Air Traffic Management-eXploration Testbed for Urban Air Mobility Research and Development

Kee Palopo
Gano Chatterji
James Murphy
Cornelius O’Connor
Alan Lee
Banavar Sridhar

June 28, 2018
Testbed Vision

• Testbed is a distributed air traffic simulation capability to **accelerate** the introduction of technologies in the National Airspace System.

• Its core purpose is to enable **realistic simulations** of proposed air traffic concepts with real systems and data.

• It enables our ATM **community**, consisting of government, industry and academia, to **share** and **leverage** each other’s data and tools.
Urban Air Mobility
Outline

• Testbed Goal
• Testbed Features
• Architecture Design
• Progress
• What’s Next?
• Take Away
Testbed Goal

• Accelerate National Airspace System Transformation
  – Simulation
  – What-if Analysis

• Create Best Design (NRA 2014-2015)
  – Architecture Design
  – Cost and Benefit Assessment

• Overcome Challenges
  – Data Sharing
  – Scenario Generation
Testbed Features

- Community Pooled Resources (e.g., Data)
- Defined Workflow
  - Automated Scenario Generation
  - Simulation Asset Configuration
  - Simulation Execution
- Defined Interfaces
- Standardized System and Data Connectivity
Architecture Design

Researchers

Developers

Vendors

Cloud Service Providers

Application Layer

Operator Center Functions

Other ATM Functions

Framework Layer

Communication Middleware

Platform Layer

Network Interconnect

Infrastructure Layer

Application Aware

Application Agnostic

Researchers

Developers

Vendors

Cloud Service Providers
Architecture Design

Researchers

Application Layer

Developers

Operator Center Functions
Other ATM Functions

Framework Layer

Application Aware

Vendors

Communication Middleware

Platform Layer

Application Agnostic

Cloud Service Providers

Network Interconnect

Infrastructure Layer
Collaboration

• NASA Provides
  – Web Access for Simulation Setup
  – Adapter Example
  – ATM simulators & systems
  – ATM Data: e.g., System Wide Information Management
  – Application Programming Interface

• Required for Partnering with NASA
  – Space Act Agreement
  – Security Plan
  – Interconnection Security Agreement
Partner Provides

Application and Framework

– Application/Model that Is Shareable/Reusable
– How to Apply/Use your Model in Testbed
– Data if Not Available in Testbed (e.g., adaptation data needed by the model)
– Domain Expertise (e.g., to determine appropriateness or correctness)
– Test or Conduct the Simulation
Progress
Concept of Operations
Simulation Design User Interface
Library User Interface
What’s Next?
Testbed Architecture

UAS Traffic Management Lab

Other Labs

Visualization

Communication Middleware

Support Services

Tools

Data

Conflict Detection

ATM Functional Services

UAS Lab

Cloud

Component
• Testbed is a community resource for accelerating ATM concept and technology development where **partners** can collaborate and leverage each other’s data and tools

• Targeted to be transitioned to community in 2020
References

1. Shadow Mode Assessment using Realistic Technologies for the National Airspace System (SMART NAS) Test Bed Development, AIAA Aviation, Dallas, TX, 22-26 June 2015


3. Automated Scenario Generation for Human-in-the-Loop Simulations, AIAA Aviation, Atlanta, GA, 25-29 June 2018
Questions?
kee.palopo@nasa.gov
Backup
Autonomous UAM as per Testbed

Assumptions:
1.) Connectivity to TestBed from N257
2.) Connectivity to TestBed form N262/N269
3.) Adapters run in cloud
4.) No TBFM functionality required
   If ATC conflicts are needed, add to CVSRF domain
Assumptions:
1.) Connectivity to TestBed from N257
2.) Connectivity to TestBed from N262
3.) Adapters run in cloud
4.) No TBFM functionality required
   If ATC conflicts are needed, add to CVSRF domain
Simulation Components

- DDS
- Live data
- Historical data
- Terrain data
- ATM Functions
  - X-Plane/eVTOL flight state,
  - Loss of separation,
  - Route structure & Geo fence, metrics
- Other Components
Example Testbed-Partner Architecture
Testbed Role

Trajectory Based Operation Concepts & Technologies

Current approach

Envisioned Testbed

Application benefits (and costs)

Time from concept to deployment and beyond
Testbed Data Tasks

**Essential for first cut**
- Commercial and GA traffic via SWIM feed.
- List of GA airports and their locations in the Bay Area.
- Population database.

**Important for realism**
- Cellular coverage database.
- Restricted locations database (SUA, power plants, stadiums, bridges etc.).
- Terrain elevation database.
Testbed Modeling Tasks

• Demand generation (number of flights, flight origin and destination).
• Flight planning (route, altitude, speed).
• Trajectory generation (position as a function of time).
• Conflict detection and resolution (AAC, dead-reckoning, actual conflict).
• Noise model (Noise Power Distance (NPD) curve for UAM vehicles)
• Noise model for background commercial and GA traffic (AEDT or simplified model)
Building an Application in Testbed

UAM

UAM
NPN Details
Testbed for Partners

Partner → NASA

Every piece of information helps

Services
MACS
DDS
SWIM
DB
Capacity HiTL Research Needs 1/2

• Application Layer for
  – GUIs, including traffic viewer, scenario generation, simulation design
  – Remote access

• Components in Framework Layer
  – Scenario, including route structure, adaptation, traffic levels (low, medium, high)
  – MACS
  – Autoresolver
  – UTM, UAS in the NAS, ATD (TBFM, STARSe)?
  – Path Planner
  – Other facilities and simulators
Capacity HiTL Research Needs 2/2

• Platform Layer
  – Access to data: e.g., VFR traffic and terrain
  – Record and Replay

• Infrastructure Layer
  – Local server vs. GovCloud (need stakeholder input)
  – ISA

V&V components that are managed by Testbed core team
ATM Test Bed

Test Bed

Legacy / Ext Sims

ARC DW

Lab Segment

DB

Model

MCE Segment

Model

DB

Simulation

Live Data
(e.g., weather, flight plans, airport arrival rates, system constraints, etc.)

Other

Airlines

Airports

ANSP

Operation

Operational System + Personnel
Structural View, Vertical Perspective

ATM Test Bed Architecture: Vertical Layers

Application Layer: Applications for Concept Alternatives, User Interfaces
Framework Layer: Component Services, Models, Parts Libraries, SNDEM
Platform Layer: Enterprise Service Bus, Data Engines
Infrastructure Layer: Hardware, Operating System, Storage, Network

Test Bed Hosting Environment

NASA Labs
FOC (Live, Simulated)
FAA Facilities (Live, Simulated)
The SMART-NAS Test Bed provides a standardized and unified simulation and test environment suitable for high-fidelity evaluations to overcome barriers to:

**NAS-wide Evaluations**: Permit evaluation of concepts spanning multiple NAS domains and having significant architectural changes

**Stakeholder Collaborations**: Permit frequent, large-scale, distributed collaborations with stakeholder assets

**End-to-End Testing**: Enable testing from concept development through operational testing with enterprise systems

**Live, Virtual and Constructive Operations**: Enable shadowing of live NAS operations with real NextGen systems

**Assessment Pace**: Automate simulation preparation and execution that is resource intensive, error-prone and limited by capabilities of individual facilities
Scenario Design
Notes

• Scenario generation, specific capability
• Ease of connection, limited to training plus some support building out infrastructure
• High fidelity of systems (connecting operational system surrogates; e.g., TBFM emulator/CTAS)
• Breadth of systems (connecting systems with NAS scope tools, even if low TRL, airport, tower, TRACON, Center, Sys Command Center, AOC, Geographical data and tools (Adaptation, Terrain, Population))
Urban Air Mobility

Ground Stations

Industry firewall

NASA firewall

Testbed

adapters
UAM Live Flight Test using UTM

Wall Display

Others

UTM

details @ next

Telemetry

Resolutions
Simulated flight data

adaptation
Scenario selection/config decision
Data mining toolbox
Other data
Other tools

AutoResolver
MACS
Tucan

Ability to ingest components and data

Testbed

Other tools

Data mining toolbox

Other data
Scenario Repository

### Traffic Scenario Generation

<table>
<thead>
<tr>
<th>Traffic Scenario Name</th>
<th>Status</th>
<th>Progress</th>
<th>Created Date</th>
<th>Updated Date</th>
<th>Actions</th>
</tr>
</thead>
</table>
Using AAC

Aircraft Pos, Route, Type

getPredictedTrajectories()

TgInitializationData

Translated trajectory

TrialPlanner
detectAndResolveConflicts()

AbstractManeuver

Route Changes to solve problems

See gov.nasa.test.AACTest
Operational Plan (OP): inter-connected volume of airspaces
Candidate Simulation Components

X-Plane/eVTOL flight state,
Loss of separation,
Route structure & Geo fence, metrics

PaxApp
FleetManager

DDS

Live data
Historical data
Terrain data

TBFM
ASTOR
MACS
AR
nCTOP

Path Planning
Scheduler
COMETTS
RTSM
FE³

Labs

nasa testbed
X-Plane/VTOL flight state,
Loss of separation,
Route structure & Geo fence,
metrics
Notional Time Steps

ecoD position ahead of SWIM counterpart

ecoD 64 second update rate

SWIM 12 second update rate

12:00:00  12:01:00  12:01:04
Merge Point at HVR
Increasing Diverse Operation

Ground Stations

Industry firewall

NASA firewall

Testbed

adapters
Application Programming Interface

Testbed

Application Programing Interface

UAM

IDO

IDM

eessD

Route Segment

Display Metrics (e.g., Noise, Emissions, Fuel)

Metrics

adapter
Testbed Hands-on Developer Meeting

- Testbed
- Hands-on Developer Meeting

Diagram:

- Tool
- Route Segment
- Metrics
- Your Org
- 0
- Display Metrics (e.g., Noise, Emissions, Fuel)
- Testbed
- adapter
Training Configuration

Partner 1 Facility
- Recovery
  - Application Server
  - TBD
  - advisory

Partner 2 Facility
- Application Server
  - TBD
  - TBD

Cloud

Communication Middleware
- SWIM historical flight schedule
- Partner Component
- TBD

Data
- Monte Carlo Runs; e.g., on GPU

NASA ATM-X Testbed

Partner Adapter