Transforming the NextGen Test Environment: Integrating Fused ADS-B Surveillance Data, Phase I Seedling Effort

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Outline

• Background
• Innovation
• Technical Approach
• Results of Seedling Phase I Effort
• Impact
• Distribution/Dissemination
• Next Steps – Phase II Proposal
• Concluding Remarks
Phase I Background

• NASA Air Traffic Management (ATM) research has historically focused on Instrument Flight Rules (IFR) flights – those under ATC control
• NASA now addressing integration of Unmanned Aircraft Systems (UAS) into National Airspace System (NAS)
• UAS may operate in same airspace as Visual Flight Rules (VFR), general aviation flights – those not under ATC control
• UAS operator situational awareness enhanced by display of position of all flights in vicinity, including VFR
• Inclusion of VFR flights also increases fidelity and credibility of scenarios used for UAS-NAS R&D
• Access to VFR flight data was minimal across NASA
UAS-NAS Integration
The Innovation

- Enable simulation and flight testing of UAS-NAS integration concepts with accurate representation of all traffic in vicinity
- Provide high-fidelity NASA dataset of US air traffic:
  - Includes all traffic, VFR and IFR, for entire NAS
  - Presents best available accuracy and high update rate for each flight track
- Set stage for Phase II two-way data sharing between UAS and NAS:
  - Enable real-time NAS surveillance data availability to UAS operators and NASA research environment
  - Ability to insert real-time positional information for UAS of all sizes and equipage into NAS
Technical Approach

• Partner with Exelis Corp. to obtain NextGen fused data product and graphical application
• Process and insert data into Oracle data warehouse
• Assess data quality for consistency, availability, and accuracy
• Cleanse data using wide array of constraints and rules
• Provide web interface enabling data download in multiple formats
• Create UAS simulation scenarios from downloaded data
Exelis NextGen Fused Data

- Fuses many sources, from surveillance radars to GPS-based ADS-B output
- Correlates track data over time for gate-to-gate records of individual flights
- Chooses best available source at each track update, for optimum accuracy
- Less than 1 second latency to client delivery
NextGen Data Content
Exelis Data Processing

Exelis NextGen Service

VPN over Internet

NASA Ames Client

XML Documents

Data Warehouse (Oracle DB)

Data Extraction Processes

HLA Output

KML Output

Text, CSV, ...

RESTful Services

- HLA Output
- KML Output
- Text, CSV, ...

- VPN over Internet
- NASA Ames Client
- XML Documents
- Data Warehouse (Oracle DB)
- Data Extraction Processes
- RESTful Services
Data Quality Analysis

• 42 continuous days of NextGen data collected March/April 2013
  – Nationwide feed of all airborne flights
  – Surface data for Charlotte and Phoenix airports
• Data stream provides flight information and track messages, correlated with each other
• Extensive processing using domain-based rules identifies data anomalies
Data Quality Issues

• Incorrectly correlated flights
  – Unexpected events during flight operation
    • Changing tail number, aircraft type, or Mode S code
    • Missing call-sign

• Mismatched FAA flight plan and track data for multi-leg flights
  – Future flight plan confused with current one
  – Especially true for airlines that leave transponders on while flying multiple legs
Data Processing Results

<table>
<thead>
<tr>
<th>Data Statistics</th>
<th>Number of Flights</th>
<th>Track Data Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw data (42 days)</td>
<td>7.7 million</td>
<td>2.7 billion</td>
</tr>
<tr>
<td>Usable data</td>
<td>6.2 million</td>
<td>2.5 billion</td>
</tr>
<tr>
<td>% Usable data</td>
<td>80%</td>
<td>94%</td>
</tr>
</tbody>
</table>

- NASA’s detailed analysis of data quality resulted in improvements to NextGen product
  - More complete data set now available to commercial customers and researchers
  - Future data collection periods will have higher percentage of usable data
Other Flight Statistics

<table>
<thead>
<tr>
<th>Flight Statistics</th>
<th>Percentage of Flights</th>
<th>Percentage of Tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFR Flights</td>
<td>68%</td>
<td>25%</td>
</tr>
<tr>
<td>ADS-B Equipped</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>IFR and ADS-B Equipped</td>
<td>16%</td>
<td></td>
</tr>
</tbody>
</table>

- Results provide visibility into mix of aircraft operations and equipage in NAS
- ADS-B expected to increase significantly through 2020
Data Warehouse Interface
Visualization in Google Earth
Realized Impact

• Integration of VFR traffic enhanced quality of UAS-NAS simulation scenarios
• NASA data analysis and feedback facilitated enhancements to Exelis NextGen data delivered to commercial users and researchers
• GPS-sourced track data enabled study of impact of better state accuracy on ATM automation
• Data warehouse with enhanced data set available to NASA researchers who require traffic information for any number of local or national air traffic analyses
Distribution/Dissemination

• NASA and its ATM/UAS partners have access to NextGen data in Oracle data warehouse.
• NASA Technical Memorandum in progress regarding Phase I efforts.
• Conference papers planned for Phase II, if selected.
Phase II Transition

• Phase I Complete
  – More realistic NAS representation now available to NASA ATM and UAS researchers
  – Filled a critical gap in NAS research data set

• Phase II Objective: Enable two-way data sharing between a UAS ground control station and NAS
  – Real-time NAS surveillance data available to UAS operators and NASA research environment
  – Insertion of real-time positional information for UAS of all sizes and equipage into NAS

**IMPACT:** NASA, in collaboration with industry, will create a path to further enable safe and effective integration of UAS into NAS through two-way data sharing
Phase II Concept

NASA Aeronautics Research Institute

Large UAV

Line-of-sight position data

All traffic sent to ground stations

Internet

ADS-B out

Exelis NextGen System

Small UAV

ADS-B out

All traffic sent to ground stations

Internet

Exelis NextGen System
Phase II Enabling Technology

- Exelis MobileVue App
  - Internet-based delivery of NAS data
  - Traffic awareness on mobile devices using cellular bandwidths

- Potential traffic situation display for small UAS operations
Phase II Architecture

NASA Aeronautics Research Institute

Participating UAS
- ADS-B In
- TIS-B ADS-R
- UAS State Data
- UAS Flight Plan

Exelis NextGen Network
- ADS-B
- RADAR
- UAS State Data
- NextGen State Data

Non-Participating UAS
- UAS Flight Plan
- State Data
- NextGen State Data

UAS Flight Plan
State Data
- Simulated
- NextGen

High-Level Architecture (HLA) Communications Framework

Core LVC Architecture

LVC Participants & Displays

DTE Gateway

DTE GW Toolbox

MACS Traffic Generator

ADRS

MACS Displays

TIS-B

ADS-R

ADS-B Out

UAS State Data

NextGen State Data

Flight Plan
Sim State Data
Concluding Remarks

• Phase I Seedling Fund effort resulted in two new capabilities for NASA:
  – NAS-wide data set representing all traffic now available to NASA ATM and UAS researchers
  – Filled critical gap in NAS research data set and provided ability to create more realistic simulation scenarios

• Phase II promises to further enable safe and effective integration of UAS into NAS through two-way data sharing
  – Ability for UAS without transponders to see and be seen by other aircraft