



International Symposium on Advanced Radio Technologies (ISART)

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Propagation Challenges for Ultra Dense (& Other Demanding Future) Wireless Systems



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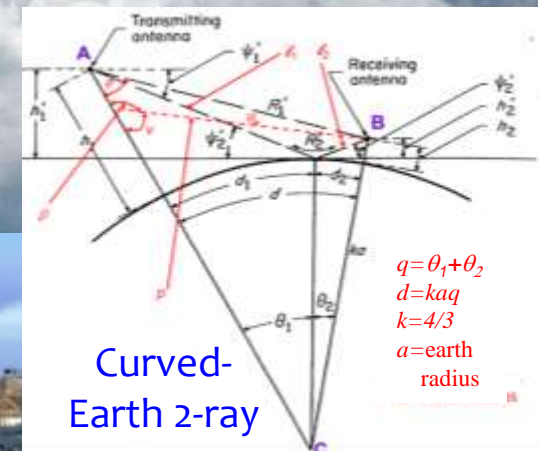


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Future Propagation/Channel Modeling

Will see more...

- Quasi-deterministic (hybrid deterministic/stochastic) models
 - More data-laden, but still w/**random** components
- Models “developed/refined-as-you-go”
 - **During** deployment/operations, w/continual updates (e.g., shadowing)
- Multi-**band** models



Demanding Future Cases

Challenges include

- **Mobile** channels (as always!): particularly V2X, Air-X
 - Higher velocities (aircraft, high-speed rail...)
 - *Continuity*
- **Ultra Reliable** (low latency) comm systems
 - Knowing *worst*-cases

Ultradense networks... will mean

- Nodes in places they have never been before
- More peer-to-peer links

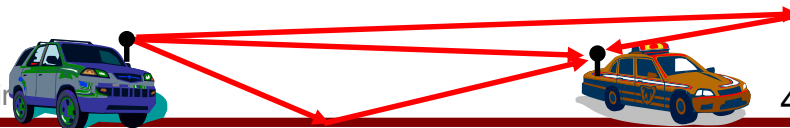
Path loss $L = \text{function}(d, f, \text{LoS}, h's, \text{Env}, \text{BW})$
Existing models $\sigma \sim 10\text{-}15$ dB

Challenging Cases (2)

- **Mobile** channels means models should
 - Be spatially consistent (no discontinuities)
 - Cover \geq desired area (volume)
 - Incorporate **time** (typically via space) accurately
- **Ultra Reliable** (low latency) comm systems
 - Require knowledge of **UN**likely events
 - To confidently quantify 1-in-a-million fade requires $\sim 10^8$ measurements
 - Must deal w/“*ultra-reflective*” environments, e.g., factories, warehouses, airport gates, etc.,



$$h_{ij}(\tau, t) = \int_{\zeta} \int_{\phi} \int_{\theta} h(r_T^{(j)}, r_R^{(i)}, t, \zeta, \theta, \phi) G_T^{(j)}(\theta) G_R^{(i)}(\phi) p(\tau - \zeta) d\zeta d\theta d\phi$$

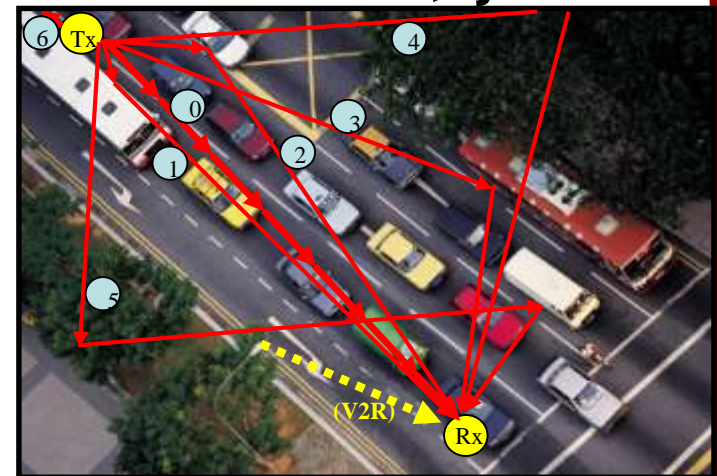


UR *Channel* Challenges

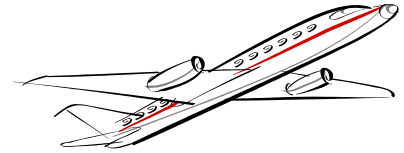
- Overcoming shadowing
 - Difficult to obtain diversity: use **polarization**
- **Im**mobility: can locate node in fading null
 - In UD case → relaying (D2D)
 - Omnidirectionality = interference broadcasting
- More data *helps*, but will **not** eliminate σ , yet



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Air-X Channel Challenges

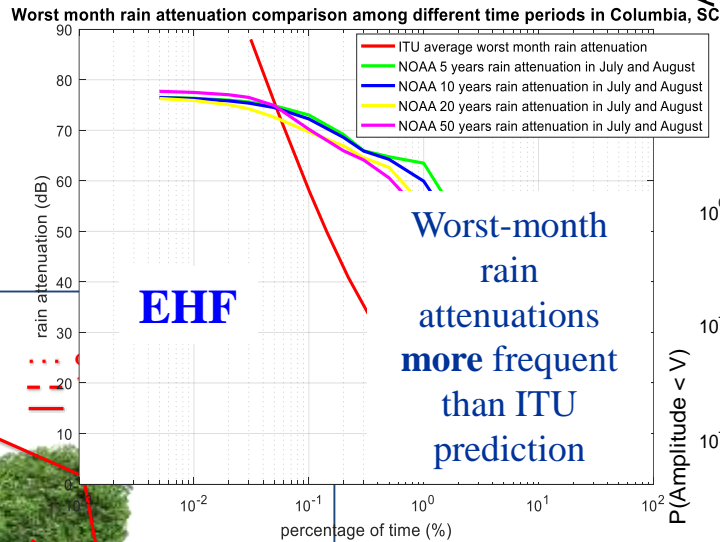


- Faster, and **3D** mobility
- Nearly **arbitrary** locations
 - Indoors (dark factories?), outdoors...
 - h_{TX}, h_{RX} from **0** to... **1000's** of m
 - SD varies w/Ricean **K**, which varies w/above
- Antenna constraints, airframe *shadowing*
- Large MPC delays (open areas)
- More data *helps*, but **won't** eliminate σ , **yet**



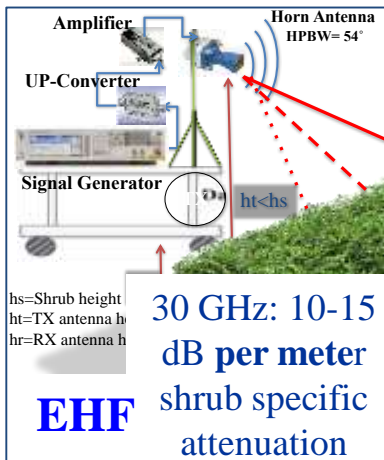
Examples: Path Loss

- AG 2-ray
- V2V severe fading
- mmWave shrubs, tropo

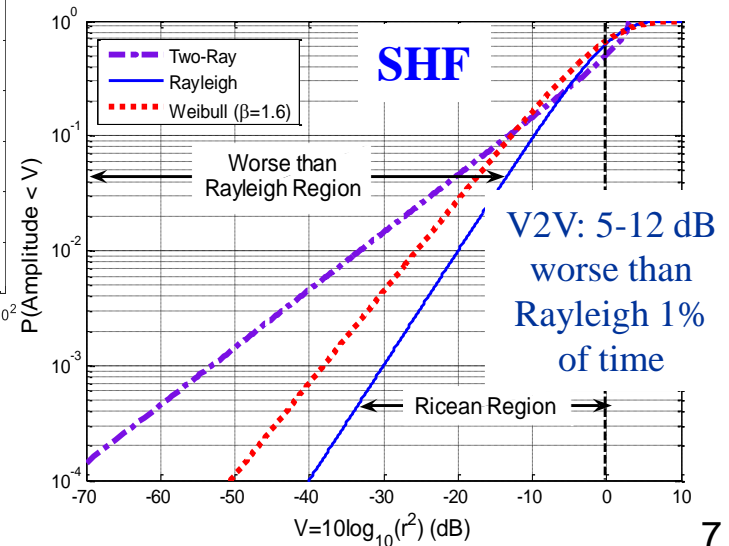
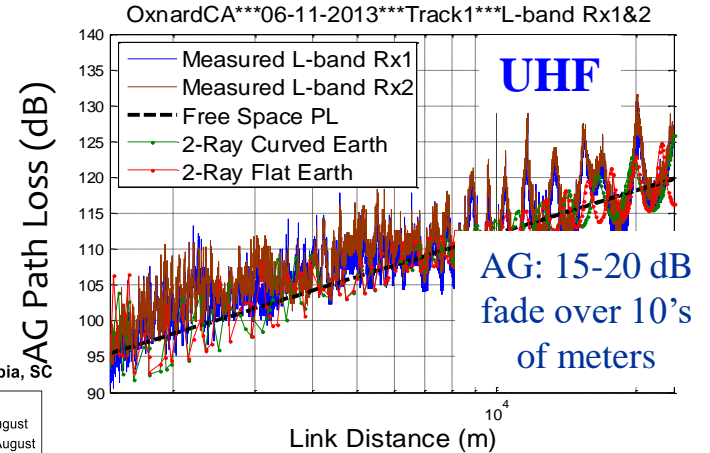


EHF

Worst-month rain attenuations more frequent than ITU prediction

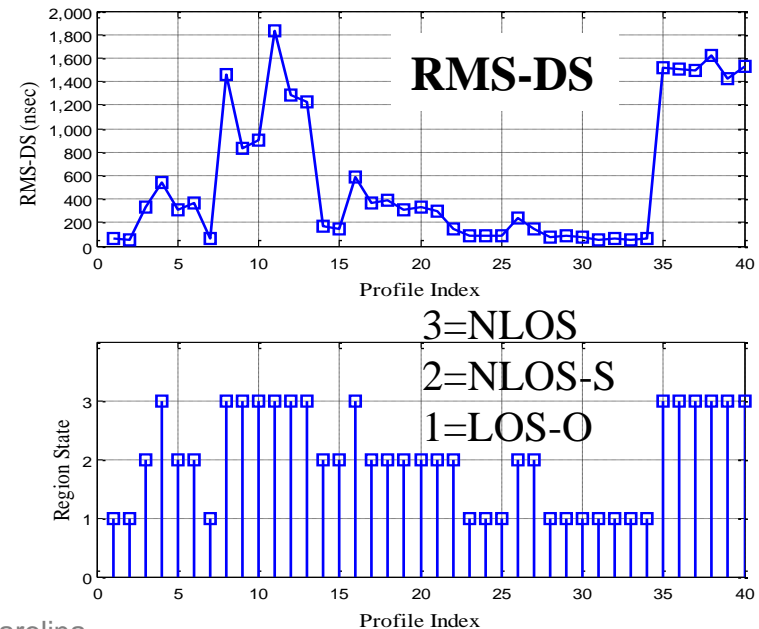
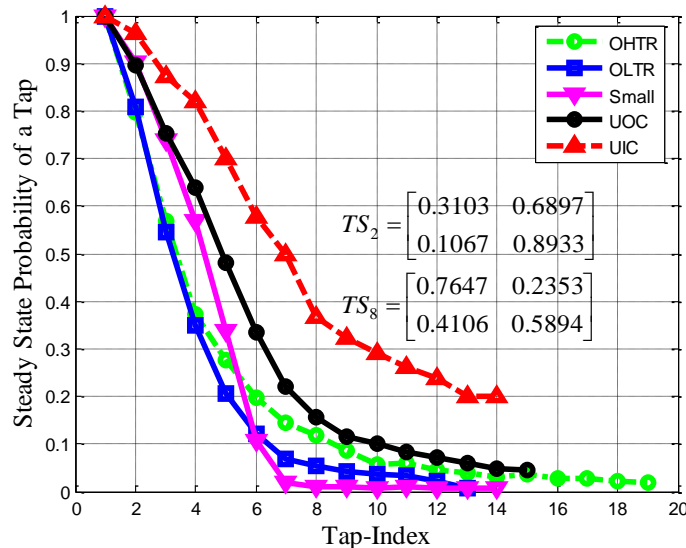
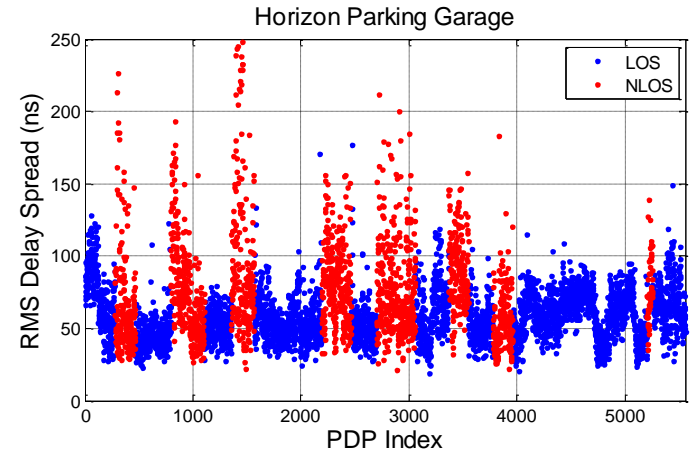


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Examples: Delay Dispersion

- Parking garage RMS-DS
- Airport surface RMS-DS
- V2V multipath component persistence



Questions?



Thank You

