APSW VII

Session II:
Topics in Ka-Band Propagation

USING ACTS PROPAGATION DATA IN SUPPORT OF MILITARY EHF SATELLITE COMMUNICATION

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OUTLINE

- INTRODUCTION
- NEED FOR PROPAGATION DATA
- DESIRED ACTS DATA PROCESSING

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INTRODUCTION

- U.S. MILITARY RELIES ON SATELLITES FOR LONG-HAUL COMMUNICATIONS
- "MILITARY EHF" SATCOM IS CRITICAL FOR PRESENT AND FUTURE CAPACITY
  - — LOW AND MEDIUM DATA RATE (≤ 1.544 MBPS) COMMUNICATIONS
  - — ASSURED ACCESS (HIGH AVAILABILITY)
  - — ROBUST (ANTI-JAM)
- RAIN LOSS DRIVES AVAILABILITY IN THE EHF BAND
- ACCURATE CHARACTERIZATION OF RAIN AND ATMOSPHERIC LOSSES NEEDED FOR EFFICIENT DESIGN

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FREQUENCIES USED FOR SATCOM

STANDARD 521 FREQUENCIES (GHz)*	USES
UHF-BAND (0.3 - 1)	→MILITARY UHF (225 - 400 MHZ) - FLTSAT, AFSATCOM
L-BAND (1 - 2)	IRIDIUM, INMARSAT
S-BAND (2 - 4)	TT&C
C-BAND (4 - 8)	INTELSAT, INMARSAT, MARISAT
X-BAND (8 - 12)	→MILITARY SHF (8/7 GHZ) - DSCS
Ku-BAND (12 - 18)	TDRS, INTELSAT, HUGHES DBS
K-BAND (18 - 27)	→MILITARY EHF DOWNLINK (20 GHZ) - MILSTAR, FEP, UFO-E; ACTS (20 GHZ BEACON)
Ka-BAND (27 - 40)	→MILITARY UPLINK (30 GHZ); ACTS (27.5 GHZ BEACON)
MILLIMETER WAVES (30 - 300)	→MILITARY EHF UPLINK (44 GHZ) - MILSTAR, FEP, UFO-E

- LINK DEGRADATION DUE TO WEATHER BECOMES SIGNIFICANT ABOVE 10 GHZ
- MILITARY EHF SATCOM (44/20 GHZ) AND ACTS BEACONS (27/20 GHZ) WILL EXPERIENCE SIMILAR DEGRADATION

* MORGAN AND GORDON (1989).

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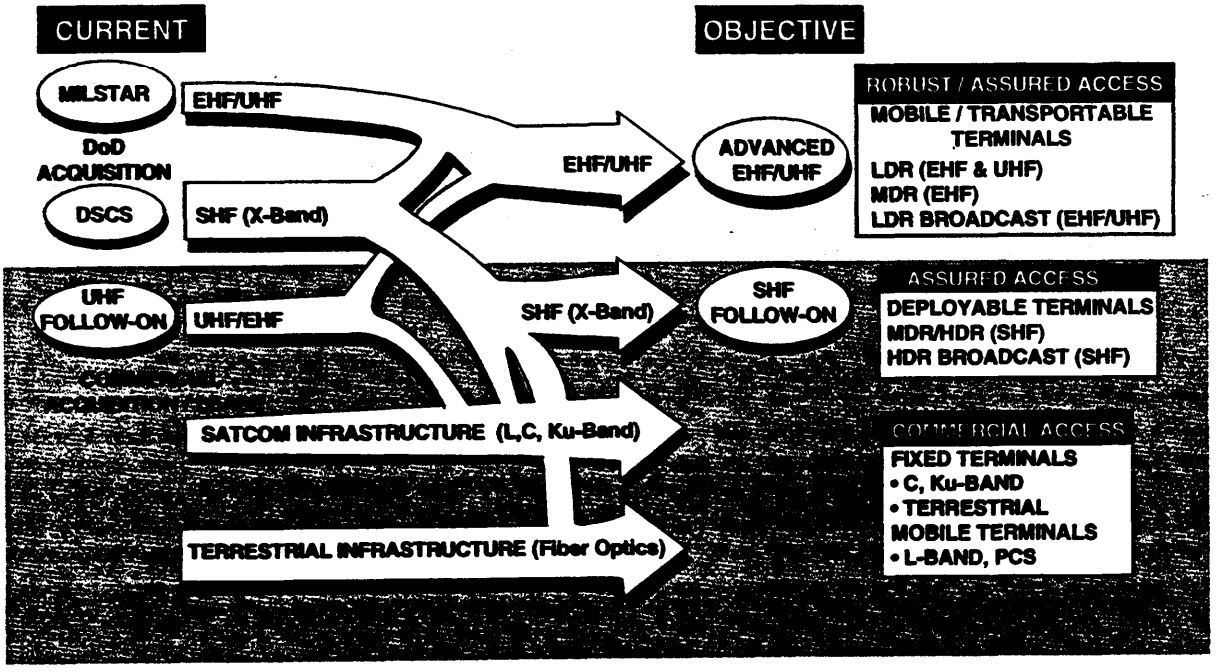
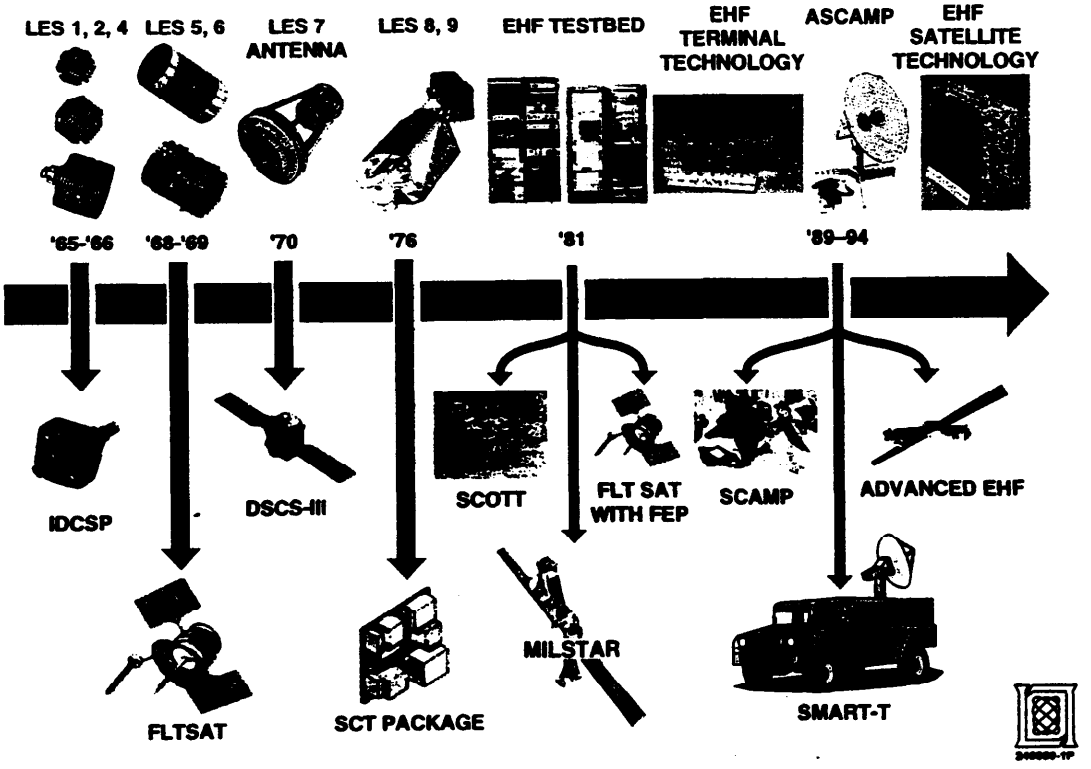
EVOLUTIONARY VIEW

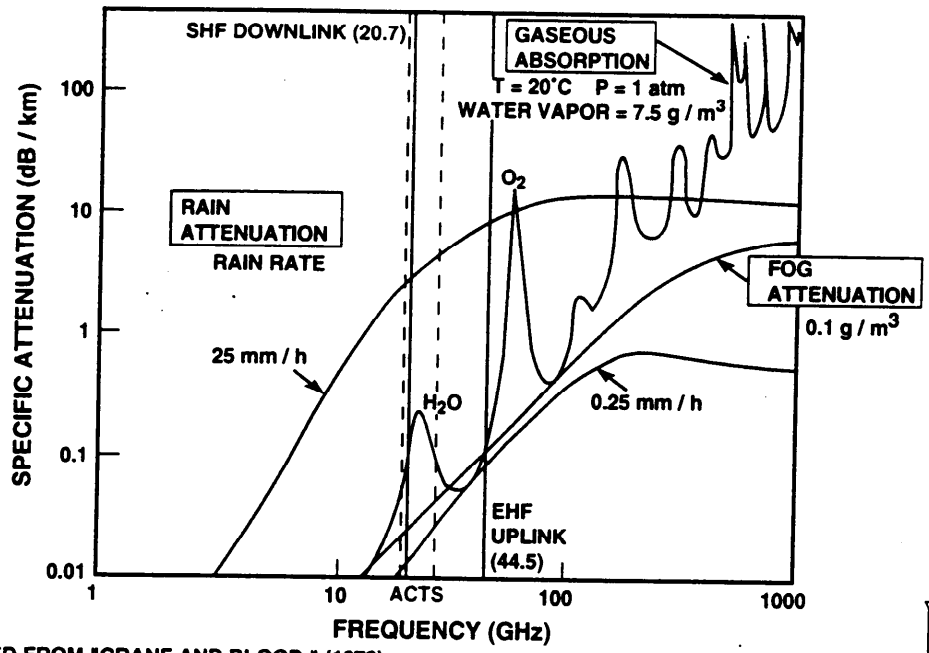


TRANSFER OF TECHNOLOGY FROM LINCOLN LABORATORY MILSATCOM PROGRAM



WEATHER EFFECTS ON MILSATCOM

- CRITICAL TO EHF AVAILABILITY
  - — ATTENUATION DUE TO RAIN AND GASES IN ATMOSPHERE
- DESIGN GOAL: SELECT LINK MARGIN FOR ACCEPTABLE PERFORMANCE
  - — UNREALISTIC TO DESIGN FOR NO OUTAGES



ADAPTED FROM "CRANE AND BLOOD," (1979)

262519-1B

EHF MARGIN SELECTION

- TRADEOFF
  - — INSUFFICIENT MARGIN REDUCES AVAILABILITY
  - — EXCESS MARGIN INCREASES TERMINAL COST AND SIZE
- CURRENT EHF MARGINS (FOR RAIN AND GASEOUS ATTENUATION)
  - — 12 dB AT 44.5 GHZ
  - — 5 dB AT 20.7 GHZ
  - — BASED ON THEORETICAL MODEL FOR PERCENT AVAILABILITY
- ISSUES
  - — MARGINS BASED ON AVAILABILITY MODELS MAY BE UNNECESSARILY HIGH
  - — USERS MAY BE MORE SENSITIVE TO OUTAGE FREQUENCY THAN AVAILABILITY
  - — MORE DATA NEEDED TO SUPPORT 97% AVAILABILITY ANALYSIS

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NEED FOR EHF PROPAGATION DATA

- TO DETERMINE IF USERS CAN TOLERATE SMALLER WEATHER MARGINS ALLOWING FOR LIGHTER, LOWER-COST TERMINALS
- TO CHARACTERIZE/MODEL OUTAGE STATISTICS
- TO EXTEND AVAILABILITY PREDICTIONS BELOW 98%

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BENEFITS OF USING ACTS PROPAGATION DATA

- ADVANTAGES
  - EXTENSIVE, CALIBRATED ATTENUATION MEASUREMENTS
  - BEACON FREQUENCIES CLOSE TO MILITARY EHF BAND
  - ELIMINATES NEED FOR COSTLY MILITARY PROPAGATION EXPERIMENT
  - UNSURPASSED EXPERTISE IN THE FIELD
- CONCERN
  - SPECIAL PROCESSING NEEDED TO APPLY DATA TO EHF MILSATCOM

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REQUESTS FOR PROCESSING ACTS DATA

- USE UNIFORM DATA FORMAT FOR ALL SITES
- SCALE DATA TO GIVE CORRESPONDING EHF LOSS
  - — FROM 20.185 AND 27.5 GHZ
  - — TO 20.7 AND 44.5 GHZ
- SCALE DATA TO GIVE INFORMATION AT SAME ELEVATION ANGLES
  - — RANGE OF INTEREST FROM UNDER 10° TO 90° (ESPECIALLY 20°)
- REPORT RESULTS FOR DIFFERENT WEATHER MARGINS
  - — 20.7 GHZ MARGINS FROM 1 TO 6 dB
  - — 44.5 GHZ MARGINS FROM 6 TO 14 dB
- COMBINE SITE DATA FOR CONTINENTAL/GLOBAL PREDICTIONS

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STATISTICAL INFORMATION DESIRED

- FADE CHARACTERISTICS
  - — DEPTH OF FADE (PDF)
  - — OUTAGE DURATION (PDF) VS. MARGIN
  - — OUTAGE FREQUENCY (MTBO) VS. MARGIN
- ATTENUATION VS. PERCENT AVAILABILITY
  - — WITH COMPARISON TO EXISTING MODELS
- SKY TEMPERATURE (PDF) AT 20.7 GHZ
  - — AS A FUNCTION OF PATH ATTENUATION

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OPEN QUESTIONS

- CAN A MODEL FOR OUTAGES BE FORMULATED ?

- HOW SHOULD YOU MODEL THE COMBINED EFFECTS OF RAIN, ATMOSPHERIC ATTENUATION AND SKY TEMPERATURE?
  - I.E., WHAT HAPPENS TO WATER VAPOR CONCENTRATION IN RAIN?

- HOW TO BEST ACCOUNT FOR INFLUENCE OF OTHER VARIABLES?
  - INSTANTANEOUS METEOROLOGICAL CONDITIONS
    EX., RAIN RATE, RAIN HEIGHT, DROP SIZE/CONCENTRATION, HUMIDITY, TEMP
  - VARIATION BY MONTH, YEAR, AND CLIMATE
  - POLARIZATION

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SUMMARY

- ACTS PROPAGATION EXPERIMENT HAS POTENTIAL TO IMPROVE THE UNDERSTANDING OF WEATHER EFFECTS ON EHF MILSATCOM

- SPECIAL DATA PROCESSING AND FORMATTING WILL ENHANCE THE VALUE TO USERS AND PLANNERS

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