

Proposed Revisions To The NASA Propagation Handbooks

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Experimenters Meeting

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Objectives

- ❑ **Begin the Process of Updating the NASA Propagation Handbooks to Include the Latest Models, Data, and Analysis Tools**
- ❑ **Include Results of Prior and On-going NASA Studies and the ACTS Propagation Measurements Campaign**
- ❑ **Update the Systems Analysis Approach to the Evaluation of Atmospheric Degradations on New Applications**
 - **Ka-Band Systems**
 - **Direct Broadcast Systems**
 - **Mobile Satellite Systems**
 - **Low Margin VSAT Systems**
 - **Frequency Re-Use Systems**

Milestones

Begin Handbook Revisions Study	April 29 1996
Preliminary Outline:	May 20, 1996
Peer Review - NAPEX XX Presentation	June 5, 1996
Handbook Revisions Development Plan	July 15, 1996

Prior Editions Above 10 GHz Handbooks

- First Edition ORI Technical Report TR 1679
R. Kaul, R. Wallace, G. Kinal
March 1980
- Second Edition NASA Reference Publication 1082
L. Ippolito, R. Kaul, R. Wallace
December 1981
- Third Edition NASA Reference Publication 1082(03)
L. Ippolito, R. Kaul, R. Wallace
June 1983
- Fourth Edition NASA Reference Publication 1082(04)
L. Ippolito
February 1989

Prior Editions Below 10 GHz Handbooks

- First Edition NASA Reference Publication 1108
W. Flock
December 1983
- Second Edition NASA Reference Publication 1108(02)
W. Flock
December 1987

Contents of Current Handbooks

Above 10 GHz Handbook

Below 10 GHz Handbook

Propagation Effects Handbook for Satellite Systems Design

*A Summary of Propagation
/impairments on 10 to 700 GHz
Satellite Links With Techniques
for System Design*

Louis J. Ippolito
[1082(04), February 1989]

- I. INTRODUCTION
- II. CHARACTERISTICS OF RAIN AND RAIN SYSTEMS
- III. AN OVERVIEW OR SEVERAL RAIN AND RAIN
ATTENUATION MODELS
- IV. DEPOLARIZATION IN EARTH-SPACE PATHS
- V. PROPAGATION DATA BASES
- VI. PREDICTION TECHNIQUES
- VII. APPLICATION OF PROPAGATION PREDICTIONS
TO EARTH/SPACE TELECOMMUNICATIONS
SYSTEMS DESIGN

Propagation Effects on Satellite Systems at Frequencies Below 10 GHz

A Handbook for Satellite Systems Design

Warren L. Flock
[1 '108(02), December 1987]

1. INTRODUCTION
2. IONOSPHERIC EFFECTS
3. TROPOSPHERIC CLEAR-AIR EFFECTS
4. ABSORPTION, SCATTER, AND CROSS POLARIZATION
CAUSED BY PRECIPITATION
5. EFFECTS OF SMALL PARTICLES AND BIOLOGICAL
MATTER
6. PROPAGATION EFFECTS ON MOBILE-SATELLITE
SYSTEMS
7. RADIO NOISE
8. PROPAGATION EFFECTS ON INTERFERENCE
9. ESTIMATION OF PROPAGATION IMPAIRMENTS
10. SPACE-COMMUNICATIONS SYSTEMS DESIGN

Major Developments Since Last Publication of The NASA Handbooks

- New Propagation Measurement Campaigns
- New Propagation Models and Prediction Procedures Developed
- New Satellite Applications - Evolutionary and Revolutionary
- Preorganization of the International Telecommunications Union (ITU)
- Increased Emphasis on Spectrum Sharing and Interference Mitigation

New Propagation Measurement Campaigns

- Olympus (ESA) -1989
 - Propagation Beacons at 12.5, 19.77, 29.65 GHz
 - Measurements in Europe and United States
- Italsat F1 (Italy) -1990
 - Propagation Beacons at 8.7, 40, 50 GHz
 - Measurements in Europe
- ACTS (NASA) - Launched Sept. 12, 1993
 - Propagation Beacons at 20.185 and 27.5 GHz
 - Measurements in CONUS, Alaska, Canada
- Land Mobile 1.5 GHz Measurements -1987-88
 - MARECS-B2 , Central Maryland
 - ETS-V and INMARSAT, S.E. Australia

New Propagation Models and Prediction Procedures

- Land Mobile Satellite Link Fading (*Vogel, Goldhirsh*)
- Tropospheric Scintillation (*Karasawa, Yamada, Allnutt*)
 - Based on Monthly Temperature and Humidity
 - Provides Both R.M.S. Amplitude Variance and Monthly Fade Level Statistics
- Extensive New ITU-R Recommendations
 - Rain Attention, Site Diversity, Tropospheric Scintillation, Gaseous Attenuation, Frequency Scaling, Worst Month, Ionospheric Effects
- Enhancements to Global Rain Model (*Crane, 1996*)

New Satellite Applications

- Low Margin VSAT Systems (Ku and Ka bands)
 - 1-3 dB margins, Global Deployment
- Direct Broadcast Satellites in the Ku-band
 - Hughes DSS; Systems in Europe, Japan
- Rapid Interest in Development of the Ka-Band
 - Filings to FCC; 14 GSO, 3 NGSO
 - Applications to ITU; GSO: 21 countries, 380+ Sats.
NGSO: 8 countries, 1200+ Sats.
 - GSO/FSS (Spaceway, VoiceSpan, Astrolink, .***)
 - NGSO/FSS/MSS (Teledesic)
 - NGSO/MSS Feeder Links (Iridium, Odyssey)

New Satellite Applications (continued)

- ❑ “Big Leo” Mobile Satellite/Personal Communications
 - NGSO (LEO, MEO, HEO), 10 to 66 Sat. Constellations (Globalstar, Iridium, Odyssey, ICO, . . .)
 - Service Links
 - Uplinks: 1610 -1626.5 MHz
 - Downlinks: 2483.5-2500 MHz
 - CDMA, TDMA/FDMA
- ❑ “Little Leo” Paging, Messaging Services
 - NGSO (LEO) 20 to 24 Sat. Constellations (Orbcom, Starnet, . . .)
 - Service Links: 137-138,148-149.9,400-401 MHz

ITU Reorganization

- **Organizational Changes Effective March 1993**
 - CCIR → ITU Radiocommunications Sector (ITU-R)
 - CCITT → ITU Telecommun. Standards Sector (ITU-T)
 - New Telecommunications Development Sector (ITU-D)
- **WARC's, Held Every Eight - Ten year ≡ replaced with World Radiocommunications Conference (WRC) - every two years WRC-93, WRC-95, WRC-97 . . .**
- **Former Study Groups 5 (Propagation in Non-Ionized Media) and 6 (Ionospheric Propagation) replaced with - Study Group 3 Radiowave Propagation**
- **New/Revised Propagation Models and Prediction Procedures Published in form of ITU-R Recommendations**

ITU-R Recommendations on Earth-Space Propagation

- ❑ “Propagation data and prediction methods required for the design of Earth-space telecommunications systems”
[Recommendation ITU-R P.618-4]
- ❑ “Propagation data required for the design of broadcasting-satellite systems” *[P. 679-1]*
- ❑ “Propagation data required for the design of Earth-space maritime mobile telecommunications systems” *[P.680-1]*
- ❑ “Propagation data required for the design of Earth-space land mobile telecommunications systems” *[P. 681-2]*
- ❑ “Propagation data required for the design of Earth-space aeronautical mobile telecommunications systems” *[P. 682-1]*
- ❑ “Ionospheric Effects Influencing Radio Systems Involving Spacecraft” *[P.531-3]*

New / Revised ITU-R Models and Prediction Procedures

- Rain Attenuation Modeling Procedure [P.618-4]
 - Precipitation Distributions and Global Maps [..837-1]
 - Specific Attenuation Coefficients [P.838]
 - Rain Height Model [P.839]
- Atmospheric Gaseous Attenuation Model [P.676.2]
 - Reference Standard Atmosphere [P.835-1]
 - Surface Water Vapor Density [P.836]
- Attenuation due to Clouds and Fog [P.840-1]
- Site Diversity [P. 618-4]
- Tropospheric Scintillation [P.618-4]
- Worst Month Statistics [P.581-2]
 - Conversion of Annual Statistics to Worst Month [P.841]
- Probability Distributions for Prop. Modeling [P.1057]

Increased Emphasis on Spectrum Sharing and Interference Mitigation

Explosion in Global Satellite Systems

- Ku-band and Ka-band FSS International, Regional, Domestic Systems
- Over 50 Notices to ITU for Global/Regional NGSO Mobile Satellite Systems

28 GHz Band

- Satellite Links (FSS Up, MSS Feeder) vs LMDS
- FCC Segmentation of 27.5-30 GHz band

1610-2500 MHz NGSO/ MSS Service Links vs FS

Space Research Applications vs Space Services

FCC Spectrum Auctioning

- 5 GHz in 5 to 60 GHz band in next 2 years

Basic Recommendations for Revised NASA Propagation Handbook

- Combine Scope of the Previous Two Handbooks into a Single Document
- Eliminate Duplication
- Provide a More Cohesive Structure for the Reader
 - Offer Several Levels of “Entrance” into Handbook
- Include Tailored Propagation Analysis Procedures For Specific Types of Satellite Applications -
 - Ka-band Systems, Ku-band Systems
 - Mobile Satellite Systems
 - Low Margin Systems
 - Direct Broadcast Systems
 -
- Provide Electronic Version of Handbook

Candidate Titles for NASA Handbook

*Propagation Effects Handbook
for Satellite Systems Design*

*Propagation Effects Handbook
for Communications Satellite
Systems Design*

*Propagation Effects Handbook for
Satellite Communications Systems*

Basic Structure of Handbook

Three Sections

SECTION I BACKGROUND

Provide Overview of Propagation Effects, including Theory and Basic Concepts, Propagation Measurements, Available Data Bases.

SECTION II PREDICTION

Provide Descriptions of Prediction Models and Techniques, Organized By Effect. Provide Step-by-Step Procedures For Each, Where Appropriate. Include Sample Calculations.

SECTION III APPLICATIONS

Provide "RoadMaps" (i.e. flow charts) of Application of Prediction Models in SECTION II to Specific Satellite Systems and Applications. Include Evaluation and Impact on Systems Design and Performance. Include Sample Calculations.

Three Section Approach

SECTION I
BACKGROUND

SECTION II
PREDICTION

SECTION III
APPLICATIONS



Researcher,
General Interest
Enters Here

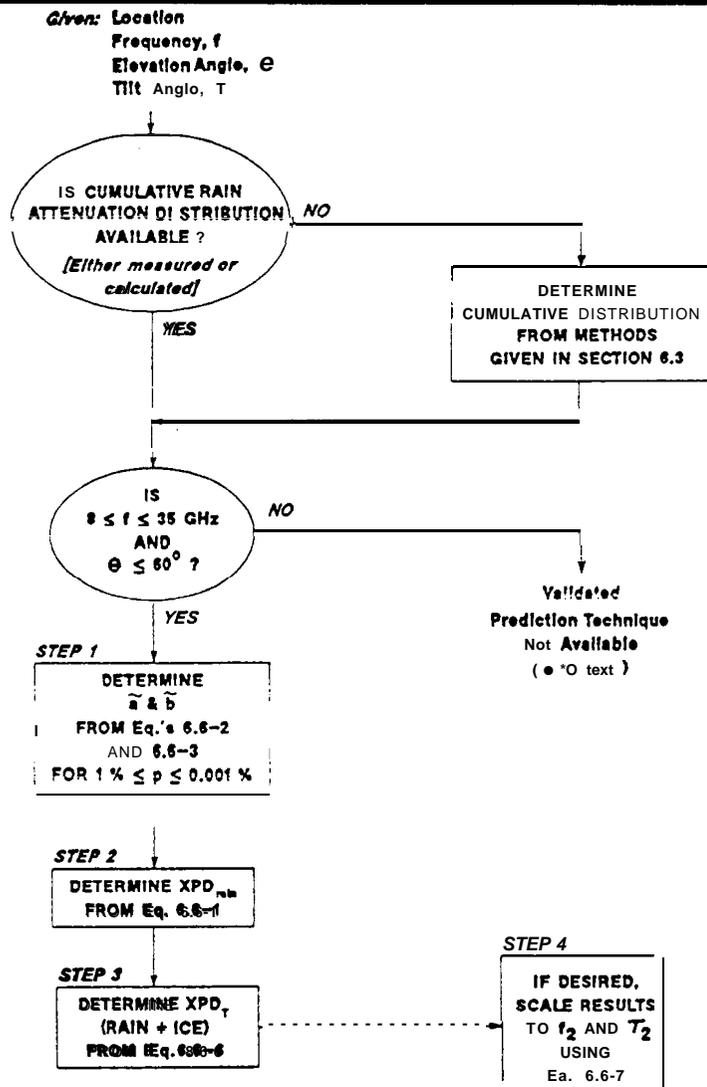


Link Analyst
Enters Here



Systems Designer
Enters Here

Sample of "Flow Chart" Depolarization Statistics Prediction



Chapters

SECTION I BACKGROUND

- I-1. Overview of Propagation Effects on Satellite Communications
- 1-2. Ionospheric Effects
- I-3. Tropospheric Effects
- I-4. Radio Noise
- I-5. Propagation Data Bases
 - Meteorological Parameters
 - Slant -Path Measurements
 - ITU-R
 - Electronic Sources

Chapters

SECTION II PREDICTION

II-1. Prediction Methods for Satellite Links Operating Below About 3 Ghz

- Ionospheric Scintillation
- . Multipath Fading
- Group Delay, Phase Advance, Bandwidth Coherence
- Polarization, Faraday Rotation
- Ducting
- Refraction and Turbulence

Sample Calculations

SECTION II PREDICTION (continued)

II-2. Prediction Methods for Satellite Links Operating Above About 3 Ghz

- Atmospheric Gaseous Attenuation
- Cloud Attenuation
- Fog Attenuation
- Rain Attenuation
- Rain Depolarization
- Ice Depolarization
- Scintillation
- Angle of Arrival
- Fade rate, Fade Duration
- Dispersive Effects
- Combined Effects Statistics

Sample Calculations

Chapters

SECTION II PREDICTION (continued)

II-3. Link Restoration Models

- Site Diversity
- Orbit Diversity
- Link Power Control
- Adaptive FEC

Sample Calculations

Chapters

SECTION III APPLICATIONS

Flow Charts for Prediction Model Application to Specific Applications

III-1. Application of Prediction Models to Systems Design and Performance

- . General Links Analysis Procedures

III-2. Mobile Satellite Systems

- Land Mobile
- Maritime
- Aeronautical

III-3. Ka-band Systems

- **Low Margin Fixed Service**
- **Non-GSO Satellite Links**
- . Mobile
- . Wideband Systems

SECTION III APPLICATIONS (continued)

III-4. Direct Broadcast Systems

III-5. Low Margin VSAT Systems

III-6. Frequency Reuse Systems

III-7. Inter- and Intra- System Interference

III-8. ITU Regulatory Considerations

- PFD Limits

- ITU Coordination Procedures

Sample Calculations

Detailed Preliminary Handbook Outline.

- Available for Review by NASA Propagation Community and Interested Industry Representatives
- Suggestions, Comments, Additions, Deletions Welcomed
 - Responses By June 21, 1996
 - Include References for New Information

Additional Considerations

Which Applications/ Systems Should Be Emphasized in SECTION III

– Industry Input Important

Relation of Revised NASA Handbook to Current NASA Land Mobile Publication-

^g“Propagation Effects for Land Mobile Satellite Systems: Overview of Experimental and Modeling Results,” J. Goldhirsh & W. J. Vogel, *NASA Ref. Pub. 1274*, Feb. 1992

– Integrate Results into Revised Handbook

– Reference Document in SECTION III, Chap. 2

Additional Considerations (continued)

- Options for Electronic Version of NASA Handbook
 - Platform: Workstation, PC, Mac, Other
 - Complete S/W Package or Run Under Application (EXCEL, MATLAB, etc.)
 - Self-financed(Charge Fee) or Distributed by NASA/JPL
- Other Relevant Documents
 - OPEX Reference Books, Five Volumes, WPP-083, November 1994.
 - ITU-R Working Party 3M, “Radiowave Propagation Information For Earth-Space Path Communications,” draft April 29, 1996.

Summary

- ❑ **The Process for Revision of the NASA Propagation Handbooks has Begun**
- ❑ **New and Updated Information Relating to Propagation Measurements, Propagation Models, Evolving Satellite Applications, and International Developments Relevant to the Handbook Have Been Identified**
- ❑ **A Three Section Structure, which Allows Reader Entrance At Different Levels, Has Been Devised**
- ❑ **A Detailed Preliminary Handbook Outline Is Available for Community and Industry Review**

Preliminary Outline
**Propagation Effects Handbook
for Satellite Systems Design**

Introduction to the Handbook

SECTION I BACKGROUND

I-1. Overview of Propagation Effects on Satellite Communications

Ionospheric
Tropospheric
Frequency Dependence

I-2. Ionospheric Effects

Multipath Fading and Scintillation
Depolarization
Group Delay

I-3. Tropospheric Effects

Atmospheric Gases
Clouds, Fog
Rain Attenuation and Depolarization
Ice Depolarization
Scintillation
Angle of Arrival
Dispersion

I-4. Radio Noise

Uplink Noise Sources
Downlink Noise Sources

I-5. Propagation Data Bases

- Meteorological Parameters

 - Rain Statistics

 - Water Vapor Density

 - Clouds

- Slant Path Measurements

 - UHF/VHF Mobile

 - 1-3 GHz Mobile

 - C-Band, Ku-Band, Ka-band Fixed

- ITU-R

- Electronic Sources

SECTION II PREDICTION

II-1 . Prediction Methods for Satellite Links Operating Below About 3 Ghz

- Ionospheric Scintillation

- Multipath Fading

- Group Delay, Phase Advance, Bandwidth Coherence

- Polarization, Faraday Rotation

- Ducting

- Refraction and Turbulence

- Sample Calculations*

11-2. Prediction Methods for Satellite Links Operating Above About 3 Ghz

- Attenuation from Atmospheric Gases

- Cloud Attenuation

- Fog Attenuation

- Rain Attenuation

- Rain Depolarization

- Ice Depolarization

- Scintillation

- Angle of Arrival

- Fade Rate, Fade Duration

- Dispersive Effects

- Combined Effects Statistics

- Sample Calculations*

II-3. Link Restoration Models

Site Diversity
Orbit Diversity
Link Power Control
Adaptive FEC
Sample Calculations

SECTION III APPLICATIONS

III- 1. Application of prediction Models to Systems Design and Performance
General Link Analysis Procedures

III-2. Propagation Effects on Mobile Satellite Systems
Land Mobile
Maritime Mobile
Aeronautical Mobile

III-3. Propagation Effects on IQ-band Systems
Low Margin Fixed Service
Non-GSO Satellite Links
Mobile Systems
Broadband Links

III-4. Propagation Effects on Direct Broadcast Systems

III-5. Propagation Effects on Low Margin VSAT Systems

III-6. Inter- and Intra- System Interference

III-7. ITU Regulatory Considerations
PFD Limits
ITU Coordination Procedures

Sample Calculations

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