UAS Integration in the NAS Project
Integrated Test and LVC Infrastructure

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LVC Connection

• Goal
  – Prototype LVC connection between UAS Test Sites and UAS Project Infrastructure for use in potential future DAA and other UAS research

• Purpose of this briefing: describe current and planned LVC usage
  – LVC Overview
  – Existing Connections
  – Planned Usage
LVC Conops

- Live: Real people operating real assets
- Virtual: Real people operating simulated assets
- Constructive: Simulated people operating simulated assets
- Distributed Environment: Brings simulation to the LVC assets increasing external partner options

Routine UAS Operations

- UAS transitioning Class E airspace to/from Class A, D, G airspace
- UAS equipped to detect and avoid traffic
  - IFR
  - ADS-B
  - Transponder
  - VFR
  - Cooperative
  - ADS-B
  - Transponder
  - Non-cooperative

Live Intruder
- ADS-B/TCAS II Equipped
- High speed

Virtual/Constructive Intruders
- ADS-B Out

Data Link
- C2
- Voice
- H&S
- Video
- Traffic

T-34C UAS Surrogate

Research GCS Displays of Proximal Traffic

ATC

Target Generation
High Level LVC Connectivity

Aircraft Simulator
ATC Emulator
UAS Test Site

T-34C (Surrogate) NASA Glenn
S-3B (Surrogate) NASA Glenn

Air Traffic Control
Vigilant Spirit
Background Traffic
B747 Simulator NASA Ames

Research GCS
Ikhana MQ-9
Ikhana Simulator NASA Armstrong

Internet (VPN)

NextGen R&D Research

MQ-9 MQ-9 GCS General Atomics

Live Surveillance Excelis

Air Traffic Control UAS Simulators
Background Traffic FAA Tech Center

MACS GCS Background Traffic Air Traffic Control NASA Langley (ATOL)
LVC Assets

• Live
  – Ikhana (NASA’s MQ-9)
  – T-34C (Surrogate UAS)
  – S-3B Viking (Surrogate UAS)
  – Vigilant Spirit Control Station

• Virtual
  – Ikhana Sim
  – B747 Flight Simulator
  – Vigilant Spirit Control Station
  – Multi-Aircraft Control System (MACS) ATC Emulator

• Constructive
  – MACS Pseudo Pilot
T-34C at NASA Glenn
S-3B Viking at NASA Glenn
Ikhana Simulator at NASA Armstrong
B747 Flight Simulator at NASA Ames
UAS Ground Control Station at NASA Armstrong

Lab Layout for Flight Test

Pilot Control Station Layout for Flight Test
ATC and Pseudo Pilots at NASA Ames and NASA Langley

Pseudo Pilot Control

Air Traffic Control
Multi-Aircraft Control System (MACS)

- Active/Ctrl AC List
- Pseudo Pilot Control
- Air Traffic Control
LVC Distributed Network

Internal NASA Network

External Network
Distributed Connectivity Demonstration

Initial test of distributed simulation capability among multiple participants

Early Equipment Integration and Checkout

ADS-B Integration on the Ikhana UAS

• Integrated a COTS (Garmin GDL-90) ADS-B onto a large UAS
  – Full ADS-B Out and In functionality
  – Unprecedented traffic situational awareness to UAS pilots

• Collected ADS-B “as installed” performance flight test data
  – Accuracy, uncertainty of position, velocity, and altitude reports
  – ADS-B Out (Mar 15/20), ADS-B In (May 8/11)

• Flight test results (Flight Test Series 1)
  – Verified ADS-B Out met FAA Advisory Circular AC 20-165 for ADS-B Out equipage
  – Valuable FAA Tech Center support with validated data analysis tools
  – Connected Dryden to LVC and Verified data exchange of live, virtual, and constructive traffic information between all participants
PT5 Experiment: High Level Architecture

- **VSCS (GCS)**
  - Intruders/Flt States
  - SS Alerts
  - SS Omni Bands
  - SS Stratway Bands
  - Ownership/Flt State
  - Traffic/Flt States
  - Trial Traj Intent

- **ATC Controller (MACS)**
  - Ownership/Flt State
  - Trial Traj Intent

- **Sim Manager (MACS)**
  - Ownership/Flt State
  - Traffic/Flt States

- **Pseudo Pilots (MACS)**
  - Ownership/Flt State
  - Traffic/Flt States

- **ADRS (ARC)**
  - Ownership/Flt State
  - Traffic/Flt States

- **LVC Gateway**
  - SaaProc/JADEM
  - DSRL/N243
  - Intruders/Flt States
  - SS Alerts
  - SS Omni Bands
  - SS Stratway Bands
  - Ownership/Flt State
  - Traffic/Flt States
  - Trial Traj Intent
  - Intruders/Flt States
  - SS Stratway Bands

- **ADRS (LaRC)**
  - Ownership/Flt State
  - Traffic/Flt States

- **Stratway**
  - Ownership/Flt State
  - Traffic/Flt States
  - Intruders/Flt States
  - SS Stratway Bands

**ATC & Pseudo Pilot Labs / N257**
FT3: Configuration 1A (Pairwise-Low Speed Ownship) – Ikhana

Live Ownership

- EDM DDR
- ADS-B
- TCAS II

Ikhana Data Link
- C2
- Voice
- Health & Status
- Video
- Intruders

Live Intruder(s)

AFTC GCS
- CPDS
- I/O Server
- VSCS
- Voice Comm
- ZEUS Display

AFRC LVC LAB
- SAA Proc
- JADEM
- Voice Comm System (DICES III)
- Trial Planning
- ADRS
- Intruders SS Alerts Omni Bands
- OS, Live Intruders
- ZEUS Display

LVC Gateway
- LVC Data Logger
- Intruders SS Stratway+ Bands, Alerts
- OS, Intruders SS Alerts Omni Bands Stratway+ Bands
- Trial Planning

AFRC SAF
- Video

NOTE: Voice Comm Details Are Presented on Separate Charts.
FT3: Configuration 1B (Pairwise-High Speed Ownship) – S-3B

Live Ownership

- **ADS-B**

CNPC Data Link
- C2
- Voice
- Health & Status
- Intruders

Live Intruder(s)

- **ADS-B** & TCAS II

CNPC Ground Station
- CNPC Radio
- Ground Station Computer

ADS-B Data
- ASR Data

AFTC Bldg. 3440

AFRC LVC LAB
- SAA Proc
- JADEM

AFRC RGCS LAB
- Voice Comm System (DICES III)
  - OS, Live Intruder(s)
  - Trial Planning
- CPDS
- ADRS
- Straylight+
- ZEUS Display

AFRC SAF
- Voice Comm System (DICES III)
  - Test: Director/Conductor Quick Look Display
  - Test: Director/Conductor Displays (ZEUS/TECCS)

Video

VPN Net

NOTE: Voice Comm Details Are Presented on Separate Charts.
FT3: Configuration – Surrogate UA

Live Ownship
- CNPC Data Link
  - C2
  - Voice
  - Health & Status
  - Intruders

Live Intruder(s)
- ADS-B Data
- ASR Data

Virtual Intruder(s)
- ADS-B Out
- Mode 3/10C
- Mode S

OS Voice Tunnel Server resides on VPN hosts at ARC and AFRIC

OS, Live Intruders, Sim Traffic, SS Alerts
LVC Connection Options

Features:

- Local UAS LVC connection to demonstrate connectivity
- Leverages existing middleware infrastructure (DDS)
- Supports integration of existing UAS technologies
- Option 1: External connection through UAS LVC infrastructure
- Option 2: External connection via DDS/HLA Bridge
Data Collection:

- LVC Gateway records all messages
- Can repeat LVC Gateways to collect data remotely
Data Connection:

- **Data Connection Agreement required**
  - Specifies machines and content of connection
  - Depends on connection design

- **Encrypted via VPN between UAS Test Site facility and NASA Ames SimLabs**
LVC Connectivity Decisions

**Points of Contact:**
- LVC Lead: Jim Murphy
- Connection: Neil Otto
- Technical Design: Srba Jovic

**Decisions:**
- **What will be connected to the LVC?**
  - Simulator, GCS, ATC, aircraft, sensors, ...
- **How will it/they be connected?**
  - Via LVC Gateway, existing middleware
- **What data will be collected?**
  - Any data sensitivity/proprietary data
- **Where will data be stored?**
  - At test site, at NASA, both

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**Diagram:**
- NASA Glenn
- NASA Ames
- NASA Armstrong
- FAA Tech Center
- UAS Test Site
- Ikhana
- MQ-9
- MQ-9 Surrogate
- T-34C Surrogate
- B747 Simulator
- Vigilant Spirit
- Background Traffic
- MACS GCS
- NextGen R&D Research
- UAS Simulators
- Air Traffic Control
- Background Traffic
- ATC Emulator
- Aircraft Simulator
- ATC Emulator
- UAS Test Site
- NASA Network