UNMANNED AIRCRAFT SYSTEM (UAS) SEARCH AND RESCUE ADDENDUM

to the

National Search and Rescue Supplement

to the

International Aeronautical and Maritime Search and Rescue Manual

Version 1.0

July, 2016

Department of Homeland Security

Department of Defense

Department of State

Department of the Interior

Department of Commerce

Department of Transportation

National Aeronautics and Space Administration

Federal Communications Commission

(www.uscg.mil/nsarc)

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Department of Defense
Department of the Interior
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National Aeronautics and Space Administration

National Search and Rescue Committee

Letter of Promulgation

Unmanned Aerial System (UAS) Search and Rescue (SAR) Addendum (Version 1.0) to the National Search and Rescue Supplement

Washington, D.C.

July, 2016

The use of UAS for a wide variety of operations and businesses is dramatically increasing both nationally and internationally. The UAS regulatory environment in the United States continues to evolve. New UAS capabilities and more effective ways to use these capabilities are constantly being developed and implemented. This *Unmanned Aerial System (UAS) Search and Rescue (SAR) Addendum* was developed by the United States National Search and Rescue Committee (NSARC) to provide background, guidance, and relevant information on the use of UAS in SAR operations.

How does this important capability improve the SAR planner's ability to search for persons in distress? Which UAS is appropriate and most effective for a search based on the circumstances of the case? How does the SAR Mission Coordinator (SMC)/Incident Commander (IC) gain approval to use UAS for a particular SAR operation? These are challenging questions that must be answered before contemplating the use of UAS in a particular SAR mission.

SAR Coordinators (SCs), SMCs/ICs, State, Tribal, Territorial/Insular Area, local SAR authorities, and volunteers interested in using UAS for SAR will also find important information and guidance in this Addendum in the development, management, and operation of their UAS programs.

The coordination and conduct of SAR operations requires people working together, sharing capabilities, and developing new ways to improve our ability to save lives. This is particularly important as the use of UAS for SAR operations continues to increase. This is the purpose of this Addendum and is provided to all who are committed to saving lives.

On behalf of the National Search and Rescue Committee,

Ms. Dana S. Tulis
Chair, National Search and Rescue Committee
Director of Incident Management & Preparedness Policy
United States Coast Guard

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Foreword

Unmanned Aircraft Systems (UAS), also known as remotely piloted aircraft (RPA) or unmanned aerial vehicles (UAV), are a rapidly growing capability of many Federal, State, Tribal, Territorial/Insular Area, and local jurisdictions. UAS have proven to be highly useful overseas for combat intelligence, surveillance, and reconnaissance (ISR), and Combat Search and Rescue (CSAR), but their domestic use has been limited by regulatory, safety, and privacy concerns. Nevertheless, as these issues are addressed in the U.S., there will be growing opportunities to use UAS for search and rescue (SAR) operations.

Depending on the circumstances of a particular SAR operation, the SAR Mission Coordinator (SMC)/Incident Commander (IC) may want to consider the use of UAS over manned aircraft for the following reasons:

- Longer endurance;
- Reduced cost;
- Effective sensor capabilities, such as multi-spectral/IR imagery, video, and radar, often with real-time transmission;
- Increased sensitivity or detection, via analysis software or human scanning of static images;
- Wide-area situational awareness;
- To provide communications relay; and
- Depending on the UAS capability available can be used in extreme weather, restricted terrain, or hazardous environments.

In order to realize the true value of these capabilities, UAS operators and SAR authorities will need to gain experience by employing UAS on actual SAR operations.

The objective of this Addendum is to provide the National SAR Committee (NSARC) guidance on how to employ UAS for SAR. It is a living document. As good ideas become best practices and bad ideas become lessons learned, this document will be updated and expanded to guide operational use, capture changes to regulations and authorities, and reflect improvements to aviation technology and system capabilities.

So that others may live.

National Search and Rescue Committee

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References

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FAA 7210.3: *Facility Operation and Administration (2015)*, FAA Order JO 7210.3Z.

FAA 8130.34C: *Airworthiness Certification of Unmanned Aircraft Systems and Optionally Piloted Aircraft (2013)*, FAA Order 8130.34C.

FAA 8900.1: *Unmanned Aircraft Systems (2014),* FAA Order 8900.1 Volume 16.

FAA MRA: *FAA Modernization and Reform Act of 2012*.

FAA Roadmap: *UAS Roadmap (2013)*.

FAA UAS Plan: *UAS Comprehensive Plan (2013).*

FAA AIM: *FAA Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures (2014).*

RTCA DO-320: *DO-320 Operational Services and Environmental Definition (OSED) for Unmanned Aircraft Systems*, Radio Technical Commission for Aeronautics (RTCA), 2010.

SAA: "Sense and Avoid (SAA) for Unmanned Aircraft Systems (UAS)" – Second Caucus Workshop Report (2013).

Glossary

A

Air Traffic Control: A service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic. (FAA AIM)

Air Traffic Service: A generic term meaning:

a. Flight Information Service.

b. Alerting Service.

c. Air Traffic Advisory Service.

d. Air Traffic Control Service:

1. Area Control Service,
2. Approach Control Service, or
3. Airport Control Service. (FAA AIM)

Aircraft: A device that is used or intended to be used for flight in the air. (14 C.F.R.)

Aircraft Certification Service: The FAA Aircraft Certification Service is the office responsible for:

- Administering safety standards governing the design, production, and airworthiness of civil aeronautical products;
- Overseeing design, production, and airworthiness certification programs to ensure compliance with prescribed safety standards;
- Providing a safety performance management system to ensure continued operational safety of aircraft; and,
- Working with aviation authorities, manufacturers, and other stakeholders to help them successfully improve the safety of the international air transportation system. (www.faa.gov)

Airspace: Any portion of the atmosphere sustaining aircraft flight and which has defined boundaries and specified dimensions. Airspace may be classified as to the specific types of flight allowed, rules of operation, and restrictions in accordance with International Civil Aviation Organization standards or State regulation. (RTCA DO-320)

Airworthiness: A condition in which the UAS (including the aircraft, airframe, engine, propeller, accessories, appliances, and control station (CS)) conforms to its type certificate (TC), if applicable, and is in condition for safe operation. (FAA 8900.1)

Airworthiness Certification: A repeatable process that results in a documented decision that an aircraft system has been judged to be Airworthy. It is intended to verify that the aircraft system can be safely maintained and safely operated by fleet pilots within its described and documented operational envelope. (FAA 8900.1)

Airworthiness Statement: Document required from public UAS applicants during a Certificate of Waiver or Authorization (COA) application process which confirms aircraft airworthiness. (FAA 8900.1)

C

Certificate of Waiver or Certificate of Authorization (COA): 1. An FAA grant of approval for a specific operation. COAs may be used as an authorization, issued by the Air Traffic Organization (ATO), to a public operator for a specific UA activity. COAs for civil and commercial operations are only for aircraft that have received an airworthiness certificate from Aircraft Certification Service (AIR). Provisions or limitations may be imposed as part of the approval process to ensure the UA can operate safely with other airspace users. (FAA 8900.1) 2. A COA constitutes relief from the specific regulations stated, to the degree and for the period of time specified in the certificate, and does not waive any state law or local ordinance. (FAA 7210.3)

Chase Aircraft: A manned aircraft flying in close proximity to a UA that carries a qualified observer and/or UA pilot for the purpose of seeing and avoiding other aircraft and obstacles. (FAA 8900.1)

Civil Aircraft: Aircraft other than public aircraft. (4) Civil aviation includes two major categories: (Federal Aviation Regulations FAR Part 91, 110, 121, 125, 135.)

1. Air transport, including all passenger and cargo flights operating on regularly scheduled routes, as well as on demand flights.
2. General aviation (GA), including all other civil flights, private or commercial.

All air transport is commercial, but general aviation can be either commercial or private. Normally, the pilot, aircraft, and operator must all be authorized to perform commercial operations through separate commercial licensing, registration, and operation certificates. (FAA UAS Plan)

Collision Avoidance: The Sense and Avoid system function where the UAS takes appropriate action to prevent an intruder from penetrating the collision volume. Action is expected to be initiated within a relatively short time horizon before closest point of approach. The collision avoidance function engages when all other modes of separation fail. (SAA)

Communication Link: The voice or data relay of instructions or information between the UAS pilot and the air traffic controller and other NAS users. (RTCA DO-320)

Congested Area: A congested area is determined on a case-by-case basis. The determination must take into consideration all circumstances, not only the size of an area and the number of homes or structures (e.g., whether the buildings are occupied or people are otherwise present, such as on roads). (FAA 8900.1)

Control Station: The equipment used to maintain control, communicate with, guide, or otherwise pilot an unmanned aircraft. (RTCA DO-320)

Cooperative Aircraft: Aircraft that have an electronic means of identification (i.e., a transponder or Automatic Dependent Surveillance—Broadcast (ADS-B) transceiver) aboard in operation. (FAA 8900.1)

Crew Resource Management (CRM): The effective use of all available resources including human, hardware, and information resources. (FAA 8900.1)

Crew Member (UAS): In addition to the crewmembers identified in Title 14 of the Code of Federal Regulations (14 C.F.R.) part 1, a UAS flight crew member includes pilots, sensor/payload operators, and visual observers (VO), but may include other persons as appropriate or required to ensure safe operation of the aircraft. (FAA 8900.1)

D

Daisy-Chaining: The use of multiple, successive observers to extend the flight of a UA beyond the direct visual line-of-sight of any other pilot in command (PIC) or VO. (FAA 8900.1)

Data Link: A ground-to-air communications system which transmits information via digital coded pulses. (RTCS DO-320)

Detect and Avoid: Term used instead of Sense and Avoid in the Terms of Reference for RTCA Special Committee 228. This new term has not been defined by RTCA and may be considered to have the same definition as Sense and Avoid when used in this document. (FAA Roadmap)

Direct Control: The capability of a remote pilot to manipulate the flight control surfaces of the aircraft in a direct fashion using, for example, a radio control box with joystick or a ground control station using conventional type aircraft controls (such as a yoke/stick, rudder pedals, power levers, and other ancillary controls). This infers a one-to-one correspondence between control input and flight control surface deflection. (FAA 8130.34C)

Due Regard: A phase of flight wherein an aircraft commander of a State-operated aircraft assumes responsibility to separate his or her aircraft from all other aircraft. (FAA 8900.1)

E

Exemption: Relief from the requirements of a current regulation as provided for in 14 C.F.R. part 11, General Rulemaking Procedures. (FAA 8130.34C)

Experimental Certificate: A type of Special Airworthiness Certificate issued for the purposes of research and development (R&D), crew training, exhibition, and market survey as defined in 14 C.F.R. part 21, § 21.191 (a), (c), and (f).

(Note: According to 14 C.F.R. part 91, § 91.319(a)(2), experimental aircraft may not be used for carrying persons or property for compensation or hire.)

1) R&D Aircraft. Aircraft testing new design concepts, equipment, installations, operating techniques, or uses for aircraft. Any UAS, including an Optionally Piloted Aircraft (OPA), is eligible for an experimental certificate under this purpose. The proponent may conduct operations only as a matter of research or to determine whether an idea warrants further development.
2) Crew Training. The process of bringing a person or persons to an established standard of proficiency. Crew training is limited to the number of flight crews required by the operator to conduct UAS aircraft operations.
3) Market Survey. Aircraft may be used for the purposes of conducting market surveys, sales demonstrations, and customer crew training of the manufacturer's customers, as provided in §21.195. (FAA 8900.1)

External Pilot: A UAS pilot who flies from outside a control station with direct visual contact with the aircraft. (FAA 8900.1)

F

FAA Recognized Equivalent: An FAA recognition that a public agency may exercise its own internal processes regarding airworthiness and pilot, aircrew, and maintenance personnel certification and training; furthermore, the agency has determined that its UAS is capable of safe operation in the National Airspace System (NAS) when conducting public aircraft operations under Title 49 of the United States Code (49 U.S.C.) §§40102(a)(41) and 40125. (FAA 8900.1)

Field of View: The angular width of a sensor's visibility, given in degrees, and often distinguished between horizontal (HFOV) and vertical (VFOV); it is a function of the sensor and lens dimensions.

Field of Regard: The area a sensor can cover by physically turning in its mount.

Flight Information Region: An airspace of defined dimensions within which Flight Information Service and Alerting Service are provided.

a. Flight Information Service. A service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights.

b. Alerting Service. A service provided to notify appropriate organizations regarding aircraft in need of search and rescue aid and to assist such organizations as required.

(FAA AIM)

Flight Level: A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet. For example, flight level (FL) 250 represents a barometric altimeter indication of 25,000 feet; FL 255, an indication of 25,500 feet. (FAA AIM)

Flight Level [ICAO]: A surface of constant atmospheric pressure which is related to a specific pressure datum, 1013.2 hPa (1013.2 mb), and is separated from other such surfaces by specific pressure intervals.

(Note 1: A pressure type altimeter calibrated in accordance with the standard atmosphere:

a. When set to a QNH altimeter setting, will indicate altitude;
b. When set to a QFE altimeter setting, will indicate height above the QFE reference datum; and
c. When set to a pressure of 1013.2 hPa (1013.2 mb), may be used to indicate flight levels.)

(Note 2: The terms 'height' and 'altitude,' used in Note 1 above, indicate altimetric rather than geometric heights and altitudes.) (FAA AIM)

Flight Termination: The intentional and deliberate process of performing controlled flight into terrain (CFIT). Flight termination must be executed in the event that all other contingencies have been exhausted, and further flight of the aircraft cannot be safely achieved, or other potential hazards exist that require immediate discontinuation of flight. (FAA 8900.1)

Flyaway: An interruption or loss of the control link, or when the pilot is unable to effect control of the aircraft and, as a result, the UA is not operating in a predicable or planned manner. (FAA 8900.1)

Formation:

1. Nonstandard Formation. A formation operating under any of the following conditions:
   - When the flight leader has requested and air traffic control (ATC) has approved other-than-standard formation dimensions;
   - When operating within an authorized block altitude or under the requirements of a letter of agreement (LOA);
   - When the operations are conducted in airspace specifically designed for a special activity.
2. Standard Formation. A formation in which proximity of no more than 1 nautical mile (NM) laterally or longitudinally and within 100 feet vertically from the flight leader is maintained by each wingman or UA.

   (Note: For more information, refer to the FAA AIM, Order JO 7110.10, Flight Services, and Order JO 7110.65, Air Traffic Control, at http://www.faa.gov/air_traffic/publications/atpubs/PCG/index.htm.) (FAA 8900.1)

I

Indirect Control: The capability of a remote pilot to affect the trajectory of the aircraft through computer input to an onboard flight control system. An example of an indirect control would be the entry of a navigational fix or waypoint on a remote system that, in turn, uploads this information to an onboard flight control computer. The flight control computer then computes the flight control inputs to achieve a flight path to the uploaded waypoint. The onboard system controls the flight control surfaces. (FAA 8130.34C)

Internal Pilot: A UAS pilot who flies from inside a control station without direct visual contact with the aircraft. (FAA 8900.1)

International Civil Aviation Organization (IACO): A specialized agency of the United Nations whose objective is to develop the principles and techniques of international air navigation and to foster planning and development of international civil air transport. (FAA AIM)

Instantaneous Field of View: A measure of the resolution of an EO/IR system; the dimension covered by a single sensor element in an array at range, given by IFOV=D/R. e.g. At a range of 1,000 meters, an IFOV of 10^{-4} would cover 10 cm. For a 1 square meter target this would provide 100 IFOVs on target. (EO/IR Tutorial)

L

Light Detection and Ranging (LIDAR): LIDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system— generate precise, three-dimensional information about the shape of the Earth and its surface characteristics. (http://oceanservice.noaa.gov/facts/lidar.html)

Lost Link: The loss of command-and-control link contact with the remotely piloted aircraft such that the remote pilot can no longer manage the aircraft's flight. (FAA 8900.1)

M

Manned Aircraft: Aircraft piloted by a human onboard. (RTCA DO-320)

Mode: The letter or number assigned to a specific pulse spacing of radio signals transmitted or received by ground interrogator or airborne transponder components of the Air Traffic Control Radar Beacon System (ATCRBS). Mode A (military Mode 3) and Mode C (altitude reporting) are used in air traffic control. (FAA AIM)

Model Aircraft: An unmanned aircraft that is capable of sustained flight in the atmosphere; flown within visual line-of-sight of the person operating the aircraft and flown for hobby or recreational purposes. (FAA MRA)

National Airspace System (NAS): The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military. (FAA AIM)

N

Non-Cooperative Aircraft: Aircraft that do not have an electronic means of identification (e.g., a transponder) aboard or that have inoperative equipment because of malfunction or deliberate action. (FAA 8900.1)

Nonstandard Formation: See Formation, above. (FAA 8900.1)

Notice to Airmen (NOTAM): Time-critical aeronautical information which is of either a temporary nature or not sufficiently known in advance to permit publication on aeronautical charts or in other operational publications receives immediate dissemination via the National NOTAM System. (FAA AIM)

O

Observer: A trained person who assists a UAS pilot in the duties associated with collision avoidance and navigational awareness through electronic or visual means. Collision avoidance includes, but is not limited to, avoidance of other traffic, clouds, obstructions, terrain and navigational awareness. A visual observer (VO) is a trained person who assists the UAS pilot by visual means in the duties associated with collision avoidance. A VO includes the OPA pilot when the OPA is being operated as a UAS. (FAA 8900.1)

Off-Airport: Any location used to launch or recover aircraft that is not considered an airport (e.g., an open field). (FAA 8900.1)

OPA Safety Pilot: The PIC that is responsible for ensuring the safe operation of an Optionally Piloted Aircraft (OPA), whether under remote control or onboard control, for the purposes of overriding the automated control system in the case of malfunction or any other hazardous situation. (FAA 8900.1)

Optionally Piloted Aircraft (OPA): An aircraft that is integrated with UAS technology and still retains the capability of being flown by an onboard pilot using conventional control methods (see OPA Safety Pilot). (FAA 8900.1)

P

Pathfinder: An initial UAS airworthiness certification program that will aid the FAA in the establishment of certification requirements. (FAA Roadmap)

Pilot Duty Period: The period beginning when a flight crew member is required to report for duty with the intention of conducting a flight and ending when the aircraft is parked after the last flight. It includes the period of time before a flight or between flights that a pilot is working without an intervening rest period. (FAA 8900.1)

Pilot in Command (PIC): The person who has final authority and responsibility for the operation and safety of flight, has been designated as PIC before or during the flight, and holds the appropriate category, class, and type rating, if applicable, for the conduct of the flight. The responsibility and authority of the PIC as described by §91.3 apply to the UA PIC. The PIC position may rotate duties as necessary with equally qualified pilots. The individual designated as PIC may change during flight *(Note: The PIC can only be the PIC for one aircraft at a time)*. For an OPA, the PIC must meet UAS guidance requirements for training, pilot licensing, and medical requirements when operating an OPA as a UAS. (4) Pilot-in-command means the person who: 1) has final authority and responsibility for the operation and safety of the flight; 2) has been designated as pilot-in-command before or during the flight; and 3) holds the appropriate category, class, and type rating, if appropriate, for the conduct of the flight. (14 C.F.R. § 1.1)

Proper Use Memorandum (PUM): A memorandum signed annually by an organization’s Certifying Government Official. The imagery user organization will submit this memorandum annually. It defines their requirements and intended use, and contains a proper use statement that acknowledges their awareness of the legal and policy restrictions regarding domestic imagery. (AFINST 14-04)

Public Aircraft: 1) An aircraft operated by a governmental entity (including Federal, State, or local governments, and the U.S. Department of Defense (DOD) and its military branches) for certain purposes as described in 49 U.S.C. §§40102(a)(41) and 40125. Public aircraft status is determined on an operation by operation basis. Refer to Part 1, §1.1 for a complete definition of a public aircraft. (FAA 8900.1) 2) Public Aircraft Operation (PAO) is limited by the statute to certain government operations within U.S. airspace. Although these operations must comply with certain general operating rules (including those applicable to all aircraft in the NAS), other civil certification and safety oversight regulations do not apply. Whether an operation may be considered public is determined on a flight-by-flight basis, under the terms of the statute (49 U.S.C. 40102 and 49 U.S.C. 40125) and depends on factors such as aircraft ownership, operator, the purpose of the flight and the persons on board the aircraft. (FAA UAS Plan)

Public Operator: An operator that is classified as government and/or otherwise qualifies for public aircraft operation under 49 U.S.C. §§40102(a)(41) and 40125. Not all flights by a public aircraft operator qualify as a public aircraft operation under the statute. Public aircraft operation status is not automatic for flights conducted by a government entity or a contractor to a government entity. (FAA 8900.1)

R

Remotely Piloted Aircraft (RPA): Alternative term with no legal or regulatory distinction from unmanned aircraft (UA) or unmanned aerial vehicles (UAV). Preferred term of use by ICAO.

RTCA: RTCA, Inc. is a private, not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management system issues. RTCA functions as a Federal Advisory Committee. Its recommendations are used by the FAA as the basis for policy, program, and regulatory decisions and by the private sector as the basis for development, investment and other business decisions. (www.rtca.org)

S

Safety Evaluation: A comprehensive review of an applicant's UAS, OPA, or OPA/UAS and all associated elements of the system. The applicant is expected to provide any and all information necessary to allow the FAA to objectively determine if the aircraft can be safely operated in the NAS. The form of this review is a presentation by the applicant to the FAA. The safety evaluation is a formal review of the information contained in the safety checklist and is performed at the discretion of the FAA. (FAA 9130.34C)

Safety Risk Management (SRM): A formalized, proactive approach to system safety. SRM is a methodology that ensures hazards are identified; risks are analyzed, assessed, and prioritized; and results are documented for decision-makers to transfer, eliminate, accept, or mitigate risk. (FAA 8900.1)

Scheduled Maintenance (Routine): The performance of maintenance tasks at prescribed intervals. (FAA 8900.1)

See and Avoid: When weather conditions permit, pilots operating instrument flight rules or visual flight rules are required to observe and maneuver to avoid another aircraft. Right-of-way rules are contained in 14 C.F.R. § 91. (FAA AIM)

Segregation: Setting apart from other air traffic operations in the NAS. Segregation is not synonymous with required air traffic separation standards. Therefore, segregation does not prescribe or mandate criteria such as vertical, lateral, or longitudinal distances. (FAA 8900.1)

Self-Separation: Sense and Avoid system function where the UAS maneuvers within a sufficient timeframe to remain well clear of other airborne traffic. (SAA)

Sense and Avoid: the capability of an unmanned aircraft to remain a safe distance from and to avoid collisions with other airborne aircraft. (FAA MRA)

Small Unmanned Aircraft: An unmanned aircraft weighing less than 55 pounds. (FAA MRA)

Special Airworthiness Certificate – Experimental Category (UAS): Airworthiness certification for experimental UAS and optionally piloted aircraft. (FAA Roadmap)

Supplemental Pilot: Pilots assigned UAS flight duties to augment the PIC. It is common for operators to have both an internal and an external UAS pilot. The supplemental pilot can assume either of these positions. The supplemental pilot may also assume duties of the PIC if the specified qualifications are met. (FAA 8900.1)

Support Equipment: All associated equipment, whether ground based or airborne, used to enable safe operation of the unmanned aircraft. This includes all elements of the control station, data links, telemetry, navigation, communications equipment, as well as equipment that may be used to launch and recover the aircraft. (FAA 8130.34C)

T

Test Range: A defined geographic area where research and development are conducted in accordance with Sections 332 and 334 of the FMRA. Test ranges are also known as test sites in related documents such as the FAA's Screening Information Request. (FAA MRA)

Transponder: The airborne radar beacon receiver/transmitter portion of the Air Traffic Control Radar Beacon System (ATCRBS) which automatically receives radio signals from interrogators on the ground, and selectively replies with a specific reply pulse or pulse group only to those interrogations being received on the mode to which it is set to respond. (FAA AIM)

U

Unmanned Aircraft: 1. An aircraft that is operated without the possibility of direct human intervention from within or on the aircraft. (FAA MRA) 2. A device used or intended to be used for flight in the air that has no onboard pilot. This device excludes missiles, weapons, or exploding warheads, but includes all classes of airplanes, helicopters, airships, and powered-lift aircraft without an onboard pilot. UAs do not include traditional balloons (refer to 14 C.F.R. § 101), rockets, and unpowered gliders. (FAA 8900.1)

Unmanned Aircraft System: 1. An unmanned aircraft and associated elements (including communications links and the components that control the unmanned aircraft) that are required for the pilot-in-command to operate safely and efficiently in the national airspace system. (FAA MRA) 2. An unmanned aircraft and its associated elements related to safe operations, which may include control stations (ground-, ship-, or air-based), control links, support equipment, payloads, Flight Termination Systems (FTS), and launch/recovery equipment. (FAA 8900.1)

V

Visual Line-of-Sight (VLOS): Unaided (corrective lenses and/or sunglasses exempted) visual contact between a pilot-in-command or a visual observer and a UAS sufficient to maintain safe operational control of the aircraft, know its location, and be able to scan the airspace in which it is operating to see and avoid other air traffic or objects aloft or on the ground. (FAA 8900.1)

List of Acronyms

A

14 CFR	Title 14, Code of Federal Regulations
4D	Four-Dimensional
ABSAA	Airborne Sense and Avoid
AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ADIZ	Air Defense Identification Zone
ADS-B	Automatic Dependent Surveillance–Broadcast
AFI	Air Force Instruction
AFPD	Air Force Policy Directive
AFS	Flight Standards Service
AGC	Office of The Chief Counsel
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AIR	Aircraft Certification Service
ALoS	Acceptable Level of Safety
AMA	Academy of Model Aeronautics
AMOC	Alternative Method of Compliance
ANSP	Air Navigation Service Provider
AR	Army Regulations
ARC	Aviation Rulemaking Committee
ASI	Aviation Safety Inspector
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
ATCAA	Air Traffic Control Assigned Airspace
ATCSCC	Air Traffic Control System Command Center
ATO	Air Traffic Organization
ATS	Air Traffic Service
AVS	Aviation Safety

B

BLOS	Beyond-Line-of-Sight

C

C2	Control and Communications Link
CDTI	Cockpit Display of Traffic Information
CFIT	Controlled Flight Into Terrain
CFR	Code of Federal Regulations
COA	Certificate of Waiver or Authorization
ConOps	Concept of Operations
CRM	Crew Resource Management
CS	Control Station

D

DAA	Detect and Avoid
DCP	Divert/Contingency Point
DHS	Department of Homeland Security
DOC	Department of Commerce
DoD	Department of Defense
DOJ	Department of Justice
DOT	Department of Transportation
DPE	Designated Pilot Examiner
DSA	Detect, Sense, and Avoid System

E

ExCom	UAS Executive Committee
EO	Electro-Optical

F

FAA	Federal Aviation Administration

FAA ARC — FAA Aviation Rulemaking Committee
FAR — Federal Aviation Regulations
FCC — Federal Communications Commission
FHA — Fault Hazard Analysis
FIR — Flight Information Region
FL — Flight Level
FMRA — FAA Modernization and Reform Act of 2012
FOV — Field of View
FOR — Field of Regard
FPV — First Person View
FRZ — Flight Restriction Zone
FSDO — Flight Standards District Office
FSIMS — Flight Standards Information Management System
FTP — Flight Termination Point
FTS — Flight Termination System
FY — Fiscal Year

G

GA — General Aviation
GAO — Government Accountability Office
GBSAA — Ground Based Sense and Avoid
GCS — Ground Control Station
GHz — Gigahertz
GMF — Government Master File
GPS — Global Positioning System
GSE — Ground Support Equipment

H

HFOV — Horizontal Field of View
HQ — Headquarters (FAA)

I

IC — Incident Commander
ICAO ASBUs — ICAO Aviation System Block Upgrades
ICAO — International Civil Aviation Organization
ICAO UASSG — ICAO Unmanned Aircraft Systems Study Group
IFOV — Instantaneous Field of View
IFR — Instrument Flight Rules
IMC — Instrument Meteorological Conditions
IPC X — Joint Planning and Development Office
IR — Infrared
ITU — International Telecommunication Union

J

JPDO — Joint Planning and Development Office

L

LIDAR — Light Detection and Ranging
LLP — Lost Link Point
LOA — Letter of Agreement
LOS — Line-of-Sight

M

MASPS — Minimum Aviation System Performance Standard
MHz — Megahertz
MOPS — Minimum Operational Performance Standards
MSL — Mean Sea Level

N

NAS — National Airspace System
NASA — National Aeronautics and Space Administration
NAVAIRINST — Naval Air Systems Command Instruction
NextGen — Next Generation Air Transportation System
NIJ — National Institute of Justice

NIMS	National Incident Management System
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NPRM	Notice of Proposed Rulemaking
NSTC	National Science and Technology Council
NTIA	National Telecommunications and Information Administration

O

OPA	Optionally Piloted Aircraft
OSED	Operational Services and Environmental Definition

P

PIC	Pilot in Command
POC	Point of Contact
POC	Probability of Containment
POD	Probability of Detection
POS	Probability of Success
PTS	Practical Test Standards
PUM	Proper Use Memorandum

Q

QRT	Quick Reaction Test

R

R&D	Research and Development
R/C	Radio Control
RD&D	Research, Development and Demonstration
RF	Radio Frequency
RM	Risk Management
RNAV	Area Navigation
RPA	Remotely Piloted Aircraft
RPV	Remotely Piloted Vehicle
RTB	Return to Base
RVSM	Reduced Vertical Separation Minimum

S

S&T	Science and Technology
SAA	Sense and Avoid
SARP	Standards and Recommended Practices
SARPs	Standards and Recommended Practices
SFAR	Special Federal Aviation Regulation
SFRA	Special Flight Rules Area
SGI	Special Government Interest
SM	Statute Mile
SMC	SAR Mission Coordinator
SMS	Safety Management System
SPC	Senior Policy Committee
SRM	Safety Risk Management
SRMD	Safety Risk Management Document
SSI	Sensitive Security Information
STA	Special Temporary Authority
sUAS	Small Unmanned Aircraft Systems

T

TAS	Traffic Advisory Systems
TC	Type Certificate
TCAS	Traffic Alert and Collision Avoidance System
TCRG	Technical Community Representative Group
TOR	Terms of Reference
TSO	Technical Standard Order

U

UA	Unmanned Aircraft
UAR	UAS Automation Roadmap
UAS	Unmanned Aircraft System

UAS-AI	Unmanned Aircraft Systems – Airspace Integration
UAV	Unmanned Aerial Vehicle
USC	United States Code
USCBP	U.S. Customs and Border Protection
USCG	U.S. Coast Guard

V

VFOV	Vertical Field of View
VFR	Visual Flight Rules
VLOS	Visual Line-of-Sight
VMC	Visual Meteorological Conditions
VO	Visual Observer

W

WRC	World Radiocommunications Conference

Introduction:
Unmanned Aerial System (UAS) Search and Rescue Addendum (Version 2.0)

Background and History

UAVs evolved from very basic aircraft with rudimentary radio control and stabilization systems to sophisticated autonomous vehicles. Accelerating improvements in miniaturized electronics have resulted in rapid development in the last two decades. UAV technology has not only benefited from expensive defense programs, but also the efforts of model-aircraft hobbyists and academia.

The earliest unmanned systems were developed as flying targets or guided weapons during World War I, such as the Sopwith AT (Aerial Target) (Figure I-1), Ruston Proctor Aerial Target, and the Hewitt-Sperry Automatic Airplane ("flying bomb") (Figure I-2).

Development continued after the war, and accelerated during World War II, the V-1 bomb being the most famous example (Figure I-3).

Figure I-1: Sopwith AT "Aerial Target" (1917)

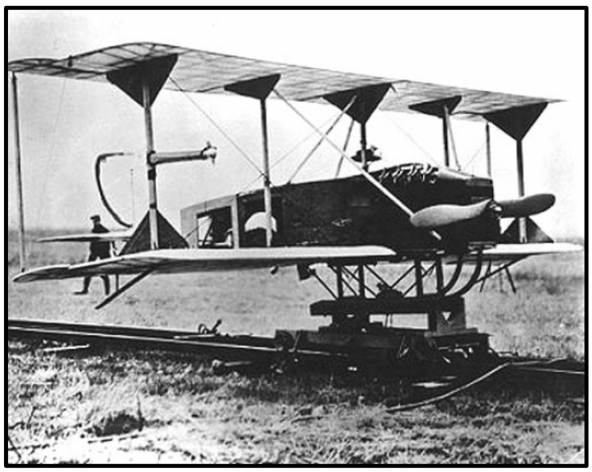

Figure I-2: Hewitt-Sperry Automatic Airplane (1917)

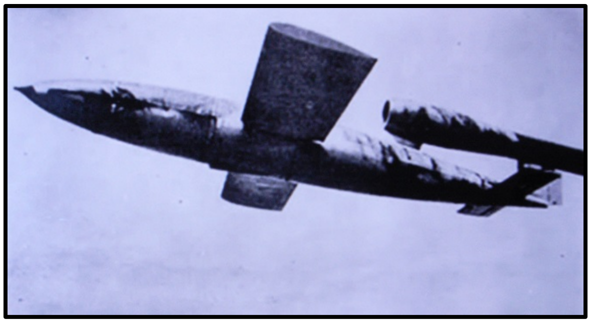

Figure I-3: German V-1 Bomb – “Doodlebugs” (1944)

Edward M. Sorensen received a patent in 1940 for a ground terminal which enabled remote-control based on instruments instead of visual observation of the aircraft. The Cold War saw the first use of UAVs for reconnaissance, such as the Aerojet-General SD-2 Overseer (Figure I-4) and Ryan Model 147 Lightning Bug, and reconnaissance UAVs were used on many occasions during the Viet Nam conflict.

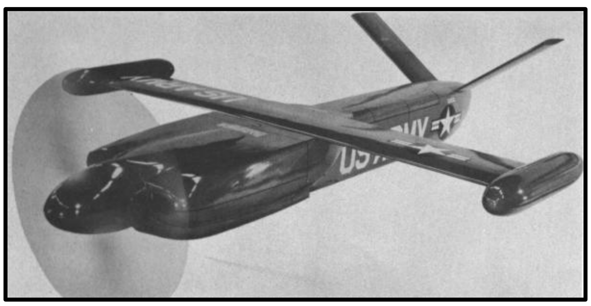

Figure I-4: Aerojet General SD-2/MQM-58 Overseer. The Overseer was a propeller-driven aircraft, launched by two solid-fueled rocket boosters from a zero-length launcher mounted on a V-260/USD truck. It was landed by a parachute recovery system. Equipment included an AN/AAD-2 infrared sensor, and data transmission system. (Photo: Ordway/Wakeford)[1]

The first successful radio-control hobby aircraft was developed in the 1930s by Bill and Walt Good. Hobby aircraft slowly evolved with developments in electronics, from binary, relay controlled systems to transistor-based, proportional servo controls. By the 1970s, multi-channel, proportional control was possible using a handheld radio. Model aircraft of this era commonly used small internal combustion engines. Around the turn of the century, advances in battery technology and brushless DC motors enabled increased power and endurance from electric propulsion. Further advances in microelectronics and computing enabled complex control mixing and radio systems that were much less prone to interference.

Battlefield use of UAVs began with the conflict between Israel and Syria in 1982. The Israelis coordinated the use of UAVs alongside manned aircraft as decoys, jammers, and reconnaissance to great success. The Gulf Wars further expanded the use of UAVs for intelligence, as well as a means of munitions delivery. By 2015 the DoD operated dozens of different models ranging in size from handheld to passenger jets (Figure I-5).

Figure I-5: (04/24/14) MQ-9 Reaper, Hurlburt Field, Florida. (Photo: Staff Sgt. John Bainter/USAF)

In the last decade, developments in autonomous model aircraft have been no less remarkable. Inexpensive, tiny accelerometers, gyroscopes, and GPS receivers have enabled automatic control and stabilization on airframes weighing no more than a few ounces. Hobbyists have designed, programmed, and built fully-functioning autopilot systems that can be purchased for a few hundred dollars and enable complex, automated flight operations. Miniature cameras, radios, and

[1] Information obtained from: Frederick I. Ordway III, Ronald C. Wakeford, *International Missile and Spacecraft Guide* (New York: McGraw-Hill, 1960).

video equipment have created rapid growth in consumer systems which can transmit live video back to the operator. This has enabled small hobby and electronics manufacturers to rapidly develop UAVs with similar capabilities to expensive, military airframes a generation prior.

UAS

Whether large or small, the increasing capability of unmanned aircraft has also increased the requirements for their control stations. From a small handheld remote with joysticks to a control van with computers, radios, and instruments, what is on the ground matters as much, if not more than what is airborne.

Unlike a manned aircraft, an unmanned aircraft is dependent on its command and control communication links to fly safely. Any aircraft must have a means for the pilot to observe its location and orientation, and for pilot control. This may be as simple as visual observation from the ground and a multi-channel handheld remote control, or a fully-enclosed ground control station, multiple line-of-sight and satellite radio links, and complex aircraft sensors and computers.

It is for this reason that these devices are now referred to as Unmanned Aircraft Systems (UAS); it is the entire system which must be evaluated, coordinated, operated, and funded.

UAS for SAR

There are numerous domestic UAS users which have or are developing UAS for SAR, including, but not limited to:

- Department of Defense;
- Department of Homeland Security:
  - Customs and Border Protection; and
  - U.S. Coast Guard (Figure I-6).
- Department of the Interior:
  - National Park Service.
- National Aeronautical and Space Administration;
- National Oceanographic and Atmospheric Administration;
- State, Tribal, Territorial/Insular Area, and local SAR authorities;
- Volunteer SAR UAS providers; and
- Various educational, science, and public agencies.

Figure I-6: (08/12/12) ScanEagle Launch. Petty Officer 3rd Class John Cartwright, a Coast Guard Cutter STRATTON crewmember, releases the Unmanned Aircraft System ScanEagle during a demonstration. (Photo: Petty Officer 2nd Class Luke Clayton/USCG).

In addition, UAS are being developed and employed for SAR by agencies in other nations (e.g., West Midland Fire Service in the United Kingdom and the Royal Canadian Mounted Police in Canada).

U.S. Regulatory Environment

UAS must share the airspace with a wide array of air traffic, from low-altitude helicopters, gliders, and general aviation (GA) aircraft, to high altitude balloons, and passenger and military aircraft, operating from major airports to small rural fields in a non-conflicting manner. Regulatory, safety, privacy, and public use issues, among others, continue to challenge efforts to successfully integrate UAS into the U.S. National Airspace System (NAS). This problem is exacerbated by the complexity of the NAS and the dramatic increase in traffic density over recent years. In 2012, Congress passed the *FAA Modernization and Reform Act*, which set deadlines and directed the FAA to create a comprehensive plan to integrate UAS into the NAS, establish FAA test sites, expedite the public-use waiver process, and exclude "model aircraft" flown for hobby or recreational use.

Since 2014, the FAA has established six test sites throughout the U.S. for UAS development and testing by commercial and academic interests, in North Dakota, New York, Virginia, Texas, Alaska, and Nevada. (http://www.faa.gov/uas/legislative_programs/test_sites/) (Figure I-7). UAS testing and research at other locations may be coordinated through these FAA designated test sites. In addition, the FAA continues to issue Exemptions and Special Airworthiness Certificates to commercial UAS operators. Numerous local police and sheriff departments, universities, and non-military public agencies now operate UAS under a Certificate of Authorization (COA), and the FAA can now provide emergency activation of existing COAs for expanded operations in exigent circumstances.

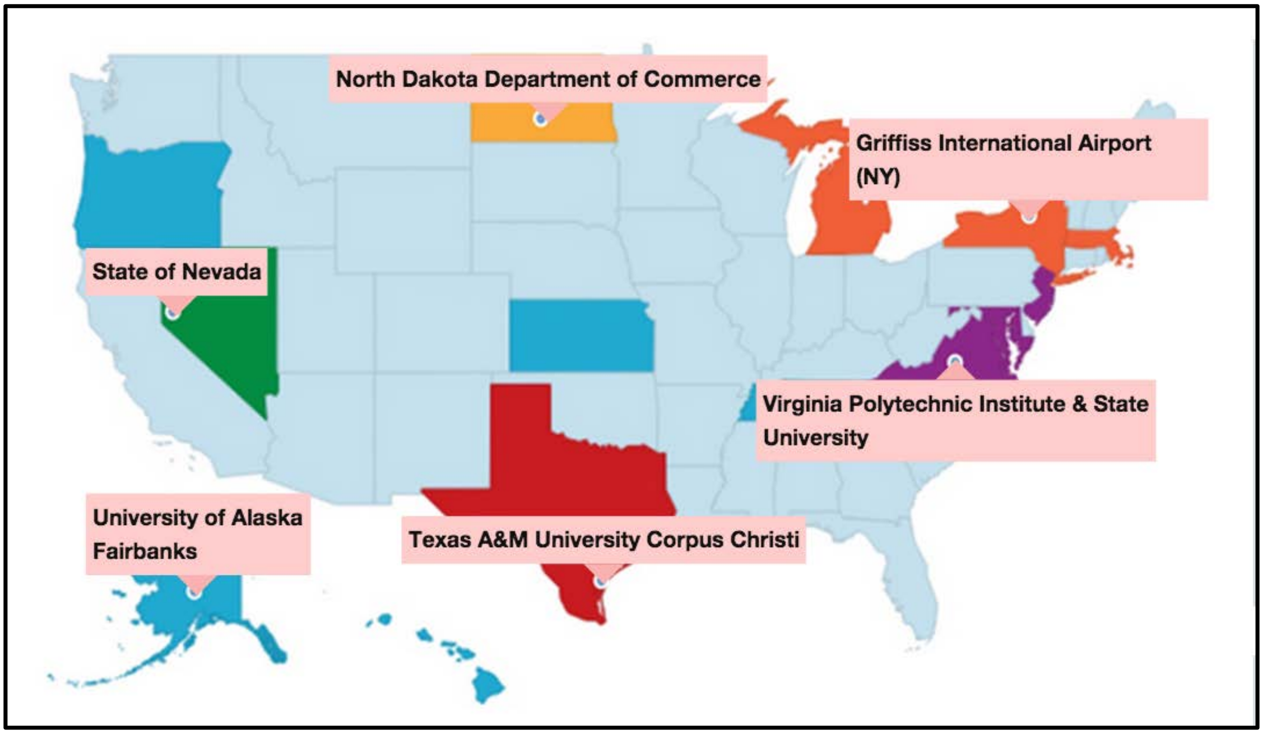

Figure I-7: FAA UAS Test Sites

In February 2015, the FAA issued a Notice of Proposed Rulemaking for Small Unmanned Aircraft, defined in the FAA Modernization and Reform Act as those weighing less than 55 pounds, for civil operations. These regulations will affect civil UAS operations, but similar safety and certification standards can be expected to apply to public UAS operations in the future.

(Note: Appendix A provides additional guidance concerning various UAS regulations, directives and policies.)

Purpose of this Addendum

Much has been written concerning the use of UAS for a wide variety of applications. For the NSARC, our goal is to provide general information concerning the use of UAS for the management and conduct of SAR operations. In addition, NSARC has strived to create a UAS Addendum that would be of benefit for any SAR authority that is either contemplating the use of SAR or is currently using UAS for SAR operations.

(Note: Appendix B is a bibliography provided for additional information.)

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Part 1: UAS Airspace Integration

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Section 1-1: National Airspace System (NAS)

This section provides a brief overview of the NAS and is largely derived from the *Pilot's Handbook of Aeronautical Knowledge* (FAA-H-8083-25A).

UAS Integration

Introducing UAS into the NAS is challenging for both the FAA and the aviation community. UAS must be integrated into a NAS that is evolving from ground-based navigation aids to a Global Positioning System (GPS)-based system in the Next Generation Air Transportation System (NextGen). Safe integration of UAS involves gaining a better understanding of operational issues, such as training requirements, operational specifications, system equipage, and technology considerations.

Instrument and Visual Flight Rules

An important distinction regarding NAS aircraft operations is the use of Instrument Flight Rules (IFR) versus Visual Flight Rules (VFR). Under IFR operations, air traffic control (ATC) provides separation services and sequencing to ensure safety of flight. This enables flight in poor weather and limited visibility, but is not limited to such weather. IFR procedures are commonly used even in clear weather, especially by large transport aircraft.

By comparison, VFR requires the pilot to maintain separation from other air traffic visually from the cockpit, under the principle of "see-and-avoid," following right-of-way rules based on relative position and type of aircraft. VFR is commonly used by general aviation (GA) aircraft and helicopter operations, especially at low altitudes.

IFR flight requires certain equipment (e.g., such as a radar transponder, communications radio, and navigation equipment), which allows for flight without visual references and communication with ATC facilities. Larger UAS are often similarly equipped for IFR flight.

IFR and VFR should not be confused with Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC). IMC and VMC describe the weather conditions under which IFR flight is required and VFR flight is permitted. An IFR flight may be conducted under VMC. A VFR flight may encounter IMC; the pilot must then either obtain an IFR clearance to proceed, attempt to regain VMC, or declare an emergency and seek ATC assistance to safely terminate the flight.

Navigational Charts

In addition to topographical or cultural maps needed for search planning, UAS operations may require the use of FAA aeronautical charts in order to fly safely and coordinate with other aircraft and ATC. These charts depict airports, airspace, navigation and communications frequencies, and other data pertinent to safe flight operations. The FAA provides a Chart User Guide at:

http://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/aero_guide/

Airspace Classifications

The Federal Government, through the FAA, exercises authority over all airspace within the U.S. territorial boundaries. Airspace, as depicted on aeronautical charts, is delineated and classified in various ways to provide control, separation, security, and safety of flight (Figures 1-1-1 and 1-1-2). The following is a brief description of the various types of airspace in the U.S., and is by no means comprehensive. More specific information can be found in the Federal Aviation Regulations and the *Aeronautical Information Manual*, commonly referred together as the FAR/AIM.

http://www.faa.gov/air_traffic/publications/

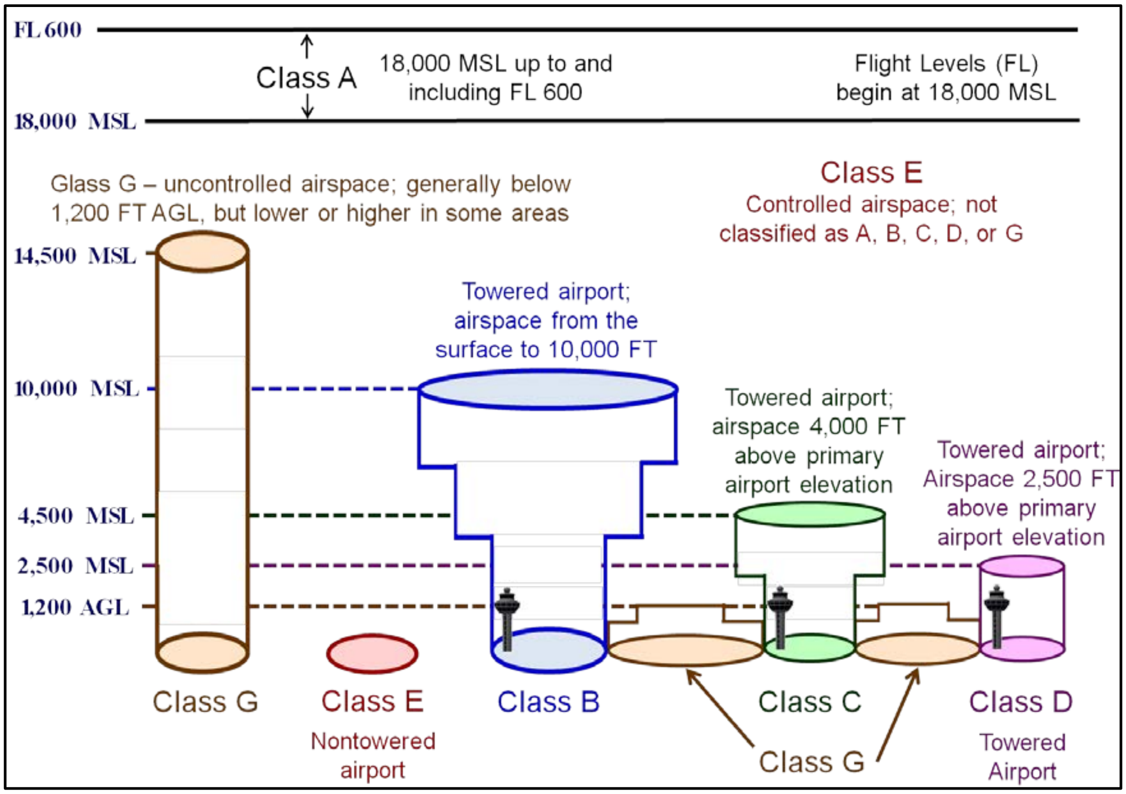


Figure 1-1-1: Airspace Classification (Source: FAA)

	Class A	Class B	Class C	Class D	Class E	Class G
Entry Requirements	ATO clearance	ATO clearance	Prior two-way communications	Prior two-way communications	Prior two-way communications	Prior two-way communications
Minimum Pilot Qualifications	Instrument rating	Private or Student certification – local restrictions apply	Student certificate	Student certificate	Student certificate	Student certificate
Two-Way Radio Communications	Yes	Yes	Yes	Yes	Yes, under IFR flight plan	Yes[1]
Special VFR Allowed	No	Yes	Yes	Yes	Yes	N/A
VFR Visibility Minimum	N/A	3 statute miles	3 statute miles	3 statute miles	3 statute miles	1 statute mile[3]
VFR Minimum Distance from Clouds	N/A	Clear of clouds	500 FT below; 1,000 FT above; 2,000 FT horizontal	500 FT below; 1,000 FT above; 2,000 FT horizontal	500 FT below;[2] 1,000 FT above; 2,000 FT horizontal	Clear of clouds[3]
VFR Aircraft Separation	N/A	All	IFR aircraft	Runway operations	None	None
Traffic Advisories	Yes	Yes	Yes	Workload permitting	Workload permitting	Workload permitting
Airport Application	N/A	• Radar • Instrument approaches • Weather • Control tower • High Density	• Radar • Instrument approaches • Weather • Control tower	• Instrument approaches • Weather • Control tower	• Instrument approaches • Weather	• Control tower

[1] Exception: temporary tower or control tower present
[2] True only below 10,000 feet
[3] True only during day at or below 1,200 feet AGL

Figure 1-1-2: Airspace Requirements (Source: FAA)

Class A Airspace

Class A airspace is generally defined as airspace from 18,000 feet Mean Sea Level (MSL) up to and including Flight Level (FL) 600 (FL 600 = approximately 60,000 feet), including the airspace overlying the waters within 12 nautical miles (NM) of the coast of the 48 contiguous States and Alaska. Unless otherwise authorized, all persons must operate their aircraft under IFR.

Class A airspace is not depicted on VFR Sectional Charts.

Class B Airspace

Class B airspace is generally defined as airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of airport operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored and consists of a surface area and two or more layers (some Class B airspace areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. An ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace. The cloud clearance requirement for VFR operations is “clear of clouds.”

Class B airspace is depicted with a transparent blue line (Figure 1-1-4)

Class C Airspace

Class C airspace is generally defined as airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and that have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C area is individually tailored, the airspace usually consists of a surface area with a five NM radius, a circle with a 10 NM radius that extends no lower than 1,200 feet to 4,000 feet above the airport elevation, and an outer area that is not charted. Each person must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while within the airspace. In addition, a Mode C transponder may be required for operations in Class C airspace. VFR aircraft are only separated from IFR aircraft within the airspace.

Class C airspace is depicted with a transparent magenta line (Figure 1-1-3).

Figure 1-1-3: Class C Airspace

Class D Airspace

Class D airspace is generally defined as airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored and when instrument procedures are published, the airspace will normally be designed to contain the procedures. Arrival extensions for instrument approach procedures may be Class D or Class E airspace. Unless otherwise authorized, each aircraft must establish two-way radio communication with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain communication while in the airspace. No separation services are provided to VFR aircraft.

Class D airspace is depicted with a dashed blue line. (Figure 1-1-4.)

Class E Airspace

Generally, if the airspace is not Class A, B, C, or D, and it is controlled, it is designated Class E airspace. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. When designated as a surface area, the airspace will be configured to contain all instrument procedures. Also in this class are Federal airways, airspace beginning at either 700 or 1,200 feet AGL used to transition to and from the terminal or en route environment, en route domestic, and offshore airspace areas designated below 18,000 feet MSL. Unless designated at a lower altitude, Class E airspace begins at 14,500 feet MSL over the U.S., including that airspace overlying the waters within 12 NM of the coast of the 48 contiguous States and Alaska, up to, but not including 18,000 feet MSL, and the airspace above FL 600 (approximately 60,000 feet). In much of the U.S., Class E airspace begins at 1,200 feet AGL. No separation services are provided to VFR aircraft.

Class E airspace is depicted variously by dashed magenta lines (for Class E to the surface), magenta (700 feet AGL) or blue faded (1,200 feet AGL) lines, or blue jagged lines (other), depending on the floor of the airspace (Figure 1-1-4).

Class G Airspace

Class G airspace is not designated as Class A, B, C, D or E and is uncontrolled airspace, generally below 1,200 feet AGL, but lower or higher in some areas.

Class G airspace is not depicted on VFR charts.

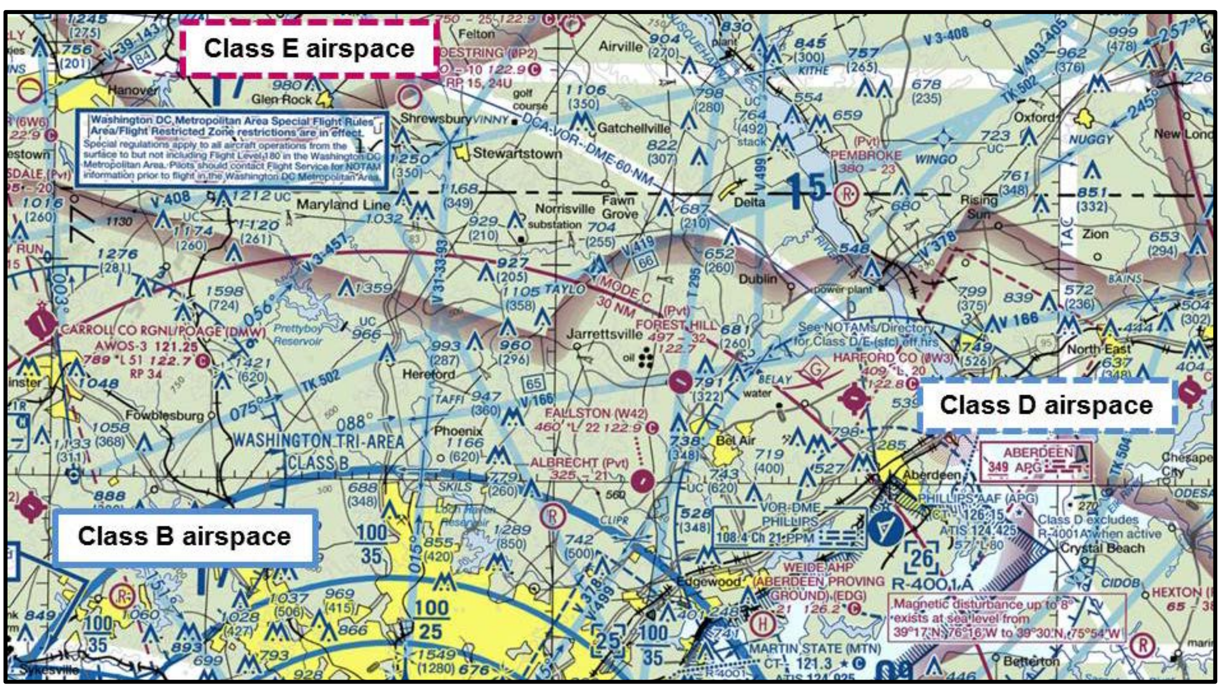


Figure 1-1-4: Aeronautical Chart with Airspace Classifications

Special Use Airspace

Special use airspace or special area of operation (SAO) is the designation for airspace in which certain activities must be confined, or where limitations may be imposed on aircraft operations that are not part of those activities. Certain special use airspace areas can create limitations on the mixed use of airspace. Special use airspace usually consists of:

- Prohibited areas;
- Restricted areas;
- Warning areas;
- Military operation areas (MOAs);
- Alert areas; and
- Controlled firing areas (CFAs).

Prohibited Areas

Prohibited areas contain airspace of defined dimensions within which the flight of aircraft is prohibited (Figure 1-1-5). Such areas are established for security or other reasons associated with the national welfare. These areas are published in the Federal Register and are depicted on aeronautical charts. The area is charted as a "P" followed by a number (e.g., P-49).

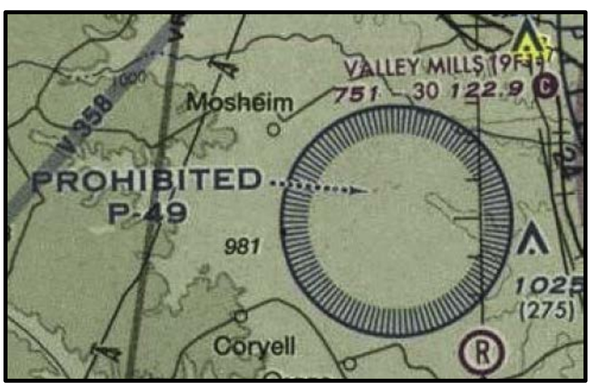


Figure 1-1-5: Prohibited Area

Examples of prohibited areas include Camp David and the National Mall in Washington, D.C., where the White House and the Congressional buildings are located.

Restricted Areas

Restricted areas are areas where operations are hazardous to non-participating aircraft and contain airspace within which the flight of aircraft, while not wholly prohibited, is subject to restrictions. Activities within these areas must be confined because of their nature, or limitations may be imposed upon aircraft operations that are not a part of those activities, or both. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft (e.g., artillery firing, aerial gunnery, or guided missiles). IFR flights may be authorized to transit the airspace and are routed accordingly. Penetration of restricted areas without authorization from the using or controlling agency may be extremely hazardous to the aircraft and its occupants. ATC facilities apply the following procedures when aircraft are operating on an IFR clearance (including those cleared by ATC to maintain VFR on top) via a route which lies within joint-use restricted airspace:

1. If the restricted area is not active and has been released to the FAA, the ATC facility allows the aircraft to operate in the restricted airspace without issuing specific clearance for it to do so.
2. If the restricted area is active and has not been released to the FAA, the ATC facility issues a clearance which ensures the aircraft avoids the restricted airspace.

Restricted areas are charted with an "R" followed by a number (e.g., R-4401) and are depicted on the en route chart appropriate for use at the altitude or FL being flown (Figure 1-1-6). Restricted area information can be obtained on the back of the chart.

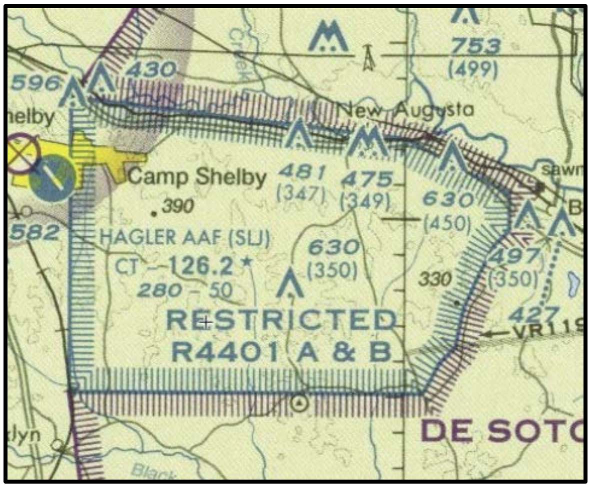


Figure 1-1-6: Restricted Area

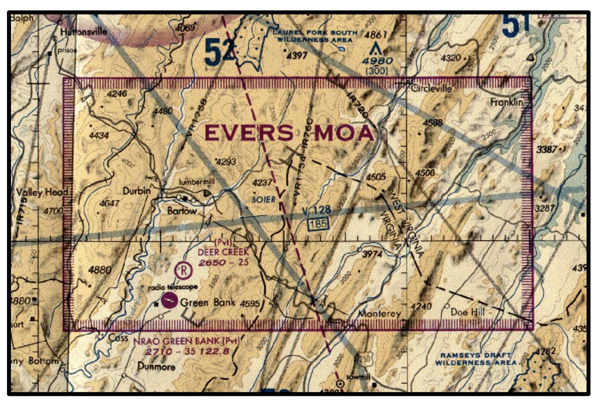
Warning Areas

Warning areas are similar in nature to restricted areas; however, the U.S. government does not have sole jurisdiction over the airspace. A warning area is airspace of defined dimensions, extending from 12 NM outward from the U.S. coast, containing activity that may be hazardous to nonparticipating aircraft. The purpose of such areas is to warn non-participating pilots of the potential danger. A warning area may be located over domestic or international waters or both. The airspace is designated with a "W" followed by a number (e.g., W-497B) (Figure 1-1-7).

Figure 1-1-7: Warning Area

Military Operation Areas (MOAs)

MOAs consist of airspace with defined vertical and lateral limits established for the purpose of separating certain military training activities from IFR traffic. Whenever an MOA is being used, non-participating IFR traffic may be cleared through an MOA if IFR separation can be provided by ATC. Otherwise, ATC reroutes or restricts non-participating IFR traffic. MOAs are depicted on sectional, VFR terminal area, and en route low altitude charts and are not numbered (e.g., "Evers MOA"). However, the MOA is also further defined on the back of the sectional charts with times of operation, altitudes affected, and the controlling agency (Figures 1-1-8 and 1-1-9).



Figures 1-1-8 and 1-1-9: Military Operation Areas

Alert Areas

Alert areas are depicted on aeronautical charts with an "A" followed by a number (e.g., A-211) to inform non-participating pilots of areas that may contain a high volume of pilot training or an unusual type of aerial activity. Pilots should exercise caution in alert areas. All activity within an alert area shall be conducted in accordance with regulations, without waiver, and pilots of participating aircraft, as well as pilots transiting the area, shall be equally responsible for collision avoidance (Figure 1-1-10).

Figure 1-1-10: Alert Area

Controlled Firing Areas (CFAs)

CFAs contain activities, which, if not conducted in a controlled environment, could be hazardous to nonparticipating aircraft. The difference between CFAs and other special use airspace is that activities must be suspended when a spotter aircraft, radar, or ground lookout position indicates an aircraft might be approaching the area. There is no need to chart CFAs since they do not cause a nonparticipating aircraft to change its flight path.

Special Flight Rules Areas

Special Flight Rules Areas (SFRAs) are described in Federal Aviation Regulations Part 93 for certain geographic areas where additional restrictions or special flying rules are implemented for the purpose of traffic management, safety, or security. Notable areas with SFRAs are Los Angeles, CA; Washington, DC; and New York, NY. In addition, within the Washington SFRA is a Flight Restriction Zone (FRZ) for which there are additional restrictions and operational requirements, and within which UAS operations are currently prohibited. See Federal Aviation Regulations Part 93 and applicable Notices to Airmen (NOTAMS) for details.

Temporary Flight Restrictions (TFRs)

A flight data center (FDC) Notice to Airmen (NOTAM) is issued to designate a TFR. The NOTAM begins with the phrase “FLIGHT RESTRICTIONS” followed by the location of the temporary restriction, effective time period, area defined in statute miles, and altitudes affected. The NOTAM also contains the FAA coordination facility and telephone number, the reason for the restriction, and any other information deemed appropriate. The pilot should check the NOTAMs as part of flight planning.

Some of the purposes for establishing a TFR include:

- Protecting persons and property in the air or on the surface from an existing or imminent hazard;
- Providing a safe environment for the operation of disaster relief aircraft;
- Preventing unsafe congestion of sightseeing aircraft above an incident or event, which may generate a high degree of public interest;
- Protecting declared national disasters for humanitarian reasons in the State of Hawaii;
- Protecting the President, Vice President, or other public figures; and
- Providing a safe environment for space agency operations.

Since the events of September 11, 2001, the use of TFRs has become much more common. There have been a number of incidents of aircraft incursions into TFRs, which have resulted in pilots undergoing security investigations and certificate suspensions. It is a pilot’s responsibility to be aware of TFRs in their proposed area of flight. One way to check is to visit the FAA website, www.tfr.faa.gov, and verify that there is not a TFR in the area (Figure 1-1-11).

An SMC may request a TFR over a search area, in coordination with ATC. This can be used to keep non-participating aircraft out of the search area, as well as to ensure safety of flight for a UAS operation in the search area.

(Note: The National SAR Supplement, Coast Guard Addendum, Land SAR Addendum, CISAR Addendum and the FAA Airspace Management Plan for Disasters provide additional information concerning the management of aircraft in the conduct of SAR operations.)

Regardless of size, the responsibility to fly safely applies equally to manned and unmanned aircraft operations.

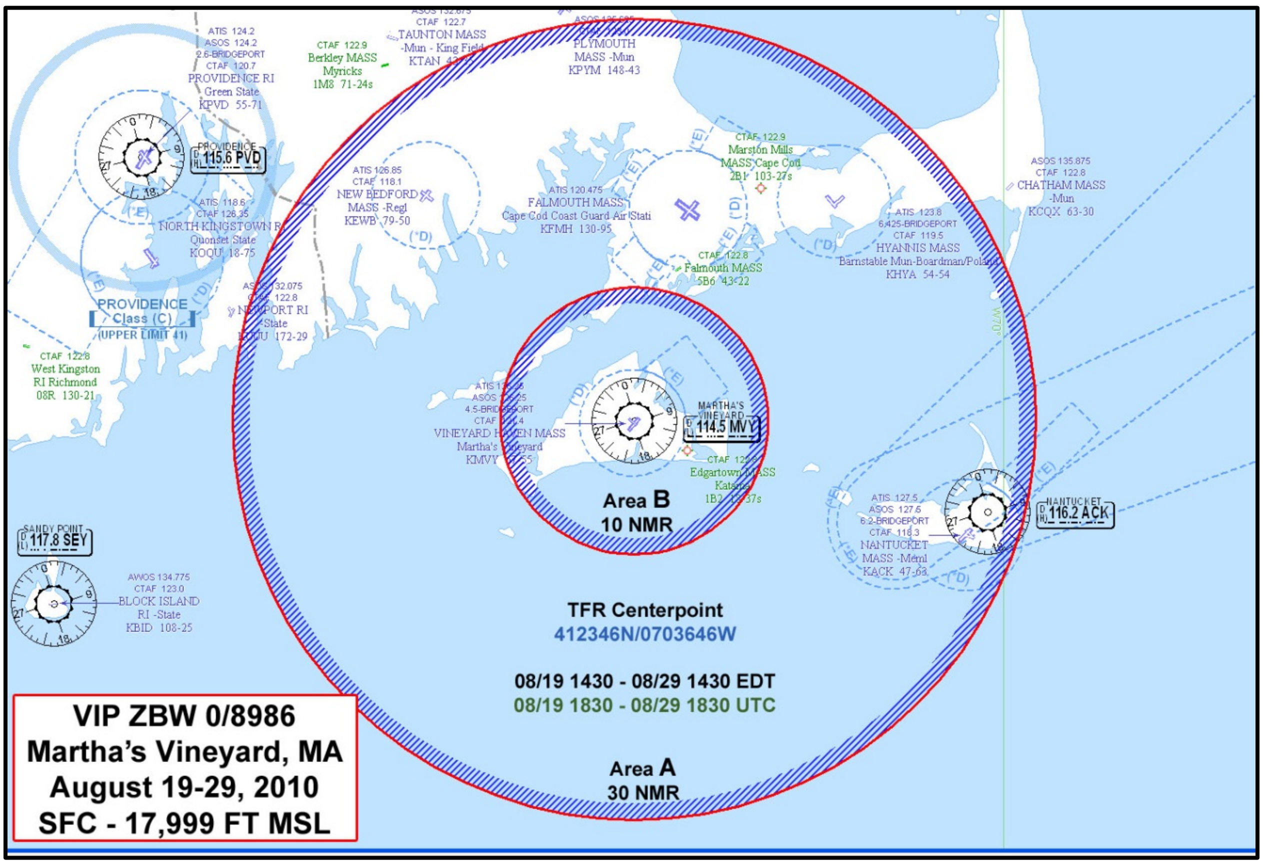


Figure 1-1-11: Temporary Flight Restriction for Presidential Visit

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Section 1-2: FAA UAS Policy

FAA Authorization

FAA Policy

Applicability and Approval Process Criteria

Coordination and Approval

Additional Information

The primary references for this section are FAA Order 8900.1 Flight Standards Information Management System, Volume 16, Unmanned Aircraft Systems, (www.fsims.faa.gov) and FAA Order N JO 7210.889, Unmanned Aircraft Operations in the National Airspace System (NAS). Both should be consulted for current and detailed regulations.

FAA Authorization

There are currently three ways to get FAA authorization to operate a UAS in the NAS for other than "hobby or recreational use:"

1. Public operators must obtain a Certificate of Authorization or Waiver (COA).
2. Civil (private-sector) operators must obtain either a:
    a. Special Airworthiness Certificate (typically for research and development (R&D), training, and flight demonstrations); or an
    b. Exemption under Section 333 of the *FAA Modernization and Reform Act* for "low risk" civil operations.

When a Section 333 exemption is granted, a "Blanket COA" is automatically provided for specifically limited operations. Otherwise, the operator must obtain a Standard COA. Blanket COAs permit operations:

- 5 NM away from an airport with an operating control tower;
- 3 NM from an uncontrolled airport with an instrument approach procedure;
- 2 NM from all other airports, heliports, and seaports; and
- At or below 200 feet AGL.

Hobbyists are not required to obtain a COA, but are restricted to operations "strictly for hobby or recreational use," which precludes SAR.

FAA Policy

Federal law identifies UAS as "aircraft" flown by a "pilot," regardless of where the pilot is located. Aircraft and pilots must demonstrate compliance with applicable sections of 14 C.F.R. to operate in the NAS. However, UAS inherently cannot comply with certain sections of 14 C.F.R. For instance, the absence of an onboard pilot means that the "see-and-avoid" regulations of 14 C.F.R. § 91 (§ 91.113) cannot be satisfied. Consequently, to ensure an Acceptable Level of Safety (ALoS), UAS flight operations require an alternative method of compliance (AMOC) or risk control to address their "see-and-avoid" impediments to safety of flight and any problems they may generate for ATC. In the future, permanent and consistent methods of compliance will be required for UAS operations in the NAS without the need for waivers or exemptions.

Applicability and Approval Process Criteria

The applicability and process to be used in UAS operational approval are dependent on whether the proposed UAS operation within the U.S. territorial airspace (the airspace above the contiguous U.S., Alaska, Hawaii, U.S. territories, and U.S. territorial seas) is defined as public or civil. UAS operations outside the U.S. territorial airspace will be classified as either state or civil operations in accordance with international law. A public operation is one that is intrinsically governmental in nature (i.e., Federal, State, and local agencies). Applicants requesting approval of public UAS operations within U.S. territorial airspace will use the COA application process. In contrast, applicants for civil UAS operations will use the Special Airworthiness Certificate or Section 333 Exemption process.

Coordination and Approval

FAA procedures are applicable for all operations in the contiguous U.S., Alaska, Hawaii, U.S. territories, and international airspace in the flight information regions (FIR) delegated to the U.S. where the FAA is the Air Traffic Service (ATS) provider. These procedures do not apply to the territorial airspace of another sovereign country that lies within FIRs delegated to the U.S. where the FAA is the ATS provider, except by agreement with that country, or airspace in FIRs delegated to other countries. All UAS operators and pilots must observe all applicable regulations as detailed in 14 C.F.R.

Some general principles for FAA coordination and approval of UAS operations includes the following:

1. In general, the UAS operator or applicant must request specific authorization to conduct UAS operations in the NAS outside of active restricted and warning areas designated for aviation use, or approved prohibited areas. Airspace inside buildings or structures is not considered to be part of the NAS and is not regulated.
2. FAA processes prescribed do not apply to hobbyists and amateur model aircraft users when operating unmanned systems for sport and recreation. Those individuals should seek guidance under the current edition of Advisory Circular *(AC) 91-57A, Model Aircraft Operating Standards*. AC 91-57A is not to be used as a basis of approval for operation of any other aircraft, including by Federal, State, and local governments, commercial entities, or law enforcement. Up-to-date guidance on model aircraft operations can be found at: http://www.faa.gov/uas/model_aircraft/
3. FAA processes prescribed also do not apply to UAS operations in FAA-controlled international airspace by an agency of, or a contractor to, the Federal Government when those operations are appropriately designated as State aircraft operations and are operated under “due regard” rules and procedures established by the Federal agency responsible for the operation.
4. Oceanic UAS operations contained within warning areas are processed in the same manner as those operations conducted in active restricted and approved prohibited areas; that is, neither specific FAA approval nor observers or chase aircraft are required by the FAA. However, UAS operations

must be approved by the controlling agency of a given warning area, and comply with flight restrictions specific to that airspace.

5. The only public aircraft that can operate via "due regard" are U.S. Government aircraft operating as State aircraft.

The methods of approval include the issuance of a COA for public aircraft operations, or for civil aircraft that have received an FAA airworthiness certificate from AIR. In the case of public aircraft operations, the operating entity applying to conduct the UAS operation must comply with its own processes, policies, and standards in the following areas:

- Pilot certification;
- Crew certification;
- Recent pilot experience (or currency);
- Medical certificates; and
- Airworthiness of public UAS.

(Note: If no established public entity processes, policies, or standards exist, it is highly recommended that the public agency/department comply with the regulations of 14 C.F.R. applicable to civil UAS operations.)

Additional Information

Additional information regarding UAS test sites, COAs, special airworthiness certification, airworthiness, training and etc. may be found at:

http://www.faa.gov/uas/

Federal Aviation Administration
UAS Integration Office, AFS-80
490 L'Enfant Plaza SW, Suite 3200
Washington, D.C. 20024
Phone: 202-385-4835
Fax: 202-385-4651

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Section 1-3: Certificate of Authorization (COA)

COA Process for Public UAS Usage

Applications for COAs are made by the agency which will conduct the UAS operations. Assistance may be provided by one of the regional FAA test sites or experienced UAS operators. In the past, public-use COAs have been issued to Federal Government agencies, public universities, and State and local police departments. The definition of "public use" is contained in law and is determined on a case-by-case basis. Advisory Circular 00-1.1A, *Public Aircraft Operations*, provides information to assist in determining whether an operation qualifies as "public."

Applicants make their request through an online process. After a complete application is submitted, the FAA conducts a comprehensive operational and technical review. If necessary, provisions or limitations may be imposed as part of the approval to ensure the UAS can operate safely with other airspace users. In most cases, FAA will provide a formal response within 60 business days from the time a completed application is submitted.

The COA allows an operator to use a defined block of airspace, and includes special provisions unique to the proposed operation. For instance, a COA may require flying only under VFR and/or only during daylight hours. COAs are usually issued for a specific period, up to two years in many cases.

Most COAs require coordination with an appropriate air traffic control facility and may require a transponder on the UAS to operate in certain types of airspace.

Specific details are outlined at: www.faa.gov/uas/public_operations/

Certificate of Authorization or Waiver Request Portal: ioeaaa.faa.gov

(Note: Classified UAS Operations: Select public UAS operations may be of sufficient national security sensitivity that they are classified. These operations are carried out under the authority of COAs granted by System Operations Security.)

Special Government Interest (SGI) Process for Expedited COA Addenda

The FAA may use an expedited Special Governmental Interest (SGI) process to develop and coordinate addenda to pre-existing COAs for Public operators and, in select cases, civil operators if the following conditions are met:

- The proponent is operating under the authority of an active COA. Blanket COAs may qualify.
- The UAS operations to be authorized must be conducted within a timeframe incompatible with the processing time required for regular COA processes, as determined by FAA Air Traffic Organization's System Operations Security directorate.
- The requested operations must be flown by a public operator or sponsored by a government entity (i.e., the operation is to be flown at the request of, or is specifically supported by a government entity) as determined by the System Operations Security.
- The operations must directly support an active (e.g., not demonstration) homeland security, law enforcement, or emergency operations effort, or some other response, relief, or recovery activity benefiting a critical public good (e.g., restoration of an electrical grid or some other critical infrastructure). The fulfillment of this requirement is determined by System Operations Security in consultation, as needed, with the FAA's interagency partners.

Law Enforcement Organizations

Law enforcement operators have the ability to obtain operational approval using a "defined incident perimeter" within their jurisdiction. This eliminates the need for obtaining a COA addendum for a specific law enforcement mission.

Law enforcement agencies with defined incident perimeters will be permitted to fly UAS with the following restrictions:

- Operations must be conducted within line of sight of the UAS pilot;
- Operations must be limited to below 400 feet AGL;
- All flights must be conducted in VMC;
- All flights must be conducted within the limitations specified in their COA;
- Operations may be permitted in Class C, D, E and G airspace as specified in the COA; and
- Agencies may be permitted to operate within 5 NM of an airport with certain restrictions as specified in the COA.

COA Contents

The agency or organization operating the UAS is responsible for obtaining the COA. The FAA must obtain enough information to assess the proposed operations following current standards and procedures. Because of the dynamic changes in the development of UAS technologies, the applicant is responsible for adequately describing the proposed operations so an appropriate safety assessment can be conducted by the FAA. For this purpose, the following information may be required in a COA application:

- Organizational and operational points of contact;
- Operational description (e.g., method of navigation, see-and-avoid);
- Systems description (e.g., airframe, control station, communications);
- Airframe performance characteristics;
- Airworthiness;
- Contingency procedures (e.g., lost command/control link, lost communications, and emergency);
- Avionics equipment;
- Lighting;
- Frequency spectrum analysis;
- Method of ATC communications;
- Surveillance capability (e.g., electronic and visual);
- System monitoring/recording capability;
- Flight crew qualifications;
- Flight operations description (e.g., flight plan);
- Special circumstances; and
- Reports of past incidents or accidents (for those applicants who have previously held a COA).

While not comprehensive, the following is an overview of the contents and requirements for a COA that directly affect SAR operations. Much of these are designed to mitigate the risks of UAS operations in the vicinity of other aircraft in the NAS by specifying contingency/emergency procedures and aircraft-avoidance measures.

Operating in the Vicinity of an Airport

In many cases, a letter of agreement (LOA) is required for public aircraft operating in the vicinity of airports. For civil aircraft, segregation procedures are incorporated into the operating limitations. UAS operations must not impede, delay, or divert other Class B operations.

Communication Requirements

The operation of communication links to and from the UAS, whether for command/control or payload, and any radiofrequency use for sensors (e.g. sense and avoid radar) falls under the jurisdiction of the National Telecommunications and Information Administration (NTIA) for Federal agencies (e.g., Departments of Homeland Security, Commerce, Interior, NASA, etc.), and the Federal Communications Commission (FCC) for non-Federal agencies such as State, Tribal, Territorial/Insular Area, and local operators (e.g. police, fire and rescue squads). UAS operators shall infer no FAA approval to operate the UAS from NTIA or FCC radiofrequency authorization. Use of the authorized frequencies shall be in accordance with applicable FCC rules and the NTIA Manual of Regulations. Where applicable, the use of authorized frequencies shall be in accordance with the conditions specified in the radiofrequency authorization and any technical and operational parameters specified in the UAS frequency assignment request.

Currently, most communications links for command/control and payload to and from small UAS used for commercial purposes operate with equipment that is license-exempt or unlicensed. The unlicensed equipment operates in three main frequency bands including the 900 MHz, 2.4 GHz, and 5.8GHz bands. There is no requirement for the UAS operator to seek FCC or NTIA authorization to use unlicensed equipment if it complies with FCC 47 C.F.R. § 15 regulations and is unmodified.

(Note: "Unlicensed" does not mean "unauthorized.")

UAS operators must be aware that radiofrequency authorization under FCC's unlicensed Part 15 regulations is on a non-interference basis. The equipment must not cause harmful interference to any station operating in accordance with the Table of Frequency Allocations. UAS operators must accept the risk of receiving harmful interference from stations operating in accordance with FCC rules including other unlicensed transmitting equipment.

To meet FAA regulations, the UAS operator may also need to have two-way communications with air traffic control, as well as any visual observers or chase aircraft being used for detect-and-avoid (DAA). Use of the radiofrequency spectrum for two-way communications or sensors on the UAS that transmit on the radiofrequency spectrum (e.g. DAA radar) also falls under the jurisdiction of NTIA and FCC. The UAS operator shall obtain all radiofrequency authorizations from NTIA and FCC prior to operating on the radiofrequency spectrum.

Lost Link Procedures

In the event of a loss of command-and-control radio link with the UAS, the UAS may be automated to fly to a lost link point (LLP), designed to allow time to reacquire control. At the LLP, the UAS may loiter for a period of time, then proceed to another LLP, autoland, or terminate the flight. LLPs need to account for airspace, airways, other aircraft, terrain, and ground-based obstructions such as tall buildings, towers, and bridges.

Detect-And-Avoid (DAA) Requirements

DAA is a primary FAA concern. The UAS must be able to meet right-of-way requirements relative to other aircraft. The two exceptions are:

- Operating in Class A airspace under IFR and on an instrument flight plan; or
- Operating in an active restricted or warning area or approved prohibited area.

DAA is usually performed by visual observers or a chase aircraft. Daisy-chaining observers may be approved after consideration of risks. Onboard cameras or sensors cannot be relied upon as the sole mitigation for DAA. Other equipment, such as on board radar that transmits on radiofrequency spectrum, must be authorized by NTIA or FCC prior to operating on those frequencies and specially validated by the FAA for UAS use. Traffic Alert and Collision Avoidance Systems (TCAS) have not been validated for this purpose.

Otherwise, risk mitigation may be based on other methods of maintaining flight separation and collision avoidance or “segregation.” This may include using a TFR for airspace or altitude reservation, or the use of surface-based radar capable of providing DAA.

Notice to Airmen (NOTAM) Requirements

The FAA may require that a Distant (D) NOTAM be issued to inform other aircraft that a UAS will be operating. The NOTAM is published online and released by FAA service centers. The NOTAM will inform pilots of the location, altitude, and time that UAS operations will be taking place.

Accident and Incident Investigations and Reporting

All accidents and incidents involving fatalities, injuries, property damage, and flyaway by civil aircraft and those public aircraft subject to 49 C.F.R. § 830 require FAA notification within 24 hours.

Flight over Congested Areas

Routine UAS operations are prohibited over congested areas, except where the level of airworthiness allows, or when specially approved during emergency or national disaster relief situations with acceptable mitigation strategies. “Congested area” is a qualitative term determined on a case-by-case basis.

Flight over Heavily Trafficked Roads or Open-Air Assembly of People

UAS operations must avoid heavily trafficked roads and open-air assemblies of large numbers of people, except where the level of airworthiness allows. If flight in these areas is required, the operator/applicant is required to support proposed mitigations with system safety cases that indicate the operations can be conducted safely.

Night Operations

Night operations may be considered if the operator provides a safety case and sufficient mitigation to avoid collision hazards at night.

(Note: Night is defined as between the end of evening civil twilight and the beginning of morning civil twilight.)

Operations from Nonconventional Airport Locations

In most cases, a nonconventional airport location should be situated no closer than 5 NM from any airport or heliport. The operational areas, including the launch and recovery zones, should be free from obstructions; reasonable efforts should be made to keep operations away from structures.

In-Flight Emergencies

The Pilot in Command (PIC) will notify ATC of any in-flight emergency or aircraft accident as soon as practical.

The PIC will notify ATC of any loss of control link as soon as practical. Loss-of-control link scenarios may be handled by ATC as an emergency.

Additional Requirements

Additional requirements are imposed by the Air Traffic Organization in FAA Order N JO 7210.889 or succeeding orders. Among the requirements which affect SAR operations:

- Pilots/observers must have an appropriate FAA medical certificate or military/agency equivalent.

  (Note: Pilots may not perform concurrent observer duties.)

- Pilots must not conduct concurrent or simultaneous UAS operations in the presence of manned aircraft unless approved segregation procedures are written in a LOA with the affected ATC facility and included in the COA.
- UAS pilots and observers must be responsible for only one UAS at a time.
- UAS operations must not impede, delay, or divert manned operations (e.g., excessive departure/arrival delays).
- All operations must be conducted under VMC, except in Class A airspace.
- In Class D, E, or G airspace, all operations must be conducted during daylight hours unless authorized in the COA.
- Special VFR procedures are not authorized.

Airspace Considerations

Class A Airspace (18,000 to 60,000 feet)

Observers are not normally required in Class A airspace. The UAS is operated under IFR and on an instrument flight plan. Entry and exit from Class A airspace is normally accomplished via restricted airspace or by employing chase aircraft.

Class B Airspace

Class B airspace is comprised of terminal areas with the highest density of manned traffic. UAS operations are currently not authorized in Class B airspace. On a case-by-case basis, the FAA may consider exceptional circumstances.

Class C Airspace

Class C airspace is terminal airspace around busy airports. The UAS must be equipped with a transponder and communications with ATC are required. Requests for operations without this equipment will be considered on a case-by-case basis and may be approved if sufficiently mitigated and a safety case has been established.

Tower-Controlled Airports, Class D, E, and G Airspace

The UAS must meet the requirements of 14 C.F.R. § 91 for Class D, E, and G airspace. Requests for approval will be considered on a case-by-case basis and may be approved if sufficiently mitigated and a safety case has been established. Communications with the tower is required.

Part 2: UAS Capabilities

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Section 2-1: UAS Types

UAS Size (Groups/Tiers)

Fixed Wing UAS

Rotary Wing UAS

Other UAS Airframes

UAS Control Stations

UAS Size (Groups/Tiers)

UAS are classified by size into tiers or groups, depending on the organization. Aside from the sub-55-pound limit for "small UAS" expected in upcoming FAA regulations, there are no regulatory delineations between these sizes. An example of DoD "Groups" is shown in Figures 2-1-1 and 2-1-2; however, each branch of the military uses different classifications for size. Generally, larger airframes can fly at higher altitudes, for longer duration, and have greater payload capacity.

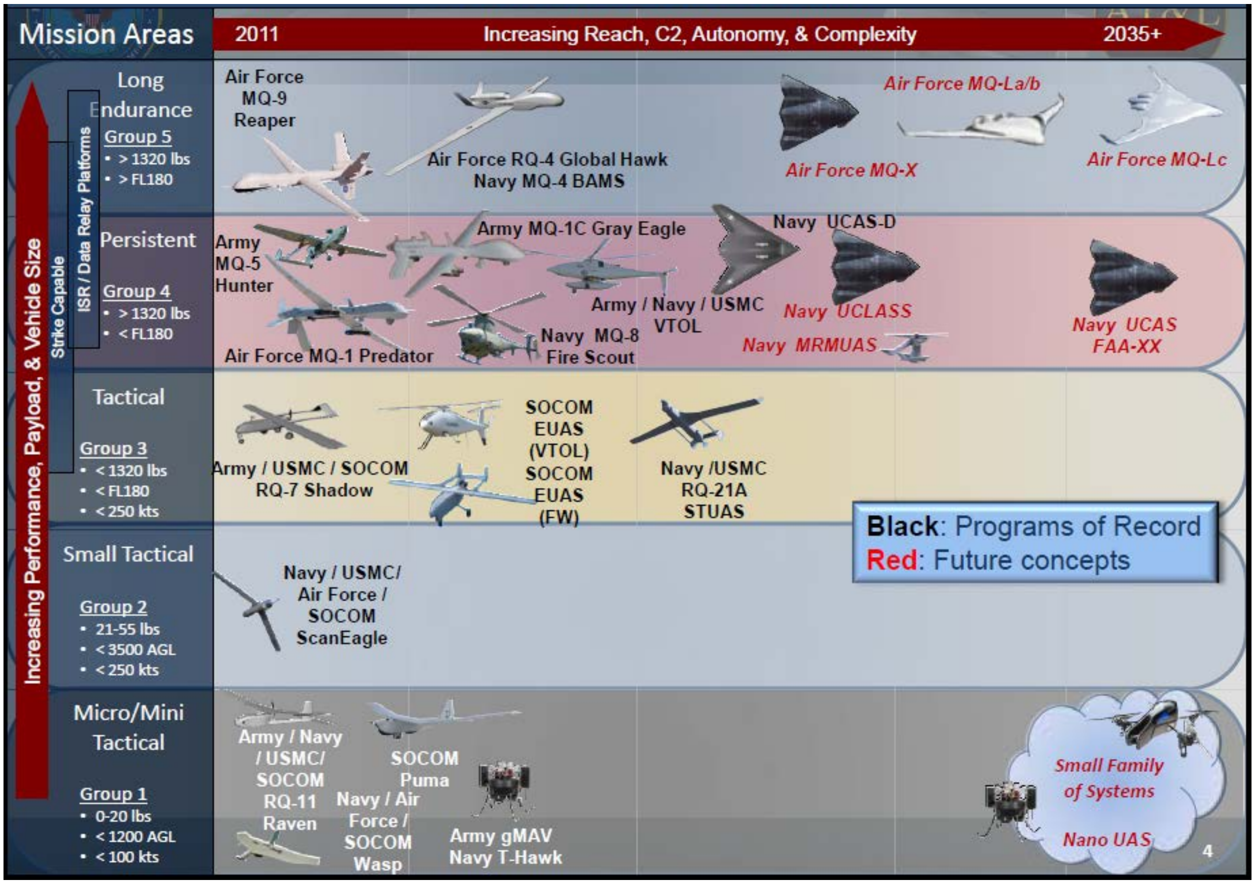

Figure 2-1-1 UAS Comparison Chart (Source: Weatherington, March 3, 2013)

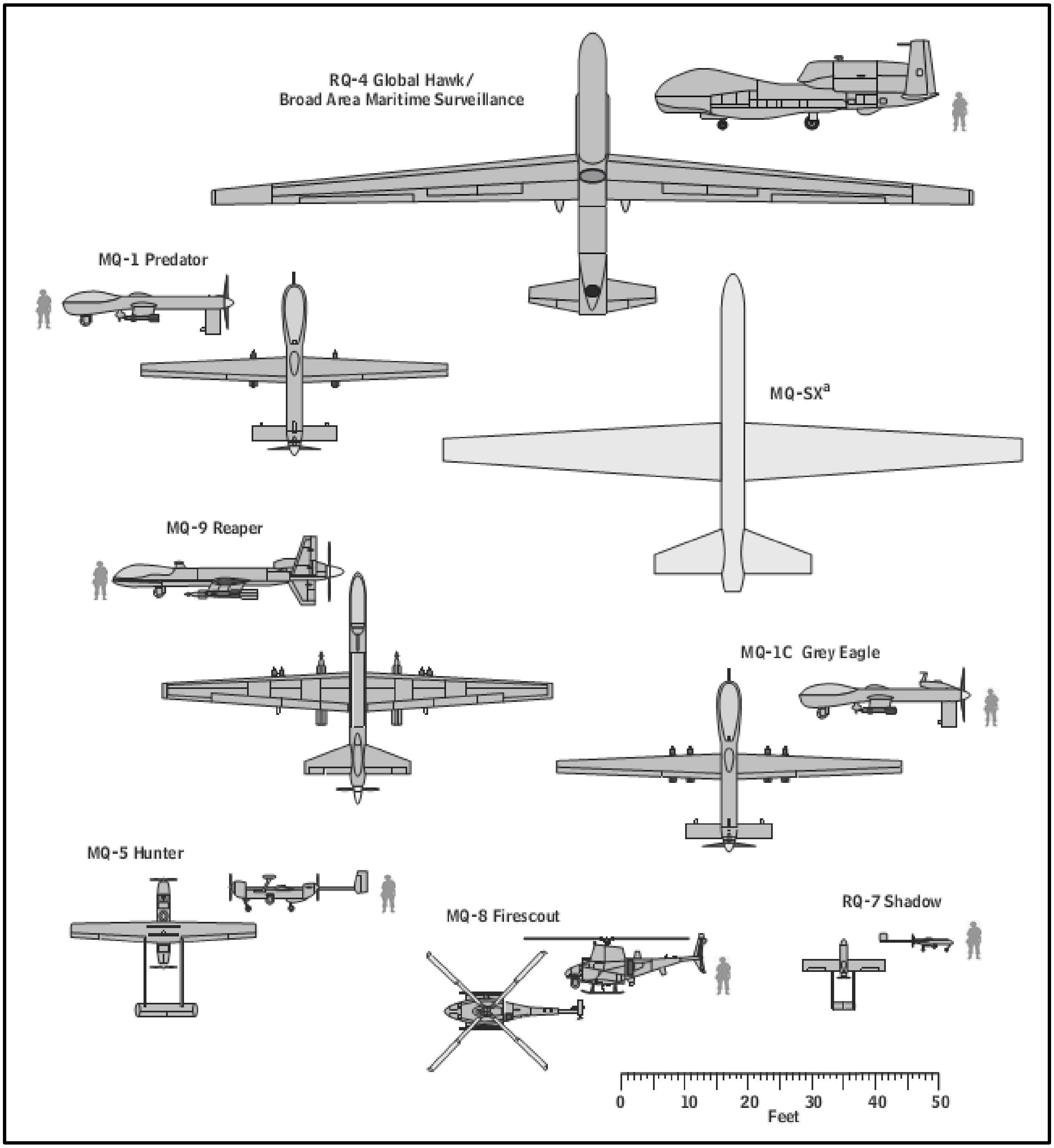

Figure 2-1-2: UAS Types (Source: Congressional Budget Office)

Fixed-Wing UAS

Fixed-wing UAS have the following general characteristics:

- Fixed-wing UAS have solid airfoils and will depend on moving through the air to generate the required lift to remain airborne;
- Require a means of propulsion, which may be an electric or internal combustion engine driving a propeller, or a jet engine;

- Range in size from tiny, hand-held electrics to 737-size jets;
- Will generally have longer range, higher speed, and greater payload capability than a similarly sized rotary-wing UAS;
- Will usually be able to fly at a higher altitude;
- Most are limited by the need to take-off and land laterally, so terrain will affect launch and recovery sites;
- Cannot be used in restricted or congested areas because of their requirement to move through the air to generate lift; and
- Without a stabilized camera, video imagery from a fixed-wing UAS can be difficult to interpret due to the constant airframe motion.

Rotary-Wing UAS

Rotary-wing UAS have the following general characteristics:

- Use a spinning rotor or propellers to generate lift, independent of airframe movement;
- Have the ability to hover – remain motionless – over a target area;
- Hovering requires more power than fixed-wing flight, so rotary-wing platforms will have shorter flight-times, lower top speed, and lower altitude limits than equivalently-sized fixed wing airframes;
- Platforms may be of the familiar main-and-tail-rotor configuration or the increasingly common multi-copter configuration;
- Multi-copters, with three, four, six, eight, or more powered rotors, benefit from mechanical simplicity and redundancy in higher-number configurations;
- Have the ability to launch from, maneuver in, and recover to very restricted terrain; and
- Can provide a steady video picture from a stationary, top-down perspective.

Other UAS Airframes

Other UAS airframes which exist but have not yet been used for SAR are lighter-than-air (LTA) aircraft (e.g., blimps) and tethered or untethered high altitude aircraft. Unmanned LTA systems would be treated much like any other fixed or rotary-wing UAS, with the benefit of prolonged endurance.

Tethered LTA aircraft (e.g., “aerostats”) are commonly employed for early-warning radar and surveillance systems; these are considered separately from UAS in FAA regulations. They provide persistent endurance with minimal fuel use. Because of the tether, aerostats cannot maneuver, but their persistency could be of use in some circumstances.

A more recent development is tethered multi-copters, which receive power from an attached cable. Because of the cable, they are capable of much longer flight times than a battery or fuel-powered aircraft. They are simpler to field and operate than an aerostat, and have some capability to maneuver within the confines of their tether.

UAS Control Stations

UAS can be controlled from a wide variety of ground control stations (GCS). The simplest UAS may use a handheld radio similar to a model aircraft radio, and require continual, active control by the operator. Other small UAS may have more automation and be controlled from a handheld terminal or laptop computer, following pre-programmed flight routines and able to hold position, orbit, or follow waypoints autonomously (Figure 2-1-3).

Figure 2-1-3: Small UAS Control Station

Larger UAS usually employ a full-featured, enclosed ground control station, with work-stations for a pilot and sensor operator, communications and data links, and multiple redundancies (Figure 2-1-4). The level of automation in large UAS is similarly variable, from continual direct control to complex autonomous flight. Some UAS use a separate control station for take-off and landing than for operations at altitude.

Figure 2-1-4: Large UAS Control Station

Section 2-2: UAS Sensor Capabilities

Introduction

UAS and their sensor payloads contribute several capabilities to SAR operations which may not be available through a manned aircraft. In many circumstances a UAS and a manned aircraft are not interchangeable alternatives; a UAS may provide a unique capability that will augment other search assets.

UAS are essentially flying sensors, and in this regard differs from a manned aircraft only in the type of sensor being flown. A manned or unmanned aircraft may provide an "eye-in-the-sky" whether human or camera. But not all manned aircraft have the same sensor and real-time transmission capabilities, and UAS may be the only assets available which can provide the sensor desired, such as thermal imagery or aerial photography. Furthermore, many UAS offer far greater endurance than their manned counterparts, thereby permitting the sensor to saturate a given search area, or maintain continuous observation of a target until other assets can arrive on scene to effect a rescue.

(Note: Use of the radiofrequency spectrum for communications to and from the UAS, for the sensors on the UAS that transmit on the radiofrequency spectrum (e.g., radar), and for payload operations transmitting sensor data, require that the UAS operator

obtain all radiofrequency authorizations from NTIA and FCC prior to operating on the frequencies (see Page 1-20, Communications Requirements).)

Chain of Observation

In any remote sensing application, there exists a complex chain of signals from the target object to recognition by the human brain.

Ambient light reflects on the object in the environment. Transmitted or reflected light, attenuated by the atmosphere, passes through optics to a sensor. The sensor converts received photons to a digital signal, then to a communications system, which passes it over a radio link to a receiver. The signal is then converted into a video display standard and sent to a display. From the display, it passes via the human eyeball to a human observer's brain.

Every link in this chain presents opportunities for signal attenuation, interruption, or noise. Signal processing is accomplished at each stage which can alter the signal to improve or degrade it. Not least, the human observer must be attentive and able to notice the resulting image and distinguish it as something of interest.

Four Functions of Remote Sensing

Remote sensing is divided into four functions, each requiring greater resolution to accomplish:

- *Surveillance*: Wide-area observation of an area, providing general awareness of terrain or environment;
- *Detection*: The ability to distinguish an object from the background (e.g., heat source, white/orange object);
- *Classification or Recognition*: The ability to determine what type of object has been detected (e.g., person, bird, buoy, etc.); and
- *Identification*: The ability to determine the exact identification of the object (e.g., vessel characteristics, car make and model).

The ability of a sensor to accomplish each function is dependent on the size of the target and the optical resolution of the sensor at range. For the conduct of SAR operations, essential functions are detection and recognition. The system must be able to distinguish an object from the background and then determine whether that object is of the type being searched for (e.g., person, vessel, car, etc.). Identification will ultimately be required to determine whether the object spotted is the specific object being searched for (e.g., the specific pleasure craft in distress as opposed to others in the area).

A given UAS and sensors' specifications may limit its ability to be employed for some functions. It may not be able to look closely enough to identify a target, or may not be able to sweep large areas with sufficient resolution to detect an object. A sensor's resolution and field of view will necessarily determine its best operational employment.

For detection, a sensor must be able to distinguish an object from its background. Recognition and identification will be affected by its ability to get a closer look, by optical zoom or platform proximity. Additional factors which may affect a sensor's effectiveness are:

- Background clutter (e.g., waves, vegetation);
- Fog, rain, haze, snow, and humidity;
- Lighting conditions, illumination, and contrast;
- Digital signal processing or compression of the image;
- Lens quality and dimensions;

- Sensor size and specifications; and
- Signal to noise ratio.

Electro-Optical (EO) Sensors

A common expectation from a UAS is live video feed. This video feed is provided by an electro-optical sensor (more commonly known as a video camera). Video cameras may be mounted directly to the airframe or on a stabilized mount. In the latter case, especially on fixed-wing platforms, the feed will be much easier to view and interpret as it will maintain a steady image despite movement of the airframe.

There is wide variety available in the resolution, frame-rate, field of view, and sensitivity of EO sensors; obviously, the sharper the picture, the easier it will be to spot a search target. EO sensors are rapidly evolving, and video cameras are available with over 4000 lines of resolution. However, greater image clarity puts a much greater demand on the UAS data-link to carry the video feed. UAS EO sensors may also have a limited field of view. Low resolution video systems may be useful for spotting large targets (e.g., cars, boats) but will have limited utility in spotting individuals or human remains, especially in a cluttered environment.

Live, low-resolution video may be less useful for detecting a target than for providing the SMC with situational awareness, reconnoitering areas prior to sending search parties, monitoring search efforts, or monitoring a located target prior to recovery. It's also highly prized for public affairs.

Photography

An alternative to live video, which has been used on many ground search operations, is still photography. Photographic cameras can record at much higher resolution than video cameras. A UAS can quickly cover a search area taking multiple photos; the resulting photos are then carefully scanned by a team or processed with software to find actionable targets. Images can be adjusted for contrast, gamma, and other variables to highlight distinctions in the image.

Unlike a video feed or manned aircraft which passes over an area once and must return or linger for more careful observation, each still photograph can be given as much or as little evaluation time as required, with no consequence to airframe resource hours. The aircraft can continue acquiring photos while a separate team processes imagery. Still photos may also be provided to ground/surface search parties for guidance and orientation.

A downside to still photography is the delay between observation and analysis, especially for systems which do not transmit images over the data-link. While this may enable better resolution than a video feed, if the target is moving it can only narrow the search location, and cannot provide real-time guidance to other rescue assets. Some systems with onboard processing are able to apply detection criteria to the photos and send only pre-filtered photos to the Ground Control System (GCS) for further analysis.

Infrared

Infrared (IR) imagery is that portion of the electromagnetic spectrum of longer wavelengths than visible light, often associated with heat and thermal imagery. All objects transmit infrared radiation over a range of wavelengths that is a function of their temperature; the higher the temperature, the shorter the wavelengths. Infrared light may also be reflected; either from the sun or an infrared light source (Figure 2-2-1).

An IR sensor will have a specified range of frequencies over which it is most sensitive, and this will affect what it best detects. Most

IR sensors currently being flown are sensitive in the 3 to 5 micrometer wavelength, or medium-wave IR (MWIR). They will show high contrast on objects like engines and exhaust, but will have lower contrast on humans or animals, especially when the background temperature is close to body temperatures. Between 6 microns and 8 microns wavelengths, most IR radiation is absorbed by water in the atmosphere. There also exist sensors which are sensitive in the low-wave IR (LWIR), from 8 to 14 micrometers. These sensors will be more sensitive in the temperature ranges of human bodies and the environment; however, these wavelengths are attenuated more by the atmosphere, and many sensors of this type are heavy or have less resolution than MWIR sensors.

Figure 2-2-1: (05/06/12) Forward Looking Infrared (FLIR) imagery from a USN helicopter. Alleged drug traffickers arrested by Colombian naval forces. (Photo: USN)

Another factor which affects IR transmission is the material's emissivity (the effectiveness of a material emitting energy as thermal radiation). The lower a material's emissivity, the less IR it will transmit, and the more it will reflect from the background. Human skin has a high emissivity of 98%, but materials such as aluminum and steel have lower emissivity and will be harder to spot unless their temperature differential from the background is very high (e.g., exhaust pipes). Water vapor absorbs some IR wavelengths, so precipitation and atmospheric humidity can greatly reduce IR visibility. IR imagers are of lower resolution than visual sensors, so closer investigation by the UAS or other search assets is often required for target recognition or identification.

(Note: Many law-enforcement agencies, military, and Civil Air Patrol already have access to IR imagery systems on their manned aircraft. If IR is a desired search capability, a manned solution may be more easily and readily obtained.)

Multi-Spectral

Another type of visual sensor that is less well-known is the multi-spectral imager. Multi-spectral sensors are able to see areas of the electromagnetic spectrum outside of human eyesight, in the near infrared (NWIR) and/or ultraviolet (UV). They have been explored extensively for crop and environmental monitoring, but their use for SAR is less well-developed. However, they have capabilities which may be useful.

For example, near-IR sensors are able to distinguish between healthy and damaged chlorophyll in plants, and disturbed soil. This has obvious benefits to a farmer, but it has also been studied for use in finding shallow or mass graves. Multi-spectral imagers have been used to track marine life just below the surface of the water. Additional capabilities and usefulness for SAR are worthy of study and experimentation.

Low-Light (Night-Vision)

Another class of EO sensors is sensitive in visible wavelengths under very low illumination; commonly called "night-vision cameras." (Figure 2-2-2) Useful under star or moonlight, these sensors use an image intensifier to multiply the few photons of light reflected off an object to increase the number hitting the sensor. This provides a monochrome picture to the user which shows greater detail than what could be seen with the naked eye or a normal EO sensor. Because of this, the resulting image is of lower resolution and contrast than an image seen under normal lighting, and can be subject to ghosting, halos, and white-out.

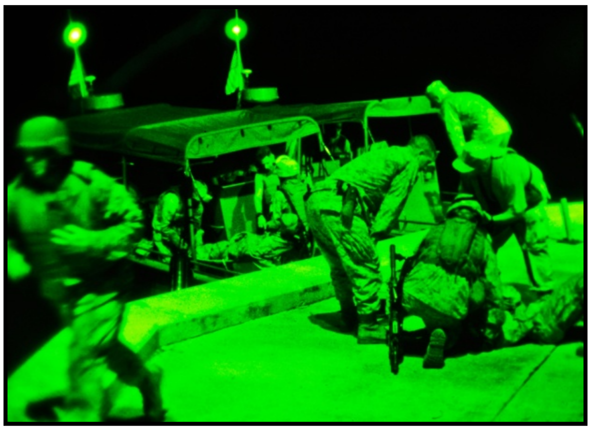

Figure 2-2-2: (08/17/11) Low Light Night Vision Imagery. U.S. Coast Guard Maritime Safety and Security Team Boston (91110) and Marine Corps Security Forces Company simulate the extraction process of an injured person during a casualty evacuation exercise, Naval Station Guantanamo Bay, Cuba. (Photo: Petty Officer 2nd class Kilho Park/USN)

Some EO/IR systems can electronically combine data from IR and low-light cameras to provide an enhanced low-light image that can be effectively used for SAR operations..

Optical Resolution, Range, Field of View

The ability of an operator to notice, recognize, and identify a target during a visual search is greatly affected by the optical resolution of the sensor. Because this is the primary means of detection by UAS, it is worth considering the limitations of digital image sensors.

A given optical sensing system, from optics to sensor to processing/transmission to display, will have a resultant resolution often described in pixel dimensions (e.g. 1024 x 768), or in vertical lines of resolution (e.g., HD 1080 – which corresponds to 1920x1080 pixels). The optics of the system will define a field of view (FOV), in degrees, which at a given range will span over a calculable distance (e.g., 5 degree FOV spans 175 meters at 2 km).

A 1920 X 1080 HD image 175 meters wide means each pixel is 9.1 cm across. This is the minimum detail that can be observed, and will affect the ability of the operator to spot objects in the scene. Thus detection ability is largely affected by image width and sensor resolution. Range and Field of View (FOV) can often be adjusted, but the resolution of the system will put a limit to how wide an area can be searched with a desired resolution.

When searching for smaller objects, such as a human body or debris, the UAS will have to search relatively narrow strips in order to achieve sufficient resolution, especially with a low-resolution sensor like IR.

Given these limitations, it is critical to understand the relationship between range and altitude of line of sight (LOS) systems, and how this can degrade the effectiveness of most optical sensors. While it is often desirable to employ UAS at or near its maximum range from the GCS, the UAS may need to climb in order to maintain connectivity. In doing so, the increased altitude degrades the resolution of a given image to the point where it may be ineffective. Even at close range, operating at higher altitudes to increase the area covered still may render UAS ineffective for a particular SAR operation.

See Appendix C for additional information.

Image Compression and Processing

A downside to electronic imagery is the use of compression algorithms to reduce the data required for storage or transmission. Image compression reduces large areas of similar data to a smaller data package, but in the process can eliminate small variations that could be the only sign of the target. (The effects of this can be seen watching online video on a slow internet connection.) For this reason, for SAR, it may be better to use raw imagery or uncompressed video feeds, despite the data storage or bandwidth limitations, so that no details are scrubbed out unintentionally.

Automated Imagery Analysis

A benefit of using digital imagery over direct human observation is the ability to post-process the picture data with software. Imagery analysts can adjust contrast, color, and other aspects to improve detection. Automated software, applied to the live feed or afterwards, can employ complex algorithms to identify and highlight distinct colors, movement, shapes, or patterns. Video or static imagery systems may be able to geo-tag the image, providing an exact location based on the aircraft's location and sensor orientation, ensuring precise guidance to other SAR assets for subsequent identification or recovery.

Some UAS developers are now implementing on-board image analysis systems to reduce communications bandwidth requirements and operator workload. These systems apply image filtering and processing algorithms on the UAS, rather than the GCS, to identify possible targets, then send only those images of note to the operator for further analysis and action.

RADAR

Some larger UAS are equipped with surface-search or synthetic aperture radars which may be employed in wide-area search, especially in the maritime domain. Coupled with an automatically or manually cued visual sensor, these systems may enable rapid processing and elimination of multiple radar contacts when searching for a target of sufficient size and material composition to create a radar return. This ability to quickly detect, classify, and identify targets is a standard maritime search aircraft capability, whether manned or unmanned.

Synthetic aperture radar (also abbreviated "SAR"), provides a photographic-like image using radar returns (Figure 2-2-3). Because of this, it can see through precipitation and clouds, unlike visible or thermal imagers. However, it has limited resolution because of the longer wavelengths used, and exhibits limited utility for a moving object, displaying it as a smear instead of a discreet image.

Inverse synthetic aperture radar (ISAR) is typically better suited for moving targets, as it virtually eliminates the latter problem, and can display multiple still images of the target as it moves. Both capabilities are employed on relatively few and expensive UAS, such as the Global Hawk and some Reaper variants, and may be optimal for certain SAR applications.

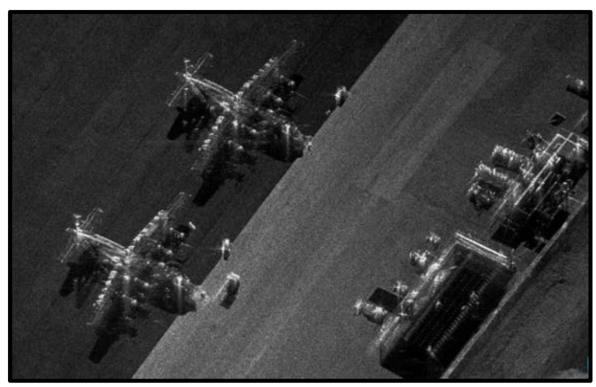

Figure 2-2-3: Ka-band RADAR image: C-130s on flight line at Kirtland AFB. (Photo: Sandia National Laboratories, Airborne ISR)

LIDAR

Similar to radar, LIDAR sends out a pulse and detects the return, but uses electromagnetic waves closer to the visible spectrum. Like SAR and ISAR, LIDAR provides a three-dimensional image (Figure

2-2-4). Given this capability, LIDAR has historically been applied for highly accurate and detailed terrain mapping, but may also prove useful for certain SAR applications.

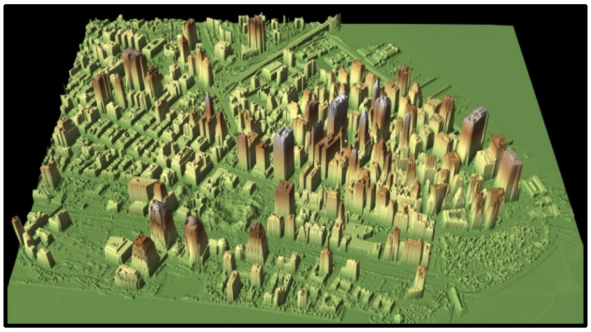

Figure 2-2-4: (09/27/01) LIDAR imagery: Lower Manhattan, New York. (Photo: NOAA/U.S. Army Joint Precision Strike Demonstration (JPSD))

Communications Detection Equipment

Some UAS are equipped with direction finding or communications network equipment which may not be available on manned aircraft. For example, the USAF MQ-1 and MQ-9 UAS are equipped with Quick Draw Interrogators which can pull data from an ejected pilot’s Hook-112G survival radio. Additionally, CBP/USCG MQ-9 UAS are equipped with AIS receivers which can track nautical transponders to identify vessels.

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Section 2-3: UAS Operational Capabilities

Communications Relay

Hazardous Environments

Restricted or Open Terrain

Limitations in Dense Top Cover

Responsiveness

Endurance and Cost

Availability

Delivery of Survival or Rescue Equipment

Mixed-Use Deployment

Overall Team Capabilities and Integration

Manpower Limitations

In addition to the sensors employed, UAS offer several operational capabilities that may be useful during a SAR operation.

Communications Relay

Some UAS are equipped with radio repeaters which can provide a line-of-sight link for ground or surface assets over the horizon or masked by terrain. This capability increases safety for search teams and improves coordination. A UAS may be able to offer this capability at lower cost and for longer endurance than a manned aircraft, or when a manned aircraft is unavailable.

(Note: Use of the radiofrequency spectrum for communications relays to and from the UAS that transmit on the radiofrequency spectrum require that the UAS operator obtain all radiofrequency authorizations from NTIA and FCC prior to operating on the frequencies (see Page 1-20, Communications Requirements).)

Hazardous Environments

A UAS can be flown in environments which are too dangerous to send a manned aircraft. This may include extremely foul weather (e.g., fog, storms, icing) or a chemical, radiological, biological, or nuclear environment (e.g. hazmat vapor cloud). While most large UAS are not yet all-weather capable, these capabilities are being added, and the risk of loss of a small, inexpensive UAS may be warranted. In some circumstances, such as a nuclear accident, where the aircraft may be rendered unrecoverable, the probability of saving a life may warrant the loss of even an expensive UAS.

Restricted or Open Terrain

UAS are frequently employed in search areas which are inaccessible to ground parties and manned aircraft. Whether due to close, high terrain, or aerial obstructions (e.g. power lines), a small, maneuverable UAS can provide search capability where other options are not available.

A UAS may be used when the terrain limits ground mobility or puts ground personnel safety in danger, such as over marshes, icy lakes, glaciers, cliffs, or rubble. It may also be used when visibility from the ground is limited by vegetation, rocks, or debris by providing a direct overhead view.

A UAS can also enable searches of wide, open areas where aerial visibility is good, without tasking large numbers of ground personnel or other search assets. In this way, the SMC could clear these areas and focus limited personnel/assets where they are most effective or required.

Limitations in Dense Top Cover

Because a UAS is an aerial sensor, they have limited ability to spot search objects through dense tree cover. However, they have been used successfully in these circumstances to assist lost individuals in communicating with responders, or to find their way out of terrain by serving as a reference point for navigation.

Responsiveness

A backpack or vehicle portable UAS, launched from the field, may be able to respond and begin searching before a manned aircraft can be activated and transit to the search area. Responsiveness will depend on fielding of UAS with trained personnel and authorization for employment.

Endurance and Cost

Because UAS do not require accommodating the space, weight, and power requirements to support a human crew, and are not subject to the limitations of the human body, many can operate for longer endurance than an equivalently-sized manned aircraft. GCS Operators can rotate to stay fresh while the UAS remains airborne in support of the SAR operation. Unlike many manned aircraft, multiple operators and automated systems can analyze the sensor feeds, enhancing search capability. The cost comparison for larger UAS is dependent on the nature of their ground system, crewing, and maintenance requirements, but is typically competitive to manned aircraft, especially when comparing fixed-wing UAS to rotary-wing manned aircraft.

The UAS cannot physically conduct a rescue, but can be used to search while a helicopter is ready to respond, searches another area; the UAS can monitor a located target while a recovery asset is dispatched and en route. At the smallest scale, a UAS can provide basic aerial search capability at orders of magnitude less cost than a manned aircraft.

Availability

It probably goes without saying that the best SAR asset is the one you actually have. In a resource restricted world, manned aircraft may be otherwise tasked or unavailable. A UAS may be the only option available to assist in a SAR operation. Furthermore, since manned aircraft are often at a premium, the employment of UAS in a SAR operation may allow manned flight hours to be conserved until required for rescue operations, thus serving as a force multiplier for the SMC.

Delivery of Survival or Rescue Equipment

UAS have been developed and employed as a delivery system for SAR equipment, by either dropping supplies or delivering rescue equipment. In the 2014 UAV Challenge Outback Rescue, the competition involved locating and delivering a bottle of water to a "lost hiker" in the wilderness; the winning team delivered the bottle to within 24 meters of the target. In 2015, a small quadcopter was used during a rescue on the Little Androscoggin River to carry a line to the person in the water, which was then used to deliver a life jacket. A UAS could be used to deliver inflatable life preservers, radio beacons, two-way radios, or other survival equipment to survivors until rescue assets can arrive.

Mixed-Use Deployment

With the expanded availability of UAS for SAR, it may be possible to reap the benefits of both fixed and rotary-wing UAS, while mitigating sensor limitations, by employing each for different roles in the search process. A fixed-wing UAS can be used to cover large areas and detect actionable targets, without being able to provide accurate recognition or identification. A rotary-wing UAS can then be used to take a closer look at each target, saving time by ground parties. Either of these roles could be fulfilled by manned aircraft, although typically at a greater cost and with less endurance, particularly when compared to fixed-wing UAS.

Overall Team Capabilities and Integration

Specific UAS or manned aircraft come with organic capabilities. For example, DoD UAS units have attached imagery analysis personnel. Civil Air Patrol manned aircraft teams include personnel and equipment able to geo-tag and upload imagery to public web sites. In considering different manned or unmanned search options, the SMC should also consider the capabilities of the overall team to collect, process, analyze, and disseminate imagery, as well as communicate with other SAR forces and respond to emergent tasking.

UAS must be evaluated and employed as an entire system: airframe capabilities, sensor capabilities, launch and recovery, airspace deconfliction, logistics, communications, product analysis and dissemination, operational integration, basing, authorities and authorization.

Manpower Limitations

Despite the "unmanned" moniker, many larger UAS require a significant manpower complement to be effectively operated. Like manned aircraft, UAS are also constrained by basic human limitations such as fatigue and limited attention span, thereby requiring multiple crews to support long-endurance flight operations. This not only applies to pilots, sensor operators, observers, mission commanders, and other front-end crewmembers, but also to back-end personnel required for data/imagery analysis and processing. Since many UAS platforms can easily outlast their human resources, this aspect must be carefully planned and managed during and throughout any UAS operation. In addition, the UAS team must also account for the cumulative effects of fatigue during multi-day SAR operations.

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Part 3: Concept of Employment

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Section 3-1: Operational Integration

Operational Coordination

Air Coordination

Radio-Frequency Coordination

Link Security/Integrity

Sensor Product Dissemination

Situations and Capabilities

Qualifying UAS Providers

Operational Coordination

UAS operators must be integrated into the overall search effort at the right level and with the right persons, depending on the type of UAS to be flown and for what purpose. Ultimately, the UAS is providing services for the SMC/IC. If operating in a National Incident Management System (NIMS) environment, the UAS team should be a component of the Incident Command Air Branch and coordinate their operations with the Air Operations Director. In any SAR case, the UAS team should coordinate their operations with the On Scene Commander and any other aviation units, as well as surface assets and personnel.

Use of DoD UAS requires additional considerations described in Appendix D.

Air Coordination

Integration with other air assets will be highly dependent on the type and method of UAS being employed. A small UAS, limited to line-of-sight operation within 400 feet AGL, may be deconflicted with other air traffic by position, altitude, time, or by a combination of these measures. A high-altitude platform may be deconflicted with other air traffic via the FAA, using a TFR and ATC to maintain separation.

(Note: The National SAR Supplement, Coast Guard Addendum, Land SAR Addendum and CISAR Addendum provide additional information concerning the management of aircraft in the conduct of SAR operations.)

Radio-Frequency Coordination

An important consideration in UAS employment in a mixed-unit, interagency SAR operation, is radio frequency coordination. A UAS will require at least one if not several frequencies for command and control, sensors, and communications. In addition, if the UAS team deploys observers to provide visual line-of-sight for aircraft avoidance, they will also need a frequency by which to communicate to the control station.

As indicated in the Communications Requirement Section (page 1-20) the operation of communication links to and from the UAS whether for command/control or payload, and any radiofrequency use for sensors (e.g., sense and avoid radar), falls under the jurisdiction of the NTIA for Federal agencies and the FCC for non-

Federal agencies. Use of authorized frequencies shall be in accordance with applicable FCC rules and NTIA Manual of Regulations to avoid potential interference. Furthermore, NTIA and FCC coordinate the use of radiofrequency spectrum that is shared among federal and non-federal uses prior to issuing an authorization to mitigate potential interference.

It is essential that the UAS team in the area of operation coordinate their frequency and airspace use with other operators, both air and surface, to avoid interference as a result of UAS congestion during a SAR operation.

Link Security/Integrity

The security and integrity of a UAS control and data frequencies and connections must be considered. Use of any radiofrequency can be vulnerable to interference or interception.

As described earlier, most communications links for command/control and payload to and from small UAS used for commercial purposes operate with equipment that is license-exempt or unlicensed. The unlicensed equipment must comply with FCC Part 15 regulations. FCC's Part 15 regulations provide for operations on a non-interference basis – the equipment must not cause harmful interference and must accept the risk of receiving harmful interference including from other unlicensed transmitters. While transmitters and receivers under this regulatory framework are designed to automatically find open channels within the band to avoid interference, a UAS at altitude is exposed to more transmitters, and potentially to equipment capable of intercepting the UAS signals.

In addition, the SAR operation may require transmission on frequencies over large distances. If this requirement entails use of special directional antennas and a clear line of sight to maintain the link, the UAS operator must be aware that modifying radiofrequency equipment in any way may cause the equipment to operate out of compliance with FCC or NTIA authorization. The UAS operator must be familiar with the requirements, limitations, and security of their radio equipment.

Sensor Product Dissemination

Ultimately, data and imagery directly from the UAS or analyzed sensor/imagery products from the UAS team will need to be provided to the SMC/IC and other SAR team members. Depending on the UAS, this may be accomplished manually via disk, external drive, printed photos, an over-the-shoulder view of the GCS, or an internet disseminated digital feed or product. Considerations include:

- Speed of access;
- Ease of access;
- Quality and clarity of imagery;
- Equipment/software needed to receive and view products;
- Protection from unintended or public release (access control);
- Limited release of Classified or Law-Enforcement Sensitive information; and
- Ability to send data to field units.

Situations and Capabilities

The following are some possible situations where UAS capabilities may be useful on a SAR case:

- Aerial thermal imagery at night or in poor weather for a highly localized missing-person search, using a small UAS at low altitude;
- Detailed search of hazardous or inaccessible terrain, such as cliffs, marshes, or ice-covered lakes;

- Rapid search and clearing of large open areas to conserve ground personnel;
- Identifying and contacting multiple maritime radar contacts to narrow search when looking for overdue or distressed vessel;
- Persistent monitoring of located survivors while awaiting arrival of SAR teams/units;
- Persistent communications relay to SAR teams/units or survivors in rough terrain or over-the-horizon;
- Aerial surveillance of an incident area to identify locations of hazards, survivors, and avenues of approach, and to quantify the scope of response; and
- Remote detection of HAZMAT.

(Note: See Appendix E for actual case examples.)

Qualifying UAS providers

Hobbyists, academia, and other UAS users have offered their services during SAR operations or other incidents, in a desire to assist in the response. As private and civil UAS use expands, this will likely become an increasingly common occurrence. SMCs/ICs should be both pragmatic and prudent in permitting UAS employment in a SAR operation.

FAA Policy currently states that hobbyist rules apply only when the UAS is being used for "sport or recreation," so a COA is required for SAR operations. This does not prevent an SMC/IC from accepting imagery from a helpful citizen, but further use of the UAS as an operational asset would cross the regulatory line.

Civil operators may require a COA addendum for use outside their existing approval, which can often be obtained from the FAA if requested with a "statement of need" from a public agency through the expedited SGI process.

The legal and regulatory limits on UAS operations, especially by private citizens, are rapidly changing and vary from location to location. While a private or civil UAS is arguably no different than a citizen with a camera, various laws have been proposed or enacted by several States, jurisdictions, and municipalities to limit UAS operations for safety and/or privacy concerns.

In addition to the considerations outlined elsewhere in this Addendum with regard to sensors, capabilities, integration, operational risk assessment, legality and risk assessment, several other questions that a SMC/IC should consider before employing a UAS are included in Appendix F.

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Section 3-2: Risk Assessment

Risks to Consider

- *Risks to Victim*
- *Risk to Searchers*
- *Risk to other Aircraft*
- *Risk to Public and Property*
- *Risk to the UAS*
- *UAS Operator Risks*
- *Planning and Coordination Risks*

Environmental Factors

- *Wind*
- *Moisture, Precipitation, and Icing*
- *Low Visibility, Clouds, and Fog*
- *Turbulence*
- *Altitude, Temperature, and Humidity*
- *Take-off and Landing*
- *Fire*
- *Low Illumination, Dusk, and Night*

Risks to Consider

In employing a UAS on a SAR case, there are several risks that should be considered by the SMC/IC:

Risk to Victim

While most persons in distress would most likely be encouraged by the sight of a UAS, the sight or sound of a UAS may be frightening to others, especially if the person is a small child or mentally challenged. If the target is located, it may be better to not move the UAS closer, but let ground personnel respond for identification.

Risk to Searchers

UAS are still a novelty, and ground parties may find the sight or sound of a UAS too much of a distraction, especially if it is unexpected. Additionally, if the UAS crashes, it may pose a danger to ground personnel from spinning rotors, punctured batteries, or spilled fuel. Ground parties should be briefed if a UAS will be operating and advised not to attempt to retrieve the aircraft if it crashes. The UAS team should be notified for aircraft recovery.

Risk to other Aircraft

UAS operations should be carefully coordinated with other search assets through the Incident Command, SMC/IC, and/or ATC as applicable. Use of a common radio frequency for air traffic deconfliction is recommended.

Risk to Public and Property

UAS, especially smaller aircraft without redundant systems, are not always reliable. The UAS team and SMC should carefully select areas of operation and flight patterns to minimize the potential risk of the UAS crashing on persons or property. The size and reliability of the UAS, operator training, and emergency procedures should be taken into account.

Risk to the UAS

The operational environment, terrain, and specific operational challenges may place the UAS itself at risk. In some cases, this risk may be warranted, especially when there is a high probability of saving a person's life, and where the cost and damage associated with loss of the UAS will not be severe. UAS are not usually expendable or inexpensive; care should be taken not to fly a UAS beyond its capabilities.

UAS Operator Risks

As in any operation, the training and fitness of UAS personnel must be considered. The operators may have limited SAR experience. UAS personnel should be properly trained in their specific equipment operation and maintenance, as well as the operational use of the UAS. UAS personnel human factors should be considered – rest, hydration, hunger, and environmental exposure – as these will affect their ability to safely and successfully execute the SAR operation.

Planning and Coordination Risks

Depending on the exigencies of the event, time for planning and coordinating UAS operations may be minimal. Limited information, uncertain coordination channels, novel employment, or rapidly changing situations can increase overall risk to the operation.

Environmental Factors

UAS are subject to weather, which will need to be considered for their employment. These may include, but are not limited to:

Wind

The airframe may not be able to operate in winds over a certain speed, the search pattern may be too distorted by wind, or the airframe's endurance may be significantly reduced while flying upwind. In addition, winds may easily strengthen to the point that smaller UAS cannot effectively transit from point to point, and may even be unable to land at the desired recovery location. It is also important to consider that the velocity and direction of surface winds may be much different than those aloft, even at very low altitudes.

Moisture, Precipitation, and Icing

Many UAS are not all-weather capable and cannot be flown in rain, snow, ice, or other precipitation. In addition to adversely affecting sensor capabilities, the UAS and ground equipment may not be able to handle significant water intrusion. Icing, in particular, can have a grave effect on aircraft performance by adhering to lifting surfaces, clogging air intakes, and/or asymmetrically accumulating on the airframe, causing significant shifts in center of gravity that can lead to loss of control. In many cases, some or all of these factors can combine to make the UAS inoperable.

Low Visibility, Clouds, and Fog

Cloud ceilings of any height may limit a UAS sensor's ability to view the ground. Clouds at flight altitude can create a particular hazard to safe flight by reducing the ability of the UAS operators to see-and-avoid other aircraft, and when operating near the ground, to avoid terrestrial hazards (e.g., towers). In the case of line-of-sight operated UAS, low visibility, clouds, or fog increase the chance of the operator losing sight and/or control of the aircraft.

Turbulence

Turbulence is often formed by wind moving over obstacles in the terrain, such as trees, buildings, or mountains. It may also be formed by rapidly rising columns of air due to solar heating, and by weather. Smaller UAS are especially vulnerable to this phenomenon. Excessive turbulence may limit the ability of the UAS to fly safely or be operationally effective.

Altitude, Temperature, and Humidity

The higher the altitude, the thinner the air and the less air the aircraft has to generate lift and propulsion. All aircraft have a maximum altitude capability, but even below this, the aircraft's payload capacity, maneuvering capability and endurance will be affected. In addition, high temperatures and high humidity also reduce the performance capability of an aircraft similar to an increase in altitude.

UAS equipment may also be limited by extreme ambient temperatures. For example, low temperatures reduce the performance of batteries, and high temperatures can lead to overheating engines, motors, or electronics.

Take-off and Landing

UAS require a safe and clear area to launch and recover. For most fixed-wing UAS, this will involve some distance of clear terrain oriented with the prevailing wind. Even rotary-wing platforms will need to have some clearance from nearby obstructions. Larger airframes may require an airport or other smooth paved surface for use as a runway.

Fire

Near a fire, a low altitude UAS will be subject to the in-flow and updrafts that form around fires, as well as the ash and heat rising from the fire. The UAS team will need to carefully plan their flight path to ensure the aircraft remains clear. In addition, the UAS must be deconflicted with any concurrent fire suppression aircraft operating in the vicinity.

Low-illumination, Dusk, and Night

Low-illumination affects the sensitivity of some sensors and the ability of the operators to safely operate the aircraft. Some UAS may be restricted to daylight operations only.

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Section 3-3: Public Perception and Privacy

Public Affairs Engagement

Legal Concerns

Federal Guidance

Organizational Guidance

Public Affairs Engagement

Because of the sensitivity of the public to perceived privacy encroachment during the conduct of UAS operations, it is vital that UAS SAR operations be coordinated with public affairs staffs.

Public affairs officers can assist the UAS team by:

- Isolating the UAS team from media inquiries so they can focus on SAR tasking (if possible, identify one UAS team member to answer specific inquiries regarding UAS utilization);
- Emphasizing the usefulness of UAS for the tasks for which it is employed; and
- Mitigating concerns by clarifying restrictions over data collection and use, and relating the capabilities to those already present in manned aircraft.

When acquiring a UAS for public use, a robust public outreach or awareness program can help mitigate concerns before the system is operationally employed. Simple measures such as making the UAS brightly colored and lit can help foster the perception that the UAS use is overt and for public safety, not covert surveillance.

Legal Concerns

Privacy laws respective to UAS differ State to State and Congress is currently developing federal UAS privacy laws; legal advisors should be consulted prior to UAS use.

Federal Guidance

On Feb 15, 2015, the Presidential Memorandum: “Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems” was submitted to the heads of executive departments and agencies outlining expectations regarding UAS implementation. The memorandum included the following:

- Collect and use information from UAS only when relevant to an authorized purpose;
- Personally identifiable information should not be retained for more than 180 days unless pertinent to an ongoing mission or investigation, in which case it must be maintained in a system of records covered by the Privacy Act of 1974;
- Information not maintained in the system should not be disseminated outside of the retaining agency unless for an authorized purpose;
- Take measures to ensure that privacy, civil rights, and civil liberties complaints can be properly investigated;

- Ensure proper oversight on UAS policies and that all policies and rules of conduct are established before they acquire a system; and
- Provide notice to the public regarding where they are authorized to use UAS in the national airspace system, keep the public informed about changes to UAS programs and annually release a description of UAS operations from the previous year.

Organizational Guidance

Regardless of whether data is collected by UAS or other means, every Federal, State, Tribal/Insular Area, and local SAR authority should have established processes and procedures for the collection, dissemination, storage, and destruction of UAS data and imagery. These can usually be accessed through the organization’s legal and/or privacy offices, and may require vetting and authorization prior to the conduct of UAS SAR operations.

Appendices

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Appendix A: Regulations, Directives, and Policies

The following regulations, directives, and polices concern the use of Unmanned Aircraft Systems, especially for search-and-rescue and disaster response.

DoD Directive 5200.27, "Acquisition of Information Concerning Persons and Organizations Not Affiliated with the Department of Defense." January 7, 1980.

DoD Directive 5240.1-R, "Procedures Governing the Activities of DoD Intelligence Components that Affect United States Persons." August 27, 2007. www.dtic.mil.

DoD Directive 3025.18, "Defense Support to Civil Authorities (DSCA)." Incorporating Change 1, September 21, 2012. http://dtic.mil/whs/directives/corres/pdf/302518p.pdf.

DoD Instruction 3003.01, "DoD Support to Civil Search and Rescue (SAR)," September 26, 2011. http://dtic.mil/whs/directives/corres/pdf/300301p.pdf.

DoD Instruction 4540.01, "Use of International Airspace by U.S. Military Aircraft and for Missile and Projectile Firings." June 2, 2015. http://dtic.mil/whs/directives/corres/pdf/454001p.pdf.

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Appendix C: Effects of Altitude and Range on Detection

Field of View

Effective Resolution

Line of Sight

Field of View

The linear length and width, of the surface (ground or sea) under observation is a function of the sensor's FOV and slant range. The slant range can be computed by the altitude and horizontal offset, or altitude and angle of the sensor's view below the horizon. From this, the linear width (W) of the image in the middle and near/far edges can be calculated (Figure C-1):

$$Slant\ Range = \sqrt{Altitude^2 + Horiz.Offset^2} = \frac{Altitude}{\sin(\theta)}$$

$$W_{mid} = 2 \times Slant\ Range \times \tan\left(\frac{HFOV}{2}\right)$$

$$W_{far} = 2 \times \frac{Altitude}{\sin\left(\theta - \frac{VFOV}{2}\right)} \times \tan\left(\frac{HFOV}{2}\right)$$

$$W_{near} = 2 \times \frac{Altitude}{\sin\left(\theta + \frac{VFOV}{2}\right)} \times \tan\left(\frac{HFOV}{2}\right)$$

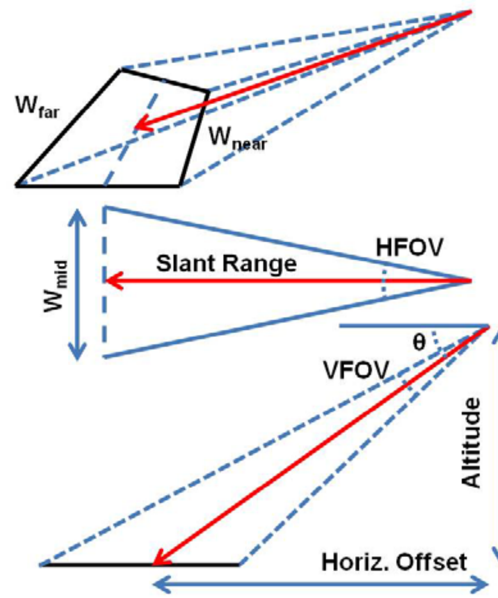

Figure C-1: Linear Width

Effective Resolution

The effective resolution of an imagery sensor is a function of its FOV, range, and the resolution of the sensor. The resolution of the sensor will be affected by the quality of the optics and sensor. The effective resolution available to the viewer will be further affected by the encoding, transmission, and decoding of the image, and the viewing system. A high-definition sensor is only standard-definition if viewed on an SD screen.

An estimate can be made by dividing the width of the image by its pixel resolution. For example, .25 nautical miles / 1,280 pixels = 14 inches per pixel. An object 14 inches wide will only be one pixel wide on the screen. A widely used criterion for minimum resolution requirements for imagery is Johnson's Criteria, based on the work of John Johnson for the U.S. Army in 1958. It states that for 50% probability of discernment at the stated level, an object must subtend:

- Detection 1.5 to 2.5 pixels;
- Recognition 6.4 to 9.6 pixels; and
- Identification 9.8 to 15.8 pixels.

A UAS operator scanning a quarter-mile wide image may only be able to detect objects 21 to 35 inches wide, and recognize objects 7.5 to 11 feet wide.

The desired resolution will be affected by knowledge of the search target and the conditions of the environment. A person in the water, a person wearing a PFD, a life raft, or a pleasure craft will need less resolution as size increases or color difference makes them more discernible, and thus enables a wider scan. The amount of background clutter will also determine the need for more resolution. White caps on the water and vegetation on land will require greater resolution to differentiate the search object from the background. Johnson's Criteria was developed for monochrome night-vision displays, and doesn't take into account noise or motion.

While the SMC should rely on the UAS operators to best employ their sensors, an understanding of EO/IR limitations is instructive to their best employment.

Further experience and research may enable the development of quantitative probability of detection tables and resolution requirements for different sensors.

Line of Sight

Absent surrounding terrain, the distance (D) that can be observed from a given altitude (distance to the horizon) can be calculated, in kilometers, given height (h) in meters is:

$$D \approx 3.86 \times \sqrt{h}$$

For distance in statute miles and height in feet:

$$D \approx 1.32 \times \sqrt{h}$$

This same equation applies to the altitude necessary for a UAS to send and receive signals from the ground control station if using line-of-sight frequencies such as VHF-FM or 2.4 GHz. Without a relayed signal, e.g. from a satellite, the UAS may be required to fly at an altitude that prevent it from effectively using its sensors. Not only does excessive altitude reduce possible resolution, it also increases atmospheric attenuation and possible interference from clouds.

Appendix D: Use of DoD UAS for SAR

In accordance with DoD Policy: "Guidance for the Domestic Use of Unmanned Aircraft Systems" (Memorandum 15-002), Commander, U.S. Northern Command (CDRUSNORTHCOM) will approve the use of DoD UAS SAR missions involving distress and potential loss of life that are properly coordinated by the Air Force Rescue Coordination Center (AFRCC) or the Alaska Rescue Coordination Center (AKRCC).

In U.S. airspace, DoD UAS may only be used for SAR during operations to support Federal, State, local, Tribal, Territorial/Insular Area SAR authorities. DoD UAS may not be used for federal, state, or local support under Immediate Response Authority.

Designated SAR authorities who seek to use DoD UAS assets in support of ongoing SAR operations should submit a request through the AFRCC or AKRCC in accordance with established SAR request procedures. The request should be capabilities and effects (i.e. performance)-based, not asset-based. The AFRCC/AKRCC will conduct an analysis and provide a recommendation to the Inland SAR Coordinator (CDRUSNORTHCOM) if UAS is determined to be the most appropriate, most capable asset, in lieu of or in addition to manned aircraft for the conduct of the SAR mission. The SMC/IC should be prepared to provide written justification to include:

- Sustained endurance efforts are required;
- Unmanned aircraft are more responsive;
- Unmanned aircraft provide superior capabilities;
- The risk to manned aircraft is assessed as unacceptably high; or
- Infrastructure limitations prohibit the use of manned rotary-wing or fixed-wing aircraft.

The AFRCC or AKRCC, through the designated chain of command, will submit, a request to CDRUSNORTHCOM including:

- A summary of the circumstances and analysis of why a DoD UAS is the best platform for a particular SAR mission;
- Confirmation the Proper Use Memorandum (PUM) is current;
- COA;
- Identification of the search area; and
- The initial requested duration of the UAS mission.

If approved, a DoD SAR mission number will be issued by either AFRCC or AKRCC and the UAS mission will be coordinated with the SMC/IC.

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Appendix E: Notable UAS SAR Cases

Royal Canadian Mounted Police: Missing Driver

U.S. Coast Guard/Customs and Border Protection: Vessel Taking on Water

West Midlands Fire Service: Missing Child

Auburn Fire Department: Little Androscoggin River Rescue

Royal Canadian Mounted Police: Missing Driver[1]

On May 9th, 2013 at 00:20hrs the RCMP Detachment at Saskatoon, SK received a report of a single vehicle rollover collision in a rural area. When emergency responders arrived at the scene they could not locate the driver and a ground search ensued within approximately 200 meters of the scene. The driver was not located. A STARS air ambulance helicopter came to the scene to assist however they were equipped with night vision and not FLIR. They widened the search area to 1000 meters in radius and reported back that they did not see anything which could indicate the location of the driver. At 01:20hrs an RCMP Collision Reconstructionist arrived at the scene and he was equipped with a UAS. By 02:10hrs a cell phone number for the driver had been obtained. The driver answered…He stated that he was cold, was only dressed in a t-shirt, had no jacket and had lost his shoes.

He could not provide any details as to where he was located. The temperature was hovering near the freezing point.

With the assistance of the cell phone company the last known GPS location of the cell phone was obtained. This GPS coordinate was 3.2km's south of the wreck site. Our Collision Reconstructionist went to the location along with the STARS helicopter. STARS began an immediate search of the area and our Collision Reconstructionist deployed his FLIR equipped UAS. He immediately located three heat signatures and was able to direct the local fire/rescue persons to the first location which turned out to be the person they were looking to find. He was curled up against the base of a tree next to a snow bank and was suffering from hypothermia and was unresponsive. (03:00hrs)

Without the FLIR equipped UAS ground searchers would not likely have found the driver until daybreak.

U.S. Coast Guard/Customs and Border Protection: Vessel Taking on Water

Sector Corpus Christi received a call from a 35 foot pleasure craft taking on water, 64 miles SSE of Corpus Christi, TX. The ready H-65 was launched to search a 30nm x 60nm area. A USCG/CBP MQ-9 was conducting training in the area at the time; Sector requested the UAS assist in conducting a track-line search of the area. After issuing an Urgent Marine Information Broadcast, a vessel responded with a location outside the search area. The UAS was able to spot the vessel, with a Good

[1] Source: Email from Cpl. Byron Charbonneau, RCMP Forensic Collision Reconstructionist, Brandon, MB, to LCDR Nathan Kendrick, dated 12 Feb 2015.

Samaritan vessel on scene, using its EO sensor. The UAS confirmed the location and condition of the vessel, and monitored the situation until the H-65 and a USCG cutter arrived on scene.[2]

West Midlands Fire Service: Missing Child

The local police service had been informed of a missing child that was playing near a frozen lake. Heavy fog in the area prevented use of a police helicopter. The West Midlands Fire Service responded with an Aeryon SkyRanger using a thermal image (IR) camera. They quickly identified a heat source near the middle of the lake in a reed bed. A technical team gained access using inflatable ice paths and found a roosting swan. At that time, a call was received that the child was found safe at a friend's house. The UAS "negated having to put responders into a potentially dangerous situation by having to search the whole of the lake in very poor weather conditions."[3]

Auburn, Maine Fire Department: Little Androscoggin River Rescue

A teenager and young boy tubing on the Little Androscoggin River were knocked off their tube and became stranded on rocks in the middle of a strong current. Only the boy was wearing a life jacket. A responding fire fighter used his personal drone to deliver a line attached to a life-jacket to the teenager, who was able to pull it to himself. The firefighters used a rescue boat to recover the boy, and then the teenager.[4]

[2] Source: Emails from Coast Guard LT Ben Sparacin, January 30, 2015 and LT Ryan Seymour, January 15, 2015 to LCDR Nathan Kendrick.

[3] Source: "Interview with Andy Cashmore, West Midlands Fire Service," *Unmanned Systems* (January, 2015)

[4] Source: ABC News, "Drone Helps Firefighters Rescue Two from River in Maine." http://abcnews.go.com/US/drone-helps-firefighters-rescue-river-maine/story?id=32163196

Appendix F: Planning Considerations Prior to UAS Operations

The following are a list of questions that a SAR Coordinator, agency, or operator may consider prior to commencing UAS SAR operations. While some represent regulatory requirements to which adherence is mandatory, others are prompts for discussion and consideration to promote a thorough analysis of alternatives and risk versus gain, and ensure safe and effective operations.

1. COA Considerations/Safety of Flight

- Does the Operator/Agency have a COA or a Section 333 Exemption?
- Is the operator flying the UAS for compensation?
- Is the operator applying for operations under an existing public COA, as a civil operator under an Exemption or Special Airworthiness Certificate, or operating as a hobbyist?
- Has an SGI Addendum to COA for the operation been requested and received from the FAA?
- Has a flight plan been filed and/or a TFR been activated, if required?
- Has the operator submitted a NOTAM for UAS operations?
- Is the UAS pilot properly certificated and current?
- Will the UAS operator maintain line of sight?
- Are visual observers (VOs) being employed? Where are they posted? How will they communicate with the operator?
- Is there a separate data sensor monitor?
- Does the operator have an FAA VFR chart of the operational area?
- What airspace will the UAS operate in? Are there transit concerns?
- What altitude will the UAS fly?
- Are there any airports close by?
- Will operations occur over a populated area?
- What See and Avoid procedures are planned and in place?
- Have NOTAMs been reviewed for the area of operations?
- What are the communications links for control and for sensors? Are they consistent with regulations and operational safety for area of operation?
- Does the operator have a VHF radio to communicate to aircraft and air traffic control?

2. **Legality**
   - Is the flight and use of imagery legal in accordance with the laws of the jurisdiction in which it will be flown?
   - Are there privacy restrictions or warrant requirements for UAS-collected imagery?
3. **Flight Experience**
   - How much experience does the operator have with the UAS equipment? How much flight time? How recent? In what circumstances?
   - How long has the operator owned and operated his or her current system?
   - Is the operator familiar with FAA policy, airspace, and communications requirements?
4. **Operational Experience**
   - How experienced is the operator in working with first responders or for an Incident Command?
   - Does the operator have any SAR experience?
   - Is the operator familiar/experienced with the operating environment (terrain, airspace, weather)?
5. **Mission Planning**
   - How much time has been available for planning?
   - How will the operator plan and conduct a UAS mission?
   - Will the operator be incorporated into daily operations, or merely providing what is observed?
6. **Land Use**
   - Are their restrictions on UAS use over the terrain to be flown? E.g. National Parks? State/Municipal laws?
7. **Environment/Weather**
   - For the entire flight area, is the UAS capable, permitted, and safe to operate, considering both current and forecast:
     - Winds/turbulence?
     - Clouds?
     - Visibility?
     - Temperature?
     - Precipitation?
     - Time of day?
   - What hazards to flight operations exist:
     - Airspace?

    - Obstructions?
    - Terrain?
    - In-flight hazards (e.g. smoke)?
    - Launch/recovery locations?
- Will ground personnel be affected by:
    - Weather?
    - Ground hazards?
    - Disaster impacts?

8. Additional Risks:

- Does the UAS create potential hazards or concerns regarding:
    - The victim/search target?
    - Other search assets?
    - Other aircraft?
    - Property on the ground?
- Will the UAS team have access to adequate rest, hydration, food, shelter, and transportation?

9. Sensors Employed

- What sensor is most effective for the operation?
- How will sensor data be collected and/or displayed?

10. Communications

- Are there any conflicts between UAS radio frequencies and other operators?
- Are there any concerns with radio link security or integrity?
- How will the UAS team communicate with other aircraft, other search assets, and the SAR Coordinator?

11. Use of Imagery:

- Who owns and controls any captured imagery, and will it be limited or available for public release, news or commercial use?
- How is the imagery controlled and released?

12. Liability and Insurance

- Who is accepting liability for the operations?
- Does the operator or agency have appropriate insurance in case of mishap, if required?

13. Funding:

- Who is paying for the operation and do they have the authority to obligate funds?

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