

**Dr. Dennis. L. Knepp**  
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### **Summary of Accomplishments**

Dennis Knepp has performed significant original research in the key technology areas involved in the hardening of U.S. communications and radar systems against the effects of ionospheric propagation disturbances. He developed both analytic and numerical techniques to calculate the effects of structured ionization on EM propagation through random ionized media. Numerical techniques for signal propagation included the first multiple phase screen code that applied to the propagation of wide bandwidth signals. The starting point for many analytic propagation calculations is his original solution to the two-position, two-frequency mutual coherence function (MCF) for spherical wave propagation. This solution led directly to his development of numerical techniques to generate statistical realizations of the received signal after propagation through ionized turbulence, including the one-way communications link and the two-way radar geometry. His work also involves original analytic calculation of the effect of aperture antennas on received signals. He has also made substantial contributions to the literature through analysis of ionospheric scintillation data obtained from the Defense Nuclear Agency (DNA) Wideband satellite. He was the principal investigator on the DNA PEAK experiment and his analysis of satellite track data obtained with the VHF/UHF ALTAIR radar resulted in the first measurement of the enhancement in average power due to two-way radar propagation through ionized turbulence.

Dr. Knepp has been the manager and key technical contributor to the Defense Threat Reduction Agency (DTRA, formerly Defense Nuclear Agency) radar analysis and mitigation effort since 1980. His work has helped to support a successful U.S. government program to develop hardened communication links and radar systems. During the course of his work he developed a number of techniques to generate realizations of disturbed signals. These techniques permitted digital simulation of the effects of ionospheric multipath on communications receivers. Additional algorithms were developed and combined with calculations of receiver performance to permit hardware testing of communications and radar systems against propagation disturbances. In the course of this work for several Government agencies (DNA, Air Force, Army, Navy), a number of mitigation techniques were developed to help harden strategic U.S. communications and radar systems.

Dr. Knepp was Principal Investigator under contract to Raytheon for the Ionospheric Data Collection (IDC) program in support of the Upgraded Early Warning Radar (UEWR). The goal of IDC was to develop mitigation techniques to enable the UEWR to perform detection, track acquisition, track, classification, and intercept support during ionospheric disturbances that are a natural occurrence in the polar region. Dr. Knepp

helped develop a data collection and analysis program and new coherent radar waveforms to track 5 calibration spheres over a period of several years. This data was intended for use in updating the existing NWRA polar region model of scintillation and to provide radar returns for development of mitigation techniques. The bulk of IDC ended in May 2002 with the deployment of the GMD Block 2002/2004 Test Bed in Alaska for missile defense.

Dr. Knepp was Principal Investigator under several contracts to Lockheed Martin (from 1999 to 2005) to Lockheed for the development of the new Navy satellite communications system (MUOS - Mobile User Objective System). He was responsible for all channel modeling activities and has written Matlab code to generate statistical realizations of disturbed signals that implement Government models of terrestrial scintillation (urban, forest canopy, shadowing, maritime, aeronautical) and ionospheric multipath. This code was used directly in the Lockheed Martin dynamic global link model that calculates link availability and capacity for MUOS. His most recent involvement in MUOS ended in June 2005 (when he left ATK-Mission Research) while developing specifications for Lockheed of the UHF and Ka-band link effects simulators.

Dr. Knepp served as a member of the NASA RCS Subject Matter Expert Team. This team supported the NASA Ascent Debris Radar Working Group (ADRWG). Activities under this work include the evaluation of shuttle track data taken by the existing radars in Florida and the selection and design of new radars to support Shuttle Return to Flight, which occurred in 2006.

Dr. Knepp is an IEEE Fellow and a member of URSI Commissions B and G.

### **List of Capabilities**

#### Radar and communications

- Data processing, waveform level signal processing
- Detection calculations, coherent processing, target discrimination
- Ground based long range radars, space based radars
- Missile Defense Agency X-band radar, Upgraded Early Warning radar (UEWR)
- Ballistic Missile Early Warning Radar (BMEWS)
- Clutter cancellation with space based radar

#### Electromagnetic propagation

- Ionospheric propagation theory, channel modeling, generation of signal realizations
- Terrestrial multipath

### **Education**

BSEE, Johns Hopkins University, Baltimore, MD.

MSEE, (Communications), Univ. of Pennsylvania, Philadelphia, PA.

Ph.D., (Electrical Engineering), Univ. of Pennsylvania, Philadelphia, PA.

## **Clearances**

DoD Top Secret (CNWDI). SCI clearances.

## **Employment History**

**1976-2005:** Mission Research Corporation (MRC), Monterey, CA. (In 2004 MRC was purchased by ATK and became ATK-Mission Research.)

**Position:** Division Leader, Communications and Radar Systems Division, with personnel located in Monterey, CA, Santa Barbara, CA and Huntsville, AL.

**Responsibilities:** Marketing, corporate planning, project leadership, original research on EM propagation through random media, channel modeling for both ionospheric scintillation and terrestrial multipath, communication and radar systems performance under disturbed propagation conditions, and the mitigation of the effects of propagation disturbances on communications and radar systems.

**Dec 2005-Sep 2006:** Vista Research Inc., Sunnyvale, CA.

**Position:** Senior Scientist.

**October 2006 - Present.** Senior Research Scientist, NorthWest Research Associates, Monterey, CA. Other offices of NWRA are in Seattle, WA and Boulder, CO.

## **Visiting Positions**

**1983-84: Visiting Professor at the University of California at Santa Barbara**  
EE and Computer Science Dept. Taught the introductory EE course entitled Circuits, Signals, and Systems.

**April-June 1997: Visiting scholar at the Australian Defense Science and Technology Organization (DSTO)**

High-Frequency Radar Division, Adelaide, South Australia. Analyzed Over the Horizon Radar (OTHR) data from the Australian Jindalee radar in an attempt to isolate aperture antenna effects on ionospheric scattering. Investigated possible mitigation techniques to combat the effects of propagation disturbances on OTH radar performance.

## **Awards**

Member of URSI Commissions B (random media) and G (ionospheric effects)

IEEE Fellow (1998)

Fellow citation: For contributions towards understanding the effects of random ionized media on signal propagation leading to the development of mitigation techniques for satellite communications and radar systems.

Naval Research Laboratory Alan Berman Research Publication Award, 1987, for the report “A VHF/UHF Space-Based Radar Study,” with G. A. Andrews and E. N. Carey.

Naval Research Laboratory Alan Berman Research Publication Award, 1993, for the report “Ionospheric Scintillation-Induced Integration Losses for Space-Based Radar,” with E. L. Mokole.

Eta Kappa Nu

Sigma Xi

Chairman, URSI Session G-2, Ionospheric Effects on Radar and Satellite Systems, National Radio Science Meeting, 1989.

U.S. delegate to URSI General Assembly, Kyoto, Japan 1993.

U.S. delegate to XXVII URSI General Assembly, Maastricht, Holland, 2002.

Member, U.S. DoD John Allen Committee on UHF Radar Discrimination, 1992.

Radar Session Chairman at joint U.K./U.S. Defense Nuclear Agency Interchange meeting, Reading, U.K., 1994.

### **Professional activities**

Secretary, Santa Barbara Chapter IEEE, 1982-83

Vice Chairman, Santa Barbara Chapter IEEE, 1983-84

Secretary, Monterey Chapter IEEE, 1985-86

Secretary/Treasurer, Monterey Chapter IEEE, 1986-87

Secretary/Treasurer, Monterey Chapter IEEE, 1987-88

Associate Editor for Radio Science, Jan 2006-present.

### **Publications:**

D. L. Knepp, “Multiple phase screen calculation of two-way spherical wave propagation in the ionosphere,” *Radio Science*, Vol. 51, 259-270, 10.1002/2015RS005915, April 2016.

D. L. Knepp, “Radar measurement of ionospheric scintillation in the polar region,” *Radio Science*, Vol. 50, 968-982, 10.1002/2015RS005740, Oct. 2015.

- D. L. Knepp and L. J. Nickisch, "Multiple phase screen calculation of wide bandwidth propagation," *Radio Science*, Vol. 44, RS0A09, doi:[10.1029/2008RS004054](https://doi.org/10.1029/2008RS004054), 2009.
- D. L. Knepp, "The Effects of ionospheric scintillation on Transit satellite measurement of total electron content," *Radio Science*, Vol. 39, January/February 2004.
- J. Todd Reinking, Dennis L. Knepp, and M. A. Hausman, "Polar Region Ionospheric Effects on UHF Radar Track Acquisition," *Radio Science*, Vol. 36, No. 5, pp. 1157-1166, September/October 2001.
- D. L. Knepp and W. A. Brown, "Average Received Signal Power After Two-way Radar Propagation Through Ionized Turbulence," *Radio Science*, Vol. 37, No. 4, pp. 1575-1596, July-August 1997.
- E. L. Mokole and D. L. Knepp, "Ionospheric Scintillation-Induced Integration Losses for Space-Based Radar," *IEEE Trans. On Aerospace and Electronic Systems*, Vol. AES-29, No. 3, July 1993.
- D. L. Knepp and E. L. Mokole, "Space-based Radar Coherent Processing During Scintillation: VHF through L-band," *Radio Science*, Vol. 27, No. 1, pp. 47-61, January-February 1992.
- D. L. Knepp and H. L. F. Houppis, "ALTAIR VHF/UHF Observations of Multipath and Backscatter Enhancement," *IEEE Transactions on Antennas and Propagation*, Vol. 39, No. 4, pp. 528-534, April 1991.
- D. L. Knepp and J. T. Reinking, "Ionospheric Environment and Effects on Space-Based Radar Detection," *Spaced-Based Radar Handbook*, Leopold J. Cantafio, editor; Artech House Inc., 1989.
- R. A. Dana and D. L. Knepp, "The Impact of Strong Scintillation on Space Based Radar Design II; Noncoherent Detection," *IEEE Trans. On Aerospace and Electronic Systems*, Vol. AES-22, No. 1, January 1986.
- D. L. Knepp, "Aperture Antenna Effects After Propagation Through Strongly Disturbed Random Media," *IEEE Trans. Antennas and Propagat.*, Vol. AP-33, No. 10, pp. 1074-1084, October, 1985.
- D. L. Knepp and R. A. Dana, "The Impact of Strong Scintillation on Space-Based Radar Design; Clutter Rejection," *Radio Science*, Vol. 20, No. 3, pp. 366-374, May-June 1985.
- D. L. Knepp and L. A. Wittwer "Simulation of Wide Bandwidth Signals That Have Propagated Through Random Media," *Radio Science*, Vol. 19, No. 1, pp. 303-318, January-February 1984.

D. L. Knepp, "Analytic Solution for the Two-Frequency Mutual Coherence Function for Spherical Wave Propagation," *Radio Science*, Vol. 18, No. 4, pp. 535-549, July-August 1983.

R. A. Dana and D. L. Knepp, "The Impact of Strong Scintillation on Space Based Radar Design; I. Coherent Detection," *IEEE Trans. Aero. Electron. Syst.*, Vol. AES-19, No. 4, pp. 539-549, July 1983.

D. L. Knepp, "Multiple Phase-Screen Calculation of the Temporal Behavior of Stochastic Waves," *Proceedings of the IEEE*, Vol. 71, No. 6, pp. 722-737, June 1983.

R. L. Bogusch, F. W. Guigliano, D. L. Knepp and A. H. Michelet, "Frequency Selective Scintillation Effects on High Data Rate Satellite Links," *Proceedings of the IEEE*, Vol. 71, No. 6, pp. 754-767, June 1983.

D. L. Knepp and George C. Valley, "Properties of Joint Gaussian Statistics," *Radio Science*, Vol. 13, pp. 59-68, January February, 1978.

George C. Valley and D. L. Knepp, "Application of Joint Gaussian Statistics to Interplanetary Scintillation," *J. Geophysical Research*, Vol. 81, pp. 4723-4729, September 1976.

D. L. Knepp, "Variance and Bias of Angle Estimation Radars," *IEEE Trans. Antennas Propagat.*, Vol. AP-24, pp. 518-521, July 1976.

D. L. Knepp, "Antenna Aperture Effects on Measurements of Propagation Through Turbulence," *IEEE Trans. Antennas Propagation*, Vol. AP-23, pp. 682-687, September 1975.

## **Symposia**

D. L. Knepp, "Ionospheric Effects on a Wide Bandwidth Chirp Signal," URSI (International Union of Radio Science) General Assembly, Montreal, Canada, August 19-26, 2017.

D. L. Knepp, "Ionospheric Effects on a Wide Bandwidth Chirp Signal," Ionospheric Effects Symposium, Alexandria, VA, May 9-11, 2017.

D. L. Knepp, C. M. Spooner, and M. A. Hausman, "A wideband channel probe for space situational awareness," (Invited Paper) International Beacon Satellite Symposium BSS-2016, Trieste, Italy, 26 June-July 1, 2016.

D. L. Knepp, "Multiple phase screen calculation of two-way spherical wave propagation in the ionosphere," Ionospheric Effects Symposium, Alexandria, VA, May 12-14, 2015.

D. L. Knepp, C. M. Spooner, and M. A. Hausman, "A wideband channel probe for space situational awareness," 2013 Beacon Satellite Symposium, Bath, UK, July 8-10, 2013.

D. L. Knepp and Keith M. Groves (AFRL), "The Effect of Ionospheric Scintillation on Phase Gradient Autofocus Processing of Synthetic Aperture Radar," 7TH European conference on antennas and propagation, Gothenburg, Sweden, 8-12 April, 2013.

D. L. Knepp, "Radar Measurement of Ionospheric Scintillation in the Polar Region," URSI General Assembly, Istanbul, Turkey, August 13-20, 2011.

D. L. Knepp and Keith M. Groves (AFRL), "The Effect of Ionospheric Scintillation on Phase Gradient Autofocus Processing of Synthetic Aperture Radar," URSI General Assembly, Istanbul, Turkey, August 13-20, 2011.

D. L. Knepp, "Radar Measurement of Ionospheric Scintillation in the Polar Region," Ionospheric Effects Symposium, Alexandria, VA, May 17-19, 2011.

D. L. Knepp and Keith M. Groves (AFRL), "The Effect of Ionospheric Scintillation on Phase Gradient Autofocus Processing of Synthetic Aperture Radar," Ionospheric Effects Symposium, Alexandria, VA, May 17-19, 2011.

D. L. Knepp, "Mitigation of the Effects of Ionospheric Scintillation on Radar Object Classification," 2010 SEASONS Conference, Johns Hopkins University/Applied Physics Lab, Laurel, Md., November 2010.

D. L. Knepp, "Wide Bandwidth Measurements of Equatorial Scintillation at UHF," Air Force Orbital Resources Ionosphere (ORION) Conference, Invited Paper, Dayton, Ohio, January 12-14, 2010.

D. L. Knepp, "Impact of the Mean Ionosphere on VHF/UHF Synthetic Aperture Radar," Air Force Orbital Resources Ionosphere (ORION) Conference, Invited Poster, Dayton, Ohio, January 12-14, 2010.

D. L. Knepp and L. J. Nickisch, "Ionospheric Propagation Effects on Wide Bandwidth Signals," 2008 SEASONS Conference, Johns Hopkins University/Applied Physics Lab, Laurel, Md., November 2008.

Dennis L. Knepp, "Wide Bandwidth Propagation, Part I: Ionospheric Propagation Effects on Wide Bandwidth Signals," (Invited Paper), XXIX General Assembly of the International Union of Radio Science (URSI), Chicago, Illinois, August 2008.

Dennis L. Knepp, "Wide Bandwidth Propagation, Part II: Multiple phase screen calculation of signal propagation through the ionosphere," (Invited Paper), XXIX General Assembly of the International Union of Radio Science (URSI), Chicago, Illinois, August 2008.

D. L. Knepp and L. J. Nickisch, "Multiple phase screen calculation of wide bandwidth propagation through the ionosphere," Ionospheric Effects Symposium, Alexandria, Virginia, May 2008.

D. L. Knepp, "Ionospheric Propagation Effects on Ground and Space Based Radars," URSI General Assembly, Oct. 23-29, 2005, New Delhi, India.

D. L. Knepp, W. A. Brown, J. C. Thacker, K. S. Shanmugan, "Channel modeling for UHF SATCOM systems," *Ionospheric Effects Symposium*, Alexandria, Virginia, May 3-5, 2005.

D. L. Knepp, W. A. Brown, F. P. Sheetz, "Wideband UHF Measurements of Equatorial Scintillation Activity," 2004 Military Communications Conference, MILCOM 2004, Monterey, CA October 31-November 3, 2004.

D. L. Knepp, J. T. Reinking, C. P. Smith, G. A. Zunich, "Hardware Testing of the BMEWS III Radar Against Propagation Disturbances," 2003 MSS Missile Defense Sensors, Environments, and Algorithms (MD-SEA) II Symposium, Naval Postgraduate School, Monterey, CA , 18-20 November 2003.

D. L. Knepp and M. A. Hausman, "Ionospheric Propagation Effects on Ground and Space Based Radars," IEEE Radar 2003 International Conference, 3-5 September 2003, Adelaide, Australia (Invited paper).

D. L. Knepp, "The Effects of Ionospheric Scintillation on Transit-Satellite Measurements of Total Electron Content," XXVII URSI General Assembly, Maastricht, Holland, 17 to 24 August, 2002 (Invited paper).

W. A. Brown, D. L. Knepp, P. A. Kullstam, K. M. Kumm, F. M. Tirpak, "Wideband Ionospheric Scintillation Experiment at 295 MHz – Analysis Results and Applications to Mobile User Objective System (MUOS), 2002 Military Communications Conference, MILCOM 2002, Anaheim, CA October 7-10, 2002.

Knepp, D. L., "The Effects of Ionospheric Scintillation on Transit-Satellite Measurement of Total Electron Content," DARPA 2002 Workshop on Defence Applications of Signal Processing, Australia, July 2002, (Invited paper.)

D. L. Knepp, "The Effects of Ionospheric Scintillation on Transit-Satellite Measurements of Total Electron Content," *Ionospheric Effects Symposium*, Alexandria, Virginia, May 7-9, 2002.

J. T. Reinking, D. L. Knepp, "Estimation of the S4 Scintillation Index that Accounts for Noise and Thresholding," *Ionospheric Effects Symposium*, Alexandria, Virginia, May 7-9, 2002.



J. Todd Reinking, D. L. Knepp, M. A. Hausman, "Polar Region Ionospheric Effects on UHF Radar Track Acquisition," *Ionospheric Effects Symposium*, Alexandria, Virginia, May 4-6, 1999.

D. L. Knepp and W. A. Brown, "Average Received Power After Two-Way Radar Propagation Through Ionized Turbulence," *1996 Antenna Propagation Society International Symposium and URSI Radio Science Meeting*, Baltimore, Maryland, July 21-26, 1996.

D. L. Knepp and W. A. Brown, "Average Received Signal Power After Two-way Radar Propagation Through Ionized Turbulence," *1996 Ionospheric Effects Symposium*, Alexandria, VA, May 7-9, 1996.

L. J. Nickisch and D. L. Knepp, "Propagation in Randomly Structured Ionization," *URSI National Radio Science Meeting*, Boulder, Colorado, 3-7 January 1995.

W. A. Brown and D. L. Knepp, "Ionospheric Propagation Effects on Cyclostationary Signals," *URSI National Radio Science Meeting*, Boulder, Colorado, 3-7 January 1995.

D. L. Knepp, "ALTAIR UHF Observations of Backscatter Enhancement," *URSI National Radio Science Meeting*, Boulder, Colorado, 5-8 January 1993.

D. L. Knepp and E. L. Mokole, "Space-based Radar Coherent Integration Loss," *1993 Ionospheric Effects Symposium*, Alexandria, Virginia, May 4-6, 1993.

D. L. Knepp and H. L. F. Houppis, "ALTAIR VHF/UHF Observations of Multipath and Backscatter Enhancement," *Seventh International Conference on Antennas and Propagation*, University of York, UK, 15-18 April 1991.

D. L. Knepp and H. L. F. Houppis, "VHF/UHF Radar Scintillation Effects Observed by ALTAIR," *IES '90 Symposium on The Effect of the Ionosphere on Radiowave Signals and System Performance*, 1990.

J. T. Reinking, T. M. Moody, and D. L. Knepp, "Effects of Ionospheric Scintillation on DPCA Clutter Rejection Performance," *IES '90 Symposium on The Effect of the Ionosphere on Radiowave Signals and System Performance*, 1990.

D. L. Knepp, "VHF Radar Scintillation Effects on ALTAIR," *URSI National Radio Science Meeting*, Boulder, Colorado, January, 1989.

D. L. Knepp and W. A. Brown, "Nuclear Effects on GBR Imaging," *1989 IEEE Military Communications Conference Record*, April 1989.

D. L. Knepp, "Analysis and Interpretation of Wideband Satellite Data," *1988 National Radio Science Meeting*, Univ of Colorado, Boulder, Colorado, January 5-8, 1988.

D. L. Knepp, C. L. Rino, and L. W. Bradford, "Scintillation Effects on Space Based Radar," *33<sup>rd</sup> Annual Tri-Service Radar Symposium*, June 23-25, 1987.

D. L. Knepp and G. W. Ullrich, "Space Based Radar Performance in a Strongly Disturbed Propagation Environment," *Tenth DARPA Strategic Space Symposium*, Naval Postgraduate School, Monterey, CA. October 16-19, 1984.

D. L. Knepp and G. W. Ullrich, "The Effects of a Disturbed Propagation Channel on Space Based Radar Performance," *RADC Space Based Radar Technology Review*, Griffiss Air Force Base, New York, June 5-7, 1984.

D. L. Knepp, "The Effect of Scintillation on Space Based Radar Performance--Clutter Rejection, Pulse Doppler Radar versus DPCA," *1984 Tri-Service Symposium on the Effect of the Ionosphere on C3I Systems*, Alexandria, VA, May 1-3, 1984.

D. L. Knepp, "Aperture Antenna Effects on Radar Observations Through Strongly Disturbed Random Media," *URSI National Radio Science Meeting*, Boulder, Colorado, 11-13 January 1984.

D. L. Knepp, "Aperture Antenna Effects after Propagation Through Strong Anisotropic Random Media," *National Radar Science Meeting*, Houston, Texas, 23-26 May 1983.

D. L. Knepp and R. A. Dana, "Impact of the Propagation Environment on Space Based Radar Design," AIAA-82-0424, *AIAA 20th Aerospace Sciences Meeting*, Orlando, Florida, January 1982.

D. L. Knepp, "Generation of Wide Bandwidth Signals After Propagation Through Random Media," *URSI National Radio Science Meeting*, Albuquerque, New Mexico, 24-28 June 1982.

D. L. Knepp, "Analytic Solution for the Two-Frequency Mutual Coherence Function," *URSI National Radio Science Meeting*, Los Angeles, CA, 16-19 June 1981.

D. L. Knepp, "Multiple Phase-Screen Calculation of the Temporal Behavior of Stochastic Waves," *URSI National Radio Science Meeting*, Quebec, Canada 2-6 June 1980.

D. L. Knepp, "Signal Coherence Properties Obtained from Wideband Satellite Data," *URSI National Radio Science Meeting*, Univ. of Washington, 18-22 June 1979.

M. Kelley, D. L. Knepp and K. D. Baker, "Direct Comparison of In-situ Plasma Density and VHF/UHF Phase Scintillation Measurements," *URSI National Radio Science Meeting*, Univ. of Washington, 18-22 June 1979.

D. L. Knepp, "Properties of Joint Gaussian Statistics," *USNC/URSI 1977 Meeting*, Stanford University, 22-24 June 1977.

D. L. Knepp, "Variance and Bias of Angle Estimation Radars," *AP-S International Symposium*, U. of Massachusetts at Amherst, 11-15 October 1976.

D. L. Knepp, "Aperture Antenna Effects on Measurements of Propagation Through Turbulence," *Symposium on the Effect of the Ionosphere on Space Systems and Communications*, Crystal City, Arlington, Virginia, January 20-22, 1975.

### **Selected Recent Reports**

D. L. Knepp and J. A. Secan, "Mitigation of the Effects of the Ionosphere on the UEWR, SBIR Phase II Final Report" Final Technical Report, NWRA-15-RM572, Electronic Systems Center, Contract HQ0147-13-C-7624, 1 December 2015.

D. L. Knepp, "Calculation of Impulse Response Function During Realistic Scenarios," Final Technical Report, NWRA-12-RS483, Defense Threat Reduction Agency, Phase I SBIR, Contract HDTRA1-12-P-0011, 26 December 2012.

D. L. Knepp and L. J. Nickisch, "Mitigation of the Effects of Scintillation on Radar Object Classification," Final Technical Report, NWRA-SEA-10-R415, Air Force Research Laboratory, AFRL-RY-HS-TR-2010-0035, 12 September 2010.

D. L. Knepp and L. J. Nickisch, "Mitigation of the Effects of Scintillation on Radar Object Classification," Final Technical Report, NWRA-BELL-07-R348, March 2007.

Knepp, D. L. and W. A. Brown, "Wide Bandwidth Channel Modeling for MUOS," MRC report MRC/MRY-R-116, prepared for Lockheed Martin Space Systems Company: MUOS Engineering Memorandum EM-SEIT-0054, 7 November 2003.

Knepp, D. L., M. A. Hausman, E. S. Li, L. J. Nickisch, J. T. Reinking, J. A. Secan, G. T. Zurich, "Mitigation of Ionospheric Effects on the UEWRs," Mission Research Corporation Report MRC/MRY-R-107, for Raytheon Electronic Systems, 31 May 2002.

Hausman, M. A. and D. L. Knepp, "PROPMOD User's Guide and Test Suite: Computing Transionospheric Radio Propagation Parameters," MRC/MRY-R-082, prepared for Defense Threat Reduction Agency, October 1999.

Hausman, M. A., D. L. Knepp, and L. J. Nickisch, "PROPMOD – A Program for Computing Propagation Effects on Transionospheric Radio Signals," Phillips Laboratory, PL-TR-95-2120, August 1995.

Knepp, D. L., "Propagation of Wide Bandwidth Signals Through Strongly Turbulent Ionized Media," Mission Research Corporation, for the Defense Nuclear Agency, DNA-TR-81-78, Defense Nuclear Agency, March 1982.