

Quality Report

AK West Aleutians Islands IFSAR 2019 D19

USGS 15' Tiles

Cell 401

INTERMAP™

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

One Degree Cell 401 15' Tiles DSM Alaska Project No. S/C#USGS G16PC00020-IT AK West Aleutians Islands IFSAR 2019 D19			n 5 2 1 5 e 1 7 5 4 5
Specification / Requirement	DSM		QCed
	Core	Client	
DATA EXTENT			
Tile Size	7.5'	15'	☑
Buffer size		350m XY	☑
COORDINATE REFERENCE SYSTEM (CRS)			
Horizontal (geodetic)			
Datum ID	NAD83	NAD83, CORS96,	
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	III		
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 and formats	FGDC	FGDC/xml, txt, html	☑
No data value	-10,000	-10,000	☑
Vertical value resolution [m]	0.01	0.01	☑
DATA PREPARATION			
Void Fill Procedures World30, NED, & SSE		Interp & fill	☑
DATA INSPECTION			
Ties with adjacent tiles			☑
Seams / ramps			☑
Elevation display in Arc			☑
Hydro enforcement			☑
QC By:	Date:		
A. Serogy		12/16/2019	

DTM Data Delivery Quality Checklist

One Degree Cell 401 15' Tiles DTM Alaska Project No. S/C#USGS G16PC00020-IT AK West Aleutians Islands IFSAR 2019 D19			n 5 2 1 5 e 1 7 5 4 5
Specification / Requirement	DTM		
	Core	Client	QCed
DATA EXTENT			
Tile Size	7.5'	15'	<input checked="" type="checkbox"/>
Buffer size		350m XY	<input checked="" type="checkbox"/>
COORDINATE REFERENCE SYSTEM (CRS)			
Horizontal (geodetic)			
Datum ID	NAD83	NAD83, CORS96,	
Ellipsoid	GRS80	GRS80	<input checked="" type="checkbox"/>
Projection	Geographic	AK Albers	<input checked="" type="checkbox"/>
Coordinate units	Decimal deg.	Meters	<input checked="" type="checkbox"/>
Vertical			
Height system	Orthometric	Orthometric	
Geoid model	NAVD88/GEOID09	NAVD88/GEOID09	
Value unit	Meters	Meters	<input checked="" type="checkbox"/>
DATA SPECIFICATION			
Intermap product specification type	III		
Tile dimension	7.5' x 7.5'	15'x15'	<input checked="" type="checkbox"/>
Pixel size (resolution, posting)	0.15"	5 meters	<input checked="" type="checkbox"/>
File format	BIL	GeoTIFF	<input checked="" type="checkbox"/>
Resolution [bit]	32 float	32 bit	<input checked="" type="checkbox"/>
File extension	.BIL	.TIF	<input checked="" type="checkbox"/>
Pixel referencing (center, corner)	center UL cr	center	<input checked="" type="checkbox"/>
Max. single file size [MB]	32.5	200	<input checked="" type="checkbox"/>
Metadata standard and formats	FGDC	FGDC/xml, txt, html	<input checked="" type="checkbox"/>
No data value	-10,000	-10,000	<input checked="" type="checkbox"/>
Vertical value resolution [m]	0.01	0.01	<input checked="" type="checkbox"/>
DATA PREPARATION			
Void Fill Procedures World30, NED, & SSE		Interp & fill	<input checked="" type="checkbox"/>
DATA INSPECTION			
Ties with adjacent tiles			<input checked="" type="checkbox"/>
Seams / ramps			<input checked="" type="checkbox"/>
Elevation display in Arc			<input checked="" type="checkbox"/>
Hydro enforcement			<input checked="" type="checkbox"/>
QC By:	Date:		
A. Seroogy	12/16/2019		

ORI Data Delivery Quality Checklist

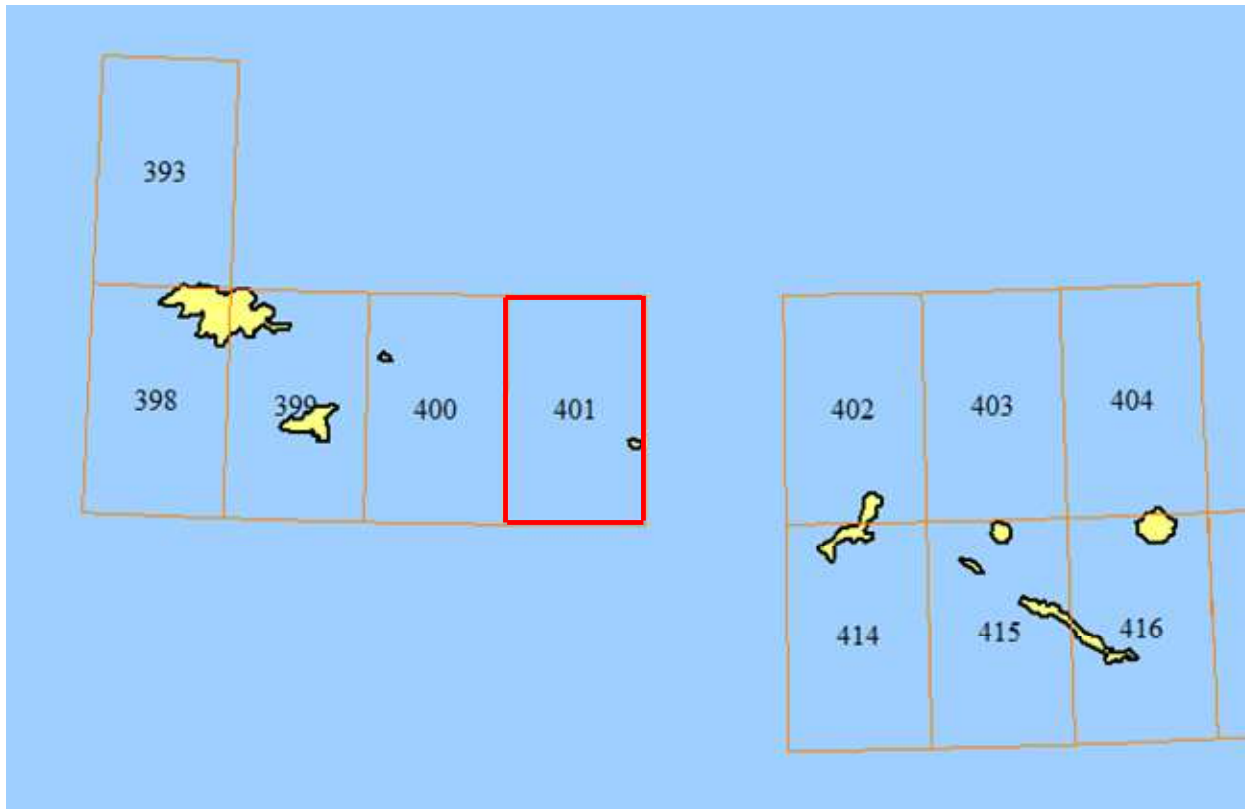
One Degree Cell 401 15' Tiles ORI Alaska Project No. S/C#USGS G16PC00020-IT AK West Aleutians Islands IFSAR 2019 D19			n 5 2 1 5 e 1 7 5 4 5
Specification / Requirement	ORI		
	Core	Client	QCed
DATA EXTENT			
Tile Size	7.5'	15'	<input checked="" type="checkbox"/>
Buffer size	1 Pixel	350m XY	<input checked="" type="checkbox"/>
COORDINATE REFERENCE SYSTEM (CRS)			
Horizontal (geodetic)			
Datum ID	NAD83	NAD83, CORS96,	
Ellipsoid	GRS80	GRS80	<input checked="" type="checkbox"/>
Projection	Geographic	AK Albers	<input checked="" type="checkbox"/>
Coordinate units	Decimal deg.	Meters	<input checked="" type="checkbox"/>
DATA SPECIFICATION			
Intermap product specification type	III		
Tile dimension	7.5' x 7.5'	15'x15'	<input checked="" type="checkbox"/>
Pixel size (resolution, posting)	0.0375"	0.625 meters	<input checked="" type="checkbox"/>
File format	GeoTIFF	GeoTIFF	<input checked="" type="checkbox"/>
Radiometric Resolution [bit]	8	8	<input checked="" type="checkbox"/>
File extension	.TIF	.TIF	<input checked="" type="checkbox"/>
Pixel referencing (center, corner)	UL corner of Pixel	Edge	<input checked="" type="checkbox"/>
Max. single file size [MB]		2.1GB	<input checked="" type="checkbox"/>
Metadata standard and formats	FGDC	FGDC/xml, txt, html	<input checked="" type="checkbox"/>
No data value		Outside Coverage "0" Water/Void "1"	<input checked="" type="checkbox"/>
DATA INSPECTION			
Ties with adjacent tiles			<input checked="" type="checkbox"/>
Radiometric Balance			<input checked="" type="checkbox"/>
Artifacts			<input checked="" type="checkbox"/>
QC By:	A. Seroogy	Date:	12/16/2019

Post-Edit Accuracy Report

Project Acquisition Area

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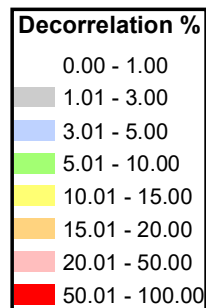
- Analysis of Cell # 401
- Total area of 7476.497 km²
- Number of 7.5' tiles = 4
- Number of 15' tiles = 1



Alaska Cell #:401

- Total land area of 18.544 km²
- 0.399 km² of the cell area is decorrelated (0.01%)
- Percentage of decorrelation in each tile is calculated based on the 0 values in the COR
- Water was excluded based on IES Edit Mask
- **None** of the 7.5' tiles exceed a decorrelation value of 0.32%
- **None** of the 15' tiles exceeds a decorrelation value of 0.09%

			0.09



Slope Based on DTM (Land Only)

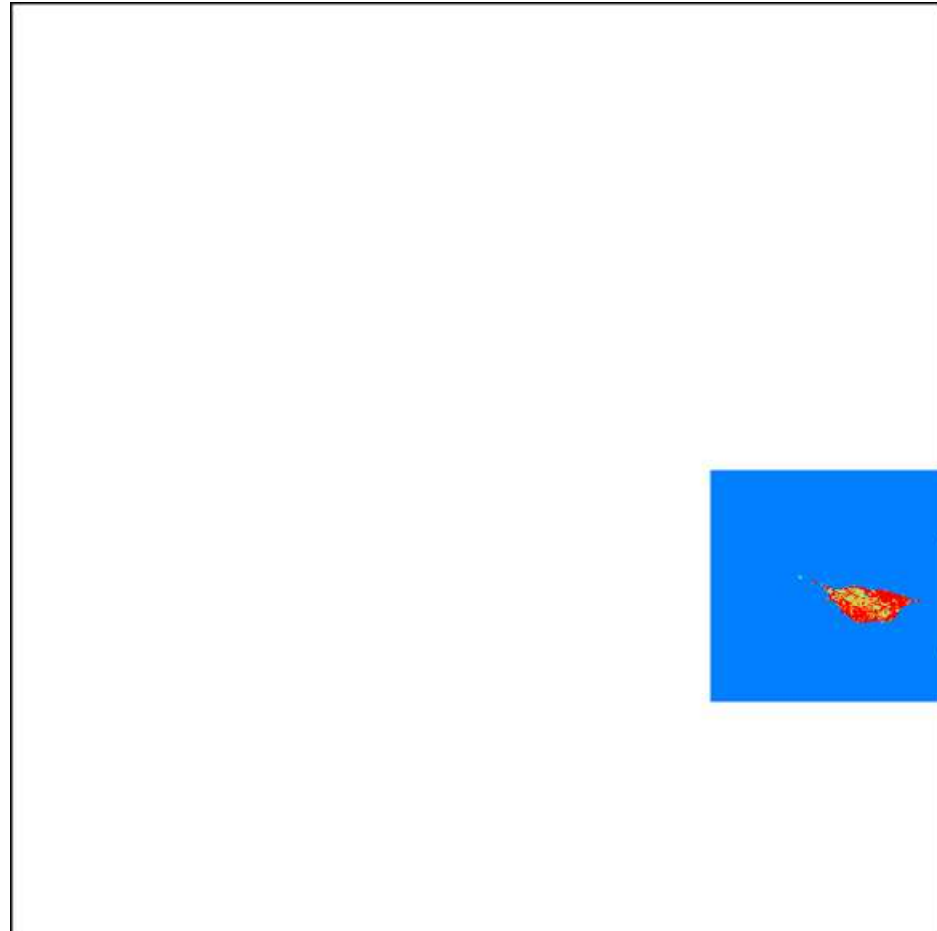
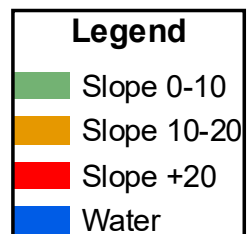
INTERMAP®

Alaska Cell #:401

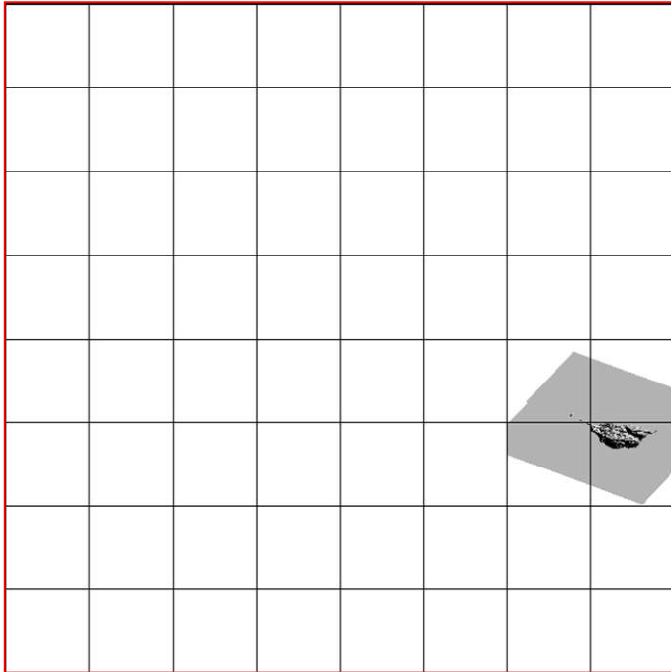
Area of slopes $< 10^\circ$: 2.466 km²
(13.30%)

Area of slopes $10^\circ - 20^\circ$: 4.424 km²
(23.86%)

Area of slopes $> 20^\circ$: 11.654 km²
(62.84%)



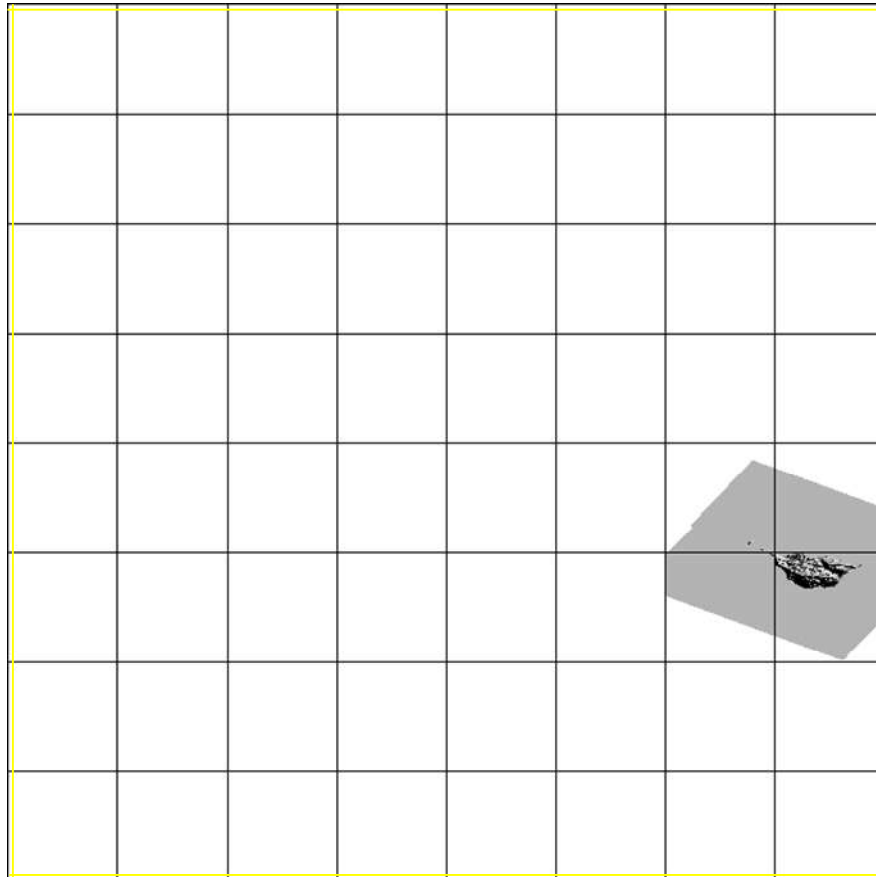
Vertical Accuracy – ICESat Reference Points **INTERMAP**



- No ICESat points available for a quantitative vertical accuracy analysis

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

Tile Edge Checks



Tile edges were checked visually for matching elevation values and seam lines in the DTM and DSM

No seam lines or ramps were observed between adjacent tiles

- ▬ The amount of void in Cell #401 is within the accepted range of 3%
 - Amount of void in DEM is 0.01%

- ▬ The amount of void in each 15' tile is within the accepted range of 5%
 - Lowest value 0.09%
 - Highest value 0.09%

- ▬ FITS usage appears to be appropriate and consistently used from tile to tile within this cell.

- ▬ No seam lines or ramps were identified in the DSM or DTM between adjacent tiles

DEM Void Analysis

Alaska Cell #401					
Intermap 7.5' Tiles	USGS 15' Tiles	USGS Void %	HRTe3 30' Tiles	HRTe3 Void %	Cell Total Void %
n52e176c2					
n52e176c1					
n52e176d2					
n52e176d1	xxx_n5215e17615	0.0855	us_n5200e17630_uncllimdis_hrte3_dem	0.0855	0.0855

Overview of Quality Management Process

Intermap has implemented a Quality Management System (QMS) corporate-wide. The quality organization consists of the Quality Manager, Registered Internal Audit Team, Engineering and Customer Support personnel. Intermap's QMS is compliant with the ISO 9001:2008 Standard.

Intermap has been audited annually by an independent international organization: Underwriter Laboratories (UL). All offices along with their respective activities are included under the single companywide ISO registration certificate:

The QM group conducts periodic internal audits and all the internal auditors have been trained in auditing procedures under ISO 9001:2008.

The Intermap ISO-9001:2008 compliant QMS 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.



CERTIFICATE



This is to certify that:

Intermap Technologies, Inc.

8310 South Valley Highway
Suite 400
Englewood, CO 80112
United States of America

with the organizational units/sites as listed in the annex

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

Scope:

The design, acquisition, processing and editing of digital elevation data, production of ortho rectified imagery and value added mapping products. The site in Englewood, CO, USA performs the following functions: processing, sale and distribution of digital data, airborne acquisition management.

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 original certification 1999-09-28
Date of certification 2015-09-27
Valid until 2018-09-22



DQS Inc.

Ganesh Rao
Ganesh Rao
Managing Director

Accredited Body: DQS Inc., 1130 West Lake Cook Road, Suite 340, Buffalo Grove, IL 60089 USA

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Annex to Certificate Registration No. 439015 QM08

Intermap Technologies, Inc.

8310 South Valley Highway
Suite 400
Englewood, CO 80112
United States of America

Location	Scope
20003832 P.T. Exsmap Asia Plaza City View - 2nd Floor, JL Kemang Timur No. 22, Pekajen Barat, Jakarta Selatan Jakarta 12510 Indonesia	The Provision of Editing Services for Elevation and 3D Road Data.
10009138 Intermap Technologies Corp. Suite 200, 840-8th Ave SW Calgary, AB T2P 3E5 Canada	The remote location at Calgary, Alberta, Canada performs the following primary functions: Design and technical support.
421330 Intermap Technologies s.r.o. Novodvorska 1010/14 142 00 Prague 4 Czech Republic	The remote location at Prague, Czech Republic performs the following primary functions: Design & development for value-added digital data and mapping products.

This annex (edition: 2015-09-27) is only valid in connection with the above-mentioned certificate.

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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 Intermap.com. The Product Handbook contains a 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 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 than 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 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 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 effects 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 than 400m in both axes).

Ground Control and Navigation Processing Methods for Alaska 2019 Far Islands and West Aleutians

2019-09-15

Project Area

The project area consisted of two acquisition blocks designated 4753 and 4754. The location of the blocks is illustrated in Figure 1 below.

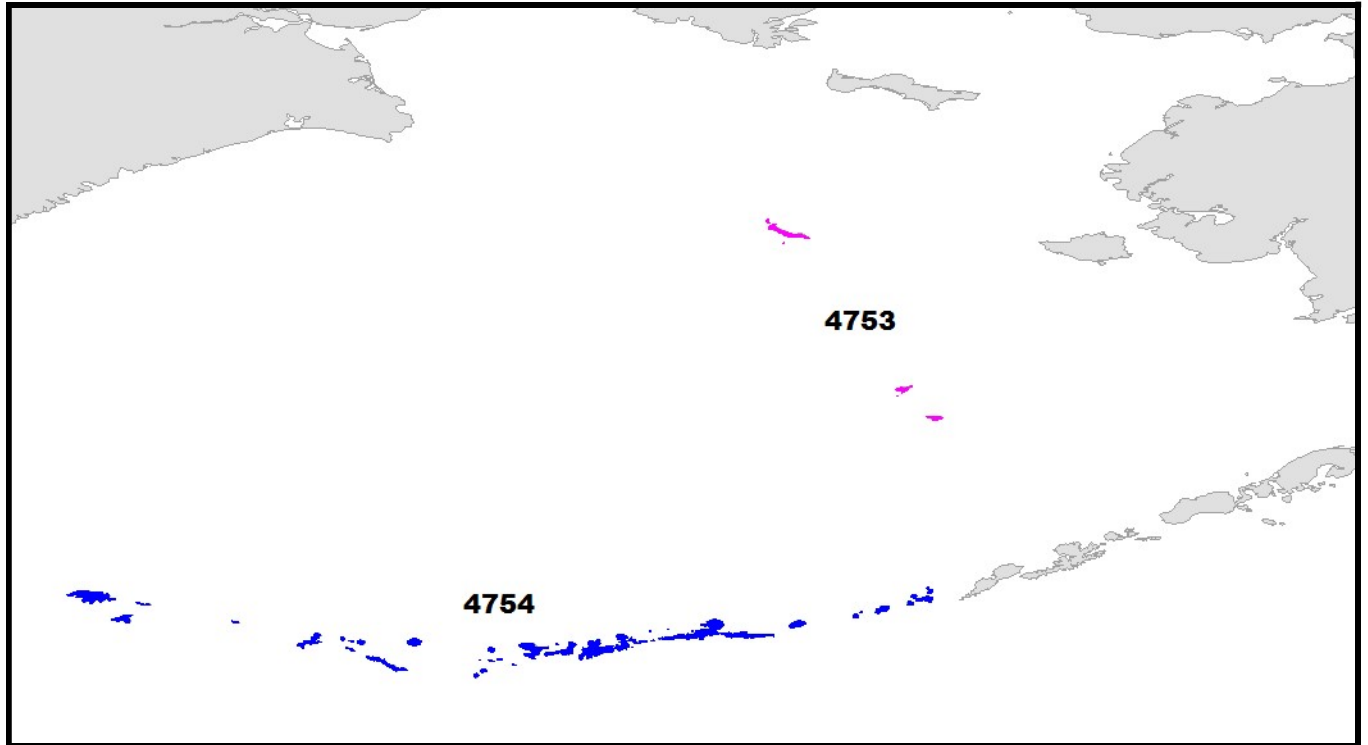


Figure 1: Acquisition Blocks

Ground Control Points

Intermap used ground control points (GCPs) to control the radar image and elevation data for Alaska. Intermap GCPs consisted of 5 directional aluminum reflectors (corner reflectors or CRs). The relative position of each GCP is depicted in Figures 2, 3, and 4 below.



Figure 2: Relative GCP placement 4753



Figure 3: Relative GCP placement 4754 (Western Hemisphere)



Figure 4: Relative GCP placement 4754 (Eastern Hemisphere)

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

A charter plane was required to reach all the GCP sites for this project.

Equipment

Intermap used Sokkia GSR2600 L1/L2 GPS receivers (or equivalent) equipped with Sokkia SK-600 or SK-702 geodetic-quality antennas.

Specifications

Each GCP survey consisted of a 2-6 hour static session with 30 second epochs (Figure 5).



Figure 5: Corner reflector survey

The required accuracy for each GCP survey was 2.5 cm RMSE after processing.

Processing Software

Intermap used OPUS online processing using precise satellite ephemeris/clock data to process the GCPs.

GCP Coordinates

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

Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (m)	Role	Session Type	Duration (min)	Date
4753A1	N 57 9 31.75434	W 170 13 41.11439	22.141	Reflector	OPUS	120	6/30/2019
4753B1	N 56 34 33.90074	W 169 39 58.26308	42.317	Reflector	OPUS	240	6/30/2019
4754A1	N 51 53 19.41266	W 176 38 2.61172	9.003	Reflector	OPUS	180	7/1/2019
4754B1	N 52 13 6.92663	W 174 12 25.43263	18.456	Reflector	OPUS	360	7/4/2019
4754C1	N 52 42 50.62169	E 174 7 38.98772	45.819	Reflector	OPUS	120	7/2/2019

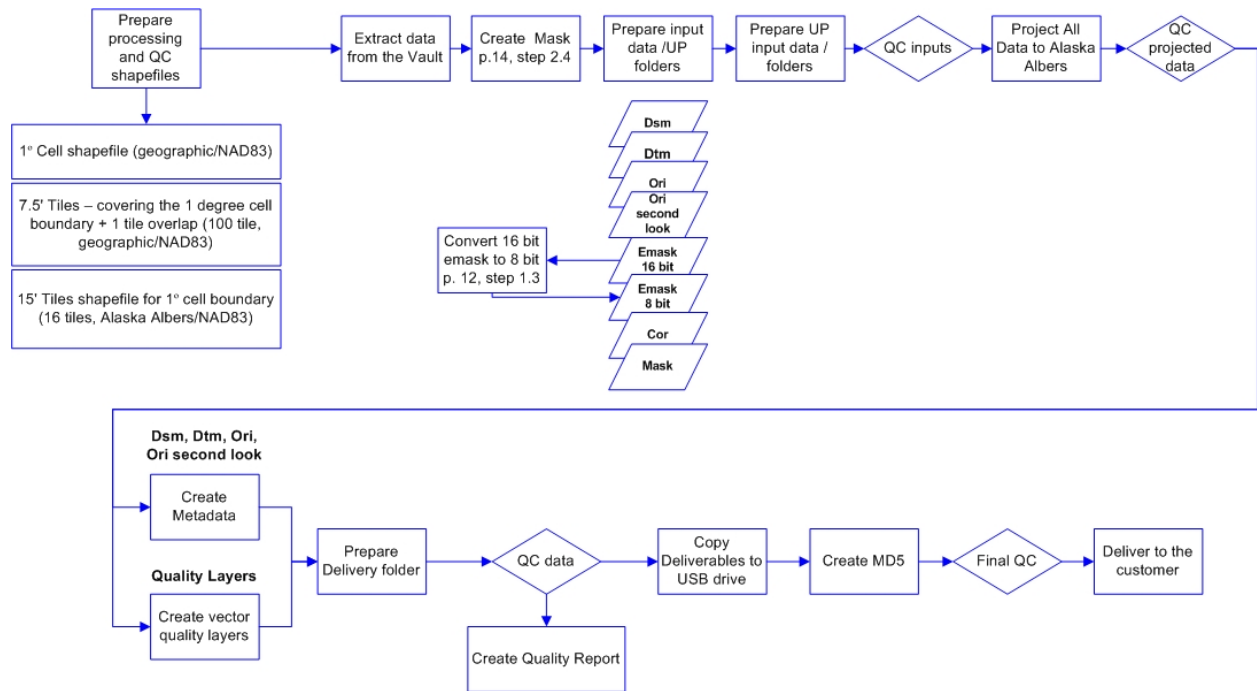
Table 1: GCP coordinates

All coordinates are in the NAD83(2011) datum.

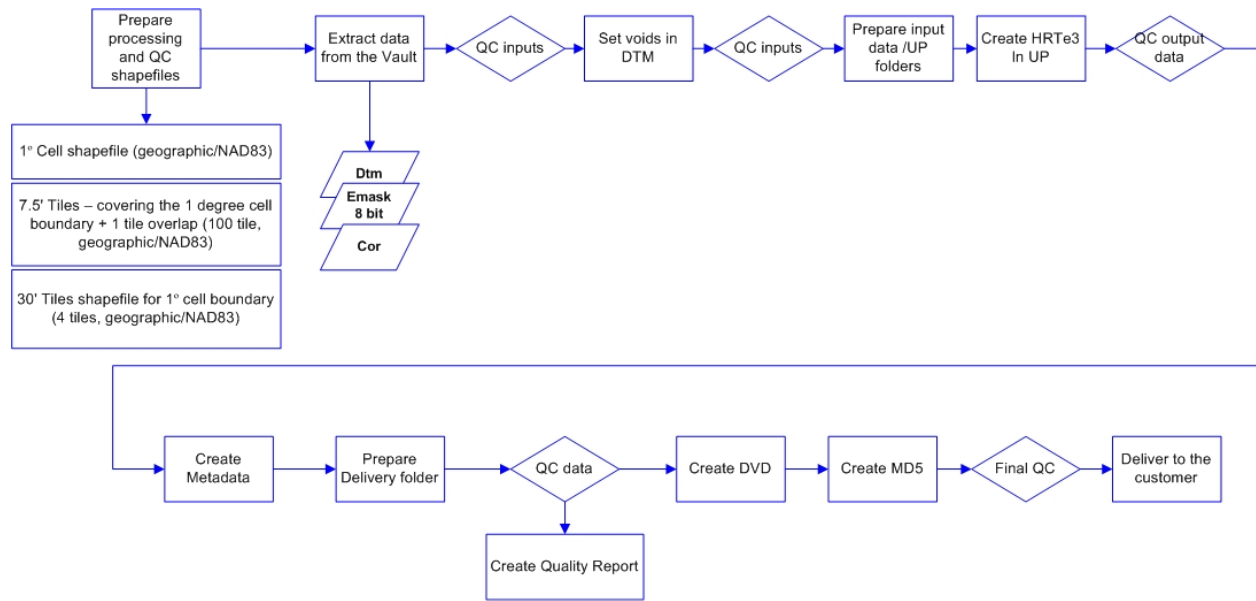
Navigation Processing

Intermap used of precise point positioning (PPP) 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). 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



USGS Deliverables Processing



NGA Deliverables Processing