NSB Recurring Aerial Imagery & LiDAR Acquisition Plan

NSB Project No. 2017-178

Task 1: Analysis of Successful Programs

Report 1 of 4

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TABLE OF CONTENTS

List of Figures

Acronyms

AOI ....Area of Interest
AOOS....................................Alaska Ocean Observation System
ASPRS ....American Society of Photogrammetry and Remote Sensing
DEM......................................Digital Elevation Model
DNR ....Department of Natural Resources
DTM......................................Digital Terrain Model
FEMA ....Federal Emergency Management Agency
FNSB.....................................Fairbanks North Slope Borough
GIS ....Geographic Information System
GPSC.....................................Geospatial Products Service Contract (USGS managed)
GSD.......................................Ground Sample Distance
LiDAR...................................Light Imaging, Detection, and Ranging
MSB ....Matanuska Susitna Borough
MOU ....Memorandum of Understanding
NRCS ....National Resources Conservation Service
NSB.......................................North Slope Borough
PSLC ....The Puget Sound LiDAR Consortium
QA..Quality Assurance
QC ....Quality Control
RFQ.......................................Request for Qualifications
RFP ....Request for Proposal
RGB ....Red, Green, Blue
SDMI.....................................(Alaska) Statewide Digital Mapping Initiative
USACE .................................U.S. Army Corps of Engineers
USFWS .................................U.S. Fish and Wildlife Service
USGS ....United States Geological Survey
URISA...................................Urban and Regional Information Systems Association
YK..Yukon Kuskokwim

Executive Summary

This report summarizes a review and investigation of successful aerial imagery and Light Imaging, Detection, and Ranging (LiDAR) programs in other places that offer lessons to the North Slope Borough (NSB) on how best to conduct imagery and LiDAR acquisition in the most cost-effective manner, as well as address strategies for managing and using this data.

Aerial imagery, and now LiDAR, are used by local governments throughout the United States to provide the basemap foundation for the organization's GIS. Mapping technology has rapidly improved making this data more accessible and usable by local governments. Costs have also greatly decreased in the past 10 years making this data more affordable.

The NSB is unique among local governments. It is a very large and remote area, with population centers (villages) disparately located along the length of the arctic ocean coast (see Figure 1), and with difficult weather and seasonal constraints. Even though the NSB is unique, however, there are lessons that can be learned from other local governments who face challenges of acquiring aerial imagery and LiDAR; mainly how to acquire and use this data without incurring high expense. This report describes the challenges that these local governments face, some of which are those the NSB faces; and solutions they used in dealing with them.

For this report, we emphasize a review of Alaska local government programs, but also include examples in Canada and the Lower 48 who have successfully solved how to fund and integrate imagery and lidar or as in the case of Canada are working to find good solutions.

Critical success factors in the programs reviewed are summarized below. Recommendations are provided in italics below.

1. **Partnerships**:
   A key factor in successful programs is to utilize partnerships to share the costs of imagery and LiDAR acquisition. If done correctly, partnerships can result in a win-win for all parties involved. Successful partnerships as demonstrated by the programs reviewed use:
   - Internal Local government partnerships: internal departments or in the case of counties/boroughs, city partnerships where funding is shared amongst these parties;
   - State and federal governments: A local government may partner with state or federal agencies to build sufficient funding for imagery and lidar acquisition;
   - Local government partnering with private sector (profit and not-for-profit organizations).

Recommendation: Form partnerships for acquisition funding, but these partners can also end up providing support for the overall GIS program (see Section 3.3.2—example of Spokane County below).

2. **A Structured Program**

Imagery and LiDAR acquisition projects are difficult to conduct in general, and local governments often find it difficult to find the time and resources to conduct them properly. A key success factor is following a structured program in which an organized, planned, and documented approach is used. Key lessons are as follows:

- The acquisition project is run or overseen by a GIS department that serves the entire local government, not in just one silo in the organization.
- Utilizing the help of a strong federal or state program to provide funding and other resources. Recently, as an example, the USGS GPSC has been very helpful to many local governments by USGS taking on the responsibilities of project management and data processing, and taking the load of running an acquisition off the backs of local government managers.
- If the local government uses its own procurement (not through USGS or similar) it is helpful to have a well-defined quality based selection and procurement process (e.g. RFP or RFQ) using successful templates (see references):
- Clearly defined technical specifications based on a user needs analysis.
- For partnership programs, clear and thoughtfully constructed partner agreements (MOU, contractual and other) are essential. There are good template examples to build upon (see references).

Recommendation: Utilize the support of larger, well developed programs such as USGS GPSC when possible. If not, an approach that leverages the expertise of a carefully selected vendor for data acquisition and processing. Utilize templates from successful models (e.g. Spokane County, Puget Sound LC).

3. Staffing

Successful programs invest in making sure the GIS resources are present internally. These staff typically consist of:

- GIS manager: program champion, working with departmental directors builds and sells the imagery and LiDAR program, oversees the vendor selection process, and process.
- Acquisition project manager. A critical role in ensuring acquisition success. Among the programs reviewed, this person was on the vendor side working closely with the GIS manager.
- Technical review and quality assurance and control of the imagery and/or LiDAR data. This can and ideally should be done partly by internal staff working closely with the vendor, and starts early, e.g. immediately after data acquisition is complete.

Recommendation: Make sure each of these roles is present or planned for prior to an imagery and LiDAR acquisition project.

4. Determination of User Needs

Investing in user group interviews and documenting needs is invaluable. This forms the basis for the data collection programs as well as determining how to make the data accessible. Successful programs we reviewed have done this and this is described in the report.

Recommendation: Document user group needs. Do the "homework" before conducting an imagery and LiDAR acquisition project. The homework includes analysis of options, business needs, and a long- term plan.

1 Introduction

This report identifies the success factors of selected imagery and LiDAR programs and how the NSB can apply these to its program. This report is the first of four reports which analyze options and present a plan for recurring acquisition of imagery and LiDAR for the North Slope Borough.

This report is based on a review of documentation and websites of the other programs, and personal interviews with program/GIS managers. Key references from Urban and Regional Information Systems Association (URISA) and American Society of Photogrammetry and Remote Sensing (ASPRS), among others were helpful. Thanks mostly to key individuals in other Boroughs and local governments who contributed of their time and knowledge to this study.

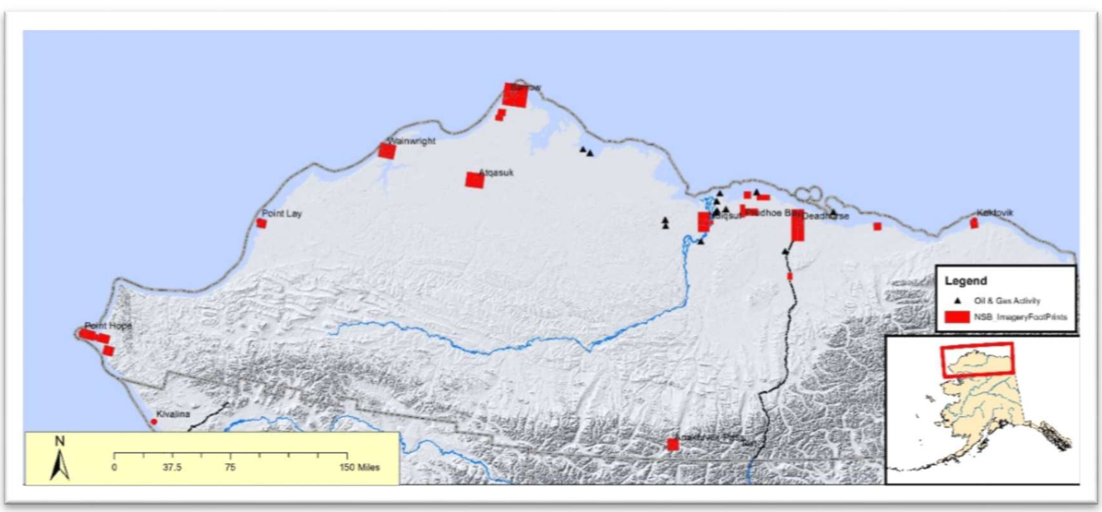
The NSB is located in northern Alaska and at approximately 95,000 square miles is one of the largest local governments geographically in the United States with a population of 9,687. Oil and gas resources in the NSB are among North America's largest reserves, and have greatly benefitted the Alaska economy in the past 40 years.

The NSB is generally a remote area far from cities and road networks. The NSB is characterized by:

- An arctic climate
- Flat terrain
- Tundra
- Permafrost
- A huge number of water bodies and streams
- One of largest arctic deltaic systems in the world (Colville River Delta).

Detailed mapping of the NSB is generally lacking, or in places where good mapping does exist, typically this is out of date. The total area considered for LiDAR and imagery acquisition is about 1,400 square miles (see Figure 1 below). The areas of interest (AOI) may be refined with time.

Figure 1. North Slope Borough and proposed (mid-2017) acquisition AOIs



2 Study Methodology

For this report, a pool of candidate imagery programs was developed based on a variety of references, research, and personal knowledge of the author. Program data was gathered from the programs' websites and reference documents and from telephone conversations with personnel. A matrix of criteria along with questions was used to compare the different programs. The programs selected for this study are based on the key criteria listed below:

- Successful recurring imagery and LiDAR acquisition projects.
- Successful funding and management approaches.
- Longevity of the imagery and LiDAR program, or indication of progressive improvement in the program.

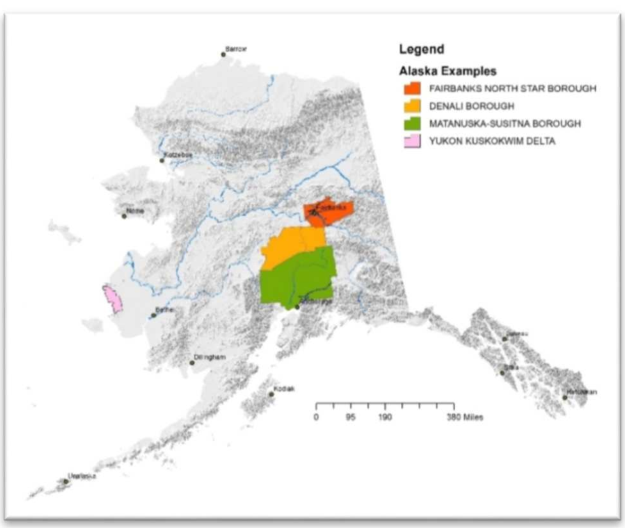
The programs studied in this report include the following:

- Alaska
    - Fairbanks North Star Borough
    - Matanuska Susitna Borough
    - USFWS YK Delta Project
- Nunavut Nation, Canada
- Washington:
    - Puget Sound LiDAR Consortium,
    - Spokane County

Assumptions

- Local government needs for aerial imagery are very similar from region to region.
- Technology options considered are currently available.
- GIS is the fundamental platform using the imagery.

Figure 2. Alaska Local Governments Reviewed



3 Successful Program Models

3.1 Alaska Programs

3.1.1 Fairbanks North Star Borough

The Fairbanks North Star Borough (FNSB) Borough in interior Alaska has a total area of 7,444 square miles (19,280 km2), and a population of 97,581, and includes Alaska's second largest city--Fairbanks. The FNSB has had aerial imagery (photography) acquisition programs since the late 1990s. However, it was not until 2010 and 2012 that the FNSB developed a more regional and comprehensive approach to aerial imagery and LiDAR. In 2010 the FNSB received USACE and FEMA grant funding for LiDAR acquisition in the Fairbanks city area resulting in LiDAR data successfully used by many of its stakeholders.

In 2012, the FNSB developed partnerships with other local governments (e.g. Denali Borough) and users to acquire regional area imagery datasets. This resulted in good quality imagery particularly well received in urban Fairbanks by the Assessing and Police departments for its value in evaluating structures. The 2012 aerial imagery program also provided many lessons including realizing that the procurement process needs to start as early as possible. Instead of one season the acquisition took two seasons due to a late start in the procurement process. However, through this process the FNSB learned valuable lessons that helped it in future projects.

In 2016-2017, the FNSB GIS built upon the lessons learned in prior acquisition projects. In 2017 the FNSB oversaw the successful acquisition of LiDAR and orthoimagery for a 2,200 square mile area. From the beginning of project planning, the FNSB engaged internal director level staff to help "sell" the program which was proposed as a region wide acquisition of imagery and LiDAR. Multiple FNSB departments and utilities (e.g. Golden Valley Electric Association) understood the products they would be getting. This outreach and partnership approach as well as having demonstrated the usefulness of LiDAR and imagery from the 2010 and 2012 projects resulted in approval in spring 2017 (by unanimous vote) by the FNSB Assembly for funding for the 2017 LiDAR and imagery program. The LiDAR part of the program was partly funded by USGS GPSC program. FNSB worked closely with the USGS to develop a LiDAR acquisition plan and application for funding, which resulted in an award by USGS of matching funds. At the time of this report, both the FNSB imagery and LiDAR acquisition projects have been successful, and FNSB staff are currently using the 2017 imagery.

<u>Lessons Learned and Success Factors</u>

- **Partnerships and Funding**: Proving the usefulness of aerial imagery to key departments, namely assessing and Police led to greater support for GIS in general, and future imagery and LiDAR acquisitions. The quality and type of imagery in particular (oblique and orthogonal for urban Fairbanks) was especially useful. This story is similar to Spokane County (see Section 3.3.2 below).

    - The greater emphasis in 2016-2017 on outreach and education to FNSB departments and Assembly paid off in terms of Assembly approval of funding in spring 2017.
- **Project Management and Structure:** The GIS Manager's continuity with the imagery and LiDAR projects since 2010 was important in building on lessons learned. Vendor project management and expertise was crucial in successful acquisition.
    - **LiDAR Acquisition**: Frequent and clear communication with program partners and vendors was a key factor in executing the imagery and LiDAR acquisitions on schedule.
    - Working with the USGS and utilizing the GPSC for LiDAR acquisition was a key factor in ensuring the project was executed on schedule.
    - A two-resolution approach to LiDAR acquisition proved successful and will help with urban city needs. QL2 (4 points/m2) was collected for the non-urban area, and QL1 (8 points/m2) for the urban city area.
    - A pilot project for LiDAR using a small area (e.g. 10 square miles) is advisable to check and review the data. The area should consist of diverse landscape, terrain, and land cover.
    - **Imagery Acquisition**: imagery acquired in 2017 used the same vendor as in 2012; and pre-existing 2010 LiDAR and 2012 imagery data helped tremendously for image processing (rectification, other)
    - An online preview tool supplied by the imagery vendor (see Figure 4) helped in expediting imagery review. FNSB staff and vendor staff could both review imagery.
    - A positive and long-term relationship with imagery and LiDAR vendors was helpful in preparations for the 2017 acquisition.

Figure 3. FNSB Location (in green color)

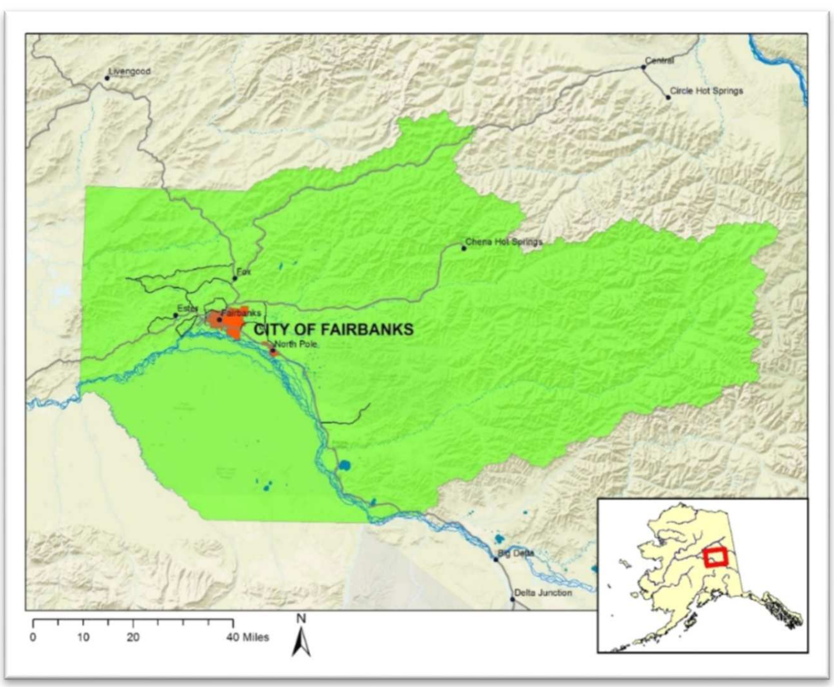
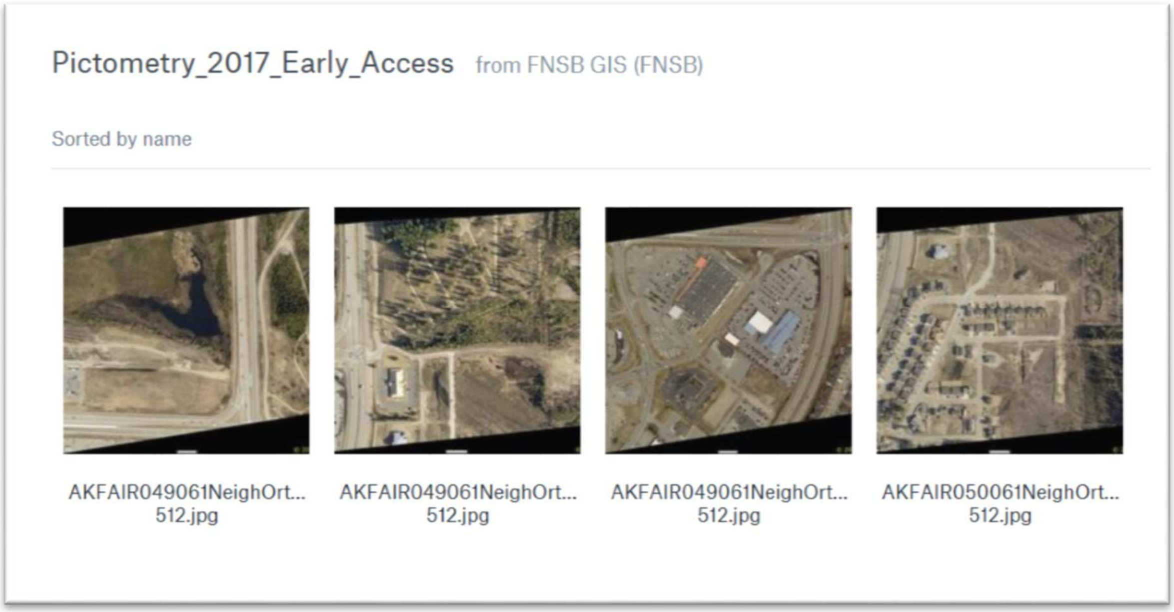


Figure 4. FNSB 2017 Imagery Samples



3.1.2 Matanuska Susitna Borough

The MSB recurring imagery program began in 2016 with development of a plan supported by extensive research into existing imagery programs, business needs of its stakeholders, and available technical options. The Recurring Aerial Imagery Acquisition Program Plan guides the MSB's acquisition of aerial imagery. Phase 1 of acquisition took place in May 2017. Key to the MSB's program is strong involvement of internal and external stakeholders, funding sources derived from partnerships with key stakeholders, and a structured process that will guide acquisition and management of imagery through a 5-year cycle. Helpful in the stakeholder outreach was a Story Map developed by MSB's Information Technology Department (see Figure 6 below).

The Recurring Aerial Imagery Program Plan includes a map of acquisition areas of interest based on a Business Needs Analysis. The goal being complete acquisition of the MSB larger area within five years (See Figure 7 below). LiDAR is not part of the plan, although the MSB invested heavily in LiDAR in 2011, and is considering LiDAR in the future.

The MSB program is also supported by a robust and capable GIS staff many of whom became educated about the various technical aspects of imagery options through the 2016-2017 planning process.

<u>**Lessons Learned and Success Factors**</u>

- **Partnerships and Funding**: Involving all stakeholders (internal and external) and gathering their input is critical to the process
    - The "Story Map" has been very valuable for stakeholder outreach and education about the project.

    - Funding commitments should be a priority early on. The 2017 acquisition got funding a bit late in the season.
- **Project Management and Structure::** A structured process and phased plan for acquisition and data management helps in the budgeting process in terms of providing a 5-year outlook.
- **Survey Control**: Identifying existing survey control far in advance of acquisition is important.

Figure 5. MSB Story Map

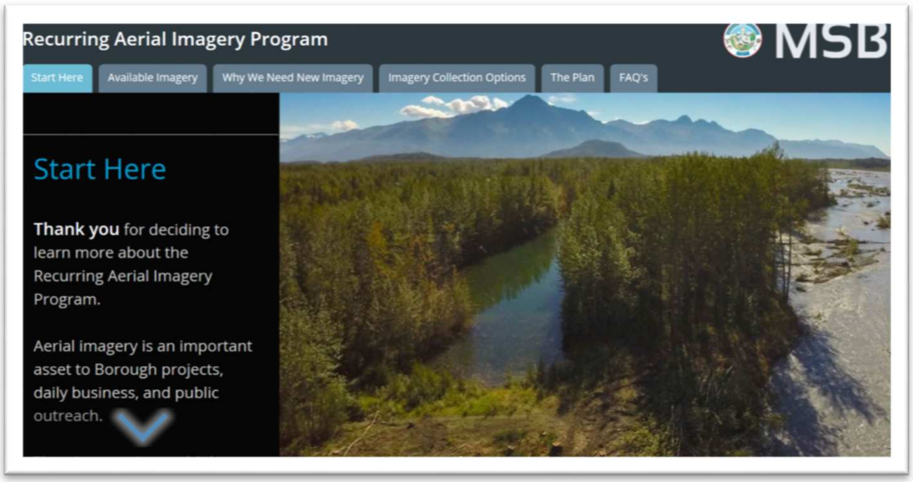
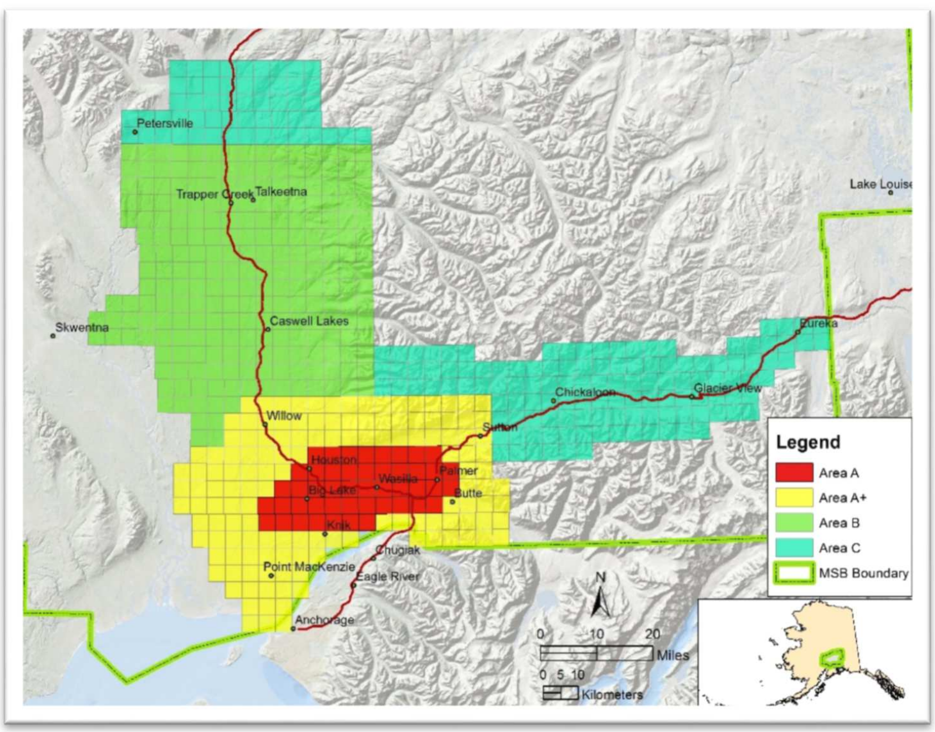


Figure 6. MSB Imagery Acquisition Plan (5 year)



3.1.3 Yukon-Kuskokwim Delta, Southwest Alaska

The Yukon-Kuskokwim River Delta in southwestern Alaska is one of the flattest and most vulnerable regions in Alaska to sea level rise and climate change. The delta is roughly 50,000 square miles, remote; and is home to 35 villages on the Bering Sea coast, some of which . The delta is highly vulnerable to coastal flooding associated with storm surges due to its shallow bathymetry, orientation, and low relief. The region is also subsiding, which increases flooding concerns. LiDAR was chosen as a technology to best map this area and provide the products needed by project partners in delineating where flooding, erosion, and subsidence will occur. The delta's remoteness and lack of infrastructure made it extremely difficult and expensive to collect data.

A LiDAR acquisition project was conducted in 2016 in the YK Delta. A partnership approach was chosen to fund the project acquisition. It was determined that existing elevation data sets did not meet the needs of the regional stakeholders, for example emergency response planning nor of the resource managers managing critical habitats in the area. All partners agreed on a set of specifications. The USFWS was project manager with the following stakeholders as funding partners.

- FEMA
- Western Alaska Landscape Conservation Cooperative
- Alaska Department of Natural Resources
- NRCS
- AOOS
- USGS *(Note: USGS provided 60% of funding overall)*

Others that considered partnering included the Calista Corporation—the regional ANCSA corporation, and several research partnerships.

Benefits are expected as follows:

- Storm surge and inundation research
- Emergency response planning
- Wildlife conservation
- Community planning
- Relocation planning in some cases
- Source of improved elevation data
- Better basemap for village infrastructure planning

LiDAR data was also determined as the best tool to assist conservation efforts to establish sustainable summer trails in communities. Not much existing LiDAR data was available. Other data include satellite (IKONOS) imagery on the northern portion of the delta; high resolution orthoimagery and ground control data in some communities, and regional SPOT5 satellite orthomosaics. As of 2017, no IfSAR elevation have been collected or scheduled for this portion of the YK delta.

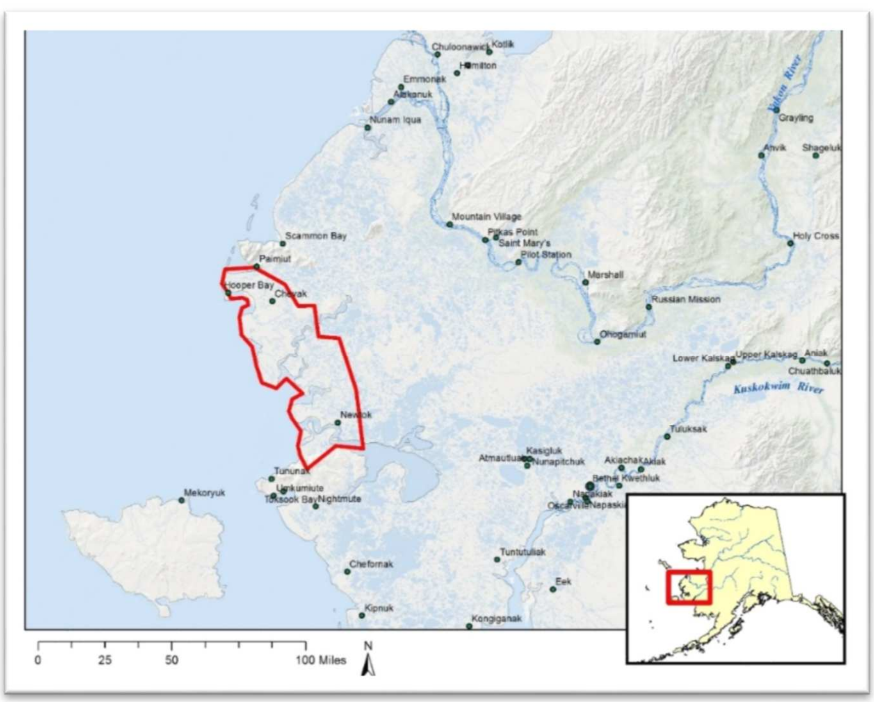
Ground control was a concern in the project. Other projects such as the State of Alaska's DNR work in 2015 which included photo-identifiable ground control points were utilized. The successful 2016 project is summarized as follows:

- Acquisition Timeframe: August 30, 2016 – October 16, 2016. Conducted on schedule.
- Processing: as of summer 2017, all LiDAR deliverables are in review by USGS

Lessons Learned and Success Factors

- **Partnerships and Funding:** Partnerships made funding possible. Close coordination with USGS is critical to ensure GPSC contract is executed properly. Federal agency partners required extensive lead times to process funding approvals.
- **Project Management and Structure:** The USGS GPSC process was instrumental in providing project structure and process without the consortium having to develop it.
- **Acquisition:** Making sure a vendor familiar with Alaska and with the industry credentials is critical
    - Weather posed challenges and provisions had to be made to collect data when possible.
    - The extreme hydrologic system necessitated invoking alternate methods for processing.
    - Intensity imagery products proved invaluable for mapping of wetlands and in hydrologic enforcement.
- **Survey Control**: Upfront investigation of control sources and pre-existing LiDAR data is essential. State of Alaska control was used where possible.

Figure 7. The YK Delta Project Area



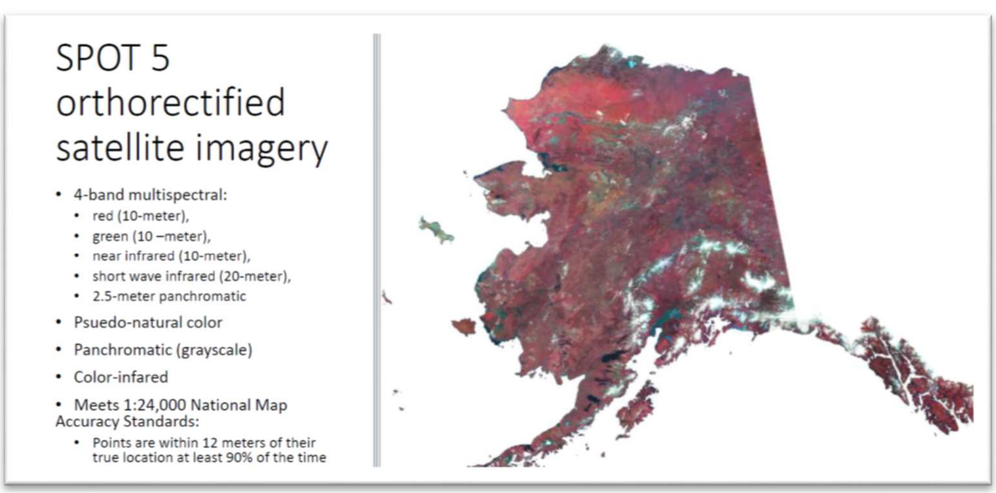
3.1.4 Statewide Digital Mapping Initiative

The SDMI was a project funded by the State of Alaska to develop an updated basemap for the entire state, and updating and replacing the existing USGS 1:24,000 topographic mapping. The project started in 2006, and was initially managed by Alaska DNR. A cooperative program was endorsed by the Governor of Alaska and implemented across six State of Alaska Departments and the University of Alaska to fund and manage SDMI acquisition and data access. To date, SDMI has successfully acquired aerial (satellite) imagery for most of the state, and about 70 percent of the state has now been mapped with ifSAR-based topographic mapping.

Lessons Learned and Success Factors

- **Partnerships and Funding**: Key to success of SDMI was the successful partnering of the State of Alaska and Federal government to fund the acquisition of ifSAR data. The State of Alaska governor's office, mainly Lt.Gov.Treadwell, played a key role in facilitating this partnership
    - In terms of data management and making imagery and elevation data accessible, it was realized in the course of SDMI operations that web mapping services could not be properly funded through a subscription model. In 2017, the State of Alaska issued an RFP to provide web mapping services. This contract was won by a private vendor and it remains to be seen if this will prove effective.
- **Project Management and Structure:** A project was implemented in 2006-2009 to guide imagery and elevation data acquisition. The project resulted in a User Needs Analysis, Technical Whitepaper, and acquisition plan that resulted that have guided SDMI for the past ten years. Vendors have played a key role in success of the SDMI projects providing project management and data acquisition oversight, and working closely with State staff.
- **Survey Control**: A study conducted in 2007 by the SDMI contractor identified potential control sources and emphasized the need for more control to support both imagery and elevation data processing. A nationally known vendor was chosen to collect additional control and consolidate it for the SDMI. This played a critical part in overall project success.

Figure 8. SDMI Project Scope and Results



3.2 Canadian Programs

3.2.1 Nunavut Nation

The Nunavut Settlement Area (see Figure 9) includes one-fifth of Canada's land mass, and is the largest jurisdiction in Canada while also having the smallest population. There are less than 40,000 residents, and over 80% are Inuit, living in 25 municipalities over three regions: the Qikiqtani, Kivalliq, and Kitikmeot. All of the communities are only accessible by air and seasonally by sea (see Figure 3 below). It is similar to the NSB in that it is entirely located in the arctic, has low population, and little connection with road networks. The Nunavut Nation has a GIS which is housed in the Canada-Nunavut Geoscience Office, where a small staff conducts geological studies and manages Nunavut's GIS program.

Imagery and LiDAR data collection, like in the NSB, is very challenging due its remoteness and seasonal constraints. In some ways Nunavut's challenges are more formidable in that it does not have the kind of resources as does the NSB with Prudhoe Bay. Additionally, the huge area of Nunavut makes regional imagery and lidar acquisitions difficult. Nunavut's GIS, however, has been utilizing some satellite imagery and aerial imagery in some community areas.

Figure 9. Nunavut Nation

<u>Lessons Learned and Keys to Success</u>

- Having capable and committed GIS and related staff based locally. This consists mainly of one person who has been with the program since 2000.
- Strong community involvement in GIS mapping.

- Partnership with other government and in some cases private resource companies (e.g. mining) for acquisition of imagery and LiDAR data.

3.3 Lower 48 Programs

3.3.1 Puget Sound LiDAR Consortium

The Puget Sound LiDAR Consortium (PSLC) is a non-profit organization composed of more than 40 partners including local counties, state agencies, and others. PLSC is an excellent example of a program that has built solid partnerships among a variety of stakeholders, and has longevity (>15 years). The PSLC has been successful at acquiring LiDAR data in a variety of regional areas in Washington serving different business needs, and some with challenging terrain. Staffing has been consistent over the program life, charactertized by strong leadership, and a continuity of technical staff among the partners devoted to developing public-domain high-resolution LiDAR topography and derivative products for the Puget Sound region.

Although the PSLC does not acquire aerial imagery, the program is also applicable to aerial imagery in these regards:

- Both aerial imagery and LiDAR require similar airborne technologies, for example aircraft mounted with sensors and sophisticated processing methods.
- Both benefit from a recurring, regular established program.
- A regional consortium approach benefits multiple partners in terms of cost.
- Clearly defined technical specifications and contracting system.
- Strong project management, technical staff support, and a team approach.

The PSLC is a non-profit organization with a long history of successful regional LiDAR acquisitions with a mix of local government and federal government participants from Kitsap County, City of Seattle, Puget Sound Regional Council, National Aeronautics and Space Administration, and the USGS. Initially driven by the need to map geohazards (faults, landslides), the program has led to the use of LiDAR data for other applications. Figure 3 below shows the PSLC website highlighting the variety of its partner composition.

<u>Lessons Learned and Keys to Success</u>

- Locally well respected program in terms of management, technical approach, and commitment to partnership and cooperation
- A technical specification that is agreed upon by all partners and developed through user needs analysis
- Regular updates of specifications, and consideration of new technology.
- Utilize a “keep it simple” approach utilizing no frills MOU, contract, and specifications that remain consistent over a multi-year period.
- Successful delivery of LiDAR data to partners over a long period of time, since 2000 due to well defined set of specifications, MOU, and vendor contract using long term contracts.

- Developed an excellent working relationship with the contractor.
- Fixed prices create budget certainty for consortium members.

Figure 10. Puget Sound LiDAR Consortium Website

3.3.2 Spokane County, Washington

A partnership approach is key to the success of the Spokane County imagery and LiDAR (and GIS) program. Funding from key partners actually funds a major part of the overall GIS program (salaries and other). The "Spokane Area Orthophotography & Oblique Imagery Program" is primarily funded by three major parties; two public, the City of Spokane and Spokane County and one private utility, Avista Utilities. The primary partners share costs equally and fly the entire County once every other year. These three entities are bound together via an interlocal agreement with Spokane County as the lead having the actual contractual agreement with the imagery vendor.

Sub-area partners (called 4th parties) are allowed to license the imagery for their specific service area. They are charged 25 percent of the actual cost of the imagery. Approximately 10-12 fourth parties on average partner for a given acquisition. Because the actual spatial footprint of the fourth parties is relatively small they only generate a small part of the revenues needed (in the range of $20,000) per flight. All of the revenues are then cost shared back to the three primary funding partners equally. Examples of fourth party partners are universities, small municipalities, water and sewer districts, and the local air force base.

Central to the Spokane County partnership is a core group of county departments who contributes most of the imagery funding. County-wide LiDAR acquisition will be funded for the utilizing the USGS GPSC in 2017.

The County department that derives the most benefit has been the County's Assessors office for property appraisal and that has been primarily due to the addition of high resolution oblique photography that helps facilitate accurate and up-to-date property assessment. This has been beneficial and led to the department greatly improving efficiencies gained through the use of imagery for annual property assessment.

Based on the successful use by the Assessing Department, the Spokane County's Sherriff Office became another key funding partner. The Sherriff Office integrated the aerial imagery into dispatch operations. They recently upgraded to a new Computer Aided Dispatch system that now allows for viewing of orthoimagery and oblique imagery by all CAD staffing, and this is used extensively.

The next level of City and County departments that benefits from aerial orthoimagery and oblique imagery is development services/planning and particularly permitting activities. The Engineering and Utility Departments also benefit but not nearly the level of the Assessors or Planning Departments.

The current Spokane County region-wide program has been in place since 2010 (necessitated because of the addition of oblique imagery). However, the program is rooted in a prior program that operated for 20 years and was managed by Avista Utilities. Program management is by the Spokane County GIS, with strong technical support for acquisition and imagery use provided by the vendor.

Lessons Learned and Keys to Success

- Defining the needs of users carefully, for example engineers and emergency response personnel are crucial to funding aerial imagery. In the case of engineers and public safety, they see the value of having high quality and high-resolution data and are increasing their applications of this data.
- The Planning/Appraisal department can use imagery options that support higher resolution and are suitable for building measurements. Determine most appropriate imagery for the Use Case.
- Defining Use Cases and using them to sell the program is important to achieve support of the stakeholders. Part of the business needs analysis consisted of visiting with each of the partners to find out how they will use the data, but now the users are finding more ways to use the data.
- Developed a clear set of specifications that exceed federal specifications.
- Strong effort into the development of an effective data distribution system that is online and easy to use, and is easier for staff to distribute.
- Competent GIS staff well versed in imagery and LiDAR data management
- A partnership/collective approach has increased the return on investment significantly for all involved.

4 References

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Spokane County, 2016, AGREEMENT AMONG SPOKANE COUNTY, CITY OF SPOKANE AND AVISTA UTILITIES FOR IMAGERY COST SHARING AND OTHER MATTERS RELATED THERETO

Spokane County, 2016, SPOKANE COUNTY IMAGERY LICENSE AGREEMENT Fourth Party Participant

Appendix A. Definition of Technical Terms

Aerial photography: A series of photographic images of the ground, taken at regular intervals from an airborne craft, such as an airplane.

American Society of Photogrammetry and Remote Sensing (ASPRS): A scientific association of specialists in the arts of imagery exploitation and photographic cartography.

Area of Interest: Area of Interest is a spatial area identified by one or more communities and/or other stakeholders where there is interest in acquiring imagery and/or LiDAR data.

Digital Elevation Model (DEM): A digital cartographic representation of the elevation of the land at regularly spaced intervals in x and y directions, using z values referenced to a common vertical datum.

Digital Terrain Model (DTM): A vector dataset composed of 3D breaklines and regularly spaced 3D mass points, typically created through stereo photogrammetry, that characterize the shape of the bare-earth terrain. Breaklines more precisely delineate linear features whose shape and location would otherwise be lost. A DTM is not a surface model; its component elements are discrete and not continuous; a TIN or DEM surface must be derived from the DTM.

Image Resolution: Describes the linear size that an image pixel or raster cell represents on the ground. Common resolutions are 3 inch, 6 inch, 1 foot, 1 meter, etc.

Geographic Information Systems (GIS): A GIS manages spatial and tabular data in one software system; and provides tools to store, retrieve, manage, display, and analyze various types of tabular and geospatial data including aerial imagery, LiDAR, and vector data.

Geospatial Product and Service Contracts (GPSC) is a suite of contracts used by Federal, State, and municipal government entities to partner with the USGS for purpose of fulfilling their geospatial data requirements. Photogrammetric and mapping services are primarily awarded under the umbrella of Architect-Engineer (A&E) contracting. The contracts are broad in scope and can accommodate any activity related to standard, nonstandard, graphic, and digital cartographic products. Services provided include, but are not limited to: imagery and LiDAR data acquisition; photogrammetric mapping; and aerotriangulation; orthophotography; thematic mapping; geographic information systems development; surveying and control acquisition; image manipulation, analysis, and interpretation; map digitizing; data manipulations; primary and ancillary data acquisition; metadata production and revision; and the production or revision of geospatial products defined by formal and informal specifications and standards. The contracts are Qualifications-Based Selection (QBS) and task orders are negotiated directly with selected firms to provide contract services. The GPSC can accomodate the mapping and photogrammetric requirements of all USGS offices and is also available to any Federal, State, or local agency. USGS provides assistance to agencies who wish to use the GPSC

Ground Control Point (GCP): GCPs are typically captured using GPS receivers to survey coordinates of photo-identifiable points on the ground. Coordinates are reported in latitude, longitude, and elevation—or northing, easting, and heights. GCPs are typically collected by surveyors who are physically sent to the location of the required control point. GCPs are used to measure and validate a position relative to photo-identifiable elements nearby, such as concrete sidewalks and buildings.

Ground Sample Distance (GSD): The distance between two consecutive pixel centers measured on the ground. The bigger the value of the image GSD, the lower the spatial resolution of the image and the less visible details. GSD and pixel are often used interchangeably.

IfSAR: Airborne IfSAR (Interferometric Synthetic Aperture Radar). A mapping technology acquiring data usually by means of a radar type sensor system mounted on jet aircraft. This radar mapping technology is an effective tool for collecting data under challenging circumstances such as cloud cover, extreme weather conditions, rugged terrain, and remote locations. Mapping products are usually in the 1:24,000 scale range, thus the data typically is not used for engineering or detailed local government purposes. The three main products are, Digital Elevation Models (DEMs), digital Orthorectified Radar Images (ORRIs), and Topographic Line Maps (TLMs). Maps from iFSAR can be created at scales ranging from 1:10,000 to 1:50,000. The State of Alaska SDMI program is utilizing IfSAR to develop a new basemap for the entire state of Alaska.

Light Imaging, Detection, And Ranging (LiDAR): An technology that uses a sensor to measure distance to a reflecting object by emitting timed pulses of light and measuring the time difference between the emission of a laser pulse and the reception of the pulse's reflection(s). The measured time interval for each reflection is converted to distance, which when combined with position and attitude information from GPS, IMU, and the instrument itself, allows the derivation of the 3D-point location of the reflecting target's location.

National Agriculture Imagery Program (NAIP): A program to acquire aerial imagery at one-meter pixel resolution during the agricultural growing seasons, mostly in the continental U.S.

Orthoimagery Mosaic: a single image mosaic of multiple raw imagery tiles or files. The orthomosaic process will generate a georeferenced image mosaic and optionally a digital surface model in various different formats.

Orthorectification: The process of correcting the geometry of an image so that it appears as though each pixel were acquired from directly overhead. The topographical variations in the surface of the earth and the tilt of the satellite or aerial sensor affect the distance with which features on the satellite or aerial image are displayed. The more topographically diverse the landscape, the more distortion inherent in the image.

Orthophotographs: Aerial photographs geometrically corrected to create uniform scale and to remove displacements caused by terrain relief, sensor distortion, and camera tilt.

Pictometry™: Pictometry is the name of a patented aerial image capture process that produces imagery showing the fronts and sides of buildings and other features. Images are captured by low-flying airplanes, depicting oblique and overhead perspectives of features. special software is needed to accurately determine objects' size and position on the maps.

Point Cloud: One of the fundamental types of geospatial data (others being vector and raster), a point cloud is a large set of three dimensional points, typically from a LiDAR collection.

Raster Data: One of the fundamental types of geospatial data (others being vector and point cloud), a raster is an array of cells (or pixels) that each contain a single piece of numeric information representative of the area covered by the cell.

Remote Sensing: The technology of acquiring multi-spectral information about the earth's surface and atmosphere using sensors mounted on airborne platform (planes, helicopter) or satellites.

Satellite images: Images taken from satellites, which orbit the earth at much higher altitudes than airplanes. Satellites use a variety of methods to produce images, including infrared, water vapor, and visible image technologies. Satellite imagery resolution varies from 30- centimeter pixel to 5 meter plus pixel in the commercial market.

Vector Data: One of the fundamental types of geospatial data (others being raster and point cloud), vectors include a variety of data structures that are geometrically described by x and y coordinates, and potentially z values. Vector data subtypes include points, lines, and polygons.