ACS Stanford Telecom

Stanford Telecom / New Mexico State University

ACTS Propagation Measurements Program

Data Analysis Summary

Julie H. Feil
Louis J. Ippolito
Stephen Horan

NAPAX XX & APSW IX
June 4-6, 1996
Fairbanks, Alaska

ACS Stanford Telecom

Agenda

- **Introduction**
  - Experiment objectives & configuration
- **ACTS K_A band measurements and analysis**
  - Processing technique differences
  - Worst month attenuation and weather measurements
  - .24 month (12/93-11/95) propagation statistics
  - Model comparisons
- **Summary and future activities**
- **New Mexico State University**
  - Station Status
  - Application of ACTS Measurements to TDRS data

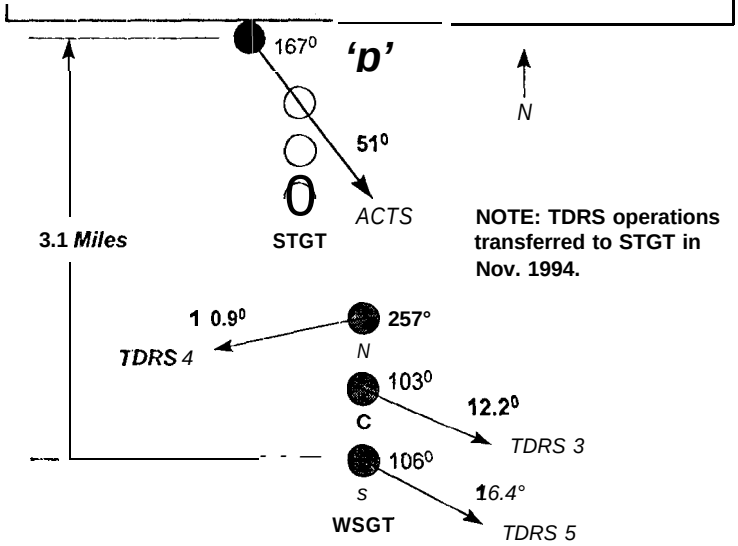
STel ACTS Propagation Experiment Objectives

- Measure and evaluate K_A band propagation effects and link performance for New Mexico
- Develop long-term statistics and prediction modeling techniques for New Mexico climate region for advanced satellite system planning and design
- Apply ACTS measurements (20.185 GHz and 27.S05 GHz) to the evaluation of current and planned TDRS Space-to-Ground Link (SGL) performance

New Mexico APT

- Elevation angle: 51°
- Measured parameters
  - Beacons: 20.185 GHz and 27.505 GHz
  - Radiometers: 20 GHz and 27.505 GHz
  - Rain rate (CRG, TBG)
  - Temperature, Relative Humidity, Wind Vector
- Ancillary Measurements from TDRS
  - 13.5GHz SGL delogged signal attenuation plots for identified weather events ('Raindance')
  - Coincident Steering Data: date, time, antenna azimuth and elevation

Site Configuration



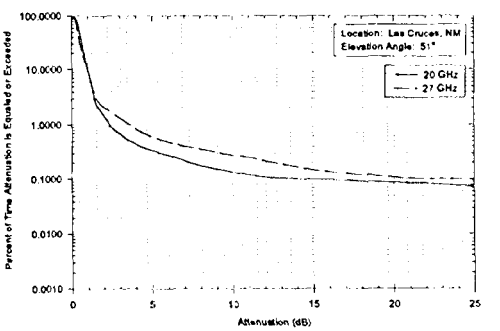
ACTS K_A Band Measurements Summary

- ❑ Two years of data processed
- ❑ Comparison of old and new processing techniques
- ❑ Worst month (in two years): August 1995
- ❑ Two year propagation statistics
- ❑ Model Comparisons
- ❑ Attenuation Ratio
- ❑ Fade Duration

Comparison of Processing Techniques

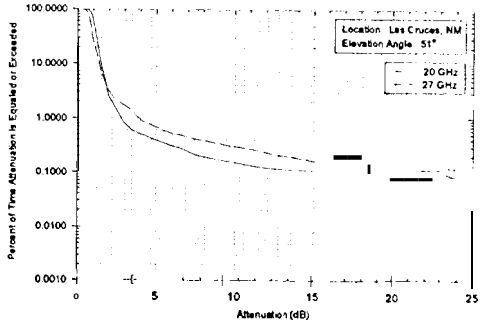
- **24 Months Statistics: December 1993 -November 199S**
  - From * .pv0 processing (ACTSEDIT)
  - From*.pv2 processing (ACTSPP)
- **Minor differences between two processing techniques**
  - Monthly Statistics are within 1 dB
  - Gaseous absorption is less for *.pv2 than for * .pv0 processing
  - Rain Attenuation is almost identical
  - Snow/ice storms illustrate greatest difference (radiometer delta >1 dB)
- **Model comparisons performed with *.pv2 processed data**

August 1995 Free Space Attenuation (AFS)



From *.pv2 files

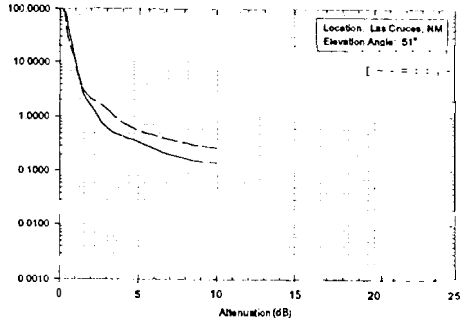
August 1995 Free Space Attenuation (AFS)



From *.pv0 files

- 9 -

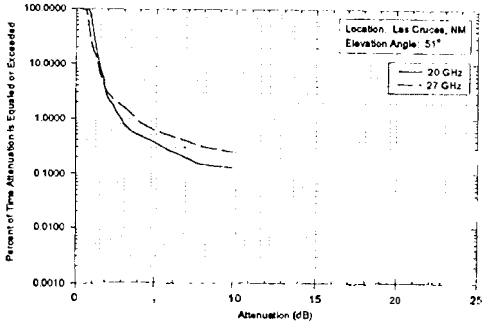
August 1995 Radiometric Derived Attenuation (ARD)



From: - pv2 files

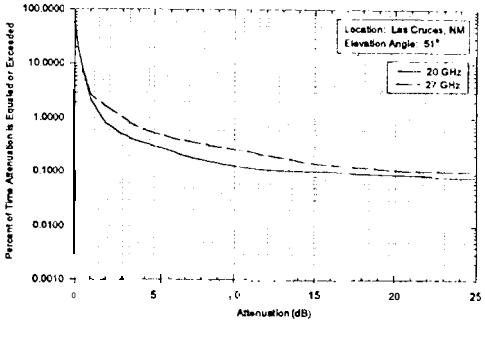
- 10 -

August 1995 Radiometric Derived Attenuation (ARD)



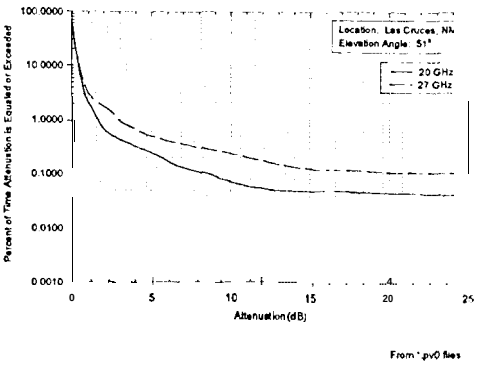
From .@ files

August 1995 Clear Air Attenuation (ACA)

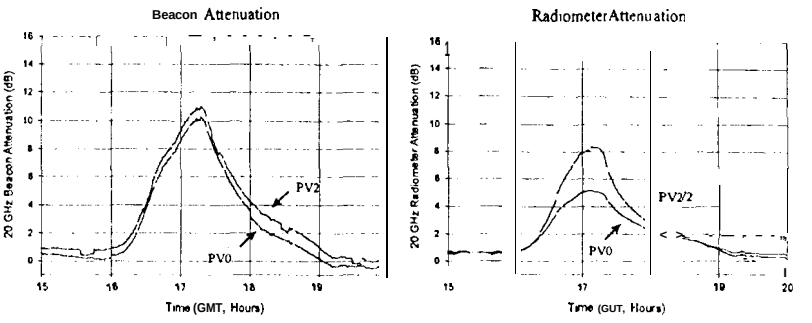


From *.pv2files

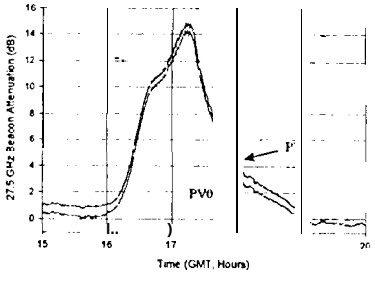
August 1995 Clear Air Attenuation (ACA)

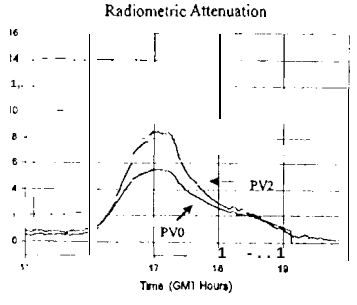


Snow/Ice Event on 20 GHz Channel January 29, 1994

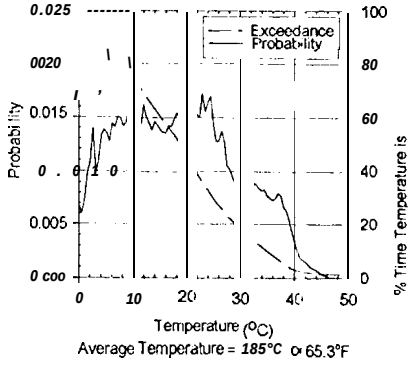


Snow/Ice Event on 27.5 GHz Channel January 29,1994

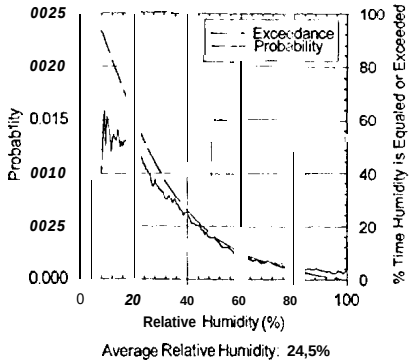




Two Year Surface Temperature



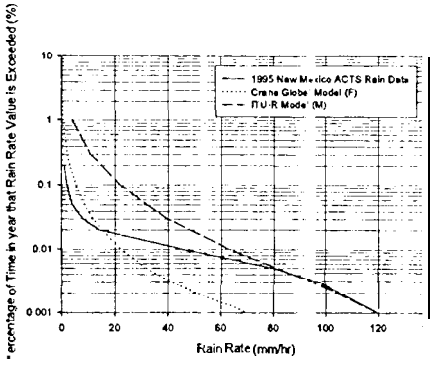
Two Year Relative Humidity



Average Relative Humidity: 24,5%

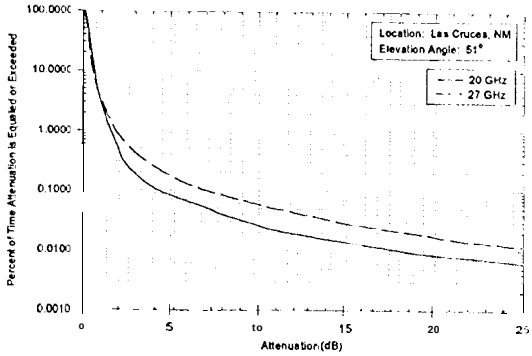
- 17 -

1995 Rain Rate Statistics



ACS Stanford Telecom

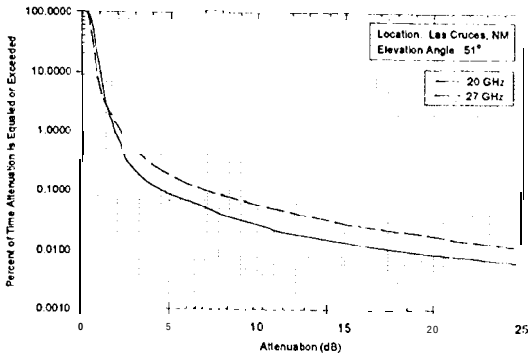
Two Year Attenuation wrt Free Space (AFS)



From *.pv2 files

ACS Stanford Telecom

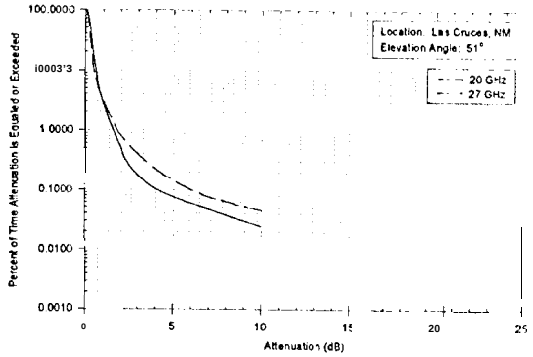
Two Year Attenuation wrt Free Space (AFS)



From . pv0 files

ACS Stanford Telecom

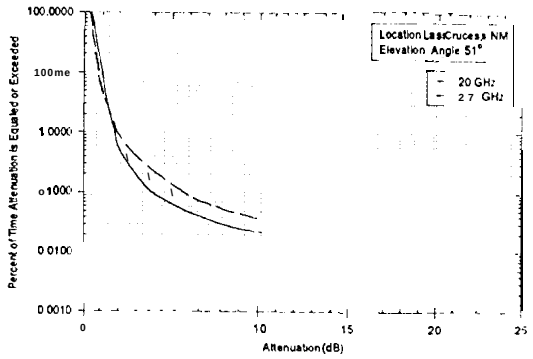
Two Year Radiometric Derived Attenuation (ARD)



From *.pv2 files

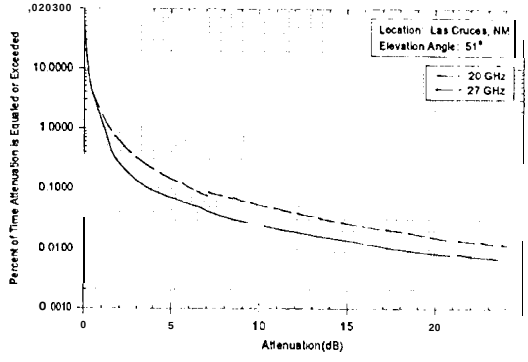
ACS Stanford Telecom

Two Year Radiometric Derived Attenuation (ARD)



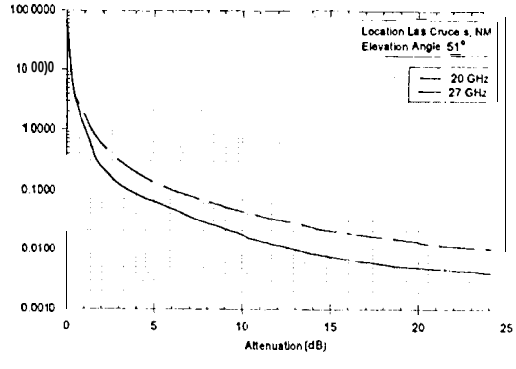
From *.p-C files

Two Year Attenuation wrt Clear Air (ACA)



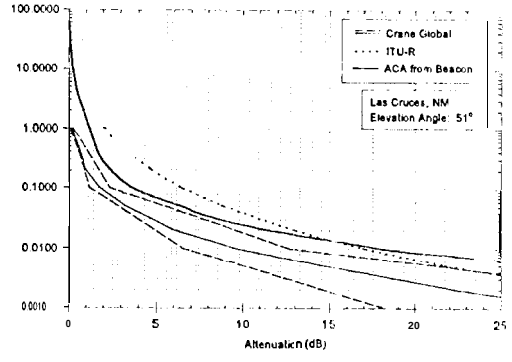
From *.pv2 files

Two Year Attenuation wrt Clear Air (ACA)



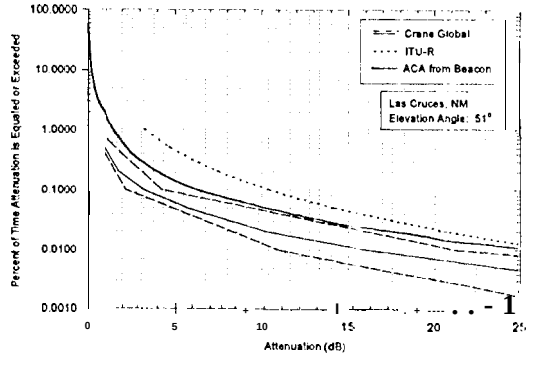
From *.pv2 files

Two Year Comparison 20 GHz Cumulative Distribution



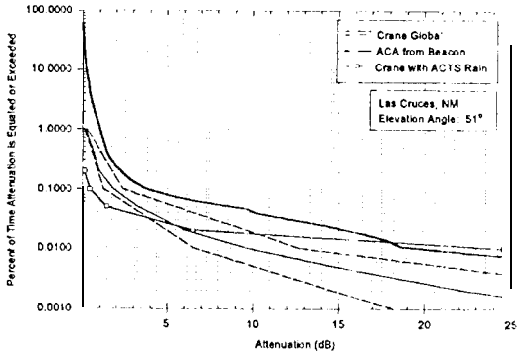
From . pv2 files

Two Year Comparison of 27 GHz Cumulative Distribution



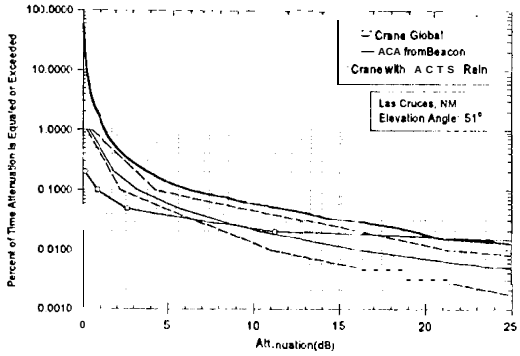
From . pv2 files

199520 GHz Crane Global Model Rain Statistics



From * pv2 files

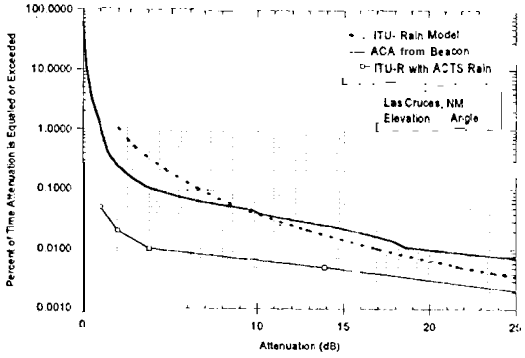
1995 27.5 GHz Crane Global Model Rain Statistics



From * pv2 files

.28

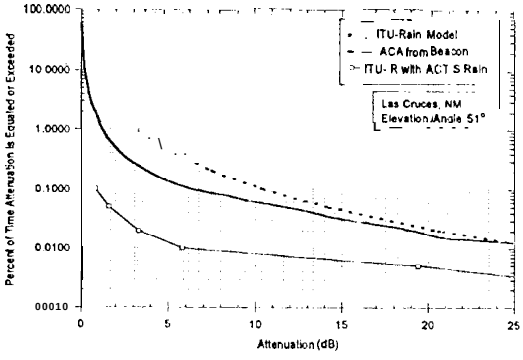
199520 GHz ITU Ruin Statistics



From ..., files

- 29

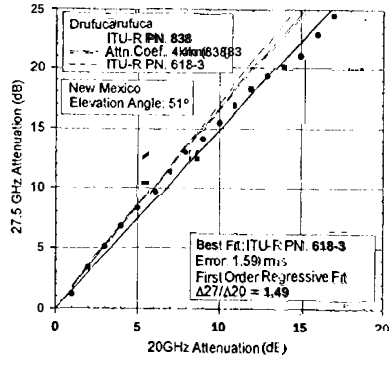
199527.5 GHz ITU Rain Statistics



From ... pv2 m.

ACS Stanford Telecom

Statistical Attenuation Ratio for A CA

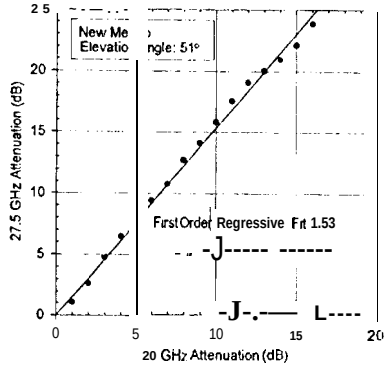


From *.pv2 files

.31.

ACS Stanford Telecom

Statistical Attenuation Ratio for AFS

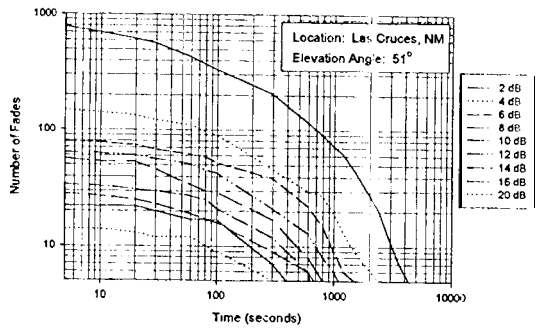


From ..... or *.pv0 files

- 32 -

ACS Stanford Telecom

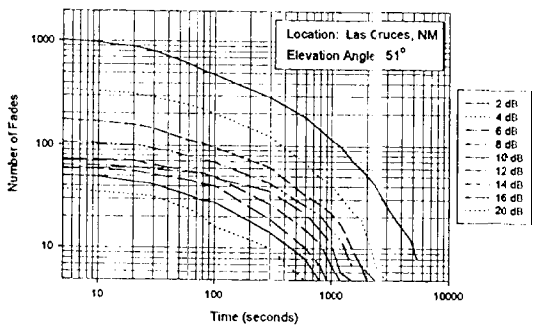
Two Year 20 GHz Fade Duration



From *.pv2 files

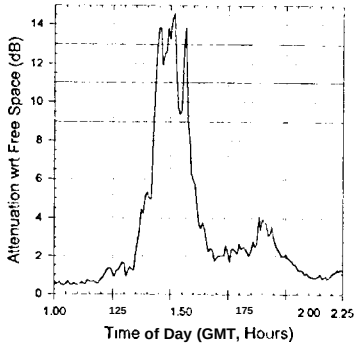
Stanford Telecom

Two Year 27.5 GHz Fade Duration



From *.pv2 files

Fade Event on November 3,1994



From *.pv0files

New Mexico ACTS Statistics Summary

- **Comparison of pv0 and pv2 processing for 24 months have minor differences (< 1 dB) in attenuation distributions**
- **Measured link performance for two year period**

Annual Link Availability	20.185 GHz	27.505 GHz
99.90 %	4.3 dB	6.9 dB
99.95 %	7.0 dB	11.0 dB
99.99 %	18.9 dB	> 25 dB

New Mexico ACTS Statistics Summary (Cont.)

- **According to the National Climatic Data Center**
  - Above average temperature
  - Average humidity
  - Slightly below average precipitation
- **Rain Attenuation model prediction comparisons**
  - ITU-R Model over-predicts by 2-4 dB
  - Crane Global Model under-predicts by 3-15 dB
  - Use of measured rain statistics does not improve predictions
- **Fade duration**
- **Attenuation ratio predicted well by models until 12 dB**

-37.

Future Activities

- **Complete 3 year cumulative distributions from *.pv0 preprocessing**
- **Complete 3 year cumulative distributions from *.pv2 preprocessing**
- **Compile 3 years of raindance data for comparison to ACTS data**
- **Contract renewal for fourth year statistics**

-38-