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| **Radiocommunication Study Groups** |  |
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| Annex 28 to Working Party 5A Chairman’s Report |
| working document towards a PRELIMINARY DRAFT NEW REPORT ITU-R M.[90-ghz.RSTT.COEXIST] |
| Coexistence between high-speed railway radiocommunication system between train and trackside operating in the frequency bands 92-94 GHz, 94.1-100 GHz and 102-109.5 GHz, and active and passive services |

# 1 Introduction

*[TBD]*

# 2 Scope

This Report provides results of sharing and compatibility studies between high-speed railway radiocommunication system between train and trackside operating in the bands 92-94 GHz, 94.1‑100 GHz and 102-109.5 GHz, and active and passive services operating in these or adjacent bands.

# 3 Related Recommendation and Report

|  |  |
| --- | --- |
| Report ITU-R M.[RAIL.RSTT](Annex 16 to Document 5A/298) | Technical and operational characteristics, implementation and spectrum needs of RSTT |
| 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 |
| Recommendation 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 |
| Recommendation ITU-R RA.769 | Protection criteria used for radio astronomical measurements |
| Report ITU-R F.2239 | Coexistence between fixed service operating in 71‑76 GHz, 81-86 GHz and 92-94 GHz bands and passive services |

# 4 List of acronyms and abbreviations

|  |  |
| --- | --- |
| RSTT | Railway radiocommunication system between train and trackside |

## 5 Summary of coexistence of 90 GHz band RSTT with the passive services

Table 1 shows the frequency band which are already allocated for use of mobile services in the frequency range 92-109.5 GHz. In accordance with Article **5** to Chapter II to Radio Regulations (see Annex), in the adjacent bands of those frequencies all emissions are prohibited in the following bands; 86-92 GHz, 100-102 GHz and 109.5-111.8 GHz. To coexist with active and passive services, the same schemes developed by Report ITU-R F.2239, “Coexistence between fixed service operating in 71-76 GHz, 81-86 GHz and 92-94 GHz bands and passive services”, could be used for sharing and compatibility studies of railway radiocommunication systems. The following sharing and compatibility cases should be addressed, as shown in Figure 1:

1) mobile service stations such as on-board radio equipment and related radio infrastructure located along trackside operating in the band 92-94 GHz with respect to the protection of Earth exploration-satellite service (EESS) stations operating in the adjacent band 86-92 GHz;

2) mobile service stations such as on-board radio equipment and related radio infrastructure located along trackside operating in the bands 94.1-100 GHz and 102‑109.5 GHz with respect to the protection of Earth exploration-satellite service (EESS) stations operating in the adjacent band 100-102 GHz;

3) mobile service stations such as on-board radio equipment and related radio infrastructure located along trackside operating in the band 102-109.5 GHz with respect to the protection of Earth exploration-satellite service (EESS) stations operating in the adjacent band 109.5-111.8 GHz;

4) mobile service stations such as on-board radio equipment and related radio infrastructure located along trackside operating in the bands 92-94 GHz, 94.1-100 GHz and 102-109.5 GHz with respect to the protection of radio astronomy service (RAS) stations operating in the band 86-111.8 GHz;

5) mobile service stations such as on-board radio equipment and related radio infrastructure located along trackside operating in the bands 92-94 GHz and 94.1‑100 GHz with respect to the protection of Earth exploration-satellite service (EESS) stations (active) operating in the adjacent band 94-94.1 GHz;

6) Earth exploration-satellite service (EESS) stations (active) operating in the band 94‑94.1 GHz with respect to protect mobile service stations such as on-board radio equipment and related radio infrastructure located along trackside operating in the adjacent bands 92-94 GHz and 94.1-100 GHz.

Table 1

Frequency bands already allocated for mobile servicers

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 92-94 |  | 94.1-100 |  | 102-109.5 |  |
|  | MS |  | MS |  | MS |  |
|  | BW1=2 GHz |  | BW2=5.9 GHz |  | BW3=7.5 GHz |  |

FIGURE 1

Sharing and compatibility schemes for coexistence between mobile services and passive services



# 6 System deployment scenarios

Figure 2 shows the schematic concept of 90 GHz wireless connection between on-board equipment and trackside radio access unit. The concept shows that 10 trackside radio access units with two antennas are equipped along the railway line. Two on-board transceivers are equipped with the driver’s room located at the first car of the train and the conductor’s room located at the end car of the train. Both on-board transceivers are complementally connected to the trackside radio access units to seamlessly maintain link connection through 90-GHz signals. If the space diversity is required to provide stable communication between train and trackside, the number of equipment becomes double.

FIGURE 2

Concept of 90-GHz wireless connection between on-board and trackside equipment



## 6.1 A number of on-board transceiver

Since two on-board transceivers are equipped with the driver’s room located at the first train vehicle and the conductor’s room located at the last train vehicle, the total number of on-board transceivers on super express train set in Japan Railway will be four. The number of train set of daily operated super express trains in all Japan Railway companies is shown in Figure 4. The maximum train set of 230 is observed in the evening of 19:00-20:00 hour. Then the total number of on-board transceivers which are operated in 19:00-20:00 hour becomes 920. This number may be used for sharing and compatibility studies taking into account the coverage area of satellite antennas.

FIGURE 4

Total number of super express train set per one day



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## 6.2 A number of trackside radio access unit

Figure 5 shows the currently operated super express service lines in Japan Railway companies. Table 2 summarizes the super express service line length and maximum speed of each Japan Railway company. The distance between on-board transceivers and trackside radio access units are changed in the range of 0.5-1 km in the condition of operational environment. In the estimation of the number of trackside RAUs, the trackside RAU is equipped 1 km interval along the super express service line. Table 2 also estimated the number of trackside RAUs. One trackside RAU has four transceivers which are independently connected to four on-board transceivers equipped on the super express train set.

FIGURE 5

Map of super express service lines in Japan



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*[Japan’s note: The tunnel may affect the sharing and compatibility studies, but the following table does not include information on tunnel length of each super express service line. These parameters will be further studies at the next meeting.]*

Table 2

Estimated number of trackside RAU in each super express service line in Japan

| Name of super express line | Service area | Line length | Maximum speed | Estimated number of trackside RAU |
| --- | --- | --- | --- | --- |
| Tokaido line | Tokyo – Shin Osaka | 562.6 km | 285 km/hour | 2 248 |
| Snayo line | Shin Osaka – Hakata | 644.0 km | 300 km/hour | 2 576 |
| Tohoku line | Tokyo – Shin Aomori | 713.7 km | 320 km/hour | 2 852 |
| Hokkaido line | Shin Aomori – Shin Hakodatehokuto | 148.8 km | 260 km/hour | 592 |
| Yamagata line1 | Fukushima – Shinjo | 148.6 km | 130 km/hour | 592 |
| Akita line1 | Morioka – Akita | 127.3 km | 130 km/hour | 508 |
| Jouetsu line | Tokyo – Niigata | 333.9 km | 240 km/hour | 1 332 |
| Hokuriku line | Tokyo – Kanazawa | 450.5 km | 260 km/hour | 1 800 |
| Kyushu line | Hakata – Kagoshimachuou | 288.9 km | 260 km/hour | 1 152 |
| 1 Yamagata and Akita lines are not included in super express service line, but the same train vehicles are operated in those lines. |

## 6.3 Activity factor of trackside radio access unit

*[Japan’s note: This section will be further developed at the next meeting.]*

## 6.4 Antenna elevation of on-board transceivers

*[Japan’s note: This section will be further developed at the next meeting.]*

Table A4.1.3-2

Operational environment of super express service line

|  |  |
| --- | --- |
| Parameters | Values |
| Roadbed width | Typ. 12 m |
| Vehicle width | Max. 3.4 m |
| Vehicle height | Max. 4.5 m |
| Minimum radius of curve | Typ. 4 000 m |
| Minimum vertical radius of curve | Typ. 10 000 m |
| Maximum gradient of track | 35‰ |
| Maximum superelevation of track | 200 mm @ rail gauge = 1 435 mm |

# 7 System characteristics

## 7.1 System characteristics of railway radiocommunication system between train and trackside operating in the bands 92-94 GHz, 94.1-100 GHz and 102-109.5 GHz

Table 2 summarizes technical and operational characteristics of RSTT stations operating in 92‑94 GHz, 94.1-100 GHz and 102-109.5 GHz bands. The total bandwidth of 15.4 GHz can be used for data transmission between on-board radio equipment and trackside radio access units. The transmission distance of these equipment is designed by the railroad line environment.

Table 2

System parameters

|  |  |
| --- | --- |
| Frequency range (GHz) | 92-94. 94.1-100, 102-109.5 |
| Seamless connection mechanism | Backward and forward switching method |
| Channel bandwidth (MHz) | 400 |
| Channelization (MHz) | TBD |
| Channel aggregation pattern | TBD |
| Antenna type | Cassgrain |
| Antenna gain (dBi) | 44 |
| Antenna beamwidth (degree) | 1 |
| Antenna height from rail surface (m) | 4 (Maximum) |
| Polarization | Linear |
| Antenna pattern | Annex 1 |
| Average transmitting power (dBm) | 10 |
| Average e.i.r.p. (dBm) | 54 |
| Receiving noise figure (dB) | <10 |
| Maximum transmission data rate (Gb/s) | 5-10 (Stationary), 1 (Running) |
| Maximum transmission distance (km) | 0.5-1 (Open), 3 (Tunnel) |
| Modulation | PSK, QPSK, 16QAM, 64QAM |
| Multiplexing method | FDD/TDD |
| Space diversity | TBD |
| Maximum running speed (km/h) | 600 |
| Switching time of trackside radio access unit (s) | TBD |
| Average distance between on-board equipment and trackside radio access unit | TBD |
| Rainfall attenuation margin (dB) | TBD |
| Wired interface of trackside radio access unit | [Recommendation ITU-T G.RoF] |
| Propagation model between train and trackside | Recommendation ITU-R P.1411 |

## 7.2 System characteristics of earth exploration-satellite service (passive) operating in the frequency ranges 86-92 GHz, 100-102 GHz and 109.5-111.8 GHz

## 7.3 System characteristics of earth exploration-satellite service (active) operating in the frequency range 94-94.1 GHz

## 7.4 System characteristics of radio astronomy service operating in the frequency range 86-111.8 GHz

# 8 Interference scenarios

The four interference scenarios listed in Table 2 and shown in Figure 1 are considered between land mobile service applications (RSTT) and passive services.

TABLE 2

Interference scenarios

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario | Interfering | Interfered with | Propagation model |
| A-1 | RSTT on-board terminal | EESS space station | Free space |
| A-2 | RSTT trackside station | EESS space station | Free space |
| B-1 | RSTT on-board terminal | EESS space station | Free space |
| B-1 | EESS space station | RSTT on-board terminal | Free space |
| B-2 | RSTT trackside station | EESS space station | Free space |
| B-2 | EESS space station | RSTT trackside station | Free space |
| C-1 | RSTT on-board terminal | RAS earth station | P.452-16 |
| C-2 | RSTT trackside station | RAS earth station | P.452-16 |

FIGURE 1

Illustration of interference scenario

 

## 8.1 Interference scenario A-1 (RSTT into EESS space station)

## 8.2 Interference scenario A-2 (RSTT FS into EESS space station)

## 8.3 Interference scenario B-1 (RSTT into EESS space station and vice versa)

## 8.4 Interference scenario B-2 (RSTT FS into EESS station and vice versa)

## 8.5 Interference scenario C-1 (RSTT into RAS earth station)

## 8.6 Interference scenario C-2 (RSTT FS into RAS earth station)

# 9 Sharing and compatibility studies

## 9.1 Compatibility studies for earth exploration-satellite service (passive)

## 9.2 Compatibility studies for earth exploration-satellite service (active)

## 9.3 Sharing studies for radio astronomy service

The bands 92-94 GHz, 94.1-100 GHz and 102-109.5 GHz are allocated on an equal primary basis to the mobile service and radio astronomy service including other radiocommunication services in all three Regions. The protection criterion used is derived from Recommendation ITU-R RA.769-2. The received power level at the radiometer is calculated by the following equation:

 *P769＝Pt+G-Loss-J*(ν)

 ＝*Pt+G*-(92.5+20\*log(*f*)+20\*log(*d*)+*Ag*)-*J*(ν)

where:

 *Pt*: transmission power of on-board equipment;

 *G*: Antenna gain;

 *d*: Separation distance;

 *L*oss: Propagation loss given by Recommendation ITU-R P.452-16;

 *J(ν)*: Knife-edge diffraction loss given by Recommendation ITU-R P.452-16.

 *Ag* = (o+*w*())*d*

where:

 *Ag*: Total gaseous absorption (dB);

 *o+**w*(): specific attenuation due to dry air and water vapour, respectively, and are found from the equations in Recommendation ITU-R P.676;

 : water vapour density:

 =7.5+2.5     g/m3

 : fraction of the total path over water.

The separation distance which satisfies with the requirement of protection level is calculated from the above equation. The line-of-sight scenario from the on-board equipment to the radio astronomy antenna gives the worst case.

# 10 Bibliography

Annex 1

Measurement results of radiation pattern at 90 GHz band

This Annex provides the antenna radiation pattern to be used for 90 GHz RSTT.

FIGURE A3-1

Measured characteristics of 44-dBi antenna

