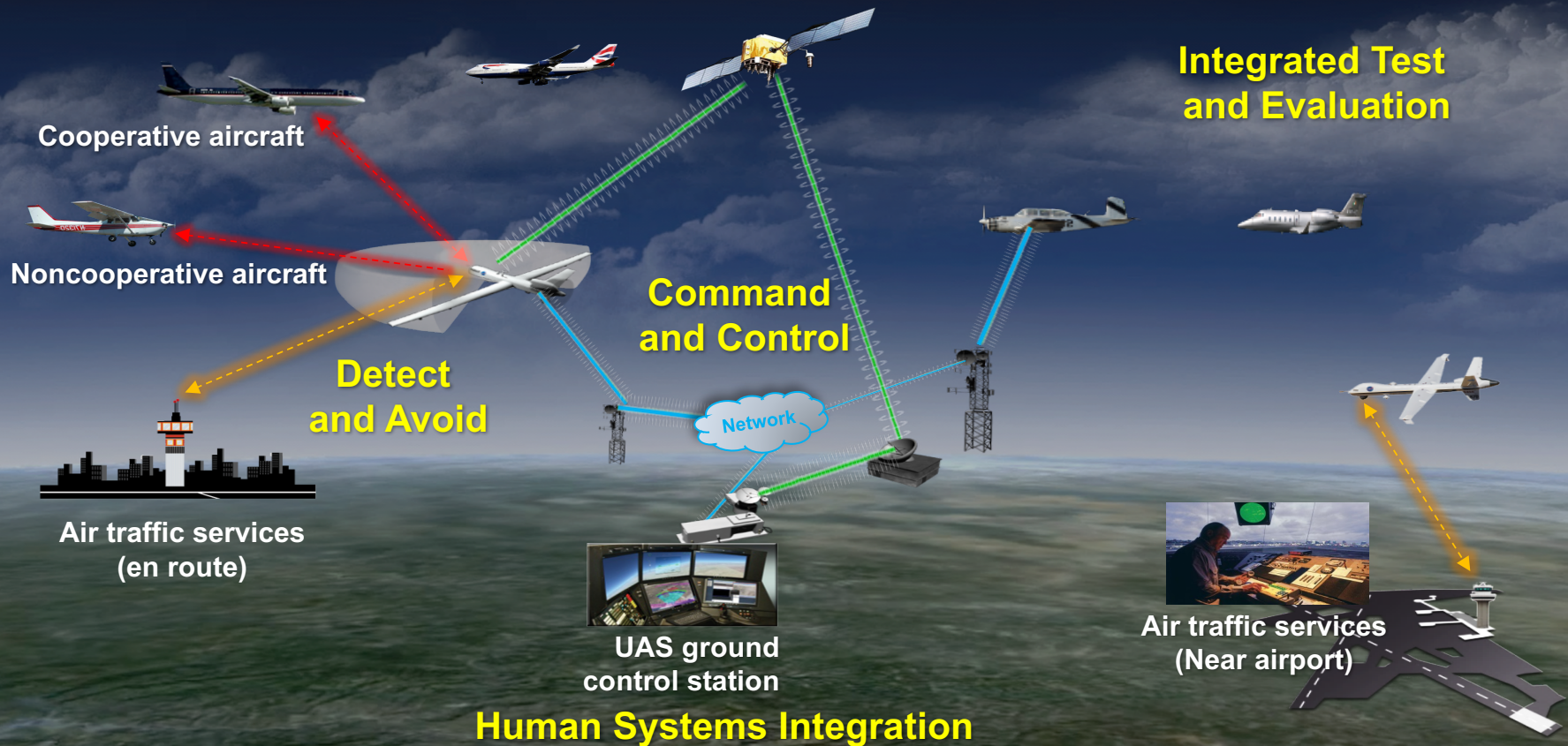# Evolution of a Distributed Live, Virtual, Constructive Environment for Human in the Loop Unmanned Aircraft Testing

Jim Murphy: NASA Ames Research Center
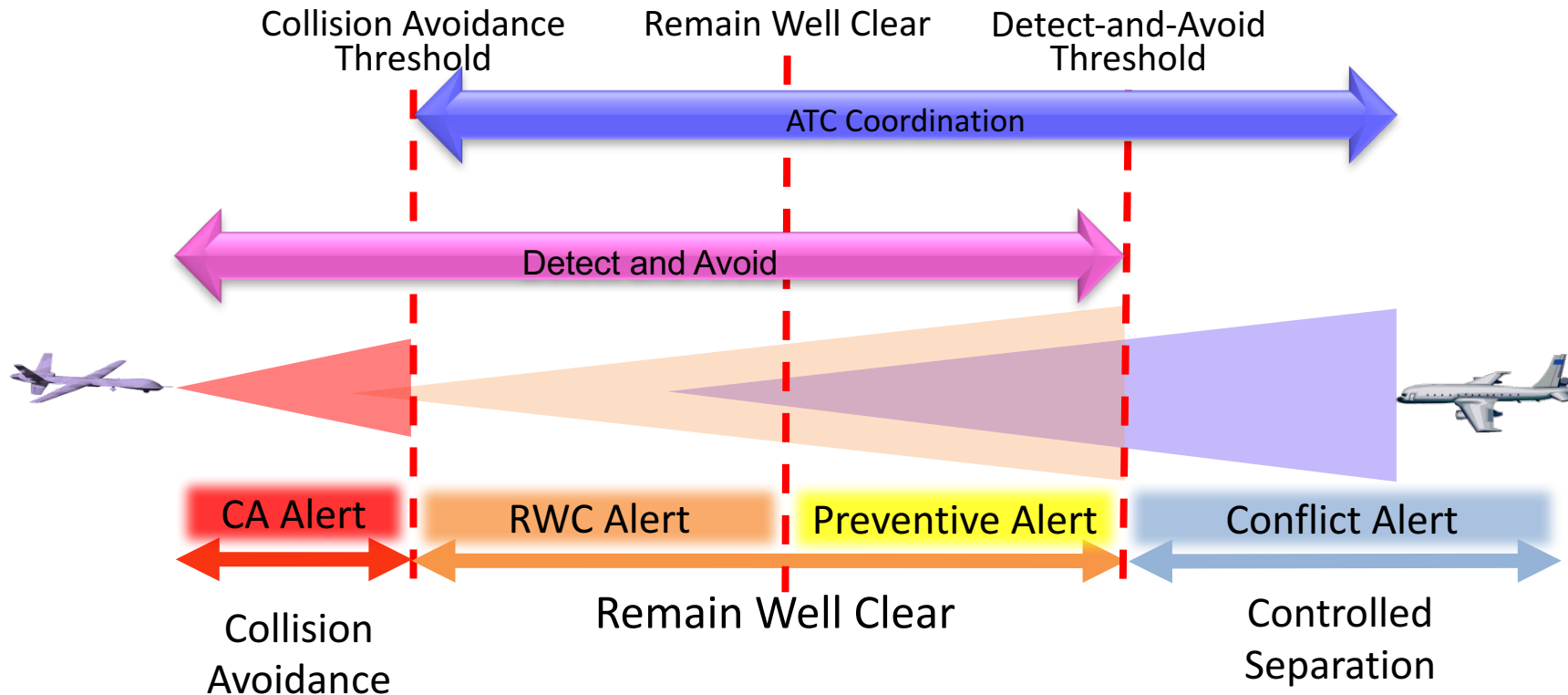
Neil Otto: Flight Research Associates

RAeS Modelling and Simulation in Air Traffic Management Conference 2017

Cooperative aircraft

Noncooperative aircraft

Detect and Avoid

Air traffic services (en route)

Command and Control

Network

UAS ground control station

Human Systems Integration

Integrated Test and Evaluation

Air traffic services (Near airport)

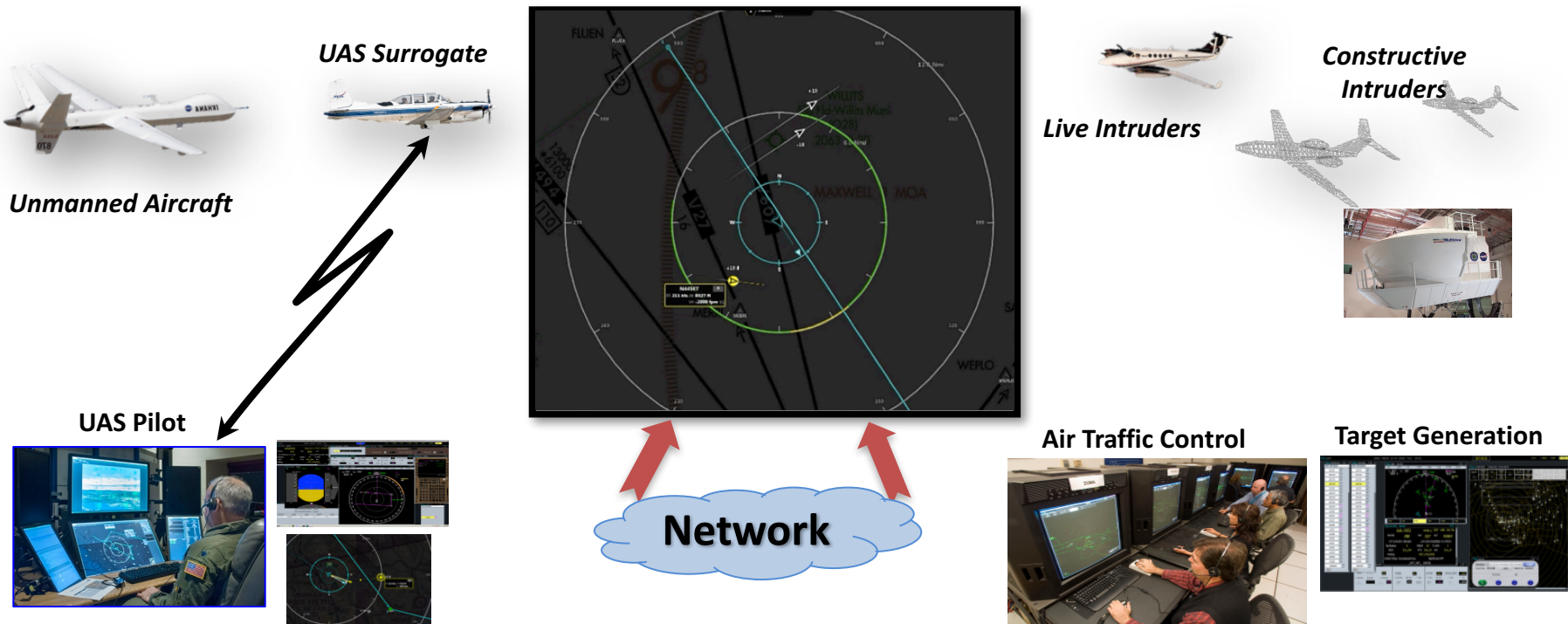# UAS use "Detect and Avoid" in place of "see and avoid"

LVC-Distributed Test Environment

Live: Real people operating real assets
Virtual: Real people operating simulated assets
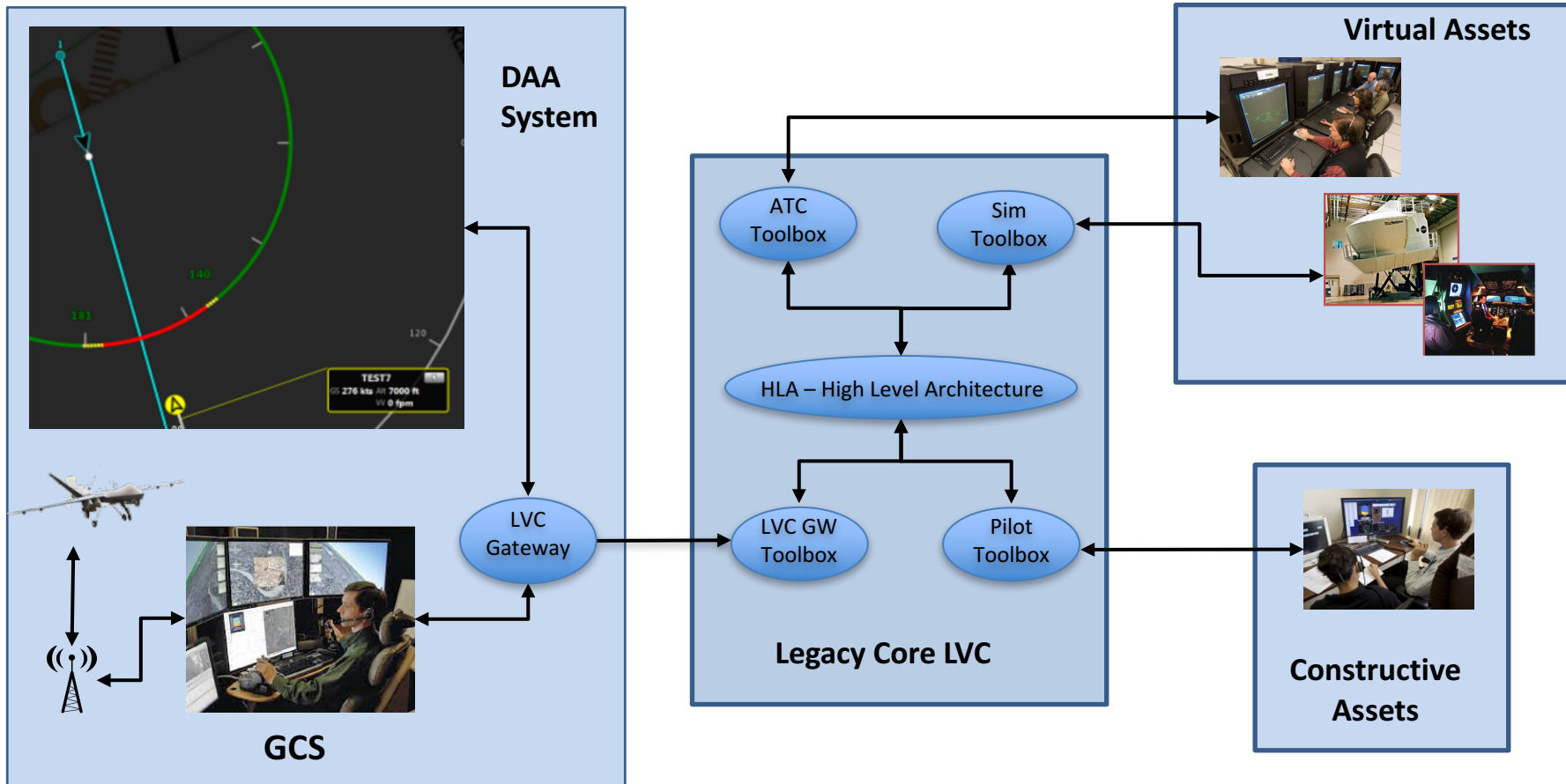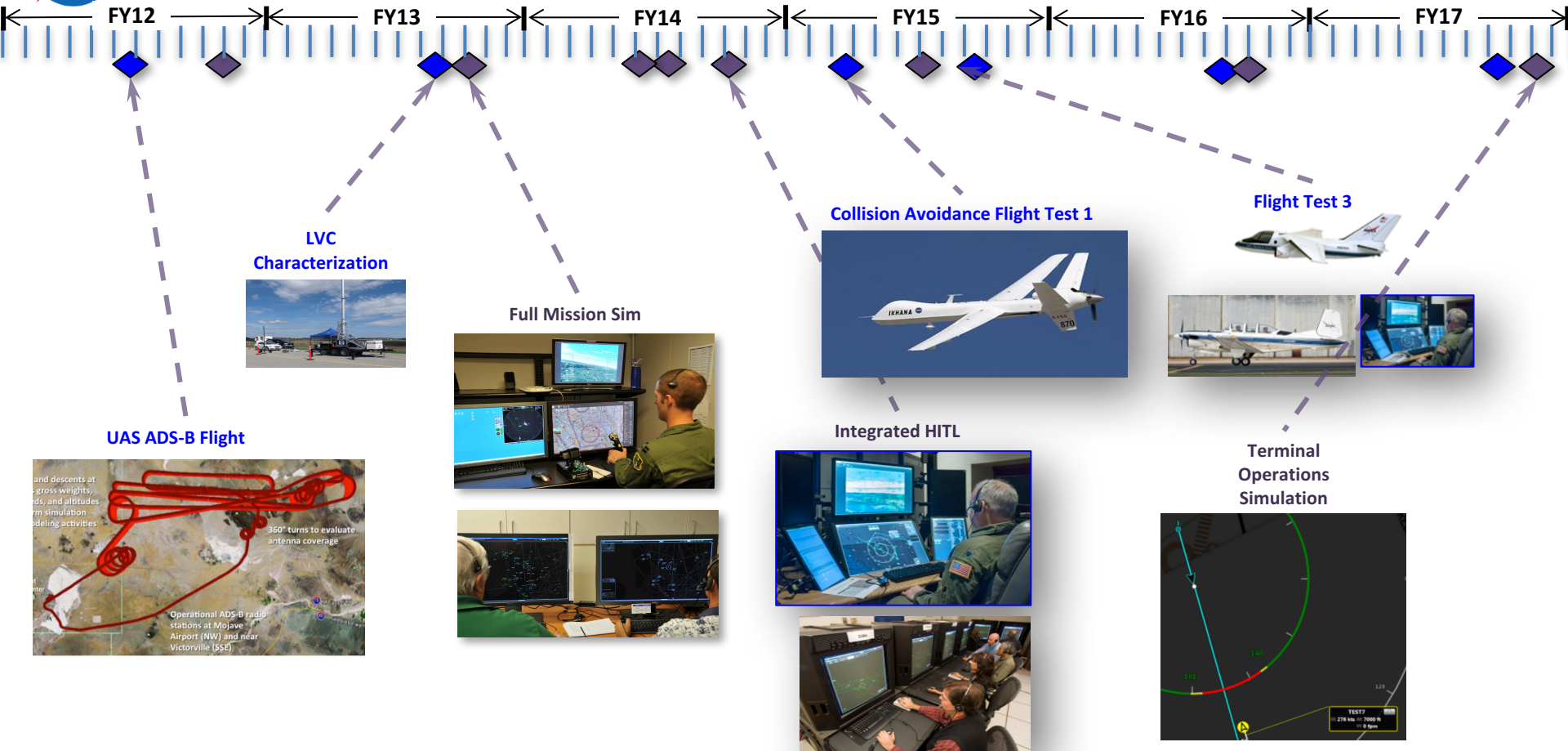Constructive: Simulated people operating simulated assets

UAS Surrogate

Constructive Intruders

Live Intruders

Unmanned Aircraft

UAS Pilot

Network

Air Traffic Control

Target Generation

LVC Architecture Build-Up

LVC/DAA Simulation and Flight Activities

FY12 — FY13 — FY14 — FY15 — FY16 — FY17

LVC Characterization

UAS ADS-B Flight

Full Mission Sim

Collision Avoidance Flight Test 1

Integrated HITL

Flight Test 3

Terminal Operations Simulation

SMART-NAS Test Bed High-Level Architecture

ATD Systems

TOWER   TERMINAL

RAMP   CENTER

ATD-2 SCHEDULERS

UTM-SE

~ 500ft

~ 200ft

LVC-DE

LVC Gateway

UAS LVC-DE

External Simulators

Visualization Services

Analytics Services

DDS – Data Distribution Service

Automation

Traffic Generators

GovCloud

Support Services
- Authentication
- Simulation Architect
- ATM Data Warehouse
- User Accounts
- Scenario Library
- Simulation Archive
- Web Services

FAA Tools

NASA Tools

Airline Tools

Industry Tools

Real-time Safety Monitoring

Airspace Traffic Generator (ATG)

Aircraft Simulation for Traffic Operations Research (ASTOR)

Multi-Aircraft Control System (MACS)

Component A

Component B

Component C

Component D

Component X

LVC Enhancement

- Live: Real people operating real assets
- Virtual: Real people operating simulated assets
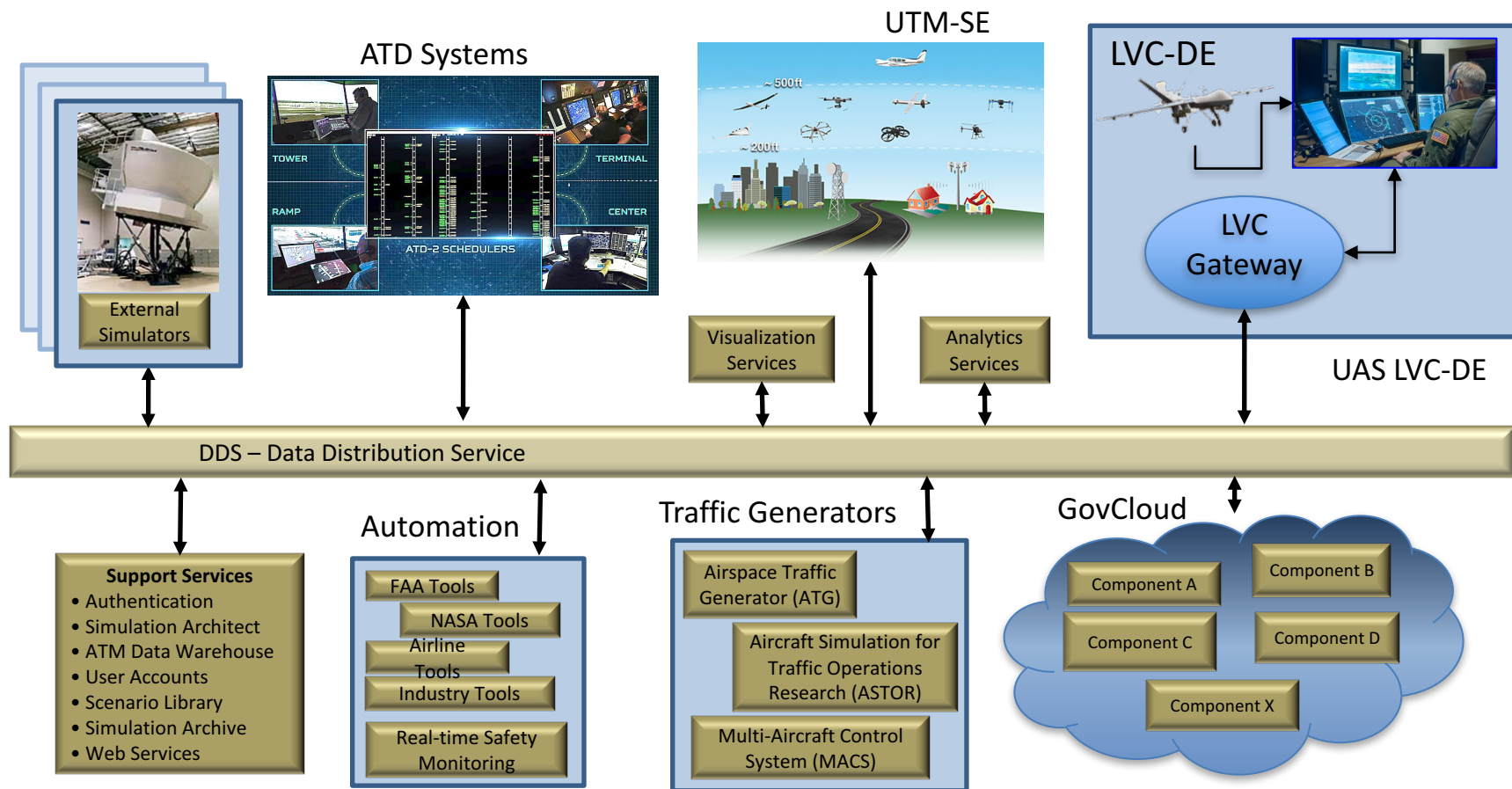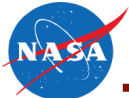- Constructive: Simulated people operating simulated assets

	Real Assets	Simulated Assets
Real People	Live	Virtual
Simulated People		Constructive

LVC Enhancement

- Live: Real people operating real assets
- Virtual: Real people operating simulated assets
- Constructive: Simulated people operating simulated assets
- Autonomous: Simulated people operating real assets

	Real Assets	Simulated Assets
Real People	Live	Virtual
Simulated People	Autonomous	Constructive
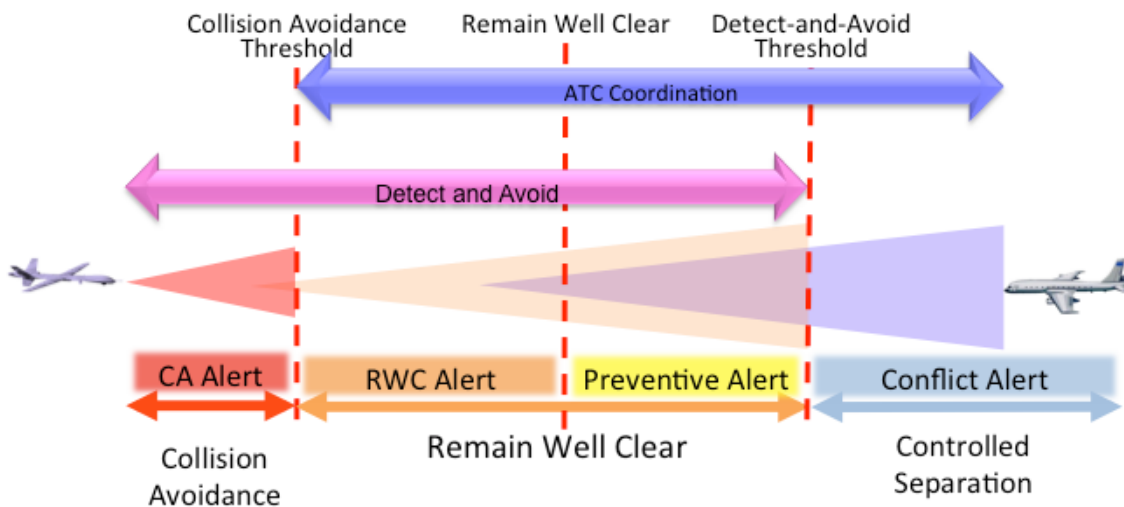
Conclusion and Next Steps

- NASA's UAS Integration into the NAS project has developed an LVC architecture to support testing of unmanned Detect and Avoid research

- LVC Distributed Test Environment was built up from legacy infrastructure and designed to meet DAA test objectives and requirements

- Integrating with NASA's SMART-NAS Test Bed will enable continued use of the LVC technologies