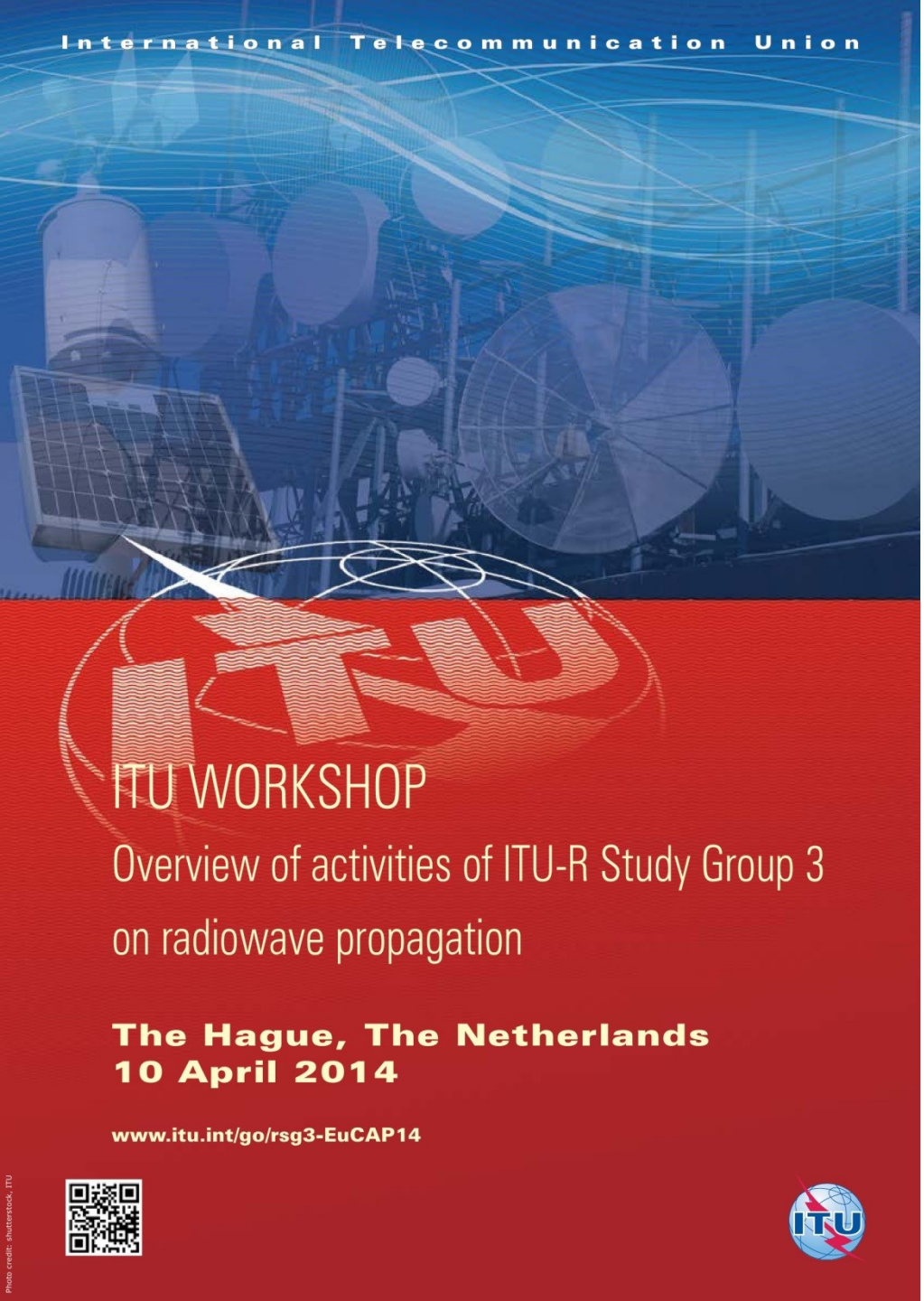

ITU WORKSHOP
Overview of activities of ITU-R Study Group 3 on radiowave propagation: (The Hague, 10 April 2014)

Activities, Critical Points and Future Needs of ITU-R WP 3K

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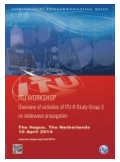
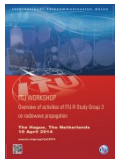


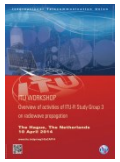
ITU-R Working Party 3K

- WP 3K is responsible for developing prediction methods for terrestrial point-to-area propagation paths. In the main, these are associated with terrestrial broadcasting and mobile services, short-range indoor and outdoor communication systems (e.g. radio local area networks, RLAN), and with point-to-multipoint wireless access systems.
  - Migration of these prediction methods from service-specific propagation models to more generic Tx – Rx models



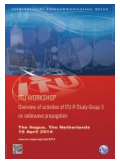
ITU-R Working Party 3K

- RECOMMENDATION ITU-R P.528-3 (SWG 3K-2)
  - Propagation curves for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands
- RECOMMENDATION ITU-R P.1546-5 (SWG 3K-2)
  - Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz
- RECOMMENDATION ITU-R P.1812-3 (SWG 3K-1)
  - A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands
- RECOMMENDATION ITU-R P.1411-7 (SWG 3K-3)
  - Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz



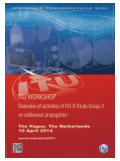
ITU-R Working Party 3K

- RECOMMENDATION ITU-R P.1410-5 (SWG 3K-4)
  - Propagation data and prediction methods required for the design of terrestrial broadband radio access systems operating in a frequency range from 3 to 60 GHz
- RECOMMENDATION ITU-R P.1238-7 (SWG 3K-3)
  - Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 900 MHz to 100 GHz
- RECOMMENDATION ITU-R P.1816-2 (SWG 3K-3)
  - The prediction of the time and the spatial profile for broadband land mobile services using UHF and SHF bands
- RECOMMENDATION ITU-R P.1791 (SWG 3K-3)
  - Propagation prediction methods for assessment of the impact of ultra-wideband devices



ITU-R Working Party 3K

- Recommendation ITU-R P.528-3
  - Curves (and Tabulations) of Basic Transmission Loss (dB) vs. Horizontal Distance (km) at Discrete Frequencies, Antenna Heights and Time Percentages
    - h2, Higher Station Altitudes (km): 1, 10, 20
    - Frequencies (MHz): 125, 300, 600, 1 200, 2 400, 5 100, 9 400 and 15 500
    - h1, Lower Station Antenna Heights (m): 1.5, 15, 30, 60, 1 000, 10 000, 20 000
    - Time Percentages: 1%, 5%, 10%, 50%, 95%
    - Distances ≤ 1 800 km
    - The results are reciprocal under exchange of the Tx and Rx



ITU-R Working Party 3K

- Recommendation ITU-R P.528-3
  - The Recommendation also gives information about how interpolations should be performed in terms of distance, frequency, antenna heights and percentage of time
  - As presented, the method appears to be completely empirical, while, in fact, the median time percentage curves are derived from basic physical principles governing radio propagation in the line-of-sight, diffraction and tropospheric scatter ranges with certain tunable parameters fixed (terrain irregularity parameter, or, inter-decile range of terrain heights parameter $\Delta h = 0$, surface refractivity (N-units) $N_0 = 301$ and the average surface refractivity lapse rate according to $\frac{dN}{dz}$ =U.S. Standard Atmosphere)
    - Deviations are based primarily on measurements
    - Basic Transmission Losses are limited by physical considerations

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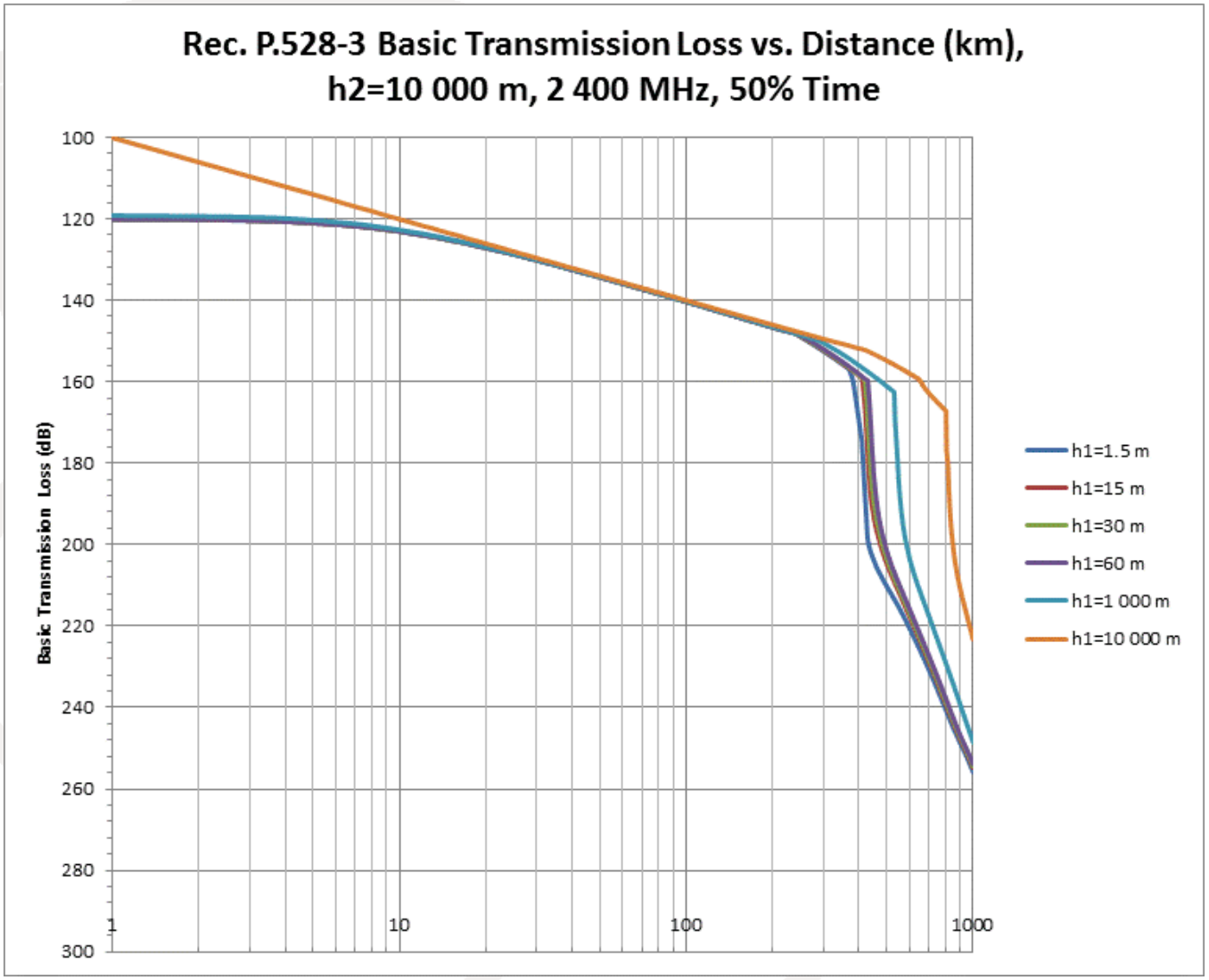
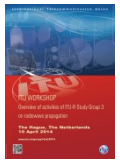
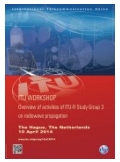




ITU-R Working Party 3K

- Recommendation ITU-R P.1546-5
  - Curves (and Tabulations) of Empirical Electric Field Strengths (dB μV/m relative to Tx Power of 1 kW EIRP) vs. Horizontal Distance (km) at Discrete Frequencies, Antenna Heights and Time Percentages for both Land and Sea Paths (both Warm and Cold Sea Curves for lower Time Percentages): Applicable Ranges: Frequency 30 – 3 000 MHz, Distance ≤ 1 000 km, h1 ≤ 3 000 m, Time Percentage 1% - 50%
    - h2, Nominal Rx/Mobile Height Above Ground or Nominal Rx at Representative Clutter Height (m): 10
    - Frequencies (MHz): 100, 600, 2 000
    - h1, Effective Tx/Base Station Antenna Heights (m): 10, 20, 37.5, 75, 150, 300, 600, 1 200
    - Time Percentages: 1%, 10%, 50%
    - Mixed Path (Land – Sea) Method Provided

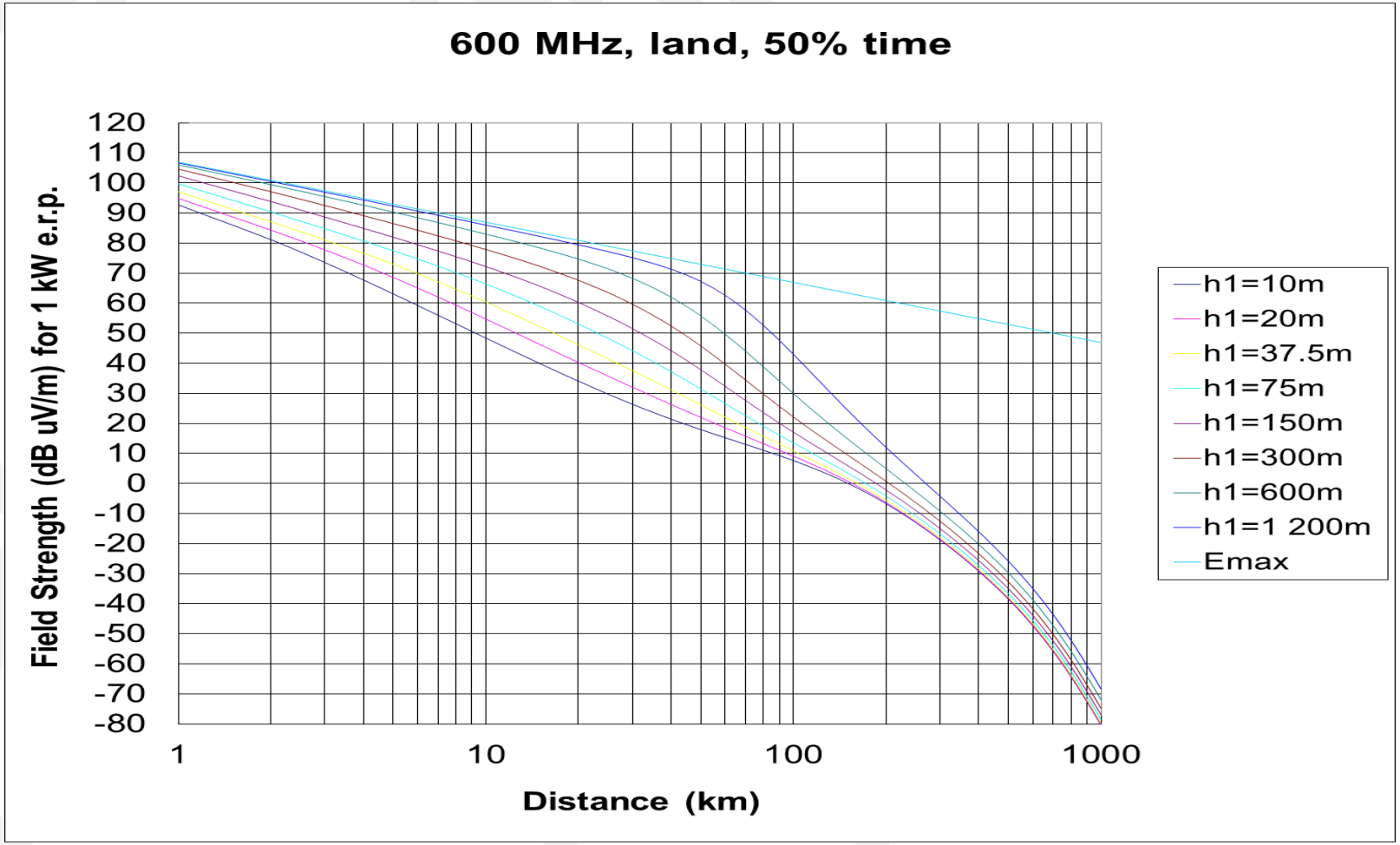


ITU-R Working Party 3K

- Recommendation ITU-R P.1546-5
  - Interpolation/Extrapolation methods are provided for frequency, Tx antenna height, distance and percentage time
  - (End) Corrections for the Tx and Rx height relative to the representative clutter height are provided
  - Rx Terrain Clearance Angle (TCA) corrections are provided
  - Location variability adjustments
  - Field Strengths are limited by physical considerations (Free Space Loss and Tropospheric Scatter)
  - Method is not reciprocal under exchange of the Tx and Rx

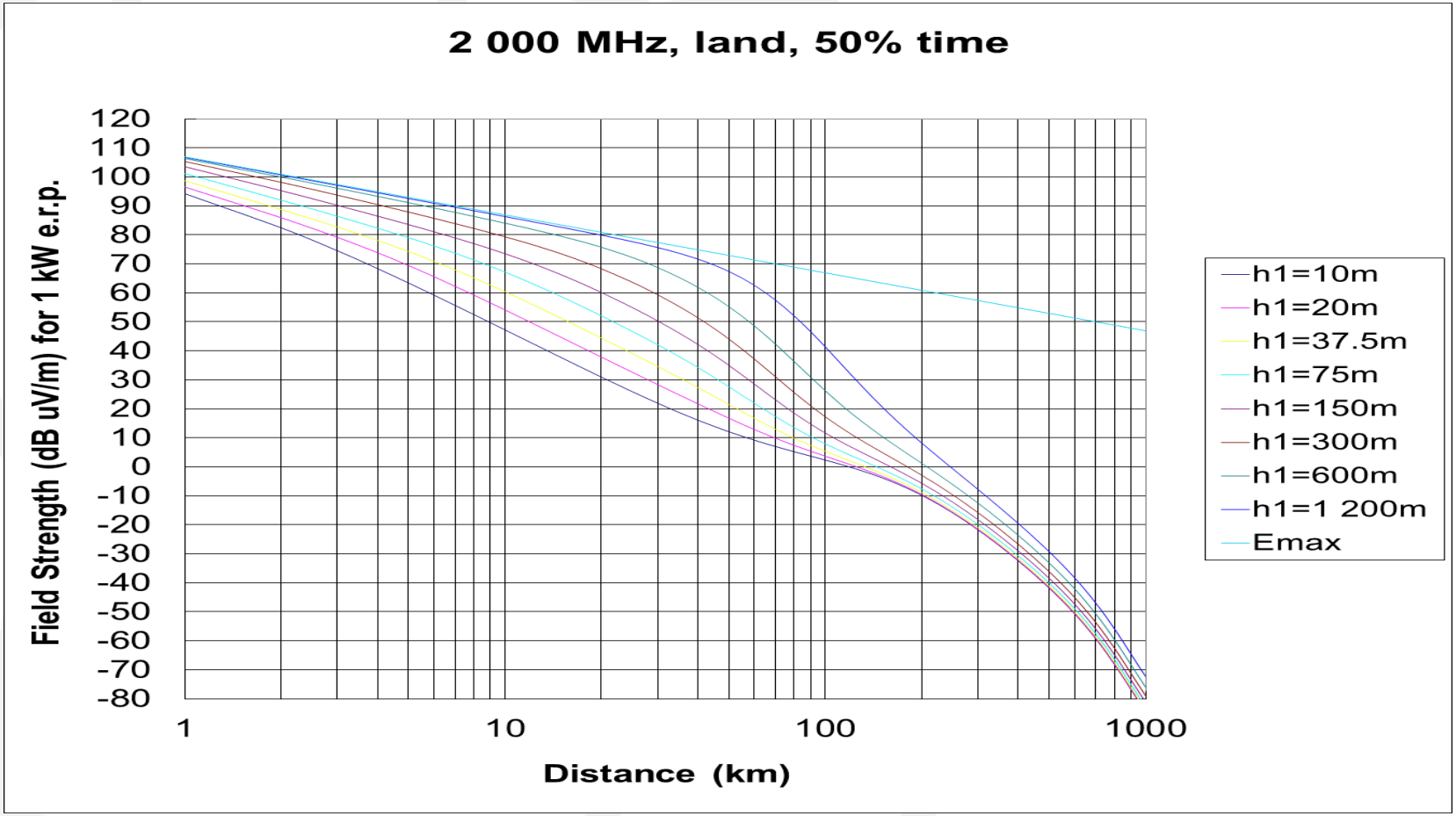
ITU-R Working Party 3K

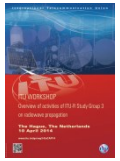
- Recommendation ITU-R P.1546-5



ITU-R Working Party 3K

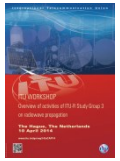
- Recommendation ITU-R P.1546-5





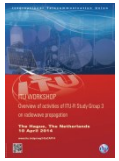
ITU-R Working Party 3K

- Recommendation ITU-R P.1812-3
  - A physically-based site-specific method for predicting point-to-area median propagation loss (i.e., point-to-multipoint predictions) including a unified line-of-sight, "terrain" obstacle diffraction (Delta – Bullington) and tropospheric scatter and ducting and layer reflection contributions to the basic transmission loss for a given path and time percentage and additional losses are calculated for height-gain variation in clutter, location variability and building entry loss
  - A great circle path terrain + clutter profile is required for each Tx – Rx pair
    - The terrain + representative clutter profile is evaluated for the radio horizon distances and elevation angles and radio-met parameters (including inland land, coastal land and sea designations)
    - Distinctions are made between line-of-sight and trans-horizon paths on each Great Circle Path
      - Trans-horizon path losses can be dominated by diffraction losses at 50% time or tropospheric scatter and/or ducting and layer reflection at very low time percentages
        - Line-of-Sight and Trans-horizon paths have attenuations relative to free space calculated using the Delta – Bullington Method and this value is interpolated for time percentages other than the median
    - Time percentages lower than the median are obtained empirically



ITU-R Working Party 3K

- Recommendation ITU-R P.1812-3
  - Applicable Distance Range: 0.25 – 3 000 km
  - Other Basic Input Data
    - Frequency (GHz): 0.03 – 3.0
    - Percentage of time: 1 – 50
    - Percentage of locations: 1 – 99
    - Latitudes of Tx and Rx (deg): -80 - +80
    - Longitudes of Tx and Rx (deg): -180 - +180
    - Antenna centre heights agl (m): 1 – 3 000
    - Polarisation: horizontal or vertical
    - Width of Street (m): 1 – 100, use 27 unless specific local values are available



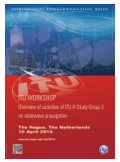
ITU-R Working Party 3K

- Recommendation ITU-R P.1812-3
  - Delta – Bullington Irregular Terrain Diffraction Method
    - Based on Rec. ITU-R P.526
    - Excess Attenuation due to Diffraction (loss relative to free space) for the general path is given by:

$$L_d = L_{bulla} + max\left(L_{dsph} - L_{bulls}, 0\right) \text{ dB}$$

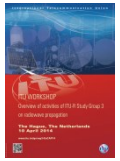
Where

- L_{bulla}=(Modified) Bullington Equivalent Single Knife-Edge Loss for the irregular terrain + representative clutter height path profile
- L_{bulls}=(Modified) Bullington Equivalent Single Knife-Edge Loss for the smooth earth path profile
- L_{dsph}=First Term of the Residue Series Solution for Smooth Sphere Diffraction (see Rec. ITU-R P.526)



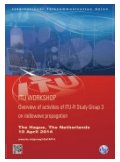
ITU-R Working Party 3K

- Recommendation ITU-R P.1411-7
  - Focus is on the mobile/portable service on short paths (d≤1 km) where terrain is not an important consideration but buildings and vegetation are important
  - Recommendation gives models for path loss, delay spread, angular spread and cross-correlation of a multi-link channel



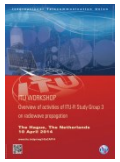
ITU-R Working Party 3K

- Recommendation ITU-R P.1411-7
- Path Loss Models
  - LOS (UHF, SHF) and NLOS (UHF, propagation around corners, both terminals below rooftops)
    - LOS models are two-exponent power-law type with distance, with lower, median and upper values of the basic transmission loss given
      - For SHF, additional losses due to gaseous attenuation and hydrometeor scatter should be included
    - NLOS model (NLOS2) requires detailed information about corner angles, etc.
      - Only the median basic transmission loss value is given



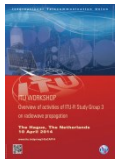
ITU-R Working Party 3K

- Recommendation ITU-R P.1411-7
- Path Loss Models (continued)
  - NLOS model (NLOS1, UHF only) for over-rooftop propagation, median value of basic transmission loss only
    - Urban environments assume a simple form for free space + multiple knife-edge diffraction + roof-to-street, if buildings are all about the same height
      - If buildings are not all about the same height, use Rec. ITU-R P.526 single knife-edge model for the tallest building
    - Suburban environments allow for a range dependent loss: direct, reflected and diffracted dominated ranges



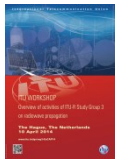
ITU-R Working Party 3K

- Recommendation ITU-R P.1411-7
- Path Loss Models (continued)
  - Model for Urban Path Loss with LOS and NLOS components
    - Both terminals located from below rooftop level to near street level (1.9-3.0 m)
    - $d \leq 3\,000$ m
    - Location percentage p: 1 – 99 %
  - Additional notes on influence of vegetation (Rec. ITU-R P.833) and Building Entry loss (Rec. ITU-R P.1238 and, now, P.2040)



ITU-R Working Party 3K

- Critical Points and Future Needs
  - Propagation Measurements for Model Validation/Improvement (CG 3K-4)
  - Increase the Frequency Range of the Site-General Terrestrial Model
  - A Site-Specific Air-Ground Model with up-to-date Gaseous Attenuation and Hydrometeor Scattering (CG 3K3M-9)
  - Better Integration of the Short-Range Clutter Dominated Models with the Long-Range Terrain and Tropospheric Scatter Dominated Models



ITU-R Working Party 3K

- Critical Points and Future Trends
  - Upgrades of the Propagation Models' Variabilities to Treat the Statistics of Aggregate Interference
    - Full Range of Time (and Location) Percentages
    - Correlated and Uncorrelated Propagation Loss Variability