ITS: The Nation's Spectrum and Communications Lab
Realizing the full potential of telecommunications to drive a new era of innovation, development, and productivity

ITS Institute for Telecommunication Sciences

ITS Propagation Modeling Research and Development

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Key ITS Propagation Models: ITM and IF77

▶ ITS develops and maintains authoritative propagation codes, e.g., P.528, and analysis programs, e.g., PMW

▶ Two important ITS-developed general-purpose models:
- Irregular Terrain Model (ITM)
- ITS-FAA Air/Ground Model (IF-77)

▶ Active areas of improvement
- [ITM] Line-of-sight geometry improvements: current proposed theoretical updates show up to 10-15 dB of prediction improvement in challenging scenarios
- [IF77] Improved ray tracing and atmospheric modeling, leveraging ITS MPM93 work, to support higher frequency air/ground propagation (>20 GHz)
- [General] Tropospheric forward scatter (troposcatter) theory re-derived from first principles — critical when modeling coexistence between two distance-sensitive systems

Millimeter Wave Propagation

▶ In March 2021, conducted measurements at 37 GHz throughout downtown Boulder

▶ Results deviated from models other Government agencies were relying on to protect systems

▶ Propagation modeling team analyzed measurements with environmental data (3D LiDAR)

- Hypothesized differences were caused by environmentally-specific clutter obstructions
- Proposed additional measurement scenario to validate
- Future modeling improvements/methods

RX Antenna

Fresnel zone

Traffic island
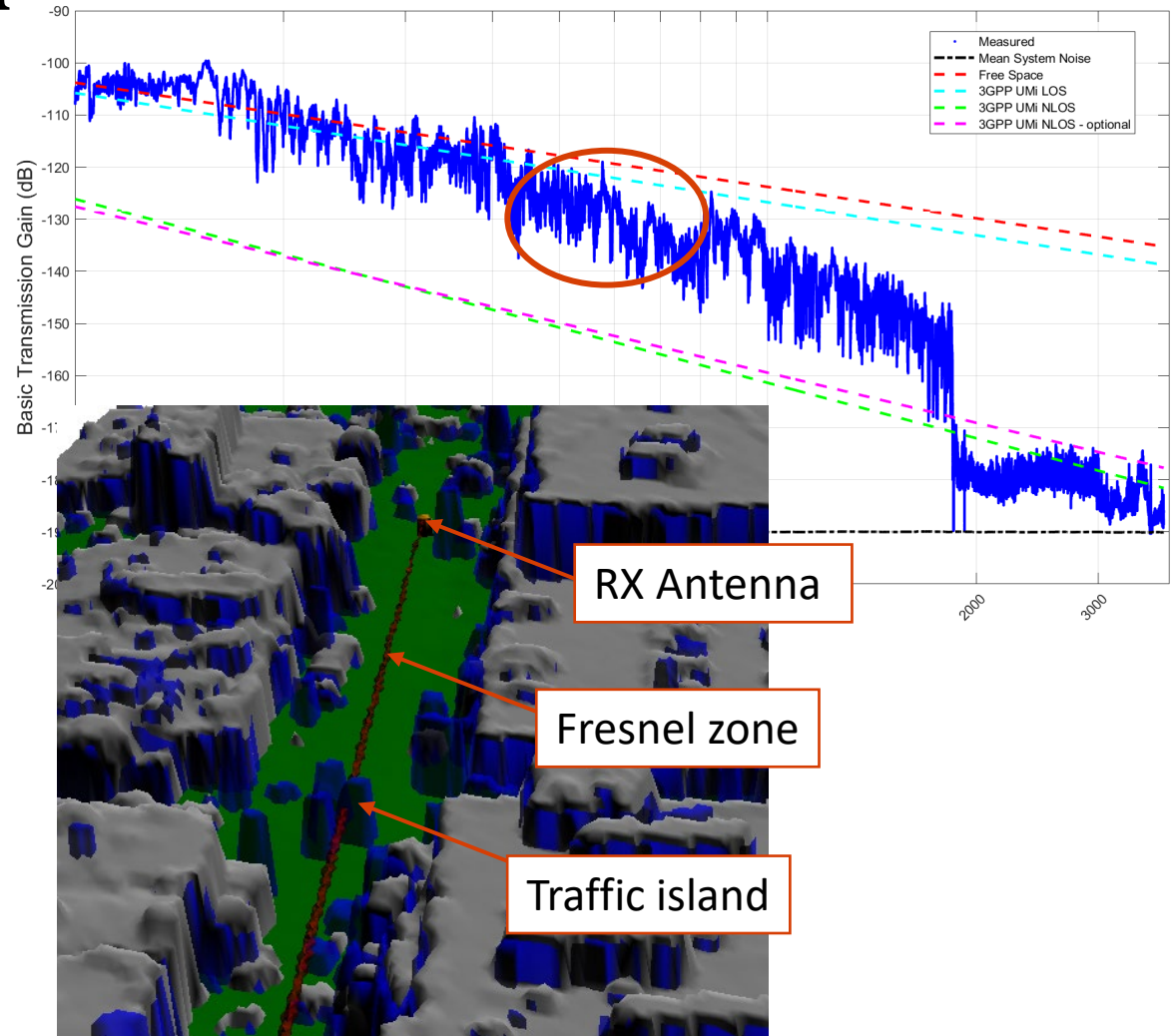
Mid-Band Propagation Model Initiative

▶ **Goal:** Establish an improved and community-accepted mid-band (i.e., 3.1–4.2 GHz) RF propagation model framework for a diverse range of link geometries, e.g., clutter, terrain, air/ground, over-water, long distance

▶ **Approach:**
- Bring the spectrum community together in an open collaborative way
- Focus collective effort to improve modeling
- Maintain a rigorous scientific process for improvements
- Model development priorities drive experimental design and measurement requirements
- Experimental results and measurement validations drive model updates
- Model implementations delivered to community as trustworthy production-level software

$$R_o \cong d_1 - x$$
$$R \cong d_2 + x$$

$$\alpha + \beta \cong \frac{d\sqrt{w^2 + h^2}}{R R_o}$$
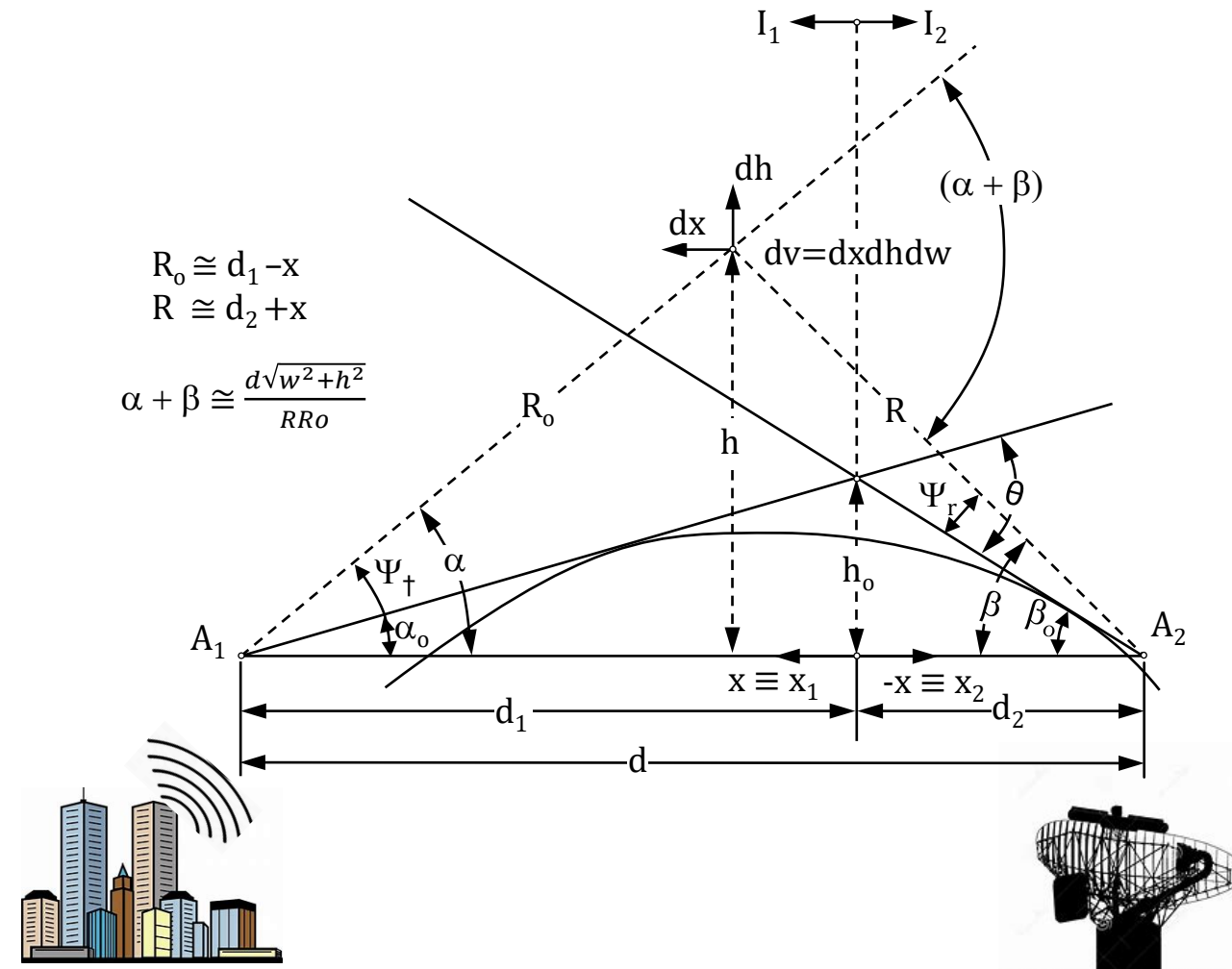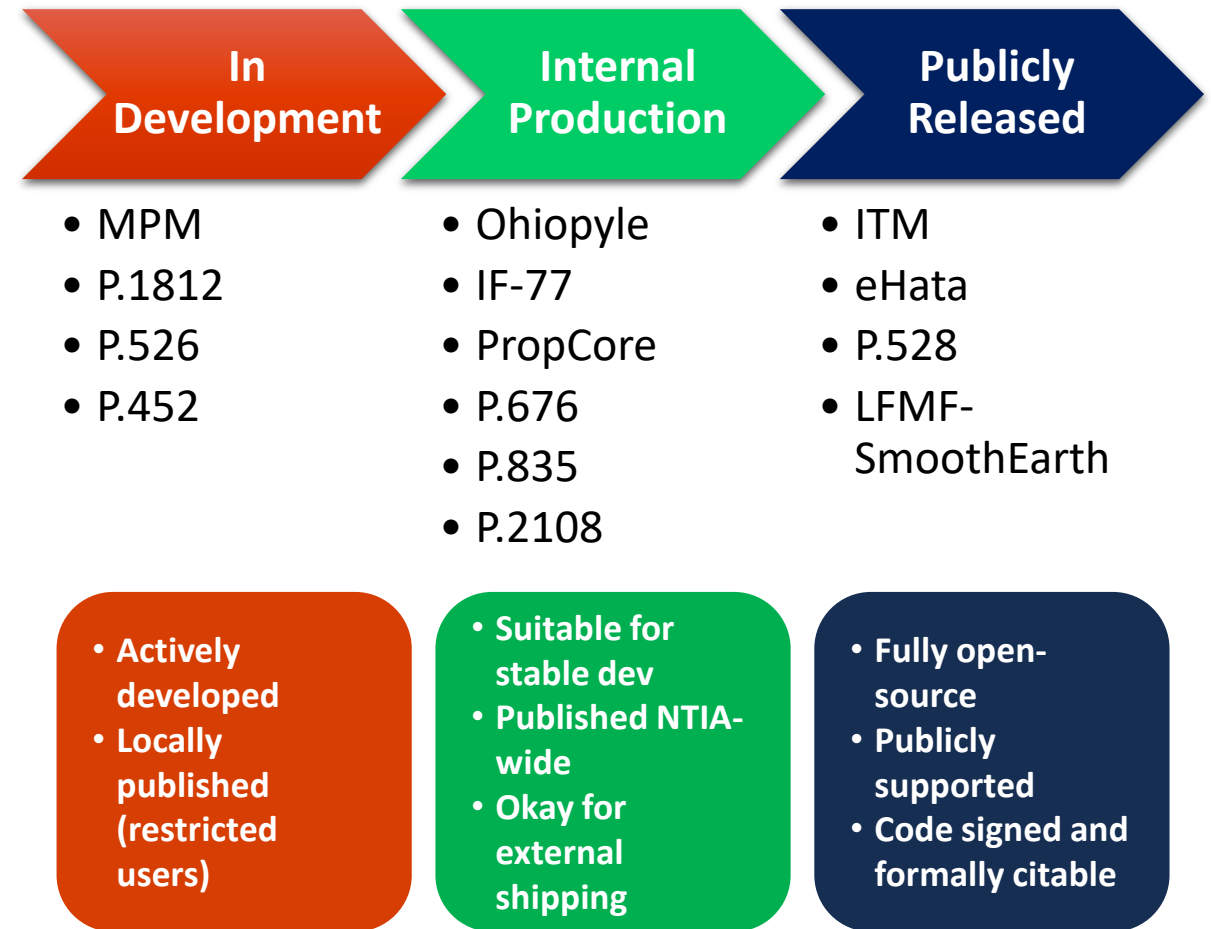
Clutter Measurements and Modeling

▶ Build on 1.7 GHz measurement and modeling

▶ Expand into mid-band frequencies

▶ Combine:
  - Electromagnetic theory
  - Empirical measurement data
  - Terrain, structural, and vegetative (via Lidar)

▶ To model:
  - Site-specific median clutter loss
  - Statistical clutter prediction method
  - Quantification of location variability

▶ And output:
  - New clutter model
  - Updates to ITM and IF77 for clutter effects
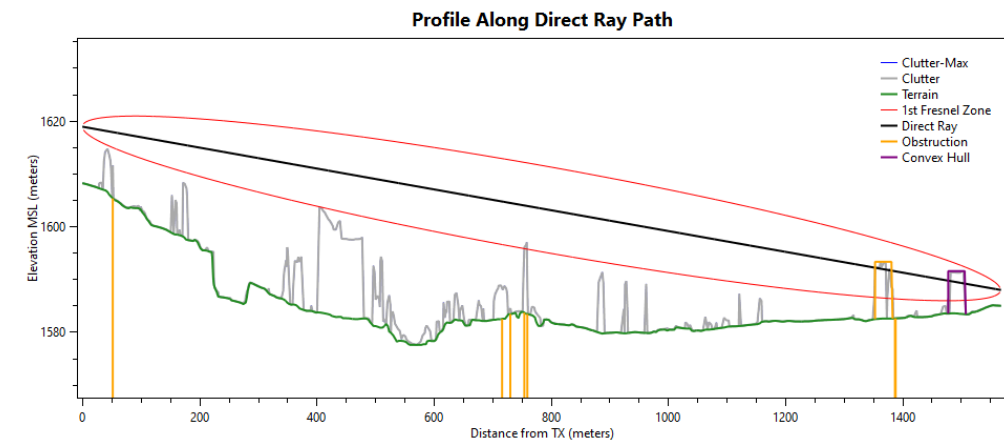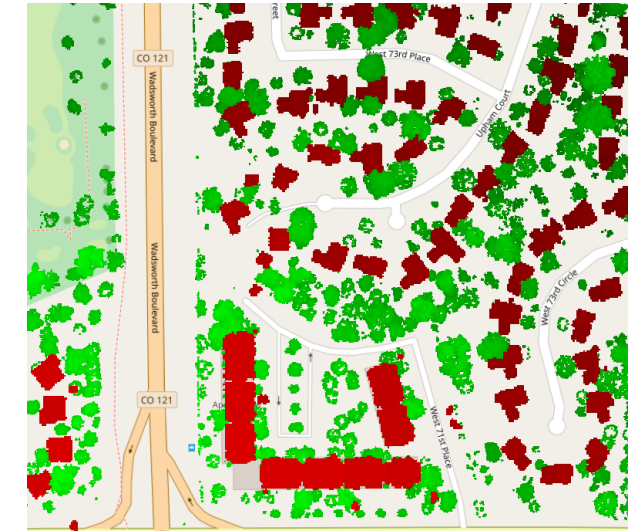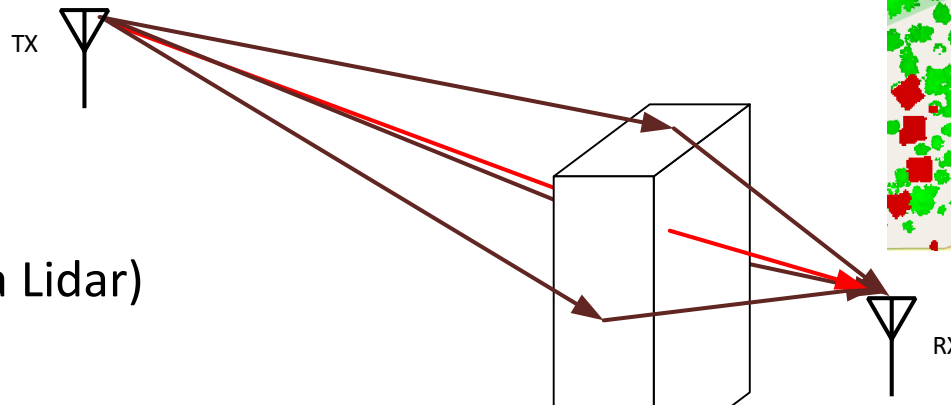
ITS Propagation Library (PropLib)

https://github.com/NTIA

▶ **Goal:** To establish authoritative and widely-used propagation model software

▶ **Approach:** ITS establishes modern software development process to ensure reliability and integrity of software research products. Once proplib codes are released, improvements originate through (1) ITS scientific process and (2) open-source collaboration.

▶ **Process:**
- In development
- Internal production
- Publicly released

In Development	Internal Production	Publicly Released
• MPM • P.1812 • P.526 • P.452	• Ohiopyle • IF-77 • PropCore • P.676 • P.835 • P.2108	• ITM • eHata • P.528 • LFMF-SmoothEarth
• Actively developed • Locally published (restricted users)	• Suitable for stable dev • Published NTIA-wide • Okay for external shipping	• Fully open-source • Publicly supported • Code signed and formally citable