History of NTIA/ITS

ISART 2010
Department of Commerce, Boulder – July 27, 2010
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Institute for Telecommunication Sciences – Boulder, Colorado
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
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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

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Large, Global Endeavors

- 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 GHz
- Jicamarca - Vertical Sounder - 9000 antennas, 21 acres. Near Lima, Peru

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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.)
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 problems; 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
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.
• **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.
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.
ITS and predecessors provided many 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.