Quality Report

Tile n6300w14530P
Cell 10

INTERMAP TECHNOLOGIES

Tile Specific

- **DSM Data Delivery Quality Checklist**
- **DTM Data Delivery Quality Checklist**
- **ORI Data Delivery Quality Checklist**

Cell Specific

- **Post-Edit Accuracy Report**
- **DEM Void Analysis**

Project Specific

- **Overview of QMS Process**
- **Ground Control and Navigation Processing Methods for Alaska**
- **Delivery Project Preparation Flow Chart**

DSM Data Delivery Quality Checklist

Alaska Project USGS #G10PC00013			
Specification / Requirement	**DSM**		
15' Tile Name **n6300w14530P**	Core	Client	QCed
DATA EXTENT			
Tile Size	7.5'	15'	✓
Buffer size		350m XY	✓
COORDINATE REFERENCE SYSTEM (CRS)			
Horizontal (geodetic)			
Datum ID	NAD83	NAD83, CORS96, Epic 2003.00	✓
Ellipsoid	GRS80	GRS80	
Projection	Geographic	AK Albers	✓
Coordinate units	Decimal deg.	Meters	✓
Vertical			
Height system	Orthometric	Orthometric	
Geoid model	NAVD88/GEOID09	NAVD88/GEOID09	
Value unit	Meters	Meters	✓
DATA SPECIFICATION			
Intermap product specification type	II+		
Tile dimension	7.5' x 7.5'	15'x15'	✓
Pixel size (resolution, posting)	0.15"	5 meters	✓
File format	BIL	GeoTIFF	✓
Resolution [bit]	32 float	32 bit	✓
File extension	.BIL	.TIF	✓
Pixel referencing (center, corner)	center UL cr	center	✓
Max. single file size [MB]	32.5	200	✓
Metadata standard	FGDC	FGDC	✓
Metadata format (HTML, TXT, XML)		All	✓
No data value		-10,000	✓
Vertical value resolution [m]	0.01	0.01	✓
DATA PREPARATION			
Void Fill Procedures NED & small ASTER strip along CAN boundary		Interp & fill	✓
DATA INSPECTION			
Ties with adjacent tiles			✓
Seams / ramps			✓
Spikes / wells		Max. 30 m	✓
Hydro enforcement			✓
QC By: Tobey Coolidge	**Date:**	5/2/2011	

DTM Data Delivery Quality Checklist

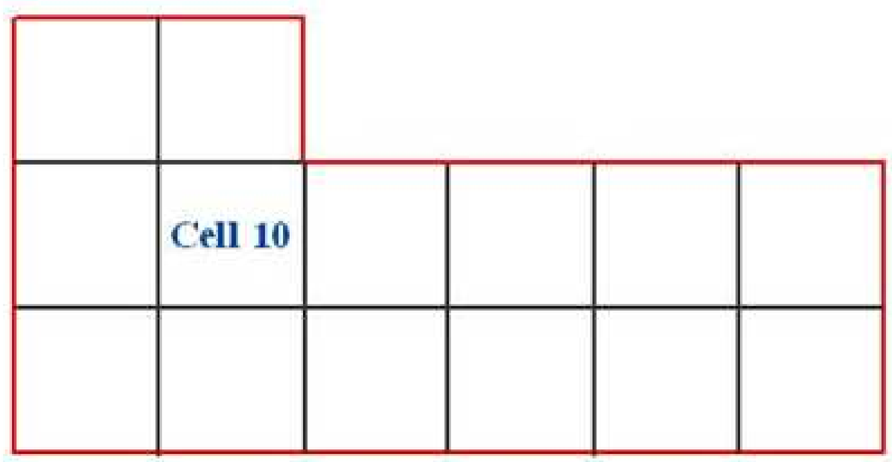
Alaska Project USGS #G10PC00013				
Specification / Requirement		**DTM**		
15' Tile Name	**n6300w14530P**	Core	Client	QCed
DATA EXTENT				
Tile Size		7.5'	15'	☑
Buffer size			350m XY	☑
COORDINATE REFERENCE SYSTEM (CRS)				
Horizontal (geodetic)				
Datum ID		NAD83	NAD83, CORS96, Epic 2003.00	☑
Ellipsoid		GRS80	GRS80	
Projection		Geographic	AK Albers	☑
Coordinate units		Decimal deg.	Meters	☑
Vertical				
Height system		Orthometric	Orthometric	
Geoid model		NAVD88/GEOID09	NAVD88/GEOID09	
Value unit		Meters	Meters	☑
DATA SPECIFICATION				
Intermap product specification type		II+		
Tile dimension		7.5' x 7.5'	15'x15'	☑
Pixel size (resolution, posting)		0.15"	5 meters	☑
File format		BIL	GeoTIFF	☑
Resolution [bit]		32 float	32 bit	☑
File extension		.BIL	.TIF	☑
Pixel referencing (center, corner)		center UL cr	center	☑
Max. single file size [MB]		32.5	200	☑
Metadata standard		FGDC	FGDC	☑
Metadata format (HTML, TXT, XML)			All	☑
No data value			-10,000	☑
Vertical value resolution [m]		0.01	0.01	☑
DATA PREPARATION				
Void Fill Procedures NED & small ASTER strip along CAN boundary			Interp & fill	☑
DATA INSPECTION				
Ties with adjacent tiles				☑
Seams / ramps				☑
Spikes / wells			Max. 30 m	☑
Hydro enforcement				☑
QC By:		**Date:**		
Tobey Coolidge			5/2/2011	

ORI Data Delivery Quality Checklist

Alaska Project USGS #G10PC00013 Specification / Requirement		Imagery ORI		
15' Tile Name	n6300w14530P	Core	Client	QCed
DATA EXTENT				
Tile size		7.5'	15'	✓
Buffer size		1 Pixel	350m XY	✓
COORDINATE REFERENCE SYSTEM (CRS)				
Horizontal (geodetic)				
Datum ID		NAD83	NAD83, CORS96, Epic 2003.00	✓
Ellipsoid		GRS80	GRS80	
Projection		Geographic	AK Albers	✓
Coordinate units		Decimal deg.	Meters	✓
DATA SPECIFICATION				✓
Intermap product specification type		II+		
Tile dimension		7.5' x 7.5'	15'x15'	✓
Pixel size (resolution, posting)		0.0375"	0.625m	✓
File format		GeoTIFF	GeoTIFF	✓
Radiometric resolution [bit]		8	8	✓
Number format		Integer	Integer	✓
File extension		.TIF	.TIF	✓
Pixel referencing (center, corner)		UL cr of pixel	Center	✓
Max. single file size [MB]			2.1GB	✓
Metadata standard		FGDC	FGDC	✓
Metadata format (HTML, TXT, XML)			All	✓
No data value			Outside Coverage="0" Water / Void ="1"	✓ ✓
				☐
VISUAL INSPECTION				
Radiometric balance				✓
Ties with adjacent tiles				✓
Artifacts				✓
QC By: Tobey Coolidge		**Date:**	5/2/2011	

Post-Edit Accuracy Report

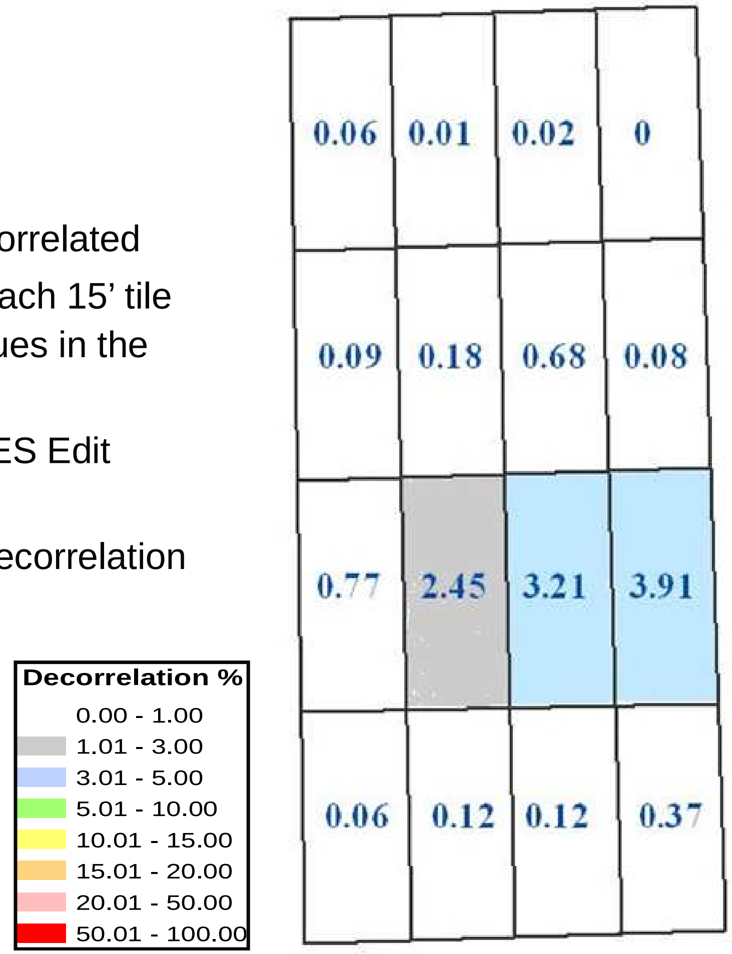
Project Acquisition Area



- Block # 4601
- T3 analysis confined to cell # 10
- Total land area of 5478.50km^2
  - Number of 7.5’ tiles= 64
  - Number of 15’ tiles= 16

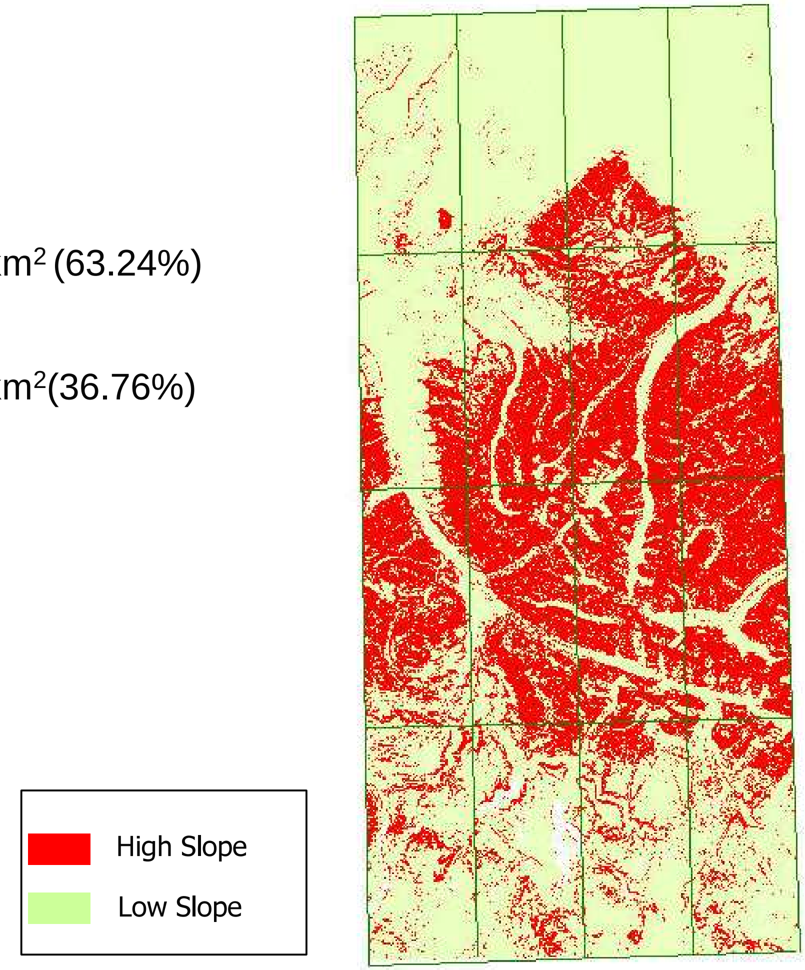
Land Decorrelation

- Alaska Cell #10:
  - Total land area of 5478.50 km^2
  - 41.92 km^2 of the cell area is decorrelated
  - Percentage of decorrelation in each 15’ tile is calculated based on the 0 values in the COR
  - Water was excluded based on IES Edit Mask
  - **<u>None</u>** of the 15’ tiles exceed a decorrelation value of 5%



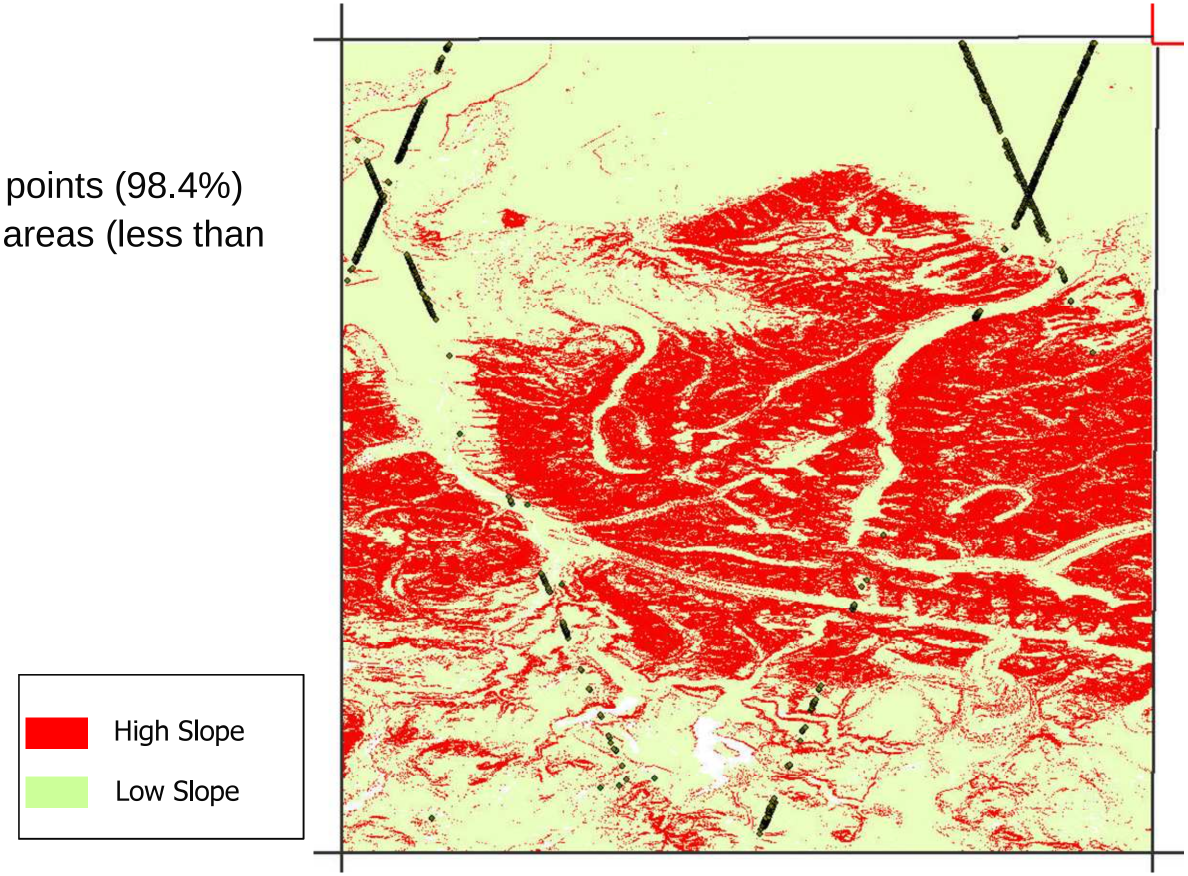
Slope Based on DTM (Land Only)

- Alaska Cell #10:
- Area of slopes < 10^{o}: 3464.86 km^2 (63.24%)
- Area of slopes >10^{o}: 2013.68 km^2(36.76%)



Vertical Accuracy Point Distribution in Cell 10

- Alaska Cell #10:
- The majority of the points (98.4%) reside in low slope areas (less than 10 degrees)



Vertical Accuracy – All Points in Cell 10

	DSM	DTM	GTOPO30
VCP COUNT	1402	1402	1402
MIN	-72.05	-72.04	-110.32
MAX	40.17	40.67	145.61
MEAN	0.90	-0.20	10.60
STDEV	3.38	2.64	17.20
RMSE	3.50	2.64	20.20
LE90	5.88	4.44	33.94

Slope (degrees)	Accuracy Requirement 90% Confidence
0-10	3m
10-20	6m
20-30	9m
30+	12m

- The RMSE for the DSM is 3.50m
- The RMSE for the DTM is 2.64m

- The 90 Percentile for the DSM is 5.88m
- The 90 Percentile for the DTM is 4.44m

Vertical Accuracy – Slope <10 degrees Unobstructed

	DSM	DTM	GTOPO30
VCP COUNT	832	832	832
MIN	-12.01	-11.73	-110.32
MAX	2.15	2.22	145.61
MEAN	-0.16	-0.16	9.02
STDEV	0.98	0.95	19.33
RMSE	0.99	0.96	21.32
LE90	1.66	1.62	35.82

- The RMSE for the DSM is 0.99m
- The RMSE for the DTM is 0.96m

- The 90 Percentile for the DSM is 1.66m
- The 90 Percentile for the DTM is 1.62m

Vertical Accuracy – Slope <10 degrees Obstructed

	DSM	DTM	GTOPO30
VCP COUNT	543	543	543
MIN	-2.31	-5.40	-26.74
MAX	25.93	23.54	134.80
MEAN	2.61	-0.15	12.82
STDEV	2.97	1.56	12.53
RMSE	3.95	1.57	17.92
LE90	6.64	2.63	30.11

- The RMSE for the DSM is 3.95m
- The RMSE for the DTM is 1.57m

- The 90 Percentile for the DSM is 6.64m
- The 90 Percentile for the DTM is 2.63m

Vertical Accuracy – Slopes >10 degrees obstructed

	DSM	DTM	GTOPO30
VCP COUNT	15	15	15
MIN	-0.04	-1.14	1.27
MAX	6.09	2.30	37.54
MEAN	3.59	0.32	14.18
STDEV	2.29	1.01	11.86
RMSE	4.21	1.03	18.23
LE90	7.08	1.73	30.63

- The RMSE for the DSM is 4.21m
- The RMSE for the DTM is 1.03m

- The 90 Percentile for the DSM is 7.08m
- The 90 Percentile for the DTM is 1.73m

Vertical Accuracy – Slopes >10 degrees unobstructed

	DSM	DTM	GTOPO30
VCP COUNT	7	7	7
MIN	-0.38	-0.38	-0.61
MAX	0.36	0.45	40.06
MEAN	-0.05	-0.04	15.38
STDEV	0.37	0.34	15.50
RMSE	0.35	0.32	21.03
LE90	0.58	0.54	35.34

- The RMSE for the DSM is 0.35m
- The RMSE for the DTM is 0.32m

- The 90 Percentile for the DSM is 0.58m
- The 90 Percentile for the DTM is 0.54m

Report Summary

- Cell #10 is within the accepted accuracy target of 3m
  - LE90 of 1.66m (DSM), 1.62m (DTM)
  - RMSE of 0.99 m (DSM), 0.96m (DTM)

- 7 VCPs reside in unobstructed areas with slopes greater than 10 degrees. This does not provide a good representation of what our vertical accuracy will be in these areas

- The amount of void in Cell #10 is within the accepted range of 3%
  - Amount of void in DEM is approximately 41.92 km^2
  - Approximately 1% of Cell 10

- The amount of void in each 15' tile is within the accepted range of 5%
  - Lowest value 0%
  - Highest value 3.91%

DEM Void Analysis

Alaska Cell #10

Intermap 7.5' Tiles	USGS 15' Tiles	USGS Void %	HRTe3 30" Tiles	HRTe3 Void %	Cell 10 Total Void %
n63145a1					
n63145a2					
n63145b1					
n63145b2	xxx_n6300w14515	0.3654			
n63145a3					
n63145a4					
n63145b3					
n63145b4	xxx_n6300w14530	0.1252			
n63145c1					
n63145c2					
n63145d1					
n63145d2	xxx_n6315w14515	4.0611			
n63145c3					
n63145c4					
n63145d3					
n63145d4	xxx_n6315w14530	3.3311	us_n6300w14530_uncllimdis_hrte3_dem	**1.9707**	
n63145e1					
n63145e2					
n63145f1					
n63145f2	xxx_n6330w14515	1.8511			
n63145e3					
n63145e4					
n63145f3					
n63145f4	xxx_n6330w14530	2.1557			
n63145g1					
n63145g2					
n63145h1					
n63145h2	xxx_n6345w14515	0.0077			
n63145g3					
n63145g4					
n63145h3					
n63145h4	xxx_n6345w14530	0.1122	us_n6330w14530_uncllimdis_hrte3_dem	**1.0317**	

Alaska Cell #10

Intermap 7.5' Tiles	USGS 15' Tiles	USGS Void %	HRTe3 30" Tiles	HRTe3 Void %	Cell 10 Total Void %
n63145a5					
n63145a6					
n63145b5					
n63145b6	xxx_n6300w14545	0.1207			
n63145a7					
n63145a8					
n63145b7					
n63145b8	xxx_n6300w14600	0.0826			
n63145c5					
n63145c6					
n63145d5					
n63145d6	xxx_n6315w14545	2.5564			
n63145c7					
n63145c8					
n63145d7					
n63145d8	xxx_n6315w14600	1.4243	us_n6300w14600_uncllimdis_hrte3_dem	**1.0460**	
n63145e5					
n63145e6					
n63145f5					
n63145f6	xxx_n6330w14545	0.7636			
n63145e7					
n63145e8					
n63145f7					
n63145f8	xxx_n6330w14600	0.1311			
n63145g5					
n63145g6					
n63145h5					
n63145h6	xxx_n6345w14545	0.0159			
n63145g7					
n63145g8					
n63145h7					
n63145h8	xxx_n6345w14600	0.2592	us_n6330w14600_uncllimdis_hrte3_dem	**0.2924**	**1.0852**

Overview of Quality Management Process

Intermap has implemented a Quality Management System (QMS) corporate-wide. The Company has a robust Quality Management (QM) group independent from the production groups. The quality organization consists of the Customer Care Department and includes Quality Management, Configuration Management, Independent Verification & Validation, and Customer Support. The Customer Care Department reports to the Senior Vice President of Operations.

The QMS is compliant with the following standards:

- ISO 9001:2000
- Configuration Management II
- Control Objectives for Information & Related Technology
- Information Technology Infrastructure Library

The Company has been audited annually by an independent international organization: Underwriter Laboratories (UL). The following offices have current ISO registration certificates: Denver, Ottawa, Calgary, Jakarta, Munich, and Prague.

The QM group conducts periodic internal audits and all the internal auditors have been trained in auditing procedures under ISO 9001:2000.

CERTIFICATE

UL DQS Inc.
Management Systems Solutions

hereby certifies that the company

Intermap Technologies, Inc.
8310 South Valley Highway, Suite 400
Englewood, Colorado
U.S.A.
80112

has implemented and maintains a **Quality Management System**.

Scope:
The design, acquisition, processing and editing of Digital Elevation Data, production of Ortho Rectified Imagery, 3D Roads production, and value added mapping products. The site in Englewood, Colorado, U.S.A. performs the following functions: processing, sale and distribution of digital data.

Through an audit, documented in a report, it was verified that the management system fulfills the requirements of the following standard:

ISO 9001 : 2008

Certificate Registration No. 439015 QM08
Date of Certification 2009-09-28
Valid until 2012-09-27

Ganesh Rao
President

1130 West Lake Cook Road, Suite 340, Buffalo Grove, IL 60089 USA

The Intermap ISO-9001:2008 compliant quality management system fully documents all production and quality control processes. These processes have been designed and implemented in accordance with ISO standards and their application audited by Underwriters Laboratories Inc. and by DQS-UL. All process documents and work instructions are fully documented within the scope of the certification throughout Intermap's Enterprise Workflow and available to all staff, at all locations, on-line through a web portal. All Intermap design, development and production facilities have been certified to the ISO standard by our external registrar. Intermap continually improves the QMS' effectiveness in accordance with the standards requirements.

Intermap's Quality Assurance procedures are an inherent part of the QMS. Through the practice of preventive and corrective action, effective design and development processes, and the monitoring and measuring of acquisition, production processes and deliverables, Intermap produces products that consistently meet specification.

Intermap's design and development, acquisition, production and delivery processes contain Quality Control (QC) procedures that allow Intermap to effectively meet product specifications and client requirements. QC procedures are incorporated in testing, inspection and quality control checkpoints in all processes for the production of Intermap products.

Since Intermap's production processes incorporate QC checks on 100% of the data at each stage in the production process the client can employ statistical sampling techniques in their acceptance testing with a very high degree of confidence that sample data will be consistent with the entire dataset. Intermap's data is warranted to comply with the specifications set out in the contract.

Please refer to Intermap's Product Handbook and Quick Start Guide available at Intermaptechnologies .com. The Product Handbook contains and comprehensive explanation of the product characteristics, specifications, accuracy and quality testing issues.

1. Orthorectified RADAR Imagery

The orthorectified RADAR image is an image formed by the intensity (magnitude) of radio signal backscattered by the surface and returned to the RADAR antennae. It is an 8-bit panchromatic image representing the strength of the return signal which, because of its side-looking geometry, accentuates and differentiates features on the ground. The image has been orthorectified to remove terrain-induced distortions and rectified to conform to the characteristics of a specified map projection.

- Projection
  - Check to ensure that the imagery has been developed on the proper projection and datum – overlay with existing maps developed on the appropriate projection and look for systematic differences in X and Y.
- Tiling, Pixel origin
  - Check to ensure that the tiles are created with the correct dimensions (rows, columns) and that each tile edge is at the specified coordinate value. Check to ensure that the tile edge is at the specified point in the pixel i.e. the edge of the pixel or the center of the pixel in each of the X and Y axes.
- Metadata
  - Check to ensure that the metadata can be read in the appropriate format (.txt, .html, .xml) and that content is complete and correct. Check to ensure that that the defining coordinates for each specific tile are correct.

- Edge checks
  - Ingest tiles into a GIS environment and check for tile-to-tile consistency across each tile edge. Check for precise match, specified overlap (if any), identical pixels in the overlap (if any), check for precise match of linear features crossing tile boundaries.
- Dynamic range (tone), speckle
  - Check for consistency in the dynamic range (tones) from tile to tile. Create a mosaic of a number of tiles and ensure tonal consistency.
- Drop outs (de-correlation voids)
  - Check to ensure that there are no large voids in the image data. There will be a certain amount of void data caused by de-correlation and shadow which is an unavoidable function of RADAR physics and the geometry of the acquisition system. There should not be more that 3% void area in total and no more than 5% on an individual tile.
- Seams (strip-to-strip)
  - Check for strip-to-strip seams in the imagery. Look for consistency at seam lines joining adjacent strips. Recognize that there will be a difference in tone across each strip with a brighter to darker fall-off in return as one moves from the near range to the far range across the strip. While balancing algorithms are applied to the data to minimize across track fall off it cannot be removed completely
- Accuracy
  - Compare the locations (XY) of well-defined features in the imagery with control points derived from other, higher accuracy data that has been validated previously. Control points may be derived from GPS ground surveys or from other, higher accuracy map products (large scale digital maps, LiDAR surveys etc.) Please refer to the Product Handbook for testing instructions.
- Artifacts
  - Examine samples of the data for various potential artifacts. Look for layover, rain shadow, signal saturation, motion ripples, and missing islands. Examples of each of these phenomena are found in the Product Handbook. Minor artifacts of these types are to be expected. The user should ensure that these phenomena are not such that they render the data unfit for purpose.

2. Digital Surface Model

The digital surface model (DSM) is a representation of the “first surface” that the RADAR signal interacts with when it is backscattered to the antenna. The DSM is a representation of any object large enough to be resolved by the RADAR. These features include vegetation, and man-made structures as well as the natural terrain. Accordingly, the DSM measures approximate tree canopy height, structure heights and ground heights in open areas. The Z-values contained within the DSM are typically orthometric heights based on a specified ellipsoid-geoid separation model.

- Projection
  - Check to ensure that the elevation model has been developed on the proper projection and datum (both horizontal and vertical) – overlay with existing maps developed on the appropriate projection and look for systematic differences in X, Y and Z.
- Tiling, Pixel origin
  - Check to ensure that the tiles are created with the correct dimensions (rows, columns) and that each tile edge is at the specified coordinate value. Check to ensure that the tile edge is at the specified point in the pixel i.e. the edge of the pixel or the center of the pixel in each of the X and Y axes.

- Metadata
  - Check to ensure that the metadata can be read in the appropriate format (.txt, .html, .xml) and that content is complete and correct. Check to ensure that that the defining coordinates for each specific tile are correct.
- Edge checks
  - Ingest tiles into a GIS environment and check for tile-to-tile consistency across each tile edge. Check for precise match, specified overlap (if any), identical pixels in the overlap (if any), check for precise match of linear features crossing tile boundaries.
- Drop outs (de-correlation voids)
  - Check to ensure that there are no large voids or areas of interpolation in the elevation data. There will be a certain amount of interpolated elevation data corresponding to the voids in the image data caused by de-correlation and shadow which is an unavoidable function of RADAR physics and the geometry of the acquisition system. There should not be more than 3% interpolated area in total and no more than 5% on an individual tile.
- Seams (strip-to-strip)
  - Check for strip-to-strip seams in the imagery. Look for consistency at seam lines joining adjacent strips. Recognize that there will be a difference in texture across each strip with a smoother texture in the near range and a rougher texture in the far range as the signal-to-noise ratio falls off towards the far range and thus the apparent noise (variability in the data) increases. While balancing algorithms are applied to the data to minimize the effects of across track fall off it cannot be removed completely
- Accuracy
  - Compare the locations (XY and Z) of well-defined features in the DSM with control points derived from other, higher accuracy data that has been validated previously. Control points may be derived from GPS ground surveys or from other, higher accuracy map products (large scale digital maps, LiDAR surveys etc.) Please refer to the Product Handbook for testing instructions.
- Artifacts
  - Examine samples of the data for various potential artifacts. Look for excessive interpolation (smoothed areas), motion ripples, and missing islands. Examples of each of these phenomena are found in the Product Handbook. Minor artifacts of these types are to be expected. The user should ensure that these phenomena are not such that they render the data unfit for purpose.
  - Examine the elevation models for improper localized anomalies in the form of vertical spikes or wells that appear to be inconsistent with the features depicted in the imagery. Such elevation “blunders” can occur in association with small areas of shadows behind buildings, landmark trees and transmission line towers and are normally removed during the interactive edit process.
  - Check for areas of negative elevations. Negative elevations can be quite common in proximity to ocean shorelines. Negative elevations should be examined in the context of local knowledge to ensure any occurrence is reasonable.
- Water Surfaces
  - Check to ensure that water surfaces of specified dimensions have been flattened and that they are monotonic in that they “flow” properly. For single line drains of specified dimensions check that they are monotonic (to the tolerance quoted in the specification). Note that all DEM cell elevation values on land adjacent to water surfaces must depict a height greater than that of the water surface.
  - Check that ocean elevations have been set to zero.
  - Check to ensure that bridges have been included or excluded in accordance with the specification. (Bridges frequently included in DSM and removed from DTM.)

3. Digital Terrain Model

The digital terrain model (DTM) is a topographic model of the “bare earth” that has had the elevations associated with vegetation and structures removed. The elevations where buildings or structures have been removed are interpolated across the building footprint. The Z-values contained within the DTM are typically orthometric heights based on a specified ellipsoid-geoid separation model.

- Projection
  - Check to ensure that the elevation model has been developed on the proper projection and datum (both horizontal and vertical) – overlay with existing maps developed on the appropriate projection and look for systematic differences in X, Y and Z.
- Tiling, Pixel origin
  - Check to ensure that the tiles are created with the correct dimensions (rows, columns) and that each tile edge is at the specified coordinate value. Check to ensure that the tile edge is at the specified point in the pixel i.e. the edge of the pixel or the center of the pixel in each of the X and Y axes.
- Metadata
  - Check to ensure that the metadata can be read in the appropriate format (.txt, .html, .xml) and that content is complete and correct. Check to ensure that that the defining coordinates for each specific tile are correct.
- Edge checks
  - Ingest tiles into a GIS environment and check for tile-to-tile consistency across each tile edge. Check for precise match, specified overlap (if any), identical pixels in the overlap (if any), check for precise match of linear features crossing tile boundaries.
- Drop outs (de-correlation voids)
  - Check to ensure that there are no large voids or areas of interpolation in the elevation data. There will be a certain amount of interpolated elevation data corresponding to the voids in the image data caused by de-correlation and shadow which is an unavoidable function of RADAR physics and the geometry of the acquisition system. There should not be more than 3% interpolated area in total and no more than 5% on an individual tile.
- Seams (strip-to-strip)
  - Check for strip-to-strip seams in the imagery. Look for consistency at seam lines joining adjacent strips. Recognize that there will be a difference in texture across each strip with a smoother texture in the near range and a rougher texture in the far range as the signal-to-noise ratio falls off towards the far range and thus the apparent noise (variability in the data) increases. While balancing algorithms are applied to the data to minimize the effects of across track fall off it cannot be removed completely
- Accuracy
  - Compare the locations (XY and Z) of well-defined features in the DTM with control points derived from other, higher accuracy data that has been validated previously. Control points may be derived from GPS ground surveys or from other, higher accuracy map products (large scale digital maps, LiDAR surveys etc.) Please refer to the Product Handbook for testing instructions.
- Artifacts
  - Examine samples of the data for various potential artifacts. Look for excessive interpolation (smoothed areas), motion ripples, and missing islands. Examples of each of these phenomena are found in the Product Handbook. Minor artifacts of these types are to be expected. The user should ensure that these phenomena are not such that they render the data unfit for purpose.

- Examine the elevation models for improper localized anomalies in the form of vertical spikes or wells that appear to be inconsistent with the features depicted in the imagery. Such elevation “blunders” can occur in association with small areas of shadows behind buildings, landmark trees and transmission line towers and are normally removed during the interactive edit process.
- Check for areas of negative elevations. Negative elevations can be quite common in proximity to ocean shorelines. Negative elevations should be examined in the context of local knowledge to ensure any occurrence is reasonable.

- Water Surfaces
  - Check to ensure that water surfaces of specified dimensions have been flattened and that they are monotonic in that they “flow” properly. For single line drains of specified dimensions check that they are monotonic (to within the tolerance quoted in the specification). Note that all DEM cell elevation values on land adjacent to water surfaces must depict a height greater than that of the water surface.
  - Check that ocean elevations have been set to zero.
  - Check to ensure that bridges have been included or excluded in accordance with the specification. (Bridges frequently included in DSM and removed from DTM.)
- DTM Above DSM
  - Subtract the DTM from the DSM and ensure that there are not large areas where the DTM values exceed the DSM values. There will be small areas where the DTM is higher than the DSM due to the effect s of smoothing algorithms used in the DTM creation but these areas should be small and the difference should be substantially within the vertical tolerance quoted in the accuracy specification.
  - Compare the DSM-DTM with the RADAR imagery to ensure that substantially all areas of structures and tree canopy have been removed from the DSM in the formation of the DTM. (Check for residual DSM heights in the DTM. Compare areas of residual forest canopy with those permitted within the specification e.g. closed canopy extending more that 400m in both axes)

Ground Control and Processing Methods

Ground Control Points

Intermap used ground control points (GCPs) to control the radar image and elevation data for Alaska. Intermap GCPs consisted of 7 directional aluminum reflectors (corner reflectors or CRs) and 5 survey arrays consisting of 13-17 points distributed over a 50 m^2 area.   The relative position of each GCP is depicted in Figure 1 below.

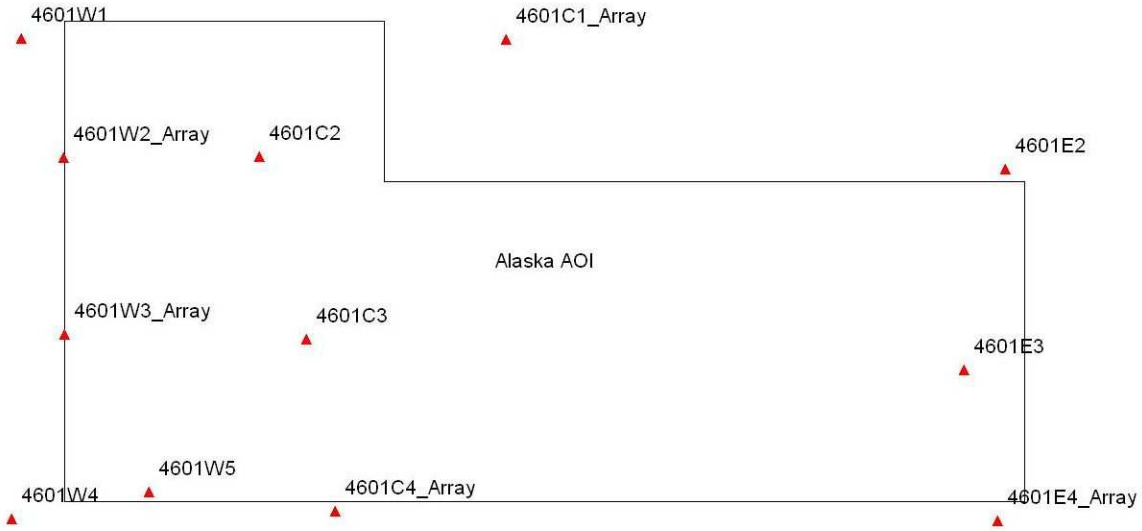


Figure 1: Relative GCP placement

All GCPs were surveyed using survey-grade GPS receivers and were measured to ground level.

Equipment

Intermap used Sokkia GSR2600 L1/L2 GPS receivers (or equivalent) equipped with Sokkia SK-600 geodetic-quality antennae.

Specifications

Each CR survey consisted of a 4-6 hour static session with 30 second epochs (Figure 2). Each survey array consisted of 1 base station with 4-6 hours of 1 second data and 12-16 array points with 15 minutes of 1 second data (Figure 3). The required accuracy for each survey point was 2.5 cm RMSE after processing.

Figure 2: Corner reflector

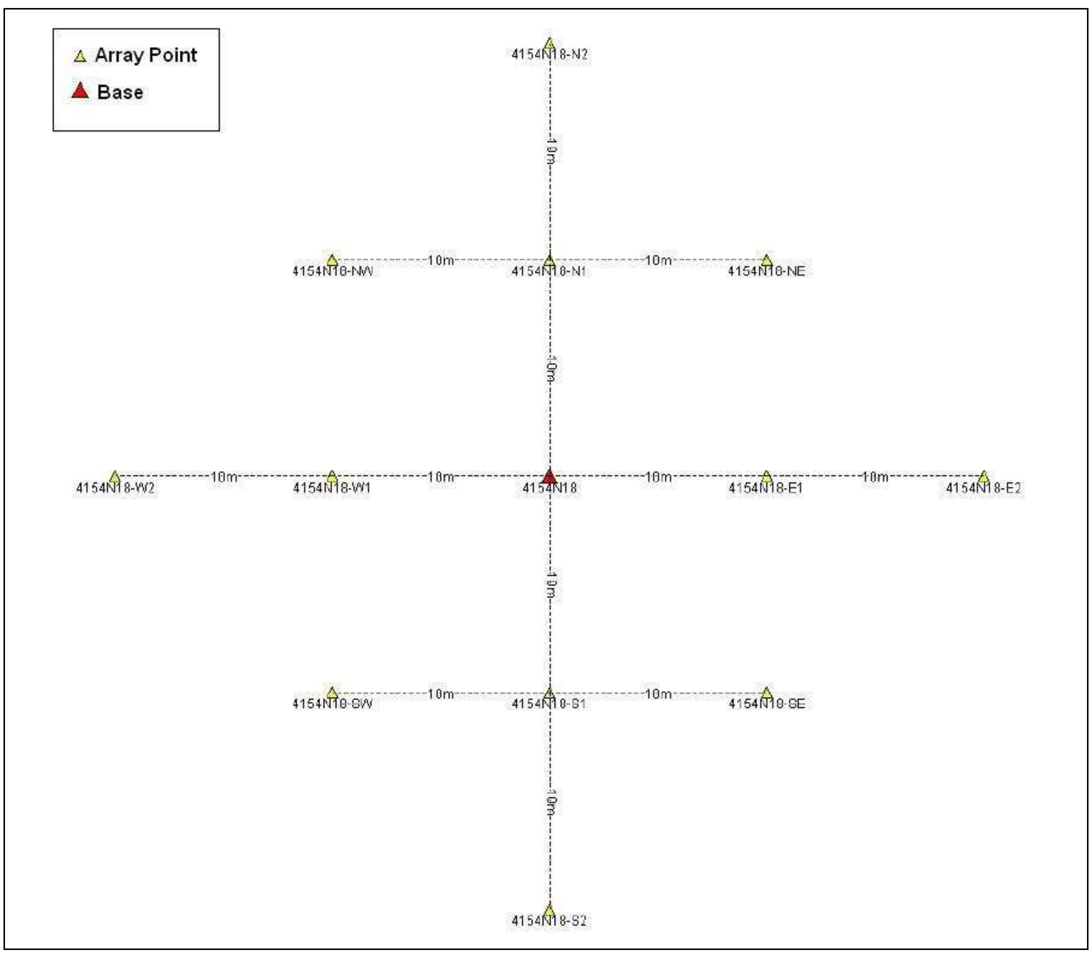


Figure 3: Survey array

Processing Software

Intermap used OPUS online processing using precise satellite ephemeris/clock data (http://www.ngs.noaa.gov/OPUS/) to process each CR. Intermap used a combination of OPUS processing and differential GPS (DGPS) processing using GrafNet to process each survey array. OPUS was used to determine the coordinates for the base station and GrafNet was used to process each of the array points.

GCP Coordinates

The final coordinates for the GCPs are listed in Table 1 below.

Name	Latitude	Longitude	Ellipsoid Height (m)	Role	Session Type	Duration (min)	Date
4601C2	N 64 9 22.46688	W 145 46 44.83742	321.391	Reflector	OPUS	360	6/14/2010
4601C3	N 63 0 57.81879	W 145 29 22.99246	818.206	Reflector	OPUS	240	6/5/2010
4601E2	N 64 4 43.23465	W 141 7 9.63373	900.352	Reflector	OPUS	240	6/11/2010
4601E3	N 62 49 22.04313	W 141 22 23.00716	633.923	Reflector	OPUS	360	6/14/2010
4601W1	N 64 53 34.10077	W 147 16 5.23896	164.972	Reflector	OPUS	240	6/6/2010
4601W4	N 61 53 36.65163	W 147 19 58.66439	939.779	Reflector	OPUS	240	6/9/2010
4601W5	N 62 3 32.25923	W 146 28 11.31762	752.272	Reflector	OPUS	240	6/8/2010
4601C1_Base	N 64 52 59.93052	W 144 14 21.2815	1040.545	Base	OPUS	240	6/18/2010
4601C1E05	N 64 52 59.92498	W 144 14 20.91495	1040.728	Array Point	DGPS	15	6/18/2010
4601C1E1	N 64 52 59.92935	W 144 14 20.52682	1040.974	Array Point	DGPS	15	6/18/2010
4601C1E2	N 64 52 59.93224	W 144 14 19.77392	1041.441	Array Point	DGPS	15	6/18/2010
4601C1N05	N 64 53 0.08834	W 144 14 21.26439	1040.625	Array Point	DGPS	15	6/18/2010
4601C1N1	N 64 53 0.2553	W 144 14 21.23619	1040.65	Array Point	DGPS	15	6/18/2010
4601C1N2	N 64 53 0.57797	W 144 14 21.19263	1040.67	Array Point	DGPS	15	6/18/2010
4601C1NE	N 64 53 0.24363	W 144 14 20.47586	1041.152	Array Point	DGPS	15	6/18/2010
4601C1NW	N 64 53 0.24742	W 144 14 21.99958	1040.127	Array Point	DGPS	15	6/18/2010
4601C1S05	N 64 52 59.77235	W 144 14 21.25193	1040.532	Array Point	DGPS	15	6/18/2010
4601C1S1	N 64 52 59.60687	W 144 14 21.27515	1040.407	Array Point	DGPS	15	6/18/2010
4601C1S2	N 64 52 59.28718	W 144 14 21.33195	1039.909	Array Point	DGPS	15	6/18/2010
4601C1SE	N 64 52 59.54853	W 144 14 20.50239	1040.655	Array Point	DGPS	15	6/18/2010
4601C1SW	N 64 52 59.64149	W 144 14 22.01912	1040.017	Array Point	DGPS	15	6/18/2010
4601C1W05	N 64 52 59.92804	W 144 14 21.66255	1040.329	Array Point	DGPS	15	6/18/2010
4601C1W1	N 64 52 59.92686	W 144 14 22.04295	1040.134	Array Point	DGPS	15	6/18/2010
4601C1W2	N 64 52 59.87459	W 144 14 22.74122	1039.772	Array Point	DGPS	15	6/18/2010
4601C4_Base	N 61 56 12.24287	W 145 18 31.47406	408.102	Base	OPUS	240	6/10/2010
4601C4E05	N 61 56 12.17154	W 145 18 31.16749	408.148	Array Point	DGPS	15	6/10/2010
4601C4E1	N 61 56 12.09943	W 145 18 30.86005	408.228	Array Point	DGPS	15	6/10/2010
4601C4E2	N 61 56 12.02662	W 145 18 30.5544	408.272	Array Point	DGPS	15	6/10/2010
4601C4N05	N 61 56 12.39332	W 145 18 31.3511	408.036	Array Point	DGPS	15	6/10/2010
4601C4N1	N 61 56 12.54157	W 145 18 31.23159	407.95	Array Point	DGPS	15	6/10/2010
4601C4N2	N 61 56 12.84379	W 145 18 30.97371	408.034	Array Point	DGPS	15	6/10/2010
4601C4NE	N 61 56 12.40256	W 145 18 30.61307	408.18	Array Point	DGPS	15	6/10/2010
4601C4NW	N 61 56 12.68371	W 145 18 31.85128	408.009	Array Point	DGPS	15	6/10/2010
4601C4S05	N 61 56 12.09426	W 145 18 31.6083	408.162	Array Point	DGPS	15	6/10/2010
4601C4S1	N 61 56 11.94414	W 145 18 31.73712	408.217	Array Point	DGPS	15	6/10/2010
4601C4S2	N 61 56 11.64542	W 145 18 31.99557	408.266	Array Point	DGPS	15	6/10/2010
4601C4SE	N 61 56 11.80277	W 145 18 31.12168	408.27	Array Point	DGPS	15	6/10/2010
4601C4SW	N 61 56 12.08906	W 145 18 32.34983	408.081	Array Point	DGPS	15	6/10/2010

4601C4W05	N 61 56 12.31559	W 145 18 31.77953	408.034	Array Point	DGPS	15	6/10/2010
4601C4W1	N 61 56 12.38698	W 145 18 32.0876	407.962	Array Point	DGPS	15	6/10/2010
4601C4W2	N 61 56 12.53533	W 145 18 32.69491	407.886	Array Point	DGPS	15	6/10/2010
4601E4_Base	N 61 52 48.95554	W 141 9 59.18561	1127.59	Base	OPUS	360	6/10/2010
4601E4E05	N 61 52 48.9382	W 141 9 58.8373	1127.643	Array Point	DGPS	15	6/10/2010
4601E4E1	N 61 52 48.93105	W 141 9 58.50047	1127.537	Array Point	DGPS	15	6/10/2010
4601E4E2	N 61 52 48.89064	W 141 9 57.81089	1127.277	Array Point	DGPS	15	6/10/2010
4601E4N05	N 61 52 49.10655	W 141 9 59.12057	1127.733	Array Point	DGPS	15	6/10/2010
4601E4N1	N 61 52 49.269	W 141 9 59.11248	1127.717	Array Point	DGPS	15	6/10/2010
4601E4N2	N 61 52 49.59437	W 141 9 59.07167	1127.625	Array Point	DGPS	15	6/10/2010
4601E4NE	N 61 52 49.27735	W 141 9 58.38522	1127.47	Array Point	DGPS	15	6/10/2010
4601E4NW	N 61 52 49.2597	W 141 9 59.79247	1127.836	Array Point	DGPS	15	6/10/2010
4601E4S05	N 61 52 48.80557	W 141 9 59.17423	1127.691	Array Point	DGPS	15	6/10/2010
4601E4S1	N 61 52 48.62942	W 141 9 59.19427	1127.681	Array Point	DGPS	15	6/10/2010
4601E4S2	N 61 52 48.30607	W 141 9 59.24379	1127.778	Array Point	DGPS	15	6/10/2010
4601E4SE	N 61 52 48.59078	W 141 9 58.51461	1127.714	Array Point	DGPS	15	6/10/2010
4601E4SW	N 61 52 48.66917	W 141 9 59.89451	1128.001	Array Point	DGPS	15	6/10/2010
4601E4W05	N 61 52 48.96162	W 141 9 59.50142	1127.802	Array Point	DGPS	15	6/10/2010
4601E4W1	N 61 52 48.98056	W 141 9 59.86824	1127.91	Array Point	DGPS	15	6/10/2010
4601E4W2	N 61 52 49.00223	W 141 10 0.56724	1128.124	Array Point	DGPS	15	6/10/2010
4601W2_Base	N 64 8 51.42927	W 147 0 23.32137	479.805	Base	OPUS	360	6/9/2010
4601W2E05	N 64 8 51.44211	W 147 0 22.9276	479.608	Array Point	DGPS	15	6/9/2010
4601W2E1	N 64 8 51.43166	W 147 0 22.54634	479.563	Array Point	DGPS	15	6/9/2010
4601W2E2	N 64 8 51.40644	W 147 0 21.82242	479.334	Array Point	DGPS	15	6/9/2010
4601W2N05	N 64 8 51.60837	W 147 0 23.32008	479.774	Array Point	DGPS	15	6/9/2010
4601W2N1	N 64 8 51.7572	W 147 0 23.36173	479.72	Array Point	DGPS	15	6/9/2010
4601W2N2	N 64 8 52.07707	W 147 0 23.34734	479.701	Array Point	DGPS	15	6/9/2010
4601W2NE	N 64 8 51.76368	W 147 0 22.62517	479.664	Array Point	DGPS	15	6/9/2010
4601W2NW	N 64 8 51.7376	W 147 0 24.10582	479.937	Array Point	DGPS	15	6/9/2010
4601W2S05	N 64 8 51.27314	W 147 0 23.31772	479.699	Array Point	DGPS	15	6/9/2010
4601W2S1	N 64 8 51.10245	W 147 0 23.35373	479.715	Array Point	DGPS	15	6/9/2010
4601W2S2	N 64 8 50.79849	W 147 0 23.39721	479.779	Array Point	DGPS	15	6/9/2010
4601W2SE	N 64 8 51.07589	W 147 0 22.61873	479.567	Array Point	DGPS	15	6/9/2010
4601W2SW	N 64 8 51.10854	W 147 0 24.09824	479.961	Array Point	DGPS	15	6/9/2010
4601W2W05	N 64 8 51.4369	W 147 0 23.70981	479.814	Array Point	DGPS	15	6/9/2010
4601W2W1	N 64 8 51.44283	W 147 0 24.10908	479.951	Array Point	DGPS	15	6/9/2010
4601W2W2	N 64 8 51.44001	W 147 0 24.83834	480.095	Array Point	DGPS	15	6/9/2010
4601W3_Base	N 63 2 40.55624	W 147 0 8.87589	966.719	Base	OPUS	240	6/6/2010
4601W3C1	N 63 2 40.255	W 147 0 9.12776	966.568	Array Point	DGPS	15	6/6/2010
4601W3E1	N 63 2 40.12546	W 147 0 8.47376	966.297	Array Point	DGPS	15	6/6/2010
4601W3E2	N 63 2 39.99957	W 147 0 7.81236	966.205	Array Point	DGPS	15	6/6/2010
4601W3N2	N 63 2 40.85665	W 147 0 8.61874	966.862	Array Point	DGPS	15	6/6/2010
4601W3NE	N 63 2 40.42892	W 147 0 8.22207	966.586	Array Point	DGPS	15	6/6/2010
4601W3NW	N 63 2 40.68342	W 147 0 9.5288	966.949	Array Point	DGPS	15	6/6/2010
4601W3S1	N 63 2 39.95411	W 147 0 9.3866	966.295	Array Point	DGPS	15	6/6/2010
4601W3S2	N 63 2 39.65322	W 147 0 9.64277	966.038	Array Point	DGPS	15	6/6/2010
4601W3SE	N 63 2 39.82394	W 147 0 8.73197	966.072	Array Point	DGPS	15	6/6/2010
4601W3SW	N 63 2 40.08409	W 147 0 10.03303	966.404	Array Point	DGPS	15	6/6/2010
4601W3W1	N 63 2 40.38135	W 147 0 9.7848	966.753	Array Point	DGPS	15	6/6/2010
4601W3W2	N 63 2 40.50643	W 147 0 10.44033	966.811	Array Point	DGPS	15	6/6/2010

Table 1: GCP Coordinates

All coordinates are in the NAD83 datum.

Navigation Processing

Intermap used a combination of precise point positioning (PPP) and DGPS processing to correct the autonomous GPS data collected by the aircraft. PPP processing required precise satellite ephemeris and clock data from the International GNSS Service (IGS). DGPS processing required one GPS base station within 300 km of the aircraft and was used when a satisfactory PPP solution could not be obtained. Five sorties out of a total of 34 sorties required DGPS processing. Intermap used the Continuously Operating Reference Station (CORS) site in Table 2 to process the aircraft GPS.

Name	Latitude	Longitude	Ellipsoid Height	Datum
AB37	N 62 58 02.36153	W 145 27 06.66494	1136.354	NAD83

Table 2: CORS site used for DGPS processing

Intermap used GrafNav software to perform PPP processing and StarNav for DGPS processing. Intermap then used StarNav to integrate the corrected GPS solution with the measurements of the inertial measuring unit (IMU) to create a final navigation solution which was then used to georeference the radar data. The final navigation solution was processed by a Kalman filter to confirm that the accuracy goals for the project had been obtained. The required vertical accuracy of the navigation solution was <20 cm for this project.

Delivery Product Preparation