Unmanned Aircraft Systems (UAS) Lessons Learned in the Arctic, Summer 2013
FAA UAS Integration Office

Introduction

The Arctic sUAS Integration Plan, mandated by the FAA Modernization and Reform Act of 2012 (FMRA) and signed by the Secretary of Transportation on November 1, 2012, required the FAA to:

> *Initiate a process to work with relevant Federal agencies and national and international communities to designate permanent areas in the Arctic where small unmanned aircraft may operate 24 hours per day for research and commercial purposes and Search and Rescue (SAR) operations. The plan for operations in these permanent areas shall include the development of processes to facilitate the safe operation of unmanned aircraft beyond line of sight (BLOS). Such areas shall enable over-water flights from the surface to at least 2,000 feet in altitude, with ingress and egress routes from selected coastal launch sites.*

On November 19 and 20, 2013, representatives from several federal agencies and stakeholders attended a series of meetings on FAA Arctic 2013 Operations Lessons Learned, hosted by the FAA's UAS Integration Office, Boeing, and Insitu. These meetings were held in Seattle, Washington and were well attended by the FAA's Air Traffic Organization (ATO) and Aviation Safety and Aircraft Certification offices, the United States Coast Guard (USCG), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), Transport Canada, Boeing, and Insitu. The discussions and presentations focused on small UAS (sUAS) operations in the Arctic during summer 2013 and included recommendations for process and safety improvements for future operations.

The purpose of this paper is to document the lessons learned in the summer of 2013, develop improved UAS-related approval, safety, and operational processes to be utilized in the Arctic Areas in subsequent projects, and to validate that these processes can be replicated in the National Airspace System (NAS) in the immediate future and beyond.

2013 Operations

The FAA's UAS Integration Office (AFS-80) is responsible for safe, efficient, and timely integration of UAS into the NAS. AFS-80 collaboratively develops operating concepts, policies, requirements, criteria, and procedures for new system evaluations, integration, and implementation of emerging UAS technologies and was tasked with developing and overseeing implementation of the Arctic sUAS Plan.

In order to authorize the summer 2013 sUAS Beyond-line-of-sight (BLOS) operations, AFS-80 hired a program manager in February 2013. Initial project tasks included forming a safety risk management (SRM) panel to identify risks and mitigations, including air traffic density analysis associated with the proposed UAS BLOS operations in compliance with Section 335 of the FAA Modernization and Reform Act of 2012 ("Safety Studies"). The SRM panel considered three (3) UAS BLOS operations in the Chukchi and Beaufort Sea as described below. The associated SRM document (SRMD) was signed by the FAA on July 15, 2013. Rules and Code of Federal Regulations (CFRs) applicable to manned aircraft were utilized to authorize the operations since UAS-specific rules do not exist at this time. A Communication Plan is attached as Exhibit A. Exhibit B lists the documents, CFRs, and rules considered by the SRM panel.

1) NASA Marginal Ice Zone Observations and Processes Experiment (MIZOPEX)

The NASA operation utilized three (3) different types of UAS to assess ocean and sea ice variability during the melt season within a key marginal ice zone region in the Beaufort Sea off the north coast of Alaska. MIZOPEX proposed the use of radar for Ground Based Sense and Avoid (GBSAA) instead of observers in order to clear airspace from the coastal launch site to international airspace. Key components of the operation included:

- Operations under a FAA Certificate of Authorization or Waiver (COA) as public aircraft while in domestic airspace
- Launch/land from a gravel runway in active special use airspace (SUA)
- Notices to Airmen (NOTAM) issued through Deadhorse Flight Service Station (FSS)
- Altitude reservation (ALTRV) issued per FAA Order JO 7610.4P and Notice 7610.99 used to create a 1 nautical mile (nm) wide by 2000 foot high ingress/egress corridor to international airspace
- Ground-based radar used for sense-and-avoid method of clearing ALTRV airspace. If any air traffic was observed, the UAS launch was to be delayed, or if in international airspace, the UAS was to loiter until traffic was clear of the ALTRV.
- No surface-based observers or chase aircraft
- Defense Visual Flight Rules (DVFR) Flight Plan filed for operations in the Air Defense Identification Zone (ADIZ)
- Mode C transponders on UAS
- Safety case used quantitative analysis to determine probability of mid-air collision
- Flight as State aircraft under Due Regard in international airspace
- Planned and vetted cross-polar operation into Canadian airspace
- Communication plan vetted with federal agencies and other airspace users
- FAA site visit during operations

NASA Recommendations

- GBSAA for clearing the airspace in UAS ingress/egress corridors: there is interest in using the NASA "UAS in the NAS" project to analyze the data from MIZOPEX and future operations to build GBSAA models for improving safety cases for flight operations. Detection and tracking is highly dependent on Doppler component; certain scenarios with tangential vectors were difficult to detect.
- Exemptions for very small, expendable UAS, such as DataHawk, to allow flight beyond control link range and ditching in the ocean
- During its second flight on June 26, the Sierra experienced a loss of propulsive thrust 60 nautical miles (nm) offshore; the aircraft glided into the ocean. A Mishap Investigation Board was convened by NASA, while the FAA notified relevant stakeholders per COA protocol. A NASA mishap report was provided to the NTSB. The report found that the proximate cause was icing in the engine’s air intake system, which caused loss of aircraft thrust. The finding resulted in a recommendation prohibiting flight in icing conditions unless icing risk mitigations, including proven anti-icing mechanisms and/or recovery procedures, are in place.

2) Insitu and ConocoPhillips (CP) ScanEagle in the Chukchi Sea

In order to establish a legal path to operate small UAS in the NAS to support oil and gas exploration and drilling activities and related environmental surveys, AFS-80 and CP developed an Other Transaction Agreement (OTA) to support the proposed commercial operation. Insitu submitted an application for a civil type certification of the ScanEagle to the Los Angeles Aircraft Certification Office (LAACO) under the restricted category (RCAT), 14 CFR 21.25(a) (2), for special purpose operations with a requirement that the UAS was previously accepted for use by the U.S. Military. The Insitu operation utilized a communication plan, NOTAM, ALTRV, and DVFR Flight Plan with transponder similar to the NASA operation. Additionally, crew members were required to have commercial pilot, medical, and airframe and power plant (A&P) certificates. Four (4) ScanEagles received special (restricted category) airworthiness certifications and were available for launch and recovery as civil aircraft from a research vessel in international waters managed by the FAA. The civil authorization included a waiver of 14 CFR § 91.113(b) (see and avoid) based upon the mitigations included in the SRMD and the waiver. During five (5) days at sea there were only two flight opportunity weather windows due to low ceilings, temperature/dew point spread, and high winds. The initial Chukchi Sea Insitu/CP BLOS operation conducted on September 12, 2013, represented the first FAA civil/commercial UAS operation.

Los Angeles Aircraft Certification Office (LAACO) Report

The LAACO and the Los Angeles Manufacturing Inspection Office (MIDO) ran a parallel process to AFS-80's operational, airspace, and safety case approval process for the Insitu ScanEagle RCAT type and airworthiness certifications. The LAACO *Small Unmanned Aircraft Systems (sUAS) Pathfinder Program Post Type Certification Report* is available as a separate document. Significant items in the report included:

- Frequency/Spectrum approval: every UAS proponent must have the appropriate National Telecommunications and Information Administration (NTIA) or Federal Communications Commission (FCC) authorization/approval to transmit on the radio frequencies (RF) used for UAS uplink and downlink of control, telemetry, and payload information. Civil users currently face the challenge of obtaining frequency/spectrum approvals that were traditionally reserved for Department of Defense (DoD) users.
- Noise Standards: 14 CFR part 36 requirements were not written for UAS. For example, the UAS has no Vx / Vy speeds and since the ScanEagle is launched from a catapult, there is no Vr runway acoustic footprint. Part 36 regulations were developed for flight profiles and runways associated with manned aircraft. The noise tests require acoustic measurements between microphones set standard distances apart. When a UAS is hand launched or catapulted, flight takes place between sets of noise recording stations, making the required noise reading difficult or impossible to obtain.
- Placards, aircraft flight manual placement, and accessibility: UAS have no human on the aircraft to read these documents as required by our current CFRs; therefore a clarification was issued for placement "with the ground control station," versus "on the aircraft." CFRs that are not applicable to UAS due to design or no human onboard the aircraft will require a waiver or exemption until a regulation applicable to UAS is in place, or unless addressed by other means such as legal interpretation.
- The ScanEagle UAS certification was limited to one ground control station, one launcher, and one recovery device while the UAS could be launched, flown, and recovered by other identical non-certificated components.
- Pilot Static Systems (Maintenance), 14 CFR part 43: The challenge of repair stations not being authorized to perform maintenance on a UAS required an A&P mechanic certificate

for validation and calibration of the systems; the Pathfinder team came up with a procedure for calibrations that meets the intent of the rule.

Insitu/CP Recommendations

- Consider training Aviation Safety Inspectors (ASIs) on UAS systems prior to their inspection site visits so they are familiar with the aircraft they are inspecting. Insitu donated ScanEagle systems to the FAA William J. Hughes Technical Center (WJHTC) in 2010 and signed a Cooperative Research Development Agreement (CRDA) with the FAA to utilize the WJHTC to train ASIs on the UAS.
- Determine UAS crew certification requirements.
- Consider use of aviation maintenance technicians for future maintenance functions in lieu of an A&P mechanic, as many UAS components are modular.
- Flexibility of RCAT "as surplused" requirements.
- Determine a process for certifying additional "surplused" aircraft, i.e. whether they need to be truly "surplused," or can be "of a type manufactured in accordance with requirements of and accepted for use by the Armed Forces" and later.
- Consider Supplemental Type Certificate (STC) options for changes based on mission requirements (still in a DoD accepted type).
- Existing RCAT type certificate data sheets limit operations to offshore Arctic Area; consider expansion to onshore operations.
- Carburetor ice caused the loss of one of the ScanEagles on approach to the research vessel. A Mishap Investigation Board was convened by NASA, while the FAA notified relevant stakeholders and the ASI onboard filed a report, per COA protocol. The mishap was also reported to the NTSB. As far back as 2007, Insitu has researched carburetor heat for its normally aspirated motors and decided to add a fuel injected, heavy fuel engine to the Type Certificate as an alternate power plant in 2014. The fuel injected ScanEagles were successfully flown without incident in summer 2014. GPS configuration should be WAAS-capable and enabled for FAA/NASA data research purposes.

3) USCG/NOAA Operation Arctic Shield

USCG Cutter Icebreaker *Healy* conducted science missions in a partnership with the Coast Guard Research and Development Center and NOAA to evaluate equipment for an oil spill response exercise. NOAA operated the hand-held Puma UAS from the *Healy* for multiple flights. The operational area included an 800 nautical mile (nm) radius around Barrow, Alaska, entirely within International/Class G airspace from 12 nm offshore Barrow, Alaska, to the 90 degree line respecting Canadian and Russian airspace boundaries.

NOAA collects information on Alaska marine mammals needed by National Marine Fisheries Service (NMFS) resource managers and external resource management groups. NOAA and its partners developed and utilized Environmental Response Management Application (ERMA) for the Arctic region. ERMA is a web-based Geographic Information System (GIS) tool that assists both emergency responders and environmental resource managers in dealing with environmental incidents. ERMA integrates and synthesizes data, providing a quick visualization of the situation and improving communication and coordination among responders and environmental stakeholders.

The USCG/NOAA UAS operation used a communication plan coordinated with the Insitu/CP operation taking place in the same time period in the Chukchi Sea, utilizing the Nationwide

Automatic Identification System (NAIS) for tracking, and NOTAMs, a DVFR flight plan, and ship-based radar for clearing airspace.

USCG/NOAA Recommendations

FAA and UAS operators should ensure that UAS flights in Alaska include procedures to mitigate the risk of conflict with manned aircraft operations. NOAA reviewed all Arctic BLOS operations to ensure that standardized deconfliction procedures are being implemented when UAS flights are being conducted concurrently with manned aircraft flights.

Other Stakeholder Recommendations

FAA Alaska Region

The Alaska Region NextGen branch (AAL-220) identified 27 coastal UAS launch sites, primarily in western and northern Alaska, for UAS flights through domestic airspace into international airspace. The additional coastal launch sites will utilize the same procedures that were developed for the summer 2013 operations, including the use of ALTRVs, NOTAMs, DVFR flight plans, communication plans and COAs, including a request for a waiver of 91.113(b) if the proposed operation is BLOS. Risks and mitigations associated with the UAS operations will be considered in an appropriate safety document. Additional recommendations include:

- Chart coastal launch sites and ingress/egress corridors including offshore common traffic advisory frequencies (CTAF)
- Develop UAS site-visit checklists for ASIs to be published in FAA Order 8900.1
- Develop ASI training for UAS incidents
- Explore methods for establishing cloud bases in the Arctic Areas

Department of Energy (DOE)

DOE submitted a SUA warning area application for scientific research north of its existing SUA restricted area R-2204 in the Anchorage Arctic Flight Information Region (FIR). AFS-80 facilitated meetings with ATO and DOE regarding the status of the application in February 2012. It is expected that the approval process for the proposed stratified and segmented 700 nm long by 40 nm wide SUA will be completed by January 2015. An Aeronautical Study was developed and published by the Anchorage Center, and public comments have been received and adjudicated. An SRM panel will be convened in late 2014, after which the process will proceed to the publication of the final rule in the Federal Register.

Additional DOE recommendations include:

- Time-release the airspace when activation of the entire area is not required by the using agency.
- To ensure the optimum use of airspace, make the assigned SUA available for the activities of DoD and other national agencies on a shared-use basis.

Transport Canada (TC)

Transport Canada was invited to attend the conference in an effort to further cooperative UAS initiatives for scientific purposes. TC has issued over 500 special flight operation certificates (SFOC)

for commercial operations within line of sight. All TC commercial operators have liability insurance and pilot certifications (flight and medical). AFS-80 has participated in regular meetings of the U.S.-Canada Regulatory Cooperative Council (RCC). TC's main recommendations were:

- Continue efforts to best address UAS regulatory divergence between the U.S. and Canada.
- Analyze TC's commercial Special Flight Operations Procedure for sUAS within line of sight, including pilot certifications and insurance requirements.

Other 2013 FAA Arctic Efforts

- The UAS Executive Committee (ExCom) is responsible for identifying solutions to the range of technical, procedural, and policy concerns arising from UAS integration into domestic airspace. AFS-80 was a member of and provided leadership to the ExCom Senior Steering Group Remote Operating Area Working Group's (ROA WG) collaborative efforts with DoD, Department of Homeland Security, USCG, NOAA, and the Massachusetts Institute of Technology to open UAS access corridors in the remote Arctic areas.
- Arctic Monitoring Assessment Program (AMAP) UAS Expert Group participation focused on the role UAS can play in AMAP's cross-polar scientific activities and needs to monitor the Arctic that cannot be met by manned aircraft or other technology. The ultimate goal of this group is pan-Arctic data gathering capability including participation with polar nations for cross-polar UAS scientific operations.

Arctic 2: Summer 2014 sUAS Arctic Operations

The summer 2014 UAS Arctic concept of operations includes:

- The continuation and expansion of the ScanEagle/ConocoPhillips RCAT operation utilizing up to five (5) additional for a total of nine (9) ScanEagles in the Arctic Areas for commercial and scientific purposes. The CP OTA has been extended to cover 2014 operations.
- AeroVironment (AV) is finalizing its RCAT certification process for three (3) Puma UAS and has made a COA application for BLOS commercial operation near Oliktok Point. An OTA with AV is in the final approval process.
- Planned ConocoPhillips joint oil spill response exercises in the Chukchi Sea with the USCG, Operation Arctic Shield 2014.
- DOE UAS operation from Oliktok Point
- NOAA and Bureau of Ocean Energy Management (BOEM) marine mammal surveys in the Chukchi Sea
- Utilization of new coastal launch sites and associated ALTRVs
- ExCom SSG ROA WG collaborative efforts to open additional UAS access corridors
- Use of existing GBSAA assets for clearing the airspace in UAS ingress/egress routes; Leverage data with stakeholder tools for future operations to build GBSAA models for improving safety cases for flight operations.
- Expanded FAA site visits to include local Flight Standards District Office (FSDO) ASIs
- AMAP UAS EG continued participation for cross-polar UAS scientific operations
- Continued cooperation with Transport Canada and RCC on cross-FIR UAS operations and review of regulatory efforts by both countries
- Eight ASIs completed an AFS-500 ScanEagle training course held in Bingen, WA at Insitu Headquarters in December, 2014.

Opportunities and Implementation Solutions for Future Arctic Operations

1) FAA DVFR flight plans

Flight plans were filed for all international airspace operations within or transiting the Air Defense Identification Zone (ADIZ) in accordance with 14 CFR § 99.11. Currently, there are no approved Technical Standard Orders (TSOs) for UAS transponders, and in the case of the Insitu/CP BLOS operations, the existing surplused transponders were utilized. FAA and International Civil Aviation Organization (ICAO) flight plans have no provision for UAS contingency flight plans in response to a lost link or emergency event; all contingencies are specified in the COA and must be relayed to the appropriate aeronautical facility by radio or satellite phone in the event they are being executed.

Proposed Solution: Expand FAA flight plan capability to include links to UAS ground stations with ability to amend flight plans without having to reference COA in the event of an emergency. Coordinate with ICAO for flight plan designators to field 10 (data link) and field 18 (UAS identifier). Continue to facilitate stakeholder efforts for TSO-approved transponders for UAS.

2) GBSAA radar utilized to clear airspace

Ground-based radar: TRS Sentinel AN/MPQ-64, X-band, 3-dimensional, pulse-Doppler radar with IFF was used during MIZOPEX for sense-and-avoid to clear ALTRV airspace. If any traffic was observed, the UAS launch was to be delayed, or if in international airspace, the UAS was to loiter until traffic was clear of the ALTRV.

Proposed Solution: The FAA is working with DoD and DOE to utilize radar feeds from existing radar facilities for U.S. Government operations in a similar manner to the summer 2013 operations as an airspace clearing radar. Proponents from NASA's "UAS in the NAS" project have expressed an interest in analyzing the data from MIZOPEX to build GBSAA models for improving safety cases for flight ops. NASA's Airborne Science Program Mission Tools Suite, a free software platform developed for airborne mission management, could be used to display scrubbed radar data as a kml/kmz file or Open GIS web-service data layer, overlaid on aircraft position and weather data. Develop GBSAA as a partial capability to meeting the Sense-and-Avoid requirement, offering "localized" UAS integration in conjunction with an airborne capability. The 2014 Arctic campaign will assist the FAA's GBSAA efforts and understanding to establish interoperability, equipage requirements, and certification standards for public and civil UAS operations.

3) Spectrum Authorization for Civil UAS

Every UAS proponent must have the appropriate National Telecommunications and Information Administration (NTIA) or Federal Communications Commission (FCC) authorization/approval to transmit on the radio frequencies (RF) used for UAS uplink and downlink of control, telemetry, and payload information. Currently, civil UAS operators are faced with a lengthy process to obtain FCC spectrum approval. In the Insitu/ConocoPhillips operation, a 2013 control and communication (C2) Frequency "experimental" license was received from FCC/NTIA.

Proposed Solution: Work with the FCC/NTIA to improve upon the process as additional civil UAS certifications applications are filed and cooperate with international communities in anticipation of an internationally harmonized dedicated radio spectrum for UAS C2 links.

4) Review existing CFRs in draft Notice of Proposed Rulemaking (NPRM)

2013 UAS Arctic operations revealed several CFRs that are not compatible with UAS.

Proposed Solution: Undertake a complete review of existing manned flight CFRs as they relate to UAS during the NPRM process. See list in Exhibit B; examples include:

- 14 CFR § 91.9: documents and flight manual in the cockpit
- 14 CFR § 91.203: Airworthiness certificate displayed at the cockpit entrance
- 14 CFR part 36: Noise Standards, Aircraft Type and Airworthiness Certification
- An FAA legal interpretation was published stating that the original intent of 14 CFR § 91.9 and § 91.203, along with § 47.3 (b) (2) and § 47.3l (c), was to display an aircraft's airworthiness, certification, and registration documents so they would be easily available to inspectors and passengers. The FAA found it impractical to carry and display these documents in UAS for operations under previous exemptions, so the documents required under these regulations must be available to the pilot in command at the ground control station of the UAS any time the aircraft is operating.

5) Ground-based communications and surveillance alternatives

The northern latitudes have little or no communication or surveillance assets.

Proposed Solution: Work with stakeholders to explore and develop alternative communication and radar signal paths between ground-based and airborne equipment.

Conclusion

A review of the 2013 Arctic UAS SRMD reveals that the BLOS operational risks were predictable. A SRM panel was convened in early 2014 in accordance with Section 335 of the FMRA to consider risks and mitigations associated with the summer 2014 sUAS BLOS operations and will build upon the lessons learned in 2013. UAS safety and operational data acquired via the Insitu/CP OTA in 2013 is currently being analyzed by the FAA and in 2014 the effort will be leveraged to include all stakeholders capable of contributing data analysis in an effort develop UAS operations and performance standards.

Ongoing collaboration and providing leadership among federal agencies, international communities, and UAS stakeholders will continue to be a key part of the UAS Arctic efforts going forward and is critical to minimizing duplication of research and addressing implementation obstacles. The goal of the 2014 Arctic UAS operations is to yield a reproducible blueprint for safe and routine integration of civil UAS into the NAS.