RTCA

Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS): A Control & Communications Perspective

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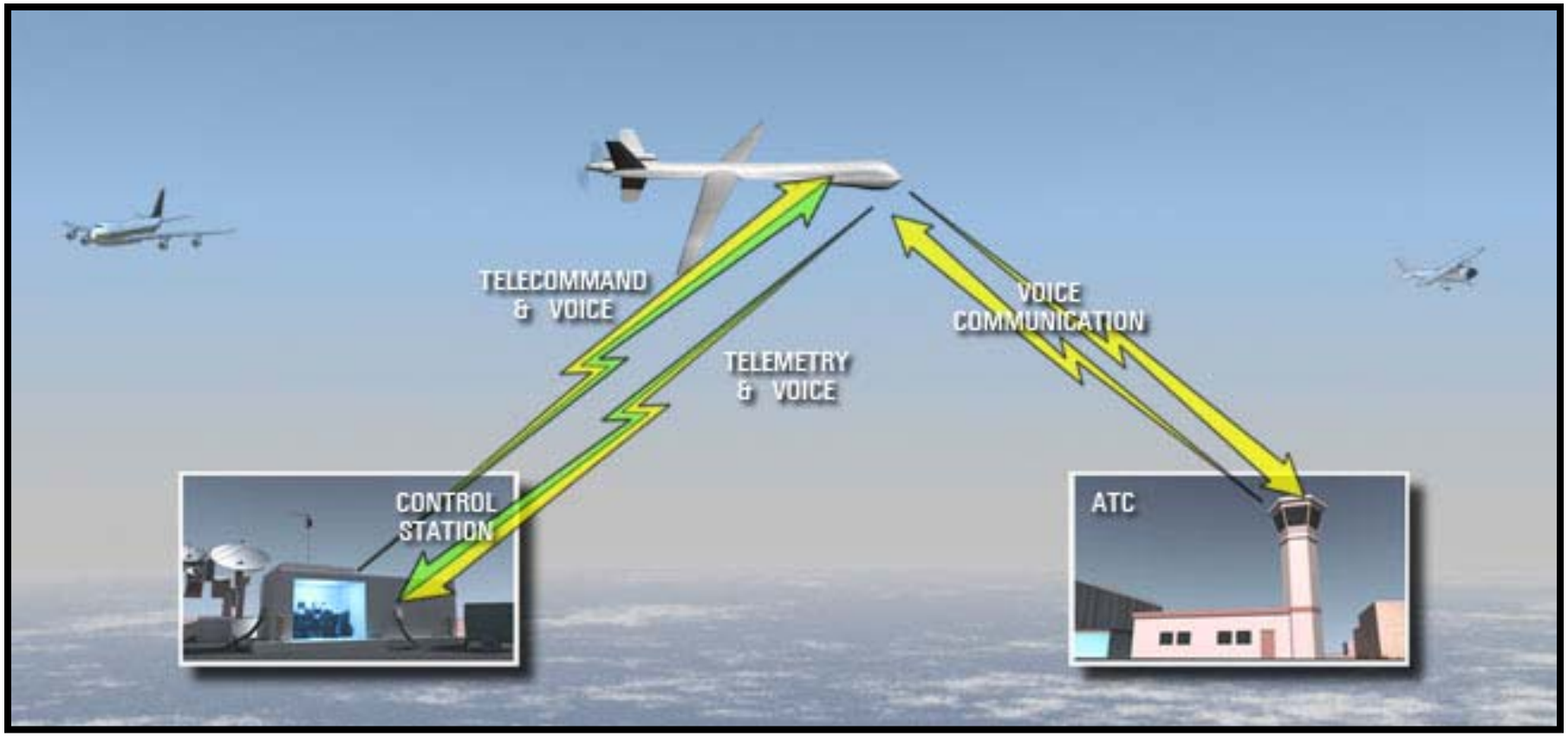
Overview

- Purpose
- Current Architectures
- Performance Metrics
  - Latency
  - Availability
- Major Challenges
  - Spectrum
  - Security
- Conclusion
- Questions

Purpose

- To bring to light, control and communications-related issues that must be addressed to enable the integration of Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS)

Line of Sight (LOS) Architecture

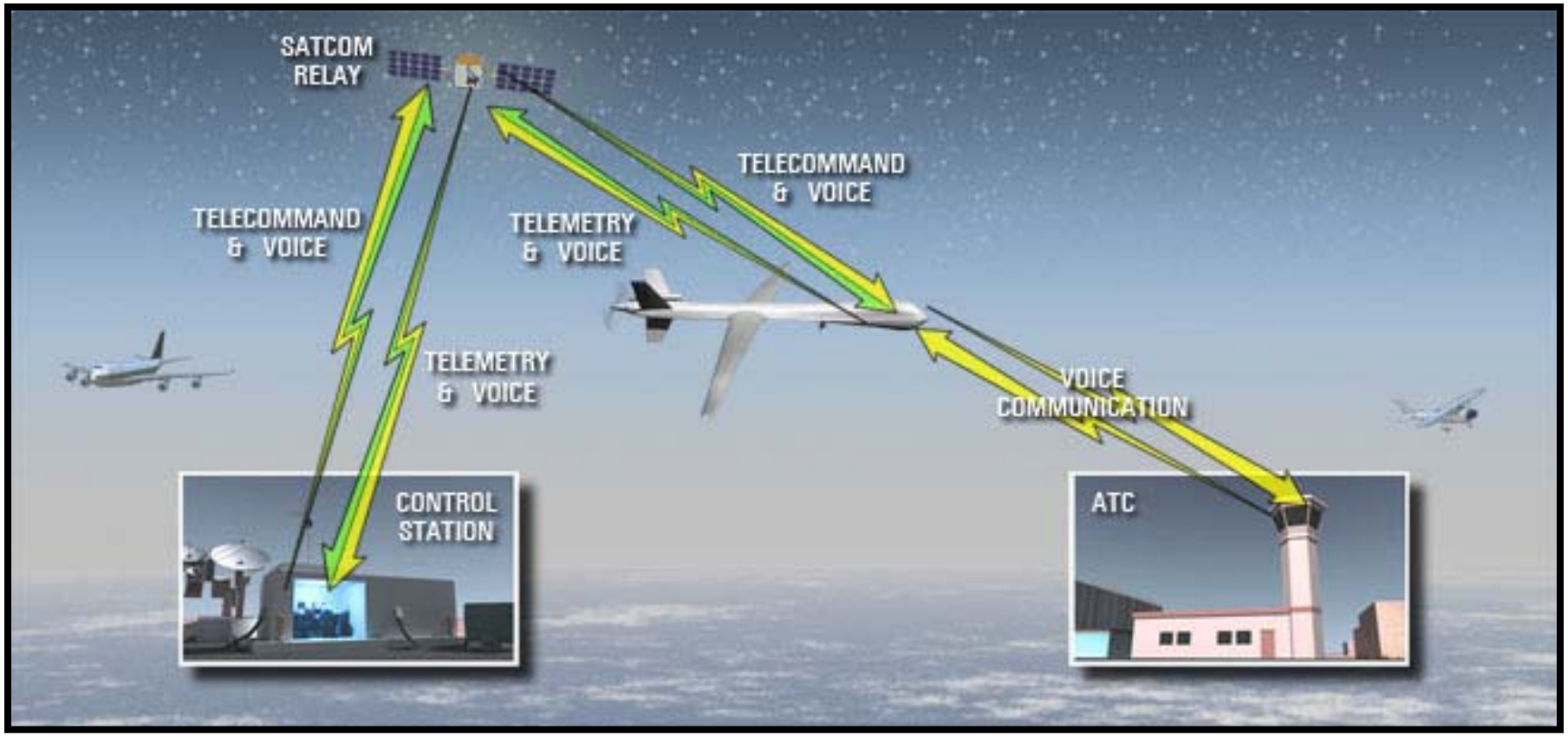


GREEN:	**CONTROL LINKS**
YELLOW:	**COMMUNICATIONS LINKS**

LOS Architecture (cont.)

- Characteristics:
  - Short-range (less than 200 miles)
  - More-reliable (most are dual-redundant)
  - Both control & communications data are using the same links
  - Low latency

Beyond Line of Sight (BLOS) Architecture



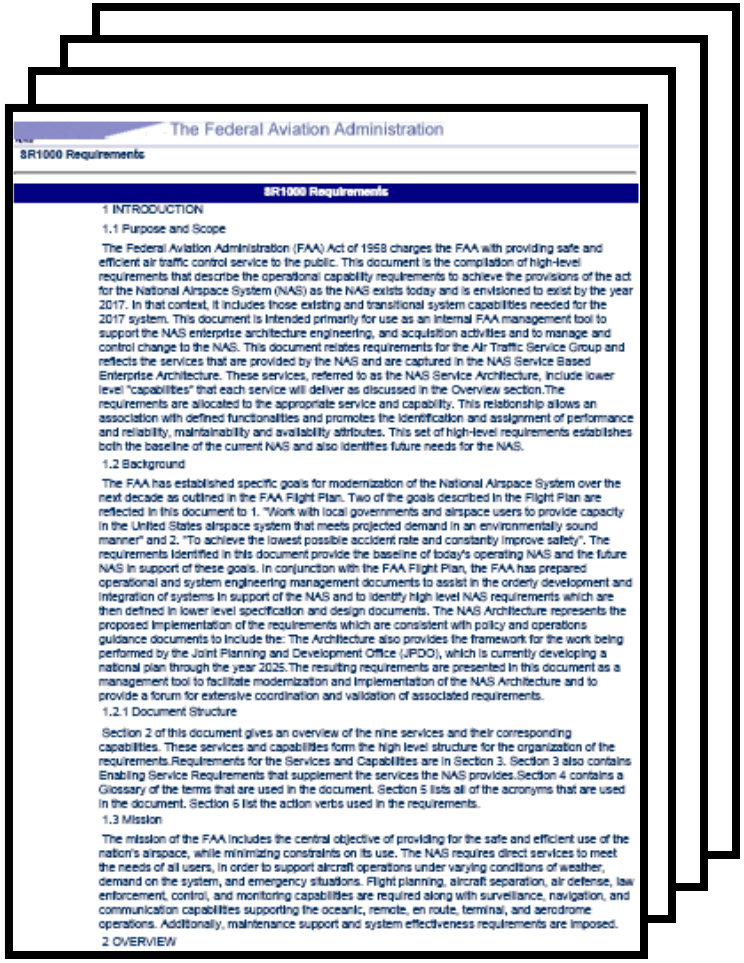
GREEN:	**CONTROL LINKS**
YELLOW:	**COMMUNICATIONS LINKS**

BLOS Architecture (cont.)

- Characteristics:
  - Most (if not all) are satellite-based
  - Longer-range (hundreds of miles)
  - Less-reliable (must mitigate loss of link occurrences)
  - Both control & communications data are using the same links
  - Rely on a LOS system for take-off and landing

Performance Metrics

- Several metrics for A/G communications can be found in NAS-SR-1000
  - Compilation of high-level, requirements that describe the operational capability requirements … for the NAS as it exists today and is envisioned to exist by the year 2017
  - Intended primarily for use as an internal FAA management tool … to manage and control change to the NAS



The Federal Aviation Administration

SR1000 Requirements

SR1000 Requirements

1 INTRODUCTION

1.1 Purpose and Scope

The Federal Aviation Administration (FAA) Act of 1958 charges the FAA with providing safe and efficient air traffic control service to the public. This document is the compilation of high-level requirements that describe the operational capability requirements to achieve the provisions of the act for the National Airspace System (NAS) as the NAS exists today and is envisioned to exist by the year 2017. In that context, it includes those existing and transitional system capabilities needed for the 2017 system. This document is intended primarily for use as an internal FAA management tool to support the NAS enterprise architecture engineering, and acquisition activities and to manage and control change to the NAS. This document relates requirements for the Air Traffic Service Group and reflects the services that are provided by the NAS and are captured in the NAS Service Based Enterprise Architecture. These services, referred to as the NAS Service Architecture, include lower level "capabilities" that each service will deliver as discussed in the Overview section.The requirements are allocated to the appropriate service and capability. This relationship allows an association with defined functionalities and promotes the identification and assignment of performance and reliability, maintainability and availability attributes. This set of high-level requirements establishes both the baseline of the current NAS and also identifies future needs for the NAS.

1.2 Background

The FAA has established specific goals for modernization of the National Airspace System over the next decade as outlined in the FAA Flight Plan. Two of the goals described in the Flight Plan are reflected in this document to 1. "Work with local governments and airspace users to provide capacity in the United States airspace system that meets projected demand in an environmentally sound manner" and 2. "To achieve the lowest possible accident rate and constantly improve safety". The requirements identified in this document provide the baseline of today's operating NAS and the future NAS in support of these goals. In conjunction with the FAA Flight Plan, the FAA has prepared operational and system engineering management documents to assist in the orderly development and integration of systems in support of the NAS and to identify high level NAS requirements which are then defined in lower level specification and design documents. The NAS Architecture represents the proposed implementation of the requirements which are consistent with policy and operations guidance documents to include the: The Architecture also provides the framework for the work being performed by the Joint Planning and Development Office (JPDO), which is currently developing a national plan through the year 2025.The resulting requirements are presented in this document as a management tool to facilitate modernization and implementation of the NAS Architecture and to provide a forum for extensive coordination and validation of associated requirements.

1.2.1 Document Structure

Section 2 of this document gives an overview of the nine services and their corresponding capabilities. These services and capabilities form the high level structure for the organization of the requirements.Requirements for the Services and Capabilities are in Section 3. Section 3 also contains Enabling Service Requirements that supplement the services the NAS provides.Section 4 contains a Glossary of the terms that are used in the document. Section 5 lists all of the acronyms that are used in the document. Section 6 list the action verbs used in the requirements.

1.3 Mission

The mission of the FAA includes the central objective of providing for the safe and efficient use of the nation's airspace, while minimizing constraints on its use. The NAS requires direct services to meet the needs of all users, in order to support aircraft operations under varying conditions of weather, demand on the system, and emergency situations. Flight planning, aircraft separation, air defense, law enforcement, control, and monitoring capabilities are required along with surveillance, navigation, and communication capabilities supporting the oceanic, remote, en route, terminal, and aerodrome operations. Additionally, maintenance support and system effectiveness requirements are imposed.

2 OVERVIEW

Delay (Latency) Requirement

- "The NAS shall assure one-way air-to-ground voice transmissions do not produce delays <u>that adversely impact</u> aeronautical operations or services."
  - Previous versions specifically stated "within 250 milliseconds of keying the specialist's microphone"
  - For LOS architectures, might be achievable
  - For BLOS, travel time, alone, approaches 250 milliseconds
- Need Modeling & Simulation to truly substantiate a performance requirement

Delay Requirement (cont.)

- M&S efforts need to address the following:
  1. Effects of UAS-Induced Latencies on Air Traffic Controllers
     - Characterize what the maximum amount of delay is that a controller can tolerate
     - Determine whether a controller can maintain the same level of safety when dealing with responses that have a range of latencies
  2. Effects of UAS-Induced Latencies on Pilot Command Functions
     - Characterize how fast a pilot needs acknowledgement of a command before the pilot sends another command

Availability Requirements

- "The NAS shall provide service availability not less than that provided by existing capabilities."

Critical Services	0.99999
Essential Services	0.999
Routine Services	0.99

- "The NAS shall assure the frequency of occurrence goal for any loss of service shall not exceed one per week."
- "The NAS shall strive to restore critical system service to users/specialists within 6 seconds of failure"

Availability Requirements (cont.)

- Requirements are written from a “NAS-service” perspective
- Unsure of how manned aviation meets these requirements
- Nonetheless, a UAS control service may be deemed critical and may need to meet these requirements
- Once again, Modeling & Simulation is necessary to determine if the requirements are achievable
  - Different architectures might offer solutions
  - Dual and possibly-triple redundant systems might be necessary

The Spectrum Challenge

- Currently, UAS are operating at many different frequencies for Control & Communications
- FAA has requested that these links operate in aviation "protected" spectrum
  - Aeronautical Mobile – Route – Service AM(R)S
  - Aeronautical Mobile Satellite – Route – Service AMS(R)S
- Very little aviation spectrum is available and no spectrum is currently assigned specifically for UAS
- Need to address the following questions:
  1. What spectrum options are available?
  2. How much spectrum do we need?
  3. How does the UAS community begin requesting their needs?

What spectrum options are available?

- Spectrum allocated to current aeronautical safety services
  - E.g. 960-1215 MHz Aeronautical Radio Navigation Band
- Spectrum allocated for use by DoD
  - E.g. 1435-1525MHz Mobile Aeronautical Telemetry Band
- Spectrum that can be reallocated for use by UA
  - E.g. Assign some Inmarsat or Iridium L-Band Satellite channels to UAS
- Spectrum that uses RF waveforms that are more immune to interference
  - E.g. Spread spectrum in the 2.4GHz Band.

How much spectrum do we need?

- Very difficult to answer
  - Sense & avoid requirements are unknown
  - Varies by class of UAS and level of autonomy
  - Many UAS use proprietary C&C systems

- This issue is being addressed through NASA-funded work being performed by ITT

How does the UAS community begin requesting their needs?

- Influence World Radiocommunications Conferences (WRC)
  - WRC-07 is upcoming and Agenda Item 1.6 proposes adding AM(R)S as an additional service for the 960 – 1024 MHz range
  - WRC-10/11 may include a UAS-specific agenda item
- Gain advocacy from the Department of Commerce
  - Office of Aerospace's purpose is to promote growth in the marketplace
  - However, strong business cases will need to be presented

The Security Challenge

- What security mechanisms will be used?
  - How will security issues be assessed?
    - Decide on a process to evaluate security
    - Identify and develop mitigations against threats
- How much security is appropriate?
  - How will the level of security be agreed?

The Security Challenge

- Decide on a process to evaluate security
  - Based on National Institute of Science and Technology (NIST) Common Criteria and Federal Information Processing Standards Pubs199 and 200
    - Develop threat descriptions
    - Perform likelihood and severity analysis for each threat
    - Identify and analyze mitigations
    - Calculate probability of occurrence
  - Security has similarities/differences to safety
    - Safety and security incidents may have identical outcomes but security relates to malevolent intent

The Security Challenge

- Develop threat descriptions
  - Threats exist to both the wired and wireless aspects of the UAS Control and Communications system
- FIPS Publication 199 definitions
  - **Confidentiality Threats** – Unauthorized disclosure
    - Eavesdropping
  - **Integrity Threats** – Unauthorized modification
    - Spoofing
  - **Availability Threats** – Disruption of access
    - Jamming

The Security Challenge

- Perform Likelihood analysis for each threat

  Frequent – Probability $>1x10^{-3}$ per hr.

  Probable – Probability $<1x10^{-3}$ per hr. but $>1x10^{-5}$ per hr.

  Remote – Probability $<1x10^{-5}$ per hr. but $>1x10^{-7}$ per hr.

  Extremely Remote – Probability $<1x10^{-7}$ per hr. but $>1x10^{-9}$ per hr.

  Extremely Improbable – Probability $<1x10^{-9}$ per hr.

- Perform Severity analysis for each threat

  None – No or negligible security impact

  Low – Limited security impact

  Medium – Serious security impact

  High – Severe – Severe security impact

  High – Catastrophic – Catastrophic security impact

The security challenge

- Identify and develop mitigations against threats
  - Confidentiality Threats
    - Message Encryption by Public Key methods
  - Integrity Threats
    - Authentication and Non-repudiation
  - Availability Threats
    - Spreading of signals over time and frequency

Conclusion

- Need for standards related to UAS Control & Communications Systems to not only identify requirements but address major challenges as well.
  - RTCA SC-203: Control & Comm. (WG#2)
  - ASTM F-38.01: Airworthiness
  - SAE: JAUS Working Group
- Leadership among UAS operators and manufacturers to address difficult challenges

QUESTIONS???

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