Recurring Aerial Imagery Acquisition Program

MSB Project No. 16-130

Report 5 of 5

Recurring Aerial Imagery Acquisition Program Plan

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Acronyms

AGC ..... Alaska Geospatial Council
ASPRS ..... American Society of Photogrammetry and Remote Sensing
CIAP ..... Coastal Impact Assistance Program
DEM ..... Digital Elevation Model
DOQQ ..... Digital Orthophoto Quadrangle
DTM ..... Digital Terrain Model
FEMA ..... Federal Emergency Management Agency
GIS ..... Geographic Information System
GSD ..... Ground Sample Distance
IFTN ..... Imagery For the Nation
ITB ..... Invitation to Bid
KE ..... Kinney Engineering, LLC
KFA ..... Kentucky From Above
LiDAR ..... Light Imaging, Detection, and Ranging
MEA ..... Matanuska Electric Association
MOU ..... Memorandum of Understanding
MSB ..... Matanuska Susitna Borough
MTA ..... Matanuska Telephone Association
NAIP ..... National Agriculture Imagery Program
NASA ..... National Aeronautics and Space Administration
NMAS ..... National Mapping Accuracy Standard
NRCS ..... Natural Resource Conservation Service
NSSDA ..... National Standard for Spatial Data Accuracy
QA ..... Quality Assurance
QBS ..... Qualifications Based Selection
QC ..... Quality Control
RFQ ..... Request for Qualifications
RFP ..... Request for Proposal
RGB ..... Red, Green, Blue
UAS ..... Unmanned Aerial Systems
USACE ..... U.S. Army Corps of Engineers
USGS ..... United States Geological Survey
URISA ..... Urban and Regional Information Systems Association
WMS ..... Web Mapping Services

Executive Summary

Digital aerial imagery is a fundamental dataset used in geographic information systems (GIS) in local, state, and federal government, private firms, non-profit organizations, and critical systems like emergency computer aided dispatch. Imagery benefits a wide range of users including private industry, public agencies, nongovernmental organizations, private citizens, and educational institutions.

The intent of the Matanuska-Susitna Borough (MSB) Recurring Aerial Imagery Program is to provide aerial imagery in areas where it is most needed, on a recurring basis, and in the most cost effective manner possible.

This report is the final of five reports developed to help create a recurring aerial imagery acquisition program. This report provides a summary of the other reports. It also presents a plan the MSB can use to successfully acquire aerial imagery on a recurring basis in a cost-effective manner.

This report incorporates information from the first four reports. Which were researched and created between September-December, 2016:

Report 1: Successful Recurring Imagery Programs
Report 2: Business Needs Analysis
Report 3: Aerial Imagery Funding Opportunities
Report 4: Aerial Imagery Acquisition Options

A summary of this analysis is provided in Section 2 of this report, with key results as follows:

- Analysis of successful local government aerial imagery acquisition programs in Alaska and throughout the Lower 48 identified a number of keys to success: establishment of stable funding sources, a well-developed technical specification that meets multiple use needs, adequate staffing and project management resources, and a carefully constructed contractual and legal framework that can be re-used in the long term for imagery acquisition. See Section 2 for more detail.
- MSB users map a variety of features as part of their work, including buildings, roads, properties, etc. These features, determined by survey responses, were documented as specific Use Cases to which the imagery resolutions and specifications needed to map these features can be correlated.
- Funding opportunities and options for sustainable funding of imagery acquisition in the MSB was analyzed. Government, utilities, and non-profit organizations provide potential for imagery funding. Potential revenue generating streams were assessed including imagery data sales and use fees.
- Aerial imagery options were evaluated and are summarized in Section 2.4 and Table 2.

An implementation program plan for MSB aerial imagery acquisition has been developed, see Section 3. The implementation plan is based on the analysis conducted in Reports 1-4, and consists of these components:

- Program Acquisition Tasks and Timelines
- Program Maintenance
- Program Success Criteria.

Program acquisition tasks are summarized in a "checklist" and "decision tree." See Appendices A and B. Program maintenance addresses:

- Project organization
- Workflow
- Project documentation

For MSB-wide imagery acquisition, a number of options have been outlined in a plan spanning a four-year period. This plan would acquire imagery for areas corresponding to areas of interest identified in the User Survey. Please see Figure 2 and Table 5 for a map depicting aerial imagery acquisition options the MSB may wish to pursue.

This acquisition approach has the following advantages:

- Acquiring the most accurate and detailed resolution imagery (and associated survey control) for the core area at the beginning of the program. Which would provide a base usable for improving the MSB's cadastral framework, and would serve as a base upon which to collect imagery refresh in future years.
- This is the most efficient management approach, as the geographic areas are more easily manageable by MSB and vendor resources.
- Duration of acquisition and processing would be shorter and online access to data would occur over a shorter time span
- A variety of mapping firms would be more likely to have capacity to compete for selection.
- With this approach it would be practical to consider differentiating resolutions for urban and forested/rural areas to potentially reduce acquisition costs per square mile.

1 Introduction

The MSB Recurring Aerial Imagery Acquisition Program was developed to support the acquisition of aerial imagery on a recurring basis in order to maintain an up-to-date Borough-wide imagery dataset. The goal is to establish a sustainable program for ensuring that MSB users have a reliable source of imagery to meet their current needs.

Access to current aerial imagery has become a critical tool for making well-informed decisions and reducing field work for MSB staff and borough citizens. Imagery is used for asset management, public safety and emergency dispatch, flood mitigation, planning and development, facility site selection, property assessment, and many other functions.

This is the final report in a 5-part series and specifically addresses two separate areas; a program approach to maintaining an imagery dataset and launching an imagery acquisition project. Reports 1 through 4 provide research and analysis information needed for initiating and developing an overall program, as well as tools to apply while planning for an imagery acquisition. Below is a list of all five reports:

Report 1: Research and Identify Successful Recurring Imagery Programs
Report 2: Perform Business Needs Analysis
Report 3: Investigate Funding Opportunities
Report 4: Identify Acquisition Options and Technical Specifications
Report 5: Create Program Plan

In Scope - Program Plan objectives:

- Sustainability: a consistent, successfully funded program
- Frequency: imagery collection occurs on a regularly scheduled basis
- Quality: imagery meets national mapping standards and Borough needs
- Accessibility: imagery users have online access to map services and downloadable files
- Cost-effective: an appropriate imagery product procured at a prudent cost

Out of scope:

- Acquire imagery
- Develop and write aerial acquisition scope, legislation, and RFP
- Evaluate, select, and negotiate proposals and contract
- LiDAR needs and acquisition

This program plan is the result of a collaborative effort between the MSB GIS staff and the contractor; surveys and other data collected as part of this study are due in large part to the work and contributions of MSB staff.

2 Summary of Reports

Report 1 revealed the following key elements of existing successful programs:

- Sustainable funding sources, ideally provided through a partnership or consortium.
- Imagery specifications developed using a comprehensive user requirements analysis.
- Organizational elements that consist of a well-defined imagery procurement process.
- Contractual and legal agreement documents that specify responsibilities amongst the parent agency, vendor/contractors, and partners; and services.
- Understanding of costs beyond the acquisition itself; such as, survey control, project management, administration, QA/QC, and data distribution.

Report 2 reported on a survey results and identified the following MSB use cases:

- Public Safety
- Property Appraisal
- Public Works
- Capital Improvements
- Land Management
- Planning and Development Services
- Facilities Management
- Utilities

Report 3 evaluated the following funding opportunities:

- Potential internal and external partners
- Grant opportunities
- Fund generation through fees and/or selling or services/data

Report 4 analyzed the following imagery options with regard to MSB user needs:

- Satellite Imagery
- Aerial Digital Orthoimagery
- Oblique and Orthogonal Imagery
- Subscription Imagery Services
- Unmanned Aerial Systems (UAS)

This final report provides a program implementation plan for recurring imagery acquisitions in Section 3. Important technical and other definitions are provided in Appendix D.

2.1 Successful Aerial Imagery Programs (Summary of Report 1)

Seven local government aerial imagery programs, located across the United States, were researched regarding what enables them to successfully operate, and to determine key factors in their ability to successfully conduct aerial imagery acquisition on a recurring basis. See Report 1. Key factors contributing to a successful program are described below.

Partnerships

Most of the successful programs studied in Report 1 are characterized by a numerous and diverse set of stakeholders who provide stable, repeatable funding sources. Many of the programs have developed partnerships or consortiums and find this is an effective way for providing sustainable funding and reducing costs. The following benefits have been realized through consortiums:

- A viable method for obtaining high accuracy aerial imagery to support multiple government needs over larger areas.
- Helps unify aerial imagery programs and improve communications among government entities.
- Assists in the integration of aerial imagery with GIS parcel database and other GIS layers used by MSB area-wide users.
- Ensures a consistent quality of aerial imagery across the region.
- Eliminates multiple acquisitions from government agencies for the same area.
- Saves taxpayers' money.

Timelines

Aerial imagery acquisition programs typically take nine months to one year from start of acquisition to delivery of imagery products. This timeline is shrinking with better acquisition methods, processing, and production and distribution tools. Several of the programs researched utilize well developed workflows and balanced use of vendor resources to ensure timelines are not excessively long.

The time required to build imagery consortiums can take a similar or longer time to fully develop. As shown by the programs studied, this process can take three to four years to mature.

Project Process and Management

Establishing and documenting an imagery acquisition process is key to a successful aerial imagery acquisition program. That process is characterized by the following elements:

Consistent Partnership Documentation
Acquisition typically utilizes a set of standard legal and contractual documents developed over time, and then used repeatedly. Core documents are:

- A standard RFQ or RFP.
- Contracts or MOUs that binds the partnership together.
- A set of thorough specifications. Examples are: Spokane County, Wisconsin, Maine, Kentucky.

Adherence to National Standards and Best Practices

National standards address feature mapping resolutions, imagery accuracy standards, and best practices for imagery acquisition. These standards include:

- ASPRS 2015 Accuracy Standards
- National Map Accuracy Standards
- USACE 2015 Manual Orthophotography and LiDAR Standards
- USGS Digital Orthoimagery Base Specification V1.0
- NSSDA

Needs Assessment and Requirements Updates

- Requirements updated annually.
- Imagery specifications should take into account multiple user needs and be updated annually.
- Procurement RFP specifications and standards (boiler plate) developed and re-used.

Preparation and Provision of Adequate Control

- A Digital Terrain Model (DTM) is needed to account for elevation warping and to ensure imagery accuracy.
- Adequate survey control should be prepared in advance.
- Survey control should have adequate metadata.

Project Management and Staff Support

- A competent project manager and functional contractor working relationship is critical to successful implementation.
- Adequate staffing is needed, either assigned internally or to the vendor. As demonstrated in a number of other programs studied, this is a critical factor in ensuring imagery is delivered in a timely manner and to quality standards.
- Large acquisition projects have the potential to over-burden internal staff resources.
- Strong team approach and adequate technical resources ensure timely project completion.

Keys to Success & Lessons Learned

- Strong partnership based programs have longevity; the main examples being the Puget Sound LiDAR Consortium, Wisconsin WROC, Maine, and Spokane County. Consortiums take time to develop and mature; often five years and longer.
- Provision of adequate project management, program management, and technical resources to ensure the program functions well.
- A program process that can be repeatedly used, and characterized by repeatable workflows and guiding documents.

2.2 Business Needs Analysis (Summary of Report 2)

User Survey and Analysis of Preferences

Understanding how and why people use imagery helps to determine what type of imagery is needed and how often the imagery needs to be updated. A business needs analysis serves as a definitive basis for developing a recurring aerial imagery acquisition program and should be continually refined. The business needs analysis conducted and described in detail in Report 2, included a user needs survey, interviews, and a public meeting.

The business needs analysis showed that aerial imagery has become an essential tool in many levels of MSB government and in the private sector. Imagery is used for asset management, public safety and emergency dispatch, flood mitigation, planning and development, facility site selection, property assessment, research by private citizens, and many other functions.

The majority of internal stakeholders' view Borough imagery through the online MSB Parcel Viewer and/or ArcMap software. Private citizens primarily view imagery through the MSB Parcel Viewer, Google Earth, and other online maps.

MSB Imagery Use Cases

Use Cases were developed from the survey response data and represent typical MSB imagery use scenarios. These help organize user needs, identify imagery specifications and can be used to help sell the imagery program idea to potential partners. These are the primary MSB Use Cases:

1. Public Safety (EMS, fire, 911 dispatch, pre-planning, disaster recovery)
2. Property Appraisal (property assessment, structures inventory, parcel delineations)
3. Public Works (roads inventory, asset management, ROW, plan & profile, solid waste)
4. Capital Improvements (transportation, facility site evaluations, road alignments)
5. Land Management (flood mitigation, mapping trails, vegetative analysis, wetlands mapping, site selection, recreational assets management and planning)
6. Planning and Development Services (land use analysis, infrastructure planning, long range planning, permitting)
7. Facilities Management (port development, lease sites, rail development, resource extraction)
8. Utilities (location of electrical, natural gas, telephone assets)

Acquisition Coverage and Refresh

The Borough encompasses approximately 25,000 square miles and includes urban, rural, and remote areas. Results of the user survey revealed that the majority of MSB users would like imagery in areas of significant change to be refreshed on a 2 to 3-year cycle. There is a need for updated imagery since the current aerial imagery base is 6 years out-of-date, acquired in 2011. Figure 1 and Table 1 identify six aerial imagery acquisition areas by level of interest based on the User Survey results.

Figure 1. MSB Imagery Acquisition Areas

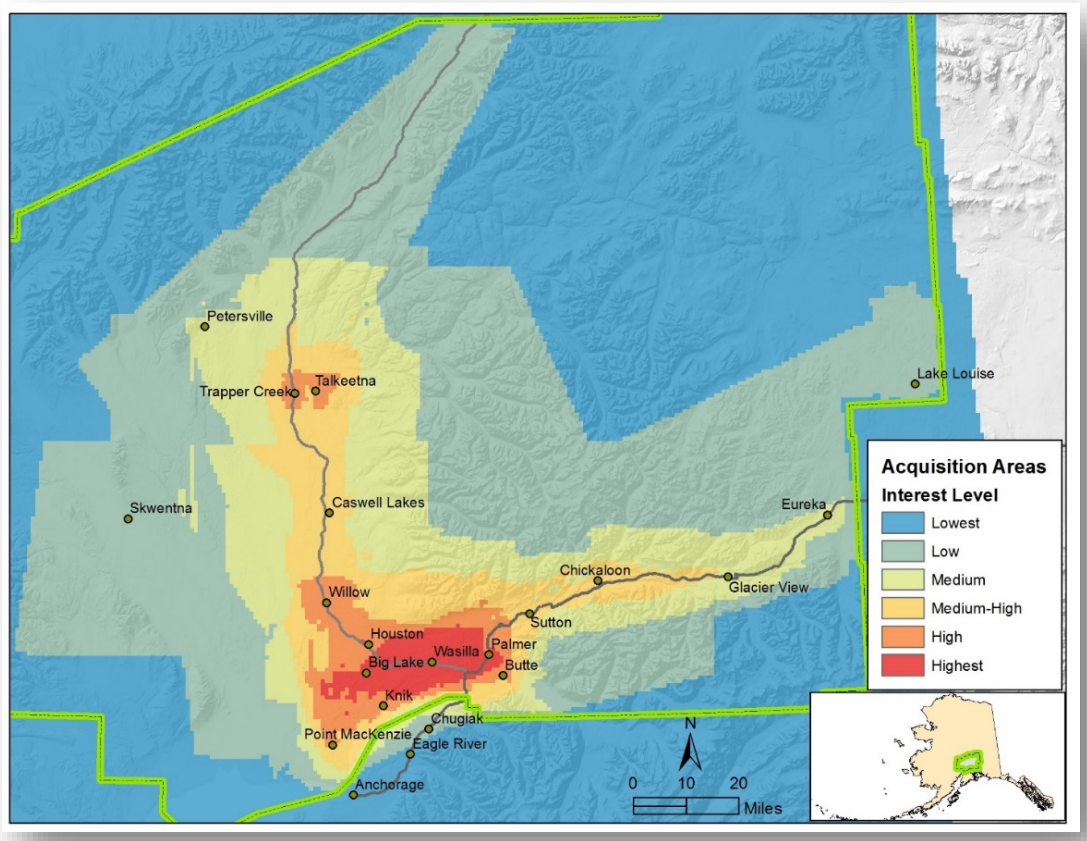

Table 1. MSB Acquisition Areas from Survey

Area of Interest	Percentage Interested	Interest Level on Map
Core Area (Wasilla – Palmer)	83	highest
Houston/Big Lake/Meadow Lakes	71	high
Knik Goose Bay/Point MacKenzie	71	high
Willow/Caswell Lakes	68	high to medium-high
Talkeetna/Trapper Creek	64	high to medium-high
Lazy Mountain/Butte/Knik River	61	high to medium-high
Sutton/Moose Creek	56	medium-high
Government Peak/Hatcher Pass	46	medium-high
Chickaloon/Glacier View/Eureka	45	medium-high to medium
North Parks Highway (north of Trapper Creek)	44	medium to low
Lake Louise	32	low
Skwentna	31	low
Other	36	lowest

2.3 Funding Opportunities (Summary of Report 3)

Stable funding source(s) are required to establish a recurring aerial imagery program. The following potential funding sources were researched and identified in Report 3:

- Funding Partners
    - Partnership (Consortium) Examples
    - Internal Partners
    - External Partners - Local
    - External Partners - State & Federal
- Grant Opportunities
- Funding Generation

The following are recommended next steps for obtaining internal funding acquisition:

1. **Create Partnerships**: Partnerships (aka consortiums) are a proven and successful approach to reducing the cost of imagery acquisition.

2. **Further Research Federal and State Funding Opportunities:** Grant opportunities described in Report 3 could be further investigated. Leveraging local federal geospatial liaisons is recommended as they can assist with grant application development as well as with networking with federal agencies.

3. **Look into Creating a Geospatial Surcharge:** Several examples of successful geospatial surcharges are described in Report 3, including revenue deriving from property transaction fees in Wisconsin, and Public Safety use fees in Spokane County.

2.4 Technical Specifications (Summary of Report 4)

Research conducted in Report 1 revealed that recurring acquisition programs typically separate acquisition areas with regard to method of collection and resolution as their required level of detail varies. Typically, acquisitions of imagery are separated into urban and rural with resolutions being higher (e.g. 6-inch pixel) in urban areas, and 9-inch to 2-foot in rural areas.

Imagery Data Ownership, Licensing, and Distribution

Imagery licensing varies from public domain to restricted use based on the contract agreement.

Typically, aerial orthoimagery and UAS products are delivered with no restrictions regarding usage and distribution.

Satellite imagery, oblique and orthogonal imagery products, and image services are typically licensed to the customer with usage distribution terms negotiated in the contract.

Report 4 explains imagery licensing for each imagery type in greater detail.

Survey Control

Survey control is a critical component of ensuring spatial accuracy of the imagery products. It addresses horizontal and vertical control involved in the imagery acquisition itself, and is used in the orthorectification process. It also ensures the deliverables meet national mapping standards.

An imagery acquisition vendor is often responsible for ensuring ground control is provided of sufficient density and accuracy to meet the accuracy requirements of the deliverable. Coordination between the imagery acquisition vendor and survey firm is critical to ensure the appropriate level of control is established. Elevation data and vertical control is also a factor in ensuring spatial accuracy; however, this is typically not included in the surveyor's responsibilities.

Since the MSB does not employ a Borough surveyor, it will need to subcontract the development of accurate control for areas where high-resolution imagery is required on a repeated basis.

Costs

Costs associated with an imagery acquisition program accrue from 1) the actual imagery acquisition itself, 2) the survey and other control required, 3) processing and QA/QC, and 4) project management. It is possible to reduce costs in each of these areas.

1. **Imagery acquisition** costs are related to imagery resolution and accuracy; the higher the resolution and accuracy of the imagery, the higher the cost. Costs can be reduced by selectively acquiring high resolution imagery in areas requiring more detailed feature mapping; and use lower resolution imagery in areas not as demanding. Imagery acquisition options were analyzed in Report 4, and a summary of pros and cons are summarized in Table 2 below.

2. **Survey and other control** costs can be reduced by leveraging pre-existing control, for example the MSB's 2011 survey control and LiDAR; and establishing a survey control network that is re-usable over a period of years.

3. **Processing and QA/QC** costs could be reduced by selectively using a combination of vendor and internal staff resources.

4. **Project management** and other support costs can be reduced by using vendor and internal staff

Imagery Options

Based on program research conducted in Report 1 and imagery options analyzed in Report 4, imagery options, the pros and cons, and costs of each are summarized below in Table 2.

Table 2. Imagery Options Analysis Summary

Imagery Option	Pros	Cons	Cost
Aerial digital orthoimagery	The standard for aerial imagery products for local government and others requiring detailed level mapping.	Requires significant acquisition resources: aircraft, control, management.	$160 to 250/square mile.
Oblique and Orthogonal imagery	Orthoimagery that provides multiple viewing angles (sides of buildings and features.) Specialized tools for feature measurement available.	Requires significant acquisition resources: aircraft, control, management. Vendors providing specialized services are often not based in Alaska.	$250 to 350/square mile depending on procurement method.
Satellite imagery - high resolution	Aerial imagery at resolutions approaching orthoimagery resolutions. Frequent refresh.	Refresh dependent on commitments from vendor as to tasking. Haze, clouds, and wildfire smoke can be a factor. Ground control costs may add to processing costs.	$50 to 80/square mile, but costs can be higher depending on effort required to process.
Satellite imagery - moderate resolution	Aerial imagery at suitable resolutions for Tier 2 feature mapping. Can acquire large scenes at one time.	Resolution not detailed. Refresh dependent on tasking. Haze, clouds, and wildfire smoke can be a factor. Ground control costs may add to processing costs.	$30 to 50/square mile depending on effort required to process.
UAS	Very high resolution (typically in the 1-inch or less) imagery and digital surface model data. Portable, inexpensive equipment.	Limited to specific project areas and small acquisition footprints. Processing can be intensive and depends on extensive ground control to ensure accuracy.	Varies depending on size of acquisition area, accuracy requirements, and amount of processing required.

3 Imagery Acquisition Project Implementation Plan

The research conducted in Reports 1 - 4 and summarized in Section 2 above contribute to establishing a long-term, successful aerial imagery acquisition program. Implementing such a program results in:

1) A cost-effective means of acquiring new imagery, and

2) Better management of existing imagery.

The plan, which is about to be outlined in this portion of the report, consists of the following processes and is designed to create a program that can be maintained over a period of years. It is characterized by repeatable workflows and documentation that is based on successful program models. See Appendices A and B which summarize program steps and timelines.

- Requirements Analysis
- Establish Funding
- Technology Research
- Procurement Process
- Imagery Acquisition
- Data Management and Distribution
- Program Documentation
- Success Criteria

3.1 Requirements Analysis

A requirements analysis should be conducted for the project, following these steps:

1. Conduct a brief survey to collect, or update, user requirements including:
    a. Area of interest boundaries.
    b. Feature types to be mapped (to determine resolution requirements).
    c. Timeframe needed for acquisition.
2. Determination of imagery priorities including:
    a. Acquisition areas by level of interest.
    b. Imagery refresh rate.
    c. Imagery specifications as determined by user needs (features mapped).

The acquisition should be planned in a phased manner to a) accommodate areas of higher interest first, and b) distribute costs over a longer timeframe and consistent manner. However, depending on the exact acquisition area of interest, need, and urgency of a project request the schedule may be adjusted.

3.2 Establish Funding

Funding sources need to be established for the project and typically include these types:

1. Internal local government, e.g. departmental
2. Use Fee
3. Federal grant
4. State grant
5. Local government grant
6. Utility
7. Non-profit
8. Consortium

Time sensitive constraints include grant application timelines and methods for obtaining funds. For example, grant opportunities often involve substantial application efforts. Legislative and fiscal constraints may involve significant amounts of time to research and prepare materials. Once funding has been identified and secured, it may need to go through a legislative approval process. Typical project time constraints include:

1. Seasonal
2. Fiscal
3. Legislative
4. Legal and Other

Table 3 provides a guideline of funding planning considerations as applied to different project types.

Table 3. Project Types, Funding Sources, and Time Constraints

Project Type	Funding Source	Time Constraints
Small site specific (e.g. landfill, school, road interchange project)	1	1, 2
Large area – urban	1, 2	1, 2, 3
Large area – urban infrastructure	1, 3, 6, 7	1, 2, 3
Large area – semi-rural	1	1, 2, 3
Large area – remote	1	1, 2, 3

Refer to Appendix A and B for a typical project checklist with task durations.

3.3 Technology Research

The project type will determine the appropriate imagery technical solution to meet the user requirements. This analysis should leverage Report 4, but this information will need to be updated to incorporate technology changes and advancements. See Report 2 and Report 4 for reference to appropriate technology with regard to Use Cases and Report 4 for imagery resolution and accuracy. A brief report describing technology recommendations in light of current options should be produced.

3.4 Procurement Process

A procurement approach that follows MSB and ASPRS guidelines is recommended. The ASPRS guidelines provide a national best practice. Please see Appendix C for a summary of procurement steps and a sample RFP. The RFP is based on those used by other successful aerial imagery programs and follows a typical digital orthoimagery RFP. It may have to be adjusted for a satellite imagery or subscription services. Following selection of the vendor, approval from the MSB Assembly is required which is completed with an action memorandum.

3.5 Imagery Acquisition

Following the selection of a vendor, the imagery acquisition should follow the series of steps shown in Table 4 and detailed below.

Table 4. Acquisition Project Steps Summary

Imagery Acquisition Planning
Imagery Acquisition
Imagery Acquisition Complete
Imagery Processing
Preliminary Imagery Delivery
Internal Review of Preliminary Imagery
Internal QA/QC (of all imagery)
Third Party Review of Imagery Products
Imagery End Products Delivery
Final Review of End Products
Project Closeout

Imagery Acquisition Planning

Prior to actual imagery acquisition the vendor in consultation with the MSB should prepare an acquisition work plan. See Report 4 for a description of a typical work plan. The work plan is reviewed in a kick off meeting with the MSB. Acquisition steps are described below, and shown in Appendices A and B.

A proposed acquisition plan is shown in Figure 2 and in Table 5. Acquisition of four areas could be phased over a period of four years. These are the areas identified as being of highest interest in Report 2. The boundaries can be adjusted based funding partner needs. This plan provides a consistent and even cost approach, with costs between $85K to $123K per year over four years.

Figure 2. Phased Acquisition Plan

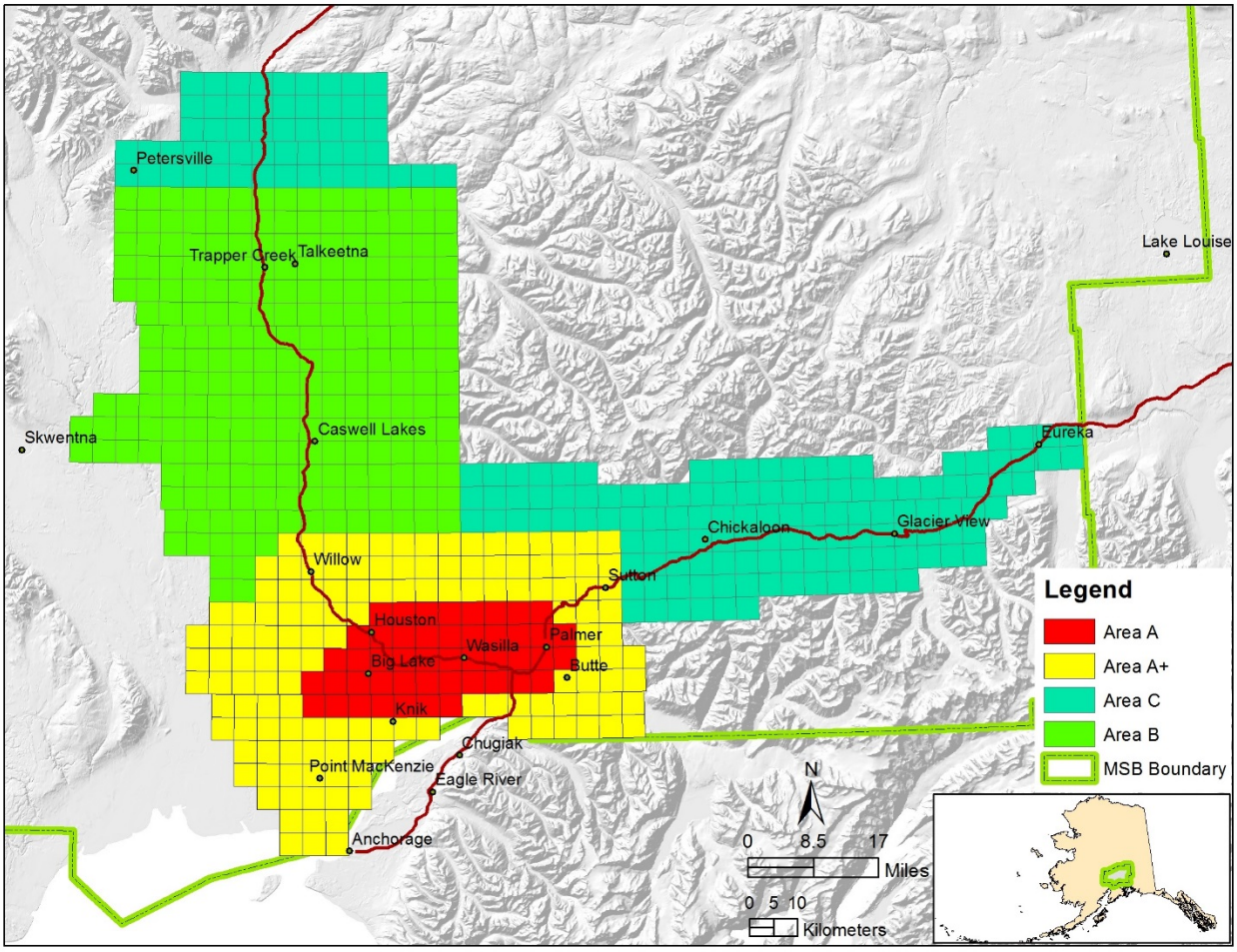

Table 5. Acquisition Options Plan

Option	Resolution	Imagery Type	Approximate Cost	Benefit
A	6-inch	Orthoimagery	$85,000	Provide accurate block of ortho imagery to use in cadastral work.
A+	30 cm.	High Resolution Satellite	$98,000	Provide ortho accurate image base for parks highway corridor area.
B	30 cm.	High Resolution Satellite	$96,000	Provide ortho accurate image base for Glenn highway corridor area.
C	30 cm.	High Resolution Satellite	$123,000	Provide ortho accurate image base for rural outlier area.

Imagery Acquisition

The vendor acquires imagery following the work plan and keeps the MSB informed regarding acquisition status.

Imagery Processing

Image processing workflow and processes follow the acquisition of imagery, and are summarized in Appendix D and described in Report 4.

Preliminary Imagery Review

Once imagery has been acquired, the vendor provides the MSB with preliminary processed imagery for a selected area within the acquisition project area. Following review, the MSB provides the vendor with comments and a request for corrections.

In-House QA/QC

An optional step is to utilize a certain level of in-house QA/QC. This does not replace vendor QA/QC, but serves as another check on data quality. See Appendix D. The major imagery vendors now provide desktop and online tools for performing internal QA/QC that can be integrated with GIS and other mapping software.

Third Party Review

A third-party firm should perform the independent Quality Assurance/Quality Control (QA/QC) work before the products are considered final, to ensure the following:

- Image quality meets national standards.
- Image accuracy standards are met.
- Image processing procedures were followed and are documented.
- Deliverables meet quality standards and follow contract specifications.
- Adequate documentation is provided with the deliverables, e.g. metadata.

Review of End Products

Imagery end products and associated report documentation are reviewed by the MSB as to completeness.

3.6 Data Management and Distribution

Methods for imagery storage, access of the imagery, and distribution of the imagery are important considerations that are often overlooked. Key tasks are as follows:

- Develop an effective tiling scheme for the imagery.
- Determine the distribution method(s).
- Regarding distribution, one option is to create web mapping service that can be ingested into numerous applications and used in online maps.
- Licensing aspects discussed with regard to satellite imagery and oblique and orthogonal imagery products will need to be worked out with the respective vendors to accommodate the MSB's needs.

3.7 Program Documentation

The documents listed below should be utilized in each of the program tasks. See Appendices A and B for a listing of these and their relationship to program tasks. Appendix F provides a description for each of these documents. Templates from other programs for agreements, RFPs, and contracts researched in Report 1 may be useful as templates.

- Imagery Specifications
- Partner Agreements
- Imagery Vendor RFP
- Imagery Vendor Contract

3.8 Success Criteria

Based on research conducted in this project, including local Alaska experience the following are considered important success criteria for a recurring aerial imagery program.

- Sound business case based on needs analysis.
- Sustainable funding sources.
- Appropriate technology to meet needs.
- Program maintenance plan with repeatable workflows.
- Realistic scheduling and timelines.
- Adequate administrative and technical support.
- Guiding documentation based on industry best practices and national standards.

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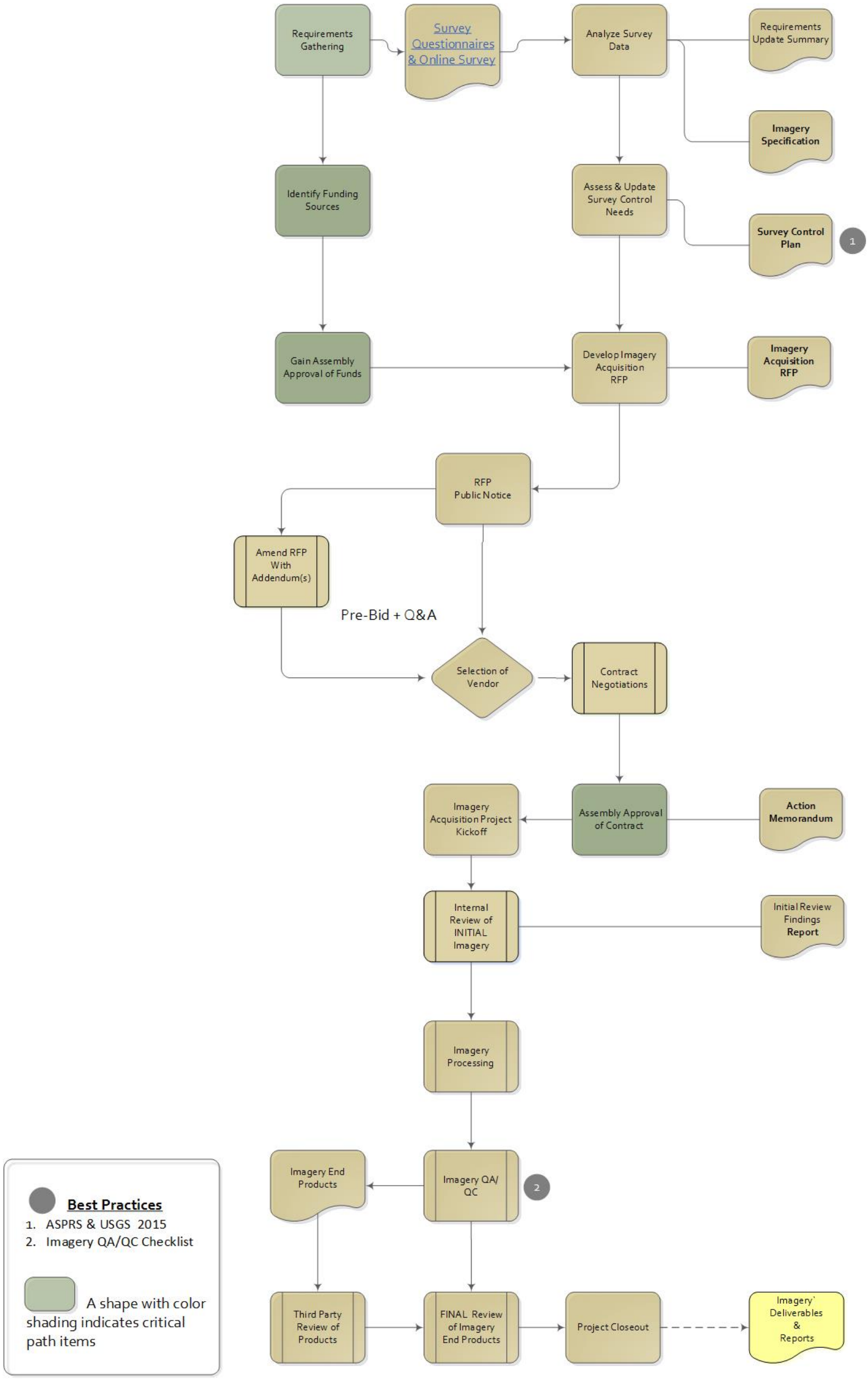
Appendix A: Aerial Imagery Acquisition Checklist

ID	Name	Duration
1	Project Start	
2	Requirements Gathering	20 days
3	Funding Plan	20 days
4	Completion of Imagery Specifications (or Update)	1 day?
5	Technology Update: Imagery Options	20 days
6	Survey Control Review & Plan	14 days
7	Secure Legislative Approval of Funding Plan	40 days
8	Develop Imagery Acquisition RFP	24 days
9	Finalize RFP	4 days
10	Publish RFP	14 days
11	RFP Pre-Bid Meeting	15 days
12	RFP Pre-Bid Q&A Process	1 day?
13	Proposal Evaluation	9 days
14	Selection of Vendor	11 days
15	Contract Approval by Assembly	14 days
16	Contract Negotiations	14 days
17	Contract Execution	16 days
18	Project Kick-Off Meeting	1 day?
19	Imagery Acquisition	20 days
20	Imagery Acquisition Complete	3 days
21	Imagery Processing	50 days
22	Pilot Imagery Delivery	2 days
23	Internal Review of Initial Imagery	7 days
24	Imagery QA/QC	30 days
25	Third Party Review of Imagery Products	20 days
26	Imagery End Products Delivery	7 days
27	Final Review of End Products	14 days
28	Project Closeout	10 days
29	Project Closeout	1 day?

Appendix B: Program Decision Tree



Appendix C: Sample RFP and Procurement Guidelines

Sample RFP

1. Purpose of the RFP
2. Program Area
3. Program Background
4. Program Objectives
5. Program Scope of Services
    a. Project Management
    b. Pre-Flight Deliverables
    c. Post-Project Deliverables
    d. Contract Term and Work Schedule
6. Methodology
    a. Project management plan
    b. Imagery Collection Approach
    c. Image Resolution
    d. Spectral Resolution
    e. Radiometric Resolution
    f. Coordinate System
    g. Horizontal Accuracy
    h. Vertical Accuracy and DTM
    i. Control and Control Access Agreements
    j. Quality Assurance and Quality Control
    k. Methods for allowing Client Visual inspection of data
    l. Options for Imagery Access and Distribution
7. Contractor Qualifications
    a. Experience
        i. Firm
        ii. Staff
8. Contractor Resources
    a. Project management
    b. Production capacity
    c. Equipment
9. References
10. Evaluation Criteria
    a. Qualifications
    b. Resources
    c. Methodology
    d. Cost
    e. Schedule

11. Proposal Format
    a. Introduction
    b. Understanding of the Project
    c. Methodology
    d. Experience and Qualifications
    e. Resources
    f. Proposed Deliverables
12. Deliverables
    Contractor is required to provide the following deliverables:
    a. Source Imagery
    b. Flight control reports
        i. Flight Diagram
        ii. Flight Lines and Exposure Numbers (reference USGS Aerial Photography Supplemental Report form)
        iii. Calibration Reports
        iv. Camera Control
        v. Airborne GPS and IMU Data
        vi. Supplemental Ground Control
    c. Processed Images
        i. Image Tile Size
        ii. Image Characteristics
        iii. Image Format
        iv. Delivery Medium and Format
        v. Metadata
13. Ownership of Data
14. Appendix A—AOI map

ASPRS Procurement Guidelines

Procurement Guidelines (reference ASPRS, 2014).

The following are procurement guidelines for a typical aerial imagery acquisition project. Note, the Decision Tree includes these steps in visual format.

1. Pre-proposal research: The requirements definition should include, at a minimum:
    - Consideration of technical requirements
    - Schedule and method of delivery
    - Acceptable warranty and/or licensing restrictions
    - Documentation expected to be provided by the provider, including specifications, and metadata
    - Geographic area to be covered
    - Availability of support / maintenance

2. Development of Source Solicitation Package. Depending on the regulations of the procuring organization and factors like the size of the procurement, a solicitation package may be required. The specific documents in the source solicitation package may include:
    - Specifications documents - These documents describe in detail the MSB requirements
    - Evaluation methodology - A description of how any proposals for MSB will be evaluated, including final award criteria and weighting.
    - Due dates, points of contact
3. Issuing the Source Solicitation Package
    - Issuing the source solicitation package involves providing the source solicitation directly to providers or placing it in an advertised location or on a web site where source solicitation packages reside.
4. Evaluating Proposals (Selection Decision and Award). The customer should evaluate proposals based on criteria defined and published prior to receipt of proposals. The organization may communicate with individual providers, as appropriate, to address the responder's understanding of the requirements, performance capabilities, price range limitations, and other terms and conditions.
5. Pre-bid question and answer period. A to the vendors to ask questions of the Borough. A one to two-week period is provided to allow the Borough to answer questions. Addendums are posted if information gleaned in this process is deemed to be useful. This is a highly useful phase of procurement where the RFP can be adjusted if necessary, and takes into account information that may be critical to ensuring the best possible proposal.
6. Selection Decision and Award- the provider should be selected based on the best value to the procuring organization, taking into account factors including, but not limited to: provider experience/capability, price, quality of deliverables, delivery schedule and method, warranty or licensing, and payment terms. The method of selection and rationale for awarding the contract should be documented and maintained by the procuring organization.

Appendix D: Imagery QA/QC Checklist

- Atmospheric artifacts: cloud cover, smoke and haze absent.
- Misalignment: (misalignment)of transportation features between adjacent image chips/tiles or seamlines.
- Tonal balance: orthophotos shall be tonally balanced to produce a uniform contrast and tone across the block and the entire project.
- Building tilt and distortion: excessive tilt in bridges, buildings, and other raised structures shall be corrected particularly to the extent they obscure transportation features.
- Transportation feature occultation: transportation features should not be obscured by shadows or buildings.
- Ground features: appearing in the orthophoto imagery, such as building roof tops, water towers, and radio towers, shall not be clipped at seamlines or between individual tiles.
- Clipping: features such as radio towers, water tanks, buildings and similar, should not be clipped at tile boundaries.
- Image mosaicking/tiling and quality: the image with the best contrast shall be used as a reference image when the color digital orthophoto tiles are created.
- Brightness values: all other images shall have their brightness values adjusted to that of the reference image.
- Image artifacts: the delivered color digital orthophotos will not contain defects such as out-of-focus imagery, blurs, whorls, twists, color blemishes, dust or lint marks, or scratches. The images shall also be free from image blurs, smears, voids, image artifacts, “cold” or “hot” pixels, color distortion, color balance or tonal problems, or any other kind of “digital blemish” or data corruption. All fiducial mark images shall be visible, clear and sharp.
- Saturation: evidence of oversaturation or undersaturation as a result of image processing or histogram manipulation should be avoided.
- Image compression: artifacts due to image compression should be absent.
- Completeness: data should cover the specified geographic extent, with no omissions or corrupt data. The image tiles delivered will contain neither background data nor NODATA pixels.
- Ground sampling distance: GSD will ensure that it meets the specified resolution.
- Assessing horizontal accuracy: testing performed if suitable test-point control is furnished as part of the deliverables; test-point control must be completely independent of control used during data production.
- Verify metadata adequacy: verify that accompanying metadata is complete.

Appendix E: Definition of 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.

Color Infrared imagery: Color infrared (CIR) imagery includes a band of near infrared (NIR) information. NIR wavelengths are slightly longer than red, and they are outside of the range visible to the human eye. They are frequently collected as part of an aerial imagery collection and delivered as a fourth band of spectral information (in addition to red, green, and blue). Color infrared images (aka false color) are especially useful because the internal cell structure of healthy plants reflects near infrared wavelengths. As a result, it is frequently used to monitor plant health for agricultural, natural resources, and environmental purposes. Conventionally, a digital CIR image is set up to display the infrared band data with a red tone. Red wavelengths are set to appear green, and green wavelengths are set to appear blue. Blue wavelengths are not displayed.

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.

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.

Light Imaging, Detection, And Ranging (LiDAR): A 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.

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

Orthoimagery: Typically, aerial imagery used for mapping consists of a rectified aerial image or orthophoto (aka orthoimagery). Orthoimagery is aerial imagery or photographs that have been adjusted using survey ground control points and vertical topography, for example a digital elevation model, to ensure that the imagery is positionally accurate. Unlike an uncorrected aerial photograph, an orthophoto can be used to measure true distances, because it is an accurate representation of the earth's surface, having been adjusted for topographic relief, lens distortion, camera tilt, and other factors.

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 poly.

Appendix F: Program Documentation

The following documents guide and describe core components of the recurring aerial imagery program. See Appendix B—Decision Tree—which shows the documents relative to project steps.

Imagery Specifications

Imagery specifications form a key element of a recurring aerial imagery acquisition program as demonstrated by the successful programs studied and discussed in Report 1. Key examples of these include Kentucky From Above, Wisconsin WROC, and Spokane County, which utilize six and nine-inch resolution orthoimagery for urban and rural areas.

Partner Agreements

In the event a partnership or consortium is utilized for funding, the legal and contractual agreements binding partners together form a key element of the recurring aerial imagery acquisition program. Key examples of these documents include those from Kentucky From Above, Puget Sound LiDAR Consortium, and Spokane County. These documents are used in the recurring programs, and in some cases have not been modified much over multi-year timespans.

Imagery Vendor RFP

Key examples of aerial imagery RFPs and contracts with vendors for recurring aerial imagery acquisition include Kentucky From Above, Puget Sound LiDAR Consortium, and Spokane County.

Imagery Vendor Contract

Key examples of aerial imagery contracts with vendors for recurring aerial imagery acquisition include the Wisconsin WROC and Spokane County.