Unmanned Aircraft System (UAS) Voice Communications Architecture

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Outline

Background

• Architecture Alternatives
• UAS Gateway Functional Requirements
• Summary
Motivation

- Current DoD UAS operate under Certificate of Authorization (COA), which is not scalable for future UAS operations
- Commercial small UAS operate in class G and is not controlled by Air Traffic Control
- Possible drivers for UAS operations into NAS are integrated cargo carriers
  - FedEx
  - UPS
  - Amazon

<table>
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<tr>
<th></th>
<th>FedEx</th>
<th>UPS</th>
<th>Amazon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Airplanes</td>
<td>660</td>
<td>237 (500 with charters)</td>
<td>20 (+)</td>
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<td>Main Hub</td>
<td>Memphis, Tennessee</td>
<td>Louisville, Kentucky</td>
<td>Wilmington, Ohio</td>
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<tr>
<td>Number of flights into Main hub</td>
<td>150-160 aircraft nightly (2007)</td>
<td>100 aircraft nightly (2007)</td>
<td>TBD</td>
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<td>Regional Hubs</td>
<td>5</td>
<td>6</td>
<td>TBD</td>
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<tr>
<td>Airports Served</td>
<td>375</td>
<td>382</td>
<td>TBD</td>
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<tr>
<td>Packages Delivered Daily</td>
<td>4 million</td>
<td>16 million</td>
<td>3.5 million (shipped)</td>
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</table>

FedEx and UPS data from 2007
Current NAS Communication

Current NVS systems leverage VoIP technologies over FAA network

NVS = NAS Voice System
VoIP = Voice over Internet Protocol (IP)
Current NAS and UAS Communication

Current NVS systems leverage VoIP technologies over FAA network

Potential for long delay or lost communication with satellite links

NVS = NAS Voice System
VoIP = Voice over Internet Protocol (IP)
Future UAS Voice Communication

UAS pilot voice communication appears the same as a manned pilot to ATC
UAS Communication Challenges

Communications which must be supported: 1. ATC – Pilot, 2. Pilot – Pilot

UAS pilot may be remote from aircraft and ATC, placing challenges on communications
UAS Communication Challenges Continued

• Security
  – UAS pilot will most likely sit outside FAA network
  – Need a security gateway to validate UAS pilot voice traffic into FAA network

• Operation
  – UAS pilot appears the same as manned aircraft pilot to the ATC operator

• Voice communication end to end latency

• Cost

An integrated voice communication architecture is needed
Outline

- Background

  Architecture Alternatives
  - UAS Gateway Functional Requirements
  - Summary
NAS Voice System (NVS) Overview

FAA is deploying next generation VoIP system
Connect UAS Pilot to AVN using legacy analog line

**ADVANTAGES**
- Easy deployment

**DISADVANTAGES**
- Place burden on air traffic controller
- Once G-G is down, UAS pilot cannot hear other pilots

Considered not a viable option by NVS
UAS NAS Architecture
Option 2 — UAS Gateway Via A/G

FTI: FAA Telecommunications Infrastructure
AVN: ATC Voice Node
RRN: Remote Radio Node
G/G: Ground to Ground
A/G: Air to Ground

Connect UAS Pilot to AVN with FTI security gateway and UAS gateway as entry point

ADVANTAGES

- Networked VoIP communications
- Direct mapping to radios

DISADVANTAGES

- FTI security gateway latency
- UAS gateway design
- May need real time knowledge of RRN
UAS NAS Architecture
Option 3 — UAS Gateway Via G/G

Connect UAS Pilot to AVN with FTI security gateway and UAS gateway as entry point

ADVANTAGES

• Networked VoIP communications

DISADVANTAGES

• FTI security gateway latency
• AVN may need to be modified to facilitate UAS operations

FTI: FAA Telecommunications Infrastructure
AVN: ATC Voice Node
RRN: Remote Radio Node
G/G: Ground to Ground
A/G: Air to Ground
UAS NAS Architecture
Option 4 — UAS Gateway over FTI

FTI: FAA Telecommunications Infrastructure
AVN: ATC Voice Node
RRN: Remote Radio Node
G/G: Ground to Ground
A/G: Air to Ground

UAS Pilots will be part of FTI and there is no need for FTI security gateway

ADVANTAGES

• Eliminate security gateway for latency

DISADVANTAGES

• Not realistic to allow for all UAS pilots to be part of FTI network
## UAS NAS Architecture Options

<table>
<thead>
<tr>
<th>Design Goals</th>
<th>Legacy Analog</th>
<th>UAS A/G Gateway</th>
<th>UAS G/G Gateway</th>
<th>UAS Gateway over FTI</th>
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<tr>
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<td>X</td>
<td>~</td>
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</table>

Need a UAS gateway design for the ground-to-ground communications architecture
Outline

• Background
• Architecture Alternatives
  UAS Gateway Functional Requirements
• Summary
UAS Gateway Functional Requirements

UAS Pilot to NVS Connection Requirements

UAS Gateway Functional Requirements

UAS to NVS Deployment Requirements

How do UAS Pilots connect to NVS?

What are UAS Gateway functions?

How do UAS Gateways connect to NVS?
Option A — UAS Gateway Deployment anywhere – one or multiple gateways

**ADVANTAGES**

- Fewer UAS gateway needed

**DISADVANTAGES**

- Need global information down to each individual frequency within the airspace
- Need global updates with changes
UAS to NVS Deployment Options

Option B — UAS Gateway Deployment 1 to 1 to AVNs

ADVANTAGES

- Detailed frequency mapping is local to AVN
- SIP session between UAS gateway and UAS gateway to AVN are static, which will reduce latency

DISADVANTAGES

- Large number of UAS gateway deployment
**Option C — UAS Gateways**
Deployed 1-to-1 to the AVNs with one or more UAS Gateways serving as access points

**ADVANTAGES**
- Access gateway can be combined with security gateway functions
- Detailed frequency mapping is local to AVN
- Only access gateway needs global knowledge of AVN

**DISADVANTAGES**
- Large number of UAS gateway deployment
An Example

Seamless communication between ATC and UAS Pilot

Route to AVN at Chicago based on frequency & location of UAS

Route to AVN at Atlanta based on frequency & location of UAS

120.55 35.08°/106.61°
124.65 35.15°/90.05°
Outline

• Problem Statement
• Architecture Alternatives
• UAS Gateway Functional Requirements

Summary
Summary

• An integrated UAS communication architecture is needed to support UAS operation in NAS

• Four high level architecture alternatives were considered and pros and cons of each alternative were discussed

• UAS gateway architecture was recommended and its associated functionality requirements were discussed

• Opportunity for further risk reduction:
  – Perform proof-of-concept via modeling and simulation of the recommended architecture