National Aeronautics and Space Administration
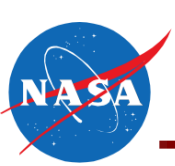
UAS in the NAS
Flight Test Series 4
Overview

UAS Integration in the NAS Project
Jim Murphy: Project Engineer, Integrated Test and Evaluation

12 May 2016
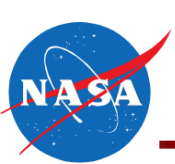
Flight Test Series 4 Goals

- Conduct flight tests in a relevant environment to contribute to the validation of the final Phase 1 DAA MOPS

- Develop and maintain the infrastructure for a relevant test environment for UAS research

Flight Test Series 4 Research Objectives

- Validate DAA requirements in stressing cases that drive MOPS requirements, including: High-speed cooperative intruder, Low-speed non-cooperative intruder, high vertical closure rate encounter, and Mode C only intruder (i.e., without ADS-B)

- Validate TCAS/DAA alerting and guidance interoperability concept in the presence of realistic sensor, tracking and navigational errors and in multiple-intruder encounters against both cooperative and non-cooperative intruders

- Validate 'Well Clear Recovery' guidance in the presence of realistic sensor, tracking and navigational errors
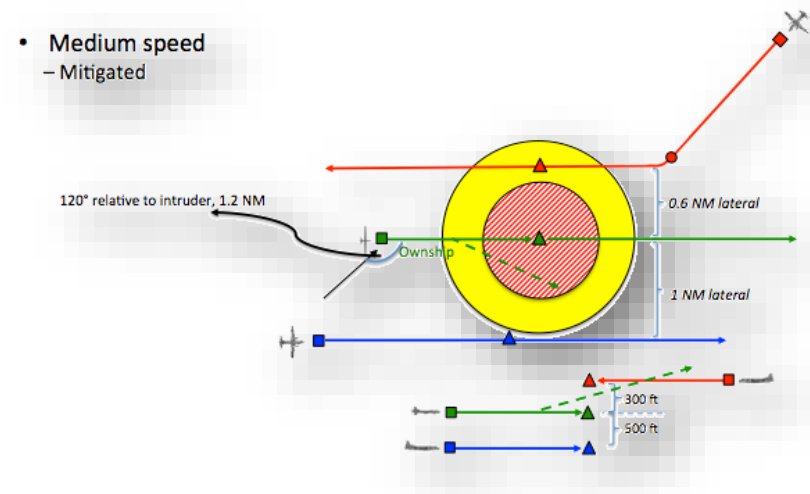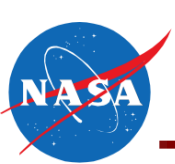
- **Support validation of final phase 1 DAA and Radar MOPS**
  - **Sensor noise, uncertainty**
  - **Navigation system errors, state data uncertainty,**
  - **Wind compensation**
  - **Support SC-228 V&V activities**

- **Refine DAA alerting and maneuver guidance algorithms**
  - **Stressing encounters**
  - **More complex multi-intruder encounters**
  - **TCAS/DAA interoperability**
  - **Well clear recovery**
 - **Mixed intruder equipage**

DAA Scripted Encounters
- **Live Ownship with Coop and Non-Coop Sensors**
- **Live Intruder(s)**

- Medium speed
  - Mitigated

120° relative to intruder, 1.2 NM

Ownship

0.6 NM lateral

1 NM lateral

300 ft

500 ft

FT4 Test System Concept

- **FT4 leverages off of FT3 & ACAS Xu**
- **DAA Scripted Encounters only**
- **Data Collection for SUT:**
  - JADEM
  - DAIDALUS
  - CPDS
  - TCAS
  - Radar
  - Honeywell
  - SC-228
- **Sensor Evaluation**
  - ADS-B
  - TCAS Hybrid Surveillance
  - EDM Radar
  - Mode C
  - Non-cooperative Target
- **Flight Test Envelope Increased**
  - Low Speed
  - High Speed
- **Increased Intruder Requirements**
  - GIII
  - TG-14
  - C-12
- **Multiship Encounters 1v4**
- **R-2515 Test Area similar to FT3**
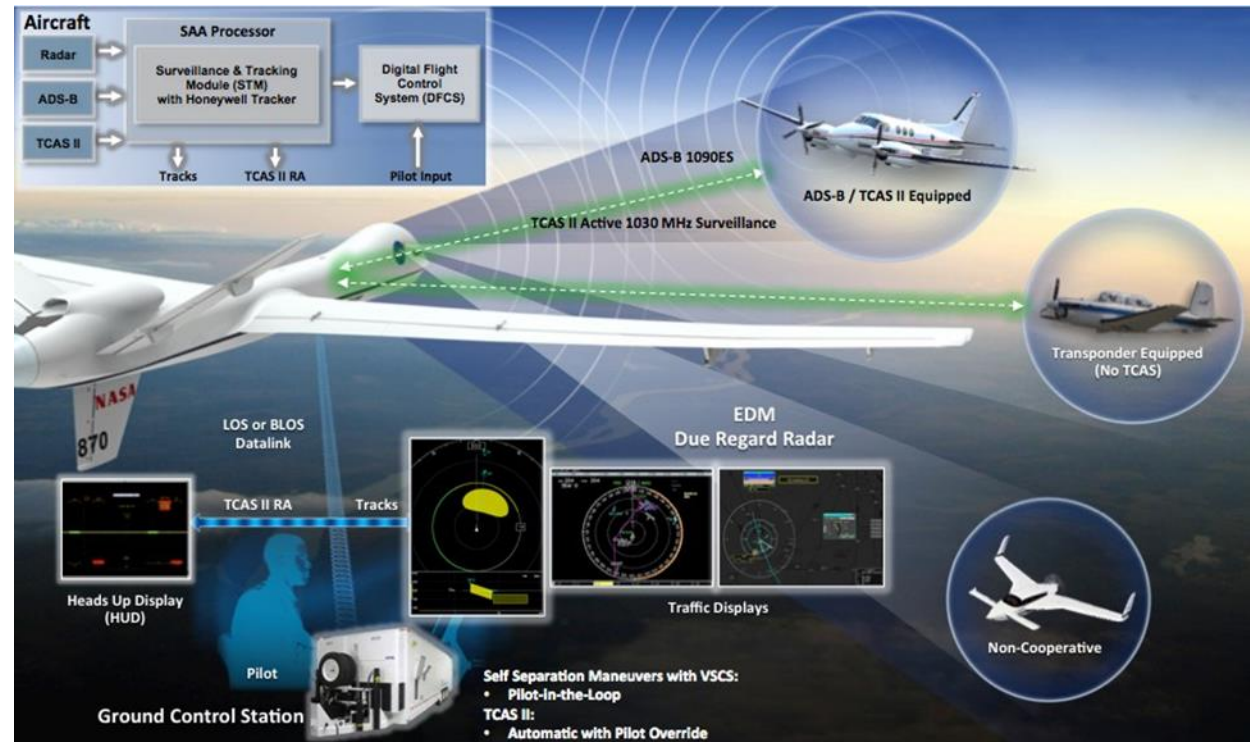
271 encounters planned for FT4 – 20% increase from FT3

Each encounter takes approximately 10 min and planning to complete ~20 encounters per flight day
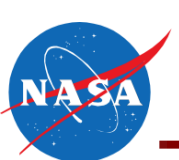
Integration Roles & Responsibilities Summary

NASA – AFRC (UAS-NAS / IT&E)
- Provide LVC-DE Infrastructure
- Provide Intruder Aircraft (T-34, G-III, TG-14, King Air)
- Provide Ownship Aircraft (Ikhana)
- Test Conductor Station (SAF)

NASA

Non-NASA

NASA - ARC (UAS-NAS / IT&E)
- Provide HLA infrastructure
- RUMS Server
- Video Distribution to LaRC

NASA - ARC (UAS-NAS / SSI)
- Provide JADEM DAA
- Provide Uncertainty model
- Devise Encounter matrix

NASA - LaRC (UAS-NAS / SSI)
- Provide DAIDALUS DAA
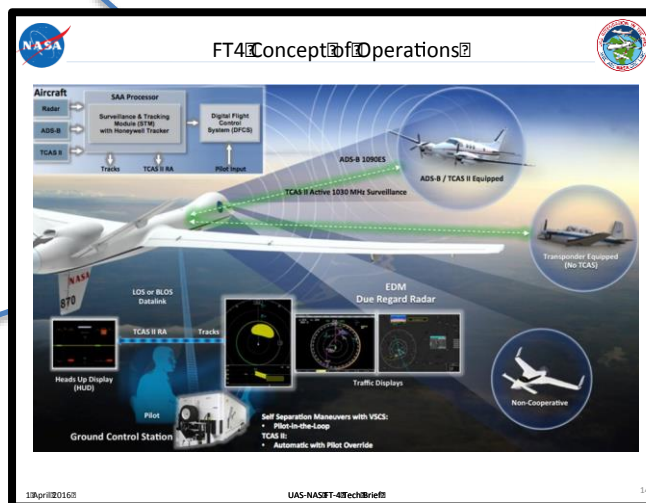- Devise Encounter matrix

SC-228
- Devise Encounter matrix

Honeywell
- Provide instrumented TCAS II equipped intruder aircraft
- Fusion Tracker
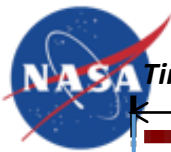- Post Flight Processing
- Devise Encounter matrix

GA-ASI
- Provide proof of concept DAA system (EDM DRR, SAAP, etc.)
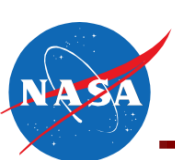- CPDS Display and IO Server
- Devise Encounter matrix

FT4 Concept of Operations

1 April 2016 — UAS-NAS FT-4 Tech Brief — 14

Flight Test 4 Milestones/Key Activities

Timeline Not To Scale

FY16

O N D J F M A M J J A
S

Legend:
- ◆ - *Development Activities*
- ◆ - *Scripted Encounters Flight Block*
- ◆ - *Intruder Aircraft Mods*
- ◆ - *Review / Tech Brief*

(11/13) ERT Decision to delete FT4 Full Mission

FT4 Requirements TIM (F2F Peer Review) — 12/16-17

FT4 Design TIM (F2F Peer Review) — 2/3-4

NASA808 ADS-B Modifications — 2/5 ... 4/11

NASA808 DGPS Modifications — 4/12 4/15

NASA801 DGPS Modifications — 4/11 4/15

NASA856 ADS-B Modifications — 4/11 4/21

Ikhana FT4 Modifications — 12/7

Ground Integration Tests/V&V — 2/8 2/25

Integrated LVC/Ikhana Ground Testing (CST) — 2/29 3/7

ARC & AFRC JADEM Regression Testing — 3/7 3/18

Flight Test Plan Complete — 2/19

System Checkout Flights / Env. Expansion Flights — 4/4 4/15
Tech Brief 4/1

Support Aircraft Airworthiness / Tech Brief — 4/7

Scripted Encounters Flight Test — 4/26 6/30
Test Data Review 4/19

FT4 Participating Aircraft
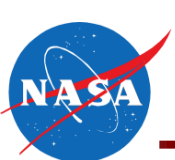
Aircraft Required Systems
- ADS-B Out
- Mode C or S Transponder
- GPS
- DGPS w/ Recording
- VHF Comm Radio (x2)

Aircraft	Role	EDM DRR	ADS-B	DGPS	TCAS-II	TCAS-I	Mode S	Mode C
	Ownship NASA AFRC Ikhana UAS	✓	✓	✓	✓		✓	✓
	Primary Intruder Honeywell Beechcraft King Air C90		✓	✓	✓		✓	
	Secondary Intruder NASA AFRC T-34		✓	✓		✓	✓	
	Secondary Intruder NASA AFRC King Air		✓	✓		✓	✓	
NEW	High Speed / Secondary Intruder NASA AFRC GIII		✓	✓	✓		✓	
NEW	Low Speed / Secondary Intruder NASA AFRC TG-14		✓	✓			✓	✓
NEW	Secondary Intruder USAF C-12 (Mode C Only)			✓				✓

Ownship – Ikhana only   New Intruders – Low Speed/RCS, High Speed, Mode C only

Aircraft Performance

"Low Speed" Intruder

AFRC TG-14
(NASA 856)

TG-14
- 100 KGS
- Small RCS (radar specific)
- Low altitude flights (5000ft-10000ft)

"Mid Speed" Intruder

HW King Air
(N3GC)

AFRC T-34C
(NASA 865)

AFRC King Air
(NASA 7 & NASA 801)

T-34
- Up to 250 KGS
- Medium RCS (radar specific)

King Airs
- Up to ~280 KGS
- Large RCS (radar specific)

"High Speed" Intruder

AFRC G-III
(NASA 808)
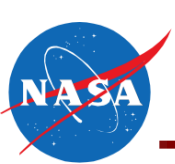
G-III
- Up to ~500 KTAS at 20k ft

Airspace Planning

- Primarily Mercury Spin, 4 Corners & Buckhorn MOA (red outline)

- 1,000 ft AGL (4.2K ft) to 20K ft MSL

- Extensions (west / north) may be requested real time for encounters that need the additional airspace

- Ops outside of test area (blue shaded areas) are planned to be performed early (before 0800) when airspace is relatively empty

- Operations between 0600 and 0700 are under Joshua control and have less geographical constraints

R-2515

RESTRICTED R-2515
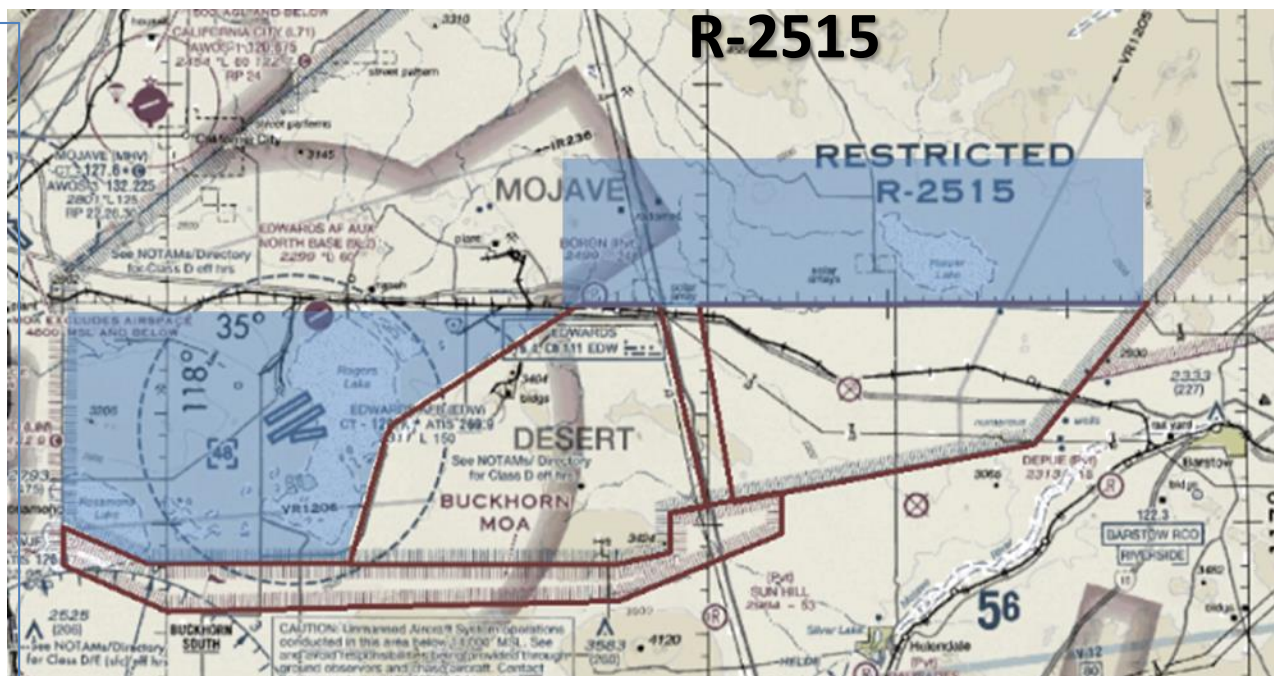
Airspace Extensions (Blue Shaded Areas)
- Conducted early 0600-0800 preferably
- Pre-coordinated 24-48 hours in advance
- Requested real-time with SPORT (after 0700)

Ikhana must remain within R-2515 at all times.   Intruder aircraft can use Buckhorn MOA, plus areas shaded in blue.

- Java Architecture for DAA Extensibility and Modeling (JADEM) software:
  - Subscribes to LVC GW for ownship and intruder flight state data (flight state message).
  - Subscribes to LVC GW for TCAS RA messages.
  - Contains DAA algorithm for conflict detection and resolution.
  - Contains DAA/TCAS interoperability logic.
  - Publishes DAA conflict resolution as heading bands and altitude tape keep out zones.
  - Publishes Well Clear Recovery (WCR) as suggestive guidance.

- Vigilant Spirit Control Station (VSCS) software:
  - Developed by AFRL as an integrated ground control station for command and control of UAS.
  - VSCS Tactical Situation Display (TSD) augmented by AFRL with DAA display elements to support NASA Human Systems Integration (HSI) objectives.
  - VSCS TSD serves as the Cockpit Display for Traffic Information (CDTI) for SSI-West experiment.
  - VSCS TSD displays DAA and WCR guidance produced by JADEM.
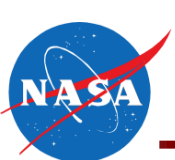 - VSCS TSD displays TCAS RA aural and visual alerts.

WCR
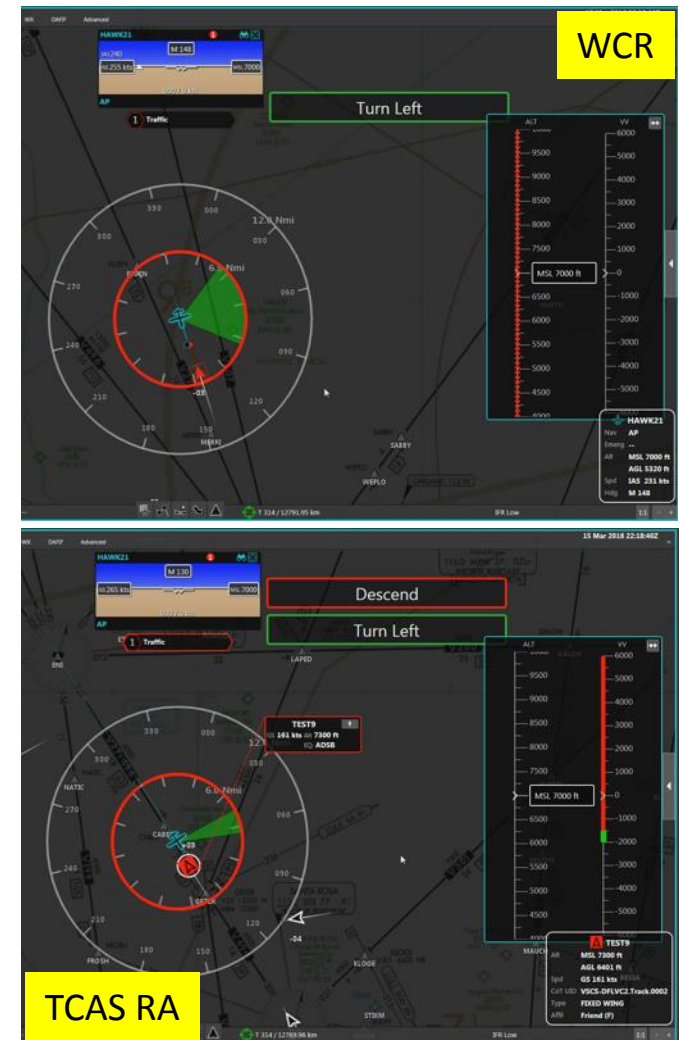
TCAS RA

- ## DAIDALUS:
  - Subscribes to LVC GW for ownship and intruder flight state data (flight state message).
  - Subscribes to LVC GW for TCAS RA messages.
  - Contains DAA algorithm for conflict detection and resolution.
  - Contains DAA/TCAS interoperability logic.
  - Provides DAA avoidance and recovery bands.
  - Provides WCR band.

- ## MACS:
  - Adapted for use as a DAA test bed.
  - Displays DAA guidance from DAIDALUS on generic HSI, VSI, and altitude instruments.
  - VSI DAA bands replaced by TCAS guidance during RAs.
  - Displays WCR band.

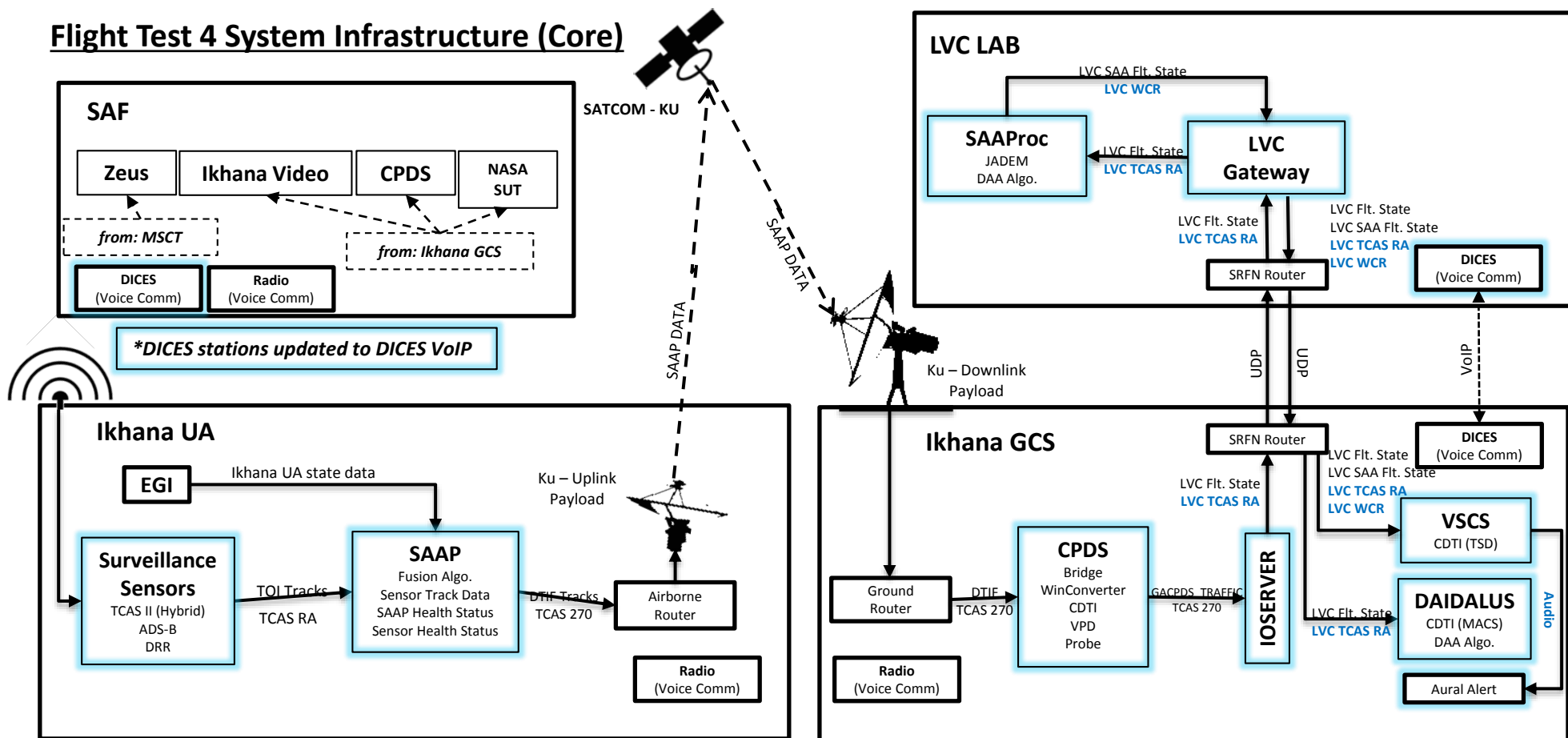Preventive

Avoidance

Warning
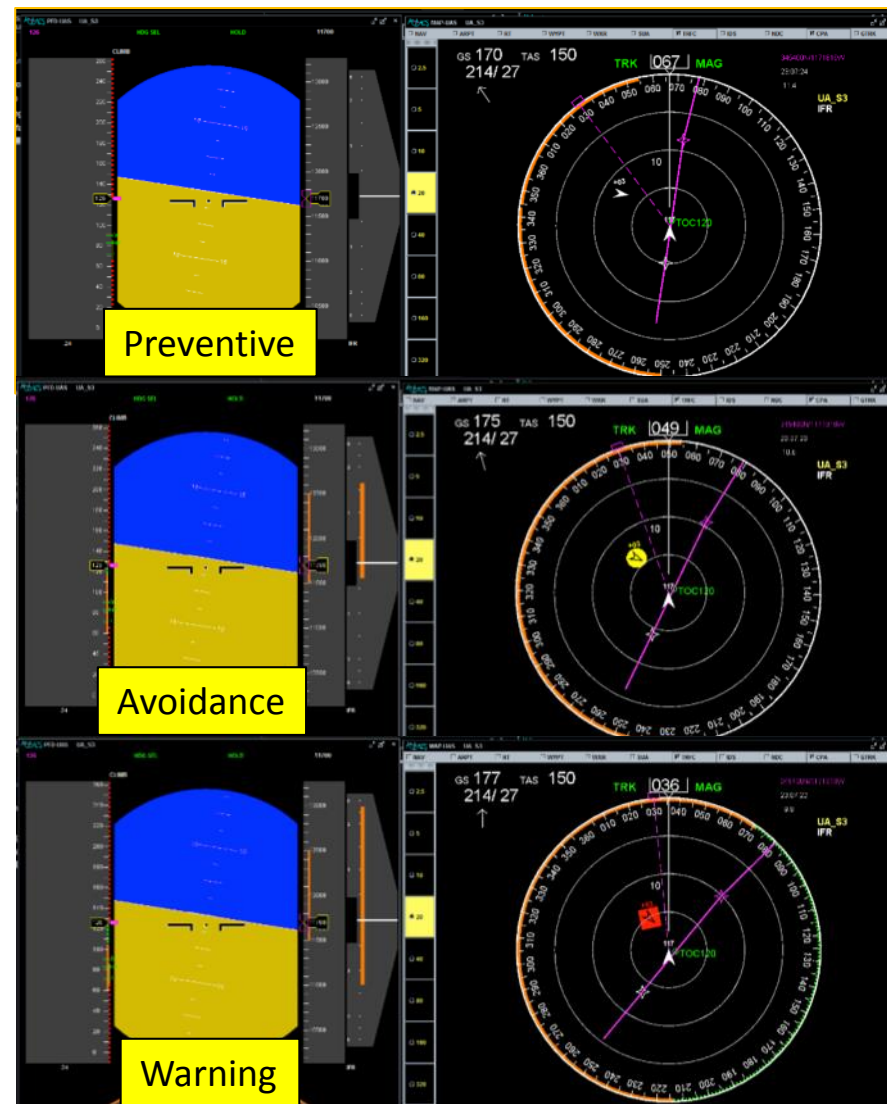
- CPDS:
  - Receives ownship and surveillance tracks from the SAAP.
  - Displays Ownship and Surveillance track data on the CDTI display and VPD.
  - Processes surveillance tracks through its DAA algorithm to create conflict probes displayed on CDTI and VPD.
  - Provides engineering display (Winconverter) with additional data on ownship and intruder.
  - Bridge module provides option to select adding UTC offset to the received A735B with readout to verify offset.
  - Bridge module includes fractional seconds in the time put in to the GA_CPDS traffic topic. Allowing IOServer to forward time.
  - Winconverter proxy panel to suppress certain data to CPDS domain.
  - Winconverter capability to send DAA alerts to HUD (if connected to flight network).
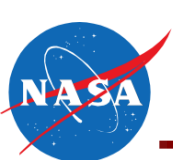 - CDTI added North-up option.

Heading/Track 30°
Abbreviated heading

"No-Go" heading band indicate time until conflict
Yellow: e.g. 120 sec
Red: e.g. 30 sec

Solid probes lie on current flight path,
Transparent probes do not

Ownship-centric with Simplified ownship symbol

Ownship position same as CDTI

"No-Go" altitude band

Traffic Symbol
- Directional (ADS-B)
- Traffic ID
- Relative Altitude
- Vertical Rate Sense

Conflict Probes:
Show pilot when and where conflicts will occur
Yellow: Loss of Separation
Red: Near Mid-Air Collision (NMAC)

Range rings with half forward range displayed; 2/3 of display in front of Ownship and 1/3 behind

Current track displayed to match CDTI

Traffic ID with Probe

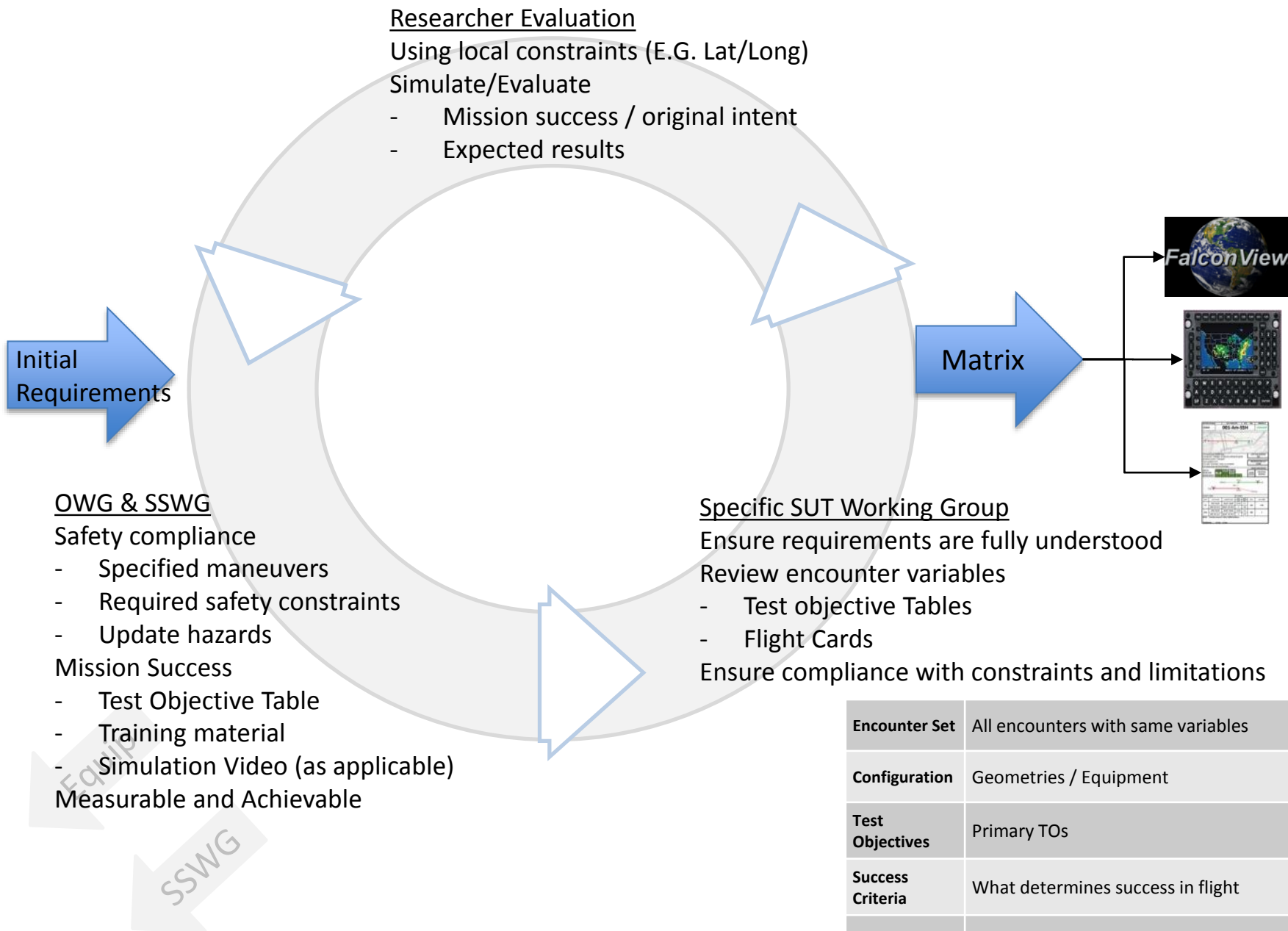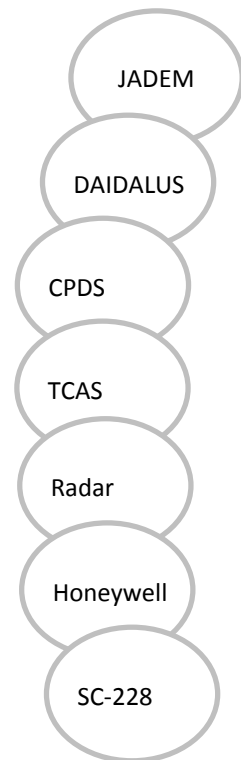Probes that do not intersect current flight path angle are transparent

8131-266-077

FT4 leverages off a core system infrastructure used for ACAS-Xu and FT3 test missions. Major changes to FT4 occur at the software level.

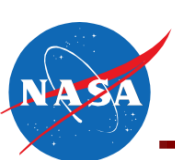# Encounter Planning Process

JADEM

DAIDALUS

CPDS

TCAS

Radar

Honeywell

SC-228

Initial Requirements

Researcher Evaluation
Using local constraints (E.G. Lat/Long)
Simulate/Evaluate
- Mission success / original intent
- Expected results

Matrix

FalconView

OWG & SSWG
Safety compliance
- Specified maneuvers
- Required safety constraints
- Update hazards
Mission Success
- Test Objective Table
- Training material
- Simulation Video (as applicable)
Measurable and Achievable

Equip

SSWG

Specific SUT Working Group
Ensure requirements are fully understood
Review encounter variables
- Test objective Tables
- Flight Cards
Ensure compliance with constraints and limitations

Encounter Set	All encounters with same variables
Configuration	Geometries / Equipment
Test Objectives	Primary TOs
Success Criteria	What determines success in flight
Test Methods	Procedures to achieve success criteria
Evaluation Criteria	Post flight analysis / data collection

Derived from
AFTC Test Planning Guide

Encounter Tolerance Development

ACAS Xu

- Probalistic approach 99.7%
- Min offsets:
  - 200' vertical
  - 0.5 nmi lateral
  - ±5, 8, 10 sec
- Altimeter & navigation calibration
- Mission Rules

FT3

- Deterministic approach
  - Leveraged off of ACAS Xu
- Min offsets:
  - 200' vertical
  - 0.5 nmi lateral
 - ±5, 8, 10 sec
- Altimeter calibration
- Mission Rules
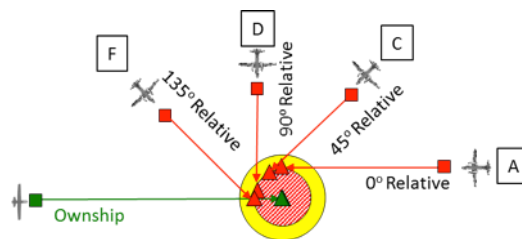
Initial Point (IP)
Maneuver Point (MP)
Closest Point of Approach (CPA)
Lateral Offset = 0.5 nmi
SS Alerting Boundary=0.75 nmi
Minimum Altitude Offset ≥ 200 ft
Priority
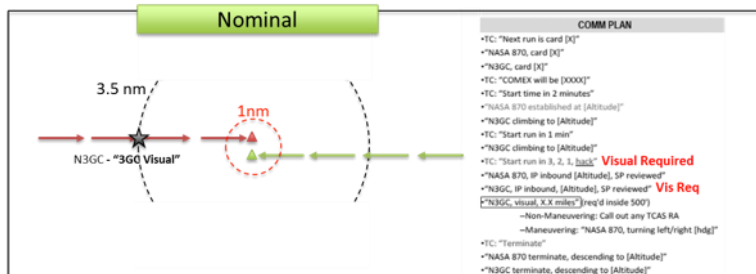
FT4

- Deterministic approach
  - Leveraged off of FT3
- Min offsets:
  - 200' vertical
  - **0.4 nmi lateral**
  - ±5, 8, 10 sec **(DAA Real Time)**
- Altimeter calibration
- Mission Rules
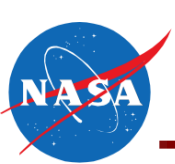

TCAS Interoperability
- Mitigated
- Unmitigated

Initial Point (IP)
Maneuver Point (MP)
Closest Point of Approach (CPA)
Lateral Offset = 0.4 NM
SS Alerting Boundary = 0.75 NM
Minimum Altitude Offset ≥ 200 ft
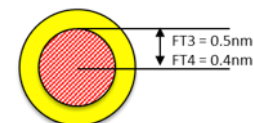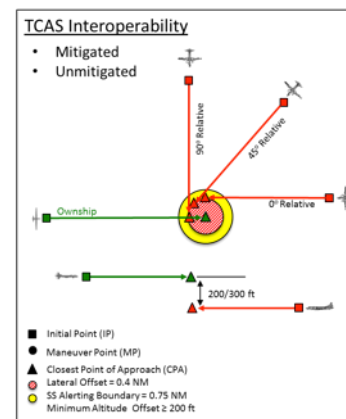
Decreased to 0.4 nm horizontal separation. Required to achieve TCAS alerting below 10K

FT3 = 0.5nm
FT4 = 0.4nm

ACAS – FT3

- High Confidence with ACAS-Xu offsets
- Mission Success criteria closely approximated ACAS-Xu
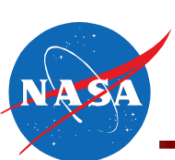- Nav/Cal- not measureable, no added value or increase safety margins

FT3 – FT4

- High Confidence with previous test planning criteria
- Decrease from 0.5 to 0.4 nm horizontal offset for mission success and;
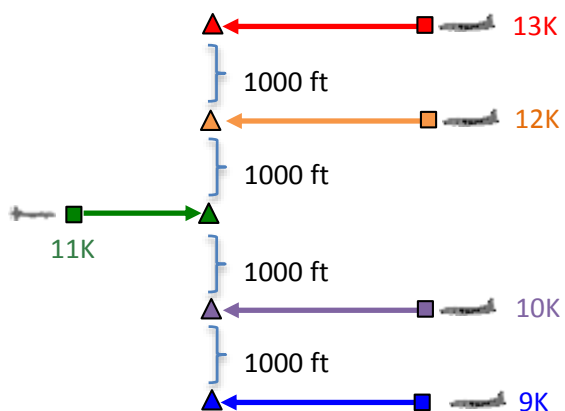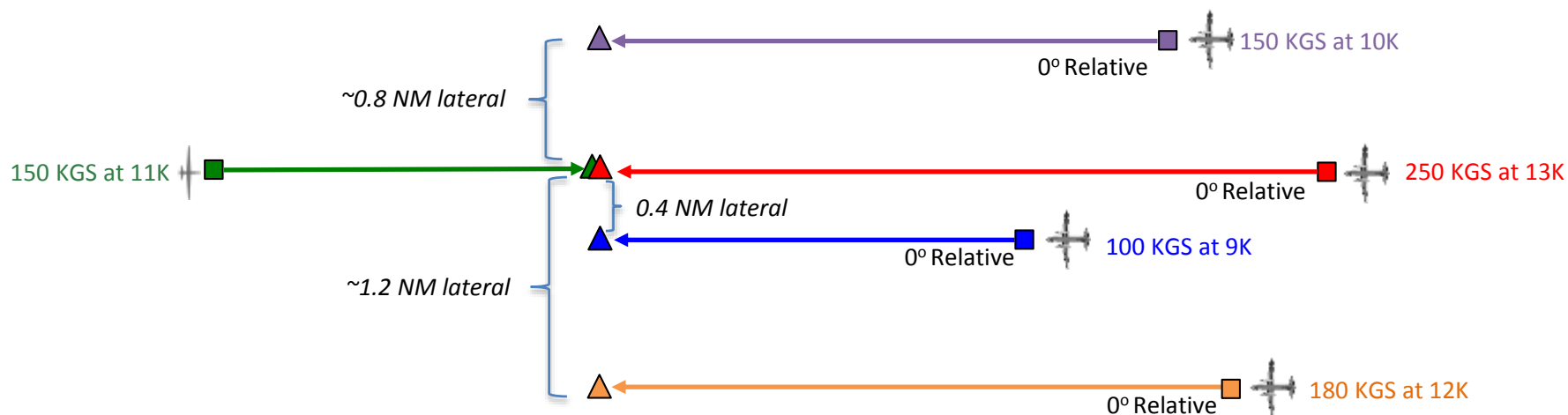- Engineering & crew judgment – min acceptable levels of safety are maintained

- 15 Flights Planned
  - Tuesdays and Thursdays, late April through June
- Up to 6.5 hour flights planned
- Single and Multiple Intruders
  - 1, 2, or 4 manned aircraft
    - Honeywell, NASA AFRC, and/or AF aircraft
- Objectives
  - Using various geometries, closing airspeeds, and altitudes
    - Demonstrate FT-4 system performance
      - Within approved FT-4 test envelope
    - Demonstrate various Self-Separation display systems
      - GA-ASI: Conflict Prediction and Display System (CPDS)
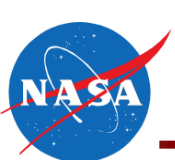   - NASA: JADEM and DAIDALUS

- Mixed speeds
  - Unmitigated

13K (red)

1000 ft

12K (orange)

1000 ft

11K (green)

1000 ft

10K (purple)

1000 ft

9K (blue)

150 KGS at 10K — 0° Relative

~0.8 NM lateral

150 KGS at 11K

0.4 NM lateral

250 KGS at 13K — 0° Relative

100 KGS at 9K — 0° Relative

~1.2 NM lateral

180 KGS at 12K — 0° Relative

■ Initial Point (IP)

● Maneuver Point (MP)

▲ Closest Point of Approach (CPA)

New for FT4
- 4 intruders, but simple fly-through encounter

Ownship Maneuver and Climb
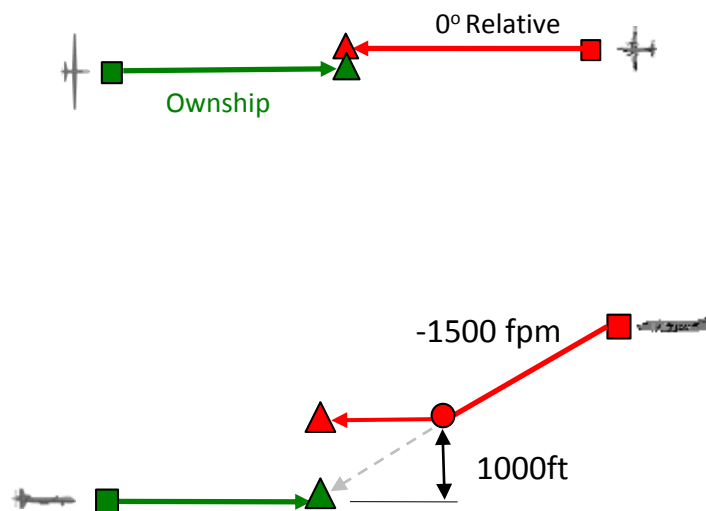
- Mitigated
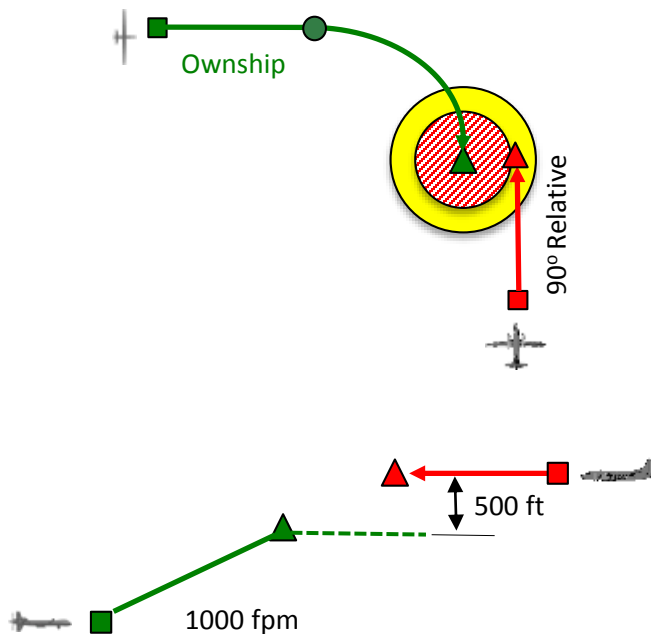
90° Relative

Ownship

500 ft

1000 fpm

- ■ Initial Point (IP)
- ● Maneuver Point (MP)
- ▲ Closest Point of Approach (CPA)
- Lateral Offset = 0.4 NM
- SS Alerting Bo
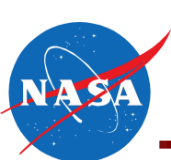- Minimum Alti

**New for FT4
-Ikhana turning and climbing**

Intruder Blunder and Level Off

- Unmitigated

0° Relative

Ownship

-1500 fpm

1000ft

- ■ Initial Point (IP)
- ● Maneuver Point (MP)
- ▲ Closest Point of Approach (CPA)

Same encounter variables as FT3

Card: OWNSHIP (NASA 870)
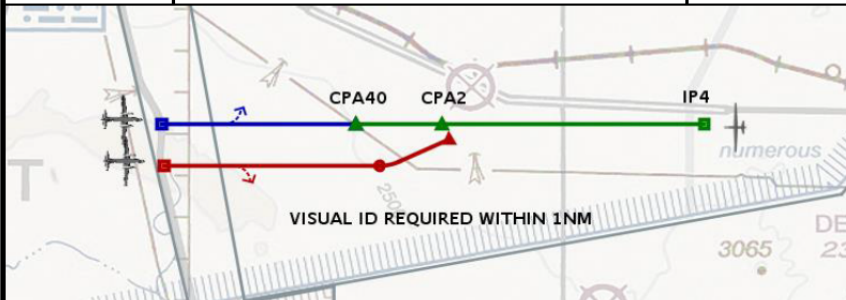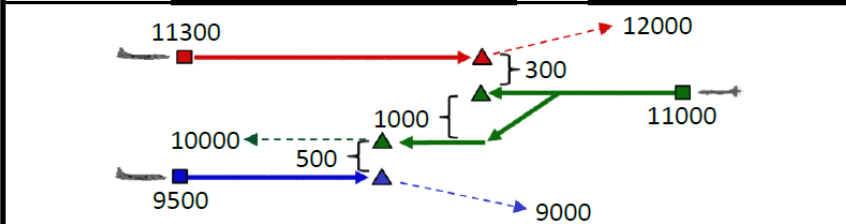
FT4 DAA Scripted	A/C: NASA 870	S/N: 001	VERSION 4

CARD# 001-Am-S5H — OWNSHIP

1. TC announces COMEX time.
2. Announce "<Callsign>, IP Inbound, altitude & special procedure review" crossing IP.
3. On condition at IP.
4. TC calls "terminate" when run complete.
5. TC announces next Card Number.

LOST LINK MISSION: TBD

DECONFLICTION ALT: 15500

DISPLAY:	JADEM	DAIDA.	CPDS
MANEUVER:	OFF	Advisory	AUTO
SENSOR SELECT:	Tracker	Radar	ADS-B	TCAS

ABORT PROCEDURE

15500 — MAINTAIN HEADING

COMEX TIME: **IP WIND:**

WPT	LATITUDE	LONGITUDE	ALT V/V	DIST MC	KGS	LEG TIME
IP1	N34° 55.20'	W117° 14.89'	15500	6.7	200	2+00
	N34° 55' 11.7''	W117° 14' 53.5''	0	258		
CPA2	N34° 55.20'	W117° 23.02'	15500	0.0	200	0
	N34° 55' 11.7''	W117° 23' 01.3''	0	258		

NOTES: Ownship maneuver. Follow JADEM Guidance.

TOLERANCE: ± 8 sec ± 5 kts

Card: INTRUDER 1 (NASA 808)
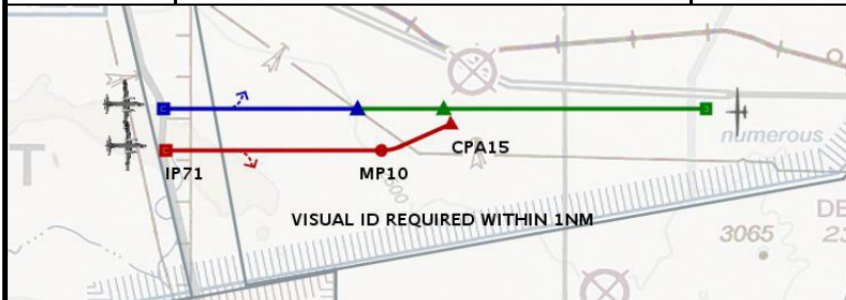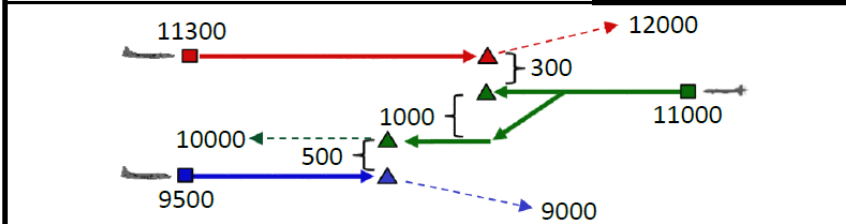
FT4 DAA Scripted	A/C: NASA 808	S/N: 001	VERSION 4

CARD# 001-Am-S5H — INTRUDER 1

1. TC announces COMEX time.
2. Announce "<Callsign>, IP Inbound, altitude & special procedure review" crossing IP.
3. On condition at IP.
4. TC calls "terminate" when run complete.
5. TC announces next Card Number.

DECONFLICTION ALT: 14500

ABORT PROCEDURE

14500   123

COMEX TIME: **IP WIND:**

WPT	LATITUDE	LONGITUDE	ALT V/V	DIST MC	KGS	LEG TIME
IP52	N34° 55.20'	W117° 40.10'	15000	14.0	420	2+00
	N34° 55' 11.7''	W117° 40' 05.8''	0	078		
CPA2	N34° 55.20'	W117° 23.02'	15000	0.0	420	0
	N34° 55' 11.7''	W117° 23' 01.3''	0	078		

NOTES: Expect Ownship maneuver.

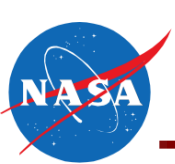TOLERANCE: ± 8 sec ± 5 kts

Multiship Intruder Test Card (1)

OWNSHIP Card

FT4 DAA Scripted	AIRCRAFT: NASA 870	S/N:	47	VERSION 4

CARD# **047-Am-M3M** — **OWNSHIP**

CPA40 CPA2 IP4

VISUAL ID REQUIRED WITHIN 1NM

1. TC announces COMEX time.
2. Announce "<Callsign>, IP Inbound, altitude & special procedure review" crossing IP.
3. On condition at IP.
4. TC calls "terminate" when run complete.
5. TC announces next Card Number.

LOST LINK MISSION:
TBD

DECONFLICTION ALT:
11000

DISPLAY: JADEM | DAIDA. | CPDS
MANEUVER: OFF | Advisory | AUTO
SENSOR SELECT: Tracker | Radar | ADS-B | TCAS

ABORT PROCEDURE

10000	MAINTAIN HEADING

11300 · 12000 · 300 · 1000 · 11000 · 10000 · 500 · 9500 · 9000

COMEX TIME: **IP WIND:**

WPT	LATITUDE	LONGITUDE	ALT / V/V	DIST / MC	KGS	LEG TIME
IP4	N34° 55.20' / N34° 55' 11.7"	W117° 15.71' / W117° 15' 42.3"	11000 / -1000	6.0 / 258	180	2+42
CPA2	N34° 55.20' / N34° 55' 11.7"	W117° 23.02' / W117° 23' 01.3"	10000 / 0	0.0 / 258	180	0
CPA40	W34° 55.20' / N34° 55' 11.7"	W117° 25.44' / W117° 25' 26.2"	10000 / 0	0 / 258	180	0

NOTES: Ownship maneuver. Follow TCAS RA Guidance for Intruder 1. Follow JADEM Guidance for Intruder 2.

TOLERANCE: ± 8 sec   ± 5 kts

INTRUDER 1 Card

FT4 DAA Scripted	A/C: N3GC	S/N:	47	VERSION 4

CARD# **047-Am-M3M** — **INTRUDER 1**

IP71 MP10 CPA15

VISUAL ID REQUIRED WITHIN 1NM

1. TC announces COMEX time.
2. Announce "<Callsign>, IP Inbound, altitude & special procedure review" crossing IP.
3. On condition at IP.
4. TC calls "terminate" when run complete.
5. TC announces next Card Number.

DECONFLICTION ALT:
12000

ABORT PROCEDURE

12000	↘ 123

11300 · 12000 · 300 · 1000 · 11000 · 10000 · 500 · 9500 · 9000

COMEX TIME: **IP WIND:**

WPT	LATITUDE	LONGITUDE	ALT / V/V	DIST / MC	KGS	LEG TIME
IP71	N34° 54.20' / N34° 54' 11.7"	W117° 30.78' / W117° 30' 46.9"	11300 / 0	6.7 / 078	200	2+42
MP10	N° 34' 54.2" / N34° 54' 11.7"	N1° 17' 24.8" / N117° 24' 46.2"	11300 / 0	0.5 / 066	200	0
CPA15	N34° 54.83' / N34° 54' 50.0"	W117° 22.82' / W117° 22' 49.0"	11300 / 0	0.0 / 053	200	0

NOTES: Expect Ownship maneuver.

TOLERANCE: ± 8 sec   ± 5 kts

Multiship Intruder Test Card (2)

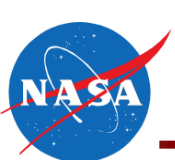# Minimum Separation

- The minimum geospatial offsets planned are 200 feet vertical and 0 foot horizontal (although not simultaneously during any test run)

- Test encounters with a minimum vertical separation of less than 500 feet will include a lateral offset of at least 2430 feet (0.4 nmi)
  - Allows for some built-in safety margin that still meets well-clear volume requirements and test data collection objectives

- Test encounters more than or equal to 500 feet vertical offset may have a 0 foot horizontal offset.

- All participating aircraft will ensure the aircraft altimeter system meets manufacturer calibration specifications and requirements for normal operation in the NAS.

- A maximum of 608 feet (0.1 nmi) navigation error (GPS derived position) is allowed for each aircraft based on the system's built-in navigation accuracy readout.

- T-1: Day before detailed brief
  - Protect crew rest for back-to-back flights possible if back up dates are utilized
- T-0 All: All crew pre-flight delta brief
- T-0 Ikhana: Individual aircraft crew brief, as required
- Each aircraft take-off to arrive within R2515 at required time
  - 0600 ish for Ikhana
- Ikhana and manned aircraft perform altitude calibration, as required
- Prior to each encounter verify encounter, configuration, visual ID requirement, expected behavior, and abort procedures per UAS-NAS encounter cards and Ikhana flight cards

- Execute Encounter
- Between Encounters
  - Maneuver Mode: Advisory/Off
  - Maintain previous encounter deconfliction altitude until laterally separated and as directed by TD for upcoming encounter
  - Configure for next encounter set up
- Execute additional encounters per flight cards
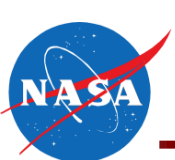- RTB, as appropriate
- Land
- De-brief

FT4 Mission Management Responsibilities

- **Test Conductor**
  - Manages mission execution over voice communication on mission net (VHF radio) with Ikhana pilot, intruder pilots, and SPORT

- **Test Director**
  - Primary liaison with test conductor
  - Manages voice communication on test team net with Ikhana mission director, SOR, LVC, local agencies, and non-local agencies (as required)

- **Mission Directors**
  - Communicates directly with co-located pilots within GCS, test director, and other agencies (as required)

- **LVC**
  - Communicates with test director on test team net to provide real-time discussions on live virtual constructive performance (as required)

- **Senior Operations Representative (SOR)**
  - Independent representative of the Code O director with authority to stop a test if it is deemed that the test team is making unauthorized changes to the briefed test cards, is confronted with unanticipated events that should be addressed on the ground, or other issues that might arise that warrant a test to be stopped and reevaluated in a less dynamic environment than in the middle of a test mission

- **Range Control Officer**
  - RCO monitors and makes coordination calls with Armstrong COMM and the SAF DATR mission system ops folks (as required)
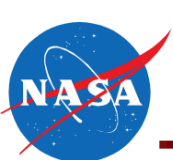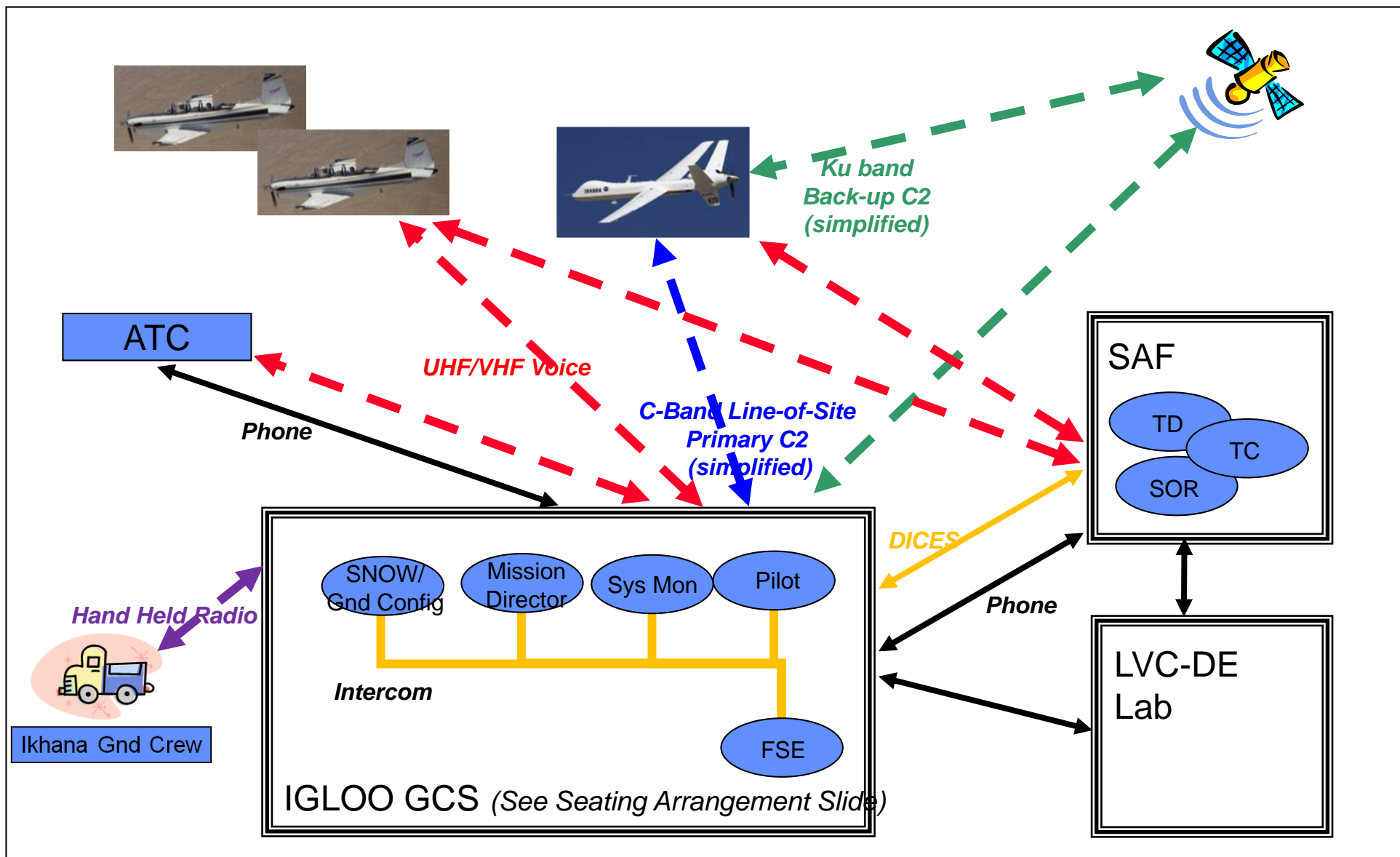
FT4 Mission Support Software
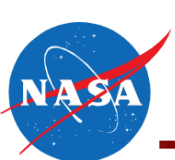

Zeus

- Thales ADS-B receiver integrated

Quicklook 2

- MITLL product in development
- Operates using a stand alone computer
- May be installed prior to FT4
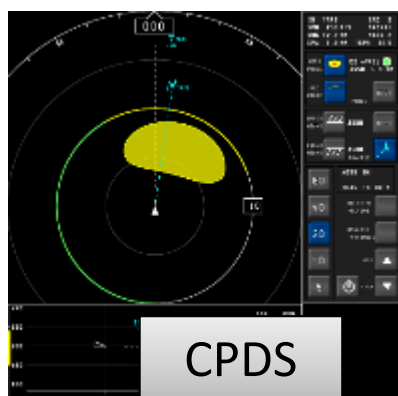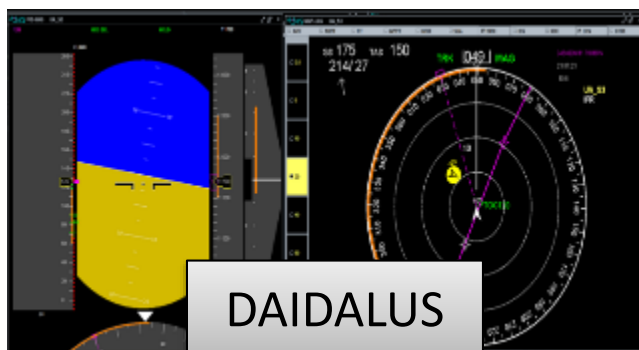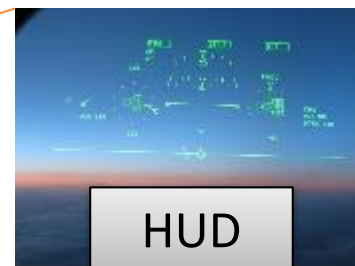- Will not be used as a SA display for FT4

ATC

SAF
- TD
- TC
- SOR

Ku band Back-up C2 (simplified)

UHF/VHF Voice

C-Band Line-of-Site Primary C2 (simplified)

Phone

DICES

Hand Held Radio

Ikhana Gnd Crew

IGLOO GCS *(See Seating Arrangement Slide)*
- SNOW/ Gnd Config
- Mission Director
- Sys Mon
- Pilot
- FSE

Intercom

Phone

LVC-DE Lab

FT4 Displays Under Test

JADEM

DAIDALUS

CPDS

HUD

- DAA Display's are located to the left of PPO-1 Station
- HUD will display TCAS alerting. HDD's display TCAS WCA
- When specifically configured HUD will display DAA and TCAS alerting (Only 1 flight)
- Aural Alerts (Commands and Tone)
  - GCS will annunciate a TCAS alert tone
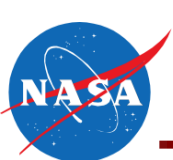 - JADEM SUT will annunciate a TCAS alert commands
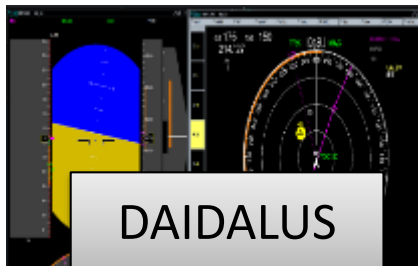
SUT
Aural Alerts

GCS
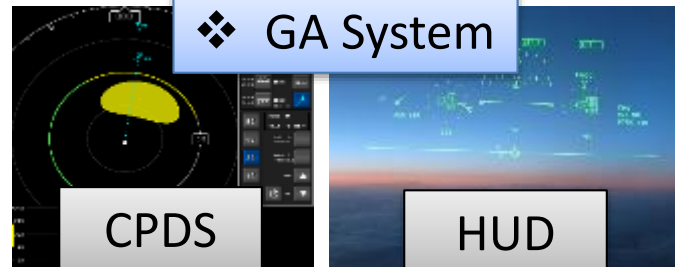Aural Alerts

FT4 Displays Under Test

(Pilot/User centric)

	JADEM	DAIDALUS	CPDS	HUD

FT3 Capabilities

JADEM
DAA Alerts (VSCS)

Descriptive / Directive

Heading Bands
"Turn Heading ###"

DAIDALUS
DAA Alerts (VSCS / DAIDALUS Display)

Descriptive

Heading Bands

CPDS / HUD
DAA Alerts — TCAS Alerting

Descriptive — Directive

Lateral & Vertical — Vertical

GCS Tone

FT4 Similarities

JADEM
DAA Alerting (VSCS)

Descriptive

Heading Bands

DAIDALUS
DAA Alerting (DAIDALUS Display)

Descriptive

Heading Bands

CPDS / HUD
DAA Alerts — TCAS Alerting

Descriptive — Directive

Lateral & Vertical — Vertical

GCS Alerts

FT4 Differences

JADEM
DAA Alerting — TCAS Alerting

Descriptive — Directive
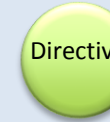
Vertical Bands
WCR — Vertical Commands

Aural Alerts

DAIDALUS
DAA Alerting — TCAS Alerting

Descriptive — Directive

Vertical Bands — Vertical Commands

Aural Alerts (May be muted)

CPDS / HUD
TCAS Alerting
Additional commands available

Descriptive / Directive

DAA alerts displayed on HUD
for 1 flight.
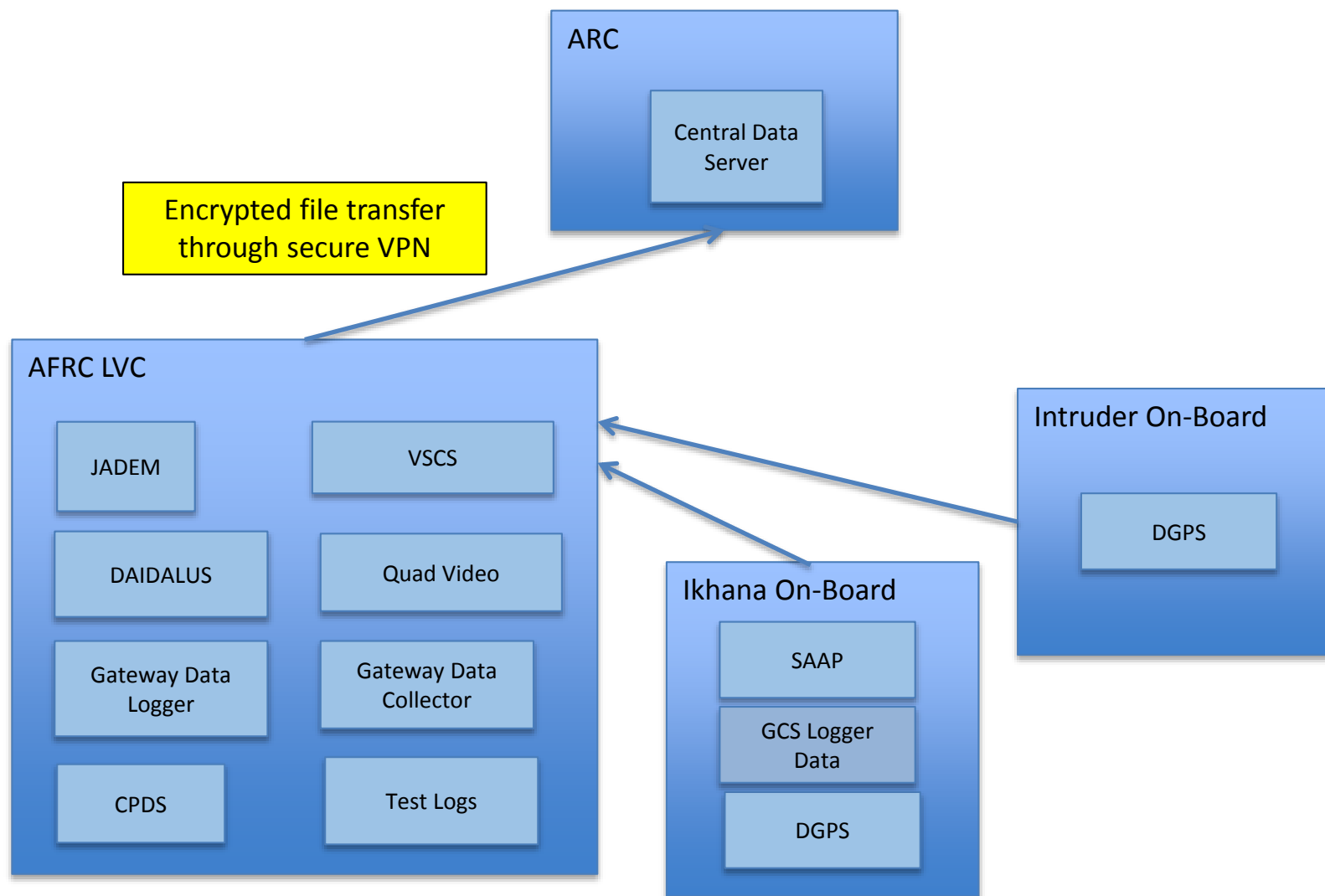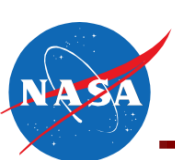
GA System
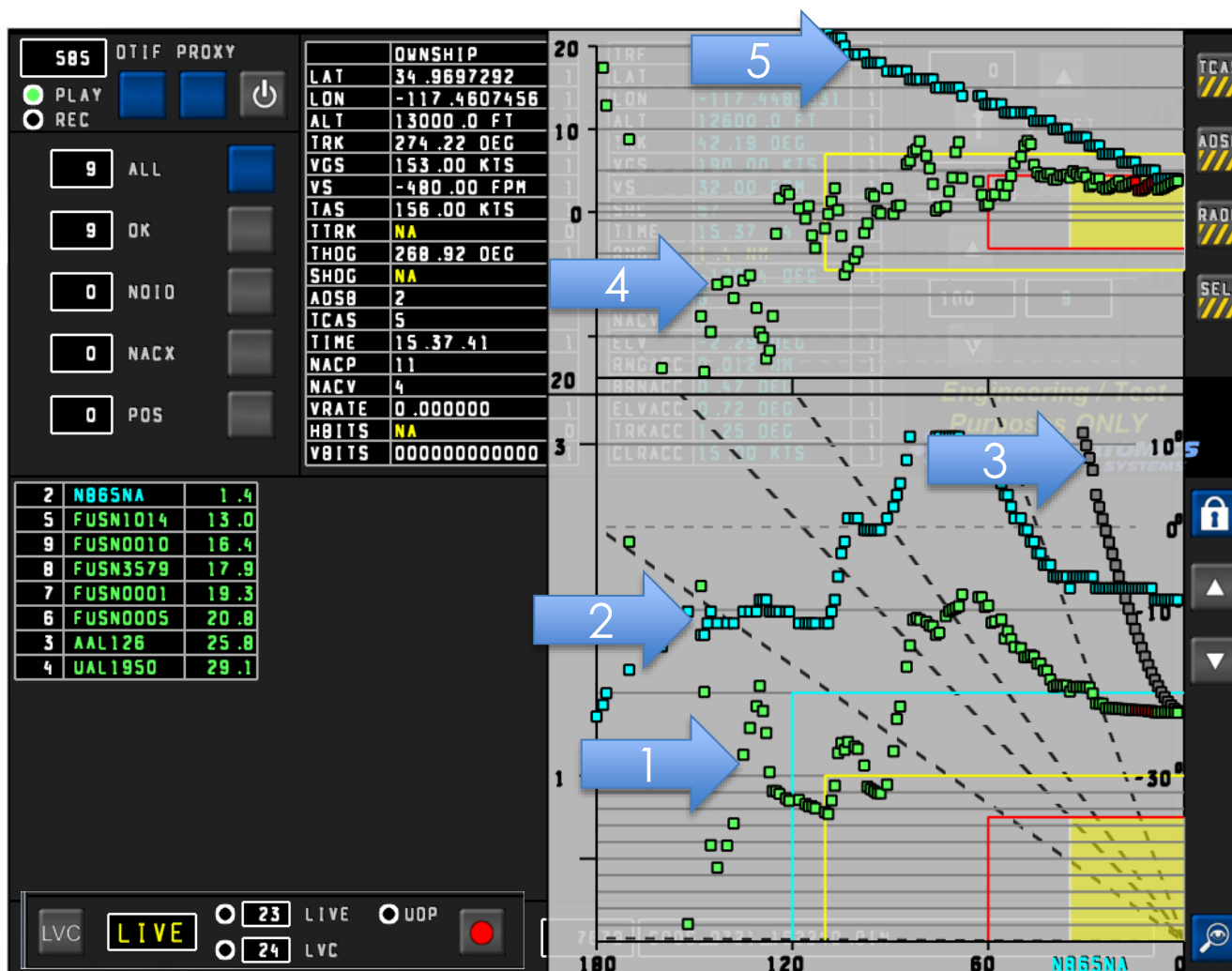
*DCPA: Distance at Closest Point of Approach

Configuration: RUMS

Configuration: Video Streaming
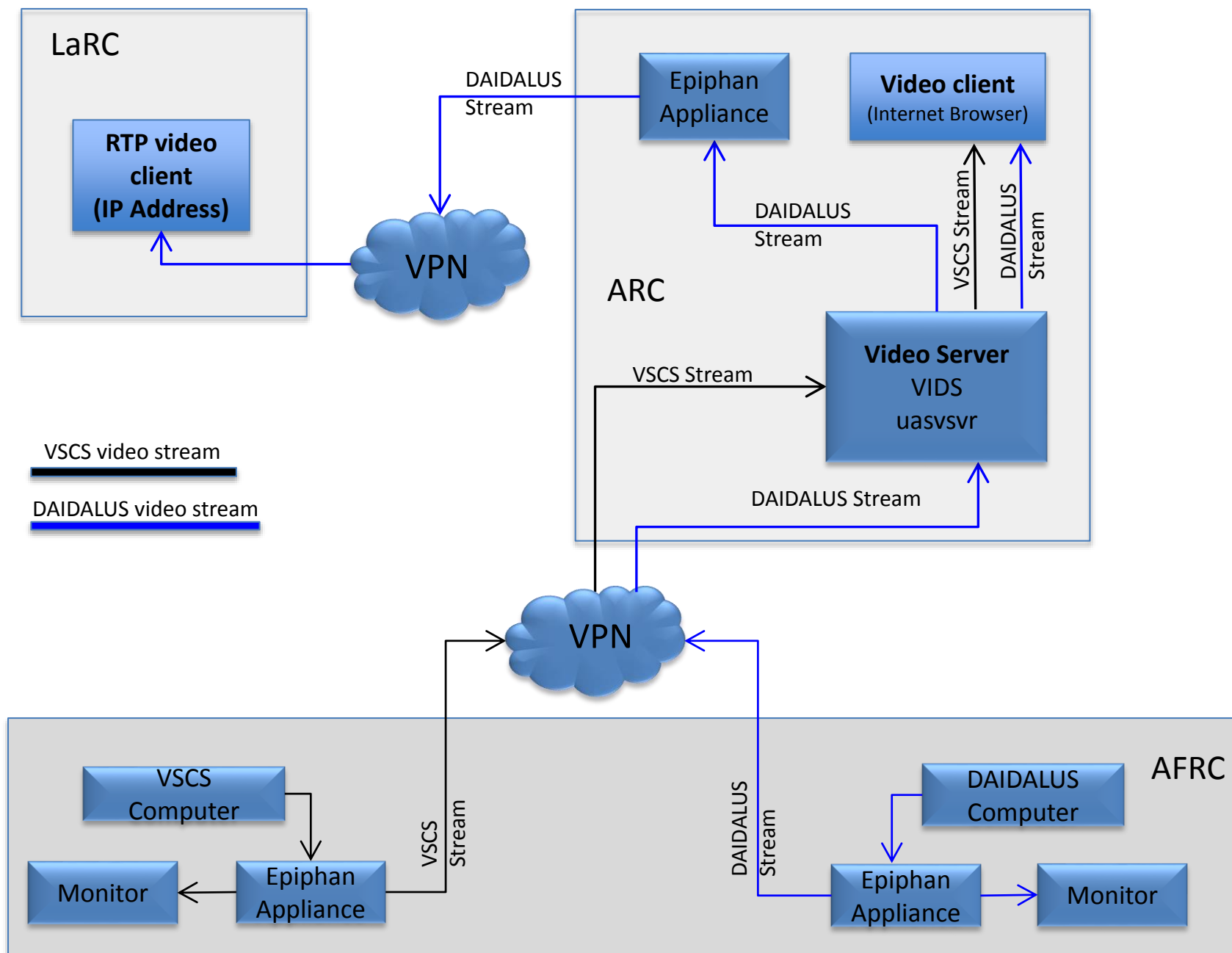
Reference: Flight Test Series 4 Data Management Plan, FT4 IT&E DMP-001
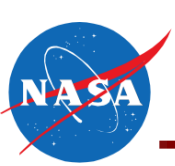
Flight Test 4 Flight Schedule

- Seeking approval from Tech Brief Board to fly FT4 Flight Test Series using current available integrated and tested version of LaRC provided DAIDALUS software.
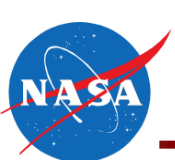
FT4 Plan A (Baseline Version of DAIDALUS only)												
	April				May					June			
	4 - 8	11 - 15	18 - 22	25 - 29	2 - 6	9 - 13	16 - 20	23 - 27	30 - 3	6 - 10	13 - 17	20 - 24	27 - 1
Sys Check Flts	██												
Env Exp/Training		██											
JADEM Flts				██	██								
Radar Flts						██	██						
CPDS Flts						██							
TCAS Flts							██						
HW Flts								██					
SC-228 Flts						██		██					
DAIDALUS Flts									No Fly (3-day wk)	██	██	██	

- LaRC working to update DAIDALUS software (final version) to be able to flight test with final version.
- Project approach:
  - Software needs to be delivered by 5/23 in order to meet FT4 completion milestone (L1) of 6/30/16.
  - 2-3 weeks of regression testing
  - Mini-tech updates
  - Complete DAIDALUS flights at the end of June

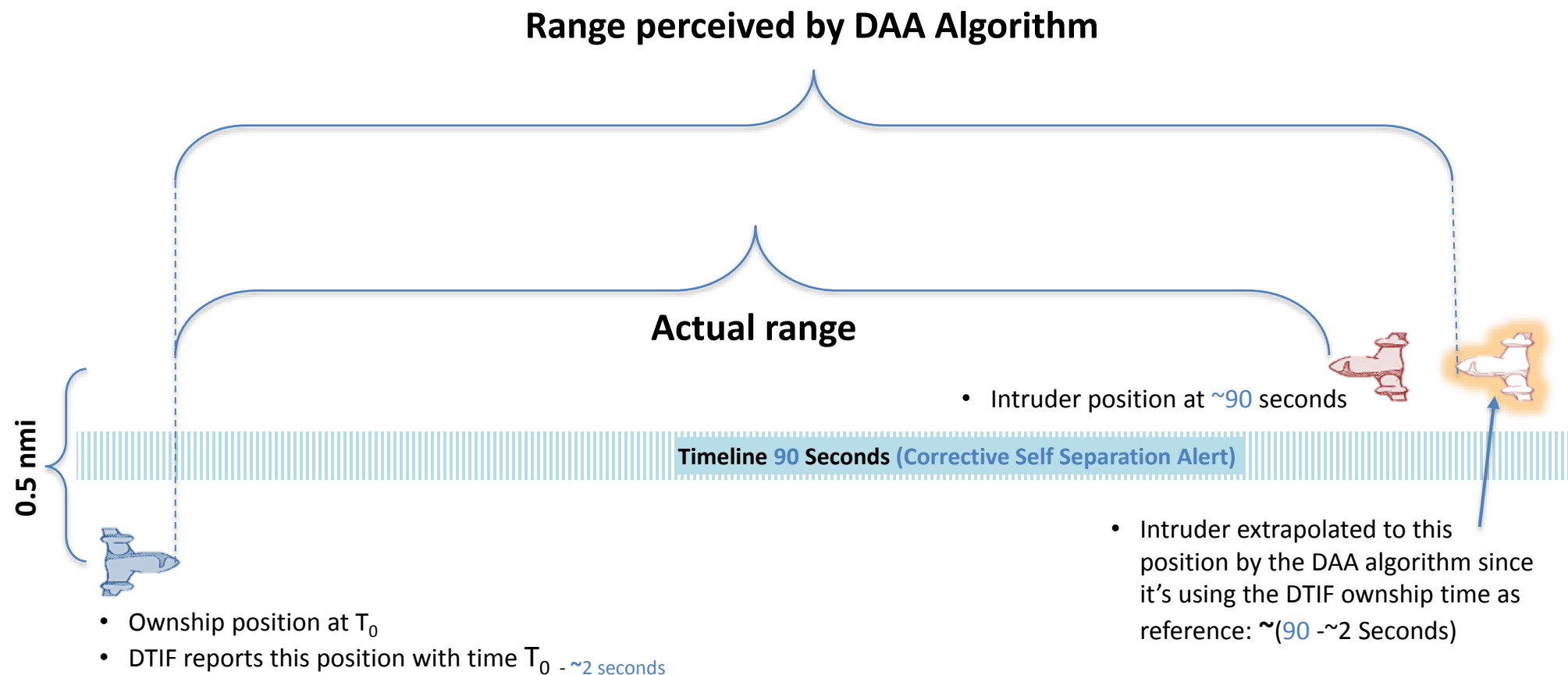| FT4 Plan B (Final Version of DAIDALUS available by May 23)												
	April				May					June			
	4 - 8	11 - 15	18 - 22	25 - 29	2 - 6	9 - 13	16 - 20	23 - 27	30 - 3	6 - 10	13 - 17	20 - 24	27 - 1
Sys CheckFlts	██												
Env Exp/Training		██											
JADEM Flts				██	██								
Radar Flts						██	██						
CPDS Flts						██							
TCAS Flts							██						
HW Flts								██					
SC-228 Flts						██		██					

Backup Charts

Background Information

- During the FT3 Data Review, the IT&E co-PE from Ames identified a timing discrepancy in the ownship 1 Hz message containing position data (latitude, longitude) from Ikhana when compared to:

  – 10 Hz & 50 Hz ownship messages on Ikhana

  – Independent GPS data from Ikhana
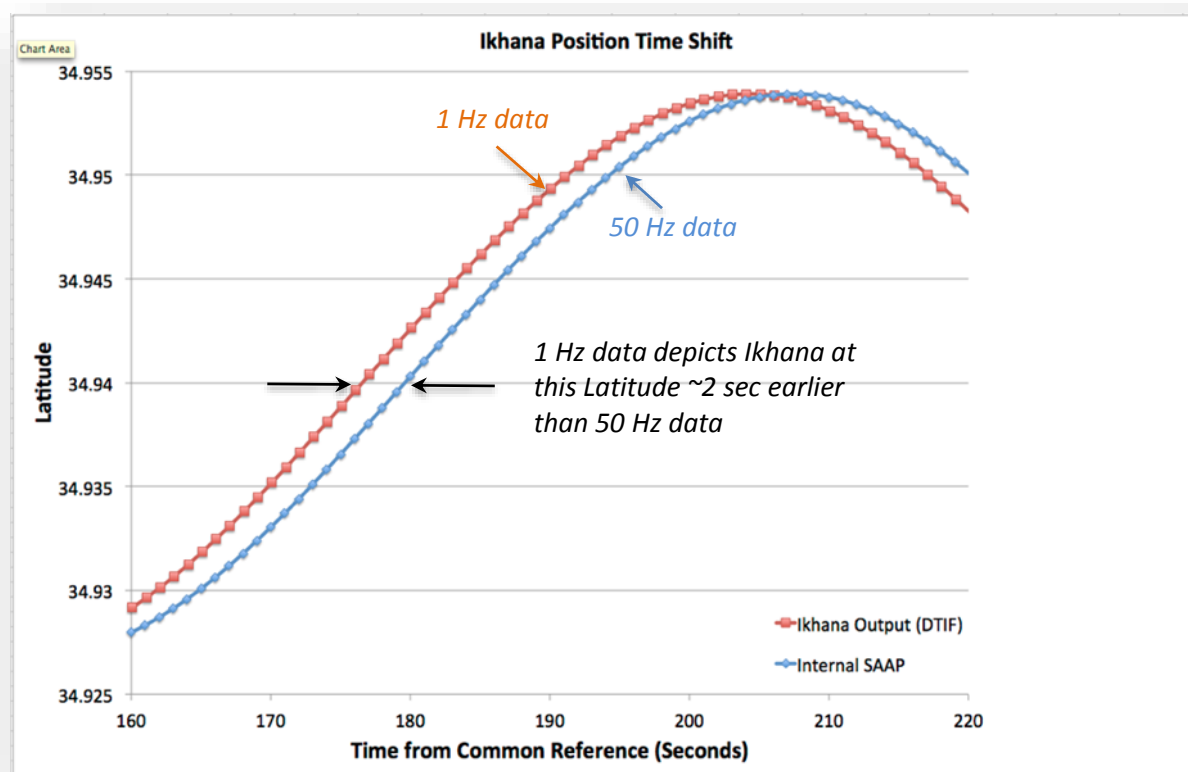
Graphs from Jim Murphy presentation 'FT3_data_analysis_v7.pptx'

Representation of Timing Discrepancy

Range perceived by DAA Algorithm

Actual range

- Intruder position at ~90 seconds

0.5 nmi

Timeline 90 Seconds (Corrective Self Separation Alert)

- Intruder extrapolated to this position by the DAA algorithm since it's using the DTIF ownship time as reference: **~**(90 -~2 Seconds)

- Ownship position at T_0
- DTIF reports this position with time T_0 -~2 seconds

Data Collection Archiving

GA

Dropbox (SAAP)

Dropbox (CPDS)

Encrypted file transfer through https protocol

Separate Dropbox used for CPDS data to allow Foreign National Stakeholder access CPDS data

AFRC LVC

CPDS

Quad Video

Intruder On-Board

DGPS

Ikhana On-Board

SAAP

DGPS

Reference: Flight Test Series 4 Data Management Plan, FT4 IT&E DMP-001

Reference: Flight Test Series 4 Data Management Plan, FT4 IT&E DMP-001