

The logo for the Air Force Aircraft Test Squadron (VX-20) is a circular emblem. At the top, a yellow banner contains the text "AIR FORCE AIRCRAFT TEST SQUADRON" in blue. The center features a stylized aircraft in flight, with a red and white fuselage and a yellow tail, set against a blue background. Below the aircraft is a green and blue map of the world. At the bottom, a yellow banner contains the text "VX-20" in blue.

# **Navy "Big Wing" Flight Test Update and Lessons Learned**

## **Air Test and Evaluation Squadron TWO ZERO VX-20**

**Brief for SETP Flight Test Safety Workshop**

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# Purpose

**Summarize flight test efforts of the Navy's "Big Wing" Developmental Test Squadron, VX-20, to include:**

- Past, Present and Future Programs
- Risk Management Principles
- Emphasis on Lessons Learned/Re-learned
- Topics unique to developmental testing of large, multi-crew fixed wing aircraft



# Air Test and Evaluation Squadron TWO ZERO

- Developmental Flight Test Squadron
  - NAS Patuxent River, MD
  - 425 members - Military, Civil Service, Contractors
  - FTE's from the Integrated Systems Evaluation, Experimentation and Test Dept (ISEET)
  
  - Land and Carrier based fixed-wing aircraft
    - 21 a/c of 11 unique T/M/S
    - CY05 - 105 Test Plans, 90 amendments, 23 Support Plans
    - Operations - 4,390 Flight hr - 1,902 Sorties

# VX-20 Aircraft Inventory



**E-2C**



**P-3**



**C-2A**



**T-34**

**Full Spectrum Flight Test for the Fleet**



**C-130**



**RQ-4A**



**T-6A**



**E-6B**



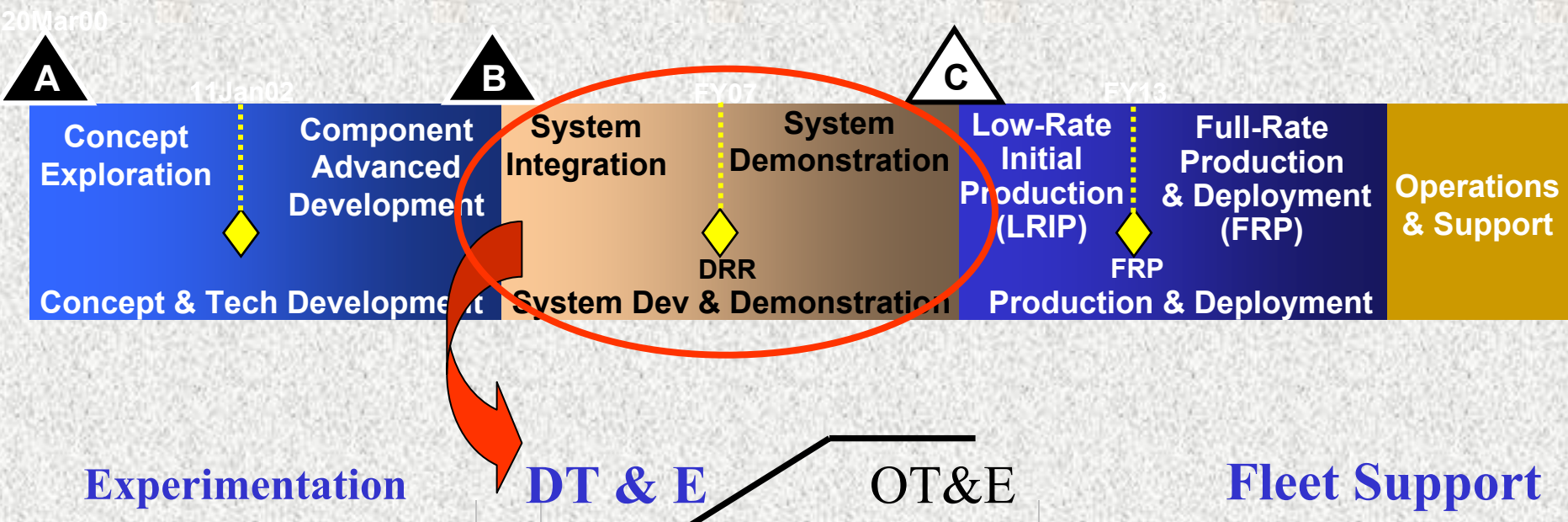
# Air Test and Evaluation Squadron TWO ZERO

- Mission areas evaluated
  - Anti-Submarine and Anti-Surface Warfare
  - Maritime Patrol and Armed Reconnaissance
  - Tactical Electronic Warfare
  - Airborne Early Warning
  - Carrier Onboard Delivery
  - Strategic Communications and Airborne Command Post
  - Transport and Logistics
  - Aerial Refueling
  - Primary, Intermediate and Advanced Flight Training
  - Unmanned Persistent Intelligence, Surveillance and Reconnaissance.



# What we do

**“FULL SPECTRUM FLIGHT TEST FOR THE FLEET”**



## ■ Customers

- The Fleet!!!! (via PMA, PMS, PMW, others)
- Other DoD Services
- Other Govn't agencies



# Air Test and Evaluation Squadron TWO ZERO

- Flight test projects cross the spectrum of RDT&E activities
  - Flying Qualities, Structures and Air Vehicle Performance
  - Propulsion System Upgrades
  - Weapon Carriage and Employment
  - Mission Systems Evaluation
  - Sensor and Weapons Systems upgrades
  - Full T&E of complex major defense acquisition programs
  - ACTD, Experimentation
  - CONOPS/Tactics Development

# Recent Projects

## E-2

- **In-Flight Refueling Demonstration**
- **Advanced Hawkeye Loads Risk Reduction Flight Test**
- NP2000 DT Complete. Fleet installation ongoing.
- NP2000 Electronic Propeller Control Software Evaluation
- Group II Mission Computer Replacement
- Mission Computer COTS Insertion Hardware Integration
- Ship Suitability Tests of MC COTS H/W Insertion & C/P Bezel Lighting
- S/W Upgrades: Multi-Function Control Display Unit, SCS-05, CEC
- Sea Power 21 Experimentation Initiatives
  - ◆ DARPA Tactical Targeting Network Technology Demo
  - ◆ Joint Expeditionary Forces Experiment/Trident Warrior
- Universal Automatic Identification System
- Low Light Level Illumination Propeller Paint System
- Joint Mission Planning System - Maritime
- Terrain Feature Upgrade to the Garmin GNS-530
- Taiwan AF E-2T Hawkeye 2000 MCU/ACIS S/W & Data Link



## C-2

- **NP2000 Baseline Flight Test and Ground Tests (New Propeller)**
- Preparing for NP2000 Flight Test
- Aircraft Wireless Intercommunication System
- Low Probability of Intercept Altimeter
- CNS/ATM
- Rewire



# Recent Projects



## E-6B

- **E-6B Level-D Equivalent Simulator (ELDES) Data Collection**
- Multifunction Display System Red Label 18 S/W Flight Test
- Automatic Data Processing (ADP) Demand Assigned Multiple Access (DAMA) & Common Avionics Flight Deck Communications Capabilities with Weight & Space Savings
- Block I
- Lower Lobe Smoke Detection Evaluation
- E-6B Ultra Low Maintenance Battery Evaluation
- E-6B Operator Workload Baseline
- E-6B MA-16 Inertial Reel Restraint System Evaluation

## KC-130/C-130

- Variable Drag Drogue
- Electronic Propeller Control System (C/KC-130)
- Aerial Refueling Drogue Response Test
- CDI-MU Control of Legacy AR POD/Pylon (Phase 1.5)
- AN/AAR-47V(2) Sensor Evaluation and Characterization
- ALE-47 Aircraft Systems Interface
- Night Vision Imaging System Mod for Com/Nav/ID Displays
- Block 5.3.8 Software Regression Testing
- Flight Simulator Evaluation
- NC-130H Navigation System Data Collection
- USCG C-130J Joint Tactical Aircraft Maritime Mission System



# Recent Projects

## P-3

- First ever “Level 5” control of UAV from an aircraft (Launch, Recovery and sensor employment)
- Sonobuoy Launched Unmanned Aerial Vehicle S&T Demo (inwork)
- Digital Autopilot System
- ASX-6 FLIR/EO System
- AN/ALR-95(V)2 ESM System
- AN/APS-137D(V) 5 Radar Processor Upgrade
- Communication Navigation Surveillance/Air Traffic Management Upgrades
- Ultra Electronics Ltd. Propeller Balance Monitoring System
- Health Monitoring System / Engine Instruments Display System (EIDS)
- AN/ALE-47 IRCM Effectiveness and MJU-57/B Flare Separation
- CNO Special Projects
- VXS-1 NP-3D Airworthiness Demo with SAR Radome
- VXS-1 NP-3D ALE-56 Mongoose CMDS and AAR-47 MWS Functional Test
- Acoustics (Multi-static Active ASW Rapid Deployment Kit, Battle-Space Tactical Environmental Characterization, AN/AQH-13(B) Acoustic Data Recorder/Reproducer Hard Disk, SSQ-125 Air Deployed Low Frequency Projector)
- Successful live fire test and SLAM-ER envelope expansion for P3
- Mission Systems S/W upgrades (ASQ-227 4.3, ASQ-222 4.3 and USQ-78B 2.0)
- Bandwidth Efficient Advanced Modulation Technology w/ AN/ARC-210 Model 1851C Transceiver
- FMS Assistance for Dutch, Norwegian and Thai P-3's



## EP-3E

- integrated Electronic Attack capability on SIGINT aircraft
- Radio Antenna Pattern Test
- JMOD Common Configuration Spiral One
- Prototype SATCOM Improvement
- SSIP FI-4.0\



# Recent Projects

## ■ T-6

### • Radial Tire Suitability

- Avionics Upgrade Program Qual Eval
- KTA 815 Traffic Advisory System
- Instrument Displays during Attitude Heading and Reference System failure
- Flight Evaluation of Oxygen Regulator Upgrades
- OBOGS Qualification
- Chase, target and pilot proficiency support for numerous platforms

## ■ T-34

- Chase, target and pilot proficiency support for numerous platforms, including H-1 and V-22 programs.
- Simulator overhaul (new comprehensive aero model)

# Recent Projects

## Commercial Derivative Aircraft

- UC-12B
  - ◆ Gyro Cam Triple Sensor Airworthiness Evaluation
  - ◆ Imaging Sensor Characterization and Demo
  - ◆ Multi-role Adaptable Transceiver Demo
- T-44A
  - ◆ Avionics Upgrade (APS-3000 Flight Control System)
- C-37B
  - ◆ CNS/ATM Upgrades
- RC-26D
  - ◆ AN/APS-140 Radar for the Range Clearance Mission
  - ◆ RC-26 Mission System Integration and test
- C-20A
  - ◆ Communications Suite Integration and test
- C-9
  - ◆ Radar Cross Section
  - ◆ Engine Hush Kit ground and flight test



# Recent Projects

## ■ S-3B

- AN/AAQ-25 LANTIRN Targeting POD and Data Transmission System
- Surveillance System Upgrade Phase III mods and fleet deployment
- Maverick Plus System Follow-on testing
- B4.6A Mission System Tactical Software (ADA)
- Replacement Pitch Rate Sensor qualification testing with F/A-18E/F tanker
- Communication Improvement Program
- APS-137 Radar and AYK-23 Gen Purpose Digital Computer Interface Data Capture
- Mass Memory Unit (MMU)

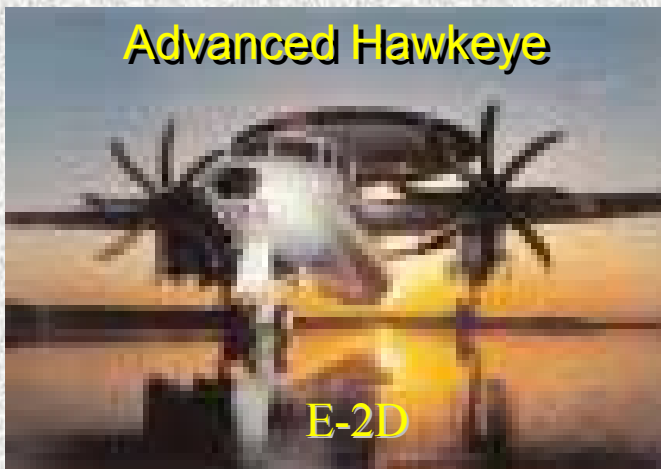
# Recent Projects



- RQ-4A Global Hawk Maritime Demonstration
  - Sensor Characterization – Maritime Modes
  - Trident Warrior 05 Experiment
  - JEFX 06 Experiment
  - CONOPS/Tactics Development iso BAMS
    - ◆ Persistent HALE ISR UAV – augment manned ISR

# A Look to the Future

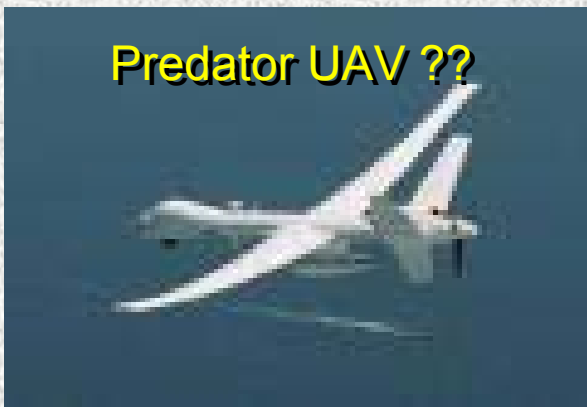
Advanced Hawkeye



Multi-mission Maritime Aircraft



Predator UAV ??



BAMS



LTA ??



# Risk Mitigation Principles

## ■ Test Planning

- Project Planning Memorandum (PPM), Test Team Reviews, Technical & Risk Assessment (TRA), Executive Review Board (elevated risk testing) , Leadership Approval
  - ◆ Team Members, Subject Matter Experts, Leadership, Safety Officer
  - ◆ Independent Safety Monitor for Cat C tests
- Test Hazard Analysis
- Safety Checklists

## ■ Training

- Aircrew, Test Conductor, Ground Station, OJT
- Rehearsals / Dry Runs / Sims / EP's

## ■ Test Conduct

- FTEs in ground station obligated to make KIO calls
- Emphasis on the “No Vote”
- CTP/CTE briefed on observed anomalies
- Practice ORM / CRM Principles
- Daily Flight Reports



# E-2C / F/A-18E/F In-Flight Refueling Feasibility Demonstration

## ■ Evaluate Preliminary Engineering Concept

- Refueling Probe
- Structural Impacts
- Flying Qualities

## ■ Approach

- Research Previous T&E Efforts
  - ◆ C-2A IFR – 1981
  - ◆ Foreign Air Force E-2 – 1990's
  - ◆ Other F/A-18E/F Tanker Programs
- Engineering/Analysis
  - ◆ CFD- Exhaust plume/rotodome and tail interaction
  - ◆ Preliminary assessment was not favorable
  - ◆ Flight clearance/Test limits

## • Instrumentation

- ◆ Balance cost, schedule, adequacy
- ◆ Temperatures, pressure, accelerations and strains

## • Test Flight Buildup

- ◆ Day F/A-18 IFR qualification
- ◆ KC-130 dry plugs
- ◆ F/A-18E/F Wake Survey 500 ft aft to pre-contact

## • F/A-18E/F dry plugs

- ◆ Qualitative evaluation of flying qualities, field of view, noise & vibes
- ◆ Monitor temperatures, pressures, accelerations and strains
- ◆ Exceeded KIO Temp limits first plug
- ◆ IR sensor on support a/c used for plume proximity KIO on remaining flights





# Lessons (Re)Learned

## E-2C IFR Demo

- Feasibility Demonstration
  - Benefits
    - ◆ Arms PM with data necessary to make programmatic decisions
    - ◆ Identifies technical issues to be addressed in follow-on program
  - Challenges
    - ◆ Limited budget and compressed schedule
    - ◆ Right balance of analysis, instrumentation, previous test data (if available) and buildup (including training)
- Considerations
  - Preliminary analysis based on conservative assumptions is a good planning tool, but should be refined as actual data is collected
  - Previous data is usually better than new analysis
  - Test limits, based on worst case analysis and conservative engineering assumptions, can result in an unexecutable test plan, limited data, excessive RTBs, and difficult to resolve inspection criteria
  - Seek alternative methods for KIO criteria
  - If results are favorable and follow-on tests are expected, plan to maintain pilot proficiency

# ELDES: “E-6B Level-D Equivalent Simulator”



- Program Objectives
  - Build a simulator that
    - ◆ functionally meets FAA “Level D” specifications
      - Not just FAA specs
      - Navy-specific requirements
      - BuNo specific – matches one particular airplane
      - replaces on-airplane training with ground-based simulator training
  - Collect the flight test data required to build this simulator

# ELDES Plan

- 9 month test, >1000 test points
- Many risk, cost and schedule tradeoffs
- Schedule pressure from Day 1
- Challenging Big Wing Test Points
  - Vmcg (Minimum Control Speed, Ground)
  - Critical Engine Failure on Takeoff
  - **Minimum Rotate / Minimum Liftoff Speed**
  - **Heavy-weight Rejected Takeoff (>320klb)**
  - Engine Out Stall testing



# E-6B ELDES Test Incidents

Rejected TO – Thermal Fuse Melt



Minimum Rotate – Tail Scrape



# Lessons (Re)Learned

## Rejected TO – Thermal Fuse Melt

What happened



Heavy-weight Rejected Takeoff

Lesson Learned

Flight Manual brake Limitations charts may not be as conservative as expected. Brief the hazard and be prepared for the possibility. Proper planning (event sequencing) can minimize the impact on test program.



# Minimum Rotate Tail Scrape NAVY AIR

- 10 May 05 – 1st attempt – Difficult to get. Elevator not fully deflected.
- 16 June 05 – 2nd attempt – tail scrape incident occurred.
  - Not detected by aircrew until post-flight.
  - Approx. 2 hrs of testing took place after the tail strike.

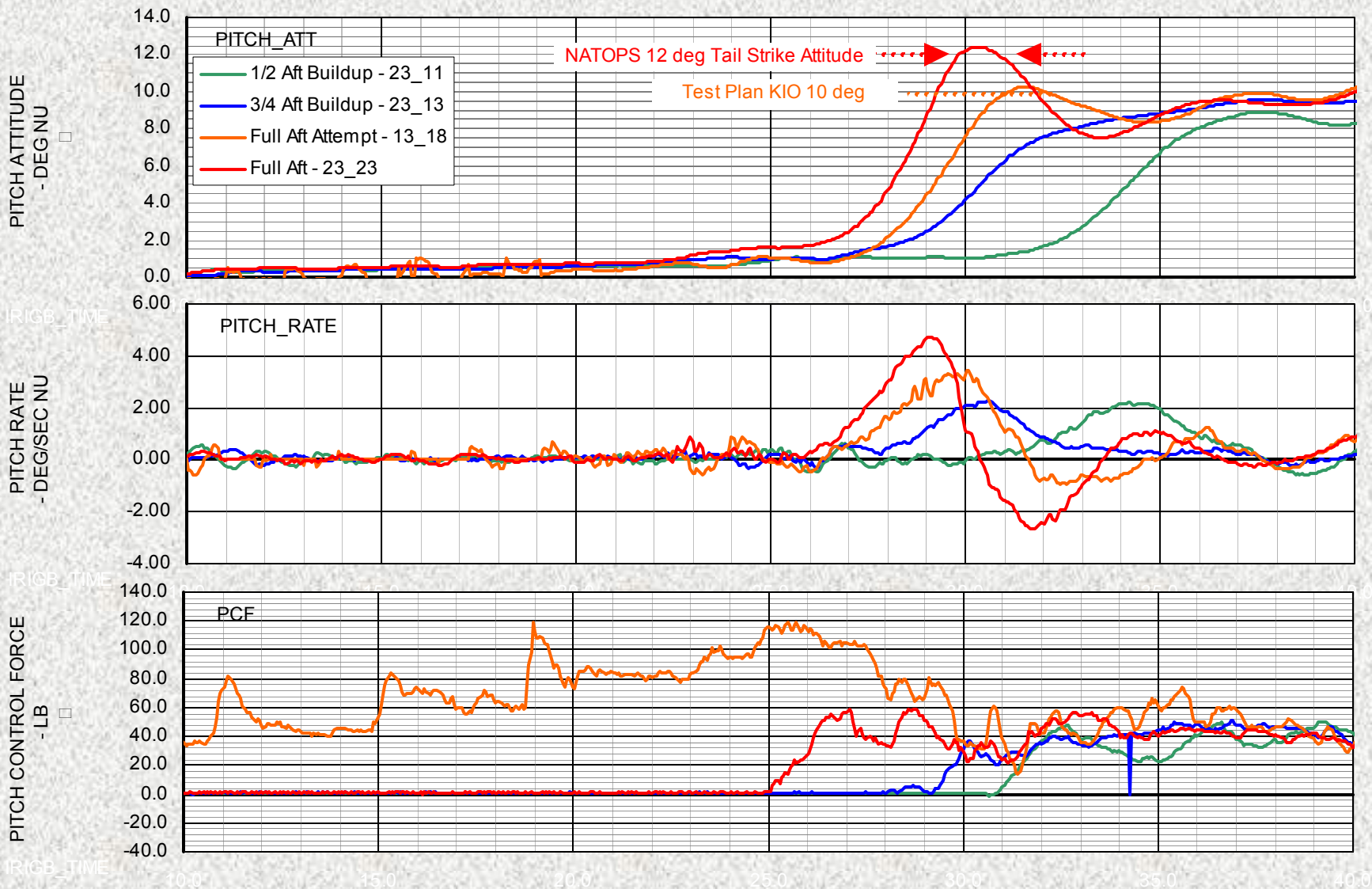


## ■ What Happened?

- Normal vs test technique, Sim, buildup, limits, THA, Flight Control system, daily report, engineering review, aircrew data review



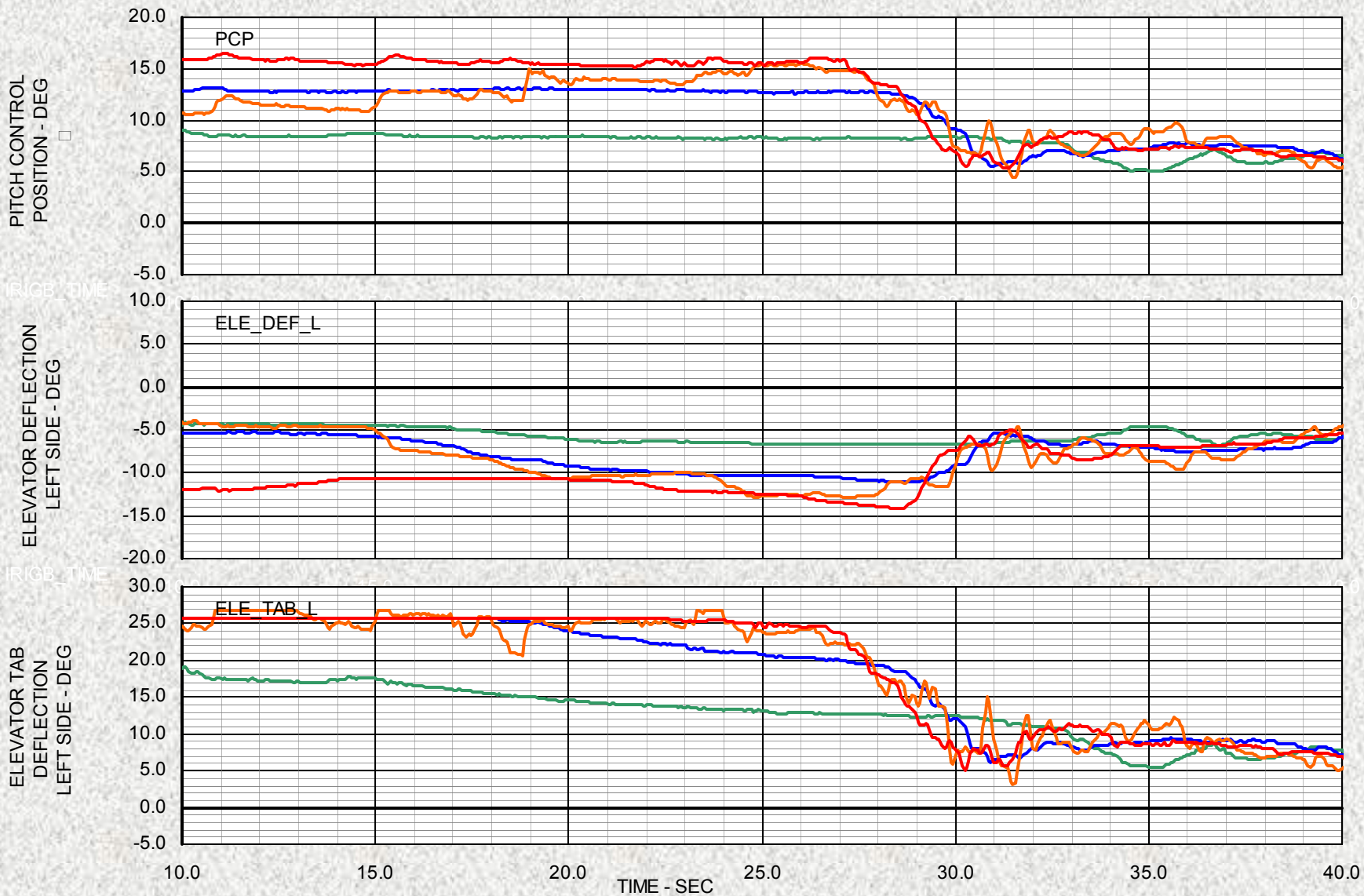
# Comparison of Buildup Data: 1





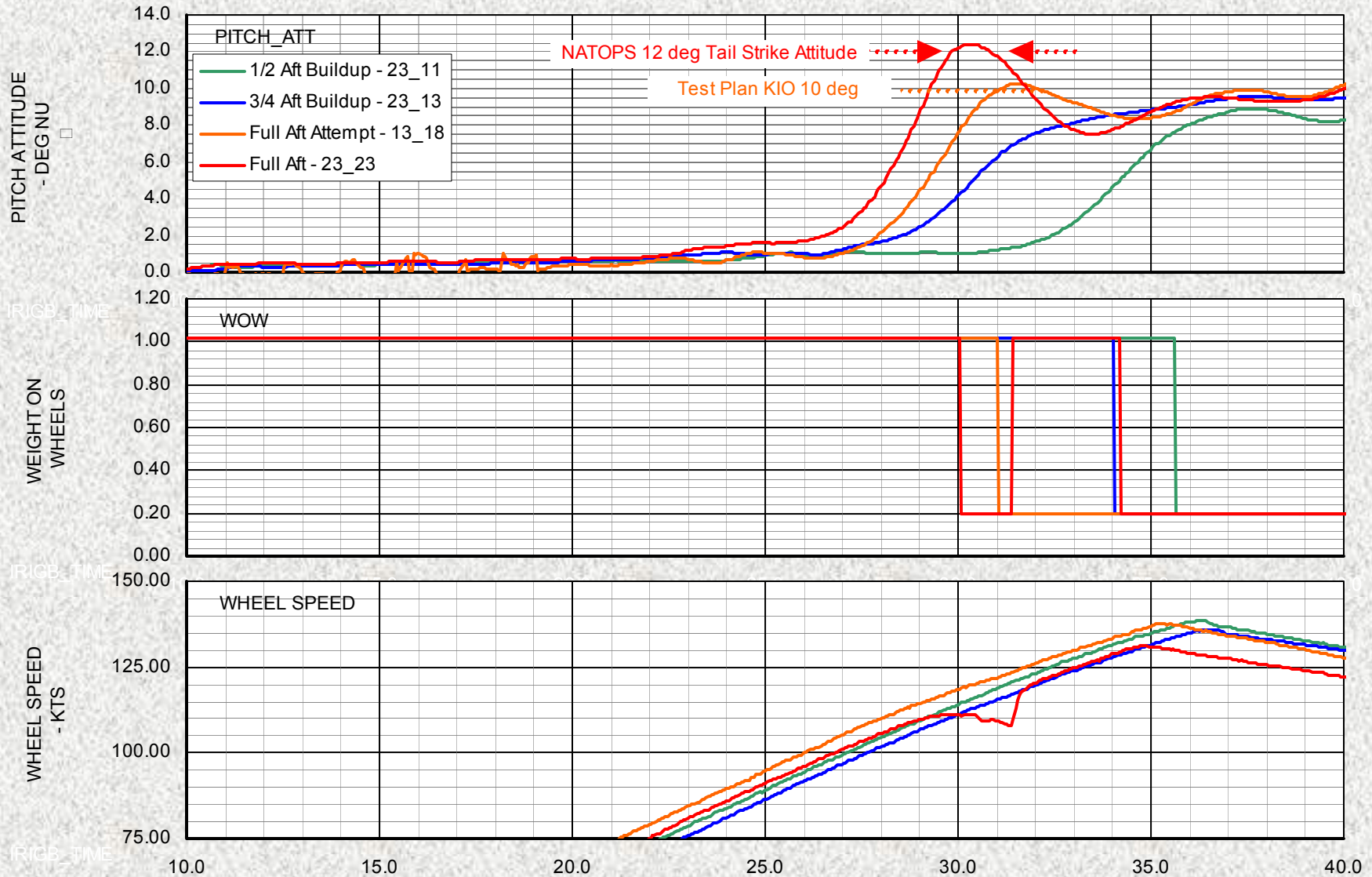


# Comparison of Buildup Data: 2





# Comparison of Buildup Data: 3





# Lessons (Re)Learned

## Minimum Rotate – Tail Scrape

- “Not a Vmu test”, nor instrumented for one
  - Instrumented well for engineering but not well for risk mitigation
    - ♦ A skid plate (wood/Styrofoam) cheaper than cost of schedule slide
    - ♦ A tail strike indicator would have prevented prolonged further flight
- Early simulator work – not representative – go figure
- Hazard analysis recommended avoiding PIO. Misplaced focus?
- Termination criteria not adequately defined in the test plan
  - Tests limit vs. Knock-it-off / RTB decision
  - Corporate understanding of these terms
  - Define, train, and review - constantly
- Engineering to aircrew
  - Decision to repeat this test point
  - Comms between crews – especially at / near endpoints
- Don’t let your anticipated result cloud your planning or execution. Not Vmu, but be ready for the unexpected.



# Lessons (Re)Learned



## Global Hawk Maritime Demo

- Nothing “unmanned” about UAV’s
- Experimentation Arena expanding quickly – Undefined requirements change focus. Discovery of capabilities and limitations vs. evaluation for mission
- Classical test discipline, processes still useful
- Network-centric systems are extremely interdependent
  - UAS – consider not only A/V, but also ground segments, Satellites, networks, bandwidth, connectivity
  - HALE platforms can saturate analysis capabilities – too much data
  - Consideration for more system-centric mindset – likely well beyond traditional aviation assets.
  - Configuration control, flight clearances, qualifications for ground segments and operators
- Experimentation results – many more interested parties than traditional T&E
  - Disparate organizations collect and analyze experimentation data, report results. Variances?
- Program Office “ownership”, Test Team / PM co-located.



# Lessons (Re)Learned



## General Items

- Acquisition Strategy - It Matters
- ITT Conops
- Team Training and Rehearsal
- Realistic Limits, appropriate buildup – rates, accels near limits
- Schedule Compression - time for data review, event planning, risk review
- Entry and Exit criteria
- Use of Fleet Squadrons
- Don't forget Logistics
  
- Onboard data acquisition (FTEs) - balance safety/efficiency



NAV AIR

