GBS/Milstar Airborne Antennas

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Presentation Outline

- Status of airborne antenna work
- Successful demonstration of Datron mechanically scanned antenna
- Electrically scanned antennas
- Summary

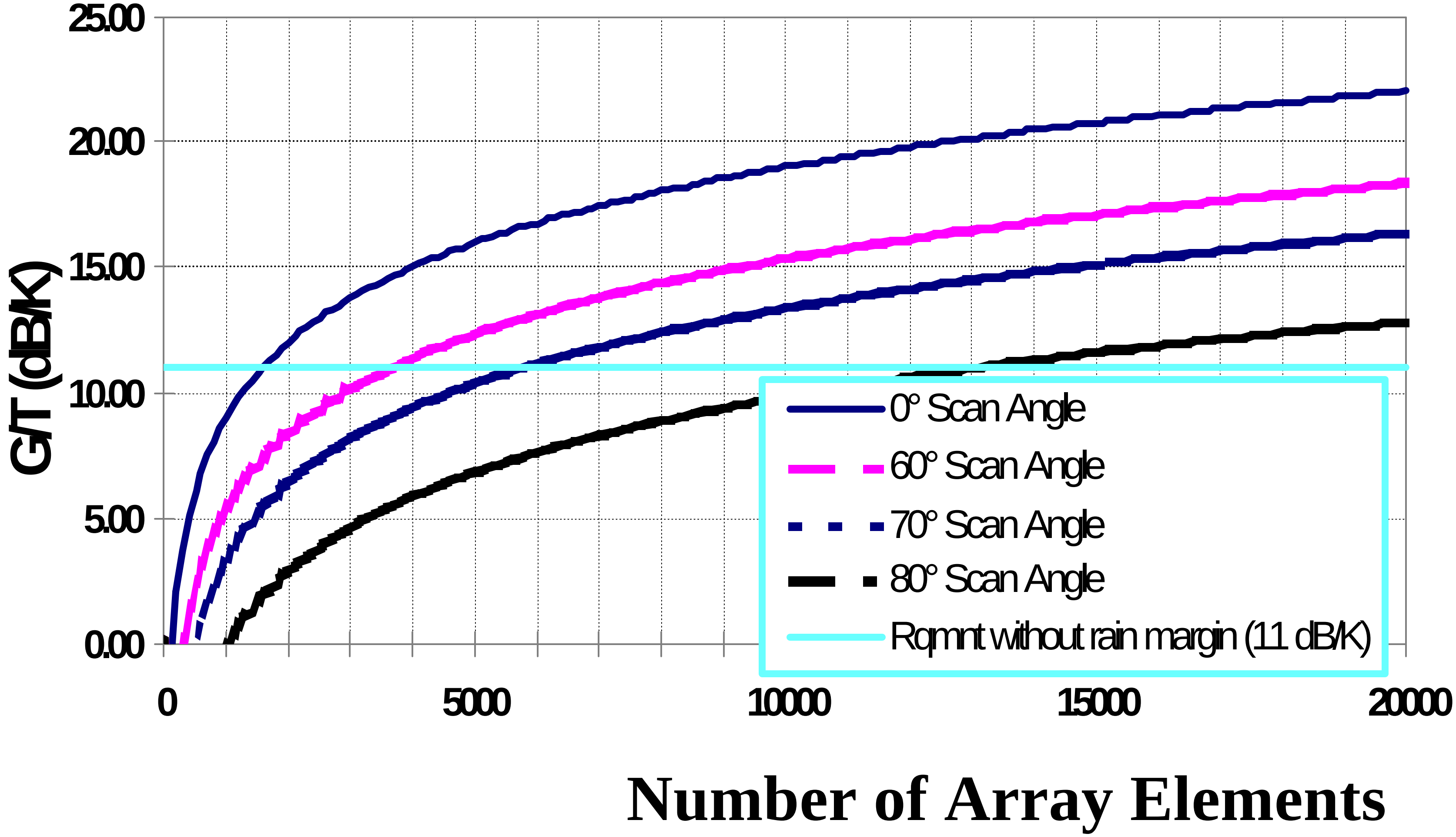
Existing Airborne Antenna Work at AFRL (IFGC & SNHA)

- Existing programs are focused on both mechanically and electrically steered (phased arrays) antennas
  – Mechanically steered antennas targeted for larger airframes (B-707 and above): JSTARS, AWACS, Rivet Joint, etc
  – Phased arrays targeted for B-2, B-1B, UCAV, fighter aircraft, SOF missions

Program Goals

- Develop low cost / low profile antennas
  - Minimize nonrecurring development and recurring production, installation, aerodynamic drag (fuel), and O&M costs
  - Utilize evolving low cost commercial antenna technology
- Near term focus on larger C2 aircraft (JSTARS, AWACS, Rivet Joint, etc)

20 GHz Receive Array Sizing - 2D Scan



Phased Array Per Element Costs at 20 GHz and 44 GHz

- 20 GHz:
  - Currently in range of $50 to $150
  - Goal of $10 in 5 years
- 44 GHz:
  - Currently in range of $80 to $250
  - Goal of $20 in 7 years

Current Airborne 20/44 GHz Phased Arrays

- Assuming manufacturing is somewhat automated, then 30 to 40% of the cost is in GaAs amplifier and phase shifter chips at 20 and 44 GHz
- Recent shift to 6 inch GaAs wafers may help
  – Raytheon, Vitesse, TriQuint, Motorola
- MEMS phase shifters could eliminate at least half the GaAs

High Level Specifications

- Frequency range specified: 19.2 to 21.2 GHz (includes part of commercial band)
  - Commercial 30/20 GHz systems planning on global land mass coverage
    - Satellite services may be made available for DoD missions in the future
- Frequency range of interest: 17.7 to 21.2 GHz

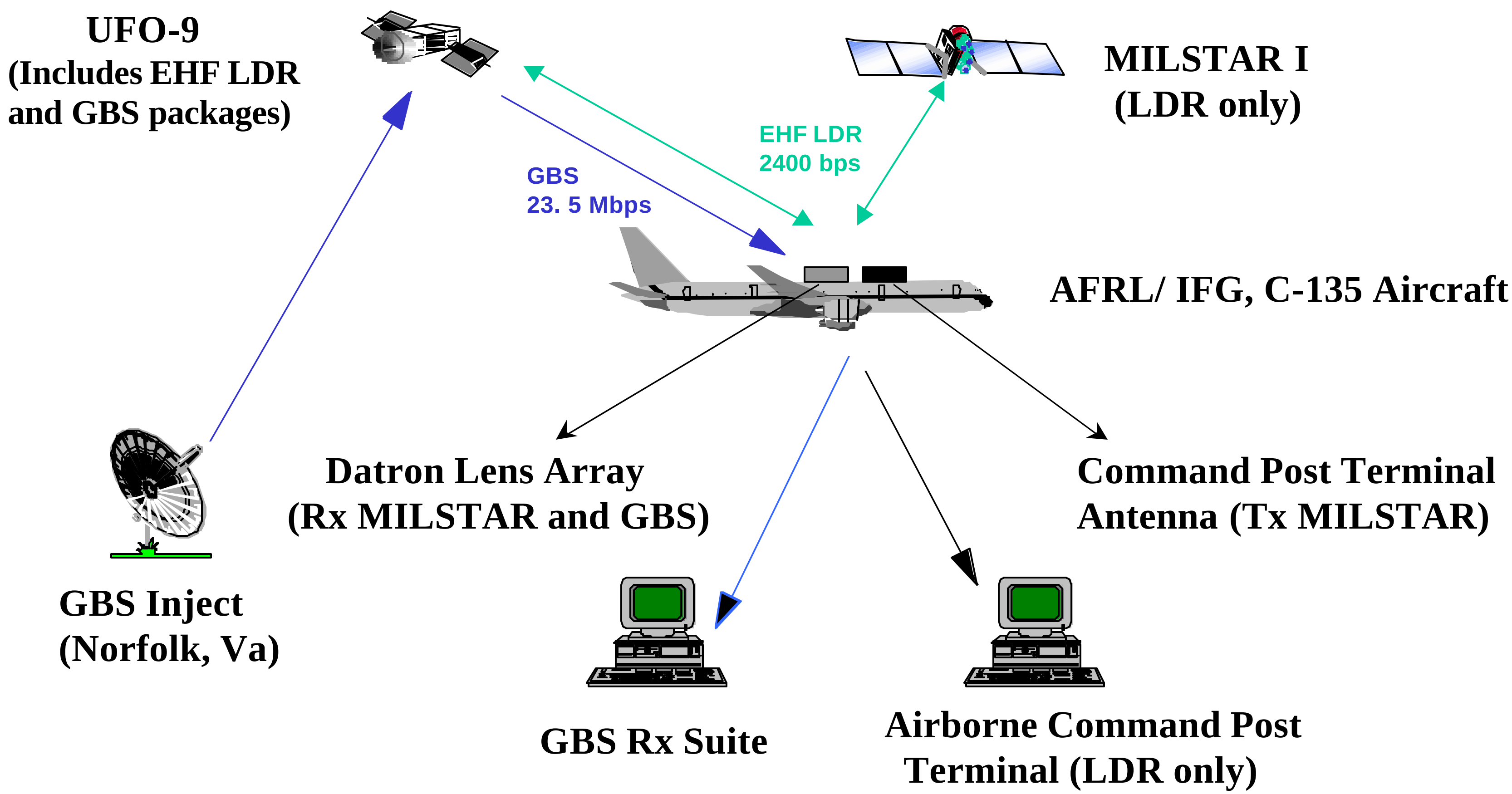
Airborne Antenna Sizing Assumption

- Predominant airborne customers will only need to operate at cruise
  - Therefore, take back 7 or 8 dB of rain/atmospherics loss in current link budget to reduce aperture size
  - G/T = 11.0 dB/K for most airborne platforms
    - Assumes a system temp of 250 K

Issues/Design Options

- Must maintain small hole through skin of aircraft to minimize installation cost
- Must minimize radome height to minimize aerodynamic drag and associated fuel costs
- Minimize intrusion into aircraft
- Include as much of transmitter/receiver electronics with antenna systems as possible
  - Minimizes prime contractor installation costs

Airborne Wideband 20 GHz Rx Demo

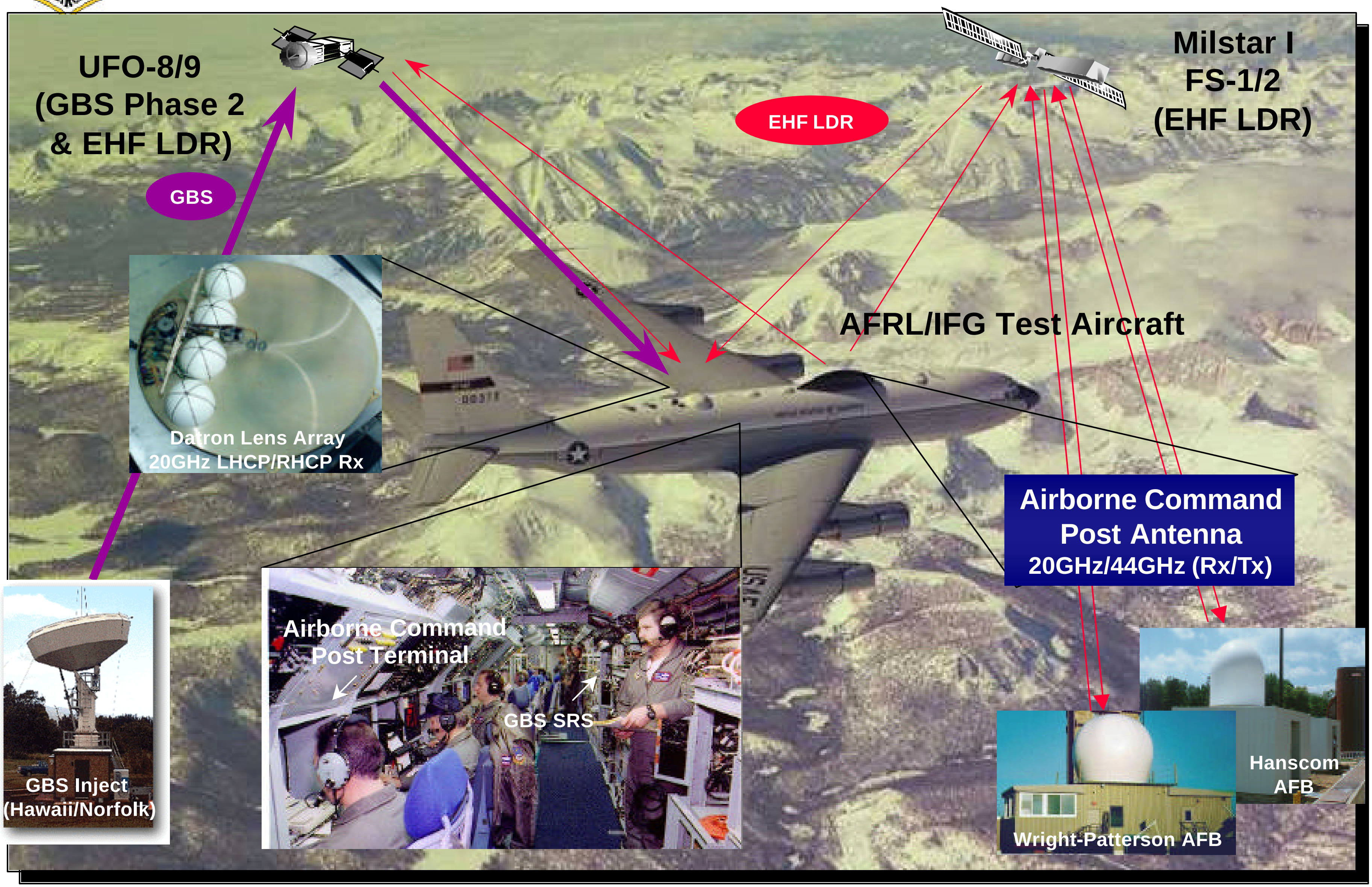


March- July,1999, received up to 23.5 Mbps to a 20 GHz antenna atop C-135

GBS Encoding vs Data Rate

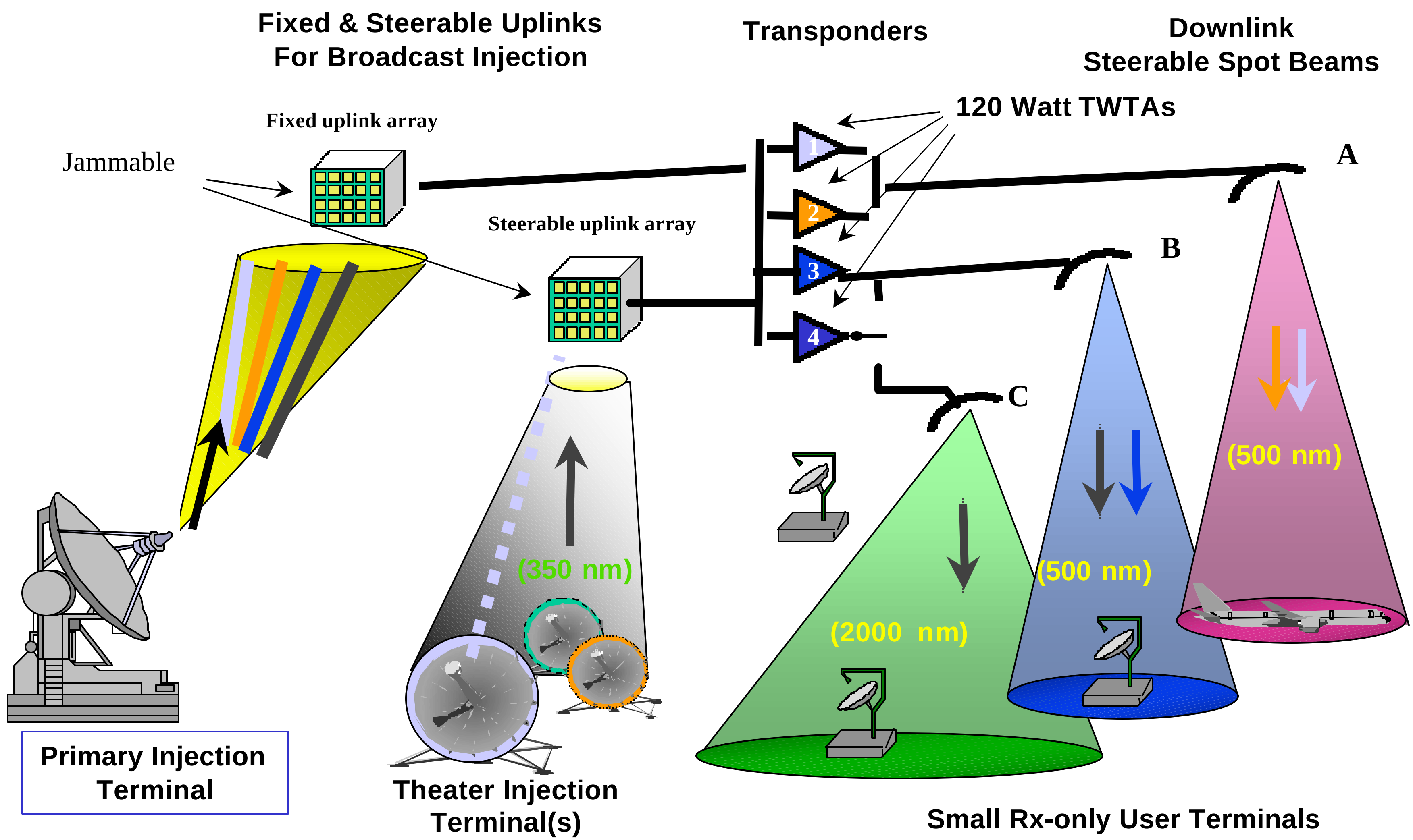
- Station broadcast manager sends 17.625 Msps
- Modulation is Quadriphase Shift Keying (QPSK)
- Antenna receives 35.25 Mbps, (two bits/symbol)
- 2/3 forward error coding provides 23.5 Mbps
- Adding Reed-Solomon coding provides 21.7Mbps
- 1/2 forward error coding provides 10.0 Mbps
- The Mbps are end user rates of video and /or data
- Video is MPEG-2 compressed (2-2.5 Mbps is excellent quality)

GBS/MILSTAR Rx Antenna
Phase I Demo



UFO GBS HOSTED PACKAGE

2-uplinks {1-fixed & 1-steerable} with 3-steerable downlink spots



20 GHz Receive Airborne Antenna Demonstration Team

* **AFRL/IFGC - Antenna and Radome Development**
  POC - PAUL J. OLESKI (315)-330-1485, oleskip@rl.af.mil

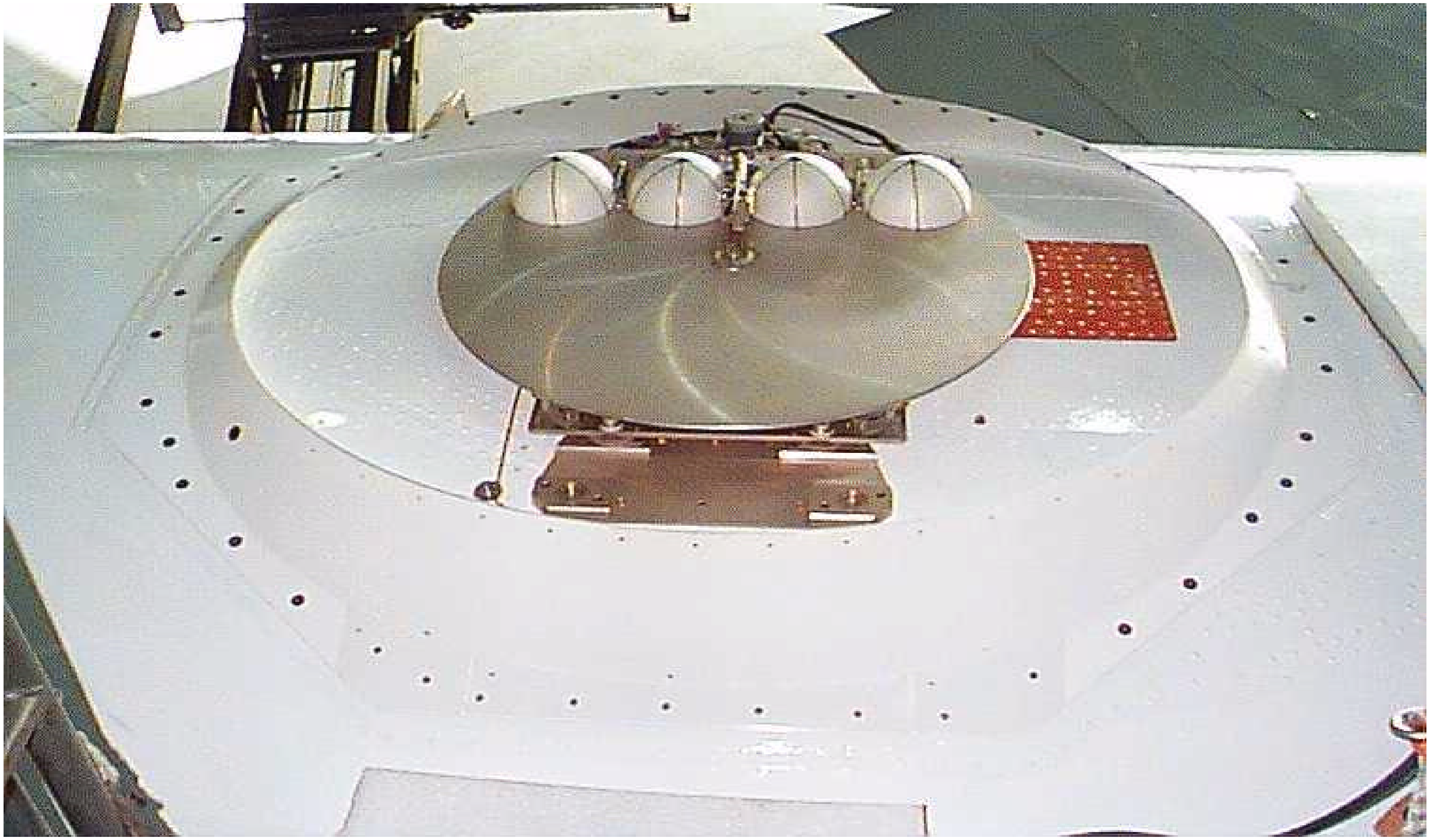
* **AFRL/IFGD - Installation & Flight test of antenna on AFRL C-135**
  POC - DAVE COBB (937)-255-4947, x 3409

* **MILSATCOM Terminal Program Office - demonstration funding and GBS receive terminal** **POC - Capt. Kevin Loucks (781)-271-5620**

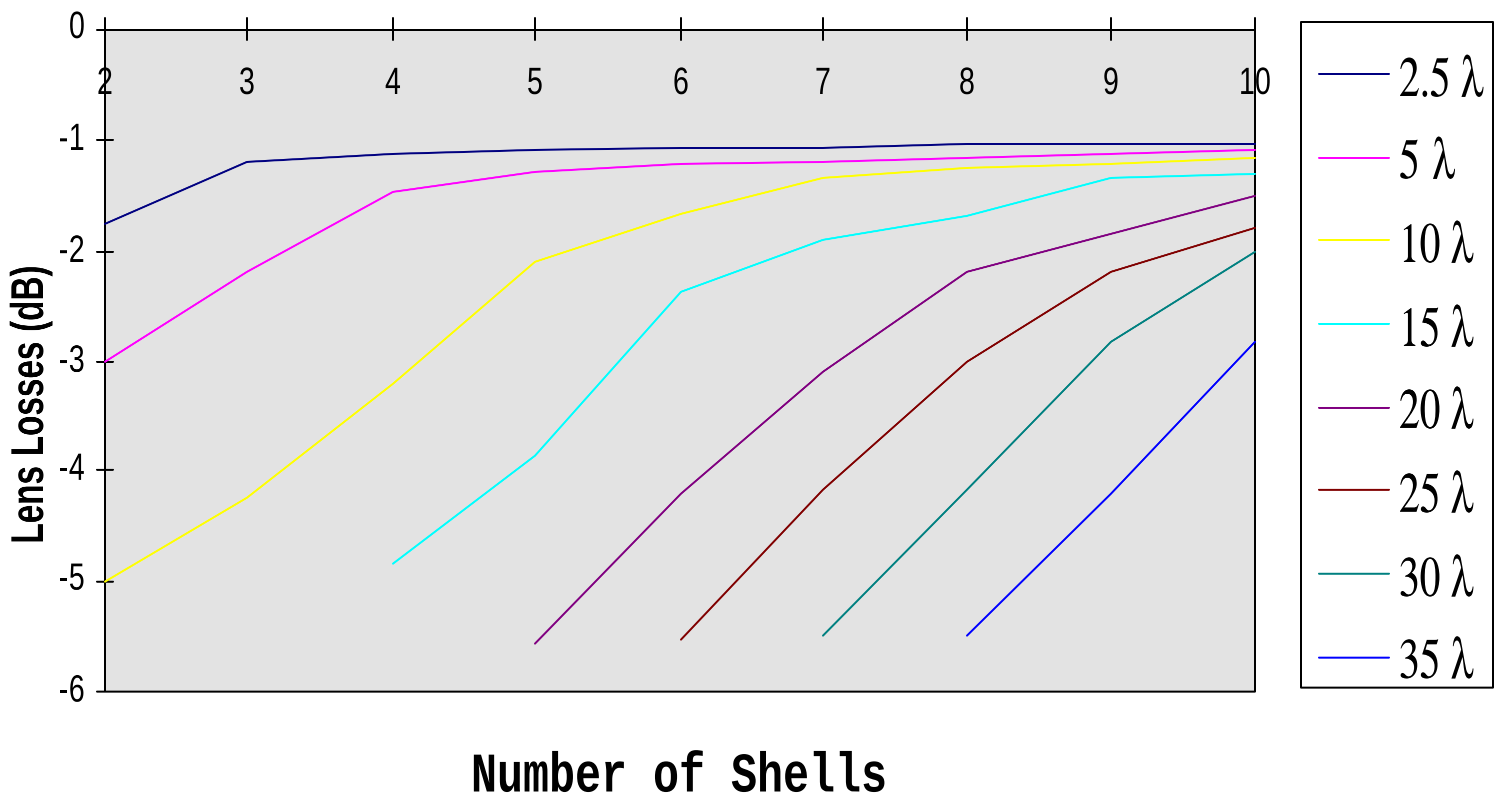
* **JSTARS - Funding of 20 GHz receive/44 GHz transmit antenna and the radome** **POC - Maj. Andy Jeselson, (781)-377-5070**

* **Datron/Transco Inc. - Design and fabrication of antenna and radomes**
  POC -Mark Rayner (805)-579-2955, mrayner@dtsi.com

GBS/Milstar 20 GHz (Ka Band) Rx Antenna atop AFRL/IFG Test Aircraft

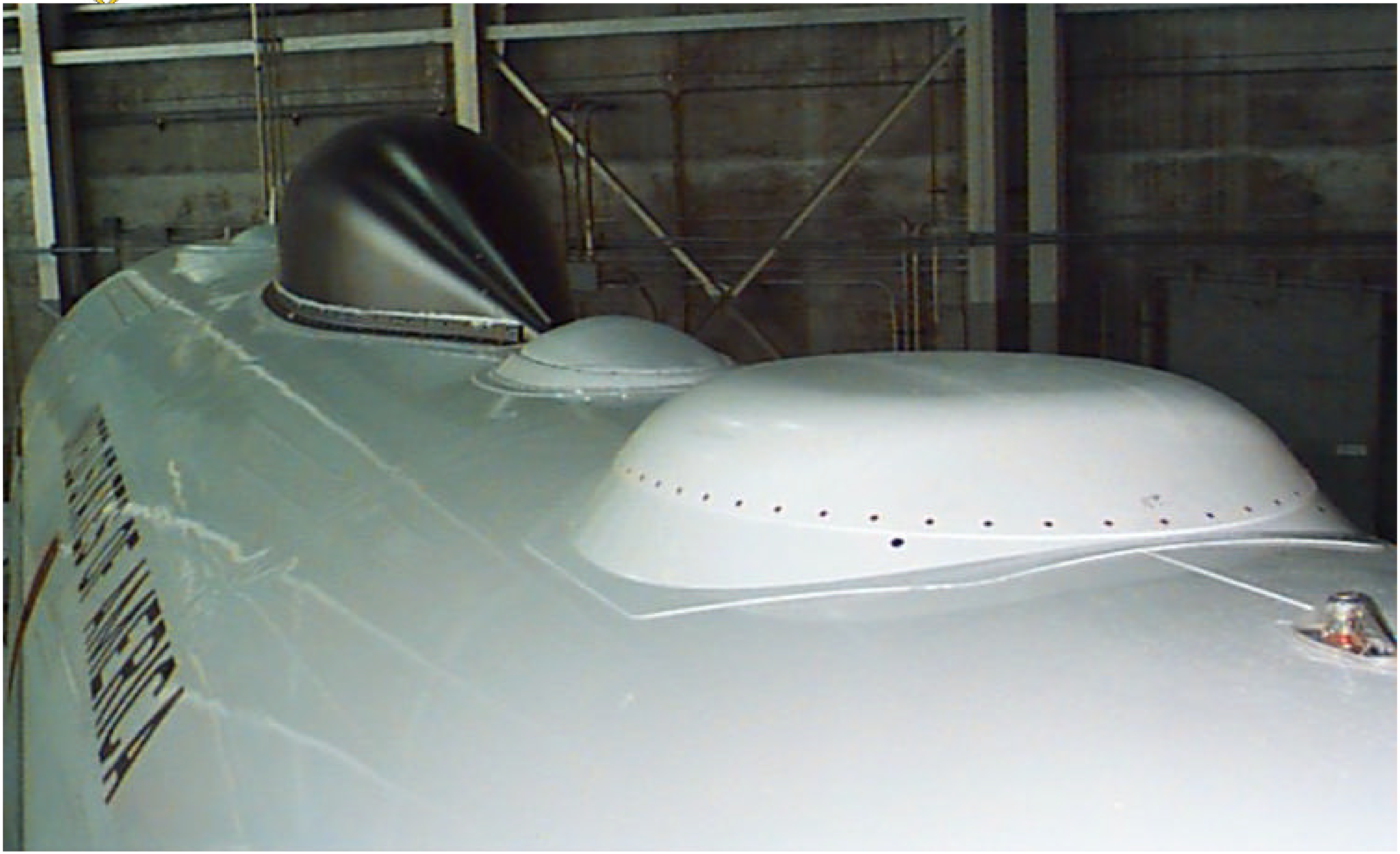


Lens Efficiency Vs Number of Shells Used for Varying Lens Diameters (Expressed in l)



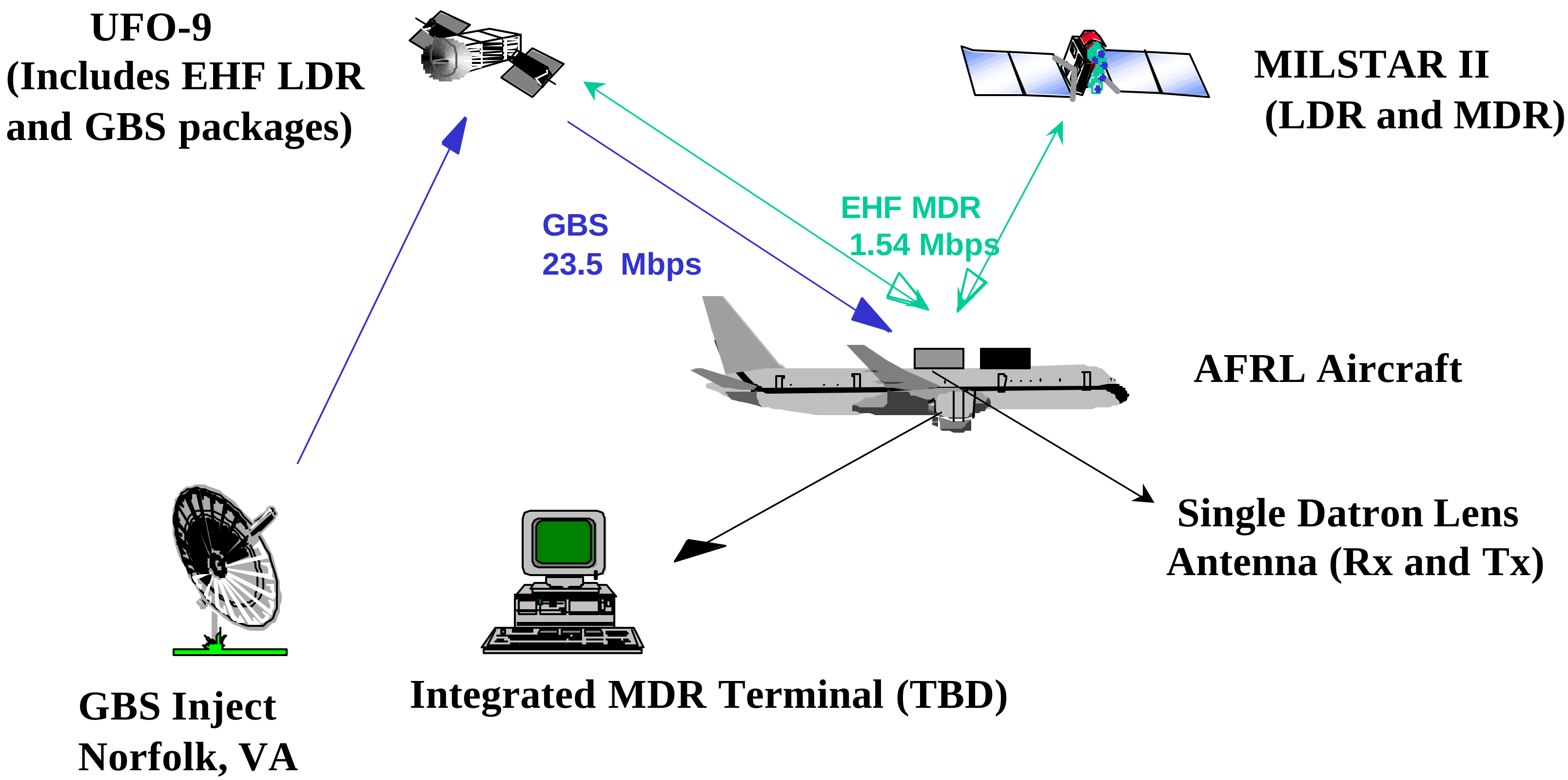
AFRL/IFG SATCOM TESTBED

8 inch high Datron Radome vs. 32 inch high Milstar Radome

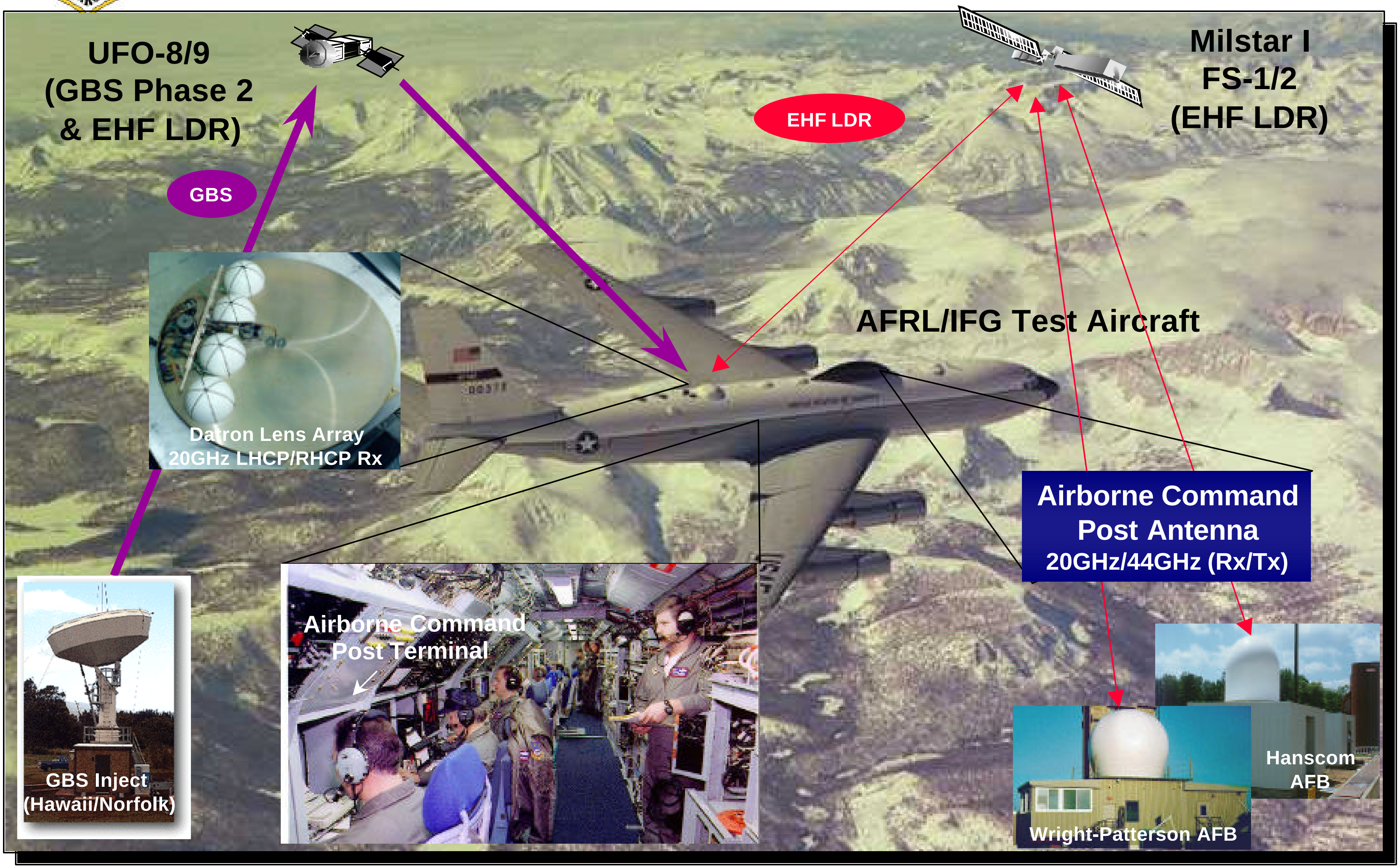


Planned GBS/Milstar 20/44 GHz Demo

- Joint Surveillance Target Attack Radar System (JSTARS) SPO, ESC/MCV, and AFRL collaborating on extending low-profile antenna technologies for airborne wideband SATCOM
- ESC/MC targeting Tx/Rx airborne demo for EFX-00, represents risk-reduction for a MDR terminal program start



GBS/MILSTAR Tx/Rx Antenna Phase II Demonstration



AFRL/Information Grid Division
GBS/Milstar 20 GHz Receive Antenna

Objective:

- Develop and Demonstrate
  - Low Profile Airborne SATCOM Antenna
  - Single Wideband Antenna for GBS/Milstar
    - High Data Rate GBS Receive (Rx)
    - MDR Milstar Transmit (Tx)
  - Low Cost System Installation (< $100K)

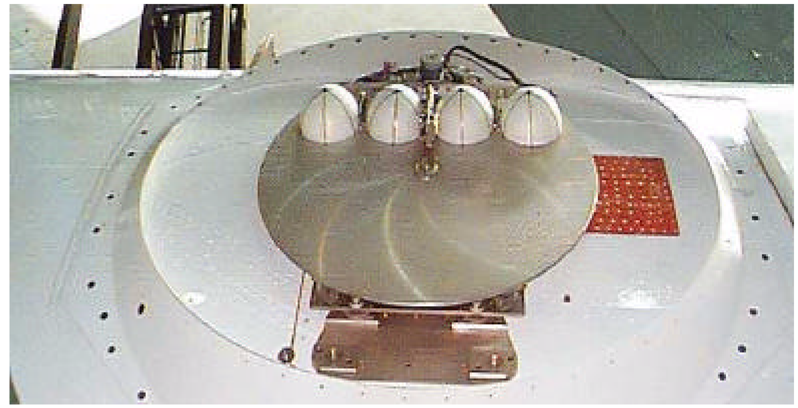
Accomplishments:

- Successful AFRL Flight Demos - March-July 99
  - ***First Time*** GBS 20 GHz Antenna flown
  - Rx Wideband (23.5 Mbps) Video/Data from UFO-9
  - Rx LDR (2.4 Kbps) Data from Milstar Satellite
  - Exceeded Antenna Track/Scan (± 82 degrees)
  - Low Cost Aircraft Integration

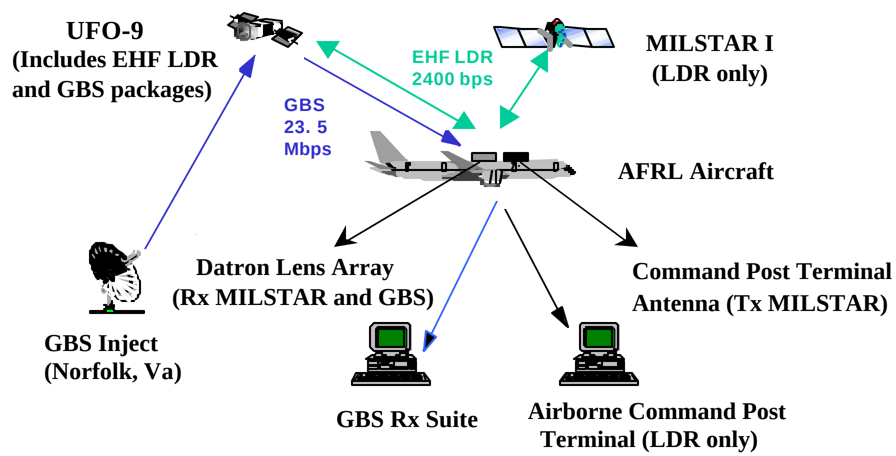
Future Transitions:

- Wideband Connectivity for AEF
  - Basis of ESC/MC, EMD Airborne Terminal Program
  - JSTARS Transmit Capability of Sensor Data
  - DoD Demo Platform (23.5Mbps Rx / 1.54Mbps Tx)
  - Support AFRL Programs (ACN, ACR, IFTW)

Datron Luneberg Lens Rx Antenna, 6.5” Radome Height



Airborne Wideband Demo (Phase I)



Demos/Evals March-July 1999

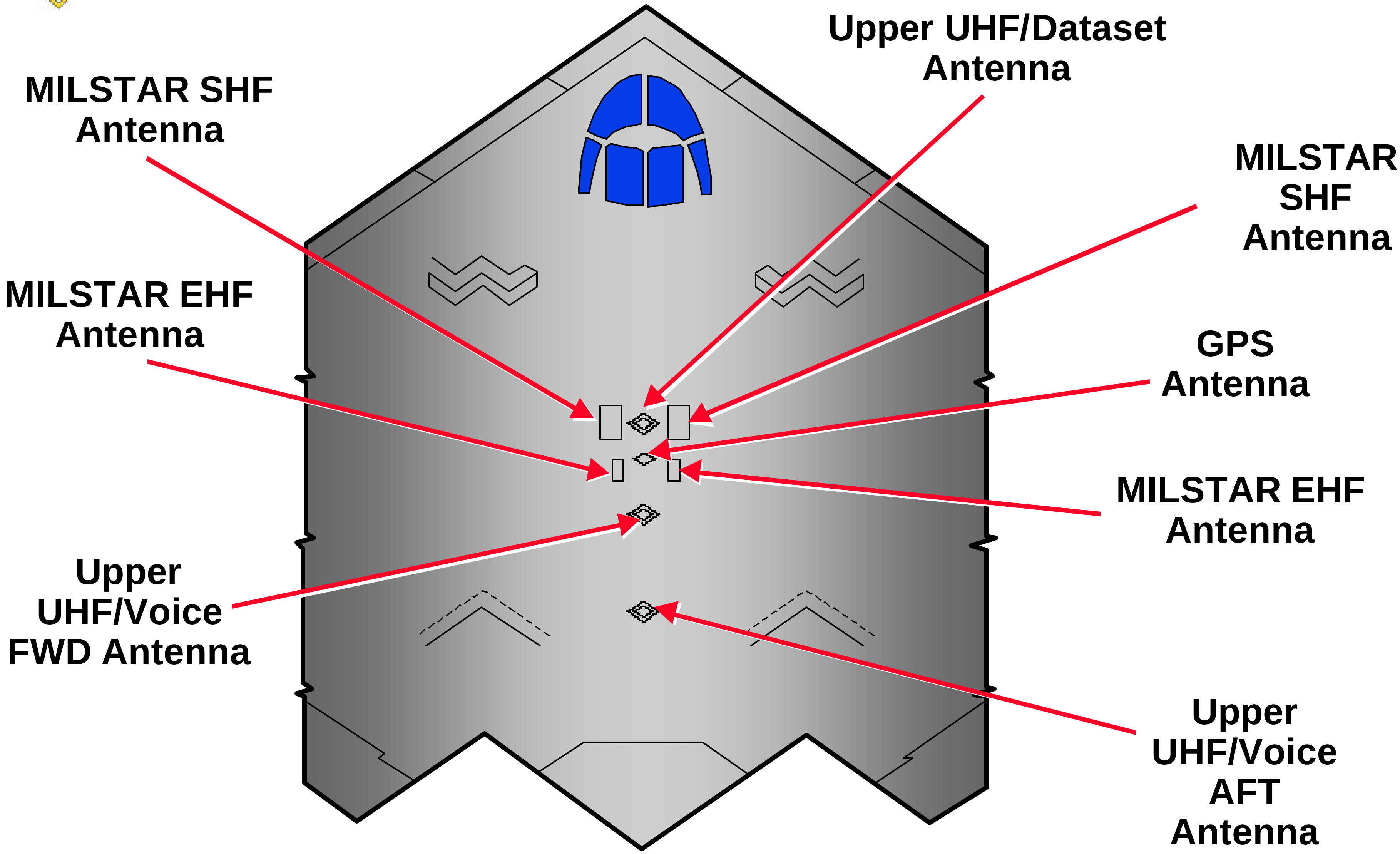
Phased Arrays

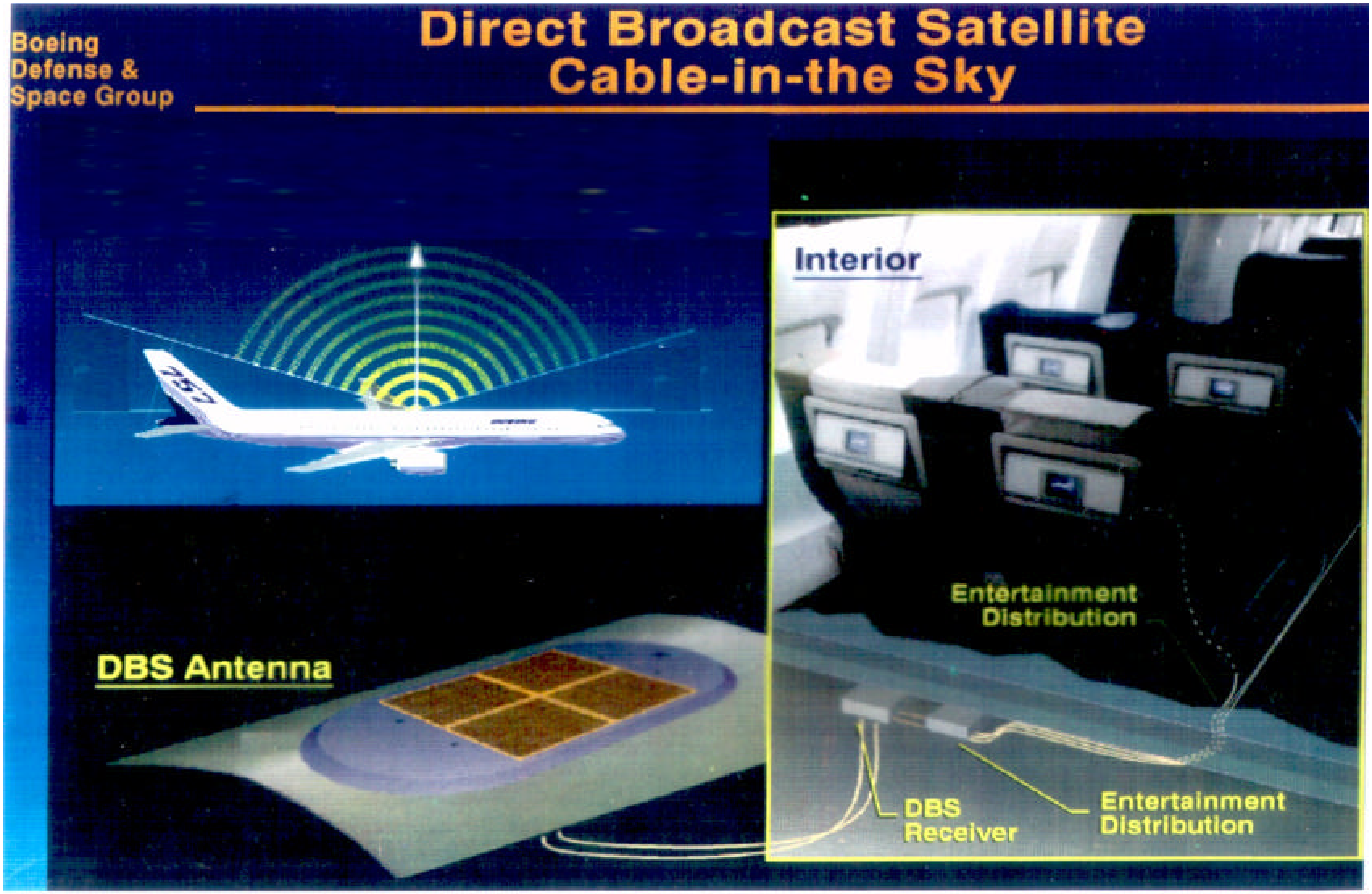
- Some airborne users need 2D electronically steered arrays
  - Fighters
  - SOF
  - B-2
  - UCAV

ESC Airborne Wideband Terminal (AWT) Program

- EMD program start in 2003 (being pushed for 2001) for MILSTAR MDR and/or GBS to aircraft
- Many aircraft targeted for AWT
- B-2 platform of special interest to support AEF
  - Phased array antenna needed for low RCS

Top View of Potential B-2 MILSTAR Installation





- 1500 element commercial Ku-band array
  - Connectivity to high power Direct TV satellites
  - Limited scan for CONUS coverage (20 to 65 degrees)

FY98 Dual Use Application Program (DUAP)

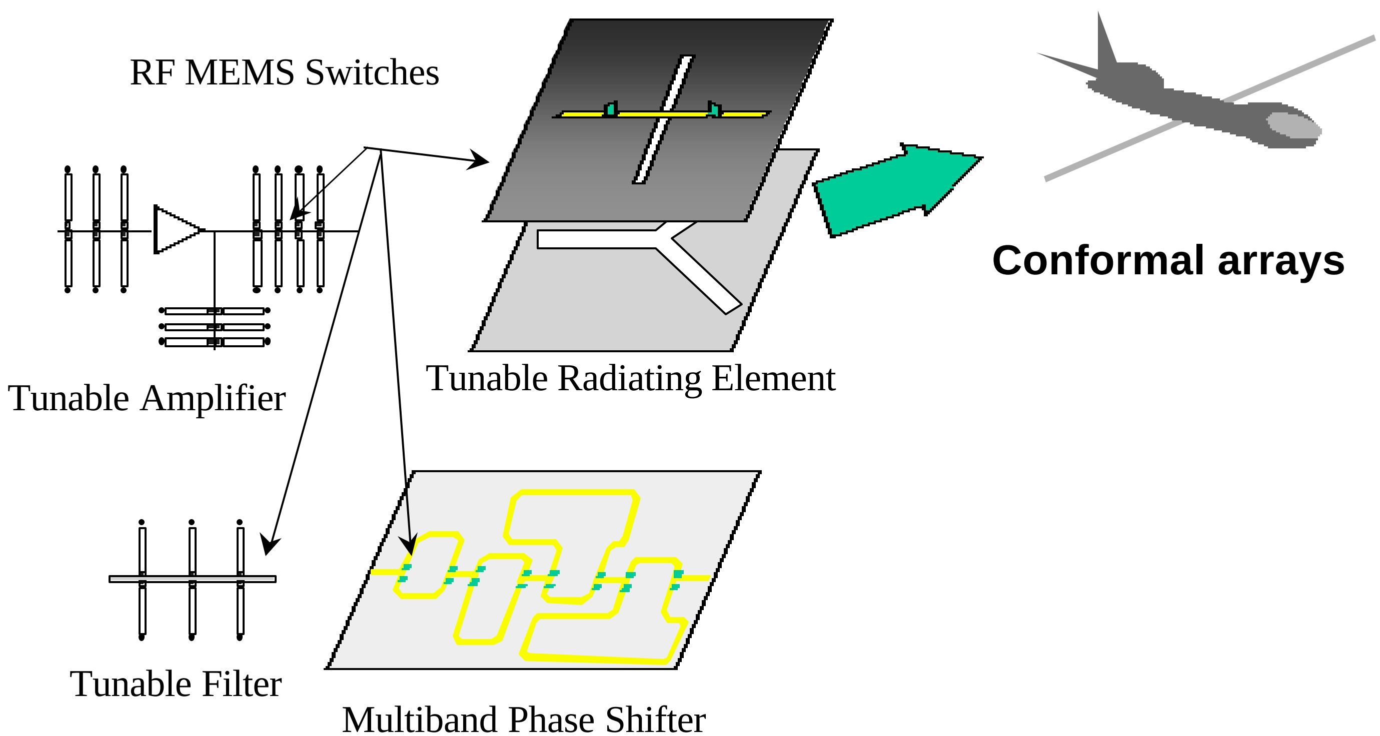
- AFRL is aligning itself with the evolving commercial markets for very low cost antenna technology that support future Ka-band systems
  - Emphasis is on 20 GHz receive arrays
  - Teledesic will address mobile users through wideband 2-way service to commercial aircraft
- DUAP program will seek to leverage these commercial development efforts in the design and manufacture of low cost military receive arrays in the 17.7 to 21.2 GHz range

Low Cost MEMS Technology

- MEMS phase shifters with low insertion loss (~ 1 dB) could be used up front near the antenna element ahead of the amplifier
  - – 1 amplifier for every N elements
    - Reduce GaAs chips by a factor of N
    - Compensate for additional insertion loss with larger aperture
  - – Phase shifters produced in batch mode on cheap substrates

Conformal Multiband MEMS Antenna Array

- **Limited real estate dictates multiband antenna systems to guarantee access to more satcom systems**



Summary

- Technology needs:
  - Mechanically steered antennas:
    - Transmit/receive (44/20 GHz) Luneberg lens
      - Resolve temperature issues on transmit
    - Full aperture single pol and dual pol CTS antennas
    - Transmitter/antenna demonstrations (solid state and TWTA)
  - Electrically steered arrays
    - Increase number of suppliers in industry
    - Emphasis on 44 GHz