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Abstract:

This document is a system level Concept of Operations (CONOPS) from the perspective of future High Altitude Long Endurance (HALE) Unmanned Aircraft Systems (UAS) service providers and National Airspace System (NAS) users. It describes current systems (existing UAS), describes HALE UAS functions and operations to be performed (via sample missions), and offers insight into the user's environment (i.e., the UAS as a system of systems). It is intended to be a source document for NAS UAS operational requirements, and provides a construct for government agencies to use in guiding their regulatory decisions, architecture requirements, and investment strategies. Although it does not describe the technical capabilities of a specific HALE UAS system (which do, and will vary widely), it is intended to aid in requirements capture and to be used as input to the functional requirements and analysis process. The document provides a basis for development of functional requirements and operational guidelines to achieve unrestricted access into the NAS.

This document is an FY06 update to the FY05 Access 5 Project-approved Concept of Operations document previously published in the Public Domain on the Access 5 open website. This version is recommended to be approved for public release also. The updates are a reorganization of materials from the previous version with the addition of an updated set of operational requirements, inclusion of sample mission scenarios, and identification of roles and responsibilities of interfaces within flight phases.

Status:

Access 5 – Recommended for NASA Approval

Limitations on use:

The perspective of this CONOPS is written with respect to HALE UAS.

HALE UAS

Concept of Operations

Version 3.0
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This document was prepared by a collaborative team through the noted work package. This was a funded effort under the Access 5 Project.

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Document Revision History

Version	Date	Changes
Version 1	September 2003	Internal Access 5 working document prepared for planning teams and work package developments.
Version 2	April 2005	Released to FAA and RTCA, Internal restriction labels removed. Project organizational chart updated.
Version 3	February 2006	General rewrite and reorganization of document to reflect overall project findings to date. Adopted use of Unmanned Aircraft System (UAS) in place of Remotely operated Aircraft (ROA).

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Table of Contents

EXECUTIVE SUMMARY	ix
1. INTRODUCTION	1
1.1 PURPOSE AND SCOPE	1
1.2 CONCEPT OF OPERATIONS VERSUS OPERATIONAL CONCEPT	1
1.3 CONOPS DEVELOPMENT ASSUMPTIONS	3
1.4 CONOPS DOCUMENT ORGANIZATION	4
2. HALE UAS DESCRIPTION	7
2.1 HALE UAS ELEMENTS	7
2.1.1 Unmanned Aircraft	8
2.1.2 Control Station & Ground Support	8
2.1.3 Data & Voice Communication Links	8
2.2 EXISTING HALE UAS	9
3. OPERATIONAL & REGULATORY ENVIRONMENTS	11
3.1 REGULATORY ENVIRONMENT – MANNED & UNMANNED	11
3.1.1 Aircraft Registration	11
3.1.2 Aircraft Certification	11
3.1.3 Pilot Qualifications	11
3.1.4 Requirements for Equivalent Level of Safety	11
3.2 CURRENT OPERATIONAL ENVIRONMENT – WAIVERS & AUTHORIZATIONS	13
3.3 CHALLENGE AREAS	14
3.3.1 Appropriate Level of Safety	14
3.3.2 Minimum Airworthiness and Operating Standards	14
3.3.3 Sense and Avoid	14
3.3.4 Frequency Spectrum	15
3.3.5 Pilot Qualifications	15
3.3.6 Separation Issues	15
3.3.7 System Safety Analyses	15
3.4 FAA CONSIDERS UAS AS AIRCRAFT	16
3.5 FUTURE NAS DEVELOPMENTS	16
4. CONOPS FOR HALE UAS IN THE NAS	17
4.1 “FILE AND FLY” CAPABILITY	17
4.2 HALE UAS OPERATING CONCEPT	17
4.3 HALE UAS EXTERNAL INTERFACES	18
4.3.1 External Interfaces Used During Pre & Post-Flight Phases	18
4.3.2 External Interfaces Used During The Flight Operations Phase	19
4.4 EXAMPLE UAS MISSION SCENARIOS	21
4.4.1 Loiter Mission	22
4.4.2 Point-to-Point Mission	22
4.5 HALE UAS OPERATIONS WITH IN THE NAS	23
4.5.1 Mission Planning Operations	23
4.5.2 Airport Operations	23
4.5.3 Departure & Arrival Operations	24

4.5.4	En-Route/Cruise Operations	24
4.5.5	Contingency Operations	24
4.6	OVERALL NAS INTEGRATION	24
5.	IMPLEMENTATION	27
5.1	POLICIES / RULES / REGULATIONS	27
5.2	ENABLING CAPABILITIES AND TECHNOLOGIES	27
5.3	UAS CAPABLE AIRPORT INFRASTRUCTURE	28
5.4	OPERATIONS WITHIN INTERNATIONAL AIRSPACE	28
6.	REFERENCE MATERIAL	29
	APPENDIX A – ACRONYMS	31
	APPENDIX B – DEFINITIONS	33
	APPENDIX C – ACCESS 5 PROJECT DESCRIPTION	37
C.1	ACCESS 5 VISION AND MISSION	37
C.2	ACCESS 5 PROJECT SCOPE	37
C.3	ACCESS 5 PROJECT STRUCTURE	38
C.4	ACCESS 5 PROJECT PLAN AND PHASES	40
C.4.1	Step 1: Routine Operations above FL430 through Pre-coordinated Airspace	41
C.4.1	Step 2: Routine Operations above FL180 through Pre-coordinated Airspace with Emergency Landings at Pre-coordinated Airports	42
C.4.3	Step 3: Routine Operations above FL180 through C, D, E Airspace with Emergency Landings at Pre-coordinated Airports	43
C.4.4	Step 4: Routine Operations above FL180 through C, D, E Airspace with Emergency Landings at any UAS Designated Airports	44

List of Tables

Table 1. HALE UAS CONOPS Development Assumptions	3
Table 2: HALE UAS Regulatory and Operational Requirements	13
Table 3. Notional Organizational Roles and Responsibilities during a HALE UAS Missions	20
Table 4. Concept of Operations References	29

List of Figures

Figure 1. Hierarchy of Operational Concept & Concept of Operation	2
Figure 2. HALE UAS Elements	7
Figure 3. Examples of HALE UAS Manufactured in the United States	9
Figure 4. HALE UAS Operational Concept	17
Figure 5. HALE UAS System External Interfaces	19
Figure 6. Example HALE UAS Mission Scenarios	21
Figure 7. Loiter Mission Timeline	22
Figure 8. Point-to-Point Mission Timeline	23
Figure C1. Access 5 Project Organization Structure	39
Figure C2. Step 1 Capabilities	41
Figure C3. Step 2 Capabilities	42
Figure C4. Step 3 Capabilities	43
Figure C5. Step 4 Capabilities	44

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EXECUTIVE SUMMARY

The demand to operate High Altitude Long Endurance (HALE) Unmanned Aircraft Systems (UAS) within the National Airspace System (NAS) is expected to increase significantly in the first decade of the 21st Century. This demand is being fueled by federal non-DoD needs (e.g., Homeland Security) and an emerging civil market driven by the need for remote sensing (e.g., weather forecasting, earth science) and advancements in telecommunications. This growth of the HALE UAS industry necessitates that the FAA establish regulatory criteria (certification of aircraft and the individuals who fly them) and operating standards (flight rules) that provide for the safe integration of HALE UAS into the mainstream of airspace users via routine access to the NAS comparable to that of manned aircraft.

This Concept of Operations (CONOPS) document provides a basis for technological, procedural and architectural investments that will lead to initial operational capabilities enabling HALE UAS to “file and fly” within the NAS. The CONOPS is not intended, nor does it attempt, to describe an end-state system. The concepts presented are the first steps in the evolution toward achieving full HALE UAS integration into the NAS.

HALE UAS systems will need to be designed, manufactured, certificated and operated under the same regulations as manned aircraft. HALE UAS flight operations will need to demonstrate that they can achieve an equivalent level of safety (ELOS) comparable with manned aircraft, so they do not pose a hazard to persons and property both in the air and on the ground. Onboard automated systems will be needed to enable the HALE UAS to achieve an ELOS in the event of any in-flight anomaly or loss of command, control or communication links. HALE UAS will operate in the same airspace as manned aircraft and not be dependent on segregation to maintain requisite levels of safety. Ensuring that HALE UAS achieve an ELOS is accomplished through processes similar to those used to demonstrate manned aircraft are safe. These procedures include: aircraft airworthiness certification, pilot certification, and compliance with the general operating and flight rules, the three aviation regulatory components comprising “aviation safety”.

This document is intended to be a system level CONOPS. It provides a concept of operations from the perspective of future HALE UAS service providers and NAS users. It describes current systems (existing UAS), describes HALE UAS functions and operations to be performed (via sample missions), and offers insight into the user’s environment (i.e., the UAS as a system of systems). It is intended to be a source document for NAS UAS operational requirements, and provides a construct for government agencies to use in guiding their regulatory decisions, architecture requirements, and investment strategies. Although it does not describe the technical capabilities of a specific HALE UAS system (which do, and will vary widely), it is intended to aid in requirements capture and to be used as input to the functional requirements and analysis process. The document provides a basis for development of functional requirements and operational guidelines to achieve unrestricted access into the NAS.

This HALE UAS CONOPS represents a user’s view of how HALE UAS will be operated in the future and offers a vision for integrating HALE UAS into the NAS. It provides details as to how HALE UAS would be integrated into the NAS, what infrastructure they will utilize, and identifies potential technologies that will be needed to allow HALE UAS to routinely operate within civil airspace in a manner similar to manned aircraft.

The CONOPS identifies future challenge areas that must be addressed prior fully integrating UAS into civil airspace. The achievement of routine fly and fly access to the NAS will require

the relevant interpretation of existing policies and standards, the development of new procedures and technologies, along with sufficient data to verify and validate that they are appropriate and adequate for safe flight in the NAS. Offered only as a vision, it is recognized that the achievement of this capability will depend on the establishment of standards from the appropriate standards organization.

The timeframe for this transition (evolution) is consistent with expected technological improvements and strategic goals contained within the Federal Aviation Administration's NAS development documents. Specifically, approved UAS systems will ensure that safety and security of the NAS is maintained, while efficiency gains are complemented. It is also expected that technological and procedural advances achieved with HALE UAS systems will have a direct, positive effect on UAS systems operating at lower altitudes within the NAS, including airport surface operations.

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

The demand to operate High Altitude Long Endurance (HALE) Unmanned Aircraft Systems (UAS) within the National Airspace System (NAS) is expected to increase significantly in the near future. This demand is being fueled by emerging civil markets (federal non-DOD and commercial), both domestic and international. The growth of the HALE UAS industry requires technology standards and regulatory criteria (certification of aircraft and the individuals who fly them) and operating standards (flight rules) that provide for the safe integration of this new aviation technology into the mainstream of airspace users.

This Concept of Operations (CONOPS) document has been prepared by the Access 5 Project (see Appendix C for the history and background on the Access 5 Project) to provide insight into how HALE UAS will integrate into the NAS, what infrastructure they will utilize, and what technology will be required to make these advances possible. It is expected that this CONOPS will form the basis for technological, procedural and architectural investments that will produce initial HALE UAS system operational requirements to operate routinely within the NAS. The operational concepts identified with this process are the first steps to implementing far reaching concepts for achieving full HALE UAS integration into the NAS. These concepts will be used as a baseline to define overall UAS system planning for access into the NAS.

1.2 CONCEPT OF OPERATIONS VERSUS OPERATIONAL CONCEPT

The terms Concepts of Operation (CONOPS) and Operational Concepts (OPSCON) are sometimes confused and erroneously used interchangeably. An OPSCON provides a vision of future operational capabilities and articulates them in a high-level description of the processes and services needed to achieve that vision. What it is that one is striving to achieve. It also provides an estimate of the level of performance required from the components of the system. A CONOPS on the other hand describes a system's functional characteristics from a user's perspective and provides a detailed description of how a system would be used.

An OPSCON is typically written at a higher level than a CONOPS. Figure 1 depicts the hierarchy of OPSCON and CONOPS documents using Air Traffic Management (ATM) as an example. The ICAO ATM Operational Concept describes an internationally recognized future gate-to-gate ATM operational concept. European Nations have created the EuroControl Operational Concept. Each identifies key changes that will need to be made and provides a general picture of the future performance of the ATM system – the organization, airport and airspace operations, demand, capacity, traffic synchronization, conflict management, and other services). An OPSCON provides a foundational basis for developing the requisite components of the future system. It is visionary in scope, is not limited by state-of-the-art (SOA) technologies, realizes benefits of current technology investments, and offers a basis for cost benefit for future technologies and innovations. In the U.S., the guiding document is the FAA (RTCA) NAS Concept of Operations.

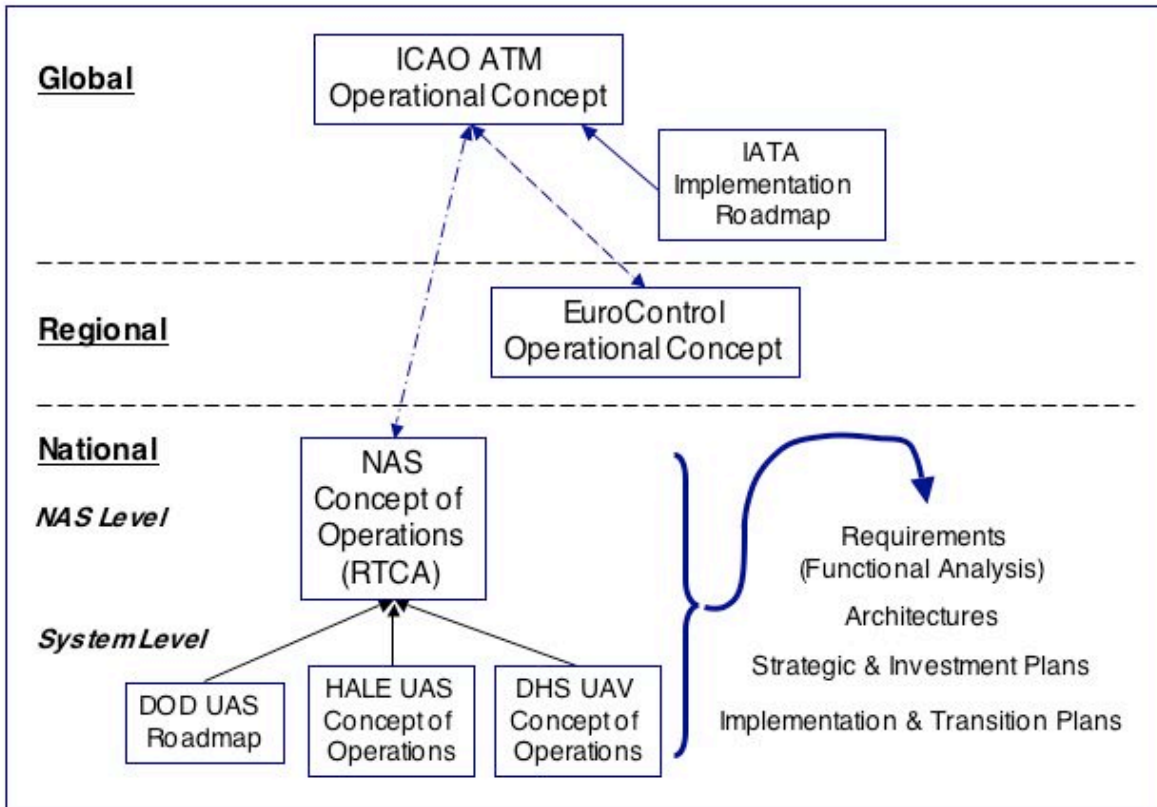


Figure 1. Hierarchy of Operational Concept (OPSCON) and Concept of Operation (CONOPS)

The FAA NAS Systems Engineering Manual (Ref: NAS Systems Engineering Manual, Ver. 3, Sept 30, 2004) describes two levels of CONOPS:

NAS Level CONOPS – “... a high-level document that indicates, from the user’s perspective, the desired end state for the respective system in the NAS.”

System Level CONOPS – “ ... an extension of a NAS Level CONOPS with an emphasis on a particular system. ... more detailed and substantial, ... it is an expression of the user’s needs with respect to a specific system with in the NAS.”

This HALE UAS CONOPS is intended to be a system level CONOPS. It provides a concept of operations from the perspective of future HALE UAS service providers and NAS users. It describes current systems (existing UAS), describes HALE UAS functions and operations to be performed (via sample missions), and offers insight into the user’s environment (i.e., the UAS as a system of systems). It is intended to be a source document for NAS UAS operational requirements, and provides a construct for government agencies to use in guiding their regulatory decisions, architecture requirements, and investment strategies. Although it does not describe the technical capabilities of a specific HALE UAS system (which do and will vary widely), it is intended to aid in requirements capture and to be used as input to the functional requirements and analysis process. It provides a basis for functional requirements development. This HALE UAS CONOPS represents a user’s view of how HALE UAS will be operated in the future and identifies future challenges associated with developing the requirements for the future NAS.

1.3 CONOPS DEVELOPMENT ASSUMPTIONS

In order to develop a CONOPS that would be feasible within a reasonable timeframe, some assumptions had to be made. These assumptions are summarized in Table 1. In short, the assumptions suggest that a HALE UAS system will need to be designed, manufactured, certificated and operated under similar regulations as manned aircraft. Onboard automated systems will be available to enable the HALE UAS to achieve an equivalent level of safety as a manned system in the event of any in-flight anomaly or loss of command, control or communication links. The HALE UAS will operate in the same airspace as manned aircraft and will not depend on segregation to maintain requisite levels of safety.

Table 1. HALE UAS CONOPS Development Assumptions

No.	Assumptions
1	Civil HALE UAS – UAS certified for civil use requires a broader level of involvement with the FAA, and is more appropriate for commercial application of UAS versus public-operated (military, federal, or state operations) UAS.
2	UAS are regulated aircraft – UAS are considered aircraft subject to FAA regulation for airworthiness and operations.
3	HALE civil/commercial UAS require type certification – Same as a manned aircraft.
4	Commercial UAS require appropriate operating certificates (includes maintenance, training, etc.) – Same as a manned aircraft. The specific crew rating requirements will be proposed as part of the Project.
5	Civil/commercial UAS require approved production process – Will be same as a manned aircraft for Type Certifications.
6	Civil UAS require an Airworthiness Certificate – Same as a manned aircraft.
7	Small aircraft (Part 23) is starting point for level of safety/performance requirements – Part 23 provides a starting basis for program planning. Actual UAS safety/performance requirements will be proposed as part of the Project.
8	Control Station part of UAS System will require Certification – The Control Station is considered part of the UAS system and therefore will need to be type certified.
9	UAS operations in the NAS will be under IFR only – All UAS flight will be conducted on an IFR flight plan. This is consistent with HALE UAS operations in Class A airspace.
10	IFR equipment requirements may change for UAS (functional equivalence is the requirement) – Since the UAS control station is separate from the aircraft, the minimum equipment requirements for flight under IFR may not be the same as for manned aircraft. The requirement is assumed to be providing equipment that delivers the same functionality as required for manned aircraft.
11	General Operating and Flight Rules (Part 91) is starting point for UAS flight operations – Part 91 provides the starting basis for program planning. Exceptions to Part 91 for UAS will be identified/proposed as part of the Project.
12	No new Special Airspace exclusive to UAS – No airspace will be designated or set aside for commercial UAS operations.
13	UAS will comply with existing Separation Standards (per FAA 7110.65) – The UAS will be treated like a manned aircraft with respect to air traffic controller requirements for aircraft separation. Unless it is determined that safety issues arise when UAS operate under existing separation standards (i.e., called out in FAA 7110.65) they will adhere to those separation standards. If safety concerns are identified, then new UAS-unique separation standards may need to be developed. ELOS comparable to manned systems will be maintained.
14	The UAS must be able to comply with all ATC instructions – Same as a manned aircraft under ATC control.
15	Pilot (operator) will be certificated under Part 61 – All UAS flight crew will be certified using 14 CFR Part 61, the same as manned aircraft. Recommendations for certification standards for UAS flight crew will be defined during the Project.

16	Maintenance requirements will be similar to General Aviation (14 CFR Part 43) —An annual inspection will be required for the UAS. All maintenance will need to be recorded in UAS logbooks and the UAS returned to service (declared airworthy) by appropriately certified personnel. The Control Station is part of the airworthy UAS system, so it will also need to be configuration controlled, too.
17	Basis for UAS system certification will be under Part 21.17 – The basis for UAS type certification will be tailored from existing certification rules and potentially new rules proposed.
18	The FAA will require UAS to achieve an Equivalent Level of Safety (ELOS) – The FAA will require safety analysis (type TBD), NAS simulation and/or flight demonstrated capability to operate safely in the NAS. The level of safety demonstrated will be commensurate with the type of operations to be conducted.
19	ELOS requirements shall be specified in functional terms – The equivalent level of safety requirements will be stated as functional requirements, and not specific design requirements.
20	Access 5 Project will NOT certify an aircraft or subsystems – The actual certification of an UAS, or UAS subsystem will be the responsibility of an UAS or subsystem manufacturer.
21	An operator will be in/on the loop during normal UAS operations – A human will always have control or override authority during normal UAS flight operations. Even when the UAS is operating autonomously, a human will have the ability to take control of the UAS.
22	Landing aids will transition to augmented navigation systems – By the end of the Project, the primary method of landing will be some augmented form of GPS (WAAS, LAAS, etc.) onboard the UAS.
23	UAS will operate in all classes of airspace – UAS equipment and operating procedures must provide the capability to operate in any class of airspace usable under IFR.
24	The airspace used by UAS will contain both cooperating and non-cooperating aircraft – By the end of the project, UAS policies, procedures, and technologies must be in place to allow operations in environments with all normal NAS traffic, and maintain an equivalent level of safety as a manned aircraft.
25	Autonomy is a system implementation preference – Whether a function is performed manually or automatically (autonomously), it will still need to meet minimum operational and performance requirements while achieving an equivalent level of safety as a manned system.

1.4 CONOPS DOCUMENT ORGANIZATION

This document conveys the Access 5 Project’s Concept of Operations for HALE UAS in the future NAS. It contains six sections and three appendices with following contents:

Section 1 provides a context for the HALE UAS Concept of Operations document, summarizes the assumptions used in development of the document.

Section 2 provides an introduction to the HALE UAS system with a description of its three operational elements and a brief overview of existing HALE UAS systems.

Section 3 describes the challenges facing HALE UAS operation within the NAS, and the current FAA regulatory environment within which HALE UAS will need to fit. Also presented is a perspective on what the requirement for an equivalent level of safety means for HALE UAS and what the future NAS holds of HALE UAS.

Section 4 contains the Concept of Operations for how HALE UAS will operate within the NAS with a “file and fly” capability. The section identifies critical HALE UAS external interfaces with the NAS and provides examples of HALE UAS mission scenarios. Activities related to mission planning, airport operations, departure/arrival procedures, en-route/cruise operations, contingency operations, and over all NAS integration issues are addressed.

Section 5 discusses issues pertinent to the implementation of a HALE UAS System and related integration activities.

Section 6 contains a list of reference material used in developing this CONOPS document.

Appendix A is a list of the acronyms used within this document.

Appendix B presents definitions of terms used within this document.

Appendix C provides an overview of the Access 5 Project, including the project vision and mission statements, project scope, the project organizational structure and a summary of the project plan highlighting the four originally planned steps (project phases) leading to routine access of the NAS for HALE UAS.

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2. HALE UAS DESCRIPTION

2.1 HALE UAS Elements

Unmanned Aircraft Systems (UAS) come in varying sizes; from the micro-size aircraft to those with wingspans greater than today's largest commercial aircraft. UAS also have a wide spectrum of operational characteristics and are capable of operating at all altitudes. For purposes of this document, HALE UAS are defined as being capable of performing mission objectives at altitudes above 40,000 feet mean sea level (MSL) for durations of at least 24 continuous hours, and operating "over the horizon" far from its control station using satellite, airborne or ground relayed communication links.

A HALE UAS certified to fly within controlled airspace would be comprised of three key elements depicted in figure 2:

- 1) *Unmanned Aircraft*,
- 2) *Control Station & Ground Support*, and
- 3) *Data & Voice Communication Links*

Each of these elements are described below.

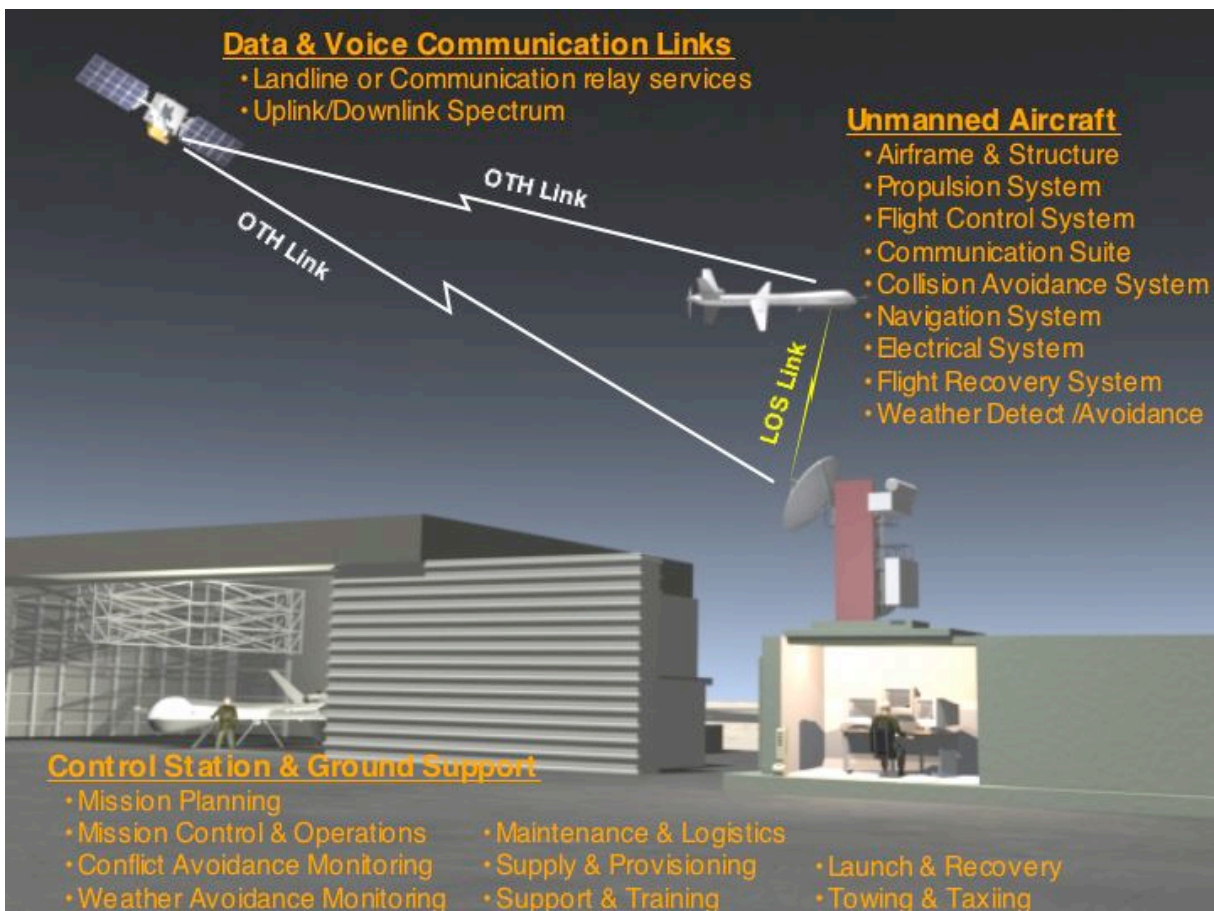


Figure 2. HALE UAS Elements

2.1.1 Unmanned Aircraft

The HALE UAS does not carry a human pilot and is operated through electronic input controlled by an UAS pilot/operator. The unmanned aircraft element includes the aircraft and onboard avionics hardware and software necessary to ensure safe and reliable operation within the NAS, and mission specific equipment. Components in the aircraft include, but are not limited to:

- > Airframe and Structures
- > Flight Controls
- > Collision Avoidance
- > Electrical
- > Weather Detection & Avoidance
- > Propulsion
- > Data Communications
- > Navigation
- > Flight Recovery System

2.1.2 Control Station & Ground Support

The Control Station (CS) & Ground Support element includes the necessary resources to perform the following functions:

- > Mission Planning
- > Aircraft Control and Operations
- > Maintenance and Logistics
- > Launch and Recovery
- > Support and Training

The necessary resources used within the control station may include hardware, software, and human personnel skilled in performing the above functions. The human interface at the control station may or may-not be co-located with the launch/recovery, maintenance, training and logistics elements.

Note that this CONOPS does not presume that the UAS has any specific Level of Autonomy (LOA, defined in Appendix B). Although all UAS will have some level of automated operations, the requirements for ELOS are paramount and will establish the operational requirements based on the level of automation incorporated into the design of the UAS system.

2.1.3 Data & Voice Communication Links

The Data and Voice Communication Links element provides the means for command and control data uplink and downlink capability when the UAS is either within line-of-sight (LOS) or over-the-horizon (OTH) from the CS, and voice communications between the UAS pilot and Air Traffic Control (ATC). This element should be highly available and reliable to ensure safe, secure, and efficient UAS operations within the NAS. Components of the Data & Voice Communications element may include:

- > LOS & OTH Communications
- > Satellite Communication services
- > Airborne Relay Communication services
- > Landline Communication services

2.2 EXISTING HALE UAS

HALE UAS currently operating within the United States includes the AeroVironment Pathfinder Plus and Helios¹, the General Atomics Predator B and Altair, Northrop Grumman's Global Hawk, and the Aurora Flight Sciences Perseus B (see figure 3). Each of these aircraft has operational characteristics that are significantly different from each other. For example, Pathfinder Plus and Helios are solar powered HALE UAS with very limited maneuvering capability. Both climb and turn slowly and their cruise speed generally does not exceed 50 miles per hour. The Perseus B cruises at 65 knots up to an altitude of 60,000 feet. The Predator B and Altair maneuvering capabilities are similar to a manned aircraft, yet their climb speed and cruise speed (200 knot range) are still considerably slower than aircraft that operate at their cruise altitude. The Global Hawk climb and cruise speeds are similar to those of commercial transport aircraft that operate in the same airspace. The Pathfinder and Helios solar powered HALE UAS do not taxi and must be towed onto the active runway, whereas, Predator B, Perseus B, and Global Hawk are each able to taxi to the active runway.

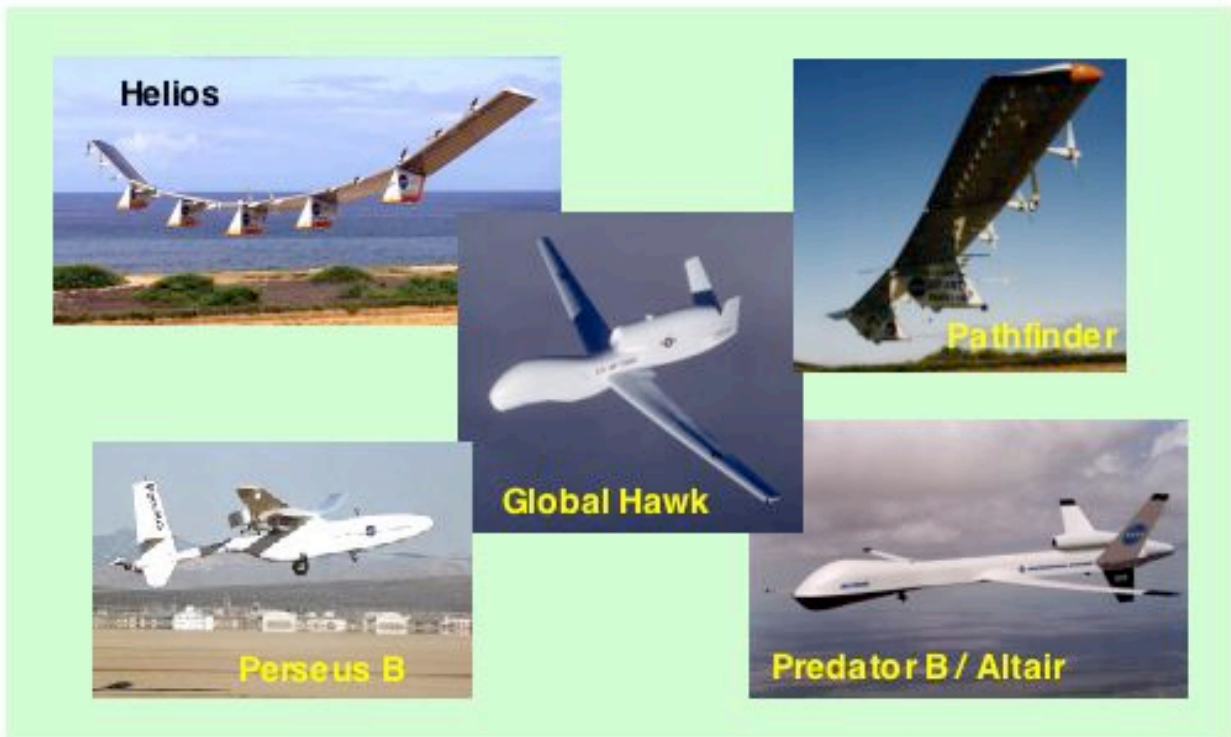


Figure 3. Examples of HALE UAS Manufactured in the United States

Currently, HALE UAS are primarily used by the DoD organizations for military reconnaissance applications, using various systems for remote sensing, such as electro-optic (EO), infrared (IR), or synthetic aperture radar (SAR) sensors. Several other government agencies, such as NASA, the National Oceanographic and Atmospheric Administration (NOAA), and the Department of Energy (DoE), have demonstrated the usefulness of these aircraft for scientific research and data collection. Some of these applications include agriculture monitoring, researching weather phenomenology, wildfire monitoring and management, and global disaster monitoring.

¹ The Helios aircraft was lost in an in-flight mishap in 2004.

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3. REGULATORY & OPERATIONAL ENVIRONMENTS

3.1 REGULATORY ENVIRONMENT – MANNED & UNMANNED

Aviation safety within the United States, and throughout the world, is achieved through regulatory processes that address the aircraft, the pilot, and operational flight rules. The FAA has the responsibility for maintaining safety in the NAS. The FAA issues a series of FAR under Title 14, Code of Federal Regulations (14 CFR), to define the applicable aircraft certification standards, pilot requirements, and general operating and flight rules.

One of the objectives of this CONOPS is to establish a basis for the regulatory criteria that will define the requirements HALE UAS operators will need to meet to be able to conduct unrestricted (file and fly) flight operations in every category of airspace. It is envisioned that HALE UAS will operate within the same regulatory system as manned aircraft.

3.1.1 Aircraft Registration

The first aspect of the regulatory requirement for aircraft, both civil and public, is that of aircraft registration. Aircraft registration is important because it uniquely identifies each aircraft. The aircraft identification is also important to the flight plan process to uniquely identify each aircraft and its capabilities. (See FAA Form 8050-1, Aircraft Registration Application.)

3.1.2 Aircraft Certification

Following aircraft registration, aircraft type and airworthiness certification is achieved. The type and airworthiness certification criteria and methods establish a minimum set of design and performance requirements for safe flight for that category and class of aircraft. All civil aircraft must obtain an FAA Certificate of Airworthiness prior to flight within the NAS. Each aircraft must also be operated and maintained in compliance with the airworthiness certificate. When a new aircraft type (design) is approved, the model identification is also recorded, and all future aircraft of that type are given the same model identification. The operational characteristics of each aircraft model are included in the FAA's aircraft performance data records. ATC uses these data to assist in controlling aircraft in the NAS. (See FAA Form 8130-6, Application for U.S. Airworthiness Certificate).

3.1.3 Pilot Qualifications

In the future regulatory environment it is expected that HALE UAS pilots will need to meet very similar qualifications as pilots of manned aircraft. The standards for manned aircraft have been established by aircraft type, class, and category associated with the classification of airspace in which flight operations are performed. Because some portion of each HALE UAS flight will be performed in Class A airspace, which requires the flight to operate under Instrument Flight Rules (IFR), it is appropriate for HALE UAS pilots to possess a current pilot certificate and instrument rating or the equivalent. These qualifications should also be satisfactory for the operation of HALE UAS in any category of airspace.

3.1.4 Requirements for Equivalent Level of Safety

HALE UAS flight operations will need to demonstrate that they can achieve an equivalent level of safety (ELOS) comparable with manned aircraft, and as such, do not pose a hazard to persons and property both in the air and on the ground. Ensuring that HALE UAS achieve an ELOS

would be accomplished through processes similar to those used to make certain that manned aircraft are safe - aircraft airworthiness certification, pilot certification, and compliance with the general operating and flight rules. These three aviation regulatory elements taken together comprise “aviation safety”. If any single element is unsafe, the entire system is unsafe.

The easiest method of demonstrating safety is to meet the existing rules and regulations for manned aircraft (14 CFR 21.21, paragraph (b)²). If existing airworthiness standards cannot be met, then the shortcoming (deficiency) must be “...*compensated for by factors that provide an equivalent level of safety.*” The process for demonstrating that a deficiency still meets the equivalent level of safety requirement is identified in Paragraph (g.) of FAA Order 8110.4B³. This order identifies the FAA aircraft certification office (ACO) as responsible for the “...*equivalent level of safety finding*” when literal compliance with a certification regulation cannot be met, and compensating factors can be shown to provide the requisite equivalent level of safety. The evaluation is often subjective, and looks at the system and/or operation to determine the risk to other users of the NAS and people/property on the ground.

Table 2 summarizes the regulatory and operational requirements that will be needed by a HALE UAS to enable it to operate routinely and safely in the NAS. These include requirements that identify where the system will be used, how the system will accomplish its mission objectives, and what environment the system will be expected to operate within.

² **14CFR 21.21; Paragraph (b.) Issue of type certificate: normal, utility, acrobatic, commuter, and transport category aircraft; manned free balloons; special classes of aircraft; aircraft engines; propeller.**

An applicant is entitled to a type certificate for an aircraft in the normal, utility, acrobatic, commuter, or transport category, or for a manned free balloon, special class of aircraft, or an aircraft engine or propeller, if:

- (a) The product qualifies under Sec. 21.27; or
- (b) The applicant submits the type design, test reports, and computations necessary to show that the product to be certificated meets the applicable airworthiness, aircraft noise, fuel venting, and exhaust emission requirements of the Federal Aviation Regulations and any special conditions prescribed by the Administrator, and the Administrator finds--
 - (1) Upon examination of the type design, and after completing all tests and inspections, that the type design and the product meet the applicable noise, fuel venting, and emissions requirements of the Federal Aviation Regulations, and further finds that they meet the applicable airworthiness requirements of the Federal Aviation Regulations or that any airworthiness provisions not complied with are compensated for by factors that provide an *equivalent level of safety*; and
 - (2) For an aircraft, that no feature or characteristic makes it unsafe for the category in which certification is requested.

³ **FAA Order 8110.4B; Paragraph (g.) Equivalent Level of Safety Finding**

- (1) Equivalent level of safety findings are made when literal compliance with a certification regulation cannot be shown and compensating factors exist which can be shown to provide an *equivalent level of safety* (reference § 21.21(b)(1) and Order 8100.5, paragraph 408.)
- (2) The applicant submits to the ACO the proposed equivalent level of safety. The ACO then submits to the Directorate the proposed equivalent level of safety with recommendations. The Directorate accountable makes all equivalent level of safety findings.
- (3) In documenting an equivalent level of safety:
 - (a) List the applicable regulation;
 - (b) Describe the features of the design that require the equivalent level of safety findings;
 - (c) Describe any design changes, limitations, or equipment imposed to make the equivalency; and
 - (d) Provide an explanation of how the actions taken provide an equivalent level of safety to that intended by the regulation.
- (4) All equivalent level of safety findings must be listed on the TCDS or on the STC.

Table 2: HALE UAS Regulatory and Operational Requirements

No.	Regulatory and Operational Requirement
Overall Requirement: UAS shall operate safely and routinely in the NAS.	
1	UAS shall be airworthy.
1.1	The UAS shall be registered with the FAA.
1.2	The UAS shall obtain and maintain an airworthiness certificate.
1.3	The UAS shall meet an equivalent level of safety to that of a manned general aviation aircraft.
2	UAS shall be operated safely in the NAS.
2.1	UAS operations shall comply with all applicable requirements in 14 CFR Part 91 – General Operating and Flight Rules.
2.2	The UAS shall obtain and maintain the necessary operating certificates for 14 CFR Part 91 commercial operations (maintenance, training, etc.).
2.3	UAS flight operations shall be conducted under Instrument Flight Rules (IFR)
2.4	The UAS shall operate under the same separation standards required for manned aircraft per FAA 7110.65.
2.5	An authorized and qualified human shall be responsible for the safe flight of each UAS.
2.6	The UAS shall operate in a predictable manner similar to that of manned aircraft in the event of an emergency or other contingency situation.
2.7	The UAS shall utilize authorized frequency spectrum for command, control, communications and payloads.

3.2 CURRENT OPERATIONAL ENVIRONMENT – WAIVERS AND AUTHORIZATIONS

Regardless of their mission or role, UAS are currently restricted as to *HOW*, *WHEN*, and *WHERE* they can operate within the NAS. Since there are few regulatory or procedural guidelines in existence for unmanned aircraft, UAS operations within civil airspace are currently treated as exceptions, one time events, and authorization to fly is granted on a per mission basis under an FAA-issued Certificate of Authorization (COA) (FAA Form 7711-1), in accordance with procedures contained in FAA Order 7610.4K, *Special Military Operations*. This FAA order is a joint agreement between the FAA and the DoD that delineates responsibilities and procedures that apply to a variety of special military operations. Currently, the FAA utilizes the COA as the means of authorizing all UAS operations in the NAS, outside restricted and warning areas.

The Air Traffic Divisions (ATD) in the various FAA regional offices are responsible for granting or denying a HALE UAS operator’s request to conduct HALE UAS flight operations in the NAS, except that the FAA Flight Standards (FS) organization will make the determination for those FAR sections assigned to them for consideration. Applications for COAs that require both ATD and FS technical consideration are handled jointly. The FS organization, as designated by the FAA Administrator, is responsible for providing advice with respect to the qualifications of civil pilots, airworthiness of civil aircraft, and safety of persons and property on the ground.

The granting of a Certificate of Authorization (COA) by the FAA constitutes relief from the specific regulations stated, to the degree and for the period of time specified in the certificate, but does not waive any state laws or local ordinances. Should the proposed operations conflict with any state or local ordinances, or require permission from local authorities or property owners, it is the applicant's responsibility to resolve the matter.

Even with a valid COA UAS are unable to routinely operate as a manned aircraft and are subject to numerous restrictions prohibiting them from performing simple activities such as: operating above populated areas of the country, taking off or landing outside special use airspace (SUA), and flying in airspace containing manned aircraft. Under the COA process, UAS are allowed to operate within the NAS, but only through means of segregation.

3.3 CHALLENGE AREAS

There are a number of challenges associated with integrating UAS into civil airspace. Close coordination with the FAA has identified seven major challenge areas that must be addressed prior to UAS having the ability to file and fly within the NAS. These challenges must be addressed to enable safe, routine operations of UAS in the NAS. All are necessary, and each is of equal importance. Although an interim work-around may be utilized in certain challenge areas to enable limited operations, full and routine access to the NAS will require policies, procedures, and technologies to be identified or developed, along with sufficient data to substantiate that they are both appropriate and adequate for safe flight in the NAS. These seven challenges are briefly discussed below.

3.3.1 Appropriate Level of Safety

As discussed in section 3.1.4, one of the key challenges that must be addressed is the definition of an appropriate level of safety for a UAS. The minimum level of safety will drive the level of airworthiness standards for the design and certification that the public demands for civil aircraft in the NAS. There are currently different minimum levels of safety that are acceptable, depending upon the classification and use of manned aircraft. The resolution of this challenge will require a proposal with adequate rationale for an appropriate UAS level of safety – a level of safety equivalent to comparable manned systems.

3.3.2 Minimum Airworthiness & Operating Standards

The minimum airworthiness and operational standards challenge is associated with the lack of identified or developed standards for type/airworthiness certification and operation of UAS. Appropriate and adequate standards have not yet been identified, or in some cases do not exist. For example, cockpit design standards may not be appropriate or adequate for a UAS control station that is physically separate from the unmanned aircraft. In such situations, new standards will need to be developed with substantiation that they are both appropriate and adequate.

3.3.3 Sense and Avoid

The sense and avoid challenge refers to the UAS capability to comply with existing “see and avoid” requirements for all aircraft in the NAS. This challenge involves both the definition of standards and the development of technology solutions to meet those standards. A key element of this challenge is to obtain agreement on an appropriate and adequate definition/description of the UAS “sense and avoid” requirement. The definition/description needs to be broad enough to

allow for varied solutions to the problem, and specific enough to actually ensure the safe operation of UAS in the NAS and on airport surfaces. Establishing sense and avoid functional and performance requirements must be a key focus of the organizations trying to address this challenge.

3.3.4 Frequency Spectrum

The frequency spectrum challenge addresses the need for allocated and approved frequency spectrum for UAS command/control use. To date, no frequencies in the electromagnetic spectrum have been allocated or approved for UAS command/control use. Current UAS, use military spectrum, or commercial voice/data services for both command/control and data transmission. UAS command/control involves flight-safety critical links and therefore needs to be in a portion of the frequency spectrum that is appropriate and adequate for command/control use, as well as allocated as a primary use by the FCC/ITU. Resolution of this challenge will require national attention and international action to obtain the use of appropriate frequency bands.

3.3.5 Pilot Qualifications

The pilot qualifications challenge involves the identification of appropriate minimum criteria for UAS pilots and/or other required crewmembers. Pilot certification based on appropriate standards is required to promote safe operations in the NAS. Resolution of this challenge will require definition of a minimum level of pilot certification/rating for the pilot-in-command of a UAS, and the definition of appropriate medical qualifications. In addition, training, currency, and testing standards will also need to be developed to correspond to the UAS pilot certificate/rating.

3.3.6 Separation Issues

The separation issues challenge deals with what the appropriate aircraft separation standards should be for UAS systems. Since most unmanned aircraft have very different structural and performance characteristics than their manned counterparts, they may require unique separation standards. For example, HALE UAS tend to have long, very flexible wings that may have susceptibility to turbulence generated by other aircraft. What the appropriate spacing of these vehicles is for take-off and landing operations around other aircraft and safe passing distances at altitudes need to be investigated to determine whether or not existing manned aircraft standards and procedures are appropriate.

3.3.7 System Safety Analyses

The system safety analyses challenge refers to the need for various safety studies to be conducted to assist in the identification and understanding of potential hazards/risks associated with UAS certification and operation in the NAS. Since the UAS is a system of systems, safety analysis should be performed on the individual elements as well as the overall system. Whatever safety plan gets implemented, it should be compatible with the system safety management plan used by the FAA.

3.4 FAA CONSIDERS UAS AS AIRCRAFT

The FAA Federal Aviation Regulations (FAR) applicable to aircraft, pilots, and general operating and flight rules do not specifically use the terms remotely operated aircraft (ROA), remotely piloted vehicle (RPV), unmanned air vehicle (UAV) or unmanned aircraft system (UAS); or any similar aviation term for that matter. However, in FAR Part 1 Definitions and Abbreviations, the statement that an “aircraft means a device that is used or intended to be used for flight in the air,” clearly places UAS in the aircraft category, just as airplanes, balloons, gliders, rotorcraft and rockets are given specific definitions in FAR Part 1.

Further evidence that the FAA considers UAS to be aircraft is seen by their recent decision to grant several UAS with tail numbers and issuance of an Experimental Airworthiness Certifications (EAC). To date, three UAS have been granted tail numbers: the General Atomics Altair, the Bell Helicopter/Textron Eagle Eye, and the Boeing Scan Eagle. Two of these three aircraft have been granted EACs by the FAA: Altair in August 2005 and Eagle Eye in December 2005. Although the EACs limit both of these aircraft in how, when, and where they can operate, the fact that the FAA issued airworthiness certificates is substantiating proof that UAS are in fact aircraft.

3.5 FUTURE NAS DEVELOPMENTS

Since the NAS is expected to evolve towards a time-based system (e.g., 4D flight) the HALE UAS will be expected to respond to time-based advisories in a manner similar to manned aircraft. Currently, it is through heading, speed, and altitude advisories. In the near future aircraft with 4D guidance may be given a preference. Policy, procedures, and technology developments must consider the projected future state of the NAS as they are planned and executed.

4. CONOPS FOR HALE UAS IN THE NAS

4.1 “FILE AND FLY” CAPABILITY

The term “File and Fly” defines the ability of HALE UAS operators to file an IFR flight plan and operate in all class of airspace, consistent with the regulatory criteria and operational requirements for manned aircraft. It assumes the UAS has compatible performance capabilities with manned aircraft operating at the same altitude(s). The flights require no pre-coordination with ATC. As with manned aircraft, any UAS flights requiring special ATC handling in order to achieve mission objectives are not “file and fly” and would need to be pre-coordinated with ATC.

4.2 HALE UAS OPERATING CONCEPT

The envisioned operating concept includes the ability to perform safe, secure, and efficient operations within the NAS, with “unrestricted” flight for HALE UAS operating above 18,000 feet (FL180). A depiction of this concept is presented in figure 4.

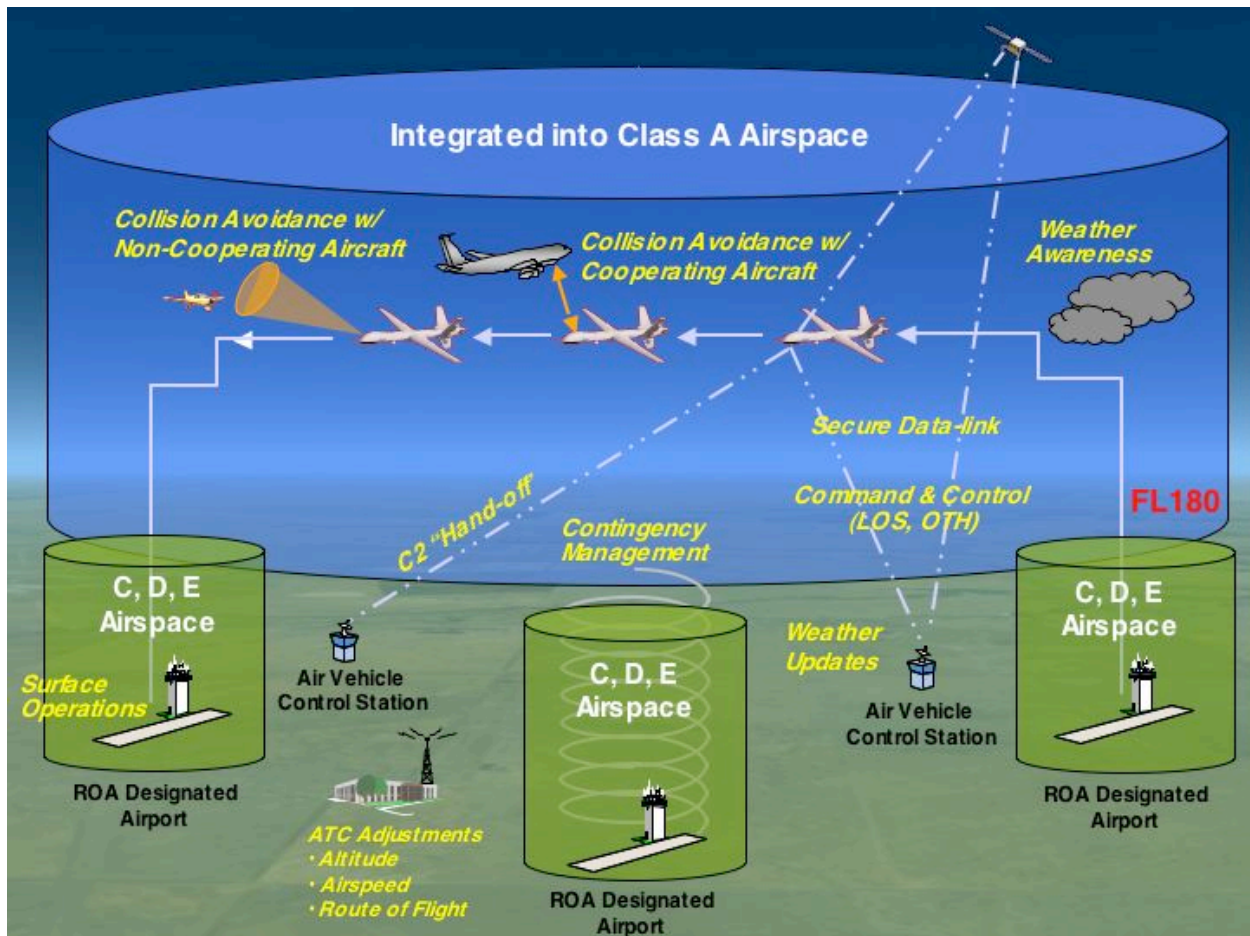


Figure 4. HALE UAS Operational Concept

In a nominal mission, the HALE UAS will takeoff from an UAS designated airport (see Section 7.3) on an IFR flight clearance, and climb to its cruising or mission altitude. The HALE UAS

will remain within or above controlled airspace for all operations. Throughout the flight the links between the UAS and the control station, and the link between the UAS pilot and ATC, will be maintained (the aircraft is either within LOS or OTH from the control station). Since the aircraft will always be under the command of a human pilot during normal operations, the links must be maintained regardless of the level of autonomy of the aircraft. The security of the control station and the command and control link will be maintained to prevent external interference with UAS operations. The aircraft will avoid adverse weather conditions throughout the flight. The aircraft will avoid conflicts with other air traffic through a combination of flight planning, ATC control, and collision avoidance technology. UAS navigation during the flight will be through a combination of onboard and off-board guidance performed from the control station. Mission specific orbits or other deviations will be coordinated with ATC, and will either be preprogrammed or directed from the control station. Any abnormal or “emergency” operations will follow pre-established procedures, or will be coordinated with ATC in real-time, to divert to an UAS capable airport or otherwise execute actions to minimize the risk to other NAS users or people/property on the ground. Approach and landing will be to an UAS designated airport using appropriate instrument arrival and approach/land procedures. In order to achieve routine operations within the NAS, the recommended Access 5 Project strategy is to attempt to incrementally gain more access to NAS with gradually less restrictions.

4.3 HALE UAS EXTERNAL INTERFACES

To completely understand how an UAS system will operate within the NAS, it is essential to identify and understand each of the external interfaces with which the UAS system must interact. Figure 5 depicts several of the essential external interfaces needed to operate in a safe, secure, and efficient manner.

The specific external NAS interfaces will change depending upon where the UAS is located within its flight profile. To better explain these external interfaces, they have been grouped according to the part of the flight profile they are encountered. To explain this we will divide a typical flight profile can be divided into the following phases:

- 1) *Pre & Post-Flight Phases*
- 2) *Flight Ops Phase*

A table depicting the roles and responsibilities of those involved in orchestrating a HALE UAS flight/mission is presented in Table 3. Each of these phases and the accompanying external interfaces are discussed in the following sections.

4.3.1 External Interfaces Used During the Pre & Post-Flight Phases

Pre-flight begins with mission planning/coordination, and the filing of an IFR flight plan. This phase ends once the aircraft has taxied to the runway and crossed the “hold-line”. The *Post-flight* phase begins when the aircraft has safely cleared the runway at the destination airport, and ends when the aircraft is parked in its designated area. For these phases, the local airport management and Flight Service Station (FSS) are the two essential external interfaces:

- Airport Management - Provides aircraft siting, safety, security, environmental, and logistics services.
- Flight Service Station - Provides weather briefings, Notice to Airman (NOTAM) announcements, and Flight Plan filing.

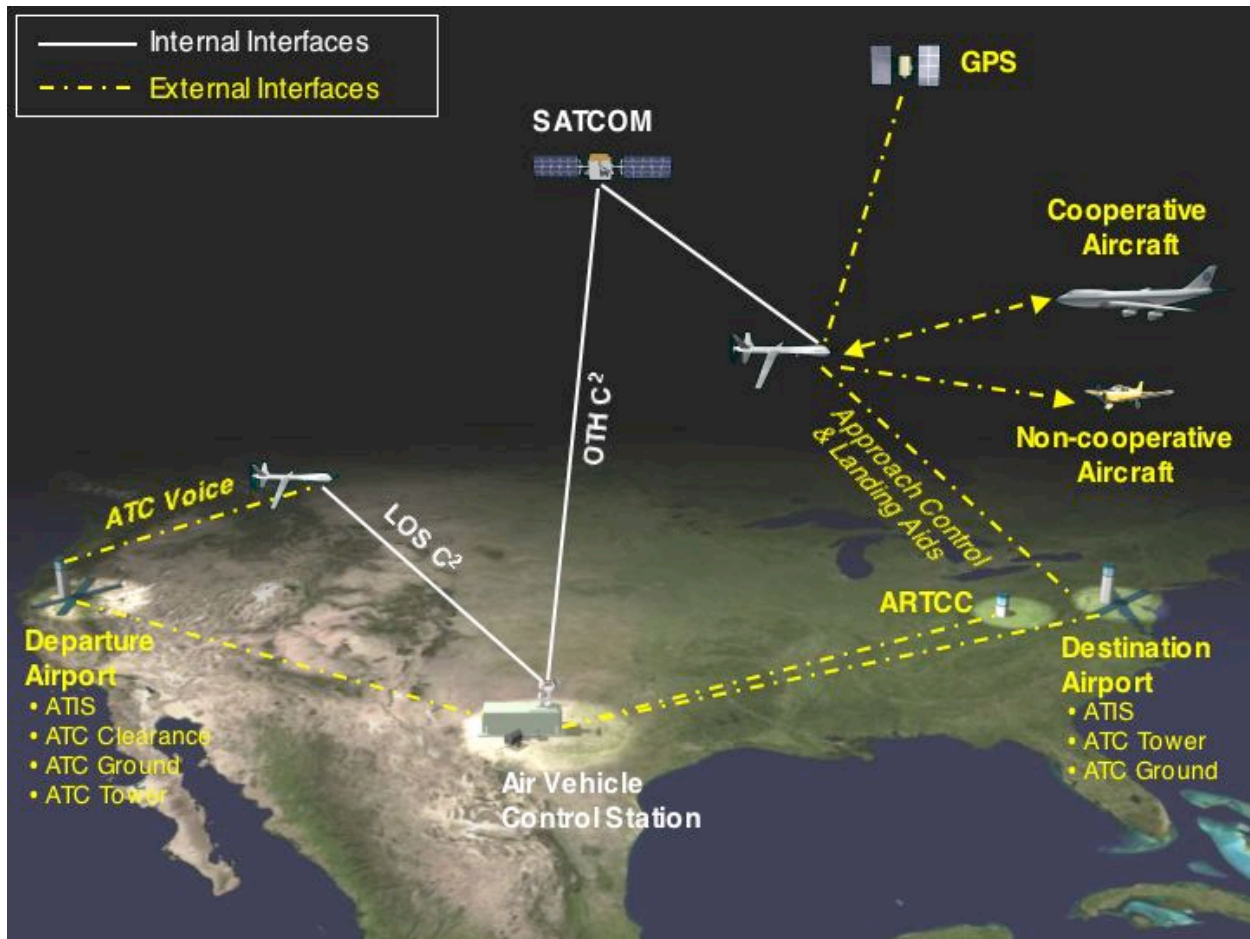


Figure 5. HALE UAS System External Interfaces

4.3.2 External Interfaces Used During the Flight Operations Phase

The *Flight Ops* phase begins when the aircraft crosses the “hold-line” and accesses the runway for take-off. Likewise, this phase ends once the aircraft has cleared the runway at the destination airport. For this phase, the external interfaces include local ATC at the departure airport, departure/enroute/approach control, and local ATC at the destination airport.

- Local ATC at Departure Airport – Provides Clearance (route and altitude), Ground (taxi clearance), Tower (take-off clearance), and Automatic Terminal Information Service (ATIS) information regarding local weather and runway usage.
- TRACON / ARTCC – Provides Departure Control, Enroute Control, and Approach Control.
- Local ATC at Destination Airport – Provides ATIS information regarding the local weather and runway usage, Tower (clearance to land), and Ground (taxi clearance).
- Other Aircraft – In addition to the items listed above, the UAS must safely interface with other manned and unmanned aircraft, both on the ground and in the air, in accordance with FAA policies, rules, and regulations. The other aircraft operating within the NAS could be cooperative or non-cooperative depending upon whether or not they operate using a

Table 3. Notional Organizational Roles and Responsibilities during a HALE UAS Mission

Mission Element	HALE UAS Operations				FAA Operations			
	Ops Manager	Ground Crew	Pilot / Operator	Payload Ops	Flight Services	Local ATC	Air Traffic Control	
Preflight Planning	Develop mission/flight plan meeting user/customer requirements	Site aircraft for preflight	Participate in flight plan development Plan contingencies, emergency procedures, etc. Prepare IFR flight plan	Participate in flight plan development	Provide weather information for extent of planned flight - duration and route			
Systems Preflight	Monitor systems preflight	Perform aircraft preflight	Preflight control station Upload flight plan into Control Station File IFR flight plan	Preflight payload systems - on aircraft and in control station	Provide weather and NOTAM updates Accept flight plan	Provide current runway usage		
Taxi	Monitor mission progress	Tow/taxi aircraft to runway	Pilot aircraft to runway		Provide weather update	Provide taxi guidance and clearance	Provide departure directives Provide inflight guidance and approvals Provide descent guidance and approach clearance	
Take-Off, Departure			Launch aircraft			Provide launch clearance		
Climb			Maintain security of Control Station	Pilot aircraft, communicate with ATC		Startup payload systems		
Enroute, Cruise, Loiter (Mission Phase)						Operate payload systems		
Descend						Shutdown payload systems		
Arrival, Landing				Land aircraft				Provide landing clearance
Taxi			Tow/taxi aircraft from runway	Pilot aircraft from runway				Provide taxi guidance and clearance
Systems Postflight	Monitor systems postflight	Park and secure aircraft	Close flight plan Document mission accomplishments, discrepancies, system anomalies, etc.	Postflight payload systems	Close flight plan			
Postflight Debrief	Ascertain mission success	Participate in postflight, vehicle status	Participate in postflight	Participate in postflight				

transponder for identifying their position to other aircraft. Many systems exist today for detecting these aircraft, thereby providing the pilot with situational awareness of all cooperative aircraft within its immediate area. Other means such as sense and avoid systems will be used to effectively and safely operate around non-cooperative aircraft.

4.4 EXAMPLE UAS MISSION SCENARIOS

UAS have the potential to perform a multitude of commercial, civil, and military roles. It is often stated that UAS are ideal for those “Dull, Dirty, or Dangerous” missions because they are not subject to the same physiological limitations commonly associated with manned aircraft. For those potentially hazardous missions required by the DoD, DHS or science community, they pose no risk to human life. Whenever persistence is required, they do not tire and their performance level is consistent throughout the mission.

The following sections describe two potential mission scenarios for UAS and identify some of their characteristics (see figure 6). For both of these scenarios, the mission altitude is above 18,000 feet and the duration of the mission, from take-off to landing, is 24-hours. Prior to beginning the mission, an IFR flight plan would be filed and all steps required for manned flight would be followed. This is an important concept - **UAS operations within the NAS are very similar to that of manned aircraft**. The timelines for the two mission scenarios used in this section help to exemplify and reinforce this.

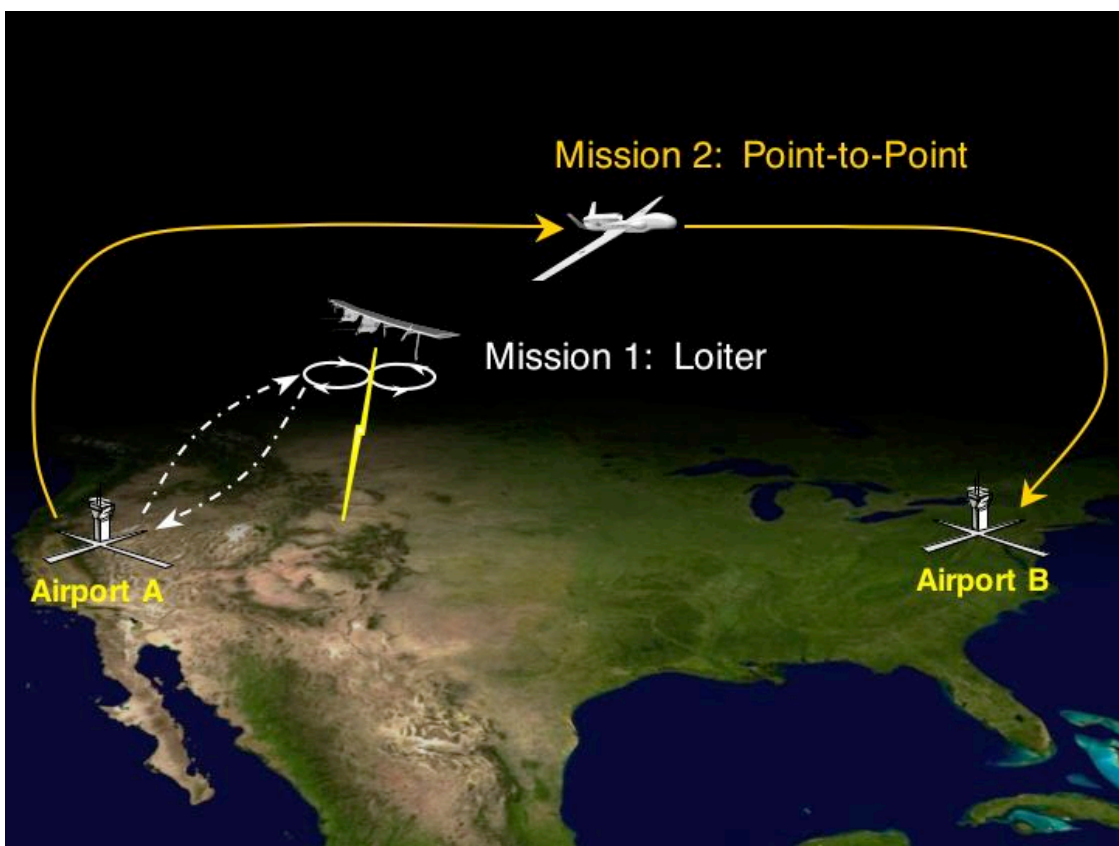


Figure 6. Example HALE UAS Mission Scenarios

4.4.1 Loiter Mission

The Loiter (e.g., Telecommunications services) scenario depicts a mission in which an HALE UAS would station-keep above a metropolitan area and provide telecommunication services like a pseudo-satellite. For this type of mission, the UAS would depart from Airport A, climb to altitude, and fly to the designated mission area, where it would loiter during its entire mission. At the end of its mission the UAS would return to Airport A to land. The revenue portion of the mission would be according to how much time the UAS spent over the mission area.

Since this type of mission would stay within line-of-sight distance from the control station, no over-the-horizon communications would be necessary for command and control of the aircraft. A single control station would be capable of operating the HALE UAS during the entire mission scenario.

The timeline shown in figure 7 depicts events that would occur during this proposed mission scenario.

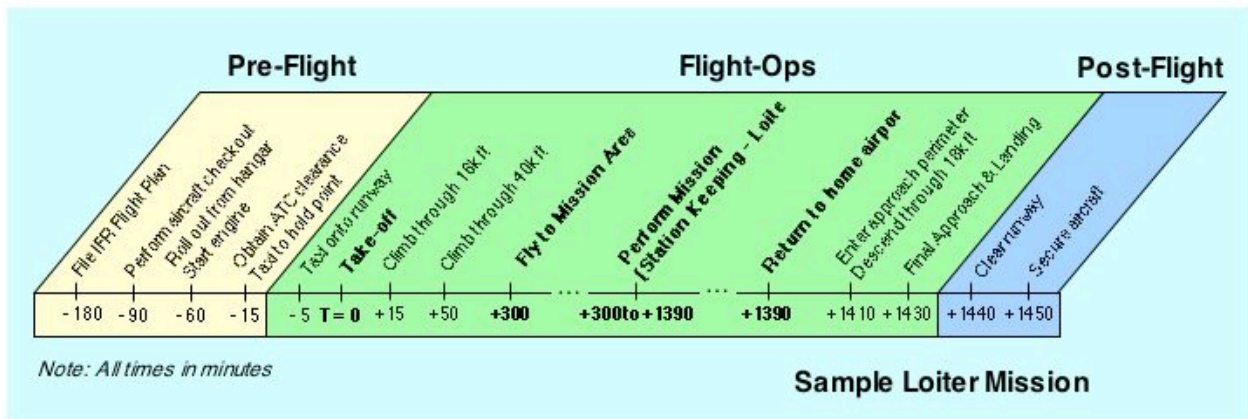


Figure 7. Loiter Mission Timeline

4.4.2 Point-to-Point Mission

The Point-to-Point (e.g., cross country transport) scenario depicts a mission where large UAS are used to transport cargo from one side of the country to the other. In this scenario the UAS would depart from Airport A, climb to altitude, and traverse the country enroute to Airport B, where it's cargo would be unloaded. The revenue portion of the mission would be the entire flight, between takeoff and landing.

Since this type of mission would exceed the line-of-sight distance from the control station some means of over-the-horizon communications would need to be used for command and control of the aircraft. Although a single control station is capable of commanding and controlling the UAS during the entire mission scenario, it could also be feasible to handover control of the aircraft to another control station, possibly located at the destination airport.

The timeline shown in figure 8 depicts some of the events that would occur during this proposed mission scenario.

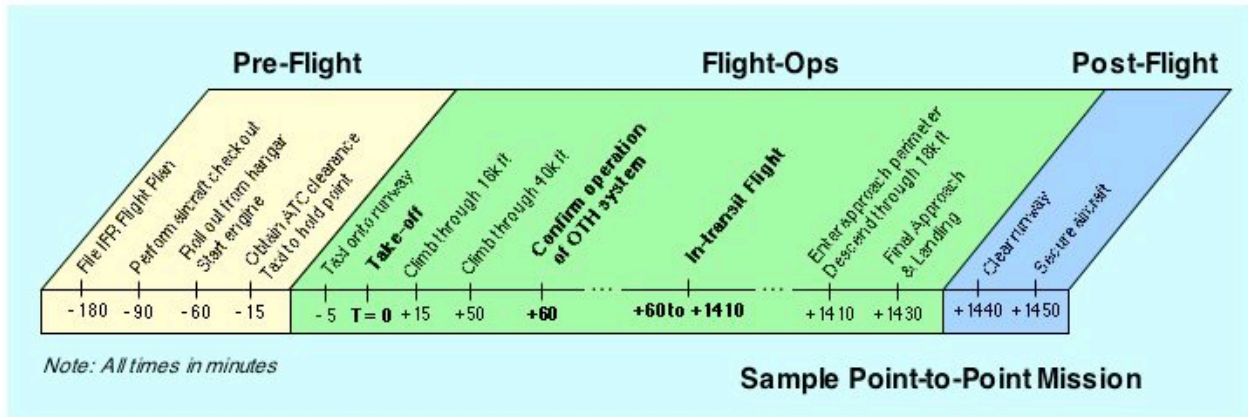


Figure 8. Point-to-Point Mission Timeline

Variants of this mission profile might include the relocated of a HALE UAS from one airport to another, or a long range mission requiring a long dwell/loiter mid-mission and return to an airport other than that which it departed from.

4.5 HALE UAS OPERATIONS WITHIN THE NAS

To operate within the NAS, HALE UAS operations will involve: 1) Mission Planning, 2) Airport Operations, 3) Departure and Arrival Operations, 4) Enroute / Cruise Operations, and 5) Contingency Operations. Each of these will be further described within this section.

4.5.1 Mission Planning Operations

The objective of mission planning is to develop a mission/flight plan that meets the user requirements, and at the same time minimize the impact on the ATC system and other airspace users. Mission planning helps to ensure the HALE UAS mission objectives can be accomplished safely and successfully within the regulatory and air traffic setting.

Operational capabilities will vary between types of HALE UAS. Therefore, a variety of issues must be considered during mission planning: airport operations, climb-out, mission profile, descent/arrival, and avoidance of special use airspace during times when the airspace is active.

4.5.2 Airport Operations

Analysis of airport operations and the surrounding environment is important for HALE UAS departure and arrival. The analysis will include identification of the airport's normal busy air traffic periods, traffic patterns for manned aircraft, noise sensitive areas, optimum location for the control station, sites for visual observers, and potential flight termination areas. HALE UAS operators will coordinate with airport management and other organizations, as required for security, safety, environmental, frequency coordination (FCC, AFTRCC, NTIA) and logistics. UAS pilots will follow standard operating procedures to the maximum extent possible or obtain waivers for any exceptions.

HALE UAS operators will use common ATC frequencies to the maximum extent possible including ATIS, ground control and clearance delivery.

When HALE UAS are unable to taxi to/from the active runway and have to be towed, procedures and schedules will need to be publicized to the other airport users.

4.5.3 Departure & Arrival Operations

HALE UAS operators will follow existing IFR departure, arrival and approach procedures to the maximum extent possible. HALE UAS operations will utilize departure control and radar approach control facilities/services. If HALE UAS are unable to navigate along the IFR departure and arrival routes designed for manned aircraft, specific routes may need to be developed in concert with the appropriate ATC facility and the appropriate FAA Flight Procedures Office. In some situations, the time of takeoff and arrival may be restricted to specific times when manned aircraft operations are minimal.

4.5.4 En-Route/Cruise Operations

The greatest factor involved in accomplishing the mission objective is the ability to operate along the mission route and/or within the mission area. Due to the nature of the mission, it may be critical that the mission portion of the flight is given priority for remaining on the profile, unless the safety of another aircraft precludes this. In any event, safety considerations will always take precedent over the mission objectives.

UAS operators will maintain contact with the air route traffic control centers (ARTCC) using common VHF/UHF communications frequencies or a direct telephone/land line (not a preferred method, emergency use only) to the center controller. The enroute portion of flight will use existing route structure to the maximum extent possible. If deviations are required, they will be coordinated with ATC.

4.5.5 Contingency Operations

The fact that a pilot is not onboard the HALE UAS to make decisions when in-flight anomalies or emergencies arise (e.g., control surface inoperable, engine-out) mandates that detailed planning be accomplished to ensure that safety is maintained. Provisions for the aircraft to automatically maintain adequate levels of safety must be maintained should the ability of the pilot to control the HALE UAS be interrupted (e.g., loss of C2 link). Depending upon the situation and requirements the UAS will use predetermined means to aborting the flight.

4.6 OVERALL NAS INTEGRATION

HALE UAS will be designed, equipped and operated so that they are compliant with today's NAS, as well as the future NAS as described within the FAA's NAS development documents (see Section 1.2). HALE UAS operations will benefit from these proposed NAS enhancements but will not depend on them. Definitions and regulations may need to be modified to allow for HALE UAS operations, but these changes will only be implemented when the FAA has assured such changes will not impact the safety, security, or efficiency of the NAS.

HALE UAS will operate in the same airspace simultaneously with manned aircraft, with limited requirements for special considerations. Although special departure and arrival procedures may be required, UAS pilots will be able to maneuver these aircraft along defined and predictable flight paths and at assigned altitudes. UAS pilots will comply with all flight rules applicable to the class of airspace that the UAS operates within. As such, HALE UAS flight operations will be performed safely in all categories of airspace by complying with the following criteria:

1. Ensure that positive flight control will be available throughout the planned route when planning the flight operation.

2. Conduct all normal and abnormal operations in accordance with the guidelines contained in a flight manual created by the HALE UAS developer.
3. Provide flight-planning information (comparable to that used for piloted aircraft) to the NAS information system for traffic conflict prediction and metering/scheduling purposes. This information should include flight plan modifications (contingencies) to be implemented in case of an emergency.
4. Ensure that one or more of the accepted methods used to sense and avoid other aircraft is employed at all times to achieve the target level of safety.
5. Satisfy the required levels of CNS/ATM/pilot performance to meet existing separation criteria.

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5. IMPLEMENTATION

5.1 POLICIES / RULES / REGULATIONS

NASA, DoD, other federal agencies and UAS manufacturers will need to work closely with the appropriate FAA organizations to develop the necessary policies, rules, and regulations supporting UAS operations within the NAS. These UAS-specific policies/rules/regulations will help define and shape the operational concepts for civil, commercial, and government UAS operating in the NAS.

5.2 ENABLING CAPABILITIES AND TECHNOLOGIES

Reliable operating equipment is essential to achieving safe flight for both manned and unmanned aircraft. The basic operating equipment requirements applied to manned aircraft (position and strobe lights, ATC radar transponder, altimeter, and navigation equipment) are applicable to HALE UAS. In addition, HALE UAS flight operations may require additional enabling capabilities and technologies in order to operate in a safe, and efficient manner. These enabling capabilities and technologies may include:

- Collision Avoidance – Collision avoidance systems enable HALE UAS to sense and avoid other air traffic in their proximate airspace. Regardless of the technologies (visual, radar, cooperative transponder, or other advanced technology) used to sense traffic or the level of autonomy used to avoid a collision, UAS must be able to perform seven basic functions. These functions are: 1) detect all cooperative and non-cooperative aircraft within the necessary surveillance volume, 2) track the aircraft that have been detected, 3) evaluate collision potential, 4) prioritize collision threats, 5) determine an appropriate avoidance maneuver, 6) command the maneuver, and 7) execute the maneuver.
- Command & Control (C2) Link – C2 equipment must provide reliable transfer of command and control information between the control station and the UAS whether in LOS or OTH mode. The OTH link could be through a satellite, airborne relay, or a series of ground-based relay towers. Regardless of the type of link, the security of the control station and the C2 link must always be maintained to prevent external interference with UAS control. Unless collision avoidance equipment automatically maneuvers the UAS to avoid another aircraft when a conflict is detected, a single channel C2 link capability may not provide the level of safety required.
- ATC Communications – ATC Communication equipment need to provide direct two-way communications between the UAS pilot/operator and the appropriate ATC facility regardless of the location of the control station or the UAS. As the ATC communication architecture, technology, and operational requirements change in the future, UAS to ATC communication capabilities will need to keep pace.
- Auto-Land – Auto-land systems may be required to enabling the UAS to automatically land at UAS designated airports in the event of a loss-link contingency.
- Navigation – Supplemental onboard navigation equipment that allow the precise navigation of the UAS regardless of the status of the global positioning satellite (GPS) system may be needed.

Other topics that will likely need to be researched in order to achieve unrestricted HALE UAS access to the NAS include:

- Reliability – Reliability purview covers the aircraft and associated on-board systems (mechanical and digital) as well as the control station systems required to support and operate the UAS. System reliability requirements and proposed certification processes for establishing safe and secure HALE UAS operations in the NAS are needed.
- Human/System Interface (HSI) – Human System Interface (HSI) guidelines and requirements for procedures and interfaces between the UAS, control station and ATC. Specific topics include: Control Station, UAS Pilot Knowledge, Skill, Abilities (KSA); and UAS system certification.
- Weather Detection & Avoidance – Weather detection and avoidance equipment that provides a way to detect weather and ensure that the UAS maintains proper separation.
- Contingency Management – Equipment and procedures providing the necessary reliability for safely operating within the NAS during anomalous conditions. This includes mission planning and system contingency requirements (e.g., flight recovery system) and procedures that reduce the likelihood of a loss-of-life or damage to property when a landing cannot be performed at an UAS designated airfield.

Mission management and aircraft flight control system functionality (i.e., level of sophistication, autonomy) will be aircraft dependent. All UAS systems will need to be able to demonstrate that it can maintain an equivalent level of safety as a manned systems at all times, regardless of the anomaly.

5.3 UAS CAPABLE AIRPORT INFRASTRUCTURE

This CONOPS envisions that HALE UAS will operate out of UAS capable airports with the necessary infrastructure, equipment, runway, and trained personnel to accommodate the take-off and landing of unmanned aircraft.

5.4 OPERATIONS WITHIN INTERNATIONAL AIRSPACE

ICAO requirements should also be considered and complied with to the maximum practicable extent. It is recognize that proposed flight operations over the high seas and within the sovereign airspace of other nations must be coordinated with the appropriate aviation authorities and approval must be obtained prior to any HALE UAS flight operation in such airspace.

6. REFERENCE MATERIAL

Reference material cited during creation of this Access 5 Concept of Operations document are listed in Table 4.

Table 4. Concept of Operations References

No.	Title	Source	Attribution	Date	Type
1	ATS Concept of Operations for the National Airspace System in 2005	FAA	M.R. Belger	9/30/97	Paper
2	Aviation Rulemaking Advisory Committee Operating Procedures	FAA	unknown	12/16/02	Paper
3	C4ISR Architecture Framework	unknown	Architecture Working Group	12/18/99	Paper
4	Certification of Light Sport Aircraft Through the Use of Consensus Standards	ASTM	S. Sedgwick	2002	Web Page
5	Certification of Aircraft and Airmen for the Operation of Light-Sport Aircraft	FAA	unknown	2002	Web Page
6	Certification of Aircraft and Airmen for the Operation of Light-Sport Aircraft; Proposed Rule	Federal Register	unknown	2/5/02	Paper
7	Charting the Course for Tomorrow's ATC System	FAA	M. Harrison	2001	Briefing
8	Circular A119: Federal Participation in the Development and Use of Voluntary	OMB	unknown	2/10/98	Paper
9	Committee F37 on Light Sport Aircraft	ASTM	Daniel Schultz	unknown	Web Page
10	Concept of Operations and Vision for the Future of Aviation	RTCA	unknown	unknown	Paper
11	Consensus Standards: Why? What? How?	ASTM	M. Jones	unknown	Paper
12	Definition of NAS Compatible HALE UAV	Northrop Grumman	J. Stout	2/20/03	Briefing
13	Global Hawk/High-Altitude Long-Endurance UAV (HALE) See-and-Avoid Technology Overview	Northrop Grumman	unknown	1/23/03	Briefing
14	High Altitude Long-Endurance Unmanned Vehicles, Certification & Regulatory Roadmap	NASA ERAST Alliance Certification Project	TAAC / MTSI	1/5/01	Paper
15	High Altitude Long-Endurance Unmanned Vehicles, Concept of Operations in the National Airspace System, Version 1.2	NASA ERAST Alliance Certification Project	TAAC / MTSI	Jul, 2001	Paper
16	Index to RTCA Documents	RTCA	unknown	unknown	Paper
17	Key Technology Initiatives Related to the "See and Avoid" Capability for Remotely Operated Aircraft (ROA)	MTSI	Russell Wolfe	3/26/02	Paper
18	Light Sport Aircraft	ASTM	Committee F37	unknown	Paper
19	NAS Operations	FAA	unknown	Jan, 1999	Paper

No.	Title	Source	Attribution	Date	Type
20	NAS Operations Evolution Plan, Version 5.0	FAA	M.C. Blakey	Dec, 2002	Paper
21	National HALE UAV Program, Joint UNITE/NASA, Initial Plan, Version 3	DFRC	Multiple	11/1/02	Briefing
22	National High Altitude Airspace Redesign Decision Tree	unknown	unknown	unknown	Briefing
23	Notional Plan for Integration of HALE UAVs into National Airspace	General Atomics	S. Dann	2/12/03	Briefing
24	<i>Operational Concept Document (ATMP/I-WP/30).</i>	ICAO		Mar, 2002	
25	Review of RTCA National Airspace System Concept of Operations and Vision for the Future of Aviation	NASA Ames Research Center	Matt Jardin	2/21/03	Paper
26	Technical Qualifications & Remotely Piloted Aircraft (RPA) Satellite Systems Communication (SCS) Approach	NuCom Data Systems Corporation	unknown	1997	Paper
27	Terms & Definitions Applicable to UAVs/ROA	EURO UVS	Blyenburgh & Co,	2/6/02	Paper
28	Unrestricted UAV Flight in the ATM System: UAV and ATM Requirements	Boeing Company	C. Monson, G. Gershzohn, J. Dwyer, M. Mullens	1/1/03	Briefing
29	White Paper Addressing the Challenges Facing ROA Operation in the NAS	NASA ERAST	MTSI	7/5/02	Paper

APPENDIX A – ACRONYMS

ACO	Aircraft Certification Office
AFTRCC	Aerospace & Flight Test Radio Coordinating Council
AFSS	Automated Flight Service Station
AIAA	American Institute of Aeronautics and Astronautics
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCAA	Air Traffic Control Assigned Airspace
ATD	Air Traffic Division
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
CFR	Code of Federal Regulations
C2	Command and Control
C3	Command, Control and Communications
CNS	Communications, Navigation, Surveillance
COA	Certificate of Authorization
CONOPS	Concept of Operations
CS	Control Station
DoD	Department of Defense
DoE	Department of Energy
ELOS	Equivalent Level of Safety
EO	Electro-Optic
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCC	Federal Communications Commission
FMCS	Flight Management Control System
FRS	Flight Recovery System
FS	Flight Standards
FTS	Flight Termination System
GFY	Government Fiscal Year
HALE	High Altitude Long Endurance
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IR	Infrared
LOA	Level of Autonomy
LOS	Line-of-Sight
MoA	Memorandum of Agreement
MOA	Military Operating Airspace
MSL	Mean Sea Level
NAS	National Airspace System
NOAA	National Oceanic & Atmospheric Administration
NOTAM	Notice to Airmen

NTIA	NATIONAL TELECOMMUNICATION AND INFORMATION ADMINISTRATION
OPSCON	Operational Concept
OSD	Office of the Secretary of Defense
OTH	Over-the-Horizon
PFC	Positive Flight Control
PIC	PILOT IN COMMAND
RAPCON	Radar Approach Control
ROA	Remotely Operated Aircraft
RPV	Remotely Piloted Vehicle
RVSM	Reduced Vertical Separation Minimum
SA	Sense & Avoid
SAR	Synthetic Aperture Radar
SARPs	Standards and Recommended Practices
STC	Space Transition Corridor
SUA	Special Use Airspace
SWIM	System Wide Information Management
TRACON	Terminal Radar Approach Control
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UHF	Ultra-High Frequency
VFR	Visual Flight Rules
VHF	Very High Frequency

APPENDIX B – DEFINITIONS

Air Traffic Control Assigned Airspace (ATCAA) – Airspace of defined vertical/lateral limits, assigned by ATC, for the purpose of providing air traffic segregation for IFR traffic within the assigned airspace.

ATC Communication Link – Two-way data and/or voice link between the UAS and Air Traffic Control and/or other aircraft.

Autonomous / Automatic Operations – Operations that do not require direct pilot control. See levels of autonomy.

Certificate of Authorization (COA) – An FAA grant of approval for a specific operation(s).

Civil Aircraft – Aircraft other than public aircraft.

Command and Control (C2) Link – The two-way data link between the UAS pilot and the UAS that is used to control the UAS and monitor the health and status of onboard systems.

Concept of Operation (CONOPS) – A detailed description of the means for implementing an operational concept that is necessary to integrate UAS into the NAS in order to accommodate a “file and fly” capability.

Control Station (CS) – A site configured to allow the pilot in command of an UAS to operate and monitor all UAS operations conducted under his/her authority. Includes the equipment from which the UAS pilot/operator remotely controls and monitors the flight and mission activity of the UAS. The launch/recovery, maintenance, training and logistics elements may or may-not be co-located with the control station.

Cooperative Traffic – Traffic that broadcasts position or other information, which assists in detecting and assessing conflict potential.

Equivalent Level of Safety (ELOS) – An evaluation, often subjective, of a system and/or operation to determine the risk to other users of the NAS and people/property on the ground.

File and Fly – The ability of UAS operator to file an IFR flight plan and operate in all classes of airspace, consistent with the regulatory criteria and operational requirements for manned aircraft. The flights require no pre-coordination with ATC. As with manned aircraft, UAS flights requiring special ATC handling in order to achieve mission objectives are not 'file and fly' and would be pre-coordinated with ATC.

Flight Management Control System (FMCS) – An operable system onboard a UAS that performs the flight control actions from input received from the pilot via the C2 link or that automatically operates the HALE UAS from data previously installed.

Flight Team Member – Any individual whose duties could affect the safe outcome of the flight.

Flight Termination System (FTS) – A device or pre-planned course of action that is used to terminate flight operations when continued safe flight is not possible.

High Altitude Long Endurance (HALE) Aircraft – An aircraft capable of performing mission objectives at an altitude above 40,000-foot mean sea level (MSL) for durations of more than 24 hours.

Letter of Agreement (LOA) – A document that is negotiated by ATC facilities and other persons/facilities/organizations for a variety of purposes. For UAS operations, the letter of agreement would normally be established to define airspace areas and associated operating procedures.

Levels of Autonomy (LOA) – Autonomy is about minimizing human involvement in the operation of the aircraft (e.g., workload) while providing enhanced mission flexibility and vehicle robustness. The American Institute of Aeronautics and Astronautics (AIAA) defines autonomy as “A systems own ability of sensing, perceiving, analyzing, communicating, planning, decision-making, and acting, to achieve its goal as assigned by human operators”. UAS will be operated for durations exceeding the physical capabilities of a human operator and the cost of operating the aircraft can be minimized by reducing the work load required to a level sufficient that numerous aircraft may be operated by a single operator. The following Levels of Autonomy are used by the NASA Vehicle Systems Program UAV Sector to articulate its autonomy goals and objectives.

Level 1. Simple Automation; – Remotely piloted with some automation techniques to reduce pilot workload. Human monitoring to start/stop tasks. (80% hands-on-time.)

Level 2. Remotely Operated – Human operator allows UAS on-board systems to do the piloting. As part of the outer control loop, the human makes decisions as to where to go, when, what to do once there). Remotely supervised, with health monitoring and limited diagnostics. Operator allows UAS to execute preprogrammed tasks, only taking over if the UAS is unable or fails to properly execute them. (50% hands-on-time.)

Level 3. Highly-Automated (or Semi-Autonomous) – UAS performs complex tasks. System understands its environment (situational awareness) and makes routine decisions and mission refinements to dynamically adjust to flight and mission variables. Limited human supervision, managed by exception. Adaptive to failures and evolving flight conditions. (20% hands-on-time.)

Level 4. Fully Autonomous – UAS receives high level objective (location, time) from operator, translates them into tasks that are executed without further human intervention. UAS has the ability and authority to make all decisions. Extensive situational awareness (internal and external), prognostics, and on-board flight replanning capability. Single aircraft operations. (Less than 5% hands-on-time.)

An important concept in above LOA is that of “hands-on-time”. Hands-on-time is defined as the percentage of a pilot’s time (direct attention paid to the UAS) that would be required to safely operate the UAS during a given mission. Hands-on-time is limited to the pilot/operator and does not include other mission personnel (e.g., sensor/payload operator). Nominal values are presented in the table, actual hands-on-time will vary with the mission.

Line-of-Sight (LOS) – The condition where the control station and the UAS are within electronic point-to-point link.

Manned Aircraft – Aircraft that are piloted by a human onboard.

Mission Area – Airspace of defined horizontal and vertical dimensions and a defined duration within which the UAS will operate during a specified mission. The mission area is not associated with the flight route from/to the departure/arrival airports (see Route).

Mission Route – The flight path to be taken within the Mission Area where sensors or other applications will be exercised. Changes to the Mission Route during the mission could adversely affect the mission objectives.

Non-Cooperative Traffic – Traffic that does not broadcast position or other information.

Operational Concept – A high level description of ATM services necessary to integrate UAS into the NAS by a given time horizon.

Operator – The individual that monitors and controls an UAS through near-real-time issuance of command and control input to the aircraft. An operator possesses the applicable aeronautical knowledge but is not necessarily an FAA rated pilot.

Over-the-Horizon (OTH) – The condition where the control station and the UAS are beyond line-of-sight of each other. Also referred to as Beyond Line of Sight (BLOS).

Pilot – The individual that monitors and controls the UAS through issuance of command and control input to the aircraft and possesses the appropriate FAA pilot certifications and ratings.

Pilot in Command (PIC) – The person responsible for the safe flight operation of a HALE UAS during all aspects of its operation, including the time that the UAS is under the direct command of a subordinate UAS pilot. The PIC may be responsible for multiple UASs at a given time.

Positive Flight Control (PFC) – A situation where the pilot/operator is assured of having line-of-sight or over-the-horizon command and control communication capability.

Public Aircraft – An aircraft used only for United States Government purposes, or is owned and operated, or exclusively leased for at least 90 continuous days, by a governmental entity such as a State, the District of Columbia, a territory or possession of the United States, or political subdivisions of such entities. DoD aircraft are public aircraft.

Remotely Operated Aircraft (ROA) – See “Unmanned Aircraft System.”

Remotely Piloted Vehicle (RPV) – An aircraft that is operated from a remote location by a pilot that issues command and control instructions to the aircraft, which are executed in real-time by an onboard flight management control system.

UAS Capable Airport – An airport that is capable of handling UAS operations.

UAS Mission – Those flight operations that have been approved by the appropriate FAA Air Traffic Division in the Certificate of Authorization or defined in the flight plan filed for “File and Fly” (see) operations.

Route – The flight path of UAS from the departure airport to the arrival airport, excluding any mission route (see) and mission area (see). Course changes to the route have no impact on the mission objectives.

Routine Operations – See "File and Fly".

Sense and Avoid – The ability to sense traffic which may be a conflict, evaluate flight paths, determine traffic right-of-way, and maneuver to avoid other traffic.

Unmanned Aerial Vehicle (UAV) – See “Unmanned Aircraft System.”

Unmanned Aircraft (UA) – An airborne element of an unmanned aircraft system that is capable of flying without a pilot onboard.

Unmanned Aircraft System (UAS) – A distributed system comprised of an unmanned aircraft, control station and data/communication links, needed to safely operate an unmanned aircraft from a remote location by a pilot/operator. The pilot/operator communicates with ATC and issues command and control instructions to the aircraft that are then executed by onboard flight management and control systems. See Unmanned Aircraft (UA), Control Station (CS), Command and Control (C2) Link, and ATC Communication Link.

APPENDIX C – ACCESS 5 PROJECT DESCRIPTION

The Access 5 Project is a government and industry partnership intended to lead the way in promoting the use of safe and reliable unmanned aircraft systems (UAS) for civil and commercial applications. All partners are committed to leveraging resources and expertise to achieve the mutually goal of achieving routine operations within the National Airspace System (NAS) for high altitude, long endurance (HALE) UAS as soon as practical.

In 2002, the major U.S. HALE UAS manufacturers/operators formed the UAV National Industry Team (UNITE) to pursue a strategic partnership with each other and key government agencies to open the NAS to routine HALE UAS flight. The UNITE approached the National Aeronautics and Space Administration (NASA) with the partnership proposition because of the Agency's prior investment in HALE UAS platform maturation, its role in planning for the evolution of the NAS, its aircraft technology expertise, and its experience in sponsoring effective government-industry alliances.

NASA as the lead agency orchestrates the participation of other federal agencies and industry partners. The Department of Defense (DoD) and the Department of Homeland Security (DHS) are essential participants as they operate most of the unmanned aircraft in use today, and sponsor several programs and government labs developing unmanned aircraft and supporting subsystem technologies. The Federal Aviation Administration (FAA) is considered to be the most vital stakeholder involved in this effort since they are responsible for the overall safety, security, and efficiency of the NAS. The FAA plays a key advisory role in the development of the necessary rules, regulations and policies established for UAS.

C.1 ACCESS 5 VISION AND MISSION

The Access 5 Project seeks to improve the HALE UAS access to the NAS while maintaining its safety, security, and efficiency. The ultimate goal of the Access 5 Project is to create the environment to allow HALE UAS to operate in all categories of airspace with the same freedom as manned aircraft. The Access 5 Project vision and mission are:

Access 5 Vision

*To operate High Altitude, Long Endurance
Remotely Operated Aircraft routinely, safely, and reliably
in the National Airspace System*

Access 5 Mission

*Through a Strategic Government/Industry Alliance, accomplish the Access 5 vision
by developing standards, regulations, and procedures
demonstrating the technologies, and implementing infrastructure
necessary to meet national priorities.*

C.2 ACCESS 5 PROJECT SCOPE

The Access 5 Project will generate recommendations to the FAA for certification and rule changes. It is also expected that new technologies will be developed and demonstrated to ensure the safety and reliability of UAS and to adapt the air traffic management system and airport infrastructure to routine UAS presence.

The top-level objectives for the project are:

- 1) Develop technologies necessary to achieve routine HALE UAS operations in the national airspace,
- 2) Develop standard operational procedures for HALE UAS in the national airspace,
- 3) Develop the ability to safely handle in-flight emergencies,
- 4) Provide information necessary to the development of policies and regulations required to permit HALE UAS to “file and fly” with the same ease of access as a manned aircraft,
- 5) Establish seamless interfaces with the national airspace system and air traffic management infrastructure,
- 6) Transition developed technology to application.

C.3 ACCESS 5 PROJECT STRUCTURE

The Access 5 Project is organized within the NASA Aeronautics Research Mission Directorate (ARMD) according to the structure presented in figure C1. Roles and responsibilities of each organizational element are defined below.

Government Lead Oversees the day-to-day management of the project and alliance activities. The project status is regularly reported to the Directors of the Vehicle Systems and Airspace Systems Programs at NASA Headquarters. NASA appoints the Access 5 Project Manager.

Industry Director Assists the Access 5 Project Manager in the day-to-day management of the project and alliance activities. The UNITE Industry Organization appoints the Industry Director.

Steering Committee Comprised of members from NASA, the FAA, DoD, DHS and Industry, the Steering Committee will establish the course for the Alliance; synchronize commitments by government and industry as well as the stakeholder objectives; and coordinate all external communications and advocacy.

Project Control, Facilitation, & Collaboration Responsible for tracking the overall project schedule and costs (invoices & billing); addresses all legal matters; provides meeting and conference support; and assists in project communications.

System Engineering and Integration Team (SEIT) Comprised of subject matter experts from government and industry, the SEIT provides the Access 5 Project with technical advice and oversight. The SEIT is responsible for overall program documentation, including the Integrated Master Schedule, Project Plan, Concept of Operations, and the Functional Requirements Document. The SEIT is responsible for coordinating the activities of the four integrated product teams and resolves any cross-task issues.

Integrated Product Teams (IPT)

The Policy IPT is responsible for drafting the proposed rules, regulations, and policies needed to routinely operate HALE UAS within the NAS. Several FAA organizations act as advisors to the Policy IPT through this activity.

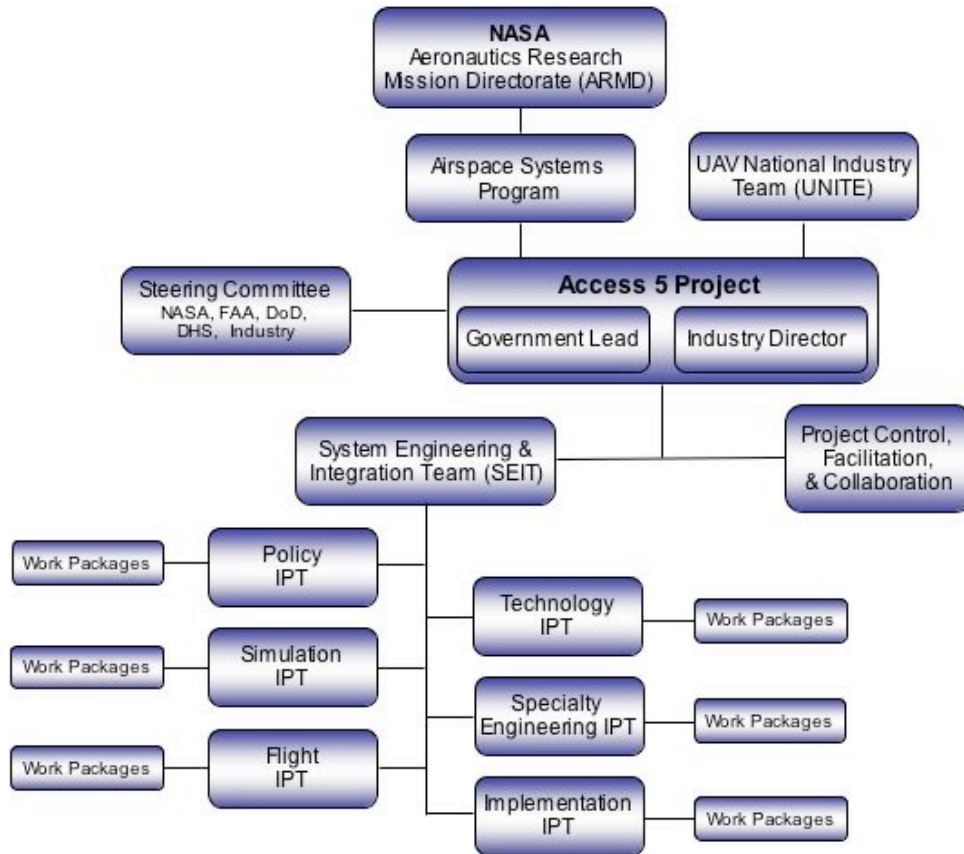


Figure C1. Access 5 Project Organization Structure

The Technology IPT is responsible for identifying the enabling technologies necessary to provide HALE UAS with an equivalent level of safety (ELOS) to that of a manned aircraft. In addition, the minimum operational, functional, and performance requirements associated with these technologies must also be developed by the Technology IPT. These requirements, along with their supporting rationale and data, are intended to support the development of policies and standards associated with these technologies. The three Technology IPT work packages are: WP02: Collision Avoidance, WP06: Command, Control, Communications, and WP09: Weather Awareness.

The Specialty Engineering IPT is responsible for providing matrix engineering support across Access 5. Like the Technology IPT, the overall objective is to identify minimum operational, functional and performance requirements necessary to define and support the appropriate level of safety for HALE UAS operations, equivalent to that of manned aircraft. The three Specialty Engineering IPT work packages are: WP05: Contingency Management and Mission Planning, WP07: Human System Interface, and WP08: Reliability.

The Simulation IPT is responsible for developing the necessary NAS simulations and UAS models that will be used to validate Access 5 proposed operational concepts.

The Flight IPT is responsible for performing flight tests demonstrating the enabling technologies, and applicable rules regulations, and policies.

The Implementation IPT is responsible for establishing the required infrastructure and necessary training in order to operationalize routine UAS access to the NAS.

Work Packages Specific research activities are accomplished through annually defined and competed work packages. Work package leads are responsible for managing the research content, cost, schedule, and resources associated with each work package. Each work package lead reports through the IPT lead responsible for the work package.

C.4 ACCESS 5 PROJECT PLAN and Phases

Between March and July of 2003 the Access 5 partners engaged in a highly integrated effort to develop a shared concept for how HALE UAS will operate in the national airspace, and what issues must be addressed to achieve the goal. The purpose of this detailed planning process was threefold. First and foremost, it focused upon arriving at a common vision of the solution and a satisfactory framework for attacking the distinct problems that must be solved. Second, it substantiated the costs for discrete activities and for the Project as a whole. And third, it defined the tasks and identified the companies/government organizations that could perform the work commencing in Government Fiscal Year 2004.

To orchestrate the planning process the Access 5 Project stood-up a Systems Engineering and Integration Team (SEIT), composed of highly qualified individuals from the participating organizations. The SEIT was charged with formulating the concept of operations and the operational concepts for HALE UAS in the national airspace. Four subject matter teams - Technology, Policies & Procedures, Implementation, and Simulation & Flight Test - were established. The four teams were populated with experts from the participating organizations. These “integrated planning teams” defined the challenges in their area, identified the possible solution sets, formulated project statements, and recommend the best approach. At the conclusion of the detailed planning process the five teams merged their findings into a single project plan that provided the directional and cost roadmaps for the overall Access 5 Project.

In order to achieve routine operations within the NAS, the strategy of Access 5 Project was to work with the FAA and industry to incrementally gain more access to NAS with gradually less restrictions. The Access 5 Project would approach the challenge of integrating HALE UAS into the national airspace using a four (4) phase or “Step” process:

Step 1: Routine Operations above FL430 through Pre-coordinated Airspace

Step 2: Routine Operations above FL180 through Pre-coordinated Airspace with Emergency Landings at Pre-coordinated Airports

Step 3: Routine Operations above FL180 through C, D, E Airspace with Emergency Landings at Pre-coordinated Airports

Step 4: Routine Operations above FL180 through C, D, E Airspace with Emergency Landings at any UAS Designated Airport

A brief synopsis of each of these four steps is provided below.

C.4.1 Step 1: Routine Operations above FL430 through Pre-coordinated Airspace

Step 1 will focus on achieving safe, reliable, and routine operational access for UAS at or above FL430⁴ with ascent / descent limited to restricted or pre-coordinated airspace. For contingencies preventing the UAS from completing its mission, the UAS will be pre-programmed to fly to a pre-designated or restricted area for recovery.

Step 1 objectives are: 1) Establish agreed-to requirements for flight operations above FL430 in the NAS; 2) Establish agreed-to policies, regulations, and procedures that achieve an initial level of certitude (i.e., registration and an experimental certificate); and 3) Demonstrate the capabilities necessary to achieve the requirements established in objective 1 above, for an experimental certificate. Figure C2 depicts the Step 1 capabilities.

At a minimum, the technologies planned for demonstration during this step will include:

- Compatible air traffic control operations and voice communications
- Pilot-in-the-loop collision avoidance with cooperative aircraft
- Reliable LOS and OTH command, control, and communications

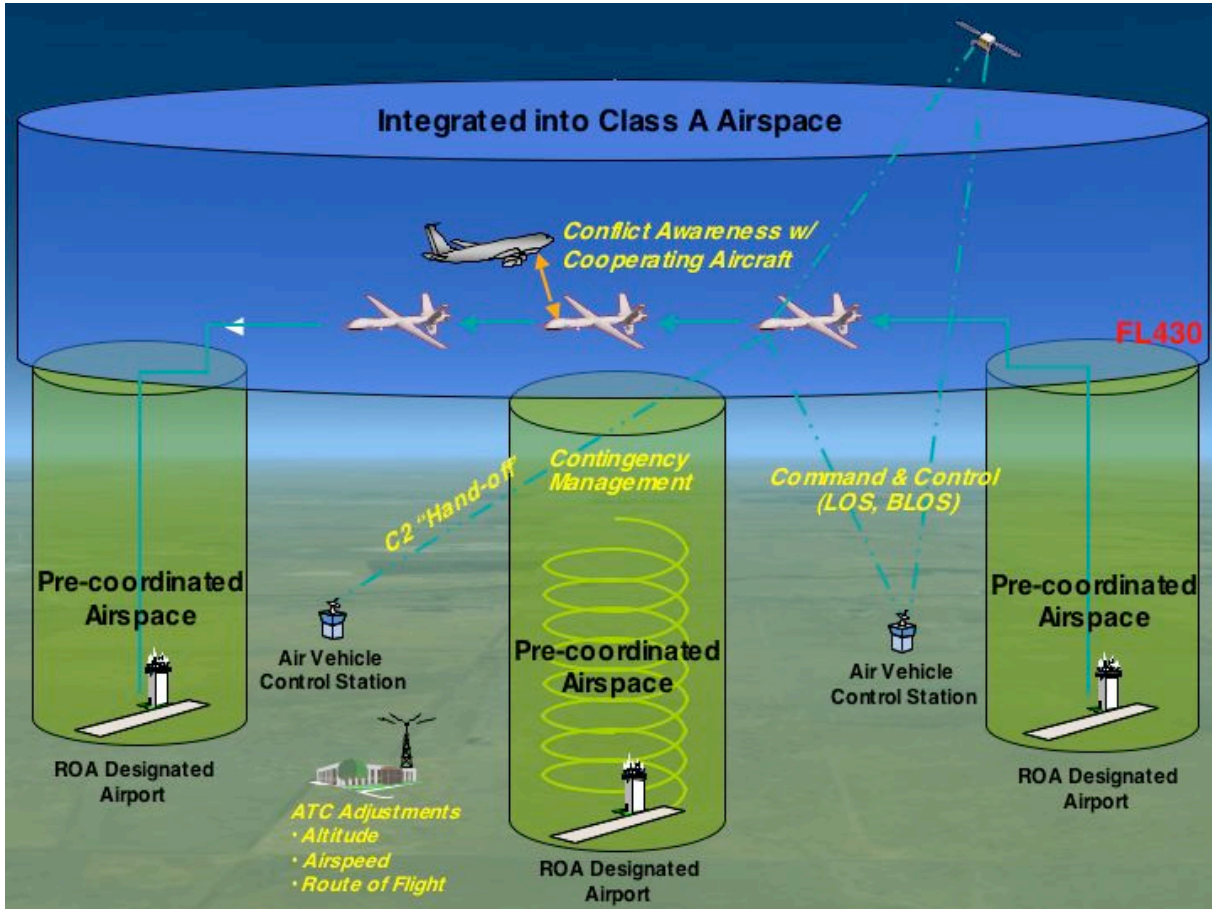


Figure C2. Step 1 Capabilities

⁴ Step 1 nominal altitude increased from FL400 to FL430 to conform with domestic RVSM instituted in January 2005.

C.4.2 Step 2: Routine Operations above FL180 through Pre-coordinated Airspace with Emergency Landings at Pre-coordinated Airports

Step 2 will focus on achieving safe, reliable, and routine operational access for UAS at or above FL180 with ascent/descent limited to restricted or pre-coordinated airspace. For contingencies preventing the UAS from completing its mission, the UAS will be pre-programmed to fly to a pre-designated or restricted area for recovery.

Objectives of Step 2 are: 1) Establish agreed-to requirements for flight operations above FL180 in the NAS; 2) Establish agreed-to policies, regulations, and procedures that achieve a Type Certification basis; and 3) Demonstrate the capabilities necessary to conduct experimental flight operations above FL180. Figure C3 depicts the Step 2 capabilities.

The technologies planned for demonstration during this step will include the Step 1 accomplishments plus:

- Enhanced LOS and OTH command, control, and communications
- Enhanced system security (e.g., identification, authentication, confidentiality, availability, integrity, non-repudiation)
- Collision avoidance with non-cooperative aircraft (Sense & Avoid)
- Near real-time weather information (e.g., thunderstorms) available at the control station provided by a weather service

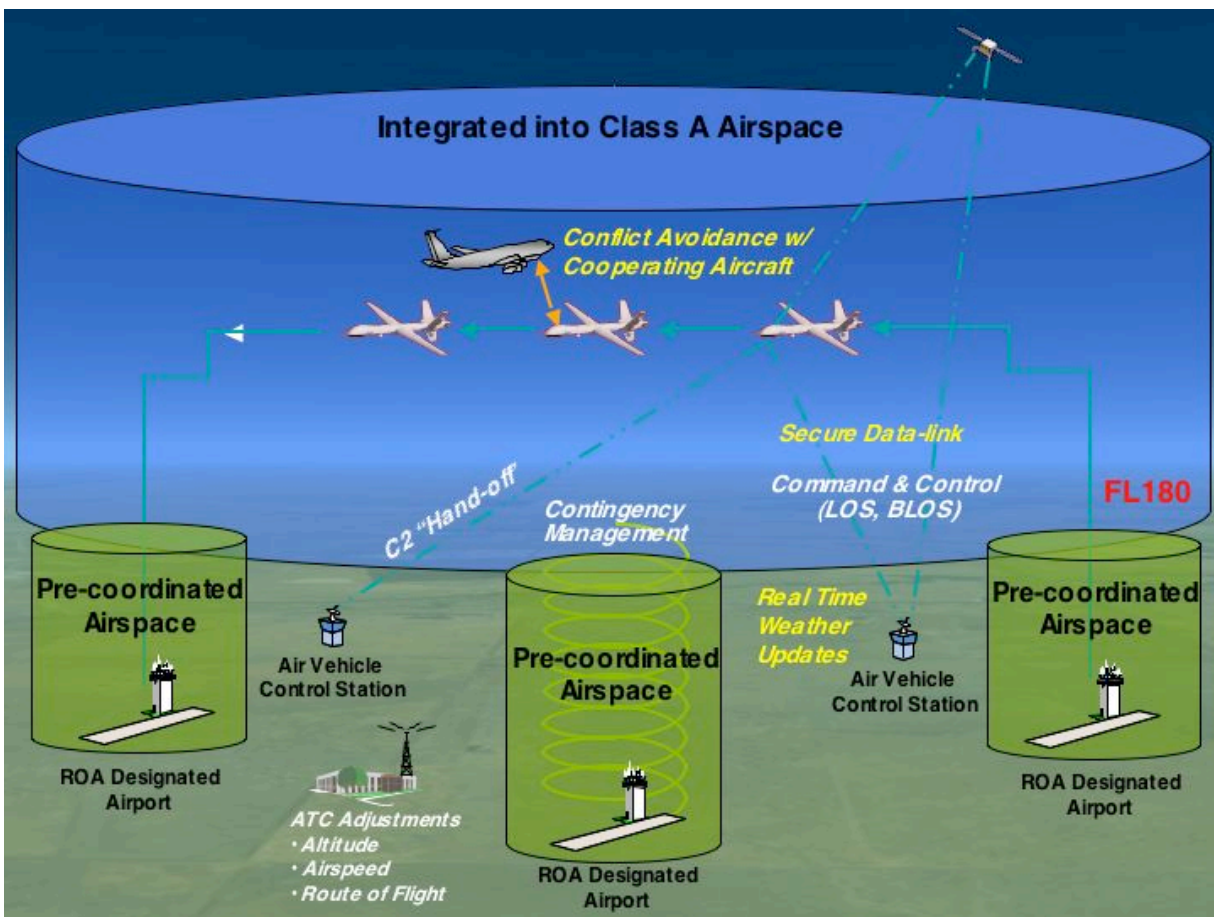


Figure C3. Step 2 Capabilities

C.4.3 Step 3: Routine Operations above FL180 through C, D, E Airspace with Emergency Landings at Pre-coordinated Airports

Step 3 will focus on achieving safe, reliable, and routine operational access for UAS at or above FL180 with ascent/descent in Class C, D, or E airspace. For contingencies preventing the UAS from completing its mission, the UAS will be pre-programmed to fly to a pre-coordinated UAS designated airport.

Step 3 objectives are: 1) Establish agreed-to requirements for flight operations above FL180 in the NAS with ascent and descent through controlled airspace; 2) Establish agreed-to policies, regulations, and procedures that would achieve a Special Certificate of Airworthiness; and 3) Demonstrate the capabilities necessary to conduct experimental flight operations above FL180 with ascent and descent through controlled airspace. Figure C4 depicts the Step 3 capabilities.

The technologies planned for demonstration during this step will include accomplishments from Step 2 plus:

- Surface operations (e.g., prevent runway accidents/incursions)
- Autonomous collision avoidance with cooperative and non-cooperative aircraft
- Air-vehicle based Auto-land (including back-up navigation)
- On-board Weather sensing (i.e., wind shear, turbulence, icing)

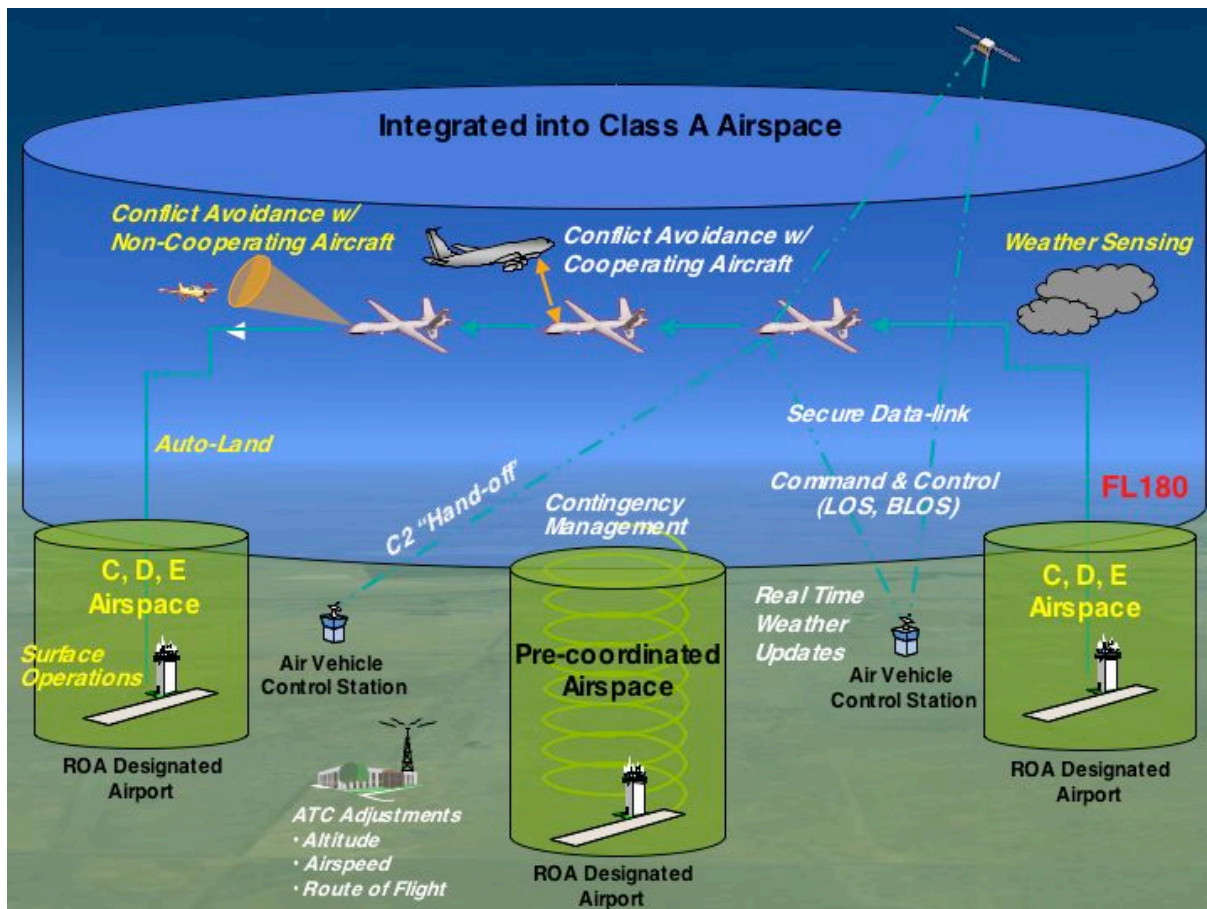


Figure C4. Step 3 Capabilities

C.4.4 Step 4: Routine Operations above FL180 through C, D, E Airspace with Emergency Landings at any UAS Designated Airport

Step 4 will focus on achieving safe, reliable, and routine operational access for UAS at or above FL180 with ascent/descent in Class C, D, or E airspace. For contingencies preventing the UAS from completing its mission, the UAS will be pre-programmed to fly to the closest UAS designated airport with FAA coordination.

Step 4 objectives are: 1) Establish agreed-to requirements for flight operations above FL180 in the NAS with ascent and descent through controlled airspace, including emergency operations; 2) Establish agreed-to policies, regulations, and procedures that would achieve a Standard Certificate of Airworthiness and an Air Operating Certificate; and 3) Demonstrate the capabilities necessary to conduct routine operations within the NAS. Figure C5 depicts the Step 4 capabilities.

The technologies planned for demonstration during this step will include the Step 3 accomplishments plus:

- Auto Voice (i.e. the ability to communicate with ATC during lost-link conditions)
- Contingency Management technologies ensuring safe operations and landings during anomalous/emergency conditions

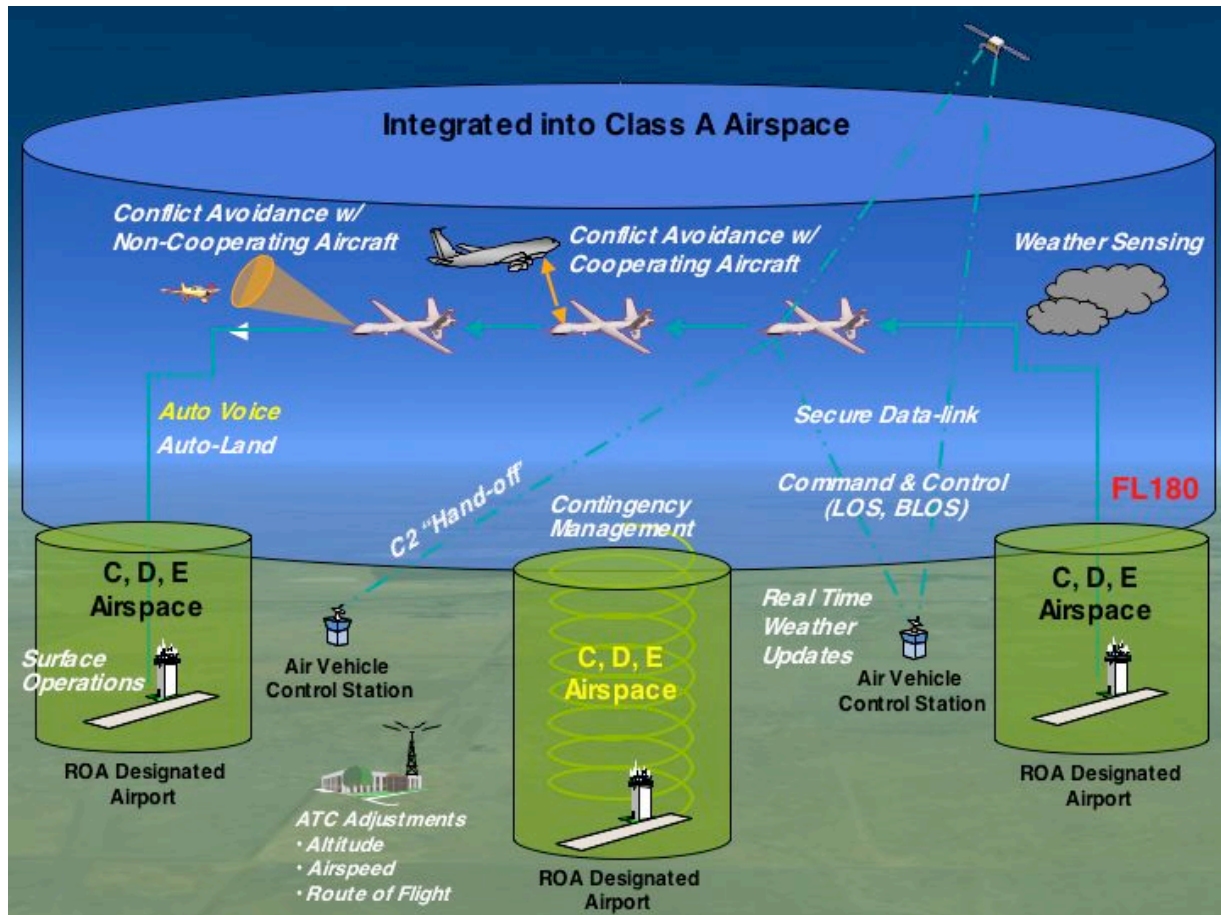


Figure C5. Step 4 Capabilities

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