History of NTIA/ITS

ISART 2010

Department of Commerce, Boulder – July 27, 2010

Al Vincent, Director, NTIA/ITS

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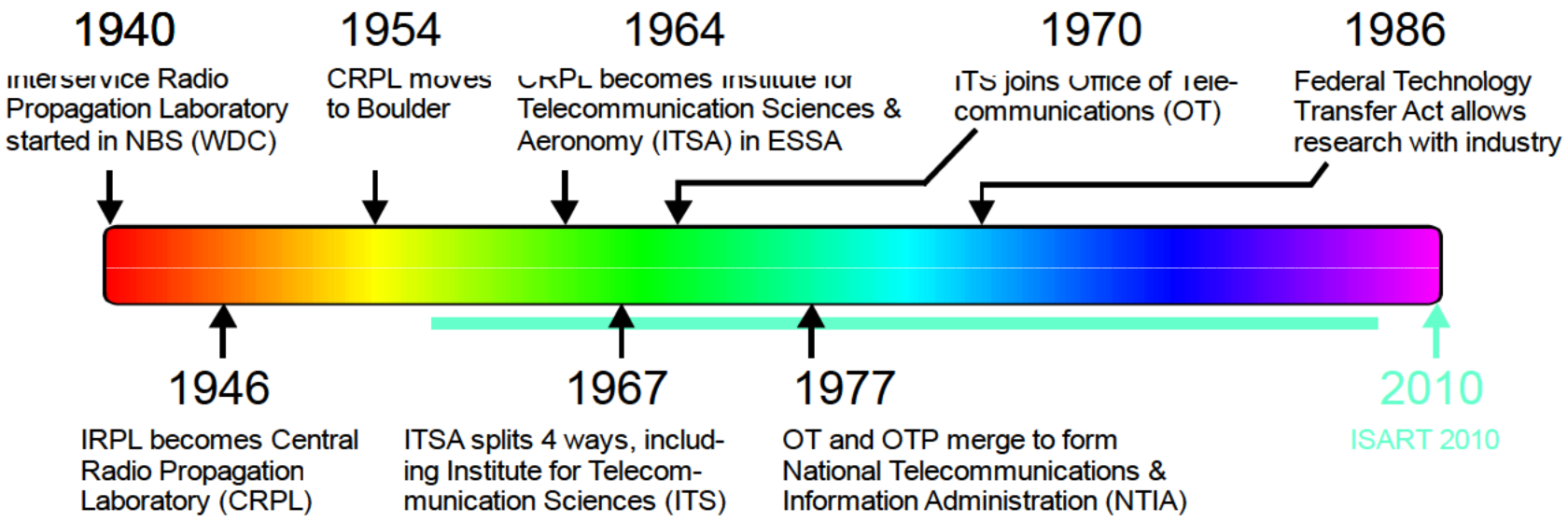
Timeline


1940
Interservice Radio Propagation Laboratory started in NBS (WDC)
1954
CRPL moves to Boulder
1964
CRPL becomes Institute for Telecommunication Sciences & Aeronomy (ITSA) in ESSA
1970
ITS joins Office of Telecommunications (OT)
1986
Federal Technology Transfer Act allows research with industry
1946
IRPL becomes Central Radio Propagation Laboratory (CRPL)
1967
ITSA splits 4 ways, including Institute for Telecommunication Sciences (ITS)
1977
OT and OTP merge to form National Telecommunications & Information Administration (NTIA)
2010
ISART 2010

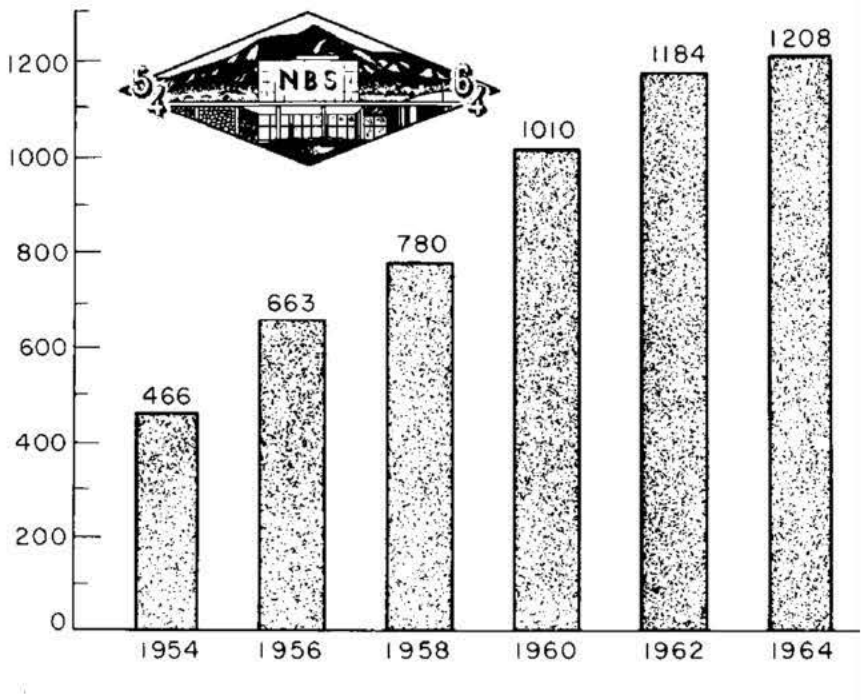
Major Historical CRPL and ITS Research Topics

- HF Propagation
- VHF/UHF Propagation
- Noise: Atmospheric & Man-made
- Radiometeorology
- Spectrum Occupancy
- Multipath
- Spectrum Sharing

Gearing Up to Work

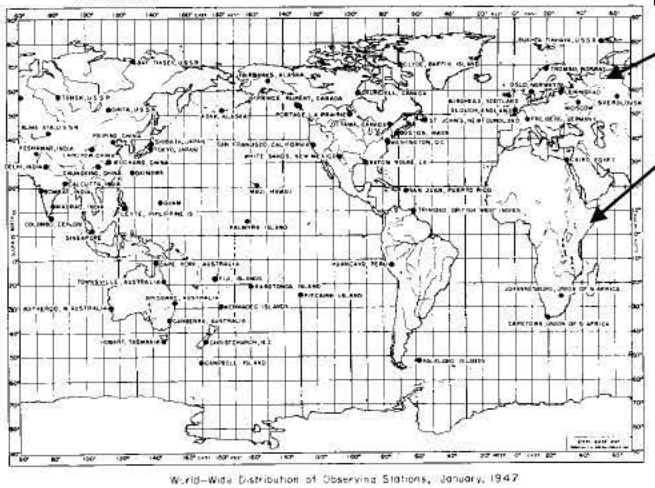
First annual Boulder NBS report (1955) shows three divisions.

- Div 81 – Cryogenic Eng.
- Radio Standards
- CRPL –
  - Ionospheric prop
  - Tropospheric prop
  - Microwave and MMW
  - Data reduction
  - Modeling
  - Forecasting Services



FULL-TIME PERMANENT STAFF, NBS BOULDER LABORATORIES

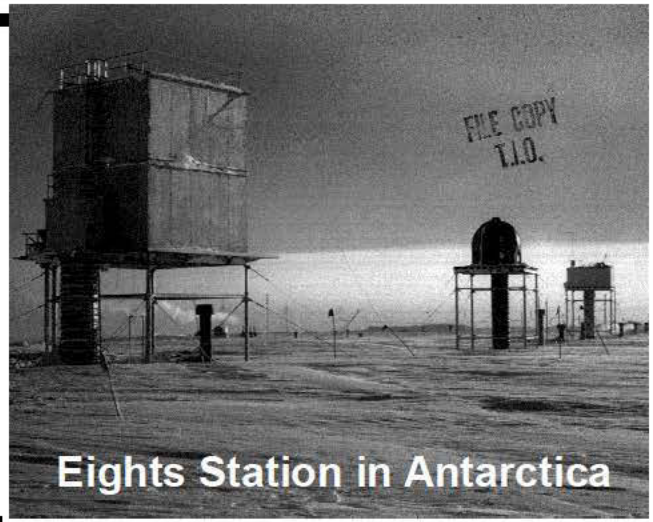
Large, Global Endeavors


World-Wide Distribution of Observing Stations, January, 1947

90 HF Sounders

25 ARN-2 Noise Measurement sites

Steerable H/V Antenna array 500' high



Eights Station in Antarctica

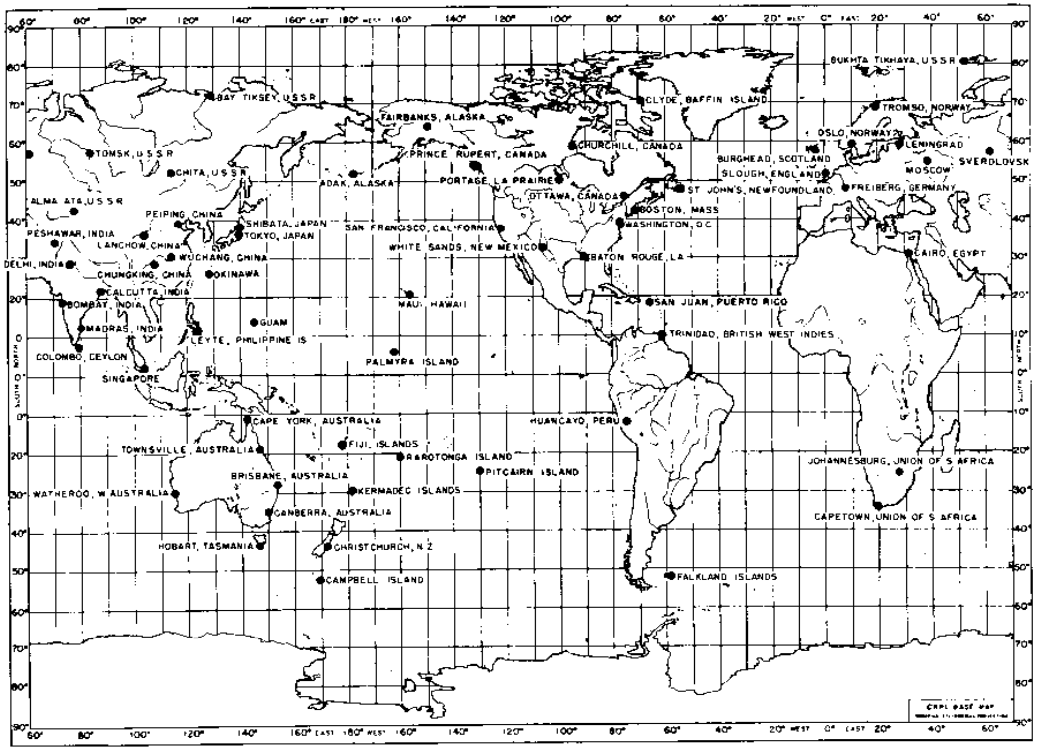

Paired 60-ft dish antennas - Tropo-scattering, 50 MHz -11


Sounder - 9000 acres. Near Lima, Peru

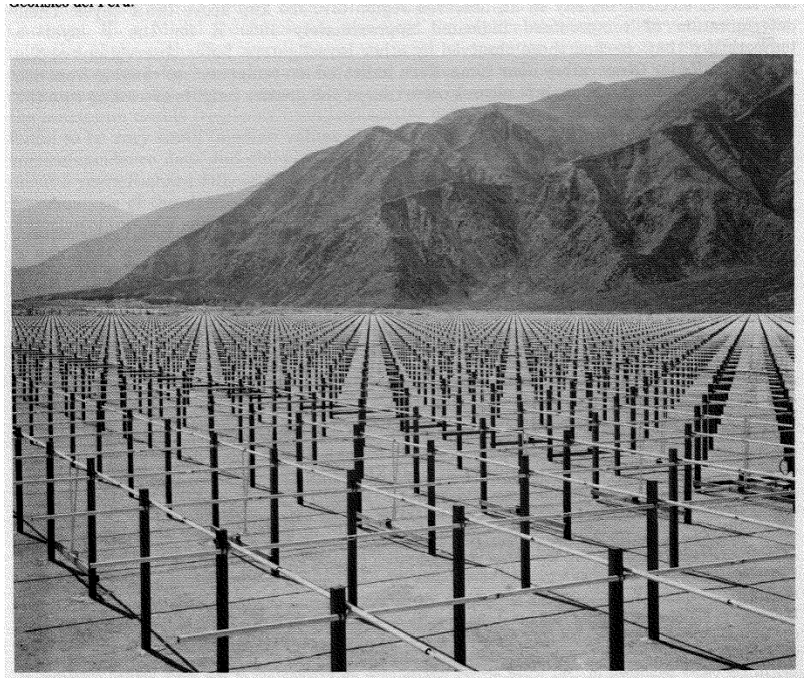
HF Propagation

- **Context**: Pre-WWII to 1960's, HF radio carried most wireless comm. Reflection by the ionosphere allowed trans-oceanic ranges, but reflection was highly variable and not well understood. Limitations of vacuum tubes prevented operation at higher frequencies
- **Stakeholders**: Radio broadcasting; Military, ship, aircraft, and land mobile comm
- **Research Areas**: Major Intl research efforts (e.g., IGY); Radio wave propagation in general; Ionospheric propagation; terrain, oceanic, magnetosphere, and solar effects
- **Scientific Achievement**:
  - NBS Pub on Ionospheric Radiowave Propagation (Davies, 1965)
  - Ionospheric Communications Analysis and Prediction Program (IONCAP, 1983)
  - Voice of America
  - Automatic Link Establishment (ALE) , 1993 (Fed Std 1045A)
- **Outcome**: Propagation models allowed for more reliable systems, and extensive international coordination for regulating frequencies (CCIR). HF models became available too late, since use of VHF/UHF had greatly expanded. This was reflected in the failed CCIR HF Broadcasting WARC (1990).

HF Propagation (cont.)



World–Wide Distribution of Observing Stations, January, 1947



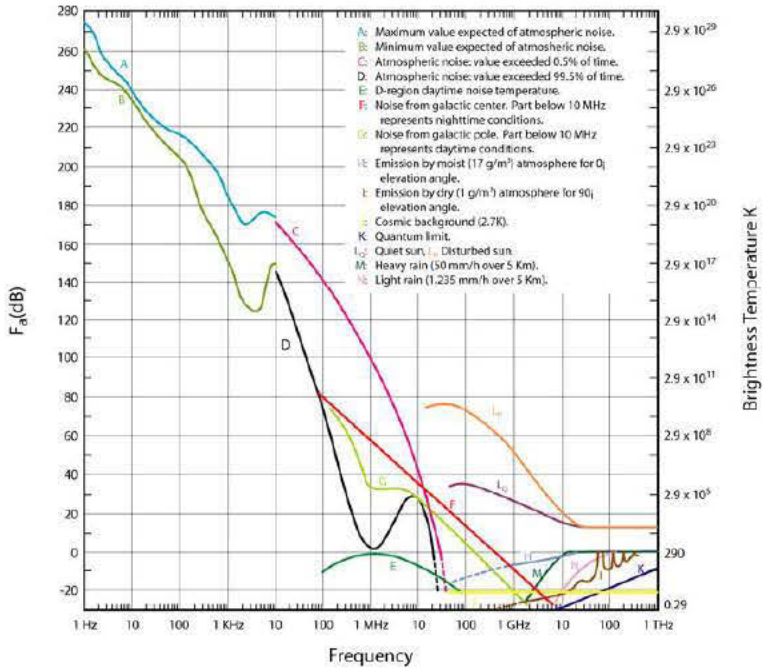
Dipoles by the thousands (9216 crossed pairs of half-wave dipoles)—covering an area of 21 acres—that serve as a huge antenna for a scatter radar installation. Construction of the facility, known as the Jicamarca Radar Observatory, began in January 1961 at Jicamarca, a site east of Lima, Peru, located near the geomagnetic equator. This venture into new realms of radio research of the ionosphere was a cooperactive project of the Central Radio Propagation Laboratory and the Instituto Geofisico de Perú.

VHF/UHF Propagation

- **Context**: After WWII, we were running out of spectrum; advanced electronic technologies finally enabled use at frequencies above HF. Radiowaves at smaller wavelengths were strongly effected by obstacles (e.g., topography, buildings). FCC created moratorium on TV broadcast due to interference issues → TASO.
- **Stakeholders**: TV/Radio broadcast; Military comm; land-mobile radio
- **Research Areas**: Diffraction, terrain effects, troposcatter
- **Scientific Achievement**:
  - Tech Note 101 (Rice, Longley, Norton, 1967)
  - Model of tropospheric transmission loss (Longley-Rice, 1968)
- **Outcome**: Better understanding of VHF/UHF propagation resolved TV interference roblems massive use of VHF/UHF “beachfront” spectrum

Radio Noise

- **Context**: Atmospheric radio noise (ARN) propagated worldwide from lightning strikes posed a significant obstacle for HF. In the mid-1960s and 1970s, as technologies enabled use of the VHF, short-range man-made noise (MMN) was a limiting factor.
- **Stakeholders**: All HF radio including military comm; some urban and mobile VHF systems
- **Research Areas**: Spatio-temporal characteristics of ARN measured on a global basis using 20-30 measurement sites for 10-15 years. MMN measured locally and intermittently with mobile measurement systems; methods for mitigating interference.
- **Scientific Achievement**:
  - Models of HF ARN (Crichlow & Disney, CCIR 322, 1966)
  - Models of VHF MMN (Spaulding, CCIR 258, 1974)
  - Models of Wideband HF ARN and MMN (Lemmon, 1990)
- **Outcome**: Characterized ARN worldwide. Modulation and coding schemes to minimize ARN interference. MMN characterized in different environments (urban, residential, rural) and development of FCC/DOT rules for noise suppression in cars, switching power supplies, etc.



Radiometeorology

- **Context**: Index of refraction (*n*) values are basic to the study of atmospheric radiowave propagation. Prior to the 1960s, dependencies of *n* on physical parameters in the troposphere were not well-understood. Later, fundamental questions about the physics at higher frequencies and higher altitudes needed attention to assess space comm systems.
- **Stakeholders**: military, satellite comm, fixed microwave links, weather radar
- **Research Areas**: *n*, ducting, troposcatter, rain scattering, 60-GHz absorption
- **Scientific Achievements**:
  - Cavity Refractrometer ()
  - Radio Meteorology text (Bean-Dutton, 1966)
  - Rice-Holmberg Rain Model (1973)
  - Millimeter-wave Propagation Model (Liebe, 1985)
- **Outcome**: Successful comm links beyond LOS , more reliable point-to-point microwave links, earth-to-space and space-to-space links; weather radar

Spectrum Occu. anc.

Context: OT needs knowledge of Federal spectrum usage to evaluate apparent LMR crowding. Wanting technical solutions to radar band crowding.

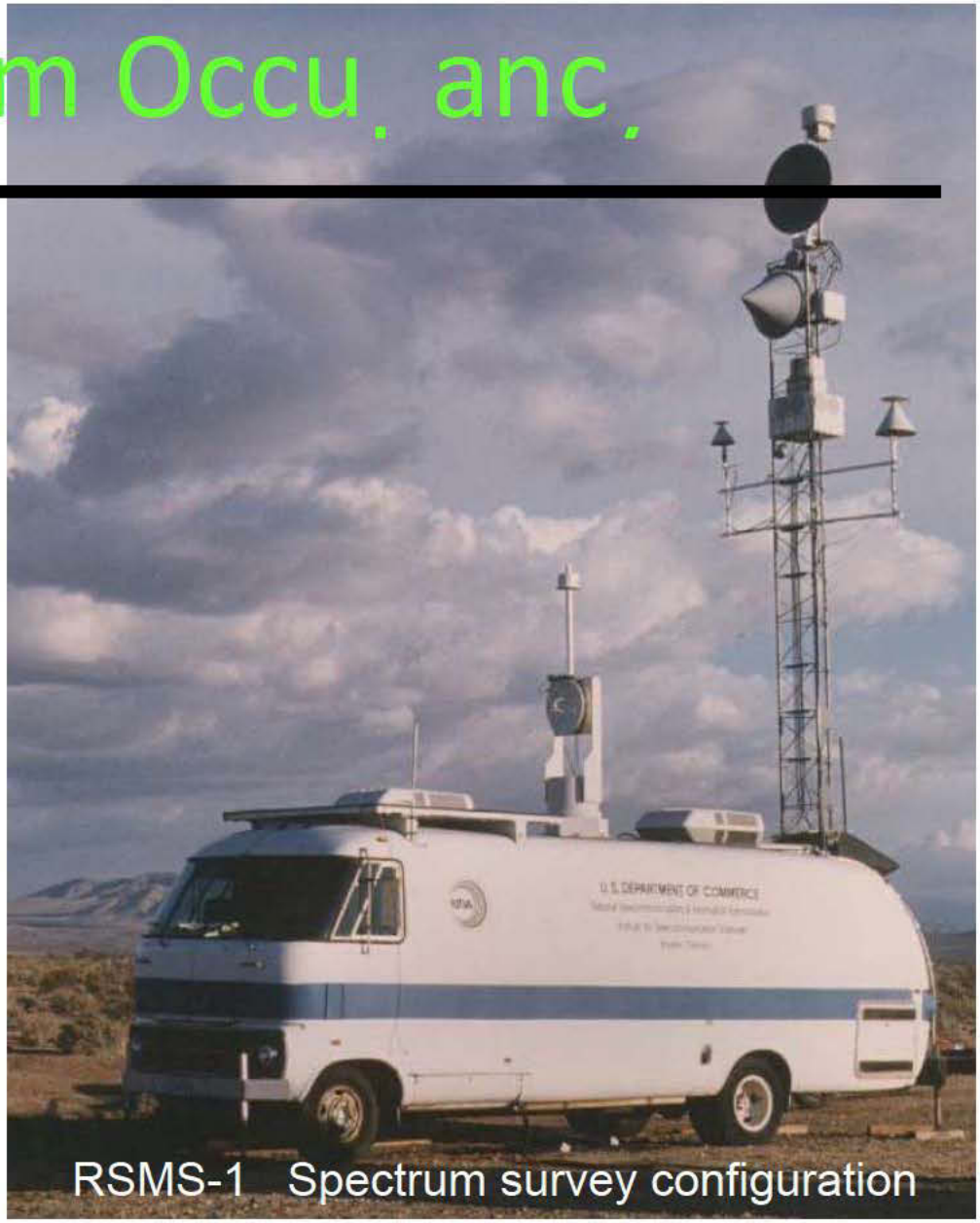
Stakeholders: Spectrum management, public safety, radar

Areas of Research: Measurement and modeling of spectrum usage information.

Scientific Achievements:

- RSMS-1 (1973)
- Radar performance measurements
- LMR band occupancy measurements
- Broadband spectrum surveys

Outcome: Identified Federal LMR spectrum misuse; developed radar spectrum-conserving techniques; developed efficient techniques for various types of signals.



RSMS-1 Spectrum survey configuration

Multipath

- **Context:** In the 1970's, microwave radios were limited by channel multipath. Later, industry wanted to deploy systems in even more difficult urban environments.
- **Stakeholders:** Microwave data links, radar, military, cellular, DTV broadcast, personal communications
- **Research Topics:**
  - Microwave air-to-ground and airport environments
  - Mobile multipath in forested environments
  - Microwave point-to-point in urban and suburban environments
  - DTV broadcast in urban multipath environments
  - Cellular and Indoor environments
  - MIMO
- **Scientific achievements:**
  - Impulse response channel probe using pn codes (Hubbard, 1976)
- **Outcome:** Provided data for the development of new comm systems, DTV.

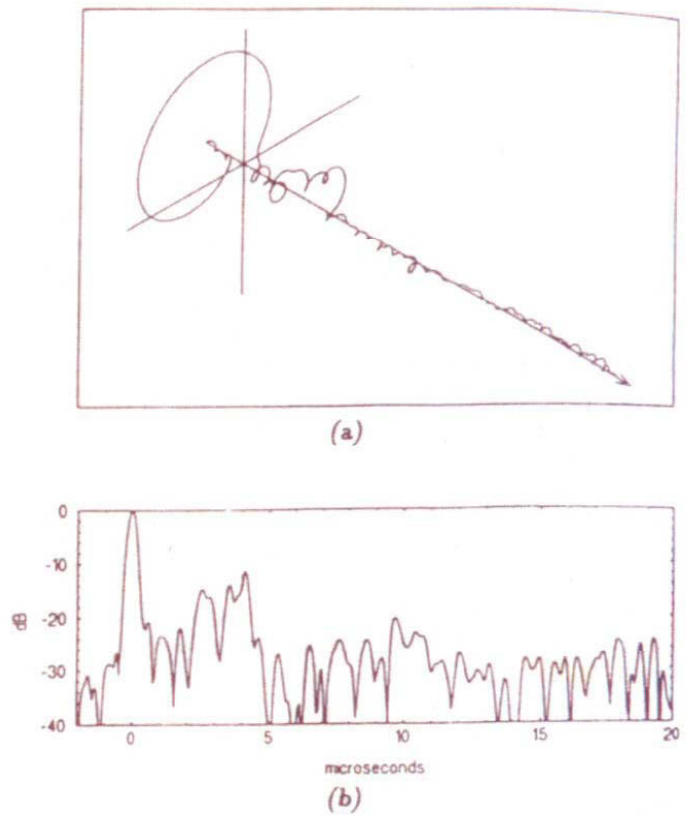
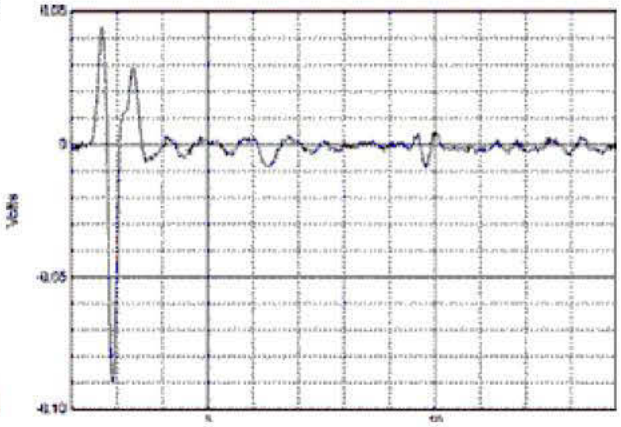


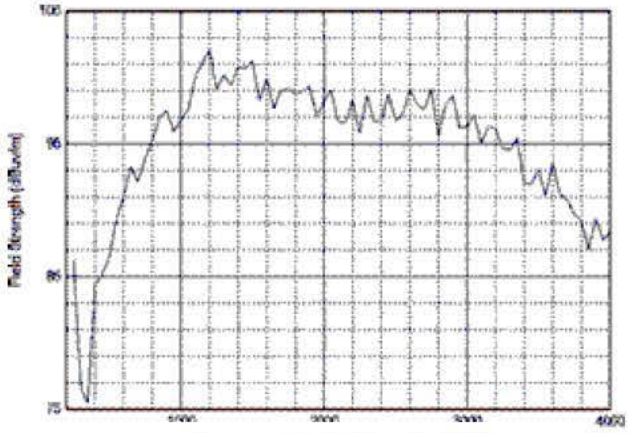
Figure 1. A measured impulse response from a location in an urban area in Millbrae, Calif.: (a) A 3-D representation of the complex-valued voltages; (b) the amplitude of the same response function.

Spectrum Sharing

- **Context:** Beginning in the 1990's, emerging services demanded more spectrum and proposed spectrum sharing as a solution.
- **Stakeholders:** GPS, Satellite TV broadcast, radar, civilian personal comm, computer comm, cellular, UWB
- **Areas of Research:** Ultrawideband (UWB) interference to GPS, LMR, and satellite TV; Coexistence between Dynamic Frequency Selection (DFS) Technologies and radar
- **Scientific achievement:**
  - Characterization of impulsive UWB devices (Kissick, 2001)
  - Methodologies for determining interference protection/coexistence criteria
  - DFS/radar coexistence white paper (Sanders, 200?)
- **Outcome:** Laboratory measurements provided justification for new rules permitting spectrum sharing, e.g., unlicensed UWB and DFS.



1 nanosecond per div



Frequency, 0 – 4 GHz

Summary

ITS and predecessors provided many of the of the Radio Propagation modeling tools in use by government and industry today.

Next: Al Vincent will describe what ITS is working on now for tomorrow and the future.