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COVER SHEET
Access 5 Project Deliverable

Deliverable Number: *HSI008*

Title: *High Altitude Long Endurance (HALE) Unmanned Aircraft System (UAS) Pilot Knowledge, Skills and Abilities*

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Abstract:

This report summarizes the initial work accomplished by the ACCESS 5 Human System Integration (HSI) team to identify Unmanned Aircraft System (UAS) Pilot Knowledge, Skill and Ability (KSA), Training and Medical requirements. To derive this information the following tasks were accomplished:

- Mission and Function analyses were performed
- Applicable FARs and FAA Advisory Circulars (ACs) were reviewed
- Meetings were conducted with NASA and FAA Human Factors personnel
- Surveys were completed by ACCESS 5 HSI Working group UA Pilots
- Coordination meetings were conducted with the ACCESS 5 Policy IPT

The results of these efforts were used to develop a summary of the current qualifications for an individual to function as a Pilot In Command (PIC) for UAs currently flown by UNITE companies, to develop preliminary Pilot KSAs for each phase of flight, and to delineate preliminary Pilot Training and Medical requirements. These results are to be provided to the Policy IPT to support their development of recommendations for UA Pilot Rating Criteria, training and medical qualifications. It is expected that the initially an instrument rated pilot will be required to serve as the PIC. However, as operational experience is gained, and automation is applied to accomplish various system functions, it is expected that pilot rating criteria could be lessened.

Status:

Document Status
Work in Progress

Limitations on use:

The current set of Unmanned Aircraft Systems Pilot Knowledge, Skills and Abilities (KSAs) was developed based on the assumption that a low-level of automation was available to the pilot. That is, for most of the mission phases, the pilot was responsible for controlling the aircraft via stick and rudder type controls. Mission requirements for a “Loiter mission” were incorporated into this version of the report. Other potential UAS missions (e.g., Surveillance, Communication Relay, etc.) were not assessed in the current KSAs.

High Altitude Long Endurance (HALE) Unmanned Aircraft System (UAS) Pilot Knowledge, Skills and Abilities

Access 5

December, 2005

The following document was prepared by a collaborative team through the noted work package. This was a funded effort under the Access 5 Project.

RECORD OF CHANGES

REV	DESCRIPTION	DATE	BY
NC	Initial document release	3/2005	B. Berson
A	Changed ROA to UAS	7/2005	"
A	Incorporated HSI Team Member and SEIT comments	7/2005	"
A	Incorporated from Policy IPT UAS Team Members	7/2005	
A	Added Definitions	7/2005	"
A	Updated Functional Requirements to align with the SEIT Functional Requirements (FRD) Document	7/2005	"
A	Updated UNITE Pilot Qualifications Table (4-1)	7/2005	"
A	Updated preliminary KSA Analysis Table (4-2)	7/2005	"
A	Developed preliminary UA pilot Training Requirements	7/2005	"
A	Developed preliminary UA pilot Medical Requirements	7/2005	"
B	Updated KSA for a Loiter Mission	12/2005	"

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EXECUTIVE SUMMARY

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The current set of KSAs was developed based on the assumption that a low-level of automation was available to the pilot. That is for most of the mission phases, the pilot was responsible for controlling the aircraft via stick and rudder type controls. Mission requirements for a "Loiter mission" was incorporated into this draft of the report. Other potential UAS missions (e.g., Surveillance, Communication Relay, etc.) were not assessed in the current KSAs.

The next version of this document will consider the impact of higher levels of automation and additional mission operations on Pilot KSAs. In addition, more detailed analyses and reviews will be conducted to refine the preliminary Pilot Medical and Training requirements provided in the current version.

1. INTRODUCTION

1.1 BACKGROUND

This report provides preliminary requirements for determining Pilot Rating Criteria for a High Altitude Long Endurance (HALE) Unmanned Aircraft System (UAS). The focus of the effort described herein is to define pilot Knowledge, Skill and Ability (KSA) requirements for safely and effectively monitoring and controlling a HALE UAS. The Access 5 Policy IPT will then use this information to develop minimum standards for a person to be the Pilot-In-Command (PIC) of a HALE UAS.

Well designed operator interfaces are critical to the successful application of UASs, whether the vehicle is directly teleoperated ("hand flown"), or one that is highly automated and thus "supervised" by the human pilot. Given that humans are to remain a key component of a UAS for the foreseeable future, it is important to recognize the unique challenges levied upon the UA pilot. These challenges include the effects of deleterious system time delays, bandwidth limitations, datalink degradations/dropouts, and loss of the rich supply of multi-sensory information afforded to onboard pilots. On the other hand, it is important to note that the physical separation of the pilot from the vehicle might also offer some unique benefits that could be exploited. Besides the obvious benefit to pilot safety, it is quite likely that available bandwidth and the variety of available information sources might be far greater for a ground-based UA pilot, potentially resulting in greater situation awareness. This of course, assumes that a well designed pilot interface exists that provides the pilot the information required to rapidly filter and fuse data to support timely and accurate decisions (Draper, et al. 2005).

An understanding of UA pilot KSAs is a prerequisite for the development of an effective Air Control Station (ACS). In addition to providing data to help determine pilot rating criteria for an UA pilot, data in this report will also provide an input into other ACCESS 5 HSI deliverables (e.g., HSI design guidelines, ACS certification, etc.).

1.2 OBJECTIVES

There are two primary objectives for this report for 2005:

1. Develop a minimal set of pilot Knowledge, Skill and Ability (KSA) requirements for an individual to function as a Pilot-In-Command (PIC) of a HALE Unmanned Aircraft (UA)
2. Identify minimal medical and training requirements (initial training and currency) for a HALE UA pilot

It is intended that this information will be used by the Policy IPT UAS Working Group to develop preliminary recommendations for UAS pilot rating criteria, training and medical requirements.

1.3 SCOPE

This document delineates preliminary Pilot KSAs that are to be used to establish minimum requirements for certifying a HALE UA pilot. The current report addresses normal operations for all phases of flight. Preliminary medical and training requirements will also be discussed. Contingency operations, detailed training requirements, and medical requirements will be addressed in 2006.

1.4 ASSUMPTIONS

Assumptions supporting the development of this document included:

- The pilot will be required to monitor and control a single UA. Control of multiple UAs from a single ACS may be investigated in future program steps.
- Differences in Level of Automation (LOA) for various UASs will not be considered in the requirements specified in this document. For the purpose of the document a low level of automation will be assumed. Where a low level of automation may require pilot skills to perform a required maneuver, a higher level of automation may require the pilot to monitor the maneuver for correct execution. It is incumbent on the manufacturer to describe the LOA planned for their UAS and to indicate how automation impacts the requirements specified in this document.
- This document only addresses requirements for an internal UA pilot. Requirements for an external UA pilot are out of scope of this effort, but could be included in a document update if specified by the Access 5 System Engineering and Integration Team (SEIT). An external pilot typically controls the UA from outside a shelter analogous to RC operations via a Line of Sight (LOS) link.
- The KSAs described in this report apply to all phases of flight, and not just to operations at or above FL 430.
- The KSAs developed apply to a ferry mission in which the aircraft traverses from one location to another. Pilot KSAs for a "Loiter" Mission were added for this draft.

1.5 DEFINITIONS

a. **Air Control Station.** A site that contains one or more pilot stations used for the control of Unmanned Aircraft (UA). The site should be configured to allow a Pilot In Command (PIC) of the UA to control/monitor all UAS operations that are being conducted under his/her authority

b. **Authorized Instructor**. For UA flight instruction, a flight instructor certificated under Part 61 who is endorsed by the UA manufacturer as being competent to teach those aspects of the UA system that are unique to the model of UA. For UA ground instruction, a certificated flight instructor under Part 61 or ground instructor under Part 61 or Part 143 who is endorsed by the UAS manufacturer as being competent to teach those aspects peculiar to the UAS. The authorized instructor should have

some operating experience in the type of UA operations and make and model of equipment for which s/he is providing instruction.

c. **Control Link**. The system whereby the UA pilots: (1) receive vehicle status and navigation information from the UA, and (2) send commands to the UA. Failure of the system to be capable of receiving information from the UA, or transmitting commands to the vehicle would constitute a loss of the control link.

d. **External Pilot**. A UA pilot who visually controls the UA flight path from a site that provides direct visual contact with the UA.

e. **Instrument Flight Rules (IFR)**. A group of rules whereby the Air Traffic Control (ATC) System, of the NAS, provides positive separation from all other aircraft operating under IFR, from takeoff through touchdown. In order to do this, an IFR flight plan must be filed and an ATC clearance must be issued to the pilot in command. A host of regulations require the pilot to comply with the initial ATC clearance and all subsequent instructions. Any time the pilot cannot comply, for any reason, with an ATC clearance or instruction, that pilot must immediately indicate such and obtain an alternative and acceptable clearance.

f. **IFR Flight Plan**. Provides information pertaining to the pilot, aircraft, and intended flight that forms the basis for issuance of an ATC clearance under Instrument Flight Rules. IFR Flight Plans may be filed for a single flight or for repetitive scheduled flights. IFR flight plans are opened by ATC and will be automatically closed when an IFR flight lands at a location with airspace controlled by ATC. The IFR Flight Plan provides minimal contingency planning information such as an alternate field for the destination and an estimated time enroute (ETE) which, when combined with the actual takeoff time, becomes the estimated time of arrival (ETA) at the destination. This ETA is used by a pilot to comply with rules for dealing with a loss of communications while operating IFR.

g. **Instrument Meteorological Conditions (IMC).** These are conditions of visibility and cloud separation that do not allow for adequate separation of aircraft by visual means.

h. **Internal Pilot**. A UA pilot who operates the UA from a site that does not provide direct visual contact with the UA.

i. **Operator.** This entity may own or coordinate the operation of one or more aircraft. Typically, an operator will coordinate maintenance, servicing, ground services, scheduling and dispatching of aircraft and crews, and provide information and support functions. An operator, due to the nature of the business, may also be certificated under a regulated authority and share some functions and responsibility with a Pilot in Command.

j. **Pilot In Command**. The individual pilot responsible for the operation and safety of the UA in flight. This is the person who is responsible for the operation of an aircraft in motion. Various tasks involved in the preparation and operation of an aircraft in motion might be shared with or delegated to other pilots

k. **Unmanned Aircraft**. An air vehicle that does not carry a human operator, and is capable of flight beyond a visual line of sight, or under remote or autonomous control.

l. **Visual Flight Rules**. A group of rules that allow for an aircraft to fly freely through certain classes of airspace while the pilot provides separation from all other aircraft. The pilot is expected to comply with such regulations that apply to the airspace and location the aircraft is in.

m. **VFR Flight Plan**. Provides information pertaining to the pilot and aircraft that is only used to determine the time and place when a VFR flight is considered overdue and missing. A pilot must specifically open and close a VFR flight plan for it to function as intended. No clearances are required or issued on the basis of a VFR flight plan nor is compliance with a filed speed or route of flight.

n. **Visual Meteorological Conditions (VMC).** A set of standards or criteria of visibility and cloud clearance that allow for separation of aircraft using a "see and be seen" principle. These conditions are required for all operations conducted under Visual Flight Rules. A flight, operating under Instrument Flight Rules that encounters VMC, can be expected to receive ATC separation only from other aircraft operating under IFR. Thus, under VMC an IFR pilot must maintain a watch for aircraft operating VFR. Additionally, a pilot under IFR may elect to accept responsibility to maintain visual separation standards while operating in VMC.

1.6 REPORT ORGANIZATION

Section 2 provides a list of applicable documents.

Section 3 describes the methodological approach that was used to develop pilot KSAs.

Section 4 summarizes preliminary pilot qualifications and KSA analysis results.

Section 5 summarizes preliminary training requirements.

Appendix A provides a list of abbreviations and acronyms.

Appendix B lists the participants at the NASA Ames KSA Meeting and the HSI Pilot Subject Matter Experts.

Appendix C provides a narrative description of Manned Pilot Functions and Responsibilities

Appendix D provides a UA Pilot Task Listing

Appendix E provides the Attendee List for the Medical and Certification Meeting held at CAMI

Appendix F lists the HSI Pilot Subject Matter Experts

2. APPLICABLE DOCUMENTS

The following documents were used to support the development of Pilot KSAs and to identify minimum training requirements:

1. Federal Aviation Administration Title 14 CFR Part 61 Certification: Pilots, Flight Instructors and Ground Instructors
2. Federal Aviation Administration Title 14 CFR Part 91 General Operating and Flight Rules
3. Federal Aviation Administration Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)
4. Federal Aviation Administration Instrument Rating – Practical Test Standards (FAA-S-8081-4D). Flight Standards Service, Washington DC, April 2004
5. Federal Aviation Administration Commercial Pilot – Practical Test Standards for Airplane (SEL, MEL, SES, MES) (FAA-S-8081-12B). Flight Standards Service, Washington DC, August 2002
6. Federal Aviation Administration Advisory Circular Pilot's Role in Collision Avoidance (AC 90-48)
7. Federal Aviation Administration Advisory Circular Crew Resource Management Training (AC 120-51)
8. Federal Aviation Administration Advisory Circular Advanced Qualification Program (AC 120-54), August, 9, 1991.
9. Federal Aviation Administration Advisory Circular Refresher Courses for Private and Commercial Pilots (AC 61-10A), September, 27, 1972.
10. Federal Aviation Administration Advisory Circular – Draft Unmanned Air Vehicle Pilot Qualification and Training, August, 5, 1996.

3. APPROACH

Figure 3-1 illustrates the approach that was used to develop the preliminary HALE UA pilot Knowledge, Skill and Ability requirements. A summary description of the tasks accomplished to provide the preliminary KSAs is provided below.

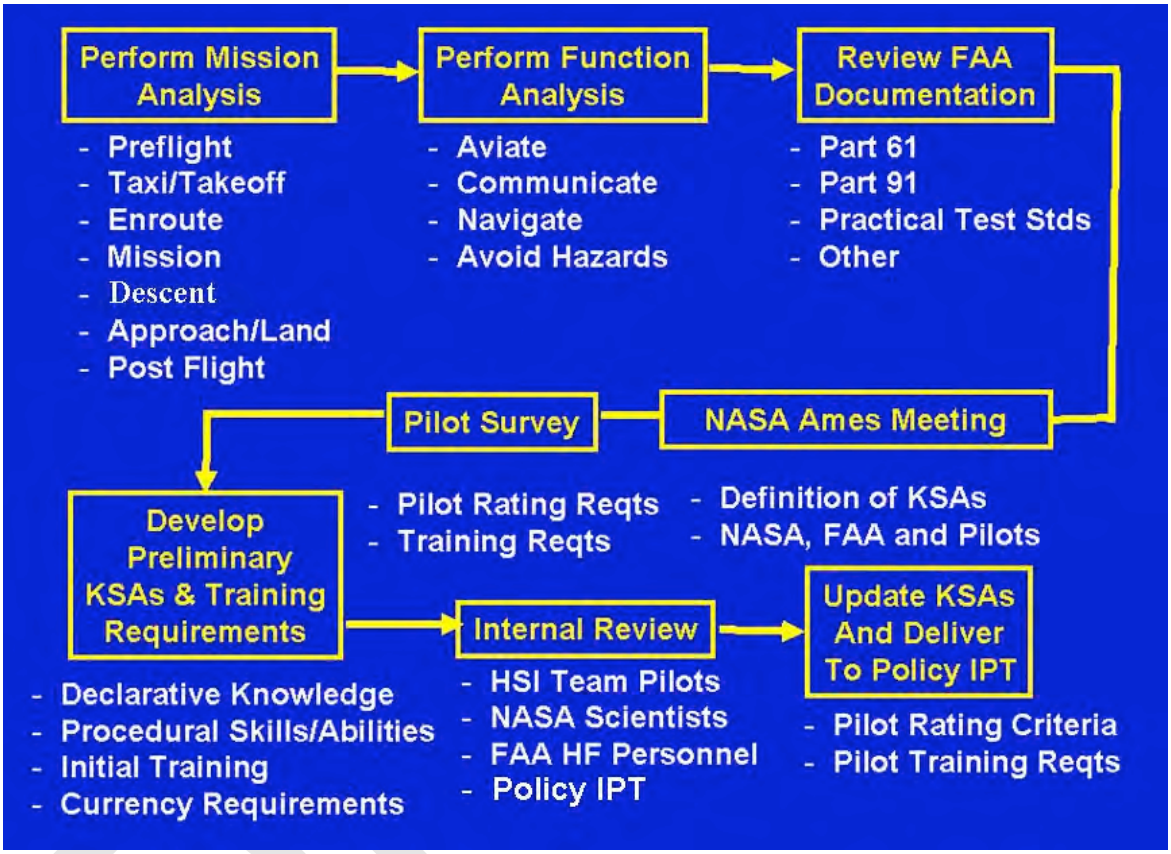

FIGURE 3-1: METHODOLOGY USED TO DEVELOP PRELIMINARY HALE UAS KSAS

3.1 MISSION ANALYSIS

A Mission Anaysis was performed to identify the major tasks and subtasks that the pilot has to perform as a function of mission phase. The Mission Analysis decomposes a mission into discrete mission time periods which has identifiable start and stop points (e.g., Taxi begins when the brakes are released and ends when the aircraft lifts off of the ground, etc.). All mission phases were included in this analysis, from Pre-flight to Post-flight. Tasks were listed in sequential order starting with the initial task that is to be accomplished within a given mission phase, and ending with the last pilot task for each specific phase. The mission phases that are listed below were provided by the ACCESS 5 Policy IPT UAS Working Group. The results of this Mission Analysis are provided in the KSA table presented in Section 4.

Start and stop points for the UAS mission phases are provided below:

- **Preflight** – This phase includes all activities required to plan a mission and to ensure that the aircraft is configured to support the current mission. The mission plan could include a navigation log, a communication plan, and a contingency plan. This phase also includes performing the pre-flight inspection and verifying the health and status of the UA and ACS components.
- **Ground Operations** – This phase begins with the first movement of the UA with intent to fly. This phase also includes communicating with ATC to obtain a flight clearance. This phase ends when the UA crosses the runway hold line.
- **Takeoff** – This phase includes maneuvering the UA to the active runway, applying power, and monitoring/controlling the UA as it proceeds down the runway and lifts off the runway.
- **Climb** – This phase begins when the aircraft is configured for flight (e.g., gear-up, flight surfaces, etc.), and ends when the UA reaches its pre-planned altitude/altitude block.
- **Enroute** – This phase includes all monitoring and control activities performed while the UA is in transit from its originating airport to either a mission area, or to its destination airport. Enroute operations can occur both prior to the UA reaching its mission area, and when the UA transits from the mission area to the destination airport.
- **Mission Operations** – This phase includes all UA and ACS activities performed while the UA is in its planned mission area. This phase starts when the aircraft reaches its mission area, and ends when the aircraft leaves the mission area to proceed to another mission area or to its destination airport. Operations in the mission area typically involve reduced NAS interaction.
- **Descent** – This phase includes all activities that are associated with monitoring/controlling the UA as it descends from its planned/assigned altitude block to the initial approach fix. Note – Phases of flight are not always sequential; it's possible to alternate between enroute, climb, and descent
- **Approach** – This phase includes all activities associated with monitoring/controlling the UA as it prepares to land at the destination or alternate airport. This phase begins when the UA reaches its initial approach fix and ends when the aircraft commits to the landing
- **Landing -** This phase includes all activities associated with monitoring/controlling the UA as it lands on the runway, and ends when the aircraft exits the active runway
- **Post Flight Operations –** This phase includes all activities associated with monitoring/controlling the UA as it exits the active runway, taxies, parks, and shuts down and ends at the completion of the last task/action necessary to close out the flight with flight crewmembers, air traffic, and other flight service providers.

3.2 FUNCTION ANALYSIS

A Function Analysis was performed to identify the major functions that the vehicle systems and UA pilot must perform to accomplish mission objectives. In effect, what the vehicle systems and pilot have to accomplish during the mission define the major system functions (e.g., Aviate, Navigate, Communicate, etc.). For HALE UAS the following major functions were identified. Functional requirements were derived from the ACCESS 5 Function Requirements Document (May, 2005).

3.2.1 AVIATE

The Aviate function includes all systems/equipment provided on the UAS and in the ACS to enable the pilot to monitor and control the aircraft on the ground and in the air for all phases of flight. The UAS shall be able to physically operate on the surface and in the air in a safe and reliable manner that is equivalent to that of manned aircraft. A normal operation has control/monitoring of the aircraft and all of its systems allowing for takeoff, climb, maneuvering, cruise, descent, and landing or recovery. The Aviate function includes:

- Control/monitor aircraft for all flight phases
- Command & Control. The UAS shall be able to command and control the unmanned aircraft
  - Maintain Critical Status Information
  - Convey Critical Status Information to the Pilot in Command
  - Control Aircraft Systems (Electrical, Propulsion, Hydraulic, Avionics, Flight Controls, etc.)
  - Develop, Receive and Select Guidance Commands
  - Display Guidance Commands
- Provide Security to the UAS. The UAS shall provide the necessary level of security to ensure no un-authorized person assumes control of the UAS:
  - Physical Security
  - Data Link Security

3.2.2 COMMUNICATE

The communicate function includes all systems/equipment provided on the UAS and in the ACS to enable the pilot to exchange information (data or voice) with external interfaces outside the UAS: These external interfaces would typically include ATC and/or other aircraft. The Communicate function of a UAS includes:

- Transmitting information to ATC / other aircraft. The UAS shall be able to transmit voice/data communications to ATC / other aircraft.
  - Comply with ATC Clearances (Cooperatively coexist in the NAS)

- Transmitting voice/data messages
- Tuning radio to any ATC frequency
- Participation in lost link procedures
- Tuning and Transmitting Transponder data

o Receive Information from ATC / Other Aircraft. The UAS shall be able to receive voice/data communications from ATC / other aircraft.

- Monitoring Voice Traffic
- Receive Transponder data
- Tuning radio to any ATC frequency

3.2.3 NAVIGATE

The Navigate function includes all systems/equipment provided on the UAS and in the ACS to enable the pilot to monitor and control the aircraft as it proceeds along its pre-specified route, or to alter the route dynamically during a flight. The UAS shall be capable of maintaining navigational control while operating in the NAS. Three essential elements to navigation include maintaining knowledge of the current position, the destination, and how the UA will get to the destination. Navigation functions include:

o Plan Flight and Mission. The UAS shall be able to develop a flight plan to desired destinations. Where a flight plan includes waypoint navigation, communication and contingency operations planning.

- Plan Safe and Secure Missions
- File Mission and Flight Plan

o Determine Current Navigational State. The UAS shall be able to determine its current navigational state. This includes:

- Displaying the location of planned destinations
- Providing the capability to update the current navigational state

o Transition to Destination. The UAS shall transition between various flight legs and waypoints to its desired destination. This includes:

- Displaying the UAs current position and planned destinations
- Providing the capability to modify planned destinations

3.2.4 AVOID HAZARDS

The UAS shall avoid hazards while operating in the NAS. Hazards include terrain, severe weather, and other traffic – both airborne and on the ground. This function also includes System Health Monitoring, and the Caution and Warning function that alerts the crew to abnormal/emergency situations, both internal and external to the UAS. Avoid Hazard functions include:

- Avoid Collisions with Terrain and other Ground Objects. This includes:
  - Avoiding ground obstacles
  - Avoiding Controlled Flight Into Terrain (CFIT)
- Avoid Collisions with other Aircraft. This includes:
  - Avoiding collisions by adhering to ATC guidance
  - Avoiding collisions by maneuvering the UA
- Avoid Severe Weather, Wake Turbulence and Windshear Conditions. This includes:
  - Detecting the presence of potentially hazardous weather cells, and other potential hazards (e.g., Wake Turbulence, Windshear, Icing, Volcanic Ash, etc.)
  - Altering the UA flight path as required to avoid potential weather, environmental and operational hazards
- Manage Contingences. The UAS shall be capable of managing contingencies in a predictable manner. This includes:
  - The UAS shall have the capability to detect or be informed of potential contingencies
  - The UAS shall have the capability to alert the pilot to impending contingencies/degraded system operations
  - The UAS shall have the capability to perform contingency management actions to reduce the likelihood of loss-of-life or damage to personal property at an equivalent level of safety to manned aircraft.
  - The UAS shall have the capability to accomplish predictable contingency management functions with or without pilot intervention

3.3 REVIEW FAA DOCUMENTATION

This task consisted of reviewing FAA documentation related to Pilot Rating Criteria and Knowledge, Skill and Ability (KSA) requirements. The primary documents used to support the conduct of this study are listed in Section 2 (Applicable Documents). Specific uses for several of these documents are listed below.

- **14 CFR Part 61** – Certification: Pilot and Flight Instructors – Defines eligibility, aeronautical, and flight proficiency requirements for pilot certification, ratings and authorizations

- **14 CFR Part 91** – General Operating and Flight Rules – Prescribes flight rules governing the operation of aircraft within the United States
- **Practical Test Standards (Instrument Rating and Commercial Pilot) –** These standards were developed to be used by FAA inspectors and designated pilot examiners when conducting instrument rating and commercial pilot proficiency checks.
- **AC 120-54 (Advanced Qualification Program (AQP))** – The AQP is a systematically developed, maintained and validated proficiency-based qualification and training alternative for personnel operating under FAR Parts 121 and 135 and for evaluators and instructors of recognized training centers

3.4 NASA AMES MEETING

A full day meeting was held in February 2005 at NASA Ames to help define a process for developing KSAs for HALE UA pilots. Participants at the meeting consisted of Access 5 HSI team members from Boeing and Lockheed Martin, Team member pilots for General Atomics Aeronautical Systems, and Aurora Flight Sciences, and NASA and FAA Human Factors subject matter experts. The list of participants is provided in Appendix B.

A long discussion was also held to identify the major differences between inhabited aircraft and UASs. It was determined that the separation of the pilot and the vehicle imposes a number of barriers to optimum human performance:

- Loss of sensory cues, and lack of control feedback/feel. Currently most information in an UA control station is provided visually.
- Delays in control and communication loops
- Difficulty in scanning the environment outside the aircraft and restricted field of view

It was recommended that these differences should be highlighted in the KSA analysis. These barriers to human performance can be overcome, to a certain extent, through the use of innovative HSI techniques. Recommended procedures/techniques for overcoming these barriers are contained in the HSI Design Guideline report **(ACCESS 5 ACS HSI Guidelines, 2005).**

It was also recommended to use definitions from AC No: 12-54 (Advanced Qualifications Program) for Knowledge, Skills and Abilities. Definitions for Knowledge and Skills were provided in this document. However, no definition was provided for ability, even though the word ability is provided in the definition for skill. These definitions are provided below:

Knowledge: Specific information required to enable a student to develop the skills and attitudes to effectively recall facts, identify concepts, apply rules or principles, solve problems and think creatively. This is demonstrated through actual performance.

Skill: An ability to perform an activity or action

The guidance provided from this meeting is reflected in the KSAs presented in Section 4 of this report.

3.5 PILOT SURVEY

A pilot survey was developed and distributed to the HSI ACCESS 5 pilot team. The list of HSI ACCESS 5 pilots is provided in Appendix F. This survey requested that each pilot provide information on requirements for serving as the Pilot in Command for UASs for their respective companies. The following information was requested:

- Pilot Rating Requirements (e.g., Commercial, Instrument Rating, Private Pilot, etc.)
- Flight Hour requirements (manned and UAS)
- Flight Test Experience
- Number of hours of classroom training required
- Number of hours of simulator training required
- Test Requirements
- Additional information as applicable to their respective UASs

The results of this survey are summarized in Section 4 of this report.

3.6 DEVELOP PRELIMINARY KSAS/TRAINING REQUIREMENTS

The preliminary KSA analysis, provided in Section 4, was developed using the results of the Mission and Function analyses, and information derived from applicable FAA FARs and ACs, and from direction by the NASA and FAA Human Factors experts. The current KSA analysis covers all phases of flight with prime focus on normal operations. It is planned to look at abnormal/contingency operations for the next update of this report. For this effort, potential contingency operations will be developed for each flight phase, and pilot KSAs required to counter each contingency will be provided. This effort will be coordinated with the Contingency Management Work Package personnel.

For Step 2 this analysis could be updated to include the impact of automation on pilot KSAs, and what additional KSAs would be required to enable a pilot to monitor/control multiple UASs simultaneously.

3.7 INTERNAL REVIEW

The preliminary KSA analysis has been distributed to all of the HSI Work Package pilots, and to human factors specialists at the FAA and NASA Ames. Review comments are being incorporated as they are submitted.

3.8 DELIVERY TO THE ACCESS 5 SEIT AND POLICY IPT

A draft version of this report was submitted to the ACCESS 5 SEIT and Policy IPT at the end of March, 2005. Two meetings with the Policy IPT were held in July, August, and October, 2005. This version of the report incorporates comments from this Policy IPT review. Remaining activities for 2005 will include:

- Perform KSA Analysis for Degraded/Contingency Operations 10-15-05
- Review KSAs with designated FAA HF personnel 10-30-05
- HSI Team Review 11-15-05
- Submit Report to SEIT 12-15-05

4. PRELIMINARY PILOT QUALIFICATIONS AND KSA RESULTS

This section summarizes the results of the preliminary pilot qualification survey and the results of the KSA analysis. Detailed training requirements, and medical requirements will be added during FY 06.

4.1 PILOT QUALIFICATION SURVEY RESULTS

Table 4-1 presents the results of a survey of pilot qualification for current UASs. The table lists the rating, flight hour (UAS and Manned aircraft), flight test experience, classroom and simulator training and testing requirements for current UASs being flown by companies represented in UAV National Industry Team (UNITE).

TABLE 4-1: SUMMARY OF UNITE PILOT QUALIFICATIONS

HALE UAS	RATINGS REQUIRED	FLIGHT HOURS	UAS EXPERIENCE	FLIGHT TEST EXPERIENCE	CLASSROOM TRAINING	SIMULATOR TRAINING	TESTING	OTHER CAPACITY
Perseus	Commercial Pilot ASEL, or rated military pilot	1500	500 Hours Preferred	Yes	Four Weeks Ground School Systems and procedures	40 Hours Initial 20 Hours Recurrent Demonstrate proficiency for all normal and EPs	Open Book for Aircraft and Ground Control System - Closed Book for Emergencies	
X-45	Rated Military Pilot/ Commercial Instrument Rating	1500	200 Hours	Not required	25 Hours Ground School	4 Sessions, 2 Normal Missions, 2 Emergency Procedure Sessions	Demonstrated proficiency required for all tasks. No test required	2 right seat missions with an IP, 2 left seat missions with an IP After 4 flights pilot is qualified as PIC
Helios /Pathfinder	Minimum, Private Pilot License	200	Not required	Not required	CRM, System Operations Training, Radio Communications 40 hours Ground School	2 Hours per day to maintain readiness- 4 Hours per week during stand down periods	Weekly – Written test on Non-Deferred Emergency Procedures	PIC for a Mobile GCS, the Pilot must be fully qualified as a stationary GCS PIC
Altair	Commercial Instrument ASEL	No Minimum Require-ment	Prior Military Time in Type Preferred	Company Will Train	29 Multi-Part Lessons in a Training Syllabus	Simulator Training Curriculum is Under Development	Open Book, Closed Book, Progress Checks, Flight Tests, Recurrent Qualification Flights	40 Flight Hours, 40 Landings, Instrument Approach Proficiency, Check-Ride with Chief Pilot
Global Hawk	Civilian: Commercial, SEL-Instrument Military: Current	No Minimum Require-ment	Currency: 1 mission W/I 45 days. Taxi or actual takeoff W/I 120 days	None required	192.5 hours Academic	80 hours simulator	Open book, closed book. 88 hours of flight training which includes	6 hours Ground Chase Training

HALE UAS	RATINGS REQUIRED	FLIGHT HOURS	UAS EXPERIENCE	FLIGHT TEST EXPERIENCE	CLASSROOM TRAINING	SIMULATOR TRAINING	TESTING	OTHER CAPACITY
	Military Instrument Rating		Landing W/I 120 days MCE Payload mission W/I 180 days				planning, brief, debrief time.	

4.2 PILOT KSA ANALYSIS

Table 4-2 provides the preliminary KSA analysis results. The current analysis focuses on normal operations. Contingency operations will be added in FY 06. Fundamentally, the UA pilot has two primary responsibilities: (1. ability to work smoothly within the NAS/ATC environment (traffic flow, weather, ATC procedures and direction, etc.) and 2. ability to monitor/control the flight of the UA.

The KSA analysis lists the major tasks to be accomplished by the UA pilot/sub-tasks for each flight phase, the nature of the requirement, pilot Knowledge, Skill and Ability Requirements, and comments that provide additional information on the nature of the requirement, or highlight differences between current manned and UAS requirements.

TABLE 4-2: PRELIMINARY KSA ANALYSIS

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
A. PRE-FLIGHT					
- UA pilot confirms knowledge of elements related to certificates	Qualified in type - Current in type - Current medical	Recent mission Regulatory	- UA pilot privileges/ limitations and recent flight experience requirements - Medical certificate class and duration - Procedures for completing Pilot logbook/Flight Records	- Reading, writing, interpreting FAR's, math skills to Support Mission Planning	POH-Pilot Operating Handbook (Dash One) AFM-Air Flight Manual FAR-Federal Aviation

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			- Operating Limitations, placards, instrument markings and POH/AFM - Knowledge of FARs/ACs		Regulation AC – Advisory Circular
- UA pilot confirms knowledge of elements related to airworthiness requirements	Ensure air worthiness certificate Ensure registration Ensure flight authority	Regulatory	- Required instruments and systems for day/night/IFR conditions and icing - Procedures and limitations for determining UA airworthiness with inoperative instruments and equipment with and without a MEL - Knowledge of FARs/ACs	- Determine mission accomplishment vs. Minimum time airborne vs. minimum fuel consumed - Ability to speak, write and understand English	MEL= Minimum Equipment List Required Maintenance Logs and Inspections
- Determine Departure, Destination and Proposed Alternates	Determine suitable runway and taxiways, appropriate servicing available, appropriate Navaids, FLIP AP/1A restrictions	Assess suitability of destination to support aircraft servicing requirements and security	- Capabilities at selected destination to support the UA - Operations at selected airport to support UA - Location of control stations at destination airport and proposed alternate sites - LOS and BLOS data link coverage capabilities	- Determine if the UA can operate within the confines of the destination airport. - Ability to plan, analyze and decide on the appropriateness of selected destination or alternates	FLIP = Flight Information Publication AP/1A = FLIP Area Planning Special Use Airspace Site Survey Course Rules and Local Procedures
- Determine route of flight to destination	Identify Navaids, fixes, coordinates for route definition, approach, and landing	UAS ability to navigate to destination and/ or alternates Applicable publications available (e.g., approach plates)	- UA Navigation Equipment capabilities and limitations - Aeronautical Charts - Flight Information files, NOTAMs, etc. - IFR rules/requirements - Enroute Navigation Aids - Pilotage and Dead Reckoning techniques - Minimum Safe Altitudes for crossing various types of terrain - LOS and BLOS Data Link Capabilities/Coverage	- Select and correctly interpret applicable en- route charts, instrument departure procedures, RNAV, STAR, and Standard Instrument Approach procedures - Correctly interpret NOTAM information - Determine if the calculated performance is within the UAs capability and operating limitations - Ability to Plan	NOTAM= Notice to Airmen Consider UA Performance Capabilities Data Link Performance and Limitations

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
				- Understand and Plan for appropriate LOS and BLOS data link coverage	
- Assess Weather (Takeoff, Enroute and Landing)	Determine ceiling, visibility, winds in limits for takeoff, enroute and landing operations. Determine presence of enroute hazards, areas of severe weather	UA ability to navigate to destination and /or alternates and hazards to flight Flight plan to weather alternate airfield	- Weather information sources and the impact of weather on aircraft, and system performance (e.g., METAR, TAF, Surface Analysis Charts, and Radar Summary Charts, Winds and Temperature Aloft, Convective, Weather Outlook Charts, etc.). - Weather Avoidance Criteria - Wind Directions and Speeds at Different Altitudes/Locations along the proposed flight route - Freezing levels, and Frost and Ice Removal/ Avoidance Procedures	- Make competent go/ no-go decision based on available information - Plan flight taking into consideration where and when weather may occur - Proceed to alternate and reassess destination weather - Interpret special weather conditions for FL 430 - Reschedule mission based on long duration weather obstacles - Ability to put together a comprehensive picture of the Weather and to forecast the impact of weather along the planned flight route and to determine whether a flight plan change is necessary	Consider weather delay- impact on crew duty cycle METAR = Aviation Routine Weather Aerodrome TAF = Terminal Area Forecast Wind, Precipitation, Icing and Turbulence Conditions Density Altitude
- Determine Altitude and Airspeed between Waypoints	Select altitudes based on aircraft performance, length of route, and hazards to flight/terrain avoidance Select speed based on optimum	Determine enroute time and fuel required.	- UA flight performance capabilities (e.g., Climb, speed, aircraft endurance, fuel burn rates, etc.) - Mission requirements (desired arrival time at destination, etc.) - Inflight Maneuver Limitations	Select altitude as determined by mission requirement, or minimum terrain avoidance, or max performance cruise (max range, max endurance, etc.) for minimum fuel used.	Performance Tables/ Charts

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
	aircraft performance and determine fuel required				
- Determine suitable emergency/alternate airfields	Determine suitable emergency and alternate airfields	Alternate plan for route and destination to comply with weather possible contingencies, weather, abnormal, emergencies, lost link, etc.	- Capabilities at alternate destination to support the UA. - Factors to consider when selecting an alternate landing site - Runway length/width & other factors that impact UA operations - Lost Link procedures - LOS and BLOS Data Link coverage	- Ability to plan, analyze & decide on an appropriateness of alternate destinations - International arena consider political climate in selecting destinations and alternates.	
- Develop Mission Plan, Fill out and File an IFR Flight Plan	Develop "Form 70" or suitable substitute to ensure adequate fuel to accomplish mission, determine fuel reserve	Regulatory Requirement	- Elements related to cross-country flight planning - Use of appropriate and current aeronautical charts - Application of pertinent information from NOTAMs, A/FD and other flight publications - IFR minimums for all classes of airspace, and operating rules - Special Use & other Airspace areas - Procedures for Filing an IFR Flight Plan - Limitations in Communication Links and impact on signal transmission/reception - Strong and weak areas for LOS & BLOS comms (e.g., Satellite footprint/ availability, etc.)	- Skill in using flight planning tools - Ability to Plan - Ability to read, interpret, and use various maps, charts, forms, etc - Skill in map reading - Ability to complete proper form for flight plan to gain access to controlled airspace - Capability to analyze enroute, arrival and alternative landing site weather conditions & forecasts - Use mission, navigation & weather data to plan mission	Form 70 = Pilot Flight Plan and Flight Log A/FD = Airport Facility Directory Flight Plan Form FAA Form 7233-1 Flight Planning Computers/Software Commercial Wx and Flight Planning Programs
Apply GO/NO-GO criteria for equipment aircraft	Assess system and weather status to make	Back up plan	- Application of ALL mission abilities added to analysis of developing	Extensive sensor systems and aircraft systems knowledge.	Risk Management Hazard Awareness

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
special requirement. Apply weather criteria for GO/ NO GO Apply minimum equipment list to GO/NO-GO criteria	GO/NO-GO Decision		weather phenomenon. Systems knowledge in development of aircraft sub systems loss/damage as it applies to risk analysis for mission accomplishment - Knowledge of criteria for making a GO/NO-GO Decision	Understand rationale for development of GO/ NO-GO criteria.	Operational Risk Assessment Management
Determine crew readiness	Determine health status of crew members Determine alertness levels of crew		- Crew duty requirements - Alcohol and drug prohibitions and limitations - Rest requirements	Ability to self analyze current and future physiological and psychological state to ensure safe operation of the UA	Crew Brief
B. GROUND OPERATIONS					

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
- Perform Preflight Inspection and Verify Health and Status of UA and control station	Pre-Flight Inspection Communicate with ground support personnel to assess UA status	Ensure readiness of UA and ACS at departure destination, and alternate airports	- Elements related to performance and limitations of aircraft systems and the impact of exceeding specified limitations - Knowledge of Flight Manual - Required instruments and equipment for day/night IFR - Procedures for determining airworthiness of the airplane with inoperative instruments & equipment with and without a MEL - Procedures for determining the Health & Status of the UA and ACS - Failure Modes and System Limitations - Procedures for Fault Isolation & correction - Procedures for establishing LOS & BLOS Communication Links and Frequency Management - Data Link limitations - Functioning of the ACS and the UA for performing the required mission	- Ability to judge whether safe flight can be conducted - Skill in operating aircraft and avionics systems - Ability to take corrective actions - Ability to establish & verify a command and control link to the UA	Might be the responsibility of ground crew personnel and not the UA pilot According to current FARs, the PIC (pilot in command) is responsible for determining the airworthiness of an aircraft before flight. Segment PIC verifies Mx Logs and Inspections PIC performs acceptance checklist/ inspections
- Start Engine and System Initiation	Perform all steps required to start engines and to apply power to required systems	Preparation for flight	- Engine start procedures & limitations - Indications of normal operations, and procedures for applying power, verifying the status of applicable aircraft systems. Flight Information, etc.) - Use of Appropriate checklist(s) - Procedures for applying power to required systems	Skill in accomplishing start procedures and use of engine start controls.	Internal/External Power Ground Power Unit or Airstart

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
- Receive Flight Clearance	Contact ATC, record clearance, acknowledge changes to filed flight plan	Regulatory requirement	- Communication procedures with ATC - Procedures for using ACS equipment to communicate with ATC (e.g., selection of radio, appropriate frequency, etc.) - Communication equipment and procedures - Appropriate ATC phraseology	- Ability to judge appropriateness of ATC instructions - Ensure credible, clear instructions - Understand English language (ICAO) standard)	UA Limitations
- Taxi to Runway/ Support Taxi Operations	Contact ATC and follow instructions Know airfield layout and directed taxi route. Avoid obstacles	Ground controller requirement	- Elements related to safe taxi procedures - Brake test procedures - Procedures for manipulating flight controls properly for current wind conditions - Procedures for complying with airport/taxiway markings, signals, ATC clearances and instructions - Procedures for accomplishing ground operations at non-towered airports	- Skill in taxiing aircraft - Skill in monitoring aircraft systems to assess system performance during taxi operations - Skill in identifying & avoiding obstacles - Ability to read and follow airport taxi diagrams - Knowledge of operating procedures at controlled and uncontrolled airports	Note: In the case of long, low wing HALE UAs landing lights and signs can sometimes pose a hazard to ground operations
- Perform Pre-Takeoff Checks and Prepare for Takeoff	Complete systems checks Ensure proper operations of flight instruments and the entire UA	Safety of flight and aircraft readiness	- Elements related to before takeoff check, including pre-flighting instruments, avionics, and navigation equipment - Procedures for detecting and rectifying malfunctions - Procedures for performing the before takeoff checklist - Takeoff performance airspeeds, takeoff distances, departure and	- Ability to read, understand and perform checklist items. - Skill in locating and using specified controls to obtain the desired outcome	Plans Loaded and verified Data link verified

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			emergency procedures - Procedures for avoiding runway incursions		
- Execute Ground and Tower Instructions	Hold short, taxi on to position and hold, takeoff immediately, abort, and taxi back	Airfield controller requirement	- Elements related to ATC communications - Procedures for selecting the appropriate communication frequencies - ATC communication phraseology/protocols - Procedures for acknowledging ATC communications and complying with instructions - Base, runway, and taxiway operations with emphasis on incursion avoidance	- Ability to comply with tower instructions - Skill to adapt to back up plan during emergency airfield operations.	
- Prepare aircraft sensors for takeoff phase of flight Power up/down required aircraft systems	Sensor knowledge and operational limits (time on ground to avoid internal heat limits).	Proper care and operational procedures for required equipment	- Knowledge of sensor limits to environmental conditions - Knowledge of environmental conditions (hot day) - Power and time limitations	- Read and accomplish checklist items - Ability to configure sensor equipment, if required - Ability to understand sensor displays and malfunction indications	Sensors required for See and Avoid, Nav, etc. are within scope. Sensors to support mission operations are not included in this analysis

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
C. ALL FLIGHT PHASES					
- Airmanship and General Piloting Knowledge & Skill - General UA Knowledge and Knowledge and Ability to respond to Contingency/ Emergency Operations - Loss Comm/Data Link Failures - Monitor Health and Status of UA and Avionics Systems - Engine Failure - Structural Failure - System Failure (e.g, Electrical, Hydraulic, Fuel, Navigation, Communication, etc.) - Hazard Avoidance - Wx Avoidance - Failures in the ACS - Avoid Pilot Induced Oscillations (PIO)	Aircraft requirements and limitations Aircraft handling Requirements of operating within the NAS Monitoring system performance and responding to alerts	Fly the aircraft with precision within the larger operational environment Safety of flight	- Aircraft performance requirements and limitations and the impact of exceeding specified limitations - Required instruments and equipment for day/night IFR - Procedures for determining airworthiness of the airplane with and without inoperative instruments & equipment, and with and without a MEL - Data Link limitations - Spatial disorientation, fatigue & countermeasures to these threats - Adverse effects of illness/injury & medications - Elements related to attitude instrument flying during straight-and-level, climbs turns, and descents while conducting various instrument flight procedures - Unsafe flight attitudes and recovery procedures - Stall characteristics and stall recovery procedures - Causes and prevention of Pilot induced Oscillations - Communication requirements and procedures with ATC - Operations at controlled and uncontrolled airports - UA and ACS operations and Emergency Procedures - Normal and Abnormal Checklist Procedures	- Demonstrate good Aeronautical Decision-Making - Maintain Situational Awareness - Ability to visualize - Demonstrate Tactical Planning Skills - Maintain control of the aircraft at all times - Instrument scan, crosscheck and interpretation procedures - Integration of instrument scan with scan of other displays - Ability to stay ahead of the UA to enable a rapid response to unplanned mission events & contingencies - Ability to recognize Spatial Disorientation and causes of PIO - Ability to compensate for response lags from pilot control input to display feedback - Ability to apply knowledge of aircraft system operations and emergency procedures to safely & effectively avoid/mitigate against unplanned mission events, contingencies and emergency events	Due to longer response times between pilot control input & display feedback, a UA pilot should stay ahead of the aircraft Since pilots will view the world through a 2-D displays, the ability to visualize objects in 3-dimensional space, and the ability to mentally project themselves into the flight environment will be important skills for UA pilots Detailed knowledge of the Emergency Procedures is required Responses to Emergencies should be memory items, whereas responses to abnormal/caution conditions/events can be aided by on-line or a hard copy of the flight manual Sample Contingency Operations include: - Loss of Command / Status links - Aircraft Mechanical Failures - Obstacle avoidance - Loss of Comm w/ATC

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
D. TAKEOFF/ CLIMB OUT					
- Perform Takeoff	Configure Aircraft	Accelerate aircraft on the ground to transition to flight environment.	- Procedures for configuring the aircraft for take-off	- Checklist and system use, including aircraft sensors	Avoid hazards
	Communicate with Tower and comply with instructions		- Knowledge of communication procedures for towered and un-towered airports	- Recognize radio instructions	
	Comply with Wake Turbulence Restrictions		- Knowledge of Wake Turbulence effects and restrictions	- Ability to recognize Wake Turbulence conditions and to accomplish avoidance procedures	
	Maintain Directional Control through Liftoff		- Procedures for accomplishing normal and crosswind takeoffs	- Ability to monitor/control the UA during takeoff	
	Assess go/no-go decision. Abort takeoff if necessary		- Aircraft takeoff performance characteristics, airspeeds, and adjustments due to atmospheric conditions, emergency procedures, and abnormal performance indications	- Recognize poor performance/ abnormal indications and perform abort/emergency procedures as dictated by the situation	
- Climb IAW Departure Instructions	Traffic/terrain avoidance and right of way		- Right of Way rules, Sense and Avoid system operations, local terrain	- System operation	
- Contact departure control for IFR Identification or VFR advisories	Communicate with ATC as required	ATC instructions to maintain require clearances while entering route structure	- ATC clearances and pilot/controller responsibilities - Limitations of aircraft in terms of the ability of the UA to comply with ATC messages - Procedures for requesting clarification, verification	- Copy and correctly interpret ATC messages - Ability to operate radio and navigation equipment	Always fly the UAS first, any other task is secondary, this includes radio communications. Aviate, Navigate and Communicate

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			and changes - Frequency Management - Standard Phraseology for reading back clearances - Appropriate communications and navigation system transponder codes in compliance with the ATC clearance		
- Monitor/Control aircraft to comply with instructions and flight plan	Control the UA during Climb	Pilot's primary responsibility	- Standard Instrument Departure procedures - Aircraft best climb profile - Wake Turbulence Avoidance Procedures - IFR and VFR flight procedures	- Basic UA instrument monitor control - Skill in using ACS interfaces to access required information	Basic Attitude Instrument skills
E. ENROUTE					
Monitor Flight to maintain compliance with instructions/ flight plan Back up navigation	Maintain assigned altitude, airspeed and route of flight. Adjust route of flight, as required	Regulatory	- Aircraft and avionic system performance monitoring requirements - Procedures for identifying & resolving system problems - Unsafe flight attitudes and recovery procedures - Stall characteristics and	- Control UA - Ability to interpret instruments for UA attitude, flight path and energy state - Ability to interpret weather related information - Ability to change	Compliance with Reduced Vertical Separation Minimums (RVSM) requirements

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			stall recovery procedures - Instrument crosscheck and interpretation procedures - Procedures for obtaining weather related data and using this data to decide whether a flight plan change is necessary	navigation log, if required	
- Maintain contact with controlling agency	Change frequencies as required, and communicate with ATC as required/ directed	ATC Requirement	- Procedures for maintaining contact with ATC - Procedures for changing frequencies to comply with ATC instructions - Procedures for communicating with ATC	- Ability to speak clearly and concisely with proper terminology - Ability to interpret radio communications - Ability to operate radio and transponder	
- Recheck enroute and destination airfield weather.	Monitor displays, radio, etc to assess potential weather or traffic impacts on current flight plan	Safety of flight	- Procedures for acquiring weather and traffic information and for making decisions of whether these conditions will impact current flight plan - Weather Avoidance Criteria - Windshear detection and avoidance procedures - See and avoid concept	- Access required weather information - Assess impact of weather on aircraft performance and navigation/flight plan - Perform required avoidance maneuvers within the capabilities of the UA	
- Adjust Flight Plan	Coordinate or receive instructions from ATC to change flight plan.	ATC Requirement	- Procedures for determining whether a flight plan change is required - Procedures for changing the UASs flight plan - Procedures for communicating flight plan changes to ATC	- Ability to respond to unplanned changes in a safe and efficient manner	FMS or Mission management software knowledge
- Perform control handoff to another ACS, if required	Establish appropriate data links with receiving station	Aircraft Control	- Procedures for accomplishing handoff - Procedures for transitioning between LOS and BLOS	- Ability to perform handoff - Skill in applying CRM principles	Difference between manned and UAs is that for the UA the handoff may not take place at the same location.

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
	Use appropriate checklist		communications - Knowledge of Crew Resource Management (CRM) procedures		Handoff could take place between different ACSs Sharing situational awareness and systems awareness among a virtual crew (not physically collocated) is a new and very challenging aspect of UAS operations.
F. MISSION OPERATIONS – (LOITER MISSION)				**For the purpose of this analysis, this mission will be characterized as a long endurance Loiter that involves reduced ATC interaction**	
a. Aviate					
- UA Monitor and Control	Monitor UA flight performance Maintain assigned altitude, airspeed and route of flight.	Regulatory	- Procedures for maintaining control of the aircraft at all times - Procedures for maintaining Situational Awareness - Unsafe flight attitudes and recovery procedures - Stall characteristics and stall recovery procedures - Instrument crosscheck and	- Control UA - Ability to interpret instruments for UA attitude, flight path and energy state - Demonstrate good Aeronautical Decision-Making - Maintain Situational Awareness - Ability to stay ahead	For this mission it is expected that extensive Aviation skills may not be required, other than monitoring UA and System Health and Safety (H&S)

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			interpretation procedures	of the airplane to enable a rapid response to unplanned mission events and contingencies - Ability to compensate for response lags from pilot control input to display feedback	
- Monitor the Health and Status of UA and its systems	- Monitor UA and system performance - Detect potential abnormal/ emergency conditions - Resolve potential problems	Safety	- Aircraft and avionic system performance monitoring requirements - Procedures for identifying and resolving system problems - Instrument scan, crosscheck and interpretation procedures - Integration of instrument scan with scan of other displays	- Ability to apply knowledge of UA system operations and emergency procedures to avoid/mitigate against unplanned mission events, contingencies, and emergency events - Skill in using ACS interfaces to access required information - Ability to recognize Spatial Disorientation and causes of PIO - Ability to compensate for response lags from pilot control input to display feedback	For this type of mission, it is expected that this will be the primary duty for the UA Pilot/Observer.
b. Navigate					
- Make changes to Flight Plan as required, or as directed by ATC	- Monitor current aircraft position vs. current position - Decide if a Flight Plan change is required to reacquire the planned track - Execute the required flight	Regulatory and Flight Safety	- UA Navigation equipment and procedures - Current flight plan and mission objectives - Procedures for obtaining weather related data and using this data to decide whether a flight plan change is necessary	- Map reading skill - Ability to use UA Navigation equipment to monitor UA position and to determine whether a change in flight plan is required to maintain planned track, or to adjust flight plan due to changing weather, mission requirements, or	It is expected that for a vast percentage of mission time, the UA navigation will be controlled via automation. For normal operations limited pilot intervention will be required.

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
	maneuvers to reacquire Planned track - Maneuver UA as required to comply with ATC directives			ATC directions	
c. Communicate					
Change frequencies as required, and communicate with ATC as required/ directed	Communicate with ATC, as required Communicate with Mission Management, as required	-ATC Requirement	- Procedures for maintaining contact with ATC - Procedures for changing frequencies to comply with ATC instructions - Procedures for communicating with ATC	- Ability to speak clearly and concisely with proper terminology - Ability to interpret radio communication - Ability to operate radio and transponder	For this type of mission it is expected that communications with ATC will be minimized (Normal Operations)
d. Avoid Hazards					
- Avoid potentially hazardous Weather	Monitor weather in area of operations Identify Potentially hazardous weather cells Change flight plan to maneuver around hazardous weather cells	Safety	- Procedures for obtaining information on weather conditions in the area of operations - Ability or UA to withstand various types of potential weather hazards - Procedures for assessing the potential impact of weather on UA system performance/survivability	- Ability to detect potential weather Hazards - Ability to determine the hazard level of weather cells - Ability to predict/determine the direction and speed of weather cells - Skill in Hazard Avoidance	It is expected for this phase of flight hazard avoidance will be one of the primary roles/ responsibilities for the UA pilot/system manager. It is also expected that an integrated caution and warning system will be required to aid pilot vigilance
- Avoid Traffic	Monitor traffic in area of operations Assess impact potential Maneuver aircraft to avoid a	Safety	- Procedures for obtaining traffic information - Procedures for responding to collision avoidance cautions and warnings (Right-of-way rules) - Maneuvering capabilities / limitations of the UA - Procedures for informing	- Ability to detect potential traffic Hazards - Skill in Hazard Avoidance - Ability to use traffic avoidance decision aids, if provided - Ability to assess the	Time permitting, planned maneuvers should be coordinated with ATC prior to accomplishing the maneuver. For unplanned maneuvers, ATC should be informed

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
	collision		ATC of flight maneuvers made to accomplish a required avoidance maneuver - Pilot roles and responsibilities for collision avoidance	effectiveness of collision avoidance maneuvers	during or after-the-fact that a deviation has been made from clearance to avoid a collision
G. DESCEND					
- Obtain Updated Weather Information	Access Weather Information and Assess impact of weather for approach and landing operations	Check suitability of destination for landing	- Procedures for acquiring weather information - Impact of weather on aircraft performance and landing operations	- Using available resources to obtain required weather information - Skill in assessing impact of weather on aircraft performance - Determine appropriate top of descent point - Ability to select and use the appropriate approach charts	
- Monitor/Control Aircraft to Holding or Approach Fix	Monitor/ control UAS position to designated fixes/ navigation points	Safety of Flight	- Holding Pattern Procedures, and preferred method for entering holding patterns - Procedures for monitoring/controlling the flight of the UA - Instrument or Visual Approach procedures	- Skill in monitoring/ controlling the flight of the UA - Ability to use navigation equipment to follow designated flight plan	
- Enter and Maintain Holding Pattern, if required	Fix to Fix Navigation, or follow controller directions and maintain holding pattern IAW established procedures	Position aircraft to support arrival flow	- Holding pattern procedures, and preferred methods for entering holding patterns - Procedures for controlling the UA in support of Holding Operations	- Control UA while accomplishing standard, non-standard, published, or non-published holding patterns - Use proper wind correction procedures to maintain desired pattern & to arrive over the fix as close as possible to a	

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
				specified time - Recognize arrival at the holding fix and to initiate prompt entry into the holding pattern - Comply with ATC reporting requirements	
- Execute Controller instructions relating to heading, speed & altitude	Adjust heading, speed or altitude as required, monitor and avoid traffic Communicate with ATC/ Tower as required	Maintain separation from other traffic	- Procedures for monitoring/controlling UA heading, speed and altitude - Procedures for maintaining awareness of traffic and procedures for minimizing the potential for traffic conflicts (for both IMC and VMC conditions)	- Monitor/control UA to accomplish the appropriate approach procedure within given criteria - Skill in traffic awareness and conflict resolution procedures	There needs to be some alternate way for UA pilots to communicate with tower ATC when comms are down. With piloted aircraft, this is done through the use of light gun signals. If at base of operations – secondary radio, otherwise, telephone
H. ARRIVAL AT DESTINATION/ APPROACH					
- Fly approach procedure to landing	Monitor/ control UA to navigate to designated approach fixes/points	Maintain separation from other traffic and terrain	- Elements related to an instrument approach - Procedures to establish communications with ATC and the use of proper phraseology and technique - Procedures for appropriate aircraft configuration and airspeed considering turbulence and windshear, if applicable - Procedures for using	- Monitor/control UAS to accomplish the appropriate approach procedure within given criteria - Recognize arrival at the holding fix and to initiate prompt entry into the holding pattern - Comply with ATC reporting requirements	MDA= Minimum Descent Altitude DH = Decision Height LNAV/VNAV Minimums Concern over whether UAs can fly "published" approaches

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			navigation equipment to support the approach - Necessary adjustments to published DH, MDA and visibility criteria - Missed approach procedures - UAS cross wind limitations, and procedures for landing in a Cross Wind	- Recognize if any flight instrumentation is inaccurate or inoperative, and to take the required remedial action - Perform a Go-Around Procedure if conditions warrant - Ability to land in Cross Wind	
- Avoid weather, traffic, and other obstacles	Monitor weather and traffic displays and take required evasive maneuvers	Safety of flight	- Procedures for acquiring weather & traffic information & for making decisions of whether these conditions will impact current flight plan - Procedures for changing flight plan to avoid weather/traffic - Weather Avoidance Criteria - Wake turbulence separation minimums and avoidance procedures - Windshear detection and avoidance procedures - See and avoid concept - Minimum IFR/VFR weather visibilities and distances	- Access required weather information - Assess impact of weather on aircraft performance and landing operations - Perform required avoidance maneuvers within the capabilities of the UA - Skill in conflict/ collision avoidance - Identify adequate visual reference to fly below minimum	
- Ensure proper configuration for landing Gear Flaps Speed Brakes Other equipment status, when to turn off	Knowledge of individual subsystems & their functions (gear, flaps, speed brakes, etc.)	Proper configuration for aircraft fuel remaining and plan to land	- Aircraft CG limits - Approach speed for fuel/ aircraft weight - Landing configuration for weather (wind, ceiling, visibility) - Unusual configuration for emergency approach and landing. - Crosswind landing	- Configuration management - Ability/skill to land with crosswinds up to the maximum allowable for the air vehicle	Consider headwind tailwind limits as well CG = Center of Gravity

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
			procedures and aircraft limitations		
Missed Approach or go around, if required		Contingency Operations	- Missed Approach Procedure - Required Aircraft Configuration and Performance - Contingency Plan	- Recognize inadequate visual references - Comply with ATC-directed missed approach - Configure Aircraft for Missed Approach & Climb - Perform Missed Approach Procedure - Proper go-around decisions & techniques	Missed Approach or go around if required
I. LANDING					
- Monitor/ Control aircraft during Landing Operations	Use of aircraft subsystems (engine, brakes) to maneuver aircraft on the ground.	Safety of Flight	- Landing gear operation - Minimum safe altitudes for crossing various types of terrain/airport obstructions - Skill in monitoring/ controlling the flight of the UA - Ability to use navigation equipment to follow designated flight plan - Spatial disorientation, fatigue & countermeasures to these threats	- Same as taxiing before takeoff - Exercise additional caution at unfamiliar destination airport. - Cross wind operations - Maintain spatial orientation (visual illusions, 3D world presented on a 2D display).	It has been DoD's experience that this is the phase that is most ripe for perceptual disorientation with regards to the runway. Spatial disorientation during the enroute phase is much less likely because there is no stimulation of the vestibular or propio-ceptive systems and thus less chance for incongruent sensory inputs.
- Contact ATC & follow instructions	Use of radio	Regulatory	- Taxi procedures - Ground operation of aircraft subsystems (engine, brakes, etc.).	- Perform ground operations of aircraft to final parking.	

FLIGHT PHASE/ PILOT TASK	SUB-TASKS	NATURE OF REQUIREMENT	KNOWLEDGE REQUIREMENTS	SKILL/ABILITY REQUIREMENTS	COMMENTS
J. GROUND OPERATIONS					
- Exit Runway & Taxi to Parking area	Maneuver aircraft as directed/ required.	Position aircraft off runway enroute to final parking position.	- Taxi procedures. - Aircraft ground operations.	- Perform checklist actions - Maneuver aircraft on the ground - Operate aircraft and sensor systems as necessary in preparation for engine shutdown.	Same KSAs as 1.15 (Taxi to Runway – Support Taxi Operations)
- Notify Ground Control when clear of runway – Comply with ATC Directions	Communicate on the radio	Communicate and coordinate instructions for safe aircraft movement.	Radio procedures	Communicate via voice in English.	
- Receive clearance to Taxi to Parking area	Avoid obstacles, same as taxi for takeoff. Request assistance with unfamiliar environment or uncertain instructions	Same as above	Same as above	Same as above	
- Avoid Hazards	Monitor taxi operations & avoid incursions	Safety	- Identify types and potential locations of known and suspected hazards - Knowledge of airfield operations - Knowledge of local hazards as published in NOTAMS	- Ability to detect potential Hazards - Skill in Hazard Avoidance	
- Park Aircraft	Monitor/ control UA to designated Parking area and Park Aircraft	Position aircraft for servicing and maintenance prior to next flight.	- Position aircraft for future servicing and maintenance - Perform shutdown procedures	Park aircraft	

4.3 INITIAL UA PILOT TRAINING REQUIREMENTS

Training requirements should be based on Pilot KSAs that are applicable to a given ACS. The KSAs provided in Table 4-2 should be used as a basis for developing a UA pilot training program. Training requirements should also be based on the level of autonomy/automation used within the UAS to perform the UA aviate, communicate, navigate and avoid hazard functions. Another determinant of training requirements is the intended purpose/mission of the UAS. The impact of automation on pilot KSAs and training requirements will be assessed during Step 2. Training requirements associated with specific mission requirements is the responsibility of the manufacturer/operator and is out of scope for ACCESS 5.

For the purpose of this analysis, it is assumed that the trainee is a FAA rated pilot. The development of recommendations for specific pilot rating requirements is the responsibility of the ACCESS 5 Policy IPT.

Based on the information in Table 4-2 and requirements derived from Draft FAR AC for Unmanned Air Vehicle Pilot Qualification and Training, preliminary UA pilot training requirements are provided below.

- **Equivalent Level of Training** – Prior to operating a UA without direct supervision of an authorized instructor, the UA pilot should, at a minimum, have the training and experience in the safe operation of the specific UA being operated equivalent to that required for a pilot of an aircraft having similar performance characteristics under similar air traffic and weather conditions. General requirements include:
  - Ascertain the airworthiness of the UA
  - Possess the knowledge, skill and abilities to safely operate the UA in the NAS for all phases of ground and flight operations
- **Ground Instruction** – A person wanting to operate a UA should, prior to operating the air vehicle without direct supervision of an authorized instructor, receive ground instruction relevant to the safe operation of the UA within the NAS. Instruction should cover at least the following areas:
  - Pilot in Command (PIC) responsibilities
  - ACS system operation
  - Structures, flight controls, electrical, navigation, propulsion, communication, flight termination, Detect, See and Avoid, and control link systems description and principles
  - Aircraft performance data/limitations
  - Flight instruments, displays and interpretation
  - Inoperative instruments and equipment
  - Emergency equipment and procedures (e.g., Loss Link procedures)
  - Flight checklists and use

- UA performance capabilities (altitude, airspeed, vertical velocity, flight envelope, etc.)
- IFR operations in controlled airspace
- Weather limitations
- Use of automation, as applicable
- Crew Resource Management

- **Aeronautical Knowledge** - Prior to operating a UA without the direct supervision of an authorized instructor, a person wanting to operate a UA should complete a test administered by an authorized instructor covering, as a minimum, all of the knowledge areas listed above. The instructor should ensure that remedial instruction is provided in the knowledge areas in which the student is determined to be deficient. **(Question: Who determines the deficiency and what criteria are used)? Use of a Biennial Flight Review? Current piloted reviews do not have pass/fail criteria?**
- **Instructional Flight Experience and Proficiency** – Pilots should be trained on the specific make and model of the UA that they will operate (equivalent to a Type rating for manned aircraft). This does not preclude computer-aided training or simulation. Because a UA pilot is not subject to all of the types of sensations and feedback available to pilots of manned aircraft, computer-aided training and simulation are well suited for providing UA instruction. Training supplemental to that received under Part 61 should be obtained particularly with respect to §## 61.107 and 61.109 because range and duration of flight may be significantly different from manned aircraft. The prospective UA pilot should have logged instruction from an authorized instructor, and the applicant's logbook should contain an endorsement by the authorized instructor who has found the applicant competent to perform the operations listed in §# 61.107, as appropriate for the UA make and model. Appropriate operations should include those operations the prospective pilot can be reasonably expected to perform, and should include normal, abnormal and emergency procedures.
- **Practical Test** - Prior to operating a UA without the direct supervision of an authorized instructor, a person wanting to operate a UA should complete a practical test, including both oral and flight/simulator components. This practical test should be administered by an authorized instructor and should be in the format of an FAA-approved private pilot practical test.
- **Recency of Experience** – Each UA operator should establish its own recency of experience requirements for its UA pilots. **(Question: Should the FAA establish a legal minimum that is applicable to all UAS operations?)** At a minimum, the following criteria are recommended for a pilot to operate a UA without direct supervision of an authorized instructor;
  - Three actual/simulated takeoffs and landings to a full stop in a UA of similar type within the previous 90 days
  - Satisfaction of recency requirements for IFR flights

4.4 INITIAL UAS PILOT MEDICAL REQUIREMENTS

4.4.1 PRELIMINARY STANDARD

In the draft FAA Advisory Circular on Unmanned Air Vehicle Pilot Qualification and Training, preliminary Medical Qualifications were listed as:

- **Pilot/Observer Medical Standards**. Pilots and observers must have in their possession a current third class (or higher) airman medical certificate that has been issued under 14 CFR 67. 14 CFR 91.17 regulations on alcohol and drugs apply to both UA pilots and observers.

Because, the ACS is not subject to rapid changes in atmospheric pressure, physical ailments due to barometric sensitivity as anticipated in 14 CFR # 67.17(c) may be waived with the appropriate marking on the medical certificate "UAS operation only" **(Note: ACS might not be on the ground- Therefore the pilot might experience rapid changes in atmospheric changes! Not sure that this would occur for civil/commercial operations, but it could!)**

Table 4-3 lists the FAA requirements for the three levels of Medical Certification.

TABLE 4-3: MEDICAL CERTIFICATION CLASSES

Certificate Class Pilot Type	First-Class Airline Transport	Second-Class Commercial	Third-Class Private
DISTANT VISION	20/20 or better in each eye separately, with or without correction.		20/40 or better in each eye separately, with or without correction.
NEAR VISION	20/40 or better in each eye separately (Snellen equivalent), with or without correction, as measured at 16 inches.		
INTERMEDIATE VISION	20/40 or better in each eye separately (Snellen equivalent), with or without correction at age 50 and over, as measured at 32 inches.		No requirement.
COLOR VISION	Ability to perceive those colors necessary for safe performance of airmen duties.		
HEARING	Demonstrate hearing of an average conversational voice in a quiet room, using both ears at 6 feet, with the back turned to the examiner or pass one of the audiometric tests below or:		
AUDIOLOGY	Audiometric speech discrimination test: (Score at least 70% discrimination in one ear) or:		

Certificate Class Pilot Type	First-Class Airline Transport	Second-Class Commercial	Third-Class Private
	Pure tone audiometric test: Unaided, with thresholds no worse than: 500Hz 1,000Hz 2,000Hz 3,000Hz Better Ear 35Db 30Db 30Db 40Db Worst Ear 35Db 50Db 50Db 60Db		
EAR, NOSE, THROAT	No ear disease or condition manifested by, or that may reasonably be expected to be manifested by, vertigo or a disturbance of speech or equilibrium.		
BLOOD PRESSURE	No specified values stated in the standards. 155/95 Maximum Allowed.		
ELECTRO-CARDIOGRAM	At age 35 & annually after age 40.	Not routinely required.	
MENTAL	No diagnosis of psychosis, or bipolar disorder, or severe personality disorders.		
SUBSTANCE DEPENDENCE & SUBSTANCE ABUSE	A diagnosis or medical history of substance dependence is disqualifying unless there is established clinical evidence, satisfactory to the Federal Air Surgeon, of recovery, including sustained total abstinence from the substance(s) for not less than the preceding 2 years. A history of substance abuse within the preceding 2 years is disqualifying. Substance includes alcohol and other drugs (i.e., PCP, sedatives and hypnotics, anxiolytics, marijuana, cocaine, opiods, amphetamines, hallucinogens, and other psychoactive drugs or chemicals.)		
DISQUALIFYING CONDITIONS Airman with these conditions may still be eligible for "**Special Issuance**" of a medical certificate.	Examiner must disqualify if the applicant has a history of: (1) Diabetes mellitus requiring hypoglycemic medications; (2) Angina pectoris; (3) Coronary heart disease that has been treated or, if untreated, that has been symptomatic of clinically significant; (4) Myocardial infarction; (5) Cardiac valve replacement; (6) Permanent cardiac pacemaker; (7) Heart replacement; (8) Psychosis; (9) Bipolar disease; (10) Personality disorder that is severe enough to have repeatedly manifested itself by overt acts; (11) Substance dependence; (12) Substance abuse; (13) Epilepsy; (14) Disturbance of consciousness without satisfactory explanation of cause; and (15) Transient loss of control of nervous system function(s) without satisfactory explanation of cause.		

4.4.2 Development of Occupational Medical Standards

The information contained in this section is based on the minutes of a meeting that was held at the FAA Civil Aerospace Medical Institute on July 26, 05. The purpose of the meeting was to discuss UA pilot medical and certification requirements. The attendees of this meeting are listed in Appendix E. A summary of the major decisions applicable to medical requirements are provided in the following paragraphs.

Basically, there are two separate reasons for the establishment of medical standards for occupations. The first reason is predicated on the need within individual organizations to establish medical standards that comply with the Americans with Disabilities Act. The procedure includes an analysis of the job requirements (Knowledge, Skills, and Abilities) for a particular position. Because the analysis is for each individual job, there is no generalizable medical standard. After the job requirements are established then the medical examiner typically receives a list of the job essential tasks (stand for 2 hours, lift 25 lbs, etc.). The examiner determines and reports whether the individual can or cannot perform the essential tasks as outlined by the employer. If they cannot, the organization has a duty to attempt to accommodate the individual (redesign the job) unless it poses an undue burden on the organization or the individual poses an undue hazard to the safety of self or others. This approach is fraught with the potential for legal litigation" (2005 Tvaryanas, personal communication).

The second reason for establishing medical standards is to protect public safety for occupations where public safety is potentially at risk such as transportation and the nuclear industry. Medical standards for these occupations are not based on an analysis of the specific tasks but, instead, are focused on the risk of impairment or incapacitation due to the pathophysiology of any preexisting medical conditions. These standards also usually stipulate provisions for drug and alcohol testing. The establishment of medical standards for unmanned aircraft pilots clearly falls under the second reason. For this reason, it is important to identify the factors associated with the risk of pilot incapacitation for unmanned aircraft in deciding on the appropriate level of medical certification.

In the end, the primary driver of the decision of which level certification to use should be based on the definition of an "acceptable public risk from UA operations and applications." This has historically driven (at least in part) the evolution of the current stratified pilot and medical certification systems for manned aviation. This cut-point (acceptable versus unacceptable risk) is not defined by the medical, scientific, or engineering communities, but rather by the policy community (e.g., our political/ regulatory institutions). For example, the current "1% rule" (derived from European civil aviation standards) for risk of incapacitation in commercial aviation is a policy threshold. It could just have easily been a "2% rule" or a "5% rule." The point is it is a completely arbitrary boundary. The function of the medical/scientific community is to then quantify an individual's risk to determine whether they may exceed this arbitrary threshold. This is accomplished in part by setting certification standards. It is inherently futile for the medical and scientific communities to try to set standards without the policy community first defining "acceptable risk." For this reason, it is imperative that FAA administrators consider this core issue early, and then return to a discussion of standards setting. Once "acceptable public risk" is defined, setting medical standards becomes a more academic exercise rather than a policy debate.

Regarding the risk of pilot incapacitation, at least a few factors distinguish this risk from manned aircraft. First, factors related to changes in air pressure can be ignored, assuming that control stations for non-military operations will always be on the ground. Second, many of the current UA systems have procedures established for lost data link. Lost data link, where the pilot cannot transmit commands to the aircraft, is functionally equivalent to pilot incapacitation. For those systems with an adequate procedure for handling a lost data link, pilot incapacitation does not compromise safety to the same extent as it would in a manned aircraft. Third, the level of

automation of a system determines the criticality of pilot incapacitation, since some highly automated systems (e.g., Global Hawk) will continue normal flight whether a pilot is present in the ACS or not.

Since not enough is known today about these aircraft to make an accurate assessment of all of the risks involved, a class III medical certification, with use of the existing medical waiver process for handling exceptions (e.g., paraplegics) is probably a good place to start. This decision is also supported by the factors identified above that mitigate the severity of pilot incapacitation. It is feasible that some applications might require a class II or I medical certification because of the increased risks involved. Imposing different certification requirements, though, would require a clearer specification of pilot certification levels and UA classes. The class III medical certification statement applies to many, if not all, existing commercial and public UA endeavors (public endeavors would include border patrol applications).

APPENDIX A: ABBREVIATIONS AND ACRONYMS

AC	Advisory Circular
ACS	Air Control Station
A/FD	Airport Facility Directory
AFM	Airplane Flight Manual
AQP	Advanced Qualification Program
ATC	Air Traffic Control & Amended Type Certificate
ATIS	Automatic Terminal Information Service
ACS	Air Control Station
BLOS	Beyond Line of Sight
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FLIP	Flight Information Publication
GCS	Ground Control Station
GPS	Global Positioning System
H&S	Health and Safety
HALE	High Altitude Long Endurance
HSI	Human System Integration
HF	Human Factors
HMI	Human Machine Interface
HSI	Human System Integration
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
IPT	Integrated Product Team
KSA	Knowledge, Skills and Abilities
LOA	Level of Autonomy
LOS	Line of Sight
MDA	Minimum Descent Altitude
MFD	Multi-Functional Display
MEL	Minimum Equipment List
NAS	National Air Space System
NOTAM	Notice to Airmen
PIO	Pilot Induced Oscillation
POH	Pilot Operational Handbook
PIC	Pilot In Command
UAS	Unmanned Aircraft System/Uninhabited Aircraft System
SEIT	System Engineering and Integration Team

SME	Subject Matter Experts
TAF	Terminal Area Forecast
RWS	Reactive Windshear System
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

APPENDIX B: PARTICIPANTS AT THE NASA AMES KSA MEETING AND HSI PILOT TEAM

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APPENDIX C: FUNCTIONAL ROLE OF A PILOT IN MANNED SYSTEMS

C.1 Pilot Functions

Over the past 100 years, the role of the pilot has evolved just as the complexity of aircraft, the airspace, air traffic and legal restrictions and requirements have evolved. Where once, the pilot used basic skills to operate in a nearly free environment, today the pilot is an integral part of a highly complex and technical system.

The actions and functions of a pilot in command, of an aircraft, carry a legal liability to the highest level of care and responsibility. An aircraft is deemed a dangerous instrument. As a result, a whole body of federal laws and regulations, procedures, letters, insurance underwriting guidelines, as well as standards for "good airmanship" exist to hold a pilot accountable for anything and everything that might occur with the operation of an aircraft.

In practical terms, it is advantageous and desirable for a pilot to rely upon others for some of the tasks associated with flight. For example, a pilot is not expected to service the aircraft with fuel. However, the pilot retains responsibility for this function even though the task may be delegated. Should a failure occur such that the fuel quantity is incorrect, the wrong type of fuel is loaded, or the service point (i.e.: fuel cap) isn't installed correctly, the pilot in command will be deemed negligent.

Title 14 of the US Code of Federal Regulations – Aeronautics and Space (14 CFR), also commonly known as the Federal Air Regulations (FARs) place great responsibility upon the Pilot and this responsibility has been upheld by a body of case law. Nearly any omission, error or dereliction can be considered a "careless or reckless" operation.

Therefore, it could be said that all operations of aircraft involve planning, compliance with regulations and operating limitations, and control and oversight of the aircraft within its phase of flight and mode of operation. Being prepared to take action and to anticipate emergency situations is also an ever present function of a pilot. It could also be said that the safe outcome of every flight should never be in doubt.

C.2 Flight Planning

The pilot is responsible for all phases of flight and will develop a plan of flight to reflect the operational objectives of the mission. The range of missions may run from a pleasure flight to a transport flight (passenger or cargo). The pilot in command is responsible for the following:

- Planning the flight/mission to meet the desired objectives
- Determine the pilot qualification and aircraft equipage requirements for the intended flight based upon airspace and weather.
- Reviewing all available data pertaining to the flight including but not limited to:
- Aircraft maintenance and airworthiness

- Aircraft performance
- Weather
- Means of navigation available including Navaids, Standard Departure and Arrival procedures, ATC preferred routes etc.
- Notices to Airmen (NOTAMs)
- Any Temporary Flight Restrictions (TFRs) along the route
- Alternate airports for emergency conditions
- Alternate airports for landing under adverse weather or field conditions
- Fuel requirements
- Weight and Balance
- Filing an IFR flight plan, if required, or a VFR flight plan with the appropriate authority (typically Flight Service).

C.3 Pre-flight of aircraft

The Pilot-in-Command is responsible for a complete pre-flight of the aircraft. During this process the pilot will review all maintenance logs, fuel records, and other documentation to ensure the aircraft is airworthy and complies with all regulations and minimum equipment lists. Consideration will be given to any operational restrictions or procedures imposed as a result of inoperative equipment or missing components.

The pilot will then inspect the aircraft and perform a prestart test of systems for any defects or items that would affect safety of flight. The physical inspection of the aircraft will be in accordance with guidelines provided by the aircraft manufacture and will include such items as major structures, landing gear and tires, flight controls, fuel, oil and hydraulic quantities and servicing caps, external antennas and lighting, and the powerplant system (intakes, exhausts, propellers as applicable etc.).

The preparation for flight typically includes preparation for navigation from departure along the planned route of flight. This may simply involve basic charts and headings but might also involve the initializing and programming of area navigation equipment such as INS, GPS, FMS etc. Although a planned navigation profile might be loaded, the pilot must be ready to modify this navigation information should the ATC clearance contain a different routing or other modifications than what was filed or expected.

An additional requirement for the preparation for startup includes the positioning of the aircraft relative to other property and the pathway to depart the starting location. It is important that any blast from the propulsion system not cause damage to other persons or property in the vicinity and that a clear path exists for taxi and/or takeoff.

C.4 Start up of aircraft

The pilot shall start up the aircraft after ensuring that all personnel are clear and it's safe to begin operation. This start up not only applies to the engine (s) but also to all subsystems including, but not limited to, electrical and avionic systems. At some point after start up and prior to takeoff, the

pilot will have to determine that all requirements for safe flight are satisfied. Any deficiency will have to be addressed prior to flight.

C.5 Opening a flight plan

For a flight which will operate under IFR, an ATC clearance will have to be obtained. This clearance may be obtained by radio, datalink, or telephone. Such clearance may be obtained prior to start up, prior to taxi or just prior to takeoff. The clearance will typically include the time and location of departure, the initial departure path or procedure, the remainder of the filed route, the initial altitude assigned for flight, and an ATC transponder code and departure frequency as applicable. Some of these details may be included in published departure procedures and are considered to be included when a specific procedure is assigned as part of the clearance. For departure from locations not staffed by FAA ATC personnel, a "void if not off by" time restriction will be added.

For flights which can be operated under VFR, a flight plan is optional and serves as an aid to identifying and locating overdue and missing flights. The opening, or activation, of a VFR flight plan is typically accomplished some time soon after the actual takeoff.
Communication with ground control and taxi

At controlled airports, that is airports with operating Control Towers, pilots will communicate with ground control prior to any aircraft movement on the taxiways. In some cases, movement is allowed on the aprons prior to communication with ground control. For rotorcraft, low hover will be considered the same as taxiing. The aircraft will then taxi to the appropriate locations as directed by ground control. It is essential that the pilot understand the location of the aircraft and the route and sequence assigned for taxi.

A thorough knowledge of the airport layout and markings is essential to ground movement especially at busy and complex airfields. The highest level of vigilance is required to avoid taxi errors that could lead to collision with other aircraft or vehicles on the surface and especially to incursions into the runway environment of landing and departing aircraft.

Airports are highly dynamic with many opportunities for distraction to pilots and controllers. It is important for pilots to avoid distractions and to remain aware of the situation surrounding their aircraft which might include visual identification of other aircraft as well as errors made by other persons. It can also be anticipated that changes to sequencing and routing might be issued at a moments notice with immediate compliance necessary.

In the future, it is hoped that improvements and enhancements in airport lighting/signage and the use of datalink and moving ground map displays will improve the orderly flow of traffic and reduce pilot and controller errors and the dependency on voice communications.

For operations conducted at airports without an operating Control Tower, all of the same apply except that the pilot is responsible for the route to taxi and the sequence with respect to other aircraft or other vehicles in the area. Radio broadcasts on a common frequency may be made as an

aid to overall situational awareness but it must be understood that some aircraft might not be equipped with radios or monitoring the same frequency. The pilot may need to determine the runway in use based upon observing wind and other meteorological conditions and visually scan for air traffic based upon knowledge of local traffic procedures and restrictions.

C.6 Final preparation for departure

Prior to departure the pilot will complete a final operational check of the aircraft to ensure correct operation. All systems, controls, and flight instrumentation must function and give appropriate indications and be configured as required for takeoff. The navigation system must be configured to begin navigation. For aircraft using published RNAV procedures, this typically will include a final quick alignment at the specific runway of departure.

The following items must be considered prior to takeoff:

- The power settings to be used for takeoff and initial climb.
- The initial heading and altitude to be flown.
- The specific airspeeds required for minimum control of the aircraft, minimum engine out speed for multiengine aircraft, rotation speed, normal climb speed and any other performance mandated speeds specified.
- The minimum safe altitude for operation in the immediate vicinity and what the plan will be should an emergency arise immediately after takeoff.
- Loss of communication plan should radio contact be lost.
- An evaluation of local weather conditions along the takeoff flight path including winds, rain storms, wind shear or possible wake turbulence, and icing conditions.

C.6.1 Towered Airport

At a point on the taxiway approaching the runway, or at a time specified by Ground Control, the pilot will switch from Ground Control to the Tower (frequency) and report ready for takeoff. Tower will respond with instructions such as Hold Short, Position and Hold, or Cleared for Takeoff. Prior to passing the limit lines at the entrance to a runway, the pilot will visually scan the approach area to the runway and the runway itself for possible traffic. Exterior lighting systems on the aircraft should be used to make the aircraft conspicuous to other aircraft.

Along with the Cleared for Takeoff release, the Tower will state the wind condition, restate the runway name, and provide any last minute restriction such as to maintain visual separation from another departing aircraft or an initial heading and/or altitude assignment. The pilot, in acknowledging the takeoff clearance also accepts these assignments and is expected to promptly commence the takeoff sequence.

C.6.2 Non-Towered Airport

Prior to departure at a non-towered airport the pilot will visually confirm that departure will not interfere with aircraft on final approach or in the pattern and will depart. The intentions of the pilot should be broadcast on a Unicom frequency. Following departure the pilot will avoid traffic in the local traffic pattern and either communicate with ATC or proceed under VFR.

C.7 Communication with Tower and Departure Control

Following takeoff, the pilot will communicate with the Tower until the aircraft leaves Class B, C, or D airspace or is handed off to enroute ATC such as Departure Control or Center. VFR flights may request handoffs to ATC to obtain traffic advisories and to maintain a flight following function.

C.8 Climb out to initial altitude and heading

Under VFR the pilot will avoid other traffic and obstacles as the aircraft climbs out of the traffic pattern and proceeds along the desired route. In some locations, local restrictions may require that the Tower or Departure Control prescribe a specific routing away from the airport. Under IFR, departure routes are typically pre-planned (SID, Standard Instrument Departure) and the pilot is expected to fly this pre-planned route as part of the ATC clearance. Some SIDs are based upon radar vectors to a navigation fix in the area. Although the initial heading and altitude may be specified, the plan is for ATC to provide continuous assignments of heading and altitude as the flight progresses toward the enroute portion.

The pilot is expected to observe all noise regulations as defined by the airport authority as well as comply with the minimum altitudes and airspeed limits as specified in the FARs.

C.9 Evaluation of aircraft performance

The pilot is responsible for evaluating the aircraft performance during climb out and transition to level flight. During this phase all of the instruments will be scanned to ensure they are in normal operating ranges. A malfunction detected may hinder the aircraft performance, control or ability to communicate or navigate. The nature and severity of any malfunction must be determined by the pilot and a course of action determined. Some malfunctions will be relatively benign and allow for the flight to be continued with or without restriction. Other more serious malfunctions will likely result in the need to land the aircraft at the nearest suitable location.

In the event of any abnormal indications or malfunctions, the pilot will communicate, if possible, with Air Traffic Control and inform them of the nature of the problem and if that condition will affect the aircraft's ability to continue the flight. If a complete loss of communications is experienced, the transponder should be selected to code 7600. The flight may continue to a landing under VFR if the aircraft is in VFR conditions. If conditions are less than VFR, the flight should proceed in accordance with the loss of communications protocol contained within the Instrument Flight Rules.

Should an emergency condition exist, the pilot in command is allowed by the FARs to deviate as necessary from any clearance, instruction, or rule to the extent necessary to meet the emergency. The transponder should be selected to Code 7700 to alert all affected ATC personnel that an emergency is in progress.

C.10 En-Route Navigation

C.10.1 Navigation to initial flight plan

The pilot is responsible for the enroute navigation of the aircraft. VFR flights may be operated below 18,000 feet MSL along published Victor airways or on direct routings as desired using ground based Navaids, GPS, or other means as appropriate. Under VFR the pilot must provide separation from other aircraft and obstacles, maintain, at least, minimum prescribed flight altitudes, maintain enroute altitudes prescribed for the direction of flight and maintain separation from clouds and in-flight visibility specified for the altitude and airspace. Frequent updates of local altimeter settings are necessary for flights below 18,000 feet. The flight path must not penetrate Class B, C or D airspace without communication and permission of the local ATC. The pilot must also avoid prohibited and restricted airspace.

IFR flights will be operated along published airways or direct routings as cleared by ATC. Navigation can be based upon ground based Navaids, GPS, IRS, INS or other approved means including radar vectors. The degree of accuracy for aircraft ground tracks are being enhanced through a program known as Required Navigation Performance (RNP). In the future, RNP criteria will dictate access to certain routings including departure and arrival procedures.

C.10.2 Flight plan changes

While enroute, the pilot may elect to or be directed to modify the flight plan. Such revisions to the plan may be due to:

- Changes as directed by ATC for traffic flow and avoidance
- Changes as directed by ATC for security reasons
- Changes as directed by ATC due to changes in the status of restricted airspace
- Changes by the pilot due to weather conditions enroute, at the destination or the alternate field
- Changes by the pilot due to equipment changes/malfunctions in both air and ground equipment
- Changes by the pilot due to fuel status and consumption
- Changes by the pilot due to changes in the mission or desired destination

Changes will be coordinated with ATC and an amended clearance issued. The pilot is then responsible to reconfigure the navigation programming of onboard navigation systems and comply with the revised clearance.

C.11 Communication with ATC

Communications with ATC must be maintained at all times under IFR. The pilot must continuously maintain a listening watch for instructions directed to the flight and for frequency changes to other ATC sectors. Pilots will be expected to make those reports that are required by the FARs. It is also advantageous to listen to all other ATC/pilot communications to maintain overall situational awareness. At all times, the pilot must be prepared to alter the aircraft flight path, or speed, as directed by ATC for avoidance of traffic conflicts. Any communications that can be sent to the flight by datalink must be acknowledged in the manner prescribed.

C.12 Enroute Aircraft Operation

C.12.1 Evaluation of Aircraft Performance

The pilot is responsible for monitoring all aspects of the aircraft performance and to be prepared to manage contingencies. This would include, but not be limited to the following:

C.12.2 Propulsion operation

The pilot will monitor the function of the propulsion units. This would include:

- Monitoring the engines and electrical systems for proper operation
- Switching fuel tanks and monitoring fuel and oil consumption. It is vital that fuel status be continuously evaluated to provide a legal and safe margin for flight to the destination and alternate as the flight actually progresses
- Being prepared for drift down and/or diversion should a failure be experienced

C.12.3 Avionics operation

Aircraft avionics today include the radios and datalinks, navigation units such as DME, VOR, INS, and GPS, and the various flight management and auto flight or autopilot systems employed in modern aircraft. In many cases these systems will provide some level of self monitoring, providing the pilot alerts in case of a malfunction. In other cases, the pilot must determine proper operation by cross checking these various systems against each other.

C.12.4 Other aircraft systems

A pilot is expected to continuously monitor all aircraft system indicating and warning systems and to evaluate any warnings or abnormal indications through cross checks and system knowledge. It is always important to determine if a warning or abnormal indication reflects a true fault or is a malfunction in the indication or monitoring system itself. While some malfunctions will result in automatic actions that will be optimal in terms of the performance of the remaining systems, others will require a specific pilot action to restore functions.

In some instances, a system or component may malfunction in a manner that clearly must be disregarded. As an example, an aural warning from a GPWS that calls out “Glide Slope, Glide Slope” when the aircraft is cruising at 35,000 feet is clearly a malfunction and must be disregarded. However, the pilot would be expected to enter this occurrence into the aircraft maintenance log.

In other, rare circumstances, a malfunction, or combination of abnormalities might be observed for which no specific procedure is prescribed by the manufacturer. In such case, the pilot will be expected to use experience, knowledge and any available resource and judgment to resolve the issue.

C.12.5 Evaluate communications links

The pilot must monitor all communication links, both data and radio, for proper performance and operation. In some cases, due to antenna placement, the pilot will switch communication from radio to radio in order to more clearly receive ATC communication. During periods of low communication activity, it might be possible to fly out of range of the active frequency and experience a loss of communication. The pilot must then determine a means to reestablish

communications on the correct frequency. A flight might leave an area where ATC has radar coverage. In this case, IFR position reporting procedures will commence. A time and location for the subsequent communication will be established. Discreet transponder codes will be changed upon request of ATC or regulations.

C.12.6 Evaluate weather

The pilot must continuously evaluate weather conditions while in-flight. These conditions are vital to the safety and efficiency of the flight operation and include:

- Conditions at the location and altitude that the aircraft is flying through
- Conditions, particularly hazardous weather, along the intended route of flight ahead
- Surface conditions at airfields in the immediate area in case an in-flight emergency mandates an immediate landing
- Conditions at the destination and alternate terminal areas

C.12.7 VMC Operations

C.12.7.1 Collision Avoidance

In VMC conditions the pilot is responsible for the avoidance of other aircraft. The "rights of way" are defined in FAR Part 91. Collision avoidance is manually flown by visual means, but may be augmented by electronic systems or ATC call outs. Presently, TCAS II is a tool installed in some aircraft to provide a display of proximate transponder equipped traffic and to provide the pilots coordinated guidance to resolve traffic conflicts. Aircraft equipped with TCAS I only have the advantage of a traffic display. TCAS resolution advisories are considered a last chance safety net system when other means of traffic detection and avoidance have failed.

C.12.7.2 Tracking and avoidance of clouds

Under VFR the pilot is responsible for remaining in VMC. Visual Meteorological Conditions are defined in FAR Part 91 for the various classes of airspace. Under IFR, the flight must remain clear of clouds if making a visual approach.

C.12.7.3 Evaluation of visibility

The pilot is responsible for the continuous evaluation of visibility. This is done through a visual analysis and is somewhat subjective but relies on visibility of the ground and/or other objects. The pilot should also monitor the official visibility reported at airports of departure, destination and along the flight path.

C.12.7.4 Emergency Operations

The pilot shall evaluate all sensor inputs from the aircraft and determine if there is an emergency condition. Some of these inputs will be from the various systems onboard the aircraft while others will be based on the sensory input of the pilot. The pilot will then take the appropriate action based on these inputs.

Some situations that constitute and emergency are:

- In-flight fire.
- Inadequate fuel supply
- Loss of aircraft control
- Electrical System failure
- Uncontrollable structural icing
- Structural failure
- Incapacitation of the pilot
- Destination airfield weather below minimums

C.12.7.5 Communication with ATC

While not all emergency situations are required to be reported to ATC, in many cases this would be the wise course of action. In some cases the FARs define the appropriate action to be taken. For example, in the case of a "lost communication" the pilot will be required to continue on the IFR flight plan based on previously approved times and waypoints.

C.12.7.6 Determination of suitable emergency landing location

In the event of an emergency that requires landing at somewhere other than the final destination the pilot will determine a suitable landing location. In the most extreme condition of total engine failure or in-flight fire, the pilot will select a location within the glide distance of the aircraft. The pilot will notify ATC of the emergency and the degree of assistance required. In VMC conditions the pilot may be able to perform these actions visually. In IMC conditions the pilot will work with ATC to, if possible, navigate to a suitable landing location.

C.12.7.7 Alert ground crew of emergencies

In many cases where landing at an airport is possible, ATC or the Tower will alert ground crews of the emergency. In the case of non-towered airports the pilot should attempt to contact the ground via the UNICOM frequency or the standard emergency frequency.

C.13 Approach and Landing

C.13.1 Terminal arrival

The descent and approach to a terminal area is handled in a manner similar to the enroute portion of flight. The point at which the descent commences depends upon the altitude of the cruise portion of the flight, the descent characteristics and capabilities of the aircraft, local weather conditions and local ATC requirements. For VFR operations, the pilot may commence descent at will. Under IFR, an ATC clearance is required to change altitude. A clearance may be issued for descent with or without restrictions at the pilot's discretion. However, ATC might issue a specific instruction to descend to a specific altitude and this instruction might also include crossing restrictions in terms of altitude and/or airspeed at specific fixes or distances from specified points.

C.13.2 Destination conditions

Prior to arrival, the pilot will obtain information pertaining to the destination runway in use and local altimeter setting and weather conditions. For destinations that do not have an operating Control Tower, this information may be obtained via radio or datalink from a Flight Service

Station, if available, or another qualified observer if available. At some locations, it might be necessary to over fly the field at some safe altitude to observe the wind indicator and local traffic and surface condition.

For airports with an operating Control Tower, this information may be obtained via ACARS (datalink), ATIS broadcast on VHF radio, or via voice communication with the Tower or Approach Control. With information regarding the wind and weather conditions, the runway and approaches in use, the pilot can review the airport diagram and applicable approach procedures in preparation for making the approach and landing.

C.13.3 IFR Arrival

Typically, within 40 miles of the destination airport, the flight will be directed to contact Approach Control. From this point, the flight may be directed to continue toward the airport navigating via a published arrival procedure that will specify the Navaids, fixes, courses etc. ATC may issue altitude and or speed instructions or direct the pilot to adhere to the published crossing altitudes/speeds. ATC will inform the pilot of which approach procedure and runway can be expected so that the pilot may configure his navigation appropriately. As an alternative to following a published arrival, Approach Control may provide radar vectoring along with altitude instructions to position the aircraft to begin the final approach. When being radar vectored, airspeed adjustments may or may not be issued to adjust spacing with other landing aircraft. The pilot must evaluate the position of the aircraft and make speed adjustments and configuration changes when appropriate if no ATC instructions to that effect are given. By the same token, if ATC speed assignments are not compatible with the aircraft's ability to make an approach and landing, the pilot must communicate to ATC what can be done. Otherwise, it is expected that the pilot will maneuver the aircraft to promptly make heading, speed and altitude changes expeditiously.

At some point specified, Approach Control will advise "Cleared for Approach". Frequently, this clearance contains a phrase such as "maintain 3000 feet until established…" or "maintain 160 knots until….". Again, the pilot is expected to comply with these instructions or advise that he/she will be unable to comply. Once the approach clearance is issued, the flight will intercept and track the published instrument approach procedure flying the course and altitude or glide path as specified. The rules for minimum weather, altitudes, criteria for continuing descent below Minimum Descent Altitude or Decision Altitude, visibility for landing, visual cues required, and requirements for a Missed Approach are all contained within the Instrument Flight Rules. As the pilot approaches the airport ATC will hand communication off to the local tower (at a towered airport) who will issue the clearance to land. In the case of an airport without an operating control tower, ATC will allow the pilot to switch to a UNICOM frequency to announce intentions of landing from the instrument approach. At some locations, it might be necessary for the pilot to activate the runway and approach lighting system by use of the radio transmitter.

C.13.4 VFR Arrival

A VFR arrival may be conducted completely at the discretion of the pilot. For airports in congested areas it may be desirable or required (Class C or B Airspace) to contact Approach Control for sequencing and traffic advisories. The flight may be directed or vectored to merge with IFR aircraft

already sequenced for arrival and landing. Heading, speed and altitudes may be assigned, as above, and the pilot is expected to comply with such instructions unless the flight would not be able to remain in VMC.

Otherwise, the pilot may establish radio communication with the Control Tower at some geographic point several miles away from the airport. As the pilot enters the airport traffic pattern he/she is responsible for visual separation from other aircraft in VMC conditions.

At a non-towered airport the pilot is responsible for avoidance of other aircraft and will normally fly a traffic pattern that is standard, as specified in the Airman's Information Manual or some other pattern as established locally and may be published in an airport directory. Such a traffic pattern will include an altitude to be flown and the aircraft should enter the flow of any traffic already established in the pattern in level flight and at an appropriate speed. The descent for landing must provide obstruction clearance and a touchdown in the touchdown zone of the runway.

The pilot must observe that the runway is clear for landing and always remain vigilant for any aircraft or other vehicle that might appear from an unexpected direction and without prior communication.

C.14 Prepare aircraft for landing

Prior to landing, the pilot is responsible for configuring the aircraft for landing in accordance with the Before Landing Checklist. Items that must be verified prior to landing include the landing gear, high lift devices such as wing flaps, spoilers, fuel selectors and fuel pumps, brake and hydraulic systems, and landing lights.

C.15 Landing the aircraft

The pilot is responsible for safely landing the aircraft. This would require some of the following skills and functions:

- Precise control of airspeed and heading
- Precise control of descent path to follow an electronic or visual glide path aid
- Compensate for wind and turbulence effects
- Achieve touchdown in the touchdown zone of the runway with the proper attitude, sink rate, and aircraft axis aligned with the centerline
- Maintain directional control and decelerate to taxi speed using any available systems such as reverse thrust, spoilers, lift dump and wheel brakes. Correct use of collective for rotorcraft
- Expeditious exit of the landing surface at a safe speed.

C.16 Communication with ground control

After clearing the active runway, or when directed, the pilot would switch communications from Tower to Ground Control. Detailed instructions will be issued to taxi to the requested or designated parking ramp or location. The responsibilities to comply with instructions and remain vigilant for other objects and vehicles is the same as in Section 1.1.5 above. At non-tower airports the pilot would generally alert other aircraft that they are clear of the runway via the UNICOM frequency.

C.17 Taxi to parking

The pilot will taxi to an appropriate parking location via the centerline of the taxiway as directed by ground control or as appropriate at an uncontrolled airport. The pilot will be responsible for avoidance of all other fixed and moveable objects and to maintain a safe speed. It may be necessary to reconfigure some aircraft systems and controls in accordance with an after landing checklist.

C.18 Post-flight

C.18.1 Vehicle shutdown

After the aircraft is brought to a complete stop at the final location, the pilot would insure the aircraft will remain stationary using brakes, chocks, tethers or tie downs as appropriate. Normal shutdown procedures as defined in the flight manual will be followed. This would include shutting down the avionics, lighting, and propulsion systems. For some aircraft, electrical power will continue to be supplied using an APU or an external power source.

The pilot is responsible for securing the aircraft and conducting a post flight inspection. This function may be delegated as appropriate to the operator or facility.

C.18.2 Close flight plan

The tower closes IFR flight plans at towered airports when the aircraft lands. The pilot may request that the Tower close a VFR flight plan prior to or after landing. However, the Tower will perform this function on a workload permitting basis and might decline this request. At non-towered airports the pilot would be responsible for closing either an IFR or VFR flight plan after landing via radio or telephone. It should be noted that no other aircraft may approach or land IFR until the flight plan is closed.

C.18.3 Entry of items into logbooks

Following the flight the pilot would enter all aircraft malfunctions and discrepancies into the aircraft maintenance log. Other information pertaining to the flight hours and cycles will be entered in the appropriate logbooks or forms.

APPENDIX D: UA PILOT TASK LISTING

The format and content of this table was derived from work performed to identify Predator Pilot Task requirements. This information was provided by Geoffrey S Parker (Civ. SAF/AQIJ). This information was tailored as appropriate to support civil/commercial operations in the NAS. The Rating Scales used for this table is provided below:

Subject Knowledge Levels:

A. Can identify basic facts and terms about the subject--facts

B. Can identify relationship of basic facts and state general principles about the subject--principles

C. Can analyze facts and principles and draw conclusions about the subject--analysis

D. Can evaluate conditions and make proper decisions about the subject--evaluation

Task Knowledge Levels:

a. Can name parts, tools, and simple facts about the task (nomenclature).

b. Can determine step-by-step procedures for doing the task (procedures).

c. Can identify why and when the task must be done and why each step is needed (operating principles).

d. Can predict, isolate, and resolve problems about the task (advanced theory).

Task Performance Levels:

1. Can do simple parts of the task. Needs to be told or shown how to do most of the task--extremely limited.
2. Can do most parts of the task. Needs help only on hardest parts--partially proficient
3. Can do all parts of the task. Needs only spot check of completed work--competent.
4. Can do the task quickly and accurately. Can tell or show others how to do the task--highly proficient.

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
PRE-FLIGHT												
Confirm Knowledge of elements related to certificates			X				X				X	
Confirm Knowledge of elements related to airworthiness requirements			X				X				X	
Plan an IFR mission			X				X				X	
Plan route to destination/alternates			X				X				X	
Determine suitable runway and taxiways			X				X				X	
Obtain weather data for mission planning			X				X				X	
Obtain operations data for mission planning – Applicable?			X				X				X	
Compute takeoff and landing data			X				X				X	
Determine Altitude and Airspeed between waypoints			X				X				X	

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	A	B	C	D	a	b	c	d	1	2	3	4
Determine suitable Emergency/Alternate Airfields			X				X				X	
Give/receive briefing on flight			X				X				X	
Obtain clearance for IFR flight			X				X				X	
Prepare maps for use during flight			X				X				X	
File Flight Plan			X				X				X	
Perform PREFLIGHT Check			X				X				X	
Check AFTO Form 781A, F, J, K. (Preflight) Applicable?			X				X				X	
Apply Go/No-Go criteria for aircraft equipment			X				X				X	
Apply weather criteria for Go/No-Go			X				X				X	
Apply minimum equipment list Go/No-Go criteria			X				X				X	
Determine Crew Readiness			X				X				X	
GROUND OPERATIONS												
Perform Pre-flight Inspection of UA			X				X				X	
Perform Pre-Flight Inspection of ACS			X				X				X	
Perform STARTING ENGINES check			X				X				X	
Start Engine and Apply Power to systems as required			X				X				X	
Perform BEFORE TAXI check			X				X				X	
Perform verbal communications/radio procedures			X				X				X	
Check transponder/TCAS, if applicable			X				X				X	
Perform GPS position check			X				X			X		
Obtain appropriate clearances before flight			X				X				X	
Obtain clearance to taxi			X				X				X	
Obtain IFR clearance over radio			X				X				X	
Verify Communication links			X				X				X	
Verify readiness of UA handoff facility, if applicable			X				X				X	
Taxi to runway			X				X				X	
Perform instrument check			X				X				X	
Check operation of navigation radios			X				X				X	
Perform BEFORE TAKEOFF check			X				X				X	

	Subject Knowledge				Task Knowledge				Task Performance			
Flight Phases & Pilot Tasks	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Taxi into takeoff position			X				X				X	
Perform LINEUP check			X				X				X	
Takeoff/Climb Out												
Aviate												
Monitor /Control UA during Takeoff/Climb Out			X				X				X	
Perform takeoff , initial climb, and all associated checks			X				X				X	
Accelerate to climb airspeed			X				X				X	
Configure Aircraft			X				X				X	
Perform Climb			X				X				X	
Perform basic departure procedures			X				X				X	
Maintain Directional Control through Liftoff			X				X				X	
Assess Go/No-Go Decision, Abort Takeoff if necessary			X				X				X	
Climb IAW Departure Instructions			X				X				X	
Perform level-off from climb			X				X				X	
Establish and maintain altitude			X				X				X	
Perform all applicable in-flight checks			X				X				X	
Comply with Wake Turbulence Restrictions			X				X				X	
Set, establish, and maintain proper altitude/attitude throughout flight			X				X				X	
Perform LEVEL OFF check			X				X				X	
Perform maneuvers as required within assigned airspace			X				X				X	
Perform clearing			X				X				X	
Change airspeed/straight-and-level as required			X				X				X	
Perform turns, climbs, descents as required			X				X				X	
Recognize and perform unusual attitude recoveries, if required – Applicable?			X				X				X	
Recognize stalls and perform proper recoveries – Applicable?			X				X				X	

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Perform departure recognition and recovery Applicable?			X				X				X	
Recognize departure and recover Applicable?			X				X				X	
Communicate												
Obtain clearance for take-off			X				X				X	
Contact Departure Control for IFR ID/VFR advisories			X				X				X	
Communicate with Tower and Comply with Instructions			X				X				X	
Maintain contact with controlling agency – Change frequencies as required			X				X				X	
Make position reports			X				X				X	
Request in-flight clearances			X				X				X	
Perform PIREP ??			X				X				X	
Navigate												
Establish basic area orientation			X				X				X	
Use local area map for orientation			X				X				X	
Monitor/Control UA position planned waypoints			X				X				X	
Adjust plan as required			X				X				X	
Avoid Hazards												
Monitor Weather			X				X				X	
Monitor Traffic			X				X				X	
Monitor UA system performance			X				X				X	
Respond to abnormal/emergency conditions			X				X				X	

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
ENROUTE OPERATIONS												
Aviate												
Monitor flight to maintain compliance with instructions/flight plan			X				X				X	
Maintain assigned altitude, airspeed and route of flight			X				X				X	
Perform instrument cross-check			X				X				X	
Perform partial panel instrument flight			X				X				X	
Establish and maintain constant altitude, airspeed, and heading during instrument flight			X				X				X	
Perform aircraft maneuvers under instrument conditions, as required			X				X				X	
Recognize and properly recover from unusual attitudes under instrument conditions ???			X				X				X	
Recognize improper nose low attitude ???			X				X				X	
Operate aircraft instruments and navigational equipment			X				X				X	
Demonstrate airmanship, judgment, and decision-making while operating an aircraft – Applies to all flight phases			X				X				X	
Perform and demonstrate UA safety procedures - Applies to all flight phases			X				X				X	
Communicate												
Maintain contact with controlling agency – Change frequencies as required			X				X				X	
Make position reports			X				X				X	
Request in-flight clearances			X				X				X	
Perform PIREP ??			X				X				X	
Perform Handoff to other ACS, if required			X				X				X	

	Subject Knowledge				Task Knowledge				Task Performance			
Flight Phases & Pilot Tasks	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Navigate												
Perform Map reading, as required			X				X				X	
Compare actual and planned positions			X				X				X	
Adjust Flight Plan, as required												
Perform instrument airway operating procedures			X				X				X	
Check and maintain in-flight log			X				X				X	
Compare actual and planned ground speeds			X				X				X	
Compare actual and planned rate of fuel consumption			X				X				X	
Perform time and fuel management			X				X				X	
Interpret radio weather condition reports			X				X				X	
Perform course intercept ???			X				X				X	
Determine angle of intercept ???			X				X				X	
Determine intercept heading ???			X				X				X	
Establish and maintain appropriate heading			X				X				X	
Determine lead point ???			X				X				X	
Determine rate of intercept ???			X				X				X	
Complete intercept ???			X				X				X	
Perform IFR navigation			X				X				X	
Perform Fix-to-fix navigation ???			X				X				X	
Maintain selected course, correcting for wind			X				X				X	
Change Flight Plan, if required			X				X				X	
Perform enroute descent			X				X				X	
Make position reports			X				X				X	
Request in-flight clearances			X				X				X	
Perform dead reckoning navigation			X				X				X	
Perform visual navigation			X				X				X	
Identify appropriate visual landmarks			X				X				X	
Correlate position with map			X				X				X	
Perform instrument airway operating procedures			X				X				X	
Check and maintain in-flight log			X				X				X	

	Subject Knowledge				Task Knowledge				Task Performance			
Flight Phases & Pilot Tasks	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Compare actual and planned ground speeds			X				X				X	
Compare actual and planned rate of fuel consumption			X				X				X	
Calculate actual fuel consumption			X				X				X	
Perform in-flight navigation planning			X				X				X	
Calculate/compensate for in-flight winds			X				X				X	
Calculate new ETAs			X				X				X	
Perform time and fuel management			X				X				X	
Use PMSV and ATIS, perform PIREP – Applicable??			X				X				X	
Avoid Hazards												
Check enroute and destination airfield weather			X				X				X	
Monitor and Avoid potentially Hazardous Weather			X				X				X	
Monitor and avoid traffic			X				X				X	
Monitor Health and Status of UA and ACS			X				X				X	
Upon discovering a problem, maintain aircraft control			X				X				X	
Analyze situation, including systems of possible emergency			X				X				X	
Recognize and perform all applicable emergency procedures			X				X				X	
Declare emergency, if required			X				X				X	
Perform Lost Comm procedures, if required			X				X				X	
Land as soon as conditions permit – Does this belong here, or should it be moved to Landing Ops?			X				X				X	
Mission Operations												
TBD												

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
DESCEND												
Aviate			X				X				X	
Monitor/Control Aircraft to Holding or Approach Fix			X				X				X	
Enter and Maintain Holding Pattern, if required			X				X				X	
Receive and follow holding instructions			X				X				X	
Enter and Maintain Holding Pattern, as required			X				X				X	
Obtain Updated Weather Information			X				X				X	
Perform wind analysis to assist in maintaining position within holding pattern airspace			X				X				X	
Depart holding pattern			X				X				X	
Perform procedure turns, as required			X				X				X	
Communicate												
Maintain contact with controlling agency – Change frequencies as required			X				X				X	
Receive ATC clearance			X				X				X	
Execute Controller instructions relating to Heading, Speed & Altitude			X				X				X	
Make position reports			X				X				X	
Request in-flight clearances			X				X				X	
Perform PIREP ??			X				X				X	
Perform Handoff to other ACS, if required			X				X				X	
Navigate												
Navigate to Designated Way Points			X				X				X	
Maintain heading, airspeed, and altitude, as required			X				X				X	
Compare planned and actual position			X				X				X	
Compare planned and actual ground speeds			X				X				X	

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Compensate for in-flight winds, as required			X				X				X	
Perform time and fuel management			X				X				X	
Avoid Hazards												
Basically the same as for Enroute Operations												
ARRIVAL AT DESTINATION/ APPROACH												
Aviate			X				X				X	
Monitor/Control UA during Approach to Landing			X				X				X	
Ensure proper Configuration for Landing (e.g., Gear, Flight Surfaces, etc.)			X				X				X	
Perform Descent Checklist			X				X				X	
Perform descent – Fly approach procedure to landing			X				X				X	
Perform approach			X				X				X	
Follow GCA controller's directions			X				X				X	
Turn to directed headings			X				X				X	
Maintain directed altitudes			X				X				X	
Maintain proper airspace			X				X				X	
Remain within cleared airspace			X				X				X	
Perform Missed Approach, or Go-Around procedures, if required			X				X				X	
Perform APPROACH TO FIELD check			X				X				X	
Analyze wind conditions			X				X				X	
Perform normal traffic pattern operations			X				X				X	
Comply with standard instrument approach plate procedures			X				X				X	
Follow local breakout procedures			X				X				X	
Clear airspace in direction of turn			X				X				X	
Perform normal overhead and straight in patterns			X				X				X	
Fly final approach			X				X				X	

	Subject Knowledge				Task Knowledge				Task Performance			
Flight Phases & Pilot Tasks	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Communicate												
Communicate with ATC												
Comply with ATC/approach control clearance			X				X				X	
Navigate												
Perform precision radar approach			X				X				X	
Make corrections to heading			X				X				X	
Perform non-precision radar approach			X				X				X	
Perform gyro-out instrument pattern			X			X				X		
Perform standard rate turns in pattern			X			X				X		
Perform gyro-out non-precision radar approach			X			X				X		
Perform half-standard rate turns on final, if required			X			X				X		
Perform gyro-out precision radar approach			X			X				X		
Perform Instrument Landing System (ILS) approach			X				X				X	
Maintain glide slope control			X				X				X	
Maintain course control			X				X				X	
Perform ILS localizer only approach			X				X				X	
Perform transition from instruments to visual			X				X				X	
Calculate VDP-Visual Descent Point			X				X				X	
Transition from glidepath to runway			X				X				X	
Transition from MDA to runway			X				X				X	
Perform circling approach			X			X				X		
Perform missed approach			X				X				X	
Comply with published missed approach procedures			X				X				X	
Comply with ATC missed approach clearance			X				X				X	
Complete missed approach check			X				X				X	
Avoid Hazards												
Basically the same as previous phases												

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	A	B	C	D	a	b	c	d	1	2	3	4
LANDING												
Aviate												
Monitor/Control UA during Landing Ops			X				X				X	
Configure Aircraft for Landing			X				X				X	
Perform Pre-Landing and other appropriate Checklists			X				X				X	
Perform approach to landing, landing, and roll-out			X				X				X	
Perform go-ahead from final approach/flare			X				X				X	
Perform go-around from final turn, if required			X				X				X	
Perform GO-AROUND/MISSED APPROACH check, if required			X				X				X	
Communicate												
Obtain clearance for landing, Change frequencies as required			X				X				X	
Obtain in-flight IFR clearance			X				X				X	
Navigate												
Navigate to Designated Way Points			X				X				X	
Maintain heading, airspeed, and altitude, as required			X				X				X	
Compare planned and actual position			X				X				X	
Compare planned and actual ground speeds			X				X				X	
Compensate for in-flight winds, as required			X				X				X	
Perform time and fuel management			X				X				X	
Avoid Hazards												
React to hazardous/adverse meteorological conditions during flight			X				X				X	
Identify weather phenomena which affect flight			X				X				X	
Monitor Air and Ground Traffic												
Monitor UA system performance												

	SUBJECT KNOWLEDGE				TASK KNOWLEDGE				TASK PERFORMANCE			
FLIGHT PHASES & PILOT TASKS	**A**	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**1**	**2**	**3**	**4**
Respond to abnormal/emergency conditions/events												
GROUND OPERATIONS												
Monitor/Control UA during Ground Ops												
Taxi clear of runway			X				X				X	
Notify Ground Control when clear of Runway												
Comply with ATC Directions												
Receive Clearance to Taxi to Parking Area												
Perform AFTER LANDING check			X				X				X	
Taxi to Parking Area			X				X				X	
Avoid Ground Hazards			X				X				X	
Perform ENGINE SHUTDOWN check			X				X				X	
Perform all safety procedures for securing aircraft			X				X				X	
Perform post landing procedures			X				X				X	
Complete AFTO form 781, 781H (post flight), Applicable?			X				X				X	
Fill out AF form 369 Applicable?			X				X				X	
Close flight plan with ATC			X				X				X	

APPENDIX E: UA PILOT MEDICAL AND CERTIFICATION REQUIRMENTS MEETING ATTENDEE LIST

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