Alaska Geographic Data Committee

# Alaska Digital Elevation Model (DEM)
# Funding and Implementation Plan

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# Alaska DEM Requirements

It is often said that Mars is mapped with greater detail and accuracy than Alaska. Whether or not this statement is true, it is a fact that Alaska is the only state that does not have USGS topographic quadrangle maps, at any scale, that satisfy the National Map Accuracy Standards (NMAS). Whereas the other 49 states were mapped at 1:24,000-scale and satisfy the NMAS, Alaska was mapped at a scale of 1:63,360 (1" = 1 mile) in the 1950s, but not to the NMAS. Today's GPS technology enables us to determine that horizontal and vertical errors for these topographic maps of Alaska are many times larger than allowed by the NMAS — as much as 100 times larger in some cases.

The contour lines on the existing USGS topographic quadrangle maps of Alaska (1:63,360-scale) were used to create Alaska's DEM in the National Elevation Dataset (NED) maintained by USGS, but this DEM has the same horizontal and vertical errors as the quadrangle maps from which the elevations were derived.

In 2000, the Shuttle Radar Topography Mission (SRTM), funded by the National Aeronautics and Space Administration (NASA) and what is now the National Geospatial-Intelligence Agency (NGA), succeeded in obtaining a consistent topographic map of the Earth's surface between 57° south latitude and 60° north latitude, but most of Alaska, including Anchorage and Fairbanks, is north of 60° and was not mapped by the SRTM.

Furthermore, Alaska is the only state that does not have gravity data needed to accurately map elevations (orthometric heights) using GPS and aerial mapping technologies. In order for DEMs to correctly model the downward flow of water, ellipsoid heights (from aerial surveys) require geoid height corrections (from gravity surveys) in order to produce orthometric heights, commonly called elevations. Whereas errors in the geoid model in the other 49 states are approximately 1-2 cm, geoid height errors are ±2 meters or more in Alaska, meaning that the best aerial mapping technologies available today will still yield orthometric height (elevation) errors of 2 meters or more in DEMs produced of Alaska. NOAA's National Geodetic Survey (NGS) has a plan called *Gravity for the Re-definition of the American Vertical Datum (GRAV-D)* for addressing this issue nationwide (see www.ngs.noaa.gov/GRAV-D/) with the highest two priority areas in Alaska. Unfortunately GRAV-D currently has no dedicated funding.

## *Alaska DEM Whitepaper*

Published in September, 2008, the Alaska DEM whitepaper, available for download at www.alaskamapped.org, documents the DEM requirements of 14 Alaska user groups including Federal and State agencies to distinguish between nice-to-have vs. true requirements, and project-specific vs. statewide DEM requirements. Those requirements are summarized in Table 1.

**Table 1 — Vertical Accuracy Requirements**

| DEM User Groups | High-accuracy 10' and below contour accuracy (Airborne LiDAR) | Mid-accuracy 20' to 30' contour accuracy (Airborne IFSAR) | Low-accuracy 40' and higher contour accuracy (Satellite Sensors) |
|---|---|---|---|
| **Alaska Aviation** | | 20' contour accuracy ICAO Area 2 standard | 200' contour accuracy ICAO Area 1 standard |
| **Alaska DCCED** | 2' contour accuracy | | |
| **Alaska DGGS** | 2' & 10' contour accuracy | | 50' & 100' contour accuracy |
| **Alaska DNR** | | | 40' contour accuracy |
| **Alaska DOT** | 4' & 10' contour accuracy | | |
| **Alaska University Users** | 2' & 10' contour accuracy | 30' contour accuracy | 50' contour accuracy |
| **BLM** | | 20' contour accuracy | |
| **DOD** | | 20' contour accuracy | |
| **NGA** | | | 50' contour accuracy |
| **NOAA** | 2' contour accuracy | 20' contour accuracy | 40' contour accuracy |
| **NPS** | | | 40' contour accuracy |
| **NRCS** | | | 40' contour accuracy |
| **USFS** | | 20' contour accuracy | |
| **USGS** | 10' contour accuracy ("ideal") | 20' contour accuracy ("preferred") | 40' contour accuracy ("acceptable") |

The DEM whitepaper further documents the advantages and disadvantages of various mapping technologies to address the high-, mid-, and low-accuracy requirements of these 14 user groups, with major conclusions as follows:

- The high-accuracy DEM requirement (2' to 10' contour accuracy) can best be satisfied by airborne LiDAR; however, only the NOAA Coastal Services Center has such a need over a large area, i.e., all of the Alaska coastlines. This will require special funding beyond the SDMI funding which applies statewide.

- The mid-accuracy DEM requirement (20' to 30' contour accuracy) can best be satisfied by airborne IFSAR. This mid-accuracy is needed to satisfy FAA and DOT Area 2 requirements for Aviation Safety, as well as statewide requirements of BLM, DOD, NOAA, USFS and USGS. These mid-accuracy statewide requirements 'drive' the overall DEM requirements of the SDMI because they essentially cover the entire state.

- The low-accuracy DEM requirement (40' contour accuracy and above) could be satisfied by several satellite alternatives to address the less-demanding needs of DNR, NGA, NPS, NRCS and USF&WS. Although the satellite options would not satisfy the more-demanding needs of FAA, DOT, BLM, DOD, NOAA, USFS and USGS, they could potentially be used to fill any voids in the terrain surface that might occur from IFSAR data.

- The vertical accuracy issue is the major issue with significant impacts on the overall cost of the SDMI.

Additional conclusions pertain to user group preferences for different data types and formats that can be accommodated with relative ease, as well as data enhancements for which Conclusion 6 states: "Those agencies with differing requirements for DEM enhancements should preferably pay the additional costs necessary for their areas of responsibility, with funding separate from SDMI funding."

## *Rationale for Mid-Accuracy DEM*

There are four overarching justifications for Alaska mid-accuracy DEMs with vertical accuracy equivalent to 20-ft contours: (a) aviation safety, (b) hydrographic analyses and modeling, (c) defense and homeland security, and (d) digital orthophotos and boundary delineations.

### Aviation Safety

Because of the remote terrain and sparse road network, Alaskans rely heavily on air transportation; and when they dial E911 for a medical emergency, they often require an air ambulance for air evacuation rather than a traditional ground ambulance. Alaska has the highest aviation accident rate in the nation due to hazardous flying conditions where aircraft navigate through mountain passes rather than over the mountains as is common elsewhere. The aviation safety issues are so severe that Appendix B of the DEM whitepaper was used to document the issues and to provide maps of Alaska airfields where aviators are routinely required to land under instrument flight rule (IFR) procedures, even though they do not have the accurate topographic data to land in the dark or during periods of poor visibility. Aviation safety and the need for accurate elevation data are major issues in Alaska which relies heavily on air transportation under the most difficult flying conditions in the U.S.

The United States is a signatory nation to the charter of the International Civil Aviation Organization (ICAO). In 2004, by not filing an objection to ICAO's Electronic Terrain and Obstacle Database (eTOD) requirements, the U.S. agreed to comply with these standards for terrain mapping and creation of an Area 1 compliant database for all of its territory by November of 2008 and Area 2 compliant database for IFR airfield sites by November of 2010. Because the Shuttle Radar Topography Mission (SRTM) did not collect elevation data north of 60°north latitude, and because of major known horizontal and vertical errors in the National Elevation Dataset (NED) of Alaska, the U.S. currently does not satisfy the relatively simple Area 1 standard in Alaska (equivalent to 200-ft contour accuracy). Neither is the U.S. prepared to satisfy the more-demanding Area 2 standard in Alaska (equivalent to 20-ft contour accuracy) within circles of 45 Km radius for hundreds of IFR site terminal control areas (peach colored circles at Figure 1).

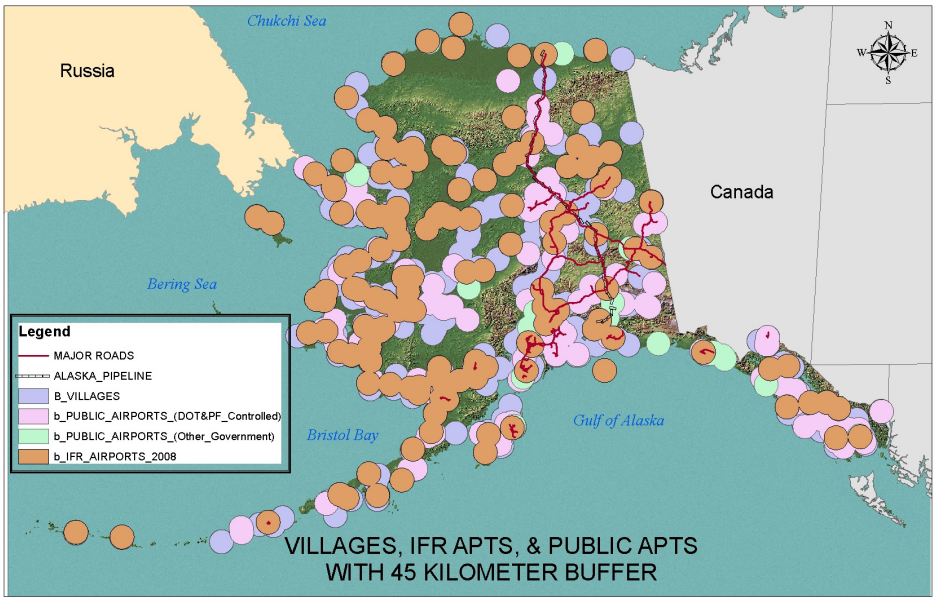


**Figure 1. Airports at Alaska villages, public airports, and FAA IFR sites combined.**

The eTOD is an internationally agreed-on standard to provide a terrain database for safe flying and navigation under Instrument Meteorological Conditions (IMC) when pilots cannot see the terrain at all due to night and clouds or other inclement weather such as heavy rain and snowfall. When Visual Flight Rules (VFR) cannot be safely followed, and especially during emergency air evacuations at remote villages, aviators then operate under IFR designed to keep aircraft from unintentionally flying into obstacles due to navigation errors. The need for elevation data to create a reliable and FAA-compliant eTOD for navigation in Alaska, during periods of limited visibility, has never been greater. IMC flying conditions have to be coped with in Alaska on a regular basis for airfields throughout the state, even for airfields that are not part of the FAA's IFR sites, including all airfields at Figure 1. Accurate DEMs are vital for flight planning, terrain avoidance, transiting through mountain passes, landing of float planes on rivers and other water bodies, and flight simulators for training of pilots flying in Alaska.

The Area 2 DEM requirements, equivalent to 20-ft contour accuracy, pertain only to the areas within the peach-colored circles shown at Figure 1. However, it makes no sense to acquire higher accuracy elevation data within those circles and lower accuracy data elsewhere. As explained in the DEM whitepaper, airborne IFSAR is the most cost effective technology for acquiring elevation data, statewide, with vertical accuracy comparable to 20-ft contours, as required by ICAO Area 2 requirements. Satisfaction of Area 2 standards would bring Alaska on-par with the other 49 states that already have full airborne IFSAR coverage, NED data that satisfies the National Map Accuracy Standard, where weather and light conditions are less severe, where flying conditions are less dangerous, and where emergency evacuations are routinely performed by ground ambulances rather than air ambulances as in Alaska. The differences between ICAO Area 1 and Area 2 standards are shown at Table 2.

**Table 2. Comparison of ICAO Area 1 and Area 2 Standards**

| ICAO | Area 1 Standards | Area 2 Standards |
|---|---|---|
| **Post Spacing** | 3-arc-seconds (≈90 meters) | 1-arc-second (≈30 meters) |
| **Vertical Accuracy (LE90)** | 30 meters | 3 meters |
| **Equivalent Contour Interval** | 60 meters (200 ft) | 6 meters (20 ft) |
| **Vertical Resolution** | 1 meter | 0.1 meter |
| **Horizontal Accuracy (CE90)** | 50 meters | 5 meters |
| **Confidence Level** | 90% | 90% |
| **Compliance Date** | November 20, 2008 | November 20, 2010 |

## Hydrographic Modeling and Analyses

Definitions: As used herein, the word *hydrography* refers to the measurement, description and mapping of the surface waters of the earth. This generalized definition is intended to include *hydrology* (the study of the movement, distribution, and quality of water); *hydraulic* (the engineering science pertaining to liquid pressure and flow); and *hydrographic-enforcement* (the processing of mapped water bodies so that lakes and reservoirs are level and so that streams flow downhill).

In a survey conducted by the SDMI, approximately 75% of the respondents indicated that they require mapping data to support some form of hydrographic modeling and/or analysis. Hydrographic applications include maintenance of navigable streams and waterways, watershed management, water quality management, floodplain management, coastal erosion monitoring, tidal inundation, sea level change, natural disasters impacting hydrographic features, fishery and wildlife management, pre-engineering assessments, claims mitigation as pertains to hydrographic features, and safe operations of float planes. With Alaska's vast natural resources, mapping and understanding the hydrography of Alaska is high on everyone's priority list.

Additionally, an IFSAR DTM of Alaska would enable the National Hydrography Dataset (NHD) of Alaska, currently georeferenced to the highly inaccurate 1:63,360-scale topographic, to be become positionally-accurate and bring it into compliance with accuracy standards required for all layers of The National Map.

## Defense and Homeland Security

The DOD in Alaska states that it needs DTED data of higher accuracy than DTED2 for military training throughout the state, though NGA only recognizes the need for DTED3 in a very small area. DOD activity in Alaska includes troop exercises within the 1.5 million acres of Army owned land, joint training within restricted airspace, and aerial activity within the 200,000 square miles of Military Operations Areas (MOAs). Higher accuracy elevation data is especially important for unmanned aerial vehicle (UAV) and rotary wing aircraft which are playing an increasing role in the training activity in Alaska where rugged terrain conditions are similar to those in Afghanistan. Outside military airspace, DEMs with 20-foot

contour accuracy are an essential tool for rotary wing operations performing search-and-rescue and medivac operations throughout the state.

The U.S. Coast Guard (USCG), part of the Department of Homeland Security, has similar requirements for search-and rescue and medivac operations along coastal areas of Alaska. For those traveling to Kodiak Island, there is a crash scene of a USCG helicopter that flew into the side of a mountain. Although the helicopter was equipped with radar to sense the terrain directly in front of the aircraft, the experienced pilot had no way to sense the terrain on the side of the aircraft in the dark, and the winds apparently blew the aircraft sideways into the mountain. This happened several decades ago, before the popular use of DEMs and eTOD data to assist pilots navigating under difficult conditions.

In summary, DOD and DHS in Alaska both have DEM needs very similar to the broader Aviation Safety community, but compounded by the urgency of their search-and-rescue and medivac operations under the most difficult flying conditions. Neither DOD nor DHS have the luxury of delaying their missions until the weather clears, which can take weeks in Alaska. A strong argument can be made that we owe it to our brave service members and emergency responders to provide them with the accurate DEMs needed for safe operations in Alaska, as already exist in the other 49 states where aerial operations are much safer.

## Digital Orthophotos and Boundary Delineation

Digital orthophotos are required by land use managers at Federal, state and local levels, and they are often used for boundary delineation. Whereas DEMs with relatively poor vertical accuracy may suffice for orthorectification of imagery that is near-vertical, or with satellite imagery that has high native horizontal accuracy such as GeoEye-1 (5m CE90) or WorldView-1 (6.5m CE90), the mid-accuracy IFSAR DEM also has horizontal accuracy better than the required 12.2m CE90 (for orthophotos to meet 1:24,000-scale accuracy standards) and could be used for geo-registration and pan-sharpening of satellite imagery with poorer native horizontal accuracy such as Ikonos (15m CE90), QuickBird (23m CE90) or SPOT5 (39m CE90). The native horizontal accuracy of satellite imagery is the error inherent in the satellite model using the best method available when ground control is not used. Typically, this would be a model that uses rational polynomial coefficients (RPCs). Most vendors provide RPCs with their non-orthorectified imagery, and they often will quote a number that represents the accuracy one can expect using RPCs without ground control points (GCPs). This is often referred to as the geolocation accuracy of the satellite. Utilization of ground control transfers influence on orthopositional error from the sensor's native accuracy specification to the sensor's improved accuracy specification coupled with the accuracy of the GCPs utilized. Note, Intermap's IFSAR is advertised to have horizontal accuracy of 3 meters (CE90) for its X-band sensor, and Fugro EarthData's GeoSAR is advertised to have horizontal accuracy of 9.1 meters (CE90) for its X-band sensor.

For many applications, orthophotos only need *relative accuracy* for measurement of angles, distances and areas. However, for boundary delineation and other applications requiring absolute positional

accuracy, orthophotos need *absolute accuracy* so that GPS surveys, for example, would be consistent with such boundaries. National Map Accuracy Standards (NMAS) pertain to *absolute accuracy*.

Satellite or airborne cameras produce images that have a perspective projection whereby the size and shape of ground features vary as a function of distance and angle to the sensor. Except within small local areas, perspective images have neither relative accuracy nor absolute accuracy. When images are oblique or off-nadir, there is a greater distortion of ground features than when images are perfectly vertical. In order to produce digital orthophotos that have the metric properties of a map, perspective imagery is converted to orthographic imagery (looking straight down, as with traditional topographic maps) by projecting the original images onto a DEM by a process called orthorectification.

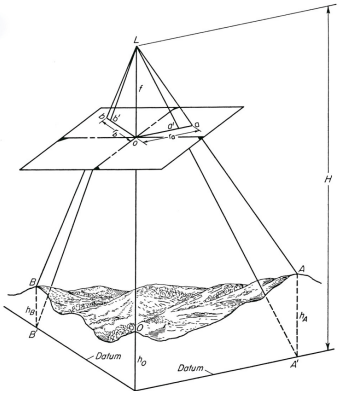


**Figure 2. Projecting an aerial image over a DEM.**

To accurately project an image onto the DEM, as shown at Figure 2, the DEM itself must be accurate, both horizontally and vertically, and six exterior orientation (EO) parameters must be accurately known for each photograph to be correctly projected onto the DEM, including the x/y/z coordinates of the perspective center of the camera lens (point "L" at Figure 2), and the roll (ω), pitch (ϕ) and yaw (κ) of the camera at the instant when the image is recorded. These six EO parameters (x,y,z, ω,ϕ,κ) are required whether imagery is from a frame or pushbroom sensor. The EO parameters are determined from: (1) direct airborne GPS measurement of x/y/z coordinates of the camera and inertial measurement unit (IMU) measurements of ω/ϕ/κ of the aircraft for each image, (2) from an aerial triangulation process, or (3) from satellite EO parameters if satellite imagery is used for the orthorectification.

If satellite imagery is used to produce digital orthophotos of Alaska, the horizontal accuracy of the orthophotos will depend on the vertical and horizontal accuracy of the DEM, the slope of the terrain, the native and/or improved positional accuracy of the imagery, the image sensor's off-nadir (incidence) angle, aerotriangulation (AT) procedures used to tie all images together in large block adjustments, and the use of GCPs that are photo-identifiable at the pixel resolution of the imagery being used. Thus, the horizontal accuracy of orthoimagery is a function of both the horizontal and vertical accuracies of the DEM, among other factors.

DEMs with high vertical accuracy are not necessarily required for accurate orthorectification when the imagery is truly vertical. For off-nadir imagery, the more accurate the DEM both horizontally and vertically, the more accurate the orthophotos produced from that DEM. The absolute horizontal positional accuracy of an orthophoto largely depends on the native or improved horizontal accuracy of the imagery used, with CE90 values that vary from 2 to 450 meters for satellite imagery.

Largely because of its poor DEM, Alaska is the only state that does not have accurate digital orthophotos. In fact, most of Alaska does not even have inaccurate digital orthophotos, much less accurate ones routinely available elsewhere in the U.S. The Alaska NED datasets are so inaccurate that

mountain ranges are horizontally displaced by several miles in some locations, and elevations are in error by hundreds of meters, causing major discrepancies between orthophotos and elevation datasets. As shown at Figure 3, orthophotos of Alaska often show rivers on mountainsides, at different locations than the lower elevations where hydrographic features are naturally present.

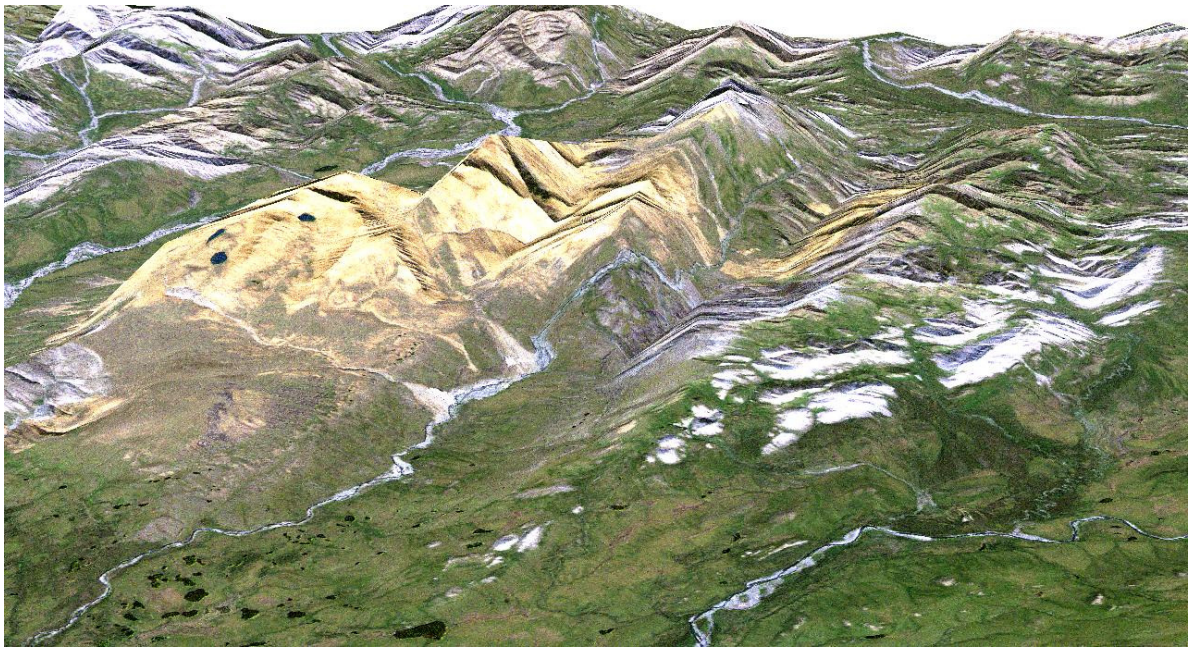

**Figure 3. Because the Alaska NED is so inaccurate, with some mountains several miles away from their true locations and with the wrong elevations, digital orthophotos of Alaska often show rivers climbing up and over mountains, causing confusion rather than clarity for users and distorting boundary delineations. BLM surveys are routinely based on stream meander lines; however, when streams are not mapped correctly, as shown here, there is no reference surface of higher accuracy on which to resolve major discrepancies.**

The Alaska DEM whitepaper evaluated various terrain options, indicating that DEMs of low vertical accuracy (40-foot contour accuracy or worse) are often usable for orthorectification, assuming the DEM horizontal accuracy is suitable for mapping at a scale of 1:24,000, but also depending on other factors such as the horizontal accuracy and incidence angle of the source imagery and the slope of the terrain.

When producing digital orthophotos at a scale of 1:24,000 (1" = 2,000 feet), the circular error at 90% confidence level (CE90) must be 12.2 meters or less from all error sources. When producing 1-meter orthophotos to standards of the Imagery for the Nation (IFTN) program, for example, CE90 should be 7.6 meters or less. These are the total horizontal error budgets from all sources.

Three basic terrain options are available, again classified as low-, mid-, and high-accuracy:

- Low-accuracy elevation data from satellites. Several satellite firms offer options for generating their own low-accuracy DEMs from stereo imagery and producing orthophotos that are guaranteed to fit those DEMs; however, without GCPs or registration to higher-accuracy image chips, those images will have relative accuracy rather than absolute accuracy. Some satellite vendors, with native horizontal accuracy worse than required for CE90 of 12.2 meters, provide operational accuracies that satisfy CE90 standards of 12.2 meters based on more-rigorous

production procedures (e.g., large block aerial triangulations) that include the use of GCPs. Recognizing that photo-identifiable GCP are very expensive to place and survey in Alaska, those satellites with better native horizontal accuracy are more likely to satisfy the CE90 standards and not consume the entire error budget or require expensive GCPs.

- Mid-accuracy elevation data from IFSAR. If Alaska succeeds in obtaining a statewide IFSAR DEM, as recommended in the Alaska DEM whitepaper, the IFSAR's orthorectified radar imagery (ORI) could be used for "pan-sharpening" of satellite multispectral imagery, registering the lower-resolution and less-accurate satellite imagery to the more-accurate and higher-resolution ORI having 1.25-meter pixel resolution, for example, and ensuring that the satellite imagery is accurately projected onto the IFSAR DEM. For users requiring high pixel definition, they could utilize the 1.25-meter imagery, per examples at Figures 4 through 7. For other users requiring lower pixel definition, imagery could be decimated to 2.5-meter, 5-meter, 10-meter, or other pixel resolution. Figure 4 shows ORI pan-sharpening of a 10 m ALOS image in a flat, urban area.

ALOS Orthorectified Image 10 m pixel ALOS pan-sharpened Image 1.25 m pixel

**Figure 4. ALOS 10 m resolution satellite image, before and after pan-sharpening with 1.25 m ORI**

Figure 5 shows ORI pan-sharpening of a 10 m ALOS image in a mountainous area.

**Figure 5. ORI used to pan-sharpen 10m ALOS satellite imagery to 1.25m**

Figure 6 shows ORI pan-sharpening of a 5 m Rapid Eye image in a flat, urban area.


**Figure 6. ORI used to pan-sharpen 5m Rapid Eye satellite imagery to 1.25m**

Figure 7 shows ORI pan-sharpening of a 5 m Rapid Eye image (partly cloud-covered) in a mountainous area; what appears to be a lake in the RapidEye image (Figure 7, center image) is actually a dark shadow from clouds. In addition to ALOS and RapidEye, such ORI pan-sharpening techniques could be used to improve the horizontal accuracy and/or pixel resolution of other satellite images to include SPOT5, IKONOS, QuickBird, ASTER, and Landsat.

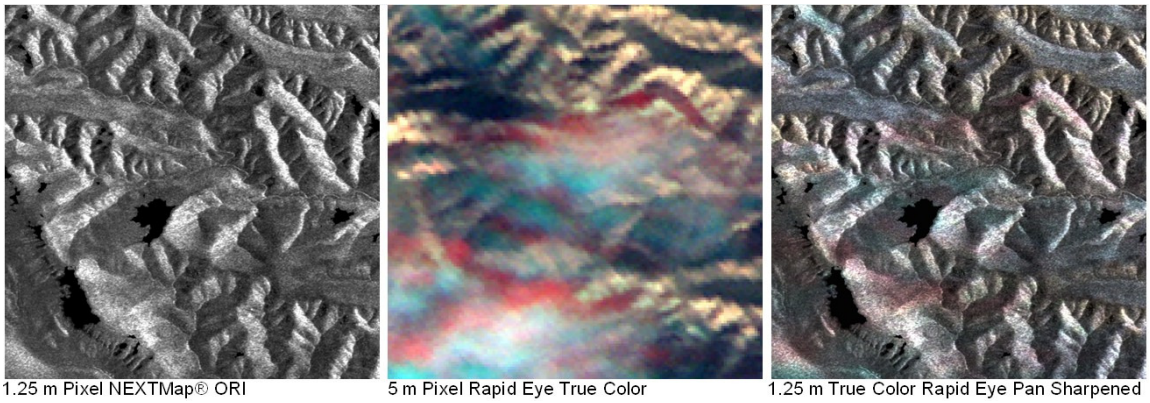


**Figure 7. ORI used to pan-sharpen 5m Rapid Eye satellite imagery to 1.25m. The dark area in the center image is a shadow from the clouds. The red and blue hues, from spectral reflection on clouds, is mostly filtered out in the pan-sharpened image on the right, while clearly showing the lakes that are not clearly defined in the satellite image.**

- High-accuracy elevation data from LiDAR. LiDAR produces the most accurate DEM, primarily because it is best able to penetrate dense forest canopy to map the bare earth terrain and produce a digital terrain model (DTM), but this option would be very expensive and difficult to justify unless the high accuracy LiDAR DTM is required for other applications. For cities requiring high resolution orthoimagery, with 12-inch or 6-inch pixels for example, it is assumed that they would contract for airborne imagery for their desired image resolution, either using stereo photogrammetry for compilation of the DEM and/or using a LiDAR DEM for orthorectification.

In summary, orthophotos can be produced using lower-accuracy DEMs (e.g., 50-foot contour accuracy), but the mid-accuracy DEMs required for aviation safety, homeland security and national defense would produce higher accuracy digital orthophotos using the same DEMs required elsewhere.

## *NDOP and NDEP Consensus*

The Alaska DEM whitepaper provides compelling rationale as to why such elevation data are urgently required, and reasons why airborne IFSAR is the most cost-effective solution. As summarized in Table 3 and Table 4 below, the primary and secondary consensus points presented in the DEM whitepaper received unanimous agreement from all members of the National Digital Orthophoto Program (NDOP) and National Digital Elevation Program (NDEP) during their combined meeting in Anchorage in August of 2008.

Table 3 refers to the urgent need for aviation safety and other requirements unique to Alaska, including national defense, homeland security, digital orthophotography, and boundary delineations as described above. Table 4 refers to the National Elevation Dataset (NED), the best-available DEM of Alaska, which does not satisfy National Map Accuracy Standards at any scale, is totally unusable for aviation safety and is not accurate enough to support production of digital orthophotos. Table 4 also refers to the Geographic Information Network of Alaska (GINA) which is expected to make an improved statewide DEM available to all when the data becomes available. The secondary consensus points can be

addressed while actions are in progress to acquire the statewide coverage of IFSAR DEMs, after we determine precise costs and obtain needed funding for project implementation.

**Table 3. Primary Consensus Points agreed to by NDOP/NDEP Participants**

| We have no time to waste | We must remain true to Alaska's requirements | We must find a timely, cost-effective solution |
|---|---|---|
| • ICAO Area 1 Requirements: effective 11/20/2008<br>• ICAO Area 2 Requirements: effective 11/20/2010<br>• Other statewide DEM user requirements: Immediate for orthorectification of optical imagery<br>• Alaska's mapping needs have been neglected for 50 years; unmet needs in Alaska are dire, especially aviation safety | • 20' contour accuracy or better<br>• Both DSM and DTM, especially mountain peaks, ridgelines and hydrology<br>• Technology that overcomes adverse weather conditions<br>• Technology that maps snow-capped mountains & glaciers<br>• Technology that is cost-effective | • Only airborne mapping options can satisfy AK's technical and accuracy requirements<br>• Airborne IFSAR costs are significantly less than airborne LiDAR or photogrammetry<br>• Multiple contracting options are available to obtain the most cost-effective solution for timely delivery of quality products<br>• Need both federal and state funding |

**Table 4. Secondary Consensus Points agreed to by NDOP/NDEP Participants**

| We have time to reach consensus elsewhere | What other requirements should be satisfied? How? By Whom? | We must find cost-effective solutions |
|---|---|---|
| • Data acquisition and post-processing can proceed if we choose ellipsoid heights and Alaska Albers, for example, knowing that the NED will be provided as geographic coordinates in ESRI grid format.<br>• Other issues can be resolved while data are being acquired and processed. | • Will GINA serve multiple datasets to the public?<br>• Will GINA provide orthometric heights that change with new geoid models?<br>• Will GINA provide GeoTiff and/or other file formats?<br>• Who will perform hydro-enforcement of DTM? How? Who pays?<br>• Who will filter DTM so roads are smooth on orthophotos? How? Who pays? | • Answers to these questions may depend on available funds and contract costs for data acquisition & processing.<br>• If available funds are inadequate to pay for everything as part of major contract, get data acquired and DSM/DTM delivered ASAP; then determine if those responsible for land management pay for hydro-enforcement, etc. if needed for their areas of responsibility. |

# *Technical Conclusions*

## Rationale for IFSAR Sensor Technology

The DEM whitepaper concluded that airborne IFSAR should be used for data acquisition for the following reasons:

- IFSAR data are acquired both day/night and all-weather, making it ideal for Alaska's conditions
- IFSAR delivers ortho-rectified radar images (ORI), plus digital surface models (DSMs) and digital terrain models (DTMs), ideal for 20-foot contour accuracy DEM requirements statewide
- Airborne IFSAR is significantly less expensive than either airborne LiDAR or airborne imagery solutions for generation of DEMs
- Airborne IFSAR is uniquely suited for DEM change detection, e.g., glacier change
- Airborne IFSAR aircraft can simultaneously collect gravity data of Alaska, also needed to convert airborne elevation data (ellipsoid heights) into required orthometric heights (elevations).

## DEM Specifications

The following specifications should be used when soliciting IFSAR technical and cost proposals for the Alaska DEM:

### Elevation Surface

Both DTM and DSM products shall be required in vegetated areas and urban areas. In non-vegetated areas, only the DSM shall be required. Separate shapefiles shall be provided to the aerial mapping contractor, if possible, to separate vegetated from non-vegetated tiles. A DTM is required by the NED. It is expected that GINA will subsequently provide both the DTM and DSM to the public.

### Data Model Type

DTMs and DSMs shall be delivered in both ellipsoid heights and orthometric heights by the aerial mapping firm for submission to the NED. It is expected that GINA will subsequently provide the DTM and DSM to the public as both ellipsoid heights and orthometric heights, potentially updated as the Geoid model is improved by NGS. DSMs and DTMs shall be gridded with 5 meter post spacing.

### Data Voids

The IFSAR data shall be collected so that voids caused by shadow, layover or other factors are less than 3% of the total area. Furthermore, these voids shall be filled by ancillary data from other sources and not by data interpolation.

### Tile Size

The tile size for the Alaska Albers Equal Area projected data shall be 100 Km x 100 Km. These tiles will subsequently be converted by USGS to geographic coordinates with tile size of 1° x 1°. USGS will

determine whether the NED dataset in geographic coordinates, produced from the Alaska Albers dataset, will have 1/3-arc-second or alternative post spacing.

### Vertical Accuracy

IFSAR DEM products shall meet a vertical accuracy of 3 meters at the 90% confidence level. This equates to a 20-ft contour interval (CI) accuracy.

### Horizontal Accuracy

IFSAR DEM and ORI products shall meet a horizontal accuracy of 12.2 meters (CE90) or 13.9 meters (CE95). This equals the horizontal accuracy requirements for maps and orthophotos at 1:24,000-scale.

### Accuracy Reporting

Rather than using "compiled to meet" accuracy standards, the DEM's vertical accuracy shall be tested for flat and sloped terrain up to 20 degrees and required to pass the following:

> *Tested 3 meters (10 ft) vertical accuracy at 90% confidence level (LE90).* [Note: This is the same as $RMSE_z$ of 1.83 meters or $Accuracy_z$ of 3.6 meters at 95% confidence level].

Similarly, the ORI's horizontal accuracy shall be tested for clearly defined point features and required to pass the following:

> *Tested 12.2 meters (40 ft) horizontal accuracy at 90% confidence level (CE90).* [Note: This is the same as $RMSE_r$ of 8 meters or $Accuracy_r$ of 13.9 meters at 95% confidence level].

### Surface Treatment Factors

Depending on the additional costs and available funding, hydro enforcement of lakes and streams could either be part of the initial IFSAR contract, or hydro enforced later by separate contract(s).

Smoothing of roads and bridges can be performed separately, as required, as part of subsequent digital orthophotography contract(s).

### Coordinate System and Units

Data shall be provided in meters, to 3 decimal places, in the Alaska Albers Equal Area projection which USGS will convert into geographic coordinates for inclusion in the NED. GINA is expected to also provide the data to the public in the Alaska Albers Equal Area projection whereas USGS provides the NED data to the public in geographic coordinates.

### Datums

The horizontal datum shall be the North American Datum of 1983 (NAD 83). The vertical datum shall be the North American Vertical Datum of 1988 (NAVD 88). The latest geoid model shall be used, currently GEOID06.

### DEM File Formats

Files shall be in ESRI binary grid format. GeoTiff files are also expected to be available from GINA.

### Data Licensing

DEMs shall be available to all via the public domain

## *Estimated Costs*

There are two airborne IFSAR providers in the U.S. capable of producing a statewide DEM that satisfies Alaska's mid-accuracy requirement, i.e., Intermap Technologies, Inc. and Fugro EarthData. All their aircraft fly at altitudes between 35,000 and 40,000 feet above the terrain, the same altitude required by the National Geodetic Survey's GRAV-D sensor, and both firms have indicated that they can accommodate NGS' gravimeter and operator to simultaneously collect IFSAR data as well as gravity data for improving the geoid height model so desperately needed in Alaska.

In one sense, Intermap Technologies may have a competitive advantage by having more flexibility with a larger fleet of aircraft, and it has proven experience for large, successful IFSAR projects in production of NEXTMap USA, NEXTMap Britain, and NEXTMap Europe.

In another sense, Fugro EarthData may have a competitive advantage because of GeoSAR's X-band and P-band sensors that may be superior for accurate mapping of both the DSM and DTM in forested regions and images the terrain with about 4x redundancy from multiple look directions to minimize shadow, layover, and other factors that cause data voids.

Potentially either firm, or both firms, could acquire the IFSAR data, produce the needed DEM datasets, and simultaneously acquire the GRAV-D data needed to convert ellipsoid heights into orthometric heights (elevations).

Both firms have been reluctant to provide cost estimates that could be used against them in subsequent nose-to-nose competition. Costs per square mile, for example, are expected to differ as a function of variables that include but are not limited by the following:

- Size and shape of vegetated and non-vegetated areas to be mapped
- Proximity to needed airfields and Continuously Operated Reference Stations (CORS)
- Need for overlapping and/or orthogonal flight lines to minimize shadow and layover.
- Unrestricted licenses so data can be placed in the public domain

Both firms have indicated that they would provide confidential technical and cost proposals when they receive a formal scope of work for acquisition, processing, and licensing.

Through past studies and comparisons of costs from other regional level IFSAR projects in Alaska, it is anticipated that the cost for a statewide mid-accuracy DEM is between $55M and $75M. However, this estimate has a large degree of uncertainty because neither firm can estimate its costs until they develop

detailed flight plans (including the NGS gravimeter and operator) that are complicated by uncertainties regarding the availability of suitable airfields and refueling capabilities at locations needed for optimum flight operations.

# Communication and Funding Initiatives

With broad consensus regarding the conclusions and recommendations of the Alaska DEM whitepaper, the AGDC provided funds to USGS to task Dewberry, under USGS' Geospatial Products and Services Contract, to develop this Alaska DEM Funding and Implementation Plan. Dewberry was tasked to communicate with agency executive leaders at DOI, DOD, DHS, FAA, NGS, USDA, the Federal Geographic Data Committee (FGDC) and the State of Alaska regarding Alaska's DEM needs. Dewberry was tasked to explain to agency executives why an IFSAR DEM of mid-accuracy is important for each agency and to identify potential partners for joint funding of the Alaska DEM as justified in the DEM whitepaper.

## *Alaska Land Ownership and Management Responsibilities*

Table 5 and Figure 8 show that only 89.8 million acres (approximately 24.1 percent of the upland land area of Alaska) is currently owned and managed by the state of Alaska. Because the Bureau of Land Management (BLM) is in the process of surveying and conveying additional lands to the State, this percentage is expected to increase to approximately 28% in 2009. The State of Alaska owns and manages an additional 65 million acres of Tide and Submerged Lands that extend from mean high water to the three mile limit. The surface waters over these lands are within scope of imaging and monitoring requirements set by users, for example, mapping offshore drilling activities and sea ice monitoring.

**Table 5. Alaska Upland Land Ownership/Management Responsibilities**

| | Million acres | $Km^2$ | % of total |
|---|---|---|---|
| **State of Alaska** | 89.8 | 363,408 | 24.1[1] |
| **BLM** | 82.5 | 333,866 | 22.1 |
| **USF&WS** | 78.8 | 318,892 | 21.1 |
| **NPS** | 52.4 | 212,055 | 14.1 |
| **ANCSA** | 39.3 | 159,041 | 10.5 |
| **USFS** | 22.4 | 90,650 | 6.0 |
| **Other private** | 5.9 | 23,876 | 1.6 |
| **DoD** | 1.7 | 6,880 | 0.5 |
| **TOTALS** | **372.8** | **1,508,668** | **100.0** |

[1] This percentage is expected to increase to 28% in 2009

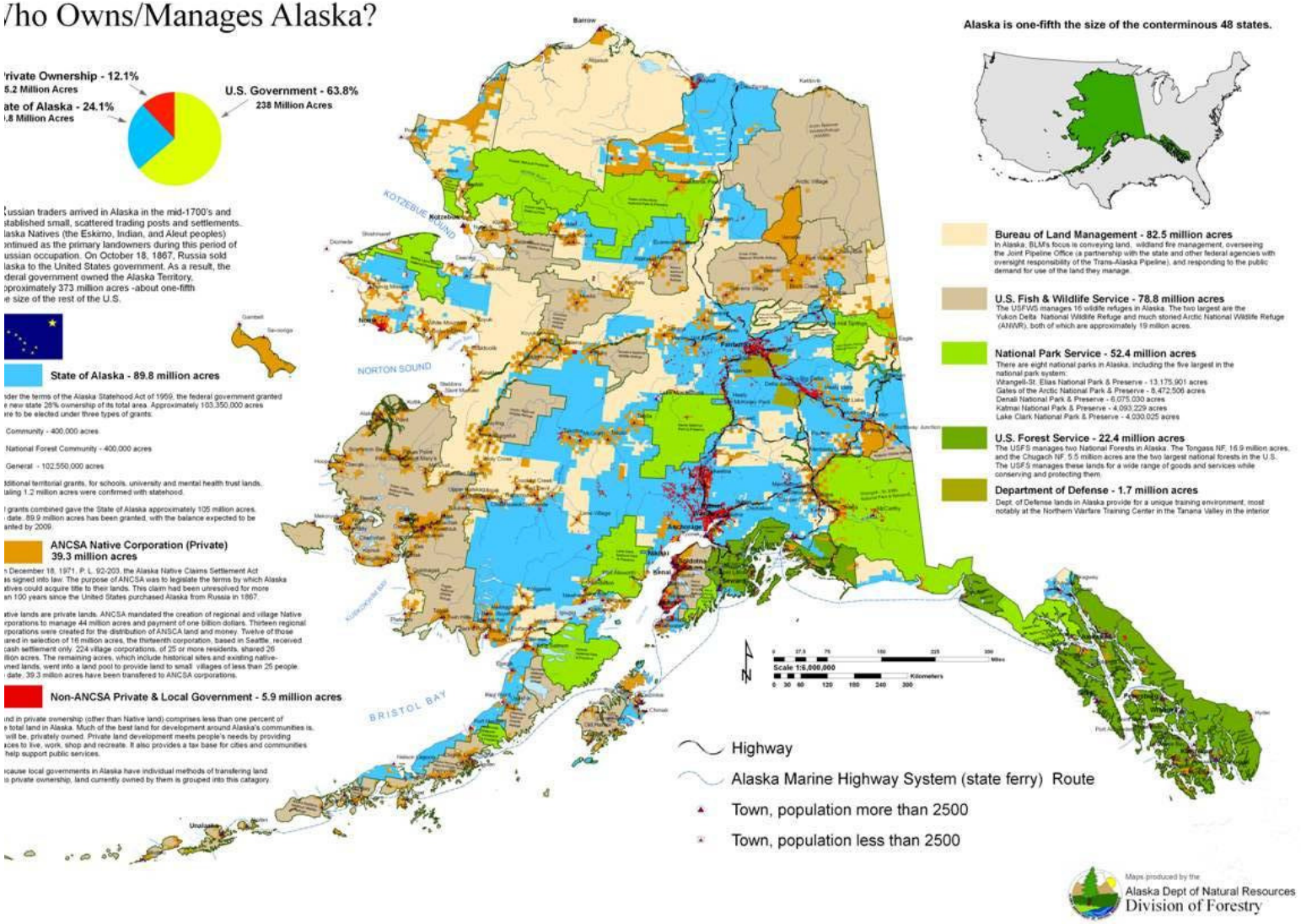


**Figure 8. Alaska Upland Land Ownership/Management Responsibilities**

In determining a fair and equitable share of needed funds, the author started with an assumption that the Alaska state government should provide approximately 25% of the funds for the DEMs identified above, and the Federal government should provide approximately 75% of the funds needed for these DEMs. These percentages are obviously subject to debate, especially when recognizing that USGS has the mission to provide elevation data nationwide.

If the cost for the DEMs is between $55M and $75M, then the funding goals would be as follows:

- Alaska state government needs to appropriate between $14M and $19M.
- Federal government agencies need to appropriate between $41M and $56M.

Identified as Issue No. 3 in the DEM whitepaper, and as indicated in Table 4 above, there are DEM enhancement costs beyond the cost of acquiring the gridded DEMs. The primary DEM enhancement is called hydro-enforcement — additional processing of DEMs to ensure shorelines of streams flow downhill and shorelines of lakes are flattened. Conclusion 6 of the DEM whitepaper states: "Those agencies with differing requirements for DEM enhancements … should preferably pay the additional costs necessary for their areas of responsibility, with funding separate from SDMI funding." In other words, if Alaska state agencies, or if Federal agencies such as BLM, NPS, USF&WS, DOD or USFS require DEMs of the land they manage to be hydro-enforced, those agencies would need to provide additional funding necessary to obtain this data enhancement. It is further assumed that USGS will need to take steps to conflate the existing National Hydrography Dataset (NHD) of Alaska to fit the new Alaska DEM, recognizing that some mountains and rivers may move by hundreds to thousands of meters when compared with the NED.

A secondary DEM enhancement involves the smoothing of DEMs on roads so that orthophotos produced from the DEM show the roads as smooth and continuous rather than jagged; this is a relatively minor additional expense that could be included in the cost of digital orthophoto production.

## *Executive Level Communications*

As part of a task order from the U.S. Geological Survey (USGS), Dave Maune and Phil Thiel of Dewberry conducted a series of briefings with Federal and State officials to identify potential teaming partners who might be able to provide funding support for the Alaska DEM Funding and Implementation Plan. The following is a summary of those agency needs, briefings and follow-on discussions.

## Department of Interior (DOI)

DOI includes the Bureau of Land Management (BLM), National Park Service (NPS), and Fish and Wildlife Service (FWS) which collectively own and manage 57.3% of the upland land area of Alaska. DOI also includes the Bureau of Indian Affairs (BIA) which is responsible for the administration and management of land held in trust by the U.S. for Alaska Natives as well as the U.S. Geological Survey (USGS) which is designated by the Office of Management and Budget (OMB), by Circular A-16, as the lead agency for elevation data.

BLM is one of the agencies that specified that DEMs with 20-foot contour accuracy are required; USGS indicated that DEMs with 20-foot contour accuracy are preferred; and NPS indicated that DEMs with 40-foot contour accuracy are required. The USFWS did not respond to requests made in researching the Alaska DEM whitepaper in 2008.

### Briefing of DOI Associate Director for Geospatial Information and Chief Information Officer

On January 27, 2009, Dave Maune and Phil Thiel met with and briefed Karen Siderelis, Associate Director for Geospatial Information and Chief Information Officer for DOI, and Kenneth Shaffer, Deputy Staff Director of the Federal Geographic Data Committee (FGDC), to discuss DOI funding support for the Alaska DEM.

### Briefing of the FGDC Coordinating Committee

Ken Shaffer immediately arranged for Dave Maune to brief the FGDC Coordinating Committee on February 3, 2009. Participants are listed below. Following this presentation, Don Campbell of the Federal Communications Commission indicated that the FCC also had a need for an accurate DEM in Alaska, but had no money to help pay for it; and Doug Vandegraft of the Fish and Wildlife Service indicated that he had previously served with the FWS in Alaska, knew of the urgent need for an accurate DEM there, and would like to be actively involved in the development of a funding solution.

| | |
|---|---|
| Ivan DeLoatch - FGDC | Don Buhler - BLM |
| Ken Shaffer - FGDC | Jeff Booth - DHS |
| John Mahoney - FGDC | David LaBranche - DOD |
| Lew Sanford - FGDC | David Morehouse - DOE |
| Milo Robinson - FGDC | Rani Balasubramanyam - DOJ |
| Pat Phillips - FGDC | Wendy Blake Coleman - EPA |
| Vaishal Sheth - FGDC | Donald Draper Campbell - FCC |
| Wonkus Baek - FGDC | Doug Vandegraft - FWS |
| Bonnie Gallahan - FGDC | Bill Wilen - FWS |
| Gita Urban Mathieux - FGDC | Bill Burgess - NSGIC |
| Vicki Lukas - USGS | Rhett Rebold – OSD/DISDI |
| Carol Giffin - USGS | Trisha Christian - SBA |
| Charles Hickman - USGS | Randy Fusaro - USCB |
| Rob Dollison - USGS | Shirley Hall - USDA |
| Mike Lee – USGS/DHS | Dennis Crow - USDA |
| Catherine Nolan – Grant Thornton | Marissa Capriotti - USDA |
| Phil Thiel - Dewberry | Ralph Crawford - USFS |

### Briefing of DOI's Enterprise Geographic Information Management (EGIM) Team

Karen Siderelis subsequently arranged for Dave Maune to brief DOI's Enterprise Geographic Information Management (EGIM) Team comprised of the national geospatial coordinators from all the DOI Bureaus

plus other key personnel. On February 19, 2009, Dave Maune met with and briefed the following EGIM personnel, seeking partnerships for the Alaska DEM Funding and Implementation Plan:

- Bob Pierce, DOI & USGS, Washington, DC
- Lee Fahrner, EGIM PMP, Washington, DC
- Lorri Peltz-Lewis, DOI & BOR, Sacramento, CA
- Jacque Fahsholtz, USGS, Boise, ID
- Debra Dinville, BLM, Denver, CO
- Tom Chatfield, BLM, Denver, CO
- David Duran, NPS, Denver, CO
- Lenny Coates, MMS, New Orleans, LA
- Chris Lett, USFWS, Denver, CO

Bob Pierce indicated that DOI is prohibited from lobbying Congress for funds, but recommended that the FGDC Executive Committee could unanimously sign an agreement that the Alaska DEM is urgently needed, to help justify Congressional "earmark" funding if sought by Alaska's Congressional delegation.

### Briefing of USGS' Director, National Geospatial Technical Operations Center (NGTOC)

On February 5, 2009, Dave Maune briefed Kari Craun, Director of the USGS NGTOC. Ms. Craun in turn provided a briefing on The National Map. While recognizing that USGS has responsibilities for many layers of The National Map, including imagery and elevation data, Ms. Craun pointed out that USGS lacks the necessary funding and relies heavily on data partnerships to leverage USGS' limited funds. For example, funding partners provide $20.1 dollars to each USGS dollar for imagery, and $10.3 dollars to each USGS dollar for elevation data.

## Federal Aviation Administration (FAA)

The FAA arguably has the strongest requirement for DEMs with 20-foot contour accuracy for aviation safety, and to satisfy Area 1 and Area 2 eTOD (see Figure 9) requirements of the International Civil Aviation Organization (ICAO). The Electronic Terrain and Obstacle Database (eTOD) is an internationally agreed-on standard to provide an accurate terrain database for safe flying and navigation under Instrument Meteorological Conditions (IMC) when pilots cannot see the terrain at all due to night and clouds or other weather such as heavy rain and snowfall. When Visual Flight Rules (VFR) cannot be safely followed, and especially during emergency air evacuations at remote villages, aviators then operate under Instrument Flight Rules (IFR) designed to keep aircraft from unintentionally flying into obstacles due to navigation errors. The need for elevation data to create a reliable and compliant FAA eTOD for navigation in Alaska, during periods of limited visibility, has never been greater. IMC flying conditions have to be coped with in Alaska on a

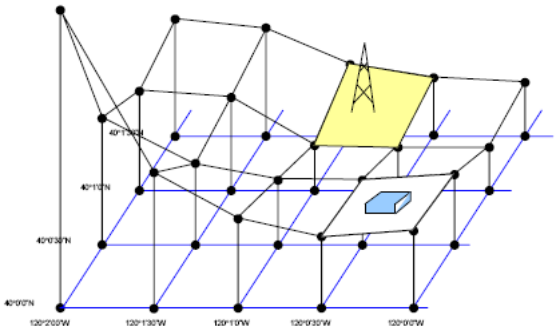

**Figure 9. An eTOD database includes gridded terrain data plus obstacles near airfields**

regular basis for airfields throughout the state, even for airfields that are not part of the FAA's 148 IFR sites. Accurate DEMs are vital for flight planning, terrain avoidance, transiting through mountain passes, and landing of float planes on rivers and other water bodies. The ICAO established Area 1 and Area 2 standards for eTOD in order to minimize *Controlled Flight Into Terrain* (CFIT), a serious problem in Alaska. Alaska has the most pressing need for eTOD data, but Alaska is the only state in the U.S. that does not have elevation data to support either Area 1 or Area 2 standards for eTOD data.

On February 11, 2009, Dave Maune and Phil Thiel of Dewberry visited FAA, met with and briefed the following personnel, seeking partnerships for the Alaska DEM Funding and Implementation Plan:

- Dick Powell, Manager, Aeronautical Information Services, FAA
- Mark Howard, Aeronautical Survey Program Manager, NOAA
- George Sempeles, Aeronautical Information Management, Quality Assurance, FAA
- Christopher Criswell, Cartographer, Aeronautical Information Services, FAA
- Adam Edmondson, Cartographer, NACO, FAA
- Nathaniel Hersh, Cartographer, NACO, FAA

Mr. Powell indicated that FAA could seek future funding for the IFSAR DEM of Alaska to the degree that there is a direct link to objectives in the *FAA Flight Plan*. Dewberry researched this plan and determined that there are numerous direct links to flight safety issues in Alaska.

The *FAA Flight Plan* (Figure 10) is FAA's strategic plan for 2009-2013, and FAA's "Increased Safety" goal is almost totally focused on Alaska because of the shocking statistics regarding Controlled Flight Into Terrain (CFIT) in Alaska. Alaska is the only state mentioned in response to this aviation safety goal, and Alaska is mentioned eight times, including reference to the use of "new technology in Alaska, such as the satellite-based Capstone navigation and terrain awareness avionics" which is of little value without accurate eTOD data that provides the terrain and obstacle data needed to avoid CFIT. In a subsequent section on Objective 2 (Reduce general aviation fatalities), Alaska is again the only state mentioned, and Alaska is mentioned three more times, as follows:

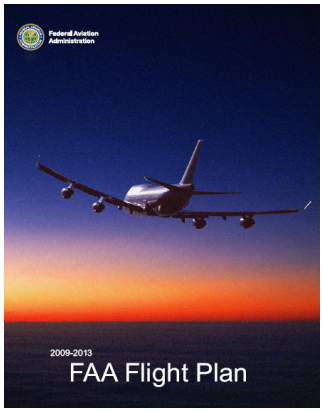


**Figure 10. The FAA Flight Plan emphasizes Alaska flight safety goals**

- "Performance Targets: Reduce the fatal accident rate per 100,000 flight hours by 10 percent over a 10-year period (2009-2018). By the end of FY 2009, reduce accidents in Alaska for general aviation and all Part 135 operations from the 2000-2002 average of 130 accidents per year to no more than 99 accidents per year."

- "Strategy: Expand and accelerate implementing safety and air navigation improvement programs in Alaska."

- "Initiatives: Achieve full operational capability of WAAS by completing all hardware and software changes needed to complete the system. Continue to optimize weather camera benefits and explore alternative technologies. Support the Medallion, Circle of Safety, and Alaska Flight Service Safety programs."

As described in the *Circle of Safety Handbook* (Figure 11), the Circle of Safety program in Alaska is especially critical because of the statistics pertaining to Controlled Flight Into Terrain (CFIT). The following information is quoted from Appendix F of the *Circle of Safety Handbook*:


**Figure 11. Circle of Safety Handbook with Alaska CFIT focus**

- "According to 'Alaska CFIT Accidents'[3] between 1990 and 1998 aviation accidents in Alaska caused 100 occupational pilot deaths. This is equivalent to an occupational fatality rate of 430/100,000/year, approximately 86 times the occupational fatality rate for all workers in the United States[4] and nearly five times the national fatality rate for all commercial pilots.[5] Additionally, this is almost 24 times the rate for other Alaskan workers[6], making flying the highest-risk occupation in Alaska."

- "The high occupational pilot fatality rate in Alaska and the high fatality rate associated with CFIT crashes reinforce the importance of addressing this type of crash and examining the associated risk factors. Understanding all the factors that result in a pilot flying a properly functioning aircraft into terrain could help in the design of appropriate interventions at multiple levels within aviation and ultimately result in the reduction of commercial aviation fatalities. "

- "Most CFIT crashes are attributed to "pilot error" … These crashes occur when failures occur at all levels, and backup safeguards are inadequate, resulting in the pilot flying the aircraft into a situation in which he is not aware of his surroundings."

ICAO Area 1 and Area 2 eTOD standards were developed to minimize the risk of CFIT crashes, and Alaska is the only state currently in non- compliance with these ICAO requirements.

FAA has traditionally spent its aviation safety funds on the Obstacle ("O") part of eTOD and not on the Terrain ("T") part of eTOD, believing that it is the responsibility of other Federal agencies to provide the digital terrain data needed. During the Dewberry/FAA meeting on February 11th, FAA personnel indicated that FAA had no funds to help pay for an IFSAR DEM in Alaska, although the proposed IFSAR DEM is highly favored and needed by FAA. However, FAA recognizes that: (1) there is a direct connection between FAA's aviation safety goals and objectives in the *FAA Flight Plan*; (2) the need is urgent; (3) there is mutual benefit in multiple agencies teaming together to fund projects such as the Alaska DEM; and (4) if not now, when? The start of a new administration may be the perfect time to launch this new funding initiative for FAA. Participants agreed that FAA would initiate actions to see what can be done to obtain funding for the Alaska DEM in FAA budget requests for FY2010 and 2011.

## Department of Defense (DOD)

DOD owns and manages 0.5% of the upland land area of Alaska, but the Army and Air Force commands in Alaska have stated a requirement for 20-foot contour accuracy DEMs statewide because of their statewide operations and training requirements, to include search and rescue missions.

In response to requests from the U.S. Northern Command (NORTHCOM), the National Geospatial-Intelligence Agency (NGA) has produced Digital Terrain Elevation Data (DTED) of Alaska, in 1° x 1° cells, at various levels of accuracy over the years. In Alaska, 440 DTED Level 1 (DTED1) cells have been produced by NGA with vertical accuracy equivalent to 60-meter contours (197-foot contours); 147 DTED Level 2 (DTED2) cells have been produced with vertical accuracy equivalent to 36-meter contours (118-foot contours). In the production pipeline for future years, but not yet started, NGA has recognized a NORTHCOM requirement for 54 additional DTED2 cells (from 440 cells total covering Alaska, many of which are water cells) plus 12 HRTE3 quarter-cells (see Figure 12). With vertical accuracy equivalent to 10-meter contours (32.8-foot contours), the HRTE3 data would come closer to satisfying the ICAO Area 2 requirement for elevation data equivalent to 20-foot contours[2].

On February 11, 2009, Dave Maune and Phil Thiel of Dewberry visited NGA, met with and briefed the following personnel, seeking partnerships for the Alaska DEM Funding and Implementation Plan:

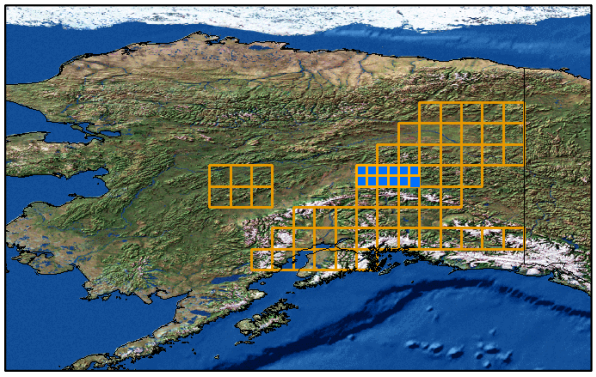

**Figure 12. 54 DTED2 cells and 12 HRTE3 quarter-cells currently validated by NGA for production**

- Steve Wallach, NGA Technical Executive
- Scott Robertson, Chief of Staff, NGA Technical Executive
- William Mullen, Staff Officer, Office of the NGA Technical Executive
- Laura Wright Hall, Staff Officer, Office of the NGA Technical Executive
- Jane Dickerson, Deputy Director, Office of Americas
- Barry Heady, Source Assessment & Global Foundation Group
- Joseph Purk, Deputy Director, Aeronautical Services
- Kraig Harms, SRTM DTED Program Manager
- Dale Hutchinson, NORTHCOM

[2] NGA notes that the accuracy values listed for DTED1, DTED2 and DTED3 are specification accuracy. The actual absolute accuracy varies, based on when it was produced and the source/method used. For example, the absolute vertical accuracy of DTED2 ranges from 8-34 meters (LE90), compared with 18 meter specification accuracy for DTED2. DTED2 produced from good stereo imagery is believed to be nearer the better end of the range specified here, i.e., closer to an LE90 of 8 meters which would be equivalent to 16 meter or 50-foot contour accuracy.

The NGA personnel were very supportive of the Alaska IFSAR DEM need and did not have any arguments with the product comparisons in Table 6 which shows that the vertical accuracy (LE90) of DTED2 data is six times larger than specified by the ICAO Area 2 standard.

**Table 6. Comparison of ICAO Area 2 and DTED Level 2 specifications**

| | ICAO Area 2 Standards | DTED Level 2 |
|---|---|---|
| **Post Spacing** | 1-arc-second (≈30 meters) latitude & longitude | 1-arc-second (latitude) 2-4 arc-seconds (longitude)[1] |
| **Vertical Accuracy (LE90)** | 3 meters | 18 meters |
| **Equivalent Contour Interval** | 6 meters (20 ft) | 36 meters (118 ft) |
| **Vertical Resolution** | 0.1 meter | 1 meter |
| **Horizontal Accuracy (CE90)** | 5 meters | 23 meters |
| **Confidence Level** | 90% | 90% |

[1] Note: DTED Level 2 variable post spacing north of 50° North Latitude

NGA indicated that they are trying to make as much of their Alaska DTED as possible available to all users, not just the military. However, they indicated that there are some issues in NGA's DTED production from commercial satellite and/or airborne imagery that sometimes have licensing restrictions. NGA supported the idea of simultaneous acquisition of airborne IFSAR and gravity data and NGA has a desire for improved gravity data over parts of Alaska. NGA stated that they would consider partnering (pooling resources) to acquire higher resolution/accuracy DEMs and gravity data, if it did not cost more and would not delay the production and delivery of required DTED data to US Northern Command.

## National Oceanic and Atmospheric Administration (NOAA)

NOAA has high priority needs for a high-accuracy DEM (2-foot contour accuracy) of Alaska's littoral areas only, as well as high-accuracy gravity data statewide. In the preparation of the Alaska DEM whitepaper, NOAA's Coastal Services Center (CSC) was one of the potential users for high-accuracy DEMs (from airborne LiDAR) for all coastal areas of Alaska. Because this need pertained only to coastal areas and is believed to be more expensive than statewide IFSAR, this requirement for a high-accuracy DEM was considered to be *project specific*, requiring project-specific funding, as opposed to the mid-accuracy DEM which is a statewide requirement. It is possible that an experimental NASA LiDAR sensor might be used for this purpose.

Within NOAA, the National Geodetic Survey (NGS) has an immediate need for a DEM of mid-accuracy as well as high-accuracy gravity data in order to create an accurate geoid model of Alaska, without which all elevations have errors of ±2 meters or more. Survey and mapping data from GPS and airborne sensors must be converted from ellipsoid heights to orthometric heights (elevations) using a geoid height model that indicates the undulation of the gravimetric geoid at any given location above or below the mathematical ellipsoid used as the datum. In the other states, the geoid model is accurate within ±2cm, but in Alaska the geoid model has errors of ±2 meters or more. Thus, all elevation surveys, even

LiDAR surveys, will yield elevations with errors on the order of ± 2 meters because of limitations in the geoid model for Alaska. Furthermore, the forces of gravity change in time because of the dynamic nature of the Earth, changes that are more severe in Alaska. NOAA's GRAV-D project (Gravity for the Redefinition of the American Vertical Datum), see Figure 13, was addressed in detail in the Alaska DEM whitepaper, based on the following priorities: (1) Alaskan littoral (coastal) regions, excluding the Aleutians, (2) southern Alaska, (3) CONUS littoral regions, (4) Hawaii, Pacific Island territories, and the Aleutian chain, (5) Inland CONUS, and (6) Northern Alaska. For the GRAV-D project (Figure 10), NOAA has a current budget request for $37 million, over a 10 year period, to collect the gravity data throughout the U.S. and its territories, but that request has not yet been funded. Therefore, NOAA currently has no dedicated funding for the GRAV-D project.

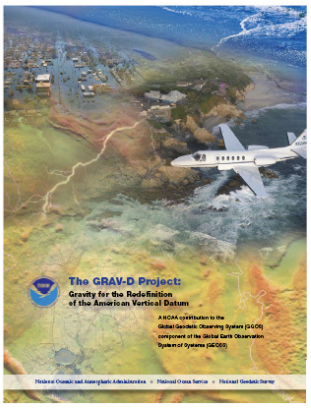


**Figure 13. GRAV-D Project to establish a geoid model for Alaska, needed for any elevation survey project**

On February 12, 2009, Dave Maune, Phil Thiel and Tim Blak from Dewberry visited NGS, met with and briefed the following personnel, seeking partnerships for the Alaska DEM Funding and Implementation Plan:

- Juliana Blackwell, NGS Director
- Vicki Childers, GRAV-D Project Manager
- Daniel Roman, GRAV-D/Geoid Team Lead
- Renee Shields, National Height Modernization Program Manager
- Chris Parrish, Remote Sensing, Physical Scientist
- Mark Howard, Aeronautical Survey Program Manager

Per recommendations in the Alaska DEM whitepaper, NGS would actually prefer to collect high-accuracy gravity data for all of Alaska, including the Aleutian chain, as priority 1 — if it can "piggy-back" its gravity meter on the same aircraft for simultaneous acquisition of airborne IFSAR data. In doing so, NOAA could save millions of dollars that would otherwise be spent on NOAA acquisition flights. For compatibility with the IFSAR aircraft, NOAA's acquisition preferences are as follows:

- Flying height: 35-40,000' AMT (same as IFSAR's preferred flying height)
- Flight line spacing: 10 Km (same as IFSAR's preferred flight line spacing)
- Flight line length: An additional 150-200 Km out to sea beyond the shoreline (this would clearly add to the acquisition time and cost of the IFSAR aircraft)
- Flight speed: 280 knots (slower than IFSAR's normal flying speed, but NGS believes it can accept the faster speed of the IFSAR aircraft)
- Electricity supply: 24 hours per day for gravity meter (IFSAR aircraft would be based at airfields where an electric supply would be available when aircraft engines are off)

None of these differences are "show stoppers." NGS as well as the two IFSAR firms considered for the IFSAR data acquisition agree that considerable synergies and cost savings would result from

simultaneous acquisition of IFSAR and gravity data. If NOAA receives funding for its GRAV-D program, a sizeable portion of that funding could be provided for the combined IFSAR/gravity surveys.

## U.S. Department of Agriculture (USDA)

USDA includes the U.S. Forest Service (USFS) which owns and manages 6.0% of the upland land area of Alaska; USFS is one of the agencies that specified that 20-foot contour accuracy DEMs are required and for which airborne IFSAR was the preferred technology. USDA also includes the Farm Service Agency (FSA) and the Natural Resources Conservation Service (NRCS), both of which are key participants in the National Digital Orthophoto Program (NDOP) that requires accurate DEMs for orthorectification of imagery.

On February 17, 2009, Dave Maune and Phil Thiel of Dewberry visited USDA, met with and briefed the following personnel, seeking partnerships for the Alaska DEM Funding and Implementation Plan:

- William Belton, USFS, Asst. Remote Sensing Program Manager
- Tommie Parham, NRCS, Director, Resources Inventory & Assessment Division
- Shirley Hall, FSA, GIS Program Manager
- Jeff Bloomquist, FSA

USDA Feedback: USDA believes they are too late to change the budget request for FY2010. They will try to obtain funding for FY2011 and FY2012, but requesting no more than 6% of the total funds needed for the statewide IFSAR project. Assuming a cost of $60M, USDA will attempt to obtain $3.6M in funding over 2-3 years, starting in FY2011, but they would prefer 5 years. They expect to have difficulty getting approval within USDA unless they can certify that USGS, BLM, FWS, NPS, FAA, DOD, NOAA, etc. are agreeing to fund specific amounts also.

## Department of Homeland Security (DHS)

DHS does not own or manage any land areas within Alaska but needs the best available geospatial data for all emergency response scenarios in which DHS operates as well as all areas in which flood insurance studies are performed. The U.S. Coast Guard is part of the aviation safety community that requires eTOD data for aerial operations under IFR conditions.

On February 18, 2009, Dave Maune of Dewberry had a discussion with Jeff Booth, Director, Geospatial Management Office, Office of the CIO, Applied Technology, DHS. Mr. Booth had previously seen Dave's presentation to the FGDC Coordinating Committee. Mr. Booth had sought input from DHS agencies, with responses as follows:

- Customs and Border Patrol (CBP): Alaska DEM not an issue
- U.S. Coast Guard: Coastal areas could be of interest, but no strong requirement
- FEMA Mitigation: IFSAR has been used elsewhere for flood studies in remote areas

Mr. Booth indicated that it was doubtful that DHS would support the Alaska DEM funding initiative.

## Alaska House Resources Committee

The State of Alaska owns and manages 24.1% of the upland land area of Alaska, but this will soon increase to 28% as BLM conveys additional lands to the state.

On February 23, 2009, as coordinated by Nick Mastrodicasa (AK DOT&PF), Dave Maune of Dewberry traveled to Juneau, met with and briefed members of the House Resource Committee seeking Alaska state partnership funding for the Alaska DEM Funding and Implementation Plan. The following Representatives were in attendance:

- Mark Neuman (co-chair)
- Craig Johnson (co-chair)
- Bryce Edgmon
- Kurt Olson
- Paul Seaton
- Peggy Wilson
- David Guttenberg
- Scott Kawasaki
- Chris Tuck

These Representatives were noncommittal, wanting to know exactly what funding was needed from the State, rather than funding estimates that had been provided.

## Alaska's Washington Delegation

On April 28-29, 2009, Nick Mastrodicasa (AK DOT&PF) and Dave Maune of Dewberry briefed the following members of Alaska's Washington delegation. Dewberry briefed details pertaining to technical requirements; Mr. Mastrodicasa briefed details pertaining to funding requirements limited to the DEM component of the base map.

- **Congressman Don Young.** Jason Suslavich, Legislative Assistant, Office of U.S. Congressman Don Young in attendance. The implications of Alaska's lack of an accurate map are well understood by the Congressman's office. This office's advocacy for the DEM and federal partnerships can be anticipated as a first step toward funding initiatives. Additional steps may include congressionally directed funding if federal support materializes and is demonstrated through a cost sharing agreements or endorsement of the overall plan in conjunction with stakeholder advocacy supporting the initiative.

- **Senator Murkowski & Senator Begich.** This meeting was a joint briefing comprised of: Arne Fuglvog, Legislative Assistant, Office of U.S. Senator Lisa Murkowski; and James Feldman, Deputy Legislative Assistant, Office of U.S. Senator Mark Begich. Both offices noted the substantial advancement in the SDMI's efforts to achieve consensus and acknowledged their advocacy. Both offices appreciated the state/federal cost sharing approach and stated congressionally directed funds would be difficult if not impossible in the existing political climate without the demonstrated support of a majority of affected federal departments in both cost sharing agreements and letters of support (Memorandums of Endorsement/Support or Memorandums of Agreement). Both offices agreed to facilitate this cost sharing effort, delegation

support and influence in terms of federal endorsement and continued advocacy. Of interest were the noted implications of an accurate DEM upon aviation safety and the pending FAA re-authorization.

- **John Katz, State of Alaska, Office of the Governor, Director of State/Federal Relations and Special Counsel to the Governor.** Russ Kelly, Associate Director, Oil, Gas, Minerals, Commerce, Finance, Telecommunications and Transportation, was also in attendance. Mr. Katz has long been an advocate for an updated digital base map of Alaska and fully understands the importance of such. The Governor's office will continue to support and facilitate the SDMI on a state level in its traditional fiscally conservative and responsible manner. The Governor's office will also continue to mentor and advise the SDMI on potential funding solutions and partners on a federal level as is appropriate.

- **Kim Elton, Senior Advisor for Alaska Affairs, U.S. Department of the Interior.** Mr. Elton immediately understood the need for updated elevation data for the State of Alaska and its impact upon aviation as well as many other sectors. Mr. Elton is an advocate for the DEM component of the proposed base map and is willing to facilitate the funding requirements within the DOI. In his estimation the short term funding request will be problematic (within DOI) due to the absence of appointed officials performing in the capacity of department and agency leadership at this time. In effect, in the short term, it will be easier to find the funding than it will be to find the responsible person to commit it. However, an attempt will be made to facilitate the immediate need and future sustained funding needs. One effort may include adding this funding component to the DOI's proposed future budget(s) to facilitate a cost sharing effort with other federal entities and the state.

### Private Organizations

Private organizations, mostly the Alaska Native Claims Settlement Act (ANCSA) Native Corporation, own and manage 12.1% of the upland land area of Alaska. Because these communities are accessed mostly by air, they need eTOD data for aviation safety, but they have virtually no funds to pay for improved DEMs. No attempt was made by Dewberry to seek private funding support for the Alaska DEM Funding and Implementation Plan.

## Existing Partnerships

### *National Partnerships*

The two most relevant national partnerships are the National Digital Elevation Program (NDEP) and the National Digital Orthophoto Program (NDOP), both of which are explained below. The NDEP and NDOP met jointly in Anchorage in August, 2008 and agreed to the primary and secondary consensus points listed in Table 3 and Table 4, respectively, and participants also agreed that Imagery for the Nation (IFTN) in Alaska cannot proceed until the Alaska DEM needs are solved so that image orthorectification can proceed.

## National Digital Elevation Program (NDEP)

The National Digital Elevation Program (NDEP) was established to promote the exchange of accurate digital land elevation data among government, private, and non-profit sectors and the academic community and to establish standards and guidance that will benefit all users. The NDEP consists of a Steering Committee, a Technical Subcommittee and a Project Coordination Subcommittee, drawing committee members from the NDEP sponsoring agencies that include: U.S. Geological Survey (USGS); National Geospatial-Intelligence Agency (NGA); U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS); U.S. Army Corps of Engineers (USACE); National Oceanic and Atmospheric Administration (NOAA); Bureau of Land Management (BLM); National States Geographic Information Council (NSGIC); National Aeronautics and Space Administration (NASA); U. S. Forest Service (USFS); Federal Emergency Management Agency (FEMA); U.S. Census Bureau (USCB); and the U.S. Fish and Wildlife Service (USF&WS).

The goals of the NDEP are to:

- Enhance data sharing among Federal, State, and local agencies; the private sector; and academia;
- Minimize redundant data production;
- Leverage resources to satisfy multiple requirements;
- Develop flexible standards common to all users; and
- Assure availability and accuracy of "best available" digital topographic data.

The benefits are as follows:

- Federal, State, and local agencies: By pooling agency resources to develop digital elevation data, limited agency funding will be maximized. In addition, establishing common standards and guidelines will maximize the utility of the data and promote the sharing of data between agencies and organizations.
- General Public: It is in the general public's interest to make the most accurate, up-to-date data readily accessible to all that need it. Moreover, sharing these data and eliminating redundancy in data collection and development by government agencies will save tax dollars.
- Remote sensing industry: Establishing a set of common, yet flexible standards is a critical factor in supporting the remote sensing industry.

## National Digital Orthophoto Program (NDOP)

The National Digital Orthophoto Program (NDOP) is a consortium of Federal agencies with the purpose of developing and maintaining national orthoimagery coverage in the public domain by establishing partnerships with Federal, State, local, tribal, and private organizations. The vision of the NDOP is to make aerial imagery and digital orthoimagery available to meet National requirements. The NDOP also consists of a Steering Committee, a Technical Subcommittee and a Project Coordination Subcommittee, drawing committee members from the NDOP sponsoring agencies that include: Bureau of Land Management (BLM); USDA Farm Bureau Agency (FBA); Federal Emergency Management Agency

(FEMA); National Oceanic and Atmospheric Administration (NOAA); National States Geographic Information Council (NSGIC); USDA Natural Resources Conservation Service (NRCS); U.S. Census Bureau (USCB); U.S. Forest Service (USFS); and U.S. Geological Survey (USGS).

The NDOP vision will be met through accomplishing the following goals:

- Serving as a focal point to coordinate aerial photography and digital orthoimagery requirements among Federal, State, local, tribal, and private organizations.
- Creating partnerships with Federal, State, and local governments, tribal and private organizations.
- Leveraging consortium resources to satisfy multiple requirements and to minimize redundant data production.
- Assuring availability of, and public access to, digital orthoimagery and associated metadata from distributed databases.
- Investigating, evaluating, promoting, and implementing new technologies in support of improved imagery accuracy, data development and access, maintenance strategies, and derivative products.
- Supporting coordination and standards goals, and objectives established by Federal, National and International Standards organizations such as the Federal Geographic Data Committee (FGDC), the National Spatial Data Infrastructure (NDSI), ANSI, and ISO.

The objectives of the NDOP:

- Orthoimagery coverage for all 50 states, Puerto Rico, the Virgin Islands, and other U.S. territories and possessions at 2-meter or finer resolutions.
- Develop and promote a national strategy that acquires or accesses the best value orthoimagery data for Federal agencies while flexible enough to create partnerships with State, local, tribal, and private organizations.
- Create and distribute an annual maintenance plans that graphically depicts on-going and planned activities.
- Implement variable-length maintenance cycles that support Federal requirements, and are coordinated with State orthoimagery maintenance programs.
- Support a variety of imagery types and formats such as natural color, black and white or color-infrared and quarter-quad tiles and county mosaics.
- Support the maintenance and archive of imagery and digital orthoimagery and associated metadata as part of the national database. Maintain all imagery in the public domain.
- Support the integration of orthoimagery data into seamless orthoimagery databases of variable resolution.
- Investigate the accessibility, accuracy, integration, and application of data collection from emerging technologies, including: digital camera imagery, satellite imagery from both commercial and national sources, and elevation collection technologies such as LIDAR, IFSAR and SRTM.

- Coordinate Federal and State agency imagery requirements and agreements through the NDOP Project Coordination Subcommittee. Federal, State liaison staff, and State GIS councils/committees or the equivalent. State GIS councils will be, where appropriate, the coordinating body for state and local requirements.

After having initially briefed the NDEP and NDOP in Anchorage on August 20, 2008, Dave Maune again briefed the NDOP by WebEx on March 17, 2009 during the NDOP's meeting in Salt Lake City, and he discussed the status of the Alaska DEM Funding and Implementation Plan. During this briefing, Dave Maune pointed out the difficulty in getting numerous Federal and state agencies to all appropriate their "share" of needed funds for the Alaska DEM, and recommending that it seemed logical to request Congressional earmark funding for this project.

Members of the NDOP asked for ideas on how this could happen. Dave Maune recommended that it would be helpful if the Alaska Congressional Delegation in Washington D.C. could be presented with a Memorandum of Agreement, signed by various Department Secretaries (e.g., DOI, DOC, DOD, DOT, USDA) stating their unanimous agreement to the urgent need for an IFSAR DEM of Alaska. However, recognizing that such an MOA might be difficult or impossible to obtain, the next best thing would be a similar MOA signed by members of the FGDC Executive Committee. Because President Obama has already indicated that he wants future requests for Congressional earmark funds to be reviewed by Federal executive departments, it appears most appropriate for the FGDC to provide its endorsement before the Alaska Congressional delegation is briefed on the issues and alternatives.

It is recognized that Dewberry, under contract with USGS, cannot lobby Congress for DEM funding. However, Dewberry can inform Congress of the urgent need for an Alaska DEM and then step aside to have others (e.g., Nick Mastrodicasa of AK DOT) discuss funding matters.

## *State Partnerships*

### Alaska Geographic Data Committee (AGDC)

The Alaska Geographic Data Committee (AGDC) was organized in the early 1990s to support the initiatives and goals of the Federal Geographic Data Committee (FGDC) in Alaska through the coordination of geospatial data activities and to promote data sharing among the Federal, state, Native, local, commercial, and non-governmental (NGO) member agencies. The Committee is co-chaired by the Senior Geographer, USGS Alaska Science Center -- Geographic Sciences Office, and the Chief, Land Records Information System, State of Alaska Department of Natural Resources. The AGDC is a group of end users who through good will seek cooperation; the committee is not legislatively defined or funded and does not act as an authority in determining geospatial policy in the state of Alaska. There are currently over 65 official members of the AGDC.

The objective of the AGDC is to build geographic information partnerships. The AGDC will assess the needs of, and promote coordination with, the Federal/non-Federal spatial data community by

facilitating communication between the AGDC and the FGDC (including lead agencies, subcommittees, and other working groups). The AGDC will pursue this objective through the following initiatives:

- Communication: Ensure continuing communication through fact-finding and information gathering between the federal and non-Federal sectors of the mapping, surveying, and related spatial data community within Alaska.
- Investigation: Identify and evaluate the scope and nature of Federal and non-Federal liaison issues based on information from the AGDC and individual Federal/non-Federal organizations in the State of Alaska.
- Coordination: Provide coordination between the FGDC and the AGDC mapping, surveying, and related spatial data community to resolve Federal and non-Federal liaison issues.

## Alaska Statewide Digital Mapping Initiative (SDMI)

The SDMI is the state-led component of the stakeholder mix. The SDMI is currently comprised of four departments of state which are bound by a Memorandum of Agreement (MOA) endorsed by the Governor of Alaska. These are the Department of Military and Veteran's Affairs (DMVA), Department of Natural Resources (DNR), Department of Transportation & Public Facilities (DOTPF), and the University of Alaska (UA). The Alaska Department of Homeland Security (DHS) also plans to enter into this MOA. The stipulations of the MOA are as follows:

- Collaborate in a coordinated effort to formulate and maintain a sustained funding endeavor to support the overall interest and needs of the SDMI;
- Build consensus between user groups concerning collection standards, postings, licensing and sharing of acquisition data;
- Foster stakeholder participation in the overall process;
- Adhere to the spirit and intent of the SDMI strategic plan;
- Encourage other agencies, departments and interested parties to support this initiative through formal Memoranda of Endorsement (MOE);
- Formulate policies and regulatory oversight of the geospatial data acquired as a result of the collaboration effort to ensure the data is made available and managed as public domain property, and
- Identify and prioritize partnering opportunities with other agencies and departments to leverage funding and maximize efficiency.

The SDMI has received $6M of General Funds from the State Legislature over three years (07-09). The intent of these funds are to develop a comprehensive plan for the creation of the base map; identify and foster stakeholder participation; create partnerships; acquire data, and construct the archive(s) to warehouse the data.

## *Project Sharing Opportunities*

### U.S. Geological Survey

The USGS Eros Data Center indicated that USGS would prefer to initially receive the IFSAR DEM in the Alaska Albers Equal Area projection for processing into the Alaska NED, but this in no way indicates what coordinate system the data within the Alaska NED would be held by USGS because the NED itself is provided in geographic coordinates of 1-, 1/3$^{rd}$, or 1/9$^{th}$ arc second post spacing.

> "If we were to receive DEMs for the State of Alaska with which to build a 'new' Alaska NED (or update the existing one), it is vastly preferred to receive data in projected coordinates over geographic latitude/longitude. Some of the software systems we use to QC and process data do not play well with data in angular horizontal units but with linear heights. It is particularly difficult to perform QC on or to generate hillshade images from mis-matched data. And having the data in a single-zone projected coordinate reference system is far preferred over multi-zone systems such as UTM or AK State Plane."
>
> *Karl Heidemann, U.S. Geological Survey EROS, August 1, 2008*

### Geographic Information Network of Alaska (GINA)

The Geographic Information Network of Alaska (GINA) is expected to serve both the DTM and DSM to the public in the Alaska Albers Equal Area Projection in both ESRI grid and GeoTiff file formats and possibly as both ellipsoid heights and orthometric heights. This will depend largely upon user demand and funds available.

### National Geodetic Survey (NGS)

The National Geodetic Survey (NGS) is eager to acquire GRAV-D data of Alaska, concurrently with the acquisition of airborne IFSAR, by placing a GRAV-D sensor and operator onboard the IFSAR aircraft during data acquisition. This will avoid duplicate flights from the same altitude and avoid duplicate acquisition costs.

### Others

Many federal and state agencies briefed by Dewberry indicated that they would work to get appropriated funds approved in their annual budgets for FY2010, FY2011 and beyond. Success may depend upon our ability to get the attention of state and federal congressional leaders to champion the need for such funding initiatives, to include Congressional earmarks for this project.

## *Conclusions for DEM Funding and Implementation*

Conclusion 1: The underlying requirements for funding support from all offices briefed are as follows:

1. It is a necessary requirement to have a qualified plan that achieves broad stakeholder support which is confirmed by the following:
    a. Federal participation and reasonable cost sharing agreements to demonstrate support;

b. State, federal, local and private endorsements of the plan demonstrating general user support, and
c. Demonstrated fiscal responsibility.

2. Federal funding opportunities will be based upon a qualified plan and general acceptance of the plan by the majority of the stakeholder community to advance funding. The DEM Funding and Implementation Plan met this requirement as briefed in Washington but it requires the development of federal partnerships in terms of cost sharing agreements and formal endorsements to facilitate such. It is suggested that parallel funding campaigns be initiated simultaneously as they relate to the DEM, they are:
    a. Advance the communications effort of the SDMI to include demonstrable partnerships in both collaborative funding efforts and endorsement by broadcasting these supporting relationships through a dedicated SDMI website devoted to a non-technical marketing effort, while fostering congressional support for directed funding based upon the above efforts, support and endorsement.
    b. Pursue Federal appropriations for the FAA to bring the entire nation into compliance with ICAO Area 1 and Area 2 requirements, while simultaneously pursuing appropriations for other Federal departments, agencies and bureaus to fund their fair shares of Alaska DEM costs.

Conclusion 2: It may be difficult for many different federal agencies within DOI (USGS, BLM, NPS, USFWS), DOC (NOAA/NGS), DOD (NGA), DOT (FAA), USDA (USFS, NRCS) and perhaps DHS to get their "stovepipe" committees in Congress to individually appropriate funds for the Alaska DEM in a coordinated manner; but this difficulty should not preclude such attempts from being made. This approach is most consistent with NDEP principles to pool agency resources and leverage them to satisfy multiple requirements while saving tax dollars and eliminating redundancy in data collection by multiple government agencies.

Conclusion 3: It could be less difficult to obtain needed Federal funding to the FAA to bring the entire U.S. into compliance with ICAO Area 2 requirements. Alaska would become the major beneficiary of such funding because of its overwhelming need compared with other states.

Conclusion 4: Whether seeking Federal funds for multiple "stovepipe" appropriations and/or for a single Congressional earmark for FAA, Congressional support would be much easier to obtain if the FGDC Executive Committee members signed a Memorandum of Agreement stating their full support for the need for an Alaska DEM, based on the use of airborne IFSAR, as needed for compliance with aviation safety and all other federal and state requirements that have been neglected for over 50 years. This message of consensus is vital for winning of political support by cost-conscious members of Congress.

Conclusion 5: It is expected to be less difficult to obtain Alaska State funding for its estimated 25% share of the total costs for the Alaska IFSAR DEM, but State legislators do need to know the actual funds needed for this purpose and whether or not the Federal government will pay its share of the total costs.

Conclusion 6: All implementation options start with the need to clearly establish the costs of alternatives to be considered.

## *Recommendations for DEM Funding and Implementation*

Assumptions: The recommendations, below, are based on the following assumptions:

a. There is broad consensus regarding the conclusions and recommendations in the Alaska DEM whitepaper regarding the need for a statewide DEM with 20-ft contour accuracy; the urgency to satisfy ICAO and other long-neglected statewide user requirements, and the recommendation that airborne IFSAR is the most cost-effective solution to this requirement.

b. There is a lack of reliable information regarding the total cost of executing the recommendations in the Alaska DEM whitepaper and a lack of consensus on how the IFSAR DEM products will be funded at state and Federal levels. Current State and Federal funds are believed to be between 10% and 20% of the total funds needed for full implementation.

c. USGS would be best able to efficiently and effectively manage all aspects of the IFSAR mapping portion of the Alaska SDMI consistent with USGS responsibilities under OMB Circular A-16.

Recommendation 1: Because Federal funding opportunities will be based upon a qualified plan and general acceptance of the plan by the majority of the stakeholder community to advance funding, actions should first be taken within the AGDC to approve or modify the conclusions and recommendations in this DEM Funding and Implementation Plan – then seek endorsement from members of the NDEP and the FGDC Executive Committee. The FGDC Executive Committee members should promptly sign a Memorandum of Agreement stating their full support for the need for an Alaska DEM, based on the use of airborne IFSAR, and that this MOA be used for execution of other recommendations below.

Recommendation 2: USGS should decide on the contract vehicle to be utilized and then develop and issue a Statement of Work for IFSAR mapping of Alaska consistent with DEM specifications in this Plan. The goal is to obtain competing technical and cost proposals from Intermap Technologies and Fugro EarthData for IFSAR data acquisition and processing, as well as technical and cost proposals for project management and quality assurance, to determine which proposals (or portions thereof) should be executed as needed funds become available for pilot and follow-on task orders. Competing technical and cost proposals should be obtained for mapping all of Alaska, as well as major portions of the state if funded separately in different years, with separate costs for the following:

- Acquisition of IFSAR data, as well as gravity data (in coordination with NOAA/NGS). Acquisition costs in Alaska are believed to be more than 70% of the total costs.

- Processing and delivery of the Alaska Digital Surface Model (DSM) in ellipsoid heights, plus additional costs for delivery of orthometric heights using the latest geoid model from NOAA/NGS.

- Processing and delivery of the Alaska Digital Terrain Model (DTM) in ellipsoid heights, plus additional costs for delivery of orthometric heights using the latest geoid model from NOAA/NGS.

- Hydro-enforcements of lakes and streams, which could be funded separately by land management agencies (e.g., Alaska DNR, BLM, USFWS, NPS, USFS, DOD, etc.)

- Processing and delivery of Ortho-rectified Radar Imagery (ORI), which could be funded separately, if needed, for example, for pan-sharpening of satellite imagery for production of digital orthophotos, should this option be chosen for the imagery portion of the SDMI.

Recommendation 3: Working with the selected USGS contractor(s) and SDMI funding partners, and consistent with available funds, USGS should execute a task order in FY2009 if possible for execution of a pilot project that acquires the IFSAR and gravity data, processes and delivers the DSM and DTM in ellipsoid heights at a minimum. The pilot project should include accuracy testing and qualitative assessments to ensure, for example, that data void criteria has been complied with. If funding permits, the pilot project could also include processing of orthometric heights, hydro-enforcement of lakes and streams, and delivery of ORI imagery of the pilot area. This pilot project will help stakeholders to see and evaluate the different products and to establish funding support for full product development statewide.

Recommendation 4: While the pilot project is in progress, budgeting initiatives should be taken by USGS, BLM, USFWS, NPS, FAA, DOD, and/or NOAA/NGS so that Federal funds can be appropriated for the 75% share in the next two fiscal years, if possible, for mapping the remainder of Alaska. Similarly, budgeting initiatives should be taken by the AGDC so that Alaska funds can be appropriated for the State's 25% share in those years.

Recommendation 5: At the same time, initiatives should be taken by the Alaska DOTPF to obtain U.S. Congressional earmark funds for FAA necessary to bring the entire U.S. into compliance with ICAO Area 1 and Area 2 requirements. Alaska would be the primary beneficiary of such funding because most other states are already in compliance with these ICAO requirements. In the unlikely event that appropriations from Recommendations 3 and 4 exceed the total funds needed for the mandatory items (data acquisition and delivery of DSM and DTM statewide), funds could be used for additional processing of orthometric heights, hydro-enforcement of lakes and streams, delivery of ORI imagery statewide, and/or funding support for the imagery portion of the SDMI.