Sea Trial / LTE

For ADS – B STIMS 21-22

NAVAIR PMA-209

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CNO Expectations ICO

Sea Trial Process

- CNO says:
  - I'm expecting this to formalize experimentation
  - I'm expecting this to be "Fleet led"
  - I'm expecting the Fleet and R&D to work together
  - I'm expecting the timelines to shrink (i.e. "speed to capability")

CNS Staff Brief to 2nd Fleet, 2003

Sea Trial

- CFFC will incorporate concept development and technology insertion into the experimentation process
- CD&E Plan will **mature pillars**, codify to doctrine, plug into acquisition via a POR
- Sea Trial Emphasis on:
  - Speed - rapid transition into doctrine and programs
  - Comprehensive - single point for Navy experimentation
  - Jointness - Max incorporation of JCD&E
  - Relevance - Applicability to mission capability gaps
  - Economy - Max effectiveness/efficiency from CD&E

CFFC - Commander Fleet Forces Command
CD&E - Concept Development and Experimentation
POR - Program of Record
JCD&E - Joint Concept Development and Experimentation

ADS-B LTE Objective:

- Perform a Sea Trial experiment which will generate metrics enabling the NNWC Fleet Collaborative Team to determine the military utility of ADS-B in support of Common Operational Picture within FORCEnet under Sea Power 21
  - If the LTE succeeds in receiving a positive military utility endorsement, then ADS-B technology would be able to provide dual use military / civil common functionality, funded via the CNS/ATM program. This would support digitization and NCW for Naval Aviation

<u>Other Positive Aspects of ADS-B LTE</u>

- Fleet process for supporting CNO Charter for CNS/ATM
- Collaboration with FAA in support GWOT
- ADS-B LTE metrics/data may assist BAMS SAA development
- LINK16 EMI compatibility test during 978MHz transmissions
- Risk reduction for ADS-B participation within Trident Warrior

ADS-B (Traffic) Depiction

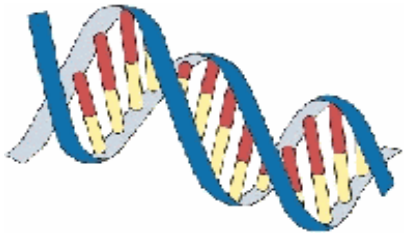
http://www.alaska.faa.gov/capstone/

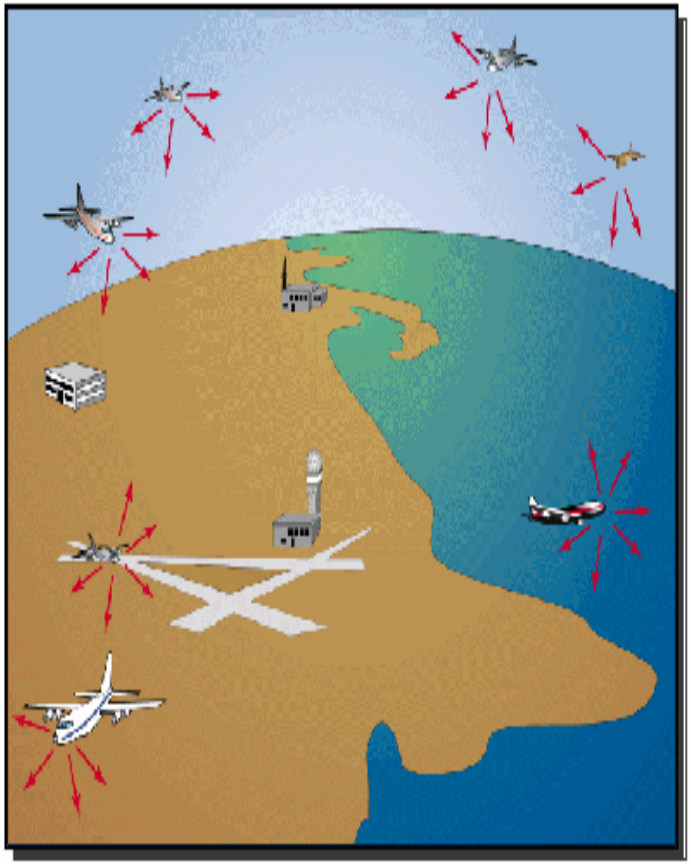
Federal Aviation Administration

What is ADS-B ?

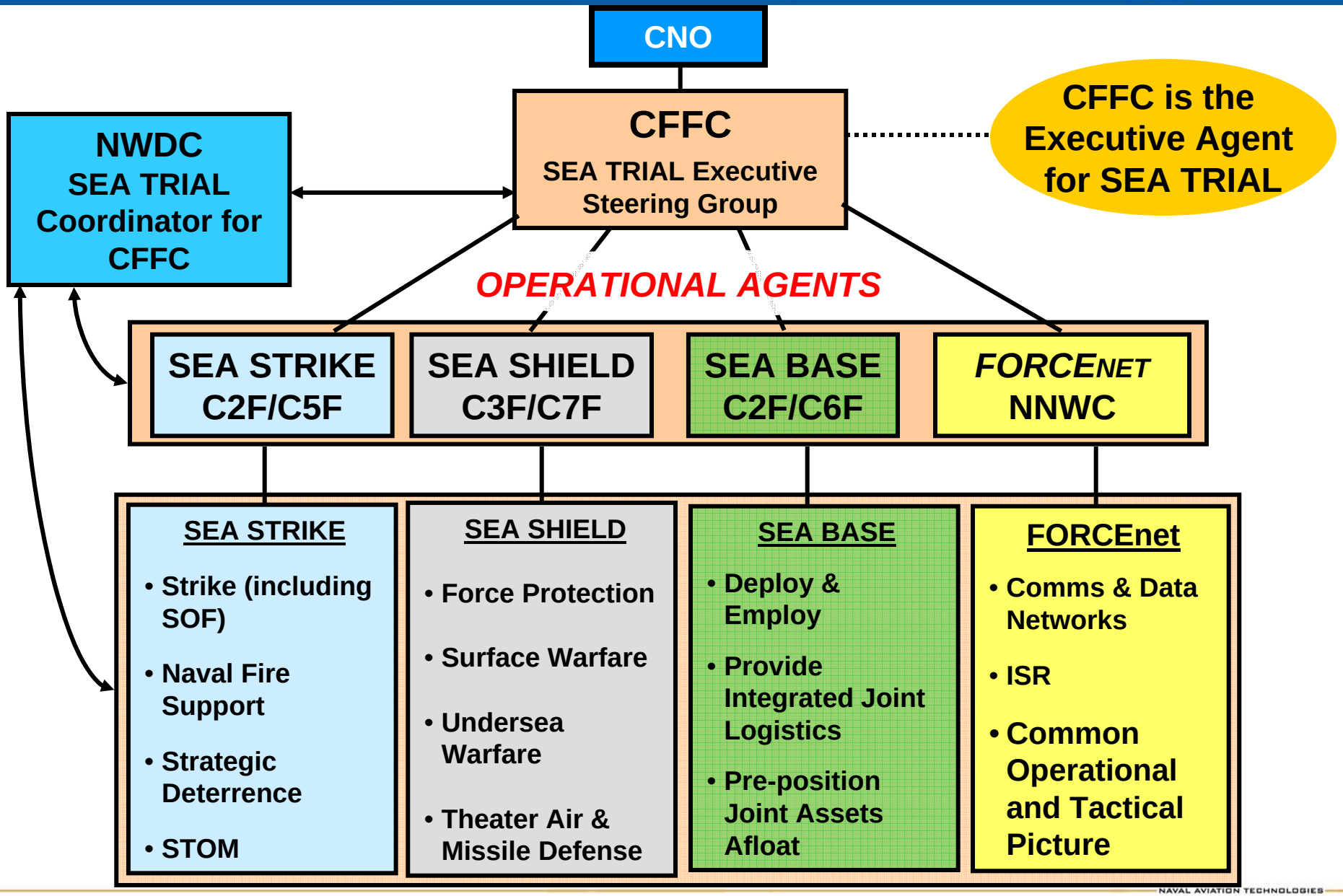
- **A**utomatic
  - No interrogation by external system, and no pilot input required
- **D**ependent
  - Position dependent on own ship's navigation - Global Positioning System (GPS)
- **S**urveillance -
  - Provides aircraft call sign, position, type, heading, altitude, velocity vector, emergency status, plus other information
- **B**roadcast
  - Data transmitted to all ground and airborne receivers, nominally once per second

"Aircraft DNA"





SEA TRIAL Organization Today



FLEET COLLABORATIVE TEAMS

CNS/ATM Requirements

For Military Aircraft

NAS

- 2005 RVSM
- 2012 RNP-2 FL290
- 2014+ ADS-B

ATLANTIC

- 1999 RVSM (NAT)
- 2001 RVSM (All)
- 2008 RNP-4

EUROPE

- 1998 BRNAV (RNP-5)
- 1999 8.33 kHz VHF
- 2001 Protected ILS
- 2002 RVSM
- 2004 P-RNAV in TMA
- 2005 ACAS II (Transports)
- 2009 Mode S with EHS
- 2010 RNP RNAV
- 2014+ ADS-B

PACIFIC

- 1998 RNP-10
- 2000 RVSM
- 2005 RNP-4
- 2014+ ADS-B

ADS-B

- 2006

LEGEND
ACAS – Airborne Collision Avoidance System
ADS-B – Automatic Dependent Surveillance - Broadcast
BRNAV – Basic Area Navigation
ELS -- Elementary Surveillance
EHS – Enhanced Surveillance
ILS – Instrument Landing System
kHz – kilohertz
Mode S – Mode Select
NAT – North Atlantic
NEXCOM – Next Generation Air-Ground Communication System
RNP – Required Navigation Performance
VDL – Very High Frequency Data Link
VHF – Very High Frequency
WATRS – West Atlantic Route System
RVSM – Reduced Vertical Separation Minimum

- Mandate In Effect
- Mandate Pending

More on ADS-B

- Airspace transitioning to ADS-B
  - Broadcast self report of ID, posit, vector
    - Cockpit Display of Traffic Information (CDTI)
- Two data links selected for the National Airspace System
  - Mode S 1090 MHz (Air Carriers & Commercial)
  - UAT (978 MHz) (General Aviation & Flight Information)
- Mode S 1090 is interoperable with TCAS II v7
- Navy CXP can do 1090ES, ADS-B – Out, and ADS-B – In with upgrade of a 1090 Receiver
- UAT as well as AIS could be waveforms within …

Military Utility of ADS-B and AIS

- **Cockpit Situational Awareness (ADS-B-Line of Sight)**
  - Enhanced visibility of civil and military air traffic
  - Enables use of civil data link information services
  - Useful ADS-B applications:
    - Conflict Mgmt (Detection, Avoidance, & Resolution)
    - Low Visibility RDZUs
    - CDTI Enhanced Flight Rules (CEFR)
- **Bridge Situational Awareness (AIS-Line of Sight)**
  - Visibility of civil and military maritime traffic
  - Improved conflict resolution
- **Command Center Situational Awareness (ADS-B & AIS)**
  - Precision Ocean Surveillance

Unsolicited System Feedback

"Wow, [prior to installing ADS-B equipment] ***I never realized how much traffic is actually out here*** [in the warning area and around Patuxent River]."

T34 Test Pilot, April 2006

USN ADS-B LTE - Scenario & Metrics

- Search and Rescue Exercise:
  - Simulated downed aircraft in southern Maryland
  - NAS Patuxent River simulated SAR assets command and conduct search
  - Search is supported by a VX-20 T-34C, P-3C, CAP, MD State Police Helicopter
  - All participating aircraft will be equipped with UAT ADS-B and Cockpit Display of Traffic Information
  - Conditions for the exercise are day VMC
  - The four search aircraft will have closest point of approach over a *simulated* target location

USN ADS-B Scenario & Metrics

Continued:

- The simulated SAR LTE was run twice:
  - First run is without ADS-B active
  - Second run is with ADS-B active

- Military Utility Metrics
  - Pilot assessment as to ADS-B situational awareness value, i.e., deconfliction, asset management/vectoring
  - Common Operational and Tactical Picture added value. Was there any difference in target acquisition on the second ADS-B run versus the first run?

LTE ADS-B Hardware

Tested ADS-B Setup:

- T-34C Airplane Testbed

- Garmin MX-20 Display

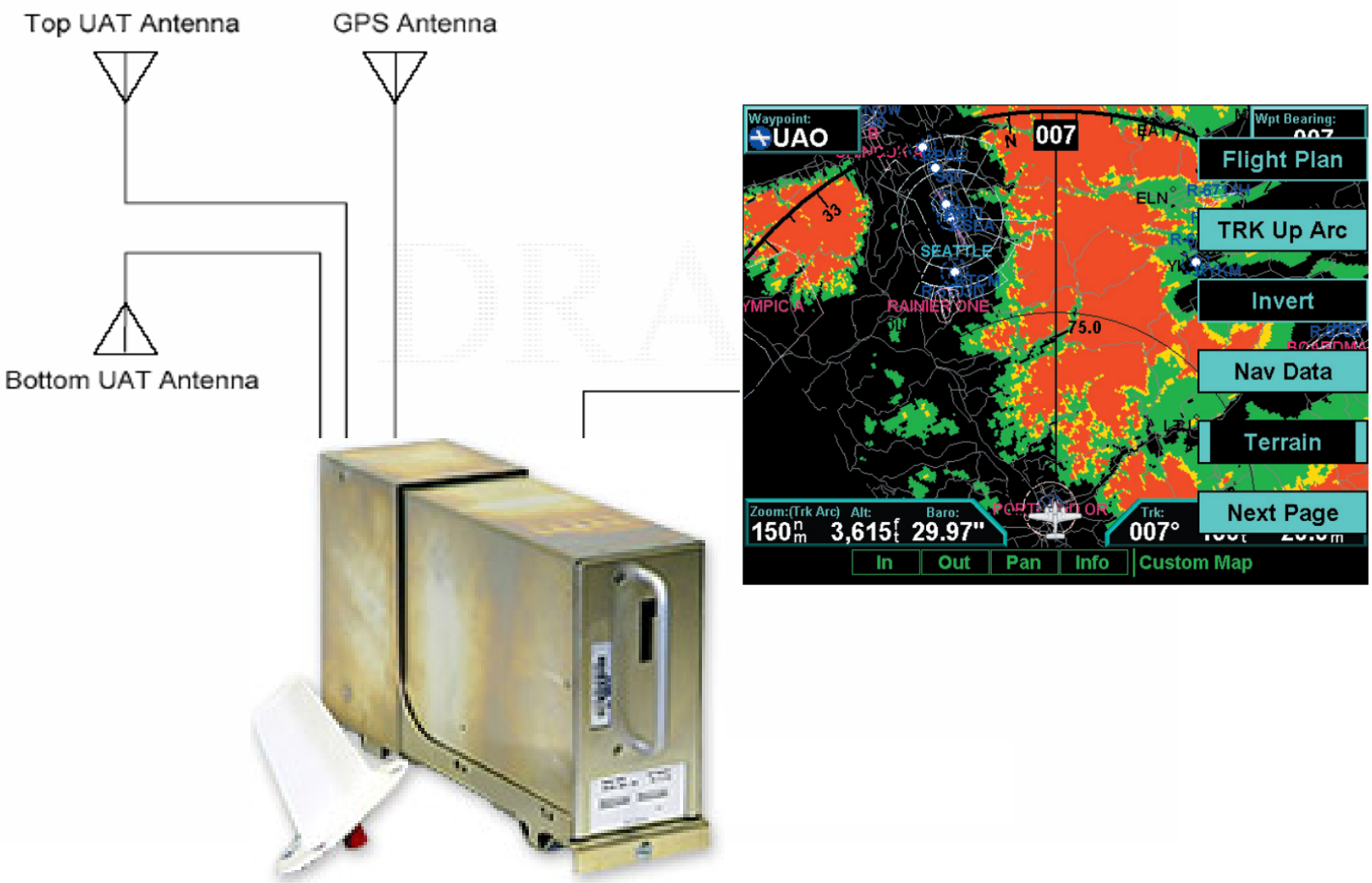
- Garmin GDL-90 Universal Access Transceiver (UAT)

- Icarus 3000 Altimeter Serializer

- 1 GPS antenna

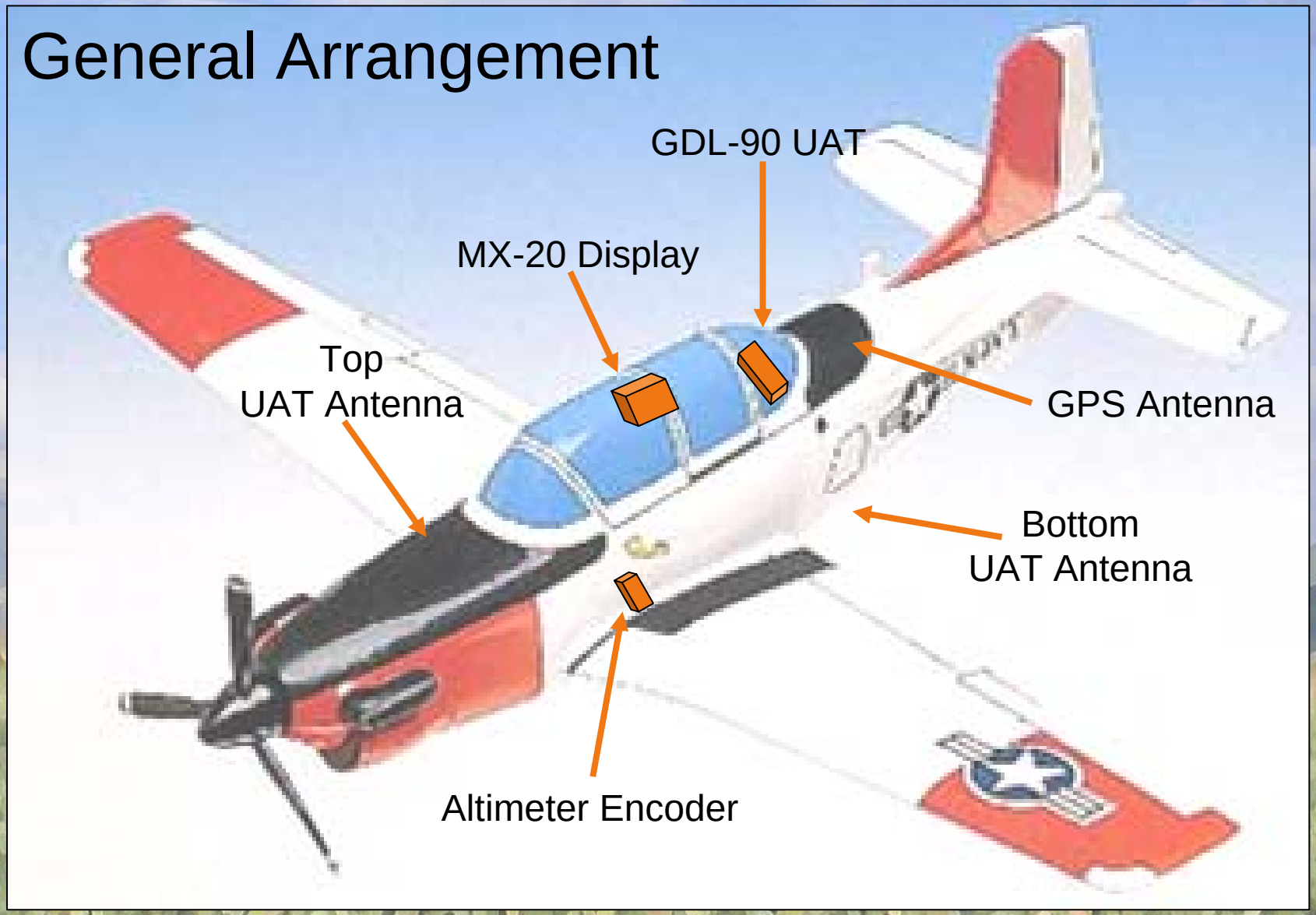
- 2 VHF antenna

Basic UAT ADS-B Aircraft System



T-34 ADS-B Installation

General Arrangement



Other Players

- VX-20 P-3C Orion
- Atlantic Test Range King Air B200
- Civil Air Patrol GA-8
- Pax River CSIL ground station
- Pax River SAIL ground station
- Desktop/internet-connected CRABS software

T-34 ADS-B Installation

- MX-20 Mounting Arrangement

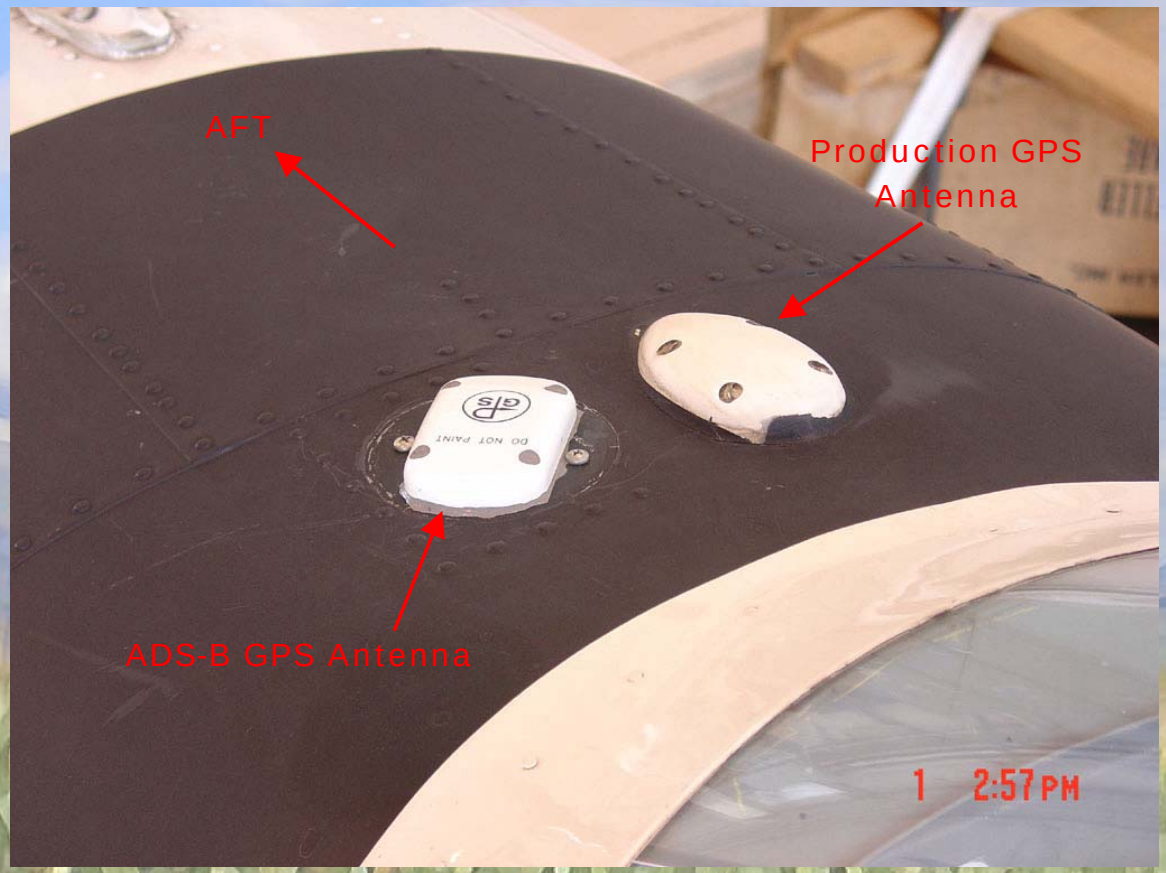
*Simulated screen images for illustration

T-34 ADS-B Installation

- GDL-90 Mounting

T-34 ADS-B Installation

- GPS Antenna Mounting



The MX-20 Display (#1)

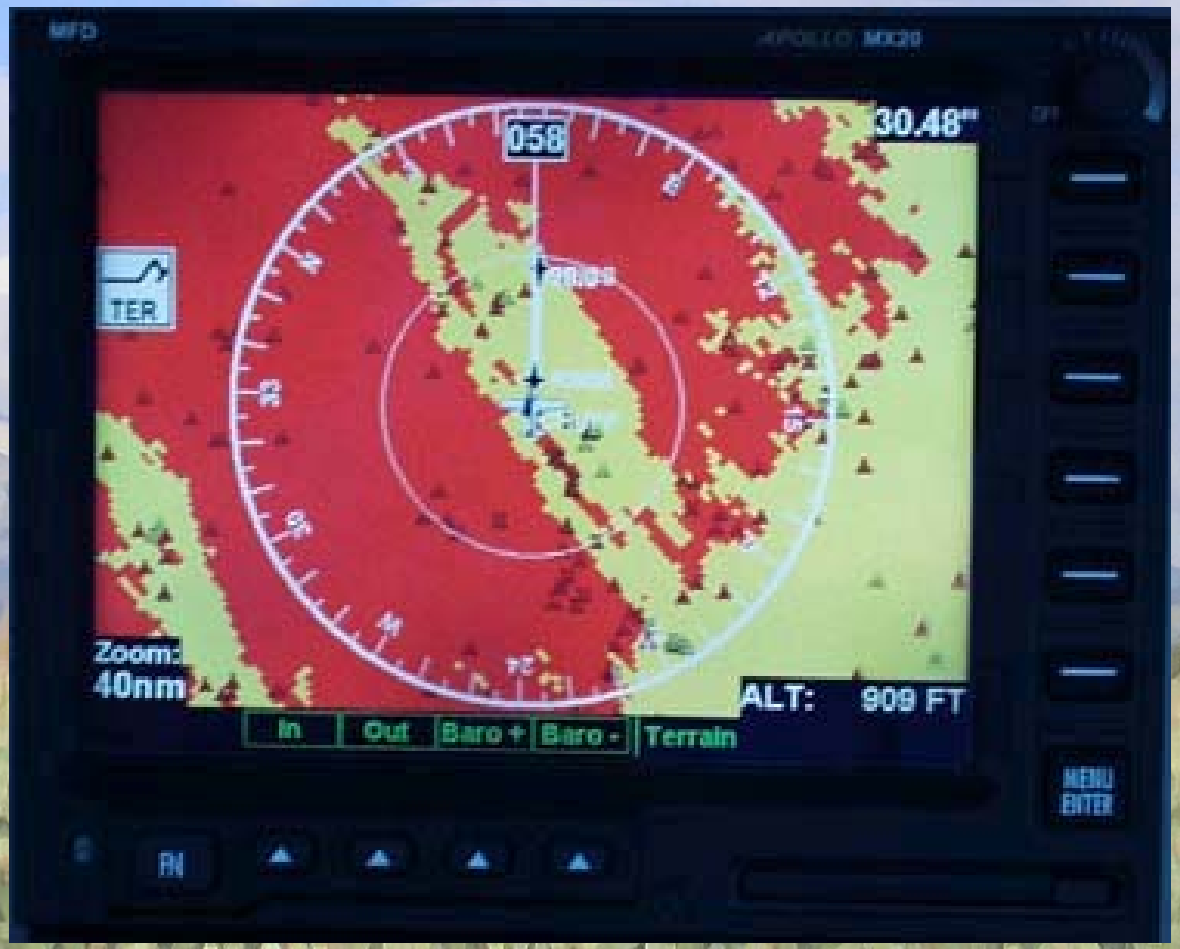
- Custom map mode with Traffic overlay

The MX-20 Display (#2)

- Traffic mode with other ADS-B targets

The MX-20 Display (#5)

- Terrain Mode



The MX-20 Display (#6)

- Weather Mode

The MX-20 Display (#3)

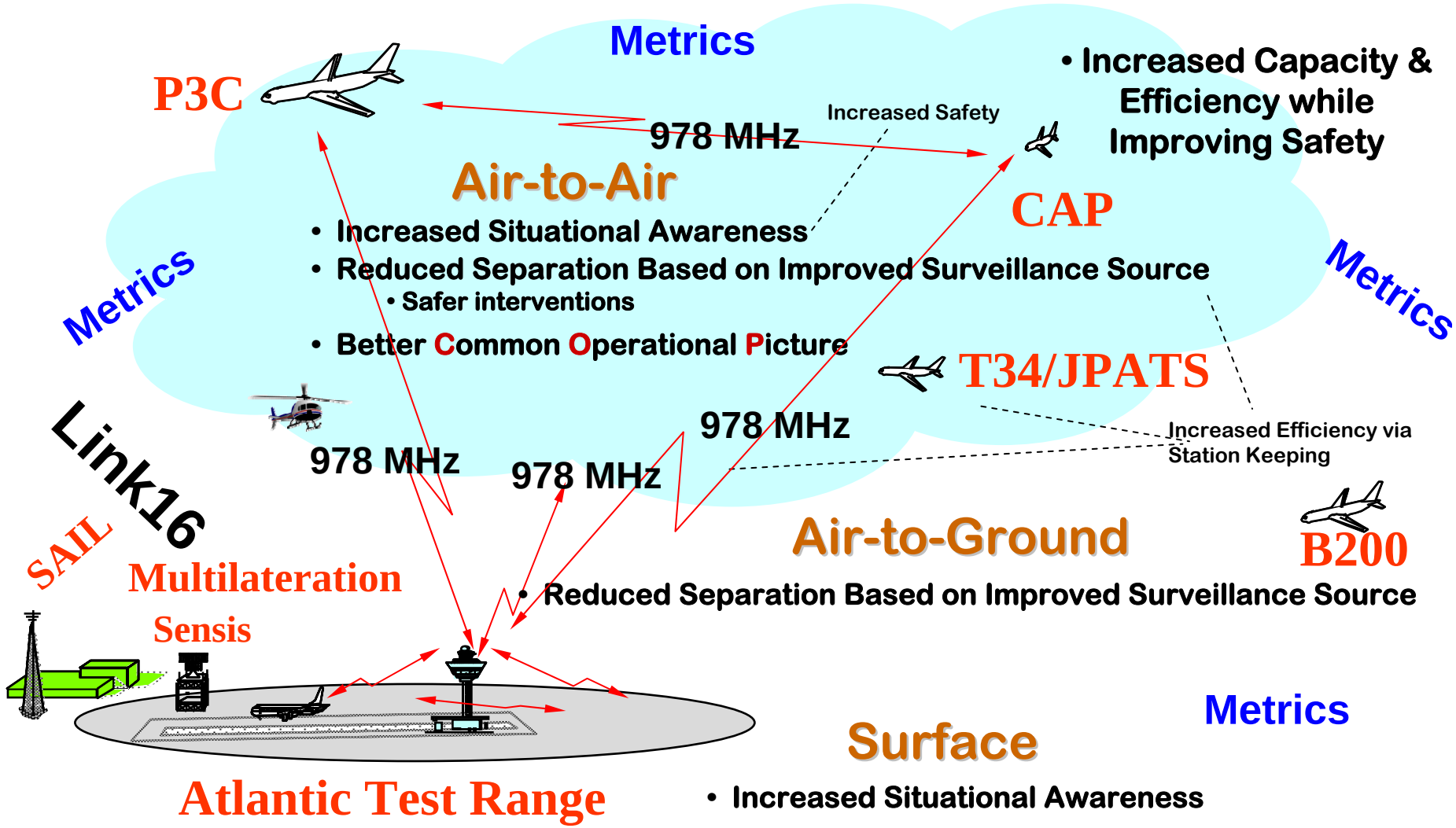
- IFR Enroute Map Mode

Scenarios Flown

- Situational Awareness
  - 10-nmi radius operating area
  - Random pattern orbits
  - Staggered altitudes
  - With and without ADS-B traffic data
- Search and Rescue
  - Same 10-nmi radius search zone
  - Ground target selected ahead of time (a red bus); participants attempted to find target
  - With and without ADS-B traffic data

ADS-B LTE Experiment

Scenario Development



Scenario Results

- Overall significant increase in SA:
  - Workload **halved** for all traffic-related tasks
  - Roughly **doubled** sightings of other aircraft
  - Increased average visual detection range by **5 nmi**
  - Easy to interpret symbology and data

Detailed Results: Contacts

Airplane	Mission	ADS-B Traffic	Number of Contacts	Contact Distance
T-34	Situational Awareness	OFF	7 contacts	4-9 miles
T-34	Situational Awareness	ON	21 total contacts 11 visual contacts	2-20 miles 2-13 miles
			Improvement: *+4 visual contacts* *+14 total contacts*	*Improvement:* *+4 miles visual* *+11 miles not seen*
T-34	SAR	OFF	1 contact	7 miles
T-34	SAR	ON	17 contacts 7 visual contacts	5-18 miles 5-15 miles
			Improvement: *+6 visual contacts* *+16 total contacts*	*Improvement:* *+8 miles visual* *+11 miles not seen*
P-3	Situational Awareness	OFF	2 contacts	3+ miles (1)
P-3	Situational Awareness	ON	11 contacts 7 visual contacts	3-6 miles 3-6 miles
			Improvement: *+6 visual contacts* *+9 total contacts*	*Improvement:* *+3 miles visual* *+3 miles not seen*
P-3	SAR	OFF	4 contacts	2-8 miles
P-3	SAR	ON	4 visual contacts	3-4 miles

Notes: (1) P-3 only logged contacts within 10 miles

Bedford Workload Ratings

Task (Selected by Pilot)	Workload without ADS-B	Workload with ADS-B	**Improvement** Due to ADS-B
Traffic deconfliction	3	2	1
Navigation	3	2	1
Search and Rescue	5	3	2
Search and Rescue	5	3	2
Search and Rescue (over land)	5	2	3
Scene of Action commander for Search and Rescue	6	3	3
Visual Meteorological Conditions traffic avoidance	4	2	2
Landing Approach	5	2	3
Weather Avoidance	(not recorded)	2	-
Secondary Navigation and Situational Awareness	(not recorded)	2	-
Average Bedford Workload	**4.5**	**2.4**	**2.1**

"… a rating scale designed to identify operator's spare mental capacity while completing a task. The single dimension is assessed using a hierarchical decision tree that guides the operator through a ten-point rating scale, each point of which is accompanied by a descriptor of the associated level of workload..."

Detailed Observations

- Significant SA increase for small aircraft with limited instrumentation
- Radar not required
- TCAS II <u>not</u> replaced (no Resolution Advisory recommendations)
- But, exceeds TCAS II SA improvements
  - More accurate data than TCAS II
  - Higher update rates than TCAS II
- More timely than flight controller calls

Mapping Improvements

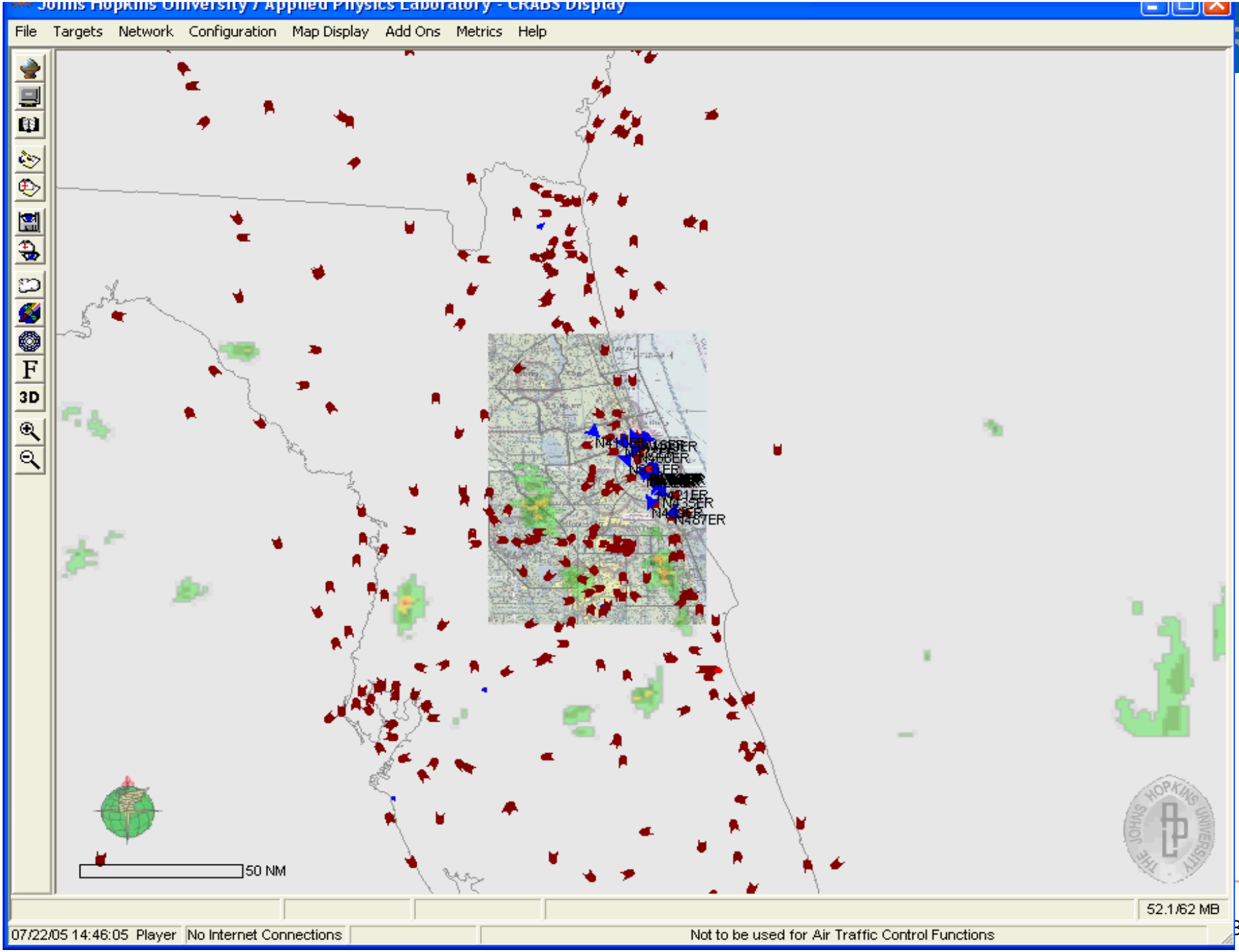
- Equipment tested: Garmin MX-20
- Substantial functionality in a very compact system
- Combination of traffic, maps, terrain and weather in one small display
- Data synthesis substantially improved comprehension
- *Disclaimer: Mapping etc. is NOT inherently an ADS-B function*

Flight Test Possibilities

- Significant SA for pilots/aircrew during testing
  - Awareness of other testers
  - Awareness of non-test civilian traffic
  - Awareness of location in test areas
- Significant SA for ground-based engineers
  - Ground systems can receive airborne data
  - CRABS can also show non-ADS-B traffic
  - Awareness of airspace effects on test points

Flight Test Possibilities (cont'd)

- Reduction in join-up times for chase aircraft and tankers
  - High-quality and timely data on altitude, position, direction, identification
- No altitude limitations like TCAS II (1500 ft)
  - Essential for rapid vertical maneuvers
  - Runway incursion
- Inexpensive and compact equipment

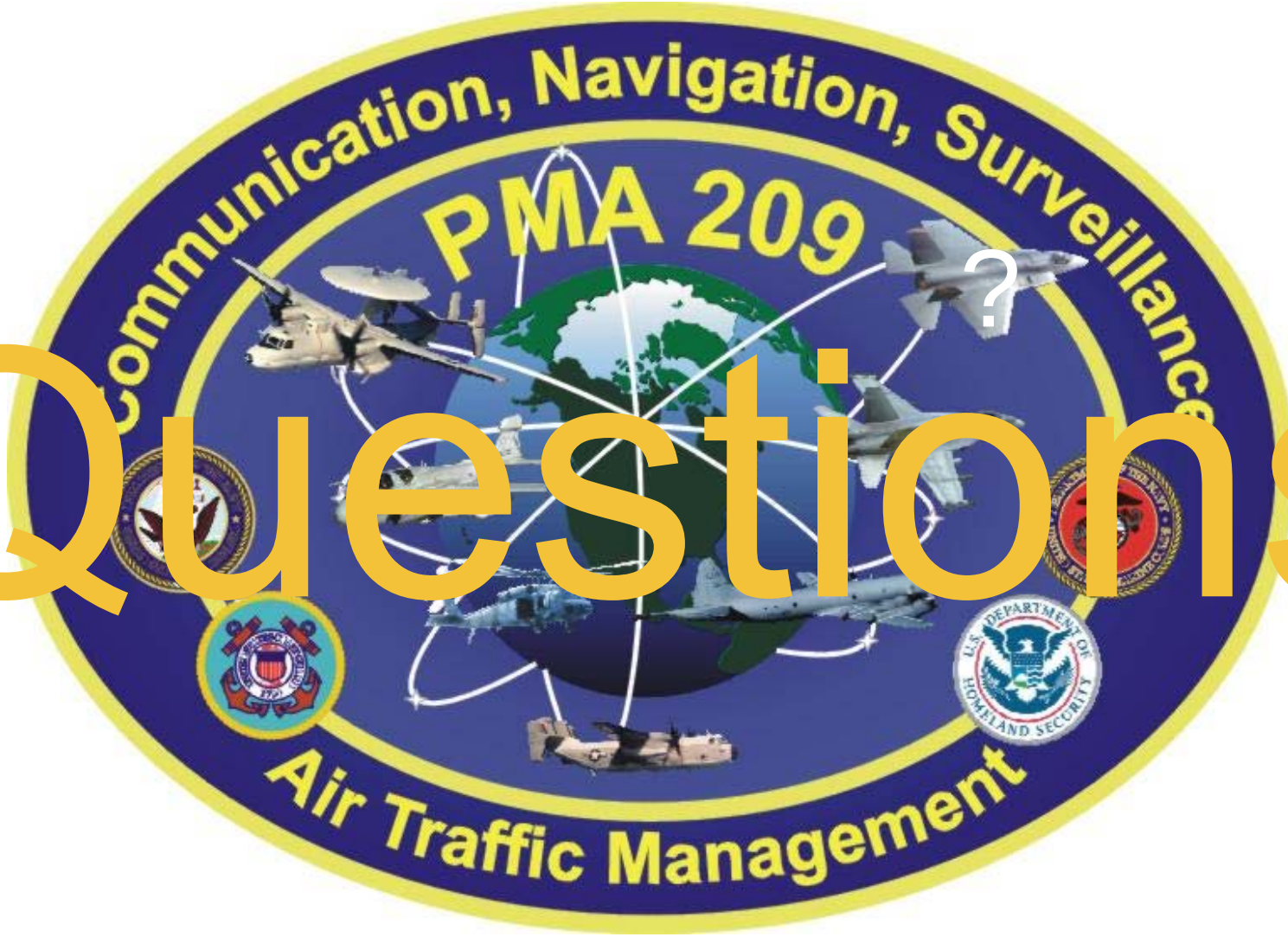

Johns Hopkins University / Applied Physics Laboratory - CRABS Display
File Targets Network Configuration Map Display Add Ons Metrics Help
3D
50 NM
52.1/62 MB
07/22/05 14:46:05 Player
No Internet Connections
Not to be used for Air Traffic Control Functions

ADS-B LTE Status

- ADS-B LTE logistics, design and installations, scenario, test plan and DCAP completed.

- LTE scenario has been completed. Navy Sea Trial Limited Technical Experiment Report in route.

- PMA209 working with the FCT and Operational Agent for MUA …


Communication, Navigation, Surveillance
PMA 209
Air Traffic Management

Questions

Selected Participants Architectures

T34

- UAT transceiver, backseat display and U/L 978 MHz and a GPS antennas

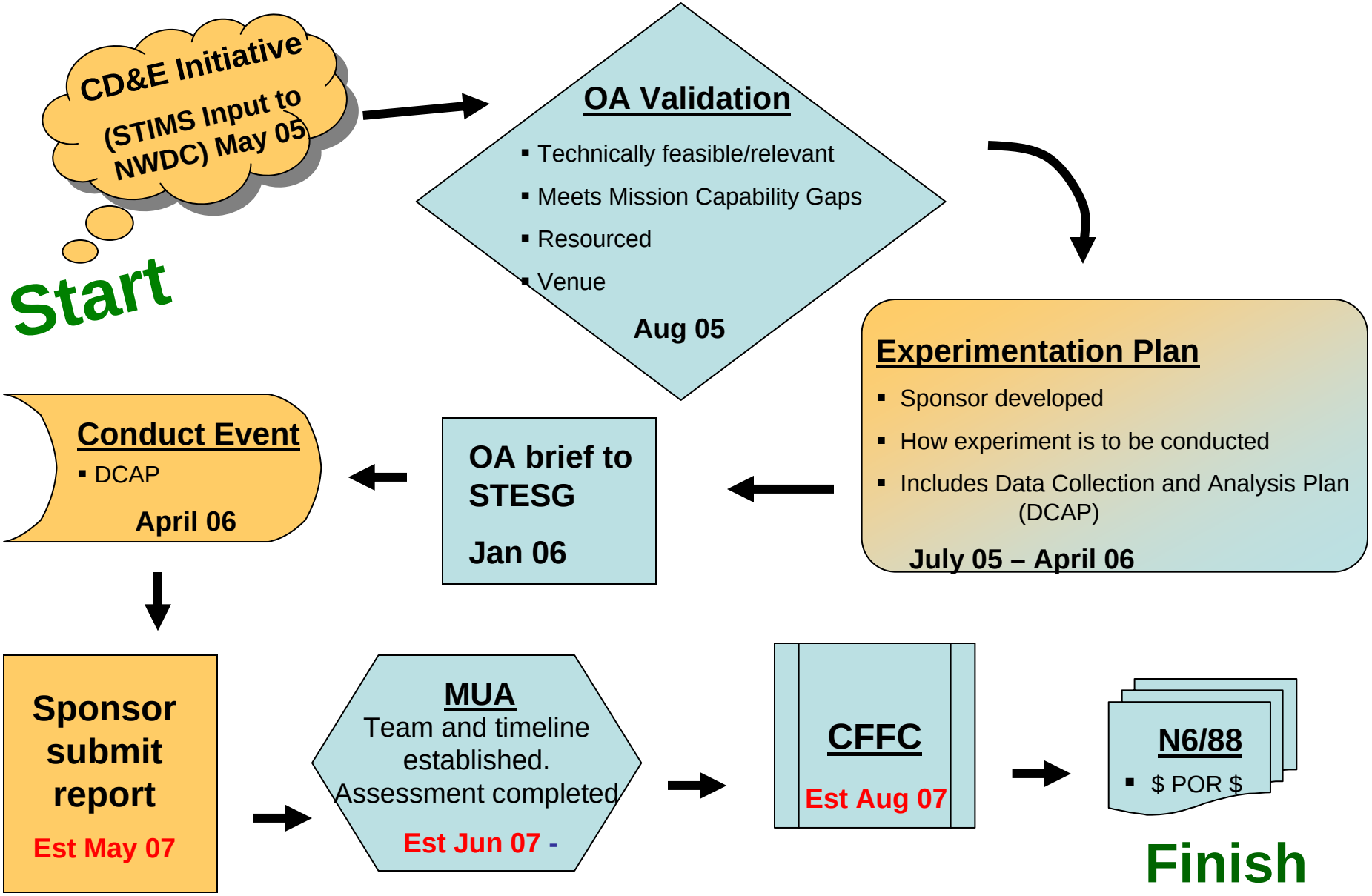
P3C

- UAT transceiver, 5x5 display plus 978 MHz antennas.

CSIL

- UAT transceiver with interface to a display for ground station recording/ receipt of ADS-B, TIS-B air picture as well as emulation of aircraft CDTI. Metrics data collection and incorporation into video presentation for leadership

NAS PAX

- DASR-11 radar feed to Potomac TRACON to the FAA for broadcast via St Mary's UAT GBT

USN Sea Trial (ADS-B LTE) Process