RESEARCH & DEVELOPMENT

Unmanned Aircraft Systems (UAS) Operations Support

[Final Report]

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NCDOT Project NGAT-57808

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Unmanned Aircraft Systems (UAS) Operations Support
Final Report

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16. Abstract

The NextGen Air Transportation Program (NGAT) at North Carolina State University has provided the North Carolina Department of Transportation (NCDOT) Division of Aviation (DOA) support for the Unmanned Aircraft Systems (UAS) Program since 2012. This project has funded that support since 2014 during the most dynamic period in the history of UAS in the United States. This report is a summary of the highlights, products, and activities that NGAT has supported to represent NCDOT and accomplish the objectives of the North Carolina UAS Program as established by the General Assembly and Division of Aviation.

This report includes a review of the progress towards UAS integration into the National Airspace System by the Federal Aviation Administration (FAA) and industry as a whole. Following the macro summary, the report includes a detailed review of NGAT activities against the original scope of work for the project, specifically the 10 objectives defined in the spring of 2014 before commercial operation approvals were granted and the national UAS test sites were just beginning operations. After reviewing the accomplishments, recognitions, and progress of the NGAT Program, the report includes three appendices that provide a set of UAS Case Studies, Best Practices, and a current UAS Program Overview presentation. Each of these sections can stand alone as a reference document for the state of UAS integration in North Carolina.

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The NGAT Team also wants to send our deepest appreciation to Rep. John Torbett in the North Carolina House of Representatives for his commitment to the UAS industry in North Carolina and the UAS Program in NCDOT.

A special “Thank you again!” to our friends in Hyde County for their dedication and commitment to the NGAT UAS Program, particularly County Manager Bill Rich, Airport Manager Jane Hodges, and County Economic Developer Kris Noble.

We also want to express our sincerest appreciation for the knowledge and dedication to NGAT’s success to Mr. Randy Breedlove, our airspace guru and FAA interpreter.

Finally, the NGAT Team would like to acknowledge the support from NC State University as we have represented the “Think and Do” moto of the university in winning the FAA UAS Center of Excellence role on the ASSURE Team. Specific “Thank you” to Dr. Nagui Rouphail (ITRE Director), Dr. Mladen Vouk (Associate Vice Chancellor for Research), Ginny Moser, the Proposal Development Unit, and the rest of the ITRE team.

EXECUTIVE SUMMARY

The NextGen Air Transportation Program (NGAT) at North Carolina State University has provided the North Carolina Department of Transportation (NCDOT) Division of Aviation (DOA) support for the Unmanned Aircraft Systems (UAS) Program since 2012. This project has funded that support since 2014 during the most dynamic period in the history of UAS in the United States. This report is a summary of the highlights, products, and activities that NGAT has supported to represent NCDOT and accomplish the objectives of the North Carolina UAS Program as established by the General Assembly and Division of Aviation.

This report includes a review of the progress towards UAS integration into the National Airspace System by the Federal Aviation Administration (FAA) and industry as a whole. Following the macro summary, the report includes a detailed review of NGAT activities against the original scope of work for the project, specifically the 10 objectives defined in the spring of 2014 before commercial operation approvals were granted and the national UAS test sites were just beginning operations. After reviewing the accomplishments, recognitions, and progress of the NGAT Program, the report includes three appendices that provide a set of UAS Case Studies, Best Practices, and a current UAS Program Overview presentation. Each of these sections can stand alone as a reference document for the state of UAS integration in North Carolina.

The NGAT Program is fortunate to have the leadership of NCDOT dedicating resources to supporting UAS integration and ecosystem development in the state. UAS services and manufacturing companies are calling North Carolina home. UAS flight operations are happening routinely and frequently around the state. UAS education programs are launching across the state to prepare the next generation workforce and to support the demand for new career opportunities. By positioning NC State University as a core member of the FAA UAS Center of Excellence team, ASSURE, NGAT accomplished the goal of establishing North Carolina as a UAS integration leader, but also raised the stakes to do even more over the next 10 years to meet the increasing needs of the community. The FAA is moving faster than ever before to meet UAS integration demands and NextGen goals as the 2020 ADS-B equipage milestone approaches. North Carolina has the leadership, needs, commitment, and resources to solve the challenges facing the modern aviation community. NGAT has demonstrated four years of success supporting NCDOT in those efforts and is prepared to continue that role going forward.

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1 INTRODUCTION

In April of 2014 the NextGen Air Transportation Program (NGAT) was approaching its second anniversary, commercial unmanned aircraft systems (UAS) were several months away from receiving FAA exemption-based approvals, the six UAS Test Sites were just beginning operations, and the HondaJet was still 20 months away from full certification from the FAA. Just over two years later, the aviation landscape has changed multiple times and many milestones considered "way off in the future" have been surpassed:

- NGAT has established a national reputation as a research program at NC State University supporting the FAA's UAS Center of Excellence called ASSURE.
- The NGAT Consortium is 35 members strong defining a Phase 2 Strategic Plan for the organization.
- In June 2016 the FAA released the Part 107 Small UAS Rule for general operations after releasing the proposed rule in early 2015.
- The six UAS Test Sites are renewed in the latest FAA Continuing Resolution, but are struggling to meet sustainment goals.
- More than half a million small UAS are registered for commercial and hobby use. While less than 15% of the national general aviation aircraft fleet, approximately 250,000 aircraft, are equipped and ready for the FAA 2020 ADS-B mandate goal.
- North Carolina is one of the first states with a formal UAS permitting program that has been implemented statewide.
- Honda Aircraft is six months into delivering fully certified aircraft.

NGAT has monitored aviation modernization activities in the state since 2012 to support NCDOT's goals of developing an Unmanned Aircraft Systems (UAS) ecosystem and preparing for nationwide UAS integration. For the last two years the NGAT Team has provided UAS flight research services using approved flight locations around the state, has provided NCDOT Division of Aviation subject matter expertise in the development of the NC UAS Permitting Program, has shared North Carolina's vision for responsibly, deliberately integrating UAS for many applications across the state, and has united the UAS community in the state. NGAT has accomplished the original goal of making North Carolina a recognized national leader in UAS integration and is prepared to continue supporting NCDOT as UAS growth expands with new capabilities and other aviation modernization programs require research and integration services.

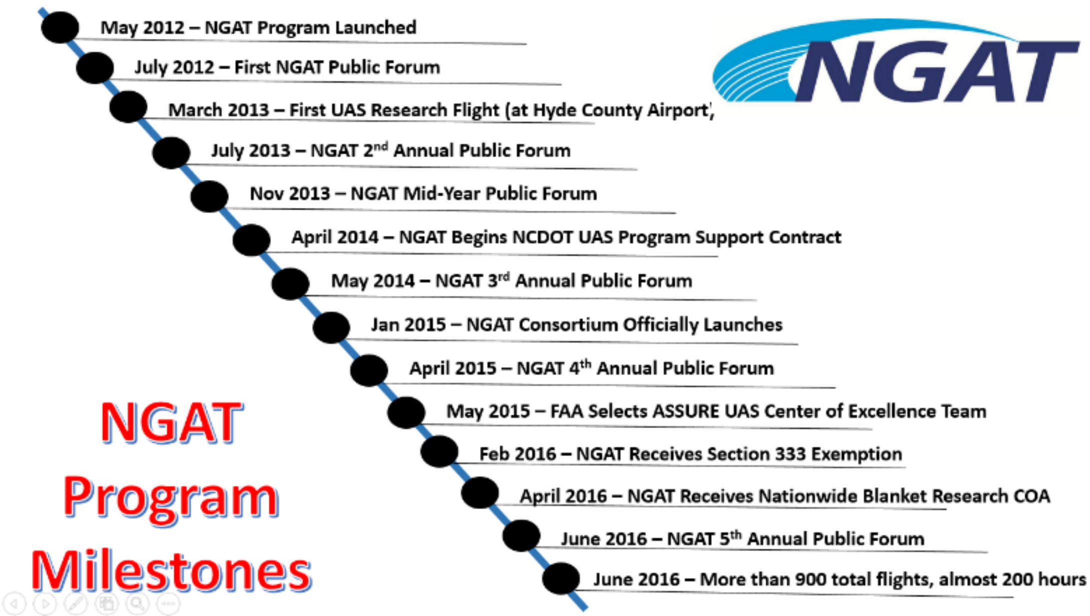

Figure 1: NGAT Program Milestones

1.1 Scope

NGAT was established to provide a centralized knowledge resource in support of NCDOT Division of Aviation objectives for making North Carolina a leader in UAS integration. In this role NGAT was built to provide flight services, research services, outreach activities, and leadership to NCDOT by accomplishing the following ten objectives:

1) Pursue, win, and execute contracts and grants for UAS research, services, and products.
2) Provide UAS Flight Research and Evaluation Services for all UAS flight activities in the state.
3) Collaborate with state and local agencies for UAS evaluation and research assessments to support statewide integration under existing federal and local policies and regulations.
4) Expand the resources for supporting airspace modernization (NextGen) in North Carolina, including UAS proliferation into the National Airspace System (NAS) for commercial and civilian users.
5) Support NCDOT UAS operator licensing, permitting, testing, and training activities.
6) Support NC Department of Commerce with UAS-related economic development projects.
7) Develop a state-wide comprehensive UAS education and training program.
8) Explore opportunities to conduct lectures, seminars, and other UAS-related information sessions to students, faculty, or public audiences.

9) Develop strategic partnerships with NC-based military units to support UAS training, testing, and deployment needs.
10) Build a positive reputation for the NGAT Program within the national UAS community and North Carolina aviation sectors.

Progress on each of these objectives is documented in a monthly report throughout the lifecycle of this project along with budget status, anticipated events, and news from the community. NCDOT's investment into the NGAT program at NC State to accomplish these objectives has been mutually beneficial to both organizations. The NGAT Team has expanded scope to support NCDOT, FAA, and Consortium members to provide research and knowledge services. NCDOT has established a UAS Program Office inside the Division of Aviation (DOA) to provided dedicated resources for managing UAS growth and operations in the state. The larger UAS landscape has gone through many changes in the two years of this contract, but this relationship between NGAT and DOA was designed to adapt to evolving need.

1.2 Staffing Approach

The NGAT staffing model follows the Institute for Transportation Research and Education (ITRE) model for providing research and technical services. The team is built with talent that is multi-dimensional, flexible, and dedicated. Students were recruited to provide support for flight operations, research operations, and technical projects as needed. Full time staff changed as the broader rules evolved and the specific needs of the organization adapted to meet those demands. NGAT also used two subcontractors during this program to provide additional subject matter expertise to fulfill project requirements. The following summary describes the staffing of this project and how the team is organized today:

- Full time staff
  - Director: Kyle Snyder
  - Flight Operations Manager: Tom Zajkowski
  - Research Engineer: Evan Arnold
  - Research Operations Associate: Darshan Divakaran
  - Program Coordination: Tanisha Wyatt
- Students
  - Research Engineer: Dawson Stott
  - Research Engineer: Shreyash Gotee
  - Research Engineer: Noah Johnson
- Subcontractors:
  - Airspace Consultant: Randy Breedlove
  - UAS Operations Consultants: Nexutech
- Former staff

- Programs Manager- Jon Gorman
- Post-doc- Fred Livingston
- Students: Maddie Lawson, Charlie West, Ryan Paul

1.3 Program Support Structure

The NGAT Team worked closely with the NCDOT DOA leadership to accomplish the program support tasks outlined in the project objectives. NGAT activities against each objective were reported every month. Additional projects were defined and delivered as requirements changed and new updates were rolled out at the national level. In 2015 NGAT began reporting directly to the new UAS Program Manager inside DOA as the primary point of contact and coordination. This structure improved the efficiency and communications between the Division and NGAT at a critical time with the FAA releasing more frequent updates and with the Division pushing to meet NC General Assembly requirements, including the establishment of the UAS Permitting Program for the state.

1.4 Organization of Final Report

This Final Report is assembled in a modular format to provide the reader with multiple levels of content. The report begins with a brief recap of the major events in the UAS community since December of 2013 through the publishing of this report. The Program Support Summary section includes a summary of the major accomplishments, research, and products of the support services that NGAT has provided NCDOT. These products include a set of case studies that describe the NGAT UAS flight operations in several different contexts- applications research, partnership development, and education. Another product is a set of Best Practices for establishing a UAS program and managing UAS flight operations. The UAS community in North Carolina is vibrant and energized. The results of the NGAT research and support capture the needs of the local and national community to achieve the goal of seamless UAS integration nationwide. Opportunities for follow on research and support services are also presented. In the appendixes are detailed Case Studies, the full set of Best Practices, and a UAS Program Overview presentation that can each stand alone as products of NGAT support.

2 UAS PROGRESS

2.1 Federal Aviation Administration (FAA) Progress

The FAA has made more changes in the last three years to support UAS integration than in all of the years before 2013. These changes are the results of years of research, collaboration with industry, pressure from industry, pressure from Congress, advancement of technologies, and general advancement of modern aviation infrastructure, processes, and regulations. The following timeline (Figure 2) captures eleven major milestones in the history of UAS integration just since December of 2013. The NGAT team has supported NCDOT with impact analyses of each of these events and adapted the support plans accordingly. The rapid adoption of the Section 333 Exemption process was not anticipated when this Program Support project began in April of 2014. When the Part 107 rule was announced in June 2016, there were more than 5,500 exemptions approved with thousands remaining in the queue for processing. UAS growth in the last two years has truly been an exponential increase.

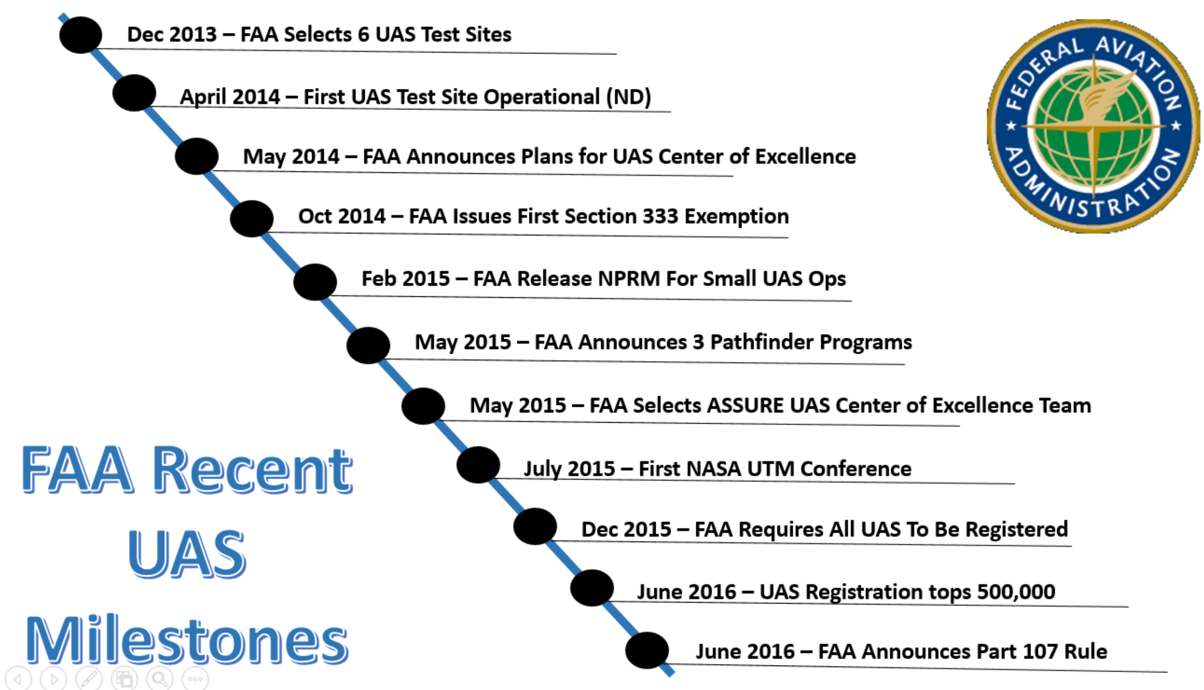

Figure 2: FAA UAS Milestones

In late 2015 the FAA also released a guidance document titled "Law Enforcement Guidance for Suspected Unauthorized UAS Operations" as a tool for preparing the general law enforcement community with the knowledge and methods for handling UAS reports. That report included a basic structure for processing UAS reports (Figure 3) and a summary of UAS authorizations at the time (Figure 4).

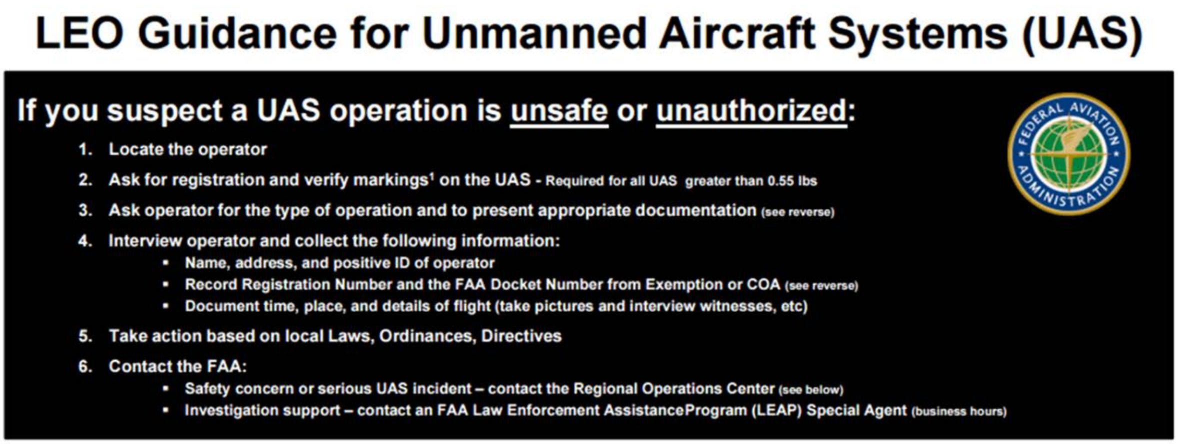

Figure 3: Law Enforcement Guidance from FAA in December 2015

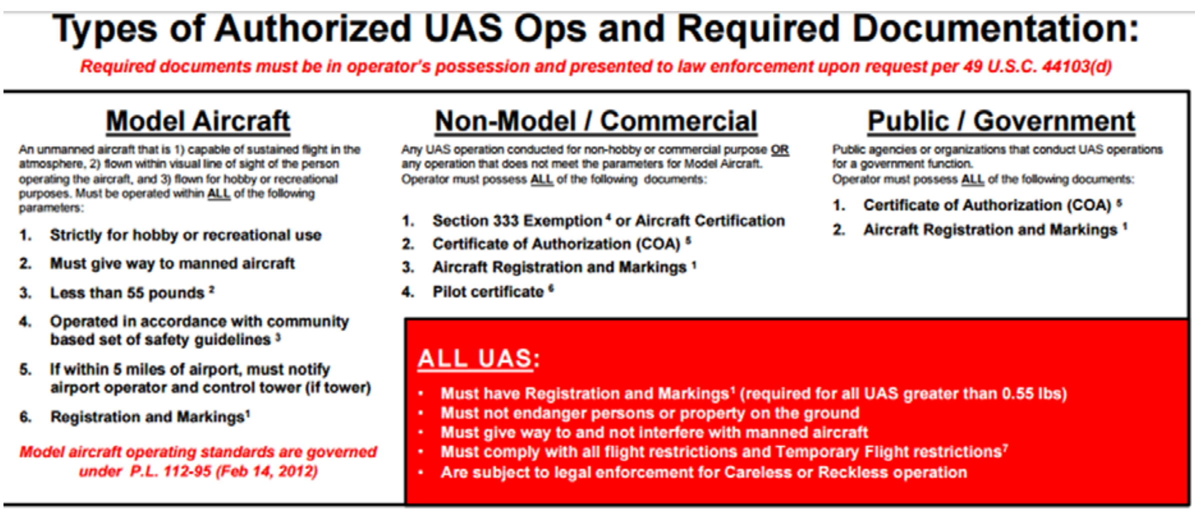

Figure 4: UAS Authorizations for Law Enforcement Guidance from FAA in December 2015

2.2 Industry

In addition to the regulatory changes in the last two years, the UAS industry has evolved just as rapidly. With the opening of the commercial services industry (via Section 333 Exemptions in October 2014), technology capabilities and staffing requirements have quickly matured and centered on a subset of qualifications. Aerial photography and video making for real estate, surveying, and marketing production are the primary mission types for the majority of the commercial exemption justifications (Figure 5) (AUVSI, 2016). Although there are plenty of flight operations to support the [originally projected target market] agriculture industry, the ability to analyze the data and provide a cost benefit from the imagery is not as straightforward as the others. There are still dozens of aircraft manufacturers designing and supplying small UAS that meet the operational requirements for commercial flights in the United States, but the

DJI product suite dominates the exemption approval list with over 60% of requests including at least one of the DJI small UAS platforms (Michel, 2016). Some other industry statistics from the UAS evolution of the last two years include:

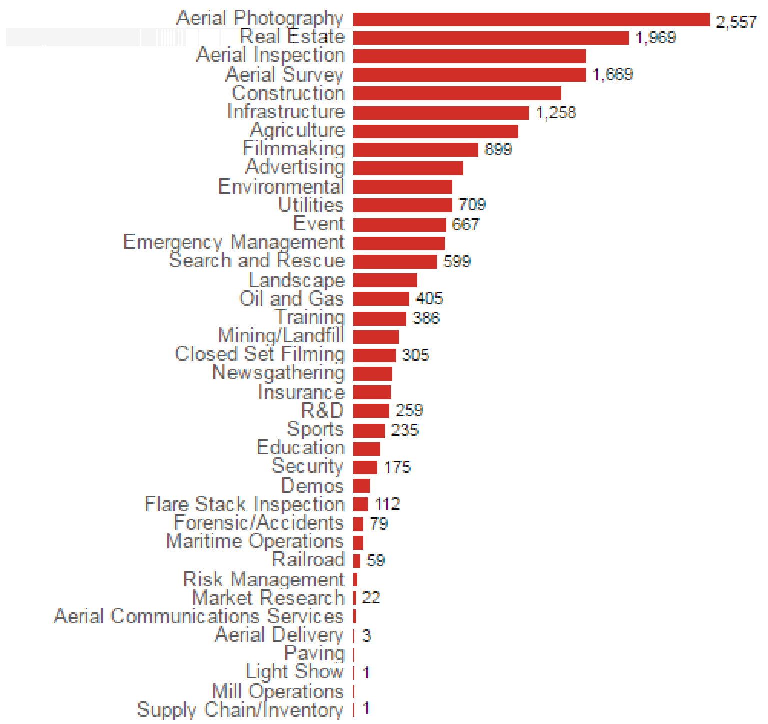

Figure 5: AUVSI Exemption Applications Analysis

- Industry users and hobbyists have registered over 500,000 UAS since the FAA started the registration requirement in December 2015. This registration number alone means that UAS outnumber general aviation aircraft at least two-to-one.
- There are approximately 100 companies based in North Carolina with UAS exemptions.
- The FAA is expecting 7 million UAS to be sold by 2020 (Levin, 2016).
- Not only is the commercial applications UAS sector projected to continuing growing, but the defense sector reliance on UAS is not expected to decrease in the coming years. Increased combat air patrols, "strike over surveillance" missions, and distribution of small UAS throughout the services will keep spending steady in that industry (Pomerleau, 2016).
- By 2025 the UAS commercial sector is the United States is forecast to surpass \$5B in economic impact (NCSL, 2016).

Other national initiatives have also helped shaped the growth and rapid adoption of UAS technologies.

- The FAA and select industry partners entered into cooperative research and development agreements to form the UAS Pathfinders Program. Those industry partners are Precision Hawk, CNN, BNSF Railroad, and CACI. The intent of the Pathfinders Program is accelerate the testing and development of UAS technologies and operating procedures to support extended line-of-sight operations, beyond line-of-sight operations, operations over people, and counter-UAS activities.

- The FAA, AUVSI, and dozens of other organizations including governments, other non-profits, and industry partners have endorsed the "Know Before You Fly" website (www.knowbeforeyoufly.com) as the recommended start location for the novice UAS user. The FAA has developed a similar smart phone app for the same community called "B4UFly". This app provides a map of known location and potential airspace conflicts in the area to consider before launching any UAS- commercial or hobbyist.

Figure 6: B4UFly App Released from FAA

- NASA has launched the UAS Traffic Management (UTM) Program to support UAS integration research in a wide variety of scenarios and configurations including urban and suburban, populated areas, over buildings and obstacles, and with manned aircraft. NASA Ames Research Center is the lead organization for UTM, but FAA, ASSURE, and dozens of industry partners have joined the program to share lessons learned, technologies, and collaborate on demonstrations. In April 2016 the UTM Program hosted a distributed exercise to demonstrate initial UTM capabilities at each of the six UAS test sites simultaneously to showcase different types of operations in different environments. The demonstration was hailed a success and even included an unexpected "virtual" site as seventh location for testing. That site was a completely simulated set of test flights at the in North Carolina south of Raleigh and was included in the demonstration because NGAT Consortium member Simulyze provides a core technology capability for situational awareness to the UTM program.
- In May 2016 the National Telecommunications and Information Administration (NTIA) released a set of "Voluntary Best Practices for UAS Privacy, Transparency, and Accountability." This set of best practices was assembled by NTIA with stakeholders from industry, associations, and government collaborating over six months to formalize a position for addressing UAS privacy concerns as adoption continues to increase. This is the most comprehensive set of best practices and recommends dealing specifically with privacy and data use for reference. (NTIA, 2016)

3 PROGRAM SUPPORT SUMMARY

3.1 Summary against Scope Objectives

The following is a brief summary of NGAT accomplishments against each of the 10 primary project objectives for NCDOT.

1) Pursue, win, and execute contracts and grants for UAS research, services, and products.
   - NGAT positioned NC State on the ASSURE team as the Command, Control, and Communications research lead. May 8, 2015 the ASSURE Team was selected to be the FAA's UAS Center of Excellence Team for the next 10 years. ASSURE funding from FAA requires a 1-to-1 match from non-federal funds. The FAA is looking at states with ASSURE schools for leadership and collaboration in support of UAS integration. ASSURE research includes small UAS, large UAS, integration with manned aircraft and air traffic control, certification, and a wide range of other research topics. www.assureuas.org
   - In the fall of 2015 NGAT supported Parson Brinckerhoff in developing the Washington State Aviation Improvement Plan to include UAS integration.
   - In the fall of 2015 NGAT collaborated with MITRE to host a workshop on UAS Airworthiness Analysis with NC State's Mechanical and Aerospace Engineering Department.
   - Officially recognized as a university Consortium, NGAT is established with service center rates to offer UAS flight operations, data analysis, and consulting services to NGAT consortium members.
2) Provide UAS Flight Research and Evaluation Services for all UAS flight activities in the state.
   - NGAT maintains a relationship with Raleigh-based Precision Hawk to support UAS testing and research operations. In 2014 and 2015 this partnership provided both sides benefits by showcasing North Carolina's commitment to UAS growth and maturation of the Precision Hawk product line. This collaboration is documented in Appendix 7: The Precision Hawk Partnership.
   - NGAT has worked with North Carolina Emergency Management since 2012 to prepare for UAS integration. In 2015 NCEM committed to developing a UAS program. NGAT hosted training on the Trimble UX5 system, supported continued training for the NCEM flight crew, and reviewed the Certificate of Authorization package development before submission to the FAA. In June 2016, NCEM hosted their first COA UAS flight at the NC State Lake Wheeler Farm flight location with NGAT onsite as observers (Figure 7).

Figure 7: NC Emergency Management First UAS Flight

3) Collaborate with state and local agencies for UAS evaluation and research assessments to support statewide integration under existing federal and local policies and regulations.
   - NGAT has worked with NCEM, North Carolina Department of Insurance, Wake County Emergency Management, City of Raleigh, the University of North Carolina System Office, and the NC Community College system to support UAS integration and standards development.
   - NGAT collaborated with the State Bureau of Investigations, Highway Patrol, and Chief Information Officer's Office to develop a Law Enforcement working group in 2014. This group was disbanded in 2015.
4) Expand the resources for supporting airspace modernization (NextGen) in North Carolina, including UAS proliferation into the National Airspace System (NAS) for commercial and civilian users.
   - NGAT maintains a current knowledge base of ADS-B advancements and integration activities as they relate to UAS and NextGen progress.
   - NGAT works closely with Raleigh-based SmartSky Networks to monitor advancements in airborne network technologies. SmartSky Networks is a unique resource in the state that is poised to have a major impact on the aviation community in the coming years.
   - NGAT is also evaluating the impacts of NASA UTM technology and components such as Simulyze's Mission Planner on NAS modernization.
5) Support NCDOT UAS operator licensing, permitting, testing, and training activities.

- In 2015 the NGAT team supported DOA with UAS and North Carolina airspace subject matter expertise to develop the aeronautical knowledge test content for the NC UAS Permit program. The team provided a sample set of questions and answers across a wide range of topics related to UAS, safe flight operations in the North Carolina, state laws, and FAA regulations.
- The team also provided recommendations for candidates for evaluating the testing and permitting process. These candidates included NGAT Consortium members and other representatives from across the state that had expressed interest in performing UAS operations or supporting such an activity.

6) Support NC Department of Commerce with UAS-related economic development projects.
    - NGAT supported several meetings with Department of Commerce for UAS and aviation related initiatives. NGAT attended multiple meetings between Commerce and Precision Hawk. NGAT also facilitated a meeting between Commerce Secretary Decker and Olaeris, as Olaeris was still trying to decide where to establish initial corporate headquarters.
    - NGAT also support Commerce Project Panther with research and onsite expertise. Although this project was not successful, NGAT's reputation as an aviation resource and commitment to the state was appreciated.
7) Develop a state-wide comprehensive UAS education and training program.
    - This concept is still under development to meet the evolving rules and opportunities.
8) Explore opportunities to conduct lectures, seminars, and other UAS-related information sessions to students, faculty, or public audiences.
    - UAS integration and technology has been such a hot topic over the last four years and North Carolina has established ourselves as national leader in this dynamic arena, that the opportunities to share our experience and structure are plentiful. Invitations to speak at local, state, and national events come in to NGAT almost weekly. These invitations have provided NGAT the platform for educating the general public on the design and intentions of the North Carolina UAS Program, why NCDOT has invested in NGAT, and what the NGAT research and services have accomplished since 2012. A list of events where NGAT was invited to speak or attended for knowledge is provided in Section 3.4.
9) Develop strategic partnerships with NC-based military units to support UAS training, testing, and deployment needs.
    - NGAT has developed a core set of relationships with most of the military units based in the state and also the UAS Integration Office in the Pentagon. Mr. Steve Pennington is the Executive Director on the Policy Board for Federal Aviation from the Department of Defense and is very familiar with North Carolina's UAS integration efforts.

- NGAT has a strong working relationship with the Airspace Manager at USMC Cherry Point. At the last NGAT UAS Public Forum in June 2016, there were six attendees from Cherry Point including UAS operators and air traffic controllers.
- NGAT has built a trusted relationship with US Army Ft Bragg Airspace Management leadership. As Ft Bragg prepares for Gray Eagle integration into MacKall Army Airfield in 2017, they continue to explore opportunities for more testing and training options.
- NGAT has spoken at the NC Military Business Center annual Aerospace Suppliers and Manufacturers Conference every summer since 2013. This conference continues to provide opportunities to share latest UAS progress, but also explore new channels for collaboration.
- NGAT collaborated with the Ft Bragg small UAS unit and the NC National Guard small UAS team to explore joint COAs for UAS testing and training. As the FAA rules have evolved, there was no need for a formal relationship, but the communication structures are established and refreshed regularly.

10) Build a positive reputation for the NGAT Program within the national UAS community and North Carolina aviation sectors.
    - Due to the speaking invitations and outreach that NGAT has engaged in to promote the NC UAS Program since 2012, North Carolina is recognized as a UAS leader with a deliberate plan for UAS integration and management.
    - Olaeris has selected North Carolina as their headquarters because of the state's commitment to UAS integration and investment in NGAT to support corporate development. Other companies are reaching out to NGAT to understand what other opportunities are available for testing, development, and research in the state. Many of these organizations are joining the NGAT Consortium, but are aware of North Carolina's commitment to UAS because of the national recognition from the UAS Permitting Program, ASSURE, and national presentations.
    - NGAT Director, Kyle Snyder, has been a member of the AUVSI UAS Advocacy Committee since 2014. In this role, NGAT is able to maintain current knowledge of national policy and federal activities related to UAS integration. In addition to supporting AUVSI position statements, the Committee shares insight into current topics such as FAA reauthorization impacts on UAS, proposed federal legislation related to UAS, FAA plans including the long-anticipated Part 107 release and the goal to release the "Flights Over People with Micro UAS" NPRM in December of 2016. This committee consists of national leaders and legislative affairs representatives from large and small companies across the country.

3.2 UAS Flight Operation Vignettes

The following eight flight summary vignettes are included in Appendix 7 as examples of the NGAT research and flight operations from the last two years. These summaries highlight NGAT's focus on small UAS integration into the National Airspace System (NAS) for commercial and civilian operations. With less than 25 flights and only a couple hours of flight time recorded when this Support Project started, the last two years have provided many opportunities to put UAS technologies and approvals into action around the state. These vignettes describe examples of UAS applications including agriculture and surveying in a range of operating conditions using multiple aircraft and payload configurations. These vignettes also document how NGAT has built relationships with industry and other government partners to show how North Carolina's UAS Ecosystem is built for longevity and collaboration.

Each vignette is presented using the following format:

- Vignette Name
- Primary Objectives- mission type(s), flight goals
- Aircraft used- UAS selected to achieve primary objectives
- Location(s) of flight operations- location(s) selected to accomplish primary objectives
- Flight Data- hours, environmental conditions, type of data, frequency
- Description- overview of the flight plan(s) and goals of the individual case
- Results- sample imagery and description of the products of the flights

Vignette List for Appendix 7:

1) The Construction Site Project
2) UAS for Agriculture Nitrogen Management
3) UAS for Emergency Management
4) UAS for Inspections
5) Hyde County Flight Operations
6) The Precision Hawk Partnership
7) The Constellis Partnership
8) North Carolina State Fair Exhibits

3.3 Best Practices Development

In 2015 the NGAT Team began assembling a set of Best Practices for UAS operations to support the broader integration of UAS statewide, in particularly the adoption of UAS by government agencies at multiple levels. This set of best practices is intended to provide guidance, lessons learned, and shared experiences in establishing a safe, repeatable, effective UAS program. The collection of best practices is a "living document" that may change as regulations or experience evolve to meet current practices, standards, and requirements. At the publishing of this set of practices, NGAT provides the following as guidelines for other public agencies, but these may be adapted by commercial companies also. The complete set of Best Practices is included in Appendix 8.

1) State Agencies and User Communities
2) Expectation Management
3) Operational Procedures
4) Crew Selection
5) Data Management
6) Procurement
7) Outreach
8) Policies
9) Business and Operation Model
10) Level of Government Operations

3.4 Major Conferences, Events, and Presentations

The NGAT team had two objectives related NCDOT education and outreach goals that required team members to attend many local, state, and national events to share the North Carolina UAS Program concept, or to learn about other activities that potentially impacted the North Carolina program. These two objectives were:

1) Explore opportunities to conduct lectures, seminars, and other UAS-related information sessions to students, faculty, or public audiences.
2) Build a positive reputation for the NGAT Program within the national UAS community and North Carolina aviation sectors.

The following list is a review of the major events that NGAT participated in during this project to fulfill these two objectives. An NGAT representative was invited to participate in most of these to share information about the UAS Program in the state as a partnership between NCDOT, NC State University, and industry. The latest NGAT briefing on the “NC UAS Program Overview” is included in Appendix 9.

- 2014
    - GIS/Surveyor Series for Gary Thompson (NCEM), across the state
    - ACEC Regional meeting, Raleigh, NC
    - North Carolina Chapter of the National Ag Aviation Association 2014 Annual Conference, Raleigh, NC

  - NGAT Annual Public Forum, Raleigh, NC
  - AUVSI 2014, Orlando, FL
  - VTOL UAS Conference, Greenbelt, Maryland
  - Extension Disaster Education Network (EDEN) Annual Conference, Florence, Alabama
  - State FIFRA Issues Research and Evaluation Group (Pre-SFIREG) regional meeting, Chattanooga, Tennessee
  - National Aviation Day, Kitty Hawk, NC
  - 2014 NC State Fair Exhibit, Raleigh
  - North Carolina Aerospace Suppliers and Manufacturers Conference, hosted by NC Military Business Center, Winston Salem, NC
  - 2014 TAAC Conference, Albuquerque, New Mexico
  - UAS Center of Excellence Proposal Development meetings- Chicago, Mississippi State University, Washington D.C.
- 2015
  - Southern Ag Leaders Conference, Myrtle Beach, SC
  - North Carolina Chapter of the National Ag Aviation Association 2015 Annual Conference, Carolina Beach, NC
  - IEEE Chapter 2015 RoboResearch Conference, Charlotte, NC
  - FedCASIC Conference, Washington, D.C.
  - ASPRS GeoTech Chapter Conference, George Mason, VA
  - NCSU Law Enforcement Executive Program (LEEP) briefing, Raleigh
  - Dare County STEM Day Presentation, Manteo, NC
  - NGAT Annual Public Forum, Raleigh, NC
  - Civil Air Patrol briefing, Raleigh, NC
  - AUVSI 2015, Atlanta, GA
  - NASA UTM 2015, Palo Alto, CA
  - South Carolina Aerospace Conference, Columbia, SC
  - North Carolina Aerospace Suppliers and Manufacturers Conference, hosted by NC Military Business Center, Raleigh, NC
  - UAS Commercialization Conference, Washington, D.C.
  - 2015 NC State Fair Exhibit, Raleigh
  - Department of Justice UAS Convening, Washington D.C.- representing State CIO office
- 2016
  - NCSU Law Enforcement Executive Program (LEEP) briefing, Raleigh
  - IEEE Chapter 2016 RoboResearch Conference, Raleigh, NC
  - FAA UAS Public meeting, Daytona Beach, FL

- AUVSI 2016, New Orleans, LA
- NGAT Annual Public Forum, Raleigh, NC
- (invited) North Carolina Aerospace Suppliers and Manufacturers Conference, hosted by NC Military Business Center, Winston Salem, NC

3.5 NGAT Resources

The following summary describes the status of the NGAT Program at NC State University at the conclusion of this support contract. The facilities, equipment, data, and approvals provide the baseline for future research and support activities. The Consortium membership is developing a 5 Year Strategic Plan that the collective membership will follow to meet their objectives and ambitions for aviation in the state.

Figure 8: KSI Data Sciences Mission Caster Box

3.5.1 Budget Status

NGAT has completed the contract on schedule and under budget. The remaining budget from the contract will not be invoiced to NCDOT.

NGAT Final Budget Report	Total Budget Mod 4	Cumulative Expenditures	% Used	Remaining
1. Subtotal: Personnel + Fringe Benefits	$813,696	$804,834	99%	$8,862
2. Contracted Services	$103,000	$98,423	96%	$4,577
3. Supplies and Materials	$255,127	$254,025	100%	$1,102
4. Domestic Travel	$47,500	$41,240	87%	$6,260
5. Current Services	$4,228	$1,708	40%	$2,520
6. Fixed Charges	$51,796	$42,374	82%	$9,422
7. Equipment	$0	$0	0%	$0
8. Subcontracts	$0	$0	0%	$0
9. Graduate Fellowship- GIS Analyst	$11,000	$10,998	100%	$2
Subtotal Direct Costs (Items 1-8)	**$1,286,347**	**$1,259,603**	100%	$26,744
10. Facilities & Administrative Costs	$255,050	$263,922	103%	-$8,872
Total costs:	**$1,541,397**	**$1,523,525**	**99%**	$17,872

Figure 9: Final Project Budget Status

3.5.2 Equipment-

The following list of hardware and software describes the tools and resources that NGAT has acquired since 2012 to support UAS testing and research. Some of this equipment was purchase on a Golden Leaf Foundation grant, some through NCDOT projects, and some through NGAT Consortium membership support. All of this equipment is managed by the acquisition and facilities management policies at the university using the approved Technology Control Plan when necessary.

- 1 Trimble UX5 small UAS- donated for Consortium membership and ASSURE research by Trimble.
- 1 DJI Inspire Pro UAS with Thermal camera- purchased with Consortium membership funds.
- 1 Nikon D5200 camera with lenses- purchased with Golden Leaf funds.
- 1 Simulyze Mission Manager license- purchased with UAS Support Contract funds.
- 1 KSI Data Sciences Mission Caster (Figure 8) and Mission Keeper software license and hardware- originally purchased with UAS Support Contract funds, renewed as a donation to Consortium for membership dues.
- 1 NAO Robot- purchased on Golden Leaf Foundation funds.
- 30 licenses of TinMan Systems A.I. Builder Software suite- donated for Consortium membership dues and community research.
- 3 Vireo Small UAS aircraft systems- purchased on Golden Leaf Foundation funds. Systems are currently retired and used for ground based testing.
- 1 broken Leica X6 UAS system- purchased on NCDOT Photogrammetry and Surveys research project.

3.5.3 Approvals

The NGAT approvals for UAS operations have evolved significantly over the last two years. At one point the NGAT Team was holding 20 FAA Certificates of Authorization to conduct UAS research in the state. In 2015 the NGAT began the process to collaborate with the FAA to obtain a statewide public COA for UAS research and services operations. The intent of the statewide COA was to get away from aircraft-location specific COAs and streamline NGAT operations and reporting to look similar to what the FAA had initiated with Section 333 Exemption holders, but also provide more access to public agencies, especially other public universities, that wanted to do UAS applications research. That structure is now in place and NGAT is aggressively developing the roll out plan to support statewide operations using the included Best Practices, the statewide Blanket COA, and an NGAT certification program to implement a flight program.

- FAA approved Certificate of Authorization (COA)
  - Puma UAS at Constellis property in Moyock, ceiling 1,500’
  - Nationwide Blanket COA for small UAS below 400’.

- FAA Section 333 Exemption
  - 400’ ceiling

  - Aircraft: DJI Inspire, DJI Phantom 2, Leica Geosystems Aibot X6, Trimble UX5, PrecisionHawk Lancaster III, Prioria Maveric, Sentera Vireo, and Sensefly eBee.
  - Issued February 5, 2016.

- Written permission to access property at the following:
  - NC State University- Centennial Campus (Lake Raleigh), Lake Wheeler Field Lab, Butner Beef Lab, Vernon James Research Center (Plymouth, NC).
  - Green Swamp outside Supply, NC from The Nature Conservancy.
  - North Carolina A&T University, Greensboro, NC- Farm Lab.
  - Hyde County Airport, Engelhard, NC- also recognized as Gull Rock Test Site (GRTS).
  - Constellis Property, Moyock, NC.
  - A construction site outside of Wilmington from a Consortium member.
  - Bodie Island Lighthouse grounds inside Hatteras National Seashore from National Park Service via NCDOT for aerial application testing.

- 5 team members with NCDOT UAS Permits.

3.5.4 Facilities

In addition to the properties that NGAT has access to conduct UAS flight operations at as described above, the NGAT team has access to the following facilities.

- NCSU Hunt Library Visualization Lab (Figure 10)
- NCSU Center for Geospatial Analytics
- The Wireless Research Center of North Carolina

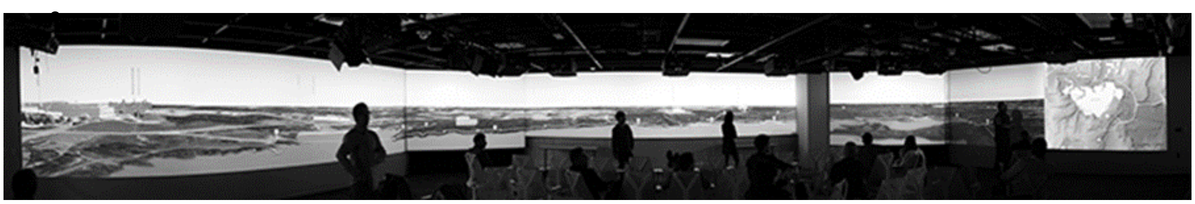

Figure 10: NCSU Hunt Library Visualization Lab

3.5.5 Consortium Members

The NGAT Consortium at NC State University is a consortium of academia, industry, and government agencies created to provide a research and application–oriented, technology transfer-focused organization for conducting aviation technology development, investigations, and field trials. The Consortium's focused is modern aviation, not just UAS, with a commitment to common objectives. NGAT's mission is *to* *discover, evaluate, implement, and disseminate advanced air transportation technologies at the regional, national, and international level to improve the capacity, safety, and environment surrounding air transportation.* The Consortium members understand the economic and strategic value of accessing airspace and creating new technologies to exploit that value. Collectively the Consortium is developing a 3 Year Strategic Plan to determine priorities and membership activities that support the immediate mission-related needs of the members. NGAT's current membership is listed in Table 1.

Table 1: NGAT Consortium Membership as of June 30, 2016

Affiliate Members			**Full Members**	
1.	Alpha and Omega Group		**26.**	East Carolina University
2.	Constellis		**27.**	KSI Data Sciences
3.	Corvus Analytics		**28.**	Precision Hawk
4.	Duncan Parnell		**29.**	RTI
5.	K2 Solutions		**30.**	Simulyze
6.	Kross		**31.**	TinMan Systems
7.	McKim and Creed		**32.**	Trimble
8.	MetLife			
9.	MIT Lincoln Labs			
10	Nexutech		**Associate Members**	
11	Olaeris		**33.**	Central Carolina Community College
12	Primal Space Systems		**34.**	Duke University Marine Lab
13	SEPI Engineering		**35.**	University of Central Florida
14	Sitech			
15	Stewart Engineering			
16	VetDS			
17	White Top Aviation			
18	City of Raleigh			
19	NC DNCR (LWS)			
20	NC East EconDev			
21	NC Emergency Management			
22	Wake County EM			
23	Brooks Pierce Law			
24	KS Law			
25	Safran Law			

4 FINDINGS AND CONCLUSIONS

4.1 Results

There are many examples of the results of the support that NGAT has provided NCDOT over the last 2 years to consider this project successful. Some of these results may not show value for years later as NGAT continues to conduct UAS flight operations and support FAA research activities; while some of these results are already influencing UAS activities in the state. Here is a short summary of highlights from the NCDOT UAS Program Support for the last two years:

- NGAT has accumulated approximately 1000 flight and 200 hours of UAS flight time since the “first flight” March 21, 2013.
- NCDOT has received an allocation of $2.5M per year for 2 two years in the 2015 state budget appropriation for UAS Program Management. This follows the 2013 $2.5M that was targeted at developing the UAS flight test program. Continued investment from the state demonstrates that NCDOT (and NGAT) are meeting legislative expectations.
- NGAT has provided dozens of UAS Overview Briefings to educate the public and specific audiences on the growth of UAS opportunities, technologies, and responsible UAS operations. The latest example of this briefing is in Appendix 9.
- NGAT has connected the UAS community in North Carolina. Over 160 attendees participated in the June 2016 NGAT Annual Public Forum.
- The state is ready for broad UAS integration under FAA Part 107 and the North Carolina UAS Permit Program. With an initial set of standard operating procedures, best practices, and lessons learned from NGAT, in addition to the plethora of examples from the rest of the user community, the value proposition for UAS integration is easier to define now than it ever has been before. State and local agencies are regularly inquiring about processes and recommendations for launching UAS activities in their routine work flow.
- NGAT has a growing number of data sets that include telemetry from flight operations, airspace use, imagery, and videos from a variety of missions.
- As a member of the ASSURE Alliance for the FAA UAS Center of Excellence, NC State is a member of an elite set of 21 universities specifically tasked with accelerating UAS integration in the NAS research over the next nine years. The matching requirement on FAA funds provides the state and industry partners the opportunity to demonstrate their respective commitments to the research required for UAS integration.
- North Carolina is recognized as a national leader in UAS integration! “I think North Carolina has done the best job of anybody I’ve seen,” the Alabama

Agriculture and Industries Commissioner John McMillan said in a 2015 Alabama UAS Task Force meeting. "They have passed legislation addressing key issues" (Lyman, 2015). North Carolina also virtually participated via simulation in the April 2016 NASA UTM national demonstration (Simulyze, 2016).

4.2 Needs

NGAT is well positioned to continue supporting North Carolina's UAS Program development as commercial operations expand and capabilities are increased. NGAT is exploring many options for further research with multiple organizations, while also collaborating with Consortium members to define services projects that include flight operations, data analysis, and knowledge exchange. NGAT has identified the following five topics as "High Needs" areas for maintaining North Carolina's leadership position in the UAS community:

1) Training standardization. Training government and industry organizations on proper UAS program management, not just flying is critical to implementing a responsible UAS flight culture.
2) Supporting industry growth. The commercial benefits of UAS technology and services has transitioned the industry from a defense sector niche into an everyday experience. Private companies developing UAS services and technologies are developing formal partnerships with governments that are willing to invest in the future and tackle the next set of integration challenges. The FAA Pathfinder programs are one national example, but companies like Precision Hawk have developed programs with other universities and state agencies to achieve common goals, where the industry partner was not expected to fund all of the effort. State matching funds to support the ASSURE Center of Excellence research helps prioritize NC State lead projects and that funding could be distributed to other UNC System schools or industry partners based in the state contributing the advancement of UAS integration technologies and research.
3) The state needs to continue encouraging UAS, "NextGen," and intelligent transportation system technology development, not just policy and regulation changes.
4) The state needs to actively monitor the pre-emption discussions currently dominating UAS policy discussions in Washington, DC (Miller, 2016). States and localities want some ability to manage/regulate access to airspace, while FAA and much of industry want a national authority to dictate the policies for all. State's that engage local constituents, the North Carolina League of Municipalities for example, to develop a position for federal and state legislative discussions will shape the long-term national policies.

5 RECOMMENDATIONS FOR FUTURE RESEARCH AND SUPPORT

There are many directions for NGAT to continue supporting NCDOT UAS Program activities. NGAT is prepared to collaborate with NCDOT and other state organizations to define specific research and support projects. Education remains the most effective method for developing a safe and responsible, active UAS user community that is self-monitoring. The Academy of Model Aeronautics attributes the decline of UAS sightings around airports to the increased education and awareness of proper UAS use over the last 18 months (AMA, 2016). Training and familiarization with capabilities and operations are essential to UAS integration and effective utilization in routine operations. Technology development will continue evolving and transition away from hardware and UAS aircraft design into infrastructure and data exploitation solutions for both airspace management and mission data usage. The following recommendations are potential topics for future research and support that can be expanded at any time on request.

5.1 Support Recommendations

- Workshops and Flight Exercises. NGAT recommendations establishing a series of workshops and flight exercises that focus on specific user communities and applications for UAS integration. These events will include flight demonstrations and data collection in live environments, while also gathering stakeholders from a targeted community to discuss the role of UAS in data collection, flight integration, technology access, and policies related to that subject area. The NGAT Team has unique experience developing and hosting these kinds of events at a national level for wildfire integration in 2009-2011.
- Educational Forums. NGAT recommendations establishing a monthly educational on a range of UAS topics that can travel around the state for informing the community on a specific topic. Sessions may focus on specific UAS applications and data sets, operational best practices, operations in specific areas (near airports, higher elevations, etc), or work force skill needs.
- Policy analysis and development. For North Carolina to maintain leadership in UAS policy development, NGAT recommends performing a national survey of what other states have implemented or considered for UAS regulations. This analysis should specifically address positions on preemption, personal property protection, and state registration/permitting programs (Froomkin, 2016).
- Endorse an NGAT UAS Operations Certificate. NGAT is developing a baseline UAS operations toolkit that includes a recommended set of hardware, software, service, best practices, operating procedures, and training classes for establishing a UAS flight program. NGAT is integrating elements from ASSURE UAS certification research, existing UAS training programs, FAA Part 107 requirements,

and statewide operational experience to develop the baseline toolkit. Working with other state agencies such as the NC Department of Insurance, NC Emergency Management, and Department of Natural and Cultural Resources, NCDOT and NGAT can develop a program that is scalable and flexible to meet a wide range of missions while streamlining the adoption process in the state.

5.2 Research Recommendations

- Command and Control (C^2). This is the focus of NGAT and NC State research on the ASSURE Team for the Center of Excellence activities. C^2 is also a critical component of modern aviation under the NextGen program as airspace becomes a digitized environment. Testing new data communication technologies ("Data Comm" in NextGen circles), autonomous control, and airborne broadband can accelerate North Carolina even further ahead into NextGen performance. With Charlotte Douglas Airport already recognized as NextGen leader (FAA, 2016), NGAT recommends more research into spectrum management and connectivity of airspace users. NGAT has relationships with multiple C^2 communication companies that would be interested in testing advanced concepts in North Carolina if there was an environment established that enabled such testing. The Ft Bragg Gray Eagle team would like to operate training flights in airspace broader than the Restricted Area around Ft Bragg. With the air traffic radar at Stanly County airport and the Ground-Based Sense and Avoid radar that the Army is installing at MacKall Army Airfield for Gray Eagle operations, there is a large corridor of airspace that will have multiple layers of coverage to provide high levels of traffic surveillance and monitoring. This would be a great location for an Advanced Aviation Command, Control, and Communications test area for UAS and other aviation users to come to North Carolina for accessing. SmartSky Networks is a local company ready to be a test client. NGAT is prepared to manage this kind of operation.
- ASSURE matching. NGAT recommends NCDOT provide a minimum annual matching commitment to NC State for the ASSURE Center of Excellence research activities. This matching can fund development of ASSURE research projects with FAA and industry partners, subcontracts to North Carolina based companies collaborating on ASSURE projects, or other North Carolina education institutions collaborating on ASSURE projects. NCDOT ASSURE matching strengthens NC State's ability to receive FAA and industry funding of projects while also investing in local resources to accomplish UAS integration. No other state has made such a formal commitment to an ASSURE university.

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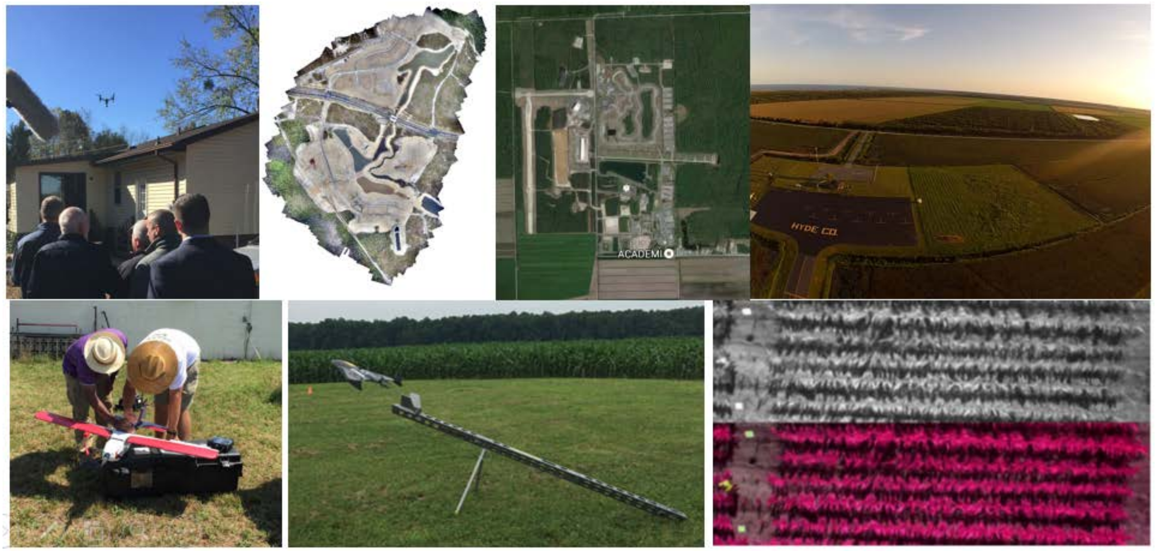
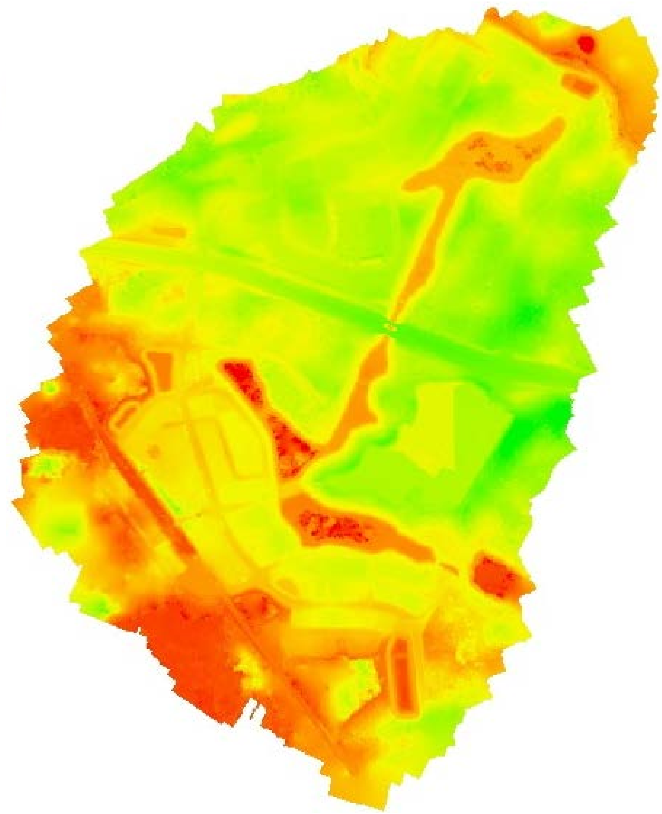
7 APPENDIX A: UAS FLIGHT OPERATION VIGNETTES



The following set of UAS flight operation vignettes are intended to provide a sample of the types of research and services that the NextGen Air Transportation Program (NGAT) has performed over the last four years in supporting the NCDOT Division of Aviation and the UAS community in North Carolina with UAS integration. These sample cases are brief descriptions of UAS operations focused on specific research for UAS applications, flight services to support an industry or public partner, or to provide education on UAS capabilities. Each of these examples includes a brief description of the flight activity, the types of data and flights that were performed, and sample results from the flights. Each of these vignettes is an aggregate of multiple flights over an extended period of time producing results including lessons learned, actionable imagery, and strong relationships. The eight sample vignettes are:

Table 2: UAS Integration Vignettes

1- The Construction Site Project	5- Hyde County Flight Operations
2- UAS for Agriculture Nitrogen Management	6- The Precision Hawk Partnership
3- UAS for Emergency Management	7- The Constellis Partnership
4- UAS for Inspections	8- NC State Fair Exhibits



7.1 The Construction Site Project

Date	April 2016
Primary Objectives	Orthomosaic Overlay, Construction 3D model, 3D Volumetric Analysis, Contour Line Map, 2D Distance Measurement, Surveying Earthwork
Aircraft	Trimble UX5
Location	River Road, Wilmington, NC

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	30 mins
	Pre & Post Flight Setup	30 mins
	Processing Time	7-8hrs
Conditions	Weather	Good, Light Winds
	Ground	Construction area, Sand, Trees, Initial roads
Type of Data	Sensor	Sony NX30
	Pre-processing	JPG, JXL, CSV, GWT
	Post-processing	TIFF, JPG, XYZ (point cloud), KMZ
Software	Flight Control	Trimble Access Aerial Imaging Software
	Data Processing	Trimble Business Center, Agisoft, Arcmap, ERDAS Imagine

Description

UAS are the modern solution to obtain up-to-date high resolution imagery of small areas to fill in the gaps from other traditional survey methods, while providing recent and precise data. Surveying refers to the detailed inspection of an object or area in order to define its boundaries, establish its characteristics, and determine its potential. Surveying methods typically include observation, measurement, researching, and mapping. A survey is commonly performed in order to investigate infrastructure, enable urban development, and assist in mining activities.

There are several reasons why land surveyors are increasingly adding UAS to their portfolio of instruments. Firstly, using UAS can vastly reduce the time spent collecting accurate data. Raster data, in the form of geo-referenced digital aerial images can be captured with resolutions as sharp as 1.5 cm (0.6 in) per pixel. With collection of aerial imagery made more accessible, surveyors now focus on using and analyzing data, rather than working out how to gather it. Large jobs that once took weeks are now completed in just a few days, and that a week’s worth of traditional data collection is now accomplished in just one day. UAS can produce actionable data such as orthophotos, photogrammetry, 3-D models, point clouds or volume calculations surveys for land, areas and objects for preparation of site plans, contour maps and existing conditions at the beginning of a project.

Results

For The Construction Site Project, the NGAT Team was working with a construction firm that is a member of the NGAT Consortium. The firm needed an orthomosaic image of a 150-acre construction site that was being built into a neighborhood development. The digital model of the site would be used for monitoring progress, volumetric analysis, and evaluating the role of UAS-capture imagery into the construction work flow. The NGAT Team analyzed the site on Google Earth prior to the selected flight day. Once on site the objectives were reviewed, takeoff and landing locations were selected, the flight plan was developed, and the aircraft was launched. Using the Trimble UX5 for image collection, the entire site was covered in approximately 35 minutes, flying at 400 feet AGL. Over 800 images (Figure 11) were taken and processed at NGAT headquarters in Raleigh and delivered to the client.

Figure 11: Raw Data from Construction Site

Prior to the flight, eight ground control points (GCPs) (Figure 12) were established around the extent of the area of interest. The use of GCPs ensures vertical and horizontal accuracy in the processed UAS dataset. Different shapes of GCPs were used per the client's request, in order to decide which works best during processing. Out of these eight, two GCPs worked best during processing providing geo-location accuracy and stitching precision.

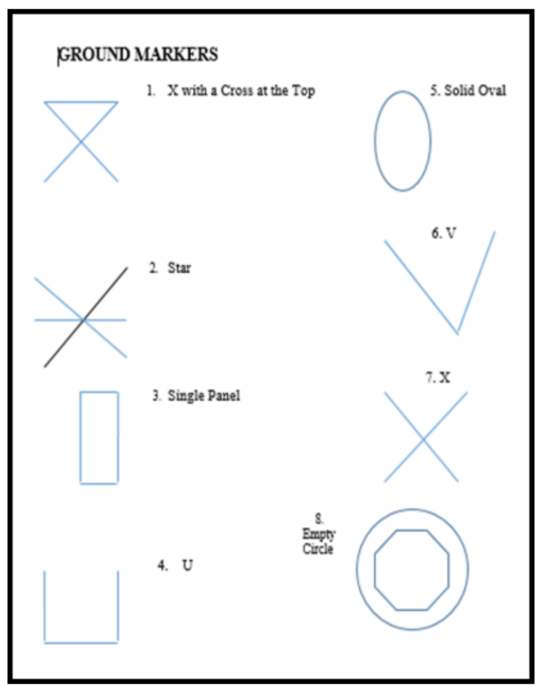


Figure 12: GCP Shapes

An Orthomosaic and Digital Surface Model (DSM) were generated using approximately 800 images from the flight. Along with this mosaic image the client requested a point cloud in order to create a 3D model. This model was used for volumetric analysis. An image classification was also done.

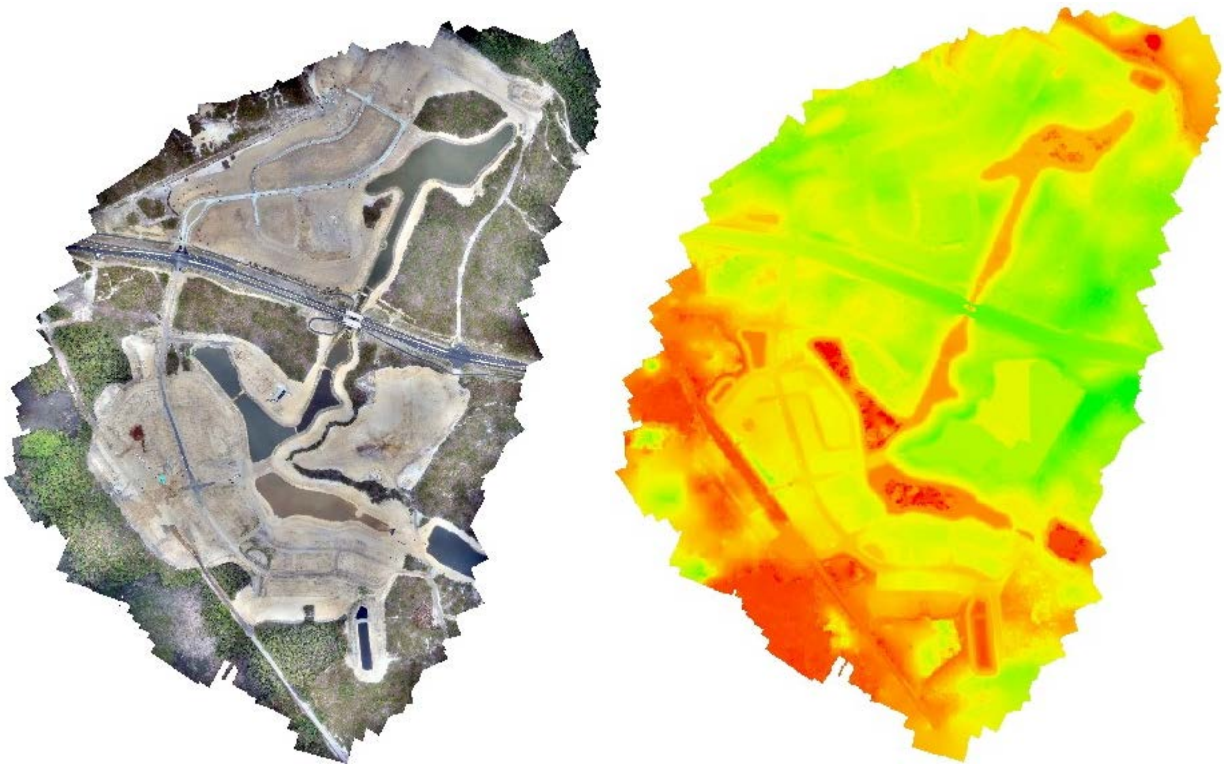


Figure 4: Construction Site Orthophoto & Digital Surface Model

7.2 UAS for Agriculture Nitrogen Management Project

Date	2014 – 2016
Primary Objective	Soil Science, Precision Agriculture, Soil Erosion mapping, Technology Assessment, University Project Support
Aircraft	Sentera Vireo, DJI Inspire, Trimble UX5
Location	Vernon James Research Station (Plymouth, NC), Lake Wheeler (Raleigh, NC)

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	15 mins per flight. Total ~75 hours.
	Pre & Post Flight Setup	15 mins
	Processing Time	2 - 3 hours
Conditions	Weather	Variable
	Ground	Field Area
Type of Data	Sensor	High resolution color, Color Infrared, Thermal Infrared, Multispectral
	Pre-processing	JPG, CSV
	Post-processing	TIFF, JPG
Software	Flight Control	Multiple
	Data Processing	Agisoft

Description

NGAT has supported Dr. Robert Austin, North Carolina State University, Soil Sciences, on a Golden Leaf Foundation funded project to determine the value of nitrogen input on row crops (corn and wheat). In this support model NGAT provided flight planning and operational services to Dr. Austin, who processed and analyzed the data. This removes the burden of flight operations from the researcher allowing him to focus on his research.

The research project started at Vernon James Agricultural Research Center, near Plymouth NC in 2015. The Vireo was originally use to collect imagery with a Tetracam multispectral sensor, and a 4K high resolution color sensor developed by NGAT student workers. The Vernon James Research Center is relatively small which limited how the flight lines could be programmed. After three Vireo data collection missions the platform was switched to the DJI Inspire. The Inspire was better suited to the small study area (5 acres) and allowed for more flexibility with the flight planning.

Dr. Austin moved his research to the NCSU Lake Wheeler Field Lab in Raleigh to allow his team more scheduling flexibility for the 2016 growing season. Again, fixed wing systems were evaluated but it was determined that the VTOL Inspire was better suited for small research plots that are surrounded by numerous obstacles. Over the life of this project NGAT and Dr. Austin's team have developed repeatable

Standard Operating Procedures (SOPs) that can be utilized for other precision agricultural applications and research.

Results

In applying crop nutrients, time equals money. Two-to-three days without nitrogen is not healthy for plants, so to compensate farmers are known to over-apply nitrogen. When they do this the excess drains off to the watershed. Since most leaf nitrogen is contained in chlorophyll molecules, there is a strong relationship between leaf nitrogen and leaf chlorophyll content, which is the basis for predicting crop nitrogen status by measuring leaf reflectance. For this research the team wanted to evaluate UAS carrying sensors that monitored crop nitrogen amounts throughout the growing season at high resolution. Using image analysis techniques to assess leaf chlorophyll content producers have actionable information to prescribe a crop management treatment on a site-specific basis.

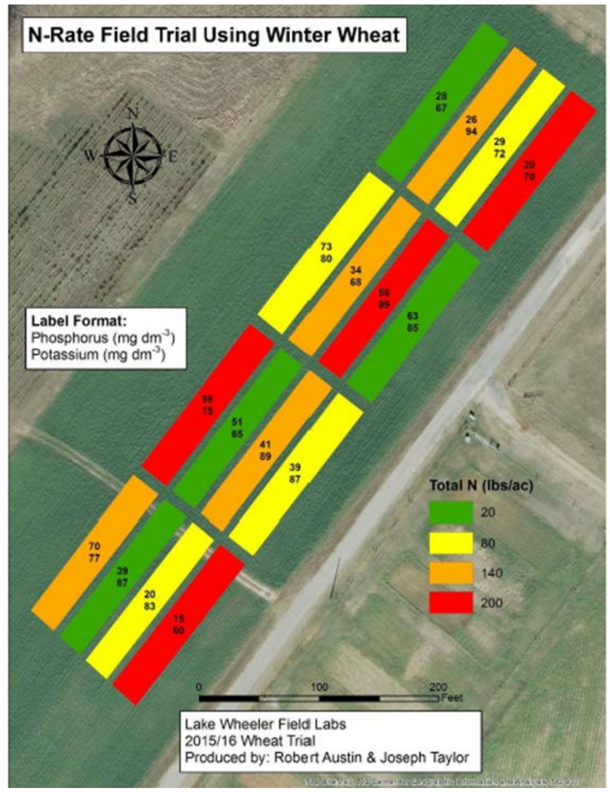


Figure 14: Nitrogen Rate Results from Winter 2016

Figure 13 shows soil phosphors and potassium levels overlaid with nitrogen treatments for the 2016 wheat trial conducted at the Lake Wheeler Field Labs in Raleigh.

Figure 13 shows a set of images that have been stitched together for evaluating nitrogen response to different rates of fertilizer in corn research plots in 2016.

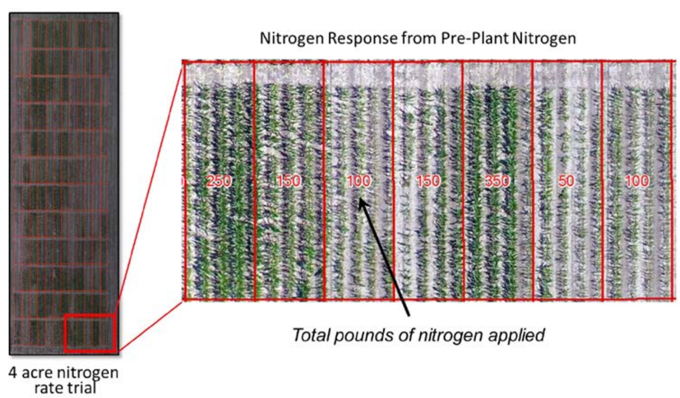


Figure 13: 2015 Corn Trial Mosaiced Image

A final report detailing the complete research on using aerial imagery for nitrogen analysis will be available in late 2016.

7.3 UAS for Emergency Response

Date	May 2016
Primary Objective	Training, Concepts of Operation Development for Emergency Response
Aircraft	DJI Inspire, Trimble UX5
Location	Harris Lake Park, Lake Wheeler (Raleigh, NC)

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	Approximately 30 hours including 1 day at Harris Lake Park
	Processing Time	Minimal processing using real-time video
Conditions	Weather	Good, Light Winds
	Terrain	Forest
Type of Data	Imagery	Hi-Res Natural Color Imagery, Natural Color, and Thermal Video
	Pre-processing	JPG
	Post-processing	TIFF
Software	Flight Control	Variable
	Data Processing	Native video player, Trimble Business Center

Description

Small Unmanned Aircraft Systems are anticipated to aid emergency management agencies through all four phases of the emergency management life cycle (mitigation, preparedness, response, recovery) now that regulations are defined. Before UAS can be utilized to their full potential they must be integrated into complex CONOPS that have existed without UAS. NGAT is working with federal, state, county, and city emergency management organization to identify areas that UAS can improve agencies' practices throughout the EM life cycle. This has been done through formal meetings, workshops, and training.

NGAT has been invited to attend and present in numerous emergency management forums including, the NC Emergency Management Association Annual Conferences, Annual Fire Cooperators Meeting, and the Florida UAS Exposition to discuss the benefits of UAS in emergency management. Through these conferences, workshops, and meetings NGAT has formed partnerships with several agencies. Two of these agencies, NC Emergency Management (state-level) and Wake County Emergency Management, have worked closely with NGAT while developing their UAS programs.

North Carolina Emergency Management (NCEM)

NC State EM is the only other state agency besides NGAT that currently has an active COA approved by the FAA. NGAT assisted this effort by supplying NCEM thorough documentation for the COA which included the NCSU developed Statement of Airworthiness for their aircraft and a baseline set of Standard Operating Procedures. NGAT and NCEM collaborated with comprehensive training that included NCEM personnel attending the NCSU Trimble UX5 training session in 2014 and NGAT personnel attending the NCEM private ground school classes. NCEM has also used the NGAT COA for currency training.

Wake County Emergency Management

Wake County EM has been working with NGAT to help them develop a UAS program to aid their search and rescue operations. On May 13, 2016 NGAT flew a DJI Inspire through fly three different search and rescue scenarios (Figure 15). One of the lessons learned was that the natural color video cameras could not reliably detect lost individuals in a typical North Carolina forest. NGAT is now working with Wake County to evaluate thermal imagery performance in future exercises. For the first three test scenarios, three subjects were in the search area wearing - camouflage clothing, blaze orange clothing, and dark color to provide the best assessment of visual recognition capabilities from the UAS.

Figure 15: Preflight Briefing During Search Exercise

Results

The results from the NGAT Support for Emergency Management take several forms. Lessons learned have been integrated into NGAT Best Practices. Recommendations for UAS integration and decision making have been shared with both organizations. Future exercises and training needs have also been identified.

NCEM Results

- UAS flight crew is trained.
- NCEM Blanket COA for small UAS operations below 400’ is approved by the FAA.
- Conducted first COA flight at Lake Wheeler June 15, 2016.
- Team is ready for operational missions to support flood plain mapping, survey, photogrammetry missions with the Trimble UX5.

Wake County Emergency Management

- 3 Scenarios were tested in the exercise at Harris Lake Park (Figure 16 and Figure 17)
  - **Scenario 1: Lost Hikers**
    - Hikers lost in the woods.
    - Incident Commander (IC) has contact with hikers via cell.
    - Hikers will wave/signal when asked to.
    - Potential Questions for Hikers
      - Can you see the UAS?
      - Can you hear the UAS?
      - Can you guide the UAS towards you?

    - **Scenario 2: Nursing Home Walk Off**
        - Alzheimer’s Patient walked Off from Nursing Home
        - Last Known Point Known with General Direction of Travel (towards the tree line).
        - No contact with the subject/Subject cannot signal
    - **Scenario 3: Despondent Subject**
        - IC has contact with subject through third party (mother/father/etc).
        - No safety concerns/weapons (verified by third party)
        - UAS Air Operations Team to guide in search team towards subject. Subject will not wave/signal nor will the subject provide feedback on the UAS (sight, sound, location).
- Lessons learned from the exercise
    - All three scenarios were “successful” in that each one provided at least one lesson learned.
    - UAS integration requires 3 dedicated resources: a pilot, an observer, and a sensor operator to interact with search crews.
    - Need to evaluate the performance of a thermal camera.
    - Need to perform more exercises for familiarization and ConOps development.
    - Probably need a system with a longer battery life than a DJI Inspire.
    - Ready to move ahead with a Blanket COA or Part 107.
    - Join NGAT Consortium to connect with community and maintain state momentum.

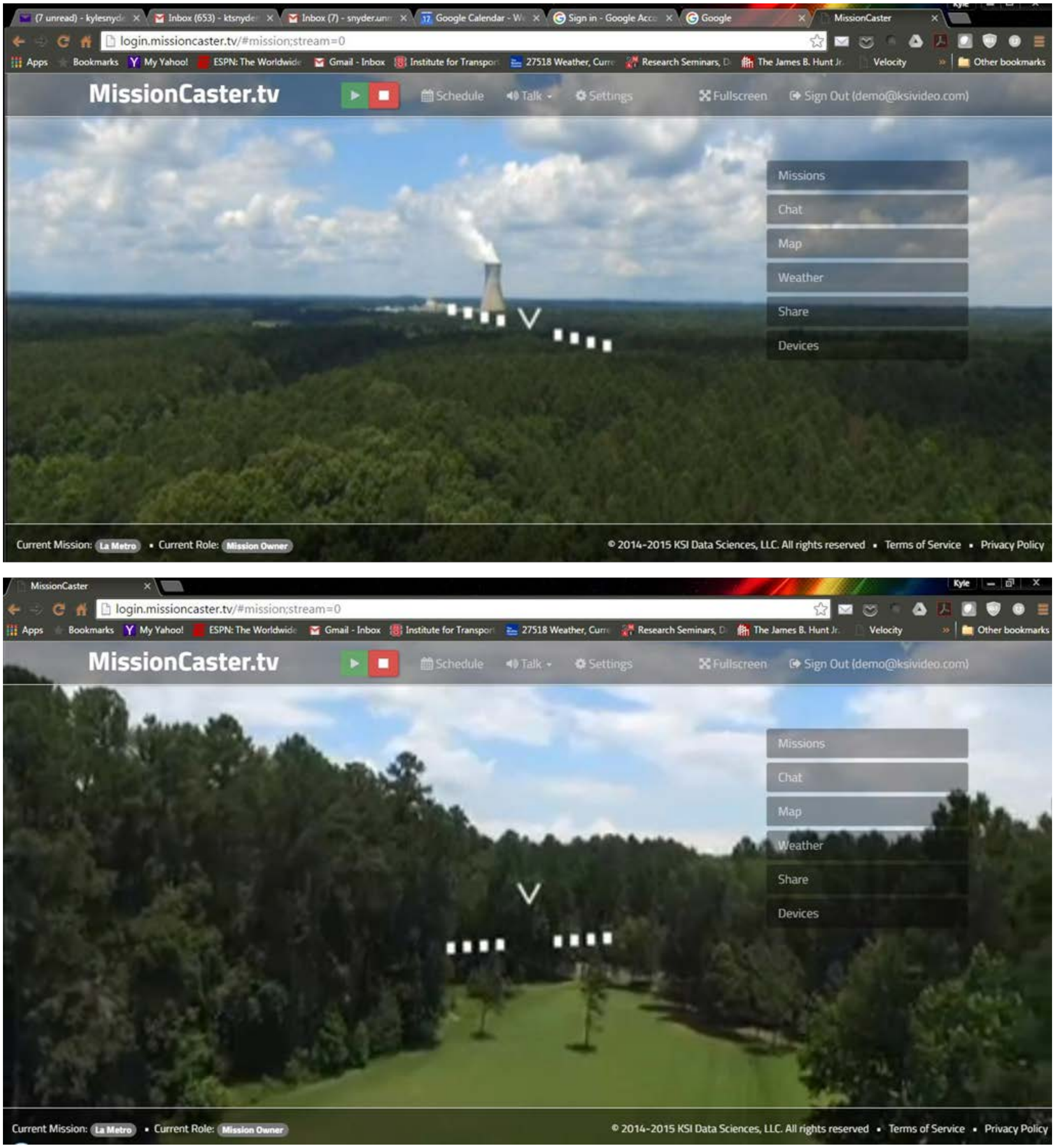


Figure 16: Screenshots from KSI MissionCaster During SAR Scenarios

Figure 17: Wake County EM Search and Rescue Exercise Planning Examples

7.4 UAS for Inspections

Date	2015-2016
Primary Objective	Technology Assessment (image quality and UAS performance)
Aircraft	Aibotix X6, Trimble ZX5, Mikrokopter, DJI Inspire
Location	Lake Wheeler, SECREF Area, Bridges

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	20 hours across 120 flights
	Processing Time	50+ hours
Conditions	Weather	Variable Winds, Different Times of Day
	Ground	Fields, structures, rolling hills, erosion research site
Type of Data	Pre-processing	JPG, CSV
	Post-processing	TIFF, JPG, CSV
Software	Flight Control	AiProFlight Software
	Data Processing	Agisoft, Arcmap

Description

Over last two years NGAT has had multiple requests and opportunities to evaluate the role of UAS as an inspection tool. One of these requests is an NCDOT project to support Photogrammetry and Surveys units in evaluating the functionality, performance, and quality of UAS in capturing aerial imagery. Another project is with an NGAT member interested in UAS applications to support home inspections and structural analysis. Potential users are urgently trying to determine if UAS imagery can support situational assessment and decision-making in a feasible, cost-effective manner. These users are also exploring options for types of aircraft, potential mission scopes to include types of imagery, flight durations, and image quality, and crew qualifications. NGAT is able to work with these kinds of partners to define specific test examples and goals for measuring performance against. This vignette provides several of these examples flying multiple aircraft, to accomplish multiple missions, and evaluating multiple partner-determined variables.

Results

NGAT has collected a wide range of experience with UAS in an inspection role because of the research over the last two years. In the scenarios where geo-referencing and high quality imaging was not as important as real-time video or individual pictures, NGAT had reliable success accomplishing the partner's research objectives flying the DJI Inspire. These flights were flown at the Lake Wheeler facility around university housing for conducting a simulated roof inspection for structural damage (Figure 17). Speed of data capture, ease of set-up and packing, and mission planning requirements were some of the parameters measured during these test scenarios. All expectations were surpassed and the member is developing future integration plans based on the NGAT support.

Figure 18: Roof Inspection Exercise

From the NCDOT project, NGAT evaluated the performance of a multiple UAS and their ability to meet DOT's surveying and inspection needs. We concluded the imagery captured by the Aibotix X6 did not meet NCDOT's standards for surveying. Some of the other data sets from other aircraft are increasing NGAT confidence that UAS can be used for surveying and inspections. There are many factors that can affect the performance of a UAS. These factors consist of weather, sensor capabilities, flight planning, software processing and, GCP design and placement.

The X6 was flown over another area of interest (AOI) at Lake Wheeler with an 80% front - 80% side overlap and 60% front-60% side overlap. 33 ground markers were placed and used as ground control points (GCPs). The ground markers were specifically positioned to meet our accuracy needs. The pixel size of the orthophoto is being used to calculate the horizontal accuracy classes for the digital orthophotos. Root Mean Square Error (RMSE) of Easting (X) and Northing (Y) locations represent the average distance from the actual location to digitized point. Image resolutions will correspond to the camera quality, however, it is important to know the resolution of the data source naturally affects the accuracy of the results. For this project, we used the Nikon D5200 which is 24.1 megapixel with a pancake lens.

- 200 feet, 60-60 overlap
- 254 flight images were stitched together to generate one orthophoto
- Study Area: 30 acres
- NAD83 (2011) / North Carolina (ft.-US) (EPSG::6543)

33 Markers

Orthophoto for 200 feet, 60-60 overlap

- 67 feet, 60-60 overlap
- 500 flight images were stitched together to generate one orthophoto
- Study Area: 8 acres
- NAD83 (2011) / North Carolina (ft.-US) (EPSG::6543)

24 Markers

33 Markers

Orthophoto for 67 feet, 60-60 overlap

Project Data Accuracy Results

Low Alignment							
Control Point Statistics	Point ID	X error (ft)	Y error (ft)	Z error (ft)	Error (ft)	Projections	Error (pix)
No. Points =		24	24	24	24	24	24
Min (ft) =		-0.03	-0.04	-0.01	0.00	4	0.03
Max (ft) =		0.04	0.02	0.00	0.04	13	0.14
Mean (ft) =		0.00	0.00	0.00	0.02	7.8	0.07
Std Dev (ft) =		0.01	0.02	0.00	0.01	1.9	0.03
RMSE (ft) =		0.01	0.01	0.00	0.02	8.0	0.08
FVA (ft) =				0.00			
RMSE R (ft) =		0.02					
Case 1 95% CE(ft) =		0.04					
Case 2 ~ CE(ft) =		0.04					

Table 4: Results table for 67 feet flight, 80-80 overlap

Low Alignment							
Control Point Statistics	Point ID	X error (ft)	Y error (ft)	Z error (ft)	Error (ft)	Projections	Error (pix)
No. Points =		39	39	39	39	39.0	39
Min (ft) =		-0.22	-0.17	-0.09	0.01	10.0	0.15
Max (ft) =		0.14	0.10	0.13	0.24	35.0	2.31
Mean (ft) =		0.00	0.00	0.00	0.08	26.7	0.72
Std Dev (ft) =		0.06	0.06	0.04	0.05	5.8	0.41
RMSE (ft) =		0.06	0.06	0.04	0.09	27.3	0.82
FVA (ft) =				0.08			
RMSE R (ft) =		0.08					
Case 1 95% CE(ft) =		0.14					
Case 2 ~ CE(ft) =		0.14					

Table 3: Results table for 67 feet flight, 60-60 overlap

Table 6: Results table for 200 feet flight, 60-60 overlap

Low Alignment							
Control Point Statistics	Point ID	X error (ft)	Y error (ft)	Z error (ft)	Error (ft)	Projections	Error (pix)
No. Points =		39	39	39	39	39	39
Min (ft) =		-0.14	-0.10	-0.27	0.02	1	0.00
Max (ft) =		0.10	0.14	0.11	0.29	9	1.79
Mean (ft) =		0.00	0.00	0.00	0.08	6.3	0.66
Std Dev (ft) =		0.05	0.05	0.07	0.06	2.4	0.38
RMSE (ft) =		0.05	0.05	0.07	0.09	6.7	0.79
FVA (ft) =				0.13			
RMSE R (ft) =		0.07					
Case 1 95% CE(ft) =		0.12					
Case 2 ~ CE(ft) =		0.12					

7.5 Hyde County Flight Operations

Date	2013 - 2015
Primary Objectives	Agricultural, Airport Operations, Community Outreach, Training, and Aeronautical Research
Aircraft	Bosh Super Swiper, Sentera Vireo, Bosh Protector 10, Bosh Condor II, Yamaha RMAX, Bosh Swiper, Precision Hawk Lancaster
Location	Hyde County Airport (Engelhard, NC)

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	17 hours
	Flights Logged	Approximately 80
Conditions	Weather	Consistently windy, hot, cold
	Ground	Fields, airport facilities, always long distance line-of-sight
Type of Data	Pre-processing	Natural Color and Thermal Video
	Post-processing	TIFF, videos
Software	Flight Control	Multiple
	Data Processing	Multiple

Description

Hyde County was selected to be North Carolina's entry for the FAA Unmanned Aircraft Systems Test Site designation in 2013 due to its remote location, wide open spaces, and access to one of North Carolinas public use airports. Ultimately the Gull Rock Test Site was not selected as one of the six official test sites, but Hyde County will always be the location for the first NGAT COA in North Carolina, scene of the first NGAT UAS research flight, and the North Carolina UAS Program kickoff location. The first flight at Hyde County was conducted March 21, 2013 using the Bosh Super Swiper small UAS on a windy, cold day much like the Wright Brothers' first flight about an hour north in Kitty Hawk. A more extensive demonstration was conducted in October 2013; the goal of this demonstration was to show case the potential for UAS growth in North Carolina for an Aviation Week Magazine reporter (Croft, 2014).

Most of the flying at Hyde County was done in partnership with Bosh Global Services (www.boshgs.com) who continued to use Hyde County for training and flight testing their entire UAS fleet which included the following aircraft:

- Super Swiper – Fixed-wing, 9 lbs., 6 foot wingspan
- Protector 10 – Fixed-wing, 36 lbs., 8.5 foot wingspan
- Condor II – VTOL, 10 lbs., 6 foot rotor span
- Yamaha RMAX – VTOL, 194 lbs. 10 foot rotor span.

A COA was also filed and received for the Bosh Swiper UAS. 2014-ESA-21-COA was intended for an extended area around the Hyde County Airport up to 1500 feet Above Ground Level. It was intended to test extended Command and Control of a small UAS. However, this COA was never activated due to BOSH Global business realignment.

One of the results of this realignment was the creation of a new company called Digital Harvest Inc. http://www.digitalharvest.farm/. Digital Harvest continued to use Hyde County for training and sensor development. In 2104 the Yamaha RMAX was tested and flight crews trained at Hyde County. This UAS has been used in Japan to spray rice farms for over two decades. NGAT worked with Digital Harvest to obtain a COA to train 2 operators to fly the RMAX and to test spraying operations. At the time this COA was one of only three RMAX COAs in the United States. Digital Harvest continued to use Hyde County into 2015 when they moved their operation to the Northwest to focus on apple and grape production in Oregon and Washington.

Results

The success stories from NGAT's partnership with Hyde County Airport and the local community stem from a commitment to collaboration from both sides. Even though the Gull Rock Test Site (Figure 18) was not selected for a UAS Test Site designation in 2013, the proposal process and development unified the stakeholders in the state behind NGAT to build a UAS resource for North Carolina.

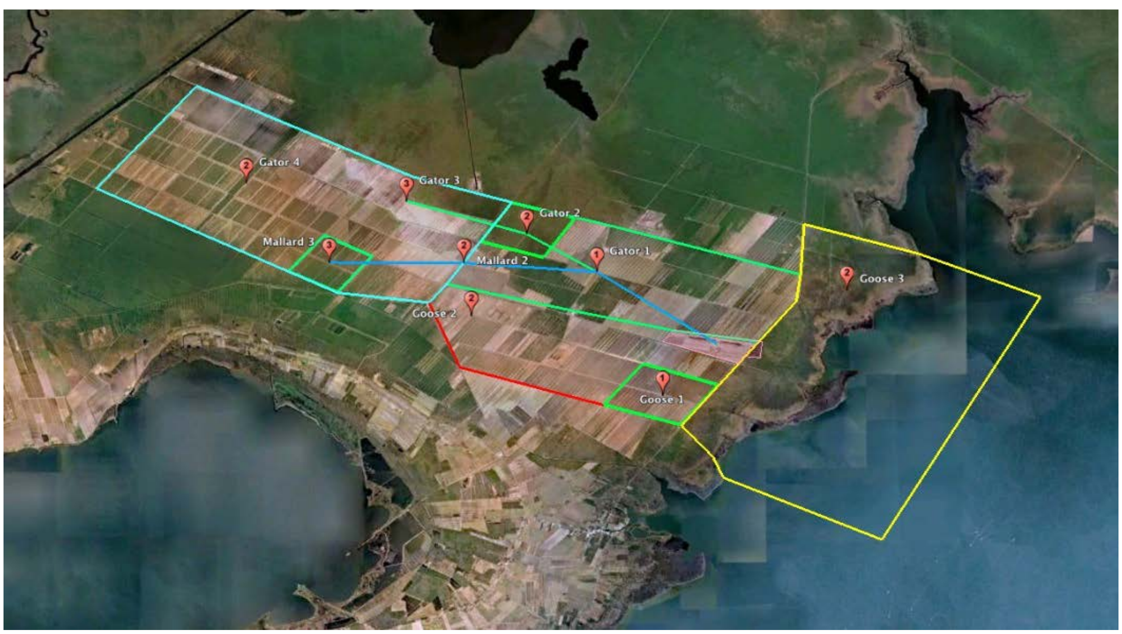


Figure 19: Proposed Gull Rock UAS Test Site

RMAX (Figure 19) training and familiarization at Hyde County provided Digital Harvest the knowledge and experience to focus on specialty crops and move the company to Oregon.

Figure 20: Yamaha RMAX Test Flight at Hyde County

The partnership with Bosh Global Services was critical to NGAT establishing a robust, high quality UAS flight program from the very beginning. This commitment to quality never changed, so NGAT and Bosh are always welcomed back to Hyde County when that large resource and remote location is needed. Bosh Global Services continues to support US Army UAS operations with training and technology development services. The company has expanded operations in Fayetteville, North Carolina and is currently recruiting for more talent at that location. Bosh Global Services was also acquired by Momentum Aerospace Group in 2015.

Figure 21: Bosh Global Services Flight Operations at Hyde County Airport

NGAT continues to receive occasional interest in Hyde County operations from industry partners exploring remote locations with access to low-use airspace. Some of these partners are interested in flight operations, some are interested in industrial capabilities of the area. NGAT will maintain the relationship with Hyde County airport and the local authorities to collaborate and promote the opportunities for aviation in the area.

7.6 The Precision Hawk Partnership

Date	2014 - 2016
Primary Objective	Training, Standard Operating Procedures Development, Airspace Integration, Industry Partnerships
Aircraft	Lancaster 1 & 2
Location	Lake Wheeler, Butner, Hyde County

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	75 hours
	Frequency	3 - 4 days per week in 2014-2015
Conditions	Weather	Good, Light Winds, year-around
	Ground	Fields
Type of Data	Pre-processing	Color, Near-infrared
	Post-processing	TIFF
Software	Flight Control	Custom
	Data Processing	Data Mapper

Description

NGAT began discussions with Precision Hawk in 2013 to support their analysis of potential locations to establish a permanent headquarters. The company was looking for a public partner to provide routine access to a flight test location for aircraft development and training, because in 2013 the only way to "legally" operate UAS was under a public COA, typically with a public university. The company was also looking for access to engineers and a workforce to support aircraft development, system design, component development and integration, software development for data processing, and data analysts. Eventually the company would begin development of a low altitude air traffic management system that has been integrated into the NASA UAS Traffic Management research program. NGAT has supported multiple meetings with state leadership including both Department of Commerce Secretaries and the Commissioner for Agriculture in efforts to secure North Carolina as the primary corporate headquarters.

In 2013 NGAT also needed another flight partner besides Bosh Global Services to achieve a high tempo frequency of flight operations to demonstrate airspace integration capabilities. One of NGAT's goals in 2013-2014 was to demonstrate the regardless of the UAS Test Site decision, that the program had the resources, structures, and state support to work with industry partners to validate standard operating procedures, develop a services model to provide UAS-enabled capabilities, and mature the reputation of the program. A portfolio of COAs and charter to provide UAS test facility management provided the foundation for achieving this goal.

Working with Precision Hawk, NGAT began almost weekly UAS operations at Lake Wheeler or Butner field labs. Precision Hawk built a strong cohort of pilots with significant flight experience, while the NGAT Program operations and support reputation gained credibility. Ultimately Precision Hawk determined that North Carolina was the right location to call home and now all references to Precision Hawk announcements and activities refer to the company as "Raleigh-based Precision Hawk…" The company has expanded relationships with multiple departments across the NC State University campus for access to researchers and users, while also using their Section 333 Exemption to conduct most of their operations today. The company did send their best flight team to Hyde County in early 2016 when the NC House Strategic Transportation Planning Committee Chairman requested a demonstration through NGAT.

Results

The results of the NGAT-Precision Hawk partnership are still producing positive opportunities today.

- NGAT COAs have dozens of hours of Precision Hawk flight operations that were incident free, demonstrating the reliability and tailoring of the NGAT standard operating procedures for routine small UAS operations.
- Precision Hawk is known as a Raleigh based company.
- Precision Hawk was selected as Pathfinder Project with the FAA and received an early Section 333 Exemption after showing high flight reliability and performance under the NGAT COA operations.
- NGAT established a regular NOTAM posting for Lake Wheeler operations originally because of Precision Hawk support flights, but that NOTAM has persisted almost weekly because of the utility of the location and predictability of the airspace use.
- Regular training by Precision Hawk under the NGAT COAs brought more people to Raleigh area creating economic development value in addition to the company's rapid growth.

The development and testing of the NGAT SOPs is the critical product of the Precision Hawk Partnership. NGAT Site managers ensured all flight operations were conducted as per FAA guidelines and COA requirements. In the process NGAT revised the Standard Operational Procedures (seen in Appendix 7) based on feedback from NGAT Site managers and observations during flight operations. The primary purpose of these Standard Operating Procedures (SOPs) are to ensure safety of flight in the National Airspace System. In some cases NGAT will select qualified designees (NGAT-D) in writing to assist in UAS operations management. These designees may serve as the Site Manager or provide aviation support for the operation of NGAT's services or research needs and the training needs of UAS operators. When activating an NGAT COA, the NGAT-D supplies the historical and technical information needed for COA operations, reports COA activities using the established process, and may provide raw data collection for academic, training, and research purposes. The NGAT SOPs are now also used as guidance for those operations conducted in accordance with any NCSU approved COA and Collaborative Agreements with the flight partners. It is expected that these agreements evolve as the operations between the partners and NCSU reveal areas where changes are needed and will act as a "living document", based on the best operational procedures for that period in the relationship between the two parties. This analysis and process implementation provides the core structure for NGAT UAS services today.

Figure 22: Precision Hawk Imagery from Hyde County Flight in 2016

Figure 24: Precision Hawk Lancaster Aircraft Pre-flight

Figure 23: Precision Hawk Imagery from Butner Field Lab

7.7 The Constellis Partnership

Date	2013-2016
Primary Objective	Training, Airspace Integration, Live video transfer
Aircraft	Puma, Sentera Vireo, Arcturus T-20, DJI Inspire
Location	Moyock, NC

VIGNETTE SUMMARY

Flight Data

Total Hours	Flight Time	Approximately 30 hours
	Processing Time	Mostly video, near real-time
Conditions	Weather	Variable conditions
	Ground	Fields, structures
Type of Data	Pre-processing	None
	Post-processing	Video
Software	Flight Control	Multiple
	Data Processing	Video, Mission Caster

Description

NGAT is working with the Constellis Group, formally Academi LLC., to collaborate on training, communication, and aeronautical research at their facility near Moyock, NC. The Constellis COA was the second COA location after Hyde County for the NGAT team. The facility at Constellis is a perfect location to conduct UAS training due to its size, controlled access, and the facilities which include food and lodging, as well as an onsite airport. In November 2013 eight individuals were trained to fly the then UTC Vireo small UAS system purchased on a Goldenleaf Foundation grant. The Constellis site has been used for currency training and aeronautical research ever since then. This research includes testing engine and propeller upgrades, endurance evaluations, and operations at altitudes higher than 400’. A COA was filed for the 120 lbs. Arcturus T-20 in 2013, the COA was awarded in 2014. The 2014-ESA-3-COA covered the entire Constellis facility, which is approximately 3 square miles up to 1500 feet AGL. NGAT coordinated with NAS Oceana and the FAA to ensure the COA was approved. While the COA was never activated due to the research project being moved to a military restricted area, valuable lessons were learned about developing, submitting, and being awarded a non-standard COA. The knowledge was used to file a similar COA for the Aerovironment Puma, which at 20 lbs. is not a large UAS but the COA covered the same area and operating altitude.

The Vireo and Puma operations have provided NGAT the opportunity to test real time communication and imagery relay from small UAS to remote locations. NGAT and Constellis are working with KSI Data

Sciences to use a low cost solution to transmit the video data from a UAS to the cloud for viewing mission data in near-real time from anywhere with an internet connection as a core functionality of the NGAT Data Management Plan. The KSI Data Sciences MissionCaster solution consists of the MissionCaster HD video encoder/broadcaster and its companion cloud service, MissionCaster.TV. The package allows users to securely broadcast live, full HD video and data from any drone or robotic platform securely over virtually any network (including LTE, Satellite and Wi-Fi) via the internet with less than 3 seconds of latency. It combines ease of use, mobility, and two-way voice communication. NGAT HQ has frequently watched live video from a Puma operating in the Constellis COA over the internet through the MissionCaster portal.

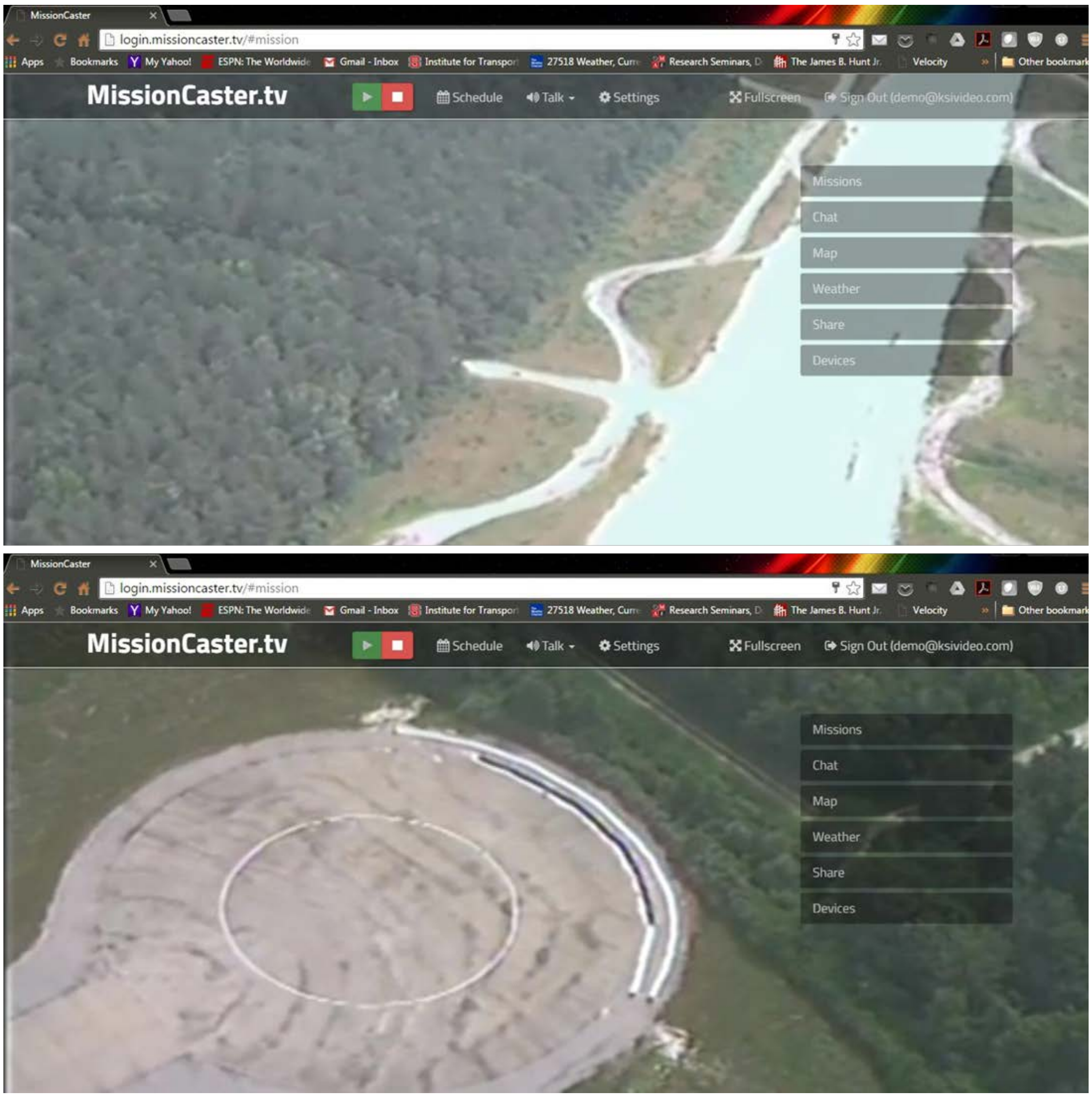


Figure 25: Sample Imagery from Constellis Broadcast Through MissionCaster

This collaboration with Constellis is ongoing and is considered very successfully by all parties.

Results

The Constellis Partnership has provided a unique set of facilities and a partner with an alternative mission set than most commercial UAS companies in the market today. The COA location and missions were approved early on in the North Carolina UAS Program by the State CIO and the FAA for NGAT operations. Since then the NGAT-Constellis partnership has provided training for the Vireo UAS product, UAS operations above 400 feet AGL (the Puma COA extends to 1500' AGL), routine UAS operations in busy airspace, and the ability to test data management tools. The controlled access to the facility, the desire to operate and train clients on Tier II class UAS, and the range of mission applications at Constellis have provided opportunities to evaluate SOPs, system capabilities, and industry partnership models with another North Carolina-based company committed to UAS growth.

7.8 North Carolina State Fair Exhibits

Date 2014 - 2015

Primary Objective Education

Aircraft AR Drone, DJI Phantom

Location State Fair Grounds, Technology Tent, Raleigh, NC

VIGNETTE SUMMARY

Description

NGAT has received an annual invitation from the North Carolina Department of Agriculture and Consumer Services to participate in the North Carolina State Fair every year since 2014. This invitation is intended to provide a communication platform for NGAT to share progress in UAS technology development, applications, and research activities as an education/outreach function of the State Fair. Inside the Technology Tent NGAT has operated a small demonstration area with a safety net to protect flight operations. NGAT uses this area to discuss UAS rules and research, UAS for Agriculture applications and news, and career opportunities in the UAS community. In 2014 the demonstration area was a small area that allowed for take-off and landing of a small quad-copter. In 2015 the NGAT team was able to integrate some additional research in GPS-denied navigation into a larger demonstration area that provided the attendees to interact with the exhibit. "The Flying Pen" demonstration was built to allow visitors to draw a flight path for a UAS to follow to accomplish a survey mission inside the net. This exhibit was very popular and received significant attention throughout the week-long Fair. Outside the net, NGAT offered handouts from the NCDOT UAS Program Office including the latest Fact Sheet and description of the state regulations related to UAS operations.

Results

The State Fair Exhibit every year has been very successful for accomplishing 2 primary objectives: outreach and routine operations.

Outreach Results

- Hundreds of fair attendees have visited the NGAT booth every year.
- NC and FAA UAS Fact Sheets were distributed in 2015.
- The NGAT relationship with the NC Department of Agriculture and Consumer Services is very strong.
- NGAT is helping Fair organizers integrate a drone racing exhibition for 2016.

Figure 26: NGAT State Fair Booth with Handouts

Routine Operation Research Results

A large number of quadrotor applications such as bridge inspection and precision landing require accurate relative localization. To enable those applications, NGAT developed a state estimation library which permits any drone with a monocular camera/processing to estimate its position and orientation relative to correctly formatted QR codes of an arbitrary size. The developed QR code based marker system is beneficial in that it not only allows flexible marker sizing and generation but also allows unique identification of each marker due to the ability to embed and retrieve arbitrary text from each marker.

Any monocular camera based passive marker solution requires determination of the position of a number of known point's; locations in the camera's 2D field of view and some way to determine scale (how large the marker is). Our state estimation library manages this problem by scanning for QR codes, finding the corners/orientation of the QR codes and then retrieving the size of the QR codes from each code's text. Each QR code has a leading text denoting the size of the QR code followed by its unique identifier ("sizeUnit-UniqueID"). Together these features allow position determination both close in with < 2 ft labels, and far out using large labels.

To test the functionality of the QR code state estimation library and work toward a solution which would allow safe and autonomous demonstration of UAS technology, NGAT developed a ROS/QR Code base state estimation library application which allows an AR Drone 2.0 to take off and maneuver relative to a large QR code (in tests, 27 in x 27 in). In this case, the monocular camera used is the front facing camera that comes with the premade drone. Video processing, state estimation and control is done on a laptop which receives video from the drone and returns a constant stream of commands. The stability of control is limited by the latency inherent in a wifi network, which is further exacerbated by the bandwidth requirements of video. This results in control that works most of the time but has occasional glitches due to the latency. By developing this software controller, NGAT was able to let visitors autonomously scan the area inside the net at the Fair without GPS localization, but still operating like a commercial UAS system would in an agriculture mission.

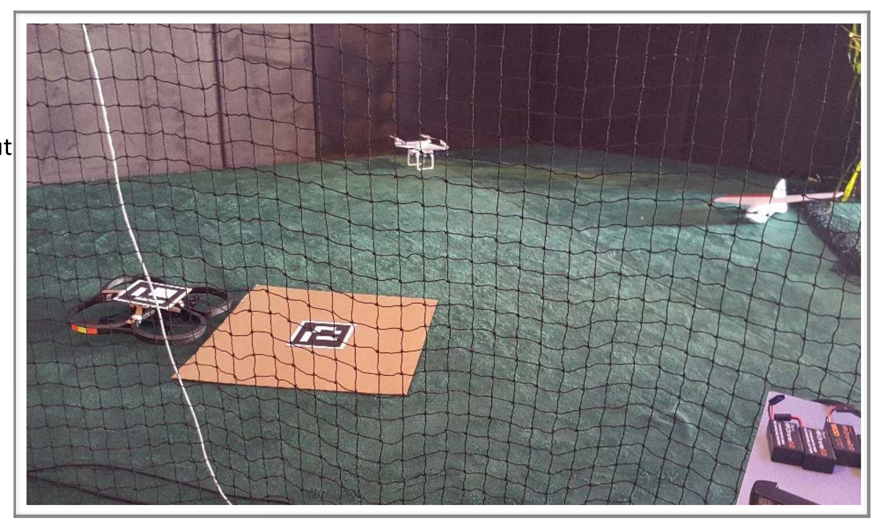


Figure 27: The Flying Pen Demonstration at the 2015 State Fair

8 APPENDIX B: BEST PRACTICES

8.1 Best Practices Introduction

The North Carolina State University's (NCSU) NextGen Air Transportation (NGAT) Program has developed a series of Best Practices to guide North Carolina public agencies and user groups in developing safe and effective Unmanned Aircraft System (UAS) programs. These documents outline agency-specific considerations that should be evaluated by the various public agencies in the State of North Carolina. Each agency, or user community, has specific requirements and operations that would benefit from integrating Unmanned Aircraft Systems (UAS) into their programs. These documents provide information to assist agency executives, program managers and operations managers in developing their programs.

The initial release of these Best Practices includes nine integrated documents.

Baseline Set of Best Practices
- Expectation Management
- Operational Procedures
- Crew Selection
- Data Management
- Policies
- Communications/Outreach

Customized Best Practices
- Tailoring the Best Practices for State Agencies and User Communities
- Business Operations Model
- Level of Government Tailored Practices

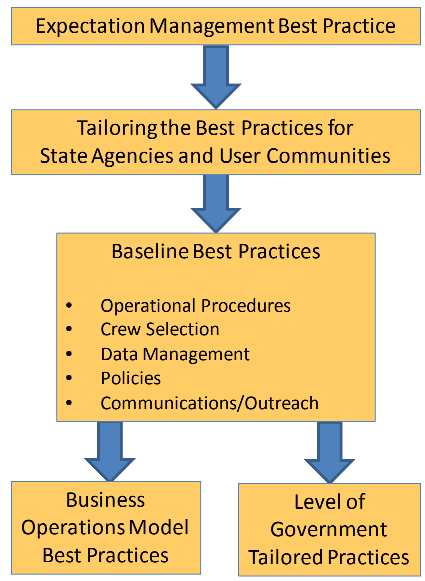
These Best Practices serve to educate and inform state agencies and to assist regulatory commissions with industry wide regulations and recommendations for safe UAS flights. NGAT offers analysis and recommendations tailored to each agency based on the agency's operational needs and available budget.

These Best Practices are based on small UAS (< 55 lbs) and have adopted the existing FAA requirement and designation that the individual responsible for the UAS and its flight safety is the Pilot-In-Command (PIC). This designation applies to both UAS operations under the Part 107 Rule for small operations that requires a PIC to obtain a Small UAS Operator Certificate for a Remote Aircraft License, and also to UAS operations under a Public Certificate of Authorization (COA) that allows the public agency to self-certify the PIC against a set of requirements. NGAT will continue monitoring the evolution of FAA certification requirements and will edit these Best Practices accordingly.

NGAT endorses the use of the *Know Before You Fly* (Figure 17) protocols in these Best Practices. *Know Before You Fly* is an education campaign founded by the Association for Unmanned Vehicle Systems International (AUVSI) and the Academy of Model Aeronautics (AMA) in partnership with the Federal Aviation Administration (FAA) to educate prospective users about the safe and responsible operation of UAS. The *Know Before You Fly* web address is www.knowbeforeyoufly.org.

Figure 28: Know Before You Fly Education Campaign Logo

In order to capture developing national level thought on UAS Best Practices, NGAT has engaged the U.S. Department of Commerce's National Telecommunications and Information Administration (NTIA) regarding commercial and private UAS and their privacy, transparency, and accountability issues. NGAT has included some of the group's stakeholder input as a derivative contribution into these Best Practices. These include the following disclaimers:



- These best practices are not intended to supersede the authority of the FAA
- Nothing in these Best Practices should take precedence over the safe operation of a UAS.
- Nothing in these Best Practices should be construed to impede the use of UAS for purposes of emergency response, including safety and rescue responses.
- UAS operators should comply with all applicable laws and regulations. These Best Practices do not replace or take precedence over any local, state, federal, or Constitutional law or regulation. Best Practices are intended to encourage positive conduct that complements legal compliance.
- Nothing in these best practices should be construed to impede the use of UAS for purposes of news or public information services.
- Nothing in these Best Practices should take precedence over the contractual obligations of a UAS operator or the representations of entities contracting UAS operators. However, entities contracting UAS operators should consider these Best Practices when setting the terms of a contract for UAS use, and UAS operators should consider these Best Practices when choosing to accept a contact for UAS use.

The terms "where practicable" and "reasonable" are used frequently in these Best Practices. What qualifies as "practicable" or "reasonable" should depend largely on the resources and circumstances of the UAS operator, the sensitivity of data collected, and the context associated with a particular UAS operation.

Suggested Sequence of Best Practice Use

Agencies considering adopting the use of UAS should begin by reviewing the nine best practice documents in the following suggested order. NGAT is available for consultation at any point in the program development process.

1. Begin with the "Expectation Management" Best Practice to discover all you need to know that is not specific to pilot responsibilities, aircraft operations, or regulations. It is for organizations seriously considering establishing a UAS Program.
2. Additional top level details for consideration are provided in the "*Tailoring the Best Practices for State Agencies and User Communities*" document. It will introduce agency

leadership and managers to the potential benefits a UAS program would bring to the agency. The information presented in *Section III (Potential Applications and Things to Consider), Section IV (Practice Description) and Section V (Benefits and Issues)* will allow the agency to conduct a top level review and assessment of how a UAS program will benefit their organization and the people they serve. Once a decision to proceed with a program is made, the agency should proceed to the set of five Baseline Best Practices.

3. The Baseline Best Practices present the basic components necessary to execute a safe and effective UAS program. These best practices articulate the policies, procedures, operations and training requirements for the programs.
4. Once these Baseline Best Practices are understood and the agency is ready to structure a program and obtain funding for it, the agency should review the final two Best Practice documents. The Business Operations Model Best Practices will help the agency decide on how best to acquire their UAS or solicit a contract for a company to provide UAS services. This Best Practice will provide information on aircraft selection and cost considerations. Finally, the agency should review the remaining Best Practice for considerations pertaining to their specific level of government.

Best Practice Format

The following nine Best Practices are presented using a common format. This format is:

- Introduction
- Key Actors
- Potential Applications (optional)
- Practice Description
- Notional Scenarios (optional)

8.2 Expectation Management Best Practice

Introduction

In order to operate UAS in the civilian airspace system, organizations need to understand the full potential of UAS. The acceptance of UAS by both regulatory bodies and the general public alike hinges on having a defined mission objective, following safety protocols, and undertaking proper maintenance of the equipment. It is critical UAS must be able to integrate seamlessly into the existing airspace environment without posing any risk to other airspace users, persons or property on the ground. Hazards associated with a proposed UAS operation can be identified based on system knowledge, risk analysis, past experience, and lessons learned. This document identifies key practices associated with mission definition, sharing the airspace and reporting logs.

Key Actors

- Flight Crew
- Site Manager
- FAA
- Airport Authority
- Air Traffic Controller
- UAS Insurance Companies
- NCDOT

Practice Description

There are four sections to this practice description: Mission Management, Sharing the Airspace, Equipment Life, and Documentation.

Mission Management

Mission Profiles

When starting a UAS program, identifying specific missions to be performed by the UAS team is critical to establishing a trusted, effective and productive program. A detailed set of mission profiles should be described to scope the initial UAS Flight operations. Those profiles should include the following –

- **Types of missions within scope of program** – crop surveys, crop spraying, surveying, mapping, building inspection, infrastructure inspection, search and rescue, fire management, accident investigation, aerial photography.
- **Size of mission areas** – Small area (Less than 10acres), Moderate Area (10 to 500 acres), Broad area (500 acres and more), Corridor, Structure/facility (Footprint + height)
- **Payload requirements** – Type (Video, spectral, IR), Size (Weight)

These descriptions help determine 1) the type of aircraft needed to accomplish flight operation tasks; 2) crew credentials; and 3) airspace approvals required to complete mission objectives.

Mission definition

Defining each flight mission is the first step to planning a flight operations for schedule. The mission plan should contain all actions, contingencies and goals for the mission objective.

1. **Identify type of mission.**
   The overall mission process starts by defining the target mission (crop surveys, surveying, mapping, building inspection) and selecting the UAS to be used to implement it. Both Fixed and Rotor wing UAS have inherent limitations so understanding the mission objective is critical to selection of the UAS. This should be determined way in advance to the arrival at the flight site.
2. **Define desired outcomes.**
   The second step is to determine the deliverables (images or video) for the flight mission. On the basis of the deliverable, additional special equipment for the UAS will need to be selected. Here the operator needs to identify the specific details of the equipment (Sensors, Spray / dispensing equipment, External loads) that is needed for the mission. This includes the make and model of the equipment and its size, weight, power, specifications, procedures and communication needs.
3. **Define operational environment**.
   - **Perimeter** – It is important for the PIC to know where he/she will be conducting flight operations. The PIC should get information about the flight area from the land owner or agency owning it. Accordingly he/she should plan the flight mission and designate all other areas (take-off, landing, safe area, etc.)
   - **Alerts** – The flight crew should be aware of obstacles or structures that could affect normal flight operations. The PIC should do a sight screening prior to the flight day to know what the terrain will be and plan the fight mission accordingly.
   - **Proximity to an airport** – The PIC should ensure that if any flight operations are conducted near (within 5 miles) to an airport, then written permission from the tower should be obtained. Also the PIC and

Observer should be extra cautious for manned aircraft flying in the vicinity.

- **Altitude** – The height at which UAS flies becomes very important especially if flown above 200 feet or higher because it increases the ability to interfere with commercial aircraft. Under no circumstances should an UAS be flown anywhere near the flight path of a manned aircraft.
- **Command Center** – PIC should plan the command center in an area that will ensure line of sight with the Observer and UAS in the air at all times. This area should be secured and clear of obstacles.

4. **Review capabilities and resources.**
   Before starting the fight operations it is necessary to recheck if all documents and approvals are current.
   - Operator's credentials should be verified and carried by the operator at all times.
   - Inspect the aircraft.
   - Check the flight software is current by regular update checks. If software upgrades are required, the best practice would be to check, download and update prior to arrival at the flight site.
   - Review the FAA approval to conduct operations. That includes COA constraints and requirements. Confirm that the NOTAM is posted.
   - Have the written permissions from the airport authority (if flight operations are conducted within 5 miles of an airport) and land owner (for conducting flight operation on private or state land in NC). For more details refer to Crew Selection and Aircraft Selection of Best Practices.
5. **Develop Mission plan.**
   A mission plan should include of 4 primary sections: a flight plan, a security plan, a data management plan, and a flight schedule.
   - **Flight Plan**
     The flight plan should describe how the UAS will fly during the mission to accomplish the objectives. Any limiting factors such as flight restricted area or obstacles, in the flight environment may alter the intended operation and require modification of the flight plan accordingly. Contingency planning should include safe routes in the event of a system failure, degraded performance, or lost communication link, if such a failsafe exists. Most UAS solutions offer ground control stations that can be used to develop flight plans, configure the UAS, plus monitor the UAS in flight using a telemetry link. Each flight plan is composed of a sequence of stages, such as take-off, departure procedure and others, which must be followed and adhered to in the correct order. Refer to Operational Procedures Best Practices for more information.

- **Security Plan**
    a) Before the starting the day's flight operations it is a best practice for the PIC to give a safety and security briefing to both the flight crew and other people participating in the flight.
    b) At full power, an average sized UAS can exceed 40 mph, so be sure to maintain safe distances between the flight crew, and spectators and the UAS.
    c) 'Safe distance' from people and property is determined by circumstances, terrain and flight mission. The flight crew is responsible to plan the flight operational perimeter in which the flight area, command center (Ground Station and other necessary equipment's needed for the flight), safe area, take off, primary landing and emergency landing will be located.
    d) If it is a hand launch make sure it will be well clear of others and take all necessary precautions for a catapult launcher as well.
    e) Keep the UAS well clear of all people, property and obstacles.
    f) Spectators should always be a safe distance away from PIC. The area where the PIC will conduct all flight operations using the ground control station should be secured as a PIC Area.
    g) Ensure that no one gets between the flight crew operations and the UAS. This can be done by placing cones or using spray paint to mark the operational area and PIC Area.
    h) If anyone intrudes beyond what is determined to be the "safe" area, the flight operation should be suspended until control area is considered clear.
    i) Having a site manager present can be of great assistance, as he/she can make sure that non-authorized personnel are clear of the flight area at all times.
    j) The only people who should be permitted to enter the flight operational perimeter during flight operations should be personnel who are authorized by the PIC.
    k) PIC should be aware of any risks at the flight location, including bodies of water, structures, trees, etc. Also prior to take off, PIC should designate a few areas as "safety zones" to safely land the aircraft in case of an unexpected situation.

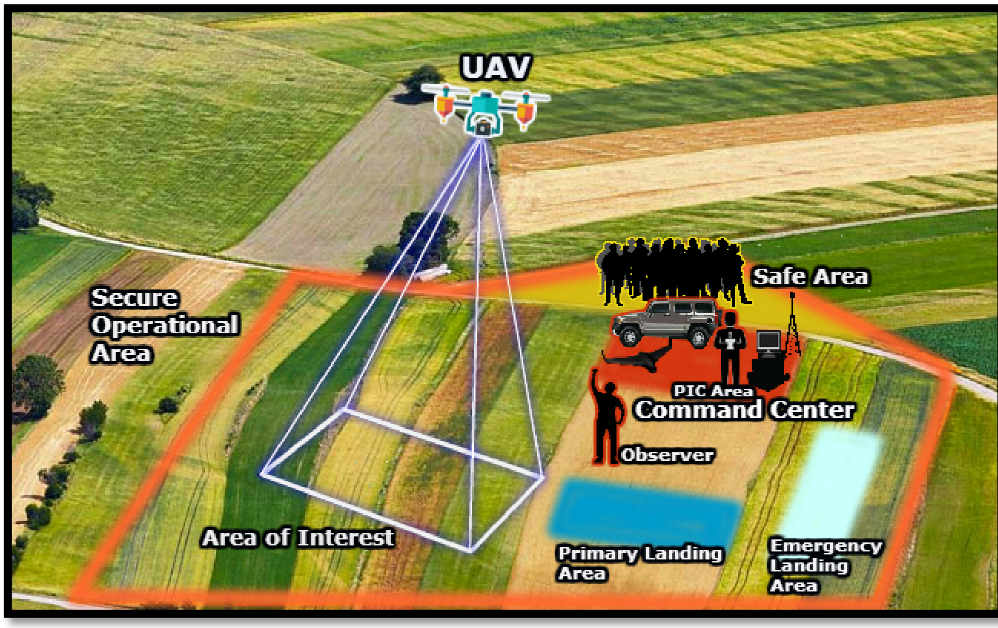


Figure 29: Recommended UAS Mission Planning Elements

- **Data Management Plan**
  a) Develop and follow a data transfer and processing plan regardless of single flight or multiple flight operations to accomplish the mission objectives. This will ensure smooth, repeatable and auditable flight operations.
  b) Multiple SD cards and data storage devices may be required for storing flight data.
  c) Data may also be transferred in real time via wireless connectivity.

  For more in depth explanation read the Data Management Best Practice.

- **Flight Schedule**
  a) Publish a daily flight schedule prepared bi-weekly or monthly. This way NOTAMs can be posted and appropriate permissions from air traffic authorities, from an airport authority, and land owners may be obtained.
  b) Flight crew and equipment should also be scheduled as part of a resource management plan.
  c) The daily schedule should include perimeter security time, crew arrival time, set up time, additional attendee arrival times, launch time(s), flight time(s), data transfer time, break(s) and departure time. While the schedule is subject to change, having a basic plan provides all participants a reference.

Example of a Mission Plan

Agency the data is for – NC Department of Agriculture

Agency flying for the data – NextGen Air Transportation Program

Flight Location – Lake Wheeler Field

1. **Type of Mission** – Crop survey
2. **Desired Outcome** – To study invasive species weed infestation
3. **Operational Environment**
    a) Perimeter – 1500 acre field, need to scan approximately 500 acres
    b) Alerts - Trees, Power lines and 1 building within the fight operational area
    c) Proximity to an airport – Just touching the 5 NM ring of the Greenville airport.
    d) Altitude – 100 meters
    e) Control Location – close to take-off location in SE corner of field.
4. **Capabilities and Resources**
    - Crew – PIC & Observer Names
    - Aircraft – Trimble UX5
    - Approvals – NCSU COA, Airport & NCSU land usage permission from land owner.
5. **Mission Plan**
    - Flight Plan
        a) Area of interest drawn on the flight computer using the Trimble Aerial Surveying Software.
        b) Winds from 250 degree.
        c) Take-off and landing into the wind.
        d) Total Flight duration – 30 mins with 45 legs
        e) Emergency landing planned.
    - Security Plan
        a) PIC area secure
        b) Site manager present to secure flight operations area.
        c) No additional attendees expected
    - Data Plan
        a) 1 SD card required
        b) SD card reader and Laptop required
        c) Data processing using Trimble Business Center
    - Schedule – NOTAM and permission obtained 2 weeks prior
        a) Crew arrival Time – 9:45am
        b) Setup Time – 30 mins
        c) Launch Time – 10:15am
        d) Recover – 10:47am
        e) Depart – 12:00pm

Mission Planning Valuable Lessons Learned

- Keep it simple
- Things can go wrong so always be prepared for contingencies and immediate action.
- Preplan the flight mission with a site visit or using Google Earth for site familiarization.
- The higher the flight, the more the area the system can map.
- Flying at noon limits shadows.
- Image processing takes lots of computing power. A data processing computer with a fast processor with lots of memory is recommended.
- High quality images equate to high quality analysis, poor images mean poor data.
- Aerial images and analysis need to be correlated with ground data to be effective for surveying and engineering missions.

Sharing the airspace

UAS can be legal airspace users, however, they need to integrate into national airspace in a safe, responsible manner. Routine access to the national airspace system poses a variety of technological, regulatory, workload, and coordination challenges. For everyone's safety, aviation is governed by a stringent set of aviation regulations. A high level of professionalism is expected from every UAS Flight Crew.

UAS do not have an completely unrestricted access to airspace use. They must integrate safely with other airspace users, so if safety provisions cannot be made or if operations are such that they negatively impact the safety of other airspace users, the operation cannot be allowed. In controlled airspace, other than Class A, the national policy states that UAS “must not impede, delay, or divert” other operations flying in that airspace. It is imperative that the capability of taking immediate active control of the aircraft by the PIC exists at all times, the same way it does with manned aircraft. The risk of a UAS colliding with another aircraft must be comparable to that for manned aircraft. Vigilance for the purpose of detecting potential collisions must not be relaxed for any aircraft in flight, regardless of the type of flight, type of aircraft or class of airspace in which the aircraft is operating.

Presently the technological focus for increasing air traffic capacity is on collision avoidance systems. The development of sophisticated and robust “sense-and-avoid” systems has been a key focus for the civil UAS sector. Also the Federal Aviation Administration (FAA) has mandated that most aircraft operating in airspace must be equipped with ADS-B Out (Automatic Dependent Surveillance-Broadcast) by Jan 1, 2020 to broadcast the aircraft’s GPS-based location in real time, including altitude and velocity information. Also to prevent collisions or accidents, UAS must currently be flown within Line of Sight under current regulations. Visual Line of Sight is termed as being the maximum distance that the PIC (not visual observer) is able to maintain separation and collision avoidance, under the prevailing atmospheric conditions. This is typically less than 1 mile from a ground based observer for a small UAS.

Sharing the Airspace Valuable Lessons Learned

- Manned air traffic has priority.
- Role of the Visual Observer(s) is to maintain the aircraft in the visual line of sight and alert the Pilot in Command (PIC) to any potential flight obstacles.
- ADS-B and other traffic surveillance technology should be used if available.
- For safe operations it is recommended to coordinate with local airports/air service providers if regular UAS operations are close to an airport. This way manned operations like crop dusters and or helicopters stay clear or fly above the flight site. This communication with the local aviation community encourages other airspace users to check NOTAMs, reach out if they have questions, and provide local knowledge.
- Utilization of the FAA B4UFly app.
- Incident response activities with other manned aircraft requires explicit UAS integration coordination with local airspace manager.
- Do not assume anything.

Equipment life

UAS are constructed of foam, kevlar, carbon fiber, wood, plastic or other materials. Just as with manned aircraft, the more they are flown the more wear and tear is expected. Although specific requirements for ongoing inspections, maintenance, and repairs may not be standardized yet, it is recommended to include these important pieces in the routine mission operations. It is important to understand that while the FAA has not yet outlined a formal maintenance program, the notion that airworthiness is a responsibility of the operator is very clearly articulated in Part 107 inspection requirements. It is important for any organization to understand and follow maintenance procedures or consult with a trusted agency who can ensure UAS are properly inspected, repaired, and returned to service in airworthy condition. NGAT has developed an airworthiness assessment process that is recognized by the FAA for approving aircraft for routine UAS operations. NGAT is able to share existing Statements of Airworthiness and develop new ones by working with other agencies. Safety is always first priority, but downtime for the aircraft also means it is not meeting its intended function. Proper UAS maintenance and inspections can avoid costly, or even total airframe losses, in the field.

When considering buying a UAS, it is important to check the warranty and after-sale services agreements. It is also important to check if the spare parts for the UAS are readily available. This is an important consideration because breaking or cracking a wing could take two weeks or more for shipping a replacement. Make sure to either have an inventory of spares, or have a nearby dealer who has a dependable supply of UAS parts.

Another suggested best practice is to protect the investment and organization with UAS insurance. Insurance companies are expecting each organization to have PIC qualifications, operating manuals, maintenance logs and a record of parts or add-ons purchased.

After every flight, if an inspection should reveal any damage, the PIC should authorize the repair of the aircraft. Repairs can consist of two types, non-critical or critical. Non-critical repairs are repairs made to the airframe or components that are not critical to the flight control or function of the aircraft in its assigned mission. Repairs of this nature are patches to covering, replacing fairings or cowlings, or repairs that enhance the mission payload. Critical repairs or those repairs that must be made that directly affect the ability of the aircraft to perform its function and to continue the mission. Typical repairs of this nature would be such as replacing a motor, or replacing a fight control servo.

Documentation

The following are examples of reports, documents, and other materials that may be generated, issued or required for UAS operations -

FAA Documentation

- **Certificate of Waiver or Authorization (COA)**
  For public aircraft operations, the FAA issues a COA that permits public agencies and organizations to operate a particular aircraft, for a particular purpose, in a particular area. The COA allows an operator to use a defined block of airspace, with a specific aircraft and includes special safety provisions unique to the proposed operation. A COA request is prepared and submitted online through the FAA's COA Management Portal. An approved COA is returned after FAA analysis and any constraints, modifications or additional requirements
- **Monthly COA reports**
  Monthly COA reports are required, even if no flights were conducted under an approved COA. The Monthly Operational report is expected to be submitted within 5 business days after end of the reporting month Reporting Requirements. Documentation of all operations associated with UAS activities is required regardless of the airspace in which the UAS operates.
  1. Name of Operator, COA or Exemption number, and Aircraft registration number
  2. UAS type and model.
  3. All operating locations, to include location city/name and latitude/longitude
  4. Number of flights (per location, per aircraft)
  5. Total aircraft operational hours
  6. Takeoff or Landing damage
  7. The number and duration of lost link events (control, performance and health monitoring, or communications) per aircraft per flight.
  8. Equipment malfunctions. Reportable malfunctions include, but are not limited to the following: On-board flight control system, navigation system, powerplant failure in flight, fuel system failure, electrical system failure, and control station failure.

- **Notice to Airmen (NOTAM)** – A NOTAM is a notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight. NOTAMs do not restrict airspace, they are a public announcement to the airspace community.
- **UAS Registration** - Registration is required for all unmanned aircraft (UA) operated for non-hobby or non-recreational purposes. An aircraft may be registered only by and in the legal name of its owner. The FAA UAS website for aircraft registration is available from the primary UAS page[2].
- **Airport Authorization –** A written approval from the airport management authority is recommended to fly within 5 miles of an airport. Before calling the airport authority, be sure to have exact location, planned maximum altitude and flight time information ready to process the flight request.

North Carolina Documentation

- **State UAS Operator Permit**
  Under the current state law, all commercial and government agency UAS users must obtain a state UAS Operator permit issued by NCDOT Division of Aviation. This permit is in addition to a federal small UAS Operator Certificate and/or COA Certification that is accepted by the FAA.
- **Land User Authorization**
  A written permission granted by the authorized approving official (state or private) to take off, land and otherwise use their facility (farm, private land, etc.). Such use permit may be issued for single or multiple occasions

Personal (Pilot in command & Visual Observers) Documentation

It is recommended that pilots of unmanned aircraft should document their flights, pilots of manned aircraft are required to document their flight time.

- **Personal Flight Log**
  Each member of the flight crew should keep a record of all flights flown. The log should contain the location flown, time of flight, aircraft used (reference the specific UAS registration number), and a flight ID number.

Organizational Documentation

Every organization should have a UAS fleet management system designed to help keep track of the organization's pilots and UAS fleet, covering all the needs and requirements for maintaining a safe and reliable UAS operation.

- Flight Crew Log
  The log should contain flight location, date, time of flight, type of aircraft, flight ID number, Crew name (PIC, VO(s), site manager).

[2] FAA Small UAS Registration page: https://registermyuas.faa.gov/

- Aircraft Log
  This log should contain location, date, time of flight, PIC, Notes.
- Maintenance Log
  The log should contain date, type of aircraft, reason for maintenance, work done, parts replaced, system tested (yes/no), notes, etc.
- Data Log
  The log should contain Flight ID, location, PIC, type of data acquired, data archive ID, and location.
- Accident Log
  The log should contain date of accident, time of accident, name of injured, accident details, action taken, notes, report ID from FAA/NTSB if applicable, etc.
- Annual Report – Review of UAS program containing data utilization, budget, and lessons learned, etc.

8.3 Tailored Best Practices for State Agencies and User Communities

Introduction

This document outlines the agency-specific considerations that should be evaluated by the various public agencies in the State of North Carolina. Each agency, or user community, has specific requirements and operations that would benefit from integrating Unmanned Aircraft Systems (UAS) into their programs. This document provides information to assist agency executives, program managers and operations managers in tailoring their program as a companion document to the Business and Operations Model Best Practices. These Best Practices are provided as guidelines and are not directive in nature. These guidelines will be incrementally revised based on operational data, trouble reports, cost reports and lessons learned.

This document sorts the State's agencies and user communities in two general categories: (1) law enforcement and public safety and (2) other agencies and user communities. Each general category is further segmented into a number of sub-categories, each with unique requirements and operational considerations, as listed below:

1. Law Enforcement and Public Safety
    a. Law Enforcement
    b. Urban Fire & Emergency Medical Services (EMS)
    c. Rural Fire (Including Wildfires)
    d. Transportation Accident Investigation
    e. Disaster Response
    f. Search and Rescue
2. Other Agencies and User Communities
    a. Environment and Natural Resources (Department of Environmental Quality) including flood plain mapping, easements and watershed activities
    b. Agriculture
    c. Storm Damage Property Assessment
    d. Fish and Wildlife Monitoring and Management
    e. Property Assessment and Real Estate Mapping
    f. Cell tower inspections
    g. Power line and pipeline surveys.
    h. Critical infrastructure inspections, security, and maintenance
    i. Commissions, licensing and trade associations

The Best Practices in this document are presented from the perspective of a State-level agency or user community. It is recognized that there are unique differences in requirements at the various levels of government. These differences are presented and discussed in a companion document, Tailored Best Practices for Various Levels of Government.

Key Actors

- Agency Executive
- Program Manager
- Contracting Authority
- Flight Operations Manager
- State Industry Regulators

Potential Applications and Things to Consider

This section provides background on several agency and user community UAS applications in order to provide an operational context for their Best Practices.

Law Enforcement and Public Safety

Law Enforcement

Law Enforcement applications and Best Practices discuss the use of UAS by law enforcement as a tool to gather information important to carrying out their duties. This section does not apply to any requirements for law enforcement assignments to investigate the illegal or inappropriate use of UAS under developing laws and public policy.

NC Section Law 2014-100, § 15A-300.1 (Restrictions on use of unmanned aircraft systems) provides the following Law Enforcement Exceptions which form the basis of typical law enforcement UAS applications. The use of UAS by law enforcement agencies of the State or a political subdivision of the State is not prohibited in the following instances:

(1) To counter a high risk of a terrorist attack by a specific individual or organization if the United States Secretary of Homeland Security or the Secretary of the North Carolina Department of Public Safety determines that credible intelligence indicates that such a risk exists.
(2) To conduct surveillance in an area that is within a law enforcement officer's plain view when the officer is in a location the officer has a legal right to be.
(3) If the law enforcement agency first obtains a search warrant authorizing the use of an unmanned aircraft system.
(4) If the law enforcement agency possesses reasonable suspicion that, under particular circumstances, swift action is needed to prevent imminent danger to life or serious damage to property, to forestall the imminent escape of a suspect or the destruction of evidence, to conduct pursuit of an escapee or suspect, or to facilitate the search for a missing person.
(5) To photograph gatherings to which the general public is invited on public or private land.

Other law enforcement UAS applications include:

- Activities where using a UAS could release manned law enforcement aviation assets for other tasking.
- Reducing the risk to the public from high speed auto chases. Using a UAS can keep the suspect in view while safe intercepts and apprehension can be planned and executed.
- Monitoring buildings and areas for suspect escape and potential flight.
- SWAT and hostage scenarios

In conjunction with fire and EMS, law enforcement UAS could assist in traffic and crowd control at a fire scene. UAS imagery would be a valuable tool to assist in planning lanes for equipment arrival and evacuating the injured.

Urban Fire & Emergency Medical Services

The UAS will become a valuable tool for gathering critical information on a fire scene. Getting an overhead view of the fire and surrounding areas as fire equipment and personnel arrive on scene will assist the on-scene commander make better and more timely decisions on how to combat the fire. It is expected that maintaining continuous eyes in the sky under the direction of the on-scene commander will lead to a reduction in injuries and property damage.

Emergency medical services will benefit from having UAS overhead imagery at fire and traffic accident scenes. EMS UAS can provide a more complete and rapid view of accident scenes to identify the location of injured people. Having real time overhead imagery will enable EMS to better plan patient triage areas, treatment locations and injured patient transportation routes.

Rural Fire (Including Wildfires)

The biggest benefit to the rural use of UAS is being able to search larger areas more rapidly to anticipate how a fire will spread. This will enable the agency to direct its resources in a more efficient and safe manner. Once a wildfire is contained, UAS flights with infrared sensors should be conducted to search for hot-spots to verify an area will not re-flash.

Depending on the number and type of UAS available and budget for flight operations, a rural agency should consider conducting UAS flights following lightning events in dry conditions. A search of reported lightning strike areas could lead to finding a wildfire before if fully develops.

Transportation Accident Investigation

Accident investigators could use UAS to collect required information at an accident scene. An overhead view would allow investigators to more efficiently map the scene and acquire evidence. Video and still shots of the area will be valuable additions to the investigation package. This should improve information collection accuracy and speed in order to clear the scene of large accidents and return to normal traffic patterns.

It is expected that the UAS imagery obtained will provide a valuable link to how roadway and infrastructure contributed to an accident. Post-accident analysis with highway safety officials could lead to safer roadways and enable modifications to traffic management schemes.

UAS would be a new tool in collecting rail accident information. Overhead imagery of the accident scene and the track leading to the scene would provide a new perspective for accident analysis by State and federal officials.

All retained UAS information should be made available to comply with NCDOT's public records request policy. Including UAS information in list of available public documents will support NCDOT's stated transparency and public document availability goals for citizens, members of the media and other organizations. Using accident scene UAS imagery could have an added benefit of reducing the time to complete litigation and insurance claims.

Disaster Response

UAS operations will become a valuable tool to assist in a wide variety of disaster response scenarios. Their use could reduce the number of personal injuries and amount of property losses resulting from hurricanes, tornados, floods, wildfires, major snow and ice storms, and any homeland security related events. Specific uses include (1) locating stranded people and communities; (2) conducting initial surveys of damage to direct damage response personnel; (3) finding damaged or blocked roadways; (4) locating dams and levees at risk for overflow or breach, and (5) locating areas where ice could lead to power line loss.

Integrating private and commercial UAS into disaster response operations could benefit the pubic and accelerate recovery operations. These UAS, however, must be registered and part of an agency's planned response. Unorganized and ad hoc arrival of private or commercial UAS could complicate the overall response effort and could lead to interference with manned aviation assets.

Search and Rescue

UAS operations will become a valuable tool to assist in a wide variety of search and rescue scenarios. These include responding to locate lost individuals on land and on the water. Integrating UAS into these search scenarios will supplement other air assets in supporting the search effort on the ground.

Other Agencies and User Communities

The benefits of public, commercial and private UAS are substantial. UAS integration is estimated to have an $82 billion economic impact on the U.S. over the next 10 years—with 100,000 new jobs created. Whether UAS are performing search and rescue missions, helping farmers grow better crops in a more sustainable manner, inspecting power lines and cell towers, gathering news and enhancing the public's access to information, performing aerial photography to sell real estate, surveying and mapping areas for stewardship decisions and public policy, delivering medicine to rural locations, providing wireless internet, enhancing construction site safety, or more—society is only just beginning to realize the full potential of UAS. Indeed, the demand for UAS for business purposes has been far-reaching, and continues to grow. UAS technology is already bringing substantial benefits to people's daily lives, including cheaper goods, innovative services, safer infrastructure, and greater economic activity. Inevitably, creative minds will devise many more UAS uses that will save lives, save money and make our society more productive.

Many State agencies and user communities will benefit from applying new UAS technology to their operations. In general, they have the potential to reduce operating costs and obtain critical data for several applications. However, the current restrictions on daytime, line of sight (LOS) UAS operations restrict the economic benefit of these systems for the near future. Therefore, agencies and user communities would be well-served to become early adopters of UAS systems examining and testing flight safety beyond the line of sight (BLOS).

Environment and Natural Resources
Related agencies include: Department of Environmental Quality, Department of Natural and Cultural Resources, North Carolina Emergency Management.

The use of UAS with optical and LIDAR (Light Detection and Ranging) sensors would enable the collection and analysis of data to better understand the changes in the State's coastline. Collaboration with the US Geological Survey on coastline morphology research could lead to better coastline strategies to protect the coast and property there from major storms.

Similarly, UAS equipped with these sensors could provide new and more cost effective data to assist officials in the responsible department for mapping easements, parks, inland waterways, and flood plains. This data would be made available to State agencies, real estate professionals, the insurance industry and the public using established data publication and distribution policies.

Agriculture
The field of precision agriculture remote sensing has embraced the use of UAS to gather crop health data. A variety of optical, thermal, infrared and spectral sensors have demonstrated their value in increasing crop yield, reducing cost and improving the environment through better chemical application strategies.

There are two major application categories for this technology. The first is in agricultural research at our universities and through cooperative research funded by agribusiness investment. In the latter case, the State's public universities can own or lease UAS as public aircraft to conduct this research under an FAA approved Certificate of Authorization (COA). Private universities and corporations can conduct agricultural imaging services using UAS with Section 333 Exemptions or under Part 107 operations beginning in the fall of 2016.

The second major application category would be in collecting and distributing crop and soil information by the NC Department of Agriculture and Consumer Services, Agronomic Services Division. UAS operated by or for the division would support its mission to provide North Carolina residents with diagnostic and advisory services that increase agricultural productivity, promote responsible land management and safeguard environmental quality.

Storm Damage Property Assessment

Initial surveys of property damage using UAS following major storms will enable public officials and non-profit managers to more effectively plan their recovery efforts using fresh imagery. This data will assist State executives in understanding the magnitude of the damage as they interact with federal aid managers supporting the recovery.

UAS flights to collect property damage information following major storms will expedite the filing and liquidation of insurance claims. This will simplify the work of agents and adjusters to serve the community and provide the necessary financial resources to recover the community.

Fish and Wildlife Monitoring and Management

The uses of UAS will increase the amount of scientific data collected for analysis to benefit the State's natural environment. This new data will assist researchers and managers better understand critical wildlife and fish habitats in order to locate and mitigate threats to these natural resources. Critical among these are collecting data on the effect of man-made changes to the environment and the progress of and damage by invasive species.

Surveying, Property Assessment and Real Estate Mapping

Using UAS for land surveying will be a valuable tool in collecting images for property assessments and real estate mapping. UAS photographs processed using photogrammetry software can produce 3D accuracy that is equal to or better than conventional aerial photography. Standard GIS software can be used to stitch and georeference the UAS photos into finished products. These products can be made available to public agencies and commercial users. This new data source may be incorporated by the NC Geological Survey into their topographic maps and aerial photographs.

Cell tower inspections

Although requirements for cell tower inspections may vary, one Telecommunications Industry Association (TIA) Standard, TIA/EIA 222-F, recommends maintenance and inspection of steel antenna towers and antenna supporting structures should be performed by the owner on a routine basis. However, "routine" is open to interpretation. They recommend that all structures should be inspected after severe wind and/or ice storms or other extreme loading conditions. Shorter inspection intervals should be considered for structures in coastal salt water environments, in corrosive atmospheres, and in areas subject to frequent vandalism. The document is more specific on suggesting a time for major inspections: 3 years for guyed towers and every 5 years for self-supporting structures. Safety and access are of the utmost concern in the process.

Small UAS can be a cost effective, quick, efficient and safe means of assessing the condition and orientation of all components of the cell tower. While these inspections will be performed by tower owners or service providers, it is important to the State and telecommunications regulators to ensure these inspections can be safely accomplished while minimizing potential damage to the telecommunications network.

Power line and pipeline surveys

Surveying "linear infrastructure" using low flying manned aircraft is costly and potentially dangerous. Adopting the use of UAS will enable collection of the required safety and maintenance data from power lines and pipelines is expected to reduce cost, minimize aviation accidents and mitigate the risk to the infrastructure being inspected.

The value of UAS inspections in these long linear infrastructure applications is limited by current FAA regulations requiring LOS operations. Early adopters should consider examining the use of new technologies and data from FAA's Pathfinder Projects in the railway and agriculture sectors to accelerate the introduction of BLOS UAS operations for power line and pipeline surveys.

The data collected for these surveys might have value to other users such as the agencies responsible for monitoring and maintaining the utility easements. Establishing a cooperative agreement to share data could reduce cost and benefit both parties.

Critical infrastructure inspections, security, and maintenance

One potential use of UAS for critical infrastructure inspections, security and maintenance is with the State's railway network. The FAA has recently established a Pathfinder Project to explore and test BLOS UAS operations on railroads. This Pathfinder Project partnered BNSF and InSitu. They recently completed their first flight using a ScanEagle to cover 64 miles of a 132-mile stretch of BNSF track.

Other critical infrastructures to consider using UAS for their inspections, security, and maintenance would include power plants, bridges, and dams. State officials should consider adopting the use of UAS to collect data for the Vulnerability Assessments and Surveys conducted with the U.S. Department of Homeland Security Protective Security Advisor (PSA), North Carolina District.

Commissions, Licensing Authorities and Trade Associations

State commissions, licensing authorities and trade associations will need to be fully cognizant of Best Practices in the industries they regulate and represent. For example, the NC Utilities Commission would have cognizance over responsible and safe UAS use by electric companies & cooperatives; natural gas distribution & pipeline companies; and telecommunications exchange companies.

Similarly, the NC Real Estate Commission and NC Association of Realtors will need to set standards for the rapidly expanding use of UAS in the real estate market. In some areas, the initial use of UAS in the real estate market was dominated by unlicensed personal hobby-grade aircraft as a low cost alternative to hiring professional UAS operators with the required Section 333 exemptions. NGAT has established relationships with the NC Surveyor Board, NC Emergency Management Association, NC GIS Council, and other organizations that determine standards and certifications for licensing and credentialing in the state.

Practice Description

This section discusses the specific agency or user community requirements and operational considerations. State agency and other user community UAS operators should review the UAS provisions contained in the North Carolina Statutes as enacted through Session Law 2014-100 which went into effect in 2014 and updated through the enacting of Session Law 2015-232 passed by the North Carolina General Assembly and signed into law by the Governor of North Carolina in 2015. A summary of these regulations can be obtained on the NCDOT website[3].

Common items are provided in the two major sections. Items important to a specific group are listed in that group's subsection.

Law Enforcement and Public Safety

Law enforcement and public safety officials have additional legal and statutory requirements to consider in their UAS operations. There are several components that need to be considered as they fulfill their responsibilities to protect and serve the public which include:

- Maintaining public trust
- Agency accountability and transparency
- Evidence collection, preservation and maintaining chain of custody
- Fourth amendment protection against unreasonable searches and seizures to include legal interpretations as to when search warrants will be required for UAS operations
- Protecting individual privacy

[3] http://www.ncdot.gov/aviation/download/UAS_Memo.pdf

It is not the intent of this Best Practice to capture the evolving state of these policy issues as they develop and pertain to UAS operations. There are several organizations and public discourse among them that will determine the eventual public laws and policy in this area. Each agency should monitor and comply with evolving federal, state and local UAS, data management, and privacy laws. NGAT will continue monitoring their developments and update this Best Practice as required.

Agencies and user communities should establish a data collection policy prior to conducting UAS flights. Users of this Best Practice should refer to the companion Data Management Best Practice. For law enforcement and public safety, the following sections of the Data Management Best Practice are most important:

- Data Architecture
- Data Flow
- Analyzing
- Data Storage & Security
- Privacy & Data Protection

Several agencies and user communities will need to institute security policies and procedures. Law enforcement and public safety agencies should consider adopting some of the security policies below:

- Agencies should have a written security policy with respect to the collection, use, storage, and dissemination of data collected via UAS that is appropriate to the sensitivity of the data collected and retained.
- Agencies should make a reasonable effort to regularly monitor systems for breach and data security risks.
- Agencies should make a reasonable effort to provide security training to employees with access to personal data collected via UAS that is consistent with the training provided for similar information collected from other sources.
- Agencies should make a reasonable effort to permit only authorized individuals to access personal data collected via UAS.

In all cases, the agencies should establish a process to gather information on the UAS operation, UAS sensor performance, how the UAS led to better decisions and any negative effects observed. This information should be regularly reviewed and analyzed in order to improve UAS operating procedures for future operations and training.

Items important to a specific user group are listed in the subsections below.

Law Enforcement

Law enforcement should adopt a cradle to grave approach to UAS data collection from the point of collection to prosecution to archive retention. This includes the digital data as well as the physical storage media. Handling all data and physical storage media should comply with existing evidence collection and maintenance policies and procedures. Obtaining crime scene video will assist prosecutors as they present that visual information during trial.

Airspace managers will need to coordinate and advise manned aircraft of the intended use of UAS at the scene in order to prevent mutual interference. Law enforcement should develop tactical procedures for UAS integration into activities such as area tactical surveillance, tracking fleeing suspects, hostage situations, bomb squad support and SWAT operations. These tactical procedures should consider the relative effectiveness of manned aviation assets versus UAS to assign the best aircraft for the scenario.

Urban Fire & Emergency Medical Services

The North Carolina Department of Insurance is developing standard operating procedures for fire-fighting training to include UAS operations and sensor selection. The use of UAS with thermal or infrared sensors will provide new information not previously available at the fire scene. Locating hot spots on building surfaces should lead to safer and more effective methods for combating the fire. If the agency's UAS does not have the capability of carrying both an electro-optic (visual) and infrared sensor, the agency should establish criteria for when and how to employ its available UAS and sensors.

Urban Fire UAS pilots-in-command (PIC) and observers should maintain a close watch on UAS performance in a very dynamic environment. Movement of the UAS to a better location for flight stability should be part of their mission planning and pre-flight briefing activities due to fire's heat generating unpredictable air flow gusts that could affect the UAS flight control systems and flight crew visibility.

Airspace managers will need to coordinate and advise manned aircraft of the intended use of UAS at the scene in order to prevent mutual interference. The fire department's intent use of UAS will need to be relayed to manned aircraft flights such as new media.

Rural Fire (Including Wildfires)

Rural area fire managers using UAS will need to consider current restrictions that limit UAS flights to line of sight. If wide area operations are planned, the on-scene commander should consider UAS flight operations with geographically dispersed PICs to enable hand off of an aircraft as it transitions from one PIC's line of sight to another. This tactic could also include having observers qualified as PICs with the ability to take control of a specific aircraft. Depending on the UAS design and endurance, transitioning a flight from one PIC to another could include landing the aircraft, replacing its batteries, and subsequently re-launching.

For large wildfires, UAS assets from State agencies should participate in interagency airspace coordination authorities while combating the fire. UAS operations should be integrated into existing manned air operations to prevent mutual interference and allocate UAS to missions where their unique capabilities can lead to better decisions to save lives and reduce property damage. UAS operators should consider using the Interagency Airspace Coordination Website[4]. This safety oriented website is dedicated to airspace issues involving USDA-Forest Service and the Bureau of Land Management.

Transportation Accident Investigation
Public safety officials and accident investigators should develop a UAS data collection checklist to efficiently collect required information and minimize the collection and retention of collateral personally identifiable information (PII). This checklist should include recommended UAS altitude and camera angles relative to the key evidence in the accident scene. The checklist should also include guidelines on how to minimize or digitally obscure non-participant PII.

On-scene public safety officials should forward UAS imagery to the NC Department of Transportation (NCDOT) officials responsible for infrastructure and roadway safety. This UAS imagery could provide valuable information and analysis on how the roadway and infrastructure contributed to an accident. For large accidents with potential roadway safety factors, the on-scene safety officials should consider posting UAS images of the scene on line for near-real-time collaboration and analysis to ensure NCDOT officials get all the UAS information they need. Post-accident analysis with highway safety officials could lead to safer roadways and enable modifications to traffic management schemes.

All collected and retained UAS information should be made available through the established NCDOT procedures to comply with NCDOT's public records request policy.

Disaster Response
When responding to a major disaster, UAS operations should be integrated into existing manned air operations within the incident management team to prevent mutual interference. They should allocate UAS to missions where their unique capabilities can lead to better decisions to locate (1) areas of severe damage, (2) injured or stranded individuals (3) optimum emergency ingress and egress routes and (4) areas where personnel and property are likely to become at risk to weather and water movement. Locations of intended UAS operations should be included in any established Temporary Flight Restrictions (TFR).

Agencies should consider instituting policies and procedures to obtain assistance from private and commercial UAS operators. This should take the form of pre-planned and pre-negotiated services and communications plans. With the large number of small UAS becoming available, it is a natural response for concerned citizens to want to assist. Their involvement should be planned such that they can be integrated into disaster response air operations. Agencies should also make the public aware that UAS operations will not be allowed without prior approval and agreements to assist the public disaster response organization.

[4] http://www.airspacecoordination.net/

In all cases, private and commercial UAS responding to a disaster will need to be registered in accordance with FAA requirements. Commercial UAS providers should have current Part 107 or Section 333 Exemption documentation. The UAS operator should have his/her flight crew qualifications available for the responsible agency to verify. The agency should inspect all documentation prior to accepting the private or commercial UAS provider and integrating them into disaster response air operations.

All agencies with UAS should participate in regularly scheduled emergency management training exercises. This will enable the agencies to become familiar with airspace integration issues. The exercises will help educate disaster response and emergency management officials on UAS capabilities and how they can contribute to mitigating the severity of the disaster. These exercises should consider examining the role of private and commercial UAS providers to supplement pubic UAS assets.

Search and Rescue

Agencies with UAS should maintain a posture where they can rapidly respond to situations requiring locating lost individuals on land and on the water. Although the agency responsible for the initial response may have their own organic UAS, other agencies and user communities should be organized in such a way to provide additional assets when requested. As in the disaster response case above, agencies should make provisions for private and commercial UAS operators to assist in the search and rescue.

Search and rescue operations on the State's waterways will require coordination with the US Coast Guard. Selection and use of UAS for this mission should consider the appropriate sensors and flight capabilities to locate personnel in the water. Navigation and geolocation on large bodies of water will complicate the operations. As in the other areas above, interagency air operations coordination will be critically important.

Other Agencies and User Communities

An agency-driven requirements approach is preferable to a one-size-fits-all approach. As in the law enforcement and public safety section above, these agencies and user groups should establish a data collection policy prior to commencing UAS flights. Users of this Best Practice should refer to the companion Data Management Best Practice.

Each agency should consider data reuse and sharing within and across organizational boundaries. This would greatly reduce redundancy, cost, and lead to improved decision-making. A good example would be sharing land survey data with agencies responsible for infrastructure security and emergency response planning. Systems that collect, utilize, or exchange geospatial information must comply with the policy statements and the standards adopted by the North Carolina Geographic Information Coordinating Council (GICC).

Items important to a specific group are listed in the subsections below.

Environment and Natural Resources

Related agencies include: Department of Environmental Quality, Department of Natural and Cultural Resources, North Carolina Emergency Management.

There are a number of fixed wing and rotorcraft UAS with the ability to collect data for the these kinds of departments. The key is selecting the appropriate sensor for the data to be collected. Sensors, their data storage, flight altitudes and power requirements will dictate UAS endurance and area coverage rates. Agency officials should consider inviting UAS providers to conduct a demonstration of their capabilities to assess performance prior to entering into a purchase, lease or service contract.

Agencies that monitor public easements for utilities should consider entering into an agreement with companies using UAS for power line and pipeline surveys. Images gathered by these companies could meet the needs of the department and result in cost savings to the government and the utility provider.

Agriculture

UAS operators collecting agricultural data need to closely coordinate with local aviation managers and farm owners to prevent mutual interference with manned aviation. Low altitude remote sensing UAS flights on one farm could pose a risk to low flying crop dusting aircraft approaching to work another farm in the area.

Storm Damage Property Assessment

If the storm damage was the result of a major disaster, the early stages of property damage assessment should be coordinated with the disaster response integrated air operations.

Once disaster response operations have concluded, agencies and user communities should require UAS registration in accordance with FAA regulations. Public UAS should be operated in accordance with an approved COA; commercial UAS should be operated as authorized by Part 107 or a Section 333 exemption. Insurance appraisers operating UAS should also comply with industry standards as they are developed.

Fish and Wildlife Monitoring and Management

The US Department of Interior has been an early adopter of using UAS for wildlife monitoring and management. State agencies should establish a relationship with the department's components, such as US Geological Survey, Bureau of Land Management, and US Fish and Wildlife Service to obtain UAS reports and lessons learned for the particular State application. Cooperative data sharing on a variety of research and management projects could be beneficial at both the state and federal level. Establishing relationships with the State's universities and private industry could accelerate UAS fish and wildlife research through federal grants, North Carolina Sea Grant, or North Carolina Cooperative Extension.

Surveying, Property Assessment and Real Estate Mapping

Prior to instituting a program to collect survey data using UAS, the agency should do an analysis of the areas required to be surveyed and assess the cost benefit of obtaining the data using UAS. Collecting data in a small area all within the line of sight of a single PIC would be best suited for UAS operations.

The agency should consider entering into an agreement with real estate developers to obtain updated surveys with UAS in areas of recent construction or site preparations. Images of this type would be valuable to the developers who could bear most of the cost of collecting the data required by state and local officials.

Cell tower inspections

Commissions and licensing authorities should adopt and enforce policies that all cell tower owners and service providers will register their UAS in accordance with FAA regulations and shall have a Small UAS Operator Certificate in accordance with Part 107 or a Section 333 exemption. These policies will result in raising safety and business regulation standards to prevent tower damage, personal injury and potential network degradation.

Power line and pipeline surveys

Current FAA restrictions on limiting UAS operations to those within the line of sight (LOS) of the pilot-in-command (PIC) will reduce the cost effectiveness of using UAS for these long linear surveys. Agencies and regulators should consider adopting the procedures and flight safety protocols being developed by the FAA in their railway and agricultural Pathfinder Projects to enable early adoption of Beyond Line of Sight (BLOS) UAS operations for power line and pipeline surveys.

Critical infrastructure inspections, security, and maintenance

State agencies should review their responsibilities and cooperation with the Department of Homeland Security's National Infrastructure Protection Plan (NIPP). The State has facilities and systems in several of the department's 16 critical infrastructure sectors[5]. The sectors' assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof.

State agencies should establish programs with their federal counterparts to investigate the use of UAS to help protect critical infrastructure. State agencies should pursue DHS grants and participate in DHS exercises to develop operational strategies to incorporate the use of UAS.

Commissions, Licensing Authorities and Trade Associations

Commissions, licensing authorities and trade associations should adopt and enforce policies that all UAS operators in their industries will register their UAS in

[5] http://www.dhs.gov/critical-infrastructure-sectors

accordance with FAA regulations and obtain a Small UAS Operator Certificate as required by Part 107. These policies will result in raising safety and business regulation standards to prevent property damage, personal injury and other losses.

Benefits and Issues

This section discusses the benefits and issues likely to be encountered with the use of UAS.

Benefits

- North Carolina can expect benefits and cost savings in power line surveys. They can expect returns similar to those reported by San Diego Gas & Electric (SDG&E) as recorded in AUVSI's testimony before the US House of Representatives Judiciary Committee in September 2015. SDG&E is a public utility that provides energy services to 3.4 million people in southern California. SDG&E, which inspects 26,000 miles of transmission and distribution power lines, uses UAS to greatly improve safety and efficiency over manual inspections. UAS also allow SDG&E to restore power more quickly after outages, especially when lines may be difficult to access because of extreme weather conditions.
- Every year there are several deaths related to cell tower inspection. UAS can mitigate this risk by entirely removing the need to climb the tower. With appropriate sensor suites, UAS can also measure signal strength of antennas and other electromagnetic characteristics.
- The National Society of Professional Surveyors (NSPS) strongly supports the safe integration of commercial unmanned aircraft systems (UAS) into the National Air Space (NAS). UAS presents an extraordinary opportunity for utilization by surveyors to provide services to contribute to public health, safety, and welfare, and enhance the quality of life of all Americans, foster economic growth, increase the efficiency of surveying activities, and create business opportunities for the surveying profession. Geospatial data is essential to commercial and governmental activities, the collection, storage and use of which can and should continue to be permitted and encouraged for the benefit of the citizens of the United States.
- The Associated General Contractors of America (AGC) has highlighted the areas in which UAS are starting to assist its 26,000 member companies in the construction industry. AGC members, which build everything from roadways and bridges to large-scale building complexes, are using UAS to improve project planning and design, safety, efficiency, quality, and environmental compliance. UAS are also documenting the progress of large construction projects, like the new Kings arena in Sacramento, to make sure each step is delivered properly and on time.

- According to the National Association of Mutual Insurance Companies, insurers are using UAS in risk assessments, especially in dangerous places like high-pitched roofs, and to speed up claims adjudication after disasters, when time is most important in helping victims recover from their losses. AIG, State Farm, and USAA are among several insurance companies that have been approved to fly UAS commercially.
- UAS have the potential to significantly change the way property adjusting is performed. Easy portability, navigation and the ability to take high-resolution videos and photos make drones the ideal solution for supplementing claims adjudication, since adjusters would no longer need to climb dangerous ladders with a point-and-shoot camera in one hand and a notepad in the other.
- UAS can also be used effectively in crop insurance — not only to determine the actual cultivatable land, but also during the claims process to understand the extent of loss and the actual yield.

Issues

- Personal Privacy. Agencies adopting UAS as part of their operations need to keep abreast of any changes to laws and policies.
- Liability. Agencies adopting UAS should consider the overall risk to the agency and the State from any UAS-related accidents.
- Use of unauthorized UAS in the National Airspace System (NAS). Airspace integration must be rigorously enforced. All UAS must be appropriately registered and authorized to operate in the airspace. The airspace users' community maintains a culture of self-monitoring and reporting as a safety mechanism to protect the integrity for everybody.
- Proliferation of hobby radio controlled aircraft. The sheer numbers of these aircraft and their low cost makes using them an attractive alternative to using professional grade UAS. The reliability of these aircraft under heavy professional duty cycles is unknown and could contribute to losses and injuries.
- Rapid growth and diversity of UAS in the market place. There are very few testing and certifying agencies with the ability to publish data on UAS operating cost, accident rates, reliability, and failure modes. Until a UAS "consumer reports" analysis is publically available, potential users will be subject to various marketing claims by UAS developers.

8.4 Operational Procedures

Introduction

All UAS operators should develop and document operational procedures for their organization that will serve to guide flight operations planning and execution. The operational procedures document best practices and internal processes for safe and effective flight operations. This includes roles and responsibilities, mission phases, and emergency procedures. The aim is to document everything that needs to be done during a mission, so it can act as a reference point for team members. The information below is provided as a guideline for organizations to use in their own development of Operational Procedures specific to their organization and the types of flight operations they conduct. However, not all of these guidelines will apply to all situations. Therefore, use your best judgment and error to the side of safety.

Key Actors

- UAS Operator and/or Pilot in Command (PIC)
- Visual Observer
- Airport Manager
- Air Traffic Controller
- Land owner or designated party for launch and recovery site

Practice Description

There are 8 sections to the practice: Pre-flight Operations, During Flight Operations, Post-flight Operations, Emergency Procedures, Flight Area/Perimeter Management, Accident/Incident Reporting, Flight Crew Communications, and External Communications.

Pre-flight Operations

Preflight activities are the duty of the pilot in command and also the observer either upon arrival at the location or before the start of the flight operation. Activities include inspection of the aircraft, assessment of the operating location, co-ordination with other crew members involved in the operation, and equipment checkouts. All flight operations should be conducted in accordance with an FAA-approved authorization, state and local legal regulations, and the operator's manual for the subject aircraft.

Planning

1. The flight crew should be familiarized with all available information concerning takeoff including, but not limited to the flight authorization constraints, weather conditions, hazards, no fly zones, etc.
2. PIC will ensure the location for take-off and emergency landing is adequate upon arrival at the location. At least one emergency landing area should be identified before the start of operations.
3. PIC should be aware of all surroundings in the event that an emergency landing is necessary. This includes the ability to recover the UAS.

Inspections

1. Before the first flight of the day, verify all batteries are fully charged.
2. Check the airframe for signs of damage, and its overall condition.
3. Check the entire aircraft per the pre-flight inspection instructions in the manual for the specific aircraft to make sure it is in good structural condition and no parts are damaged, loose, or missing.
4. Check the propeller or rotor blades for chips, cracks, looseness and any deformation.
5. Check that camera(s) and mounting systems are secure and operational.
6. Perform an overall visual check of the aircraft prior to arming any power systems.
7. Repair or replace any part found to be unsuitable to fly during the pre-flight procedures prior to takeoff.

Weather

1. Before each flight the PIC and observer should ensure that he/she gathers enough information about the existing and anticipated near-term weather conditions throughout the entire mission environment. As a best practice he/she should utilize FAA approved weather resources to obtain the latest and most current weather conditions.
2. Wind direction plays a major factor in flight operations. Operators should take precautions to ensure that wind conditions do not exceed the aircraft limits stated in the aircraft operations manual/specifications. An anemometer (pocket anemometers are available from a variety of sources) is a low-cost and simple to use tool that can be utilized in order to better estimate the wind speed and determine if it is within the necessary limits of the UAS being flown. Use of an anemometer is highly recommended, in particular in cases where wind conditions and whether they are within limits may be questionable.
3. The PIC should ensure that the flight will occur within the weather requirements specified in their FAA-issued airspace authorization. While the FAA has authorized certain types of operations in particular locations for night-time or beyond line of sight operations, the vast majority of authorizations are for FAA VFR conditions only (refer to FAA § 91.155 Basic VFR weather minimums) and

require Visual Line of Sight between the aircraft and the UAS Operator as well as between the aircraft and the Visual Observer at all times.

Checklist

It is a best practice to use a pre-flight checklist to ensure that safety procedures are followed before and during every flight. The checklist is usually integrated into the UAS flight software or can be obtained from the UAS vendor. In case that is not available, a standard Flight Checklist (Figure 19*)* should be made and followed by the flight crew. PIC should utilize the checklist to ensure the highest level of safety. At a minimum, this pre-flight checklist should contain the following:

1. Weather conditions suitable.
2. Check air frame for cracks and check all screws are tight.
3. Propeller(s)/Rotor(s) not damaged and tightly fixed.
4. Propulsion system mounting(s) secure.
5. Batteries fully charged and securely mounted.
6. Communications (datalink) check.
7. Ensure the GPS module (if any) has GPS “fix.”
8. Check mission flight plan.
9. “Return Home” and/or “Emergency Landing” locations (if supported by the particular UAS) are selected, located appropriately, and loaded to the GCS and aircraft.
10. Ensure sensors are calibrated and that the right setting is loaded.
11. Complete flight crew briefing.
12. Ensure the launch site is free of obstacles.
13. Recheck wind direction before launch.
14. Confirm phone number for nearest Air Traffic Control facility in event of emergency.

FLIGHT CHECKLIST

PRE FLIGHT →	DURING FLIGHT →	POST FLIGHT
At office	**After launch**	**After landing**
☐ 333 exemption / COA documents ☐ NOTAM ☐ Local regulations and permissions. ☐ Proximity to the airport. ☐ Weather condition permits flying. ☐ All Batteries Charged ☐ Flight Gear check	☐ Aircraft reached safe altitude. ☐ Confirm observer has the aircraft in sight. ☐ All systems green ☐ Satellite and GPS check ☐ Check Battery remaining	☐ Power down UAV ☐ Remove and safely store batteries ☐ Airframe inspection ☐ Check camera/ sensor to ensure data collected ☐ Transfer data and flight log ☐ Make logbook entry
In the field	**Before Landing**	**Back at office**
☐ Scan area for obstacles, e.g. take-off and landing area. ☐ Wind check ☐ Daily Flight Report filled. ☐ Assemble UAV, ensure screws are tight and propeller check ☐ Sensor/ Camera setting check ☐ Batteries securely mounted ☐ Ensure GPS fix ☐ Confirm Mission flight plan ☐ Operators checklist (Integrated) ☐ RC remote check (if used) ☐ Final airframe inspection ☐ Flight Crew briefings, e.g. flight mission and safety ☐ Wind check again for launch.	☐ Ensure UAV flight done according to mission plan. ☐ Scan landing area for obstacles. ☐ Wind check ☐ Observer briefing for landing ☐ All systems green	☐ Flight and Maintenance Report ☐ Charge Batteries ☐ SD card cleaned and ready to use ☐ Airframe checked ☐ Data processed

SAMPLE

*Figure 30: Example of a Flight Checklist**

** This checklist is considered a guide and not definitive checklist for all UAS's. Use common sense when operating UAS's. Consult local UAS agency or vendors to ensure your checklist is appropriate.*

Documentation

Once the PIC confirms the location is safe to fly and becomes familiarized with the surroundings, it is recommended that he/she document all the details in a Pre Flight Report. The Pre Flight Report can often be filled out prior to arrival at the site as a part of mission planning and then signed off by the PIC once on site and the PIC has confirmed that the operation can be conducted safely at the site. In some cases, for example in scenarios where the UAS is to be operated in support of emergency or time-critical operations, it may be necessary to complete the Pre Flight Report (Figure 20) after the mission has concluded, however even in these cases, the PIC should confirm that the operation can be conducted safely prior to launch. Furthermore, it is recommended that such a report be completed for each mission regardless of whether it is completed prior to or after the flight as the report serves as an essential piece of documentation associated with the UAS operation.

An example of what the report should contain is:

1. Altitudes to be flown
2. Mission overview
3. Frequencies to be used
4. Planned flight time, including reserve fuel requirements
5. Contingency procedures
6. Pilot Name
7. Observer(s) name(s)
8. Date & Time

PRE FLIGHT REPORT

Documents	
Section 333 / COA	*XXXXX*
NOTAM	*XX/XXX*
Plan	
Call signs & Phraseology	*Loiter, RTL*
Altitude to be flown	*100 meters*
Mission Overview	*Crop data*
Frequencies	*2.4 ghz*
Planned Flight time, including reserve	*30 mins*
Contingency procedure: lost link, divert, etc.	*Return to land*
Hazards unique to the flight being flown	*Variable winds*
Closest Airport	*KRDU*
Emergency Contact	
Law Enforcement	*911*
Closest Tower Frequency	*127.450*
Site Manager	*James B.*
Roles	
Pilot	*Marc A.*
Observer 1	*Rachel J.*
Observer 2	*none*
Data Analyst	*Peter S.*

SAMPLE

*Figure 31: Example of a Pre-Flight Report**

**This report is considered a guide and not definitive report for all UAS's. Use common sense when operating UAS's. Consult local UAS agency or vendors to ensure your checklist is appropriate.*

During Flight Operations

1. The UAS PIC should launch, operate, and recover from preset locations so that the aircraft will fly according to the mission plan.
2. After the UAS is launched, the observer(s) should have a clear view of the aircraft at all times. Observation locations should be selected for the maximum line of sight throughout the planned flight operations area.

3. All flight operations should be conducted using a minimum of one visual observer who is not the UAS Operator to perform traffic avoidance and visual observation to fulfill the see-and-avoid requirement of FAR 91.113 and airspace Right-of-way rules.
4. To ensure the flight is going according to the flight plan, the UAS Operator should communicate with the observer at all times.
5. It is a good habit to let the observer know what the aircraft is supposed to be doing and the altitude of the aircraft above ground level.
6. Flights taking place over populated areas, heavily trafficked roads, or an open-air assembly of people should be avoided. If the mission dictates that flight operations be conducted in such areas, the PIC should ensure that the FAA-issued airspace authorization allows operations in such conditions and that proper coordination with local authorities, property owners and any persons in the operational area has been completed per applicable Federal, State and Local regulations.
7. The observer should make the pilot aware of any possible flight hazards during the flight.
8. Upon any failure during the flight or any loss of visual contact with the UAS, the PIC should command the aircraft back to the recovery location or utilize the built-in fail-safe features to recover the aircraft. Emergency procedures as defined in the specific UAS operator's manual should be followed.

Post-flight Operations

1. PIC should scan the landing area for potential obstruction hazards and recheck weather conditions.
2. PIC should announce to the observer and any other people around that the aircraft is on final approach and inbound to land.
3. PIC should always be prepared to do a "Go-around."
4. Carefully land the aircraft away from any obstructions and people.
5. After landing:
    - Shut down the UAS and disconnect the batteries.
    - Power down the camera or sensors.
    - Visually check aircraft for signs of damage and/or excessive wear.
    - Verify that mission objectives have been met.
    - If imagery or other data are recorded onboard the aircraft during flight, transfer the data as necessary to the GCS or a backup storage device. If all data and imagery is transmitted to the GCS and recorded on the GCS during the flight, then operators may wish to consider backing up the data prior conducting additional flight operations.
    - Enter logbook entries recording flight time and other flight details.
    - In case there are multiple flights to be conducted, repeat checklist steps to prepare the aircraft for launch again.

Emergency Procedures

Emergency procedures are specific to each UAS type as designed by the manufacturer. It is the responsibility of the flight crew to be proficient with the aircraft operational manual provided by the vendor before any flight operations are conducted. It is also a best and safe practice to prepare an Emergency Checklist (Figure 25) in case of emergencies. The PIC should always be prepared to execute an emergency procedure in instances where there is a lost link, or there are other aircraft or obstructions in the flight path. He/she should brief the flight crew before the start of the flight operations about emergency procedures and have a mission abort site for landing in the case of an emergency. After the aircraft has safely landed, it should be documented for maintenance purposes.

Some possible emergencies due to system failures are as follows:

- Loss of Datalink communications
- Loss of GPS
- Autopilot Software error/failure
- Loss of Engine power
- Ground Control System failure
- Intrusion of another aircraft into the UAS mission airspace

This is not meant to be a comprehensive list as the types of failures and associated emergency conditions vary for different UAS, airspace events, and crew performance.

Many UAS have a number of failsafe options in case of failures or emergency situations. These often include using methods of stabilization and an automated Return to Land (RTL) or Loiter mode. Other features include fail-recovery software. The specific failsafe options available for each type of UAS should be outlined in the UAS documentation (Operator's Manual, Checklists, etc.). These fail-safe mechanisms should be tested during training and currency flights. Flying without these fail-safe mechanisms in working order is not recommended.

An emergency avoidance procedure should be determined before landing. It may be to land immediately, move to a predetermined location and altitude, or another approach, but handling incursions must be assessed for risk mitigation.

Emergency Checklist		
Loss of Data link/ Ground Control System (GCS) Failure	**Autopilot software failure**	**Battery Warnings**
Result of both datalinks lost (no heartbeats) or GCS laptop and radio links fail for more than 10 seconds.	**Result if the autopilot software crashes during flight mode**	**Result of main GCS laptop and radio links fail for more than 10 seconds.**
→ UAV will loiter for 2 minutes (check operators manual for exact time) → If datalink not re-established within this time, flight will terminate and return to land (fail safe setting)	→ Try reconnecting from GCS laptop → RC control should be established and the UAV should be landed. If no RC then flight will terminate and return to land (fail safe setting)	→ If Battery low warning or battery percentage 35% then landing is advised. Use landing zone or alternate landing area. → If Battery percentage 10% for more than 5 seconds then lading or abort sequence is advised. → If 0% then engine shuts down.
Loss of GPS	**Loss of engine power**	**Intruding Aircraft**
Result when UAV loses GPS signal in the flight mode	**Result of airspeed and altitude drop, engine most likely stopped working.**	**Result of another aircraft entering the UAS mission airspace (refer to FAR 91.113)**
→ UAV will automatically loiter around point of GPS lock loss for 20 seconds (check operators manual for exact time) → UAV will navigate to Home waypoint → RC control should be established and the UAV should be landed. If no RC then flight will terminate and return to land (fail safe setting)	→ The UAV will attempt to glide to airfield home (fail safe) → Make sure the UAV is in line of sight at all times.	→ If approaching head-on both aircrafts alter their heading to the right. Same applies to UAVs too → Use FLY here option if available. → Immediately descend the UAV to safe altitude

*Figure 32: Example of an Emergency Checklist**

**This checklist is considered a guide and not definitive checklist for all UAS's. Use common sense when operating UAS's. Consult local UAS agency or vendors to ensure your checklist is appropriate.*

Flight Area/Perimeter Management

The selection of launch and landing sites is based first and foremost on safety. It is the job of the PIC to ensure that all flight operations are within the FAA-issued airspace authorization parameters and UAS flight limits. Flight boundaries, including any restrictions imposed by FAA approvals, nearby airport locations, restricted areas, TFRs, etc. should be reviewed prior to commencing flight operations. In addition, the PIC should identify the following:

1. Primary Take-off and Landing site - Typically the primary landing shall be the same as the launch site however this does not have to be the case for many UAS. The PIC has final authority for any approaches to the primary site and may wave off any approach deemed unsafe.
2. Alternate landing sites - The PIC shall designate at least one alternate landing site. In the event that a wave off is not possible and the primary landing site is deemed unsafe, procedures to utilize the back-up site will be invoked.
3. Mission Abort Sites - The PIC may optionally designate an “abort site” whereby the aircraft may be landed in directly in an emergency situation. The abort site should be

located so as to provide absolute minimal risk if the aircraft is required to vacate airspace in an emergency. If the PIC deems it necessary, the UAS may be flown to this site and landed without regard to the risk to the flight equipment or the unmanned aircraft. The safety of persons, manned aircraft, and surrounding structures should be prioritized over the risk to the UAS equipment.

4. Flight Over populated areas- The PIC should make every effort to select a landing site that minimizes approaches over populated areas.
5. Landing Safety & Crowd control - All landing sites should be maintained and operated in the same manner as the launch sites. A buffer of at least 50 feet should be maintained at all times between aircraft operations and all nonessential personnel (all personnel other than the UAS Operator/PIC and the Visual Observer).

Accident/Incident Reporting

In the case of any aviation accident or incident within the United States, operators should consult Part 830 of the National Transportation Safety Board (NTSB) Regulations. This applies to registered-UAS as well. It is important to understand the regulations so that proper reports and notifications can be prepared following an accident or incident. In general, all accidents and certain incidents must be reported immediately to the nearest NTSB office. Enforcement action can be taken against the operator if notification is not made in a timely manner.

NTSB defines an accident when:

- any person suffers death or serious injury,
- the aircraft receives substantial damage which adversely affects the structural strength, performance, or flight characteristics of the aircraft.

The NTSB defines an incident as an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

Within 10 days after an accident and before additional flights, the operator must provide notification to the FAA (Figure 22).

In the event of a lost link or fly away, the PIC should immediately notify the nearest airport tower and state the intentions.

INCIDENT/ACCIDENT REPORT

Date of Accident:

Time of Accident:

COA/333 Exemption #:

Proponent:

Contact:

System Information

Type Aircraft:

Aircraft Location:

Latitude Longitude Altitude (state MSL or AGL):

Ground Control Station Type:

Ground Control Station Location:

General Flight/Mission Description

Flight # on Day of Accident:

Flight Duration:

Total Time /Number of Flights on Aircraft at Time of Incident:

Flight Crew Information:

Flight Details:

Additional Info / Comments:

Description of Accident:

Damage and Fix Action

Damages and Injuries:

Immediate Fix Action(s):

Investigation Plan:

*Figure 33: Accident/Incident Report**

**This report is a sample format of the FAA online accident/incident report.*

Flight Crew Communications

In order to facilitate effective communication, one must understand how the flight management process flows. It is important for the UAS PIC, Visual Observer, and other essential flight personnel to maintain communication at all times. It is also important for the observer and other flight personnel to acknowledge that he/she received a message. This way the flight crew can coordinate flight operations in an organized and effective manner. A proper decision making structure should be identified prior to Pre Flight Operations and should be followed by the flight crew at all times, i.e. PIC, Site Manager, Observer, and Data Analyst. It is a best practice for the visual observer to handle all external radio communications during flight while ensuring the aircraft is in sight.

External Communications

When flight operations are conducted in Class A or D airspace or, when required, in Class E and G airspace, the PIC must establish and maintain direct two way radio communication with the airport manager and airport air traffic controller with prior notice of the flight operation. The information to relay includes:

- The flight's date and time,
- Exact location,
- Maximum altitude of UAS operation for the mission.

For best practices, the PIC should file a NOTAM (Notice to Airmen) with the AFSS (Automated Flight Service Station). It is also best practice to have the local emergency responder's phone number on hand in case of emergencies.

8.5 Best Practice Crew Selection

Introduction

The crewmember selection criteria for UAS flight teams are as varied as the unmanned aircraft themselves. Even so, the implementation of a UAS program and the selection of a qualified flight team share many of the same characteristics as manned flight operations. In addition to effectively conducting the UAS mission, it is the duty of the flight crew to protect safety/integrity of the airspace. A UAS flight team should, at a minimum, consist of a Pilot in Command (PIC) and a Visual Observer. Any organization considering using data capture from UAS must determine different ways of analyzing and presenting the data. In cases such as these, it may be desired to include an additional flight team member, a data analyst, whose main task would be to process and analyze the collected imagery or data. The flight crew should work together to accomplish specific mission(s). This requires aviation knowledge, mission data knowledge, and local area coordination. Building a UAS flight crew requires balance of skills, careful review and thorough understanding of expectations.

Key Actors

- UAS Operator
- Pilot in Command
- Visual Observer
- Data Analyst

Practice Description

There are 5 sections to this Best Practice: UAS Operator, Pilot In Command, Visual Observer, Data Analyst, and Training.

UAS Operator

This is the person who is actually manipulating the controls for the unmanned aircraft. This person may be acting in both the UAS Operator and Pilot in Command role, in which case he/she will be required to meet the qualifications of a Pilot in Command, listed below. If the UAS Operator and the Pilot in Command are separate people, then the Pilot in Command is in charge of the operation and is the responsible party with respect to FAA and State regulations.

Recommended minimum qualifications for a UAS Operator are:

- **FAA UAS Certification**.
  Operators should hold a current FAA Remote Aircraft License with a Small UAS Operator Certificate.
- **OEM UAS qualification training**.
  Operators should demonstrate proficiency or certification from the manufacturer on a specific UAS platform.
- **State certifications and permits**.
  For operations that occur within the State of North Carolina, all operators conducting commercial or governmental (public aircraft) UAS operations must have passed the North Carolina Unmanned Aircraft Systems (UAS) Operators' Knowledge Test and must possess a valid NC UAS Operator Permit issued by the NCDOT, Division of Aviation[6].
- **Medical requirements.**
  A Class II Medical Certificate is recommended.
- **UAS Type currency (via pilot logbook) + Continuation Training**

Pilot in Command (PIC)

The Pilot in Command (PIC) is in charge of the operation and is the responsible party with respect to FAA and State regulations. This person may act as both PIC and UAS Operator, however if a separate person acts as the UAS Operator, the UAS Operator acts under the command of the PIC and must follow PIC instructions at all times.

Recommended minimum qualifications for a UAS Operator are:

- **FAA UAS Certification**.
  Operators should hold a current FAA Remote Aircraft License with a Small UAS Operator Certificate or a minimum manned aircraft Sport Pilot License.
- **State certifications and permits**.
  For operations that occur within the State of North Carolina, all operators conducting commercial or governmental (public aircraft) UAS operations must have passed the North Carolina Unmanned Aircraft Systems (UAS) Operators' Knowledge Test and must possess a valid NC UAS Operator Permit issued by the NCDOT, Division of Aviation.
- **Medical requirements.**
  A Class II Medical Certificate is recommended.

Visual Observer

The role of the Visual Observer is to keep watch on both the UAS being operated as well as the surrounding airspace to maintain the safety/integrity of the airspace and meet "See and Avoid" requirements as outlined in FAR Part 91.113. In an ideal setting, the Visual Observer would possess qualifications similar to the UAS Operator and/or the Pilot in Command. From the crew

[6] https://www.ncdot.gov/aviation/uas/

perspective, this allows for the organization to have the depth required and to possess operational commonality between the crewmembers. Otherwise the recommended qualifications would be the following:

- **Medical requirements.**
  A Class II Medical Certificate is recommended.
- **UAS Operational Experience and specific platform certifications**

The flight crew should have knowledge of the rules and responsibilities described in –

1. 14 CFR 91.11, Operating Near other aircraft
2. 14 CFR 91.113, Right-of-Way Rules
3. 14 CFR 91.155, Basic VFR Weather Minimums
4. Knowledge of air traffic and radio communications, including the use of approved ATC/ Pilot phraseology
5. Knowledge of appropriate sections of the Aeronautical Information Manual (AIM)

Data Analyst

The Data Analyst is the person responsible for processing the images or video from flights. He/she should assist the PIC in preparing the flight plan to accomplish specific mission data objectives. The analyst would be required to be in the field in instances where flight data needs to be quickly processed and analyzed. The recommended qualifications are as follows:

- Subject Matter Expertise for the type of data being collected and analysis to be performed.
- Knowledge of using data processing software appropriate for the planned mission.
- FAA Class II medical Certificate is optional (in case he/she will be involved with the flight operations on the field)

Training

Although UAS flight crews will probably not be hired or assigned as complete, consistent units, individual crew members should be tested and expected to provide examples of their previous work during the selection process. This may include flight demonstrations or the review of a data portfolio. Certification does not mean competency for being able to deliver the expected mission product. More than certifications, application and expansion of UAS knowledge are developed through regular training. Initial and recurrent training requirements help ensure that the flight team has the necessary skills to safely operate in NAS, while capturing various mission objectives. Additionally, job aids should augment training to make sure that the crewmembers have adequate checklists and information to complete their missions safely during each flight. (See Flight Operational Procedures Best Practices) Recurrent training is not limited to actual Operator/PIC/ observer skills but includes knowledge of all pertinent UAS/aviation matters. Currency training should also include Personally Identifiable Information (PII) policy for the complete flight crew to support data management practices.

8.6 Data Management

Introduction

Unmanned Aircraft Systems (UAS) are getting smaller, simpler and cheaper to operate and can carry multiple types of sensors, cameras and surveying technologies. Besides conventional cameras, UAS can also carry high tech sensing equipment such as infrared, thermal imaging cameras, hyperspectral sensors and LiDAR. A typical short UAS flight, for example, could generate about 400 plus high resolution images with a total folder size of 2 GB or more depending on the area of interest and image overlap expectation for final product quality. In addition to mission data (imagery and video), every flight produces flight performance data such as telemetry, weather, traffic, aircraft, and crew performance information that should be recorded with the mission data. Surveying technologies allow different types and large amounts of data to be collected continuously throughout the UAS flight and uploaded to a data repository like the cloud or a server for near-real time analysis. As the amount of available data grows, the problem of managing the data becomes more difficult, which can lead to information overload for an organization. Installing a data management process form the beginning should minimize the impact of growing UAS data streams, while also providing the organization with a repeatable, defendable, reliable structure for processing, archiving, accessing and protecting data.

Key Actors

- UAS Operator
- Pilot in Command
- Data Analyst
- Data Manager

Practice Description

Once the mission objective is set and the appropriate UAS is selected (refer to “Platform Selection” in Policies Best Practice) comes the important part of capturing, storing, collating and processing data. The primary reason to invest in a UAS is to analyze the data it collects. This data could be either raw images, video, environmental conditions (wind, particles) or other data captured with an airborne sensor. There are 2 sections to practice: Data Architecture and Data Flow.

Data Architecture

The mission planning and selection of an area of interest varies from project to project, but even across a variety of UAS mission plans, the output from the UAS remains fairly consistent. Most UAS come with an operational manual for capturing, storing and processing data. Below are some general descriptions of components of a UAS data architecture (Figure 23):

- The first step in data collection should be to create a mission plan and fly the UAS. After the flight is flown or during the flight, data (images or videos) is transferred to the Ground Control Station (GCS) post flight via SD card or in real time via wireless connectivity. The metadata is also attached to the images or a separate flight log is generated for context. Metadata may include georeferencing GPS location information, time data, camera/aircraft attitude information, content descriptions.
- From the GCS the data (images or video with metadata) is uploaded to the cloud or a local permission controlled server for storage. It can also be saved in external hard drive or memory card but this is not recommended for best practices.
- It is recommended to use a "Mission Manager" software package for flight operations. This software should have the capability to store weather, traffic, pilot information along with flight log. This helps in generating flight reports, reviewing flight histories, fleet and crew management.
- For certain UAS configurations, data can be available in near-real-time, providing time-critical, highly-topical information from UAS flights. In order to accomplish this, a UAS with real-time downlink equipment is required.

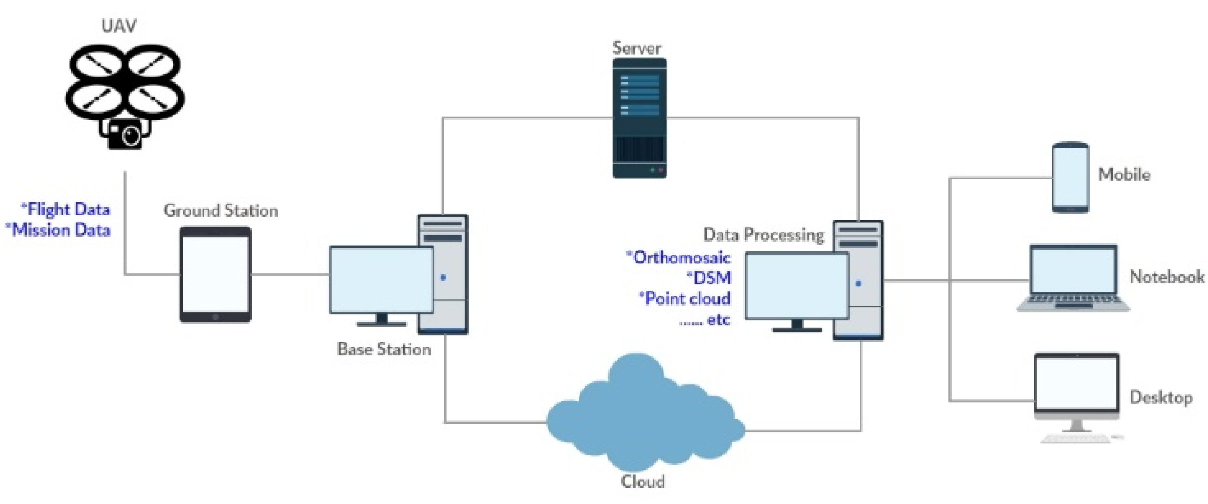


Figure 34: Example UAS Data Architecture

Data Flow

After the flight is complete comes the next step of what to do with the raw images. Raw images need to be processed, analyzed, published and then stored (Figure 24). The first step of the data processing is to examine the input datasets and desired product objectives. This helps in choosing the right options for all processing settings as well as to get a rough idea about the processing time. Some details that are important:

- File format (e.g. jpg or tif)
- Number of input datasets
- Type of the used image orientation (EXIF, external file, no orientation)
- Coordinate reference system of reference data (center coordinates of the images)
- Geographic projection for the mission area

Figure 35: UAS Data Flow Diagram

Processing

The most common method of post processing aerial images for surveying or mapping is to stitch them together using commercially available software, such as Trimble Business Center, PIX4D, or Agisoft. Below is a brief explanation some of the critical steps in the processing of UAS data:

- The software will examine for matching points by analyzing all images quickly and accurately.
- Those matching points as well as estimated values of the image position and orientation provided by the metadata are used in a bundle block adjustment to reconstruct the exact position and orientation of the camera for every acquired image.
- Based on this re-establishment the matching points are corroborated and their 3D coordinates calculated.
- Those 3D points are interpolated to form a triangulated irregular network (TIN) in order to obtain a Digital Elevation Model (DEM). At this stage, construction of a dense 3D model increases the spatial resolution of the triangulated data.
- This DEM is used to project every image pixel and to calculate the geo-referenced ortho-mosaic. The ortho-image generated will be devoid of positional and terrain displacement inaccuracies.

For processing video or individual pictures not intended for orthomosaicing, the raw data may need to be processed with a customer viewer or processed through a file conversion tool for further analysis or publication.

Analyzing

It is recommended to have a Data Analyst (see Crew Selection Best Practice) who has a background in the content of mission data for each flight. That may mean a GIS/Remote sensing expert for a survey flight or an agronomist/ spectral imagery expert for a crop health, environmental analysis flight (see example data sets in Figure 25). A person with knowledge of using data processing software appropriate for the respective mission is the goal. Identifying points of interest in an image vary greatly according to who is using the imagery, what the expected results are, and what the context of the imagery is such as an accident scene, storm damage, crop health, or infrastructure inspection mission.

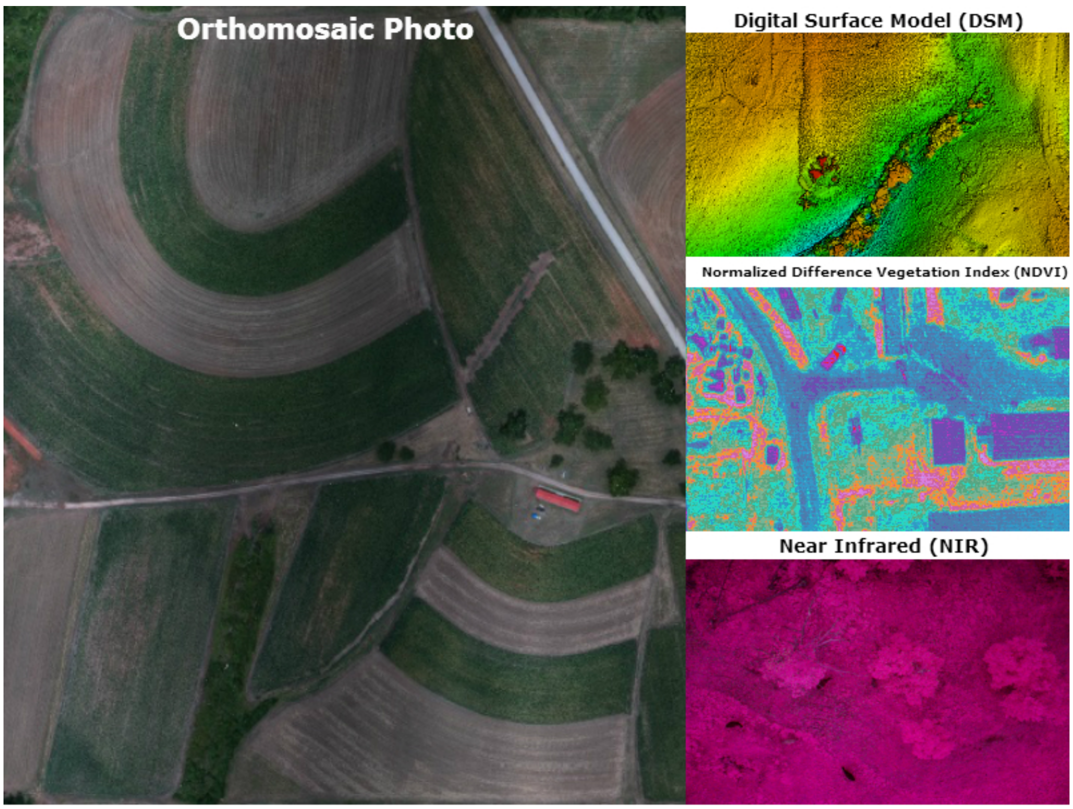


Figure 36: Sample UAS Imagery

Publishing

Once the data is analyzed, the next step is to publish it in a format that is accessible for a client or user to open and distribute through an established process.

Data Storage and Security

The final step in the data management process is defining the long term data storage and security structure for the organization's data. This process may already be defined for other data-centric operations and may just need to be reviewed for UAS data integration. There are four primary components to a data storage and security plan: location, access, permission management, and data lifecycle management.

Location

There are many options for data storage including hardware and cloud-based alternatives. Hardware solutions provide the organization the opportunity to use established servers and IT infrastructure that may streamline the data utilization into existing work flows. Portable hard-drives and memory options also present a localized management strategy with the ability to physically control access. Many new organizations that are experiencing data growth are turning to cloud-based virtual data management options to reduce IT infrastructure and management responsibilities within the organization. Evaluating existing policies and available resources is essential to selecting a long term storage solution. NGAT is prepared to assist with the decision making process and provide alternative solutions.

Access

Related to the location selection, defining the data access process determines how stored data is retrieved. Accessing data may require physical retrieval, fees, and/or special permissions to meet security protocols. Establishing these requirements from the beginning is strongly recommended.

Permissions

Different levels of permissions to access stored data are also recommended. Some users may have access to retrieve and distribute, some may have access to add and remove data from the storage location, some may have access to only certain data sets for analysis, and some may have access to only processed data, not raw data. Explicitly defining permission levels and qualifications for each level provides an audit trail for data management and a level of assurance that data is protected by multiple layers of security.

Lifecycle

Since UAS missions are identified before launching a UAS program, data lifecycles can also be specified early in the program definition. The lifecycle of data is the description of how long data is saved in the data storage solution. There are multiple strategies for managing the data lifecycle process. Periodic strategies require data to be purged on specific time cycle such as every 2 weeks, once a month, or once a year. Other strategies require data from different missions to be retained on different schedules, for instance survey data may be stored permanently, but public safety video is purged the first of every month unless tagged for something specific.

8.7 Procurement

Introduction

Each agency developing a UAS Program should establish a process for acquiring UAS products and supplies. This process should determine the selection criteria that meet the mission objectives and agency resources. These criteria determine sensor and aircraft performance requirements. These requirements provide the data necessary to select the appropriate product to meet the agency UAS Program goals.

Key Actors

- Agency,
- Flight Crew,
- UAS Vendor

Practice Description

There are three sections to this Best Practice: Product Selection, Ownership versus Leasing, and Working with Vendors.

Product selection

Currently there are over 700 manufacturers of UAS systems globally. Many potential UAS users may benefit from acquiring both a fixed wing platform as well as a rotary wing platform, but the selection process should be driven by the mission, budget, and flight crew qualifications. Battery technology is still one of the primary limiting factors in relation to flight time, which may or may not be a factor. One of the other primary considerations is the payload capability of the respective airframe and the various sensors that it is capable of supporting. When purchasing a platform, make sure to know the total cost of operating the system. The cost of the platform may only be a fraction of the total cost (the 'system', including communications, maintenance, other equipment).

Recommended criteria for evaluating UAS products:

- Application specific requirements – What is the scope of the mission sets? What types of data will be collected?
- Processing software capabilities – What software is used to process flight data and mission data?
- Endurance – How long (time) and how far (distance) are the mission requirements?

- Ease of use – How easy is mission planning, autonomous flight, launch and recovery, and data management?
- Payload capacity – How much weight can it carry? How much does it need to carry?
- Cost – What is the total cost of not just the UAS, but also spares, ground equipment, maintenance, transport, etc?
- Customer service and technical support – How good is after-sale support for maintenance and troubleshooting?

How to decide if a fixed wing or rotor wing is most appropriate:

- If the user application requires wider geographic coverage (acres of farm) or needs highly specialized sensors, (multispectral camera, thermal imaging, Lidar, etc.) or needs to operate at higher altitudes, then a fixed wing may be the best solution for what you need. Examples are the Trimble UX5, SenseFly eBee, Aerovironment Puma, and Altavian.

- If an application needs limited geographical coverage (real estate photography) or has narrowly defined physical constraints (bridge inspections) and needs relatively straight forward data collection sensors (short video and RGB still photography) then a multirotor may fulfill the objectives. Examples are the DJI Inspire, Aibotix X6, Trimble ZX5.

Table 5: Fixed Wing vs Rotary Wing Decision Matrix

		**Fixed Wing** 	**Rotor Wing** 
Characteristics	*Maintenance*	Less complicated maintenance and repair process thus allowing the user more operational time at a lower cost.	Generally more complicated maintenance and repair processes thus decreasing operational time and resulting increases in operational costs.
	Sound	Quiet	Noise at low altitude
Flight Characteristics	*Endurance*	Longer flight durations	Shorter flight durations.
	Speeds	Higher Speed	Lower Speed
	Operational Altitude	Higher Altitude	Lower Altitude
Take-off / Landing area	*Launching Method*	Dependent upon either a launcher (including human) or a runway to facilitate takeoff and landing.	Capability for Vertical Takeoff and Landing (VTOL)

	Obstacle Clearance	Requires obstacle clearance path to climb or descend.	Requires less obstacle clearance to climb or descend.
Payload Capacity		Better sensors and cameras	Greater flexibility with heavier payloads
Uses	*Application*	Aerial mapping and terrain modelling larger areas.	Detail inspections or surveying hard-to-reach areas.
		Topographic surveys which requires the capture of geo-referenced imagery over large areas.	Maneuvering around tight spaces. Small area photography.
Flight Path		3D Waypoint NAV (recommended) Fixed altitude cruise or orbits.	Remotely controlled or 3D Waypoint NAV and the capacity to hover and perform agile maneuvering.
PIC Requirements		GCS Training. Minimal flight skill needed for autonomous operations.	GCS Training. Advanced manual training for remote control operations.

Table 6: Performance Comparison between Aibotix X6, DJI Inspire and Trimble UX5

	DJI Inspire 	**Aibotix X6** 	**Trimble UX5** 
Type	Rotary Wing	Rotary Wing	Fixed Wing
Ground Sampling Distance	5 cm	2.5 cm	2.0 cm
Maximum Speed	80km/h (50mph)	50km/h (31mph)	140km/h
Wind Resistance	10 m/sec	10 m/sec	18 m/sec
Maximum Flight Time	18 mins	30 mins	50 mins
Applications	Aerial film making, Surveying, Rapid response, etc.	Industrial Inspections, Aerial Survey, Overview of accidents and disasters, etc.	Surveying, Mining, Agriculture and Forestry, Erosion monitoring, Archaeology survey, etc.
Take off Type	Vertical	Vertical	Catapult Launch

Ownership vs leasing

For agencies, owning a UAS product provides them the flexibility to modify and use at will. Although many agencies do not have the ability to acquire UAS, they still want to take advantage of the technology. An alternative solution for them is leasing. Leasing UAS is an increasingly used practice internationally and is becoming a feasible options in the US. Typically this model is called fee-for-service.

- It is recommended to purchase a UAS if the initial capital investment is below $10,000.
- **Maintenance**. Typically aircraft maintenance is the responsibility of the owner, so leasing removes the burden of maintenance from the purchasing agency.
- **Save Money**. Leasing helps a company to conserve its working capital for its intended purpose. The company could lease the UAS system and pay for the lease rentals out of its operating budget instead of the capital budget.
- **Keeping up with technology**. Leasing helps avoid the risk of ownership, as opposed to purchasing. A key risk of ownership is that of the equipment obsolescence, because of rapid technology changes. The inherent risk of owning technologically-sensitive equipment is that the equipment may become economically useless for the company owning it much earlier than expected. A lease can be written for a term that fits the equipment's usefulness. At the end of the term, the equipment may be returned and a new lease can be written for new equipment that best suits a needs
- **Potential for Ownership at lease end**. If an agency feels that owning the UAS is the preferred strategy at the end of a lease, the agency may negotiate to purchase the equipment.

Working with Vendors

Selecting the right UAS is not simple. Many factors affect this decision, the most important being the UAS vendor. With a little legwork, agencies can learn how accessible vendors are, what standards they are held to, and how long they have been in business. Identifying a vendor with credibility and business stability is recommended for long term satisfaction.

Accessibility – Many UAS companies sell their products through dealers rather than establishing a relationship directly with their customers. Although, working with a local dealer may sound reassuring and convenient, dealers often push certain products and get in the way of valuable relationships between buyers and vendors. Buying directly from a vendor offers many advantages, including clear communication. Important product information does not always make it from the vendor to the buyer and vice versa. Additionally, resolving issues regarding recalled UAS components can be difficult without a direct relationship with a vendor. Moreover, in the end dealers are often helpless, since the power to approve refunds, manage repairs, and implement improvements falls entirely in the hands of the vendor and not the dealer.

Company Stability - Since most businesses fail within the first few years, the length of time a vendor has been in business reveals how stable they are. A safe approach is to consider only vendors who have been in business for at least 2-3 years and have good references. Asking for a product demonstration will help in choosing the right UAS equipment, and also ensure that the vendor is not just a web storefront.

ITAR / Export Control Considerations - UAS vendors must be knowledgeable about both the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). In order to capitalize on global markets for the products, staying compliant with U.S. export law will be an essential element of the business. Whether the company involved in UAS products is located in the US or not, it needs to understand ITAR/export controls. Many UAS components, autopilots, related software, launchers, etc. are subject to export controls. ITAR controls can affect the transport of these items, whether the transfer is temporary, for personal use, or part of doing business. Failure to comply with these regulations could end in serious consequences like fines, denial of export privileges, and possible prison sentences for the vendors. ITAR regulations do not encompass all countries export control laws, it only refers to US export control laws. An export is the transfer of anything controlled to a foreign person or country by any means, anywhere, anytime. Commonly exported items are hardware, technical data, software, and defense services. Nothing can be exported from the United States without authorization, which means permission from the United States government

Shipping – Whether it is initial purchase or returns for repair/upgrades, UAS must be shipped from a vendor. Often those vendors are producing and packaging aircraft outside the United States or at least in locations outside North Carolina. Factoring in shipping costs and timelines into delivery and maintenance cycles should be considered in purchasing a system.

Level of Technical Support – It is important for UAS vendors to have good Technical Support available to buyers at all times. When choosing a vendor it is best practice to review the following:

- Does the vendor use an issue tracking system? If not, much time can be wasted updating staff each time customers contact them about a problem.
- Is the technical support team and product development team one in the same? A support staff who specializes is more effective.
- Is their technical support anonymous? Buyers and vendors both risk exposing critical details and privileged secrets to competition when they use internet forums for technical support.
- Are enough people on staff to handle support calls?
- Is system and software training provided with product purchase?

Products for future needs - UAS manufacturers can save money and time when they choose a single-vendor solution. Because the UAS market is dynamic, manufacturers need to implement upgrades and modifications quickly, all at minimal cost to stay competitive. Many times vendors have other vendor partnership for parts and accessories. So it is important to get information of all vendor partners, in case a need arises in the future. Vendors may also offer other complimentary products/ services that increase the performance or value of the UAS solution. For example, a distributor may offer software licenses for analytics tool that can be used to process data from an UAS that did not come with a data processing software tool.

8.8 Outreach

Introduction

More and more UAS are flying with new capabilities and new operating areas available to users, with flying continuing to increase in frequency in populated areas. Agencies should educate the public about any UAS Program plans including aircraft, sensors, and the types of activities the UAS will perform, expected outcomes and the risk mitigations implemented to ensure public safety. This education process should start early in the decision making process to include public comment opportunities and participation.

Key Actors

- **Agencies**
- **Public**
- **Media**
- **NCDOT**
- **Industry Expert**
- **Law Enforcement**

Practice Description

There are two sections to this Best Practice: Public Awareness/Input and Transparency.

Public Awareness/Input

Agencies that are looking to introduce UAS into their operations should initiate a UAS Awareness Campaign for the local community. Building and maintaining community support for UAS operations is an important process that should involve providing the relevant law enforcement agency notice of upcoming operations. The community should be informed about the agency's goals for a UAS Program to include what types of missions are expected to be flown and how the flight activities could impact the public. The community should be encouraged to ask questions and express any concerns. It is the responsibility of the agency to educate the public on the federal and state rules and regulations under which the agency will fly. For example the FAA's 'No Drone Zone' initiative, designed to raise public awareness of the FAA Notice to Airmen process for prohibiting unauthorized aircraft, including UAS, from flying over or near NFL regular- and post-season football games is a success.

Recommended topics for a public engagement presentation for starting a UAS Program include the following guidelines:

1. UAS Overview –
    - Describe the different types of UAS.
    - Explain the capabilities and limitations.
    - Explain what is a UAV, UAS and drone.
    - Explain what UAS authorization options are (COAs, 333 exemptions, Part 107).
2. The aircraft and flight missions –
    - Let the public know which type of aircraft the agency is considering.
    - What sort of flight missions will be conducted? What are the data goals, flight times, notification expectations of these missions?
    - How flight areas and routes will be selected, published and secured.
    - The restrictions and safety standards by which the agency will operate.
3. The flight crew –
    - Introduce to the public the anticipated flight crew. If no selection is made then explain how the selections would be made.
    - What qualifications and training is required.
4. Explain benefits to the Community.
    - Operating costs, safety impacts on agency staff, marketing for the community, situational awareness.
5. Explain the authority by which the agency will operate –
    - FAA approval
    - State approval
    - Local approval (if necessary)

Transparency

The law may not require transparency, but organizational legitimacy now does. It is recommended that every agency has a detailed plan for sharing information concerning UAS operations to both the media and general public.

1. First and foremost, a Communications Plan with those that handle related external communications inside the agency should be established. These should be finalized and ready for distribution well before the agency is prepared to take on its first operational mission. The agency should keep the public informed about the changes that would significantly affect privacy, civil rights, or civil liberties. Information will be provided via the public request process.
2. Publish for the public on an annual basis, a general summary of the UAS operations during the fiscal year, to include a brief description of types or categories of missions flown, the safety standards maintained and the value provided by using UAS.
3. An agency should also have a Public Liaison Officer (PLO) who should be available via email or phone to answer any concerns or questions the people have regarding UAS.
4. Safety and protection of people and property, both on ground and in the air, should be the priority for the agency. To ensure this the agency should create an oversite

committee which includes at a minimum the Agency PLO, NCDOT representative, UAS Industry representative, Law Enforcement and local government representative. The oversite committee should ensure that the agency is maintaining high safety standards. The committee should meet quarterly and should be briefed by the PLO on the progress. The agency should let the committee know if any changes or additions will be made to the proposed program and get the necessary approvals. The committee should review the annual report to assess the efficiency and success of the program.

8.9 Policies

Introduction

If an agency is intending to establish UAS operations the following processes should be considered essential for conducting transparent, legal, routine, managed UAS activities. Each policy should be customized to meet an agency's specific needs, but each of these policies should be included for responsible UAS Program Management.

Key Actors

- Agency,
- Flight Crew,
- Vendors

Practice Description

There are eight recommended policies in this Best Practice. These are NOT example policies, but are the recommendations of what policies to include a UAS Program management structure.

Contracting UAS Services vs Building Internal Capabilities Policy

It is recommended to have policies defined for agencies to determine whether contracting UAS services or building an internal team(s) meets the agency objectives.

Factors to consider are:

- Core mission – It is important to plan in advance what the flight mission is and if it requires a long term commitment. In the long term case, creating an internal flight team may best fit the agency. If it is a short term commitment then contracting an external flight crew may fulfill the agency's needs.
- Flexible staffing – Some agencies have limited staffing and due to budgeting cannot hire more people. In such cases contracting may best suit the agency.
- Specialty services – If an agency is working on a specific flight mission that requires expertise or special equipment, then contracting may be advisable. For example, if an agency has only a fixed wing UAS and their next mission requires rotor wing UAS then contracting may best fit the need.

- Proficiency – Many agencies do not have adequate resources and expertise to train a flight crew, maintain currency (frequent missions) and develop skills. For those agencies contract services are recommended.
- Ownership – Agencies have to understand that there is more to purchasing a UAS than just buying the initial unit. They need to purchase sensors, extra batteries and spare parts. The agency is also required to register all aircraft and have an airworthiness analysis performed [for COA operations]. Regular maintenance is also required to ensure the UAS stays in working condition. Agencies that are not able to fulfill all these requirements should contract the services.

For more information regarding recommended policies, refer to the NGAT Expectation Management, Crew Selection, and Data Management Best Practices.

Manned or Unmanned Operations Selection Policy

A policy should be established to decide if the flight mission should be conducted using manned aircraft or unmanned aircraft. This policy will detail the evaluation criteria for selecting the solution, the decision makers involved in the selection process, and the process for making the selection.

Table 7: Example of Manned versus Unmanned Decision Analysis

Landfill Inspection Costs		
	Manned Aircraft	**Unmanned Aircraft**
Resource Availability (Crews, aircraft equipment)	Flight Crew (Pilot, Co-pilot) 1 Aircraft with heavy sensor	Flight Crew (Pilot, Observer) 1 UAS with small sensor
Operational Costs (Crews, aircraft, equipment)	Estimated $10,000	Estimated $2000
Desired Products (Resolution, size)	Fly at higher altitudes to cover larger survey areas. Image quality depends on weather. Will require less passes hence less time to cover the area.	Fly at lower altitudes to get high accuracy data. Image quality depends on quality of sensor. Will require more passes hence more time to cover the area
Logistics (Planning time, set up, approvals, weather)	Takes about a week to fly and get the data. Weather can delay it further.	Can be planned and executed in a day or two.
Authority to operate (Locations, conditions)	ATC, nearest airport tower	Land owner for take-off and landing, FAA for airspace access (COA, Part 107)

Access to land policy

Agencies need to ensure that permissions are obtained from private or state land owners before using their facility for UAS flight operations per NC law. A written consent is required and signed from the land owner before conducting any take offs or landings. Agencies should ensure that all flight operations conducted by the flight crew be within the approved procedures. A site safety assessment should be made prior to flight operations to ensure no person and property would be endangered by the UAS.

For more information refer to Expectation Management Best Practice.

Training policy

A policy should be in place for specifying flight crew training requirements. This way the crew stays current with flying proficiency and also with the rules and regulations. Flight crew training requirements should be divided into three phases.

- Pre-ops Training - This phase of preparatory work will take each crew through the online resources, manuals, preparing flight site and maintenance area. This will prepare them before receiving the Vendor Training and flight experience. This also includes NC law review.
- Vendor Training - This training is intensive, hands-on training that includes flying preparation, flying, maintenance, Air Law, flight planning and basic post processing of data. The training concludes with a flight test, issue of certificate and the signing of logbooks.
- Ongoing Training - It is not unusual that crews forget some of their training, or may experience a gap between mission operations. Therefore it is crucial to ensure that they stay current with flight operations and regulatory changes.

For more information refer to Crew Selection Best Practice.

Data management to include handling Personally Identifiable Information

Agencies should have policies in place on how to gather data, store data, process data, and share data. A great importance on the security of all Personally Identifiable Information (PIA) associated with the data should be implemented. There should be strict security measures in place to protect against the loss, misuse and alteration of personal data under the agencies control. Security and privacy policies should be periodically reviewed and enhanced as necessary and only authorized personnel should have access to user information.

Reporting/auditing

Agencies need to ensure that all flights are documented for auditing and required reporting purposes. Agencies should establish policies for documenting all flight operations. This should contain information like type of aircraft flown, name of PIC and Observer, type of sensor used, total images gathered, etc.

For more information refer to Operational Procedures Best Practice.

Equipment Selection policy

Agency should have a set policy that defines the process for selecting a UAS platform. This policy will explain the decision making process for selecting fixed wing or rotary wing type aircraft, specific vendors, and crew requirements.

For more information refer to Procurement Best Practice.

Procurement Policy

Purchasing a UAS should follow existing agency procurement practices. Defining a policy that ensures UAS equipment, data storage, data analysis software, and field support equipment are purchased using agency procurement policies is recommended.

This policy may be expanded to include working with vendors. These vendors may be either UAS equipment providers or UAS service providers. The related policy needs to:

a. Define an evaluation process
b. Align with existing organization rules/policies for working with vendors.
c. Identify the required licenses the training vendors will need to operate under an agency services contract.

For more information refer to Procurement Best Practice.

8.10 Business and Operations Model Best Practices

Introduction

This document presents various business and operations models available to public agencies in the State of North Carolina. It includes procedures, best practices and internal processes for managing an agency's Unmanned Aircraft System (UAS) acquisition and flight operations. These best practices are provided as guidelines and are not directive in nature. These guidelines will be incrementally revised based on operational data, trouble reports, cost reports and lessons learned.

The rapid growth in UAS technology development has brought a wide variety of systems to the marketplace. These systems vary widely in their technological maturity, airworthiness, failure rates, failure modes and cost. Many of these systems have been operated without any requirements to file accident reports so the true reliability and liability risks are unknown. Much of the information available is anecdotal with marketing information that does not reflect true system performance.

Individuals and organizations should establish quantitative and qualitative performance requirements prior to system purchase, lease or entering into service contracts. Performance metrics should be gathered to measure actual performance against the stated requirements in order to enable better contracting decisions among all North Carolina agencies in the future.

These best practices will discuss the benefits and limitations of both fixed wing and rotorcraft Unmanned Aircraft Vehicles (UAV). (**Note: This Best Practice will use the term/abbreviation UAV when it relates only to the air *vehicle* component of the UAS.**) The business and operations models presented will include operations with UAS purchased by the agency, UAS leased by the agency and UAS services contracted by the agency through private commercial UAS companies.

Key Actors

- Agency Executive
- Program Manager
- Contracting Authority
- Flight Operations Manager
- Maintenance Manager

- State Industry Regulators

Practice Description

Each agency has specific needs for UAS operations that will be constrained by the agency's budget and personnel staffing levels. This best practice offers three specific business operations models for the types of contracting strategy to accomplish the desired operations. These models are:

1. Operations with UAS purchased, operated and maintained by the agency.
2. Operations with UAS leased and operated by the agency. The UAS maintenance in this case can be accomplished by the agency or by the company providing the leased UAS subject to the terms of the leasing agreement. (These two sub-models are broken out separately in Section VI.)
3. Operations with UAS services contracted through a private commercial UAS company where the UAS company operates and maintains the UAS and delivers the system data as a contract deliverable. In this case, the UAS services company must obtain and provide documentation of FAA approval to operate with their contract proposal.

The pros and cons of each of these models are presented in Section VI. Business and Operations Model Comparisons.

Business and Operations Model Considerations

Within each of the three business and operations models, there are specific UAS design, contracting and operations considerations that each agency should evaluate. These include:

1. Aircraft reliability, maintainability and availability.

   An UAV is constructed of foam, Kevlar, carbon fiber, wood, plastic or other materials. Just as with manned aircraft, the more they are flown the more wear and tear is expected. Although specific requirements for ongoing inspections, maintenance, and repairs may not be standardized yet, it is a best practice to include these considerations when selecting a UAS. It is important to understand that while the FAA has not yet outlined a formal maintenance program, the notion that airworthiness is a responsibility of the operator is very clearly articulated. It is important for any organization to understand and follow maintenance procedures or consult with a trusted agency who can ensure UAVs are properly inspected, repaired, and returned to service in airworthy condition.

2. UAS technology insertion strategy.

   New UAS sensor, navigation, control and data analysis technology is continuously developed and introduced to the marketplace. Buying a UAS that cannot be easily upgraded could reduce system effectiveness over the lifetime of the system. Buying the newest system on the market every year would not be supportable by most agency budgets. An agency could keep pace with technology upgrades to provide best available performance with a leasing or services contract approach to business operations.

3. UAS sensor modularity.

   New technology upgrades can be used in existing UAVs, but only if the mechanical, electrical and data interfaces are well established to support modular updates. This strategy could yield significant performance improvements at a reasonable cost. In addition, some applications could require multiple sensors to be flown sequentially on the same UAV. A good example of this is precision agriculture remote sensing where it would be beneficial to fly optical, thermal and spectral sensors from a single UAV on a single mission day. Agencies should obtain an expert's assessment on whether particular sensors and subsystems can be effectively integrated into a previously purchased UAV.

4. Aircraft type and how well it supports the agency's mission plan:

Table 8: Pros and Cons of Various Unmanned Aircraft Types

Aircraft Type	Pros	Cons
Fixed Wing	• Good endurance • Largest area coverage • High payload fraction • Many size and performance options	• May require runway • Recovery methods may damage aircraft • Glide range on lost link could take UAV out of operating area
Single Rotor	• Good sensor image GIS • Easily deployed in remote locations • No runway required	• Less endurance compared to fixed wing • Open rotor may cause injury
Ducted Fan (not tethered)	• Good sensor image GIS • No runway required	• Lowest endurance • Lowest payload fraction • Some are gasoline powered and noisy
Multi-Rotor (not tethered)	• Good sensor stability • Good sensor image GIS • Many size and performance options • Easily deployed in remote locations • No runway required	• Less endurance compared to fixed wing (unless tethered) • Low payload fraction • Some have open rotor designs that pose potential injury risk
Tethered Rotorcraft	• Highest endurance if power source is in ground base unit • Excellent data collection capability with data transmitted through fiber	• Cost • Tether and tether management systems are new technologies with reliability to be

	to ground base unit. • Good mobility if system has "operator-following" technology. • Good sensor stability • Good sensor image GIS • No runway required	demonstrated

In each case above (Table 8), a competent authority will need to validate the airworthiness of the UAV against the agency's requirements. This can be done by the agency itself, the UAV provider or a third party. The NextGen Air Transportation Program (NGAT) at North Carolina State University has developed an airworthiness assessment process that has been recognized by the FAA for approving routine UAS operations. NGAT is able to share existing Statements of Airworthiness and develop new ones by working with other agencies. Safety is always first priority, but aircraft downtime reduces operational availability and increases agency cost. Proper UAV maintenance and inspections can avoid costly, or even total airframe losses, in the field.

5. Level of pilot/operator certification

   Each agency should evaluate the availability of its most qualified aviators to become UAS PICs when building their agency strategy. These considerations should include

   - How would the assignment of PIC duties affect the agency when an employee is removed from his current duties?
   - What is the total number of flying hours, including training and actual operations?
   - How should the UAS operations staff be structured?
   - Where are the employees located relative to the location of UAS operations?
   - Does the agency have training funds to hire or retrain non-pilots to become their PICs?

6. FAA COA approvals.
   The agency should consider when it needs to commence UAS operations as part of the planning process. An agency should consider taking advantage of COAs already obtained within the State by NGAT or other public agencies if they are applicable in order to minimize the time. If a new COA is needed, an agency has the option of applying for its own COA or could request NGAT to develop and collaborate on the COA application with the agency.

7. UAS control frequency and data frequency management
   An agency should establish a frequency management plan to prevent UAS control interference. Some UAS have the capability to down-link data while the UAV is airborne.

In this case, the data link frequencies should also be included in the frequency management plan. Prior to operations, the agency should sample the RF environment at the flight location to determine whether there will be any interference. RF interference could disrupt safe operations or cause the UAV to execute its lost link procedures. Either of these cases could result in operating delays or UAV loss/damage.

The agency should also check the operating frequencies of UAS prior to purchase/lease. Some UAVs were designed using radios whose operating frequencies have been re-assigned by the Federal Communications Commission (FCC). These UAVs could require an upgrade to their communications prior to obtaining a COA.

8. Integrated budget and contracting schedules.
   The agency should consider establishing an integrated master schedule to include all decision processes and lead times from the point where the agency executives decide to pursue UAS operations to the day of the first UAS flight. Significant lead time could be required for fact-of-life bureaucratic realities such as budget planning, budget approval, contract solicitations, source selection processes and contract awards. Each agency should consider its individual processes in order to build an accurate schedule to support the desired UAS operations. An agency could mitigate schedule risk with a multi-agency approach to budgeting and contracting.

9. Cooperative agreements with other agencies/jurisdictions
   In order to reduce UAS system operating costs and mitigate schedule or performance risk, agencies could consider cooperative agreements with other agencies or adjacent jurisdictions. A business and operations model strategy could include the purchase or lease of a pool of UAS to be shared by local and state law enforcement and emergency management agencies. This would enable each participating agency/jurisdiction to budget for a portion of the UAS pool operations. In this case, certain processes and priorities should be established in a formal Memorandum of Agreement.

10. Pre-negotiated basic ordering agreement contracts for services on-demand
    Agencies responsible for emergency management, disaster response and public safety may find it difficult to predict the number of UAS required and flight hours required to meet their mission. Acquiring too many UAS would result in a costly over capacity, especially when considering the cost of maintaining aircraft airworthiness and PIC qualifications.

    Some states have entered into agreements with service providers under pre-negotiated contracts such that an event requiring a rapid response to protect lives and property can be achieved. Such contracts have been established for oil and other hazardous material spills where on-call private contractors respond immediately and invoice the government agency once the event is concluded. This could be an effective model for UAS public safety and disaster response scenarios.

11. Past performance on similar operations
    Agencies should share operating and cost performance data in order to build a state-wide data base for use by all agencies in future purchases, leases and/or service contracts. This data base will lead to better UAS strategies and more accurate budget planning.

Cost Considerations

Many of the factors discussed in previous sections have cost implications. As in most system acquisitions, cost is sometimes the dominant factor over schedule and technical performance in building an agency's operating strategy. These cost considerations include:

- Acquisition cost (purchase, lease or service contract)

- Life cycle costs to include maintenance, repair, spare parts and system retesting

  When considering buying a UAS, it is important to check the warranty and after sale services agreements. It is also important to check if the spare parts for the UAV are readily available. This is an important consideration because if you break or crack a wing, it could take two weeks or more for shipping a replacement. Make sure to either have an inventory of spares, or have a nearby dealer who has a dependable supply of UAV parts.

- Level of pilot/operator certification
    - Labor cost of initial qualifications
    - Labor cost of maintaining currency
    - Opportunity cost of taking employee away from other duties to maintain flight certification

- Labor cost to obtain FAA approvals for COAs or Small UAS Operator Certificates under Part 107.

- Insurance costs

  Another suggested best practice is to consider additional UAS insurance. UAS insurance acts like any other insurance policy. If you lose your UAV or get into an accident, the company will cover your damage and liability costs to a certain extent. But the insurance companies want organization to have PIC qualification, operating manuals, maintenance logs and a record of parts or add-ons purchased. Public agencies in the state should coordinate with the state Department of Insurance through their associated Risk Management Office.

Business and Operations Model Comparisons

Table 9: UAS Operations Model Alternatives

Model	Pros	Cons
Agency Purchase	• System operations under agency control • System always available to agency • Maintain law enforcement evidence chain of custody	• High acquisition cost and maintenance cost • Agency responsible for maintenance • Additional staff required for operations and maintenance • Operators unavailable for other agency tasking • Cost of operator certification
Agency Lease with No Maintenance Agreement	• Lower cost compared to purchase • Technology insertion and system upgrades could be part of the leasing agreement. • Maintain law enforcement evidence chain of custody	• Additional staff required for operations and maintenance • Cost of operator certification
Agency Lease with Maintenance Agreement	• Contractor responsible for maintenance • Technology insertion and system upgrades could be part of the leasing agreement. • Maintain law enforcement evidence chain of custody	• Additional staff required for operations • Cost of operator certification
Services Contract	• All costs rolled into cost per flight hour • Purchase flight hours needed • Purchase hours based on budget • Contractor responsible for maintenance • Contract for new capabilities as technology develops • Contractor provides Section 333 exemption	• Non-agency contractor operations • High cost per flight hour • Data collected by contractor • Need process for law enforcement to collect and maintain evidence chain of custody

Notional UAS Operational Model Scenarios

1. **Law Enforcement Purchase or Lease with Maintenance Agreement versus Manned Aviation.**
   A county with jurisdiction over both rural areas and small towns is considering adding small UAS to its existing aviation program. With anticipated requirements for law enforcement to collect evidence and maintain a chain of custody, it is recommended that law enforcement officials operate the UAS system. Therefore, only purchase and lease options are considered in this scenario to present an appropriate comparison to manned aviation.

   a. System Purchase Considerations

      For this option, the jurisdiction should consider the following factors:
      - How will the system be deployed? If the plan is to deploy a rotorcraft in cars or SUVs, an officer in the unit will need to be a qualified PIC.
      - How many systems will the jurisdiction require?
      - What are the flight missions to be assigned? These would vary depending on the geographic extent of the jurisdiction and types of tasks. In large rural areas, fixed wing UAS may provide better service for search and rescue. In more urban environments, rotorcraft for crime scene mapping might be more appropriate.
      - Does the jurisdiction have an aviation maintenance division that could repair and maintain the UAS? If not, the lease with maintenance agreement could be the better alternative.
      - What is the jurisdiction's topography and how will it affect UAS flights requiring PIC and observers maintaining visual contact on the UAS?
      - Is it possible to share UAS resources with adjacent jurisdictions?

   b. Lease with Maintenance Agreement Considerations

      For this option, many of the above system purchase considerations also apply. The primary differential considerations are:
      - Does leasing a fleet of UAS (fixed wing, rotorcraft or a mix of both) best fit the requirement for the number of UAS and the given budget?
      - What additional staff is required to repair and maintain the desired number of UAS?
      - Will the anticipated number of flight hours drive maintenance costs to an unacceptable level?
      - Will the anticipated number of flight hours lead to early UAS replacement?

The agency should develop a cost comparison given likely scenarios and assumptions to complete a quantitative analysis of the purchase versus lease option.

c. Manned Aviation Considerations

Perhaps the most significant consideration for making the strategic decision to add UAS to a jurisdiction's aviation program is the cost and personnel differential compared to historical manned aviation. A jurisdiction may determine that having an appropriate number of UAS available for simple and routine tasking can reduce the number of manned assets required for public safety. Therefore, it is a best practice to consider UAS as a component of an integrated law enforcement aviation strategy.

For example, a jurisdiction may have one helicopter approaching the end of its service life with another newer helicopter in its inventory. Historical data indicates that operations of both helicopters were required on only a small number of days. Analysis may indicate that purchasing a small fleet of fixed wing and rotorcraft UAS would result in acquisition, operations and maintenance costs at a fraction of those for replacing the helicopter. Further analysis may indicate that using the new UAS for routine and simple tasks would reduce the number of required flight hours on the other helicopter, thereby reducing its operating costs and extending its service life. Under these conditions, the jurisdiction should pursue a strategy of mixed manned and unmanned aviation assets.

2. Emergency Management Purchase versus Services Basic Ordering Agreement.

A county emergency management agency is establishing a new program to have the capability to deploy UAS for search and rescue, disaster response, and emergency preparedness exercises. It has a limited budget and no qualified UAS operators. The emergency management director and staff are considering two options: (a) purchase two fixed wing systems with optical and infrared sensors and two rotorcraft systems with optical and infrared sensors and (b) establish a set of contracts with pre-negotiated costs per flight hour under agency basic ordering agreements.

a. System Purchase Considerations.
- The system purchase considerations listed for law enforcement above also apply to emergency management and should be included in an agency's strategy.

- Does the county have a manned aviation division with the capacity to support UAS operations and maintenance with existing personnel?
- If not, what would be the added cost for hiring and training UAS operators and maintainers?
- Consider multi-jurisdictional shared assets to budget for anticipated number of flight hours. If actual flight costs exceed those budgeted and an adjacent jurisdiction has excess hours, an agreement could help balance year-to-year variances.
- Are federal assets available for major disasters? If so, consideration should be given to operational and communications interoperability with federal assets arriving on scene.
- Does the county have a budget for emergency preparedness exercises? If so, deploying UAS assets will improve response during actual disasters and help gain actual operating, maintenance and cost data to support future budgets. These exercises will provide valuable command-and-control lessons learned for airspace coordination and optimum UAS tactical deployment.

b. Services Basic Ordering Agreement Considerations.
   - Contracting for services by organizing local companies with FAA approval to operate might be a more cost effective alternative for agencies with small budgets or without any prior experience with aviation assets.
   - Does the county have a contracting mechanism to have private contractors on call for emergency response? If it does, can the contract be expanded to include UAS services companies?
   - Some of the system purchase considerations may also apply to the services contract case.

Benefits Estimation

The North Carolina Enterprise Project Management Office has established a Benefits Estimation process[7]. Using this process could be beneficial to agencies as they establish their programs for justifying investment into UAS capabilities and completing annual performance reports.

Agencies should consider comparing the costs and benefits of UAS operations versus manned aviation if the agency's budget and culture supports. Agencies should consider historical data in operations for which UAS would provide beneficial results. When possible, objective metrics should be established for these comparisons. A good example is the cost per acre for manned aircraft agricultural applications compared to anticipated cost for a UAS system.

[7] https://ncit.s3.amazonaws.com/s3fs-public/documents/files/0300-0310-035-C-Benefits-Estimation.pdf

8.11 Best Practices Considerations Based on Level of Government

Introduction

This Best Practice presents how UAS program management and operations vary based on the agency's position or level of government. Those agencies considering developing a UAS program should review two companion Best Practices: Business and Operations Model Best Practices and Tailored Best Practices for State Agencies and User Communities. The former presents information on business and operations models available to public agencies in the State of North Carolina for making the most effective use of an agency's budget. The latter provides information relevant to a particular agency's functional operations. These best practices are provided as guidelines and are not directive in nature. These guidelines will be incrementally revised based on operational data, trouble reports, cost reports and lessons learned.

There are 552 municipalities in North Carolina and 100 counties. These are the general purpose local governments that should consider applying these best practices if they anticipate using UAS. At the local level, each government entity has a charter designating whether a municipality will be known as a city, a town or a village. There is no legal difference in the designations. There are cities of 1,000 residents, and towns with populations greater than 100,000. This document will use the term municipality to apply for all local government entities.

Key Actors

- Agency Executive
- Executives at Other Levels of Government
- Program Manager
- Contracting Authority
- Flight Operations Manager
- Maintenance Manager

Practice Description

Each agency having specific needs for UAS operations will be constrained by the agency's budget and personnel staffing levels. This best practice reiterates three specific business models for the types of contracting strategy to accomplish the desired operations for the particular level of government. These models are:

4. Operations with UAS purchased, operated and maintained by the agency.
5. Operations with UAS leased and operated by the agency. The UAS maintenance in this case can be accomplished by the agency or by the company providing the leased UAS subject to the terms of the leasing agreement. (These two sub-models are broken out separately in Section VI.)
6. Operations with UAS services contracted through a private commercial UAS company where the UAS company operates and maintains the UAS and delivers the system data as a contract deliverable. In this case, the UAS services company must obtain and provide documentation of FAA approval to operate with their contract proposal.

As executives at the various levels of government consider their approach to provide UAS services to their citizens, it is a best practice for a particular government entity to enter into inter-agency agreements vertically and horizontally with other government entities. This will provide the best level of service for a particular entity.

Vertical inter-agency agreements refer to those among state, county and municipal entities. Horizontal inter-agency agreements include (1) regional agreements among two or more counties/municipalities and (2) functional agreements between two or more sister agencies (e.g. the Department of Transportation and the Department Commerce's Division of Science, Technology & Innovation). North Carolina has a number of commissions and non-profit organizations that could be effective organizations for coordinating inter-agency agreements, UAS best practices, cost data, performance data and lessons learned. Some of these are presented in the next section. They are provided for discussion and example purposes; they do not imply any endorsement.

Level of Government Considerations

1. One of the key points made in the Business and Operations Model Practice was Consideration #9: Cooperative agreements with other agencies/jurisdictions. It is repeated here for emphasis.
   In order to reduce UAS system operating costs and mitigate schedule or performance risk, agencies could consider cooperative agreements with other agencies or adjacent jurisdictions. A business and operations model strategy could include the purchase or lease of a pool of UAS to be shared by local and state law enforcement and emergency management agencies. This would enable each participating agency/jurisdiction to budget for a portion of the UAS pool operations. In this case, certain processes and priorities should be established in a formal Memorandum of Agreement.

2. Consider North Carolina's Mutual Aid System for inter-agency agreements.
   North Carolina's Mutual Aid System[8] is based on the premise that it makes sound economic and logistic sense to share some types of emergency response equipment and

[8] https://www.ncdps.gov/Index2.cfm?a=000003,000010,001685

resources since no community can own and maintain all of the resources that might be needed to respond to any given event.

The obvious benefit of joining the Mutual Aid System is having access to all of the state's response capability without incurring the costs to purchase, maintain and insure an inventory of underused resources. Participating in the system provides efficient and effective assistance among governments, as well as faster reimbursement from the Federal Emergency Management Agency.

Mutual Aid System Participants: The Mutual Aid System is a voluntary agreement among North Carolina municipalities to share resources during a disaster. All 100 counties, the Eastern Band of Cherokee Indians and nearly three-fourths of the municipalities have signed the mutual aid agreement. (See full participants list in WebEOC File Library under Mutual Aid Agreements.)

3. Leverage Federal Programs

Several federal government departments and agencies have established UAS programs as well as funding to support some of the functional areas where UAS could be used. State, county and municipal entities should investigate how particular federal programs could support their UAS requirements. This federal support could take the form of grants, inter-agency agreements or support for local programs. Some of these federal programs are managed by the following departments and agencies:

a. US Geological Survey (USGS) National UAS Program. The USGS UAS Project Office[9] is leading the research of UAS technology in anticipation of transforming the Department of the Interior (DOI) approach for collecting remote sensing data. UAS technology is being investigated by monitoring environmental conditions and landscape change rates, responding to natural hazards, recognize the consequences and benefits of land and climate change, conduct wildlife inventories and support related land management missions. The USGS is teaming with all of the DOI bureaus, academia, industry, state and local agencies under guidance from the Federal Aviation Administration (FAA) and the DOI Office of Aviation Services (OAS) to lead the safe, efficient, cost-effective and leading-edge investigation of the potential uses for UAS technology in scientific research and operational activities of the Department

b. Bureau of Land Management (BLM). In conjunction with other agencies within the DOI and the National Interagency Fire Center[10], BLM provides mission support for wildfire, wild horse gathers, habitat monitoring, cadastral survey,

[9] http://rmgsc.cr.usgs.gov/uas/
[10] https://www.nifc.gov/

law enforcement, aerial mapping, range survey, etc. Information on BLM activity and programs and activity can be found at on the BLM website[11].

c. US Forest Service (USFS). The USFS (Department of Agriculture) is highly interested in new technologies and believes there is potential to use Unmanned Aircraft Systems (UAS) to support a host of natural resource management activities, including forest health protection, wildfire suppression, research, recreational impacts, and law enforcement. One of their website postings contains a good discussion of UAS acquisition tradeoffs for their Aerial Vegetation Survey Program[12].

d. National Oceanic and Atmospheric Administration (NOAA). NOAA (Department of Commerce) manages a robust and advanced UAS research program[13]. The NOAA UAS Vision: *UAS will revolutionize NOAA observing strategies comparable to the introduction of satellite and radar assets decades earlier*. UAS can revolutionize NOAA's ability to monitor and understand the global environment. There is a key information gap today between instruments on Earth's surface and on satellites - UAS can bridge that gap. UAS can collect data from dangerous or remote areas, such as the oceans, wild lands, and wildfires. Better data and observations improve understanding and forecasts, save lives, property, and resources, advancing NOAA's mission goals. NOAA's Program Goals:

Goal 1: Increase UAS observing capacity
Goal 2: Develop high science-return UAS missions.
Goal 3: Transition cost-effective, operationally feasible UAS solutions into routine operations

e. US Coast Guard (USCG). The Coast Guard's unmanned aircraft system strategy[14] is to acquire land and cutter-based UAS, while emphasizing commonality with existing DHS and Department of Defense programs and ensuring the projects are technologically and production mature.

4. At the county level, executives should consider leveraging organizations such as the North Carolina Association of County Commissioners[15]. One of their referenced postings was "Drones … they are here to stay"[16] posted on August 4, 2015 by Todd McGee. It includes the following recommendations:

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[11] http://www.blm.gov/style/medialib/blm/es/jackson_field_office/planning/planning_pdf_nc_rfds.Par.49259.File.dat/N_Carolina_RFDS_R1.pdf
[12] http://www.fs.fed.us/t-d/programs/im/aerial/bvb.shtml

[13] http://uas.noaa.gov/
[14] http://www.uscg.mil/acquisition/uas/
[15] http://www.ncacc.org/
[16] http://www.ncacc.org/Blog.aspx?IID=190

> *"If your county is considering using UAVs in your operations, such is in law enforcement, emergency response, correction facility security, or even building inspections, it is important to note doing so currently requires a Certificate of Authorization or Waiver (COA) from the Federal Aviation Administration (FAA) to operate a drone. Doing so is further complicated by the fact that traditional general liability and law enforcement liability insurance policy language has always specifically excluded liability extending to and for the operation of "aircraft." This was clarified, at least temporality, last November when the National Transportation Safety Board (NTSB) ruled that drones are in fact aircraft and reversed a prior ruling that drones were NOT aircraft. This reversal creates potential coverage problems in property/casualty coverage forms."*

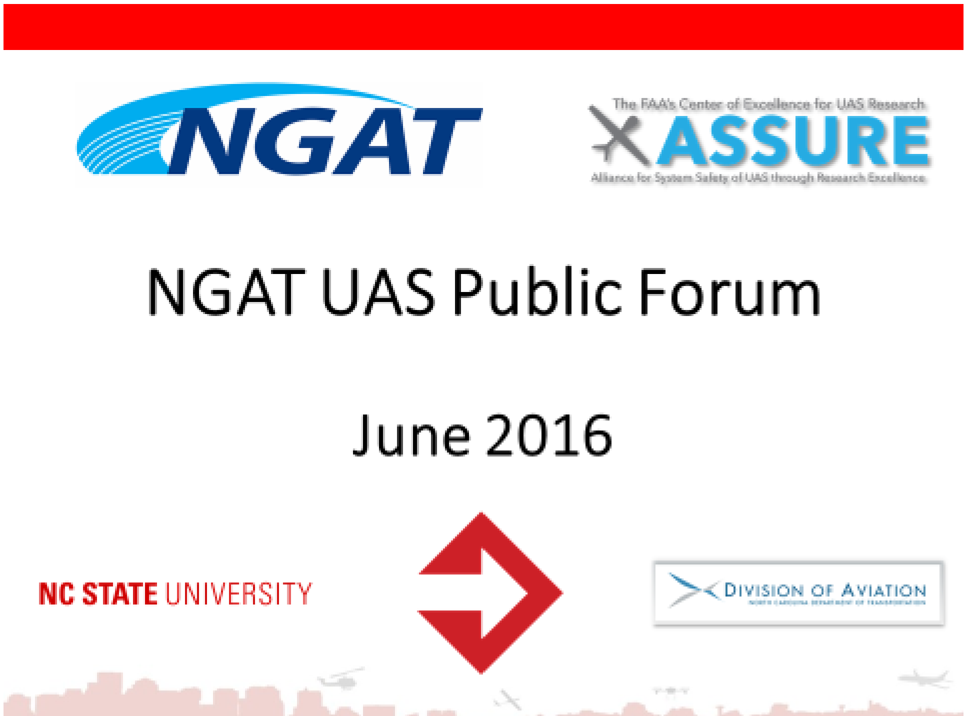
5. At the local municipal level, executives should consider leveraging organizations such as the North Carolina League of Municipalities[17].

6. Education Programs. Education programs at the State's public universities, colleges and community colleges can be the focal point for organizing some of the state, county and municipal efforts. Establishing education and workforce developing programs to leverage resources from federal, state, county and student sources can benefit government entities. While conducting funded research, universities can fly data collection and operational missions as the subject of the research. The NextGen Air Transportation Program[18] at North Carolina State University maintains a current database of educational activities in the state.

[17] https://www.nclm.org/about/Pages/default.aspx.
[18] https://itre.ncsu.edu/focus/aviation/uas/

9 APPENDIX C: NC UAS PROGRAM OVERVIEW

The following presentation is the North Carolina UAS Program Overview slides from the 2016 NGAT Public Forum event on June 27, 2016 at NC State University. This event was attended by over 160 attendees to review the latest news from the FAA (Part 107 released the week before), the progress with the North Carolina UAS Permit process, and NGAT research activities.


NGAT
The FAA's Center of Excellence for UAS Research
ASSURE
Alliance for System Safety of UAS through Research Excellence
NGAT UAS Public Forum
June 2016
NC STATE UNIVERSITY
DIVISION OF AVIATION

NGAT 2016 UAS Public Forum

Agenda

- 3:00 Check-in
- 3:15 Welcome
- 3:30 NGAT Update
- 4:00 FAA Update
  - Part 107 Review
  - Center of Excellence ASSURE Research Overview
- 4:30 NCDOT Permit Program Overview
- 5:00 Commercial Operations in NC Discussion
- 5:30 Open Forum
- 6:00 Networking Reception

NGAT 2016 UAS Public Forum

Welcome

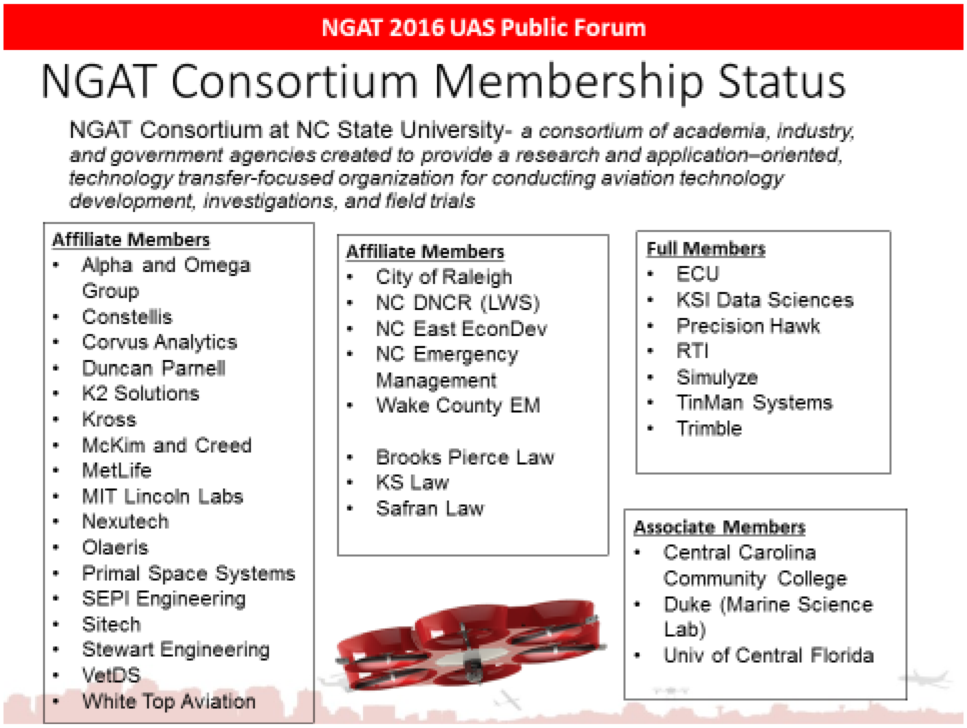
NGAT 2016 UAS Public Forum

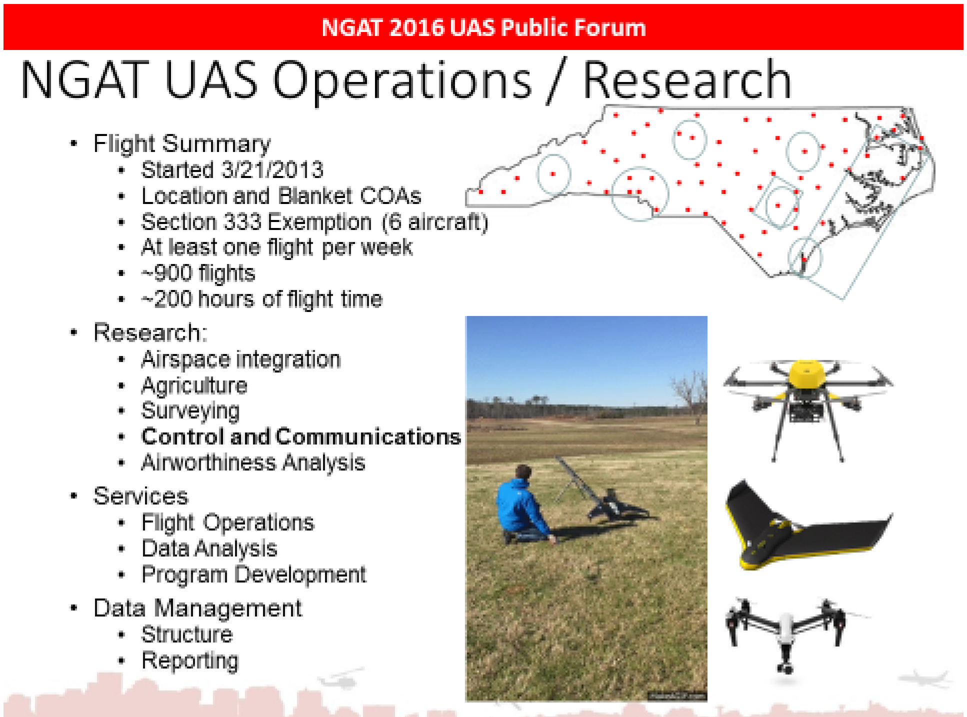
NGAT Program History

- Launched in 2012 under NCDOT Division of Aviation Leadership
  - **Goal: Develop NC UAS Ecosystem**
  - **Home: Institute for Transportation Research and Education (ITRE)**
- Began UAS flight operations March 2013 at Hyde County Airport
- Now approved for nationwide operations
- Established as an NC State Consortium in 2015
  - NGAT Consortium at NC State University- *a consortium of academia, industry, and government agencies created to provide a research and application–oriented, technology transfer-focused organization for conducting aviation technology development, investigations, and field trials*
- Core member of ASSURE Alliance selected May 2015 for the FAA UAS Center of Excellence research program for 5 years.

DIVISION OF AVIATION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Golden LEAF FOUNDATION

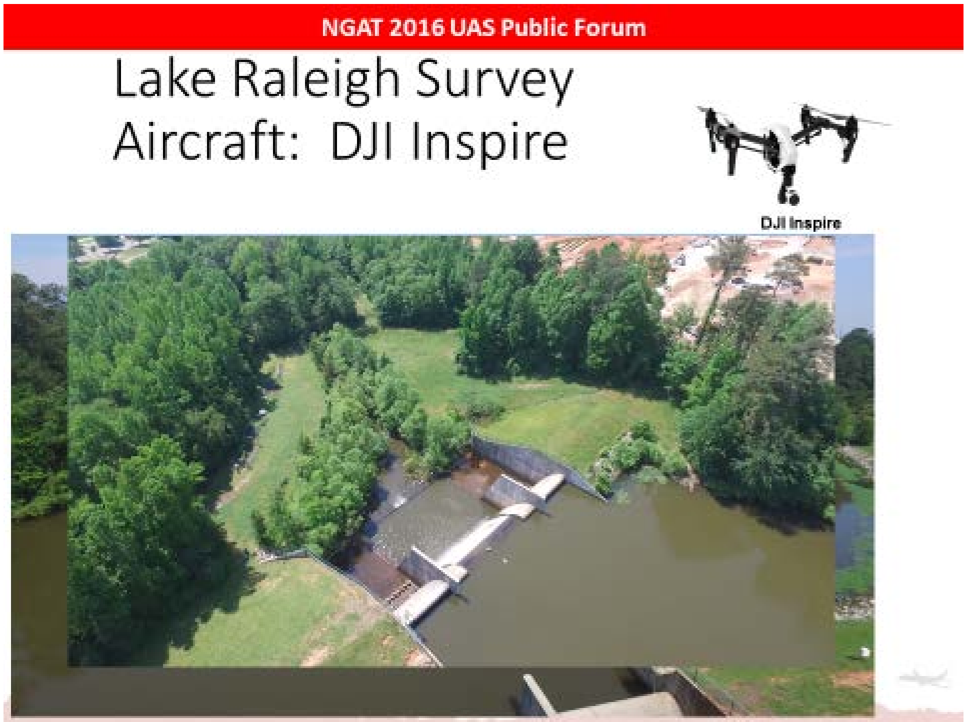

NGAT 2016 UAS Public Forum
NGAT Consortium Membership Status
NGAT Consortium at NC State University- a consortium of academia, industry, and government agencies created to provide a research and application–oriented, technology transfer-focused organization for conducting aviation technology development, investigations, and field trials
Affiliate Members
• Alpha and Omega Group
• Constellis
• Corvus Analytics
• Duncan Parnell
• K2 Solutions
• Kross
• McKim and Creed
• MetLife
• MIT Lincoln Labs
• Nexutech
• Olaeris
• Primal Space Systems
• SEPI Engineering
• Sitech
• Stewart Engineering
• VetDS
• White Top Aviation
Affiliate Members
• City of Raleigh
• NC DNCR (LWS)
• NC East EconDev
• NC Emergency Management
• Wake County EM
• Brooks Pierce Law
• KS Law
• Safran Law
Full Members
• ECU
• KSI Data Sciences
• Precision Hawk
• RTI
• Simulyze
• TinMan Systems
• Trimble
Associate Members
• Central Carolina Community College
• Duke (Marine Science Lab)
• Univ of Central Florida

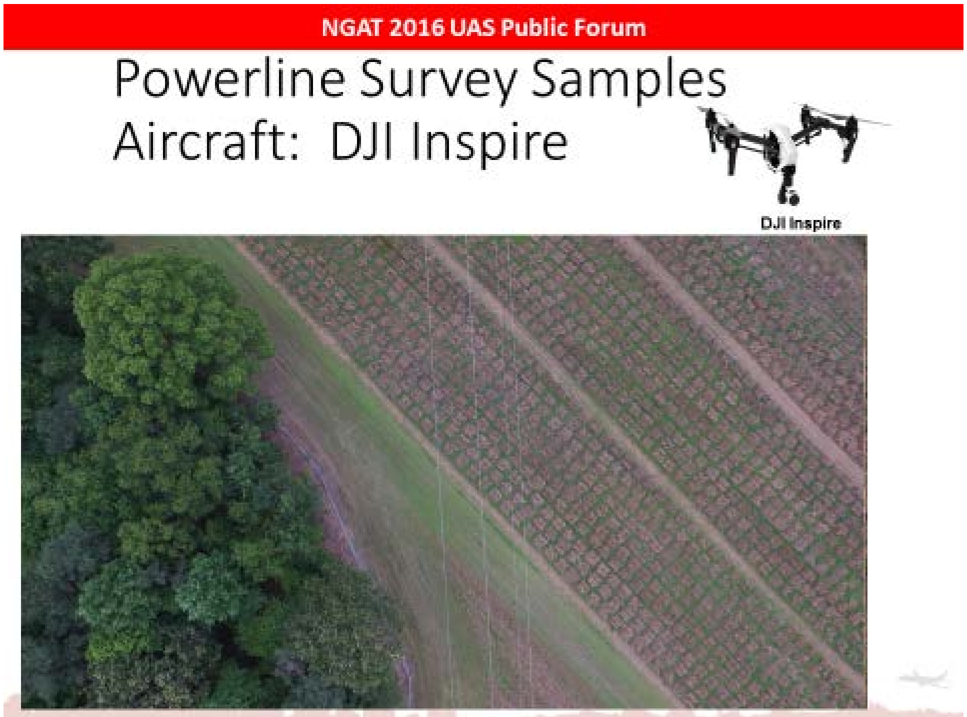

NGAT 2016 UAS Public Forum
NGAT UAS Operations / Research
• Flight Summary
• Started 3/21/2013
• Location and Blanket COAs
• Section 333 Exemption (6 aircraft)
• At least one flight per week
• ~900 flights
• ~200 hours of flight time
• Research:
• Airspace integration
• Agriculture
• Surveying
• Control and Communications
• Airworthiness Analysis
• Services
• Flight Operations
• Data Analysis
• Program Development
• Data Management
• Structure
• Reporting


NGAT 2016 UAS Public Forum
Construction Project
Aircraft: Trimble UX5

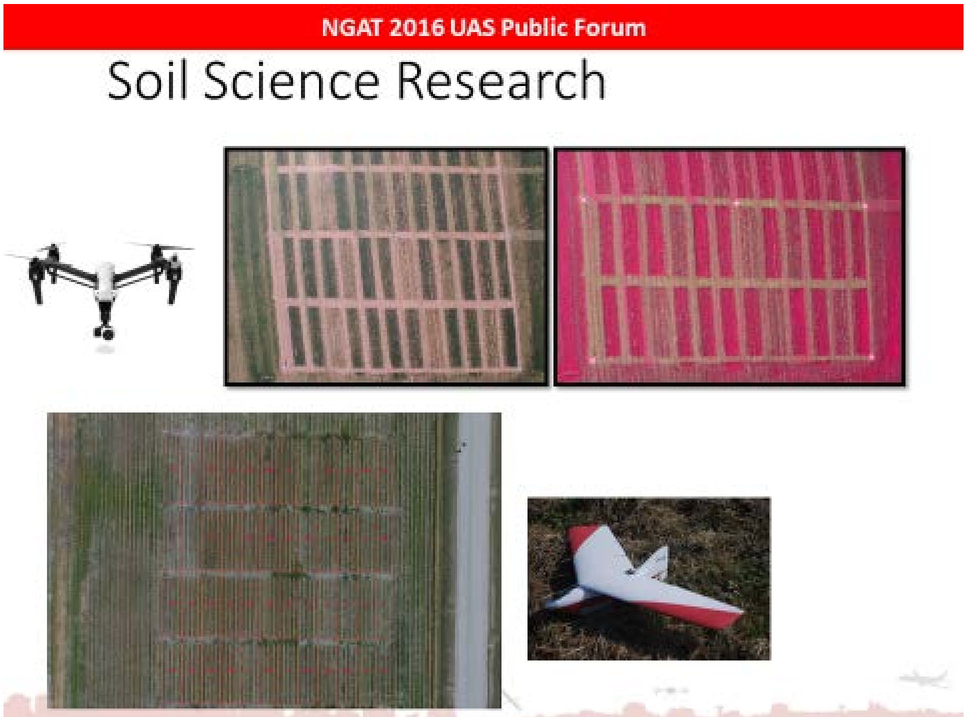

NGAT 2016 UAS Public Forum
Lake Wheeler Survey Flights
Aircraft: Trimble UX5


NGAT 2016 UAS Public Forum
Lake Wheeler Survey Flights
Aircraft: Leica X6
200 feet 60-60 overlap


NGAT 2016 UAS Public Forum
Lake Raleigh Survey
Aircraft: DJI Inspire
DJI Inspire


NGAT 2016 UAS Public Forum
Powerline Survey Samples
Aircraft: DJI Inspire
DJI Inspire


NGAT 2016 UAS Public Forum
Traffic Monitoring
Aircraft: DJI Inspire
DJI Inspire


NGAT 2016 UAS Public Forum
Soil Science Research

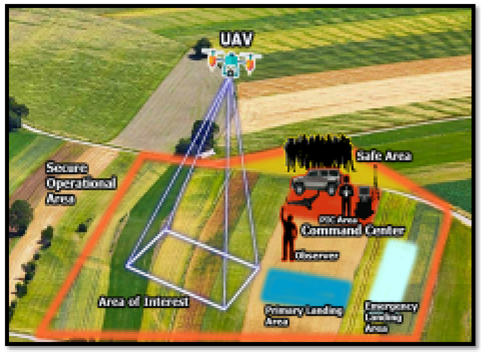

NGAT 2016 UAS Public Forum
Emergency Management Support
NC EMERGENCY MANAGEMENT

NGAT 2016 UAS Public Forum

UAS: Best Practices (1)

- **Expectation Management**
  - Mission Management- profile, definition, plan
  - Sharing the airspace
  - Equipment Life
  - Documentation- Federal, State, Organizational, Personal, Annual

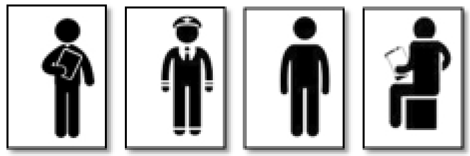
- **Operating Procedures**
  - PreFlight
  - During Flight
  - Post Flight
  - Emergency
  - Flight Area Management
  - Communications



NGAT 2016 UAS Public Forum

UAS: Best Practices (2)

- **Crew Selection and Qualifications**
  - Flight team- PIC, VO(s)
  - Data Analyst
  - Training



- **Policies**
  - Contracting versus Internal Development
  - Manned versus Unmanned Decision
  - Training
  - Platform Selection
  - Working with Vendors
  - Access to Land

NGAT 2016 UAS Public Forum

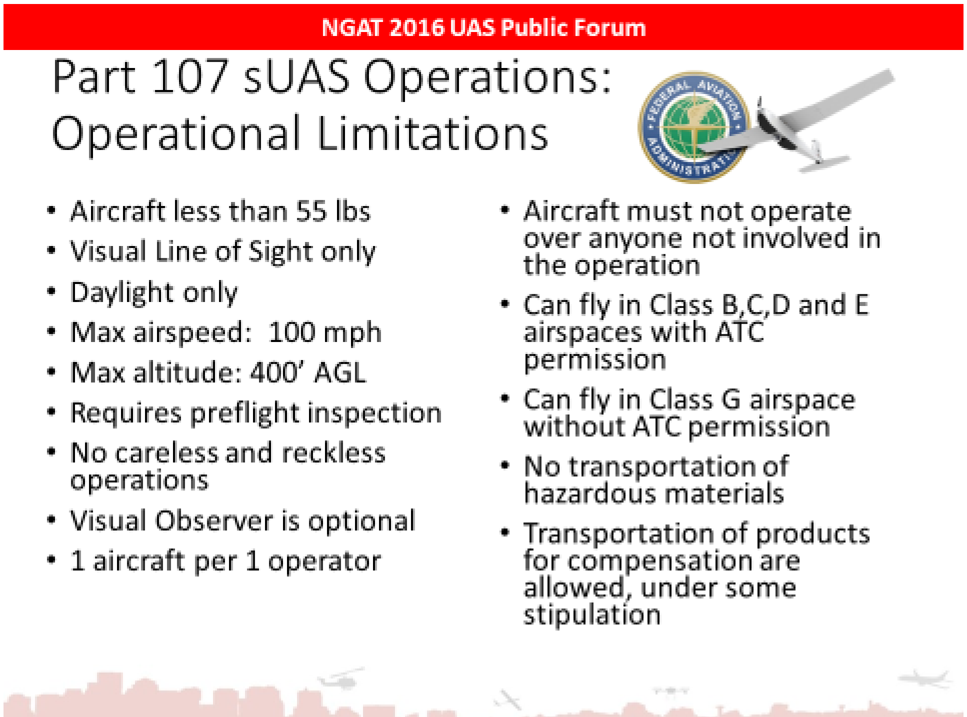
UAS: Best Practices (3)

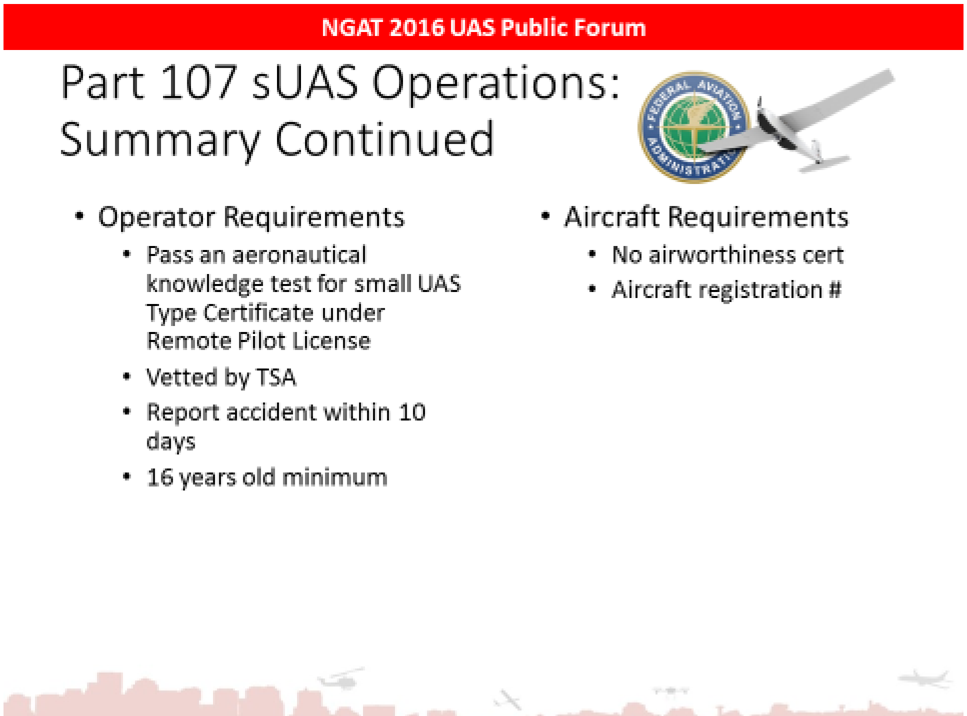
- **Data Management**
  - Architecture
  - Data Flow

- **Outreach**
  - Public Awareness
  - Transparency

Protect the Integrity of the Airspace and the General Public!


NGAT 2016 UAS Public Forum
FAA Updates


NGAT 2016 UAS Public Forum
Part 107 sUAS Operations: Operational Limitations
• Aircraft less than 55 lbs
• Visual Line of Sight only
• Daylight only
• Max airspeed: 100 mph
• Max altitude: 400' AGL
• Requires preflight inspection
• No careless and reckless operations
• Visual Observer is optional
• 1 aircraft per 1 operator
• Aircraft must not operate over anyone not involved in the operation
• Can fly in Class B,C,D and E airspaces with ATC permission
• Can fly in Class G airspace without ATC permission
• No transportation of hazardous materials
• Transportation of products for compensation are allowed, under some stipulation


NGAT 2016 UAS Public Forum
Part 107 sUAS Operations: Summary Continued
• Operator Requirements
• Pass an aeronautical knowledge test for small UAS Type Certificate under Remote Pilot License
• Vetted by TSA
• Report accident within 10 days
• 16 years old minimum
• Aircraft Requirements
• No airworthiness cert
• Aircraft registration #

NGAT 2016 UAS Public Forum

Other FAA/Federal Updates

- FAA
  - Students can operate as hobbyists for class, not for sponsored research
  - Law Enforcement Guidance
    - https://www.faa.gov/uas/law_enforcement/
  - Establishing a Drone Advisory Committee
- NTIA Best Practices published for Privacy/Data Management
  - https://www.ntia.doc.gov/files/ntia/publications/voluntary_best_practices_for_uas_privacy_transparency_and_accountability_0.pdf
- NASA UAS Traffic Management (UTM) Progress
  - https://utm.arc.nasa.gov/index.shtml
  - http://www.simulyze.com/media-room/simulyze-mission-insight-successfully-deployed-in-nasas-utm-test-for-unmanned-aircraft-systems


NGAT 2016 UAS Public Forum
FAA UAS Center of Excellence, the ASSURE Team:
The FAA's UAS Center of Excellence for UAS Research
ASSURE
Alliance for System Safety of UAS through Research Excellence
CORE TEAM
Alabama
UNIVERSITY of ALABAMA in HUNTSVILLE
Alaska
UNIVERSITY of ALASKA in FAIRBANKS
Arizona
EMBRY AERONAUTICAL UNIVERSITY-PRESCOTT
California
UNIVERSITY of CALIFORNIA DAVIS
Florida
EMBRY RIDDLE AERONAUTICAL UNIVERSITY
Kansas
KANSAS STATE UNIVERSITY
UNIVERSITY of KANSAS
WICHITA STATE UNIVERSITY
Montana
MONTANA STATE UNIVERSITY
New Mexico
NEW MEXICO STATE UNIVERSITY
North Carolina
NORTH CAROLINA STATE UNIVERSITY
North Dakota
UNIVERSITY OF NORTH DAKOTA
Oregon
OREGON STATE UNIVERSITY
Ohio
THE OHIO STATE UNIVERSITY
Pennsylvania
DREXEL UNIVERSITY
AFFILIATE TEAM
Alabama
AUBURN UNIVERSITY
TUSKEGEE UNIVERSITY
Indiana
INDIANA STATE UNIVERSITY
Louisiana
LA TECH UNIVERSITY
Canada
CONCORDIA UNIVERSITY
United Kingdom
UNIVERSITY of SOUTHAMPTON
Concordia
OSU
UC DAVIS
Kansas State University
KU
NC STATE UNIVERSITY
Indiana State University
Drexel
Southampton
MISSISSIPPI STATE UNIVERSITY
LEAD UNIVERSITY
http://assureuas.org


NGAT 2016 UAS Public Forum
MISSISSIPPI STATE UNIVERSITY
ASSURE Research Areas
MISSISSIPPI STATE UNIVERSITY
Executive Director
Mississippi State University
Vice Executive Board Director
University of Alaska Fairbanks
Airworthiness
Wichita State University
Mississippi State University
Training
Kansas State University
Air Traffic Integration
Embry Riddle Aeronautical Univ.
University of Alabama in Huntsville
C2 & Spectrum Management
North Carolina State University
The Ohio State University
Human Factors
Drexel University
Detect & Avoid
University of North Dakota
New Mexico State University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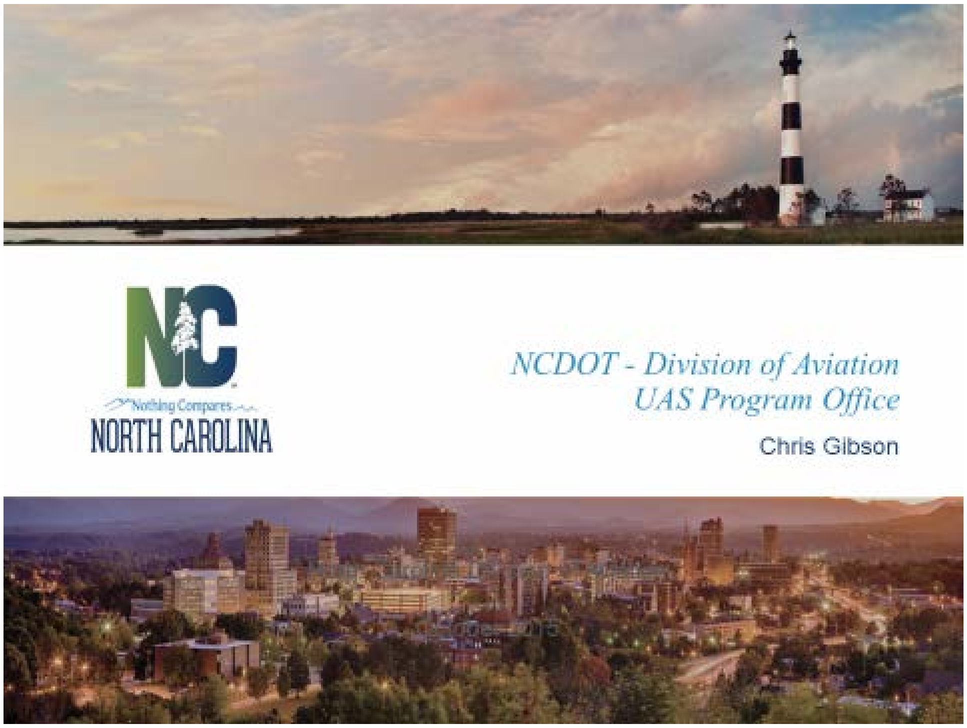
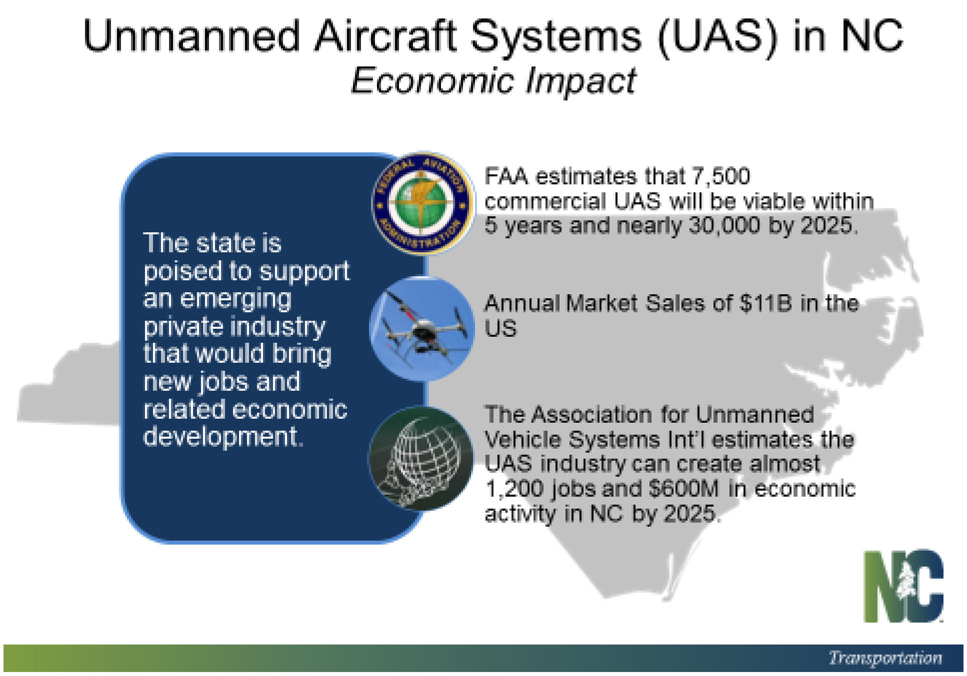
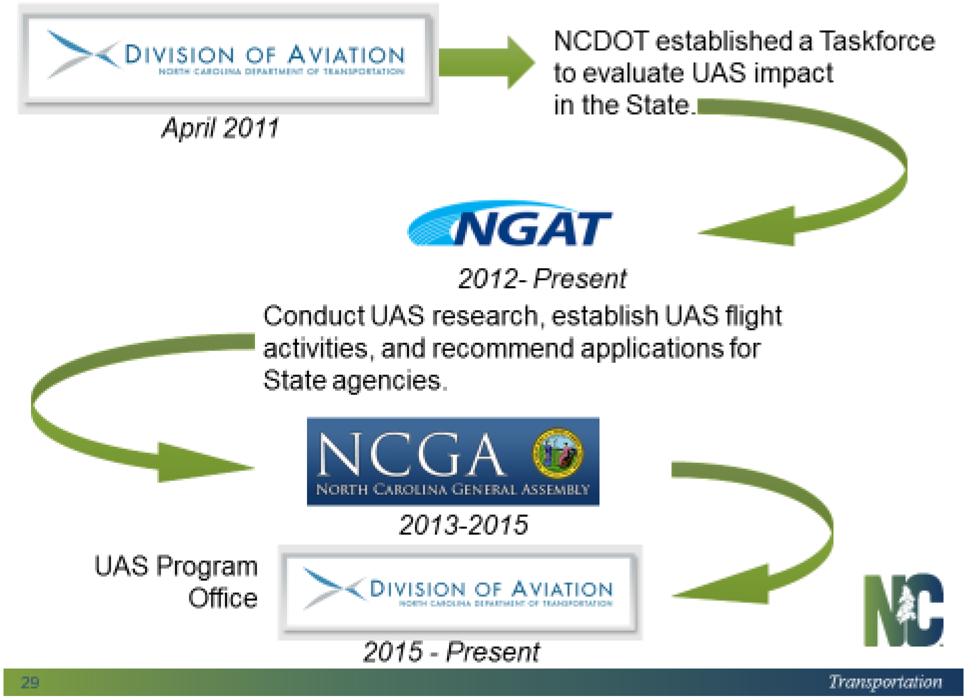
A6: Surveillance Criticality Overview
Need/Approach
Need – There is no known research to examine the impact of existing airborne surveillance equipment predicated on the pilot in the aircraft operational concept in terms of NAS operational safety. Research must determine the sufficiency of existing airborne surveillance equipment for manned aircraft (e.g. transponders and/or ADS-B) for providing separation provision and collision avoidance functions for UAS.
Approach – The research team will develop a methodology and toolset for evaluating SAA technologies using available analysis processes, simulation environments, and equipment characterizations. The team will utilize industry partner knowledge and resources, recognized UAS integration ConOps (from RTCA) scenarios, and a team of researchers to conduct a 3 phase iterative analysis and testing plan.
Major Activities
Activity
Status
Phase 1: Data Reporting
Continuous
Phase 2: Baseline scenarios, equipment characterizations, failure analysis, simulations
In progress
Phase 3: Complex scenarios, characterization updates and expansion, failure analysis, sims
July 2016
Phase 4: Final scenarios, characterization updates and expansion, failure analysis, sims
Sept 2016
Lead Principal Investigator
Kyle Snyder, NC State University
Research Partners
PrecisionHawk
Simulyze
Harris
CGH Technologies
Adaptive Aerospace Group
Rockwell Collins
ASSURE Research Performers
JW Bruce, Mississippi State
Jim Gregory, Ohio State
Mohammad Moallemi, Embry Riddle
William Semke, Univ of North Dakota
Michael Wing, Oregon State
FAA Sponsor
Paul Campbell (AFS-88)
FAA Program Manager
William Dehlschlager (ANG-C21)
Projected Benefit of Research
Input to Standards (RTCA, ASTM F38) development
UTM updates
ADS-B spectrum management analysis
Design Assurance performance expectations updates
Issues & Risks
Too many scenarios to analyze- large and small UAS, equipped and non-equipped aircraft, large number of operating environments
NC STATE UNIVERSITY
EMBRY-RIDDLE
UND
NORTH DAKOTA
MISSISSIPPI STATE UNIVERSITY
THE OHIO STATE UNIVERSITY
OSU

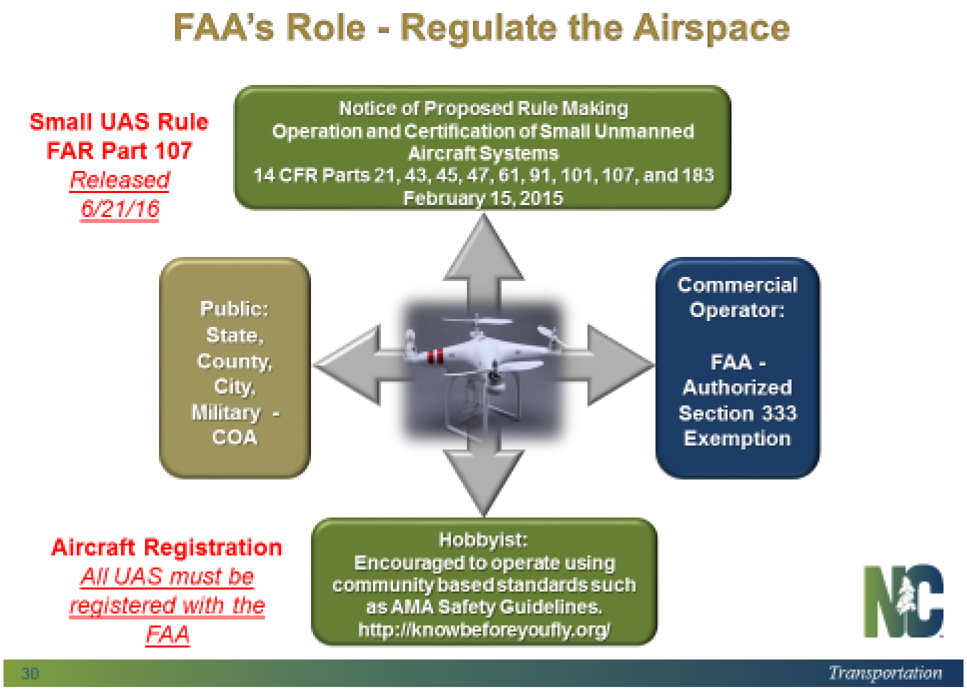

NGAT 2016 UAS Public Forum
A6: Surveillance Criticality Overview
TRK
176
TRU
15
18
21

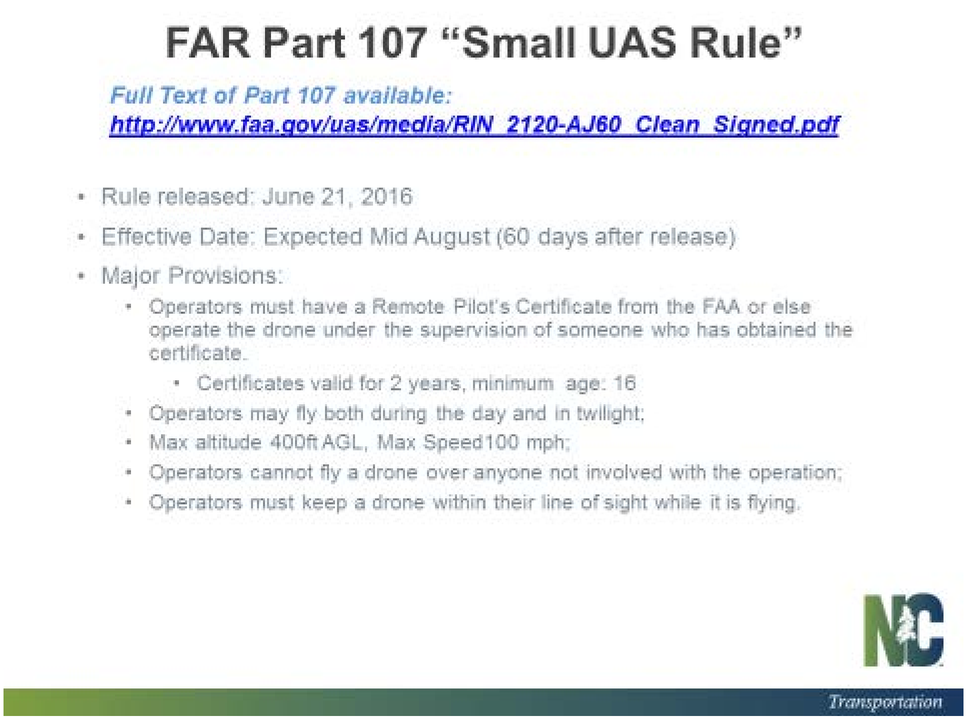

NGAT 2016 UAS Public Forum
ASSURE Engagement
Join ASSURE
Identify Research Area Lead
Develop Whitepaper (2 pages)
Align with Sponsor Priority
Scope Project
Prepare Proposal with University Lead
NCSU- Command, Control, Communication, Spectrum Management Lead
QUALITY
ASSURENCE
STAMP OF APPROVAL


Nothing Compares
NORTH CAROLINA
NCDOT - Division of Aviation
UAS Program Office
Chris Gibson


Unmanned Aircraft Systems (UAS) in NC
Economic Impact
The state is poised to support an emerging private industry that would bring new jobs and related economic development.
FAA estimates that 7,500 commercial UAS will be viable within 5 years and nearly 30,000 by 2025.
Annual Market Sales of $11B in the US
The Association for Unmanned Vehicle Systems Int'l estimates the UAS industry can create almost 1,200 jobs and $600M in economic activity in NC by 2025.
NC
Transportation


DIVISION OF AVIATION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
April 2011
NCDOT established a Taskforce to evaluate UAS impact in the State.
NGAT
2012- Present
Conduct UAS research, establish UAS flight activities, and recommend applications for State agencies.
NCGA
NORTH CAROLINA GENERAL ASSEMBLY
2013-2015
UAS Program Office
DIVISION OF AVIATION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
2015 - Present
NC
29
Transportation

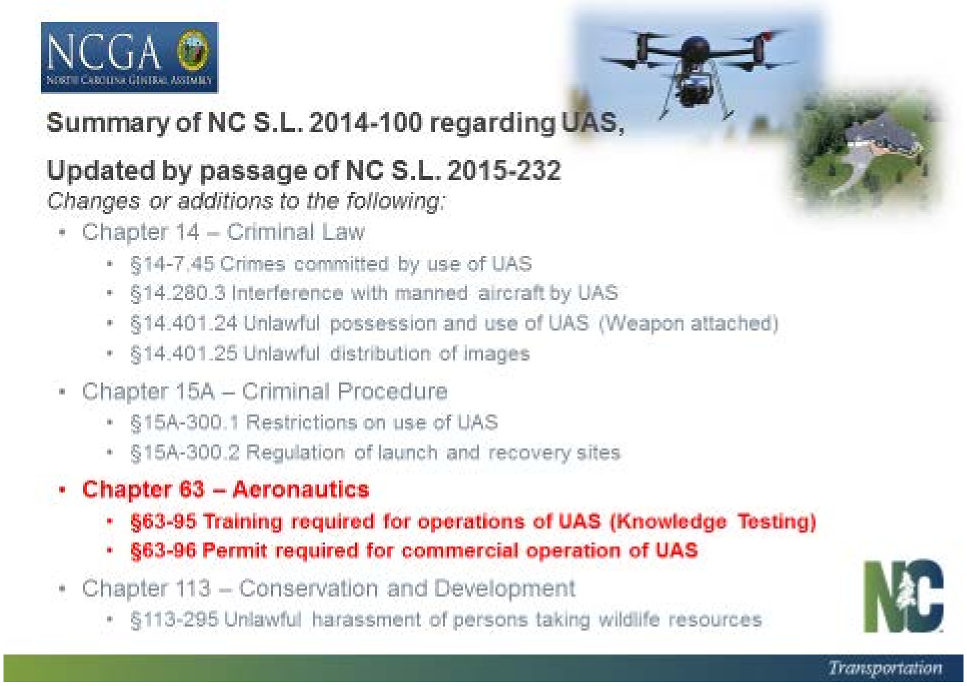

FAA's Role - Regulate the Airspace
Small UAS Rule
FAR Part 107
Released
6/21/16
Notice of Proposed Rule Making
Operation and Certification of Small Unmanned Aircraft Systems
14 CFR Parts 21, 43, 45, 47, 61, 91, 101, 107, and 183
February 15, 2015
Public: State, County, City, Military - COA
Commercial Operator:
FAA - Authorized Section 333 Exemption
Aircraft Registration
All UAS must be registered with the FAA
Hobbyist:
Encouraged to operate using community based standards such as AMA Safety Guidelines.
http://knowbeforeyoufly.org/
30
Transportation

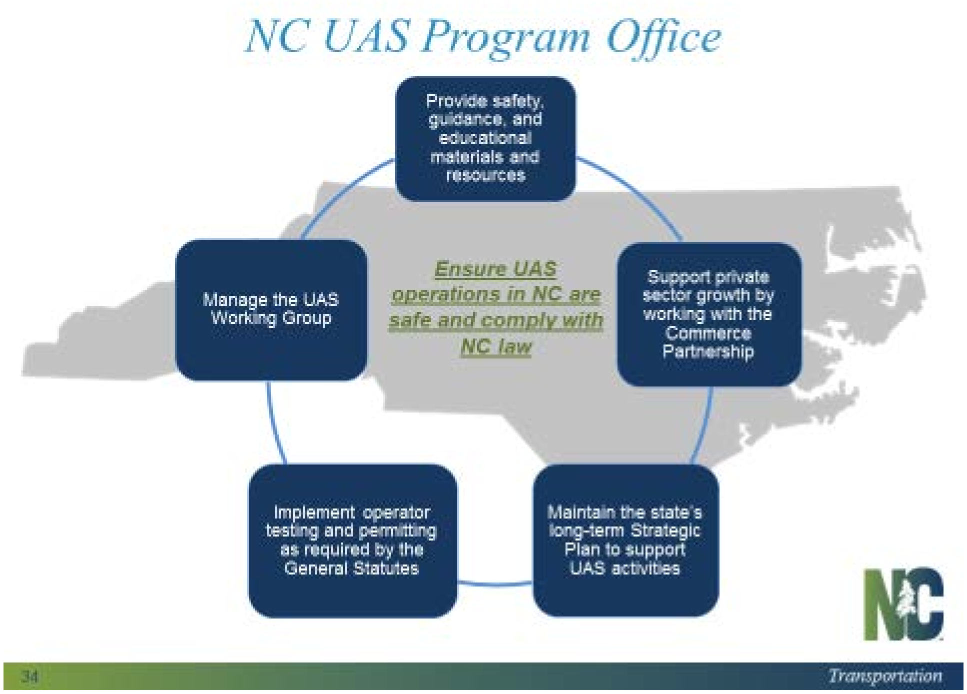

FAR Part 107 "Small UAS Rule"
Full Text of Part 107 available:
http://www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf
• Rule released: June 21, 2016
• Effective Date: Expected Mid August (60 days after release)
• Major Provisions:
• Operators must have a Remote Pilot's Certificate from the FAA or else operate the drone under the supervision of someone who has obtained the certificate.
• Certificates valid for 2 years, minimum age: 16
• Operators may fly both during the day and in twilight;
• Max altitude 400ft AGL, Max Speed100 mph;
• Operators cannot fly a drone over anyone not involved with the operation;
• Operators must keep a drone within their line of sight while it is flying.
Transportation

FAR Part 107 "Small UAS Rule"

- COA and Section 333 Holders may continue operations under the authority of their current FAA-issued waivers while waiting for the rule to go into effect.
- Once Part 107 goes into effect, Operators can choose to operate under their existing FAA-issued waivers or under the terms of Part 107.
- FAR Part 107 Remote Pilot Certificate
  - Available once Part 107 becomes effective
  - FAR Part 61 pilots can obtain FAR Part 107 Remote Pilot Certificate by completing an online test at https://www.faasafety.gov/ once the rule becomes effective.
  - Others must pass FAA Aeronautical Knowledge Test administered by FAA-approved Flight Testing Centers and pass TSA background check.

Transportation


NCGA
NORTH CAROLINA GENERAL ASSEMBLY
Summary of NC S.L. 2014-100 regarding UAS,
Updated by passage of NC S.L. 2015-232
Changes or additions to the following:
• Chapter 14 – Criminal Law
• §14-7.45 Crimes committed by use of UAS
• §14.280.3 Interference with manned aircraft by UAS
• §14.401.24 Unlawful possession and use of UAS (Weapon attached)
• §14.401.25 Unlawful distribution of images
• Chapter 15A – Criminal Procedure
• §15A-300.1 Restrictions on use of UAS
• §15A-300.2 Regulation of launch and recovery sites
• Chapter 63 – Aeronautics
• §63-95 Training required for operations of UAS (Knowledge Testing)
• §63-96 Permit required for commercial operation of UAS
• Chapter 113 – Conservation and Development
• §113-295 Unlawful harassment of persons taking wildlife resources
Transportation


NC UAS Program Office
Provide safety, guidance, and educational materials and resources
Support private sector growth by working with the Commerce Partnership
Maintain the state's long-term Strategic Plan to support UAS activities
Implement operator testing and permitting as required by the General Statutes
Manage the UAS Working Group
Ensure UAS operations in NC are safe and comply with NC law
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Transportation


NC UAS Program Office - Resources
Unmanned Aircraft Systems in NORTH CAROLINA
NORTH CAROLINA GENERAL STATUTES
Session Law 2014-100
Unmanned Aircraft Systems in NORTH CAROLINA
HOBBYIST GUIDELINES
UAS Fact Sheets and FAQs being updated based on Part 107 Release
ncdot.gov/aviation/uas/
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Transportation

NC UAS Website

- Online administration of NC UAS Operators Knowledge Test
- Commercial and Government UAS Operator's Permits can be acquired online
- UAS Safety Guide and NC Statutes
- Helpful Links

ncdot.gov/aviation/uas/

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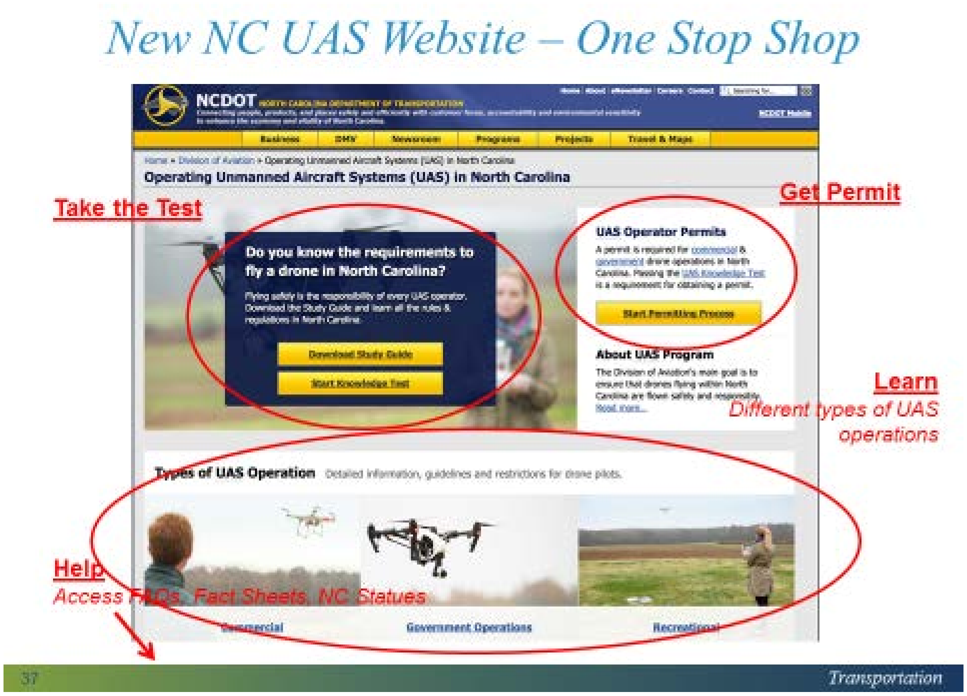
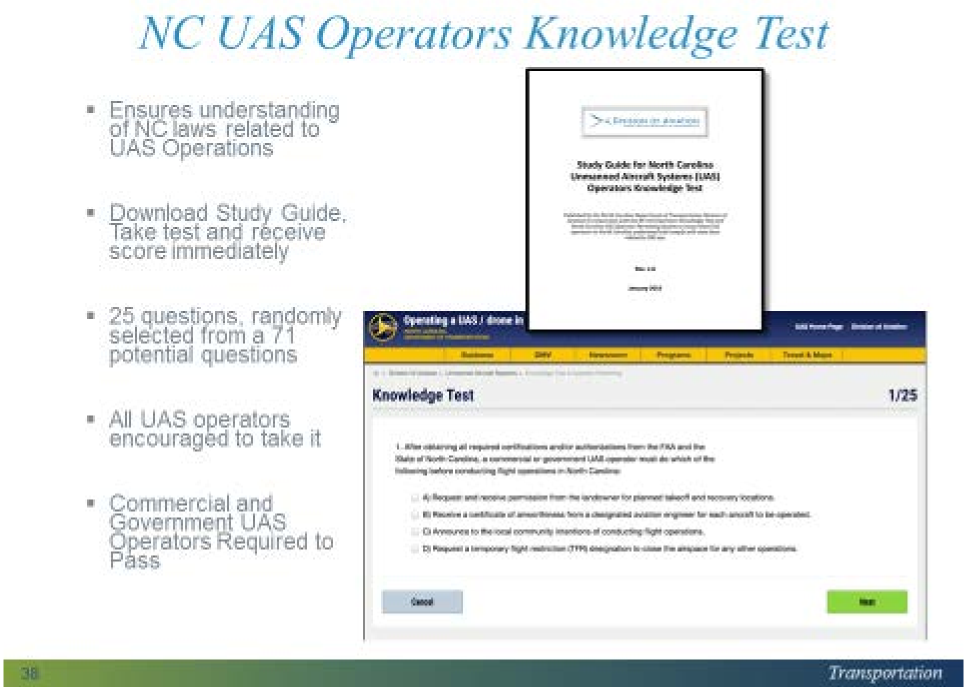
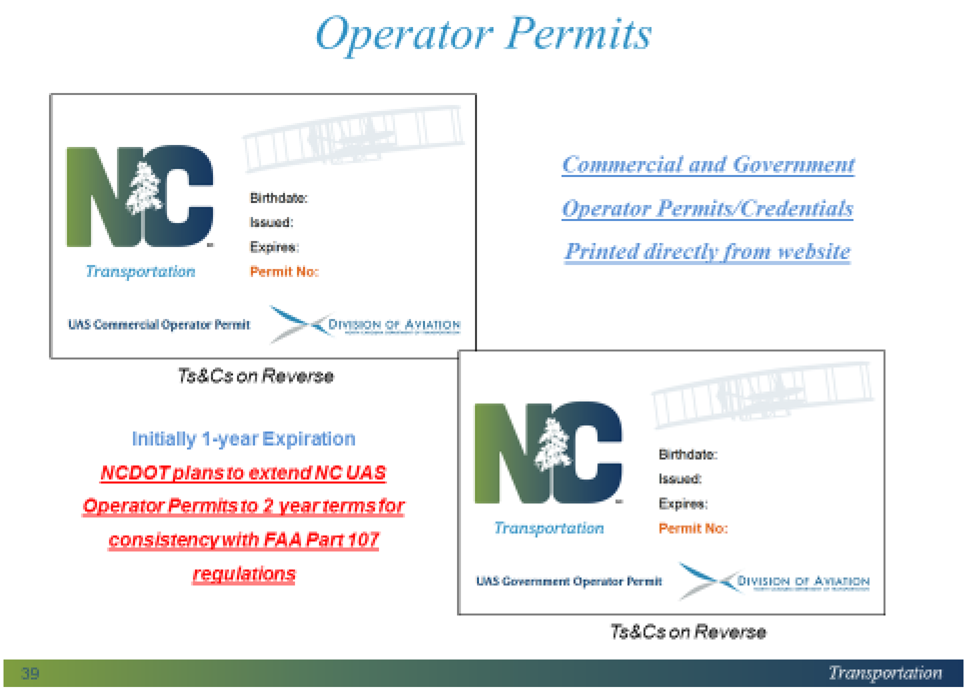

New NC UAS Website – One Stop Shop
NCDOT
Business
DMV
Newsroom
Programs
Projects
Travel & Maps
Operating Unmanned Aircraft Systems (UAS) in North Carolina
Take the Test
Do you know the requirements to fly a drone in North Carolina?
Flying safely is the responsibility of every UAS operator. Download the Study Guide and learn all the rules & regulations in North Carolina.
Download Study Guide
Start Knowledge Test
Get Permit
UAS Operator Permits
A permit is required for commercial & government drone operations in North Carolina. Passing the UAS Knowledge Test is a requirement for obtaining a permit.
Start Permitting Process
About UAS Program
The Division of Aviation's main goal is to ensure that drones flying within North Carolina are flown safely and responsibly.
Read more...
Learn
Different types of UAS operations
Types of UAS Operation
Detailed information, guidelines and restrictions for drone pilots.
Help
Access FAQs, Fact Sheets, NC Statues
Government Operations
37
Transportation


NC UAS Operators Knowledge Test
Ensures understanding of NC laws related to UAS Operations
Download Study Guide, Take test and receive score immediately
25 questions, randomly selected from a 71 potential questions
All UAS operators encouraged to take it
Commercial and Government UAS Operators Required to Pass
Study Guide for North Carolina Unmanned Aircraft Systems (UAS) Operators Knowledge Test
Operating a UAS / drone in
Knowledge Test
1/25
Cancel
Next
38
Transportation


Operator Permits
Birthdate:
Issued:
Expires:
Permit No:
Transportation
UAS Commercial Operator Permit
Division of Aviation
Ts&Cs on Reverse
Commercial and Government
Operator Permits/Credentials
Printed directly from website
Initially 1-year Expiration
NCDOT plans to extend NC UAS Operator Permits to 2 year terms for consistency with FAA Part 107 regulations
Birthdate:
Issued:
Expires:
Permit No:
Transportation
UAS Government Operator Permit
Division of Aviation
Ts&Cs on Reverse
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Transportation


Certificate for Recreational Operators
CERTIFICATE OF COMPLETION
is awarded to
Chris Gibson
for passing the Division of Aviation NC UAS Operators Knowledge Test.
January 14, 2016
Transportation
DIVISION OF AVIATION
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Transportation

NGAT 2016 UAS Public Forum

Upcoming Events

- July 12- NSF ATE Proposal meeting for developing UAS certificate program- curriculum and certification in NC. *Looking for industry engagement.*
- July 18- Hosting International Visitor Leadership Program: Aviation Leaders Delegation
- Aug 15-16- Midwest UAS Conf (Dayton, OH)
- Aug 18- Southeast Region Aerospace Supplier and Advanced Manufacturing Summit (Winston Salem)
- Nov 8-10- UTM 2016 (Syracuse, NY)
- Dec 12-15- TAAC (Santa Fe, NM)
- Feb 2-3- Campbell Law UAS Event (Raleigh)

NGAT 2016 UAS Public Forum

UAS Resources

- NGAT Website: www.itre.ncsu.edu/ngat
  - Consortium information
  - Research activities
  - News and Events
- NCDOT UAS Program Office: http://www.ncdot.gov/aviation/uas/
  - State statutes, regulations, guidelines
  - Fact Sheets
  - Licensing/Permitting Program Information
- FAA UAS : https://www.faa.gov/uas/
- Know Before You Fly : http://knowbeforeyoufly.org/
- AUVSI : www.auvsi.org
- 333 Exemption Holder Map:
  - http://www.suasnews.com/faa-drone-333-exemption-holders/

NGAT 2016 UAS Public Forum

For More Information

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cgibson2@ncdot.gov

It is not really necessary to look too far into the future; we see enough already to be certain it will be magnificent. Only let us hurry and open the roads.

- *Wilbur Wright*