

# **Ka Band Hardware and Wideband Multibeam Antennas**

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*Web Page: <http://kronos.lerc.nasa.gov/acts/tve.html>*

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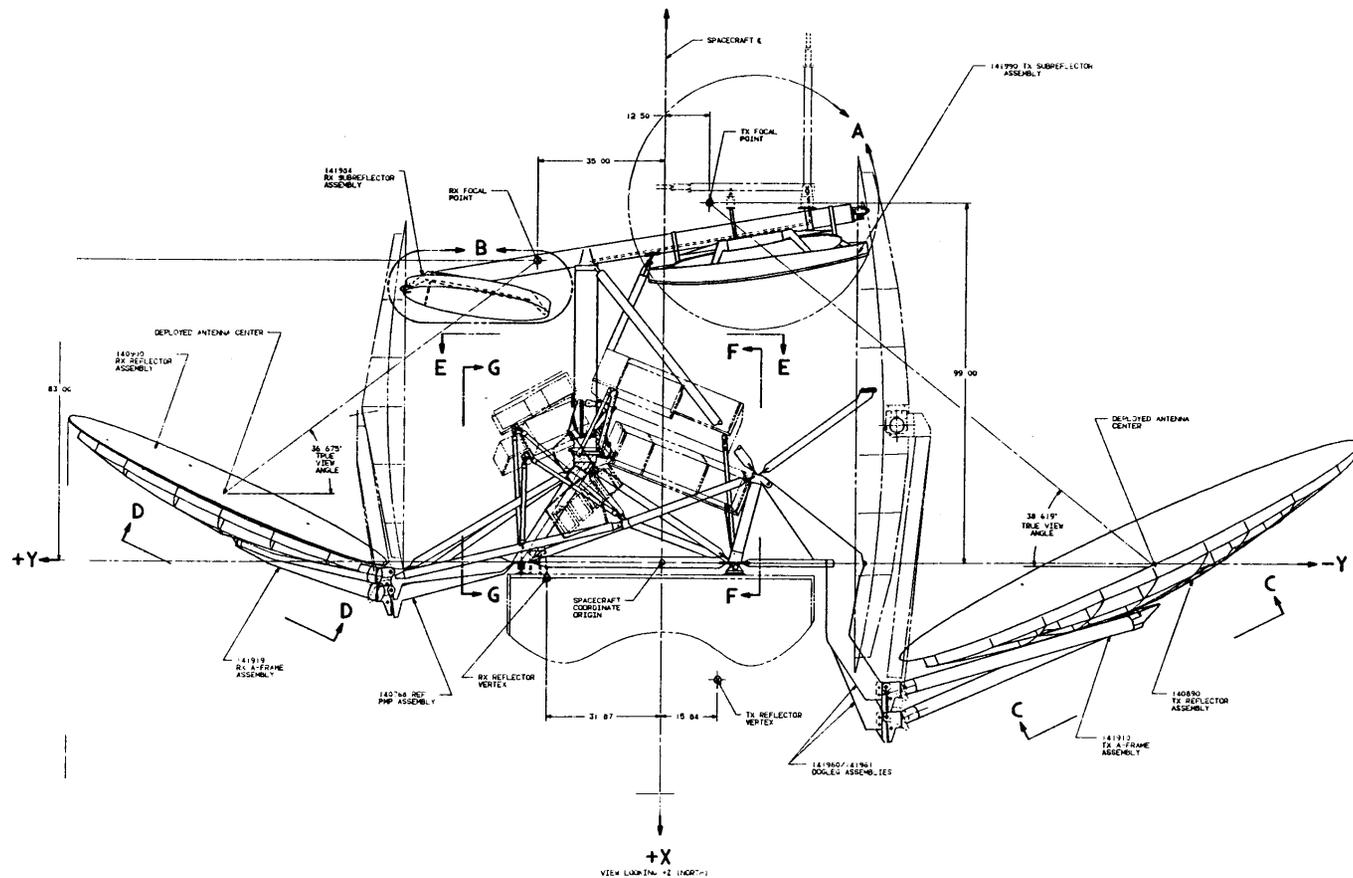
# Summary of Presentation



- *ACTS MBA system*
- *Thermal analysis ACTS MBA*
- *On-orbit test results*
- *ACTS Lessons Learned*
- *Recommendation for future MBA designs*

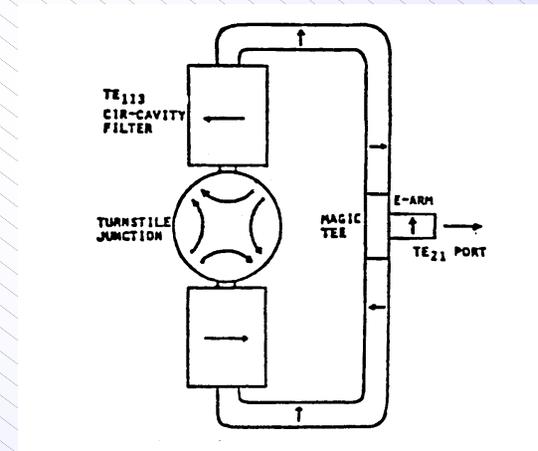
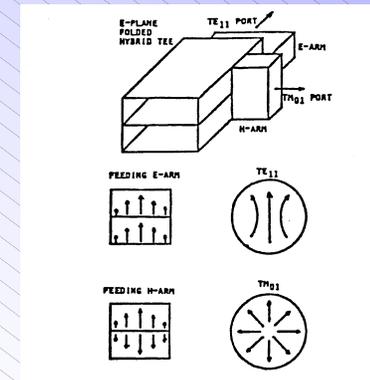
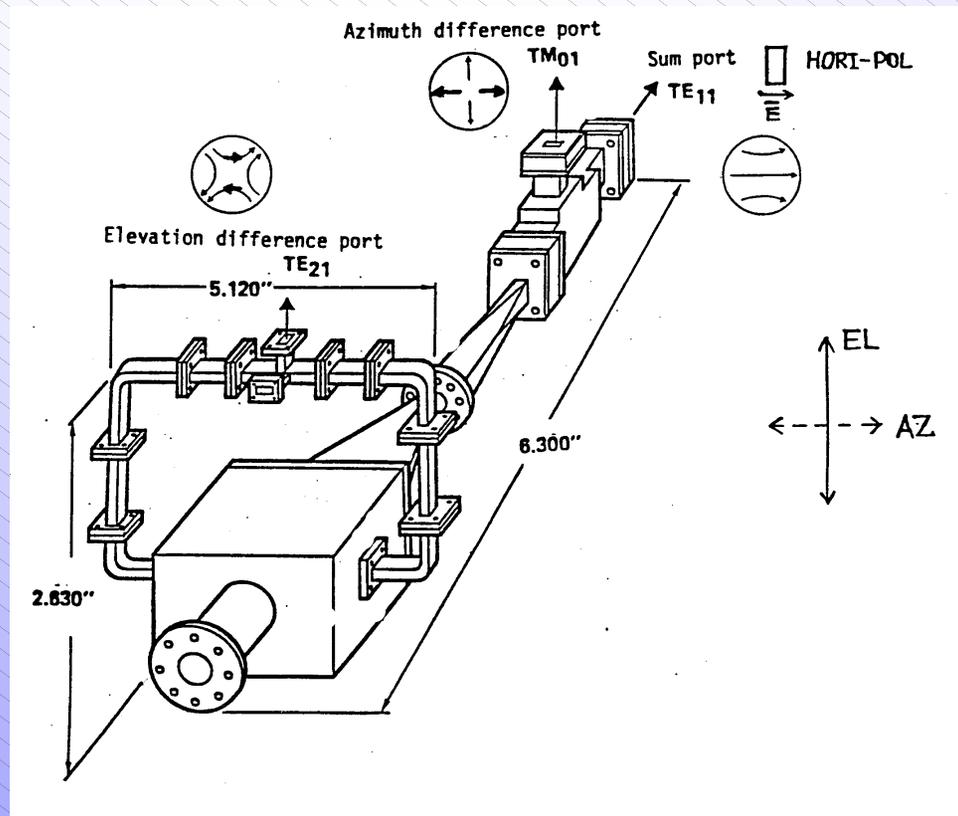


# MULTIBEAM ANTENNA DIAGRAM



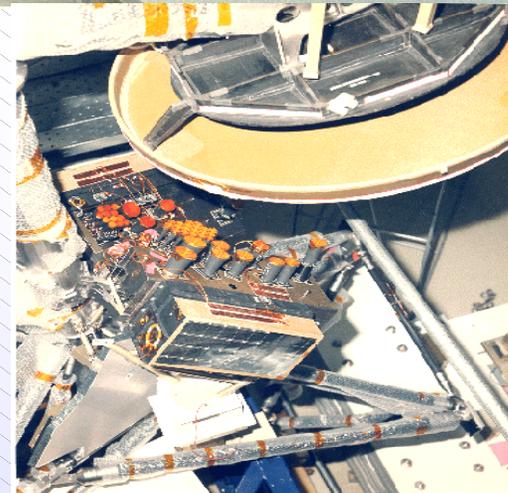
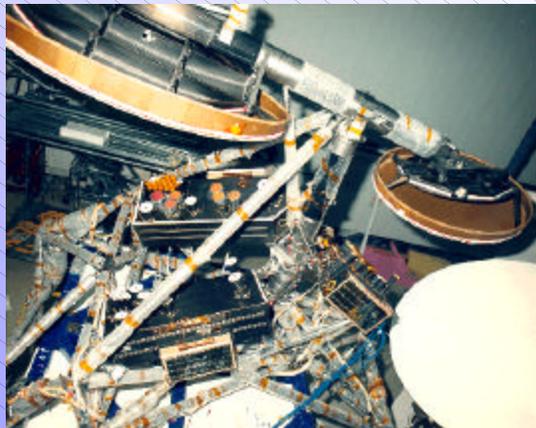
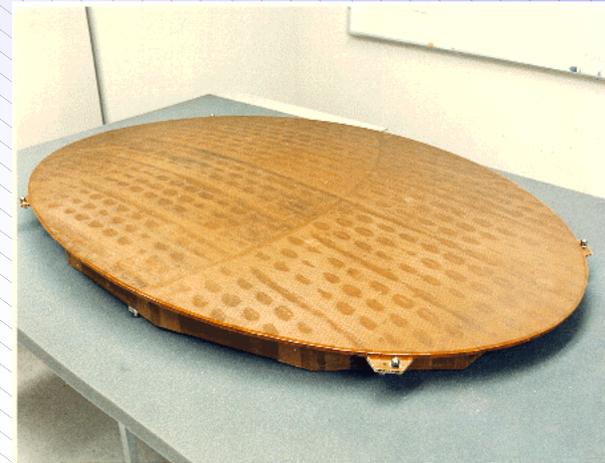


# AUTOTRACK BEAM FORMING NETWORK



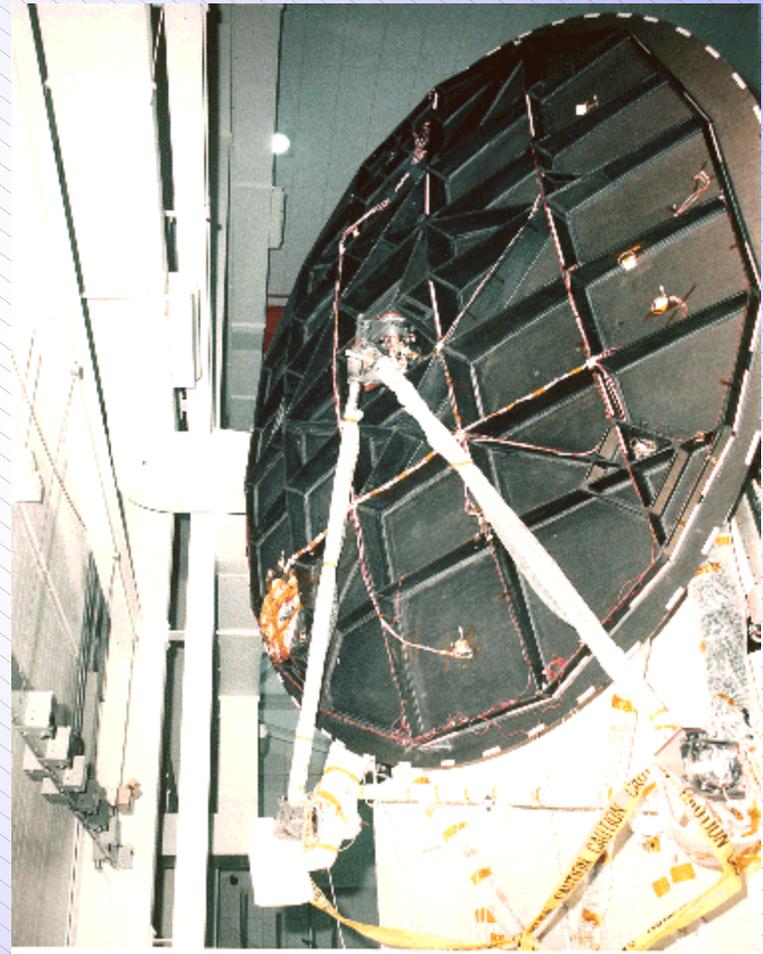
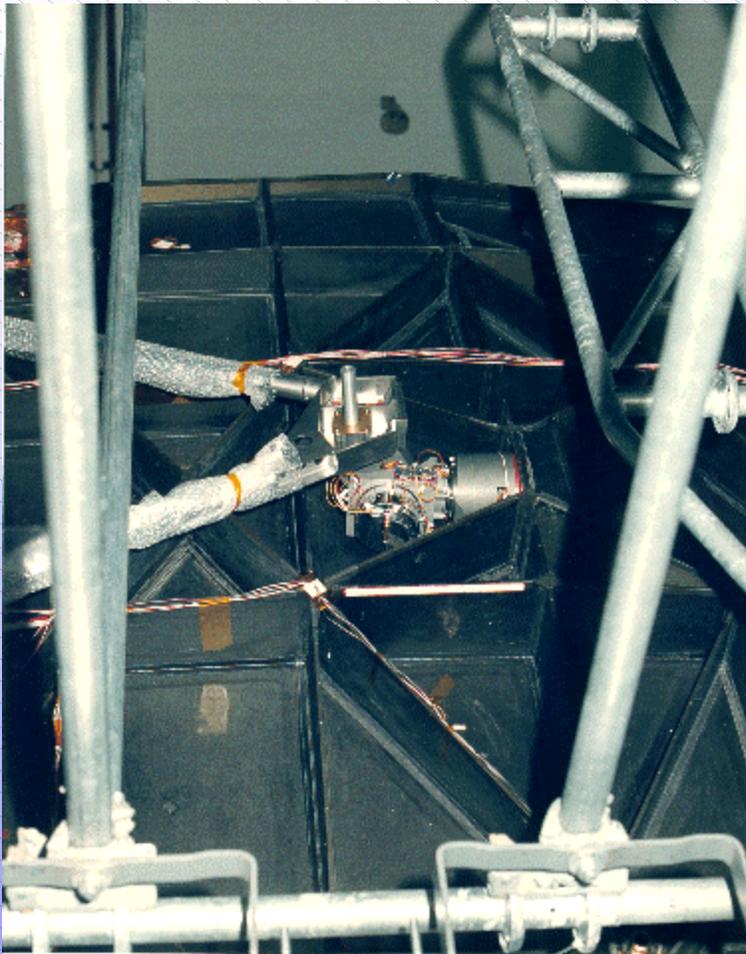


# FRONT AND BACK SUBREFLECTORS





# BIAX-DRIVE MOTOR ON TRANSMIT MAIN REFLECTOR

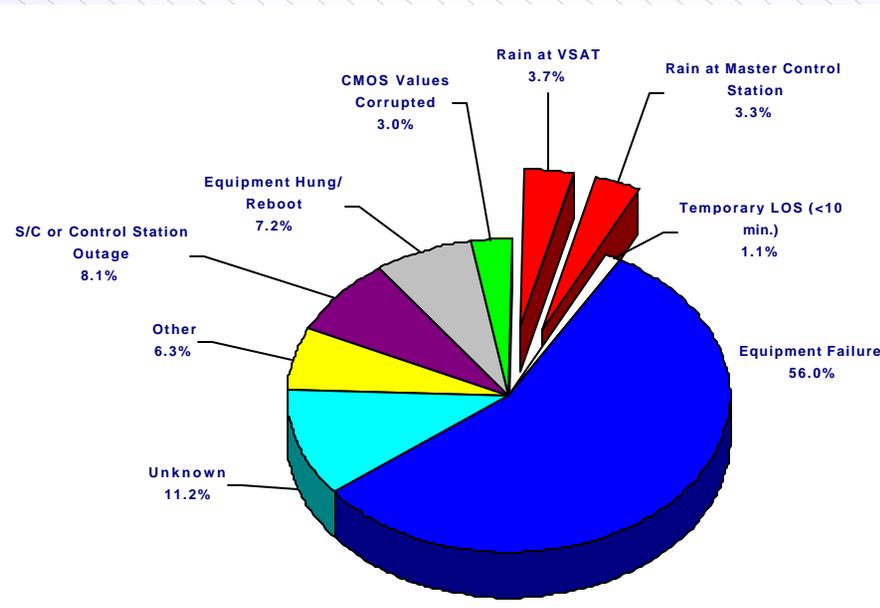




# ACTS-System/Propagation Results Lessons Learned



	Pasadena CA	Reston VA	Clarksburg MD	Boulder CO	Boca Raton FL	Bogota Columbia	Quito Ecuador	Avg. of 7 VSATs
<b>Total Availability*</b>	95.766%	95.727%	90.455%	94.986%	83.636%	89.637%	69.335%	90.783%
<b>VSAT Rain (DL)</b>	99.972%	99.611%	99.809%	99.981%	99.041%	99.738%	97.024%	99.599%
<b>VSAT Rain (UL &amp; DL)</b>	99.834%	99.232%	99.516%	99.638%	98.388%	99.402%	96.947%	99.256%
<b>Avg. Rainfall (in)</b>	9.20	53.00	50.80	25.60	65.50	35.00	29.50	38.37



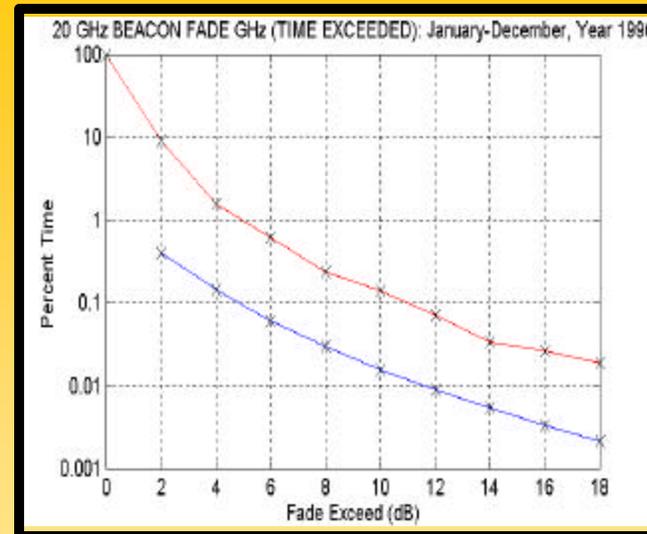


# PROPAGATION AND SYSTEM EFFECTS AT Ka-BAND



## THEORY vs. EXPERIMENT

### FADE AVAILABILITY FOR CLEVELAND - 1996



### Ground Station System Degradation Effects

- Antenna wetting
- Snow accumulation
- Antenna pointing errors - during rain
- De-Icers thermal effect
- Ground station thermal stability - LNA, LO, etc.
- Measurement error

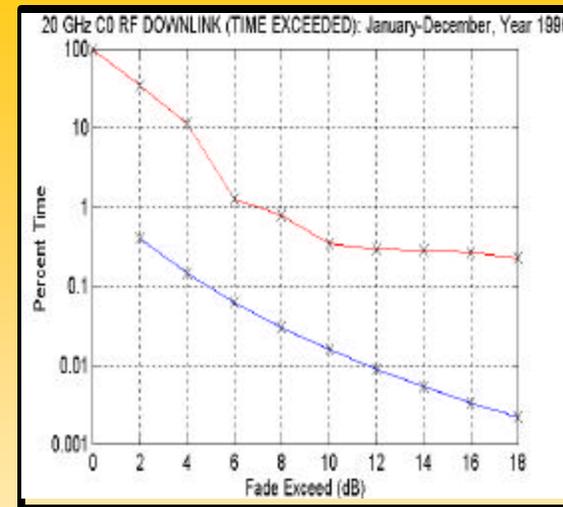


# PROPAGATION AND SYSTEM EFFECTS AT Ka-BAND



## THEORY VS. EXPERIMENT

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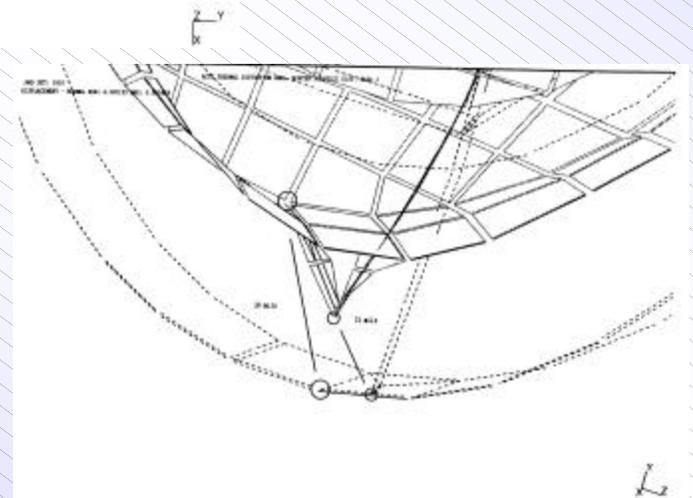
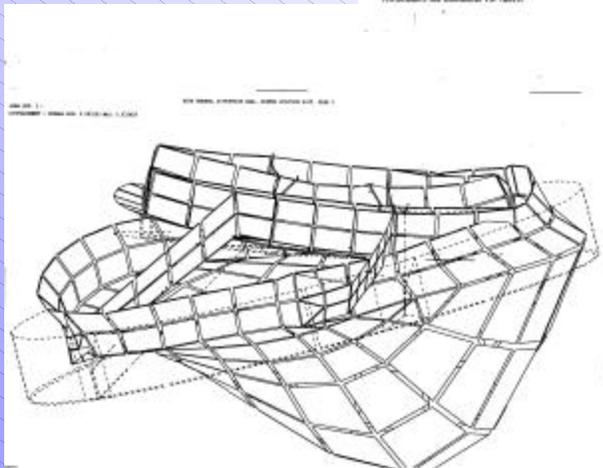
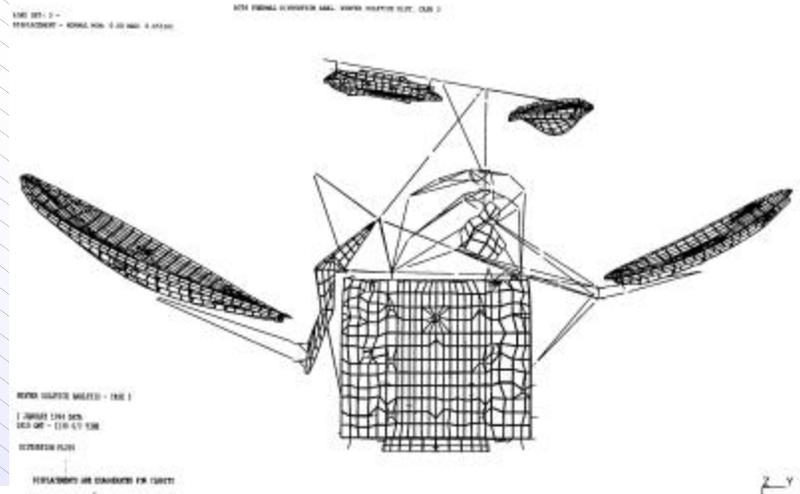


### GROUND STATION AND SPACECRAFT DEGRADATION EFFECTS

- Multibeam antenna pointing errors
- Attitude control errors
- Measurement errors

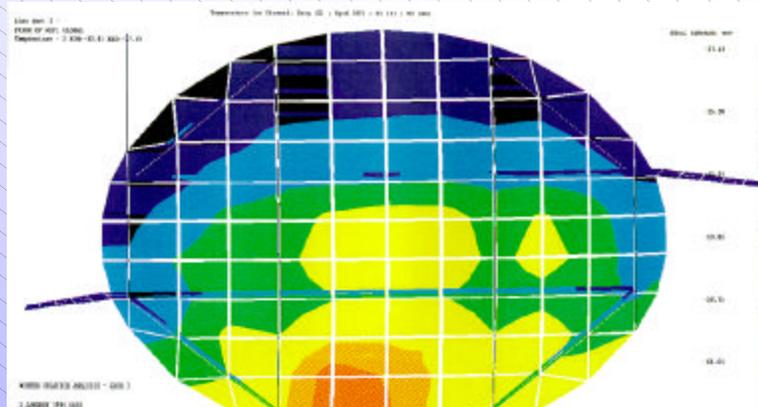
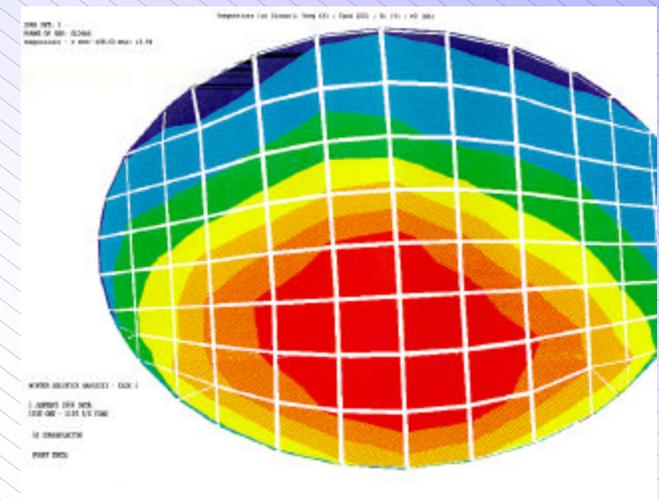
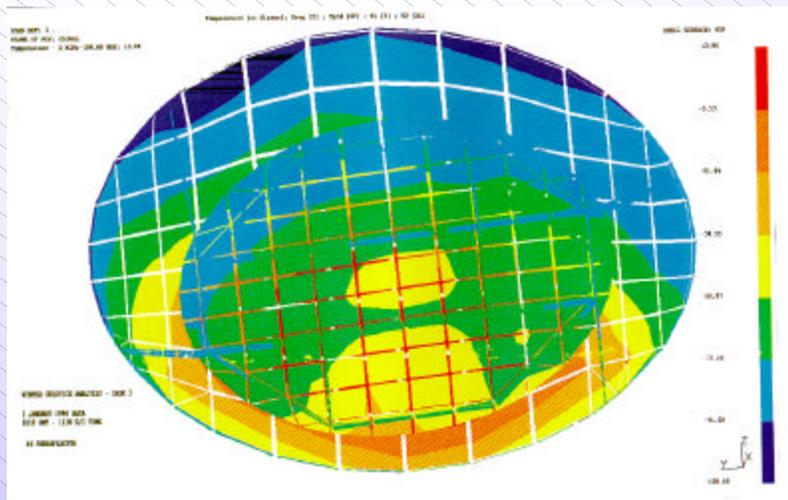


# Structural Analysis





# Thermal Analysis





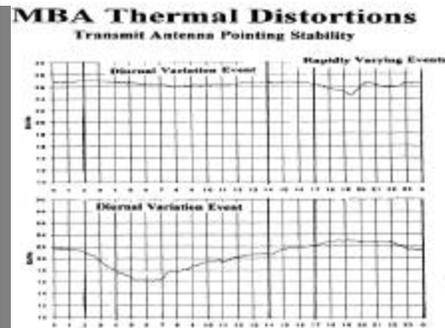
# ON-ORBIT TEST RESULTS



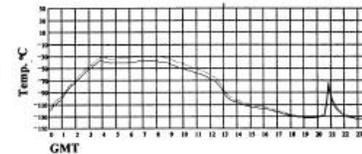
## Correlation of RF Signal Variations with Temperature

East Beams

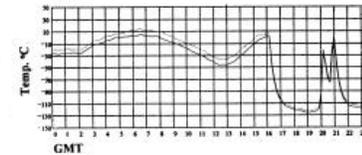
West Beams



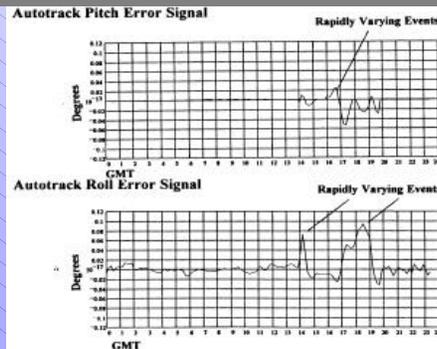
Probe #1



Probe #2

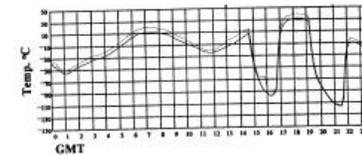


## Pitch and Roll - Autotrack

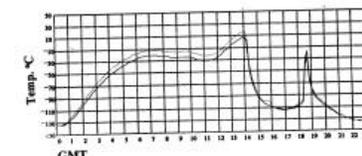


## Sub-Reflector Temperatures

Probe #1



Probe #2

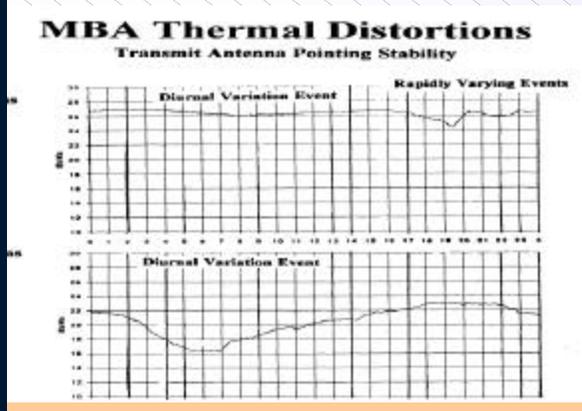




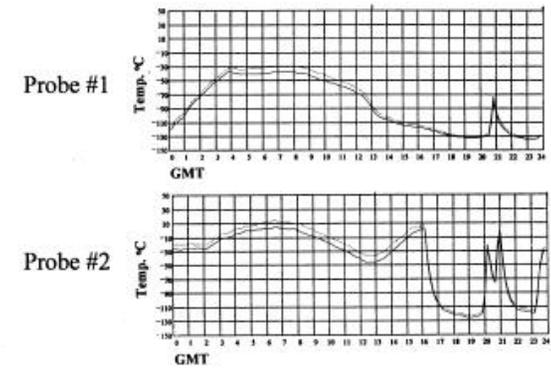
# ON-ORBIT TEST RESULTS



East Beams  
West Beams

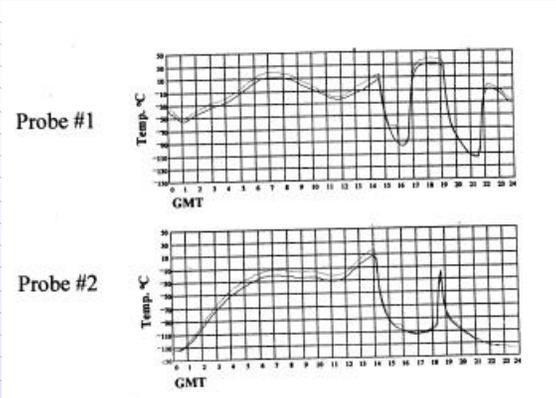
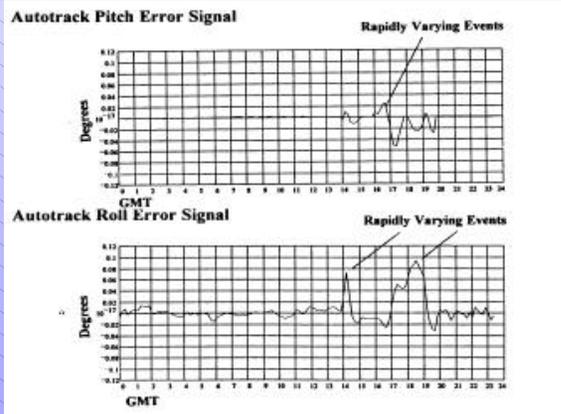


MBA Thermal Distortions  
Transmit Sub-Reflector Temperature Profile



Pitch and Roll - Autotrack

Sub-Reflector Temperatures



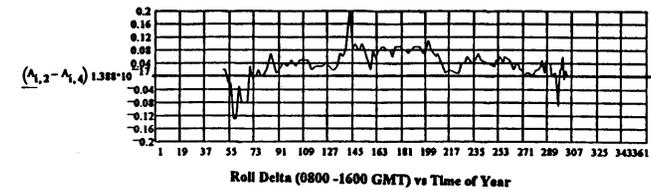
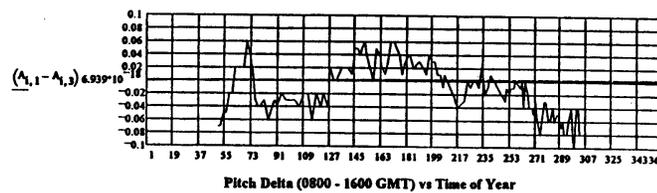
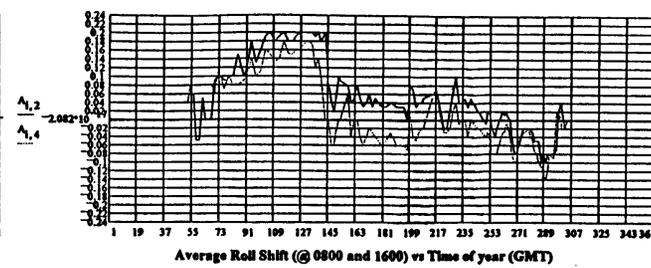
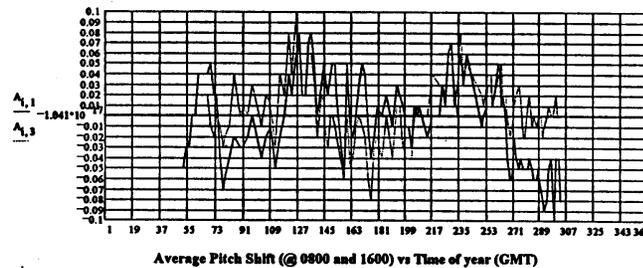


# ON-ORBIT TEST RESULTS



## MBA Thermal Distortions

### Quasistatic Distortion



Pitch Angle (East-West)

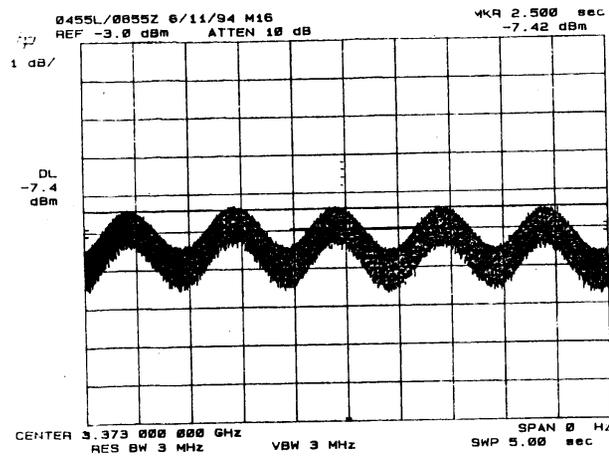
Roll Angle (North-South)



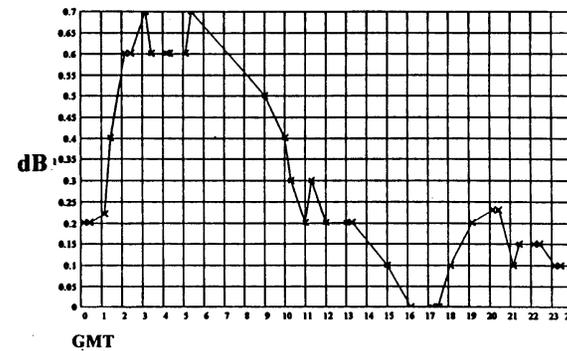
# ON-ORBIT TEST RESULTS



## MBA Non-Thermal Distortions



Received LET 20GHz signal (Beam shifted 0.12 degrees).



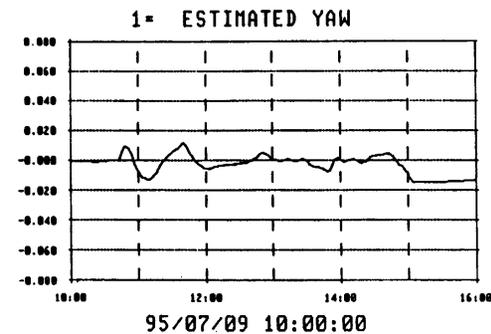
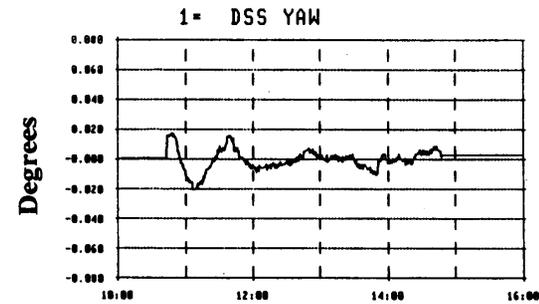
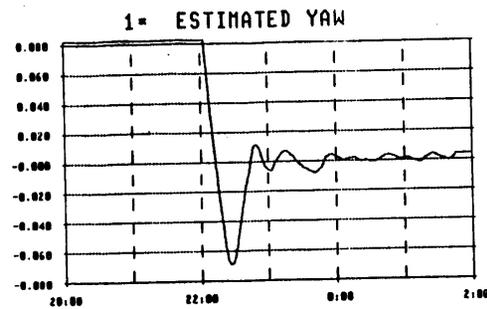
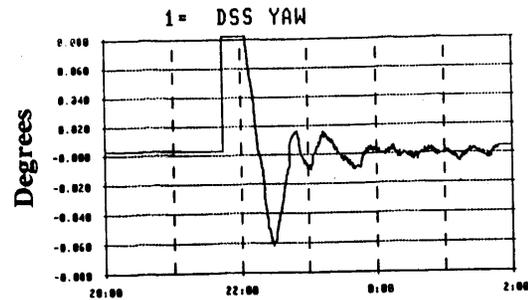
Distortion amplitude variation for a 24 period.



# ON-ORBIT TEST RESULTS



## MBA Non-Thermal Distortions

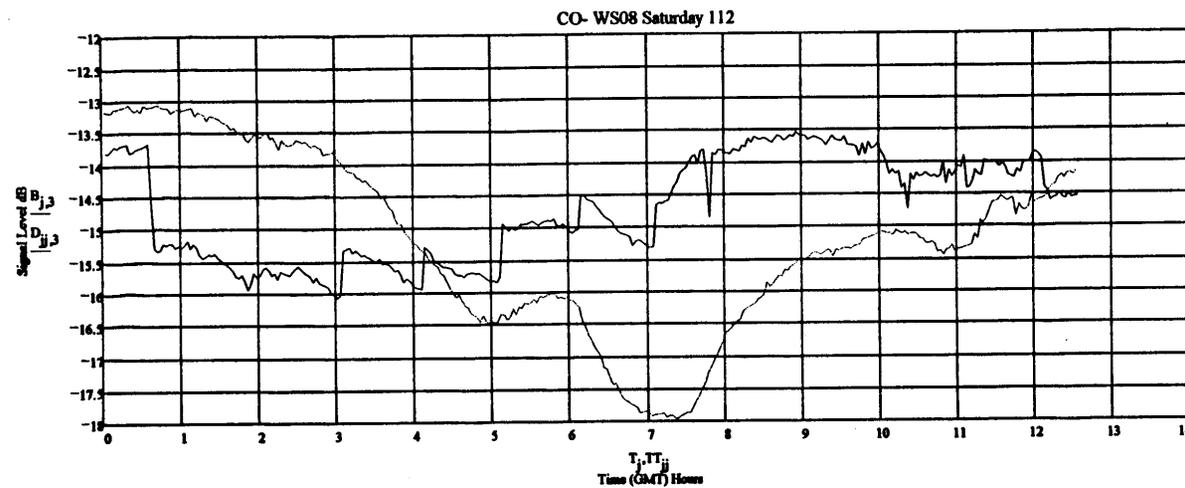




# ON-ORBIT TEST RESULTS



## Compensation of Thermal Distortions





# ACTS LESSONS LEARNED



- Provide means of easily offsetting the S/C in pitch and roll to establish beam centers
- Continuous yaw sensing (vs. estimating) and a more direct yaw & roll control (momentum wheel vs. torquers) should be considered for precise spot beam
- Perform a careful; thermal distortion analysis for narrow spot beam antenna systems (Beam wondering may occur at other than at maximum temperature gradients or extremes)
- Conduct low frequency dynamic analysis to ensure structural members do not cause spot beam wondering (Micro disturbances from spacecraft control system can cause large antennas to oscillate)
- For separate transmit and receive antenna systems, provide a means for adjusting receive and transmit beam alignments



# Future Ka-Band Systems

## Small Beam Technology



**Small Beam Technology** (Light weight, low cost). Higher rates using GEO Satellites will require small spot beams ( $<1.0^\circ$ ).

- *ACTS utilizes  $0.3^\circ$  spot beams but had difficulties with thermal distortions and antenna systems weights. ( $>30$  lb/sq. m)*

### Reflector Antenna Technology

- *Antenna Modeling - Thermal*
- *Light Weight ,  $< 20$  lb/sq. m.*
- *Low Cost*
- *Gridded reflector technology*
- *BFN SW  $\leq 1$  msec*
- *Thermally Stable Ref., Structures*