Eastern U.S. Space-Diversity Experiment: One Year of ACTS 20 GHz Measurements

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  - Diversity gains
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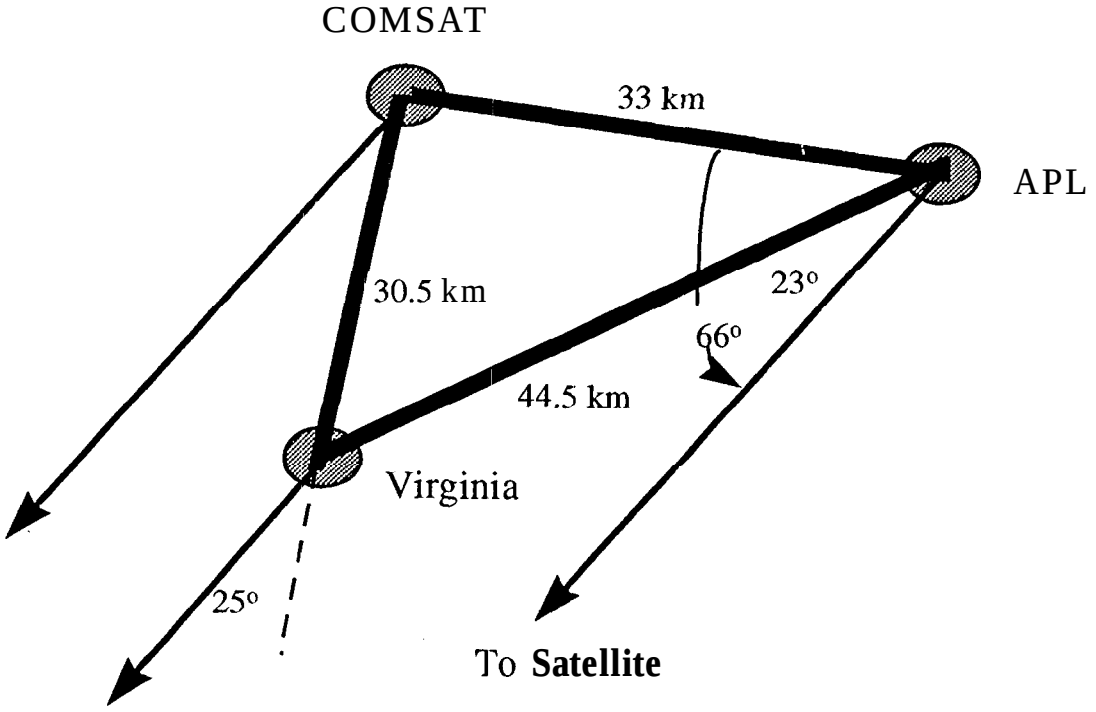
Background

- Three-site diversity experiment initiated September 1, 1994
- 20 GHz receivers located
  - APL (Howard County, MD), COMSAT (Clarksburg, MD)
  - MITRE (Reston, VA) until early April, 1995
  - Stanford Telecom (Reston VA) after April, 1995 (0.5 km distance)
- Time is synchronized with WWV

Background
(Continued)

- Details of 1 year results in:
  - "Three--Site Diversity Experiment at 20 GHz Using ACTS," by Goldhirsh, Musiani, Dissanayake, and Lin, APL/JHU Technical Report F2F-96-U-0-002, March , 1996.

GEOMETRY FOR APL-COMSAT-VIRGINIA DIVERSITY LINK



APL- COMSAT-Virginia Link Parameters

PARAMETERS	ALL	APL	COMSAT	Virginia
Frequency	20.185			
Polarization	v			
Beacon EIRP (dBW)	19			
Rec. Antenna Diamete m	1.2			
Rec. Antenna Gain (dl	45.9			
Rec. Beamwidth (deg)	.85			
Rec. Bandwidth (Hz)		400	65	20
Carrier to Noise (dB)		28	34	36
Rec. Dynamic Range (B		22	28	30

Objectives

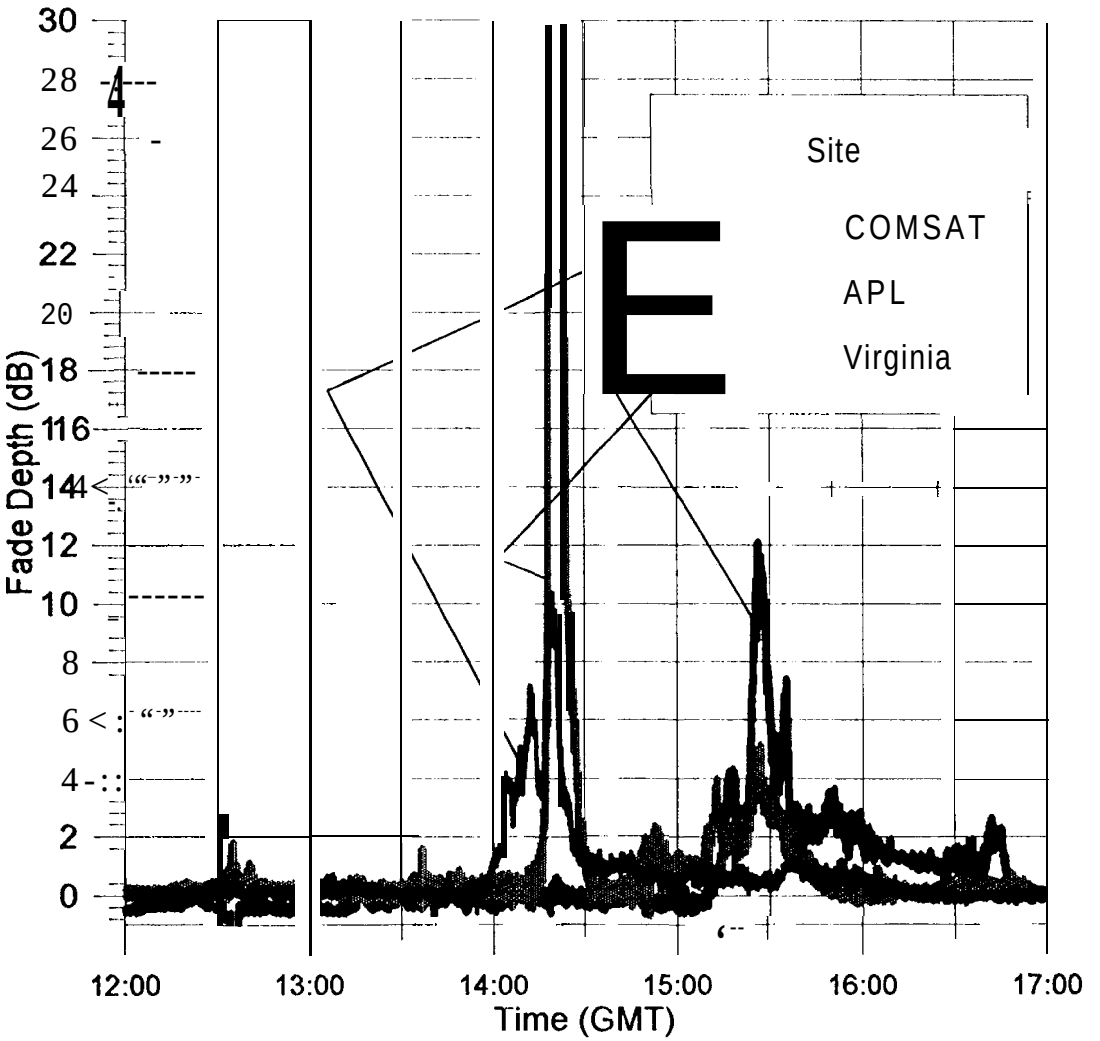
- Single terminal, joint probability distributions, diversity gains
  - Three site scenario
    - APL, COMSAT, Virginia
  - Two site scenario combinations

    APL-COMSAT

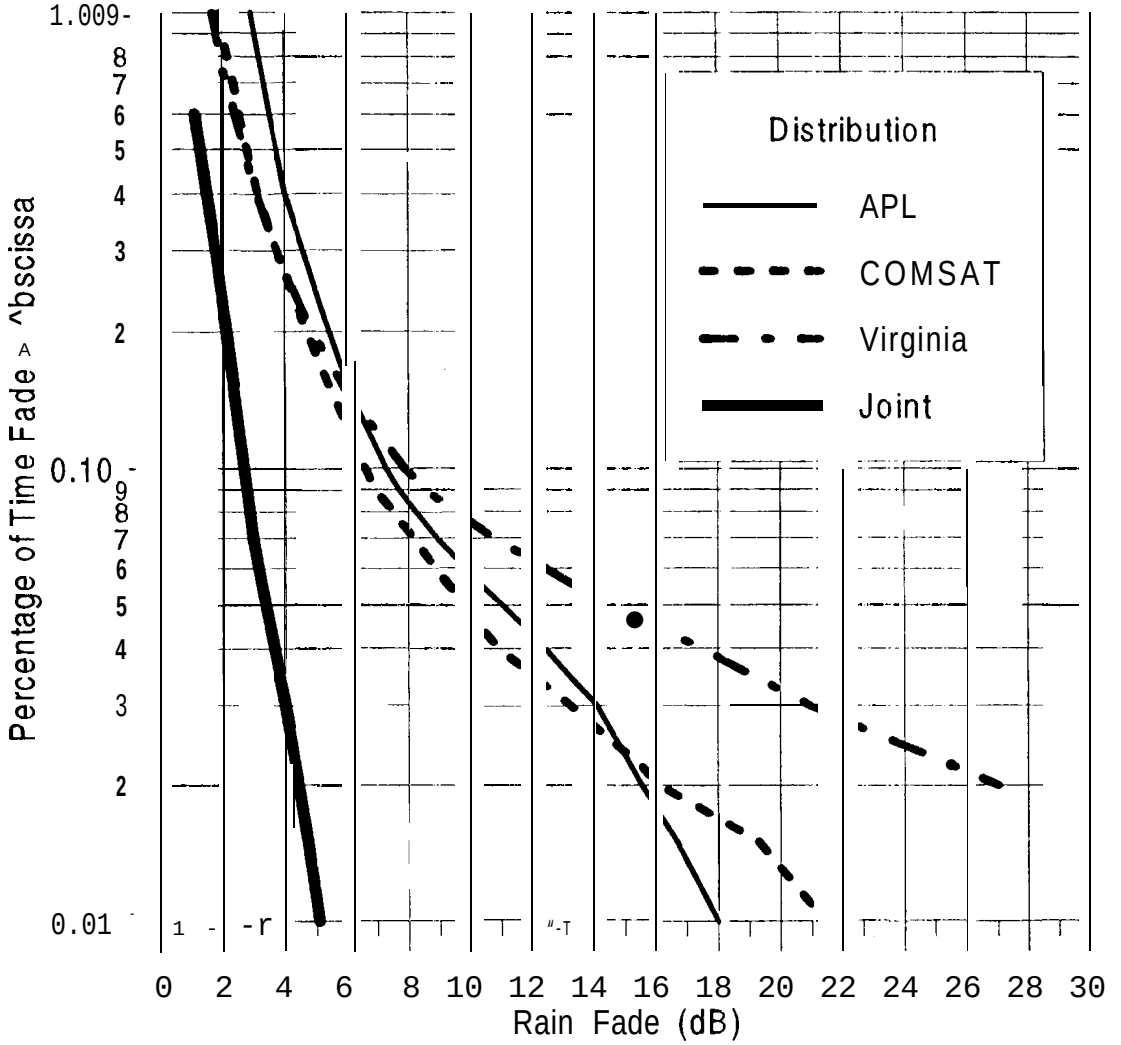
    APL-Virginia

    COMSAT--Virginia
  - Seasonal Effects
  - Compare results with models
    - Two site scenarios

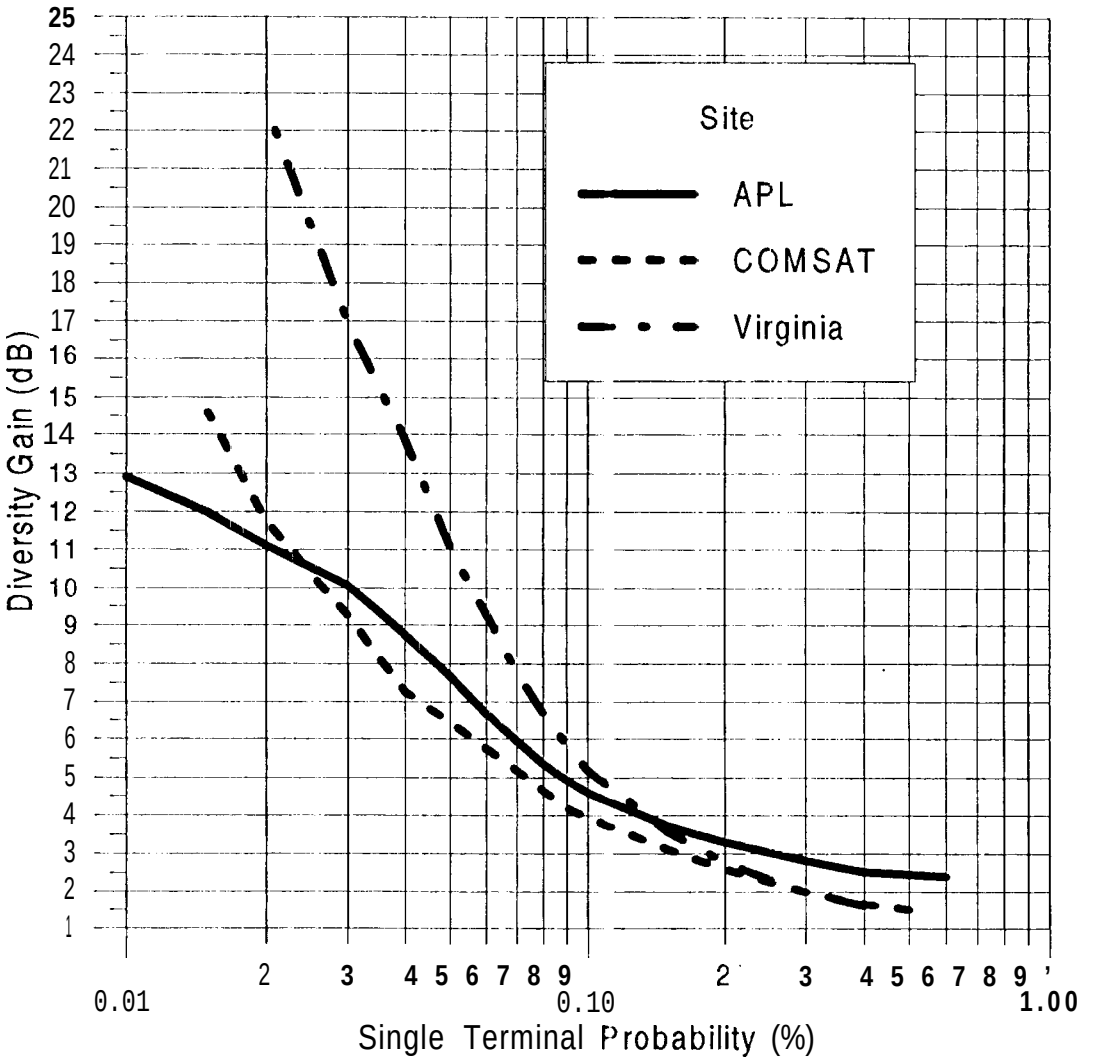
APL, COMSAT and Virginia Rain Fade Time-Series for November 1, 1994



Single Terminal and Three-Site Joint Distributions for 1 Year Period (September 1994- August 1995)



Diversity Gains Versus Single Terminal Probability at APL, CO MSAT, and Virginia for Three-Site Diversity Scenario (ACTS 20 GHz)



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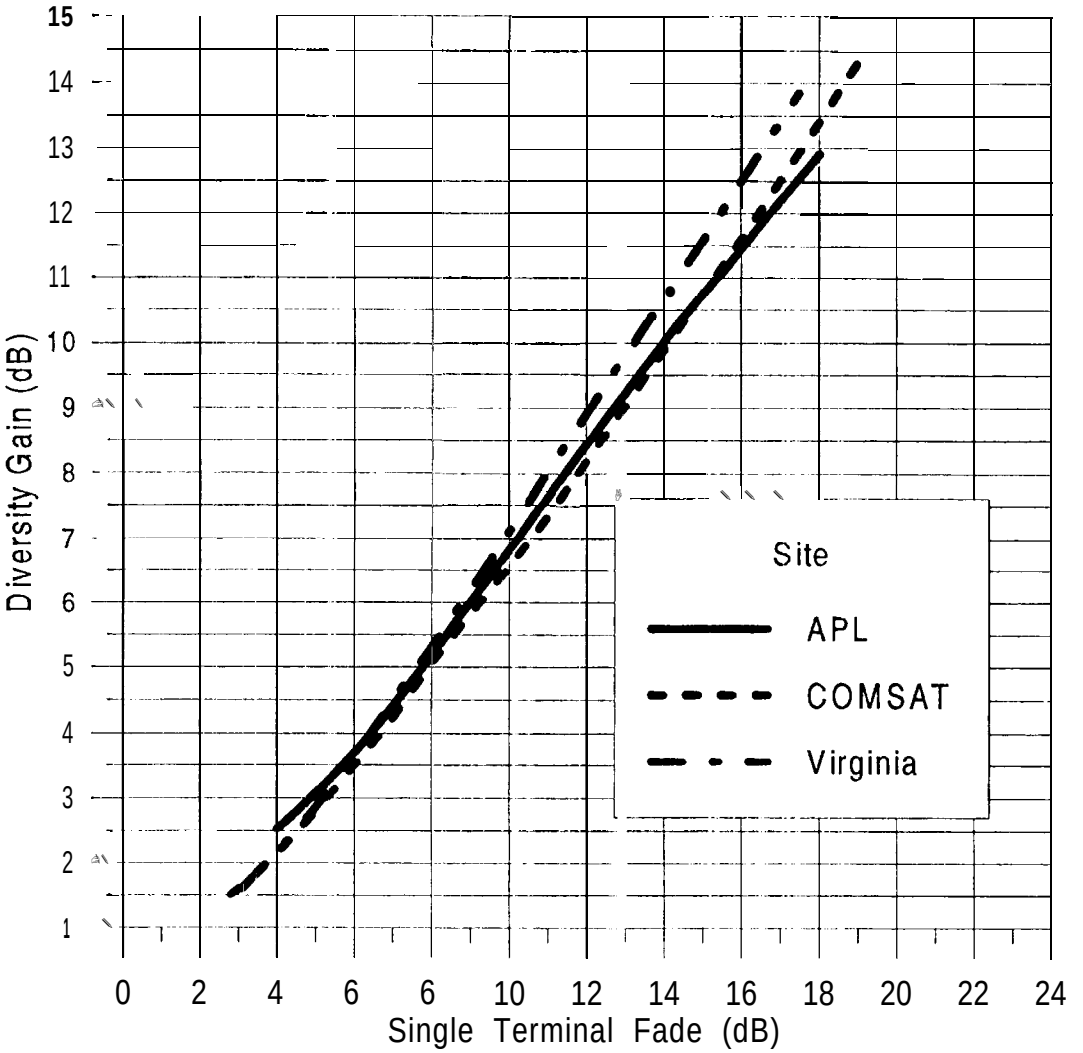
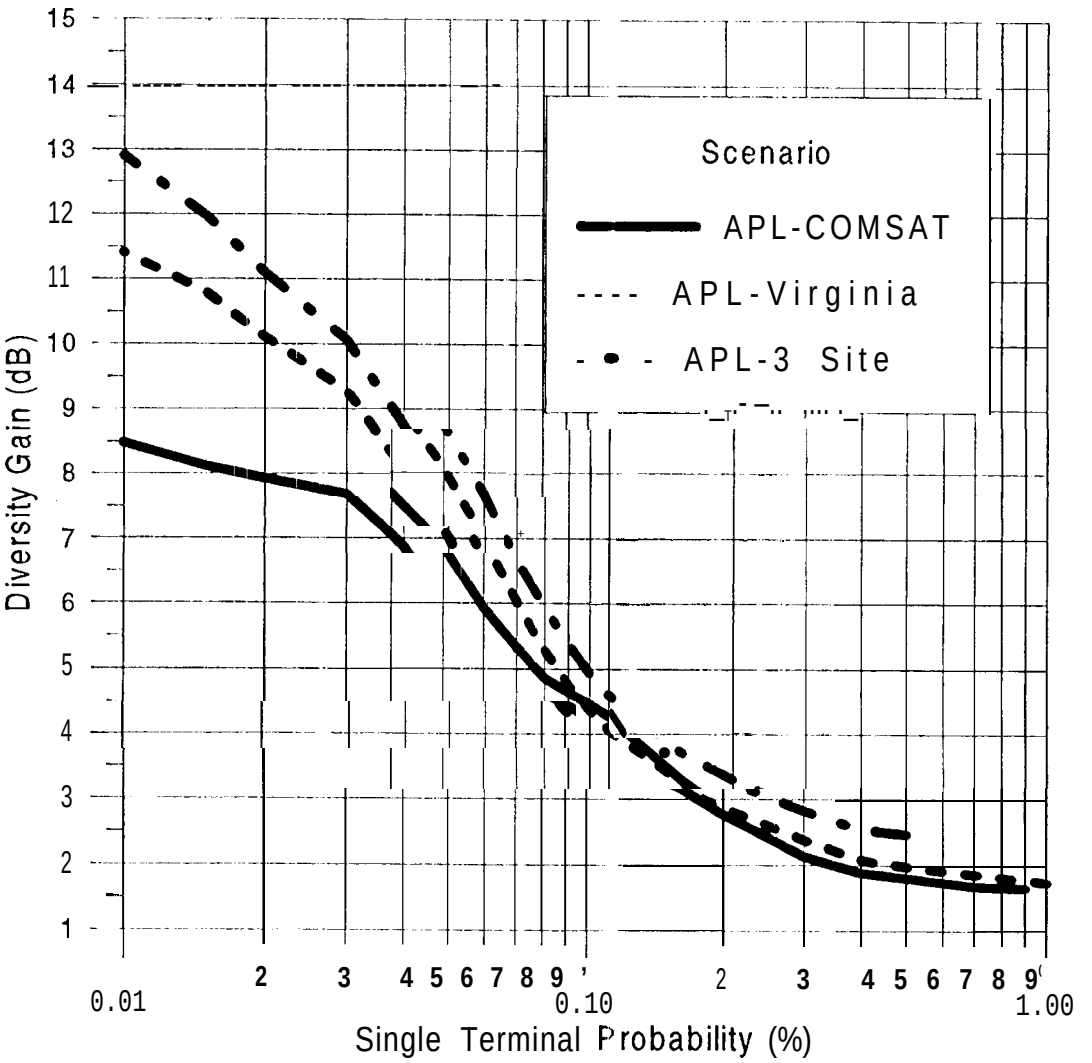
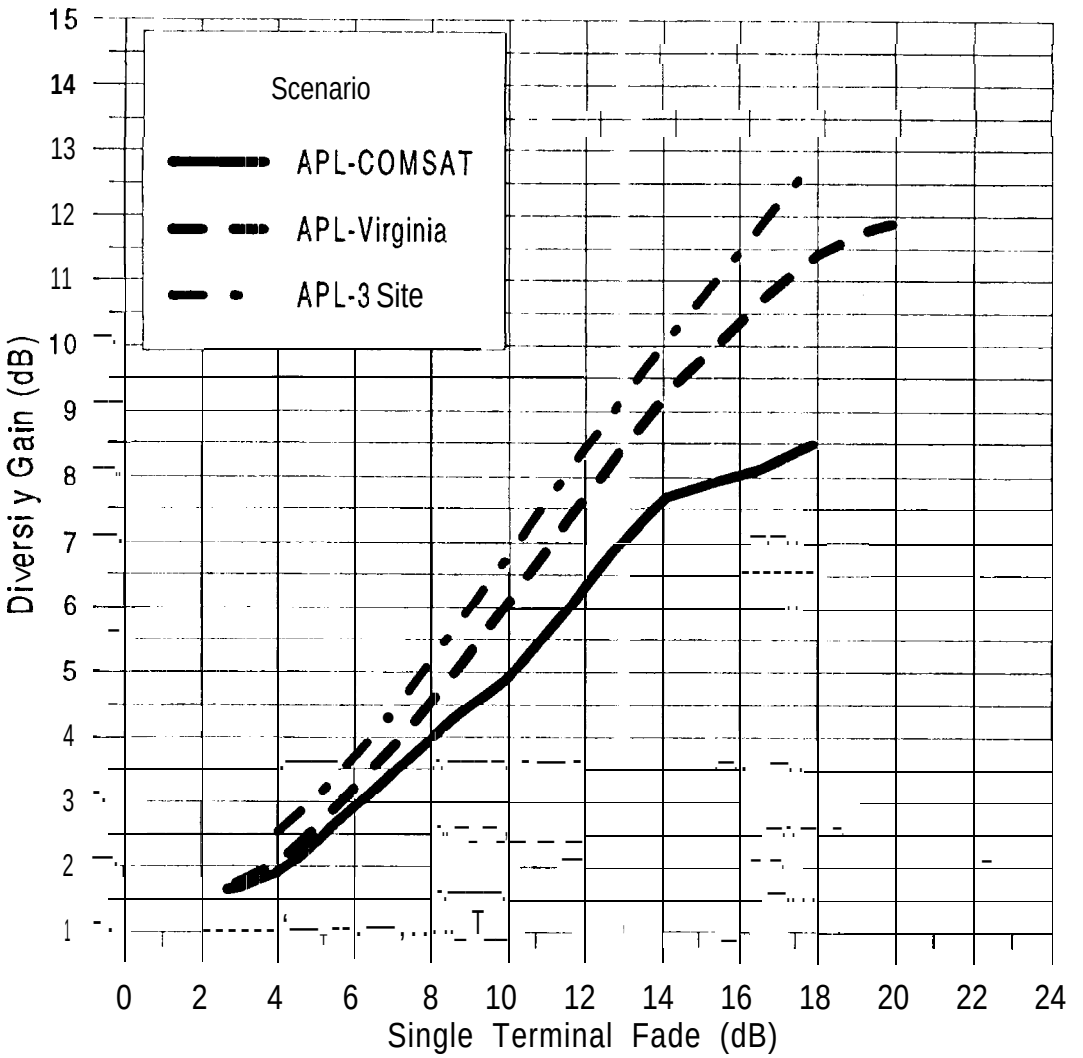


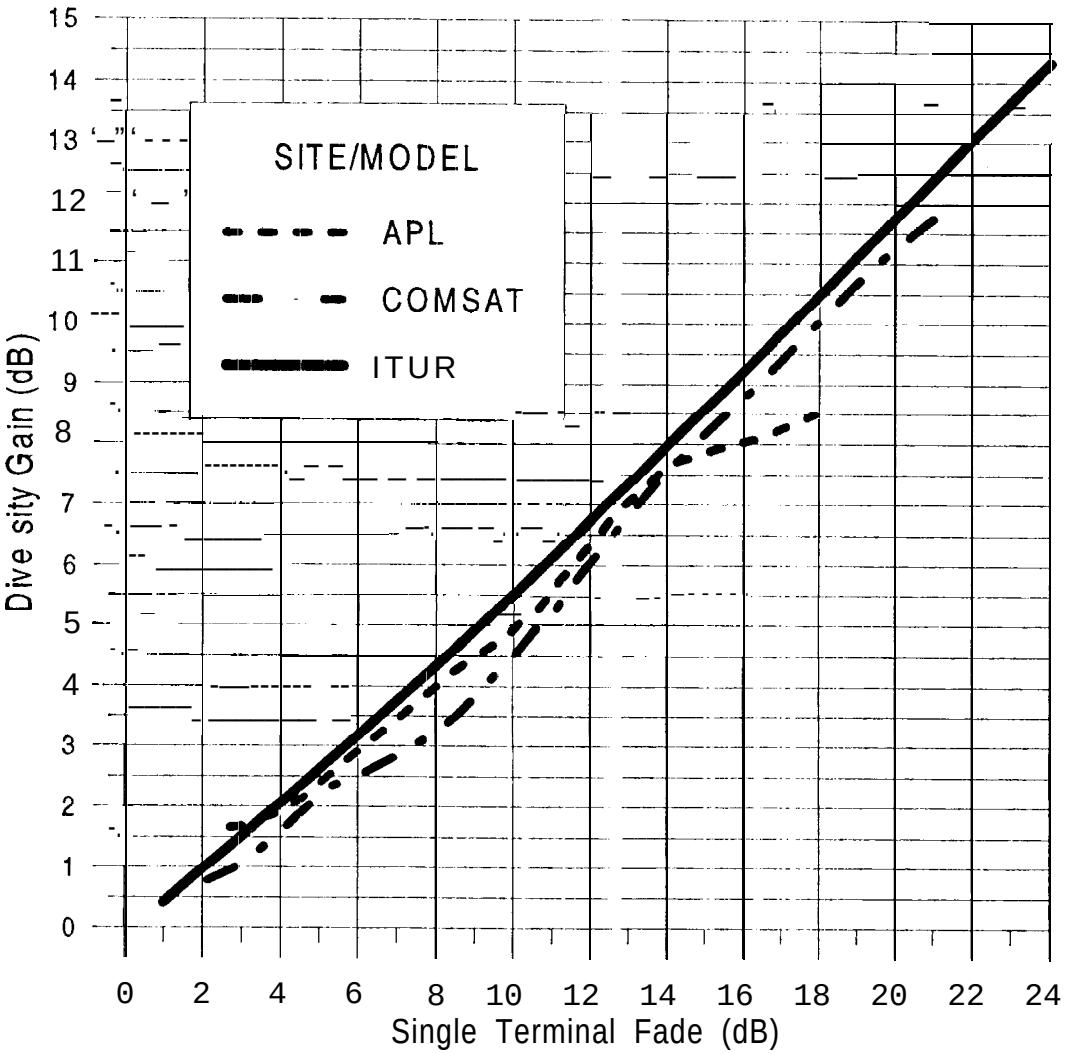
Diversity Gain Versus Single Terminal Probabilities for APL-C **OMSAT,** APL-Virginia, APL-3 Site Diversity



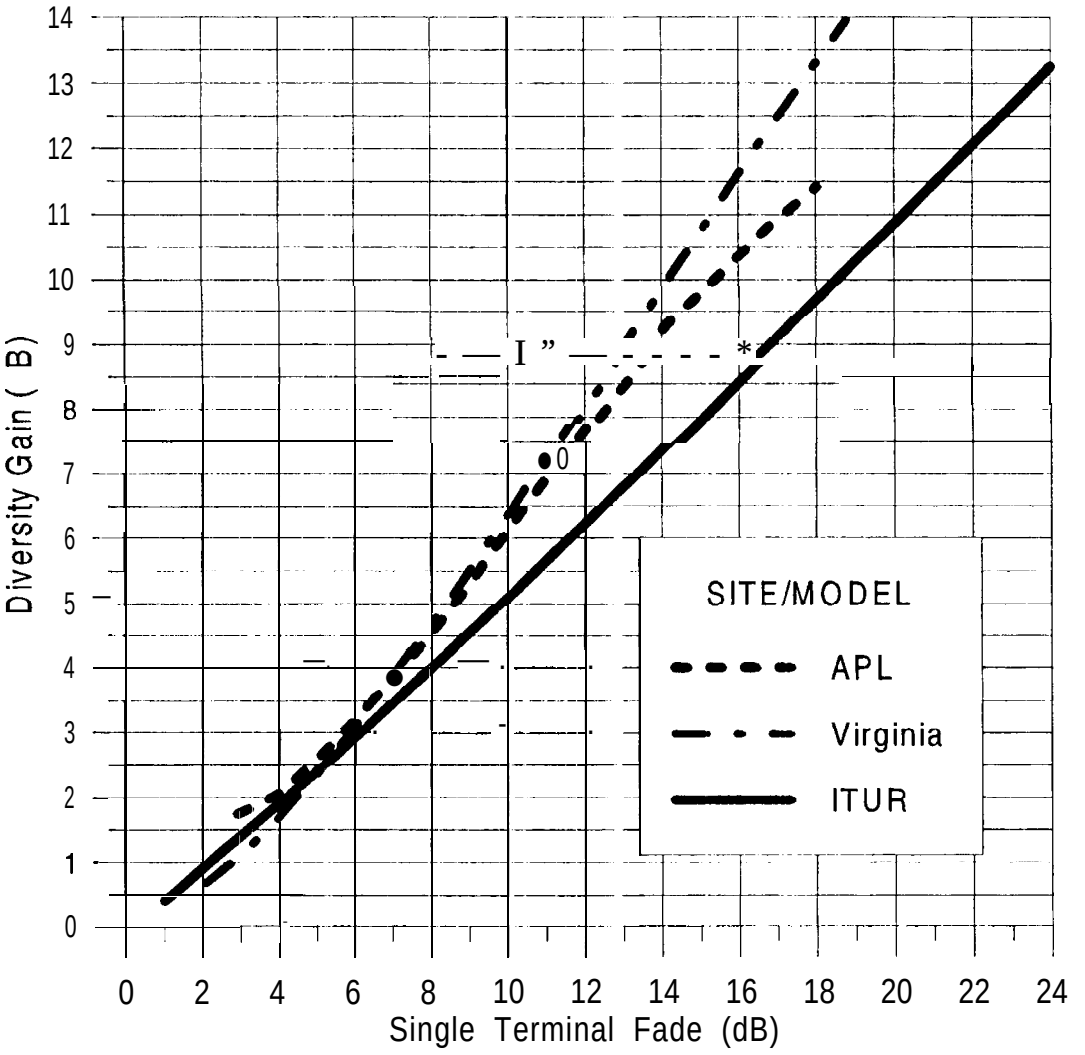
Diversity Gains Versus Single Terminal Fades for APL-CO **MSAT,** APL-Virginia, APL-3 Site Diversity



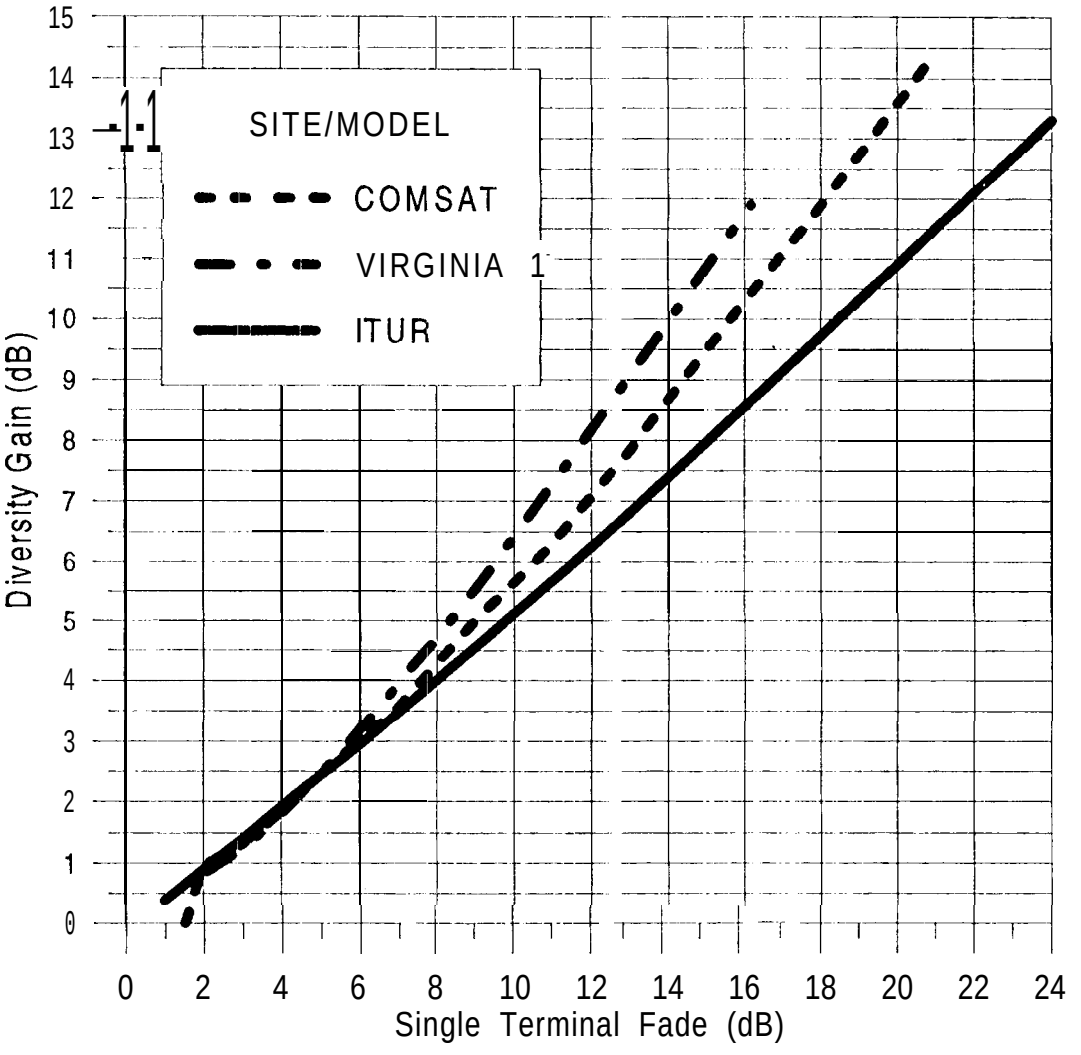
Diversity Gain Versus Single Terminal Fades for APL and COMSAT Two-Site Diversity Scenario



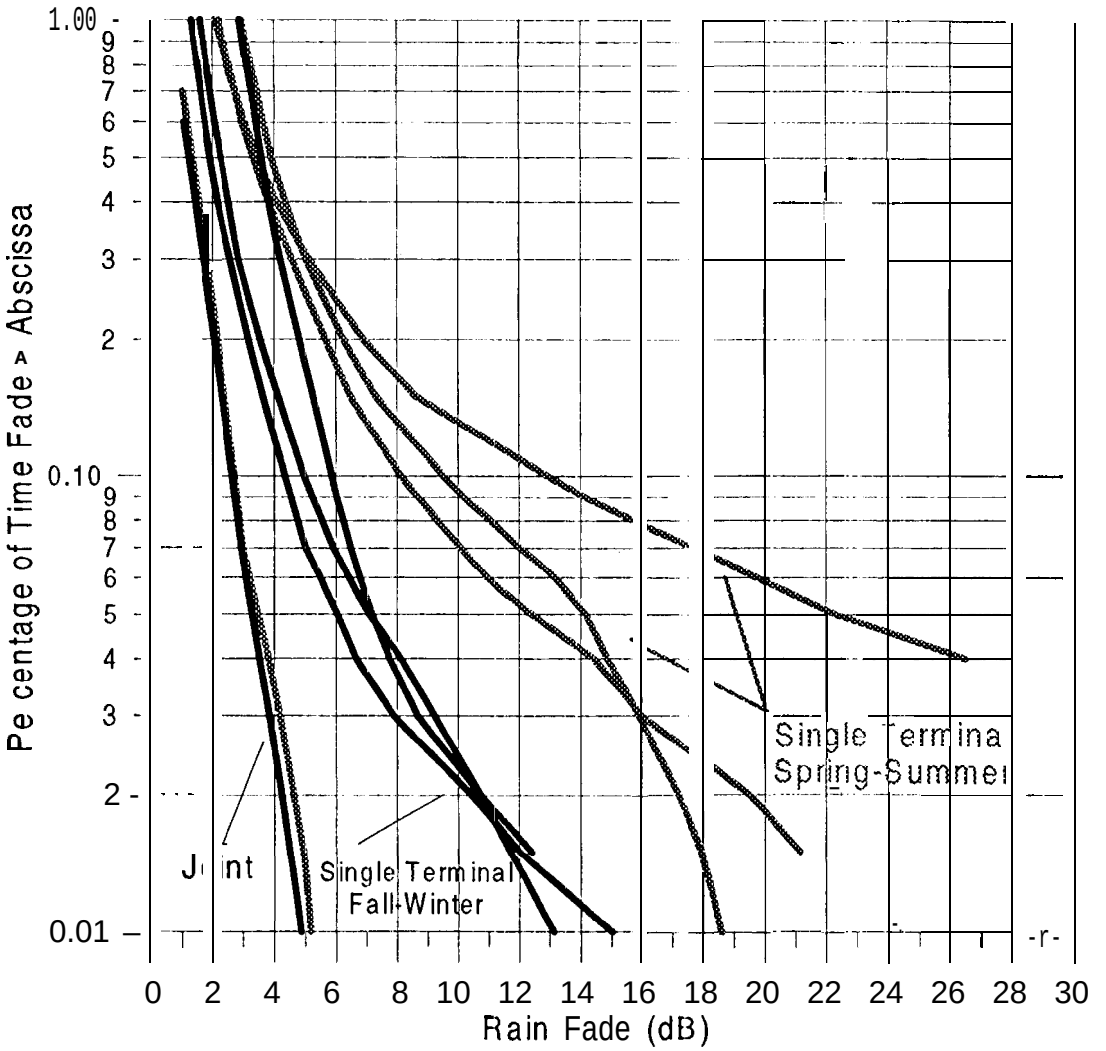
Diversity Gain Versus Single Terminal Fades for APL and Virginia Two-Site Diversity Scenario



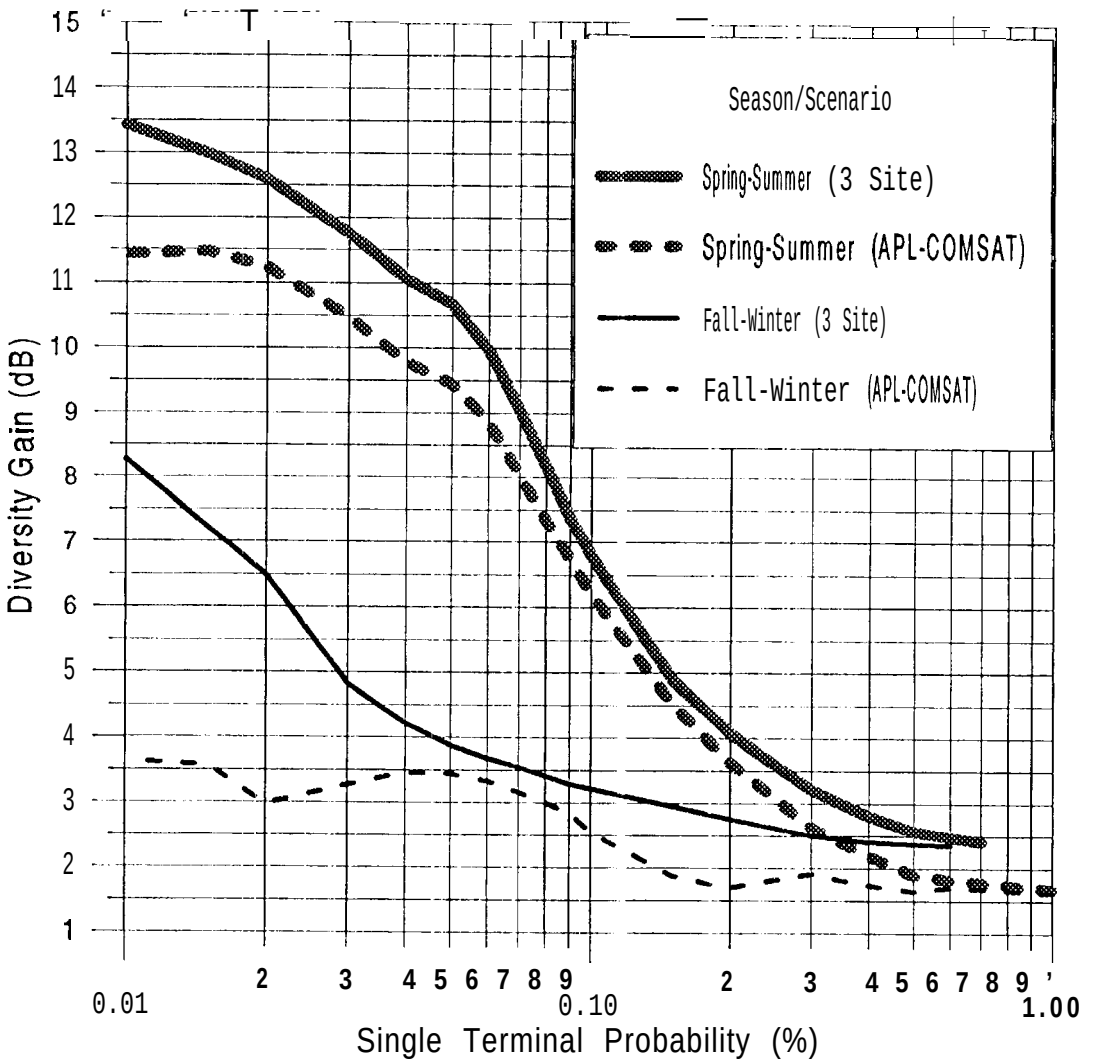
Diversity Gain Versus Single Terminal Fades for
COMSAT and Virginia Two-Site Diversity Scenario



Seasonal Dependence **on Single and 3-Site Joint Distributions at the Three Site Locations**



Diversity Gain Versus Single Terminal Probability Showing Seasonal Effects for **APL-3** Site and APL-COMSAT Scenarios



Summary and Conclusions

- Three Site Diversity Required Margins
  - At P = 0.05% --> 3.5 dB
  - At P = 0.01% --->5.0 dB
- Two Site Diversity Required Margins
  - 1 to 2 dB more (2 Scenarios)
  - 2 to 4 dB more (APL-COMSAT)

Summary and Conclusions (Continued)

- ITU-R model agrees to within 1 dB as follows:
  - Up to fade margin of 9 dB for two of three scenarios
  - Up to fade margin of 15 dB for APL-COMSAT

Summary and Conclusions (Continued)

- Seasonal Effects
  - Three Site Diversity Fade Margin
    - At P --001 % -->5 d13 (Convective and Stratiform Periods)
  - Significant Increase in Diversity Gain During Convective Season
  - Greater than 6 dB at P = 0.05%
- Second Year of Measurements and Analysis Underway
  - Mitigate statistical noise