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Unmanned Aerial Systems Business Model Assessment for DOT&PF

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This project aimed to enhance the precision and efficiency of land surveying using Small Unmanned Aerial Systems (sUAS) equipped with Real-Time Kinematic (RTK) technology. By integrating advanced RTK workflows, the project sought to eliminate the need for extensive ground control, thus reducing time and effort in data collection. The research included detailed setups of RTK-enabled drones, comprehensive flight mission planning, and meticulous data processing to achieve high-accuracy geodetic positioning. Additionally, the project involved evaluating the performance of sUAS in Arctic conditions, comparing RTK and Post-Processed Kinematic (PPK) techniques, and developing best practices for data processing. The findings demonstrate significant improvements in data precision, safety for field crews, and the overall quality of survey products. These enhancements support civil engineering and transportation project designs, offering a reliable and efficient alternative to traditional land surveying methods.

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APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4		mm
ft	feet	0.3048		m
yd	yards	0.914		m
mi	Miles (statute)	1.61		km
		AREA		
in^2	square inches	645.2	millimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.4046	hectares	ha
		MASS (weight)		
oz	Ounces (avdp)	28.35	grams	g
lb	Pounds (avdp)	0.454	kilograms	kg
T	Short tons (2000 lb)	0.907	megagrams	mg
		VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL
gal	Gallons (liq)	3.785	liters	liters
ft^3	cubic feet	0.0283	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3

Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
ºF	Fahrenheit temperature	5/9 (ºF-32)	Celsius temperature	ºC
		ILLUMINATION		
fc	Foot-candles	10.76	lux	lx
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2
		FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

These factors conform to the requirement of FHWA Order 5190.1A *SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	Miles (statute)	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
km^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.471	acres	ac
		MASS (weight)		
g	grams	0.0353	Ounces (avdp)	oz
kg	kilograms	2.205	Pounds (avdp)	lb
mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces (US)	fl oz
liters	liters	0.264	Gallons (liq)	gal
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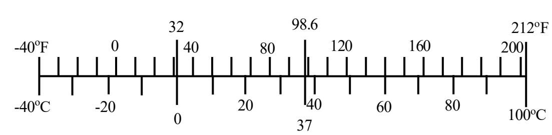
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
ºC	Celsius temperature	9/5 ºC+32	Fahrenheit temperature	ºF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi



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This project was conducted under the provisions of the Federal Aviation Administration (FAA) 49 USC 44803, 44804, 44805, and 44806, ensuring compliance with all relevant regulations and standards.

This research would not have been possible without the collaborative efforts and dedication of all the team members involved.

Executive Summary

The rapid advancement of technology in unmanned aerial systems (UAS) presents significant opportunities for land surveying. Recognizing this potential, the Alaska Department of Transportation & Public Facilities (DOT&PF) initiated a research project titled "HFHWY00207 - Unmanned Aerial Systems Business Model Assessment for DOT&PF," conducted in collaboration with the University of Alaska Fairbanks (UAF) and the Alaska Center for Unmanned Aircraft Systems Integration (ACAUSI) at the Alaska UAS Test Site. The primary objectives of this research were to evaluate the effectiveness of UAS technology in land surveying, focusing on accuracy, efficiency, and cost-effectiveness; develop a business model for integrating UAS into DOT&PF's standard surveying practices; identify best practices for data collection and processing using UAS; and ensure compliance with Federal Aviation Administration (FAA) regulations and standards.

The research methodology encompassed several key phases. Initially, the project involved collaboration with ACAUSI to develop a UAS suitable for surveying tasks, focusing on equipping the drone with Real-Time Kinematic (RTK) or Post-Processed Kinematic (PPK) GPS, accurate Inertial Measurement Units (IMUs), and a camera payload for photogrammetry. After facing initial setbacks, the team adopted DJI's Phantom 4 RTK drone, which met the technical requirements of the project. The team then optimized data collection and processing workflows, including the use of ground control points. Field data collection was conducted across various terrains using the Phantom 4 RTK, with ground control points verifying the accuracy of the UAS-captured data. The collected data was processed and analyzed to compare the accuracy and efficiency of UAS-based methods with traditional surveying techniques. Based on the findings, a business model was developed for the integration of UAS technology into DOT&PF's operations.

The major findings of the research indicated that using RTK/PPK significantly improved the accuracy of geodetic positions embedded in UAS images, making them suitable for high-precision surveying tasks. UAS-based surveying methods demonstrated a marked increase in efficiency, reducing the time required for data collection compared to traditional methods. While the initial investment in UAS technology is significant, the long-term cost savings due to reduced labor and time make it a cost-effective solution. The research identified best practices for data collection and processing, including optimal flight planning, the importance of ground control points, and efficient data processing workflows.

The recommendations based on these findings are as follows: DOT&PF should integrate UAS technology into their standard surveying practices, leveraging the demonstrated efficiency and accuracy benefits. Comprehensive training should be provided for DOT&PF staff on UAS operations, data collection, and processing to ensure effective adoption of the technology. It is crucial to continue ensuring that all UAS operations comply with FAA regulations, particularly under 49 USC 44803, 44804, 44805, and 44806. Further research is recommended to explore the use of UAS in different environmental conditions and for other types of surveying tasks, and to investigate the integration of additional technologies, such as LiDAR, to enhance data collection capabilities. Finally, a phased plan should be developed for scaling the use of UAS across all relevant departments within DOT&PF, ensuring a smooth transition and widespread adoption of the technology.

By embracing UAS technology, DOT&PF can significantly enhance the efficiency, accuracy, and cost-effectiveness of their surveying operations, positioning themselves at the forefront of modern surveying practices. This research provides a robust foundation for the integration of UAS, offering clear guidelines and best practices for successful implementation.

CHAPTER 1 - INTRODUCTION AND RESEARCH APPROACH

Problem Statement and Research Objective

In recent years, the need for more efficient and precise land surveying methods has become increasingly apparent. Traditional surveying techniques, while reliable, are often time-consuming, labor-intensive, and subject to various limitations, including accessibility challenges and environmental constraints. In 2017, this need was further highlighted within the Alaska Department of Transportation & Public Facilities (DOT&PF), where the demand for high-precision geodetic data in diverse and often remote terrains underscored the inadequacies of conventional methods. The advent of Small Unmanned Aerial Systems (SUAS) presented a promising alternative. However, there was a significant gap in understanding how to effectively integrate this emerging technology into standard surveying practices, especially in the challenging Alaskan environment.

Initial attempts to develop a custom SUAS capable of meeting these requirements encountered technical hurdles, including the need for precise Real-Time Kinematic (RTK) or Post-Processed Kinematic (PPK) GPS integration, accurate Inertial Measurement Units (IMUs), and suitable payload capacities for photogrammetry equipment. Despite the potential benefits, the lack of established workflows and best practices for utilizing SUAS in land surveying further complicated their adoption. Recognizing these challenges, DOT&PF initiated this research project to assess the viability of SUAS for land surveying, develop a business model for their integration, and establish guidelines for their effective use. This project aimed to address the critical need for a more advanced, efficient, and precise surveying solution to enhance DOT&PF's operational capabilities.

The primary objectives of this research were to evaluate the feasibility and effectiveness of using Small Unmanned Aerial Systems (SUAS) for land surveying within the Alaska Department of Transportation & Public Facilities (DOT&PF). This evaluation focused on several key areas:

1. **Accuracy and Precision**: To assess the ability of SUAS to capture high-precision geodetic data comparable to traditional surveying methods.
2. **Efficiency**: To determine whether the use of SUAS can reduce the time and labor required for surveying tasks, particularly in remote or difficult-to-access areas.
3. **Cost-Effectiveness**: To analyze the cost implications of integrating SUAS into DOT&PF's surveying operations, including initial investments and long-term savings.
4. **Best Practices Development**: To identify and establish best practices for data collection and processing using SUAS, ensuring consistency and reliability in survey results.
5. **Regulatory Compliance**: To ensure that all SUAS operations adhere to Federal Aviation Administration (FAA) regulations, particularly those outlined in 49 USC 44803, 44804, 44805, and 44806.
6. **Business Model Formulation**: To develop a comprehensive business model for the integration of SUAS technology into DOT&PF’s standard operating procedures, facilitating smooth adoption and scalability.

Ultimately, this research aimed to provide DOT&PF with a robust framework for utilizing SUAS in land surveying, enhancing operational efficiency, accuracy, and cost-effectiveness.

Scope of Study

The study aims to develop a Small Unmanned Aerial System (SUAS) integrated with Real-Time Kinematic (RTK) and Post-Processed Kinematic (PPK) GPS technologies and evaluate its effectiveness in capturing high-precision geodetic positions under various environmental conditions in Alaska. The research will be conducted in two primary phases: development and evaluation. In the development phase, the SUAS will be designed, assembled, and calibrated to ensure optimal functionality and precision. The evaluation phase will involve selecting and documenting diverse testing sites across different terrains and environmental conditions in Alaska, followed by multiple flight tests to collect geodetic data at these sites. The accuracy of the SUAS will be assessed by comparing the collected data with known ground control points, evaluating the system based on positional accuracy, reliability, ease of use, and operational efficiency.

The geographic scope of the study will be confined to selected sites within Alaska, and the technical scope will focus on the specific RTK/PPK GPS technologies used in the SUAS, without exploring other potential GPS technologies. While the evaluation will include various weather conditions, extreme weather scenarios may not be comprehensively covered due to safety concerns. Data collected from the field tests will be analyzed using statistical and geospatial methods, and the results will be benchmarked against industry standards and existing high-precision geodetic methods. The study will document the design, testing procedures, data analysis, and findings in detailed technical reports, providing recommendations for the practical application of the SUAS in high-precision geodetic surveying and identifying potential areas for further research.

The expected outcomes of this study include a validated SUAS equipped with RTK/PPK GPS that can deliver high-precision geodetic data, a comprehensive understanding of the system's performance across different terrains and conditions in Alaska, and recommendations for deploying such systems in professional surveying tasks and suggestions for future research improvements. By adhering to this defined scope, the study will ensure a systematic approach to developing and evaluating the SUAS, providing valuable insights and practical outcomes for high-precision geodetic applications.

Research Approach

In 2018, a research request was initiated to develop a SUAS specifically for high-precision geodetic applications. The Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) at the University of Alaska Fairbanks (UAF) agreed to undertake the project. The focus was on creating a drone capable of carrying a camera payload, equipped with RTK/PPK GPS technology, and featuring an accurate Inertial Measurement Unit (IMU) and gimbal for stable and precise data capture.

During the initial development phase, several technical challenges were encountered, particularly related to integrating the RTK/PPK GPS with the SUAS platform and ensuring the reliability of the IMU and gimbal under various operational conditions. To address these issues, the development team evaluated several commercial off-the-shelf solutions. Ultimately, DJI's Phantom 4 RTK was adopted as it met the necessary specifications for the project, including robust RTK/PPK GPS integration, high payload capacity, and reliable IMU and gimbal performance.

From 2019 to 2020, the research focus shifted to optimizing data collection and processing methods to ensure the SUAS could deliver high-precision geodetic data. This phase involved extensive field testing at various sites across Alaska to refine the operational procedures. Ground control points were established at each test site to provide reference data for evaluating the accuracy of the SUAS. Additionally, advanced photogrammetry workflows were developed to process the collected data. This included the use of specialized software to create high-resolution orthomosaics, digital elevation models (DEMs), and 3D point clouds from the aerial imagery.

Throughout the project, data analysis was conducted using statistical and geospatial techniques to compare the SUAS-derived geodetic data with the known ground control points. This rigorous evaluation process helped to assess the accuracy, reliability, and overall performance of the SUAS in different environmental conditions and terrains. The findings from these tests were documented in detailed technical reports, which also included recommendations for further system enhancements and practical applications in geodetic surveying.

By following this comprehensive research approach, the study aims to deliver a validated SUAS equipped with RTK/PPK GPS technology, capable of providing high-precision geodetic data for a wide range of surveying and mapping applications.

CHAPTER 2 - FINDINGS

The data collection for this study involved the use of DJI Phantom 4 RTK drones, which are equipped with high-precision Real-Time Kinematic (RTK) and Post-Processed Kinematic (PPK) GPS, as well as an Inertial Measurement Unit (IMU). These drones were selected for their ability to deliver accurate geospatial data in diverse environmental conditions and terrains.

Flights were meticulously planned to ensure comprehensive coverage of various terrains, including mountainous regions, coastal areas, and flatlands, under different weather conditions. The flight plans included predefined paths and altitudes to optimize the data capture process and ensure consistent overlap between images.

To enhance the accuracy of the RTK GPS, Trimble R10/R12 GNSS units capable of broadcasting Networked Transport of RTCM via Internet Protocol (NTRIP) were utilized. These units created a correction stream that the drone could use in real-time during flight, further improving the positional accuracy of the collected data.

Ground control points (GCPs) were established at each test site to verify the accuracy of the drone-captured data. These GCPs were surveyed using traditional high-precision geodetic equipment and served as reference points for validating the positional accuracy of the data collected by the SUAS. The locations of the GCPs were selected to provide a well-distributed network across the test area, ensuring robust verification of the drone data.

Data Analysis

The collected data was analyzed according to the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data. This involved processing the images using photogrammetry software to create high-resolution orthomosaics, digital elevation models (DEMs), and 3D point clouds.

The results of the data analysis indicated that the use of RTK/PPK, supplemented with the correction stream from the Trimble R10/R12 GNSS units, significantly improved the accuracy of the geodetic positions embedded in the images. Although RTK allowed for real-time corrections, the PPK method consistently showed tighter accuracies with the reality capture products. The positional accuracy of the drone-derived data was assessed by comparing it with the coordinates of the established GCPs. Statistical methods were used to calculate the root mean square error (RMSE) of the positional data, which confirmed that the accuracy met or exceeded the ASPRS standards for high-precision geospatial data.

Furthermore, comparisons between traditional surveying methods and the drone-based methods showed a notable reduction in time and cost, with comparable or improved accuracy. The drone-based surveys required significantly less field time and labor compared to conventional methods, while still delivering high-precision results. This efficiency makes the SUAS a valuable tool for large-scale geodetic surveys and other applications where high accuracy is essential.

The findings demonstrated that the DJI Phantom 4 RTK drones, when used in conjunction with RTK/PPK GPS and real-time correction streams from Trimble R10/R12 GNSS units, provide a reliable and efficient method for high-precision geodetic data collection. This approach not only enhances the accuracy of geospatial data but also offers substantial benefits in terms of time and cost savings, supporting its adoption for various surveying and mapping applications.

Impact on Avalanche Program

This research proved pivotal for augmenting our avalanche program's use of UAS for close mapping in rapidly changing mountainous terrain. Due to geometric dilution of precision (GDOP), drone operations requiring precision guidance need RTK to correct for equatorial satellite connections that cause significant Z-axis offsets (ranging from 0 to 300 feet), which can result in controlled flight into terrain. The use of RTK provided essential real-time corrections that mitigated these issues, ensuring safer and more accurate drone operations in challenging environments.

CHAPTER 3 - INTERPRETATION, APPRAISAL, AND APPLICATIONS

The findings from this research have significant implications for the broader field of geospatial data collection and analysis. The use of Small Unmanned Aerial Systems (SUAS) equipped with RTK/PPK GPS technologies presents a viable and efficient alternative to traditional land surveying methods. The high precision and accuracy achieved through the integration of RTK for real-time corrections and PPK for post-processing validation underscore the reliability of SUAS in capturing geodetic data.

The study demonstrated that SUAS can dramatically reduce the time and labor required for surveying projects while maintaining, or even improving, the accuracy of the data collected. This efficiency makes SUAS particularly advantageous for large-scale surveys and projects in remote or difficult-to-access areas where traditional methods would be time-consuming and costly. The success of using SUAS for high-precision geodetic data collection suggests potential for broader applications across various surveying and mapping projects. These applications include, but are not limited to, topographic mapping, infrastructure monitoring, environmental assessments, and agricultural planning. The ability to rapidly deploy SUAS and obtain high-quality data can enhance the responsiveness and adaptability of surveying practices in dynamic environments.

One of the most significant benefits of using SUAS is the enhanced safety for operators. Traditional surveying often requires personnel to work in hazardous conditions, such as busy roadways, unstable landslide zones, or avalanche paths. By using SUAS, operators can collect necessary data from a safe distance, significantly reducing the risk of injury. This capability is particularly crucial in areas prone to natural hazards, where on-the-ground surveying could pose serious safety risks. The integration of RTK/PPK GPS with SUAS not only enhances data accuracy but also improves operational safety, particularly in challenging terrains. The real-time corrections provided by RTK help mitigate the risks associated with geometric dilution of precision (GDOP) and Z-axis offsets, which are critical for preventing controlled flights into terrain. This capability is especially important for applications such as avalanche monitoring and management, where precision and safety are paramount.

The findings highlight the need for ongoing research and development to further optimize SUAS technologies and methodologies. Future studies could explore the integration of additional sensors and advanced processing algorithms to expand the capabilities of SUAS. Additionally, developing standardized protocols for SUAS operations in various environmental conditions will further enhance their reliability and acceptance in the industry. As SUAS technology continues to evolve, there will be important policy and regulatory implications to consider. Ensuring that regulations keep pace with technological advancements will be crucial for enabling wider adoption of SUAS in commercial and governmental applications. This includes establishing guidelines for safe operation, data privacy, and integration with existing geospatial data infrastructures.

The research confirms that SUAS equipped with RTK/PPK GPS technologies offer a powerful tool for modern surveying and mapping needs. The implications of these findings extend beyond the immediate benefits of increased efficiency and accuracy, suggesting a transformative potential for the surveying industry as a whole. The study sets a foundation for future innovations and broader adoption of SUAS, ultimately contributing to more precise, efficient, and safe geospatial data collection practices.

Practical Applications of Findings

The practical applications of these findings are wide-ranging and can significantly enhance operational practices across various fields. For instance, the Alaska Department of Transportation and Public Facilities (DOT&PF) can integrate SUAS technology into their standard surveying practices, potentially reducing operational costs and improving data accuracy. By adopting SUAS for routine surveys, DOT&PF can achieve more efficient data collection processes, enabling faster project completions and reducing the need for extensive on-site labor.

Moreover, the business model developed from this research can guide the implementation and scaling of SUAS technology across different departments within DOT&PF. This model provides a framework for training personnel, managing equipment, and standardizing operational procedures to ensure consistent and reliable use of SUAS. By following this model, other departments, such as environmental monitoring and emergency response, can also leverage the benefits of SUAS technology.

In environmental monitoring, SUAS can be used to gather high-resolution data on natural habitats, track changes over time, and assess the impact of infrastructure projects on the environment. This application is particularly relevant for managing protected areas and ensuring compliance with environmental regulations. For emergency response, SUAS can provide real-time aerial imagery and data during natural disasters, such as floods, landslides, and avalanches, enhancing situational awareness and aiding in the coordination of rescue efforts.

One of the critical recommendations from this research is the standardization of RTK across the entire SUAS fleet. Ensuring that all SUAS operators utilize RTK technology will provide a consistent baseline of data accuracy, which is crucial for maintaining high standards of geospatial data quality. This standardization should be incorporated into the statewide strategic plan for DOT&PF's UAS program to ensure uniformity and reliability across all operations.

The findings of this research highlight the potential of SUAS technology to revolutionize surveying and mapping practices, making them more efficient, accurate, and safe. By integrating these systems into their operations, organizations can achieve significant improvements in data quality, operational efficiency, and safety for their personnel.

CHAPTER 4 - CONCLUSIONS AND SUGGESTED RESEARCH

The research demonstrated that SUAS equipped with RTK/PPK GPS are highly effective for land surveying and geospatial data collection. The adoption of DJI's Phantom 4 RTK addressed the initial technical challenges and provided reliable, high-precision data. This integration of RTK/PPK GPS technologies significantly enhanced the accuracy of the geodetic positions captured, making the SUAS a robust tool for various surveying applications.

The study highlighted several key benefits of integrating SUAS into the Alaska Department of Transportation and Public Facilities (DOT&PF) surveying practices. Firstly, the use of SUAS can lead to substantial cost savings by reducing the time and labor required for data collection. The efficiency of SUAS in covering large or hard-to-reach areas quickly and accurately minimizes the need for extensive on-site personnel and equipment, thus lowering operational costs.

Secondly, the enhanced safety for operators is a critical advantage. SUAS allow data collection from a safe distance, mitigating the risks associated with working in hazardous conditions, such as busy roadways, landslide-prone areas, or avalanche paths. This capability not only protects the operators but also ensures the continuous and reliable collection of data even in challenging environments.

The research also underscored the importance of RTK standardization across the entire SUAS fleet. Ensuring all SUAS operators utilize RTK technology provides a consistent baseline of data accuracy, which is crucial for maintaining high standards of geospatial data quality. This standardization should be incorporated into the statewide strategic plan for DOT&PF's UAS program to ensure uniformity and reliability across all operations. Moreover, the integration of Trimble technology should go hand in hand with the deployment of RTK-enabled drones. Utilizing Trimble R10/R12 GNSS units for broadcasting NTRIP correction streams ensures real-time accuracy and consistency, which is essential for precise geospatial data collection.

An additional significant benefit of RTK integration is the ability to conduct repeatable missions and change detection through comparing previous volumes and Digital Surface Models (DSM) using GIS tools. This capability is critical for monitoring and managing changes in the landscape over time, allowing for accurate volume calculations and assessments of terrain modifications.

The integration of SUAS into DOT&PF's surveying practices offers significant benefits, including cost savings, enhanced accuracy, improved safety for operators, and the capability for repeatable and precise change detection missions. The findings suggest a transformative potential for the surveying industry, paving the way for future innovations and broader adoption of SUAS technology in various applications. By adopting these advanced systems, organizations can achieve more precise, efficient, and safe geospatial data collection, ultimately enhancing the overall quality and effectiveness of their operations.

Recommendations for Further Research

Based on the findings of this research, several areas warrant further investigation to enhance the capabilities and applications of SUAS equipped with RTK/PPK GPS technologies. Further research is recommended to explore the use of SUAS in various environmental conditions beyond those tested in this study. Investigating performance in extreme weather conditions, such as heavy rain, snow, and high winds, will provide valuable insights into the operational limits and necessary adaptations for SUAS technology in diverse climates.

Expanding the research to include different types of surveying tasks, such as utility inspections, archaeological surveys, and coastal erosion monitoring, can help understand the full range of applications for SUAS. Each of these tasks presents unique challenges and requirements that could benefit from the precision and efficiency of RTK/PPK-enabled drones. Conducting a comprehensive analysis of the long-term cost benefits associated with the integration of SUAS into routine surveying practices is essential.

This analysis should include not only the initial savings in time and labor but also the potential reductions in maintenance costs, improved data quality, and the economic impact of enhanced safety for operators.

Investigation into the potential integration of SUAS with other emerging technologies, such as LiDAR (Light Detection and Ranging), thermal imaging, and multispectral sensors, would be valuable. Combining these technologies with RTK/PPK GPS could significantly enhance data collection capabilities, enabling more detailed and comprehensive surveys. Further research is needed to develop standardized protocols for the use of RTK/PPK SUAS across various applications and environments. Establishing best practices and operational guidelines will ensure consistent data quality and facilitate broader adoption of the technology.

Implementing Continuously Operating Reference Stations (CORS) would provide a reliable and precise reference framework for RTK/PPK operations, improving the overall accuracy and reliability of SUAS data. Research into the optimal placement and integration of CORS in various terrains would enhance the utility of RTK/PPK systems. Exploring the use of satellite and LTE-based Networked Transport of RTCM via Internet Protocol (NTRIP) for real-time corrections can improve the flexibility and coverage of RTK/PPK systems. This technology would be particularly beneficial in remote areas where traditional ground-based networks are unavailable.

Developing robust image server solutions for storing, processing, and sharing large volumes of SUAS-collected data can streamline operations and facilitate real-time data access and analysis. Research into secure and efficient image server architectures would support more effective data management practices. Investigating the deployment of drone-in-a-box solutions for remote management of projects and geohazards can significantly reduce risks to operators during repeat data collection. These autonomous systems can be stationed in remote or hazardous areas, performing regular surveys and transmitting data back to central servers for analysis. This approach would ensure continuous monitoring while keeping operators safe from potential dangers.

Research into the specific impacts of SUAS on environmental monitoring and management, such as tracking wildlife populations, monitoring deforestation, and assessing the health of aquatic ecosystems, could demonstrate additional benefits of the technology. These applications could support more sustainable environmental practices and inform policy decisions. Developing methods for real-time data processing and analysis on-board the SUAS could streamline operations and provide immediate insights during missions. Research into advanced algorithms and machine learning techniques for on-the-fly data interpretation could enhance the utility of SUAS in dynamic and time-sensitive situations.

By addressing these areas in future research, the potential of SUAS equipped with RTK/PPK GPS can be fully realized, leading to more innovative, efficient, and accurate geospatial data collection and analysis methods. These advancements will further solidify the role of SUAS in modern surveying and mapping practices, providing substantial benefits across various industries and applications.

REFERENCES

- American Society for Photogrammetry and Remote Sensing (ASPRS). (2015). **ASPRS Positional Accuracy Standards for Digital Geospatial Data**. Photogrammetric Engineering & Remote Sensing, 81(3), A1-A26.

- Alaska Department of Transportation and Public Facilities (DOT&PF). (2020). **Research Development & Technology Transfer Program Manual**. Retrieved from http://www.dot.state.ak.us/stwddes/research/index.shtml.

- DJI. (n.d.). **Phantom 4 RTK**. DJI. Retrieved from https://www.dji.com/phantom-4-rtk.

- Federal Highway Administration (FHWA). (2018). **Guidance on State Planning and Research Program (SP&R)**. Retrieved from https://www.fhwa.dot.gov/research/t2/.

- Trimble. (n.d.). **Trimble R10 and R12 GNSS Systems**. Trimble. Retrieved from https://www.trimble.com/Land-Survey/Trimble-R10-R12.aspx.

- University of Alaska Fairbanks (UAF). (2018). **Alaska Center for Unmanned Aircraft Systems Integration (ACUASI)**. Retrieved from https://www.uaf.edu/acuasi/.

- Federal Highway Administration (FHWA). (2020). **EDC-5: Using Unmanned Aerial Systems (UAS) to Improve Safety, Efficiency, and Accuracy of Highway Inspections**. Retrieved from https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/uas.cfm.

- Utah Department of Transportation (UDOT). (2020). **UAS Program Findings and Reports**. Retrieved from https://www.udot.utah.gov/.

APPENDIXES

1. DOT&PF GOM
2. UAS Camera Requirements
3. Imagery Prequalification
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UAS Operations Manual

14 CFR Part 107

&

14 CFR Part 91

Version 1.5

6/19/2024

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1. Contents

Signature and Revisions

Approved by: ______________________________ Date__6/19/2024________

Ryan Marlow
UAS Program Coordinator
Alaska Department of Transportation and Public Facilities

Version Number	Date	Changes	Revised by
1.0	5/12/2020	First Draft	Mark Henspeter Russell Kirkham Ryan Marlow
1.1	6/12/2020	Formatting and Terminology Correction	Ryan Marlow
1.2	7/10/2020	Graphics Update and Formatting	Ryan Marlow
1.3	7/28/2020	Contacts Update	Ryan Marlow
1.4	12/16/2021	Part 91 Operations, Battery Safety, HAZMAT Shipping Requirements, Contacts Update and Acronyms	Ryan Marlow
1.5	6/19/2024	Grammar Updates	Ryan Marlow

1. Purpose

The purpose of the Alaska Department of Transportation & Public Facilities (DOT&PF) small Unmanned Aerial System (sUAS) Program is to support and augment DOT&PF's operations with aerial equipment, increase efficiencies and create new opportunities to manage state-owned land, water, and natural resources. The following procedures and information are intended to promote safe, efficient, and lawful operation of DOT&PF sUAS. Safety and privacy protection are primary concerns during DOT&PF sUAS operations, regardless of the nature of the mission.

2. Philosophy & Mission Statement

DOT&PF values safety, integrity, quality, and people. Our mission is to keep Alaska moving through service and infrastructure. Our strategic goal is to maintain an exemplary safety record protecting people, property, and the environment.

3. Protection of Rights and Privacy

DOT&PF sUAS Program goals are to respect privacy and property rights during DOT&PF sUAS operations. As such, DOT&PF sUAS operators must implement best practices throughout every phase of sUAS missions, including planning, pre-flight check, execution, and post-flight information management phases, to respect privacy and property rights.

The use of sUAS allows DOT&PF to cover wide geographic areas in support of the agency mission to responsibly manage Alaska's resources. Subject to exceptions found in applicable statutes[1] and other authority, DOT&PF sUAS are principally operated from State lands and waters, and from other lands and waters where sUAS operations are not prohibited.

DOT&PF sUAS operators must observe the following:

1. To the extent practical, the sUAS should be flown with the onboard cameras turned to face away from occupied structures, etc. to minimize inadvertent video or still images of uninvolved persons or property. Reference Alaska's Drone Operator Safety and Privacy Guidelines for more information
2. Individuals using state lands are not intentionally monitored by sUAS during the course of DOT&PF's regulatory operations unless sUAS monitoring is necessary to complete regulatory obligations.
3. DOT&PF's sUAS must be operated within applicable privacy laws and regulations. Prior to operating the sUAS, operators must request and obtain the proper authorizations and permissions. This includes civil operations under Part 107 and public aircraft operations under Part 91 which are only authorized through a COA. All operations shall balance the need to accomplish the mission with respecting privacy and property rights.
4. Information collected during DOT&PF sUAS operations, including video, still photography, and telemetry data is considered a public record under AS 40.25. Information that is considered confidential under AS 40.25.120(a) must be protected from release. Information collected by or on

[1] *See*, *e.g.*, AS 34.65.020, AS 27.21.230, and AS 27.21.290.

behalf of DOT&PF that knowingly contains Personally Identifiable Information (PII)[2] will be handled in accordance with Section 8 of this Operations Manual.

5. Criminal conduct recorded during operations and not under the jurisdiction of DOT&PF should be turned over to the appropriate authorities. Upon successful transmittal the images or video not relevant to the operation should be removed.

4. Data Minimization

Video, images, and other data collected during sUAS operations should be minimized in terms of review and retention, consistent with state records retention requirements. Only data pertaining to the original purpose of the sUAS flight should be retained.

5. Applicability

This operation manual applies to all departments and offices within DOT&PF that utilize sUAS for civil and public aircraft operations. This operations manual sets the minimum requirements for all DOT&PF employees. Individual Regions may establish more stringent requirements for sUAS operations.

6. Administration

6.1 Operations Manual

1. The purpose of this document is to outline minimum requirements for DOT&PF to conduct sUAS operations. This document is designed to be flexible while ensuring that DOT&PF sUAS activities are conducted in the safest manner possible in compliance with statutory requirements.

2. This manual is not intended to be all-inclusive, but as a supplement to other department or regional guidelines, Federal Aviation Administration regulations, pre-flight safety checklists, aircraft manufacturers' approved flight manuals, etc.[3]

3. This manual is written to address sUAS operations as they exist at the time of its drafting. Regulations, equipment, personnel, environment (internal and external), etc., change over time. The management of change involves a systematic approach to monitoring organizational change and is a critical part of the risk management process. Given this, this manual must be reviewed and updated annually, at a minimum. Any changes to the manual will be communicated as currently dictated by department policy.

[2] The National Institute of Standards and Technology Special Publication 800-122 defines PII: Any representation of information that permits the identity of an individual to whom the information applies to be reasonably inferred by either direct or indirect means. Further, PII is defined as information: (i) that directly identifies an individual (e.g., name, address, social security number or other identifying number or code, telephone number, email address, etc.) or (ii) by which an agency intends to identify specific individuals in conjunction with other data elements, i.e., indirect identification. (These data elements may include a combination of gender, race, birth date, geographic indicator, and other descriptors). Additionally, information permitting the physical or online contacting of a specific individual is the same as personally identifiable information. This information can be maintained in either paper, electronic or other media.

[3] In developing this Manual, DOT&PF reviewed operations manuals of public entities from across the United States. This document incorporated the best practices found in these manuals as well as developing policy and practices specific to Alaska.

4. DOT&PF Regions, Departments or working groups may create operational manuals to meet additional needs and policy.
5. A copy of the manual (electronic and/or paper) shall be provided to every person identified as having sUAS responsibilities.

6.2 DOT&PF UAS Steering Committee

1. Purpose: DOT&PF UAS Steering Committee will convene monthly for the purpose of reviewing the existing sUAS procedures as well new technologies, laws, and regulations on sUAS usage. The UAS Steering Committee of personnel from across DOT&PF and includes representatives from participating DOT&PF departments. The identified department representative(s) will ensure operations comply with DOT&PF procedures and requirements.
2. Membership will consist of the Chief Pilots from each department and other personnel as deemed necessary by the working group.
3. Chief Pilots will select a chairperson. The Chairperson will be responsible for guiding meetings and reporting to the Commissioner's office as needed.

6.3 Department Level Organization

1. The sUAS Project Team is comprised of those personnel approved by a department for involvement in sUAS operations, and includes
   a. Program Coordinator
   b. Chief Pilots(s),
   c. Operator(s),
   d. Visual Observers (VOs), and
   e. Others deemed necessary for involvement by appropriate management.

   Assignment to the sUAS Project Team is defined by appropriate department management and is comprised of trained staff members from within the department that possess knowledge of sUAS Operations, the National Airspace System, local laws and regulations, or other relevant subject matter expertise.
2. The sUAS operations conducted by the sUAS project team shall be with the knowledge of the department representative to the DOT&PF UAS Steering Committee. A quarterly report on sUAS activities should be provided to the department representative for reporting to the UAS Steering Committee.

6.4 Personnel

This document categorizes sUAS personnel into six categories based on the duties and level of responsibilities. Individuals may perform duties under more than one category based on the needs of their department and/or section. Depending on their role or level of responsibility DOT&PF employees must be trained and certified through either the DOT&PF's sUAS Program, a department specific program, or the FAA before operating DOT&PF sUAS.

1. **Chief Pilot:**

a. Qualified individual(s) identified by the department to be responsible for the overall direction and performance of the region's sUAS project team and exercises command and control over operations.
b. Serves as the regional representative to the DOT&PF UAS Steering Committee, unless a different person is assigned the regional representative role.
c. Maintains flight and maintenance records for all regional aircraft in accordance with manufacturer guidance and regulatory requirements.
d. Maintains a file for each PIC and VO, which includes copies of training records, sUAS incidents, etc.
e. Maintains contact with the FAA and understanding of regulations as they change.
f. Evaluates existing airframes, maintains inventory, and provides guidance on necessary sUAS equipment service and replacement based on mission needs.

2. Pilot in Command (PIC):

a. Any individual performing the role of PIC must meet required minimum qualification as put forth by the FAA for the operation of sUAS and this document. This requires at a minimum that the individual holds a valid, active FAA remote pilot certificate for the operation of sUAS aircraft or a department specific certification program approved by the FAA.
b. Must maintain training as outlined in Section 9.4 sub-section 1.
c. PIC must understand and maintain compliance with FAA Regulations applicable to the airspace where the sUAS operates.
d. Individuals may be temporarily removed from flight status at any time by the Chief Pilot, for reasons including performance, proficiency, physical condition, etc. Should this become necessary, the operator will be notified verbally and in writing of the reason, necessary corrective action to be taken and expected duration of such flight suspension.
e. PIC must maintain flight records for all flights and be able to provide logs to the Chief Pilot, at a minimum, quarterly.
f. PIC is responsible for ensuring that a sUAS to be used for any field operation is airworthy and has been appropriately charged and updated before use.

3. Operator/Pilot:

a. Any individual performing the role of operator/pilot (if different from PIC) must meet required minimum qualification as put forth by the FAA for the operation of sUAS and this document. This requires at a minimum that the individual holds a valid, active FAA remote pilot certificate for the operation of sUAS aircraft or a department specific certification program approved by the FAA.
b. Must receive and maintain ongoing training as outlined in Section 9.4 Sub-section 1.
c. Operator/Pilot must understand and maintain compliance with FAA Regulations applicable to the airspace where the sUAS operates
d. Individuals may be temporarily removed from flight status at any time by the Chief Pilot, for reasons including performance, proficiency, physical condition, etc. Should this become necessary, the operator will be notified verbally and in writing of the reason, necessary corrective action to be taken and expected duration of such flight suspension.

e. The only exception to this requirement is for missions identified as training. An individual without an active remote pilot certification may operate a DOT&PF sUAS if for the duration of the flight is under the direct supervision of a person who holds such a certificate.

4. **Visual Observers (VO):**

a. Any individual performing the role of VO must be competent and capable of maintaining situational awareness provided by sight and sounds of the operational environment. A VO is not required to hold a valid FAA remote pilot certificate for the operation of sUAS aircraft but should be provided with sufficient training to communicate clearly to the operator any observed air traffic and obstacles.

b. Receive training as outlined in 9.4 Section 2.

c. Should be provided a general orientation to project airspace and sUAS operation by the PIC, including an overview of anti-collision lighting to aid in monitoring sUAS orientation and guidance.

d. A VO's primary duty is to scan the skies and ground constantly, ensuring that the flight path and surrounding area is free of potential obstacles, maintain a visual line of sight with the sUAS, and maintain effective communication with the person manipulating the flight controls and remote PIC at all times.

e. A VO's secondary duty is to monitor radio communications with airspace traffic, and to communicate with other crew members and property owners/individuals.

5. **Mission Specialist:**

a. A mission specialist is any person whose primary function is to operate/monitor a sensor (such as a camera, video feed, FLIR, etc.) onboard the sUAS.

b. The mission specialist will communicate directly with the PIC/operator as needed to facilitate the mission and ensure that the mission's task has been completed.

c. A mission specialist will be trained in the specific requirement for the operation of the sensor to be used.

d. The mission specialist will be the only person on the flight crew who will be allowed to wear FPV goggles during any mission. The use of FPV goggles requires at least one VO.

e. When not operating such equipment, the Mission Specialist will have the same duties as a VO.

6. **Maintenance Crew:**

a. Any individual responsible for performing regular maintenance on the sUAS and any sensor to be attached to a sUAS.

b. Implementing maintenance schedules and tasks to include high-time components and forced-removal components per manufacturer's guidance and, where none exists, developing a schedule similar to the example provided in Appendix D.

c. Up keeping maintenance records for each Ground Control Station, aircraft, and software system required for operating sUAS. Records will be completed on the form provided in Appendix E or similar form.

d. Will maintain contact with the sUAS manufacturer and its suppliers for replacement parts and technical support.

6.5 Facilities

1. sUAS equipment is housed and maintained at location(s) designated by each Region. Equipment must be stored in a secured location, and any use of the equipment shall be monitored and tracked by the UAS Program Coordinator.
2. Personnel must not remove equipment from a designated facility without making sure the sUAS equipment is secured in a fashion to prevent it from theft or damage.

6.6 Complaints or Inquiries

1. Inquiries from the news media must be forwarded to the Communications Director (currently Meadow Baily, meadow.baily@alaska.gov). Operators/Visual Observers shall follow currently established regional level policy regarding interactions and inquiries from the media or the public.
2. Requests for support from state and federal agencies will be responded to by the UAS program Coordinator. If the request involves an immediate threat to life, or property, the operator is authorized to accept or decline the request. Proper policy and procedure, as well as FAA regulations must be followed when accepting mutual aid support for the sUAS.
3. Complaints or information request regarding sUAS operations must be referred to the UAS Program Coordinator, or the Deputy Commission's Office.

7. Safety

The priority in all DOT&PF sUAS missions is the safety of employees, contractors, participants, and the public. DOT&PF personnel performing sUAS functions must be service oriented and meet all qualification requirements of the department and their individual departments. Risk management will be inherent in all aviation missions and programs. Prior to conducting any mission, all risks will be mitigated to the lowest practical and acceptable level possible.

All aviation personnel are empowered and expected to manage the risks of aviation operations and make reasonable and prudent decisions to accomplish the mission. Aviation personnel must take every opportunity to plan missions thoroughly, and respect aircraft and the environment in which they operate. Individuals will be held accountable for their decisions, which should be based on policy, principles, risk management, training, experience and the given situation.

7.1 Safety Policy

1. DOT&PF is committed to having a safe and healthy workplace, including:
   a. The ongoing pursuit of an accident free workplace, including no harm to people, no damage to equipment, the environment, and property.
   b. A culture of open reporting of all safety hazards in which management will not initiate disciplinary action against any personnel who, in good faith, disclose a hazard or safety occurrence due to unintentional conduct.
   c. Support for safety training and awareness programs.
   d. Conducting regular audits of safety policies, procedures, and practices by the UAS Program Coordinator.
   e. Monitoring the sUAS community to ensure best safety practices are incorporated into the organization.

2. It is the duty of every member within the sUAS flight crew to contribute to the goal of continued safe operations. This contribution comes in many forms and includes operating in the safest manner practicable and avoiding unnecessary risks. Any safety hazard, whether procedural, operational, or maintenance related must be identified as soon as possible after, if not before, an incident occurs. Any suggestions in the interest of safety should be made to the Department level Chief Pilot.
3. If any member of the sUAS Project Team observes or has knowledge of an unsafe or dangerous act committed by another member, the Chief Pilot is to be notified immediately so that corrective action may be taken.

7.2 Project Aviation Safety Plan

The pilot will prepare a PASP and submit it to his or her immediate supervisor for review prior to any project. DOT&PF has developed a PASP template for sUAS operations. The minimum elements of a PASP template are listed below, and an example can be accessed at the following link PASP. Every project site is required to have a PASP completed and signed prior to conducting a flight. All PASP's must include at a minimum all information detailed below.

1. **Project Name and Objectives** - Brief description of the project and its objectives. A single PASP may cover a project area where multiple flight may be necessary.
2. **Justification** - Indicate why the project will require the use of an sUAS and list the most practical alternative for completion of the project.
3. **Project Dates** - Dates the project will begin and end or if it is a recurring project. Dates may be approximate, since the exact dates of flight may not be known or change due to weather conditions.
4. **Location** - Enter a descriptive location and include a map clearly showing the area where the flights will occur. Aerial hazards must be clearly indicated.
5. **Aircraft** - Identify the sUAS(s) to be used and the date acquired by DOT&PF
6. **Pilot** - Identify Pilot(s) and provide certification number an initial certification date,
7. **Participants** - List individuals involved in flights, their qualifications for their role (e.g., Project Coordinator, visual observer etc.) , and include individual's project responsibilities.
8. **Aerial Hazard Analysis** - An aerial hazard analysis with attached map will be prepared by the PIC before the flight and distributed to the flight crew.
9. **Risk Assessment** - List of all identified risk and mitigation strategies.

PASP created for recurring projects will be reviewed prior to each mission asses any changes in risk associated with the project.

7.3 Risk assessment and management

DOT&PF encourages a four-tiered approach to managing risks associated with the sUAS program. This will include employee training as noted in section 10, use of a Project Aviation Safety Plan (PASP) similar to the plan listed in section 7.2 for each flight and/or flight area, empowering employees to determine when to cancel flights because of unsafe conditions, reporting of all incidents and accidents and periodic program evaluations.

1. **Safety of Human life Considerations**
   In many instances, UAS use provides a safe alternative to manned aircraft operations. In UAS operations, from the point of view of safety to human life, the most severe possible outcomes are those that result in injury or death to persons on the ground or persons in other aircraft.

2. **Property Damage Considerations**
   Identification of hazards and assessment of risk related to deployment of sUAS in the Alaska is a continuously applied process that is aimed at ensuring all risks are mitigated to a medium or low rating with the goal being to mitigate to the lowest possible rating. It also incorporates provisions that allow those risks which cannot be mitigated to be addressed. Below is a 'Risk Determination' Matrix, with severity classifications, likelihood of occurrence, and related definitions.

Risk Determination Matrix

	Severity of Risk when it occurs					
Likelihood of Risk Occurring	Severity/ Likelihood	No Safety Effect	Minor	Major	Hazardous	Catastrophic
	Frequent					**High**
	Occasional					
	Remote				**Serious**	
	Improbable		**Medium**			
	Extremely Improbable	**Low**				

High	Unacceptable	Immediate mitigation action and escalation is required. Operation should not be considered
Serious	Tolerable with Mitigation	The risk should be mitigated as low as possible (including significant limitation to sUAS operations) and may be approved
Medium	Tolerable	The risk should be mitigated as low as reasonability practicable and should be approved
Low	Acceptable	No action Required

Table 7.1 Risk Determination Matrix based on FAA's Risk Management Handbook and Safety Risk Assessment for UAV Operation, Drone Industry Insights, Safe Airspace Integration Project, Part One, Nov. 2015

3. <u>Severity Classifications and Likelihood of Occurrence Definitions</u>

Severity Classifications	
Severity Level	**Definition**
Catastrophic	**Mishap results in fatalities or significant damage/destruction of infrastructure.** Failure conditions that are expected to result in one or more fatalities or serious injury to persons, or the persistent loss of the ability to control the flight path of the aircraft, normally with the loss of the aircraft where loss would result in damage/destruction.
Hazardous	**Severe injury, and/or damage/destruction of property.** Failure conditions that would reduce the capability of the RPAS or the ability of the flight crew to cope with adverse operating conditions to the extent that there would be the following: (1) A large reduction in safety margins or functional capabilities; (2) Physical distress or higher workload such that the RPAS flight crew cannot be relied upon to perform their tasks accurately or completely; or (3) Physical distress to persons, possibly including injuries.
Major	**Reportable injury/damage to property other than the sUAS. Significant repairable damage to sUAS.** Failure conditions that would reduce the capability of the RPAS or the ability of the flight crew to cope with adverse operating conditions to the extent that there would be a significant reduction in safety margins or functional capabilities; a significant increase in flight crew workload or in conditions impairing flight crew efficiency; a discomfort to the flight crew, possibly including injuries; or a potential for physical discomfort to persons.
Minor	**Minor injury or minor sUAS damage.** Failure conditions that would not significantly reduce RPAS safety and would involve flight crew actions well within their capabilities. Minor failure conditions may include a slight reduction in safety margins or functional capabilities or a slight increase in flight crew workload (such as routine flight plan changes).
No Safety Effect	**No injuries/sUAS damage.** Failure conditions that would have no effect on safety (that is, failure conditions that would not affect the operational capability of the airplane or increase flight crew workload).

Table 1.2: Adapted from NASA Hazard categories for RPAs. (NASA 2007), FAA Risk Management Handbook (2009).

Likelihood of Occurrence	
Likelihood	**Definition**
Frequently	**Likely to occur many times or has occurred frequently.** Anticipated to occur one or more times during operation of an item. (“five times during the operation/flight”)
Occasional	**Likely to occur sometimes or has occurred infrequently.** Anticipated to occur one or more times during the entire system//operational life of an item. (“Every second operation”)
Remote	**Unlikely to occur but possible or has occurred rarely.** Unlikely to occur to each item during its total life. May occur several times in the life of an entire system or fleet. (“I know it occurred from some event(s)")
Improbable	**Very unlikely to occur or not know to have occluded.** Not anticipated to occur to each item during its total life. May occur a few times in the life of an entire system or fleet. (“It happened once and I heard about it from other operator”)
Extremely Improbable	**So unlikely that it is not anticipated to occur during the entire operational life of an entire system or fleet.** (“never happened”)

Table 1.3: Five categories of likelihood of occurrence. Each level of likelihood has a qualitative and quantitative definition. This table shows the revised qualitative definitions based on various risk assessment guidance. The quantitative levels vary across aviation advisory material depending on the aircraft system in consideration.

7.4 Employee Prerogative

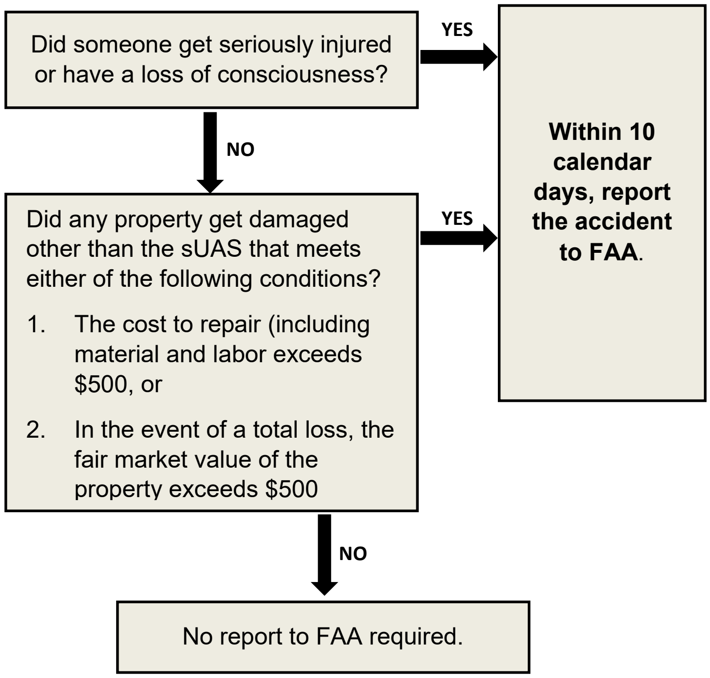
While performing their duties, DOT&PF personnel may elect without fear of reprisal not to fly under any condition they consider to be unsafe. It is the employee's responsibility to immediately report any aviation hazard that compromises the safety of personnel or equipment directly to their Department's sUAS management team.

7.5 Accident and Hazard Reporting, and Review

1. Occurrences are unplanned safety related events, including accidents and incidents that could affect safety. A hazard is something that has the potential to cause significant harm or damage. The systematic identification and control of all major hazards is foundational to the safe operation of sUAS.
2. Within 30 days of an occurrence or hazard a written report will be given to the UAS Program Coordinator.
3. At a minimum, the accident/hazard report should include:
    a. The date, time, location, and description of the project and the specific operation being conducted when the incident occurred.
    b. A description of the sUAS equipment being used.
    c. A listing of the flight crew involved in the operation at the time of the incident.
    d. A listing of any other persons present at the time of the incident.
    e. A detailed description of the incident based on the observation of the PIC and/or crew member witnessing the incident.
    f. A detailed description of any actions taken by the flight crew.
4. Every accident/hazard report will be reviewed by the UAS Program Coordinator and the flight crew reporting the incident. The UAS Program Coordinator will at their discretion draw on the expertise of other members of the DOT&PF UAS Steering Committee as necessary. The services of an independent subject matter expert may be necessary in some cases to assure a thorough and complete review.
5. Any report or recommendation resulting from the review of accident/hazard report will be made available to DOT&PF UAS Steering Committee and all DOT&PF personnel involved in sUAS operations.
6. **ALL MEMBERS ARE AUTHORIZED TO TAKE ACTION TO CORRECT A HAZARD** if in that member's opinion delay will result in accident or injury. The UAS Program Coordinator will be notified immediately in such situations.
7. Any report or recommendation concerning an accident/hazard will be distributed to all DOT&PF flight personal.

7.6 FAA Accident Reporting

1. In addition to the DOT&PF reporting requirements, the FAA may require notification of a sUAS incident. The FAA notification decision tree is shown below.



2. Within 10 calendar days after an accident (as defined by regulation) and before additional flights, the operator must provide notification to the FAA per Part 107.9 and Part 91 (49 CFR Part 830).

   FAA defines an accident when:

   a. Any person suffers death or serious injury.

   b. Damage to any property, other than the small sUAS if the cost is greater than $500 to repair or replace the property.

3. The accident report can be submitted FAA Regional Operations Center (ROC) electronically (https://www.faa.gov/uas/report_accident/) or by telephone for accidents in Alaska at 425-227-1999. The ROC Reports may also be made to the nearest jurisdictional Flight Standards District Office (https://www.faa.gov/about/office_org/field_offices/fsdo/).

4. The report should include the following information:

   a. PIC's name and contact information;

   b. PIC's FAA airman certification number;

   c. sUAS registration number issued to the aircraft, if required (FAA registration number);

   d. Location of the accident:

   e. Date of the accident;

   f. Time of the accident;

   g. Person(s) injured and extent of injury, if any or known;

h. Property damaged and extent of damage, if any or known; and

i. Description of what happened.

5. All accidents reported to FAA should also be reported to the UAS Program Coordinator and to the DOT&PF Commissioner's Office

7.7 Safety Officer - Operator/Visual Observer/Coordinator

All members of the sUAS Project Team are responsible for the following:

a. Ensuring all flight operations personnel understand applicable regulatory requirements, standards and organizational safety policies and procedures.

b. Observe and maintain control of safety systems and actively monitoring all operations.

c. Review the standards and practices of agency personnel.

d. Communicate all reported safety related problems and the corrective action taken. If there were any in-flight problems (or learned experiences), the proper procedures for handling that problem should be discussed.

e. Copy and circulate pertinent safety information.

f. Copy and circulate emergency safety bulletins.

7.8 Crew Health

A self-assessment of physical condition shall be made by all members during pre-flight activities.

1. **Illness/Medical/Fatigue Restrictions** – Physical illness, exhaustion, emotional problems, etc., seriously impair judgment, memory, and alertness. The safest rule is not to act as an operator or visual observer when suffering from any of the above. Members are expected to "stand down" when these problems could reasonably be expected to affect their ability to perform flight duties.
2. **Alcohol** - No member shall act as an operator or visual observer within eight hours after consumption of any alcoholic beverage, while under the influence of alcohol, or while having an alcohol concentration of 0.04 (FAR 91.17).
3. **Drugs** – Performance can be seriously hampered by prescription and over-the-counter drugs. The sUAS Coordinator must be advised anytime such drugs are being taken. If it is **determined** that the medication being taken could hamper an operator or visual observer, that member shall be prohibited from the deployment or exercise and may be asked to leave the site immediately.

8. Protection of Personal Identifiable Information (PII)

The loss of PII can result in substantial harm to individuals, including identity theft or other fraudulent use of the information. Because DOT&PF employees may have access to personal identifiable information concerning individuals and other sensitive data, we have a special responsibility to protect that information from loss and misuse. Some examples of PII would be your full name, driver's license number, social security number, passport number, email address, vehicle registration number, biometric data (face, retinal, or fingerprint scans), birthdate, and telephone number. The definition of PII is not anchored to any single category of information or technology. Rather, it requires a case-by-case assessment of the specific risk that an individual can be identified. In performing this assessment, it is important for an agency to recognize that non-PII can become PII whenever additional information is made publicly available — in any medium and from any source — that, when combined with other available information, could be used to identify an individual.

8.1 Privacy Impact Assessments (PIA)

DOT&PF collects, maintains and uses personal information on individuals to carry out the agency's mission and responsibilities and to provide services to the public. By State law and regulation, privacy issues and protections must be considered for information technology systems that contain any personally identifiable information. DOT&PF uses the Privacy Impact Assessment (PIA), located in Appendix H as a key tool in fulfilling these legal and regulatory obligations. By conducting PIAs, DOT&PF ensures that:

1. The information collected is used only for the intended purpose;
2. The information is timely and accurate;
3. The information is protected according to applicable laws and regulations while in DOT&PF 's possession;
4. The information is maintained according to DOT&PF ’s retention schedule and in accordance with AS 40.21.110 and AS 45.48.500- 45.48.530;
5. The impact of the information systems on individual privacy is fully addressed; and
6. The public is aware of the information DOT&PF collects and how the information is used.

8.2 Images captured by an unmanned aircraft system

While the DOT&PF does not anticipate the collection of any PII during typical sUAS mission, it is possible during the course of conducting missions, imagery and video captured by sUAS –may contain sufficient detail to capture PII.

8.3 Review of imagery and video to insure PII is protected

Prior to the public release or posting of any video or imagery to a publicly accessible site this data will be reviewed for PII and redacted as necessary. Review of the full extent image or video should look for contextual information such as license plate, mailbox addresses, house numbers, or faces that when combined may be used to compromise an individual’s identity.

9. Training

9.1 Objective

1. The key to continued safe operations is by maintaining a professional level of competency. The first step in this process is establishing minimum qualifications for selecting members for the sUAS Project Team, and the second step involves training those personnel.
2. Departments may substitute their own training plan based on the department’s operational needs.

9.2 Instructors

1. Any members who are FAA certified remote pilots, may be given instructor duties. Such duties can include developing training courses; provide training, and student evaluation and documentation.
2. Instructors are designated by those within the department and approved by the DOT&PF’s UAS Program Coordinator

9.3 Training Plans

1. All members who will act as PIC, operator or Visual Observer will have a training plan on file that outlines training objectives for the upcoming year. This training plan will be held in conjunction with the member's normal sUAS training file.
2. The approved training plan is developed by the UAS Program Coordinator.
3. All deployments or exercises are documented and count toward a member's training.
4. It is the member's responsibility to verify their training file contains all pertinent information.

9.4 Initial Training

1. **Remote Pilot (PIC) and Part 61 Airmen**
    a. Must obtain a valid and current Federal Aviation Administration (FAA) Part 107 Remote Pilot Certificate with an sUAS rating.
    b. In addition the operator should, at a minimum, have knowledge of the rules and responsibilities described in 14 CFR 91.111, Operating Near Other Aircraft; 14 CFR 91.113, Right-of-Way Rules: Except Water Operations; and 14 CFR 91.155, Basic VFR Weather Minimums; knowledge of air traffic and radio communications, including the use of approved ATC/pilot phraseology; and knowledge of appropriate sections of the Aeronautical Information Manual.
    c. Must have a minimum of four (4) hours of verifiable flight experience with an appropriate sUAS
    d. Must attend training sessions that will include, at a minimum:
        i. Basic physics of sUAS flight
        ii. Hazard recognition and preflight planning (see 9.6 below).
        iii. Cold-weather care and operation of sUAS equipment
        iv. Proper takeoff and landing procedures
        v. sUAS and environment check procedures prior to take-off
        vi. Adverse (e.g., wind, rain) condition flying and its consequences
        vii. Recognition and recovery from out-of-limit conditions
        viii. Emergency procedures
        ix. Airspace Operations and Procedures
    e. (class specific training) must include a minimum of two (2) verifiable hours of flight experience under the guidance of an instructor, operating the specific class of sUAS [4] to be used, to establish a working knowledge of sUAS hardware and software configurations and limits. **This time may be counted towards the four-hour minimum if the same sUAS class is used**
    f. Optional requirements for operators wishing to conduction automated flights: DOT&PF approved operators must complete four (4) successful automated flights covering 1-acre or more under the direction of a DOT&PF instructor with experience with automated flights, to

[4] General classes of sUAS include Octa-Hexa- copters, Large quadcopters (DJI Inspire, DJI Matic or similar), small quadcopter (3DR Solo, DJI Phantom or similar), fixed wing and VTOL aircraft. Regions may narrow these classes based on their specific needs.

establish a working knowledge of automated flight software and limits. **Flight time of automated flights may be counted towards the four-hour PIC minimum and/or two-hour platform minimum if the same sUAS platform is used**

2. **Visual Observers:**
    a. Must have completed sufficient training to communicate to the pilot any instructions required to remain clear of conflicting traffic. This training, at a minimum, shall include knowledge of the rules and responsibilities described in;
        i. 14 CFR 91.3, Responsibility and authority of the Pilot In Command (PIC)
        ii. 14CFR 91.13, Careless or reckless operation
        iii. 14CFR 91.17, Alcohol and drugs
        iv. 14CFR 91.25, Aviation safety reporting program
        v. 14CFR 91.103, Preflight actions
        vi. 14CFR 91.111, Operating Near Other Aircraft;
        vii. 14CFR 91.113, Right-of-Way Rules: Except Water Operations; and
        viii. 14CFR 91.155, Basic VFR Weather Minimums
    b. Should Knowledge of air traffic and radio communications, including the use of approved ATC/pilot phraseology; and knowledge of appropriate sections of the Aeronautical Information Manual.

9.5 Recurring Training

1. PIC/Operators are required to retest by the FAA every 2 years to keep their sUAS rating current. Failure to maintain sUAS rating will result in the removal of sUAS PIC/Operator responsibilities.
2. All members within the unit shall maintain proficiency in their PIC/operator/visual observer abilities. Members who do not have any documented training or operational flight time within the previous 90 days will have to demonstrate proficiency to the Chief Pilot before acting as PIC/operator during a project. Operators are encouraged to maintain at least 60 minutes of flight time with an appropriate sUAS within any given 90-day period.
3. Recurrent training is not limited to actual operating/visual observer skills but includes knowledge of all pertinent sUAS/aviation matters.
4. Failure to prove proficiency can result in removal from sUAS responsibilities.

9.6 Safety Training

1. All PIC/operators/VO shall receive training in the following subjects prior to operating the sUAS:
    a. Agency commitment to safety
    b. sUAS member's role in safety
    c. risk management
    d. Emergency safety procedures
2. All members shall review the department safety policy and procedures on an annual basis and that review shall be noted in their training history

9.7 PIC Training

1. All PIC/operators/VO shall receive training in the following subjects prior to operating the sUAS
    a. Alaska Privacy Rules;
    b. Expectation of Privacy; and
    c. Data Management.
2. All members shall review the department PII on an annual basis and that review shall be noted in their training history

9.8 Miscellaneous

1. All requests for training shall be approved through the appropriate department management, and timekeeping during those training hours shall be documented and provided to the UAS Program Coordinator.
2. Depending on the nature of the training request, all efforts are made to accommodate the hours of training so as little impact is made to staffing levels.
3. Members are encouraged to attend, and forward information on FAA sponsored safety seminars, industry conferences, sUAS online training, etc.
4. Training shall only be conducted in Class G airspace and follow the provisions within the approved FAA regulations.

10. General Operating Procedures

10.1 Request for sUAS Support

1. Requests for sUAS support shall be made through the UAS Program Coordinator or designee
2. Requests for sUAS support should be requested at least 1-week advanced notice
3. The following factors should be considered when reviewing a request for sUAS support:
    a. **Operational need**: Identify the priority the request, and the relevance to the identified priorities in section 3.3. This includes the designation of civil vs public aircraft operations. reference AC 00-1.1B for qualification requirments.
    b. **Type of airspace**: Identify the type of airspace using the dot.alaska.gov/uas/ and see if there are specific provisions or permissions that are needed in order to fly.
    c. **Other aircraft operations**: Check to see if there are any other aircraft operations within the immediate vicinity such as local airstrips, military training sites or aircraft use considerations.
    d. **Hazards**: Use maps, aerial photography and aeronautical charts to check for possible nearby hazards (e.g. high-intensity radio, industrial sites, live firing, military bases etc.)
    e. **Local Ordinance**: If flying outside state lands check to see if there are any local bylaws which would restrict or limit the use of the sUAS.
    f. **Obstructions**: Using Aerial Photography, Google maps and or GIS, verify that there is not any immediate physical restrictions to operations.
    g. **Extraordinary restrictions**: Using aeronautical charts and NOTAM's check to see if there are any restrictions around objects.

h. **<u>Habitation and recreational activities</u>**: Check to see if the flight area is used for any recreational activities (such as dog walking, ball games, play areas etc.)

i. **<u>Public Access</u>**: Is there any public access to the site and surrounding areas? What is the likelihood of encountering a member of the public?

j. **<u>Permissions</u>**: Leaseholders, operators, or private landowners should be notified a minimum of 12 hours before conducting any operation that requires prior permission.

k. **<u>Operating Site and Alternative Sites</u>**: Identify the operating site and any possible alternative sites should the primary site be compromised or not fit for purpose when on site.

l. **<u>Weather conditions</u>**: Check the weather forecast for the date of the planned event to see if they are within the sUAS's tolerances. This will be checked using www.1800wxbrief.com.

10.2 Deployment Priorities

1. The sUAS shall not be used for the purpose of random surveillance
2. If several separate requests for sUAS support are received simultaneously, they shall be prioritized, and grouped on a regional or temporal basis if practicable
3. In general terms, requests for sUAS support are prioritized as:
    a. Regulatory Requirements & Needs
    b. Inspection and/ or Survey needs
    c. Imagery or Video Collection
    d. Wildlife Monitoring or Mitigation
    e. Traffic Monitoring and congestion identification
    f. Other

10.3 Personnel Responsibilities for Deployments

1. **Remote Pilot in Command (PIC)**
    a. The PIC is directly responsible for and is the final authority over the actual operation of the sUAS. The PIC will retain operational control of any sUAS mission performed by the state.
    b. PIC have absolute authority to reject a flight based on personnel safety or violation of FAA regulations. No member of DOT&PF, regardless of status, shall order an PIC to make a flight when, in the opinion of the PIC, it poses a risk to personnel or is in violation of FAA regulations.
    c. PIC are responsible for compliance with this manual, department policy and procedure and FAA regulations.
    d. The PIC main duty during the deployment of the sUAS is to oversee the operation of the sUAS safely while accomplishing the goals of the deployment.
    e. The PIC will assist the Operators to see-and-avoid any obstacle that will lessen safety during the mission.
    f. PIC shall be responsive to the requests of the visual observer in order to accomplish the deployment.

g. Operators shall be responsible for documentation related to mission training and updating of flight books.

h. Shall insure that required maintenance is completed while in the field.

2. **Operator**

   a. An operator if different from the PIC is responsible for the operation of the sUAS.

   b. Operator have absolute authority to reject a flight based on personnel safety or violation of FAA regulations. No member of DOT&PF, regardless of status, shall order an operator to make a flight when, in the opinion of the operator, it poses a risk to personnel or is in violation of FAA regulations.

   c. The operator's main duty during the deployment of the sUAS is to operate the sUAS safely while accomplishing the goals of the deployment.

   d. Operators shall see-and-avoid any obstacle that will lessen safety during the mission.

   e. Operators shall be responsive to the requests of the visual observer in order to accomplish the deployment

3. **Visual Observer (VO)**

   a. VOs shall see-and-avoid any obstacle that will lessen safety during the mission

   b. VOs are responsible for the operational aspect of the deployment, including interacting with individuals on the ground

   c. VOs shall operate any attachments to the sUAS, as necessary, allowing the operator to maintain complete focus on the operation of the sUAS

   d. VOs shall assist the operator in the main objective of safe operations of the sUAS

   e. VOs shall be responsible for ensuring the Operator maintains documentation for mission training and updating of flight books

4. **<u>Mission Specialist</u>**

   a. A mission specialist will operate/monitor a sensor (such as a secondary camera, video feed, FLIR, LIDAR device etc.) onboard the sUAS during the mission.

   b. Will work with the PIC/Operator to insure the sUAS is in the proper position to complete the mission.

   c. When not operating or monitoring a sensor a mission specialist will perform the functions of a VO

The PIC will be responsible for the necessary mission planning activities necessary to perform a successful operation and meet the objectives of the Request for sUAS Support.

10.4 Operational Area

1. Although there may be requests for sUAS support in restricted airspace, FAA regulations for sUAS operations dictate deployment inside restricted airspace and Temporary Flight Restrictions (TFR)
2. At no time shall sUAS support be granted inside restricted airspace without first obtaining a waiver or authorization from the FAA. LAANC automatic FAA authorizations are considered sufficient airspace authorizations as long as they are documented with the flight records.

3. Unless a COA is granted from FAA, the maximum altitude shall not be set more than 400 feet above ground level of the intended flight area or the tallest structure per the FAA regulatory standards.
4. Part 107 prohibits a person from flying a small UA directly over a person who is not under a safe cover, such as a protective structure or a stationary vehicle. However, a sUAS may be flown over a person who is directly participating in the operation of the sUAS, such as the remote PIC, other person manipulating the controls, a VO, or crewmembers necessary for the safety of the SUAS operation has been appropriately briefed by the remote PIC. There are several ways that the operator can comply with these requirements, such as:
    a. Selecting an operational area (site) that is clearly unpopulated/uninhabited.
    b. Establishing an operational area in which the operator has taken reasonable precautions to keep free of persons not directly participating in the operation.
    c. Develop a plan of action which ensures persons remain clear of the operating area, remain indoors, or remain under safe cover until such time that the small UA flight has ended. Safe cover is a structure or stationary vehicle that would protect a person from harm if the small UA were to crash into that structure or vehicle.
    d. The operator will obtain the consent of all persons involved in the mission and ensure that only consenting persons will be allowed within 100 feet of the flight operation, and this radius may be reduced to 30 feet based upon an equivalent level of safety determination.

10.5 Minimum Personnel Requirements

1. For any DOT&PF sUAS mission in unrestricted Class G airspace and not flying under a waiver to any Part 107 requirement the minimum personnel required is a Remote PIC, and depending on the mission **it is recommended to include** at least one VO.
2. VO are not necessarily required for operation of sUAS by DOT&PF. However, the PIC must consider how their absence will affect the intended flights safety and effectiveness. This consideration should be addressed and mitigated in the PASP.
3. Any DOT&PF sUAS mission in controlled airspace or operations under a waiver to any part of the FAA requirements must include a Remote PIC and depending on mission at least one VO.

10.6 Personal Equipment

1. The operator/ VOs should take necessary measures to deploy in a professional matter, wear appropriate PPE (Hi-Visible vest, hard hat, safety glasses) for the project area, and take into consideration that all deployments are subject to media requests.
2. Operators/ VOs will take into consideration the current weather conditions when planning to deploy, and wear appropriate clothing to deploy comfortably for the duration of the mission
3. Operators/ VOs shall wear clothing that easily identifies them as DOT&PF sUAS Flight Crew members.

11. Pre-Flight, Flight, and Post-Flight Actions

11.1 Inspections

1. Operators/ VOs are both responsible for a thorough preflight inspection of the sUAS.
   Before and after each deployment (whether a mission or training), the operator and VOs shall

conduct a thorough inspection of the sUAS in accordance with the instructions contained in the manufactures user's manual or as required by DOT&PF sUAS Inspection policy, if one exists.

2. Any issues found that would put the safe operation of the sUAS in jeopardy shall be documented and resolved immediately **prior** to flight.
3. Any physical equipment that cannot be resolved on-site and has an impact on safety or the mission, will cancel the deployment.
4. It has been recognized that the use of a checklist is a significant method to combat sUAS accidents. A pre-flight checklist is contained with each sUAS Base Station and is utilized prior to each flight.

11.2 Weather

1. Before each deployment, the operator/ VOs will ensure that they gather enough information to make themselves familiar with the weather situation existing throughout the area of deployment. The operator shall utilize FAA approved weather resources to obtain the latest and most current weather conditions.
2. An anemometer should be utilized to better estimate the wind speed and determine if it is within the capabilities of the airframe being flown.
3. The weather conditions reported for the operation shall be recorded in the pre-flight checklist.
4. No flight should be undertaken if the weather exceeds the safety guidelines of the sUAS. The sUAS shall not be flown in inclement weather conditions. The flight may also be aborted if there is significant chance of any of the previous mentioned weather conditions occurring during the flight. The PIC will decide when on location if a flight will proceed.

11.3 Documentation

1. Pre-flight inspection and weather will be documented prior to flight within the each regions logbook.
2. Records will be kept for each flight. These will be stored as individual project which will contain the original request, flight plans, a completed Planning Checklist (Appendix A), a completed Pre-Flight Checklist (Appendix B), a completed Post Flight Checklist (Appendix D), the logs from the sUAS, incident reports (if one had to be raised) as well as the data captured using the sUAS in accordance with part 4.0.
3. For Public Aircraft operations, flight will be emailed

11.4 Planning

1. The operator/ VOs shall familiarize themselves with all available information concerning the deployment including, but not limited to, the weather conditions, hazards, land status, deployment goals, etc.
    a. Before a flight is undertaken, an on-site hazard inspection must be undertaken in order to ensure there are no risks and hazards, which were not prevalent during the initial planning stages. These will be noted in Appendix B. Using the previously completed Appendix A the pilot and crew will walk the immediate area identifying any possible hazards which were not picked up in the planning stage. As with the hazards in the planning stage, any new hazards will be compared against the risk matrix to see if the flight is still safe to undertake. Where it is possible, steps will be suggested to help minimize the impact of the new hazard (such as changing take off position).

2. Check NOTAM's in the area for the required period
3. Check relevant Aviation Charts
4. Operators will ensure that the location for take-off is adequate for a safe deployment.
    a. **Landing Zones** – Prior to the flight a suitable take-off and landing area must be selected. This includes a secondary landing site for use in an emergency or if the primary landing site is compromised. The primary and secondary sites must be a minimum of 100 feet away from any vehicle, building, or person not under your control. Attention must be paid to the area the sUAS will be taking off from as well as the return to home location. A take-off and landing zone will not be used if the ground is too small, is too closely surrounded by potential obstacles, if the surface is waterlogged, too muddy or too dense in vegetation and if there is a slope, which could affect the landing of the sUAS. The ideal surface is dry, flat, hard, and not surrounded by vegetation, buildings, or other potential hazards. In addition, no objects must overhang the site, as this would cause serious issues when using the return to home feature. A weighted mat will be use as a takeoff/landing pad.
    b. **Ground Risks** – When on site an assessment must be done to highlight potential risks. These can include nearby power pylons, water sources, uneven ground, large trees and buildings etc. Any object that could impact on the safety of the flight must be noted and analyzed in order to find ways to minimize its impact e.g. to find a different landing and take-off site (Appendix B).
5. The take-off/landing area should be clearly marked and identifiable with short cones or landing pad.
6. At least one emergency landing area should be identified per deployment.
7. Operators will ensure that they are aware of their surroundings in the event that an emergency landing is necessary. This includes the ability to recover the sUAS.
8. The Operator will then make a decision based on the planning form to see if a flight is suitable and safe to progress to the next stage.
9. If unsuitable, the Operator will reply to the requestor explaining why the flight cannot be undertaken.
10. If a safe flight can be conducted then the Operator will contact the requestor to organize a suitable date to fly dependent on weather, ground conditions and other obstacles not present at the planning stage.

11.5 Checklists

PIC/Operators/VO shall utilize pre-flight checklists to ensure the highest level of safety for deployment. Each flight will use the example checklist found in appendices B-E or use department specific checklist.

12. In-Flight Emergency Plan

The In-Flight Emergency Plan (adapted from the TX DOT Operators and User's Manual) describes the steps that must be followed in the event of an in-flight emergency. Activation of the plan resulting in damage to the sUAS or other property or from an occurrence that created a significant hazard to flight operations requires alerting the UAS Program Coordinator once the emergency situation has been resolved. The following emergency situations are covered by the plan:

- Total loss of aircraft power

- Partial loss of aircraft power
- Airspace Encroachment.
- Loss of control of the aircraft including sustained and transient loss of control
- Erratic aircraft behavior, including sustained and transient erratic behavior
- Aircraft fly-away
- Bird strikes
- Fixed object strikes
- Outside interference with flight crew
- Nearby or collocated emergency response activities

12.1 Total Loss of Aircraft Power

Anecdotal evidence suggests that one of the most common causes of a UAS crash is battery failure and the subsequent loss of power for propulsion and control of the aircraft. Unfortunately, for rotary-wing, fixed-wing, and hybrid aircraft alike, a total loss of power offers few options for the PIC.

A rotary-wing aircraft will usually make a rapid descent when power is lost. The rate of descent depends on a number of factors, including the wind resistance of the vehicle and feathering of the propellers. For a rotary-wing aircraft starting at a flight altitude of 400 feet AGL, impact with the ground is expected within five seconds of a full power loss.

The rate of descent for a fixed-wing and hybrid aircraft depends on the flight maneuver being done at the time of the power loss. For level flight, aircraft with fixed wings will glide. However, if the aircraft is in a turn or other maneuver at the time of the power loss the descent may be rapid.

In either case, during a full power loss there is little the PIC can do other than observe the event and plan for a response once the aircraft impacts the ground or other object.

Unless otherwise directed by the aircraft operations manual, the following sequence of events shall occur during a total loss of power in-flight:

1. The PIC announces the emergency to the flight crew.
2. The PIC attempts to restore power.
3. The PIC and VO attempt to warn nearby persons of the imminent crash by shouting a warning.
4. The PIC and VO attempt to stay in visual contact with fixed-wing or hybrid aircraft gliding towards an impact.

Because the PIC has few options during a full power loss situation, attention should shift to mitigation of the possibility of a chain reaction resulting from the crash of the aircraft. The following sequence of events shall occur once the aircraft has come to a rest:

1. If so equipped, the PIC will immediately send a remote shutdown command to the aircraft.
2. The PIC will shut down all control and communication systems.
3. The PIC shall quickly determine if the crash of the aircraft will cause a subsequent hazardous situation(s) based on the crash location or other factors.

4. If the crash has caused or has the potential to cause a chain reaction of hazardous events, the PIC must call 9-1-1 and request emergency assistance. The flight crew must never attempt to prevent a chain reaction (e.g., by attempting to retrieve an aircraft in a hazardous location) or mitigate a hazardous situation if doing so places their safety in jeopardy.
5. If the aircraft is not in a hazardous location, the flight crew will secure the crash site and power down the aircraft if not already done so remotely. The flight crew will check for fire caused by the crash or for fluid leaks resulting from damage to the fuel cells. If a fire has started, the flight crew will attempt to extinguish the fire. If a fluid leak is found the flight crew will attempt to contain the spread of the fluid by placing absorbing material on the liquid or mounding soil to prevent flow of the liquid.
6. Once any emergency response has concluded or after the crash site has been secured with effective mitigation of any fire or fluid leak hazards, the recovery of the sUAS will begin as described in Section 13., Downed Aircraft Recovery Plan.

12.2 Partial Loss of Aircraft Power

A partial loss of power may allow the PIC to maintain some control over the aircraft. The primary goal of the PIC when handling a partial loss of power emergency and subsequent landing is to:

- First: Avoid injury to persons.
- Second: Avoid causing a chain reaction of additional emergency events.
- Third: Avoid damage to property.

To accomplish this goal the PIC may need to sacrifice the aircraft by ditching or by performing a controlled collision with a fixed object.

The following sequence of events shall occur during a partial loss of power in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC with aid of the VO identifies an emergency landing or ditching area.
   a. Emergency and ditch landings are prohibited on the roadway or its shoulder.
   b. A ditch area is to be used if the probability of a safe landing is unlikely. A safe landing is any landing that does not pose a threat of injury or property damage.
   c. The ditch area can be any location or feature that will limit the effect of the crash. For example, a controlled collision of the aircraft with a concrete bridge column is preferable over an impact with a person or vehicle.
3. The PIC and VO attempt to warn nearby persons of the imminent crash by shouting a warning.
4. The PIC will immediately land or ditch the aircraft.
5. If so equipped, the PIC will immediately send a remote shutdown command to the aircraft.
6. The PIC will shut down all control and communication systems.
7. The PIC shall quickly determine if the crash of the aircraft will cause a subsequent hazardous situation(s) based on the crash location or other factors.
8. If the crash either already has or has the potential to cause a chain reaction of hazardous events, the PIC must call 9-1-1 and request emergency assistance. The flight crew must never attempt to

prevent a chain reaction or mitigate a hazardous situation caused by the crash of an aircraft if doing so places their safety in jeopardy.

9. If the aircraft is not in a hazardous location, the flight crew will secure the crash site and power down the aircraft if not already done so remotely. The flight crew will check for fire caused by the crash or for fluid leaks resulting from damage to the fuel cells. If a fire has started, the flight crew will attempt to extinguish the fire. If a fluid leak is found, the flight crew will attempt to contain the spread of the fluid by placing absorbing material on the liquid or mounding soil to prevent flow of the liquid.

10. Once any emergency response has concluded or after the crash site has been secured with effective mitigation of any fire or fluid leak hazards, the recovery of the sUAS will begin as described in Section 13., Downed Aircraft Recovery Plan.

12.3 Airspace Encroachment

An airspace encroachment occurs when any aircraft, either manned or unmanned, enters the operational area of the project. However, the flight crew must remain alert to any aircraft operating in the vicinity that might cause an encroachment. The flight crew must anticipate an encroachment and prepare accordingly.

The following sequence of events shall occur during an airspace encroachment or in anticipation of an encroachment:

1. The PIC announces the emergency to the flight crew.
2. If a collision is imminent, the PIC shall take immediate evasive action.
3. If a collision is a near-term possibility, the PIC will land the aircraft and will not resume flight operations until the encroachment hazard has passed.
4. If a collision is not imminent or a near-term possibility, the PIC will place the aircraft in a loitering position.
5. The position and heading of the encroaching or anticipated encroaching aircraft is monitored until the hazard has passed.
6. The VO will continue to monitor the entire project site in addition to monitoring the encroaching or anticipated encroaching aircraft.
7. Flight operations will not resume until the encroachment hazard has passed.

12.4 Loss of Aircraft Control – Sustained and Transient

Many UAS aircraft have a “return to home” function that will automatically return the aircraft to the launch site if communication between the controller and aircraft is lost. The return to home position must be set for the current project location at the beginning of the flight operation. If the position is not correctly set, the aircraft may attempt to return to a previous project location stored in memory. Loss of aircraft control includes the loss of the navigational GPS signal.

The following sequence of events shall occur during a loss of aircraft control in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC attempts to issue a “return to home” command (if so equipped) and continues to issue the command until the aircraft responds.
3. The PIC attempts to restore control through manipulation of the flight controls.

a. If the PIC regains control, the aircraft shall be landed immediately. After landing, the cause of the loss of control must be investigated and mitigated before flight resumes. It is possible that mitigation may require the use of a different technology to gather the required data.

b. If control cannot be restored, the aircraft is considered to be in a fly-away condition the pilot will follow the procedures in Section 12.6., *Aircraft Fly-Away*.

12.5 Erratic Aircraft Behavior – Sustained and Transient

The following sequence of events shall occur during an erratic aircraft behavior in-flight emergency:

1. The PIC announces the emergency to the flight crew.

2. The PIC attempts to issue a "return to home" command (if so equipped) and continues to issue the command until the aircraft responds.

3. The PIC attempts to land the aircraft either at the designated landing location, an emergency landing location, or at a ditch location. Depending on the nature of the erratic behavior, the PIC must consider the threat of injury or property damage due to the aircraft.
4. If the PIC decides for an emergency or ditch landing, the PIC will follow the procedures in Section 12.2., Partial Loss of Aircraft Power.

5. After landing, the cause of the erratic behavior must be investigated and mitigated before flight resumes. It is possible that mitigation may involve using a different technology to gather the required data. This may be necessary in areas with high electro-magnetic interference (EMI).

6. If the erratic behavior creates a situation in which the aircraft is incapable of landing, the aircraft is considered to be in a fly-away condition. The pilot will follow the procedures in Section 12.6., *Aircraft Fly- Away*.

12.6 Aircraft Fly-Away

A fly-away condition occurs when the aircraft does not respond to commands from the PIC and flies out of the project area. A fly-away has the potential to be disastrous and requires immediate action on the part of the air crew.

The following sequence of events shall occur during an aircraft fly-away in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC attempts to issue a "return to home" command (if so equipped) and continues to issue the command in case the aircraft responds.
3. The PIC notes the time of the loss of control, the remaining flight range based on available fuel, and the heading and altitude of the aircraft.
4. The PIC and VO will attempt to keep the aircraft in sight by moving to vantage points or following the aircraft on foot. The use of a chase vehicle to follow a fly-away aircraft is prohibited.
5. The PIC shall quickly determine if the fly-away will cause a subsequent hazardous situation(s) based on the project location, nearby airspace, nearby infrastructure (e.g., refineries, electric substations, etc.), or other pertinent factors.

   a. If there is any possibility that the fly-away aircraft will enter controlled airspace, the PIC isrequired to contact the local air traffic control center (ATC) immediately.

b. **If there is a reasonable expectation that the fly-away aircraft will cause injury to a person, the PIC is required to contact 9-1-1.**

6. If emergency response is required, no other activities shall take place until the emergency response concludes. Once the emergency response has ended, the Downed Aircraft Recovery Plan (DARP) as described in Section 13 will begin.

12.7 Bird Strikes

Certain bird species can be aggressive towards UAS aircraft. Typically, these are larger birds of prey including hawks and eagles. However, it is possible that smaller birds may inadvertently collide with an aircraft.

The amount of damage done to the aircraft by a bird strike will vary. The damage may be imperceptible or may result in an aircraft crashing in the case of damage to a control surface or propeller. The PIC and VO must remain vigilant to birds flying near the aircraft and particularly to birds displaying aggressive behavior.

The following sequence of events shall occur during a bird strike in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC attempts to land the aircraft as quickly as possible.
3. Depending on the nature of the damage to the aircraft a crash landing may occur. If the bird strike incapacitates the aircraft resulting in a crash, the PIC will follow the procedures in Section 12.1. Total Loss of Aircraft Power. If some control of the aircraft remains after the bird strike the PIC will refer to the in-flight emergency check sheet for Partial Loss of Aircraft Power.
4. Following a bird strike the UAS must be inspected for airworthiness before flight operations continue.

12.8 Fixed Object Strikes

The following sequence of events shall occur during a fixed object strike in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC attempts to land the aircraft as quickly as possible.
3. Depending on the nature of the damage to the aircraft a crash landing may occur. If the fixed object strike incapacitates the aircraft resulting in a crash, the PIC will refer to Section 12.1, Total Loss of Aircraft Power. If some control of the aircraft remains after the fixed object strike the PIC will refer to Section 12.2 Partial Loss of Aircraft Power.
4. Following a fixed object strike, the UAS will be inspected for airworthiness before flight operations continue.

12.9 Interference with Flight Crew

The flight crew should be aware that some individuals may have concerns that a sUAS aircraft is being used for surveillance or for a nefarious activity or are interest in the sUAS activity and may approach the flight crew. The PIC and VO should be alert to individuals approaching the flight crew. The VO has the primary responsibility of monitoring the project site and is responsible for alerting the PIC if an unknown individual approaches flight crew.

The following sequence of events shall occur during an outside interference in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC places the aircraft in a loitering position.
3. The PIC quickly assesses the volatility of the situation.
    a. The PIC notes the number of individuals involved, their posture, tone and volume of voice, and the possession of weaponry.
    b. The PIC remains in contact with the VO to aid in assessing the situation.

If there is a reasonable expectation that the situation will escalate to the point of violence or injury to the flight crew:

1. The PIC will immediately land the aircraft.
2. The PIC will contact 9-1-1 .
3. Depending on the situation, the PIC and VO may need to immediately abandon the project location.

12.10 Nearby Emergency Operations.

If an emergency event occurs near the UAS project site (e.g., a vehicular collision, fire or other emergency incident) flight operations will cease until the emergency response has ended.

The following sequence of events shall occur during a nearby incident in-flight emergency:

1. The PIC announces the emergency to the flight crew.
2. The PIC attempts to land the aircraft as quickly as possible.

Flight operations will not resume until the emergency response has concluded.

13. Downed sUAS Recovery Plan (DARP)

The Downed sUAS Recovery Plan (DARP) describes the process and procedures to follow after an aircraft has crash landed. Per Section 12, *In-Flight Emergency Plan*, a crash landing may or may not require an emergency response. An emergency response is required when the location or condition of the downed aircraft either already has or has the potential to cause a chain reaction of additional incidents.

As part of the emergency response, the responders may recover the aircraft or may instruct the flight crew to recover the aircraft. However, in no event should the flight crew attempt to recover the aircraft during an emergency response without being directed to do so by the emergency responders. Recovery of an aircraft during an emergency response is not part of the DARP.

The DARP is implemented through a checklist describing a series of steps to be performed in sequential order.

Activation of the DARP requires reporting to the UAS Coordinator. The reporting requirements and report form are described in Section 7.5 Accident and Hazard Reporting, and Review and 7.6 FAA Accident Reporting.

13.1 DARP General Rules

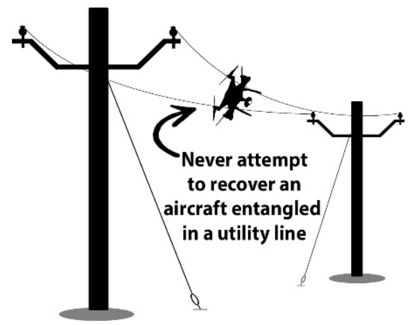
Rules that apply to the recovery of a downed aircraft are:

Rule 1: No attempt will be made to recover a downed aircraft located in a hazardous area.

Hazardous areas include:

1. A downed aircraft entangled in a utility line. Never attempt to recover a downed aircraft entangled in any type of utility line. The local utility provider must be contacted for recovery of the aircraft.

2. An aircraft in any location that could reasonably be expected to endanger the person or persons attempting to recover the aircraft. This includes an aircraft entangled in a tree or in a structure like a tower. A qualified contractor must be contacted for recovery of the aircraft. If the position of the aircraft is not precarious and there is a reasonable expectation that the aircraft can be recovered without causing injury, property damage, or further damage to the aircraft, the aircraft may be recovered by the flight crew.



3. A downed aircraft in a precarious location on or near a roadway or railway. Never attempt to recover a downed aircraft on a roadway with heavy traffic. For any downed aircraft on a roadway, the location of the aircraft and its impact (or potential impact) on traffic may require a 9-1-1 response. The PIC is responsible for contacting 9-1-1. In some situations, the PIC may need to contact AK DOT or the local police department or the Alaska Railroad to assist in traffic control and recovery of the aircraft.

4. A downed aircraft in an area of precarious terrain including cliffs or steep grades, sinkholes, or unstable soil.

5. A downed aircraft in water. Water presents unique hazards that may not be detected by viewing the surface. Never attempt to recover a downed aircraft in swift water. If the aircraft is within five feet of the bank and there is a reasonable expectation that it can be recovered without incident, the aircraft may be recovered. If the aircraft is located more than five feet from the bank, the use of a recovery boat is required. Recovery of a submerged aircraft may require the assistance of a diver.

Rule 2: Do not attempt to recover a downed aircraft on privately owned property without the prior consent of the landowner or other responsible entity. The only exception to this rule is if there is an imminent threat that the downed aircraft, due to its condition, may cause further damage to property or there is a risk of starting a fire. If there is a reasonable expectation of an imminent threat from the downed aircraft that may cause additional damage to property, the flight crew may enter the private property to mitigate the risk.

However, this does not necessarily mean that the aircraft can be removed from the property. If the condition causing the threat can be mitigated without removal of the aircraft, the aircraft must remain in place until the landowner or other responsible party can be contacted for approval to enter the property.

Rule 3: Government-owned fenced areas require approval from the responsible governmental agency before a downed aircraft can be recovered.

13.2 The DARP Procedures

No recovery activities can begin until all emergency response has concluded. The only exception is if the emergency responders direct the flight crew to remove the aircraft from the crash location.

The steps to recovering a downed aircraft are outlined in the checklist attached as Appendix E. The recovery of a downed aircraft must be documented, particularly if there is the possibility of litigation resulting from the incident. The PIC is responsible for:

1. Confirm that all emergency response has concluded. Emergency response includes the act of entering private property to address an immediate hazard such as a fire caused by the crash aircraft or the leaking of hazardous materials from the aircraft.
2. Verify that all aircraft, control, and communications systems are powered off.
3. Secure the project site by stowing any equipment or supplies not needed for the recovery effort.
4. Determine if the crash site in on public or private property. If the aircraft is on private property attempt to identify the landowner from on-site information such mailboxes or nearby houses. If the landowner cannot be identified on-site other resources to check include the county appraisal district property maps, neighbors, or possibly local law enforcement. The Local Borough land use and platting section or the DOT&PF ROW map may be able to assist in determining the landowner.
5. Determine if assistance is required to recover the downed aircraft. DO NOT attempt to recover an aircraft in a hazardous location.
6. Document the recovery by taking notes, making sketches, and taking photographs.
7. Complete an accident Report as outlined in Section 7.5 Accident and Hazard Reporting, and Review and 7.6 FAA Accident Reporting.

14. Maintenance and Shipping

14.1 Maintenance

1. sUAS maintenance includes scheduled and unscheduled overhaul, repair, inspection, modification, replacement, and system software upgrades of the sUAS and its components necessary for flight.
2. Although there are few parts on the sUAS that need servicing, it is necessary that the manufacturer's maintenance schedule is followed and properly documented.
3. Any issues that arise during maintenance that cannot be resolved by routine methods shall be forwarded to the manufacturer for further technical support.
4. Firmware updates of the sUAS shall be completed at a minimum of every two months. This includes the updated of flight apps, aircraft, controller, and all battery packs.

14.2 Battery Safety

1. Lithium-polymer (LiPo) batteries can pose a safety hazard because they contain a flammable electrolyte and are pressurized. Do not use batteries that are damaged, cut, puffy, or

physically abnormal. All LiPo batteries shall be handled in accordance with the manufacturer's recommendations. At the end of serviceable life, qualifying batteries shall be disposed at an authorized collection facility.

2. Safe Battery Charging: LiPo batteries offer normal charging performance at cooler temperatures and may even allow fast charging within a temperature range of 41°F to 113°F (5°C to 45°C). Consumer-grade LiPo batteries should not be charged at temperatures below 32°F (0°C). If overheated or overcharged, LiPo batteries may suffer "thermal runaway", to include a cell rupture, and in extreme cases combustion can occur. Batteries should not be left unattended when charging or near flammable objects.

3. Battery Transport: **Contact Statewide Remote Sensing Laboratory at (907) 337-6813** to verify compliance for IATA and 49 CFR Part 173 for shipping dangerous and hazardous goods.

14.3 sUAS System Shipping

For safety purposes it is very important to follow the shipping requirements for lithium batteries for the sUAS. Lithium Batteries or equipment containing lithium batteries are considered "dangerous goods" because they can pose significant safety risks in transportation. Shippers must ensure batteries are properly packed, prepared, and communicated to the air carrier to ensure shipments arrive safely. Visit www.faa.gov/go/safecargo to learn more.

1. UA with Batteries:
    a. Packaged in hard case or backpack inside cardboard box
    b. Only 3 batteries in package in own slot not in craft
    c. Must have 1 of 2 labels below on package
    d. Three (3) batteries or less keeps it under 5 kg limit
    e. Must provide phone number for HAZMAT certified 24-hour line
2. Shipping UA with Batteries by passenger AIR carrier:
    a. **Contact Statewide Remote Sensing Laboratory at (907) 337-6813** to verify compliance for IATA and 49 CFR Part 173 for shipping dangerous and hazardous goods.
    b. Lithium batteries less than or equal to 100 Watt hour (Wh): Only allowed as the carry-on luggage, no quantity limit. **Lithium batteries are not permitted in checked luggage.**
    c. Lithium batteries rated at 101-160 Wh: With air carrier approval are only allowed as the carry-on luggage, Limit is two (2). Lithium batteries are not permitted in checked luggage.
    d. Lithium batteries rated at greater than 160 Wh: Contact airlines for shipping requirements (may need to pre-ship as cargo)
    e. Battery terminals must be protected from short circuit (i.e., the terminals must not come in contact with other metal). Battery terminals be stored in their retail packaging, covering battery terminals with tape, using a battery case, using a battery sleeve in a

camera bag, or putting them snugly in a plastic bag or protective pouch when shipped as a part of your carry on bags.

To calculate Watt Hours (Wh) multiply the battery voltage (V) by the Amp hours (Ah). For milliamp hours (mAh), divide by 1000 (to get to Ah) and then multiply by the volts.

See: https://www.faa.gov/hazmat/packsafe/

3. Shipping Batteries alone:
   a. Weight under 66 lbs.
   b. Must be specialty packaged
   c. Dangerous goods surcharge
   d. Must be labeled with 1 of 3 stickers as shown below

See: https://www.faa.gov/hazmat/safecargo/media/Battery_Slides.pdf

15. References

Final Rule of FAA Part 107 https://www.federalregister.gov/documents/2016/06/28/2016-15079/operation-and-certification-of-small-unmanned-aircraft-systems

FAA Advisory Circular 107 – 2: https://www.faa.gov/documentlibrary/media/advisory_circular/ac_107-2.pdf

Drone/UAS Operator Safety Guidelines and FAQs about Privacy Prepared by the UAS Legislative Task Force 29th Alaska State Legislature, October 1, 2015 https://www.commerce.alaska.gov/web/Portals/6/pub/UAS%20Operator%20Guidelines%2010-1-15.pdf.

Public Aircraft Operations https://www.faa.gov/uas/public_safety_gov/drone_program/public_aircraft_operations/

American Civil Liberties Union (ACLU) "Protecting Privacy from Aerial Surveillance (recommendations for Government Use of Drone Aircraft) December 2011", https://www.aclu.org/files/assets/protectingprivacyfromaerialsurveillance.pdf.

National Telecommunications and Information Administration (NTIA) "Voluntary Best Practices for UAS Privacy, Transparency and Accountability" https://www.ntia.doc.gov/files/ntia/publications/uas_privacy_best_practices_6-21-16.pdf

Oak Ridge National Laboratory "An Early Survey of Best Practices for the Use of Unmanned Aerial Systems for the Electric Utility Industry" dated February 2017", https://info.ornl.gov/sites/publications/files/pub73072.pdf

U.S.DOI, OSMRE National Aviation Management, Dated March 2017.

TxDOT UAS Flight Operations and User's Manual, 4-2017 https://www.txdot.gov/government/programs/sharing/uas-services.html

Drone/UAS Operator Safety Guidelines and FAQs about Privacy, Prepared by the UAS Legislative Task Force, 29th Alaska State Legislature Version No.1 October 1, 2015. https://www.commerce.alaska.gov/web/Portals/6/pub/UAS%20Operator%20Guidelines%2010-1-15.pdf

Antarctic Unmanned Aerial Systems (UAS) Operator's Handbook -prepared by the COMNAP UAS Working Group https://documents.ats.aq/ATCM39/att/ATCM39_att011_e.pdf

FAA Pilot Handbook, Chapter 2 Aeronautical Decision-Making https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/04_phak_ch2.pdf

Risk Management Handbook (FAA-H-8083-2)

Safety Risk Assessment for UAV Operation, Drone Industry Insights, Safe Airspace Integration Project, Part One, Nov. 2015

16. Abbreviations, Acronyms, and Definitions

CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
PIC	Remote Pilot In Command
sUAS	Small Unmanned Aircraft Systems
VO	Visual Observer
PAO	Public Aircraft Operations
COA	Certificate of Waiver or Authorization
TFR	Temporary Flight Restriction
GDOP	Geometric Dilution Of Precision

Aircraft – as defined in 14 CFR 1.1, is a device that is used or intended to be used for flight in the air. sUAS are considered aircraft and must comply with applicable regulations, policies, and procedures required by FAA.

Ground Control Station – Any device, computer, or remote control used to program or remotely operate an aircraft or attached sensor.

NOTAM – A Notice To Airmen or NOTAM is a notice containing information (not known sufficiently in advance to publicize by other means) concerning the establishment, condition, or change in any component (facility, service, or procedure of , or hazard in the National Airspace System) the timely knowledge of which is essential to personnel concerned with flight operations.

Operational Control – per 14 CFR 1.1 Operational control, with respect to a flight, means the exercise of authority over initiating, conducting or terminating a flight.

small Unmanned Aircraft System(s) – a sUAS is a combination of unmanned aerial vehicle (UAV) and all associated support equipment, control station, data links, telemetry, communications, and navigation equipment, etc., necessary to operate the unmanned aircraft. UAVs are also known as drones.

Unmanned Aircraft (UA) An aircraft operated without the possibility of direct human intervention from within or on the aircraft.

sUAS Crewmember – personnel directly involved in the setup, launch, recovery or manipulating the controls of the sUAS and anyone else that may be directly participating in the sUAS operation. A person is also a direct participant in the sUAS operation if his or her involvement is necessary for the safe operation of the sUAS

Appendix A. DOT&PF Point of Contact

1. Statewide Aviation

Address: 4111 Aviation Avenue

Phone: (907) 269-0741

Contact Name: Ryan Marlow Email:ryan.marlow@alaska.gov

2. Northern Region Survey

Address: 2301 Peger Rd Fairbanks, AK 99709

Phone: (907) 451-5436

Contact Name: Troy Hicks Email: troy.hicks@alaska.gov

3. Central Region Survey

Address: PO Box 196900 Anchorage, AK 99519-6900

Phone: (907) 269-0556

Contact Name: Travis Test Email: travis.test@alaska.gov

4. Southcoast Region Survey

Address: PO Box 112506, Juneau, AK 99811-2506

Phone: (907) 465-4737

Contact Name: Jim Papoi Email: james.papoi@alaska.gov

5. Statewide Remote Sensing Laboratory

Address: 5700 East Tudor Road

Phone: (907) 337-6813

Contact Name: Caprice A. Larimer-Musty Email: caprice.larimer-musty@alaska.gov

6. Bridge Design

Address: PO Box 112500 Juneau, AK 99811-2500

Phone: (907)465-8411

Contact Name: Jesse Escamilla Email: jesse.escamilla@alaska.gov

Appendix B. Sample Project Aviation Safety Plan (PASP)

<table>
<tr><th colspan="6">Project Aviation Safety Plan (PASP)/Mission plan</th></tr>
<tr><td colspan="4">Project Name:</td><td colspan="2">Point of Contact:
Name:
Phone:</td></tr>
<tr><td colspan="2">Target Start Date:</td><td colspan="2">Target End Date:</td><td colspan="2">Location
Latitude (N):
Longitude (W):</td></tr>
<tr><td colspan="6">Recurring Project: Yes No (If yes, enter operational period in target dates above)</td></tr>
<tr><td colspan="2">Purpose of Flight:</td><td colspan="2">Nearest Community:</td><td colspan="2">Nearest Airport/Runway:</td></tr>
<tr><td colspan="6">Objectives:</td></tr>
<tr><td colspan="6">Justification:</td></tr>
<tr><td colspan="2">Maximum Flight Altitude to be used:</td><td colspan="2">Is an FAA waiver required?</td><td colspan="2">Airspace Class
B D G
C E (at ground level)</td></tr>
<tr><th colspan="6">Aircraft to be used:</th></tr>
<tr><td colspan="3">Type:</td><td colspan="3">Make/Model</td></tr>
<tr><td colspan="3">Registration #:</td><td colspan="3">Additional Equipment:</td></tr>
<tr><td colspan="3">Type:</td><td colspan="3">Make/Model:</td></tr>
<tr><td colspan="3">Registration #:</td><td colspan="3">Additional Equipment:</td></tr>
<tr><th colspan="6">Project Participants</th></tr>
<tr><td></td><td colspan="2">Name</td><td colspan="2">Responsibility</td><td>Certification #</td></tr>
<tr><td>1</td><td colspan="2"></td><td colspan="2">PIC Operator
VO Mission specialist</td><td></td></tr>
<tr><td>2</td><td colspan="2"></td><td colspan="2">Operator
VO Mission specialist</td><td></td></tr>
<tr><td>3</td><td colspan="2"></td><td colspan="2">Operator
VO Mission specialist</td><td></td></tr>
<tr><td>4</td><td colspan="2"></td><td colspan="2">Operator
VO Mission specialist</td><td></td></tr>
<tr><td>5</td><td colspan="2"></td><td colspan="2">Operator
VO Mission specialist</td><td></td></tr>
<tr><td colspan="6">Other Participants:</td></tr>
<tr><td colspan="6">Page 1 of 4</td></tr>
</table>

Project Aviation Safety Plan (PASP)/Mission plan	
Project Name:	General Location Map
Instructions: Provide a map showing the general location of the project. Show nearby town, roads, airport and other features to aid in locating the project	
Other Information:	
	Page 2 of 4

Project Aviation Safety Plan (PASP)/Mission plan	
Project Name:	**Project Map**
Instructions: Provide a map showing the project site. Show the area over which the flight will be conducted and potential hazards. If possible, include the limits of sUAS operations, proposed take off and landing sites and other information necessary to assist in a hazard analysis	
Other Information:	
	Page 3 of 4

Project Aviation Safety Plan (PASP)/Mission plan

Project Name:	**Hazard and Risk**

Aerial Hazard Analysis:

Has a Risk Assessment and mitigation analysis been completed?
Yes (If yes attach to the PASP)
No

Risk Profile			**Risk Assessment Completed by:**
	Initial	Mitigated	
Flight Risk (Highest Mitigated Risk)			**Risk Assessment Review by:**
Mean Risk (Avg. of Initial/Mitigated Rick scores)			

Other Information:

PASP Complete by:	**Date Complete**

Page 4 of 4

Appendix C. Risk Mitigation Form

Completed by:		**Location:**	
Date Completed:			
Project:		**Mission Type:**	

AT RISK (Column 2)	**SEVERITY (Column 5 and 9)**		**LIKELIHOOD (Column 4 and 8)**		**RISK RATING (Column 6 and 10)**
					Severity x Probability – 1 to 3 **LOW** May be acceptable, review to see if risk can be further reduced.
					Severity x Probability – 6 to 9 **MEDIUM**
E – Flight Crew	1	No Safety Effect:	1	Extremely improbable	May be acceptable, review to see if risk can be further reduced.
C - Clients	2	Minor	2	Improbable	Severity x Probability – 10 to 12 **SERIOUS**
V – Visitors	3	Major	3	Remote	Procced with extreme caution additional mitigation measures
P - Public	4	Hazardous	4	Occasional	Severity x Probability – 13 to 25 **HIGH**
A - All	5	Catastrophic	5	Frequently	Task should not proceed

	1. Hazard (Something with the potential to cause harm, how will it be realized and what is the potential injury?)	**2. At Risk**	**3. Existing Control Measures**	**Initial Risk** 4. Likelihood	5.Severity	6. Risk	7. **Further Control Measures**	**Mitigated Risk** 8. Likelihood	9. Severity	10. Risk
1	UAS Losing control and falling to the ground causing personal injury.	A	UAS regularly inspected. Visual check of UAS prior to take off. Pre-deployment briefing to all staff on site Pre deployment survey will be carried out during planning phase. Flight planned to minimize likelihood of flying over people.							
2	High winds or rain affect the capability of the UAS increasing risk of UAS malfunction resulting in collision.	A	Accurate weather forecast checked prior to deployment. The flight may be delayed or cancelled							

	1. Hazard (Something with the potential to cause harm, how will it be realized and what is the potential injury?)	2. At Risk	3. Existing Control Measures	Initial Risk			7. Further Control Measures	Mitigated Risk		
				4. Likelihood	5.Severity	6. Risk		8. Likelihood	9. Severity	10. Risk
			at any time if the weather risks the capability of the UAS. Weather to be monitored at all times during flight with a view to landing should weather deteriorate.							
3	UAS in airspace risking collision or near miss with other air users.	A	NOTAMS will be checked prior to flight for specific information relating to the deployment area. UAS will remain below 122m (400 ft) at all times.							
4	Public ingress in area of operation	P								
5										
6										
7										
8										
9										
10										
11										

Risk Profile	Initial	Mitigated	**Risk Assessment Sign off:** (By DOT&PF qualified remote pilot other than person completing risk assessment)	
Flight Risk (Highest Mitigated Risk)			Name:	Date:
Mean Risk (Avg. of Initial/Mitigated Rick scores)				

Appendix D. Sample Privacy Impact Assessment

*Under Development

Please refer to your Regional Chief Pilot or department contact listed in Appendix A

Appendix E. Sample Pre- During- and Post- Flight Checklist

sUAS Preflight Checklist			
	Item	**Action**	**Status**
1	Project	Review mission/flight objectives	
2	Safety Brief	Review Hazards	
3	Safety Brief	Review In flight Emergency Procedure	
4	Weather Check-Wind Speed		
5	Weather Check-Temperature		
6	Weather Check-Visibility		
7	Weather Check-Precipitation		
8	Takeoff/landing area	Delineate and clear of debris (complete onsite hazard checklist)	
9	Airworthiness check	Visually inspect aircraft	
10	Airworthiness check	Visually inspect control surfaces and linkages	
11	Avionics	Inspect control link transceiver, comm/navigation equipment, and antennas	
12	Airworthiness check	Inspect props for balance, damage, connections, tighten nuts	
13	Airworthiness check	Check camera/gimbal security, wiring and free from obstructions	
14	Remote Control	Verify batteries	
15	Battery	Verify sUAS battery	
16	Monitor	Verify display panel working properly	
17	Compass	Calibrate compass, if necessary	
18	Navigation	Check navigation and telemetry connection	
19	Airworthiness check	Confirm weight and balance is within manufacturer's recommendation	
20	Registration	Registration markings, for proper display and legibility;	
21	Non-participants	Remove from takeoff area	
22	Camera	Check camera operation	
23	Failsafe/RTH	Enter program safe parameters	
24	Ground support equipment	Check proper operation and location	
25	Data Storage	Confirm data storage installed and functional	
26	Phone calls	Contact ATC and Manager as necessary	
27	All clear check	Check takeoff area, airspace, flight area	

Onsite Hazard Inspection		
Hazard	**Action**	**Comment**

Flight Checklist			
	Item	**Action**	**Status**
1	GPS lock/Ready to fly		
2	Home point updated		
3	Clear area	Remove from takeoff area, announce take off	
4	Execute takeoff and hover position for 30 seconds	Observe sUAS for performance issues or other issues that would impact flight operations	
5	Check flight conditions	Re Check takeoff area, airspace, flight area	
6	Start mission		

Post Flight Checklist			
	Item	**Action**	**Status**
1	Clear landing area	Remove from takeoff area, announce landing	
2	If quick turnaround, turn off sUAS,	replace battery /redo Flight checklist	
3	Turn off sUAS		
4	Secure gimbal		
5	Check for Damage	Visually inspect for damage from the flight or from take off or landing	
6	Complete logbook entry		

Appendix F. Sample Maintenance Schedule

sUAS Maintenance Schedule*	
Before every mission prior to leaving the office	
Check for firm ware and/or system updates to the sUAS, display devices and attached sensors.	
Before and After every flight	
Check condition of props	
Check motor shafts have no free play	
Check motors move freely when spun by hand	
Check condition of battery, battery connectors and data pins	
Check camera/payload mounts are secure	
Check antennas are securely fastened	
When powered up and idling confirm no unusual noise or vibration from motors.	
Every 5 hour (~10 flights)	
Visual inspection of shell and other plastic components for cracking/damage	
Check tightness of motor retaining screws and shell retaining screws	
Check batteries for number of cycles and discharge per manufacturer recommendations if required.	
Every 20 hours (~40 flights)	
Remove upper shell and check state of all wiring, plugs fully seated, condition of all solder joints, condition of visible circuit boards and wiring runs, internals generally clean and no debris/loose items. (verify warranty)	
Every 100 hours (~300 flights)	
Remove and replace camera rubber shock/vibration mounts on gimbal	
Remove and replace motors	
Remove and replace propellers	
Check batteries for number of cycles and voltage level. Replace/retire as needed	
*Suggested schedule if no schedule is provided by the manufacturer	

Appendix G. Inflight Emergency Checklist

*Under Development

Please refer to your Regional Chief Pilot or department contact listed in Appendix A

Appendix H. Downed Aircraft Checklist

*Under Development

Please refer to your Regional Chief Pilot or department contact listed in Appendix A

Appendix I. Sample Maintenance/Repair Log

sUAS Maintenance Record

sUAS Make/ Model	FAA registration Number	sUAS Serial Number
Purchase Date		

Item (e.g., Description of maintenance, prop, battery, firmware)	Time			Last Inspection Date mm/dd/yyyy	Inspected By Last Name
	Previous	New	Total		

Maintenance Discrepancy	Description	Who	Date

sUAS Repair Log							
Fault #	**Date**	**System affected**	**Issue**	**Corrective Action**	**Serviced by**	**Repair Date**	**Notes**

Appendix J. Sample Flight Log

Flight ID:________ Date:_____________

Flight Location: _____________________

Lat/Long: __________________________

Mission:____________________________

Pilot:______________________________

Spotter:____________________________

Flight Type: (Auto/PIC/OTHER) _________

Weather: __________________________

Notes:_____________________________

____

____

____

____

Pre Flight Checklist

- ◊ Verify sources of potential interference
- ◊ Software/Firmware up to date
- ◊ UAS gimbal damp removed and stored
- ◊ MicrSD card inserted into UAS camera slot
- ◊ Check general condition of UAS
- ◊ Check UAS battery status fully charged
- ◊ Insert UAS battery
- ◊ Check propellers are in good condition
- ◊ Install propellers on proper axis
- ◊ Mount monitor and connect to controller
- ◊ Position controller antennas properly

Mission Intervals

Flight	Battery	Time
1		
2		
3		
4		
5		
6		
	Total	

Issues: ____________________________

____

____

____

Flight Checklist

- ◊ GPS lock/Ready to fly
- ◊ Home point updated
- ◊ Clear area
- ◊ Execute takeoff and hover position for 30 seconds
- ◊ Check flight conditions
- ◊ Start mission

Post Flight

- ◊ Clear landing area
- ◊ If quick turnaround, turn off UAS, replace battery/redo Flight portion of checklist
- ◊ Turn off UAS
- ◊ Secure gimbal
- ◊ Check for Damage
- ◊ Complete logbook entry

PHANTOM 4 RTK CHECKLIST

Pre-departure

- ☐ Licenses.......................... Current & on-hand
- ☐ Batteries.................................. Fully Charged
- ☐ Altitude Unlock................................ Enabled
- ☐ Digital Surface Model....................... Installed

Site Assessment

- ☐ GNSS Forecast............................... 6 or more
- ☐ Airspace.. Checked
- ☐ Weather.. Checked
- ☐ GCP's/DRTK2................. Strategically placed

Flight Planning

DJI GSR Settings

- ☐ New Mission........... Terrain Awareness Mode
- ☐ Height.................................. 250-400ft AGL
- ☐ Speed.................................... Adjust for flight
- ☐ Shooting mode....................Distance Shooting
- ☐ Finish....................................Return to home

Camera Settings

- ☐ Photo ratio.. 3:2
- ☐ White balance........ Set to weather conditions
- ☐ Gimbal angle.. -90
- ☐ Shutter priority....................... Enabled -1/1000
- ☐ Distortion correction....................... Disabled

Advanced Settings

- ☐ Horizontal & vertical overlapping............. 75/75
- ☐ Margin.. 0
- ☐ Course angle....................... Flight time >10 min

Pre-flight

- ☐ D RTK2................................ Setup & Inspect
- ☐ D RTK2... Power on
- ☐ Aircraft............................... Setup & Inspect
- ☐ Aircraft.................... MicroSD card installed
- ☐ Aircraft..................... Insert charged battery
- ☐ Controller......................... Antennae Vertical
- ☐ Controller... P Mode
- ☐ Operator............................ Flight safety brief
- ☐ Controller.. Power on
- ☐ Aircraft.. Power on

Survey

DJI GSR App

- ☐ Mission..................... Create/edit flight plan
- ☐ Altitude............................ Clear of obstacles
- ☐ Mission.................................... Save changes

Flight

- ☐ Takeoff area... Clear
- ☐ GSR App............................... Execute mission
- ☐ Aircraft............................ Always monitoring

Post-flight

- ☐ Aircraft.. Power off
- ☐ Controller.. Power off
- ☐ D RTK2... Power off
- ☐ Computer................. Import & review images

Charter

DOT&PF Imagery Standards Team

Background

The Department of Transportation & Public Facilities (DOT&PF) utilizes airborne imagery products derived from manned and unmanned aerial system (UAS; "drone"). With remote sensing technologies becoming easier to source and implement, it has opened up the ability for the department and consultants to collect and produce geospatial products. Due to fiscal and resource limitations, and for general best practices, the need for cross-Department collaboration and sharing has become increasingly apparent.

Purpose

The purpose of this team is to bring together DOT&PF subject matter experts to enforce AELS regulations, adopt and enforce ASPRS imagery standards and establish approved airborne geospatial products and equipment for DOT&PF

Team

The Imagery Standards Team is intended to have subject matter experts representing each DOT&PF Department currently providing data, lessons learned and recommendations for their Department, or for their Division/Program and through cross-Division/Program collaboration. The focus will start with DOT&PF and will add on DEC, DFG, DNR and DOT to help satisfy task needs.

Goals

Following are identified goals, which are subject to change as needed.

- Data sharing
- Equipment Knowledge sharing
- AELS rules updates and response
- ASPRS rules updates and response
- Operating as a Public Aircraft Operation (PAO) with a Certificate of Authorization (COA)
- Approved Equipment List
- UAS Sensor Requirements
- SFM Accuracy Standards for non-vegetated surfaces
- Emergency response coordination

Communication

Currently, the DOT&PF UAS Committee Workgroup is facilitating the meetings, but this may be delegated as needed. Meetings are held every third Thursday of every month but may be modified as needed.

Charter Updates/Revisions

At this time, the DOT&PF Imagery Standards Team Charter is an informal guide that may be updated as needed. It is recommended that a formal review be completed annually.