

INTERMAP

Product
Handbook
and
Quick Start
Guide

Version 3.3

Document History	iii
Corporate Information	iv
List of Figures	v
List of Tables	viii
1.0 Overview	1
2.0 Introduction to Core Products	3
2.1 Product Overview.....	4
2.2 Core Products Gallery.....	7
3.0 Purchasing Intermap Products	11
3.1 Product Purchasing Options.....	11
3.2 Ordering a Custom Data Project	12
4.0 Understanding IFSAR	17
4.1 Interferometric Radar	17
4.2 Core Product Attributes	20
4.3 Understanding Accuracy.....	29
4.4 Datums and Coordinates	45
5.0 Core Product Specifications	49
5.1 General Specifications	50
5.2 ORI Specifications	55
5.3 DSM and DTM Specifications	56
6.0 Introduction to Applications	65
6.1 Core Products Applications	65
6.2 Value-Added Products.....	69
6.3 Other Optional Products and Services	77
7.0 Quick Start Guide	79
7.1 Loading a DEM into ESRI Workstation ARC/INFO	79
7.2 Loading an ORI into ESRI Workstation ARC/INFO	80
7.3 Loading a DEM into ESRI ArcView 3.x	80
7.4 Loading an ORI into ESRI ArcView	81
7.5 Loading a DEM into ESRI ArcMap 8.x	82
7.6 Loading an ESRI ASCII formatted image into ArcMap 8.x	84
7.7 Loading an ORI into ESRI ArcMap 8.x	86
7.8 Loading a DEM into ERDAS IMAGINE	87
7.9 Loading an ORI into ERDAS IMAGINE	89
7.10 Loading a DEM into MapInfo	89
7.11 Loading an ORI into MapInfo	90
7.12 Loading a DEM or ORI into ER Mapper	92
7.13 Loading an ORI in ENVI 3.5	96
7.14 Loading a DEM into PCI Geomatica Focus	96
Appendix A: Product Licensing	101

Date	Version	Change
January 14, 2000	Version 1.0	Initial release
February 25, 2000	Version 1.1	Includes explanations of how water data are processed, DEM holes are filled, DEM accuracies are measured and how they compare with DTEDs; describes the pricing structure for partial tiles and expands the list of enhanced (non-standard) products that can be purchased
March 28, 2000	Version 1.2	Reorganizes chapter on Enhancements and Applications; now called Value-Added Products
May 29, 2000	Version 1.3	Adds reference to SCH Interim Delivery
August 1, 2000	Version 1.4	Changes the tile width transition to 56° latitude
March 9, 2001	Version 2.0	Updates GT Product Specifications (incorporates GTF and IM1 products, DT products—bald earth DTMs); clarifies null values; updates Value-Added Products
June 13, 2001	Version 2.1	Updates GT Product Specifications; incorporates GT Quick Start Guide into Appendix A
April 19, 2002	Version 2.2	Updates GT Product Specifications with NEXTMap Britain products
July 1, 2002	Version 2.3	Updates GT Product Specifications
July 17, 2002	Version 2.4	Updates GT Product Specifications; adds more software options to Appendix A
May 7, 2003	Version 2.5	Updates NEXTMap Britain specifications
May 23, 2003	Version 3.0	Defines and explains core products with added background information
July 1, 2003	Version 3.0	Includes applications/value-added details
July 15, 2003	Version 3.2	Reformatted for hardcopy release
June 15, 2004	Version 3.3	Updates to reflect revised Core Product Edit Rules and improved edit capability

Intermap has offices at these addresses in the United States, Canada, and Germany:

U.S. Head Office

400 Inverness Parkway, Suite 330
Englewood, CO 80112-5847
United States
Phone: (303) 708-0955
Fax: (303) 708-0952
www.intermaptechnologies.com

Calgary Engineering Development Office

#1000, 736-8th Ave. S.W.
Calgary, AB, T2P 1H4
Canada
Phone: (403) 266-0900
Fax: (403) 265-0499

Ottawa Production Office

#200 – 2 Gurdwara Road, Suite 200
Ottawa, ON, K2E 1A2
Canada
Phone: (613) 226-5442
Fax: (613) 226-5529

Wessling Engineering Development and Production Office

P.O. Box 1143
82230 Wessling
Germany
Phone: +49 8153 8890
Fax: +49 8153 889101

Product information is available as follows:

Phone: (303) 708-0955
Toll-Free: 1-877-TERRAIN (1-877-837-7246), within the United States and Canada
Email: products@intermaptechnologies.com

The information in this document is subject to change without notice, as Intermap continues to improve its processes and technology. To ensure you have the latest version, visit our Web site at www.intermaptechnologies.com.

Copyright © 2004, Intermap Technologies, Inc. All rights reserved. No part of this document may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior written permission of Intermap Technologies, Inc.

Figure 1: ORI example	4
Figure 2: DSM example (colorized)	5
Figure 3: DTM example (colorized)	6
Figure 4: ORI example	7
Figure 5: DSM example (colorized)	7
Figure 6: DTM example (colorized)	8
Figure 7: ORI example	8
Figure 8: DSM example (colorized)	9
Figure 9: DTM example (colorized)	9
Figure 10: Digital surface model shaded relief mosaic—England and Wales— created by mosaicking approximately 2,000 tiles and resampling them to 30-meter posts	10
Figure 11: One wavelength is the distance between two adjacent points on the wave that have the same slope; the vertical axis shows the amplitude of the wave, time or distance could be represented on the horizontal axis	17
Figure 12: Example of two identical waves that are out of phase (their crests and troughs do not line up)	18
Figure 13: A radar pulse is reflected back to antenna A and B in phase from the same point on the ground (left) and slightly out of phase from a nearby point (right). The rate at which the phase changes is used to measure changes in terrain elevation. The waves are not shown to scale.	19
Figure 14: The geometry of layover	21
Figure 15: Layover is a perspective effect most noticeable in mountainous regions	22
Figure 16: Dark region in center of image is an area of shadow where the radar pulse was not able to reach	23
Figure 17: The effect of rain clouds can be seen as a darkening on the image in the region where the radar signal strength was reduced.	24
Figure 18: This is the DEM of the same region shown above	25
Figure 19: Data recovery in areas of signal saturation	25
Figure 20: This example shows excess motion ripples (dark bands) in the two images. In the left image, the motion was severe enough to cause unrecoverable data loss.	26
Figure 21: Data are missing from the end of the causeway shown in this image	27
Figure 22: Reprocessed data from previous image, showing the missing areas...	27
Figure 23: Data loss due to low correlation	28
Figure 24: Error distribution with mean offset (m)	30
Figure 25: Error distribution with RMSE and 95% confidence level	32
Figure 26: Small samples from a larger area show that scale can affect localized results, but the overall results for the entire area are still within the 95% confidence level	33

List of Figures

Figure 27: Unobstructed regions of modest and constant slope (red polygons) are suitable locations to test the data; regions such as the blue polygon, which are rough or obstructed, are not suitable	35
Figure 28: Red stars indicate a typical scattering of GCPs in a collection area	37
Figure 29: Purple points indicate locations used in completing a vehicle transect	38
Figure 30: Corner reflector in an ORI, magnified by a factor of 10	41
Figure 31: Typical DSM difference histograms	43
Figure 32: Typical DTM difference histograms	43
Figure 33: DSM relative noise	44
Figure 34: DTM relative noise	44
Figure 35: The ellipsoid and the geoid as reference surfaces	46
Figure 36: File origins for Intermap core products	51
Figure 37: Block widths are 7.5' (left) below 56 degrees latitude (center) and 15' above	53
Figure 38: Vertical accuracy measures for core products, grouped by type	57
Figure 39: DTM example	65
Figure 40: Orthorectified Image	66
Figure 41: 3D Visualization	67
Figure 42: STARplus example	69
Figure 43: Topographic line map example	70
Figure 44: Colored shaded relief containing a white line that is shown in profile (below)	71
Figure 45: Line-of-site calculation	71
Figure 46: Typical viewshed analysis created with Intermap products	73
Figure 47: Aspect analysis of Morrison, Colorado (from DSM)	74
Figure 48: Degree slope of Morrison, Colorado (from DTM)	75
Figure 49: Shaded relief of Morrison, Colorado (from DSM)	76
Figure 50: ArcToolBox	82
Figure 51: Floating Point Data to Grid dialog box	83
Figure 52: ArcToolbox—ArcView	84
Figure 53: ASCII to Grid dialog box	85
Figure 54: Intermap ORI in ArcMap	86
Figure 55: IMAGINE Import/Export dialog box, set to Import	87
Figure 56: Import Generic Binary Data dialog box	87
Figure 57: Change Map Info dialog box	88
Figure 58: Projection Chooser dialog box	88
Figure 59: Pop-up menus for importing a DEM	92
Figure 60: Import Binary_BIL dialog box	93
Figure 61: Import Setup dialog box	93
Figure 62: Geocoding Wizard pop-ups	94
Figure 63: Geocoding Wizard dialog box	94
Figure 64: Geocoding Wizard second dialog box	95
Figure 65: Geocoding Wizard third dialog box	95

Figure 66: Import pop-up menu	96
Figure 67: Import File dialog box	97
Figure 68: Message box	98
Figure 69: Image parameter dialog box	98
Figure 70: Translate (Export) File dialog box	99
Figure 71: Maps tab in main workspace	100

List of Tables

Table 1: Product type and delivery methods	11
Table 2: Classification of core product attributes	20
Table 3: Core product accuracies (refer to Table 9 and Table 10 for type definitions)	45
Table 4: Vertical and horizontal datums for core products	50
Table 5: Standard projections for NEXTMap Britain core products	50
Table 6: Intermap data file extensions	54
Table 7: ORI accuracy specifications	55
Table 8: ORI feature content	56
Table 9: DSM vertical accuracy specifications (units in meters)	57
Table 10: DTM vertical accuracy specifications (units in meters)	57
Table 11: DSM and DTM feature content	58
Table 12: Contour intervals, by product type	66

Welcome to the Intermap Product Handbook and Quick Start Guide!

Perhaps you want an introduction to the benefits of our radar products and how they can be put to work for you. Or maybe you are a seasoned user who simply needs to understand how to import our data into your software. Either way—this book is for you.

Here's how it's organized:

- *2.0 Introduction to Core Products* describes our three core products—orthorectified images, and two types of elevation models (one contains buildings and vegetation, the other does not).
- *3.0 Purchasing Intermap Products* explains how to order our products right off the shelf, or how to have us fly a specific area of interest in case we don't already have the data you need.
- *4.0 Understanding IFSAR* describes how our radars work and explains some of the characteristics that are unique to this type of sensor.
- *5.0 Core Product Specifications* contains specific information relating to accuracy, file types, size and much more—to understand what you will be getting when you place an order with us.
- *6.0 Introduction to Applications* provides an overview of the wide range of uses for both our core and value-added products.
- *7.0 Quick Start Guide* gives you a head start on loading our products into several popular software packages on the market today.

Some quick tips if you are new to Intermap:

- We are a global provider of high-accuracy, high-resolution digital elevation map products. Our fixed-wing aircraft image the earth's surface using interferometric synthetic aperture radar (IFSAR)—which operates day or night, in clear or cloudy conditions.
- Our end-to-end commercialization of this technology (which can acquire data at up to 100 square kilometers per minute) is comprised of ISO-registered processes—part of our quality assurance system here at Intermap—to make sure that you receive the very best, every time.

Overview

- Our flexibility and high volume throughput mean we are less expensive than competing technologies, while still providing you with highly accurate elevation products that have a wide range of applicability.
- We have over one million square kilometers available for purchase right off the shelf—and we can fly virtually anywhere. Go online to our data store at **www.intermaptechnologies.com** to view and order data for your areas of interest. Or contact us to either place an order or to inquire about hiring us to fly a custom project for you. We can be reached via:
 - Phone: (303) 708-0955
 - Toll-free: 1-877-TERRAIN (1-877-837-7246), within the United States and Canada
 - Email: products@intermaptechnologies.com

Intermap's core products are created from X-band IFSAR¹ data and are used in a wide range of applications. This chapter explains what they are and gives a quick overview of how they are frequently used. Check *5.0 Core Product Specifications* and *6.0 Introduction to Applications* for details.

We have three core products: orthorectified images (ORIs), digital surface models (DSMs) and digital terrain models (DTMs). ORIs look somewhat like monochromatic aerial photos and are always generated in pairs for any particular scene. Because of this pairing, we are able to create DSMs, which not only contain location information, but elevation information as well. Our ORIs and DSMs display the first surface on the ground that the radar strikes, including terrain features, buildings, power lines, and vegetation such as large trees or forests.

We use DSMs to create DTMs by digitally removing the cultural features described above, as well as the treed areas. DTMs are useful for applications where you need an accurate sense of the underlying terrain. These three core products frequently provide the base data layer for a wide range of information, such as accurately located drainage networks or road vectors.

Core products are created according to tightly controlled specifications. These products only vary when the specifications are upgraded—to reflect improvements in our hardware, for example. If your particular application requires products that fall outside of our core products specifications (perhaps you need something other than our standard accuracy levels or file formats), we also offer a wide range of value-added products, with pricing negotiated on a per-project basis.

You can choose products off the shelf (from previously acquired projects), or you can order data in areas of interest to target specific needs. Off-the-shelf products have two advantages—they are highly cost effective, and they can be delivered very quickly. If we have not yet acquired data in your area of interest, you can engage us to collect it for you. That way you can be assured of getting the exact regions you require, and the information will be current (to the date of acquisition). However, delivery takes longer because of the time required for acquisition and processing.

Table 1 in *3.0 Purchasing Intermap Products* is a simple matrix that illustrates the costs and benefits of deciding between the types of products (core vs. value-added) and the delivery method (off-the-shelf vs. custom).

¹ X-band refers to the particular wavelength of the radar pulse, which is about 3 centimeters. Intermap is also doing research using a P-band radar, which has a wavelength of about 1 meter. IFSAR stands for interferometric synthetic aperture radar – basically, radar that creates images by combining signals received from two antennae.

2.1 Product Overview

This section explains the key features of our core products and gives some examples of applications for which the products work very well. See *2.3 Core Products Gallery* for more examples.

2.1.1 Orthorectified Radar Image (ORI)

An ORI is a grayscale image of the earth's surface that has been corrected to remove geometrical distortions that are a normal part of the imaging process. This product looks similar to a black-and-white aerial photograph. The difference is that, instead of being made of visible light, the radar pulses the ground with "flashes" of radio waves, which then return from the ground (or whatever they strike, including buildings and trees) to the antennae to give distance and intensity measurements. The key feature of this product is that it provides a means of viewing the earth's surface in a way that accentuates features far more than is possible with aerial photography. The radar looks to the side of the aircraft and casts "shadows" that enable users to visually perceive the elevation information in the image, even if they are unfamiliar with the underlying technology. The ORI has many applications in value-added products. For example, it can be used to extract cultural features such as road networks and buildings, as well as lending itself readily to terrain, land cover, and geological analysis. Figure 1 is an example of an ORI from Intermap's NEXTMap Britain project, which involved mapping all of Great Britain.



Figure 1: ORI example

2.1.2 Digital Surface Model (DSM)

A DSM is a topographic model of the earth's surface that can be manipulated using a computer. It is comprised of elevation measurements that are laid out on a grid. These measurements are derived from the return signals received by the two radar antennae on the aircraft. The signals bounce off the first surface they strike, making the DSM a representation of any object large enough to be resolved. This includes buildings, vegetation and roads, as well as natural terrain features. The key feature of this product is that it provides a geometrically correct reference frame over which other data layers can be draped. For example, the DSM can be used to enhance a pilot's situational awareness, create 3D fly throughs, support location-based systems, augment simulated environments, and conduct viewshed analyses². It can also be used as a comparatively inexpensive means to ensure that cartographic products such as topographic line maps, or even road maps, have a much higher degree of accuracy than would otherwise be possible. Figure 2 shows the corresponding DSM for the same region displayed in Figure 1. Note: DSMs contain no intrinsic color, but are easily colorized after they have been imported into most viewing applications. In this color map, blue has been associated with the lowest elevation, red with the highest.

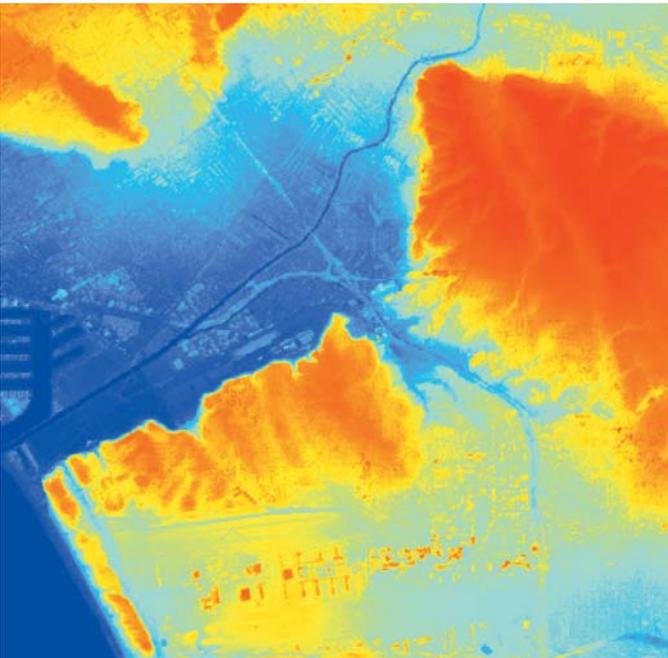


Figure 2:
DSM example
(colorized)

² These are usually digitally generated maps that indicate the terrain that is visible from a particular vantage point in the scene. See 6.2 *Value-Added Products* for an example.

2.1.3 Digital Terrain Model (DTM)

A DTM is a topographic model of the bare earth that can be manipulated using a computer. A DTM has had vegetation, buildings and other cultural features digitally removed, leaving just the underlying terrain. This is achieved using our proprietary software called TerrainFit®, which derives terrain elevations based on measurements of bare ground contained in the original radar data (DSM). The key feature of a DTM is that it enables users to infer those terrain characteristics that may be hidden in the DSM. For example, the DTM (coupled with surface analysis tools) supports applications such as the development of topographic maps. It is also a valuable component in analyses involving various terrain characteristics such as profile, cross-section, line-of-sight, aspect, and slope. As well, the DTM supports flood plain analyses, agricultural, and intelligent vehicle applications. In Figure 3, you can see how the buildings that were evident in the previous figures are no longer visible.

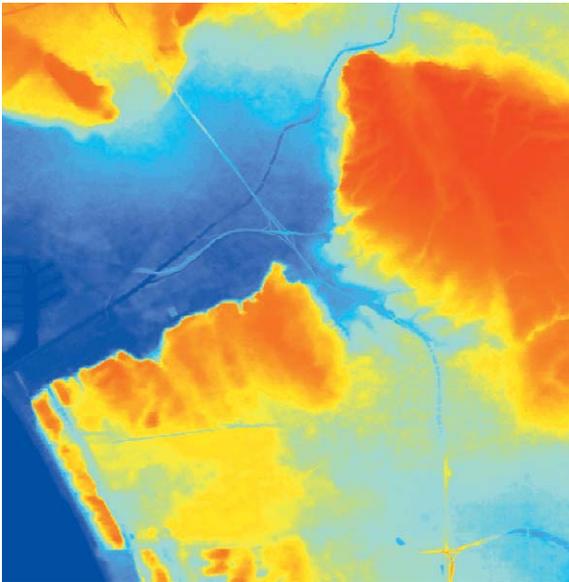


Figure 3: DTM example (colorized)

2.2 Core Products Gallery

In this section are a few images of our core products, showing their various differences, qualities, and attributes.

These images (Figures 4–6) showcase the Morrison, Colorado, area, with Bear Creek Lake on the south side. The ORI has a pixel resolution of 1.25 meters, while the DSM and DTM are Type II products with 1-meter RMSE vertical accuracy, posted at 5-meter intervals.



Figure 4:
ORI example

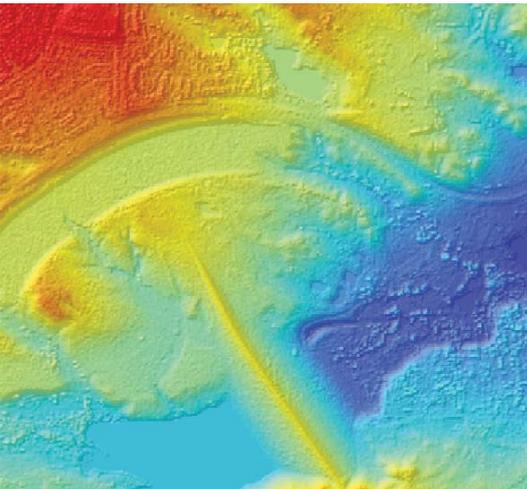


Figure 5:
DSM example (colorized)

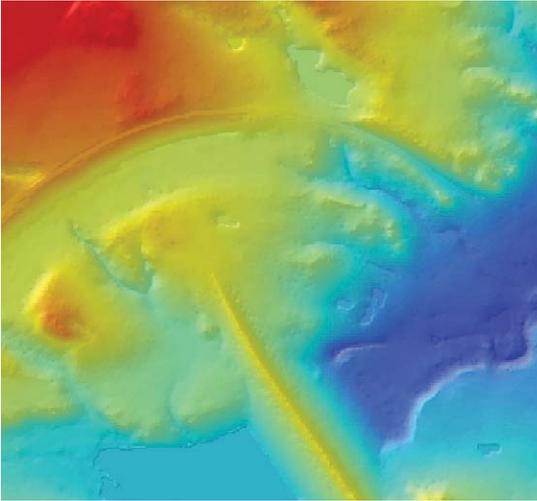


Figure 6: DTM example (colorized)

Figures 7–9 depict the Menai Strait in northern Wales, which separates the Isle of Anglesey from the mainland of Wales. In the scene, to the southeast on the mainland, is the city of Caernarfon and Waterloo Port, where the River Afon Seiont flows into the Menai Strait. This ORI has a pixel resolution of 1.25 meters and is part of our NEXTMap Britain dataset.



Figure 7: ORI example

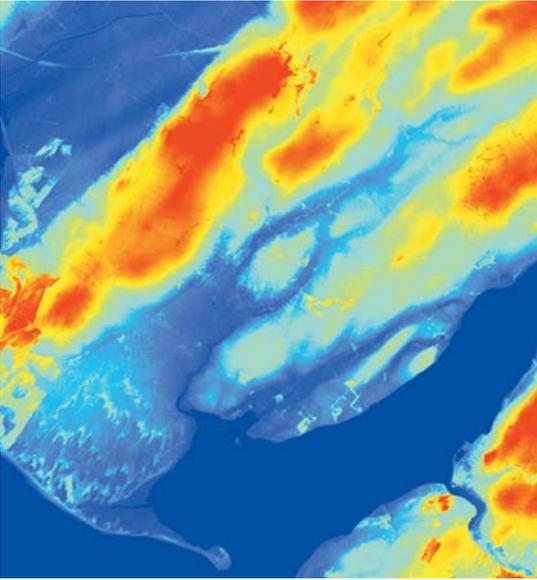


Figure 8: DSM example (colorized)

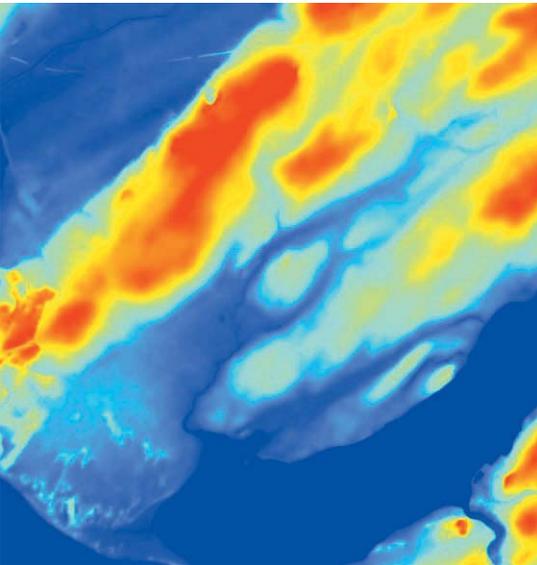


Figure 9: DTM example (colorized)



Figure 10: Digital surface model shaded relief mosaic—England and Wales— created by mosaicking approximately 2,000 tiles and resampling them to 30-meter posts

Purchasing Intermap Products

3.1 Product Purchasing Options

At Intermap we work hard to understand your expectations as a client—and we do everything we can to meet them. That’s why we have made it easy for you to get to a best-fit solution. We want to offer you great quality with a range of choices that will fit both your particular applications and your budget. You can order products right off the shelf or arrange with us to do a custom acquisition in your specific area of interest. Table 1 summaries four options for purchasing a license to our products.

		Products	
		Core	Value-Added
Delivery	Off-the-shelf	Option 1: Economy Great choice if you are on a budget, you need the products quickly but don't require the information to be completely current, and your applications are straightforward	Option 2: Economy plus Keeps costs down by developing value-added products from off-the-shelf data; an excellent choice to meet the needs of more demanding applications
	Custom acquisition	Option 3: Premium Up-to-date core products of exactly the areas you need	Option 4: Premium plus Same precision coverage and timely delivery, with value-added for specialized applications

Table 1: Product type and delivery methods

3.2 Ordering a Custom Data Project

Here we present answers to questions frequently asked regarding the custom acquisition process:

How is a custom project different than buying a product off the shelf?

With a custom project, you get exactly the coverage areas you need—and you know they will be up to date. However, because you are directing the resource of our aircraft, which is expensive to operate on a daily basis, the price is going to be higher than if you were to purchase the same data off the shelf—assuming the aircraft is available.

How is a custom project different than buying a product off the shelf?

With a custom project, you get exactly the coverage areas you need—and you know they will be up to date. However, because you are directing the resources of our aircraft, which is expensive to operate on a daily basis, the price is going to be higher than if you were to purchase the same data off the shelf—assuming the aircraft is available.

In spite of the higher cost for a custom acquisition project, it is important to bear in mind that Intermap's IFSAR systems represent the best value around. On a per-dollar basis, no one can cover the vast areas that we can—and as accurately as we do.

What, exactly, do I get when I place a custom order?

Aside from selecting the coverage area very precisely, you can choose which of our core or value-added products you would like to have delivered. Talk to one of our sales representatives for details and suitability.

How do I know that Intermap products will do what I need?

Our elevation and image products have been used effectively in countless applications that vary widely across many industries (see *6.0 Introduction to Applications*). However, the only way we can determine the product suitability to your specific purpose is if you discuss your exact needs with an Intermap sales representative. Then we can recommend a product solution.

How long does it take to do a custom project?

That depends on several factors, which are not mutually exclusive:

- Your urgency in acquiring the data
- The size of the project
- Our current backlog (in production as well as acquisition)
- Location of the aircraft
- Weather, especially if there are seasonal considerations

Because of the popularity of our products, our acquisition teams are typically booked several months in advance. However, depending on how urgently you require your products, and depending on the itinerary of these teams, it may be possible to expedite your order. We cannot guarantee this, and you should call us to check. Bear in mind, too, that snow and ice on the ground hamper the radar's ability to pick up a good signal, so acquisition in more extreme latitudes should be booked to account for seasonal variability.

Depending on the size of the project, acquisition can take a few days or a few weeks. Processing the data can take from several weeks to three months. Specific timelines will be established when the order is finalized.

How much does a custom acquisition order cost?

Intermap's custom acquisition projects are the most cost-effective way to collect high-accuracy elevation and orthorectified image products. They are much less costly than other sensors because we can cover large areas very efficiently. Costing on a project varies according to a number of factors:

- Size of the project area (a minimum order is 3,000 square kilometers)
- Shape of the area (flight lines can be hundreds of kilometers, and long lines facilitate efficient collection)
- Nature of the terrain (rugged areas require more effort to ensure coverage is as complete as possible)
- Type of products to be generated from the data
- Incidental charges relating to aircraft ferrying, etc.

Once these factors have been determined, your Intermap sales representative will give you a detailed price analysis of your project.

Who retains the intellectual property rights to the data?

Intermap retains all rights to the data, which become part of our product inventory.

What are the specifications of the data?

Refer to the *5.0 Core Product Specifications* for detailed information about our products.

Does Intermap have a rigorous quality assurance program?

Yes. Intermap is an ISO 9001:2000-registered company, audited on a regular basis by Underwriters Laboratories, Inc. Underwriters Laboratories is an independent company that checks to ensure we document and then follow our procedures for acquiring and processing data. We have put stringent controls in place because we know they save time and money. This makes us more competitive and ensures that you will receive the products you ordered on time. Another stipulation of being ISO-registered is that we must have a defined process for correcting problems when they occur, and take measures to ensure that the problems don't happen again.

How do I actually order a custom data project, and what is involved in seeing it through to completion?

This is typically how events unfold:

1. You decide on your area of interest (having the exact coordinates helps, but is not essential at this point). Then you decide on the resolution of the information that you require.
2. Contact an Intermap sales representative in your area or call 1-877-TERRAIN (1-877-837-7246).
3. The sales representative discusses your plan with you and asks you for additional information. Then he or she orders a Preliminary Flight Plan (PFP) from the Intermap Mission Planning Department. The PFP shows a map of your area of interest and gives an estimate of the number of days required to collect the data. The sales representative presents you with this information, along with an approximate cost for the project.
4. If you feel that the plan meets your technical and budgetary requirements, the sales representative then orders a Detailed Flight Plan (DFP). This builds on the information contained in the PFP but also includes actual flight lines for the aircraft. If you wish to change the coverage area or scale back the project to make it more affordable, the sales representative submits a request for a modified PFP, which he or she again presents to you for your consideration before going to the DFP stage.
5. Once the particulars have been finalized in the DFP, the sales representative orders a Contract Flight Plan (CFP). This document contains all of the previous information and includes technical details related to the aircraft flight lines and radar operation. The project is flown according to the specifications defined in this document, which you will be asked to formally approve. It becomes the basis for all of the logistical and technical planning that is subsequently undertaken to ensure the project is a success.
6. Once you have signed the CFP, a project manager is assigned to oversee the administration of your work. One of his or her first tasks is to instruct that an Acquisition Manual is created. This is a document that is used by the office and field crew to ensure that the planning for the project is complete in every detail. It covers everything from crew visa requirements and hotel accommodations to ensuring everyone understands exactly what is required in terms of data acquisition for your project.

7. At the appointed time, the aircraft is ferried to the project area. A GPS base station network is established to help pinpoint the aircraft while it is collecting data and to serve as independent check points throughout the processing tasks.
8. The aircraft begins flying the lines that were defined in the CFP. At the end of each day, the data undergo a field quality check to ensure they are within specifications, especially with respect to the motion and navigational parameters.
9. At the end of the project, the data tapes are shipped to the Processing Center where they are used to create map sheets from the project flight lines.
10. The map sheets are sent for editing, at which point they are used to create mosaics that are edited to remove artifacts and then cut into tiles.
11. The tiles are saved as core products. If required, value-added products are then produced using the specified core products as input. They are checked one last time to ensure they conform to the terms of the contract, and then they are shipped to the address you have supplied.

Can I make changes to the project once I sign the Contract Flight Plan?

Changes will be considered, assuming they are logistically possible. They become more difficult to implement as the deployment date nears. Your sales representative will advise you on additional charges, which will vary according to the nature of the request.

How do I contact Intermap?

Please visit our Web site at **www.intermaptechnologies.com** or contact us by email or telephone at:

- Phone: (303) 708-0955
- Toll-free: 1-877-TERRAIN (1-877-837-7246), within the United States and Canada
- Email: products@intermaptechnologies.com

Understanding IFSAR

Intermap uses a type of sensor called an interferometric synthetic aperture radar, or IFSAR for short. This chapter explains how it works, and some of the attributes that are specific to IFSAR products. It also explains how we measure the accuracy of our data and how we apply datums and coordinates. The actual characteristics of our products can be found in *5.0 Core Product Specifications*.

4.1 Interferometric Radar

The basic principle of radar is simple: Radio waves travel at a constant speed, if the medium has a constant density, making them a good indicator of distance. All you need to do to measure how far it is to a particular object is measure how long it takes for a radio pulse to travel from your location, bounce off the object and come back. Divide the time by two (to measure the distance one way instead of round trip) and multiply the result by the speed of light to get your answer.

Interferometry builds on this concept using ideas that Isaac Newton became aware of in the 1700s.

One of the keys to interferometry is that light has a wave-like characteristic—and one of the attributes of waves is that their lengths can vary. (In fact, the color of a beam of light is defined by its wavelength. Pure red light has a wavelength that is longer than pure blue light, for example. Likewise, radio waves also have very specific wavelengths, and they vary depending on how much energy they carry.)

Figure 11, below, shows a typical wave. One wavelength is defined as the distance between two adjacent points on the wave that have the same amplitude and slope. In this case, the measurement is taken from the tops of two adjacent crests. In the case of X-band radar, a wavelength is about 3 centimeters, or just over 1 inch.

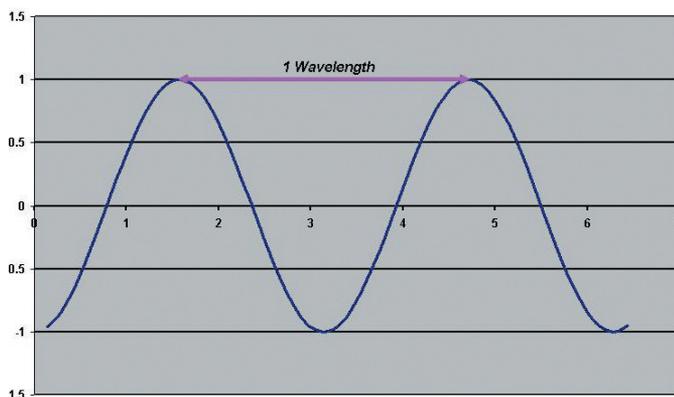


Figure 11: One wavelength is the distance between two adjacent points on the wave that have the same slope; the vertical axis shows the amplitude of the wave; time or distance could be represented on the horizontal axis.

Interferometry relies on picking up the return signal using antennae at two different locations. Our airborne radar systems have two antennae that face sideways, parallel to each other and separated by 1 meter. Each antenna collects data independently of the other, and the images each receives are almost identical, except for the almost insignificant difference in their range to any specific target. In other words, there is no appreciable separation (parallax) between the images. Traditional stereo models are made with a significant separation between images, relative to the viewing distance—but that is not the case here. With interferometric radar, the patterns of electromagnetic radiation (light waves) emanating from the same point on the ground strike each antenna independently. This is because they are at slightly different ranges, due to the separation of the antennae. As a consequence, these waves do not always overlap each other exactly, as shown in Figure 12, and are said to be out of phase by some amount.

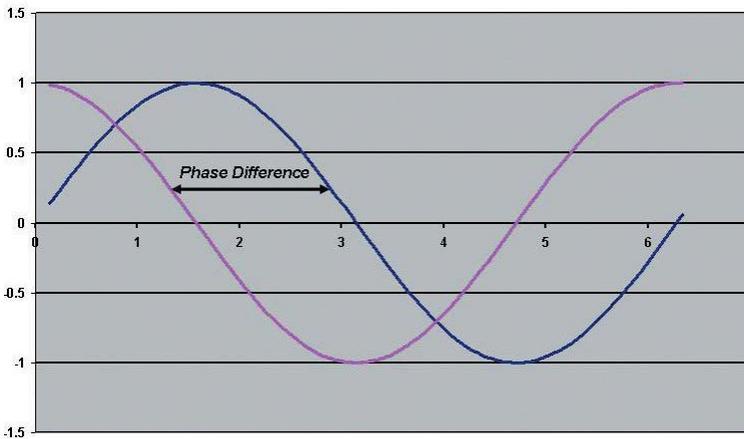


Figure 12: Example of two identical waves that are out of phase (their crests and troughs do not line up)

This is also called a phase difference. The waves that are received in antenna A shift in and out of phase with respect to those received at antenna B, depending on where the point is located from which they are being reflected. This is illustrated in Figure 13, which shows two cut away views of the antennae in the radome under the fuselage of the aircraft. For example, if a point on the ground is an integer number of wavelengths away from each antenna, then those waves will be exactly in phase. If the point is slightly closer or farther away from the aircraft, then the waves will be out of phase. On flat terrain, these changes in phase will occur at a certain rate. When phase changes occur more quickly than normal, this indicates an increase in terrain elevation. Conversely, when the phase changes occur more slowly, this indicates a decrease in elevation (from the previously measured point).

This phase difference result, and the geometry formed by the positioning of separation of the antennae viewing across the imaging dimension, provide all the information required to derive the height and corresponding x, y position of any target that interacted with the broadcast energy.

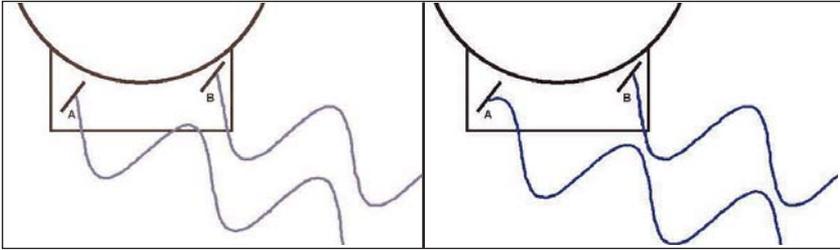


Figure 13: A radar pulse is reflected back to antenna A and B in phase from the same point on the ground (left) and slightly out of phase from a nearby point (right). The rate at which the phase changes occur is utilized to measure changes in terrain elevation. The waves are not shown to scale.

However, these results can be improved, and that is where the term synthetic aperture comes into the description of this type of radar. It refers to the manner in which image resolution is enhanced in the direction that is parallel to the track of the aircraft. Any device that is designed to use optical principles to form an image has an opening that collects incoming radiation, called an aperture. Common examples of devices with apertures are cameras, telescopes and eyes. Resolution is determined by the ratio of the wavelength of light being observed to the length of the aperture being used to collect it. The larger the aperture, the better the resolution. Intermap uses radar antennae that are only about a meter in length, because designing them any larger creates problems relating to the airframe and to antenna stability.

To compensate for this comparatively small aperture, we digitally combine the return signals that are collected while the aircraft is flying. By doing this, we are able to look at each point on the ground from a much wider angle. This amounts to increasing the length of the antenna and gives a resolution that is far greater than could be achieved by simply using the 1-meter aperture aboard the aircraft—without the additional processing. (Radio astronomers frequently use the same principal to enhance stellar observations by coordinating data acquisition from dishes that are separated by many kilometers.)

4.2 Core Product Attributes

In order to ensure our products are of the highest possible quality, we put them through numerous quality assurance checks. This is not a completely intuitive task, because we do not interpret the world around us using ranging devices and signal processing. It means that some of the attributes of radar are not as familiar as those associated with photography, for example, which uses many of the same principles of the human eye. Therefore, certain characteristics that exist in IFSAR data require close attention to ensure the final products are not adversely affected. This section explains the type of radar artifacts we look for and describes how we fix them when necessary.

Table 2 identifies artifacts first by class and then by type. The following sections provide examples of each.

Artifact Class	Type
Geometric	Layover
	Shadow
	Rain shadow
Sensor	Signal saturation
	Motion ripples
Phase unwrap	Missing islands
	Missing data

Table 2: Classification of core product attributes

4.2.1 Layover

Layover results from the side looking nature of the radar with respect to the ground it is imaging. It is a severe form of a perspective effect called foreshortening, which is the tendency for an object to look shorter than it really is, because of the viewing angle of the observer. For example, a pencil tipped toward your eye appears shorter than when it is held upright. The effect of layover is most noticeable in mountainous areas, making features appear to be closer to the radar antennae than they actually are.

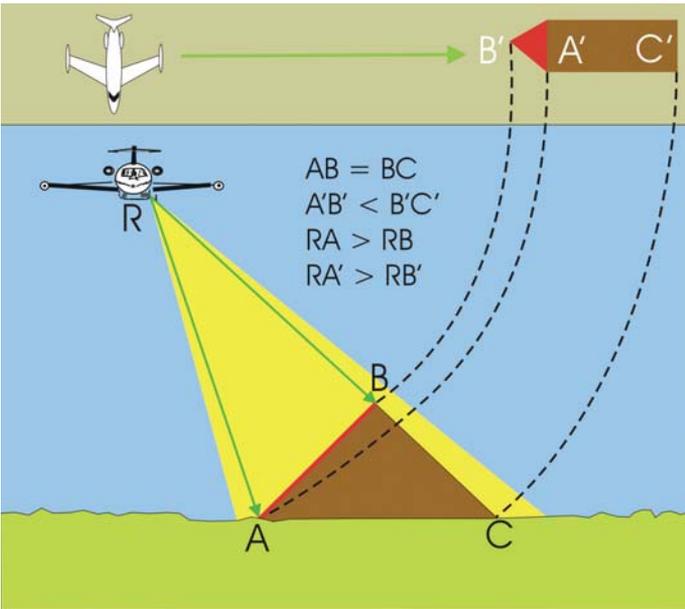


Figure 14: The geometry of layover

Figure 14 illustrates the geometric relationship that must exist between the ground and the radar for layover to occur. The strip along the top of the figure is the view of the scene looking down from above. The lower portion is a front view of the aircraft and the mountain being imaged. The dotted black lines connect corresponding points in each representation. They are key to understanding layover because they show the time that the radar pulse takes to reach various parts of the mountain. Because the top of the mountain (B) is closest to the aircraft, it is imaged ahead of everything else (B'). The effect is to eclipse the view of the front of the mountain (in red).

Understanding IFSAR

Layover causes mountains to resemble sharks fins, due to the visual compression of the near slopes. As part of the production process, the data are corrected so that all image pixels can be used as a map output (orthorectified). The effect is to stretch the previously compressed regions. Thus, layover often appears as a blurred region, because the processor has tried to “pull” areas of higher terrain back to their correct position.

In this example, the striped pattern in layover regions is caused by interpolation of an ancillary data file where there is significant data loss (Figure 15). In most cases, such regions would simply appear black to indicate missing data.

During the planning process, your Intermap sales representative will be able to advise you as to how much of your area of interest might be affected by layover and provide you with the most cost-effective ways of mitigating the effect.

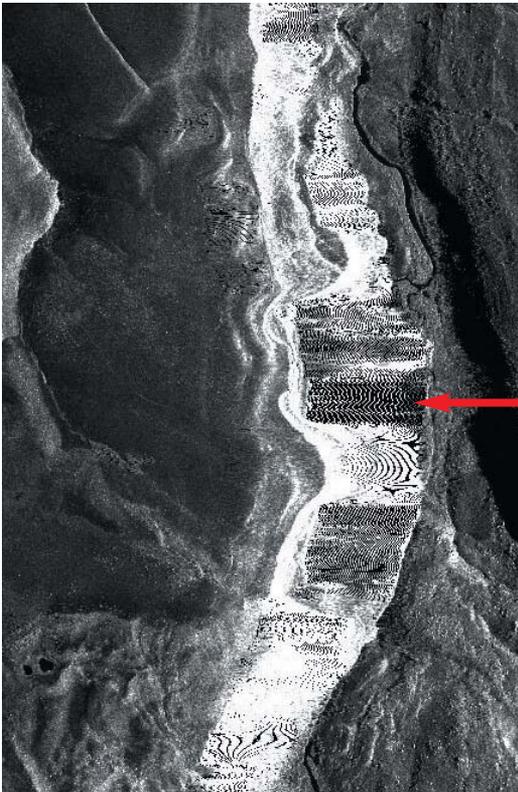


Figure 15: Layover is a perspective effect most noticeable in mountainous regions.

4.2.2 Shadow

If you think of the radar as a camera that images an area by illuminating it with a flash of radio waves, then shadows occur in regions where the flash cannot reach. Put another way, shadows occur when the radar pulse cannot reach both sides of high objects, such as mountains. Areas of shadow have no reflectivity and appear black on the imagery.

Shadow is evident in Figure 16. Note that the location of the shadow gives an obvious clue as to the look direction of the radar. In this case the radar is looking to the right and, as a result, areas of shadow are on the right sides of the mountains. Conversely, the left sides return the strongest signals and hence appear brighter.

Shadow is a geometric artifact that cannot be easily rectified. If an adjacent pass covers the shadow area it is possible that the area will be filled with data during the merge. If a large part of the pass is affected by shadow, second look data may need to be acquired to fill these areas in the DEM. As with layover, your Intermap representative will be able to indicate the extent to which shadow might be a factor and how it might be minimized through effective mission planning. If you are considering purchasing off-the-shelf products, a so-called “void mask” is available that will indicate areas where data are missing.

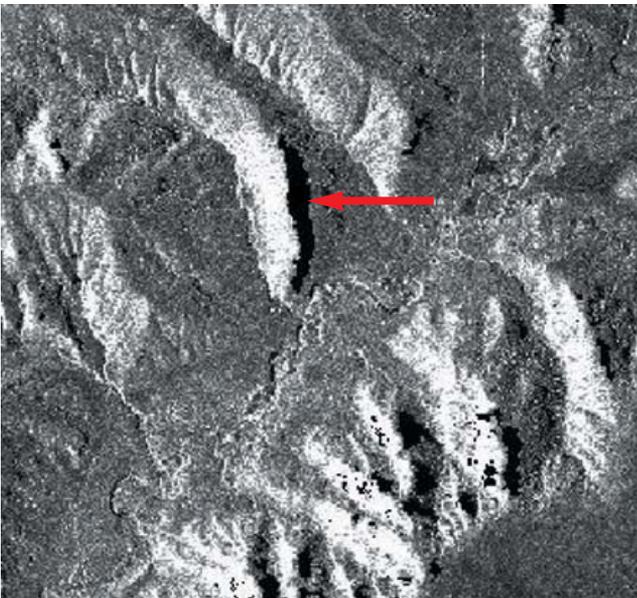


Figure 16: Dark region in center of image is an area of shadow where the radar pulse was not able to reach.

4.2.3 Rain Shadow

Radar can operate at night and in cloudy conditions because it does not rely on natural lighting. However, rain clouds can significantly absorb the radar signal, the effect of which is shown in Figure 17. The effect is variable, depending on the moisture content of the clouds in the area. The probability of rain shadow appearing in the final dataset is very low. This is because rain clouds would usually only be present in an area when the weather was too turbulent to successfully collect data, so flights would be postponed until conditions improved. The affected area would typically be replaced with data from an adjacent line.

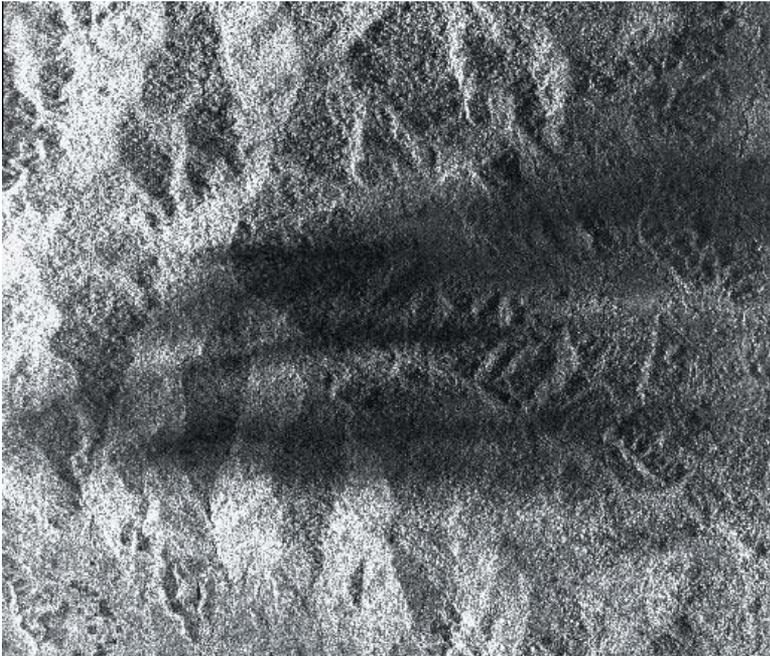


Figure 17: The effect of rain clouds can be seen as a darkening on the image in the region where the radar signal strength was reduced.

4.2.4 Signal Saturation

Signal saturation in radar is similar to taking a picture with a flash camera while standing too close to the subject. Too much light is returned to the camera and image detail is lost. The same applies to radar. If the return signal is too strong, it can overwhelm the digitizer and, rather than simply having an overexposed image, data loss occurs. Ideally, the gain control will be set to a level that is appropriate for a particular mission and the radar operator monitors this. However, this gain change can cause loss of detail in the low return areas, so it is not always easy to maintain a balance. As well, sometimes the signal strength changes faster than the operator can compensate (if the terrain changes abruptly, for example). Signal saturation is most often a problem over urban areas because of the strong return from buildings.

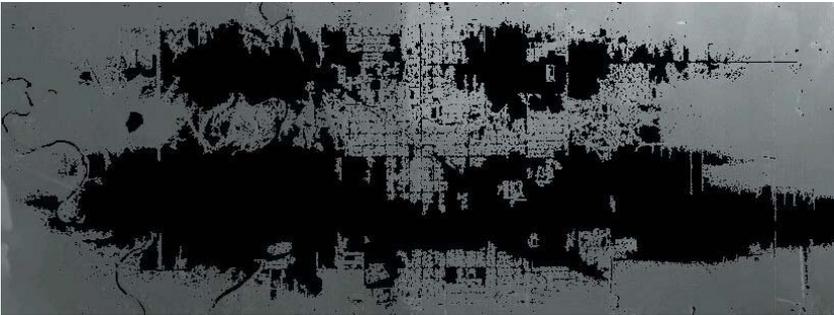


Figure 18: An example of signal saturation in a DSM

Figure 18 shows a DSM in which signal saturation has occurred. Intermap deals with this by generalizing the DSM across the affected areas, which means the vertical accuracies are slightly degraded in those regions. However, in many cases, the ORI data can be completely recovered, as shown in Figure 19.



Figure 19: Data recovery in areas of signal saturation

4.2.5 Motion Ripples

Motion ripples are the result of excess motion caused by turbulence in the aircraft that could not be properly compensated for within the processor. They can appear as height ripples in the direction of flight, and usually appear squinted (angled as opposed to being perfectly parallel). Motion ripples cannot be eliminated completely, but Intermap guarantees they will not exceed the quoted specifications for the products in which they may appear. Figure 20 shows examples of motion ripples.

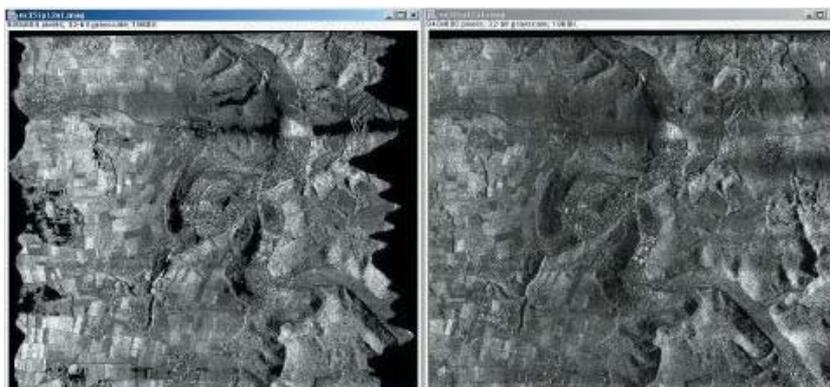


Figure 20: This example shows excess motion ripples (dark bands) in the two images. In the left image, the motion was severe enough to cause unrecoverable data loss.

4.2.6 Missing Islands

You may recall from the discussion in *4.0 Understanding IFSAR*, above, that interferometric radar relies on phase differences to detect changes in elevation. Because of the way these phase differences are processed, it is possible that small islands or peninsulas could drop out of an image. This can also occur with river bends and along coastlines.

In Figure 21, below, a causeway can be seen extending from the coast and apparently ending abruptly in the water.

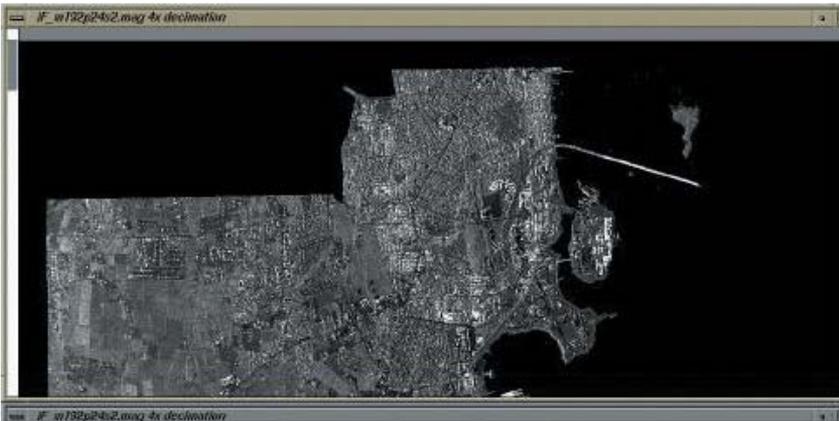


Figure 21: Data are missing from the end of the causeway shown in this image.

One of the steps in the production process involves checking a raw image against a processed image to ensure that nothing has been lost. In Figure 22, the island that is the destination for the causeway reappeared after the segment was reprocessed.



Figure 22: Reprocessed data from previous image, showing the missing areas

4.2.7 Missing Data

Sometimes small regions of data loss occur because of a processing problem in regions where the terrain is particularly steep. You may recall from the discussion in *4.0 Understanding IFSAR* that changes in phase difference between the two antennae and the same points on the ground make it possible to calculate the different elevations of those points. However, if the data processor is unable to confidently predict where certain areas are located against an absolute reference frame, it will leave them blank until it receives more information. To solve the problem, the operator gives the processor more seed points from surrounding areas to build a better elevation framework for placing the data that had previously dropped out. Figure 23 shows steep terrain along a coastal region where data loss on different scales has occurred.

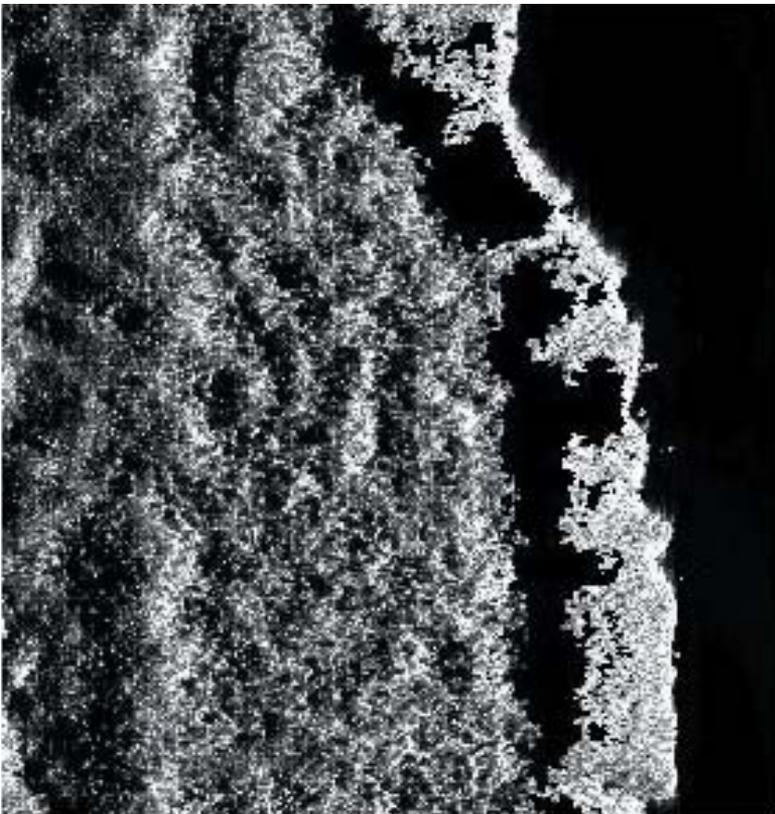


Figure 23: Data loss due to low correlation

4.3 Understanding Accuracy

To select the Intermap product that best matches your needs, it is important to understand how we arrive at the accuracy figures that we quote in *5.0 Core Product Specifications*. The purpose of this section is to explain how we tackle certain issues that inevitably crop up as part of any statistical analysis.

The vertical accuracy³ of the DSMs and DTMs, and the horizontal accuracy of the ORIs described in this document are specified in statistical terms. However, the conditions under which these specifications apply must be carefully defined. The statistical terms and the limiting conditions are described below.

Several types of products and associated accuracy specifications are created by Intermap's IFSAR systems. Trade-offs occur between desired accuracy and cost. In general, better accuracy implies greater cost, as it is associated with shorter GPS baselines, more stringent quality control criteria, lower flight altitudes, and possibly the introduction of additional ground control. The table in *5.0 Core Product Specifications* displays the vertical accuracy specifications associated with the three major DSM and DTM product types. Two points should be noted:

- These specifications represent upper limits on the achievable accuracy when tested under conditions as stated below—basically unobstructed, moderately sloped terrain. They incorporate the results of multiple tests in different situations against reference data of higher levels of accuracy (see *4.3.1 Statistical Measures*).
- They should be interpreted in the light of the explanatory information below which describes the statistical measures (next section) and the conditions under which they are valid, as well as the particular terrain and terrain-cover situations that may lead to larger errors (see *4.3.2 Validation Criteria*).

³As (potential) users of our products, you may very well ask: "What is the horizontal accuracy of your DEMs?" It is an Intermap (and the industry) practice to infer the horizontal accuracy associated with a DEM by assessing the horizontal accuracy of the corresponding ORI.

4.3.1 Statistical Measures

We provide some background on statistical measures. Every measurement of height h has an error $\tilde{\sigma}$ associated with it, and a common assumption is that these errors are normally distributed with zero mean. Under these assumptions, the standard deviation σ of the observed error distribution may be related to the probability that any single measurement will lie within $\pm \tilde{\sigma}$ (or some multiple of it) of the true elevation. For example, if it turns out that $\sigma = 1$ meter, then we would expect that $\sim 68\%$ of all measurements would be within ± 1 meter of the true elevations or equivalently, that 95% of all measurements would lie within ± 2 meters of the true elevations. Often the RMSE (Root Mean Square Error) is used as an approximation to σ , although as noted below, this is only valid in the case of zero (or sufficiently small) mean error. RMSE is calculated as $RMSE = \sqrt{\sum \tilde{\sigma}_i^2 / (N-1)}$, where $\tilde{\sigma}_i = (h - h_{true})_i$ and the summation is done over the N measurements. Under these assumptions, the mean error m is defined as $m = \sum \tilde{\sigma}_i / N = 0$.

Often, however, the governing assumption that the error distribution is normally distributed with zero mean is invalid. This is due to the presence of systematic errors that have not been totally removed and/or due to slowly varying errors over the area that is being sampled. Such an error could be caused, for example, by GPS errors either constant or variable. These can contribute to a “mean offset” or “bias” as they are sometimes referred to, in the statistical results over the sample area in question. In other words, the mean offset $m = \sum \tilde{\sigma}_i / N$ is non-zero, as illustrated in Figure 24. Using ground control, the mean offset can be removed from the dataset or at least reduced in magnitude. It should be noted, however, that the magnitude of such an offset would likely be dependent upon the extent of the area being sampled.

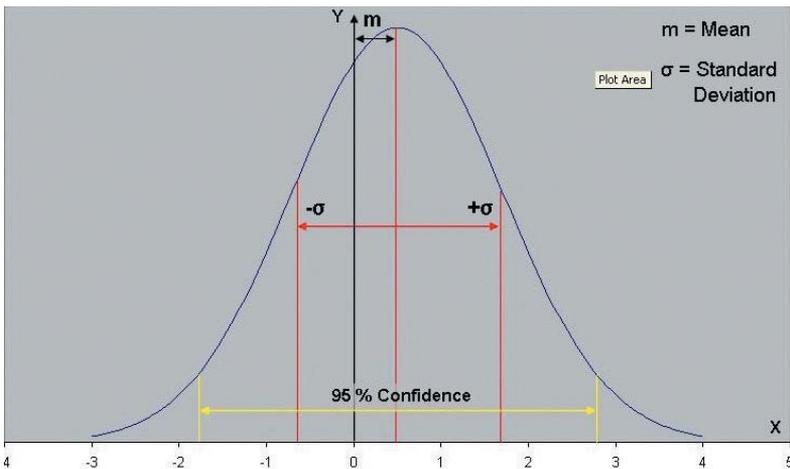


Figure 24: Error distribution with mean offset (m)

The standard deviation is more generally calculated as $\hat{\sigma} = \text{SQRT} (\sum (\hat{\sigma}_i - m)^2 / (N-1))$ and represents the relative part of the observed errors. As can be immediately noted, in the absence of any mean offset it becomes the same as the RMSE defined above. In fact it can be easily shown that $\text{RMSE}^2 \sim s^2 + m^2$ where the approximation is very good for large N. It should also be noted that the assignment of probability is with reference to s , not to the RMSE, so that attributing a 95%, 90% or 68% confidence level, based upon computed RMSE, which is the norm for the mapping industry, is not valid unless the mean offset, m is zero, or at least small compared to s . Internal studies of our DSMs indicate that the two error indicators are often of comparable magnitude and, depending on the size of the area being sampled, either one may be dominant. Moreover the distribution may not be normal as assumed.

This creates a dilemma in terms of reporting accuracy. In the technical literature, $\hat{\sigma}$, m and RMSE are often reported without reference to standard confidence levels. However, from a user's perspective, the notion that X % of the error measurements are within some specified upper limit is of particular interest. We address this dilemma in the following section.

4.3.1.1 Parameters Specified

In order to overcome this difficulty with respect to the specifications quoted in this document, we are reporting both RMSE and the 95 % (percentile) confidence level value, where the latter has been computed not from the probability distribution but simply as a percentile. For example, in a sample of 100 measurements, 5 or fewer measurements should be found with absolute errors larger than the error corresponding to the 95%, provided the tests are done according to the rules described below. This quantity turns out to be very close to $2 \times \text{RMSE}$ for offsets in the range usually observed, although it varies depending on the particular values of s and m . In section 5.0 *Core Product Specifications*, we also provide the upper limits of the mean offset m , and the standard deviation s that may be observed in any test situation.

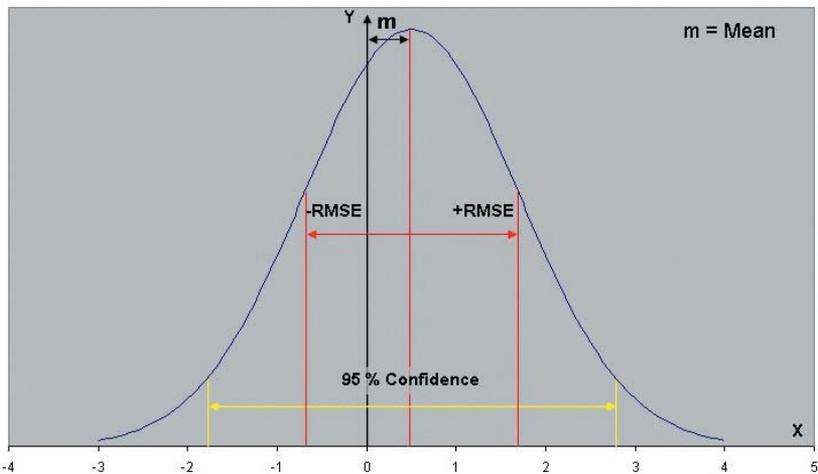


Figure 25: Error distribution with RMSE and 95% confidence level

4.3.1.2 Scale Effects in Statistical Sampling

Provided the particular error distribution remains the same over the total area of interest, the same statistical results should be observed irrespective of the size of the area sampled. This implies that intensive sampling of a unit as small, for instance, as 100 m x 100 m would generate the same results as those from an area 100 km x 100 km or larger. However, over small areas, the distribution may depart from that experienced on average over the larger area. This may occur because of spatially limited motion effects experienced by the aircraft or perhaps in small areas where the terrain reflectivity is exceptionally low. While it is possible to correct these problem areas in principle, it would obviously counter the economic benefits gained by having the large area data capture capability. Therefore, the specifications reflect the fact that, over the smallest mapping unit or tile delivered, the error distribution may differ from that of the project area as a whole.

Our NEXTMap Britain project is an example. The mapping unit we created is a 10 km x 10 km tile over a project area totaling more than 150,000 km². Where highly accurate ground-truth data were available, 17 random test sites each of 2 km in extent were intensively sampled across the region (according to the rules described in 4.3.2 *Validation Criteria*) and comparative statistics generated. In 16 of 17 test sites, the resulting RMSE results were well within the Type I specification. In one test site, however, the results were outside the specification in a localized sub-area owing to a platform motion error. This would be viewed as a statistically satisfactory outcome. Figure 26 is a graphical representation of a group of test sites falling within the 95% confidence level, in spite of a single test site falling outside.

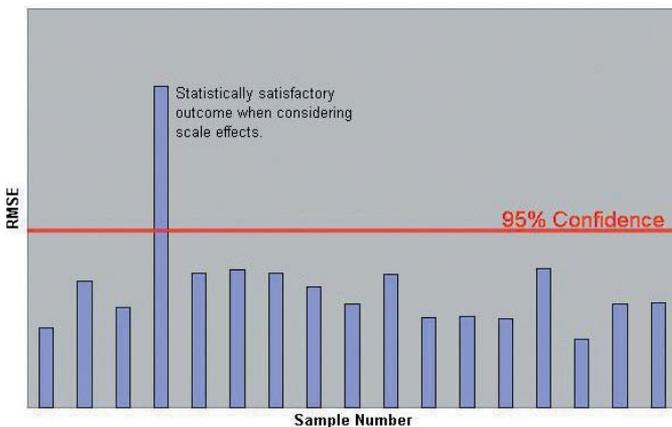


Figure 26: Small samples from a larger area show that scale can affect localized results, but the overall results for the entire area are still within the 95% confidence level.

4.3.2 Validation Criteria

Section 4.3.3 Test Rules for IFSAR DSM and DTM Validations describes the conditions under which the stated specifications are valid. These may be thought of as a statement of the fundamental accuracy (with a little “headroom” thrown in) of the system and the associated processes. It is important to understand the circumstances under which errors may be generated that are outside the stated specifications. Then a set of “validation rules” may be generated that describe the allowable circumstances under which testing or validation of the fundamental product accuracy may occur.

4.3.2.1 IFSAR Features that Affect the Accuracy of DSMs and DTMs

A DSM represents the scattering surface observed by the radar. (In other words, it is the first surface encountered by the radar pulse that returns a signal.) This scattering surface may include buildings and other structures as well as vegetation and bare ground. The DTM is “extracted” from the DSM. Basically, an automated process samples what the algorithm perceives to be as bare ground and an interpolative surface is then fit to these points to create a regular raster representing the “bald earth.” An interactive editing process modifies the points thus collected, so that the final DTM that is delivered has “blunders” removed by a skilled editor.

There are several potential sources of error that can exist in the DSM and the derived DTM. A few that are particularly important are noted here:

Radar “integration footprint”: Radar integrates over a square footprint somewhat larger (about 50%) than the 5-meter posting. Therefore, the DSM sample at that point will contain the effects of all the scattering objects within it. In other words, the DSM is a smoother surface representation in which an elevation structure that is finer than the post spacing is not represented. For example, if it contains bare ground and a raised object such as a structure or tree, both will contribute to the sample elevation. Similarly, if the sample is at the edge of a road, it may also contain the ditch at the side of the road. If the DSM sample is being compared with a ground control point (GCP) somewhere in the footprint, it may give an over-estimate or under-estimate of the elevation. Therefore, it is important that the GCP be in a situation of unobstructed, modest, and constant slope such as an open field or park. Figure 27 shows examples of areas that meet these criteria (red polygons). The blue polygon encloses an area that does not meet these criteria, and therefore, a GCP situated within it would be excluded as a point of comparison.

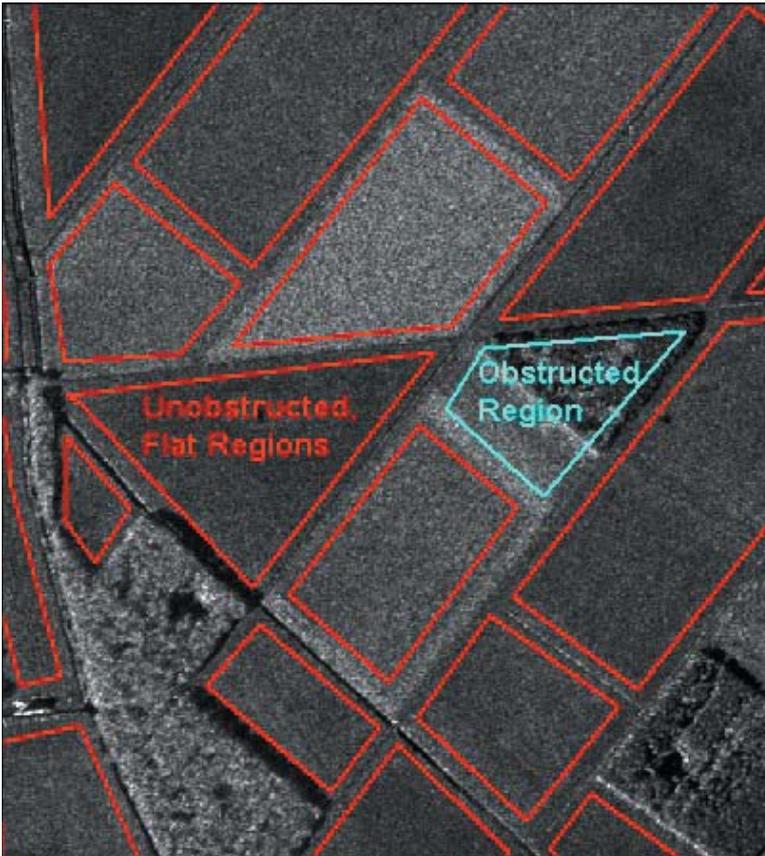


Figure 27: Unobstructed regions of modest and constant slope (red polygons) are suitable locations to test the data; regions such as the blue polygon, which are rough or obstructed, are not suitable.

Side-viewing geometry: Radar looks to the side of the aircraft with local incident angles (in flat terrain) of about $(45^\circ \pm 15^\circ)$. Therefore, in the direction perpendicular to the flight path there are shadow effects behind tall structures and layover effects in front. This has two consequences in urban areas:

- These areas are usually void of data, and interpolation is used for infill. These interpolations may have associated errors.
- In areas with narrow streets parallel to the flight line, the buildings may obscure the streets, so there may be no sampling of the bare earth in the street itself.

DTM-related issues: The bald-earth algorithm (proprietary software developed by Intermap called TerrainFit®) attempts to sample the DSM as densely as possible, in order to preserve the topographic features, while at the same time ensuring that it is sampling the ground rather than local minima such as flat roofs on buildings.

- If, as noted above, the ground is obscured by buildings over a large enough area (>100 meters in all directions), the algorithm will sample points intermediate between the buildings and the street, in the belief that they represent the bare ground. In these circumstances the DTM points will be above ground.
- A similar situation may occur in heavily vegetated (wooded) areas. In such situations, the algorithm will falsely sample local minima in the canopy, not necessarily on the ground. The algorithm is not designed to handle wooded areas of extent greater than ~100 meters in all directions.

The consequence of these two situations is the creation of “edge effects” near the boundaries of these areas where interpolation between true ground and falsely elevated points creates intermediate elevations. The transition zone is usually less than 25 meters horizontal.

Rapid changes in terrain: Changes in terrain at road or drainage embankments, for example, may not be preserved due to an inadequate sampling density. The effect is that the DTM interpolation process may cut across the terrain discontinuity creating local errors of 1–3 meters. The introduction of breaklines can solve this problem, but at the time of this release, an automated solution has not been implemented. Manual breaklines are introduced at the editing stage, but completeness is driven by project considerations.

Slope effects: Slopes greater than 10 degrees cause reduced accuracy. The impact depends on the magnitude of the slope, whether the slope is positive or negative, aspect angle, and where it lies in the radar swath (look angle). A general rule of thumb is that the error will double at slopes 20–30 degrees and will increase further as the slope increases.

4.3.3 Test Rules for IFSAR DSM and DTM Validations

There are generally three ways to create vertical accuracy validation statistics for radar-derived DTMs. Each has advantages and disadvantages, as discussed below.

Individual GCPs: The advantage of using individual GCPs is that they are usually high precision points (typically 5–25 cm RMSE) in x,y,z , tied in to first-order benchmarks. The disadvantage is that they are often relatively few in number and may not represent the spatial variability of the subject DTM over a range of conditions. Industry practice usually specifies a minimum of 25–30 GCPs uniformly distributed over the test area. Often the test area size is not referenced, so the remarks in section 4.3.1.2 *Scale Effects in Statistical Sampling* are worth noting. Figure 28 contains stars that represent a typical scattering of GCPs in part of a collection area.

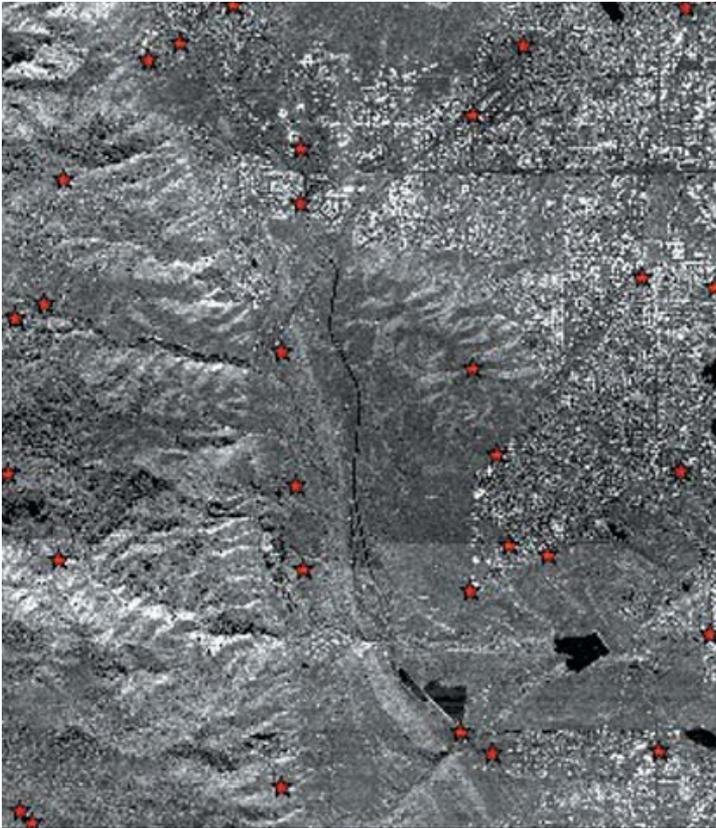


Figure 28: Red stars indicate a typical scattering of GCPs in a collection area.

GPS transects: It is possible to attach a GPS antenna to a vehicle and use kinematic differential processing to sample the roads over large areas quickly and relatively inexpensively. However, the results are usually less accurate than point measurements and are subject to intermittent GPS outages due to obscuration from bridge overpasses, overhanging trees, etc. More importantly, if the vehicle is constrained to roads, there will be an interpretation problem related to roadside ditches and radar obscuration by adjacent buildings and trees. This is due to the width of the radar footprint that will integrate over an area broader than the transect path. Therefore, it should be used in controlled circumstances only. The purple cross shown in Figure 29 represents multiple readings taken during a vehicle transect, with one or two isolated points also visible.



Figure 29: Purple points indicate locations used in completing a vehicle transect.

Higher-accuracy DSM/DTM: If an independent DSM or DTM is available that has a suitably high sampling density and accuracy, the comparative accuracy over larger, continuous areas of the Intermap product can be obtained. The disadvantage is the expense; however it may be possible to obtain smaller subsets and use them to characterize the performance of the radar DTM in a variety of conditions. Several of the validation exercises conducted by Intermap have used lidar-derived DSMs and their associated point sets as comparative “truth.” Of course, these systems have their own errors and anomalies, so care must be exercised.

Test site selection rules: The main rule is that the site on which test points will be acquired (individual GCPs or lidar ground points) should consist of *unobstructed, level, bare terrain*. A rough guide is that the site should be clear of objects within at least a 5-meter radius surrounding the desired test point location. The scattering surface within this circle should be flat or of uniform slope (less than 10°). In the case of lidar, because of its high sampling density and extent, it is easy to mask out areas where these constraints are not satisfied. They can usually be identified in the radar imagery, in the lidar DSM, and in ancillary photography.

An important additional rule is that data points in the radar shadow or layover region of buildings or wooded areas should be avoided by creating a buffer of width about twice the height of the buildings/woods.

Lastly, any area where interpolation has been required in the DSM due to low correlation will not provide representative statistics. These are usually areas within built-up urban areas where combinations of multi-path effects and obscuration will create reduced correlation and hence invalidate the specifications noted.

4.3.4 ORI Accuracy⁴

Because the ORI is produced as part of the interferometric process, conditions that introduce errors into the associated DSM will affect the ORI as well. Therefore, many of the remarks of the previous sections apply to the ORI. For example, the edges of buildings will not present the same level of horizontal accuracy that would be measured through use of a bright, point-like target such as a corner reflector (trihedral).

The validation method of choice is through the use of corner reflectors, which appear to return all the scattered energy from a single "point" (and can be surveyed to within a few centimeters). These are also used for validation of the spatial resolution of the system. This enables the horizontal location of the reflector to be checked to sub-pixel accuracy. Under test conditions in which corner reflectors are deployed in flat, unobstructed areas, the horizontal accuracy has been validated at the 2.0 meter RMSE level, where in this instance we refer to the circular error, which accounts for errors in the two-dimensional horizontal sense. If RMSE is calculated as $RMSE_c = \text{SQRT}(RMSE_x^2 + RMSE_y^2)$, where the x and y refer to the orthogonal spatial components of the error (for example in conventional easting and northing units), then we can also calculate a 95% probability, similar to that for the vertical errors. The circular case is more complicated, but it can be shown to be $CE(95) = 1.73 * RMSE_c$. That is, $CE(95)$ represents the radial distance within which 95% of the errors may be found. The problem related to offsets that was discussed in section 4.3.1 also applies in this case. Experience indicates that simply approximating $CE(95)$ as $2 * RMSE_c$ is adequate, and we do so in the specifications table.

⁴Note that an ORI is a 2D product and does not contain height/elevation information. Thus, only horizontal or planimetric accuracy can be assessed. Vertical accuracy information is described for DSMs and DTMs.

The star in Figure 30 denotes the center of a typical corner reflector as it appears in an ORI that has been enlarged 10 times.

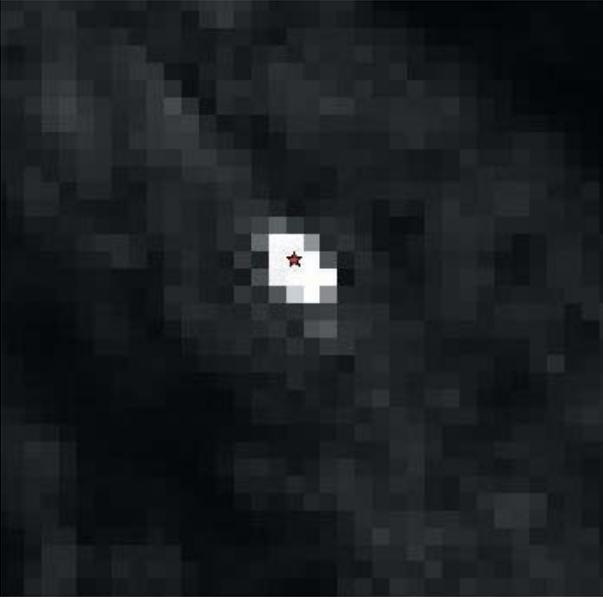


Figure 30: Corner reflector in an ORI, magnified by a factor of 10

It should be noted that an alternative validation method often employed is to use visible features such as road intersections that have been surveyed at their intersecting centerlines. While this is a useful approach, it will tend to overstate the apparent error. Or rather, the observed error is really a combination of the uncertainty associated with the identification of the centerlines, and the fundamental ORI pixel position error. The former uncertainty is dependent upon the nature of the features chosen and the feature-matching method chosen. Typical uncertainties of this nature are 2–3 pixels in magnitude. For this reason, the specification relates to the underlying accuracy derived from reflector tests.

4.3.5 Vertical Resolution

As mentioned previously, Intermap periodically compares its DSMs and DTMs to high-accuracy samples of elevation data that have been independently collected. These samples are taken from within larger areas that we have also flown. Using them, we are able to calculate the relative noise in our data and determine the *smallest possible changes in elevation* that can be identified when using our products. The threshold at which these changes are verifiable is defined as a difference in elevation that is *equal* to the *apparent* elevation differences caused by the relative noise of the data.

So from this it follows that, if you can measure the relative noise in the data, you are, in effect, measuring its *vertical “resolution”*—the *precision* with which the data can be used to identify the vertical relationship of one point *relative* to another. Any change in elevation that is greater than the threshold described above will be detectable in the data. A change that is less than the threshold will not be distinguishable from the relative noise. (By comparison, the vertical *accuracy* refers to how well the data conform to an *absolute* reference frame.)

In determining the relative noise level with respect to vertical accuracy of the DSM and DTM surfaces, the assumption is made that the “truth” data have a relative noise level of less than 10 cm (that they do not contribute significantly to the overall relative noise), and the difference histogram (between the truth data and the Intermap data) is approximately normally distributed. The different histograms in Figure 31 and Figure 32 show typical results with Intermap DSM and DTM data when referenced against sample data, confirming that the second assumption is valid.

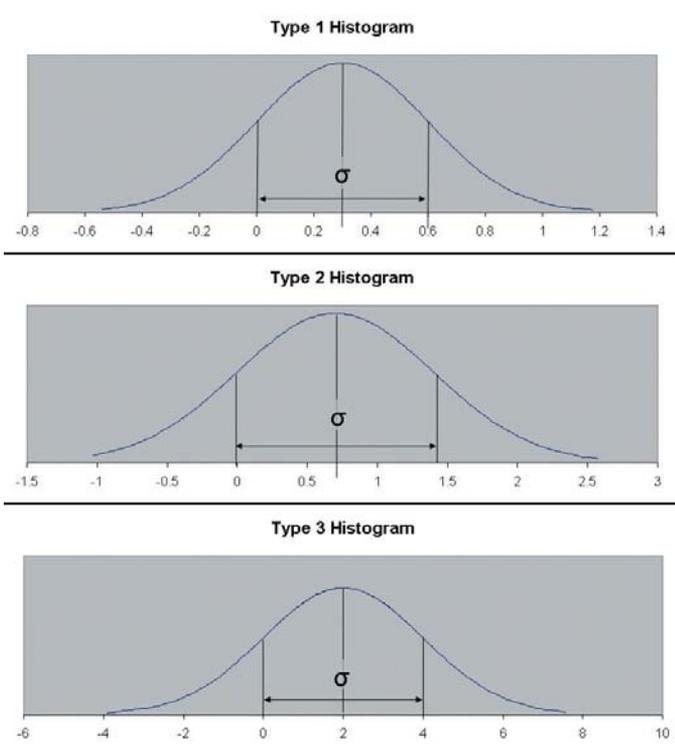


Figure 31: Typical DSM difference histograms

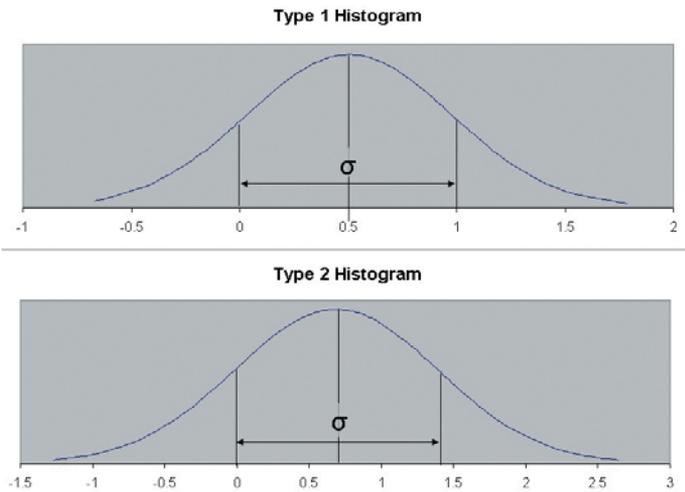


Figure 32: Typical DTM difference histograms

Understanding IFSAR

Based on these assumptions, the relative noise level can be simplified to plus or minus the standard deviation. In Figure 33 and Figure 34, below, the error bars represent the elevation range such that any change in height will be distinguishable outside this range.

It can be seen that it is possible to distinguish differences in elevation that are in excess of the uncertainty bars shown in the graphs. For example, a Type I DSM (0.5 m RMSE) has a vertical accuracy of 1 meter. However, it is possible to detect changes in elevation of 0.3 m or greater, because it has a relative noise level of only ± 0.3 m. So the height difference in the DSM figure, below, would be detectable with a Type I DSM. Similarly in a Type II DSM (1.0 m RMSE) it is possible to detect changes in elevation of 0.6 m or greater, because it has a relative noise level of only ± 0.6 m. However, the same height difference would not be detectable with a Type III product, because the relative noise exceeds the change in elevation (i.e., the purple uncertainty bars overlap each other). It should be further noted that subtle elevation features that are persistent over extended areas (trenches, for example) might be detected in shaded relief or other visualizations owing to the integration effect of the observation.

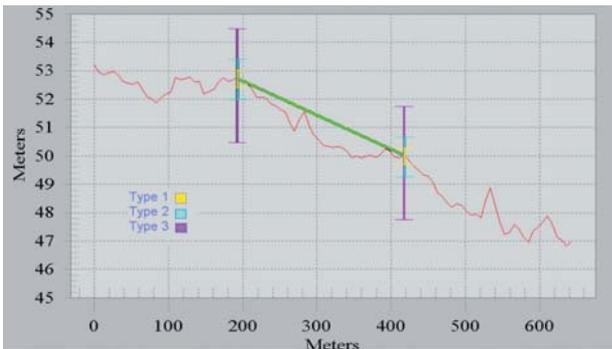


Figure 33:
DSM relative noise

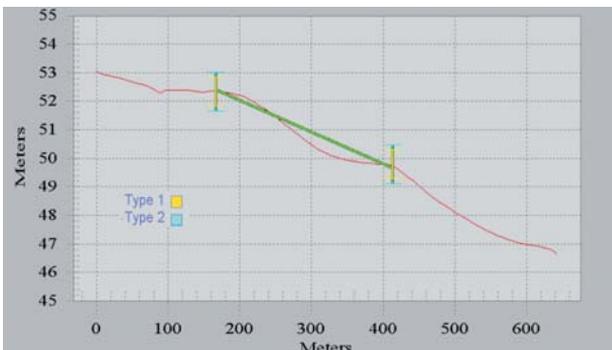


Figure 34:
DTM relative noise

4.4 Datums and Coordinates

Even though we tend to think of the earth as a sphere (or at least as a regularly shaped object), it is in fact an irregular body. These irregularities do not affect navigation over short distances or where coarse scale maps are involved. However, they are significant headaches for geographers attempting to develop reference systems that map from the real world to a two- or three-dimensional representation in an acceptably accurate fashion. The definition of “acceptable” has, of course, increased in stringency over the past several hundred years and has given rise to a profusion of techniques for ensuring location measurements are as accurate and useful as possible. This section begins with some definitions and then explains how we realize and select datums and coordinates at Intermap. Refer to *5.0 Core Product Specifications* for specific information on the datums and coordinates we use at Intermap.

4.4.1 Definitions

A **reference ellipsoid** is a geometric approximation to the surface of the earth. It is defined as an ellipsoid of revolution (obtained by rotating an ellipse about its shorter axis), with parameters that are selected such that it best fits the shape of the earth for use as a convenient reference surface.

A **global geodetic datum** is a framework that enables us to define the location of points anywhere on the earth. The framework can be thought of as the combination of a reference ellipsoid and of some parameters that define the spatial relationship of that ellipsoid with respect to the earth.

The **coordinate** is an expression of location. When expressed in a useful datum, it provides a unique and meaningful statement of the position of a topographic feature. When a global geodetic datum is used, the coordinate is expressed as latitude, longitude, and ellipsoidal height.

It is also possible to express the horizontal coordinates in a two-dimensional representation, known as a **projection**. Projected coordinates are used to specify position with respect to a map, and usually as a northing and easting.

Today, the term **horizontal datum** is often used synonymously with the horizontal components of a geodetic datum, corresponding in coordinate space to the latitude and longitude.

A **vertical datum** can be thought of as a reference surface for the height component of a coordinate. Although a geodetic datum defines a reasonable vertical datum (e.g., via the ellipsoid), the height reference at Intermap is defined by a surface known as a **geoid**. The resulting height is known as an **orthometric height**, which, as shown in Figure 35, is more physically meaningful than the corresponding ellipsoidal height because water flows downhill.

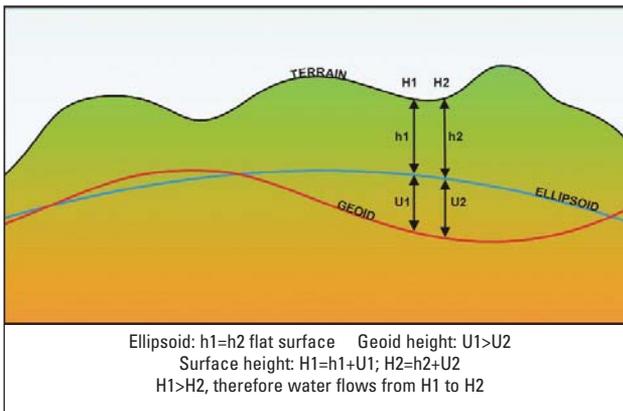


Figure 35: The ellipsoid and the geoid as reference surfaces

4.4.2 Selection and Realization of Datums at Intermap

General criteria for the selection of datums at Intermap are named in this section. Because of the importance of height information, the selection of datums is driven by criteria in the vertical. These include the need for a physically meaningful vertical datum, the vertical accuracy requirements, and that the datum is realizable and accessible across the region of interest. As such, a geoid model gives the vertical datum for all core products. Further, preferred are regional or national standard geoid models that meet the above criteria.

The selection of geodetic (horizontal) datums is driven by the requirements to:

- Be consistent with the selected vertical datum.
- Be geocentric, accessible, realizable, and consistent across the region of interest.
- Be tectonic plate-fixed.

As such, the geodetic datum is realized via the terrestrial reference frame that best meets the above criteria.

It is noted that in the absence of suitable regional or national datums, the vertical datum is realized through the use of the globally applicable geoid model that best meets the above criteria, and the geodetic datum is realized through a compatible terrestrial reference frame.

This chapter describes our ORI, DSM, and DTM core product specifications. Chapter 6.0 *Introduction to Applications* contains information regarding alternative products and formats that we offer through our value-added services. The Intermap Web site (www.intermaptechnologies.com) describes our products created prior to January 2002. The specifications in this chapter are organized as follows:

- General specifications—applies to all products and includes
 - Datums
 - Projections
 - File origin definition
 - Metadata
 - Data delivery, including naming conventions and file size
- ORI specifications
 - Accuracy
 - Feature content
- DSM and DTM specifications
 - Accuracy
 - Feature content

It is important to note that we have one accuracy specification for ORIs, which is a horizontal accuracy. Three levels of accuracy are reported for DSMs and two for DTMs. These are shown in Table 3.

Core Product	Given as
ORI	2 m RMSE or 4 m CE(95) (definitions of horizontal accuracy)
DSM	Type I, II, III (definitions of vertical accuracy)
DTM	Type I, II (definitions of vertical accuracy)

Table 3: Core product accuracies (refer to Table 9 and Table 10 for Type definitions)⁵

⁵ Note that the Types described here refer to vertical accuracy only and therefore do not apply to ORIs. Likewise, horizontal accuracies are given for ORIs only, and therefore are not reported in DSMs or DTMs.

5.1 General Specifications

The geodetic specifications that are part of our core products are described below. Note that other datums and projections are available on a value-added basis.

5.1.1 Datums

The vertical datums and horizontal datums are listed in Table 4.

Region	Vertical Datum (Geoid Model)	Corresponding Horizontal (Geodetic) Datum
UK	ODN (OSGM91)	ETRS89
USA	NAVD88 (Geoid99)	NAD83
Canada	CGVD28 (GSD95)	NAD83
Australia	AHD (AUSGeoid98)	GDA94
Elsewhere	(EGM96)	ITRF2000

Table 4: Vertical and horizontal datums for core products

5.1.2 Projections

In all cases, the vertical coordinate of the core product is an orthometric height with respect to the surface implied by the geoid model. Units are meters. The horizontal coordinates of the standard core product are provided in either geographic coordinates (latitude/longitude) with units of degrees or as northings/eastings in meters.

Region	Available Projection	Unit
UK	OSGB36 (as derived from OSTN97)	degrees/meters
USA	UTM or State Plane	
Default	UTM	

Table 5: Standard projections for NEXTMap core products

5.1.3 File Origin

File origin for all core products is the upper-left corner of the upper-left pixel. Coordinates of the file origin are published in the header information. Intermap follows the industry standard on file origin by treating the ORI as area-based, while the DSM is treated as point-based, and is therefore center-referenced. The two are related to each other in the manner shown in Figure 36, below. The effective areas (boundary of the red square) are equivalent.

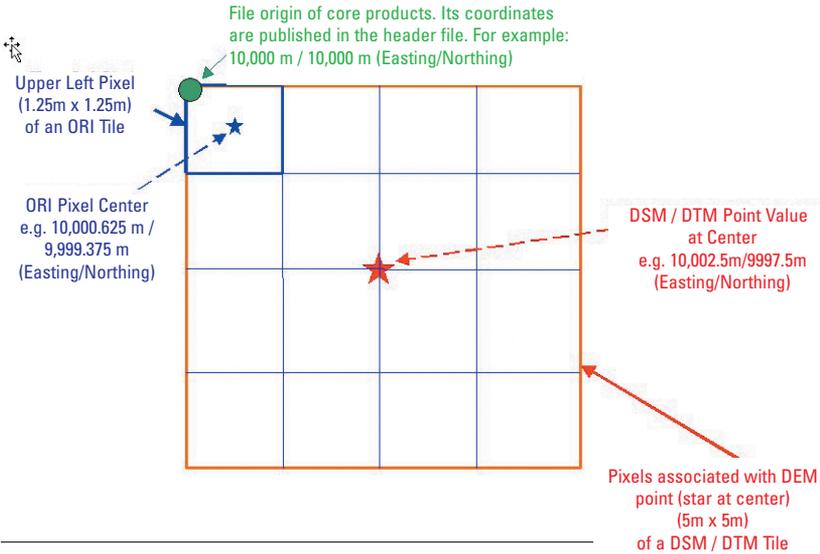


Figure 36: File origins for Intermap core products

Standard formats for metadata files, including HTML, XML, and flat ASCII, are supported. These formats can be generated, so they comply with a number of widely recognized standards, including FGDC.

The following is a list of core product attributes that Intermap stores in the database:

- Intermap Project Number
- Project Manager
- Country
- Task Order Number
- Project Area
- Version (Issue Identification)
- Product Level
- Product Level Accuracy (meter RMSE)
- Acquisition Start Date (YYYYMMDD)
- Acquisition End Date (YYYYMMDD)
- Publication/Process Date (YYYYMMDD)
- Horizontal Accuracy (meters (1 sigma))
- DSM Vertical Accuracy (meters (1 sigma))
- DTM Vertical Accuracy (meters (1 sigma))
- Flight Height
- Primary Look
- Secondary Look
- Mission #(s)
- Phase Unwrapper
- Look (Primary or Secondary)
- Horizontal Datum
- Vertical Datum
- Projection
- Ellipsoid
- Spheroid
- Alternative/Forced Zone
- EULA

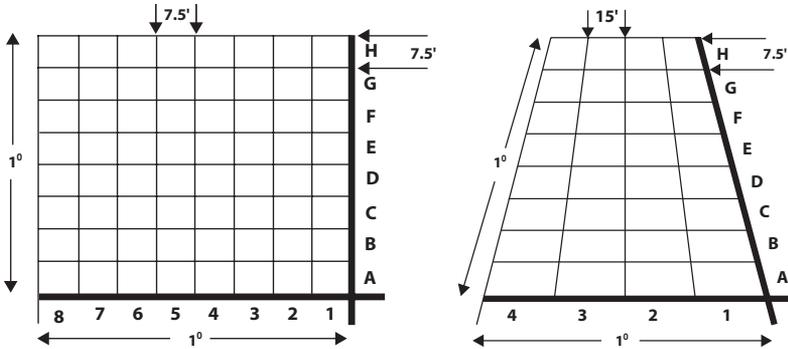
5.1.5 Data Delivery

This section describes the file naming conventions, file sizes, and file formats of our core products.

5.1.5.1 Delivered File Naming Conventions

Orders are delivered in either a database or file containing the complete area of interest (AOI) or in a tiled format. For orders that are requested in tiled format, the naming convention is based upon a 1° X 1° block of tiles. The name contains the latitude and longitude at the lower right hand corner of the block, followed by row (letter, increasing north) and column (number, increasing west). Tile width is doubled to 15' above 56° latitude to compensate for the convergence of the lines of longitude as they approach the poles. This is illustrated in Figure 37, which also shows how the area of the tiles varies as a function of latitude.

(Note that Intermap's pricing is based on a per-square kilometer charge, not on a per-tile charge.)



Latitude (North or South)	Average Tile Area (sq. km.)
0 to 8	197.4
8 to 16	197.4
16 to 24	196.6
24 to 32	188.7
32 to 40	179.8
40 to 48	163.1
48 to 56	145.0
56 to 90	123.2

Figure 37:
Block widths are 7.5' (left) below 56 degrees latitude (center) and 15' above

A folder is created for each tile that is delivered, and each folder contains all files pertaining to the tile. The files are named according to the standard format and type of delivery, with an extension that indicates the contents of the file. These extensions are listed in Table 6.

Extension	Contents
*.BIL	DSM or DTM data in 32-bit floating point binary grid format
*.TIF	ORI in 8-bit unsigned GeoTIFF format
*.html	Metadata in HyperText Markup Language (HTML) format—FGDC compliant standard
*.xml	Metadata in eXtensible Markup Language (XML) format—FGDC compliant standard
*.txt	Metadata in ASCII text

Table 6: Intermap data file extensions

Alternative file formats such as ESRI's ArcASCII grid (*.adf) are available as a value-added service. For example, had you ordered the tile named N32W117G3, you would find a folder of that name created on the delivery medium. The folder would contain all the files related to the tile, named as follows:

- N32W117G3DSM1.BIL—for a Type I DSM product
- N32W117G3DTM1.BIL—for a Type I DTM product
- N32W117G3ORI.TIF—for the ORI product
- N32W117G3Met.html—for the metadata in HTML format, etc.

Delivery of any dataset comprised of a specific area of interest (not comprised of standard tiles) will follow a customer-derived or operator-derived naming convention that provides a descriptive reference to the source area.

5.1.5.2 File Sizes

We process data in production units called blocks and tiles. However, we sell products based on the number of square kilometers in an order. The combined file size for a complete dataset (ORI, DSM, DTM, and metadata) is nearly one megabyte per square kilometer.

The breakdown, per 100 square kilometers, is as follows:

- DSM and DTM products are approximately 16 MB each
- Corresponding ORI is 65 MB

Intermap supports the following standard data delivery media based on file size:

- Internet for < 100 MB
- CDs for < 4 GB
- DVDs for > 4 GB and < 20 GB
- USB hard disc for > 20 GB.

5.2 ORI Specifications

5.2.1 Accuracy

Table 7 gives the horizontal accuracy specifications for Intermap ORI. (Vertical accuracies are derived from the DSMs and DTMs, below.) These specifications are only valid for specific conditions, which are defined in *4.3 Understanding Accuracy*. Refer to this section for an explanation of the methodology used to calculate these values.

Pixel Size (m)	RMSE (m)	CE (95) (m)
1.25	2.0	4.0

Table 7: ORI accuracy specifications (verified using corner reflectors)

5.2.2 Feature Content

The ORI feature content is identified in Table 8.

Feature	ORI Characteristics
Dynamic range	ORI will be optimally stretched to take advantage of 254 gray levels based on a standard histogram of the whole acquisition area.
Specific pixel values	"0" is reserved for NULL data where original radar imagery was not acquired—typically water areas that were not imaged by the sensor. "1" is reserved for those pixels where the sensor imaged data but could not resolve the returned signal. This typically occurs in disparate locations and is usually only a few pixels in extent.
Radiometric balance	An antenna pattern correction will be applied and an image tonal balance (gain and contrast) will be achieved for overall "acquisition boundary" areas. Adjacent swaths and segments will be balanced such that apparent radiometric differences across seam lines are minimized.
Re-orthorectification with the final processed DTM	To improve the geometric accuracy and visual quality of the ORI core product, it is recommended that a re-orthorectification with the final processed DTM be conducted as a value-added service.

Table 8: ORI feature content

5.3 DSM and DTM Specifications

Fully populated grid files represent the elevation models. In the event that the sensor was not targeted at the surface, the values in the grid for this area are set to -10,000, otherwise known as the NULL data value. Where the sensor was targeted at the ground but no return signal was received, the elevation is interpolated from the surrounding terrain. The location of these areas of interpolation is identifiable in the correlation file, optionally available from Intermap.

5.3.1 Vertical Accuracy

Table 9 and Table 10 give the accuracy specifications for Intermap DSMs and DTMs. These specifications are only valid for specific conditions, which are defined in section 4.3 *Understanding Accuracy*, above, explaining the methodology used to calculate these values. Note that Type III products are not available for DTMs—hence only Type I and II are shown. The values in the tables are depicted graphically in Figure 38. Note that the horizontal accuracy of the DSM and DTM core products are inferred by the horizontal accuracy (2 m RMSE or 4 m CE (95) of the corresponding ORI).

The standard deviation associated with each type of DSM or DTM can be used to determine relative differences in elevation. Refer to *4.3.5 Vertical Resolution* for more information.

Product Type	Measures of Accuracy			
	Specifications		Nominal	
	RMSE	95%	Mean	Standard Deviation
I	0.5	1.0	0.3	0.3
II	1.0	2.0	0.7	0.7
III	3.0	6.0	2.0	2.0

Table 9: DSM vertical accuracy specifications (units in meters)

Product Type	Measures of Accuracy			
	Specifications		Nominal	
	RMSE	95%	Mean	Standard Deviation
I	0.7	1.5	0.5	0.5
II	1.0	2.0	0.7	0.7

Table 10: DTM vertical accuracy specifications (units in meters)

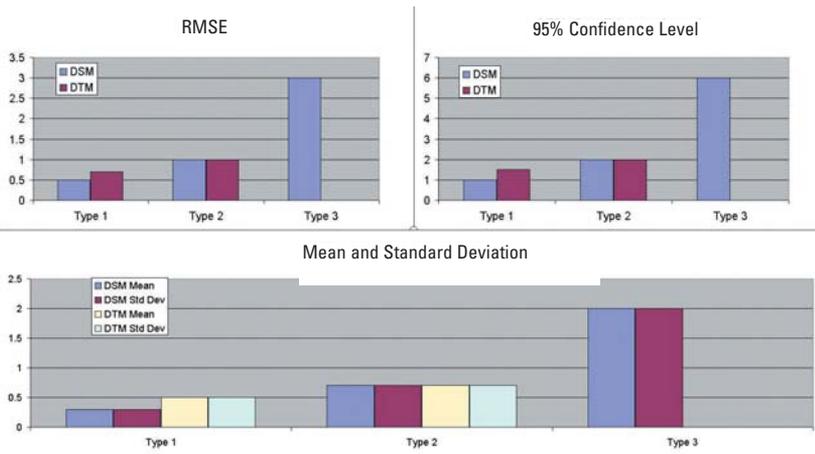


Figure 38: Vertical accuracy measures for core products, grouped by type

5.3.2 Feature Content

Due to the nature of radar, Intermap needs to edit features to some extent in the DSM and the corresponding DTM. To ensure products are consistent, well-defined rules have been established and are abridged in Table 11, below. The abridged version below does not include all exceptions and are provided as a guide only. In some cases, ancillary data are required to aid in feature identification. The complete edit rules are available to all Intermap clients and form a part of the contract for data. The edit rules also indicate where ancillary data are required to support the elevation model editing.

Features	Definitions	Characteristics	Core Product Type I & II	Core Product Type III	NEXMap Britain	NEXMap Indonesia, Vanuatu, Solomon Islands	NEXMap USA
Lakes	Greater than 400 m ² in area	DSM: Lakes will be leveled to a single elevation (expressed to the nearest 0.1 m) based on the water elevations and the surrounding shoreline.	√	√	√	√	√
		DTM: Extents and elevations of lakes will be the same as those in DSM.	√	√	√	N/A ¹	√
Rivers	Greater than 20 m in width AND greater than 400 m in length	DSM: Rivers will be flattened in a stepped fashion with a 0.1 m step factor to ensure a monotonic flow based on the river elevations and the surrounding shorelines.	√	√	√	√	√
		DTM: Extents and elevations of rivers will be the same as those in DSM.	√	√	√	N/A	√

Core Product Specifications

Features	Definitions	Characteristics	Core Product Type I & II	Core Product Type III	NEXTMap Britain	NEXTMap Indonesia, Vanuatu, Solomon Islands	NEXTMap USA
Streams	Less than 20 m in width AND greater than 1 km in length	DSM: Streams will not be delineated in the DSM.	√	√	√	√	√
		DTM: Elevations along the stream will be modified to maintain the monotonic flow within the vertical accuracy limit of radar elevation data.	√	√	√	N/A	√
Oceans	All oceans and nearby mudflats and tidal areas	DSM: Oceans will be flattened at 0 m elevation. Ocean shoreline will be delineated at the water shoreline visible in the ORI.	√	√	√	√	√
		DTM: Extents and elevations of oceans will be the same as those in DSM.	√	√	√	N/A	√
Islands	Greater than 400 m ² in area	DSM: Elevations will have the first surface nature in the DSM on the islands.	√	√	√	√ ²	√
	Smaller islands may not appear	DTM: Elevations will have the bare earth nature in the DTM on the islands	√	√	√	N/A	√

Core Product Specifications

Features	Definitions	Characteristics	Core Product Type I & II	Core Product Type III	NEXTMap Britain	NEXTMap Indonesia, Vanuatu, Solomon Islands	NEXTMap USA
Bridges	Bridges over streams, rivers, lakes and oceans	Water levels and river monotonicity shall be maintained irrespective of the presence or absence of bridges. Once water elevations are determined, bridges then interrupt monotonicity of rivers. Bridges will be classified and edited to the correct elevation to the width of the edited transportation feature. If the bridge does not support a road or railway feature, the edit will take place on any bridge greater than 20 m in width.	√	√	x√ ³	√ ⁴	√
	Bridges over roads						
	Bridges holding water (aqueducts)		√	√	N/A ³	N/A	√
Buildings	All buildings	DSM: All buildings will exist in the DSM as sensed by radar. However, due to the nature of IFSAR, buildings (heights and edges) may not be well defined.	√	√	√	√	√
		DTM: Buildings will be removed where possible. Urban clutter will be removed. Buildings in outlying areas obscured by vegetation may still be present in the DTM.	√	√	√	N/A	√

Features	Definitions	Characteristics	Core Product Type I & II	Core Product Type III	NEXMap Britain	NEXMap Indonesia, Vanuatu, Solomon Islands	NEXMap USA
Trees	Isolated trees, clump of trees, tree rows, and forests	DSM: Trees will be in the DSM as sensed by radar.	√	√	√	√	√
		<p>DTM: Single trees, small clumps of trees and tree rows will be removed.</p> <p>Trees include all types of vegetation that stand alone, in clumps, rows and areas that are fully encompassed in a circle of radius 50 m will be removed.</p> <p>Any treed region that exceeds a circle of radius of 50 m in all directions will not be removed. Any treed region attached to this region that does not exceed a circle of radius 50 m in all directions will be removed.</p>	√	√	√	N/A	√
Major Roads	Highways equal or greater than 30 m in width (shoulder to shoulder)	DSM: Major roads will be flattened from shoulder to shoulder.	√	√	N/A ⁵	N/A ⁵	√
		DTM: Extents and elevations of major roads will be the same as those in DSM.	√	√	√	X	√

Core Product Specifications

Features	Definitions	Characteristics	Core Product Type I & II	Core Product Type III	NEXTMap Britain	NEXTMap Indonesia, Vanuatu, Solomon Islands	NEXTMap USA
Railways	All railways	DSM: Railways will be flattened to a 10 m width.	√	√	N/A ⁵	N/A ⁵	√
		DTM: Extents and elevations of railway will be the same as those in DSM.	√	√	√	N/A	√
Airports	All airports supported by ORI	DSM: Runways, aprons and taxiways will all be smoothed. Runways will follow the lay of the land.	√	√	√	√	√
		DTM: Extents and elevations of airports will be the same as those in DSM.	√	√	√	N/A	√
Utility Features	Transmission towers, poles, lines	DSM: These features will remain in the DSM if sensed by the radar.	√	√	√	√	√
		DTM: These features will be removed in the DTM. In some circumstances such as proximity to large wooded areas or buildings, these features may not be completely removed.	√	√	√	N/A	√

Features	Definitions	Characteristics	Core Product Type I & II	Core Product Type III	NEXTMap Britain	NEXTMap Indonesia, Vanuatu, Solomon Islands	NEXTMap USA
Flood Defenses	Dykes and other structures built for flood prevention	DSM: As sensed by the radar	√	√	√	√	√
		DTM: Will be preserved if supported by radar elevation data.	√	√	√	N/A	√
Piers and Docks	Structures built into water for landing and loading	DSM: Piers and docks will be removed if they are not supported by radar elevation; otherwise, they will remain as sensed by radar.	√	√	√	√	√
		DTM: Same as DSM	√	√	√	N/A	√

Table 11: DSM and DTM feature content

Notes:

¹ NEXTMap Indonesia, Vanuatu, Solomon Islands projects are only for DSMs. No DTMs are involved.

² Size independent. However, the islands that are included in the DSM must be visible in both the ORI and DSM.

³ All bridges are removed from the DTM based on the NEXTMap Britain project specifications. In DSMs, bridges over rivers are removed while bridges over streams remain. However, no manual efforts are involved to bridge editing except for manual depression/spike removal.

⁴ All bridges in NEXTMap Indonesia, Vanuatu, Solomon Islands projects are kept as radar sensed. No manual efforts are involved to bridge editing except for manual depression/spike removal.

⁵ Roads/railways are not flattened in the DSMs.

Introduction to Applications

Intermap's image and elevation products provide a fundamental base layer for many geospatial applications. Our core products can be used directly (without further processing) in many of these applications. Specific client requests that go beyond our core products are fulfilled as value-added products or services.

This section discusses applications in which both types of products have worked well in the past. Through all of this, it is important to note that the scale of your particular application, as well as the tools and processes you are using, can directly impact the suitability of our data.

6.1 Core Product Applications

Flood modeling/watershed analysis: As a primary application of Intermap's DTM core product, great care is given to the representation and editing of hydrology and flood defense features. Our value-added service offering supports requests regarding the editing and modeling of individual features to support specific hydrology applications. The image below indicates an ORI of Eastern Shrewsbury, England, that was produced specifically in support of producing flood insurance maps for Norwich Union Insurance.



Figure 39:
Flood hazard
example

Overlaying our DTM data onto the ORI of the area generated the shaded area of a flood plain in Eastern Shrewsbury, England.

Topographic mapping: A natural extension of the DTM elevation data is the production of contour maps or specific spot heights. Intermap's core DTM products support the generation of contours as outlined in Table 12. Vertical accuracy of contours generated from the core DTM products can be one-half of the contour interval. So for example, if the contour interval is 1.5 m, the vertical accuracy is within 0.75 m of truth.

DTM Type	Supported Contour Interval
I	1.5 m
II	3.0 m

Table 12: Contour intervals, by product type

Image rectification: A DTM is needed to remove terrain relief-induced image displacement during the orthorectification process. Intermap's core DTM products can support a final orthoimage scale up to 1:4,800 (1" = 400') and smaller when using high-resolution optical satellite imagery. Final orthophoto products at a scale of 1:2,400 (1"=200') and smaller are supported when aerial photography with sufficient side and forward overlap is available.

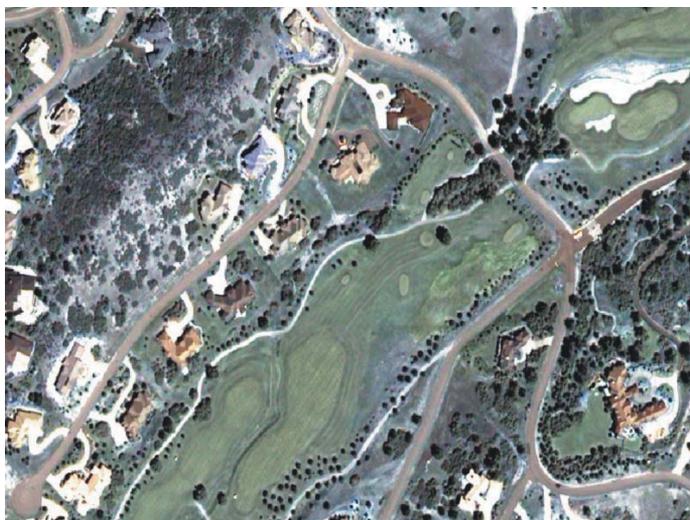


Figure 40: Orthorectified image

This example of Castle Rock, Colorado, features a Digital Globe Quickbird .7-meter image orthorectified with an Intermap DTM.

Base mapping: Because of the underlying geospatial accuracy and orthorectification (every pixel is properly represented with a x, y, z coordinate), the ORI core product provides an economical data layer in areas where aerial photography or cloud-free satellite imagery is not readily available. In addition, ground control coordinates of identifiable features (such as road intersections) can be extracted from the ORI to assist with the georeferencing of complimentary data layers.

Three-dimensional visualization: “Traditional” 3D visualization applications, involving the draping of thematic or place-specific data over 3D landscapes, are primarily associated with such activities as land use planning (visual impact of new development), in-office viewing of real estate properties, and virtual tourism. When fused with appropriate imagery layers, Intermap’s DSM products provide the base data layer for such applications.



Figure 41: 3D visualization

A Space Imaging 1-meter pan-sharpened IKONOS satellite view was draped over an Intermap DSM to create this 3D perspective of Morrison, Colorado.

Vehicle navigation/intelligent vehicle systems: Numerous programs within the automobile industry need high-resolution 3D-enabled roadway network databases that are supported by Intermap’s elevation and image products. Some examples are turn-by-turn in-car navigation, road departure collision avoidance programs, vision enhancement products, and adaptive cruise control and related warning and control systems.

Flight simulation/in-cockpit situational awareness: Three primary applications of Intermap's core products can be found in the aviation industry: interactive 3D approach charts and flight planning tools; in-cockpit synthetic vision, situational awareness and Terrain Avoidance Warning Systems (TAWS); and flight simulators.

Location-based systems: There is a trend toward embedding various handheld and broadband wireless communications devices with a range of 3D rendering and position tracking capabilities. For many applications, a 3D interface and supporting 3D data enhance both the understanding and usability of the data. This type of next-generation interface requires 3D terrain at resolutions supported by Intermap's DSM and DTM products.

Precision farming/forestry: Slope and aspect derived from Intermap's elevation and image products are well-suited to support various agricultural and forestry applications, such as the following:

- Farm boundary delineation within major domestic crop producing areas
- Conservation planning/wetland delineation
- Monitoring subsidy programs associated with slope or challenged terrain
- Inventory assessment
- Watershed management programs
- Erosion run-off and nutrient management plans, such as Concentrated Animal Feeding Operations (CAFOs), variable rate planting, and fertilizer application plans

6.2 Value-Added Products

We at Intermap are happy to work with you to provide value-added products and services to optimize the fit of our data to your particular application. For example, we can help you develop specific tools to match your processing needs. Or we can discuss changes to our own data finishing processes to shift the emphasis we normally place on the finalization of our core products. Pricing is negotiated on a per-project basis, using core products and readily available technology to the fullest extent possible.

We are always ready to work in new and challenging areas, but here is how we are frequently called upon to provide value-added assistance:

STARplus upgrade: We create this product by combining an Intermap ORI with a Landsat 7 image. The colorized final product preserves the classification capabilities of the Landsat 7 image, while maintaining the spatial accuracy of the Intermap ORI.

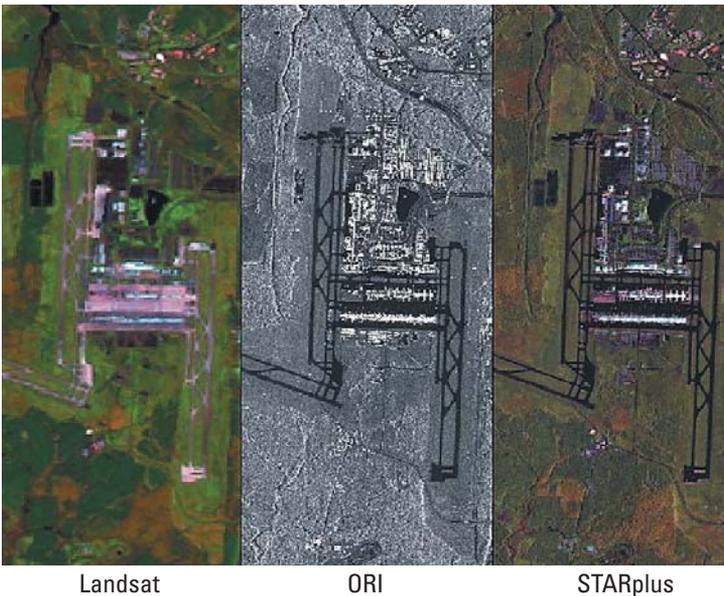


Figure 42: STARplus example

These images of Dulles International Airport illustrate the sharpening that is possible when a color Landsat 7 image is merged with an Intermap radar image. The resolution of our radar image, center, is much richer in detail—clearly showing the location of buildings, runways and other features, while retaining the multispectral characteristics of the Landsat 7 image.

Topographic line map (TLM): A map showing major features such as hydrology, major transportation, and political boundaries is commonly referred to as a topographic line map. This type of planimetric mapping, with features extracted from Intermap's ORI, can be produced at a scale of 1:4,800 and smaller.



Figure 43: Topographic line map example

In this image, a topographic line map of Jobos, Puerto Rico, was created by extracting features from the Intermap ORI.

Surface analysis applications: Our core products are well-suited to the following surface analysis and viewshed applications:

- Contouring
- Creation of profiles and cross sections
- Determination of spot heights
- Line-of-sight calculations
- Viewshed analysis
- Determination of flow lines
- Creation of slope and aspect maps
- Area and volume calculations
- Distance measurements

We can provide these services to you or provide the tools that enable you to make full use of the data.

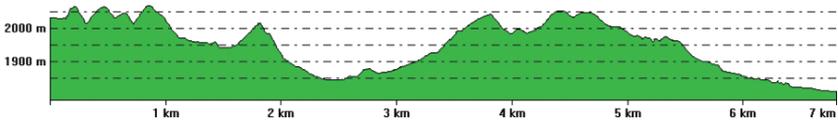
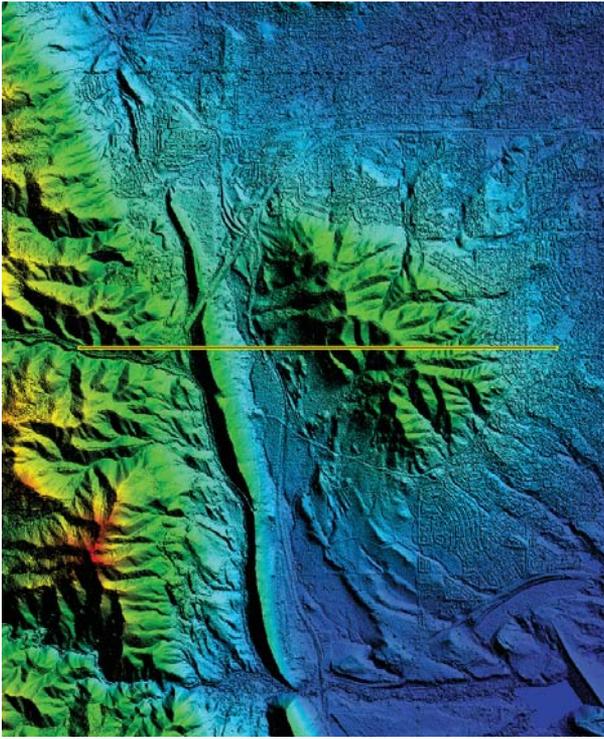


Figure 44: Colorized shaded relief (above) containing a white line that is shown in profile (below)

Figure 44, above, is a profile of an Intermap DSM for Morrison, Colorado. The white line drawn across the image is calculated and graphed in the green profile, with the origin to the left.

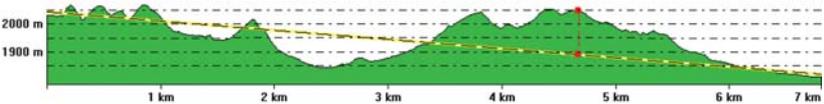


Figure 45: Line-of-site calculation

Using Intermap elevation data, line-of-sight calculations can be conducted in order to assess the viewable terrain from a given position in a DEM. Figure 45 is a line-of-sight calculation for a transmitter and receiver located 10 meters above the ground in the shaded relief image of the Morrison image above. In this example, the transmitter and the receiver are located at the same elevation. However, from the point of view of someone standing at the transmitter, the receiver appears to be lower because it is further away (indicated by the lower red dot). This is a perspective effect, best known to artists in the classic example of a row of telephone poles that all appear to diminish in size as they recede from the observer and approach a vanishing point—an imaginary location on the horizon that approximates infinity. In this figure, it is apparent that all of the green area above the yellow line represents terrain that intervenes to block the line of sight between the receiver and the transmitter. This demonstrates how it is possible for a lower peak to block the view between two higher peaks, if the lower one is close enough to the observer.

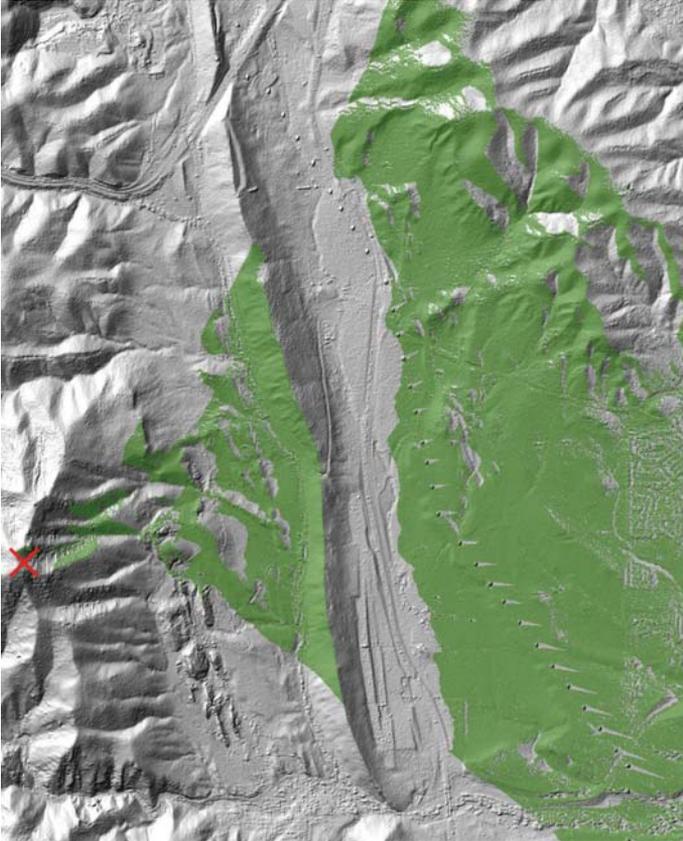


Figure 46: Typical viewshed analysis created with Intermap products

Figure 46, above, is the resulting output of a viewshed analysis using Intermap DEM data. The red X represents the observation point selected for this analysis. The surrounding green areas depict the terrain that is visible to an observer standing at that observation point.

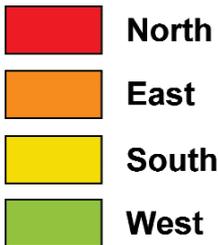
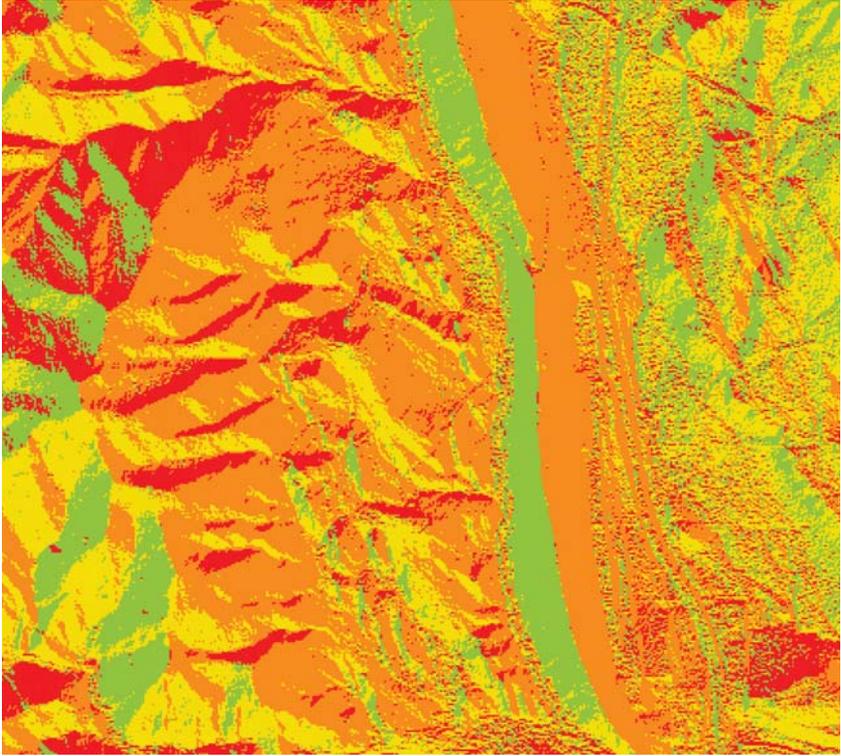


Figure 47: Aspect analysis of Morrison, Colorado (from DSM)

Figure 47, above, is the resulting large-scale output from an aspect calculation using Intermap's Morrison, Colorado, DSM data. Each color represents a range of aspect (azimuth) according to the topography of the area. In other words, you can determine which slopes point in a particular direction, by referring to the legend beneath the image.

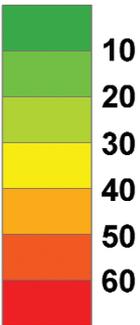
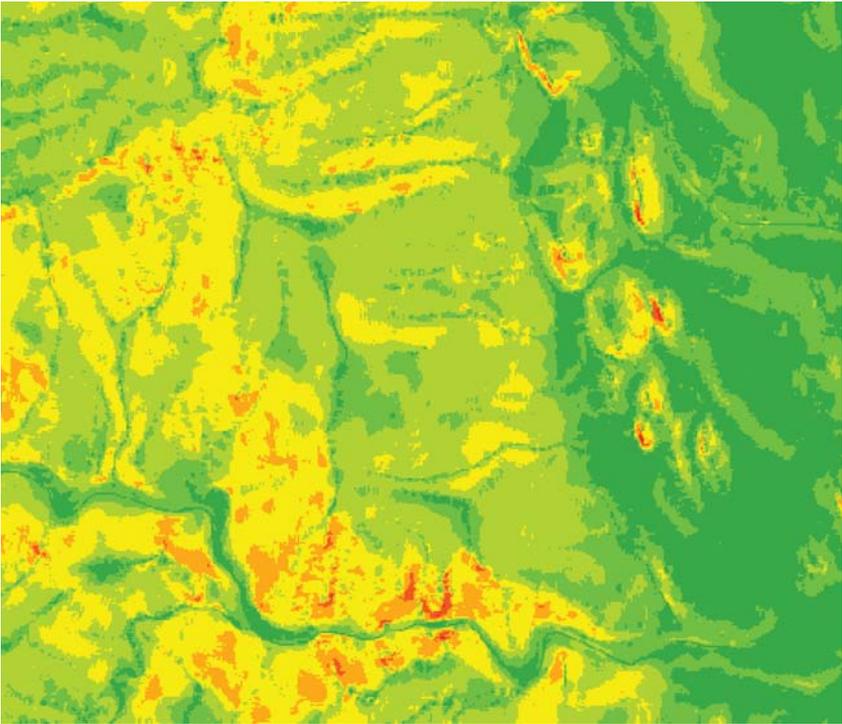


Figure 48: Degree slope of Morrison, Colorado (from DTM)

Figure 48, above, is the resulting large-scale output from a slope calculation using Intermap's Morrison, Colorado, DTM data. Each color represents a range of slope by degree according to the topography of the area.

Shaded relief: As the name suggests, a shaded relief product draws out terrain features by controlling their appearance with the use of digitally created sunlight. The effect is created by specifying an angle and direction for the sun and then calculating the length of the shadows these terrain features would cast, given the elevation information contained in the DSM or DTM. A shaded relief is more intuitive to use than either the DSM or DTM on which it is based. This is because it does not rely on pixel brightness to connote elevation. And because it has a monochromatic character, subtle features in a shaded relief, such as drainage systems, are more readily apparent than in a corresponding ORI, where the same information can be overwhelmed by textural information.

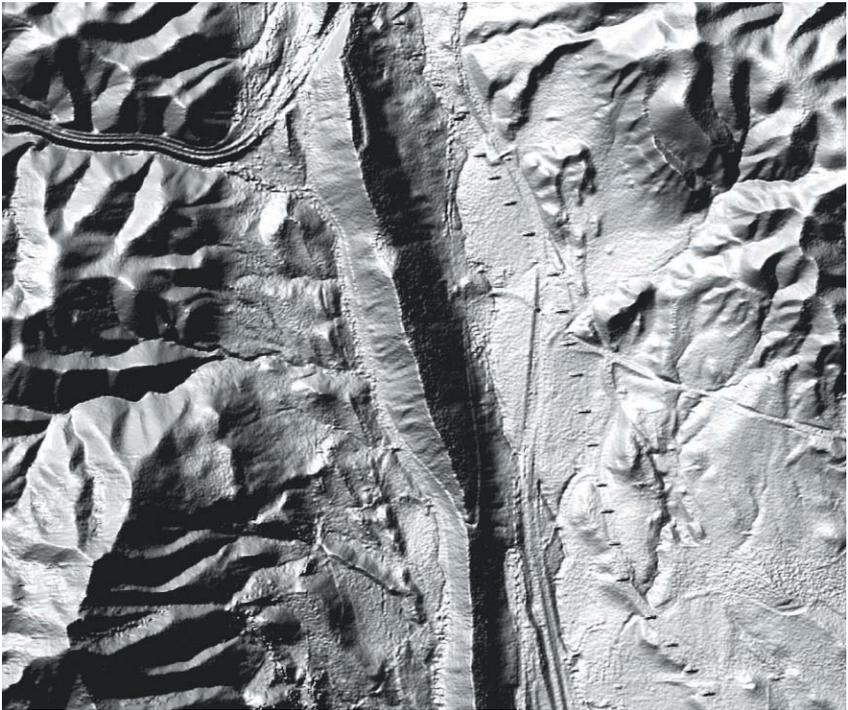


Figure 49: Shaded relief of Morrison, Colorado (from DSM)

In Figure 49, above, a shaded relief of Intermap's DSM data for Morrison, Colorado, clearly shows the topographic features of the area to a level of detail where even power transmission line towers can be discerned as small dots on the right side of the image.

6.3 Other Optional Products and Services

Difference layer: Intermap can provide a file containing only the change in elevation “difference” between the DSM and DTM, which is valuable for such applications as forest inventory.

Decimated data sets: Intermap can provide the DSM and DTM core products at reduced resolutions (i.e., at 10-meter or 100-meter postings, etc.) to support applications where a high detail of elevation data is not required.

Alternative geodetic reference systems: We can include data transformations to support the realization of any existing or customized datum, map projection or units.

Customized metadata file structures: Our metadata files can be exported to be compliant with any existing or customized file structure.

Customized delivery: We can deliver data in alternative specifications of file formats, tile size, file-naming conventions, overlap between adjacent tiles, pixel origin, etc. to be compliant with industry-specific software programs or client requests.

Customized feature characteristics: Intermap can do custom editing of DSM or DTM features to meet your specific needs. For example, your application might require setting the pixel value to 1 for all water bodies within the ORI product, removal of all trees, editing of all bridges, or the removal of specific radar attributes. Standard editing rules for our products are shown in Table 11.

Correlation file: An optional product associated with the DSM or DTM is the radar correlation data file. The data are co-registered with the elevation products and provide insight as to the relative agreement of the received signal strength at each antenna for each measurement.

Substitution of other DEM sources: We can substitute localized areas in our core products with alternate DEM sources (when available) where you have higher accuracy/density needs.

The following sections describe how to load Intermap products into some popular software packages. We have endeavored to ensure this information is complete, but you may need to check with individual vendors if you have questions about their latest releases. Note that DEM (digital elevation model) refers to either a DSM or DTM.

7.1 Loading a DEM into ESRI Workstation ARC/INFO

1. Open the metadata file associated with the DEM.
2. Copy the following information from the metadata into a blank text file, using the format shown below:

NCOLS	2801
NROWS	2801
XLLCORNER	123456.7
YLLCORNER	123456.7
CELLSIZE	5
NODATA_VALUE	-10,000
BYTEORDER	MSBFIRST

XLL and YLL above refer to the X and Y coordinates of the lower left corner of the DEM.

3. Save the newly created file as a header file. Use the same name as the .bil file, but with a .hdr extension (sample.hdr, sample.bil), and in the same directory. The file name must be lowercase and must not start with a number.
4. Start Workstation ARC/INFO and run the "floatgrid" command, which will convert a file of binary floating point numbers to a grid. An example of the "floatgrid" command is shown below:

```
Arc> floatgrid sample.bil output_name
```

5. Start Workstation ARC/INFO, open a display, set the map extent, select the image and draw it, as shown in the following sample command lines:

```
Arc> arcplot  
Arcplot> display 9999  
Arcplot> mapextent output_name  
Arcplot> image output_name
```

7.2 Loading an ORI into ESRI Workstation ARC/INFO

To load an 8-bit GeoTIFF Intermap ORI file into Workstation ARC/INFO, do the following:

1. Start Workstation ARC/INFO.
2. Set the mapextent, select the image, and draw the image, as shown in the following sample command lines:

```
Arc> arcplot  
Arcplot> display 9999  
Arcplot> mapextent sample.tif  
Arcplot> image sample.tif
```

7.3 Loading a DEM into ESRI ArcView 3.x

1. Open the metadata file associated with the DEM.
2. Copy the following information from the metadata into a blank text file, using the format shown below:

NCOLS	2801
NROWS	2801
XLLCORNER	123456.7
YLLCORNER	123456.7
CELLSIZE	5
NODATA_VALUE	-10,000
BYTEORDER	MSBFIRST

XLL and YLL above refer to the X and Y coordinates of the lower left corner of the DEM.

3. Save the newly created file as a header file. Use the same name as the .bil file, but with a .hdr extension (sample.hdr, sample.bil), and in the same directory. The file name must be lowercase and must not start with a number.
4. Activate a view.
5. From the File menu, choose Import Data Source (this requires the Spatial Analyst module).
6. Select the type of raster file to import. You can choose between ASCII, Binary, USGS DEM and US DMA DTED. Choose Binary and press OK.

7. With the next dialog, navigate to the directory that holds the raster files you want to import. Make sure the List Files of Type is set to All Files. Highlight the .bil file to import. Press OK. A grid data set will be created for each file you select.
8. Provide a name and directory to place each of the new grid data sets created. Grid data set names must be less than 14 characters long and cannot contain a period or space. Press OK.
9. After the raster files have been imported to grid data sets, you can add the new grid data sets to a view as themes with the Add Theme button.

7.4 Loading an ORI into ESRI ArcView

1. Open a new view.
2. From the menu bar select View and then select Add Theme.
3. In the dialog box, select the directory path and the file to be opened, and set the data source type to Image Data Source. Click OK.
4. From the main view window, click the box beside the listed .tif filename, and the 8-bit GeoTIFF image will be displayed.

7.5 Loading a DEM into ESRI ArcMap 8.x

1. Open the metadata file associated with the DEM (*.bil) you wish to load.
2. Copy the following information from the metadata into a blank text file, using the tab-delimited format shown below:

NCOLS	2801
NROWS	2801
XLLCORNER	123456.7
YLLCORNER	123456.7
CELLSIZE	5
NODATA_VALUE	-10,000
BYTEORDER	MSBFIRST

XLL and YLL above refer to the X and Y coordinates of the lower left corner of the DEM.

3. Save the newly created file as a header file. Use the same root name as the .bil file, with a .hdr extension (e.g. sample.hdr, sample.bil), and in the same directory. NOTE: THE FILE NAME MUST NOT CONTAIN ANY SPACES IN EITHER THE PATH NAME OR THE FILE NAME. For example, "C:\Documents and Settings\bsmith\Desktop\sample.hdr" will not work; use, for example, something like "C:\bsmith\sample.hdr".
4. Launch ArcToolbox. Under Conversion Tools, select Import to Raster. Under Import to Raster, choose Floating Point Data to Grid.



Figure 50: ArcToolBox

5. In the pop-up dialog box that follows, click the folder icon to the right of "Input float file." Navigate to the directory where your DEM (*.bil) file is saved.
6. For the Output grid, provide a name and directory to place each of the new grid datasets created. Grid dataset names must be less than 14 characters long and cannot contain a period or space. Make sure that the path name where the dataset is to be saved contains no spaces. Press OK. In order to import several .bil files at one time (batch process), click Batch on the lower right corner of the import dialog. This will expand the dialog and enable you to build a table of input/output paths for multiple files. Make sure that the output path does not contain spaces.

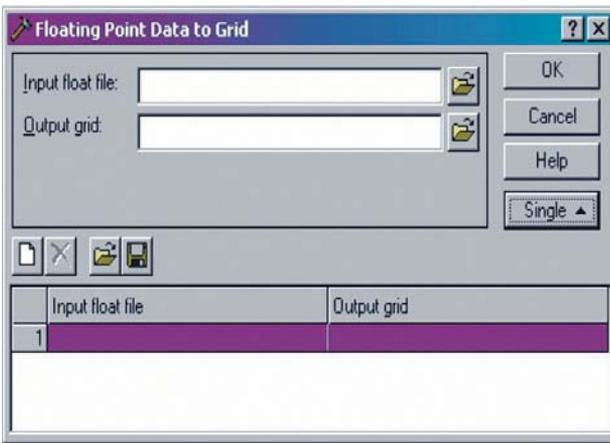


Figure 51: Floating Point Data to Grid dialog box

7. After the raster files have been imported to grid datasets, remain in ArcToolbox. Under Data Management Tools, select Projections>Define Projection Wizard (coverages, grids, TINs).
8. In the dialog box that follows, choose "Define coordinate system interactively" and press Next. In the dataset selection screen that follows, navigate to the grid file exported in step #6. Press Next.
9. In the screens that follow, the wizard will ask you a series of questions regarding the specifics of the projection of the dataset that you are working with (projection type, parameters, datum, spheroid, etc...). Use the metadata associated with your DEM file to answer these questions, and press Finish.
10. Launch ArcMap. To load the DEM into to a map file, select Add Data under the File Menu, and navigate to your new grid file location.

7.6 Loading an ESRI ASCII formatted image into ArcMap 8.x

1. A properly formatted ASCII file contains the necessary header information the first seven lines of the file such as:

NCOLS	2801
NROWS	2801
XLLCORNER	123456.7
YLLCORNER	123456.7
CELLSIZE	5
NODATA_VALUE	-10,000
BYTEORDER	MSBFIRST

2. Launch ArcToolbox. Under Conversion Tools, select Import to Raster. Under Import to Raster, choose ASCII to Grid.

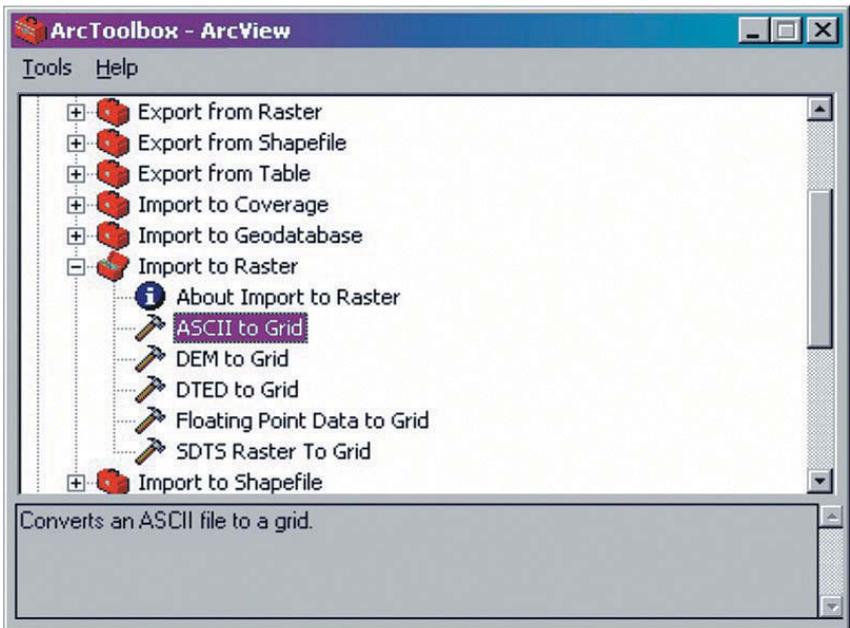


Figure 52: ArcToolbox - ArcView

3. In the pop-up dialog box that follows, click the folder icon to the right of "Input ASCII file." Navigate to the directory where your ASCII formatted DEM file is saved.

- For the Output grid, provide a name and directory to place each of the new grid datasets created. Grid dataset names must be less than 14 characters long and cannot contain a period or space. Make sure that the path name where the dataset is to be saved contains no spaces. Press OK. In order to import several ASCII files at one time (batch process), click Batch on the lower right corner of the import dialog. This will expand the dialog and enable you to build a table of input/output paths for multiple files. Make sure that the output path does not contain spaces. To import Intermap DSMs and DTMs you must select the Float radio button for the Grid type in ArcToolbox, otherwise the data will not correctly import.

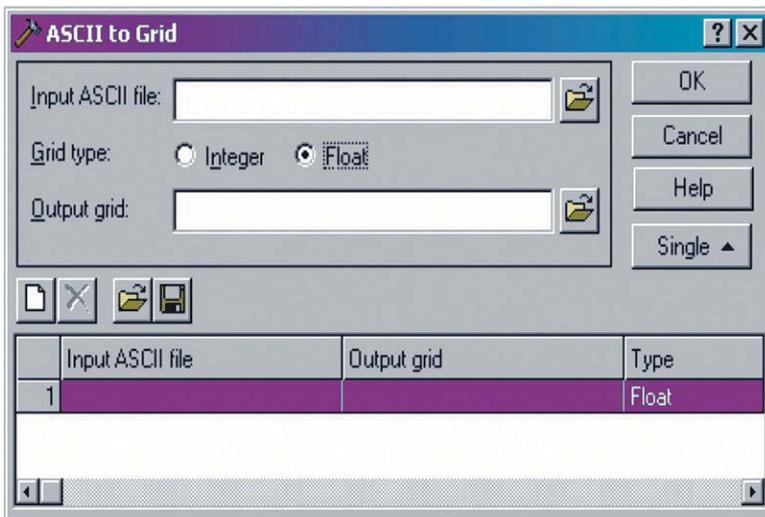


Figure 53: ASCII to Grid dialog box

- After the raster files have been imported to grid datasets, remain in ArcToolbox. Under Data Management Tools, select Projections>Define Projection Wizard (coverages, grids, TINs).
- In the dialog box that follows, choose “Define coordinate system interactively” and press Next. In the dataset selection screen that follows, navigate to the grid file exported in step #4. Press Next.
- In the screens that follow, the wizard will ask you a series of questions regarding the specifics of the projection of the dataset that you are working with (projection type, parameters, datum, spheroid, etc...). Use the metadata associated with your DEM file to answer these questions, and press Finish.
- Launch ArcMap. To load the DEM into to a map file, select Add Data under the File Menu, and navigate to your new grid file location.

7.7 Loading an ORI into ESRI ArcMap 8.x

1. Open ArcMap.
2. Click "A NEW EMPTY MAP" and then click OK.
3. Click Add Data (black cross in the yellow diamond) and navigate to the file to open.
4. Click OK, and the image will appear in the screen.

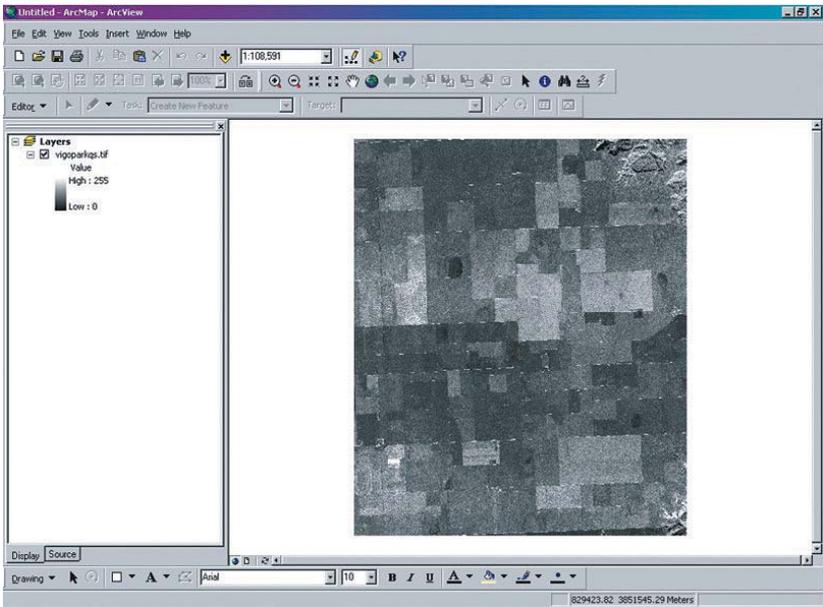


Figure 54: Intermap ORI in ArcMap

7.8 Loading a DEM into ERDAS IMAGINE

1. Start IMAGINE.
2. Click Import to convert the Intermap DEM .bil file into an ERDAS .img file.

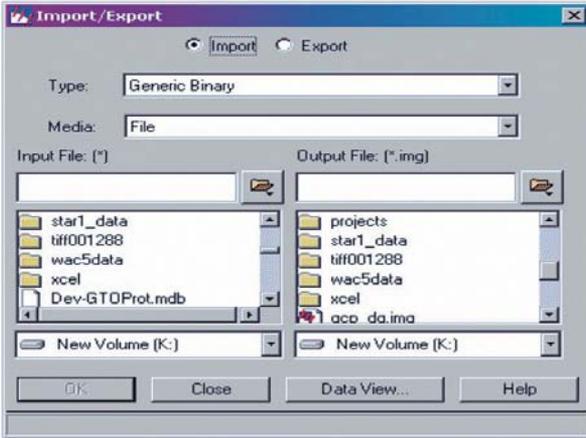


Figure 55: IMAGINE Import/Export dialog box, set to Import

3. In the new submenu, select the Import radio button, set the Type to Generic Binary. Then set the Media to either CD-ROM or "file" depending on the location of the .bil file. Finally, select Input and Output directories.
4. After clicking OK, the following submenu will appear.

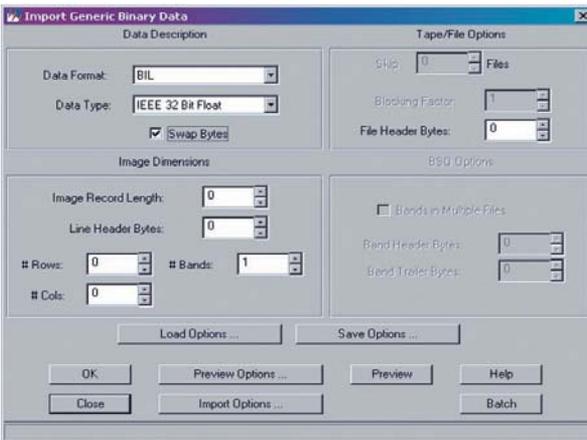


Figure 56: Import Generic Binary Data dialog box

5. Set Data Format to BIL, Data Type to IEEE 32 Bit Float, set the # rows and # cols (values for these can be taken from the associated metadata file (in .txt format). Click the Swap Bytes box (only in the Windows version—leave this option off in the UNIX version). Click OK to import.
6. Load a new viewer in IMAGINE by clicking the “viewer” button on the main Imagine toolbar then, from the viewer menu bar, select File. Then select Open, Raster Layer and specify new .img file.
7. The image is now viewable, but not properly referenced to geographic coordinates. To begin referencing, select Utility and Layer Info. In this new submenu, the General and Projection tabs are incomplete and need to have information updated.
8. In new submenu, select Edit and Change Map Model. The information to enter here can be found in the associated .txt file. Enter the Upper left georeferencing datum (UTM), pixel size (5) units (meters) and projection (UTM). Click OK.

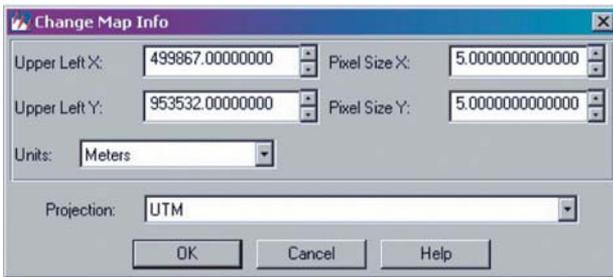


Figure 57:
Change Map Info dialog box

9. Select Edit, then select Add/Change Projection. In the submenu, select the Standard tab, change the Categories dropdown to UTM zone UTM WGS 84 North or South depending on your data. From the list of UTM Zones, click the one in which your data was collected. Click OK.

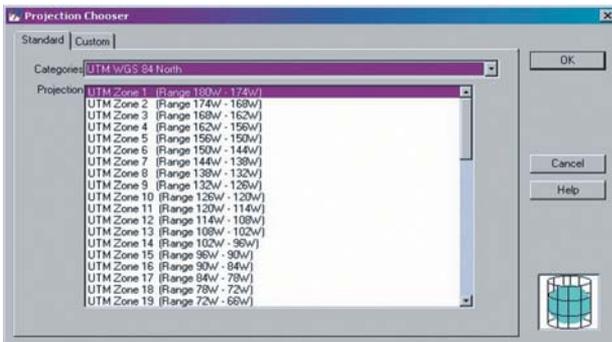


Figure 58:
Projection Chooser dialog box

10. The Layer Info menu should now be complete and the .img file ready for IMAGINE.

7.9 Loading an ORI into ERDAS IMAGINE

1. Start IMAGINE.
2. Select the Import option to convert the ORI .tif file into an ERDAS .img file.
3. In the new submenu, select Import, set the Type to TIFF. Then set the Media to either CD-ROM or "file" depending on the location of the .tif file. Finally, select Input and Output directories.
4. After clicking OK, another submenu will appear. Click OK to import.
5. Load a new viewer in IMAGINE by clicking the Viewer button on the main Imagine toolbar then From the viewer menu bar, select File. Then select Open, Raster Layer and specify new .img file. (The georeferencing from the original GeoTIFF will be saved in the newly imported .img file).

7.10 Loading a DEM into MapInfo

1. Convert the *.bil DEM into an ASCII "XYZ" format text file (e.g., Easting, Northing, Elevation) using third-party software (such as PCI EASI/PACE).
2. From the File menu in MapInfo, select Open Table... and set Files of Type to Delimited ASCII.
3. Select desired text file and click Open.
4. Select delimiter (e.g., Tab or Space).
5. For most cases, the default File Character Set can be used.
6. If text file has column headings (e.g., Easting, Northing, Elevation), click the Use First Line for Column Titles check box. Otherwise, leave it unchecked.
7. Click OK to load the text file into MapInfo. For large text files, this step can take several minutes and MapInfo may appear to have frozen.
8. To create a Vertical Mapper Grid file select Vertical Mapper from the menu bar. Then select Create Grid and Interpolation.
9. Select Rectangular (Bilinear) Interpolation. Click Next to continue.
10. Under Select Table to Grid, choose the table that was created in Step 7.
11. Under Select Column, select the column containing the elevation information.

12. Under X Column, select the column containing the x (Easting) coordinate information.
13. Under Y Column, select the column containing the y (Northing) coordinate information.
14. Click the Projection... button.
15. Under Category, select Universal Transverse Mercator (WGS 84).
16. Under Category Members, select the desired UTM Zone for the dataset and click OK.
17. Type in a Data Description (e.g., Elevation).
18. Select the correct unit (e.g., meters) from the Unit Type dropdown box. Click Next to continue.
19. Set Cell Size to 5 meters and leave the Search Radius as the default value.
20. Use the Browse button to select a filename and location for the new grid file. Click Finish to generate the grid file.

7.11 Loading an ORI into MapInfo

1. Obtain coordinate information for 3 pixels within the image (usually the upper-left, lower-left and lower-right corner pixels). The coordinates must refer to the upper-left corner of each pixel and not to the center of the pixel.

For example:

An ORI that is 1000 pixels wide and 2000 lines long, with a pixel size of 2.5 meters, is to be registered. The upper-left coordinate is given in UTM (WGS 84) coordinates (referenced to the center of the pixel) and is (450500 E, 5400850 N).

The coordinates required to register the image would be as follows:

Point 1 (Upper-Left):	450498.75 E	5400851.25 N
Point 2 (Lower-Left):	450498.75 E	5395853.75 N
Point 3 (Lower-Right):	452996.25 E	5395853.75 N

In a general case, given the upper-left center of pixel coordinate for the image, the number of pixels and lines that make up the image, and the pixel size:

Map X	Map Y	Image X	Image Y
Given upper-left easting - half the pixel size	Given upper-left northing + half the pixel size	0	0
Point 1 easting	Point 1 northing - {(number of lines - 1) x pixel size}	0	Number of lines - 1
Point 1 easting + {(number of lines - 1) x pixel size}	Point 2 northing	Number of pixels - 1	Number of lines - 1

2. From the menu bar in MapInfo, select File and then Open Table... and set Files of Type to Raster Image.
3. Select desired raster file and click Open.
4. Click the Register button.
5. Click the Projection... button.
6. Under Category, select Universal Transverse Mercator (WGS 84).
7. Under Category Members, select the desired UTM zone for the ORI and click OK.
8. Click the Units... button.
9. Select meters from the drop-down menu and click OK.
10. Click anywhere within the image to select Point 1.
11. Set Map X to the calculated Easting coordinate set Map Y to the calculated Northing coordinate. Set Image X to 0 and set Image Y to 0 (for Upper-Left pixel). Click OK.
12. Repeat Steps 10 and 11 for Point 2 and Point 3. For Point 2, Image X and Image Y would be 0 and the Number of Lines minus 1, respectively. For Point 3, Image X and Image Y would be the Number of Pixels minus 1 and the Number of Lines minus 1, respectively.
13. Click OK.

7.12 Loading a DEM or ORI into ER Mapper

Both the 32-Bit Binary DEM and GeoTIFF image can be viewed in ER Mapper or ER Viewer in their present formats simply by “File—Open,” however the DEM file requires a standard ARC/INFO header file, an example of which is given below. The coordinates in the ARC/INFO header file are referenced to the center of the upper left DEM pixel, whereas ER Mapper references the upper left of the upper left pixel and does not make a correction when reading the header file. In order to correct for this discrepancy, the “ulxmap” and “ulymap” coordinates must have a half pixel subtracted and added, respectively, when creating the header file. The DEM row, column, pixel size and georeferencing information for the header file can be extracted from the metadata file supplied with the data. Both programs can display the two-dimensional UTM georeferencing of the DEM and GeoTIFF, but ER Mapper requires the DEM to be imported and registered before any three-dimensional georeferencing can be displayed.

Sample ARC/INFO Header File	ncols	2811
	nrows	2811
	nbands	1
	nbits	32
	byteorder	M
	layout	BIL
	ulxmap	555557.50
	ulymap	9958662.50
	xdim	5.0
	ydim	5.0

Now do the following:

1. Once the header file has been created, the DEM can be imported through the Utilities menu.

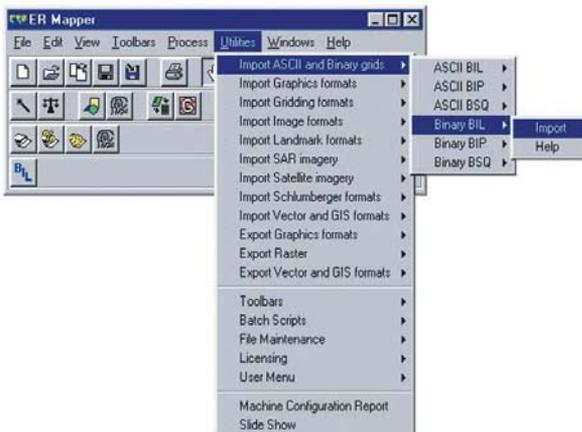


Figure 59:
Pop-up menus for
importing a DEM

- On the Import Binary_BIL window, enter the DEM .bil file in the Import File/Device Name field and an output name in the Output Dataset Name. Geodetic Datum and Map Projection information can be retrieved from the metadata file supplied with the DEM. All other fields are optional. Once the information has been entered click on the Setup button.

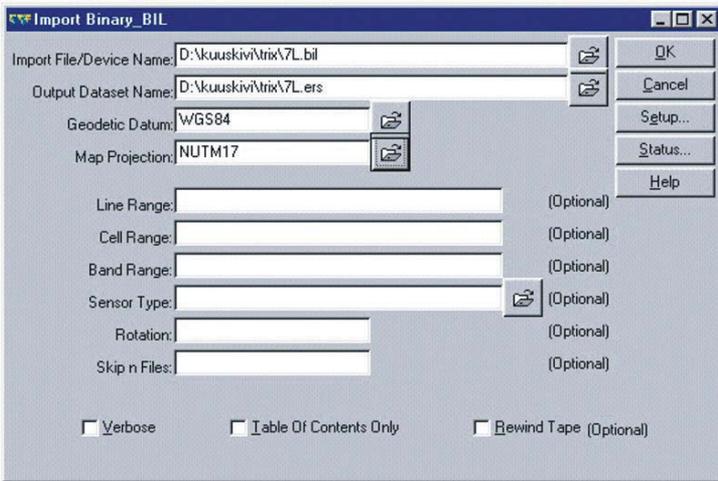


Figure 60: Import Binary_BIL dialog box

- In the Import Setup window, set Input Data Type to IEEE 4-Byte Real, Byte Order to Motorola and Number of Bands to 1. Get Number of Lines (Rows) and Number of Cells (columns) values from the metadata file. When complete click OK and then OK on the Import Binary_BIL window and the DEM will start to import into an ER Mapper format.



Figure 61: Import Setup dialog box

- Once the DEM has been imported, the elevation values can be viewed, but to get the Easting and Northing coordinates, the file has been georeferenced. Georeferencing information is added through the Process-Geocoding Wizard... menu.

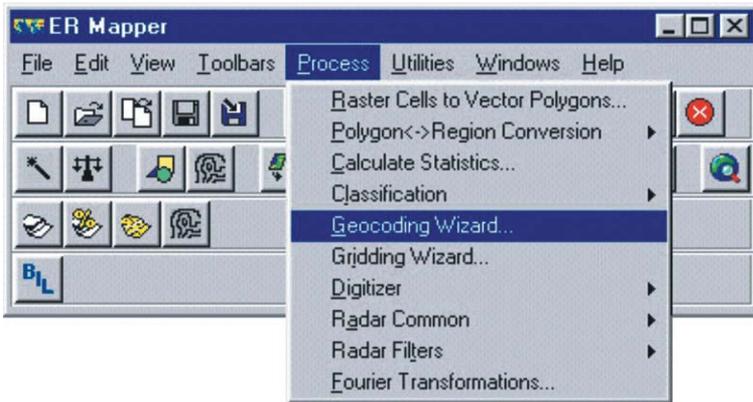


Figure 62: Geocoding Wizard pop-ups

- On the Start window enter the name of the imported .ers DEM in the Input File field and click the Known point registration option.

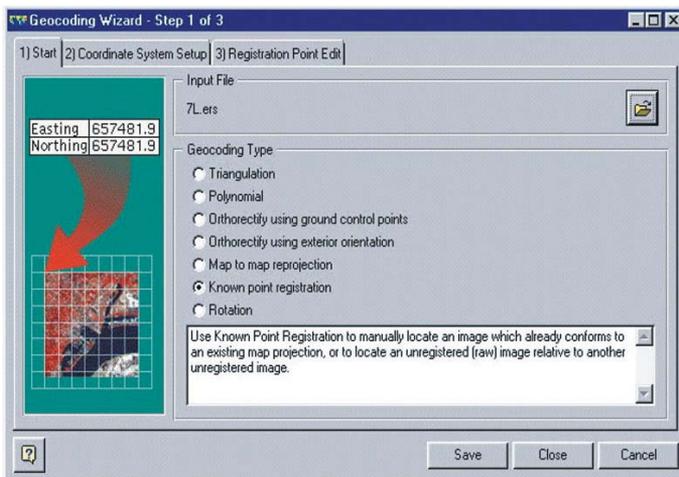


Figure 63: Geocoding Wizard dialog box

- On the Coordinate System Setup window, the Datum, Projection and Coordinate type fields should be correct, but the Units should be changed to the appropriate unit of measure.

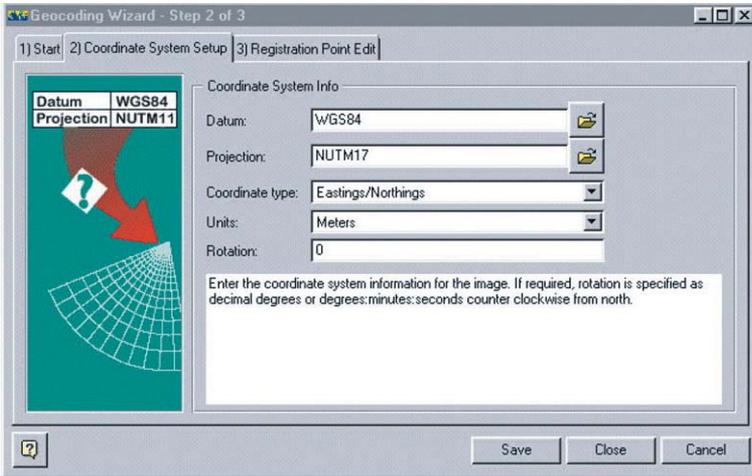


Figure 64: Geocoding Wizard second dialog box

- On the Registration Point Edit window, change Cell size X and Cell size Y to the values from the metadata file and the Eastings and Northings to the values from the ARC/INFO header file. Click Save and Close. The ER Mapper file will now be fully georeferenced.

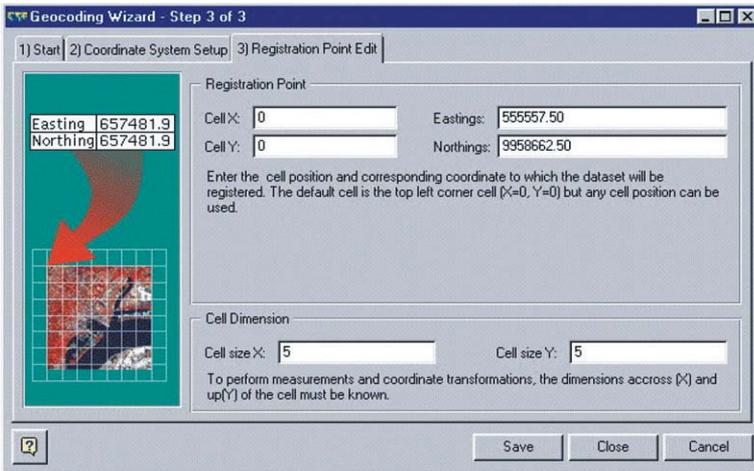


Figure 65: Geocoding Wizard third dialog box

7.13 Loading an ORI in ENVI 3.5

1. Open ENVI.
2. Click FILE and then OPEN EXTERNAL FILE.
3. Pick either LANDSAT or IKONOS GeoTIFF, then navigate to the desired file (will be a .tif).
4. Double click on the file name in the box that pops up, and the ORI should be seen in the viewers.

7.14 Loading a DEM into PCI Geomatica Focus

1. Open PCI Geomatica.
2. Click FILE, UTILITY, IMPORT from the main menu.

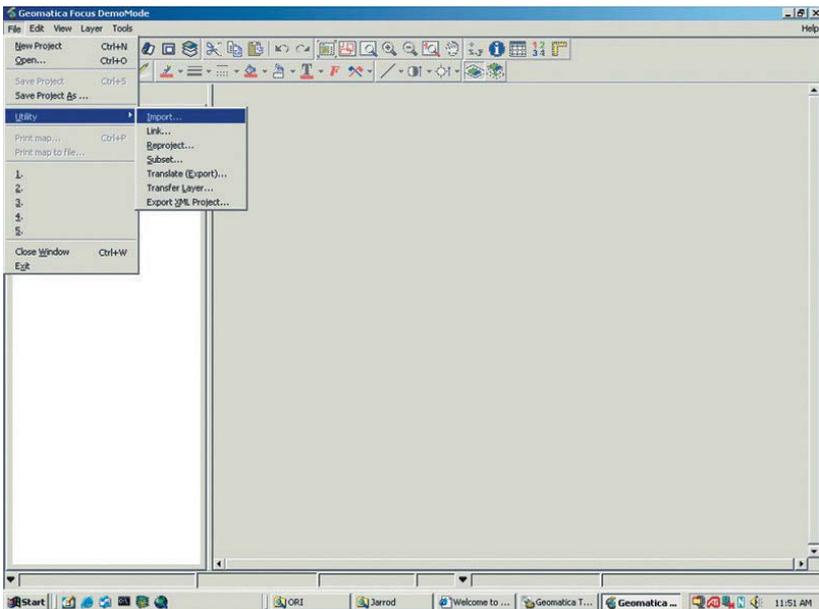


Figure 66: Import pop-up menu

3. In the following dialog click the Select button and navigate to the .bil file.

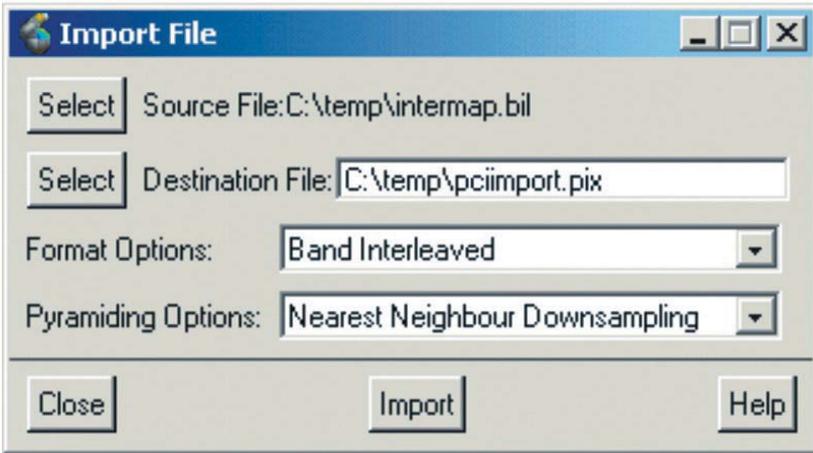


Figure 67: Import File dialog box

4. You will be prompted with the following message box; click yes and proceed.

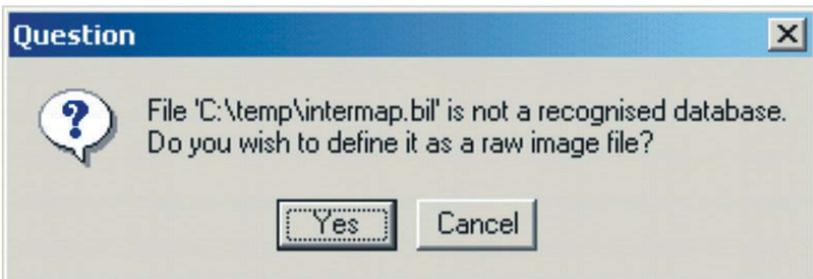


Figure 68: Message box

5. At this point, you need to define the image parameters based on the header file information provided with the Intermap DEM. Using the following dialog, be sure to choose the Line for Data Interleaving, 32 bit Real for Data Type, and LSB: Intel/VAX for Byte Order. Enter 0 for the header bites. Click Accept, and Focus will prompt you to save the information you just entered to a .aux file. Choose yes and the Import File dialog will reappear.

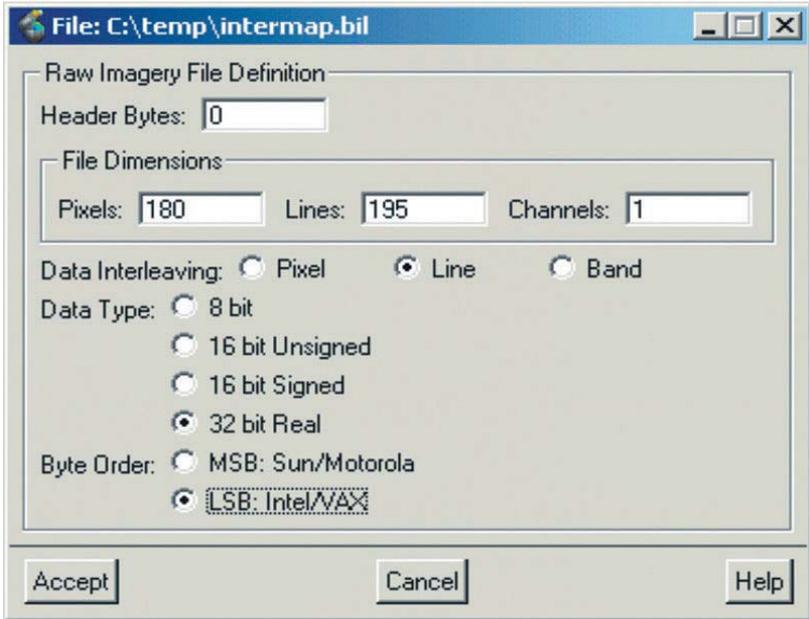


Figure 69: Image parameter dialog box

6. With the Import File dialog showing, be sure that the Format Options is still set to Band Interleaved and the Pyramid Options is still set to Nearest Neighbour Downsampling. Press the Import button.
7. PCI Geomatic Focus now understands the parameters of the file, but has not yet converted formats. In order to convert the .bil file into a PCI formatted file, add the .bil to Focus using the add file command from the file menu.
8. Once the .bil has been added to the layer list, right click file in the table of contents to export the file to a PCI format. The following dialog will appear:

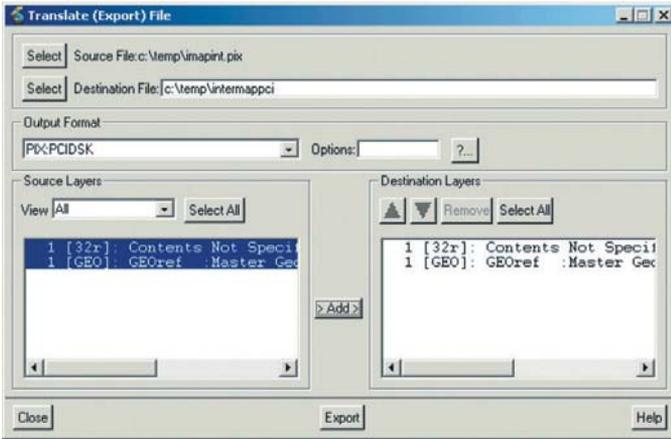


Figure 70: Translate (Export) File dialog box

9. Provide a destination file path WITH a .pix file extension, choose PIX-PCIDSK from the Output Format dropdown list, press the Select All button, click the add button to define the destination layers, and then click the Export button.
10. Once Focus has finished converting the .bil, click the add data button in the viewer, navigate to the location of the last file you just created (.pix), format, and add it to Focus:

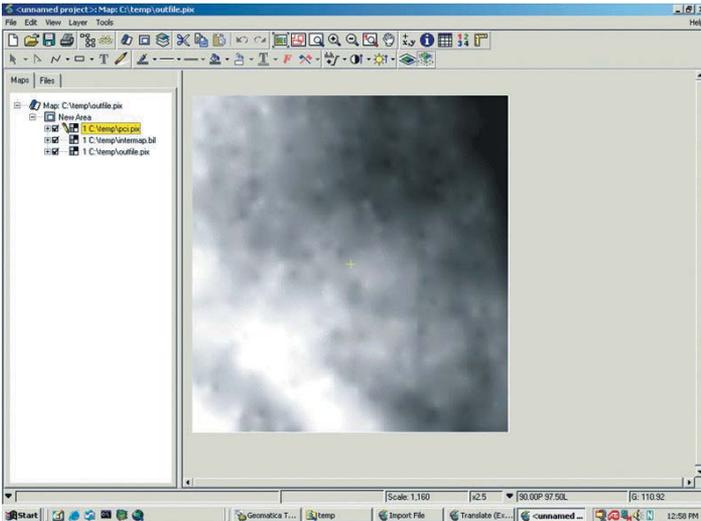


Figure 71: Maps tab in main workspace

Appendix A: Product Licensing

A

Intermap offers flexible license agreement terms to its customers. We have developed various license agreements to address the specific needs of our users, four of which are contained in this appendix:

- Demo User License Agreement
- Annual End User License Agreement
- Perpetual End User License Agreement
- Project End User License Agreement

Demo Use License Agreement (DULA) Elevation and Orthorectified Image Map Products

To: Intermap Technologies Inc.
400 Inverness Parkway, Suite 330
Englewood, Colorado 80112
United States
Tel: 303.708.0955
Fax: 303.708.0952

Intermap Technologies Inc. offers the use of the Digital Elevation Model ("DEM") and Orthorectified Radar Image ("ORI") data products for the _____ area in the country of _____ as Evaluation Map Products. Evaluation Map Products are delivered to the undersigned solely for the purposes of evaluation, demonstration, marketing, promotion and other activities that demonstrate the use of the data products.

Intermap believes there is much to be gained by both parties cooperating to further the use of the data products in association with the applications of the undersigned.

The Evaluation Map Products are provided to the undersigned for the purposes stated above upon the following conditions:

1. that all examples developed will include an acknowledgement of Intermap Technologies Inc.;
2. that the Evaluation Map Products will not be used for commercial or operational purposes;
3. that the Evaluation Map Products will not be disclosed, given or otherwise distributed to third parties except products developed for marketing purposes, which may be distributed to the extent that the products are not such that the DEM can be reverse engineered (thus giving away the product); and
4. that to the extent practical, examples of demonstration products created with the products by the undersigned will be forwarded to Intermap Technologies Inc.

As an authorized representative of the _____ organization, I agree to the above stated conditions. Please sign and either fax or send to the address above. This demonstration license is terminable at any time by Intermap.

Signature: _____ Date: _____

Name (please print) _____

Phone: _____ Email: _____

Please sign and fax to the number above.

If you have questions, please call: 1-877-TERRAIN or 1-303-708-0955

**INTERMAP TECHNOLOGIES INC.
ANNUAL END USER LICENSE AGREEMENT**

1. **Introduction.** This End User License Agreement (“EULA”) is between Intermap Technologies Inc. (“Intermap”) and the licensee (“Licensee”) identified at the end of this EULA. This license governs Licensee’s use of the data products or documentation accompanying this EULA (the “Products”). By using the Products, Licensee agrees to be bound by the terms of this EULA. If Licensee does not agree with these terms, it must promptly return the unused Product to Intermap, and license fees paid will be refunded in full. The Products include the data, databases, and data products of Intermap and its third party providers.

2. **Scope of License.** Intermap grants Licensee a limited, restricted, revocable, non-transferable, non-exclusive license to use the Products in the manner set forth in this EULA. If so stated in the attached Exhibit A, Licensee may have the limited right to allow use and access to the Products to additional parties identified in Exhibit A, and in all events subject to the terms of this Agreement. Licensee’s use of the Products must strictly comply with the following restrictions: (a) Licensee may only use the Products for Licensee’s valid internal business purposes, and not for redistribution; (b) Licensee may not itself, or allow others, to create or distribute Product Derivative Works (as defined in Section 3). Licensee may create and distribute orthoimagery products so long as the product media and packaging at all times include the Intermap Technologies Inc. logo, in the form made available by Intermap at Licensee’s request. Licensee is authorized to distribute Thematic Derivative Works (as defined in Section 4).

3. **Product Derivative Works.** Product Derivative Works are defined as any image, representation or alteration of the Products from which the Products or portions thereof are capable of being reverse engineered, recreated, discerned, or otherwise made available. Examples of Product Derivative Works include, but are not limited to, contour maps, elevation data from resampled Products and or any derived product that contains elevation information or spot heights derived from Intermap data.

4. **Thematic Derivative Works.** Thematic Derivative Works are defined as any image, representation or alteration of the Products from which the Products cannot be reverse engineered. Examples of Thematic Derivative Works include thematic maps, hazard maps, fly-through videos, perspective views, vector-based road center lines, building or feature outlines, mapping class boundaries, or other vector-based data extraction results.

5. **Restrictions.** Licensee shall not disclose, publish, sell, assign, lease, share, lend, sublicense, market or transfer the Products in whole or in part, or use the Products in any manner or for any purpose not expressly authorized by this EULA. Intermap reserves all rights not expressly granted by this EULA. Unless otherwise expressly provided in Exhibit A, Licensee may not use the Products on behalf of, or allow the Products to be used by, any third party, whether or not a subsidiary or affiliated entity controlled by or related to Licensee. If Licensee is a federal, state, or local government agency, the Product is licensed solely to the particular agency and not by any other government agency, unless otherwise expressly provided in Exhibit A. Licensee acknowledges that the Products contain and embody proprietary materials, trade secrets, and copyrights of Intermap and its suppliers. Unauthorized reproduction, modification, distribution, or display of the Products in whole or in part, and in any manner not expressly authorized herein is prohibited. Licensee shall keep confidential and use its best efforts to protect the Products and prevent their unauthorized disclosure or use. Licensee shall immediately notify Intermap upon discovering evidence of a current or threatened misuse or unauthorized use or disclosure of the Products by any party. If the right to share access to the Products with other parties is granted in Exhibit A, such other parties shall in no event themselves have the right to further share or distribute the Products, and their use shall in all other respects be subject to compliance with this Agreement.

6. **U.S. Government End Users.** The Product is a “commercial item” as that term is defined at 48 C.F.R. 2.101 (Oct. 1995), consisting of “commercial computer software” and “commercial computer software documentation,” as such terms are used in 48 C.F.R. 12.212 (Sept. 1995). Consistent with 48 C.F.R. 12.212 (Sept. 1995) and 48 C.F.R. 227.7202-1 throughout 227.7202-4 (June 1995), all U.S. Government End Users acquire the Products with only those rights set forth herein. Contractor/manufacturer is Intermap Technologies Incorporated, Englewood, Colorado, USA. If the Products or any Thematic Derivative Works are used in connection with the performance of any government contracts or subcontracts, You shall ensure that (i) the Products and any Thematic Derivative Works shall not constitute a deliverable under any governmental contracts or subcontracts; and (ii) in no event shall a government entity acquire any rights other than those provided in this Section.

7. **LIMITED WARRANTY AND DISCLAIMERS.** INTERMAP WARRANTS FOR SIXTY (60) DAYS AFTER THE DELIVERY OF THE PRODUCTS THAT THE DATA DELIVERED WILL BE OF THE AREA OF INTEREST ORDERED AND THE MEDIA USED TO CARRY THE DATA WILL BE FREE FROM MATERIAL PHYSICAL DEFECTS. LICENSEE'S SOLE REMEDY, AND INTERMAP'S SOLE OBLIGATION UNDER THIS LIMITED WARRANTY SHALL BE FOR LICENSEE TO RETURN THE DEFECTIVE MEDIA TO INTERMAP WITHIN THE WARRANTY PERIOD, AND TO RECEIVE REPLACEMENT MEDIA. EXCEPT FOR THE LIMITED WARRANTY SPECIFIED HEREIN, THE PRODUCTS ARE PROVIDED WITHOUT WARRANTY OF ANY KIND, AND ALL WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED. INTERMAP DOES NOT WARRANT THAT THE PRODUCTS WILL MEET LICENSEE'S NEEDS OR EXPECTATIONS OR THAT USE OF THE PRODUCTS WILL BE ERROR FREE OR UNINTERRUPTED. IN NO EVENT SHALL INTERMAP BE LIABLE FOR ANY CLAIM OR LOSS INCURRED BY LICENSEE, INCLUDING WITHOUT LIMITATION COMPENSATORY, INCIDENTAL, INDIRECT, SPECIAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES, EVEN IF ADVISED OF THE LIKELIHOOD OF SUCH DAMAGES. THIS LIMITATION APPLIES TO ALL CAUSES OF ACTION, INCLUDING WITHOUT LIMITATION BREACH OF CONTRACT OR WARRANTY OR TORT. IF THE LIMITATION OF LIABILITY SET FORTH IN THIS AGREEMENT SHALL FOR ANY REASON BE HELD UNENFORCEABLE OR INAPPLICABLE, LICENSEE AGREES THAT INTERMAP'S LIABILITY SHALL NOT EXCEED THE LICENSE FEES PAID BY LICENSEE TO INTERMAP WITH RESPECT TO THE PRODUCTS AT ISSUE.
8. **Term and Termination.** This EULA shall become effective upon use of the Product and shall continue in force for one year thereafter. This EULA may be renewed annually upon Licensee's payment of the then effective annual license fee by no later than fourteen (14) days prior to the expiration of the then current one year term. Failure to timely remit such annual license fee shall result in automatic termination of this EULA and the license herein granted. In addition, this EULA shall terminate immediately if Licensee fails to comply with any of its terms. Upon termination of this EULA for any reason, Licensee shall deliver to Intermap all copies and embodiments of the Products and certify in writing that no copies are left in Licensee's possession.

9. **Dispute Resolution and Governing Law.** This EULA shall be construed and enforced in accordance with the laws of the State of Colorado notwithstanding its conflict of laws provisions. The parties agree to attempt to settle any claim or controversy arising under this EULA through consultation and negotiation in the spirit of mutual friendship and cooperation. If such attempts fail, then the dispute shall first be submitted to a mutually acceptable neutral advisor for initial fact finding in preparation for mediation or other form of alternate dispute resolution. The exclusive jurisdiction and venue for any lawsuit or other dispute resolution proceeding between the parties arising out of this EULA shall be in Denver, Colorado, USA. The parties consent and submit to the exclusive personal jurisdiction of the courts resident in Denver, Colorado.

10. **Miscellaneous.** This EULA is the complete and exclusive statement between Licensee and Intermap with respect to the Products and may be amended or modified only in a written instrument signed by a duly authorized representative of both parties. If any provision is determined to be invalid or unenforceable, the remaining provisions of this EULA shall continue to be valid and enforceable. Neither this EULA nor any of the rights granted by it may be assigned or transferred by Licensee. This restriction on assignments or transfers shall apply to assignments or transfers by operation of law, as well as by contract, merger or consolidation. Licensee shall be solely responsible for obtaining any and all required government authorizations, including without limitation, any export or import licenses and foreign exchange permits. Nothing in this section shall restrict the ability of Intermap to pursue any legal or equitable remedy or to obtain an injunction to protect any rights Intermap may have arising out of or relating to the Product or any of Intermap's intellectual property rights. Sections 5, 6, 7 and 8 shall survive expiration or termination of this EULA.

11. **Export Licensing Notification.** The products delivered hereunder are subject to the export licensing regulations of the United States Department of Commerce. The recipient of the Products may be obligated under US law to comply with such regulations in distributing the Products. Licensee shall be solely responsible for compliance with same.

12. **Remedies.** Licensee shall defend, indemnify, and hold Intermap, its affiliates, directors, employees, and agents from and against any claim, action, proceeding, loss, cost, expense, damages, and liability, including reasonable attorneys' fees, arising from Licensee's breach of any provision of this EULA. If Licensee is granted any rights to share access to the Products with other parties, as may be provided in Exhibit A, Licensee shall at all times remain responsible for all such users, and

shall ensure their full compliance with the requirements of this Agreement. Conduct in violation of this Agreement by such other parties shall be deemed to be a material breach of this Agreement by Licensee.

EXHIBIT A

List additional parties to which Licensee may disclose or allow access to the Products.

INTERMAP TECHNOLOGIES INC. PERPETUAL END USER LICENSE AGREEMENT

- 1. Introduction.** This End User License Agreement (“EULA”) is between Intermap Technologies Inc. (“Intermap”) and the licensee (“Licensee”) identified at the end of this EULA. This license governs Licensee’s use of the data products or documentation accompanying this EULA (the “Products”). By using the Products, Licensee agrees to be bound by the terms of this EULA. If Licensee does not agree with these terms, it must promptly return the unused Product to Intermap, and license fees paid will be refunded in full. The Products include the data, databases, and data products of Intermap and its third party providers.
- 2. Scope of License.** Intermap grants Licensee a limited, restricted, perpetual, revocable, non-transferable, non-exclusive license to use the Products in the manner set forth in this EULA. If so stated in the attached Exhibit A, Licensee may have the limited right to allow use and access to the Products to additional parties identified in Exhibit A, and in all events subject to the terms of this Agreement. Licensee’s use of the Products must strictly comply with the following restrictions: (a) Licensee may only use the Products for Licensee’s valid internal business purposes, and not for redistribution; (b) Licensee may not itself, or allow others, to create or distribute Product Derivative Works (as defined in Section 3). Licensee may create and distribute orthoimagery products so long as the product media and packaging at all times include the Intermap Technologies Inc. logo, in the form made available by Intermap at Licensee’s request. Licensee is authorized to distribute Thematic Derivative Works (as defined in Section 4).
- 3. Product Derivative Works.** Product Derivative Works are defined as any image, representation or alteration of the Products from which the Products or portions thereof are capable of being reverse engineered, recreated, discerned, or otherwise made available. Examples of Product Derivative Works include, but are not limited to, contour maps, elevation data from resampled Products and or any derived product that contains elevation information or spot heights derived from Intermap data.
- 4. Thematic Derivative Works.** Thematic Derivative Works are defined as any image, representation or alteration of the Products from which the Products cannot be reverse engineered. Examples of Thematic Derivative Works include thematic maps, hazard maps, fly-through videos, perspective views, vector-based road center lines, building or feature outlines, mapping class boundaries, or other vector-based data extraction results.

5. **Restrictions.** Licensee shall not disclose, publish, sell, assign, lease, share, lend, sublicense, market or transfer the Products in whole or in part, or use the Products in any manner or for any purpose not expressly authorized by this EULA. Intermap reserves all rights not expressly granted by this EULA. Unless otherwise expressly provided in Exhibit A, Licensee may not use the Products on behalf of, or allow the Products to be used by, any third party, whether or not a subsidiary or affiliated entity controlled by or related to Licensee. If Licensee is a federal, state, or local government agency, the Product is licensed solely to the particular agency and not by any other government agency, unless otherwise expressly provided in Exhibit A. Licensee acknowledges that the Products contain and embody proprietary materials, trade secrets, and copyrights of Intermap and its suppliers. Unauthorized reproduction, modification, distribution, or display of the Products in whole or in part, and in any manner not expressly authorized herein is prohibited. Licensee shall keep confidential and use its best efforts to protect the Products and prevent their unauthorized disclosure or use. Licensee shall immediately notify Intermap upon discovering evidence of a current or threatened misuse or unauthorized use or disclosure of the Products by any party. If the right to share access to the Products with other parties is granted in Exhibit A, such other parties shall in no event themselves have the right to further share or distribute the Products, and their use shall in all other respects be subject to compliance with this Agreement.
6. **U.S. Government End Users.** The Product is a “commercial item” as that term is defined at 48 C.F.R. 2.101 (Oct. 1995), consisting of “commercial computer software” and “commercial computer software documentation,” as such terms are used in 48 C.F.R. 12.212 (Sept. 1995). Consistent with 48 C.F.R. 12.212 (Sept. 1995) and 48 C.F.R. 227.7202-1 throughout 227.7202-4 (June 1995), all U.S. Government End Users acquire the Products with only those rights set forth herein. Contractor/manufacturer is Intermap Technologies Incorporated, Englewood, Colorado, USA. If the Products or any Thematic Derivative Works are used in connection with the performance of any government contracts or subcontracts, You shall ensure that (i) the Products and any Thematic Derivative Works shall not constitute a deliverable under any governmental contracts or subcontracts; and (ii) in no event shall a government entity acquire any rights other than those provided in this Section.

7. **LIMITED WARRANTY AND DISCLAIMERS.** INTERMAP WARRANTS FOR SIXTY (60) DAYS AFTER THE DELIVERY OF THE PRODUCTS THAT THE DATA DELIVERED WILL BE OF THE AREA OF INTEREST ORDERED AND THE MEDIA USED TO CARRY THE DATA WILL BE FREE FROM MATERIAL PHYSICAL DEFECTS. LICENSEE'S SOLE REMEDY, AND INTERMAP'S SOLE OBLIGATION UNDER THIS LIMITED WARRANTY SHALL BE FOR LICENSEE TO RETURN THE DEFECTIVE MEDIA TO INTERMAP WITHIN THE WARRANTY PERIOD, AND TO RECEIVE REPLACEMENT MEDIA. EXCEPT FOR THE LIMITED WARRANTY SPECIFIED HEREIN, THE PRODUCTS ARE PROVIDED WITHOUT WARRANTY OF ANY KIND, AND ALL WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED. INTERMAP DOES NOT WARRANT THAT THE PRODUCTS WILL MEET LICENSEE'S NEEDS OR EXPECTATIONS OR THAT USE OF THE PRODUCTS WILL BE ERROR FREE OR UNINTERRUPTED. IN NO EVENT SHALL INTERMAP BE LIABLE FOR ANY CLAIM OR LOSS INCURRED BY LICENSEE, INCLUDING WITHOUT LIMITATION COMPENSATORY, INCIDENTAL, INDIRECT, SPECIAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES, EVEN IF ADVISED OF THE LIKELIHOOD OF SUCH DAMAGES. THIS LIMITATION APPLIES TO ALL CAUSES OF ACTION, INCLUDING WITHOUT LIMITATION BREACH OF CONTRACT OR WARRANTY OR TORT. IF THE LIMITATION OF LIABILITY SET FORTH IN THIS AGREEMENT SHALL FOR ANY REASON BE HELD UNENFORCEABLE OR INAPPLICABLE, LICENSEE AGREES THAT INTERMAP'S LIABILITY SHALL NOT EXCEED THE LICENSE FEES PAID BY LICENSEE TO INTERMAP WITH RESPECT TO THE PRODUCTS AT ISSUE.
8. **Term and Termination.** This EULA shall become effective upon use of the Product and shall continue in force until terminated as provided herein. This EULA shall terminate immediately if Licensee fails to comply with any of its terms. Upon termination of this EULA for any reason, Licensee shall deliver to Intermap all copies and embodiments of the Products and certify in writing that no copies are left in Licensee's possession.

9. **Dispute Resolution and Governing Law.** This EULA shall be construed and enforced in accordance with the laws of the State of Colorado notwithstanding its conflict of laws provisions. The parties agree to attempt to settle any claim or controversy arising under this EULA through consultation and negotiation in the spirit of mutual friendship and cooperation. If such attempts fail, then the dispute shall first be submitted to a mutually acceptable neutral advisor for initial fact finding in preparation for mediation or other form of alternate dispute resolution. The exclusive jurisdiction and venue for any lawsuit or other dispute resolution proceeding between the parties arising out of this EULA shall be in Denver, Colorado, USA. The parties consent and submit to the exclusive personal jurisdiction of the courts resident in Denver, Colorado.
10. **Miscellaneous.** This EULA is the complete and exclusive statement between Licensee and Intermap with respect to the Products and may be amended or modified only in a written instrument signed by a duly authorized representative of both parties. If any provision is determined to be invalid or unenforceable, the remaining provisions of this EULA shall continue to be valid and enforceable. Neither this EULA nor any of the rights granted by it may be assigned or transferred by Licensee. This restriction on assignments or transfers shall apply to assignments or transfers by operation of law, as well as by contract, merger or consolidation. Licensee shall be solely responsible for obtaining any and all required government authorizations, including without limitation, any export or import licenses and foreign exchange permits. Nothing in this section shall restrict the ability of Intermap to pursue any legal or equitable remedy or to obtain an injunction to protect any rights Intermap may have arising out of or relating to the Product or any of Intermap's intellectual property rights. Sections 5, 6, 7 and 8 shall survive expiration or termination of this EULA.
11. **Export Licensing Notification.** The products delivered hereunder are subject to the export licensing regulations of the United States Department of Commerce. The recipient of the Products may be obligated under US law to comply with such regulations in distributing the Products. Licensee shall be solely responsible for compliance with same.

12. **Remedies.** Licensee shall defend, indemnify, and hold Intermap, its affiliates, directors, employees, and agents from and against any claim, action, proceeding, loss, cost, expense, damages, and liability, including reasonable attorneys' fees, arising from Licensee's breach of any provision of this EULA. If Licensee is granted any rights to share access to the Products with other parties, as may be provided in Exhibit A, Licensee shall at all times remain responsible for all such users, and shall ensure their full compliance with the requirements of this Agreement. Conduct in violation of this Agreement by such other parties shall be deemed to be a material breach of this Agreement by Licensee.

EXHIBIT A

List additional parties to which Licensee may disclose or allow access to the Products.

**INTERMAP TECHNOLOGIES INC.
PROJECT END USER LICENSE AGREEMENT**

1. **Introduction.** This End User License Agreement (“EULA”) is between Intermap Technologies Inc. (“Intermap”) and the licensee (“Licensee”) identified at the end of this EULA. This license governs Licensee’s use of the data products or documentation accompanying this EULA (the “Products”) for the Project specified in the accompanying contract (Project Number _____). By using the Products, Licensee agrees to be bound by the terms of this EULA. If Licensee does not agree with these terms, it must promptly return the unused Product to Intermap, and license fees paid will be refunded in full. The Products includes the data, databases, and data products of Intermap and its third party providers.

2. **Scope of License.** Intermap grants Licensee a limited, restricted, perpetual, revocable, non-transferable, non-exclusive license to use the Products in the manner set forth in this EULA. If so stated in the attached Exhibit A, Licensee may have the limited right to allow use and access to the Products to additional parties identified in Exhibit A, solely in connection with the Project, and in all events subject to the terms of this Agreement. Licensee’s use of the Products must strictly comply with the following restrictions: (a) Licensee may only use the Products for Licensee’s valid internal business purposes, solely in relation to the Project, and not for redistribution; (b) Licensee may not itself, or allow others, to create or distribute Product Derivative Works (as defined in Section 3). Licensee may create and distribute orthoimagery products so long as the product media and packaging at all times include the Intermap Technologies Inc. logo, in the form made available by Intermap at Licensee’s request. Licensee is authorized to distribute Thematic Derivative Works (as defined in Section 4).

3. **Product Derivative Works.** Product Derivative Works are defined as any image, representation or alteration of the Products from which the Products or portions thereof are capable of being reverse engineered, recreated, discerned, or otherwise made available. Examples of Product Derivative Works include, but are not limited to, contour maps, elevation data from resampled Products and or any derived product that contains elevation information or spot heights derived from Intermap data.

4. **Thematic Derivative Works.** Thematic Derivative Works are defined as any image, representation or alteration of the Products from which the Products cannot be reverse engineered. Examples of Thematic Derivative Works include thematic maps, hazard maps, fly-through videos, perspective views, vector-based road center lines, building or feature outlines, mapping class boundaries, or other vector-based data extraction results.

5. **Restrictions.** Licensee shall not disclose, publish, sell, assign, lease, share, lend, sublicense, market or transfer the Products in whole or in part, or use the Products in any manner or for any purpose not expressly authorized by this EULA. Intermap reserves all rights not expressly granted by this EULA. Unless otherwise expressly provided in Exhibit A, Licensee may not use the Products on behalf of, or allow the Products to be used by, any third party, whether or not a subsidiary or affiliated entity controlled by or related to Licensee. If Licensee is a federal, state, or local government agency, the Product is licensed solely to the particular agency and not by any other government agency, unless otherwise expressly provided in Exhibit A. Licensee acknowledges that the Products contain and embody proprietary materials, trade secrets, and copyrights of Intermap and its suppliers. Unauthorized reproduction, modification, distribution, or display of the Products in whole or in part, and in any manner not expressly authorized herein is prohibited. Licensee shall keep confidential and use its best efforts to protect the Products and prevent their unauthorized disclosure or use. Licensee shall immediately notify Intermap upon discovering evidence of a current or threatened misuse or unauthorized use or disclosure of the Products by any party. If the right to share access to the Products with other parties is granted in Exhibit A, such other parties shall in no event themselves have the right to further share or distribute the Products, and their use shall in all other respects be subject to compliance with this Agreement.

6. **U.S. Government End Users.** The Product is a "commercial item" as that term is defined at 48 C.F.R. 2.101 (Oct. 1995), consisting of "commercial computer software" and "commercial computer software documentation," as such terms are used in 48 C.F.R. 12.212 (Sept. 1995). Consistent with 48 C.F.R. 12.212 (Sept. 1995) and 48 C.F.R. 227.7202-1 throughout 227.7202-4 (June 1995), all U.S. Government End Users acquire the Products with only those rights set forth herein. Contractor/manufacturer is Intermap Technologies Incorporated, Englewood, Colorado, USA. If the Products or any Thematic Derivative Works are used in connection with the performance of any government contracts or subcontracts, You shall ensure that (i) the Products and any Thematic Derivative Works shall not constitute a deliverable under

any governmental contracts or subcontracts; and (ii) in no event shall a government entity acquire any rights other than those provided in this Section.

7. **LIMITED WARRANTY AND DISCLAIMERS.** INTERMAP WARRANTS FOR SIXTY (60) DAYS AFTER THE DELIVERY OF THE PRODUCTS THAT THE DATA DELIVERED WILL BE OF THE AREA OF INTEREST ORDERED AND THE MEDIA USED TO CARRY THE DATA WILL BE FREE FROM MATERIAL PHYSICAL DEFECTS. LICENSEE'S SOLE REMEDY AND INTERMAP'S SOLE OBLIGATION UNDER THIS LIMITED WARRANTY SHALL BE FOR LICENSEE TO RETURN THE DEFECTIVE MEDIA TO INTERMAP WITHIN THE WARRANTY PERIOD, AND TO RECEIVE REPLACEMENT MEDIA. EXCEPT FOR THE LIMITED WARRANTY SPECIFIED HEREIN, THE PRODUCTS ARE PROVIDED WITHOUT WARRANTY OF ANY KIND, AND ALL WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED. INTERMAP DOES NOT WARRANT THAT THE PRODUCTS WILL MEET LICENSEE'S NEEDS OR EXPECTATIONS OR THAT USE OF THE PRODUCTS WILL BE ERROR FREE OR UNINTERRUPTED. IN NO EVENT SHALL INTERMAP BE LIABLE FOR ANY CLAIM OR LOSS INCURRED BY LICENSEE, INCLUDING WITHOUT LIMITATION COMPENSATORY, INCIDENTAL, INDIRECT, SPECIAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES, EVEN IF ADVISED OF THE LIKELIHOOD OF SUCH DAMAGES. THIS LIMITATION APPLIES TO ALL CAUSES OF ACTION, INCLUDING WITHOUT LIMITATION BREACH OF CONTRACT OR WARRANTY OR TORT. IF THE LIMITATION OF LIABILITY SET FORTH IN THIS AGREEMENT SHALL FOR ANY REASON BE HELD UNENFORCEABLE OR INAPPLICABLE, LICENSEE AGREES THAT INTERMAP'S LIABILITY SHALL NOT EXCEED THE LICENSE FEES PAID BY LICENSEE TO INTERMAP IN THE TWELVE (12) MONTH PERIOD PRECEDING LICENSEE'S CLAIM WITH RESPECT TO THE PRODUCTS AT ISSUE.
8. **Term and Termination.** This EULA shall become effective upon use of the Product and shall continue in force until completion of the Project. Upon completion of the Project, Licensee shall return to Intermap the Products and confirm in writing that the Project has been completed, and that Licensee has destroyed all copies of the Products in its possession or under its control. This EULA is non-renewable. In addition, this EULA and the license herein granted shall terminate immediately if Licensee fails to comply with any of its terms. Upon termination of this EULA for any reason, Licensee shall deliver to Intermap all copies and embodiments of the Products and certify in writing that no copies are left in Licensee's possession.

9. **Dispute Resolution and Governing Law.** This EULA shall be construed and enforced in accordance with the laws of the State of Colorado notwithstanding its conflict of laws provisions. The parties agree to attempt to settle any claim or controversy arising under this EULA through consultation and negotiation in the spirit of mutual friendship and cooperation. If such attempts fail, then the dispute shall first be submitted to a mutually acceptable neutral advisor for initial fact finding in preparation for mediation or other form of alternate dispute resolution. The exclusive jurisdiction and venue for any lawsuit or other dispute resolution proceeding between the parties arising out of this EULA shall be in Denver, Colorado, USA. The parties consent and submit to the exclusive personal jurisdiction of the courts resident in Denver, Colorado.

10. **Miscellaneous.** This EULA is the complete and exclusive statement between Licensee and Intermap with respect to the Products and may be amended or modified only in a written instrument signed by a duly authorized representative of both parties. If any provision is determined to be invalid or unenforceable, the remaining provisions of this EULA shall continue to be valid and enforceable. Neither this EULA nor any of the rights granted by it may be assigned or transferred by Licensee. This restriction on assignments or transfers shall apply to assignments or transfers by operation of law, as well as by contract, merger or consolidation. Licensee shall be solely responsible for obtaining any and all required government authorizations, including without limitation, any export or import licenses and foreign exchange permits. Nothing in this section shall restrict the ability of Intermap to pursue any legal or equitable remedy or to obtain an injunction to protect any rights Intermap may have arising out of or relating to the Product or any of Intermap's intellectual property rights. Sections 5, 6, 7 and 8 shall survive expiration or termination of this EULA.

11. **Export Licensing Notification.** The products delivered hereunder are subject to the export licensing regulations of the United States Department of Commerce. The recipient of the Products may be obligated under US law to comply with such regulations in distributing the Products. Licensee shall be solely responsible for compliance with same.

12. **Remedies.** Licensee shall defend, indemnify, and hold Intermap, its affiliates, directors, employees, and agents from and against any claim, action, proceeding, loss, cost, expense, damages, and liability, including reasonable attorneys' fees, arising from Licensee's breach of any provision of this EULA. If Licensee is granted any rights to share access to the Products with other parties, as may be provided in Exhibit A, Licensee shall at all times remain responsible for all such users, and

shall ensure their full compliance with the requirements of this Agreement. Conduct in violation of this Agreement by such other parties shall be deemed to be a material breach of this Agreement by Licensee.

EXHIBIT A

List additional parties to which Licensee may disclose or allow access to the Products.

