APL-COMSAT-Mitre 20 GHz Diversity Experiment Using ACTS

Julius Goldhirsh, Bert Musiani,
Applied Physics Laboratory, JHU
Asoka Dissanayake, K. T. Lin,
COMSAT Laboratories

Background

- Three Site Diversity Link Initiated September 1, 1994
- APL Contract Commenced 4/10/95
- 20 GHz Receivers at APL, COMSAT, Mitre Locations
  - Central Maryland and Virginia
  - Transferred to Stanford Telecom 4/8/95 (0.5 km Distance)
- COMSAT Provided All Receivers and Oversees Health
  - Provides APL with COMSAT and Mitre (or Stanford Telecom) Data
  - APL Performs Diversity Analysis

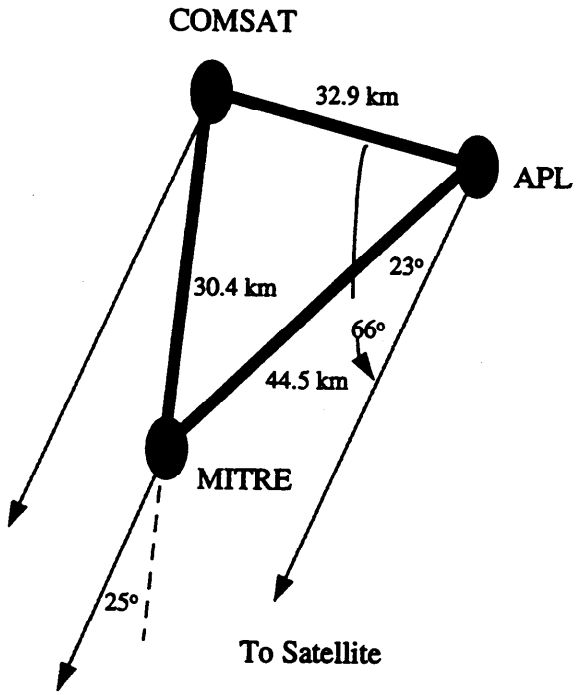
Long Term Objectives

- Establish Single Terminal and Joint Probability Distributions
  - Three Site Scenario
  - Monthly
  - Annual
- Establish Diversity Gains
  - Three Site Scenario
  - Monthly
  - Annual
- Compare Results with Previous Models

Objectives Today's Talk

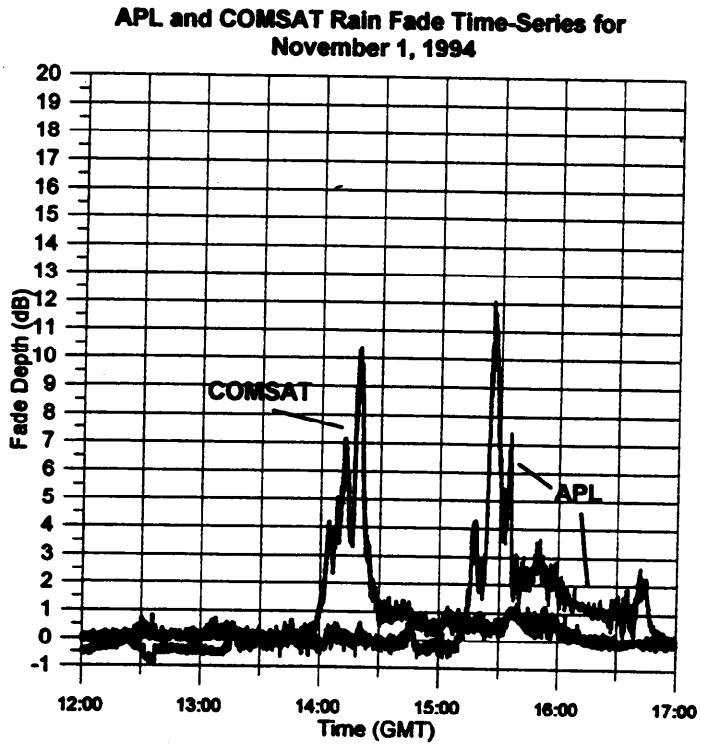
- Provide Background Regarding Experiment
- Single Terminal and Joint Probability Distributions
  - Sept., Oct., Nov. 1994
  - APL-COMSAT Scenario
- Diversity Gains
  - Sept., Oct., Nov. 1994
  - APL-COMSAT Scenario

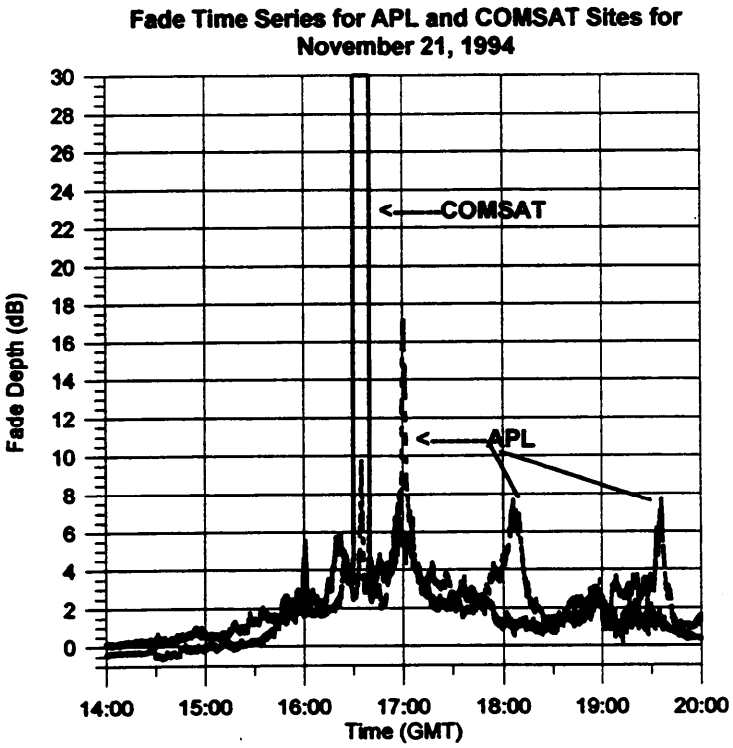
GEOMETRY FOR APL-COMSAT-MITRE DIVERSITY LINK



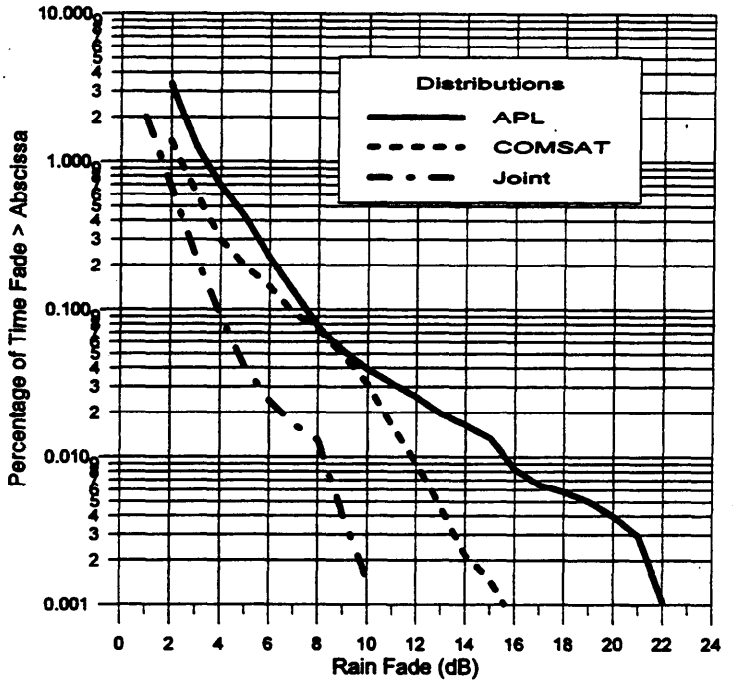
Geometrical and Nominal Electrical Parameters of APL-COMSAT-MITRE Link

PARAMETERS	ALL	APL	COMSAT	MITRE
GEOMETRIC				
Latitude of Sites (deg)		39°10'7.5"	39°13'12"	38°57'
Longitudes of Sites (deg)		77°53'55.5"	77°16'30"	77°19'48"
Azimuth Pointing (deg)		214.0	213.5	213.6
Elevation (deg)		38.7	38.8	39.1
Dist. from APL (km)			32.9	44.5
Dist. from COMSAT (km)		32.9		30.4
ELECTRICAL				
Frequency	20.185			
Polarization	V			
Beacon EIRP (dBW)	19			
Rec. Antenna Diameter (m)	1.2			
Rec. Antenna Gain (dB)	45.9			
Rec. Beamwidth (deg)	.85			
Rec. Bandwidth (Hz)		400	65	20
Carrier to Noise (dB)		28	34	36
Rec. Dynamic Range (dB)		22	28	30

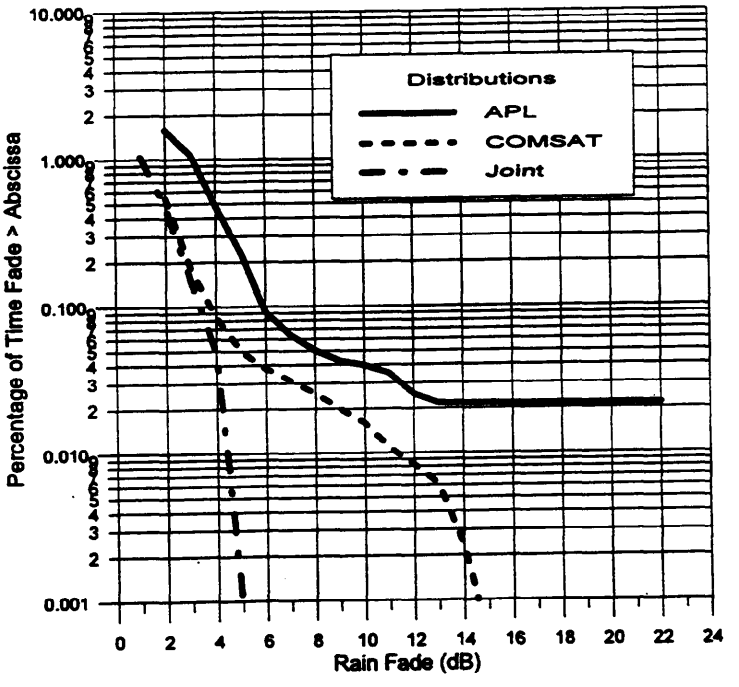

APL and COMSAT Rain Fade Time-Series for
November 1, 1994
Fade Depth (dB)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
COMSAT
APL
12:00
13:00
14:00
15:00
16:00
17:00
Time (GMT)


Fade Time Series for APL and COMSAT Sites for
November 21, 1994
Fade Depth (dB)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
<——COMSAT
<——APL
14:00
15:00
16:00
17:00
18:00
19:00
20:00
Time (GMT)

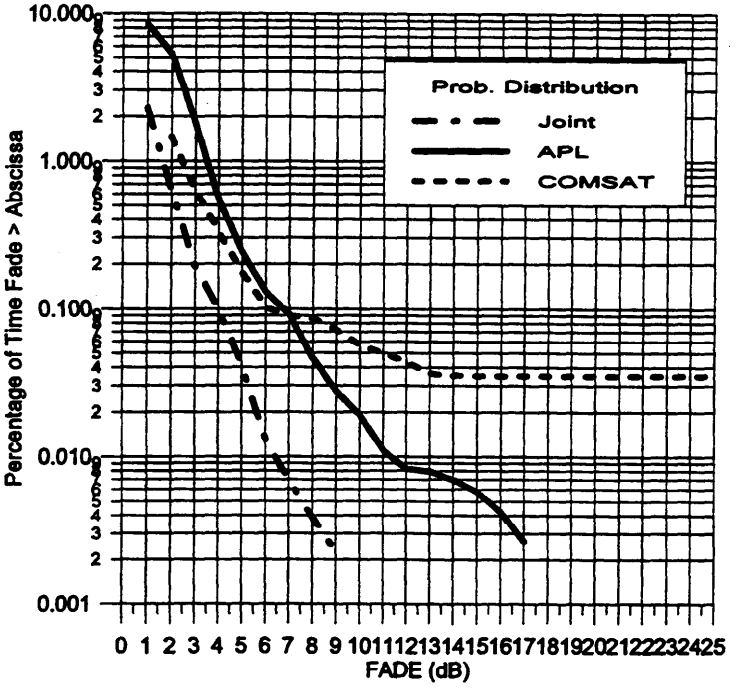
ACTS 20 GHz Single Terminal and Joint Fade Distributions for APL and COMSAT Sites - September, 1994



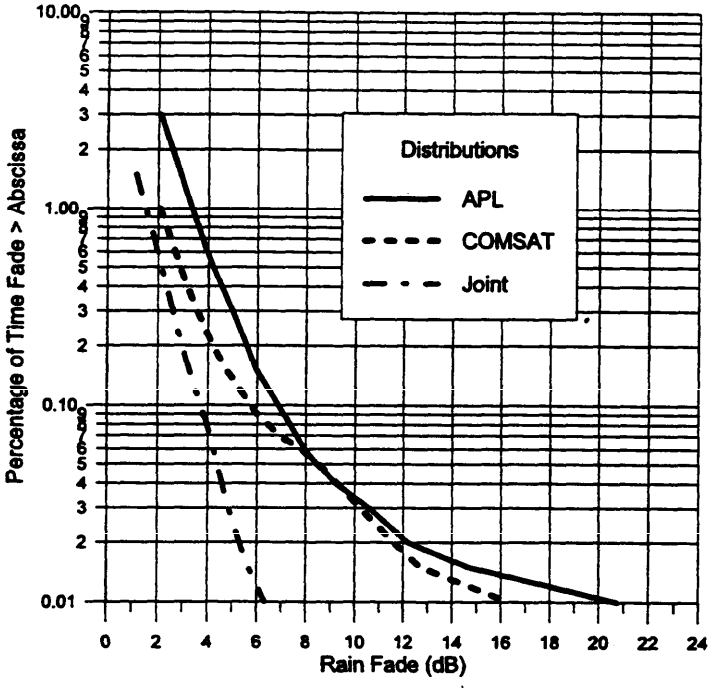
ACTS 20 GHz Single Terminal and Joint Fade Distributions for APL and COMSAT Sites - October, 1994

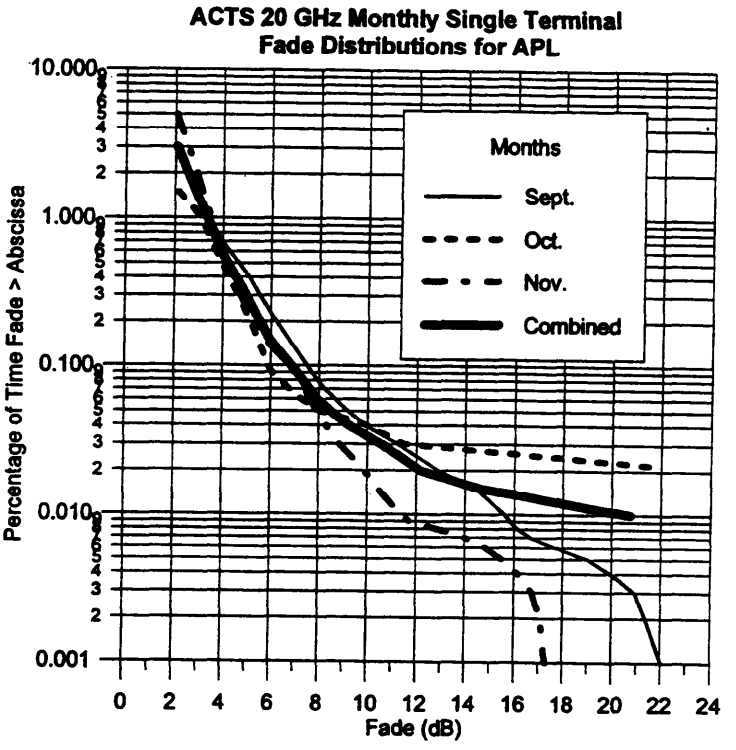


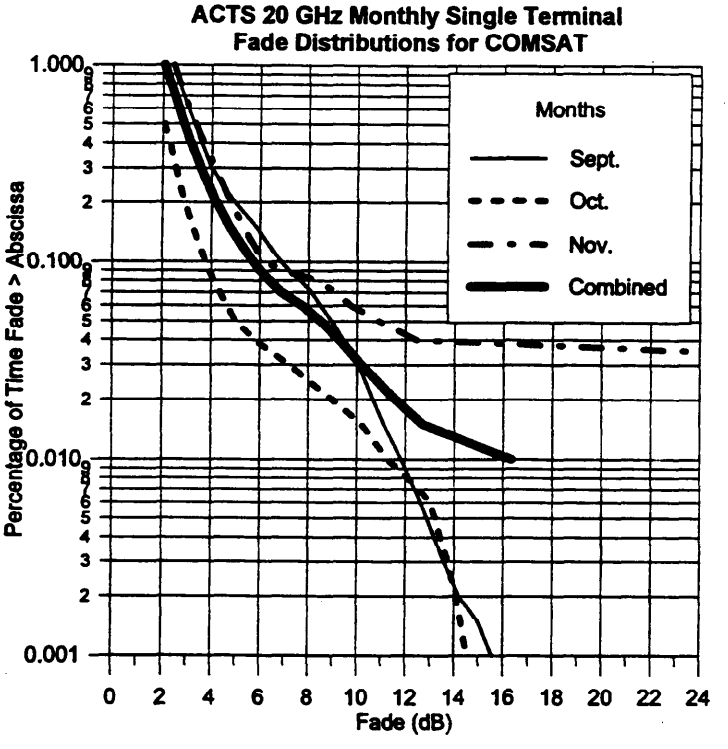
Single Terminal and Joint Cumulative Distributions for APL and COMSAT Sites for November 1994

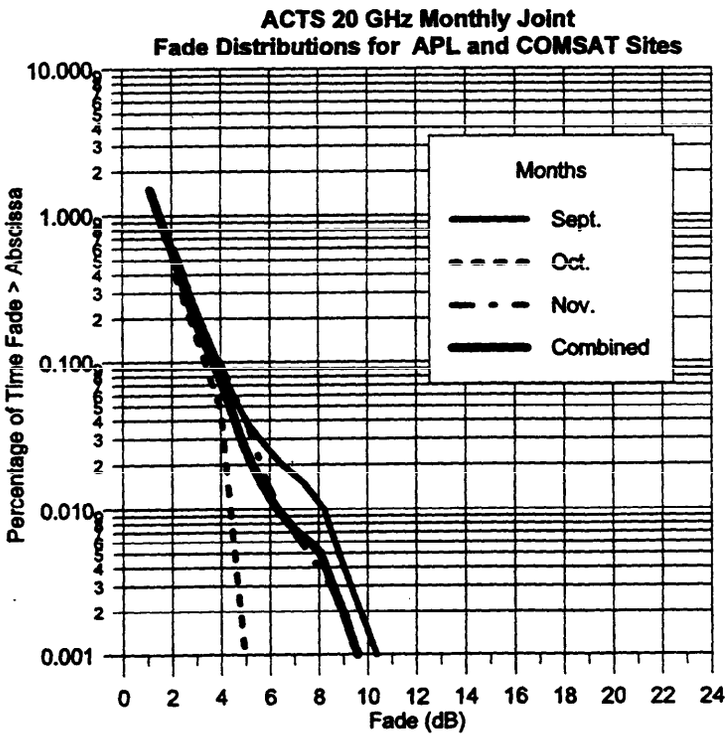


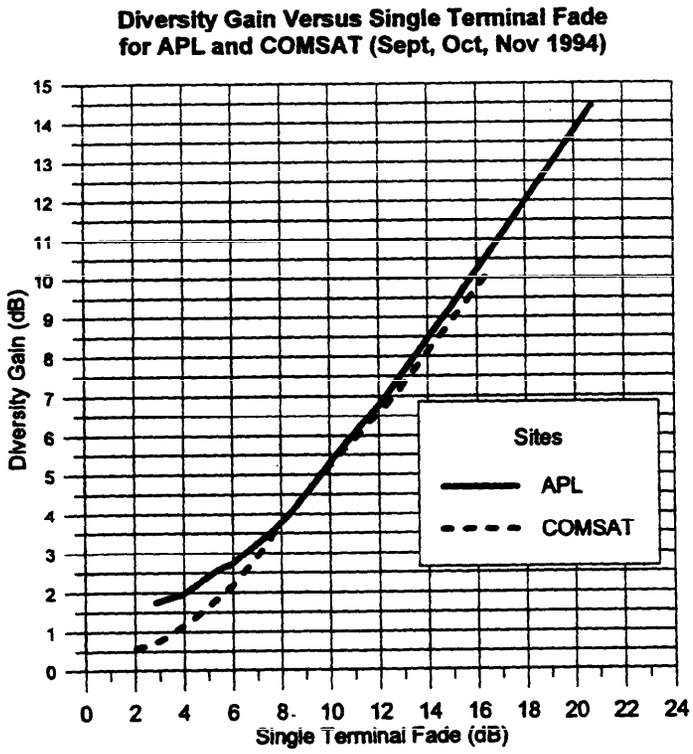
ACTS 20 GHz Single Terminal and Joint Fade Distributions for APL and COMSAT (Sept, Oct, Nov. 1994)

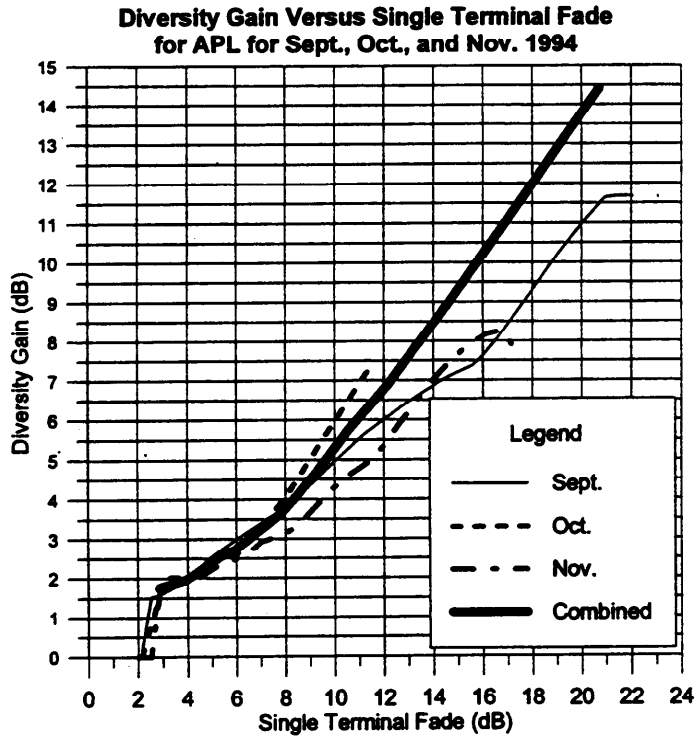


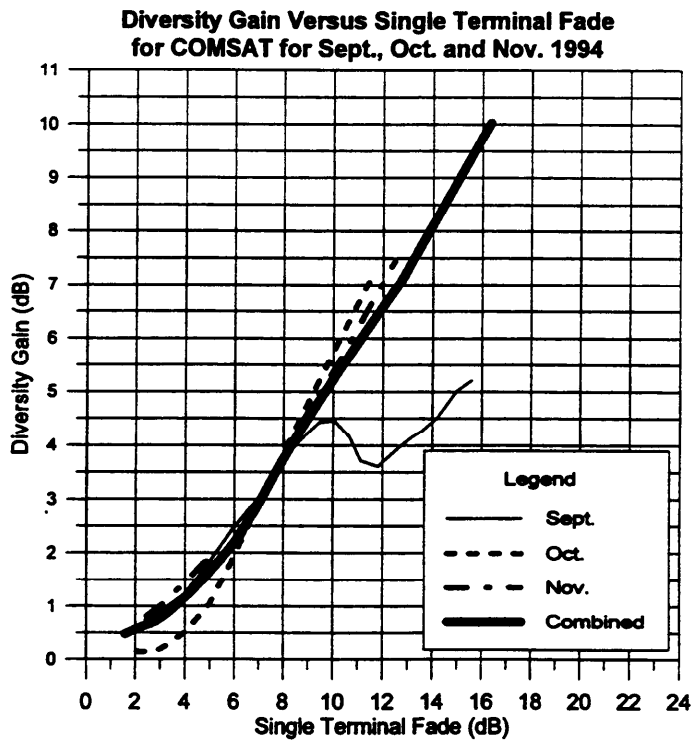

ACTS 20 GHz Monthly Single Terminal
Fade Distributions for APL
Percentage of Time Fade > Abscissa
Fade (dB)
Months
Sept.
Oct.
Nov.
Combined

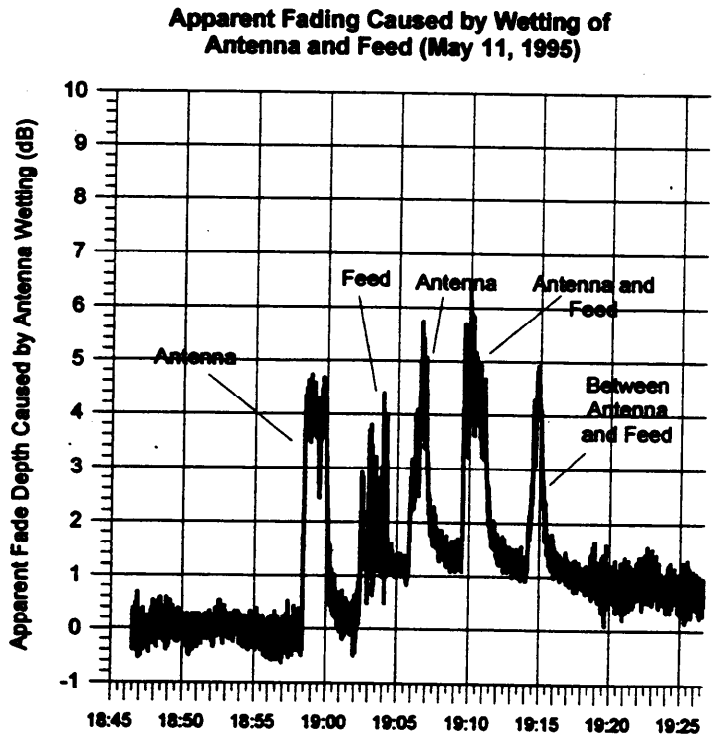

ACTS 20 GHz Monthly Single Terminal
Fade Distributions for COMSAT
Percentage of Time Fade > Abscissa
Fade (dB)
Months
Sept.
Oct.
Nov.
Combined


ACTS 20 GHz Monthly Joint
Fade Distributions for APL and COMSAT Sites
Percentage of Time Fade > Abscissa
10.000
1.000
0.100
0.010
0.001
Fade (dB)
0 2 4 6 8 10 12 14 16 18 20 22 24
Months
Sept.
Oct.
Nov.
Combined


Diversity Gain Versus Single Terminal Fade
for APL and COMSAT (Sept, Oct, Nov 1994)
Diversity Gain (dB)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Single Terminal Fade (dB)
0 2 4 6 8 10 12 14 16 18 20 22 24
Sites
APL
COMSAT


Diversity Gain Versus Single Terminal Fade
for APL for Sept., Oct., and Nov. 1994
Diversity Gain (dB)
Single Terminal Fade (dB)
Legend
Sept.
Oct.
Nov.
Combined


Diversity Gain Versus Single Terminal Fade
for COMSAT for Sept., Oct. and Nov. 1994
Diversity Gain (dB)
Single Terminal Fade (dB)
Legend
Sept.
Oct.
Nov.
Combined



Salient Conclusions

- Assuming a 0.01% Probability for APL - COMSAT Diversity Operation
  - 6 dB Rain Fade Margin Required
    - 21 dB APL Margin
    - 16 dB COMSAT Margin
  - Month to Month Variability is 4 dB
    - 4 dB Margin Required in October
    - 8 dB Margin Required in September
- Diversity Gains of COMSAT and APL - Average Case
  - Within 2 dB from 1% to 0.01%
- Monthly Variability of Diversity Gain for 10 dB Single Terminal Fade
  - DG = 5 dB +/- 1 dB for APL
  - DG = 5 dB +/- 0.5 dB for COMSAT