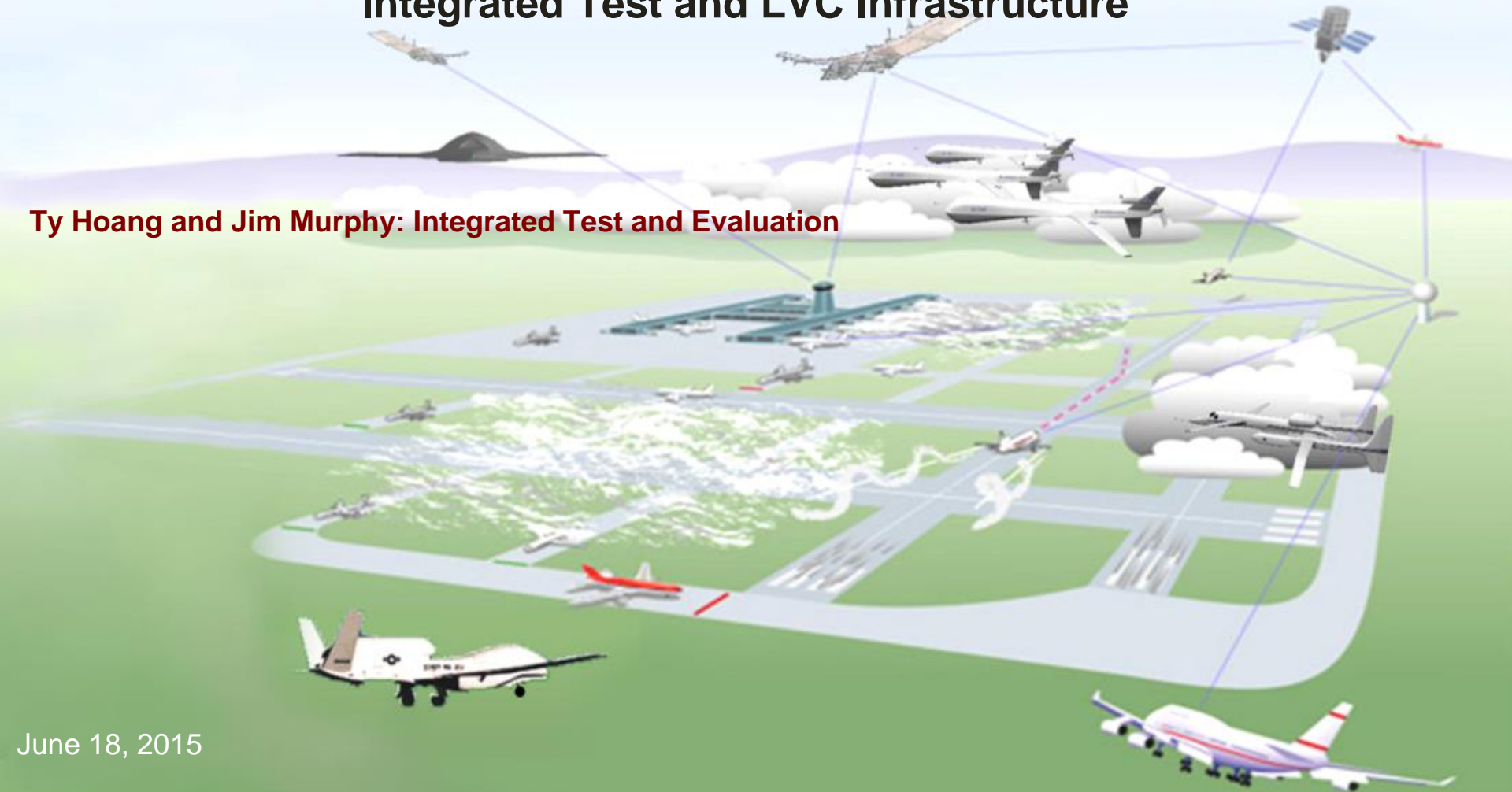




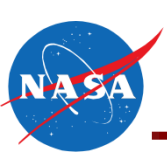
National Aeronautics and Space Administration

UAS Integration in the NAS Project Integrated Test and LVC Infrastructure

Ty Hoang and Jim Murphy: Integrated Test and Evaluation

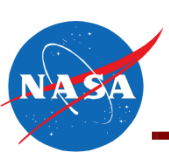


June 18, 2015



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

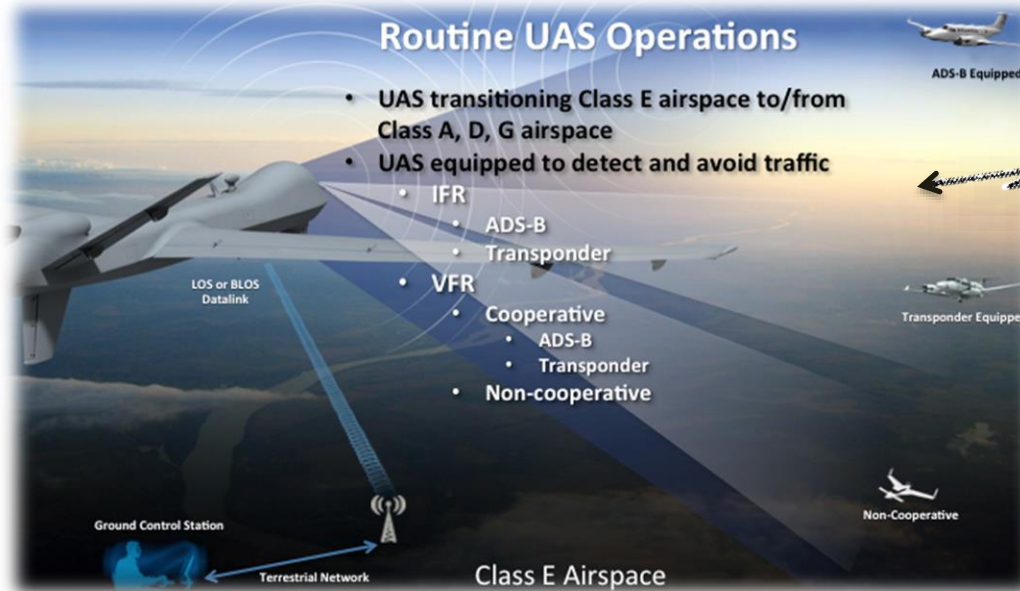
T-34C UAS Surrogate



CNPC Data Link

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

UAS Pilot



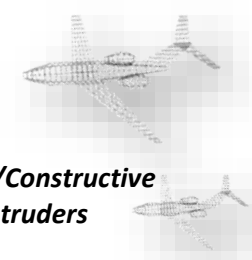
Live Intruder

- ADS-B/TCAS II Equipped
- High speed



ADS-B Out

Virtual/Constructive Intruders



Research GCS



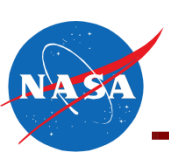
Displays of Proximal Traffic



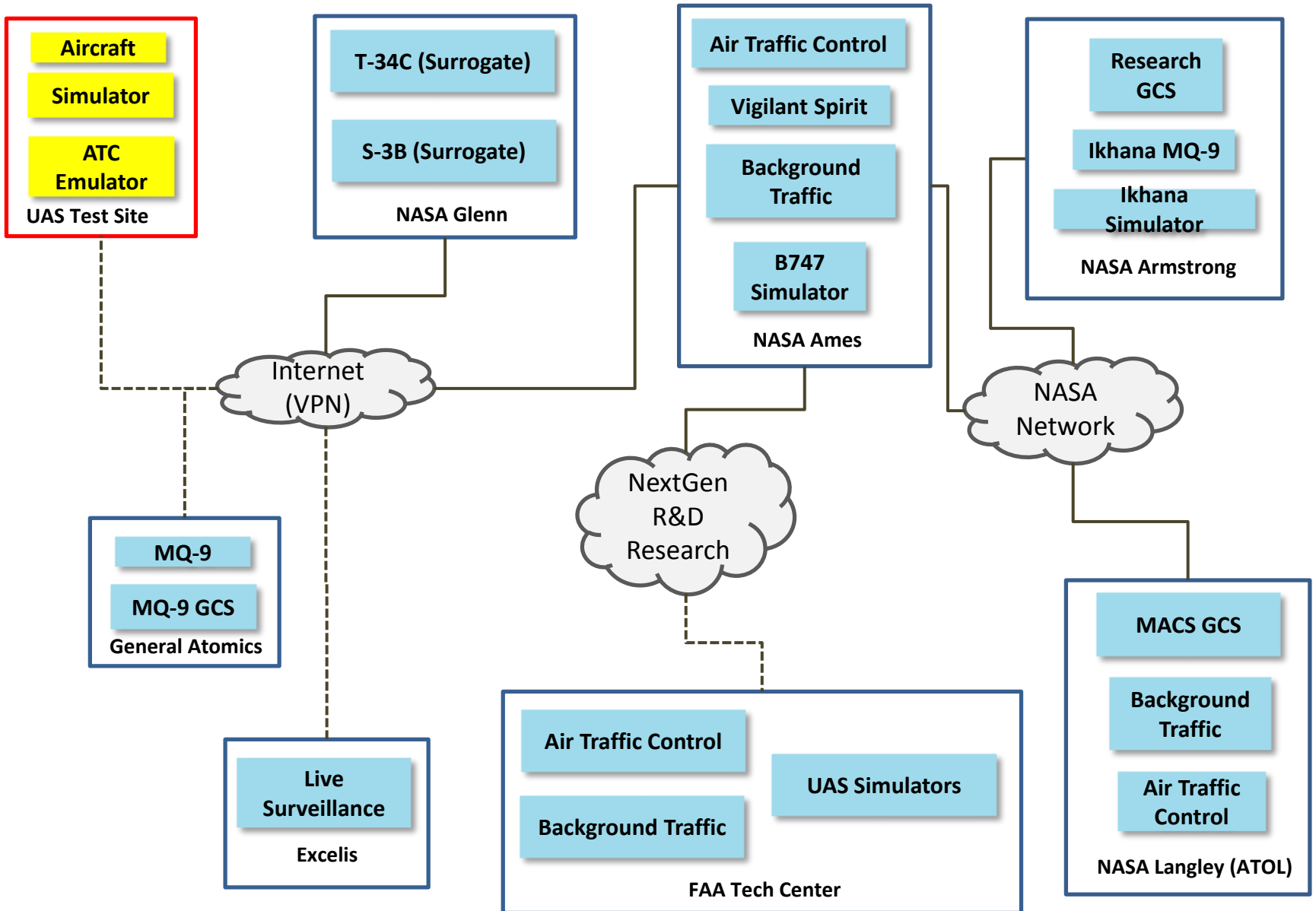
ATC

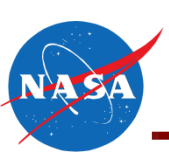


Target Generation



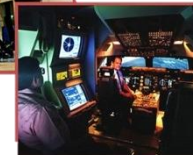
High Level LVC Connectivity

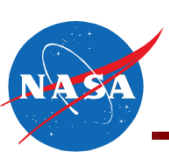




LVC Assets

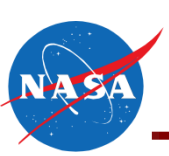
- Live
 - Ikhana (NASA's MQ-9)
 - T-34C (Surrogate UAS)
 - S-3B Viking (Surrogate UAS)
 - Vigilant Spirit Control Station
- Virtual
 - Ikhana Sim
 - B747 Flight Simulator
 - Vigilant Spirit Control Station
 - Multi-Aircraft Control System (MACS) ATC Emulator
- Constructive
 - MACS Pseudo Pilot





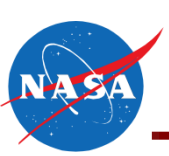
Ikhana MQ-9 Predator B at NASA Armstrong





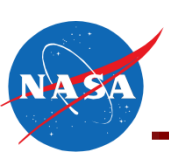
T-34C at NASA Glenn





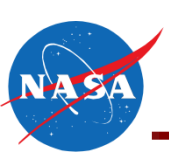
S-3B Viking at NASA Glenn





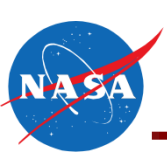
Ikhana Simulator at NASA Armstrong





B747 Flight Simulator at NASA Ames





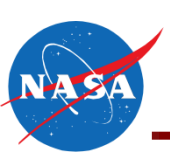
UAS Ground Control Station at NASA Armstrong

Lab Layout for Flight Test



Pilot Control Station Layout for Flight Test





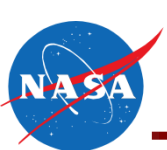
ATC and Pseudo Pilots at NASA Ames and NASA Langley



Pseudo Pilot Control



Air Traffic Control



Multi-Aircraft Control System (MACS)

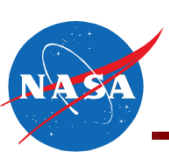
Active/Ctrl AC List

Pseudo Pilot Control

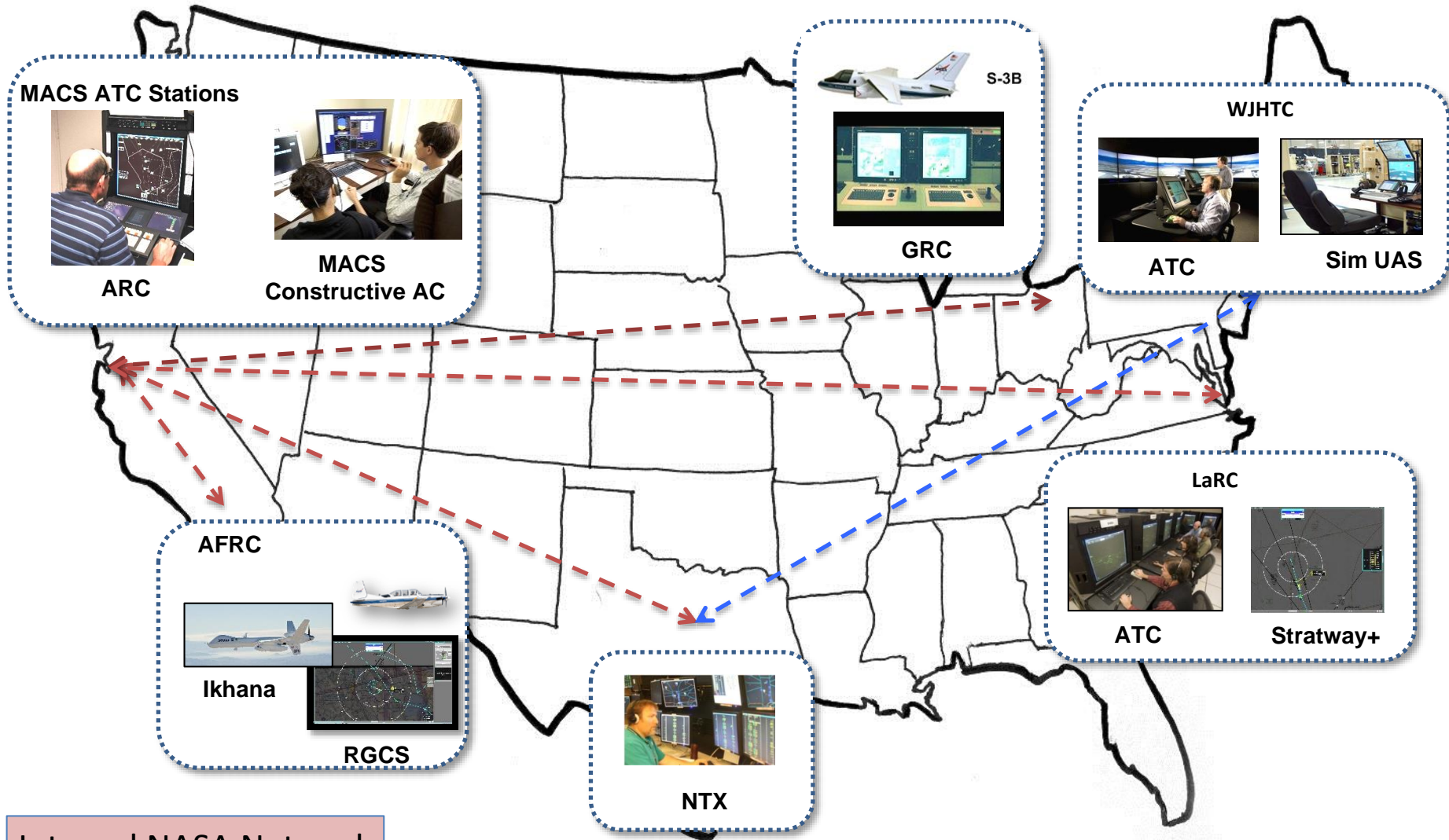
Air Traffic Control

The screenshot displays the Multi-Aircraft Control System (MACS) interface, which is divided into several functional areas:

- Active/Ctrl AC List:** Two side-by-side lists of aircraft. The left list is titled 'MACS ACTIVE IN AC' and the right is 'MACS CTRL IN AC'. Both lists show aircraft identifiers (e.g., AAL153, AAL1507, AAL1423) and their associated aircraft types (e.g., B738, A321).
- Pseudo Pilot Control:** A central panel for aircraft AAL1553. It displays flight parameters such as Mach (280), heading (227), altitude (16967), and position (X/Y=418.203 / 286.649). It also shows status indicators like 'Sp-Brakes 0', 'GEAR UP', 'FLAPS 0', and 'Holding'. At the bottom, there are control buttons for speed, heading, altitude, and vertical speed.
- Air Traffic Control:** A large radar display on the right side. It shows a top-down view of the aircraft's path and surrounding traffic. The display includes various control elements like 'RANGE', 'PLACE DATA', and 'OFF CTRL'. A 'Simulation' window at the bottom right shows the current time (22:10:58) and elapsed time (00:03:27).

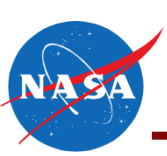


LVC Distributed Network



Internal NASA Network

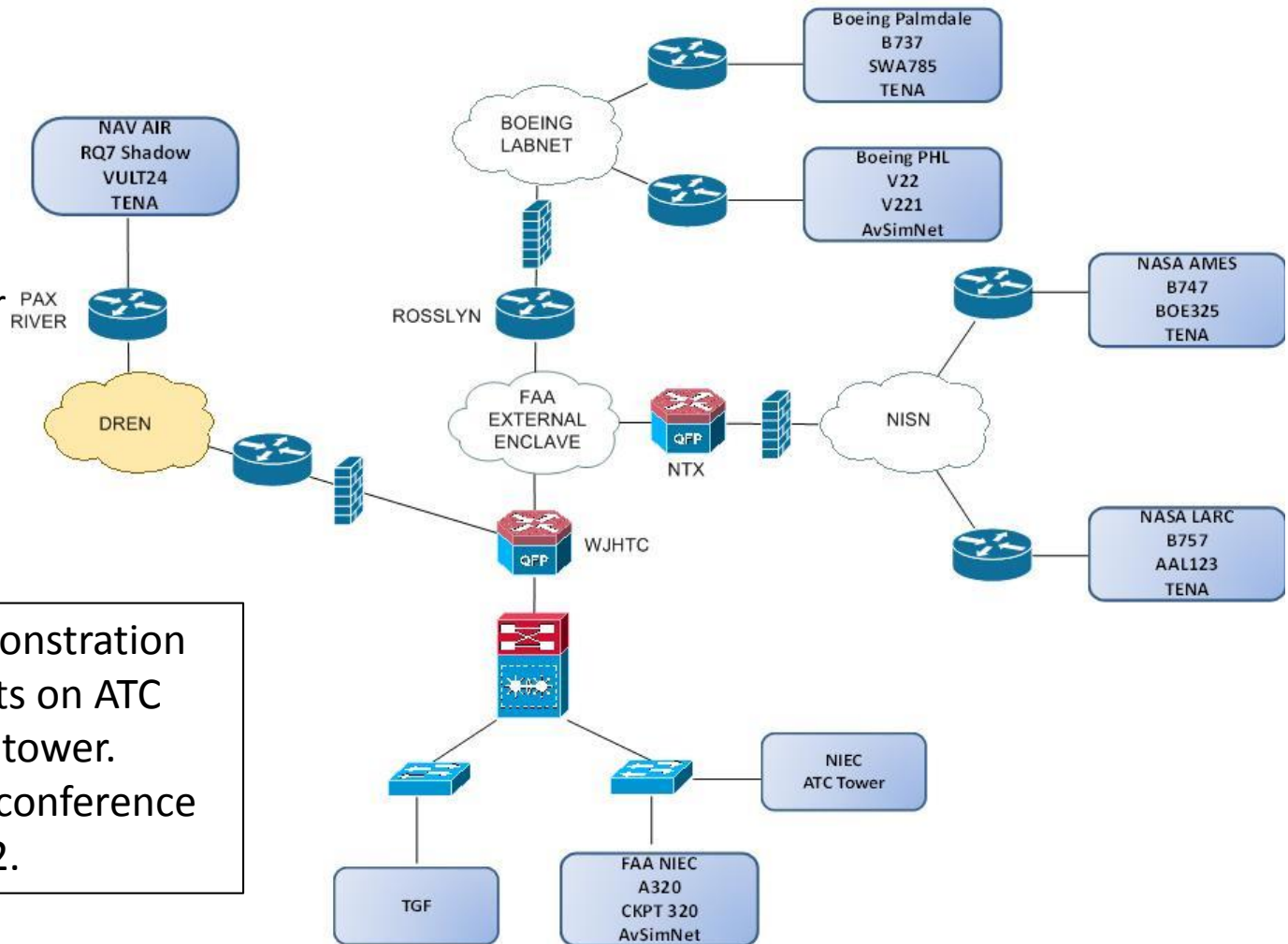
External Network



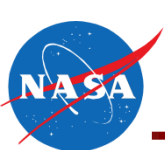
Distributed Connectivity Demonstration

Initial test of distributed simulation capability among multiple participants

NASA Ames
NASA Langley
DoD NavAir Pax River
Boeing Palmdale
Boeing Philadelphia
FAA Technical Center



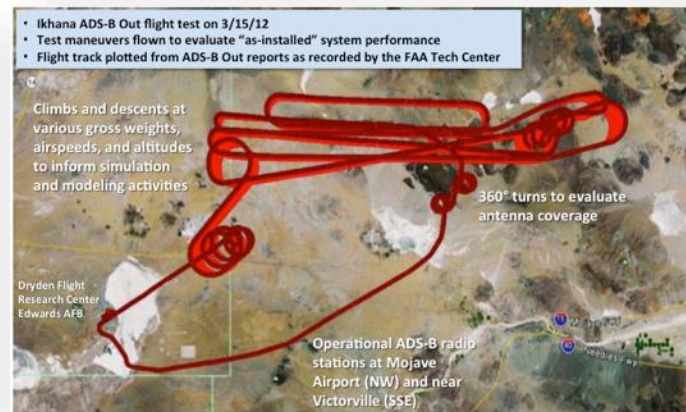
August 2012: Demonstration of simulated targets on ATC scopes and virtual tower. Presented at ITEA conference in September 2012.



Early Equipment Integration and Checkout

ADS-B Integration on the Ikhana UAS

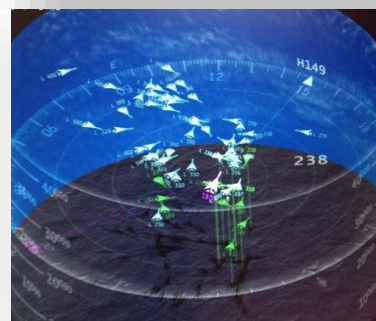
- Integrated a COTS (Garmin GDL-90) ADS-B onto a large UAS
 - Full ADS-B Out and In functionality
 - Unprecedented traffic situational awareness to UAS pilots
- Collected ADS-B “as installed” performance flight test data
 - Accuracy, uncertainty of position, velocity, and altitude reports
 - ADS-B Out (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**



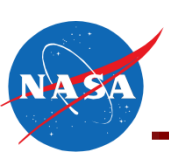
Ikhana flight path as tracked by the national ITT ADS-B Surveillance Network



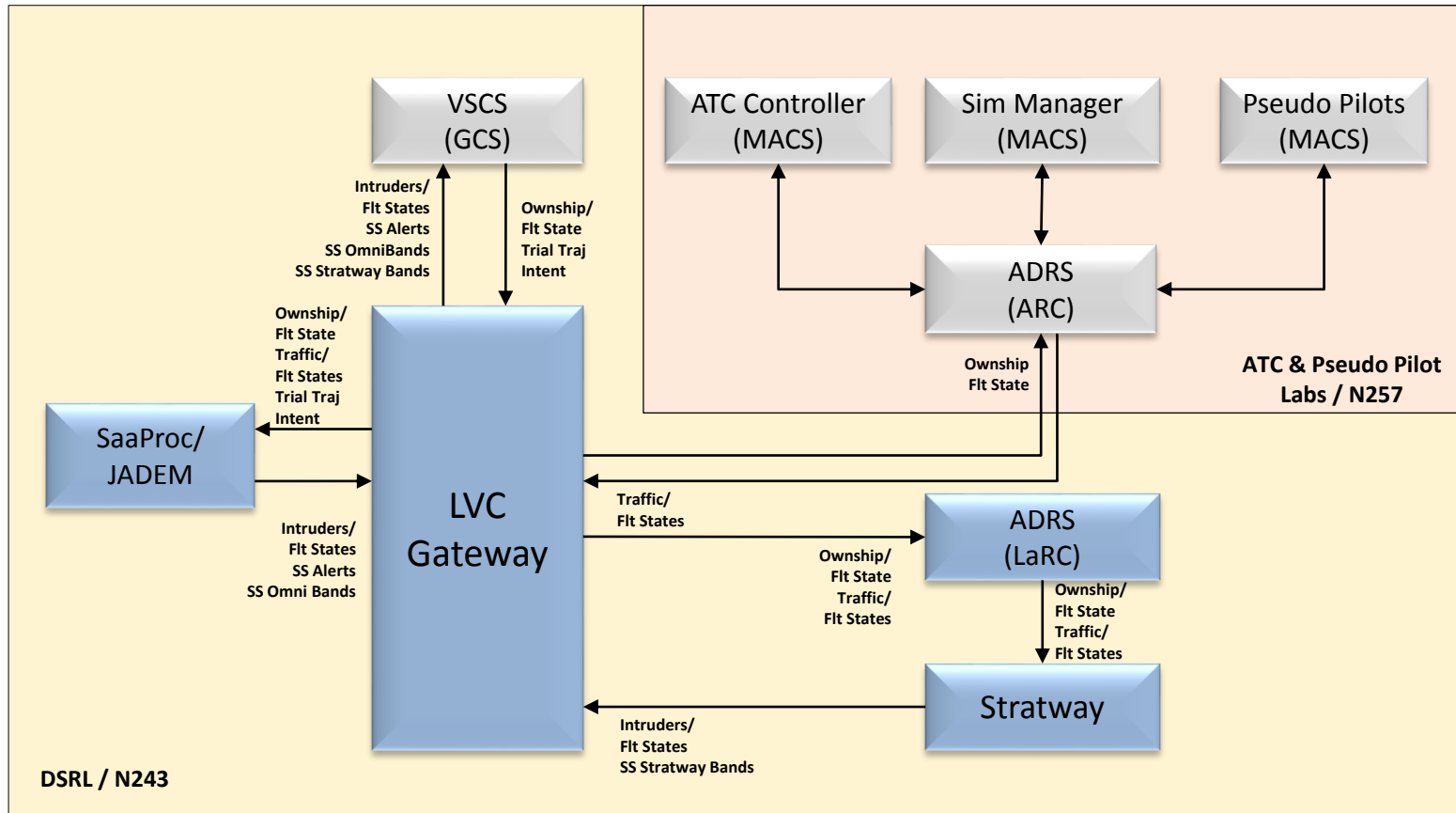
ADS-B Ground Tests on Ikhana UAS

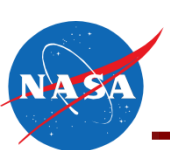


Live ADS-B and TIS-B data shown on virtual cockpit display

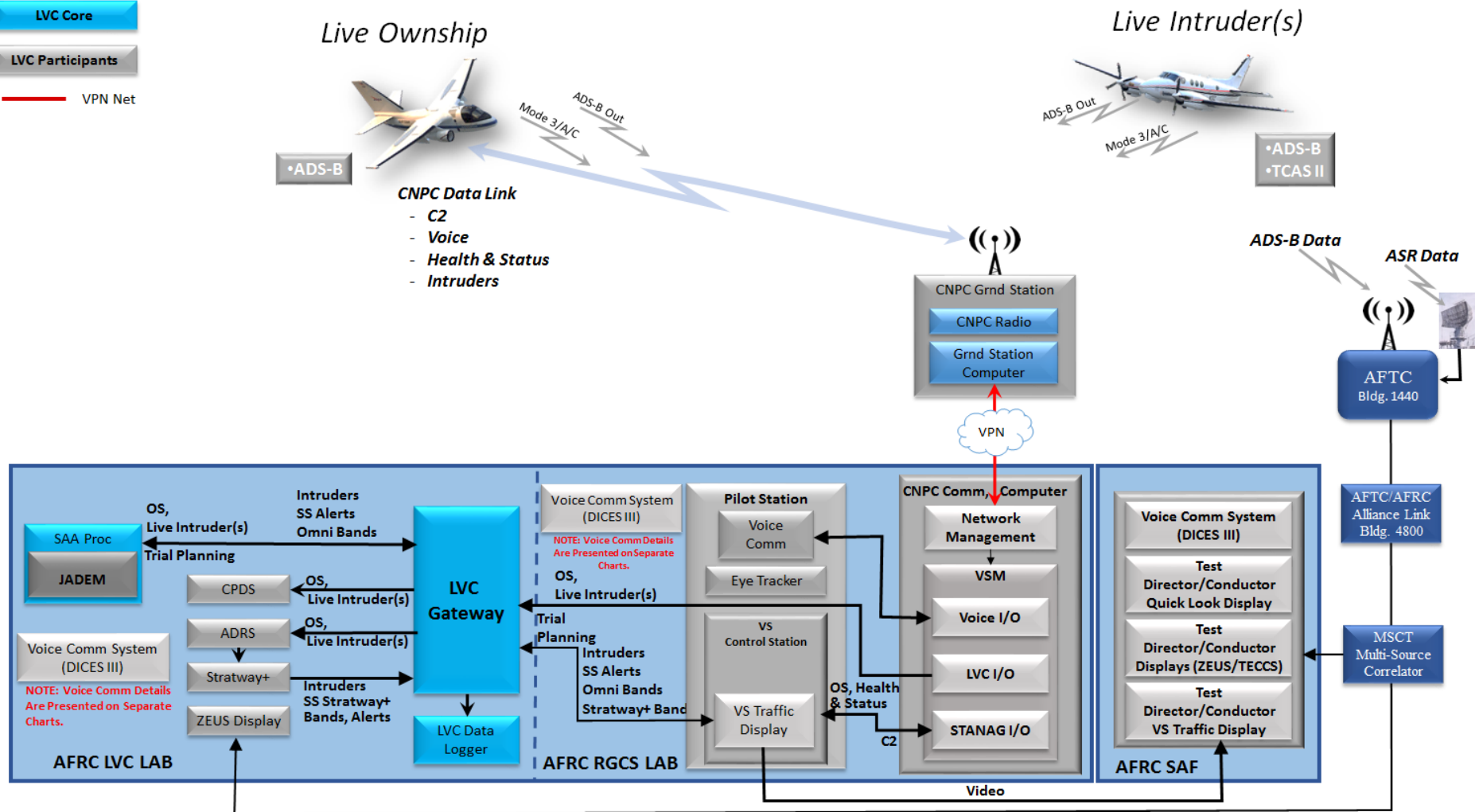
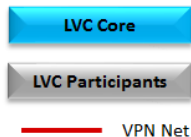


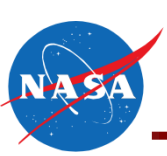
PT5 Experiment: High Level Architecture



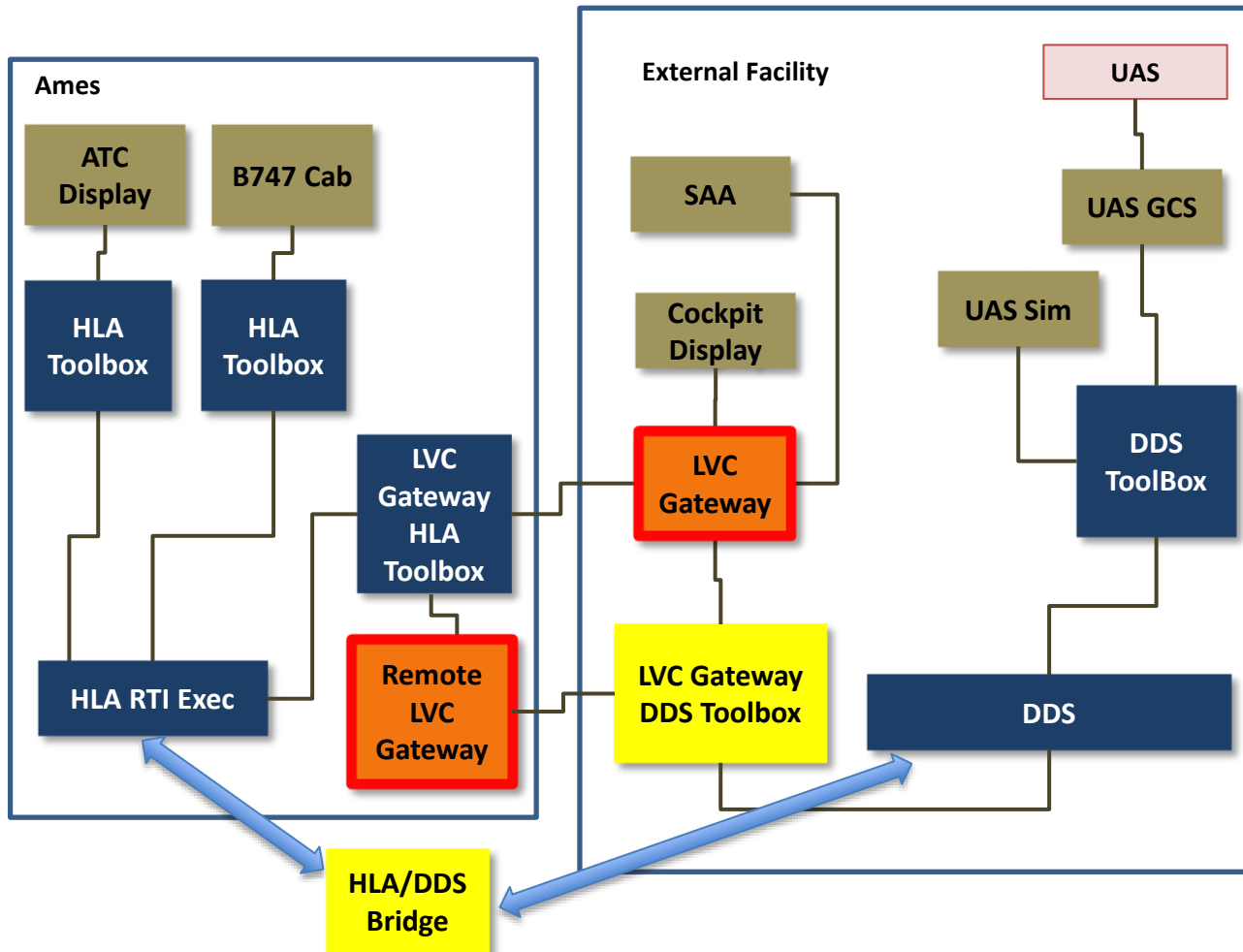


FT3: Configuration 1B (Pairwise-High Speed Ownership) – S-3B



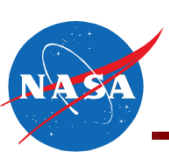


LVC Connection Options

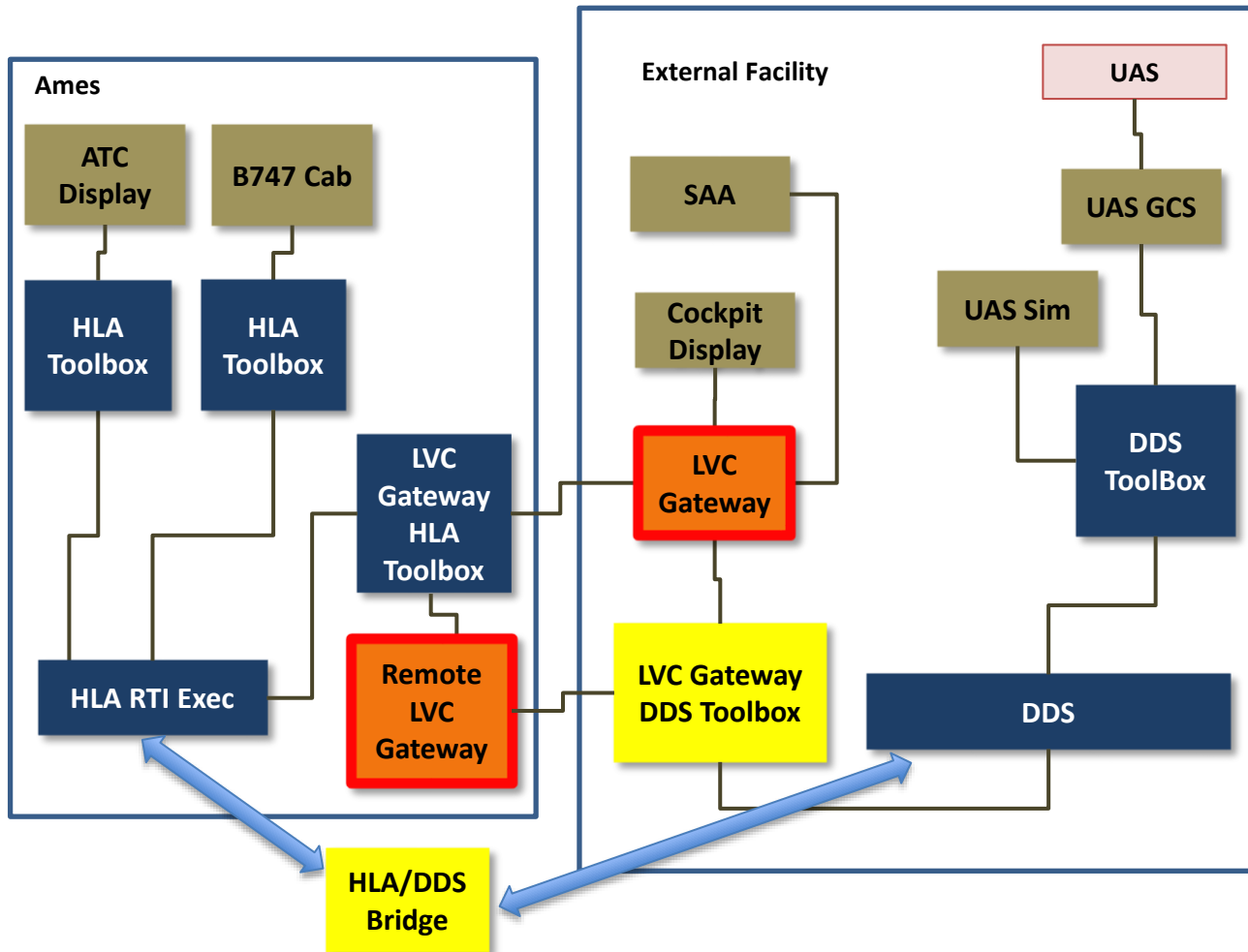


Features:

- 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

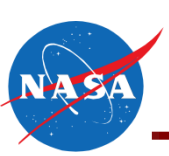


LVC Connection Options

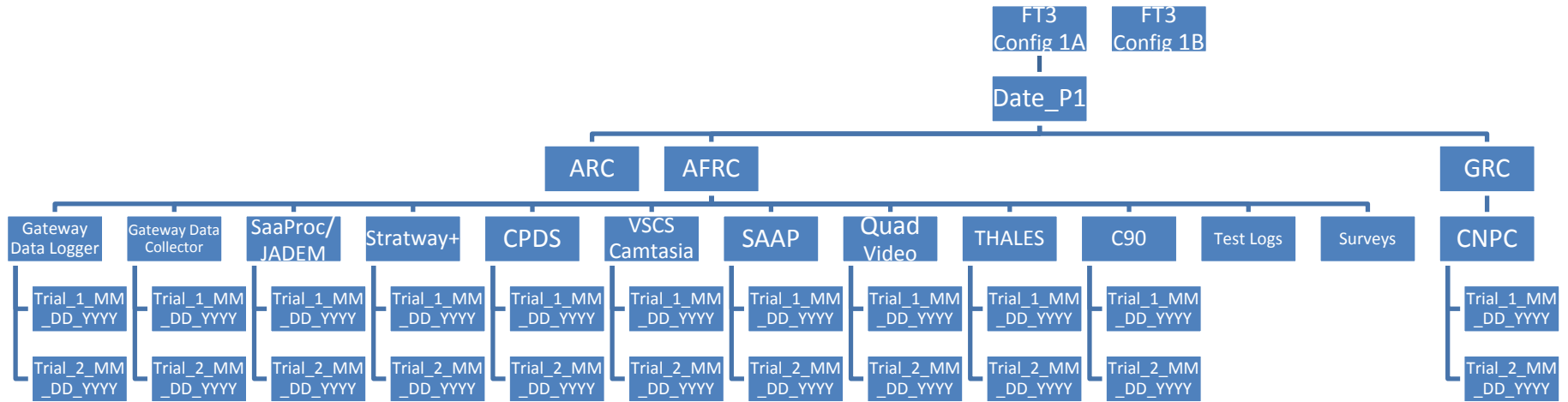


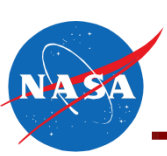
Data Collection:

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

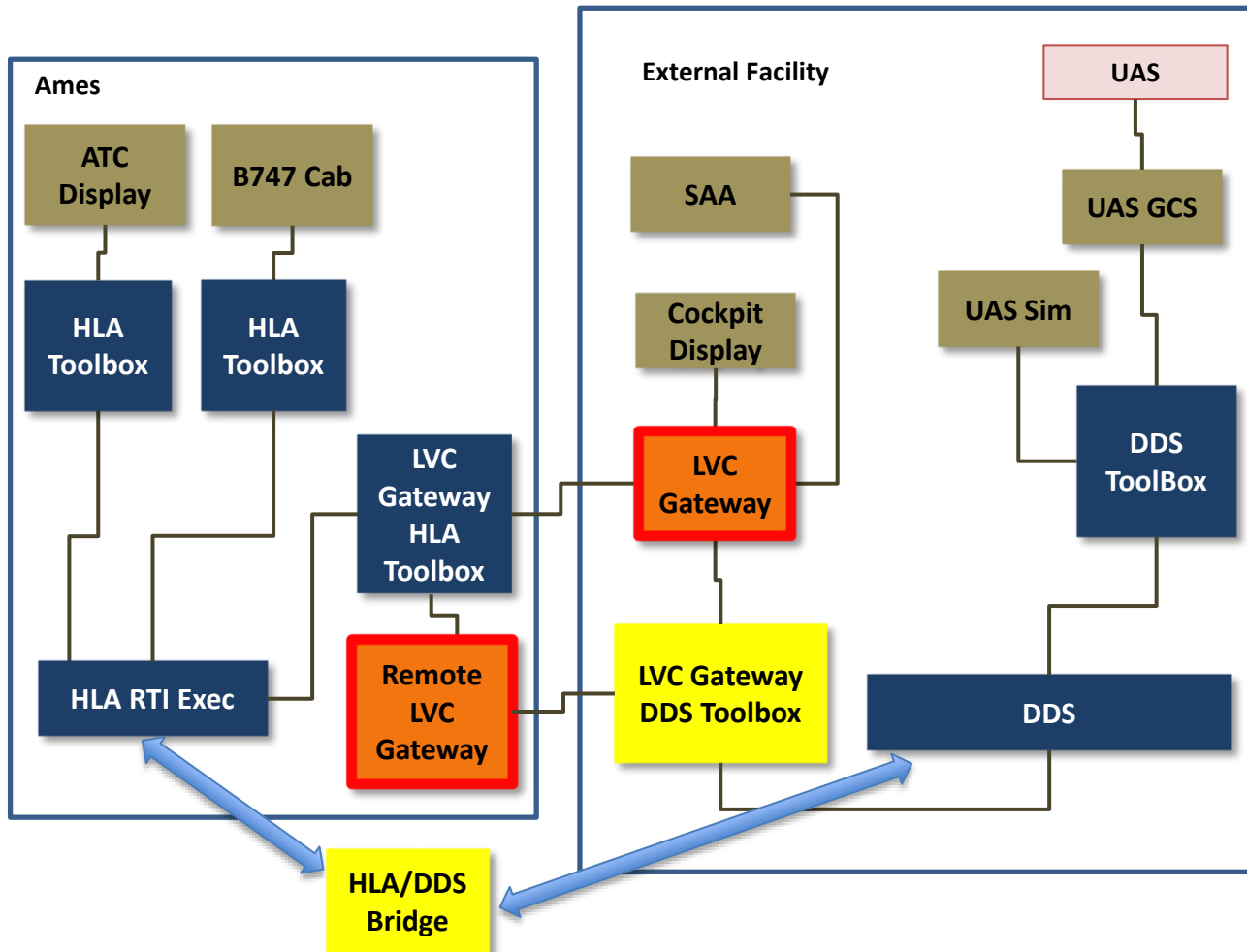


Example Data Archive Directory Structure



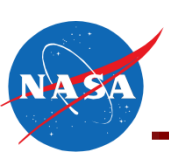


LVC Connection Options

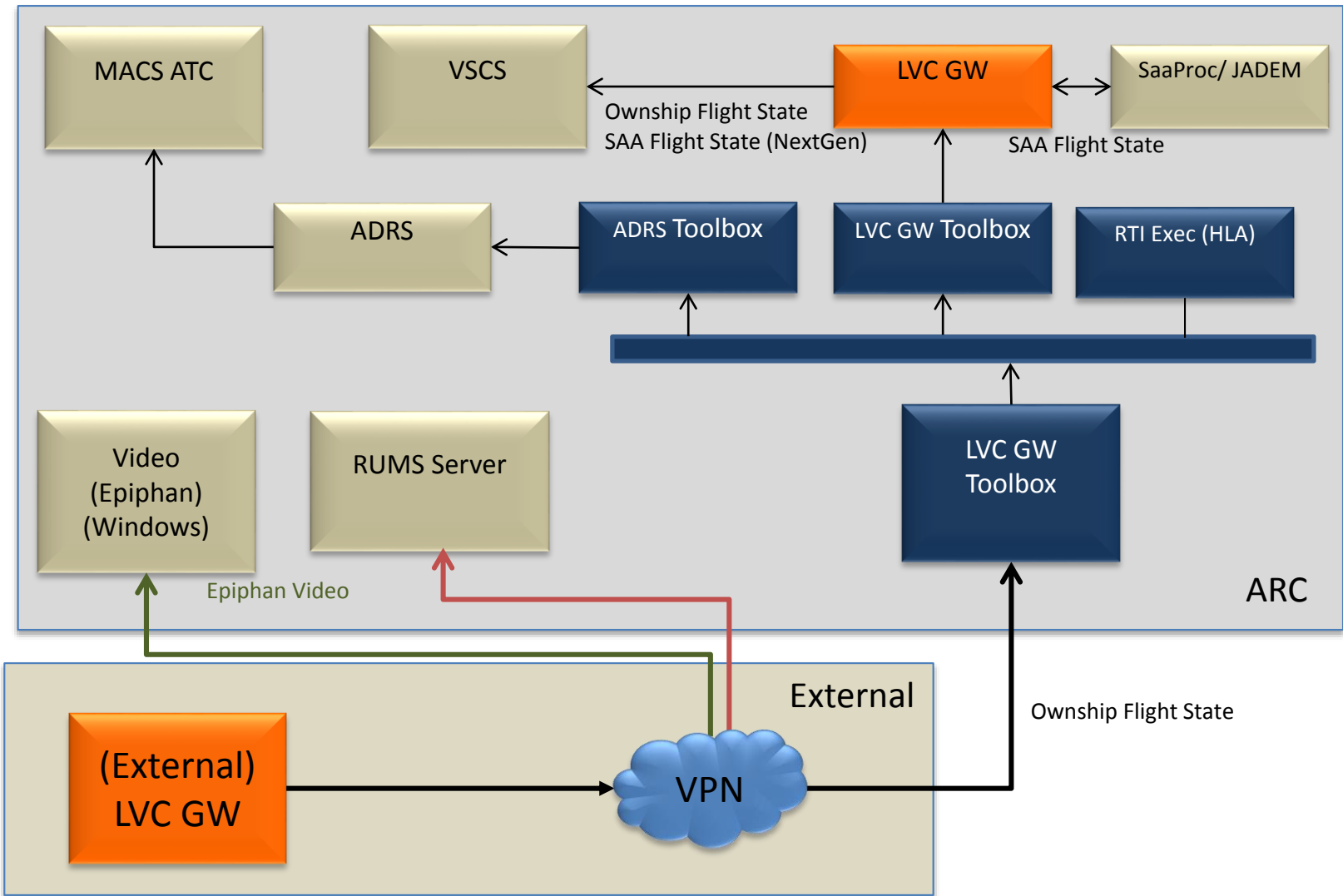


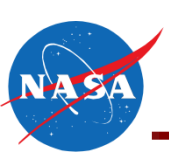
Data Connection:

- **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**

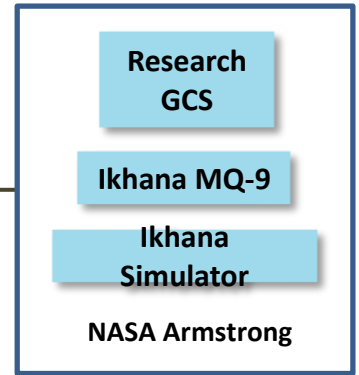
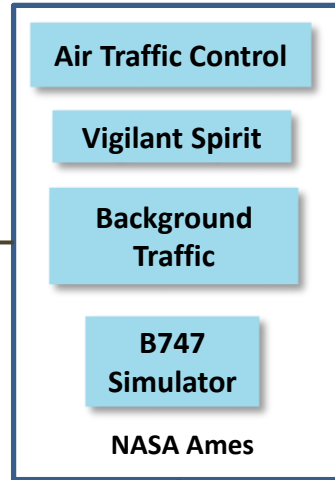
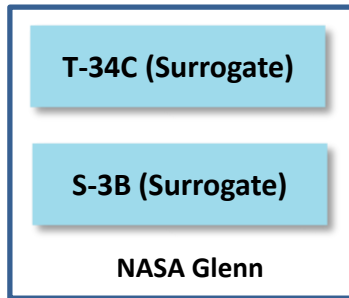
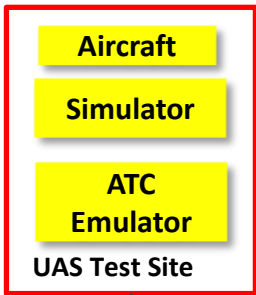


Alternative Connection





LVC Connectivity Decisions



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

Points of Contact:

- LVC Lead: Jim Murphy
- Connection: Neil Otto
- Technical Design: Srba Jovic

