Recent Standardization Activities in ITU-R SG 3

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Abstract

When considering new frequency allocation and transmission technology, it is essential to standardize the radio-wave propagation model. This article reports on the latest trends in ITU-R (International Telecommunication Union - Radiocommunication Sector) Study Group 3, an international standardization organization for radio-wave propagation models led by the author and his colleagues as the representative of the NTT Group.

Keywords: WRC, IMT, HIBS

1. Configuration and role of ITU-R SG 3

An interference-evaluation model for conducting frequency-sharing studies is developed when considering a new wireless system to be discussed in each Study Group (SG) of the International Telecommunication Union - Radiocommunication Sector (ITU-R). SG 3 [1], the group of radio-wave propagation experts, receives and responds to inquiries about propagation models from other SGs in the form of liaisons. It plays the role of advancing the discussion of each SG. Therefore, the primary purpose of SG 3's activities is to support other SGs. To provide this support in a timely manner, it is essential to model all propagation characteristics before system examination, and these propagation models are recommended and reported as the ITU-R P Series. These Recommendations and Reports of the P Series are used not only for the use of ITU-R but also for the institutionalization of each country, including Japan.

At the June 2021 meeting, deliberations were centered on the World Radiocommunication Conference (WRC)-23 agenda, which was decided at WRC-19 under the structure shown in **Table 1**, resulting in 24 revisions to the P Series Recommendations and Reports.

This article describes the latest trends in the hot topics of the June 2021 meeting, i.e., "New Frequency Allocation to IMT (International Mobile Telecommunications)" and "Propagation Model for High-altitude Platform Stations."

2. New Frequency Allocation to IMT

The WRC-23 agenda 1.2 to consider identification of the frequency bands 3300–3400 MHz, 3600–3800 MHz, 6425–7025 MHz, 7025–7125 MHz, and 10.0–10.5 GHz for IMT was decided. The target frequency range in the Asian region is only 7025–7125 MHz. In response to this decision, SG 3 is in the process of revising the relevant Recommendations. **Table 2** shows SG 3-related Recommendations related to this agenda.

From Working Party (WP) 5D, which is in charge of this agenda, to SG 3, inquiries about radio-wave propagation models for frequency-sharing and system-compatibility evaluation for the four scenarios shown in **Fig. 1** have been issued.

To respond to this inquiry, SG 3 is considering introducing the utilization method for the element that can be applied by the current Recommendation and revising the Recommendation by incorporating the corresponding technology for the element that cannot be applied by the current Recommendation. Since each Recommendation has differences in the target environment and frequency, it is necessary to evaluate frequency sharing and system compatibility by combining various Recommendations to correspond

Table 1. SG 3's June 2021 meeting structure.

<table>
<tr><td colspan="4">ITU-R SG 3: Radiowave propagation
Chair: C. Wilson (Australia)
Vice-Chair: G. A.-A. Aws Majeed (Iraq), C. Allen (UK), S.-H. Bae (Korea), M. Pattanaik (India), Y. R. M. Dhossa (Togolese), A. Belkhadir (Morocco), L. Castanet (France), T. Al-Saif (Kuwait), O. Iastrebtsova (Russia), Z. Zhao (China)
Counsellor: M. D. Botha</td></tr>
<tr><td rowspan="4">WP 3J:
Propagation fundamentals</td><td rowspan="4">Chair: C. Riva (Italy)
Vice-Chair: L. Castanet (France)</td><td>Sub-G 3J-1: Effects of the clear atmosphere</td><td>Chair: C. Allen (UK)</td></tr>
<tr><td>Sub-G 3J-2: Effects of clouds and precipitation</td><td>Chair: A. Martellucci (ESA)</td></tr>
<tr><td>Sub-G 3J-3: Global mapping and statistical aspects</td><td>Chair: L. Castanet (France)</td></tr>
<tr><td>Sub-G 3J-4: Vegetation and obstacle diffraction</td><td>Chair: S. Salamon (Australia)</td></tr>
<tr><td rowspan="3">WP 3K:
Point-to-area propagation</td><td rowspan="3">Chair: P. Mckenna (USA)
Vice-Chair: H. Suzuki (Australia),
W. Yamada (Japan)</td><td>Sub-G 3K-1: Path-specific prediction methods</td><td>Chair: I. Stevanovic (Swiss)</td></tr>
<tr><td>Sub-G 3K-2: Path-general prediction methods</td><td>Chair: F. Lewicki (Poland)</td></tr>
<tr><td>Sub-G 3K-3: Short-range propagation</td><td>Chair: W. Yamada (Japan)</td></tr>
<tr><td rowspan="3">WP 3L:
Ionospheric propagation and radio noise</td><td rowspan="3">Chair: C. Behm (USA)
Vice-Chair: A. Canavitsas (Brazil)</td><td>Sub-G 3L-1: MF, LF and lower-frequency propagation</td><td>Chair: A. Canavitsas (Brazil)</td></tr>
<tr><td>Sub-G 3L-2: Trans-ionospheric propagation</td><td>Chair: R. Orus-Perez (ESA)</td></tr>
<tr><td>Sub-G 3L-3: Radio noise</td><td>Chair: E. Hill (USA)</td></tr>
<tr><td rowspan="5">WP 3M:
Point-to-point and Earth-space propagation</td><td rowspan="5">Chair: G. Feldhake (USA)
Vice-Chair: R. Rudd (UK)
L. Lin (China)</td><td>Sub-G 3M-1: Terrestrial paths</td><td>Chair: S. Salamon (Australia)</td></tr>
<tr><td>Sub-G 3M-2: Earth-space paths</td><td>Chair: L. Castanet (France)</td></tr>
<tr><td>Sub-G 3M-3: Interference paths</td><td>Chair: I. Stevanovic (Swiss)</td></tr>
<tr><td>Sub-G 3M-4: Digital products</td><td>Chair: A. Martellucci (ESA)</td></tr>
<tr><td>Clutter and building-entry loss</td><td>Chair: R. Arefi (Intel) and R. Rudd (UK)</td></tr>
</table>

LF: low frequency
MF: medium frequency

Table 2. P Series Recommendations related to Agenda 1.2.

Recommendation	Title of Recommendation
ITU-R P.452	Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz
ITU-R P.528	A propagation prediction method for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands
ITU-R P.619	Propagation data required for the evaluation of interference between stations in space and those on the surface of the Earth
ITU-R P.1238	Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 450 GHz
ITU-R P.1411	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 P.1546	Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4000 MHz
ITU-R P.1812	A path-specific propagation prediction method for point-to-area terrestrial services in the frequency range 30 MHz to 6000 MHz
ITU-R P.2001	A general purpose wide-range terrestrial propagation model in the frequency range 30 MHz to 50 GHz
ITU-R P.2108	Prediction of clutter loss
ITU-R P.2109	Prediction of building entry loss

SHF: super high frequency
UHF: ultra high frequency
VHF: very high frequency

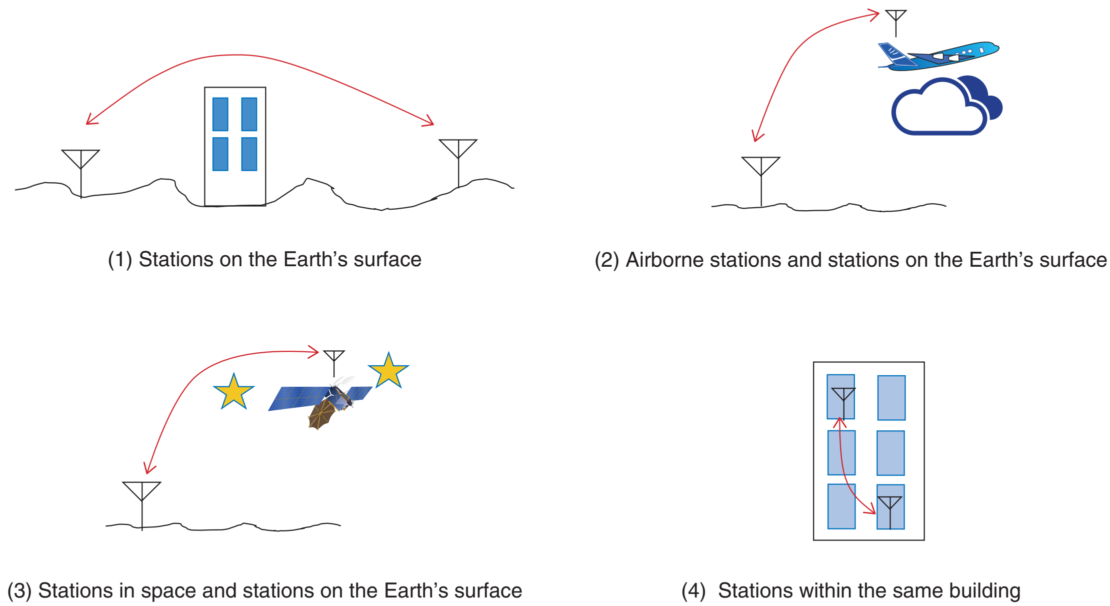

Fig. 1. Scenarios required for studying new frequency allocation to IMT for WRC-23.

to the four scenarios in Fig. 1. The following describes the use of each Recommendation for frequency-sharing and system-compatibility evaluation.

2.1 Stations on the Earth's surface

(1) Recommendation P.452: Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz

This Recommendation aims to calculate the interference between ground stations at frequencies of about 0.1 to 50 GHz. When using the clutter correction of this Recommendation as an interference evaluation, information on the distance between the radio station and nearby obstacles and the height of those obstacles is essential. If there is no information about nearby obstacles, the additional loss should be calculated using the method in Recommendation P.2108. In this Recommendation, the basic propagation-loss calculation of free space was revised at the June 2021 meeting so that the actual distance can be used instead of the great circle distance*1 used thus far.

(2) Recommendation P.2001: A general purpose wide-range terrestrial propagation model in the frequency range 30 MHz to 50 GHz

This Recommendation provides a time-percentage calculation method for the fundamental propagation loss in the range of 30 MHz to 50 GHz. This calculation method is suitable when using Monte Carlo simulations because it can provide a full-time percentage range from 0 to 100%. This Recommendation was updated at the June 2021 meeting to revise the calculation of the total propagation loss in free space so that the actual distance can be used instead of the great circle distance.

(3) Recommendation P.1812: A path-specific propagation prediction method for point-to-area terrestrial services in the frequency range 30 MHz to 6000 MHz

This Recommendation is suitable for predicting wireless-communication systems with a frequency range of 30 MHz to 6 GHz, a distance of 0.25 km to about 3000 km, and a ground clearance of about 3 km. Power fluctuations can predict time percentages in the range of 1 to 50% and location probability in the range of 1 to 99%. This method makes detailed estimation possible on the basis of the terrain profile in which the propagation path contains clutter. This Recommendation was revised at the June 2021 meeting to extend the upper-frequency limit from 3 to 6 GHz and address the double count of clutter losses.

(4) Recommendation P.1546: Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4000 MHz

*1 Great circle distance: The distance of the route connecting two points on the Earth with an arc along the ground.

This Recommendation is a terrestrial-service-prediction method in the frequency range of 30 MHz to 4 GHz, intended for use on land, sea, and mixed land-sea routes up to 1000 km in length, with an effective transmit antenna height of up to 3000 m. This method builds an estimation formula on the basis of interpolation/extrapolation from the field-strength curve derived from actual measurements such as distance, antenna height, frequency, and time percentage. This method has clutter correction for the receiving terminal but cannot be combined with Recommendation P.2108.

(5) Recommendation P.1411: 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

This Recommendation provides a method of predicting outdoor propagation losses on routes less than 1 km. The environments covered in this Recommendation are very high-rise/high-rise/low-rise cities as well as suburban, residential, and rural. While many prediction methods are based on specific frequencies within the target range, site-general prediction methods can be used to calculate a basic transmission loss characteristics by arbitrarily specifying the frequency, environment, and distance. It is inappropriate to add clutter loss since it inherently involves the effects of clutter. However, building-entry losses needs to be considered separately, and Recommendation P.2109 can be used.

2.2 Airborne stations and stations on the Earth's surface

(1) Recommendation P.528: A propagation prediction method for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands

This Recommendation describes how to predict basic transmission losses in the 100 MHz to 30 GHz frequency range for air-to-air, ground-to-air, and air-to-ground propagation paths. The parameters required for the calculation are the distance between the antennas, height of the antenna from the average altitude above sea level, frequency, polarization, and time percentage. This Recommendation does not include the effects of hydrometeor[*2], scintillation[*3], and diffraction due to irregular topography. However, it can model propagation paths beyond the horizon that may be useful for interference analysis.

2.3 Stations in space and stations on the Earth's surface

(1) Recommendation P.619: Propagation data required for the evaluation of interference between stations in space and those on the surface of the Earth

This Recommendation provides a method for calculating propagation effects, such as tropospheric refraction and beam diffusion loss, and a combination of calculations for single-entry or multi-entry interference analysis and is valid up to 100 GHz. If the terrain radio station explicitly has information on the location and dimensions of the terrain or scatter obstacles on the local path, it describes how to calculate the associated loss. This Recommendation also refers to Recommendation P.2108 on clutter loss. When using the entry loss of a building, it is necessary to calculate an additional loss using Recommendation P.2109 in accordance with the environment of the ground terminal. At the June 2021 meeting, explanations were added to help more accurate understanding of this Recommendation.

2.4 Stations within the same building

(1) Recommendation P.1238: Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 450 GHz

This Recommendation covers the frequency range from 300 MHz to 450 GHz and provides various estimation methods for propagation paths contained in a single building. Therefore, it helps in the study of interference scenarios in which terminals are in the same building. At the June 2021 meeting, a new basic propagation-loss prediction model was established that covers the frequency range of 100 GHz or less for office, factory, and corridor environments, and the coefficients required for propagation-loss prediction at 310 and 410 GHz were added.

2.5 Propagation model related to all scenarios

(1) Recommendation P.2108: Prediction of clutter loss

This Recommendation calculates the additional loss of propagation due to clutter, such as buildings around the radio station. The height-gain model that

*2 Hydrometeor: A phenomenon in which raindrops and ice particles fall or float in the atmosphere.

*3 Scintillation: A phenomenon that causes short-period fluctuations in amplitude when radio waves pass through the atmosphere or ionosphere.

corrects the loss for height described in Section 3.1 of this Recommendation can derive the frequency range from 30 MHz to 3 GHz of the additional loss caused by the clutter around the radio station. Diffraction is assumed to be the primary phenomenon in forest and urban environments, and reflection and scattering are considered to be the main phenomena in other environments such as water or sea area, countryside, suburban, and dense urban. When deriving the additional loss with this model, it is necessary to define a typical clutter height. At the June 2021 meeting, the applicable frequencies were expanded on the basis of the measured data to accommodate a broader range of frequencies. The additional loss in cities and suburban environments, which is essential from the viewpoint of interference evaluation, corresponds to the tilt angle of the propagation path. However, the frequency range from 10 to 100 GHz is the estimation range of the current Recommendation. For this reason, studies are underway to extend this estimation method to 10 GHz or less for the next meeting.

(2) Recommendation P.2109: Prediction of building entry loss

This Recommendation derives the additional loss when one radio station is outdoors and the other is inside a building. Coefficients are given to calculate the further loss for two types: typical buildings and thermal efficiency. Since the building-entry loss calculated in this Recommendation was examined independently of other propagation phenomena, the estimation when clutter exists around the radio station is possible by adding the building-entry loss derived in the Recommendation in units of decibels to the additional loss derived in Recommendation P.2108. However, when finding a specific probability for the loss, a mathematical convolution operation is required to find the combined probability distribution.

3. Propagation Model for High-altitude Platform Stations

WRC-23 agenda 1.4 decided to "consider, in accordance with Resolution 247 (WRC-19), the use of high-altitude platform stations as IMT base stations (HIBS) [2] in the mobile service in certain frequency bands below 2.7 GHz already identified for IMT, on a global or regional level." In response to this decision, SG 3 is in the process of revising the relevant Recommendations. The main WP in charge of this agenda is WP 5D. However, they inquired about the radio-wave propagation model that can be used for frequency-sharing and compatibility evaluation between HIBS and terrestrial/aviation/satellite services to SG 3.

Recommendation P.1409 recommends a propagation model related to high-altitude platform stations. However, it is raised in Agenda 1.4, such as the fact that a radio-wave propagation model of 10 GHz or more from the sky to urban and suburban environments has not been defined. The radio-wave propagation model for assessing the impact of HIBS was not sufficient. Therefore, the development of a radio-wave propagation model that enables various evaluations of HIBS is underway. In the previous Recommendation P.1409, the model was formed from the six elements of free-space loss, attenuation due to the atmosphere, attenuation due to clouds, backward scatterings such as raindrops, rainfall attenuation, and convection-sphere scintillation. While cloud attenuation is merged into rainfall attenuation, new elements, such as convection scattering, earth diffraction, topography and obstacle diffraction, clutter attenuation, vegetation attenuation, and indoor penetration loss have been added. A model consisting of 11 elements (**Fig. 2**) has been recommended.

However, since the radio-wave propagation model required for frequency-sharing and compatibility evaluation could not be developed, an offline meeting was held at Correspondence Group 3J-3K-3M-14 to conclude at the next meeting. Discussions will continue until the next SG 3 meeting.

4. Conclusion

ITU-R SG 3 is essential for the effective use of frequencies, which are rare resources shared worldwide. Since wireless systems are an area where technological progress is rapid, ITU-R SG 3 must produce results in a shorter period while deepening cooperation with other SGs. In addition, it is expected that discussions related to Beyond 5G (fifth-generation mobile communication systems) and 6G will proceed after WRC-23. While observing these latest trends, we will continue to actively promote standardization activities to contribute to the effective use of frequencies for the NTT Group, Japan, and the world.

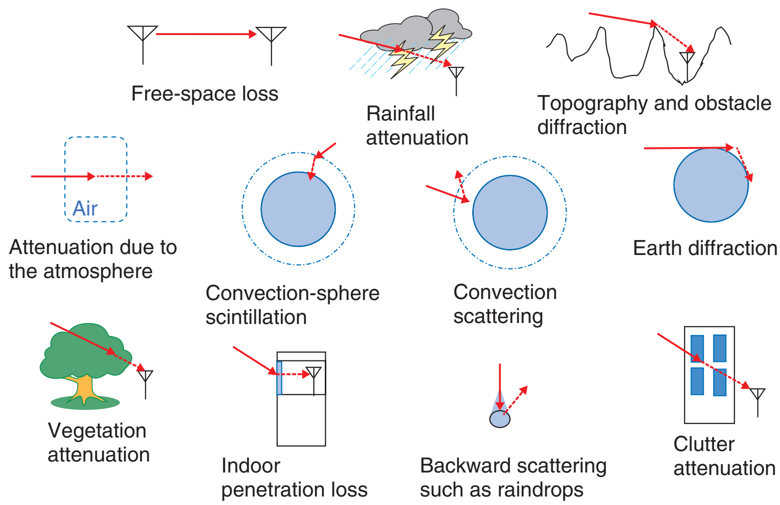

Fig. 2. Eleven propagation elements required for HIBS study.

References

[1] ITU-R SG 3, https://www.itu.int/en/ITU-R/study-groups/rsg3/Pages/default.aspx

[2] Press release issued by NTT DOCOMO, "Zephyr High Altitude Platform Station (HAPS) achieves connectivity in trial conducted by Airbus and NTT DOCOMO," Nov. 15, 2021. https://www.nttdocomo.co.jp/english/info/media_center/pr/2021/1115_00.html

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He received a B.E., M.E., and Ph.D. from Hokkaido University in 2000, 2002, and 2010. Since joining NTT in 2002, he has been engaged in the research of propagation characteristics for wide band access systems. From 2013 to 2014, he was a visiting research associate at the Centre for Telecommunications Research in King's College, University of London, UK. He has been serving as a vice-chair of Working Party 3K in ITU-R Study Group 3 since 2016. He received the Young Researcher's Award in 2006, the Communications Society Best Paper Award in 2011, the Best Paper Award in 2014 and 2019 from the Institute of Electronics, Information and Communication Engineers (IEICE), and the Best Paper Award in International Symposium on Antennas and Propagation (ISAP) in 2016. He is a member of the Institute of Electrical and Electronics Engineers (IEEE).