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

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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

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Cloud Service Providers
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

User

Web Browser

1

Web Server

2

Authentication

3

Authorization

4

Application Server

5

Simulations
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

ATC Lab

UAS Lab

Cloud

Component
Take Away

• 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?
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Backup
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 form N262
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If ATC conflicts are needed, add to CVSRF domain
Traffic Viewer
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
NPN Details
Testbed for Partners

Every piece of information helps

MACS DDS SWIM DB

Partner NASA
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
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

**ATM Test Bed Boundary**

**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

UTM

Details @ next

Wall Display

Others

Telemetry

Resolutions
Simulated flight data

Testbed

adaptation

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

AutoResolver

MACS

Tucan

Ability to ingest components and data

Other tools
Scenario Repository
Using AAC

Aircraft Pos, Route, Type

TgInitializationData

getPredictedTrajectories()

Translated trajectory

TrialPlanner
detectAndResolveConflicts()

Route Changes to solve problems

AbstractManeuver

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

Labs

Path Planning
Scheduler
COMETTS
RTSM
FE3
X-Plane/VTOL flight state,
Loss of separation,
Route structure & Geo fence,
metrics

2018-2020

Cloud
Path Planning
COMETTS
Scheduler
TGS
CSM

Live data
RTSM
TAAC
DAA
MACS
TBFM
FDA
ASTOR
AEDT
FE³
ATG

Historical data
Terrain data
Population
Etc.
Notional Time Steps

ecoD 64 second update rate
SWIM 12 second update rate

ecoD position ahead of SWIM counterpart

12:00:00 12:01:00 12:01:04

time
Merge Point at HVR
Increasing Diverse Operation

Ground Stations

Industry firewall

NASA firewall

Testbed

adapters
Application Programming Interface

- Tool
- Route Segment
- Metrics
- Testbed
- Display Metrics (e.g., Noise, Emissions, Fuel)
- adapter
Testbed Hands-on Developer Meeting

- **Your Org**
- **Testbedi**
- **Tool**

- **Display Metrics (e.g., Noise, Emissions, Fuel)**
- **Route Segment**
- **Metrics**

**adapter**
Training Configuration

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

Partner 2 Facility
- Application Server
  - TBD
  - TBD

Cloud

Communication Middleware

Data

SWIM historical flight schedule

Monte Carlo Runs; e.g., on GPU

TBD

Partner Component

Partner Adapter