the river, heading southeast first. One point collected just south of the canal displayed sand and algae only in very murky water. The three points along the mangroves of Marsh Bay were very shallow and took additional time to get to. They contained very dense and continuous *Halodule wrightii*, with *Syringodium filiforme* in some areas. Next, there was a cluster of 5 points very close to one another just north of Black Point and the Cruickshank Trail. Three points had very dense and continuous *Halodule wrightii* and *Syringodium filiforme* with algae covering the seagrass blades. The other two points had minimal seagrass and occasional drift algae. The northmost point in the Indian River contained a lot of coarse green algae with only a handful of seagrass blades. As we headed south along the eastern perimeter of the Indian River, points showed mostly *Halodule wrightii* and *Syringodium filiforme* with patches of very dense algae. Some areas had thick seagrass beds and others were very thin and sparse. The green algae *Acetabularia acetabulum*, also known as Mermaid's Wineglass, was found growing among the seagrass in one location. Finishing up the Indian River, five points were collected northwest of the Haulover Canal. The water quality was excessively murky, however, seagrass was found at all locations but one. *Chaetomorpha* algae was found at one location growing heavily among the *Syringodium filiforme*.

Next, we took the canal over to Mosquito Lagoon and headed north. Water quality at the first three points was very poor, with only one point containing *Halodule wrightii*. A large sandbar located in the middle of the Lagoon made it difficult to access the next two points. Once we arrived at the point locations, we found dense and continuous *Halodule wrightii* and *Syringodium filiforme*. Three points on the east side of Mosquito Lagoon near Three Cabbage Island contained dense seagrass in very shallow, murky water. When these were completed, we crossed over the sandbar into the deep areas to assess three points which all had limited visibility and no seagrass present. The day ended around 3:00pm due to afternoon storms. A total of 31 points were collected between the Indian River and Mosquito Lagoon. Water levels were very shallow and water quality was poor, causing us to move many inaccessible points.

Left: Close-up of the green algae Acetabularia acetabulum. Right: Seagrass bed that contained the green algae.

Day 3: July 8, 2015

Personnel: Melanie Masessa, Dewberry; Bob Virnstein, SEA

Location: Mosquito Lagoon north up to Cedar Island, FL

Weather conditions: Sunny and hot with no clouds or breeze. Morning temp around 85°F. Afternoon temp around 95°F.

Daily field activities: Launched from Haulover Canal around 7:00am and traveled north up the Mosquito Lagoon. Five points were assessed along the west coast of the lagoon around the spoil islands. Three points had no seagrass with a sand/shell bottom and two had dense *Halodule wrightii*. We proceeded to head north up the ICW along the west coast of the lagoon. Points either contained some seagrass or shell/oyster hash and sand. Two points were moved from within the inaccessible areas of the mangroves toward the ICW near Brickhouse Cove. The seagrass was dense near here, however, much of the previous polygons were exposed due to shallow water levels. One more point was collected in the ICW just south of Blue Hole and contained no seagrass. We traveled northeast through the mangroves to assess two relocated points due to shallow sandbars. Both points had sand only. Heading south along the eastern waterway, only one of the eight points had seagrass (*Halodule wrightii*). The two points near Plantation Island showed dense and continuous *Halodule wrightii* with algae growing on the blades. Heading south along the large sandbar in the lagoon toward Bird Island, almost every point had continuous seagrass and poor water clarity, but three of the points were moved because of very shallow water levels. One point near the sandbar had no seagrass. We ended the day around 3:00pm and a total of 32 points were assessed. Much of the lagoon had a high

population of manatees, low water levels, and poor water clarity, making navigation very difficult throughout the area. There were also many fisherman, which were difficult to work around.

Area around a point location with really shallow and exposed seagrass.

Day 4: July 9, 2015

Personnel: Melanie Masessa, Dewberry; Bob Virnstein, SEA

Location: Mosquito Lagoon south down to Pelican Island, FL

Weather conditions: Sunny and hot with no clouds or breeze. Morning temp around 87°F. Afternoon temp around 94°F.

Daily field activities: Launched from Haulover Canal around 7:00am and traveled south down the Mosquito Lagoon. We traveled along the west side of the lagoon, where three points had soft sand with shells and no seagrass, and one point had dense and continuous *Halodule wrightii*. Two points heading toward Pelican Island were moved because of a large sandbar. Five of the points in the south section of Mosquito Lagoon had very dense *Halodule wrightii*. Prop scars from boats were visible, leaving bare streaks between the seagrass beds. There was dense and continuous seagrass right at the point by Cucumber Island, but the existing polygon contained many bare patches of sand only. The final four points collected in the lagoon, between Pardon Island and Cucumber Island, had minimal seagrass present. A total of 17 points were collected in the southern region of Mosquito Lagoon. We ended the day around noon.

Location of Trip 2 Field Points. Separate days divided by yellow lines.

The second Accuracy Assessment trip (July 6th-9th) encompassed every point north of the Martin Andersen Beachline Expy in the Indian River, as well as all points located in Mosquito Lagoon. There were a total of 112 accuracy points assessed and documented in the ArcMap feature class.

TRIP 3 for Accuracy Assessment Field Work

Day 1: August 4, 2015

Personnel: Dan Bubser, Melanie Masessa, Dewberry; Bob Virnstein, SEA

Location: Banana River south of Martin Andersen Beachline Expy, Tip of Merritt Island/Buck Point, FL

Weather conditions: Sunny and hot with few clouds. Morning temp around 85°F. Early afternoon temp around 90°F.

Daily field activities: Launched from Kelly Park Boat Ramp in the Banana River at 9:30am in Merritt Island. We traveled toward the north side of the Martin Andersen Beachline Expy to complete one point near a spoil island. This point had very dense and continuous *Halodule wrightii*, which became thin and patchy as we drifted away from the island. Then we traveled south to assess two points southeast of the expressway; both points had short and thin, but continuous *Halodule wrightii*. Small amounts of *Halophila engelmannii* were found at one point. The point near Milford Point of Merritt Island contained very patchy and short *Halodule wrightii* blades with shell hash. Continuous and short *Halodule wrightii* was also present near the Merritt Island Causeway. The point we assessed near Big Island in the Banana River had short seagrass which was quite sparse in some areas. Due to the shallow water level and difficult navigation, we had to move one point from within the mangroves of Catfish Creek to the Houseboat Cut area, west of the original point. The new point had a few sprigs of *Halophila engelmannii* and *Halodule wrightii* but was primarily sand with clumps of algae. Extremely thin but continuous *Halodule wrightii* was present on the north side of the Cocoa Isles Country Club. Patchy *Halodule wrightii* presented itself within the mangroves on the south side of the country club. Of the three points assessed around Jones Creek, two contained continuous *Halodule wrightii*. No seagrass was found at the final point of the day between the tip of Merritt Island and Jones Creek. We concluded the day by examining some of the 2013 seagrass polygons that looked questionable based on the new imagery. Three polygons along Merritt Island, along with one just south of the country club were looked at and documented. On this day, 13 points were assessed in the Banana River, with the day on the water ending around 2:30pm.

Small patch of short seagrass found in the Banana River.

Day 2: August 5, 2015

Personnel: Dan Bubser, Melanie Masessa, Dewberry; Brenton, KSC Ecological Program

Location: Banana River north of NASA Causeway in NASA restricted zone, Banana River south of NASA Causeway in Permit only zone, FL

Weather conditions: Sunny and hot with few clouds and little wind. Morning temp around 88°F. Early afternoon temp around 95°F.

Daily field activities: Met with Kennedy Space Center Ecological Center at 9:00am after going through KSC security and badging center. Drove with KSC personnel to NASA Causeway, where we launched airboat and headed north through restricted zone of Banana River. Points were assessed along the east side of the Banana River while heading north. Three of the five points we covered had continuous and dense *Halodule wrightii*, while the other two had tiny amounts of seagrass but not enough to map. The five points clustered in the north had an array of seagrass – *Halodule wrightii*, *Syringodium filiforme*, and some *Ruppia maritima*. One point contained the algae *Acetabularia acetabulum*. The two points in the very north of Banana River had soft, silty sand with no seagrass present.

Next, we headed south on the airboat to complete the accuracy points south of the NASA Causeway in the "permit-required" zone of Banana River. As we headed south along the east side of the river, we noticed many points with dense *Halodule wrightii* and *Syringodium filiforme*, with a small amount of *Halophila engelmannii* present at one point. The three points on the southeast side of the permit area were very diverse. One point had continuous seagrass covered in algae. Another point was very patchy *Halodule wrightii*, and the southernmost point had very murky water with tiny amounts of seagrass and a shelly bottom. As we headed west, we assessed one point in the center of the river that was bare but had some seagrass in the vicinity of it. Most of the points on the west side of the river as we headed north had various types of seagrass present. *Halodule wrightii*, *Ruppia maritima*, and *Syringodium filiforme* were found in dense, continuous areas with a lot of algae covering the blades. Only three of the points did not contain any seagrass, but did contain patches of drift algae.

Band of Halodule wrightii covered in algae located along NASA Causeway.

On this day we completed 36 points in the Banana River, with 16 points in the NASA restricted zone, and 20 in the permit zone. When the day started on the airboat, the water was calm and smooth, making visibility at points very good. As the day concluded around 2:30pm, wind had picked up and waters were murky and very choppy.

The third and final Accuracy Assessment trip (August 4th-5th) covered all points remaining in the Banana River, from the tip of Merritt Island up to the northernmost point in the NASA restricted zone. There were a total of 49 accuracy points assessed and documented in the ArcMap feature class.

Left: Dan and Mel from Dewberry conducting Accuracy Assessment from the KSC airboat.
Right: Location of Trip 3 Field Points. Separate days divided by yellow lines.

CLASSIFICATION ACCURACY ASSESSMENT REPORT
2015 Indian River Lagoon Seagrass Mapping

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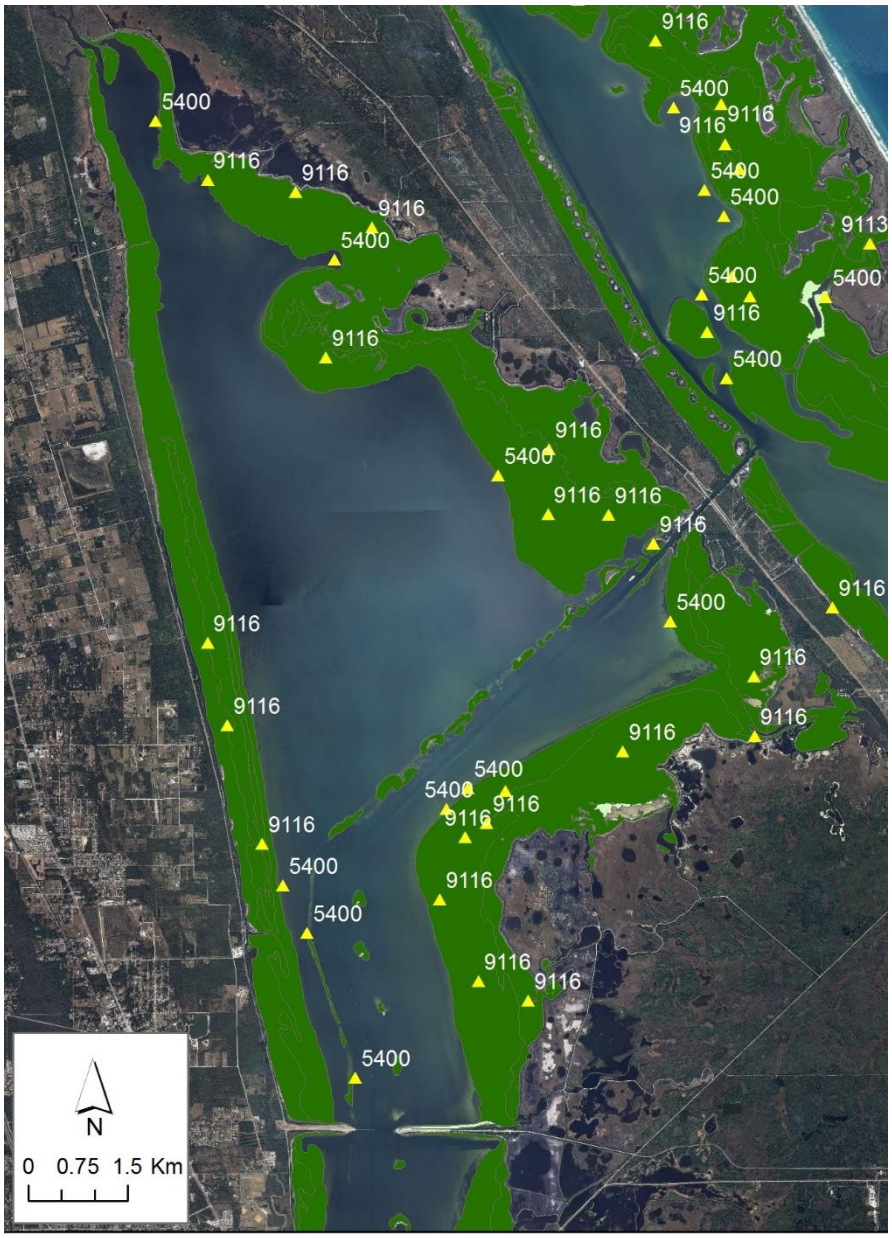
St. Johns River Water Management District

May 2016



Background

A primary objective of the Indian River Lagoon (IRL) Surface Water Improvement and Management (SWIM) Plan is to protect and restore seagrasses. The IRL SWIM Plan directs the South Florida and St. Johns River Water Management Districts to map seagrasses in the Indian River Lagoon at 2 to 3 year intervals and to acquire aerial photographs each of the other non-mapping years. Accordingly, Indian River Lagoon seagrass maps have been prepared for the following years: 1943, 1986, 1989, 1992, 1994, 1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011 and 2013. The seagrass maps being reviewed here are delineated from the aerial photography obtained in May and June 2015.

Classification accuracy assessment is performed when the final maps are received to determine the map accuracy with regards to classification of seagrass beds by the photo interpreters.

Methods

For the 2015 IRL Seagrass Map project, Dewberry was contracted to conduct the accuracy assessment field surveys for the entire project area shown in Figure 1. Attachment A contains the Accuracy Assessment Field Report delivery to the District. The SJRWMD was responsible for completing the accuracy assessment analysis once the draft map was delivered, QA'd, edited, and finalized.

For the accuracy assessment of the 2015 seagrass mapping in the Indian River Lagoon, 270 sampling points were generated using a slightly-stratified spatially-balanced sampling method. The proportionally distributed points were desired to avoid clustering and under-over representation.

For the 2015 points, the ESRI geostatistical tool "Create Spatially Balanced Points" was used in ArcGIS 10. The tool generates a set of sample points based on inclusion probabilities, maximizing spatial independence and sampling efficiency, where each point represents roughly the same proportion of the total study area.

The 2015 AA point generation used polygon feature classes representing the two most recent seagrass mapping events (2011 and 2013) and a third input polygon feature that is a 50-foot buffer of the most recent seagrass (2013). The probabilities for each polygon input were assigned to the probability field. Several additional steps utilizing the ESRI Tool, "Create Spatially Balanced Points," generated the points for the sublagoons. The tool has two inputs: the number of output points and the field of inclusion probabilities. The tool determines spatial balances and distances from the input information.

An ESRI Shapefile was created with these points which were loaded into a GPS enabled ruggedized laptop equipped with ArcMap as well as a sub-meter Trimble GPS to document information at each location surveyed. Dewberry staff navigated to each point and surveyed using a mask/snorkel or visually in shallow clear water. All points surveyed covered an area of approximately 0.25acre. Map categories used are: bare bottom or algae only (5400 or 9121) and seagrass (9116 or 9113). Descriptive comments were made for each point visited as well as seagrass percent cover, drift macroalgae percent cover, *Caulerpa* percent cover, and water depth.

Imagery for the IRL was collected between May 8 and June 26, 2015. Field work for classification accuracy assessment was completed between June 2 and August 5, 2015.

The results of the field surveys were then compared with map data to test overall map classification accuracy.

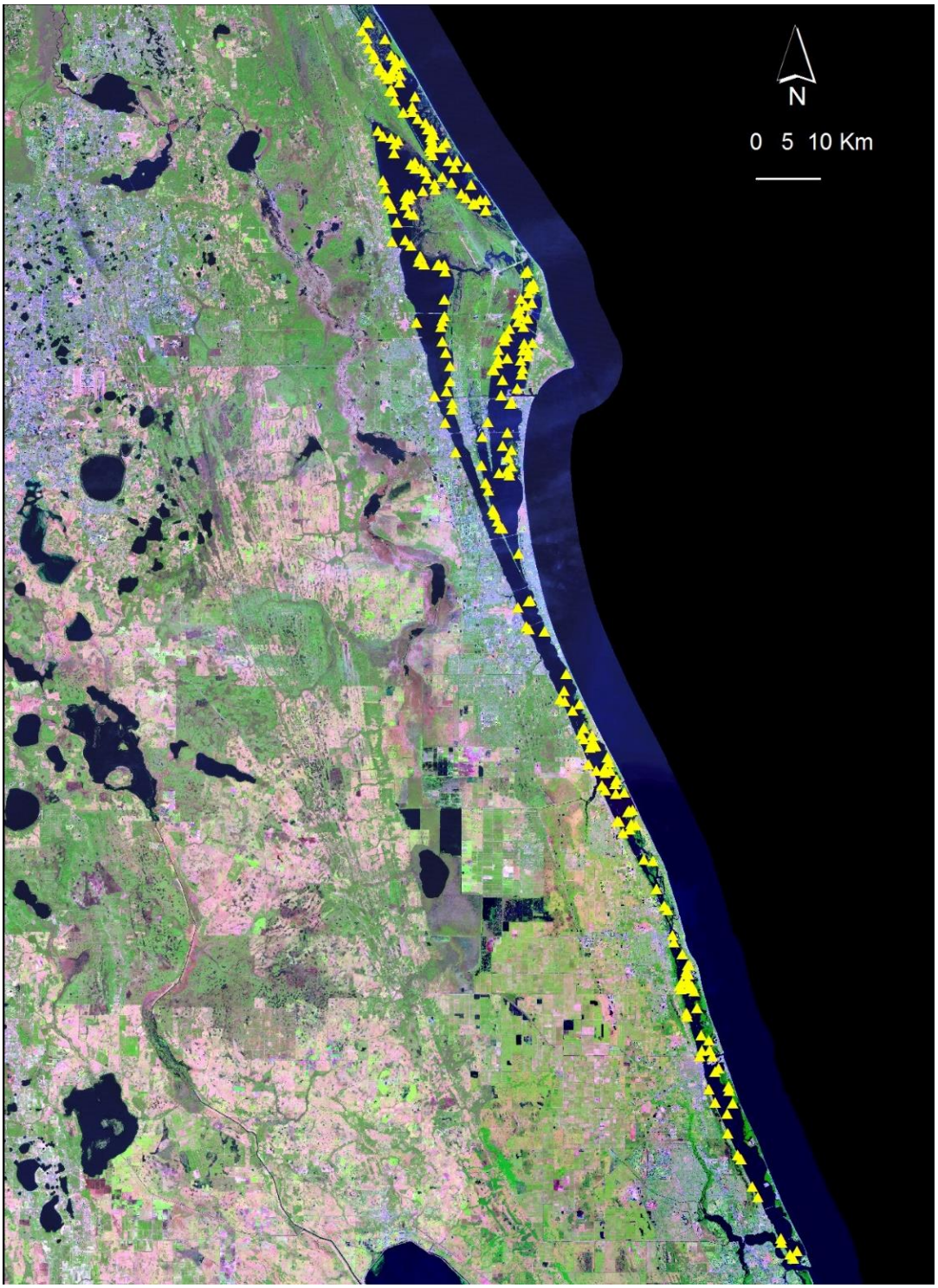


Figure 1. Accuracy Assessment points for Seagrass Mapping Project Area

Results

Sample results of the field effort are shown in Table 1. Of the 270 points surveyed, 110 points were field classified as “bare bottom” or had “only algae present” (code 5400 or 9121, respectively); 160 points were classified as seagrass (code 9116 or 9113); for the accuracy assessment, no difference was made between the 9113 patchy and 9116 continuous classifications. Similarly, no difference was made between points with no seagrass present (5400 or 9121).

Of the 270 points surveyed, 238 points matched the map classification and 32 points did not match the map classification. There were 17 points where seagrass was mapped but the field survey found bare bottom or algae only. There were 15 points where seagrass was not mapped but was found at the survey point. Four of the 15 points mapped as 5400 were located less than 10m from an adjacent mapped bed. Figure 2 shows the segmentation boundaries in the project area. Figure 3 shows the distribution of points throughout the lagoon segments with results.

The overall map accuracy for the IRL 2015 Seagrass Mapping was determined to be 88%.

TABLE 1. Sample Results of the 2015 Indian River Lagoon Classification Accuracy Assessment.

Dewberry Comment	Seagrass % Cover	Algae % Cover	Caulerpa % Cover	Depth (m)	Ground Truth Habitat	2015 Mapped Habitat	Y/N
Short and thin Halodule wrightii but very continuous; Some small patches of Caulerpa and occasional drift algae	90	5	10	2.5	9116	9116	Y
Large amounts of thick and dense Halodule wrightii with some drift algae; Seagrass is very continuous	100	25	0	4.0	9116	9116	Y
Continuous but not dense Halodule wrightii; some patches of Caulerpa and drift algae; Manatees everywhere	85	10	15	3.5	9116	9116	Y
Very dense and continuous Halodule wrightii; Some small patches of drift algae and some patches of sand; Otherwise very continuous	95	15	0	3	9116	9116	Y
Water is very murky; Continuous Syringodium filiforme with a lot of thick algae growing among it	100	55	0	1.5	9116	9116	Y
Very little amount of Halodule wrightii, but not enough to map; Drift algae is present in heavy patches	35	65	0	4.5	5400	9116	N
Thick, continuous and dense Syringodium filiforme; Chaetomorpha algae heavy and growing among the continuous seagrass	85	45	0	3.5	9116	9116	Y
Very dense and continuous Halodule wrightii and Syringodium filiforme; Algae growing on seagrass; Water very murky	100	25	0	3	9116	9116	Y
Difficult area; Halodule wrightii and Syringodium filiforme continuous but very thin; When moving dense algae in area, seagrass was underneath; Floated few boatlengths and saw an abundance of grass	45	50	0	3.5	9116	9116	Y
Sand only at point; No seagrass	0	0	0	2	5400	5400	Y
Some small patches of Halodule wrightii but area is mostly coarse sand and shells; Dark patches in imagery are algae (see photo)	10	15	0	4.5	5400	9116	N
Hard sand and no seagrass at point	0	0	0	5	5400	9116	N
Sandy bottom with continuous Halodule wrightii; Blades are short and thin but continuous; Water clarity very poor	80	0	0	3	9116	9116	Y
Bottom is coarse sand and shells; No seagrass	0	0	0	4.5	5400	5400	Y
Very shallow with continuous and dense Halodule wrightii and Syringodium filiforme	100	0	0	1.5	9116	9116	Y
Dense and continuous Halodule wrightii; Water very murky; Some algae growing on seagrass blades	100	15	0	1.5	9116	9116	Y
Continous and dense Halodule wrightii at point; Some red drift algae and some Ruppia maritima; Seagrass was continous leading up to point with lots of drift algae and some Caluerpa	100	20	0	1.7	9116	9116	Y
Sand only at point; No seagrass	0	0	0	5.5	5400	5400	Y
Sandy bottom with small amounts of drift algae but no seagrass	0	0	0	5	5400	5400	Y
Continuous Halodule wrightii but very thin; More drift algae than seagrass; Drifted around polygon and seagrass is still thin; Shelly and sandy bottom	65	55	0	4	9116	9116	Y
Thick and beautiful carpet of Halodule wrightii and Syringodium filiforme; Water is very shallow and clear	100	5	0	2.5	9116	9116	Y
Clear water with continous and dense Halodule wrightii; some small patches of drift algae	95	5	0	4	9116	9116	Y
Extremely dense drift algae about a foot in thickness; When drift algae was parted, Halodule wrightii was underneath in a continuous layer; Very stagnant water with little visibility	75	85	0	3	9116	9116	Y
Soft sand and no seagrass at point and in general area outside of polygon	0	0	0	3.5	5400	5400	Y
Dense and continous Halodule wrightii with some drift algae and some patches of bare, sandy areas	90	10	0	4	9116	9116	Y
Halodule wrightii is thin but continuous with some Caulerpa; Seagrass lessens as you drift away from the polygon	90	0	5	2	9116	9116	Y
Very dense and continuous Halodule wrightii at point; Very shallow and poor water clarity	100	0	0	1.3	9116	5400	N
Very sparse patches of Halodule wrightii but not enough to map	30	0	0	3	5400	9116	N

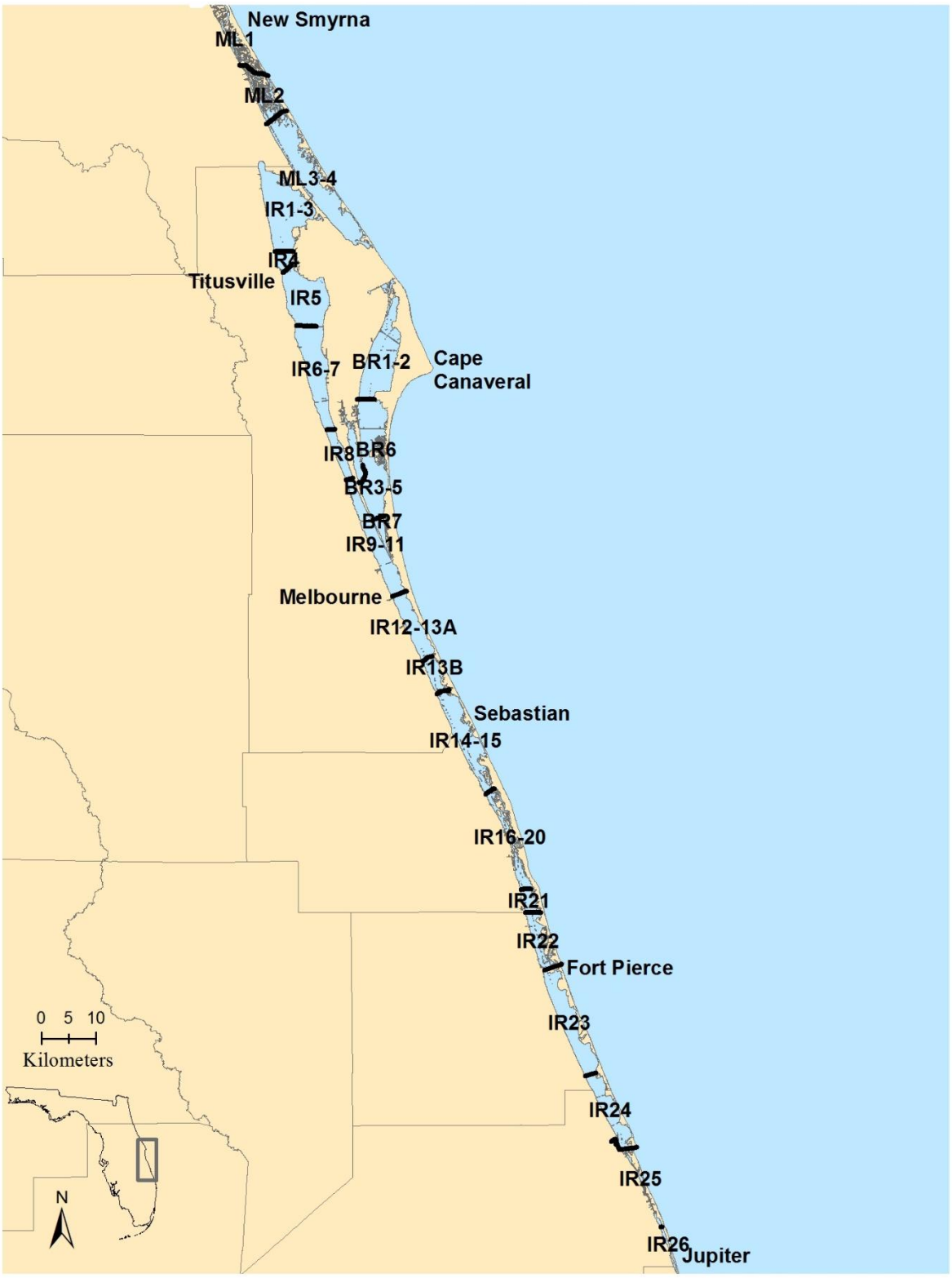


Figure 2. Indian River Lagoon Segment Map

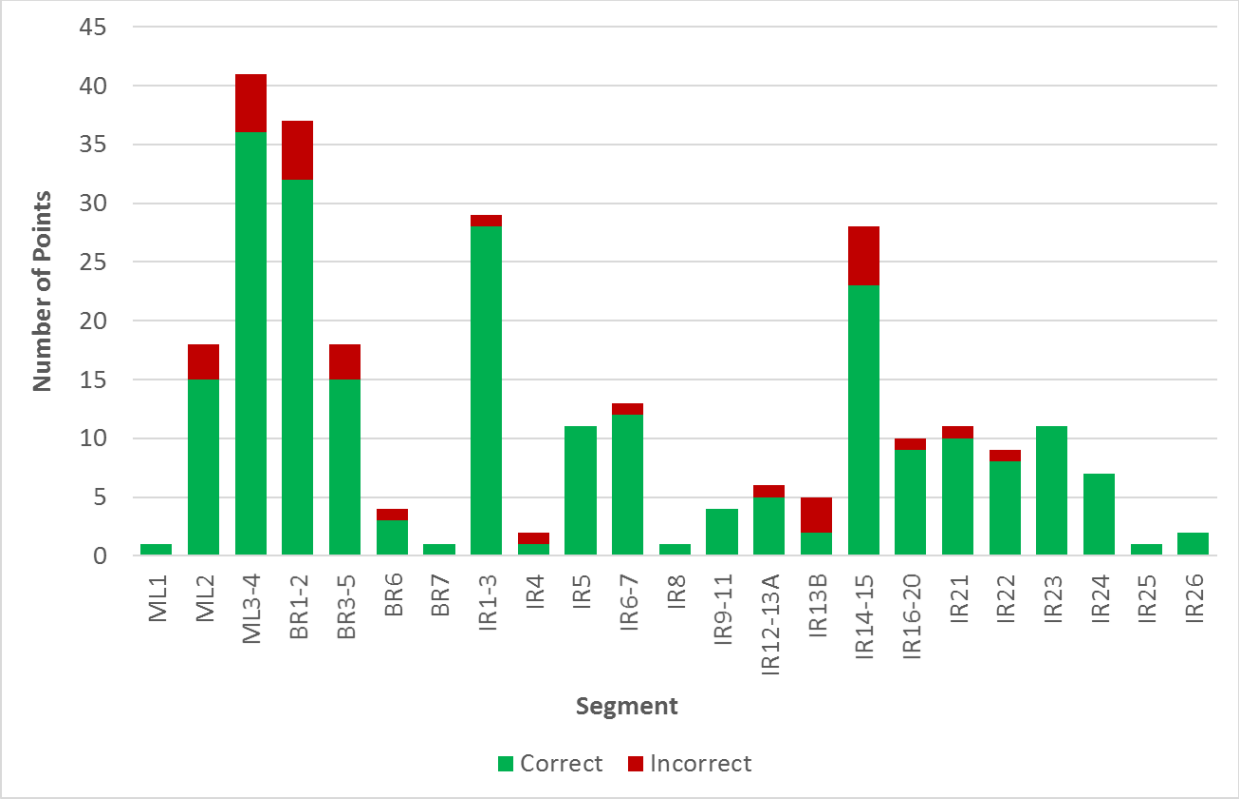


Figure 3. Segment Distribution of Accuracy Assessment Points.