National Aeronautics and Space Administration

EXPLORE EARTH

A Time of Change for Earth Science Research: B777-200ER

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June 28, 2023

Airborne Science at NASA, Why?

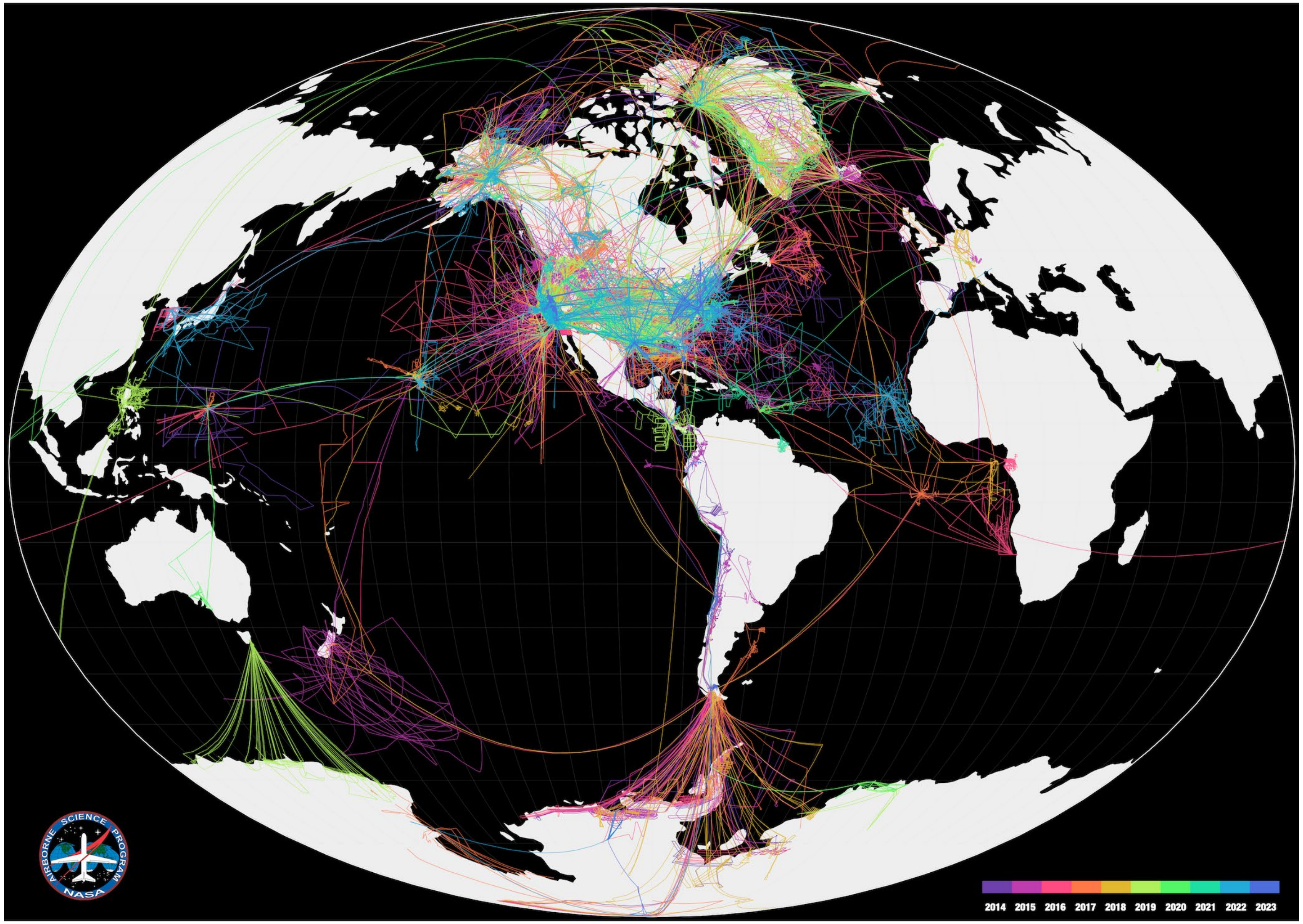
Scientific

- Make important scientific measurements not possible from satellite or surface-based platforms
- Calibration and validation of satellite remote sensing observations and models
- Develop new remote sensing and in-situ instruments

Programmatic

- Develop early career investigators
- Develop leadership skills in promising early and mid-career investigator

Mission Flight Tracks, 2014 - Present



Airborne Science, Core Platforms

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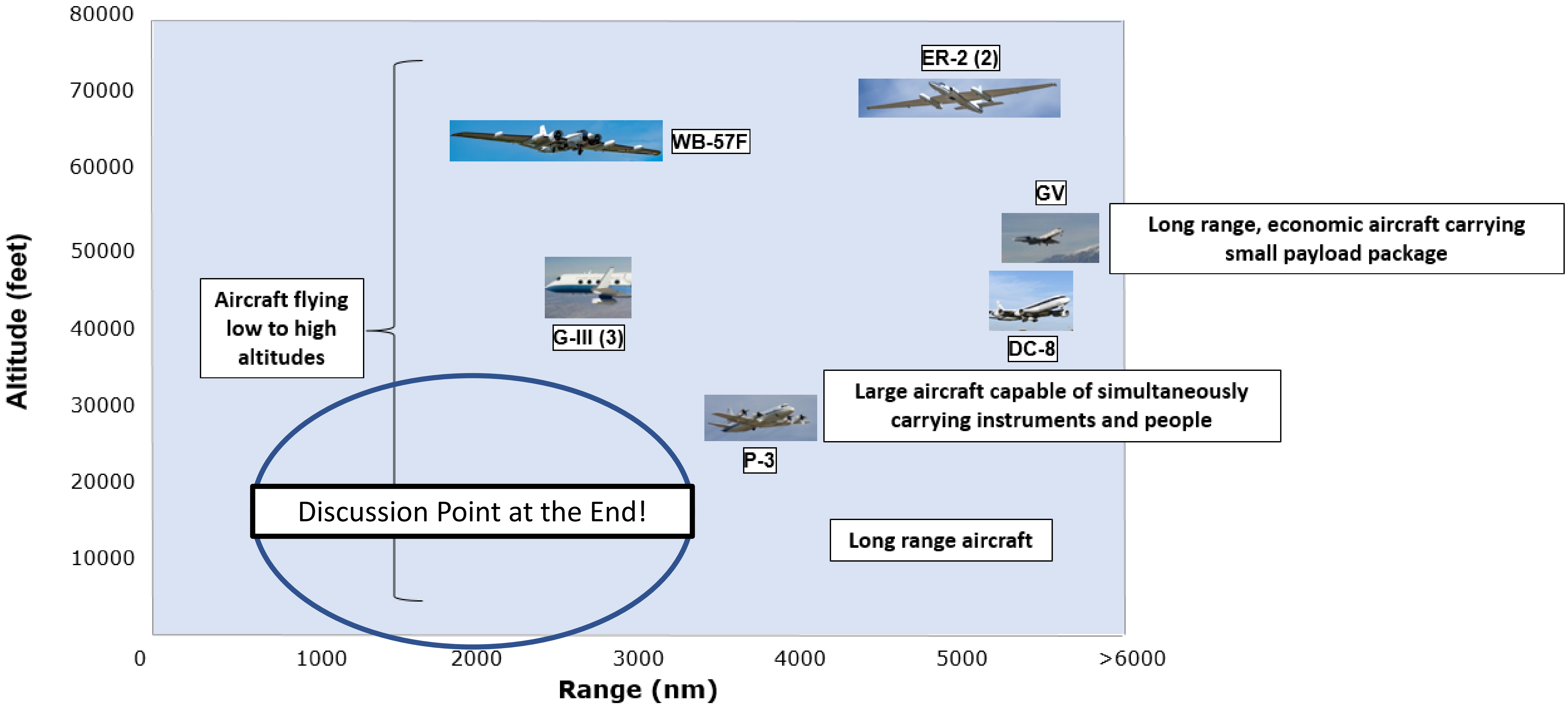


DC-8 Historical Requirements

- DC-8 acquired to replace the CV 990
- Missions have relied on the DC-8 for the following requirements
  - Heavy Lift – enables multiple payloads to provide coincident measurements most often for atmospheric chemistry, weather, and instrument inter-comparisons (ASCENDS)
  - Long range – enables measurements across regions/basins to enable process studies over large regions
  - Vertical profiling – the long endurance capability enables sampling from the surface to 12km with repeat profiles at various altitudes
  - Onboard operators – the ability to host instrument operators allows for adjusting instruments during a mission in addition to enabling science collaboration in real time, backbone support for SARP

So, Why Replace the DC-8?

- With few pilot simulators available and limited spare parts, NASA's Armstrong Flight Research Center suggested that the DC-8 would end operations in 2025
  - Fuel probes, brakes, tires, emergency door slides
- Market research showed viable, affordable, vibrant used aircraft market

How Do You Replace the DC-8?

Independent Analysis of Platform Alternatives
NASA Langley Research Center and Analytical Mechanics Associates
2017 - 2018

Large commercial aircraft
Military aircraft
Fleet of GVs
Cost per payload pound per mile

Best Replacement Option:
B767-200ER

National Academies of Science Study Assessed Long Term Need for Long Range Aircraft
2019-2021

"NASA should acquire, maintain, and operate a large aircraft … to address priority questions developed for the 2017 Earth Science … Decadal Survey."

Budget Approved
2022

Aircraft Procurement Timeline

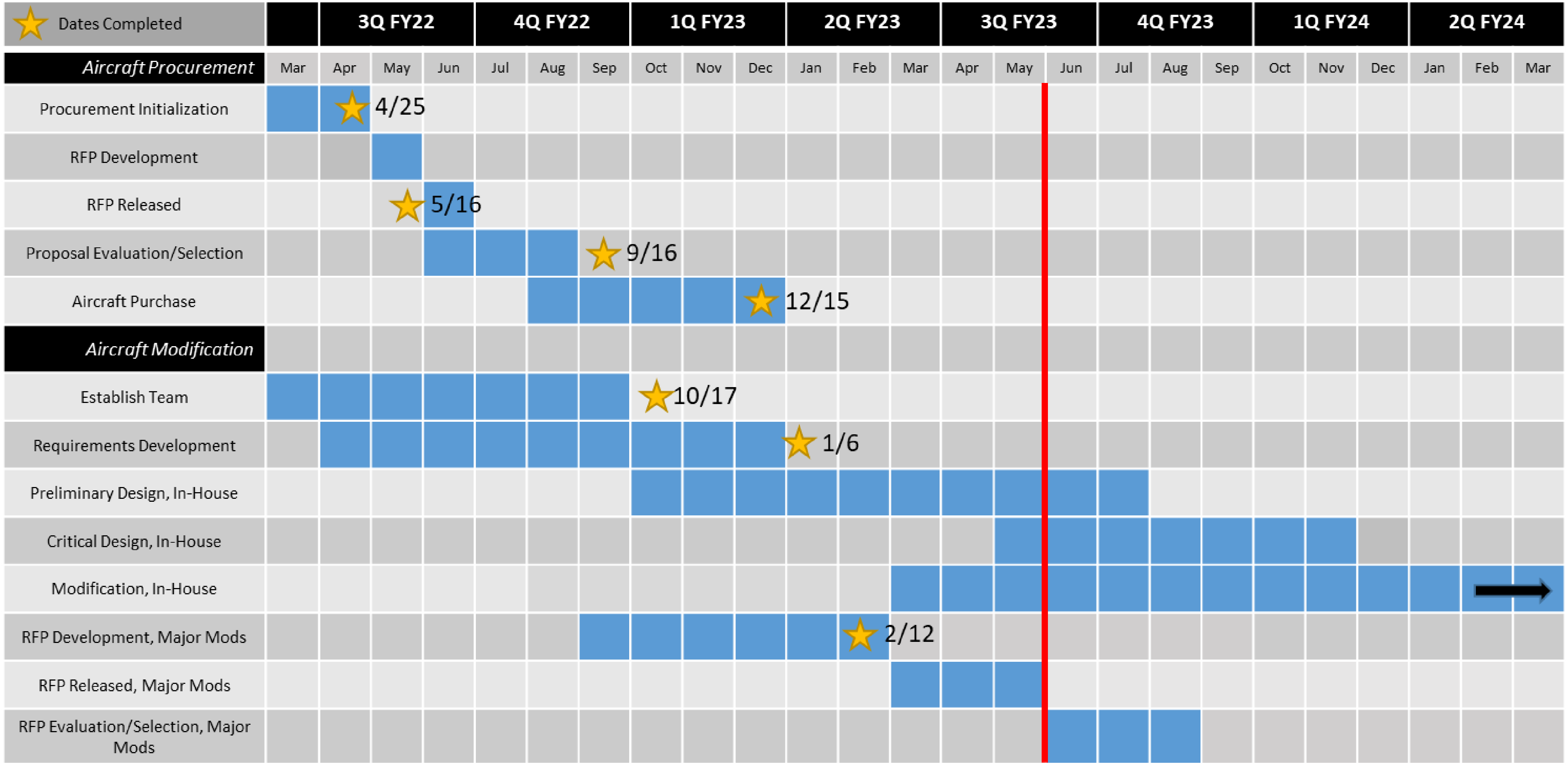
- B767 vs B777 and the Amazon Prime Air market effect
- Selected a Japan Airlines B777-200ER that was a summer 2020 COVID casualty
- Not a Government contract: purchased via aviation support contractor!
  - 4 months from RFP release to contract award
  - 3 months to bring aircraft out of preservation
- Delivered to NASA LaRC on December 15th, 2022

Aircraft Delivery

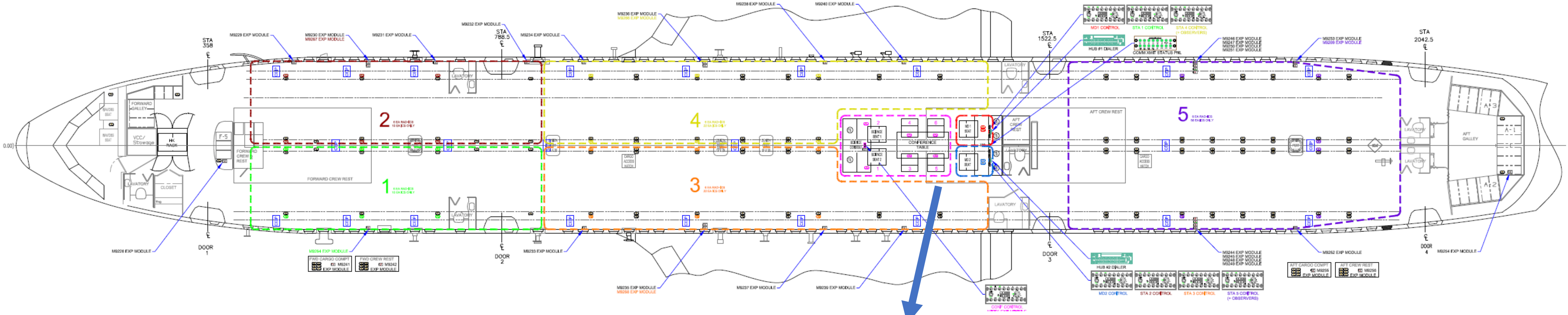
Aircraft Modification

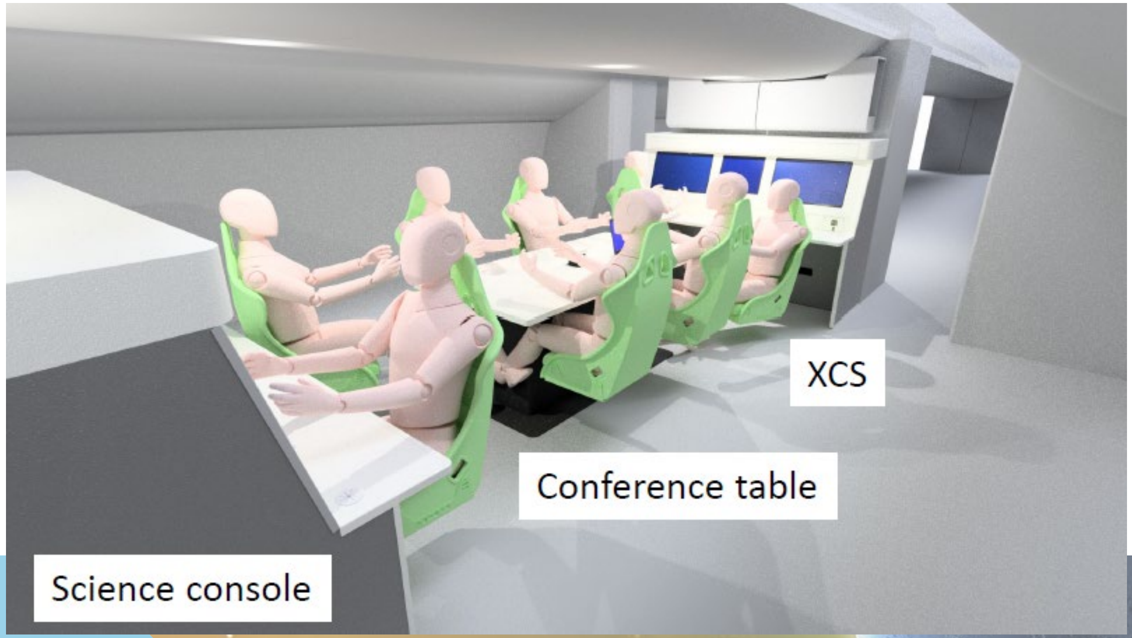
- Engineering design, analysis, and modification efforts were commencing in parallel with the aircraft procurement process
  - Engineering “Dream Team” assembled from across the Agency to complete “in-house” modifications
    - 4 participating Centers
    - New model of ASP HQ-driven team interleafing with Center airworthiness
  - Modification broken up into two phases
    - “In-House”
      - Research power, network and data, SATCOM, ICS, dropsonde/sonobuoy, research antennas
      - Completed SRR, January 6th, 2023
      - Launched into preliminary design and have completed 7 PDRs to date
    - Vendor modification for structural portals
      - RFP release in July 2023, award September
      - What will the capability be: ???

Aircraft Modification

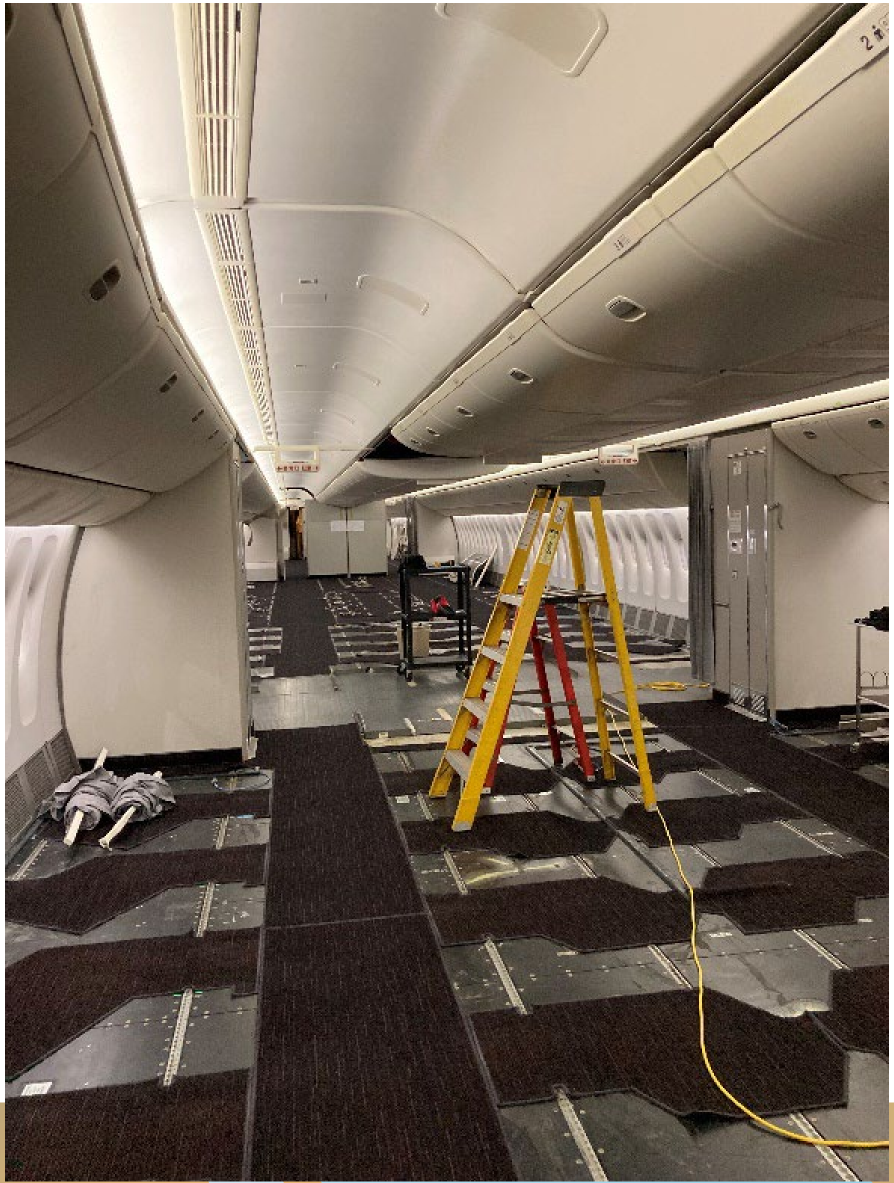


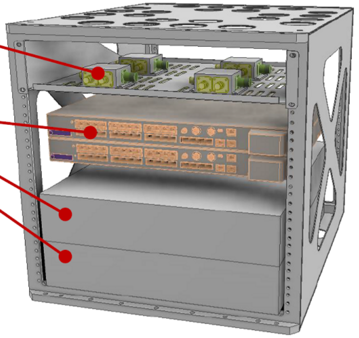
Aircraft Modification





Aircraft Modification

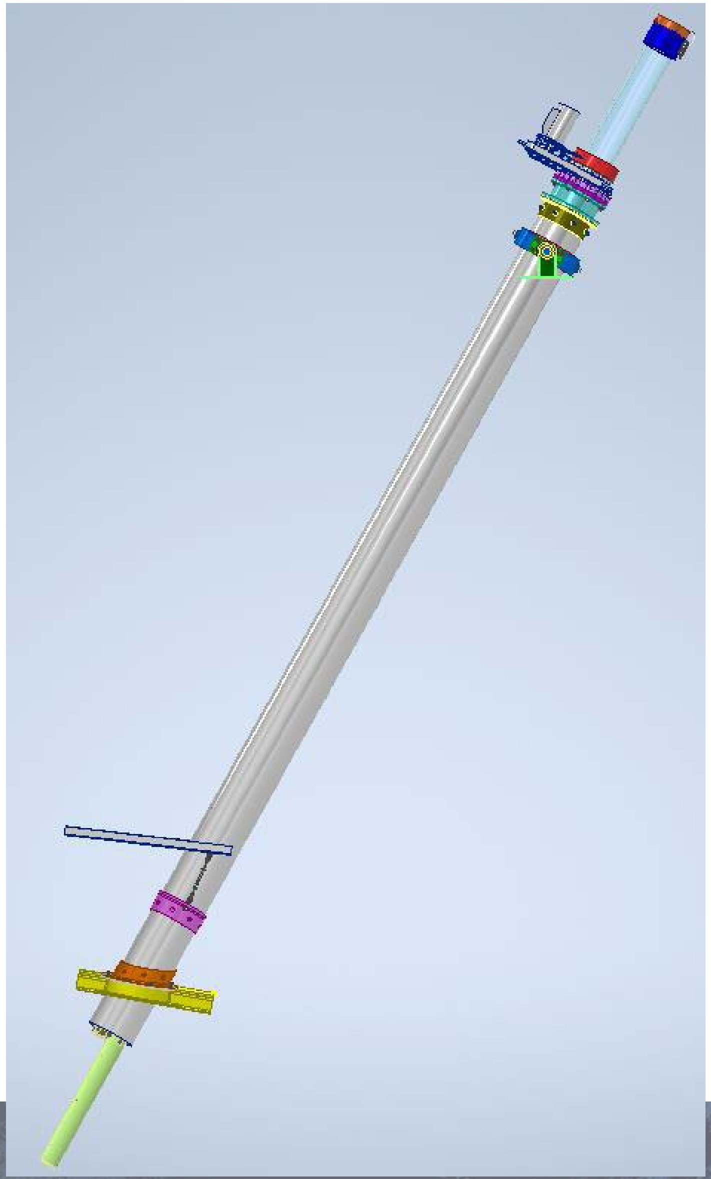




Network Rack

- Equipment at each rack includes:
  - 4X GPS splitter + tray
    - GPS Source MS14
    - 0.624 lb ea + mounting provisions = 1.5 lb (ea)
  - 2X Cisco 9300 network switch (“**Distribution Switches**”) = 15 lb (ea)
  - 1X Falcon ED4-2400RM-3/1-6-M UPS = 45 lb
  - 1X Falcon EDBR-1SH-M UPS battery bank = 60 lb
- Rack design:
  - Standard 19” rack, 24” depth
  - Welch Mechanical Designs (WMD) Lightweight Rugged Electronics Rack (L-RER), 10U height
  - Weight = 21.14 lb
  - Rack is aviation certified and used extensively by LaRC on various aircraft
- Total weight ~**175 lb**

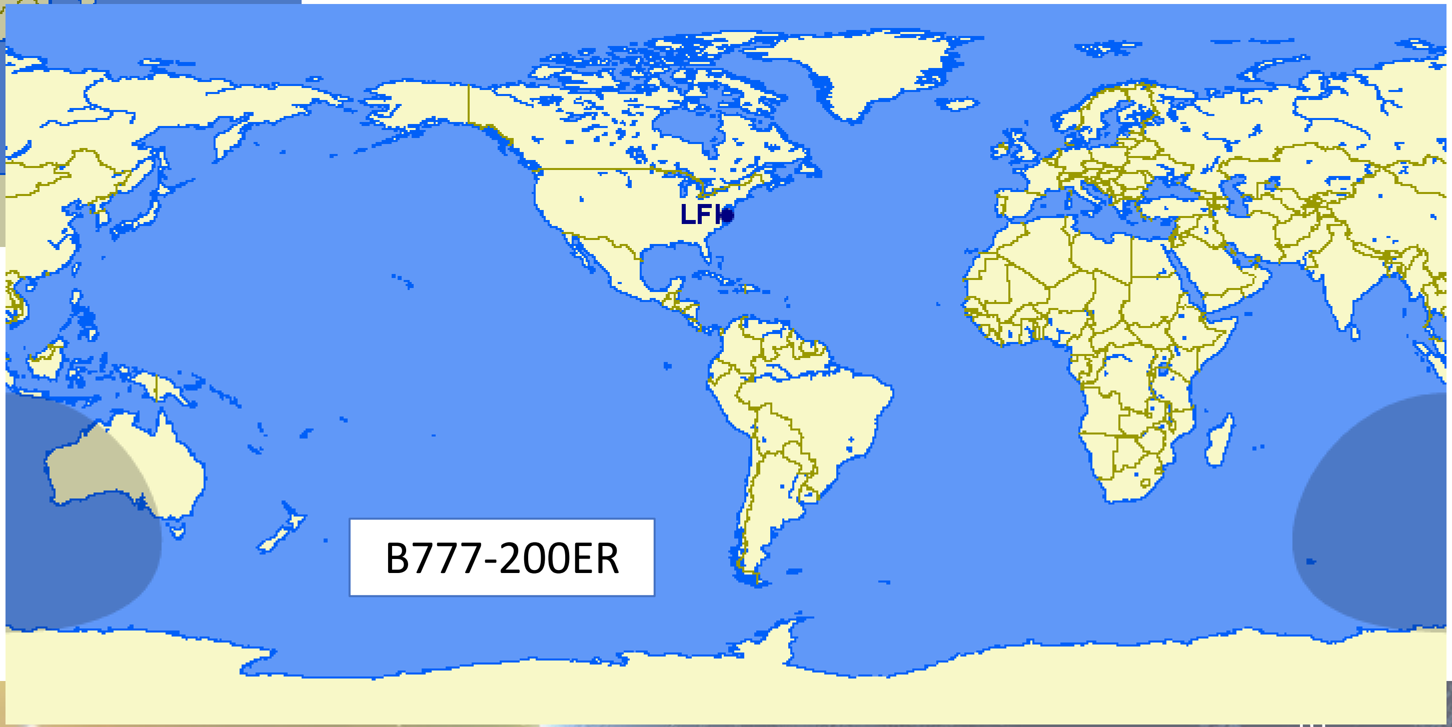
*Generic components shown, final components similar in size & weight
*WMD L-RER 10U shown



Aircraft Modification

	3Q FY24			4Q FY24			1Q FY25			2Q FY25			3Q FY25			4Q FY25			1Q FY26			2Q FY26		
Aircraft Modification (cont.)	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Modification, In-House																								
Modification, Major Mods																								
Major Scheduled Maintenance																								
Aircraft Paint																								

B777-200ER Performance



B777-200ER Performance

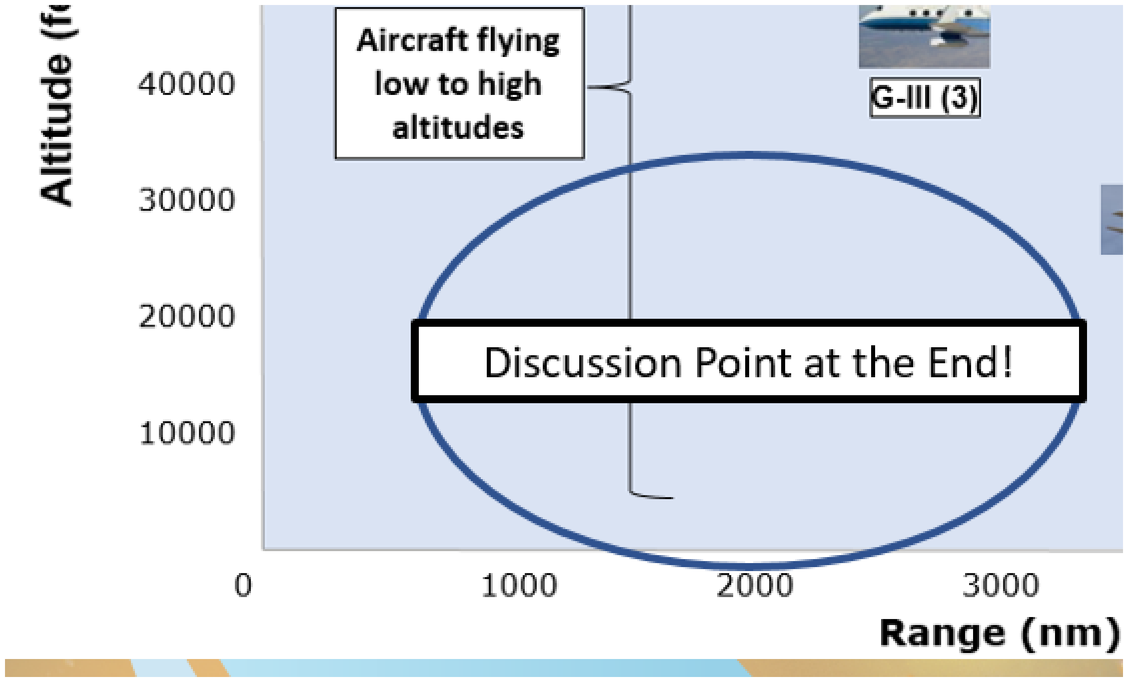
Aircraft	Payload Weight (lbs)	Fuel Load (%)	Range (nmi)	Endurance (hr)
DC-8	50,000*	100	~5000	11
B777-200ER	50,000	55	5400	11.7
	50,000	100	9000	19
	100,000	85	7400	15.6

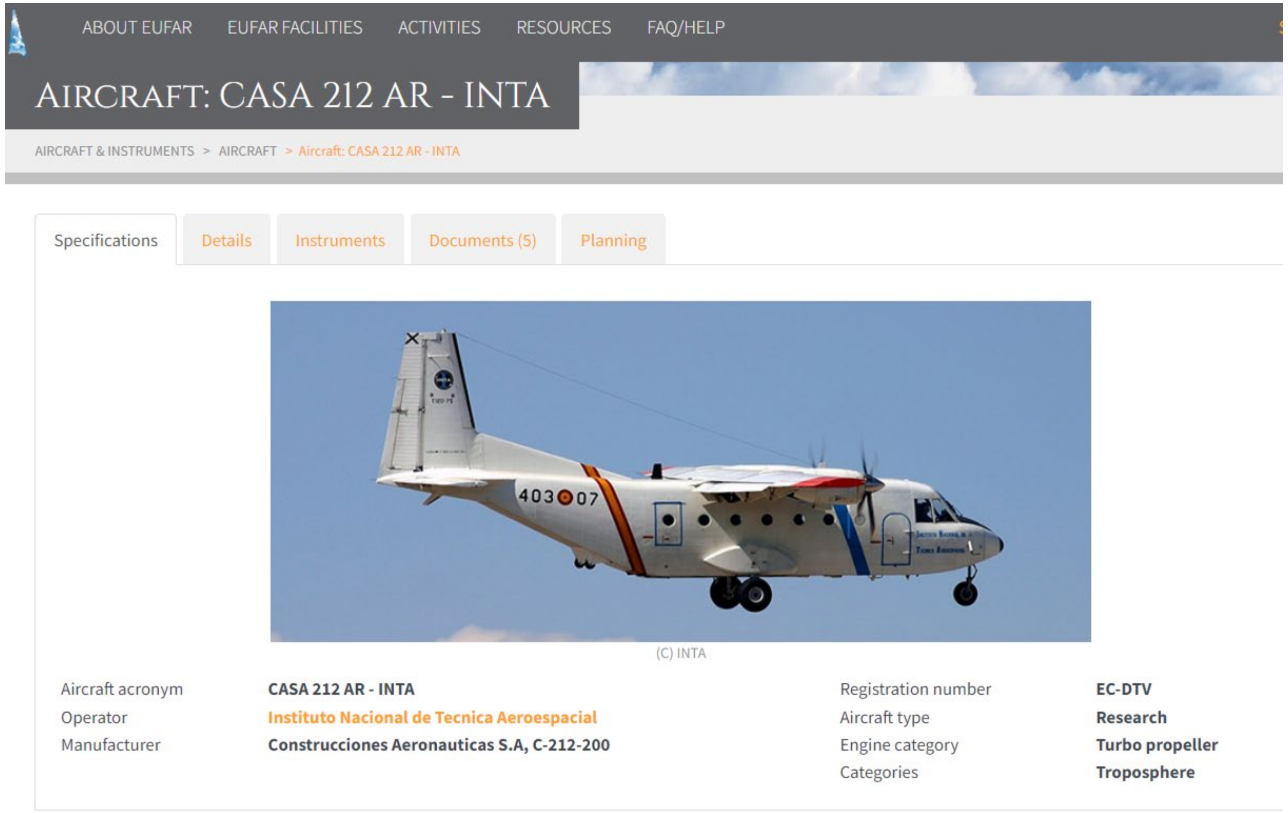
*Approximate ATom-4 payload weight: instruments, passengers, etc.

- B777-200ER will have unmatched payload and range capability for the airborne research community for decade to come unlocking possibilities that were never achievable before
  - True polar, worldwide platform
  - Can overfly large geographic regions where basing aircraft has been difficult in the past
  - Increased collaboration with international partners with increased payload capacity

Question for EUFAR

- NASA Airborne Science does not have any “low and slow” core aircraft: use commercial services like Dynamic Aviation, Kenn Borek Air
- Always searching for more options in this flight regime: status of CASA 212??





Questions?

BACKUP

DC-8 Missions

- **ATom (2016-2018)**
- FIREX-AQ (2019)
- SARP (2009-2019)
- CPEX (2017)
- CPEX2 (2019)
- HIWC (2015, 2017)
- KORUS-AQ (2016)
- ASCENDS (2013, 14, 16, 17)
- OLYMPEX (2015-2016)
- PolarWinds (2015)
- PECAN (2015)
- SEAC4RS (2013)
- GCPEX (2012)
- DC3 (2012)
- Operation IceBridge (2009-2018)
- ARCTAS (2008)
- TC-4 (2007)
- INTEX-B (2006)
- INTEX-NA (2004)
- SOLVE II (2002-2003)
- TRACE-P (2001)
- SOLVE (1999-2000)
- PEM-Tropics B (1999)
- SONEX (1997)
- PEM-Tropics (1996)
- PEM-WEST B (1993-1994)
- TOGA-COARE (1993)
- TRACE-A (1992)
- AASE II (1991-1992)
- PEM-WEST (1991)

DC-8 Capabilities and Features

Description:

Crew: Two Pilots, Flight Engineer, Navigator
Length: 157 feet
Wingspan: 148 feet
Engine: Four CFM56-2-C1 High Bypass Turbofan Jet
Base: Dryden Aircraft Operations Facility, Palmdale, CA

Performance

Altitude: 1,000 to 41,000 ft
Range: 5,400 nautical miles
Duration: 12 hours
Speed: 425 – 490 knots True Air Speed (cruise)
Payload: 30,000 lb

Accommodations

Zenith and nadir instrument ports
Modified window ports for instrument and probe mounting
External antenna mounts
Wing pylon instrument mounts
Optical windows of various materials
Dropsonde delivery tube
Air and aerosol sampling probes
Standard equipment 19-inch racks
Laser chiller unit
Both 400 Hz and 60 Hz power available to experimenter stations
Up to 20 racks and 25 instruments typically accommodated
Seating for up to 44 experimenters and flight crew

- **Heavy Lift** – enables multiple payloads to provide coincident measurements most often for atmospheric chemistry, weather, and instrument inter-comparisons (ASCENDS)
- **Long range** – enables measurements across regions/basins to enable process studies over large regions
- **Vertical profiling** – the long endurance capability enables sampling from the surface to 12km with repeat profiles at various altitudes
- **Multiple payload types**: *in situ*, active, passive
- **Onboard operators** – the ability to host instrument operators allows for making adjustments to instruments during a mission in addition to enabling science collaboration in real time
- **All weather capability**
- **International basing**