



Access 5 Project Office  
NASA  
P.O. Box 273  
Edwards, CA 93523 USA  
661-276-2440  
661-276-3880 FAX  
www.access5.aero

## COVER SHEET

### Access 5 Project Deliverable

**Deliverable Number:** HSI006

**Title:** *Human System Integration Regulatory Analysis*

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**Abstract:**

This document was intended as an input to the Access 5 Policy Integrated Product team. Using a Human System Integration (HSI) perspective, a regulatory analyses of the FARS (specifically Part 91), the Airman's Information Manual (AIM) and the FAA Controllers Handbook (7110.65) was conducted as part of a front-end approach needed to derive HSI requirements for Unmanned Aircraft Systems (UAS) operations in the National Airspace System above FL430. The review of the above aviation reference materials yielded eighty-four functions determined to be necessary or highly desirable for flight within the Air Traffic Management System. They include categories for Flight, Communications, Navigation, Surveillance, and Hazard Avoidance.

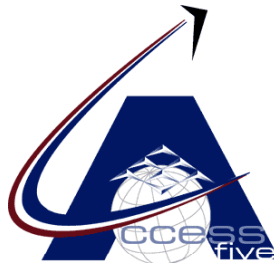
**Status:**

<b>Document Status</b> <b>SEIT Approved</b>

**Limitations on use:**

*This document represents thoughts and ideas of the Human System Integration Work Package team. It has not been reviewed or approved as an Access 5 project position on this subject; the information needs substantiation through simulation/flight demonstrations. Analysis was limited to enroute operations above FL430. Operations below FL430 and terminal operations have not been addressed in this document.*

# Human System Integration Regulatory Analysis



Access 5

February 2005

## Foreword

The Human System Integration (HSI) tasks that were performed in FY04 contributed to the development of functional requirements and design guidelines for High Altitude Long Endurance (HALE) Remotely Operated Aircraft (ROA) operation at or above FL400 in the National Airspace (NAS). The Access 5 intent is to provide file and fly access to the NAS for HALE ROAs, identically to that available to manned aircraft.

The HSI FY04 work package prepared the following deliverables to contribute to the Step 1 program objectives:

- HSI Concepts Requirements and Definition Report, dated September 2004

The Access 5 Systems Engineering Integration Team (SEIT) reviewed the above document and requested that it be divided into four component reports in order that content be more readily assimilated by users of the material. These component parts are:

- HSI Regulatory Analysis, dated February 2005
- HSI ROA Comparisons, dated February 2005
- HSI Functional Decomposition, dated February 2005
- HSI Top Level Requirements, dated February 2005

The Concept Requirements and Definition Report was written in an integrated fashion and as a result breaking the material into stand-alone parts could not always be done with clear distinctions. The reader is encouraged to consult the integrated document if additional clarifications are needed.

Other FY04 deliverables for the HSI Work Package were:

- HSI ROA Guidelines Outline (Annex A)
- HSI Functional Requirements- ROA C3 and CCA Subsystems (Annex B)

This deliverable is intended as an input to the Policy IPT. It aimed to answer the following question:

Based on regulatory analyses of the FARS (specifically Part 91), the Airman's Information Manual (AIM) and the FAA Controllers Handbook (7110.65) what are the requirements for ROA operation in the National Airspace System above FL400?

Through a review of aviation reference material, including Federal Aviation Regulations (FAR), Aeronautical Information Manual (AIM), FAA Order 7110.65, and Eurocontrol documents, eighty-four functions were derived that are necessary or highly desirable for flight within the ATM system. They include categories for Flight, Communications, Navigation, Surveillance, and Hazard Avoidance.

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## 1 Overall Problem: Unrestricted ROA Flight in the ATM System

ROA operations and, hence, sales are not meeting their full potential because of ATM-induced penalties. Currently, each ROA flight is handled as a special case, which is time-consuming, complex, and expensive. ROA operators are unable to operate efficiently due to ATM-mandated restrictions. As a result, potential ROA buyers and operators are reluctant to make large purchases due to ATM-related issues.

There is a large variety of existing and planned ROAs, each with its own unique in-flight capability. Some are very-high performance turbojets, some are piston-driven low-performance aircraft, and some are akin to model aircraft in size and performance.

None of these, however, currently possesses the functionality for unrestricted flight in the ATM system. They lack the requisite functionality by design; operate as military-unique vehicles employing special handling within civil or military airspace; or simply have not been designed with an eye toward flight in commercial airspace.

Access 5 efforts now underway aim to allow ROAs unrestricted access to the NAS for normal flight operations. This implies new concepts, rules, and regulations for both ROAs and the ATM system.

### 1.1 HSI Issues: Unrestricted ROA Flight in the ATM System

There are very few HSI issues unique to ROA operation in the NAS. This is because, for the most part, ROAs are similar to inhabited aircraft and are expected to be able to comply with most existing regulations.

However, the issues that do exist are significant and have, to date, disallowed unrestricted ROA flight in the NAS.

The Primary Issues for the ROA pilot are:

- Pilot ability to obtain required information on ROA performance and status in a timely fashion while operating on the ground and in flight
- Pilot ability to affect control of the ROA as required and in a timely fashion while operating on the ground and in flight
- Pilot ability to operate the ROA safely while operating on the ground and in flight
- Pilot ability to operate the ROA in compliance with Federal Aviation Regulations while operating on the ground and in flight

The Primary Issues for the air traffic management (ATM) system are:

- Air traffic controller ability to obtain required information on ROA performance and status in a timely fashion
- Air traffic controller ability to control the ROA as part of the overall traffic flow

In addition, there are Secondary Issues that must be resolved to satisfy the issues above:

- Satisfactory performance of ROA automation and autonomy including pilot override capability
- Pilot-directed or autonomous design to accomplish hazard avoidance
- Satisfactory performance of the pilot-ATM communications link
- Satisfactory performance of the pilot-ROA communications link
- Development of procedures and plans for specific non-normal and emergencies operations

The 2004 HSI effort is aimed at examining these and other issues to define HSI concepts and requirements for the pilot and air traffic controller that allow unrestricted ROA flight above FL400 in the NAS.

## 2 Scope

In this 2004 study, due to schedule and cost constraints, the HSI team was not able to analyze all domestic, foreign, civil, and military ROAs that might operate in the NAS. Therefore, to cover part of the spectrum of interest to Access 5, four ROAs were selected as representative samples of ROA designs. These are Altair, Perseus B, Helios, and Global Hawk. Each ROA has unique functionality and performance features. While each may not differ from inhabited aircraft in every dimension, each possesses capabilities that set it apart from standard aircraft.

In addition, as this analysis is conducted in Step 1 of the Program, focus is placed on HSI issues that exist for operations at and above FL400. These requirements will be refined throughout Step 1, and a final requirements document will be produced at the end of the Step, covering operations above FL 400.





### 3 Objectives

This task is composed of several objectives. Objectives focus on the Primary and Secondary Issues involved in supporting unrestricted ROA flight in the NAS. As this is the first full year of the Program, these HSI results represent only the first stepping stones in the process of achieving solutions to the Primary and Secondary Issues described above. In succeeding years, HSI results will provide data illustrating clear cut options and answers to these Issues.

As an initial step, it is necessary to identify the types of ROA that are flying currently. For each ROA, this provides an indication of operational capability, which leads to a definition of the role for its pilot.

At the same time, it is necessary to identify Federal Aviation Regulations (FARs) and recommended practices for the pilot (e.g., Aeronautical Information Manual (AIM)) for ROA flight in accord with Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). This is accomplished by surveying the appropriate FARs and AIM sections and then analyzing them for their applicability to ROA flight. These requirements represent new, probable flight operational goals for an ROA and indicate the functionality it must have to operate in the NAS. They also represent additional functions and task for the pilot in his or her need to comply with these ATC-related functions and tasks.

Air Traffic Control also publishes regulations that affect flight in the NAS. The FAA Order 7110.65 defines ATC procedures and actions for the air traffic controller. These also need to be surveyed and analyzed for applicability to ROA flight in the NAS.

A final review of regulatory documents in the context of ROA capability indicates the level of expected compliance by an ROA. Where an ROA has the capability to comply with an existing regulation or practice, it will be expected to do so. In some cases, it may not be possible to do so, in which case the FAA may define new regulations accordingly.

Finally, once the analysis defines probable requirements in FARs, AIM, and Order 7110.65, a complete definition of functions and task provides allows performance of an analysis of pilot and air traffic controller information requirements and control functions. These define the information that must be presented to the pilot and air traffic controller and the control actions they must be able to affect.

These objectives represent the goals in the process for defining HSI guidelines and requirements for the pilot; air traffic controller; hardware, software, and procedures; and overall concepts of potential ROA operations in the NAS. This process and connectivity between objectives is illustrated in Figure 1.

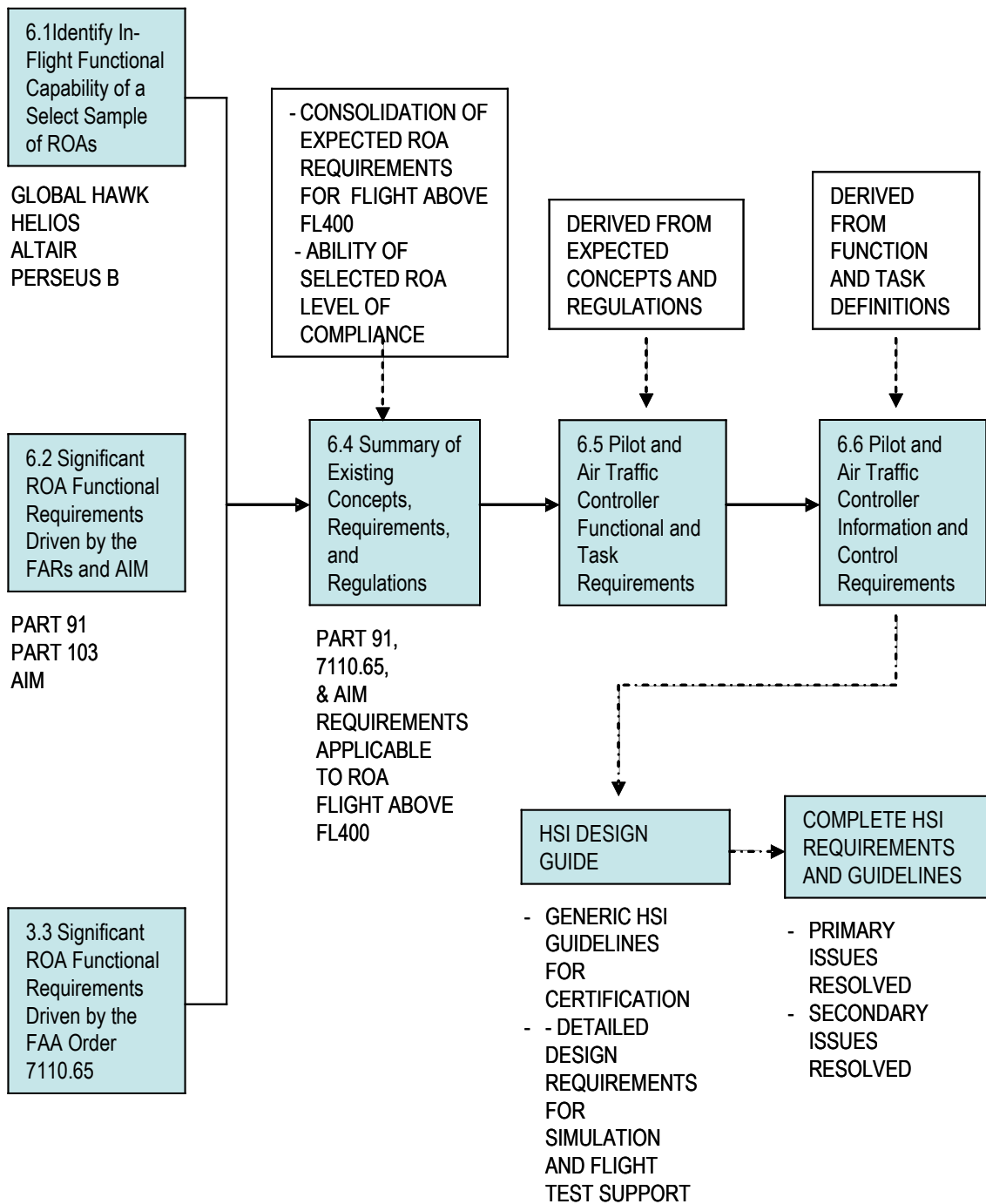


Figure 1. Process for defining HSI guidelines and requirements for the pilot; air traffic controller; hardware, software, and procedures; and overall concepts of potential ROA operations in the NAS

## 4 Assumptions and Ground Rules

Assumptions and ground rules are partitioned into the following categories:

- General Operation
- Airspace
- Hazard Avoidance
- Weather Detection
- Visual Acquisition and Identification of Ground and In-Flight Elements
- Communications
- Autonomy
- Emergency Operations
- Pilot skill, knowledge and ability requirements
- ROA functionality

Assumptions are based on the premise that a HALE ROA can have almost all the technological capability needed to satisfy rules and regulations. That is, the vehicle can meet most stated requirements and will not be granted exemptions, waivers, or changes to regulations (for its benefit) simply for convenience or profit. Technological issues that are unsolvable during the Access 5 Program timeframe will result in a CONOPS different from that now planned and different from a *de facto* inhabited aircraft.

The list of concepts and requirements outlined in this analysis is not comprehensive. Instead, it is a description of potential issues, in the opinion of the authors, requiring changes in ROA functionality; modifications to the human interface between the ROA and its pilot; and upgrades to Order 7110.65 concepts and procedures. In addition, the standard flight practices, recommended procedures, and FAA regulations are only briefly described here where necessary for clarity or depth<sup>1</sup>. It is the charter of a CONOPS-development organization to evaluate every flight operation detail.

### General Operation

- The HALE ROA will never operate under Visual Flight Rules (VFR) and will always operate under Instrument Flight Rules (IFR).

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<sup>1</sup> Most of this information can be found in the FARs, Aeronautical Information Manual, and FAA Order 7110.65N.

- Each ROA complies with all applicable FARs and ATM procedures defined in Order 7110.65N except for the following:
  - The ROA manufacturer or user elects non-compliance and accepts the associated penalties (e.g., exclusion from airspace).
  - Compliance is not cost-effective and it is agreed by all applicable government and industry parties that the ROA is exempted from the applicable FAA regulation(s).
  - Compliance is not technically feasible and it is agreed by all applicable government and industry parties that the ROA is exempted from the applicable FAA regulation(s).

#### Airspace

- A HALE ROA operates as any *de facto* inhabited aircraft in any Class airspace and adheres to the FARs appropriate to each airspace.
- The ROA traverses other classes of airspace in normal climb and descent, as well as in emergency descent.
- For normal ‘file and fly’ operations, the ROA employs standard departure and arrival procedures (e.g., Departure Procedure, Standard Terminal Arrival Route).
- Each ROA operates in congested areas in the same manner as a *de facto* inhabited aircraft.
- There is no special handling to avoid compliance with normal operations.
- There is no flight in Special Use Airspace (SUA) to avoid compliance with normal operations.

#### Hazard Avoidance

- Airborne traffic and weather hazards are avoided in their entirety without outside special assistance (e.g., chase vehicle).
- Hazard avoidance maneuvers are consistent with ATC avoidance procedures.
  - Traffic - Airborne

- It is the sole responsibility of the ROA to avoid other aircraft at all times<sup>2</sup>.
- Cooperative Collision Avoidance (CCA) System does not alter or diminish the pilot's basic authority and responsibility to ensure safe flight. Since CCA system does not respond to an aircraft which is not transponder equipped or aircraft with a transponder failure, CCA system alone does not ensure safe separation in every case<sup>3</sup>.
- The position and nature of cooperative traffic is known with the functional equivalency of an inhabited aircraft (via, e.g., TCAS, ADS-B, imaging sensors). Cooperative traffic is able to determine the position and nature of the ROA and, hence, the required redundancy exists for two conflicting aircraft to sense-and-avoid each other using coordinated actions.
- Appropriate detection technology is employed in concert with a ROA Ground Control Station (GCS) display.
- The position and nature of non-cooperative traffic is known with the functional equivalency of an inhabited aircraft (via ROA's sensor systems' functionality). Identification technology is not in place on non-cooperative aircraft (e.g., transponder, ADS-B), primarily for financial reasons. Non-cooperative traffic is not able to determine the position and nature of the ROA and, hence, no redundancy exists for two conflicting aircraft to sense-and-avoid each other using coordinated actions.

## Weather Detection

- Airborne
  - Weather hazards encountered in climb, cruise, descent, and approach are avoided to the same degree as in an inhabited aircraft<sup>4</sup>. Weather sensor data that is augmented by pilot direct viewing is superior to sensor data alone.

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<sup>2</sup> FAA Advisory Circular 90-48C, Pilot's Role in Collision Avoidance. "See and Avoid Concept. (1) The flight rules prescribed in Part 91 of the FARs set forth the concept of "See and Avoid." This concept requires that vigilance shall be maintained at all times, by each person operating an aircraft, regardless of whether the operation is conducted under Instrument Flight Rules (IFR) or Visual Flight Rules (VFR).

b Visual Scanning. (1) Pilots should remain constantly alert to all traffic movement within their field of vision as well as periodically scanning the entire visual field outside of their aircraft to ensure detection of conflicting traffic."

<sup>3</sup> AIM, 4-4-15. Traffic Alert and Collision Avoidance System (TCAS I & II) (c).

<sup>4</sup> Hazards include icing (engine and airframe), thunderstorm, tornado, wind shear, microburst, turbulence, hail (including from thunderstorm anvils), severe precipitation, and volcanic ash.

- In-flight visibility (day and night) can be determined<sup>5</sup>. Hence,
  - The ROA can determine if it is in VMC or IMC.
  - The ROA can determine the flight visibility required for landing.
  - The ROA can operate according to VFR.
- Distance from clouds (day and night) can be determined<sup>6</sup>. Hence,
  - The ROA can determine if it is in VMC or IMC.
  - The ROA can operate according to VFR.

### Visual Acquisition and Identification of In-Flight Elements

- In-Flight Elements
  - The ROA can locate, identify, and separate itself from airborne traffic (e.g., for purposes of following another aircraft).

### Communications

- Telemetry and bandwidth as well as data and voice communication do not cause communications delays affecting any operation including an emergency or hazard avoidance maneuver.
- The Operator communicates with ATC as a pilot of a *de facto* inhabited aircraft.

### Autonomy

- The level of autonomy and automation provides for ROA compliance with all applicable FARs and ATM requirements (except as noted within this analysis).

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<sup>5</sup> It is assumed that a sensor is available to perform this function.

<sup>6</sup> It is assumed that a sensor is available to perform this function.

## Emergency Operations<sup>7</sup>

- In an emergency, the ROA adheres to applicable FARs, e.g., Part 91 or equivalent.
- The following events are emergencies:
  - Engine failure
  - Loss of communications between Operator and ATC
  - Loss of link between Operator and ROA
  - Major system's failure (specifics dependent on vehicle design)
  - Significant failure of GCS elements
- A ROA makes an emergency descent and landing by adhering to the appropriate FARs.
- If a ROA has lost link with the Operator, it makes an emergency landing only if it can locate a suitable landing site.
- A ROA makes an emergency landing at any suitable airport after the pilot has notified the airport control tower in the appropriate manner.
- A ROA with AutoLand capability makes an emergency landing at any suitable airport without a control tower if it identifies local hazards, traffic pattern flow and direction, and the pilot notifies local aircraft of its intent (if practical), e.g., by transmitting on 121.5 or 243.0 MHz, as appropriate.
- A ROA without AutoLand capability makes an emergency landing at a suitable airport without a control tower only if a GCS is in place for its control; the pilot at the GCS identifies local hazards, traffic pattern flow and direction; and the pilot notifies local aircraft of the ROA's intent, e.g., by transmitting on 121.5 or 243.0 MHz, as appropriate.
- A ROA has an emergency when it acts unpredictably in response to an unexpected failure, generic software fault, or unforeseen event.
- A ROA priority or emergency request is acceptable as long as it occurs only rarely.

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<sup>7</sup> Except where noted, Emergency Operations are those that have been planned for (as part of vehicle design and certification) and include appropriate hardware, software, and (human and automation) procedural solutions.

- ROA disruption of normal ATC traffic flow for a valid reason is acceptable as long as it occurs only rarely.



## 5 Method

### 5.1 For the Objective: Identify Significant ROA Functional Requirements Driven by the FARs and AIM.

Information was collected from reference material and combined to form a basic set of flight operations requirements for a ROA.

- FAA regulations were reviewed:
  - 1 Definitions and Abbreviations
  - 11 General Rulemaking Procedures
  - 23 Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter
  - 61 Certification: Pilots, Flight Instructors, and Ground Instructors
  - 65 Certification: Airmen Other Than Flight Crew Members
  - 91 General Operating and Flight Rules
  - 103 Ultralight Vehicles

A review of FAR Parts 23 and 91 and AIM was the primary focus to gather basic flight operations information. For civil operations, FAA rules, regulations, and standard practices are the governing criteria. Of primary applicability is FAR Part 91, General Operating and Flight Rules that governs general aircraft operating rules in civil airspace<sup>8</sup>. This Part was reviewed in its entirety. Based on previously gained knowledge of ROA operating capabilities, a preliminary analysis was performed to identify Part 91 paragraph content that may pose a challenge to ROA design and/or operations. This yielded an identification of specific paragraphs that, in the opinion of the authors, may or may not need to be changed or modified to accommodate ROA operations. In addition, changes were identified to standard practices and procedures that are not listed explicitly in Part 91.

FAR Part 103, Ultralights, was examined due similarities between ultralights and small-sized ROAs.

The AIM was reviewed also. However, in general, its content largely mirrored that of the FARs and so little information directly attributable to the AIM was used.

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<sup>8</sup> Pilots use FAR Part 91 as instructive and regulatory information that describes how aircraft must be operated in civil airspace.

## 5.2 For the Objective: Identify Significant ROA Functional Requirements Driven by the FAA Order 7110.65.

FAA Order 7110.65 was evaluated in its entirety. A comparison was made of ROA functional capabilities and the requirements in 7110.65. This yielded an identification of specific 7110.65 paragraphs that, in the opinion of the authors, may or may not need to be changed or modified to accommodate ROA operations. In addition, changes were identified to standard practices and procedures that are not listed explicitly in 7110.65.

These data were compared to the known capabilities of the four ROAs chosen for this study to identify areas in which the ROAs did or did not satisfy the requirements. In the opinion of the authors, some of these areas are easily attainable by any ROA while others are problematic. In this study, only the difficult or challenging areas were emphasized.

## 5.3 For the Objective: Summary of Potential Concepts, Requirements, and Regulations.

Findings from previous analyses of the FARs, AIM, and FAA Order 7110.65 were combined. The total of this information was analyzed in light of expected ROA capabilities to yield an indication of probable ROA compliance. This led to a definition of requirements that an ROA is expected to comply with and those it would not. Changes required to the documents were described. Rationales were given for each.

The summary of these findings led to definition of a concept for ROA flight in the NAS, where most regulations and requirements for inhabited aircraft are adhered to by an ROA, but with some exceptions. The exceptions are described as irregularities to the current concept of flight for inhabited aircraft in the NAS.

Safety was selected as the most critical topic. After reviewing the literature, ROA requirements were categorized according to safety-related criteria:

- Communications
- Emergencies
- Automation and autonomy

For each area, a requirement or concept was defined with an associated rationale for its applicability to a HALE ROA.

## 5.4 For the Objective: Identify Pilot and Air Traffic Controller Functional and Task Requirements.

Pilot functions were identified through a decomposition of potential concepts, requirements, and regulations. Functions were derived from these concepts, in concert with standard functions required of a pilot in an inhabited aircraft, to yield a set of ROA

pilot functions for flight above FL400. Pilot task analysis and air traffic controller functions and task analyses were not performed; these will be conducted in FY05.

#### 5.5 For the Objective: Determine Pilot and Air Traffic Controller Information and Control Requirements.

Pilot information requirements were identified through a decomposition of pilot functions. These requirements were derived from the functions analysis, in concert with standard information required of a pilot in an inhabited aircraft, to yield a set of ROA pilot information requirements for flight above FL400. Pilot control requirements and air traffic controller information and control analyses were not performed; these will be conducted in FY05.

#### 5.6 Collaborative and Coordinating Efforts

The Access 5 Human Systems Integration (HSI) team interacted with relevant Access 5 Integrated Product Teams (IPTs), manufacturers, and operators to analyze ROA-ATM issues. In support of formal objectives, analytic, interview, and literature search methods were employed to gather all relevant data regarding the interface between these ROAs and their pilots, and ATM. Manufacturer representatives and ROA pilots provided data describing their respective ROAs through interviews and questionnaires. The general HSI areas emphasized include:

- Functions and Task Analysis – Analysis for identification of HSI functions required of the crew-ROA systems and ROA-ATC integration
- Information and Control Capability Analysis – Analysis for identification of the information required of the ROA pilot and air traffic controller and required control functions for each.
- Procedures Definition - Definition of standard HSI operational procedures for ROAs in the NAS
- Coordination with Other IPTs - Delivery of information necessary Policy, ROA Impact, Technology, and Simulation IPTs

## 5.7 Significant ROA Functional Requirements Driven by the FARs and AIM.

This objective is concerned with documenting existing FARs for inhabited aircraft and recommended practices in the AIM that appear applicable to ROA flight. These requirements must be defined in order to compare them to ROA functionality. While no requirements exist currently for ROA flight in domestic airspace, it may be assumed that existing FARs for inhabited aircraft and recommended practices in the AIM will largely mirror those for ROAs. Part 91 or a new Part equivalent to Part 91 may be developed for ROAs.

This comparison must be undertaken for two reasons: (1) The Access 5 charter has indicated that ROAs shall operate as *de facto* inhabited aircraft, which implies the need for them to adhere to most existing FARs for inhabited aircraft and recommended practices in the AIM. In addition, (2) functions and tasks required of the pilot, and pilot interfaces to hardware, software, and procedures as well as interfaces with ATC must be based on the assumption that an ROA will adhere to most of these requirements and practices. This mandates an assessment of requirements and in-flight capabilities for ROAs and their pilots that will operate in the NAS on a regular basis. While it is reasonably clear at the outset that ROA functionality, and functions required of the pilot, must be similar to those of inhabited aircraft, the ROA's uninhabited status and large variability in size and performance make its requirements definition unique.

The scope of this task is limited to flight above FL400.

### 5.7.1 Analysis of FARs

Part 91 FARs applicable to ROA flight above FL400 were surveyed and are shown in Table 1, AIM paragraphs are shown in Table 2. These FAR and AIM requirements and practices will be compared to ROA capabilities shown in Table 1. In the analysis described in section 5.9, identification is made of which of these requirements an ROA can and cannot satisfy. That analysis also notes additions and changes to the FARs and AIM that may be necessary for ROA operation in the NAS. Some sentences or paragraphs in these documents are not applicable to an ROA, or ROA pilot, because they make reference to a crew in an airborne flight deck. Due to time and budget limitations, the applicable and non-applicable parts of each FAR Section and AIM paragraph have not been analyzed in this way.

## Table 1. FARs Applicable to ROA Operation Above FL400

### Subpart A -- General

#### Sec.

- [91.1](#) Applicability.
- [91.3](#) Responsibility and authority of the pilot in command.
- [91.5](#) Pilot in command of aircraft requiring more than one required pilot.
- [91.7](#) Civil aircraft airworthiness.
- [91.9](#) Civil aircraft flight manual, marking, and placard requirements.
- [91.11](#) Prohibition on interference with crewmembers.
- [91.13](#) Careless or reckless operation.
- [91.15](#) Dropping objects.
- [91.17](#) Alcohol or drugs.
- [91.19](#) Carriage of narcotic drugs, marihuana, and depressant or stimulant drugs or substances.
- [91.25](#) Aviation Safety Reporting Program: Prohibition against use of reports for enforcement purposes.

### Subpart B -- Flight Rules

#### GENERAL

- [91.101](#) Applicability.
- [91.103](#) Preflight action.
- [91.105](#) Flight crewmembers at stations.
- [91.109](#) Flight instruction; Simulated instrument flight and certain flight tests.<sup>9</sup>
- [91.111](#) Operating near other aircraft.
- [91.113](#) Right-of-way rules: Except water operations.
- [91.119](#) Minimum safe altitudes: General.
- [91.121](#) Altimeter settings.
- [91.123](#) Compliance with ATC clearances and instructions.
- [91.135](#) Operations in Class A airspace.
- [91.139](#) Emergency air traffic rules.
- [91.143](#) Flight limitation in the proximity of space flight operations.

#### INSTRUMENT FLIGHT RULES

- [91.167](#) Fuel requirements for flight in IFR conditions.
- [91.169](#) IFR flight plan: Information required.
- [91.171](#) VOR equipment check for IFR operations.
- [91.173](#) ATC clearance and flight plan required.
- [91.179](#) IFR cruising altitude or flight level.
- [91.180](#) Operations within airspace designated as Reduced Vertical Separation Minimum airspace.
- [91.181](#) Course to be flown.
- [91.183](#) IFR radio communications.
- [91.185](#) IFR operations: Two-way radio communications failure.
- [91.187](#) Operation under IFR in controlled airspace: Malfunction reports.

### Subpart C -- Equipment, Instrument, and Certificate Requirements

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<sup>9</sup> It is not clear at this time if this Section is applicable.

- [91.201](#) [Reserved]
- [91.203](#) Civil aircraft: Certifications required.
- [91.205](#) Powered civil aircraft with standard category U.S. airworthiness certificates: Instrument and equipment requirements.
- [91.207](#) Emergency locator transmitters.
- [91.209](#) Aircraft lights.
- [91.213](#) Inoperative instruments and equipment.
- [91.215](#) ATC transponder and altitude reporting equipment and use.
- [91.217](#) Data correspondence between automatically reported pressure altitude data and the pilot's altitude reference.
- [91.219](#) Altitude alerting system or device: Turbojet-powered civil airplanes.<sup>10</sup>
- [91.221](#) Traffic alert and collision avoidance system equipment and use.<sup>11</sup>
- [91.224-91.299](#) [Reserved]

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<sup>10</sup> It is not clear at this time if this Section is applicable.

<sup>11</sup> It is not clear at this time if this Section is applicable.

Table 2. AIM Paragraphs Applicable to ROA Operation Above FL400

**Chapter 4. Air Traffic Control**

**Section 2. Radio Communications Phraseology and Techniques**

<a href="#">4-2-1.</a>	General	<a href="#">4-2-8.</a>	Figures
<a href="#">4-2-2.</a>	Radio Technique	<a href="#">4-2-9.</a>	Altitudes and Flight Levels
<a href="#">4-2-3.</a>	Contact Procedures	<a href="#">4-2-10.</a>	Directions
<a href="#">4-2-4.</a>	Aircraft Call Signs	<a href="#">4-2-11.</a>	Speeds
<a href="#">4-2-5.</a>	Description of Interchange or Leased Aircraft	<a href="#">4-2-12.</a>	Time
<a href="#">4-2-6.</a>	Ground Station Call Signs		
<a href="#">4-2-7.</a>	Phonetic Alphabet		

**Section 4. ATC Clearances/Separations**

<a href="#">4-4-1.</a>	Clearance	<a href="#">4-4-9.</a>	Adherence to Clearance
<a href="#">4-4-2.</a>	Clearance Prefix	<a href="#">4-4-10.</a>	IFR Separation Standards
<a href="#">4-4-3.</a>	Clearance Items	<a href="#">4-4-11.</a>	Speed Adjustments
<a href="#">4-4-4.</a>	Amended Clearances	<a href="#">4-4-15.</a>	Traffic Alert and Collision Avoidance System (TCAS I & II)
<a href="#">4-4-6.</a>	Pilot Responsibility upon Clearance Issuance	<a href="#">4-4-16.</a>	Traffic Information Service (TIS)

**Chapter 5. Air Traffic Procedures**

**Section 1. Preflight**

<a href="#">5-1-1.</a>	Preflight Preparation	<a href="#">5-1-10.</a>	Change in Flight Plan
<a href="#">5-1-2.</a>	Follow IFR Procedures Even When Operating VFR	<a href="#">5-1-11.</a>	Change in Proposed Departure Time
<a href="#">5-1-3.</a>	Notices to Airmen (NOTAM) System	<a href="#">5-1-13.</a>	Canceling IFR Flight Plan
<a href="#">5-1-7.</a>	Flight Plan- IFR Flights	<a href="#">5-1-14.</a>	RNAV and RNP Operations

**Section 3. En Route Procedures**

<a href="#">5-3-1.</a>	ARTCC Communications	<a href="#">5-3-5.</a>	Airway or Route Course Changes
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<a href="#">5-3-2.</a>	Position Reporting	<a href="#">5-3-6.</a>	Changeover Points (COP'S)
<a href="#">5-3-3.</a>	Additional Reports	<a href="#">5-3-7.</a>	Holding
<a href="#">5-3-4.</a>	Airways and Route Systems		

### **Section 5. Pilot/Controller Roles and Responsibilities**

<a href="#">5-5-1.</a>	General	<a href="#">5-5-9.</a>	Speed Adjustments
<a href="#">5-5-2.</a>	Air Traffic Clearance	<a href="#">5-5-10.</a>	Traffic Advisories (Traffic Information)
<a href="#">5-5-6.</a>	Radar Vectors	<a href="#">5-5-15.</a>	Minimum Fuel Advisory
<a href="#">5-5-7.</a>	Safety Alert	<a href="#">5-5-16.</a>	RNAV and RNP Operations
<a href="#">5-5-8.</a>	See and Avoid		

### **Section 6. National Security and Interception Procedures**

<a href="#">5-6-1.</a>	National Security	<a href="#">5-6-4.</a>	Interception Signals
<a href="#">5-6-2.</a>	Interception Procedures	<a href="#">5-6-5.</a>	ADIZ Boundaries and Designated Mountainous Areas
<a href="#">5-6-3.</a>	Law Enforcement Operations by Civil and Military Organizations		

## **Chapter 6. Emergency Procedures**

### **Section 1. General**

<a href="#">6-1-1.</a>	Pilot Responsibility and Authority
<a href="#">6-1-2.</a>	Emergency Condition- Request Assistance Immediately

### **Section 2. Emergency Services Available to Pilots**

<a href="#">6-2-2.</a>	Transponder Emergency Operation	<a href="#">6-2-5.</a>	Emergency Locator Transmitter (ELT)
<a href="#">6-2-3.</a>	Direction Finding Instrument Approach Procedure	<a href="#">6-2-7.</a>	Search and Rescue



[6-2-4.](#) Intercept and Escort

### **Section 3. Distress and Urgency Procedures**

<a href="#">6-3-1.</a>	Distress and Urgency Communications	<a href="#">6-3-4.</a>	Special Emergency (Air Piracy)
<a href="#">6-3-2.</a>	Obtaining Emergency Assistance	<a href="#">6-3-5.</a>	Fuel Dumping

### **Section 4. Two-way Radio Communications Failure**

<a href="#">6-4-1.</a>	Two-way Radio Communications Failure
<a href="#">6-4-2.</a>	Transponder Operation During Two-way Communications Failure
<a href="#">6-4-3.</a>	Reestablishing Radio Contact

## **Chapter 7. Safety of Flight**

### **Section 1. Meteorology**

<a href="#">7-1-3.</a>	Use of Aviation Weather Products	<a href="#">7-1-17.</a>	Reporting of Cloud Heights
<a href="#">7-1-4.</a>	Preflight Briefing	<a href="#">7-1-19.</a>	Estimating Intensity of Rain and Ice Pellets
<a href="#">7-1-5.</a>	En Route Flight Advisory Service (EFAS)	<a href="#">7-1-21.</a>	Pilot Weather Reports (PIREP's)
<a href="#">7-1-6.</a>	Inflight Aviation Weather Advisories	<a href="#">7-1-22.</a>	PIREP's Relating to Airframe Icing
<a href="#">7-1-7.</a>	Categorical Outlooks	<a href="#">7-1-23.</a>	PIREP's Relating to Turbulence
<a href="#">7-1-8.</a>	Telephone Information Briefing Service (TIBS)	<a href="#">7-1-15.</a>	ATC Inflight Weather Avoidance Assistance
<a href="#">7-1-9.</a>	Transcribed Weather Broadcast (TWEB)	<a href="#">7-1-24.</a>	Wind Shear PIREP's
<a href="#">7-1-10.</a>	Inflight Weather Broadcasts	<a href="#">7-1-25.</a>	Clear Air Turbulence (CAT) PIREP's
<a href="#">7-1-11.</a>	Flight Information Services Data Link (FISDL)	<a href="#">7-1-27.</a>	PIREP's Relating to Volcanic Ash Activity
<a href="#">7-1-12.</a>	Weather Observing Programs	<a href="#">7-1-28.</a>	Thunderstorms
<a href="#">7-1-13.</a>	Weather Radar Services	<a href="#">7-1-29.</a>	Thunderstorm Flying
<a href="#">7-1-14.</a>	National Convective Weather Forecast (NCWF)		

## 5.8 Significant ROA Functional Requirements Driven by the FAA Order 7110.65.

This objective is concerned with documenting existing sections of FAA Order 7110.65 for inhabited aircraft and then determine which appear applicable to ROAs. In addition to requirements in the FARs and AIM, requirements exist in FAA Order 7110.65. These requirements dictate operational rules for the ATC system and air traffic controller functions and tasks. Inhabited aircraft comply with these rules as they are issued via an ATC clearance. ROAs are expected to adhere to these rules as well.

This objective also is concerned with identifying those paragraphs of 7110.65 that may require modification due to ROA functionality. ROA functionality may not be completely compatible with all paragraphs in FAA Order 7110.65. This may be due to their unique designs and performance capabilities. There are precedents for this, not only for unusual aircraft but also for aircraft that require extra latitude in flight operations.

As described in the previous section, this comparison must be undertaken for two reasons: (1) The Access 5 charter has indicated that ROAs shall operate as *de facto* inhabited aircraft, which implies the need for them to adhere to most existing FAA Order 7110.65 en route sections for inhabited aircraft. In addition, (2) functions and tasks required of the pilot and air traffic controller, and pilot and air traffic controller interfaces to hardware, software, and procedures must be based on the assumption that an ROA will adhere to most of ATC's standards. This mandates an assessment of requirements and in-flight capabilities for ROAs, their pilots, and air traffic controllers. While it is reasonably clear at the outset that ROA functionality, functions required of the pilot, and functions required of the air traffic controller must be similar to those of inhabited aircraft, the ROA's uninhabited status and large variability in size and performance make its requirements definition unique.

These FAA Order 7110.65 requirements will be compared to ROA capabilities shown in Table 1 in the analysis described in 5.9. In that analysis, identification is made of which FAA Order 7110.65 requirements an ROA can and cannot satisfy. That analysis also notes additions and changes to FAA Order 7110.65 that may be necessary for ROA operation in the NAS.

The scope of this task is limited to flight above FL400.

### 5.8.1 Analysis of FAA Order 7110.65

FAA Order 7110.65 paragraphs applicable to ROA flight above FL400 were surveyed and shown in Table 3. Some sentences or paragraphs in these documents are not applicable to an ROA, or ROA pilot, because they make reference to a crew in an airborne flight deck or flight with passengers onboard. Due to time and budget limitations, the applicable and non-applicable parts of each paragraph have not been analyzed in this way.

Table 3. FAA Order 7110.65 Paragraphs Applicable to ROA Operation Above FL400

**Chapter 2. General Control**

**Section 1. General**

<a href="#">2-1-1.</a>	ATC Service	<a href="#">2-1-13.</a>	Formation Flights
<a href="#">2-1-2.</a>	Duty Priority	<a href="#">2-1-14.</a>	Coordinate Use of Airspace
<a href="#">2-1-4.</a>	Operational Priority	<a href="#">2-1-17.</a>	Radio Communications Transfer
<a href="#">2-1-5.</a>	Expeditious Compliance	<a href="#">2-1-18.</a>	Operational Requests
<a href="#">2-1-6.</a>	Safety Alert	<a href="#">2-1-22.</a>	Bird Activity Information
<a href="#">2-1-7.</a>	Inflight Equipment Malfunctions	<a href="#">2-1-26.</a>	Pilot Deviation Notification
<a href="#">2-1-8.</a>	Minimum Fuel	<a href="#">2-1-27.</a>	TCAS Resolution Advisories
<a href="#">2-1-10.</a>	NAVAID Malfunctions		

**Section 4. Radio and Interphone Communications**

<a href="#">2-4-1.</a>	Radio Communications	<a href="#">2-4-12.</a>	Interphone Message Format
<a href="#">2-4-2.</a>	Monitoring	<a href="#">2-4-13.</a>	Interphone Message Termination
<a href="#">2-4-3.</a>	Pilot Acknowledgement/ Read Back	<a href="#">2-4-14.</a>	Words and Phrases
<a href="#">2-4-4.</a>	Authorized Interruptions	<a href="#">2-4-19.</a>	Facility Identification
<a href="#">2-4-16.</a>	ICAO Phonetics	<a href="#">2-4-20.</a>	Aircraft Identification
<a href="#">2-4-17.</a>	Numbers Usage	<a href="#">2-4-21.</a>	Description of Aircraft Types
<a href="#">2-4-18.</a>	Number Clarification		

**Section 5. Route and NAVAID Description**

<a href="#">2-5-1.</a>	Airways and Routes	<a href="#">2-5-3.</a>	NAVAID Fixes
<a href="#">2-5-2.</a>	NAVAID Terms		

**Section 6. Weather Information**

- |                        |  |                        |                   |
|------------------------|--|------------------------|-------------------|
| <a href="#">2-6-1.</a> | Familiarization  | <a href="#">2-6-3.</a> | PIREP Information |
| <a href="#">2-6-2.</a> | Hazardous Inflight Weather<br>Advisory Service (HIWAS) |                        |                   |

### **Section 7. Altimeter Settings**

- |                        |   |  |  |
|------------------------|---|--|--|
| <a href="#">2-7-1.</a> | Current Settings                                  |  |  |
| <a href="#">2-7-2.</a> | Altimeter Setting Issuance Below Lowest Usable FL |  |  |

## **Chapter 4. IFR**

### **Section 1. NAVAID Use Limitations**

- |                        |                   |                        |         |
|------------------------|-------------------|------------------------|---------|
| <a href="#">4-1-3.</a> | Crossing Altitude | <a href="#">4-1-5.</a> | Fix Use |
|------------------------|-------------------|------------------------|---------|

### **Section 2. Clearances**

- |                        |                       |                        |                                 |
|------------------------|-----------------------|------------------------|---------------------------------|
| <a href="#">4-2-1.</a> | Clearance Items       | <a href="#">4-2-5.</a> | Route or Altitude<br>Amendments |
| <a href="#">4-2-2.</a> | Clearance Prefix      | <a href="#">4-2-6.</a> | Through Clearances              |
| <a href="#">4-2-3.</a> | Delivery Instructions | <a href="#">4-2-9.</a> | Clearance Items                 |

### **Section 4. Route Assignment**

- |                        |                             |                        |                    |
|------------------------|-----------------------------|------------------------|--------------------|
| <a href="#">4-4-1.</a> | Route Use                   | <a href="#">4-4-4.</a> | Alternative Routes |
| <a href="#">4-4-2.</a> | Route Structure Transitions |                        |                    |

### **Section 5. Altitude Assignment and Verification**

- |                        |                            |                        |                                    |
|------------------------|----------------------------|------------------------|------------------------------------|
| <a href="#">4-5-1.</a> | Vertical Separation Minima | <a href="#">4-5-6.</a> | Minimum En Route<br>Altitudes      |
| <a href="#">4-5-2.</a> | Flight Direction           | <a href="#">4-5-7.</a> | Altitude Information               |
| <a href="#">4-5-3.</a> | Exceptions                 | <a href="#">4-5-8.</a> | Anticipated Altitude<br>Changes    |
|                        |                            | <a href="#">4-5-9.</a> | Altitude Confirmation-<br>Nonradar |

### **Section 6. Holding Aircraft**

- |                        |                          |                        |                      |
|------------------------|--------------------------|------------------------|----------------------|
| <a href="#">4-6-1.</a> | Clearance to Holding Fix | <a href="#">4-6-4.</a> | Holding Instructions |
|------------------------|--------------------------|------------------------|----------------------|

<a href="#">4-6-2.</a>	Clearance Beyond Fix	<a href="#">4-6-6.</a>	Holding Flight Path Deviation
<a href="#">4-6-3.</a>	Delays	<a href="#">4-6-7.</a>	Unmonitored NAVAIDs

## **Chapter 5. Radar**

### **Section 1. General**

<a href="#">5-1-8.</a>	Merging Target Procedures	<a href="#">5-1-12.</a>	Position Reporting
<a href="#">5-1-9.</a>	Holding Pattern Surveillance	<a href="#">5-1-13.</a>	Radar Service Termination
<a href="#">5-1-10.</a>	Deviation Advisories		

### **Section 2. Beacon Systems**

<a href="#">5-2-1.</a>	Assignment Criteria	<a href="#">5-2-13.</a>	Code Monitor
<a href="#">5-2-2.</a>	Discrete Environment	<a href="#">5-2-14.</a>	Failure to Display Assigned Beacon Code or Inoperative/ Malfunctioning Transponder
<a href="#">5-2-3.</a>	Nondiscrete Environment	<a href="#">5-2-15.</a>	Inoperative or Malfunctioning Interrogator
<a href="#">5-2-4.</a>	Mixed Environment	<a href="#">5-2-16.</a>	Failed Transponder in Class A Airspace
<a href="#">5-2-5.</a>	Radar Beacon Code Changes	<a href="#">5-2-17.</a>	Validation of Mode C Readout
<a href="#">5-2-6.</a>	Function Code Assignments	<a href="#">5-2-18.</a>	Altitude Confirmation-Mode C
<a href="#">5-2-7.</a>	Emergency Code Assignment	<a href="#">5-2-19.</a>	Altitude Confirmation-Non-Mode C
<a href="#">5-2-8.</a>	Radio Failure	<a href="#">5-2-20.</a>	Automatic Altitude Reporting
		<a href="#">5-2-22.</a>	Beacon Termination

### **Section 3. Radar Identification**

<a href="#">5-3-1.</a>	Application	<a href="#">5-3-4.</a>	Terminal Automation Systems Identification Methods
<a href="#">5-3-2.</a>	Primary Radar	<a href="#">5-3-5.</a>	Questionable Identification

## Identification Methods

<a href="#">5-3-3.</a>	Beacon Identification Methods	<a href="#">5-3-6.</a>	Position Information
		<a href="#">5-3-7.</a>	Identification Status

## **Section 4. Transfer of Radar Identification**

<a href="#">5-4-1.</a>	Application	<a href="#">5-4-6.</a>	Receiving Controller Handoff
<a href="#">5-4-2.</a>	Terms	<a href="#">5-4-7.</a>	Point Out
<a href="#">5-4-3.</a>	Methods	<a href="#">5-4-8.</a>	Automated Information Transfer (AIT)
<a href="#">5-4-4.</a>	Traffic	<a href="#">5-4-9.</a>	Interfacility Automated Information Transfer
<a href="#">5-4-5.</a>	Transferring Controller Handoff	<a href="#">5-4-10.</a>	Prearranged Coordination

## **Section 5. Radar Separation**

<a href="#">5-5-1.</a>	Application	<a href="#">5-5-7.</a>	Passing or Diverging
<a href="#">5-5-2.</a>	Target Separation	<a href="#">5-5-8.</a>	Additional Separation for Formation Flights
<a href="#">5-5-3.</a>	Target Resolution	<a href="#">5-5-10.</a>	Adjacent Airspace
<a href="#">5-5-4.</a>	Minima	<a href="#">5-5-11.</a>	Edge of Scope
<a href="#">5-5-5.</a>	Vertical Application	<a href="#">5-5-12.</a>	Beacon Target Displacement
<a href="#">5-5-6.</a>	Exceptions	<a href="#">5-5-13.</a>	GPA 102/103 Correction Factor

## **Section 6. Vectoring**

<a href="#">5-6-1.</a>	Application
<a href="#">5-6-2.</a>	Methods

## **Section 7. Speed Adjustment**

<a href="#">5-7-1.</a>	Application	<a href="#">5-7-4.</a>	Termination
<a href="#">5-7-2.</a>	Methods		

### **Section 14. Automation- En Route**

<a href="#">5-14-1.</a>	Conflict Alert (CA) and Mode C Intruder (MCI) Alert	<a href="#">5-14-5.</a>	Selected Altitude Limits
<a href="#">5-14-3.</a>	Computer Entry of Assigned Altitude	<a href="#">5-14-6.</a>	Sector Eligibility
<a href="#">5-14-4.</a>	Entry of Reported Altitude	<a href="#">5-14-7.</a>	Coast Tracks
		<a href="#">5-14-8.</a>	Controller Initiated Coast Tracks

## **Chapter 10. Emergencies**

### **Section 1. General**

<a href="#">10-1-1.</a>	Emergency Determinations	<a href="#">10-1-4.</a>	Responsibility
<a href="#">10-1-2.</a>	Obtaining Information	<a href="#">10-1-5.</a>	Coordination
<a href="#">10-1-3.</a>	Providing Assistance		

### **Section 2. Emergency Assistance**

<a href="#">10-2-1.</a>	Information Requirements	<a href="#">10-2-9.</a>	Radar Assistance Techniques
<a href="#">10-2-2.</a>	Frequency Changes	<a href="#">10-2-10.</a>	Emergency Locator Transmitter (ELT) Signals
<a href="#">10-2-3.</a>	Aircraft Orientation	<a href="#">10-2-13.</a>	Emergency Airport Recommendation
<a href="#">10-2-4.</a>	Altitude Change for Improved Reception	<a href="#">10-2-14.</a>	Guidance to Emergency Airport
<a href="#">10-2-5.</a>	Emergency Situations	<a href="#">10-2-16.</a>	Volcanic Ash
<a href="#">10-2-6.</a>	Hijacked Aircraft		

### **Section 4. Control Actions**

<a href="#">10-4-4.</a>	Communications Failure
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## 5.9 Summary of Potential Concepts, Requirements, and Regulations.

This objective is concerned with summarizing the results from the analyses of FARs, AIM, and FAA Order 7110.65. The summary indicates those regulations and practices that an ROA is expected to comply with. These lead to the definition of requirements for pilot and air traffic controller functions, tasks, and information and control requirements. In addition, this task outlines regulations and practices that may be need to be changed, based on HSI analysis, because of ROA functionality shortfalls and interfaces for the pilot and air traffic controller.

The scope of this task is limited to flight above FL400.

### 5.9.1 ROA Ability to Satisfy Requirements for Flight in the NAS

An analysis of FAR Part 91, applicable sections of the AIM, and relevant paragraphs from FAA Order 7110.65 was made to identify a complete set of requirements for IFR flight above FL400. This includes functions for the ROA, pilot, and air traffic controller. Table 4 lists only those capabilities that are required for IFR flight above FL400 against the capability of the four selected ROAs to provide the necessary functionality.

Inspection of the table shows that, for the four ROAs under review, most NAS requirements have been satisfied. The primary exception is hazard avoidance, which takes the form of the ROA’s inability to detect and avoid traffic and weather. It can be seen also that hazard avoidance capability is subject to ROA design. Nevertheless, it is generally understood that traffic and weather detection and avoidance are issues for most ROAs. Incorporation of the requisite hardware and software, to provide traffic and weather information to the pilot and/or automation, will satisfy these requirements.

Table 4. Functionalities Required for IFR Flight Above FL400 Compared to Capabilities of the Four Selected ROAs

ID	Functionality Description	Functionality Capability			
		Vehicle	Altair	Perseus B	Helios
FLIGHT <sup>12</sup>					
1	Pitch, Roll, Yaw <sup>13</sup>	YES	YES	YES	YES
4	Indicated/Calibrated/Equivalent Airspeed	YES	YES	YES	YES
5	Mach Number <sup>14</sup>	N/A	N/A	N/A	YES
6	Altitude	YES	YES	YES	YES
7	Barometric Altimeter Setting	YES	YES	YES	YES

<sup>12</sup> Control or display capability.

<sup>13</sup> Requirement dictated by aircraft design.

<sup>14</sup> Only as required by airspeed/Mach envelope.



9	Vertical Speed	YES	YES	YES	YES
12	Pilot-ATC Communication	YES	YES	YES	YES
13	Pilot-ROA Communication	YES	YES	YES	YES
14	DELETED				
NAVIGATION <sup>15</sup>					
16	Heading	YES	YES	YES	YES
18	Track (Magnetic/True)	YES	YES	NO	YES
21	Vertical Profile Deviation	YES	YES	YES	YES
23	Lateral Profile Deviation	YES	YES	YES	YES
30	Interactive Flight Plan Revising	YES	YES	YES	YES
32	RNAV Capability (via GPS, INS, or equivalent)	YES	YES	YES	YES
33	Radio (VHF/UHF) <sup>16</sup>	YES	YES	YES	YES
34	DME (Distance measuring)	YES	YES	YES	YES
41	Distance to Go	YES	YES	YES	YES
42	Time to Go	YES	YES	YES	YES
43	Wind Speed and Direction	YES	YES	YES	YES
44	Estimated Time of Arrival at Waypoint	YES	YES	YES	YES
45	DELETED				
46	Aircraft Position	YES	YES	YES	YES
SURVEILLANCE					
59	Permit ATC Secondary Surveillance Radar Identification via Transponder or Datalink	YES	YES	YES	YES
HAZARD AVOIDANCE – SURVEILLANCE <sup>17</sup>					
60	Weather (Direct View)	YES	YES	NO	NO
61	Weather (Radar)	YES	YES	NO	NO
62	Precipitation (Direct View)	YES	YES	NO	NO
63	Precipitation (Electronic)	YES	YES	NO	NO
64	Turbulence (Direct View)	YES	YES	NO	YES
65	Turbulence (Electronic)	YES	YES	NO	NO
66	Lightning (Direct View)	YES	YES	YES	NO
67	Lightning (Electronic)	YES	NO	NO	NO
68	Volcanic Ash (Direct View)	YES	YES	NO	NO
74	Flight Traffic (Direct View)	YES	YES	NO	NO
75	Flight Traffic (Electronic)	YES	NO	NO	NO
MISCELLANEOUS					
84	Identify Visual Flight Rules Conditions	YES	YES	NO	NO

<sup>15</sup> Control or display capability.

<sup>16</sup> Navigation capability may be satisfied by use of self-contained navigation capability or via NAVAIDS.

<sup>17</sup> Hazards may be identified by direct view or electronic display.

### 5.9.2 ROA Lack of Capability for Hazard Avoidance

The main HSI issue for ROA operation in the NAS is providing the pilot-ROA system information for see-and-avoid, or hazard avoidance functionality. In this sense, ‘hazard’ is defined as anything that is hazardous to the vehicle and must be avoided. It is characterized by (1) traffic and (2) weather, both of which exist on the ground and in flight (see ID 60-75 in the table above).

The analysis of see-and-avoid for traffic has been conducted in 2004 by MTSI and is documented in Annex B to this report.

The main issue of hazard avoidance centers on the ROA’s inability to provide the functional equivalency of inhabited aircraft. ROAs typically do not have imaging systems that provide, in total, an equivalent functionality of the human pilot. Their imaging systems are deficient in one or more technical areas such as resolution, field-of-view, field-of-regard, color resolution, etc. Some ROAs employ excellent sensors that are used as payloads. But they are not designated as full-time, hazard avoidance devices solely for the purpose of satisfying requirements to fly in the NAS. Detailed requirements for the functionality and information required by the pilot are shown in **Error! Reference source not found.** and **Error! Reference source not found.**

An option that may provide functional equivalency is the use of electronic data in combination with, or in lieu of, imaging. Data displays may provide the required functional equivalency of the human pilot by displaying data that describe the position and hazardous level of traffic and weather. Work is underway to determine the utility of these technologies by the Cooperative Collision Avoidance group of the Technology IPT.

As of 2004, for flight above FL400, ROA shortfalls exist in the detection and avoidance of traffic and weather at a level of competency that is required for flight in the NAS.

### 5.9.3 Potential Changes to FARs and/or FAA Order 7110.65

A FAR or ATM Change Requirement and Rationale are used to describe the FAR or FAA Order 7110.65 paragraph or other requirement that is unlikely to be satisfied by a HALE ROA. This is based on an HSI analysis of planned ROA operations and the roles of the pilot and air traffic controller. The FAR or ATM Change Requirement describes the requirement and compares it to ROA capability. Rationale describes the basis for changing the requirement and the impact on the ROA-ATM system.

In some instances, FAR or ATM Change Requirement may not be the best description of the relationship between the HALE ROA and the NAS. The Access 5 government/industry partnership may decide that a ROA should not comply with an FAR or 7110.65 requirement even though it has the technical capability to do so. While the

ROA may be able to comply, it may not be operationally prudent for it to do so due to lack of operational necessity and safety concerns.

The results were partitioned into two categories:

1. Communications

This constitutes an operation where the ROA pilot is required to make a pilot report (PIREP) of significant weather or safety of flight issues. In general, it does not appear likely that this can be accomplished without an onboard pilot. However, ROA sensors may provide some data to report. ATC should not always expect a PIREP in accord with 7110.65, paragraph 2-6-3.

2. Emergencies

This constitutes operations where the ROA experiences expected and unexpected emergencies. Expected emergencies should be handled well and in accord with applicable procedures and regulations. Unplanned emergencies are expected due to unexpected failures, generic software faults, or unforeseen events that are beyond the capability of automation control. Here, the ROA will act unpredictably with unknown consequences yet it must act in accord with FARs covering emergency operations. The primary areas include: Communications Failure and Automation.

5.9.3.1 Changes and Their Expected Impact on Operations

FAR Part 91 and FAA Order 7110.65 paragraphs that may need to be changed for unrestricted HALE ROA flight above FL400 and their associated operational impact on ROA and ATM operations are shown in Table 5. The Impact on Operations estimates the potential level of disruption to the ROA and ATM system (assuming a standard operating day without unusual mission, traffic, or weather events).

Table 5. FAR, AIM, and 7110.65N Paragraphs (and Associated Impacts) that May Require Change for Unrestricted HALE ROA Flight Operations (Year 2008)

Paragraph Number	ATM Change Requirement	Impact on Operations	
		ROA	ATM
FAR 91.155/91.175	Flight Visibility and Distance to Clouds	Low*	Low*
AIM, 7-1-21	Communication (PIREP)	Low	High*
FAR 91.185/new 7110.65, 3-2-1	Communications Failure	High	High
7110.65 new	ROA Autonomy	High	High

\*TBV

### 5.9.3.1.1 Flight Visibility and Distance to Clouds

#### 5.9.3.1.1.1 ATM Change Requirement

Under FAR 91.155 and 91.175, ATC should not expect a ROA to determine

- its flight visibility or clearance from clouds
- the flight visibility required for landing<sup>18</sup>
- if it is in VMC or IMC.

##### 5.9.3.1.1.1.1 Rationale

- It is expected that in-flight visibility and distance to clouds (day and night) cannot be determined due to technical shortfalls in sensor technology. The human pilot has limited ability to determine flight visibility but not accurately (i.e., not to fractions of a mile or within hundreds of feet) in a low visibility IFR approach.
- In-flight visibility determination is not a significant issue. As long as the reported ground visibility for the approach is at or above approach minimums for the ROA, the ROA may make the approach and land if it has the runway environment<sup>19</sup> in sight at the Decision Height or Missed Approach Point (as appropriate). As long as the ROA sensor system can detect one or more of the runway environment elements, it complies with 91.175 and may land. If it cannot, it may not land and will either need to make the approach again or proceed to an alternate.
- The role of required visibility for landing is TBD for those ROAs that are certified to land without direct pilot involvement.
- In-flight determination of the distance to clouds is applicable only in the determination of VMC and IMC conditions, and in particular, when an aircraft is complying with VFR cloud clearance rules. If a ROA will not operate under VFR, this issue is academic.

#### 5.9.3.1.2 Communications<sup>20</sup>

##### 5.9.3.1.2.1 In Flight Reports (PIREPs)

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<sup>18</sup> FAR 91.175 (d): Landing. No pilot operating an aircraft, except a military aircraft of the United States, may land that aircraft when the flight visibility is less than the visibility prescribed in the standard instrument approach procedure being used.

<sup>19</sup> FAR 91.175 (c): Operation below DH or MDA. ... (i) The approach light system, except that the pilot may not descend below 100 feet above the touchdown zone elevation using the approach lights as a reference unless the red terminating bars or the red side row bars are also distinctly visible and identifiable. (ii) The threshold. (iii) The threshold markings. (iv) The threshold lights. (v) The runway end identifier lights. (vi) The visual approach slope indicator. (vii) The touchdown zone or touchdown zone markings. (viii) The touchdown zone lights. (ix) The runway or runway markings. (x) The runway lights.

<sup>20</sup> Communications failures are listed in section 5.9.3.1.3, Emergencies

#### 5.9.3.1.2.1.1 ATM Change Requirement

ATC should not expect a ROA to volunteer a PIREP nor be able to provide substantial information about its environment when questioned.

#### 5.9.3.1.2.1.2 Rationale

It is standard practice for a pilot to make PIREP of a significant or unusual condition that affects flight safety and/or operations. FAA air traffic facilities are required to solicit PIREPs. Pilots are urged to cooperate and promptly volunteer reports of these conditions and other atmospheric data such as cloud bases, tops and layers; flight visibility; precipitation; visibility restrictions such as haze, smoke and dust; wind at altitude; and temperature aloft. They can be extremely important in providing last minute, detailed information on significant weather, such as clear air turbulence, airframe icing, and wind shear. Without a human in the ROA, it seems unlikely that the capability exists to make a comprehensive PIREP. However, the Operator may obtain certain information from the ROA sensors and report to ATC (TBV).

#### 5.9.3.1.3 Emergencies

##### 5.9.3.1.3.1 Communications Failure

###### 5.9.3.1.3.1.1 Operator – ATC Loss of Communications

###### 5.9.3.1.3.1.1.1 ATM Change Requirement

Under FAR 91.185, ATC should expect the ROA to proceed to the nearest suitable airport and land as soon as practicable, regardless of whether the ROA is in VFR or IFR conditions.

###### 5.9.3.1.3.1.1.2 Rationale

This type of communications failure is analogous to a loss of communications between the pilot of a normal aircraft and ATC. In such a case, the philosophy behind the applicable FARs is that the aircraft should remain aloft for the minimum amount of time while not under ATC control. Landing takes the aircraft out of controlled airspace, where it causes disruption to ATC traffic flow, sequencing, separation, controller workload, and safety, and places it on the ground.

FAR 91.185 and AIM 6-4-1 specify the procedure for the pilot. A distinction is made regarding whether the aircraft is in IMC or VMC. If in IMC, the aircraft must remain on its IFR flight plan. However, if it encounters VMC and determines that it is in VFR conditions, it must abandon its IFR flight plan and land as soon as practicable<sup>21</sup>.

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<sup>21</sup> VFR conditions are specified in FAR 91.155

In the case of a ROA, as it has been assumed in this analysis that it cannot determine if it is in VFR conditions, it should land as soon as practicable regardless of weather conditions. In addition, the capability exist in ROAs with self-contained navigation capability, i.e., INS and/or GPS, to navigate from its present position to a nearest suitable airport regardless of weather conditions.

#### 5.9.3.1.3.1.2 Operator – ROA Loss of Link

##### 5.9.3.1.3.1.2.1 ATM Change Requirement

Under new, proposed FAR and 7110.65 sections, ATC should expect the ROA to proceed to the nearest suitable airport and land as soon as practicable.

##### 5.9.3.1.3.1.2.2 Rationale

This type of communications failure is not analogous to any type loss of communications for inhabited aircraft. It represents a case where the Operator has lost direct control of the vehicle and the aircraft operates solely according to programming with no real-time human involvement. The ROA may or may not operate safely in such a circumstance with the probability of failure increasing over time.

In such a case, the philosophy behind the proposed regulation(s) FARs is that the aircraft should remain aloft for the minimum amount of time while not under ATC control and land at the nearest suitable airport as soon as practicable.

Annex B to this report, prepared by MTSI, provides HSI requirements and guidelines for ROA pilot-ATC (C2) , command and control.

#### 5.9.3.1.3.2 Automation

##### 5.9.3.1.3.2.1.1 ATM Change Requirement

Under a new, proposed 7110.65 section for normal ROA operations, ATC should be made aware that ROA automation exhibits the following characteristics:

- ROA automation/autonomy exhibit functionality for normal and emergency operations to comply with applicable FARs (as would a *de facto* inhabited aircraft).
- The Pilot has real-time data on ROA systems' status and performance (as would the pilot of an inhabited aircraft).
- The Pilot may or may not have the capability for immediate automation/control override during any phase of flight or whenever the ROA may pose an immediate hazard to persons or property (unlike the pilot of an inhabited aircraft).
- The Pilot communicates with ATC to carry out all ATC clearances (as would the pilot of an inhabited aircraft).

Under a new, proposed 7110.65 section for abnormal and emergency ROA operations, ATC should be made aware that ROA automation may exhibit the following characteristics:

- Unexpected failures, generic software faults, or unforeseen events that are beyond the capability of automation control, may cause the ROA to act unpredictably with unknown consequences.
  - During a loss of link between the Pilot and ROA, the Pilot has no direct control of the vehicle and ROA operates solely according to programming with no real-time human involvement

#### 5.9.3.1.3.2.1.2 Rationale

These sections should be added to 7110.65 to educate and alert the controller to ROA capabilities and actions. (As ROA-ATC operations mature, specific details may be added to 7110.65.) Controllers are aware of the performance and capabilities of the aircraft under their control. However, those aircraft that are extreme in their performance (e.g., very fast, very slow) can precipitate extra workload in controlling such aircraft with the mainstream flow of other traffic.

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