Radio Navigation Satellite Service

ITU Progress Report 2010

(After the 7th RES-609 meeting)

Attila MATAS, ITU-BR, Space Department
ITU in brief

- 20 countries founded on 17 May 1865
- the International Telegraph Union (ITU)

- Today: 192 Member States
- > 700 Sector Members & Associates
- 750 staff / 71 nationalities
- Annual budget = 140 mil. USD

ITU is the leading UN agency for information and communication technologies

http://www.itu.int
ITU Key priorities

- **radio spectrum**
  (stewardship of the radio spectrum through global treaties)

- **international standards**
  (adopting international standards to ensure seamless global communications and interoperability)

- **emergency communications**
  (to develop early warning systems and provide access to communications during and after natural disasters)

- **climate change monitoring**
  (promoting the use of ICTs to combat climate change)

- **digital divide**
  (bridging the digital divide, through infrastructure projects, capacity building and assisting to Member States in developing an enabling regulatory environment)

- **cybersecurity**
  (to build confidence and security in the use of ICTs)
RNSS and the ITU Radio Regulations

- RNSS definition from the ITU Radio Regulations (RR)
  - No. 1.43 **radionavigation-satellite service (RNSS):**
    A radiodetermination-satellite service used for the purpose of **radionavigation**
  - No. 1.59 **safety service:**
    Any radiocommunication service used permanently or temporarily for the safeguarding of human life and property
  - No. 1.169 **harmful interference:**
    Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with the RR
  - No. 5.28 **Stations of a secondary service:**
  - No. 5.29 **shall not cause harmful interference** to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date
  - No. 5.30 **cannot claim protection from harmful interference** from stations of a primary service to which frequencies are already assigned or may be assigned at a later date
RNSS Allocations

before WRC-2000

Both bands used by GPS and GLONASS.
WRC-2000 Added …

New RNSS systems

and ENHANCE existing RNSS systems
(GPS and GLONASS)
Outcome of WRC-03...

- **RNSS**
  - 1164 MHz
  - 1215 MHz
  - 1260 MHz
  - 1300 MHz
  - 4990 MHz
  - 5000 MHz

- **RNSS**
  - 5010 MHz
  - 5030 MHz

- **RNSS**
  - 960 MHz

- **ARNS**
  - 960 MHz

- **RNS & RLS & EESS & SRS**
  - 4990 MHz
  - 5000 MHz

- **RA**
  - 4990 MHz
  - 5000 MHz
  - RADIO ASTRONOMY (RA)
  - RADIONAVIGATION (RNS) (No. 5.331)
  - RADIOLOCATION (RLS)
  - EARTH EXPLORATION-SATELLITE (active) - EESS
  - SPACE RESEARCH (active) (SRS)
  - FIXED and MOBILE (No. 5.330)
  - AERONAUTICAL RADIONAVIGATION (ARNs)
Outcome of WRC-03...

- epfd limit shared by all RNSS
  \[ \leq -121.5 \text{ dB}(W/m^2-1\text{MHz}) \] (No. 5.328A / RES-609 (r.WRC-07))

How to share this limit?

‘Real’ RNSS systems only

- Satisfy milestone criteria
  annexed to
  RES-609 (r.WRC-07)

PFD limit per RNSS space station

- \[ \leq -129 \text{ dB}(W/m^2-\text{MHz}) \]
  REC-608 (r.WRC-07)

Consultation Meeting

The Bureau participates / observes / publishes results in the BR IFIC
RES 609 Consultation Meeting (1)

- All ADMs operating or planning to operate RNSS systems shall, *in collaboration*, take all necessary steps, including, if necessary, by means of appropriate modifications to their systems, to ensure that the aggregate interference into ARNS systems caused by such RNSS systems operating in these frequency bands is *shared equitably among the systems and does not exceed* the *aggregate equivalent power flux-density* (epfd) protection criterion \( \leq -121.5 \text{ dB(W/m²)} \) in any 1MHz band.
Definition of epfd

• The definition of equivalent power flux-density (epfd) is based upon RR No. 22.5C.1 and Rec. ITU-R M.1642

Method for calculating the maximum aggregate epfd from all RNSS systems

• Each GSO and non-GSO RNSS system will, having followed the methodology of Rec. ITU-R M.1642, provide a consultation meeting with a list of maximum epfd versus latitude (applicable at all longitudes) and a signal spectral shape.
• The determination of aggregate epfd of RNSS systems may be achieved using steps following the methodology of Rec. ITU-R M.1642
RES 609 Consultation Meeting (3)

- that all potential RNSS system operators and ADMs are given full visibility of the process
- **no single RNSS system** shall be permitted to use up the entire interference allowance
- ADMs operating or planning to operate RNSS systems will need to **agree cooperatively** to achieve the level of protection for ARNS
- ADMs participating in this process of epfd calculation should hold Consultation meetings on a regular basis
- ADMs participating in the Consultation meeting shall designate one ADM that shall **communicate to the Bureau the results of any aggregate sharing determinations**
RNSS progress

- **Before 2000** - 2 RNSS systems (NAVSTAR-GPS and GLONASS)
- **WRC-2000** created new allocations for the RNSS
- **2000 – 2003 period** - 70 new satellite filings (51 GSO and 19 N-GSO)
- **12.2003** – 1st RES 609 Consultation Meeting – NO epfd calculation
- **01.2004** - ITU BR identified 117 satellite filings representing 66 RNSS networks (18 N-GSO and 48 GSO) from 11 administrations (CAN, CHN, D, F/ESA, F/GLS, G, I, IND, J, RUS, USA)
- **06.2004** - 2nd RES 609 Consultation Meeting - calculations of the aggregate equivalent PFD (epfd) for 5 GSO and 4 N-GSO
- **06.2005** - 3d RES 609 Consultation Meeting - calculations of the aggregate equivalent PFD (epfd) for 14 GSO and 6 N-GSO
- **09.2006** - 4th RES 609 Consultation Meeting - calculations of the aggregate equivalent PFD (epfd) for 15 GSO and 8 N-GSO
- **05.2008** - 5th RES 609 Consultation Meeting - calculations of the aggregate equivalent PFD (epfd) for 20 GSO and 6 N-GSO
- **09.2009** - 6th RES 609 Consultation Meeting - calculations of the aggregate equivalent PFD (epfd) for 18 GSO and 6 N-GSO
- **06.2010** - 7th RES 609 Consultation Meeting - calculations of the aggregate equivalent PFD (epfd) for 21 GSO and 6 N-GSO
- **09.2010** - 204 satellite filings representing 124 RNSS networks (22 N-GSO and 102 GSO) from 18 administrations (ARG, ARS/ARB, B, CHN, D/GLS, EGY,F,F/GLS,G,I,I/GLS,IND,J,LUX,NIG,RUS,TUR,USA)
### Results (1)

<table>
<thead>
<tr>
<th>Country</th>
<th>Satellite System</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>INMARSAT-4 25E, -4A 25E, XL1, -4 143.5, -4A 143.5, -4 98W, -4A 98W (GSO) (3)</td>
</tr>
<tr>
<td>CHN</td>
<td>COMPASS-160E, 140E, 110.5E, 80E, 58.7E, -B-84E, -B-144.5E (GSO)</td>
</tr>
<tr>
<td>IND</td>
<td>INSAT-NAV(34), (55), (82), (83), (132) (GSO)</td>
</tr>
<tr>
<td>J</td>
<td>MTSAT-C-140E, -145E (GSO)</td>
</tr>
<tr>
<td>LUX</td>
<td>LUX-G6-2-E (GSO)</td>
</tr>
<tr>
<td>NIG</td>
<td>NIGCOMSAT 1G, 1R (GSO)</td>
</tr>
<tr>
<td>USA</td>
<td>LM-RPS-133W, 107.3W (GSO)</td>
</tr>
<tr>
<td>CHN</td>
<td>COMPASS-M, MG, H (2) (N-GSO)</td>
</tr>
<tr>
<td>J</td>
<td>N-SAT-HEO2 (N-GSO) (4)</td>
</tr>
<tr>
<td>RUS</td>
<td>GLONASS-M (N-GSO)</td>
</tr>
<tr>
<td>USA</td>
<td>NAVSTAR GPS IIRF (N-GSO) (5)</td>
</tr>
<tr>
<td>F/GLS</td>
<td>MSATNAV-2 (1) (N-GSO)</td>
</tr>
<tr>
<td>IND</td>
<td>INSAT-NAV-GS (N-GSO)</td>
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</tbody>
</table>

1 - The following filings remain available for Galileo and shall be treated with MSATNAV-2 filing as a single planned RNSS system for purposes of performing the epfd calculations - MSATNAV-3 and 4 (F/GLS), GALILEO-NAV-2004 (D/GLS), GALILEO-M-NAVSTAR (I/GLS), and SNS (G))

2 - Compass-M, -MG, and -H represent a single system for purposes of the Res 609 consultation process

3 - INMARSAT filings represent a single network for the purposes of the Res 609 (Rev.WRC-07) consultation process.

4 - QZSS system shall be treated with the N-SAT-HEO2 as a single planned RNSS system for purposes of performing the epfd calculations.

5 - USRSR system shall be treated with NAVSTAR GPS-IIRF as a single planned RNSS system for purposes of performing the epfd calculations.
The maximum epfd of all satellites associated with the referenced RNSS systems (presented on the 7th RES-609 Consultation meeting) was $-122.58 \text{ dB (W/m}^2/\text{MHz})$ i.e. $1.08 \text{ dB below the RES-609 limit of -121.5 dBW/ m}^2/\text{MHz}$.

It is noted that the results are based on the use of worst-case assumptions in terms of interference from RNSS into ARNS.
2nd RES 609 Consultation Meeting results

Res609 epfd criterion

Frequency (MHz)

epfd (dB/W/m²/MHz)

-160 -155 -150 -145 -140 -135 -130 -125 -120 1164 1166 1168 1170 1172 1174 1176 1178 1180 1182 1184 1186 1188 1190 1192 1194 1196 1198 1200 1202 1204 1206 1208 1210 1212 1214
Maximum RNSS Aggregate Epfd per MHz

-160 1160 1170 1180 1190 1200 1210 1220
Center Frequency (MHz)

-160 -150 -140 -130 -120
Max Epfd (dB(W/m²/MHz))

-120
Max Aggregate Epfd Limit

-120
Max Aggregate Epfd
Maximum aggregate epfd


Frequency (MHz)

epfd (dBW/m²/MHz)

Maximum Res609 Aggregate Epfd Level

Max Aggregate Epfd (Table 2 systems)
5th RES 609 Consultation Meeting results

Maximum RNSS Aggregate epfd per MHz with 1° steps

- Frequency (MHz)
- epfd (dBW/m^2/MHz)
- Limit
- Max agg. epfd

Graph showing the maximum RNSS Aggregate epfd per MHz with 1° steps.
Maximum RNSS aggregate epfd per 1 MHz with 1° step

-160.00 -155.00 -150.00 -145.00 -140.00 -135.00 -130.00 -125.00 -120.00

1160 1170 1180 1190 1200 1210 1220

Frequency in MHz

epf (dB(W/m²/MHz)

Limit

Max agg. epfd
Maximum RNSS aggregate epfd per 1 MHz with 1° step
• Retained existing protection of RNS
• Extended protection to RLS (No. 5.329)
• *EESS and SRS shall not cause harmful interference or claim protection from RNSS* (No. 5.332)
• *Additional PRIMARY for FX and MOB service in certain countries* (No. 5.330)

• *No additional constraints* for RNSS in 1215-1260 MHz, if brought into use prior WRC-2000 *(RES-608 (WRC-03))*
This band is also allocated to the FX on a PRIMARY basis until 01.01.2010 in (list of countries…) and on secondary basis until 01.01.2015 and at this time this allocation shall no longer be valid. Administrations are urged to take all practicable steps to protect the RNSS and the ARNS and not authorize new frequency assignments to FX service systems in this band. (Nos. 5.362 & 5.362C)

- No additional constraints for RNSS & ARNS in 1559-1610 MHz
PFD limit (GSO RNSS) & EPFD limit (NGSO RNSS)

- **PFD** ≤ -171 dB(W/m²·10MHz) for any GSO RNSS
- **EPFD** ≤ -245 dB(W/m²·10MHz) by all NGSO RNSS 2% of time, over 5deg elevation; over RA band

- **RES-741 (WRC-03)**
- **RR No. 5.443B** also no interference to the MLS
Frequency Spectrum for the RNSS

**Regulatory situation summary**

**RES-609 (r. WRC-07)**
RNSS-ARNS Compatibility
(960)1164 - 1215 MHz

**ARNSS - For Safety-of-Life Services**

**RES-608 (WRC-03)**
No constrains on use of "old" RNSS
in the band 1215 – 1260 MHz

**“old" RNSS allocation 1215-1260 MHz**

**RES-610 (WRC-03)**
Coordination and bilateral resolution of technical compatibility issues for RNSS networks

**EPFD -121,5 dBW/m² in 10 MHz for all sats in view**

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The ITU BR is maintaining a special web site and web forum – **RES-609 Consultation meeting**

- posting of required information from administrations
- exchange of information
- posting the results of the epfd calculation from the participants of the RES-609 Consultation meeting
- Posting the results of all RES-609 Consultation meetings

WP 4C is responsible for studies related to all mobile-satellite services including RNSS.

- Studies on the RNSS are very active.
- Sharing and protection criteria have been intensively investigated for existing spectrum allocation for RNSS.
- Studies are also on-going for newly allocated bands for future enhancements and newly planned RNSS systems, addressing frequency sharing with other services.
- These studies contribute not only to the development of ITU-R M Series Recommendations but also to WRC-12 preparation.
- Free online access to current ITU-R Recommendations is provided on a trial basis to ITU Member States administrations, Sector Members and Associates of all Sectors via TIES until further notice.

http://www.itu.int/publ/R-REC/en
There are 523 contributions for the WP 4C activities covering the study group period from December 2007 (after WRC-07) up to October 2010.

- **List of most important ITU-R Recommendations related to RNSS (1)**

  - **ITU-R M.1088** - Considerations for sharing with systems of other services operating in the bands allocated to the radionavigation-satellite service.
  
  - **ITU-R M.1318-1** - Evaluation model for continuous interference from radio sources other than in the radionavigation-satellite service to the radionavigation-satellite service systems and networks operating in the 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz and 5 010-5 030 MHz bands.
  
  - **ITU-R M.1463-1** - Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 1 215-1 400 MHz.
  
  - **ITU-R M.1477** - Technical and performance characteristics of current and planned radionavigation-satellite service and aeronautical radionavigation service receivers to be considered in interference studies in the band 1 559-1 610 MHz.
ITU-R M.1479 - Technical characteristics and performance requirements of current and planned radionavigation-satellite service receivers to be considered in interference studies in the frequency bands 1 215-1 260 MHz and 1 559-1 610 MHz

• ITU-R M.1582 - Method for determining coordination distances, in the 5 GHz band, between the international standard microwave landing system stations operating in the aeronautical radionavigation service and stations of the radionavigation-satellite service

• ITU-R M.1642-2 - Methodology for assessing the maximum aggregate epfd at an aeronautical radionavigation service station from all radionavigation-satellite service systems operating in the 1 165-1 215 MHz band

• ITU-R M.1787 - Description of systems and networks in the radionavigation-satellite service and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz

• ITU-R M.1831 - A coordination methodology for RNSS inter-system interference estimation
List of ITU-R Questions related to RNSS

- QUESTION ITU-R 217-2/4 - Interference to the radionavigation-satellite service in the ICAO GNSS

- QUESTION ITU-R 288/4 - Characteristics and operational requirements of radionavigation-satellite service
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Questions?