Interference and mitigation of harmful interference to Radionavigation Satellite Service (RNSS)

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OBJECTIVES

- To study causes of harmful interference to RNSS and review mitigation techniques.

Introduction

- Radiodetermination service is used in the determination of the position, velocity and or other characteristics of an object or
- Obtaining of information relating to these parameters by means of propagation properties of radio waves.
- Radio Navigation Satellite Service (RNSS): radiodetermination service used for the purpose of radionavigation.
- RNSS signals have low power of the order of -160dBW and are susceptible to interference by inband and adjacent band services and require protection.
- Harmful interference endagers the function of a service and may degrade it, obstruct it or lead to repeated interruptions.

Definition of Radionavigation Satellite Service (RNSS)

- RNSS specifically refers to the space-to-Earth component of GNSS.
- It emphasizes the safety-of-life service provided by GNSS.
- The Aeronautical service in RNSS is GNSS and its Augmentations.
- GNSS is currently provided by GPS, GLONASS, Galileo and BeiDou global constellations.
- They are available for all purposes where a position fixing facility is required.
- Augmentation systems to improve GNSS integrity are available on the Aircraft and on the ground.

Radionavigation Satellite Service (RNSS) Bands

- 1164-1250 MHz; 1 559–1 626.5 MHz; 5000-5010MHz and 5030-5091 MHz bands have been allocated to RNSS
- GNSS operates in segments of the 1 559–1 610 MHz frequency band.
- The spectrum is conditionally shared by ARNS and RNSS.
- Ground Based Augmentation System (GBAS) operates in the 108–117.975 MHz band allocated to ARNS.
- The RNSS bands are generic and complex sharing arrangements need to be agreed on by service providers to ensure smooth operation.

RNSS BANDS

- GPS: L1 :1575.42 MHz, L2 :1227.60 MHz and L5:1176.45 MHz
- GLONASS: L1:1602.0 MHz, L2: 1246.0 MHz and L3:1202.025 MHz
- Galileo: E1:1575.42 MHz, E5a:1176.45 MHz, E5b: 1207.14 MHz and E6: 1278.75 MHz
- BeiDou: E1: 1575.42 MHz, E2: 1561.098 MHz, E5B: 1207.14 MHz and E6:1268.52 MHz
- In addition to the varying (and sometimes overlapping) frequencies used by the different GNSS constellations.

Sources of RNSS Interference

- Satellite navigation systems provide weak received signal power
- An interference signal can cause loss of service at a lower RNSS receiver power level than with terrestrial navigation systems.
- Interference can occur wherever the GNSS signal is authorized for use.
- Jamming devices, commonly referred to as “GNSS jammers”, “signal blockers” or “privacy jammers” can cause interference.
- Harmful interference in the L1 band can disrupt the onboard receivers of aircraft, causing the degradation or total loss of communication for passenger, cargo, and humanitarian flights.

Sources of harmful interference:

- Primary or secondary allocations to the FS for point-to-point microwave links are allocated in the frequency band used by GPS and GLONASS .
- Services operating in adjacent bands to GPS or GLONASS
- Services operating in bands outside the 1 559– 1 610 MHz band
- Harmonics and spurious emissions of aeronautical VHF transmitters
- Discrete spurious products and intermodulation products (IMP) from radio services operating near the 1 559–1 610 MHz band.
- Harmful interference to GPS and GLONASS on an aircraft depends on the aircraft, its size, and what transmitting equipment is installed.

Sources of harmful interference:

- The possible generation of intermodulation products on the aircraft from one transmitter with multiple carriers
- Multiple transmitters controlled by transmitter filtering and frequency management.
- Some on-board interference could be due to harmonics generated by weathered joints and connections
- Transmitters operating within specifications may radiate significant power into the GPS band.
- VHF and UHF TV broadcast stations and other high-power sources and out-of-band noise.

Sources of harmful interference:

- Unintentional inteference like system failures, operational errors and Pseudolites
- GNSS repeaters and effects that delay the signal, and thus cause issues with the timing of the signal reception.
- Ionospheric effects lead to signal propagation delay,upper atmosphere ionised by solar radiation, that can “bend” and reflect the signal.
- GNSS constellation anomaly,position drift, as with clocks, miniscule errors in satellite orbit position.
- Intentional interference like spoofing and jamming, Ultra wide band devices,IMT Sources,aircraft and/or receiver failure, environment masking,Multipath or space weather.

Mitigation Techniques for Interference of RNSS

- Reinforce the resilience of navigation systems by using technologies with multi-frequency/multi-system receivers and anti-jamming capabilities and develop mitigation techniques for loss of service.
- Invest in spoofing resilience by building security directly into GNSS satellites-cryptography, signal-distortion detection, and direction-of-arrival sensing.
- Increase collaboration between regulatory, aviation, and law enforcement authorities and reinforce civil-military coordination to address interference risks in testing and conflict zones.
- Retain essential conventional navigation infrastructure for contingency support in case of RNSS outages.

Mitigation Techniques for Interference of RNSS

Regulatory:

- The Radio Regulations preparation and update process ensures allocation, allotment and assignment in conformity with up to date knowledge to ensure compatibility and sharing where deemed fit.
- A safety margin (public safety factor of 6dB for GNSS for example), is provided for safety-of-life applications to account for risk of loss of life due to RFI and Navigation alert is in-built whenever receiver susceptibility is exceeded.
- International agreements and expert strategic and technical planning and use of technological advances ensure efficient use of frequency spectrum

Mitigation Techniques for Interference of RNSS

Management and Control

- Ensure conformance with RR in System and Equipment manufacture, installation, operation and licensing.
- Control and clear interference as necessary
- Adhere to ITUR recommendations that specify coordination distances, interference calculations, computation of separation distances and technical characteristics and protection criteria.
- Studies should be carried out to institutionalise detection and protection within ITU to establish limits for each service through controlled studies.

Mitigation Techniques for Interference of RNSS

Assessment and protection:

- Interference reports observed by users should be studied, recorded and analysed to establish the nature and locations of occurences
- Such as aircraft and/or receiver failure and GNSS constellation anomaly, environment and weather effects
- Frequency or distance separation should be effected as necessary.
- Installation conditions should be assessed to establish Antenna losses.
- Receiver interference rejection performance should be verified.

Conclusions

- ITU has introduced several protective measures to protect RNSS.Res 609 rev WRC 2007 and Resolution Com/5/5 of WRC-23 introduced measures against interference with RNSS.
- Standard installation and routine maintenance should be used to eliminate sources of interference early.
- Existing and future frequency assignments in the 1 559–1 610 MHz band with the potential to interfere with the GNSS operations should be moved to other bands.
- While technology evolves and ITU's Member States consider the way forward, ITU and the Radio Regulations Board should continue to follow up closely on every potential case of interference.

References

- ITU Radio Regulations
- ICAO Handbook on Radio Frequency Spectrum requirements for Civil Aviation Doc 9718
- Manual on testing of Radio Navigation aids Doc 8071 Vol 1
- Manual on testing Satellite based aids Doc 8071 Vol 2
- ICAO Annex 10 Aeronautical Telecommunications

Thank you.