



Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

**REGULATORY FRAMEWORK FOR
GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) REPEATERS**

St. Petersburg, May 2010

EXECUTIVE SUMMARY

Global Navigation Satellite System (GNSS) repeaters are devices that some industry and commercial organisations want to use to enable today's 'SatNav' receivers (Radionavigation Satellite devices) to continue reception in areas of signal blockage of the GNSS signals. Examples of such places are vehicle garages or laboratories where products using GNSS receivers are tested.

GNSS repeaters receive GNSS signals and re-radiate them inside buildings in order to provide a usable signal. However, they like any active radio transmitter device, have the potential to cause interference. The impact on GNSS receivers in the vicinity outside the intended repeater coverage area needs particular consideration. GNSS repeaters should be limited to the bands 1164-1215 MHz, 1215-1300 MHz and 1559-1610 MHz.

The report concludes that GNSS repeater installations should be for justified needs subject to national considerations.

The report also concludes that any authorisations or licences for GNSS repeater installations could include guidance for reduction and reasonable checking of the potential to cause interference.

The report identifies that other general recommendations related to the authorisation regime may apply such as:

- That installation within airport boundaries may require clearance from the local aviation authorities, even though they might not own the airport.
- That there are particular site limitations placed by military or other government authorities.

The report recommends individual licensing of GNSS repeater devices and that there is no licence exempt operation.

The report recommends that administrations avoid mobile use of these GNSS repeater devices and do not permit this type of operation.

The report recommends specific technical and operating conditions that should be included in any licence. In addition guidance for installation is given.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
DME	Distance Measuring Equipment
EEA	European Economic Area
EESS	Earth Exploration Satellite Service
ETSI	European Telecommunications Standards Institute
GALILEO	A European Union GNSS system
GNSS	Global Navigation Satellite System operating within the RNSS
GPS	Global Positioning System of the United States, a GNSS system
RNSS	Radionavigation Satellite Service
R&TTE	Radio and Telecommunications Terminal Equipment

Regulatory Framework for GNSS repeaters

1 INTRODUCTION

Global Navigation Satellite System repeaters are devices that some industry and commercial organisations want to use to enable today's 'SatNav' receivers (Radionavigation Satellite devices) to continue reception in areas of signal blockage of the GNSS signals. Examples of such places are vehicle garages or laboratories where products using GNSS receivers are tested.

A GNSS repeater enables a receiver within its coverage area to continue to lock to the satellite signal such that on return to an unblocked signal environment, it will quickly acquire the direct satellite signals so that a current and accurate position fix can be determined immediately in the normal manner. Industries using GNSS receivers in production devices want to be able to test the embedded GNSS receivers without having to resort to leaving the building to obtain a direct view of the satellite constellation.

GNSS repeaters receive GNSS signals and re-radiate them inside buildings in order to provide a usable signal. However, they, like any active radio transmitter device, have the potential to cause interference and the impact on GNSS receivers in the vicinity outside the intended repeater coverage area needs particular consideration.

In 2008, CEPT within its Regulatory Affairs Working Group issued a questionnaire to CEPT administrations posing several questions about their approach to GNSS repeaters. Most administrations expressed concerns about the potential loss of accuracy of GNSS receivers and interference to other services that could result from the use of these devices. Consequently, they were considered as not being suitable for licence exemption and some countries had prohibited their use pending the development of a suitable regulatory policy.

This Report describes the general form of GNSS repeaters, their potential benefits and issues such as the interference potential arising from their use. It also considers whether GNSS repeaters should be licensed or exempt from individual licensing. The Report concludes that the most suitable approach to authorising their use is through national licensing, subject to constraints designed to limit potential interference and loss of accuracy of other GNSS receivers to acceptable levels. Suitable technical constraints are contained in ECC Report 129 and the general recommendations of this Report are also discussed. In 2010, ETSI approved a harmonised standard for GNSS repeaters EN 302 645.

2 REGULATORY OVERVIEW

It is essential that any licence regime developed for GNSS repeaters should include a safe and reliable method to limit the potential for harmful interference to GNSS receivers receiving in the same band and in areas adjacent to the repeater coverage area. This must be done through the establishment of a balanced, reasonable, practical and effective regulatory policy, covering non-governmental and governmental applications.

2.1 CEPT Working Group Regulatory Affairs action

In 2008, CEPT asked several questions on the issue of GNSS repeaters and received responses from: Austria, Belgium, Croatia, Cyprus, Czech Republic, Estonia, France, Germany, Greece, Iceland, Ireland, Finland, Latvia, Lithuania, Malta, Netherlands, Norway, Portugal, Romania, Slovak Republic, Slovenia, Sweden, Switzerland, Turkey and the United Kingdom.

CEPT concluded the following from the summary of the responses from the administrations that:

- Only one administration reported to have licensed a GPS repeater. However, this was within strict guidelines such that interference would not be expected to affect other GPS users.
- A local repeater device could cause position fix errors and several CEPT administrations expressed their concern that any change in potential accuracy due to this should be minimised;
- A limited number of CEPT administrations have prohibited these devices, while awaiting regulatory policy development;
- Concerns exist because of the interference potential;
- Development of a harmonised standard could help manufacturers;
- Except in two instances, the repeater devices are not considered to be candidate for licence exemption;
- Market surveillance and enforcement of a ban on sales of these devices has occurred;
- There is a general view that conformance with R&TTE directive is essential;

- Opinions on the potential interference of these devices differ from administration to administration.

While the US policy decision¹ is interesting, CEPT considers that it should consider this matter separately (Only US federal government agencies and departments may, under the conditions specified, operate mobile devices that re-radiate signals received from the Global Positioning System (GPS) at 1575.42 ±12 MHz (L1)). GPS repeaters are not legally sold in the US since the frequency bands they are meant to use are restricted².

2.2 Current legal status of GNSS repeaters

GNSS repeater equipment is, in general, not allowed to be used and is currently banned from the market in most countries. In early 2009, one CEPT administration approved a GNSS repeater device and allowed its sale.

2.3 EC position

There are currently no published EU views on the potential sale of these devices. It is expected that it should be possible to build such equipment in conformity with the Directive. To comply with the Directive they should not disrupt normal GNSS services, ideally by design or through strict usage conditions (e.g. licensed use). Harmonised standards are needed that will ensure compliance. ETSI has adopted a work item to develop such a standard and has produced EN 302 645 for public enquiry.

CEPT administrations who are also members of the EU should, note that ETSI has adopted a harmonised standard for GNSS repeaters - EN 302 645. These devices can assist receivers in emergency vehicles to continue to track signals when parked in indoor areas. They also allow embedded GNSS receivers to be tested when they are installed in consumer products (such as cars or other products using location-based information).

As with other legal frameworks for the use of radio and telecommunications terminals, GNSS repeaters: -

- Would have free movement within the EEA, in accordance with article 8 of the R&TTE Directive (1999/05/EC). This is allowed when they meet the essential requirements of the Directive (there is a relevant standard for GNSS) and they would not cause harmful interference.
- Must have their actual use authorised through national regulations. These national regulations need to ensure the safe use of these devices and to develop limitations in terms of licensing and site limitations; ideally, these should have some common aspects within CEPT.

2.4 Frequency bands for RNSS

GNSS repeaters are considered for operation in the RNSS allocations: 1164 -1215 MHz, 1215 - 1300 MHz and 1559 - 1610 MHz.

2.5 Radio Regulatory status of GNSS “repeaters”

The ITU frequency allocations for the relevant bands are shown in the table below. Whereas there are primary allocations for radionavigation-satellite service (space-to-Earth), no allocations exist for their use under a terrestrial radionavigation allocation. GNSS repeaters will operate according to any national licensing conditions and this should be on a non-interference non-protected basis.

1 <http://www.ntia.doc.gov/osmhome/redbook/8.pdf> , section 8.3.28

2 www.fcc.gov/eb/Orders/2006/FCC-06-30A1.html

1 164-1 215	AERONAUTICAL RADIONAVIGATION 5.328 RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328A	5.328B
1 215-1 240	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.329 5.329A SPACE RESEARCH (active) 5.330 5.331 5.332	
1 240-1 300	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.329 5.329A SPACE RESEARCH (active) Amateur 5.282 5.330 5.331 5.332 5.335 5.335A	
1 559-1 610	AERONAUTICAL RADIONAVIGATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.329A 5.341 5.362B 5.362C	5.208B 5.328B

2.6 Development of a harmonised EN

Within ETSI, an EN standard on GNSS repeaters is due for completion in 2010. GNSS repeaters are not considered as Short Range Devices (SRD).

ECC Report 129 gives the minimum technical requirements necessary to avoid interference. The ETSI harmonised standard EN 302 645 provides approved standards and test procedures to enable compliance with the requirements of the R&TTE Directive to be demonstrated and therefore allow GNSS repeaters to be used or to be placed on the market.

2.7 Enforcement

A malfunctioning or a badly installed GNSS repeater could cause inaccuracies in normal GNSS receivers operating in areas near to the coverage area of the repeater.

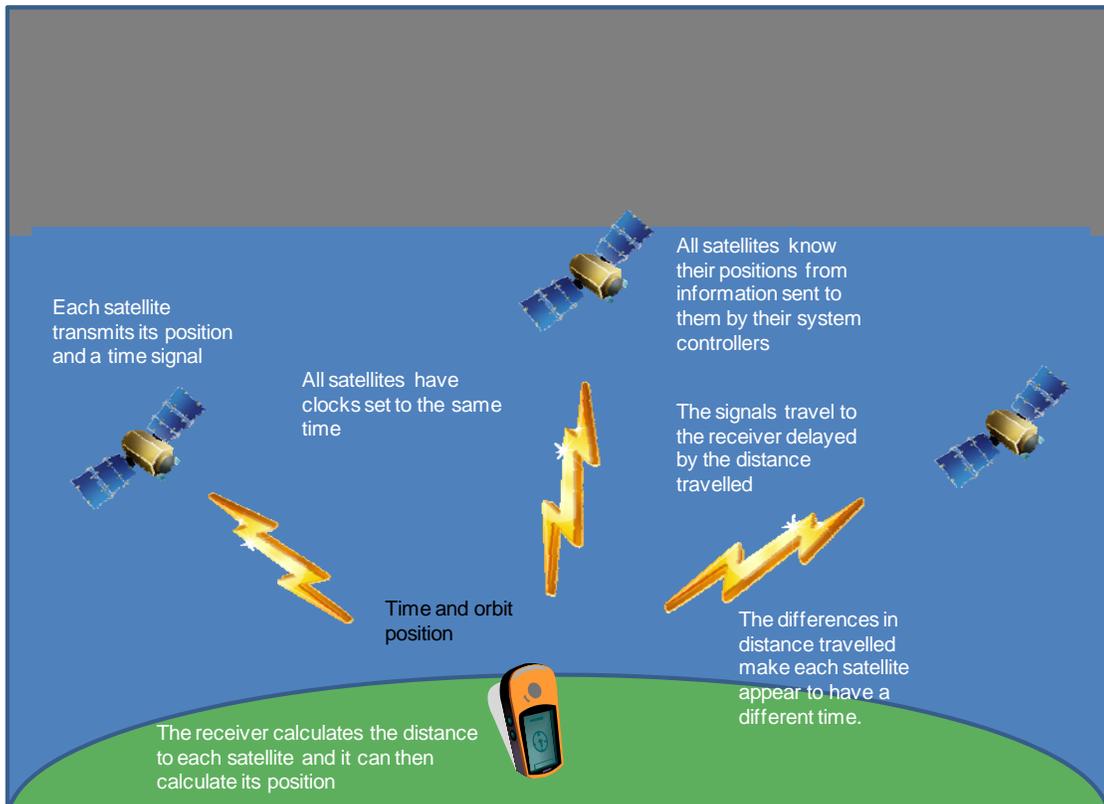
As some transport vehicles use GNSS receivers for accurate positioning, there is a need for rapid enforcement actions if interference is caused and reported to GNSS services. However, low-level signals may not be easily detected and there might be a problem in locating any interference. Consequently, administrations are reliant on the reports of interference to begin to find these.

A database of local GNSS repeater licences would assist enforcement resources to enable the discounting of these as a problem installation. If an installation is found to cause interference, this should be rectified by comparing the installed equipment against the technical and operational conditions attached to the licence and perhaps including measured results of the affect on other non-participating GNSS receivers in the local vicinity. If necessary, adjust any installation or methods of interference assessment. If no licensed installation was faulty, identification and resolution of an unlicensed GNS repeater or other source of harmful interference is required.

As knowledge of the location of GNSS repeater installations through licensing is highly recommended, CEPT administrations should not allow the installation of GNSS repeaters in any mobile vehicles. At least one administration received reports of GNSS repeater applications used to support "Lone Workers" so that the GNSS receivers of mobile support personnel can be used for tracking and providing locations, immediately on exiting the vehicle. Any deployment of GNSS repeater devices in moving vehicles would not allow management of the interference environment. Therefore, these should be avoided.

3 DESCRIPTION OF GNSS AND GNSS REPEATERS

3.1 GNSS systems



Systems using the Radio Navigation Satellite Service (RNSS) or Global Navigation Satellite Systems (GNSS) have developed into indispensable assets for navigation around the globe. Examples are GPS, GLONASS and the future Galileo system that provide data for navigation devices.

A GNSS receiver must lock to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude) and time. Once the user's position has been determined, the GNSS receiver can calculate other information such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time.

3.2 GNSS applications

Applications based on use of global navigation satellite systems have become very popular with professionals and the general public alike. Several applications in society such as aircraft use depend on the availability of accurate location information, provided by these systems. Coverage of a GNSS system is generally limited to line-of-sight visibility between at least four satellites and the receiver.

3.3 Examples of the need for GNSS repeaters

The annex of this Report describes different usage scenarios for GNSS repeaters. This section of the Report gives three of these examples.

3.3.1 Maintain receiver synchronisation with no satellite visibility

One function of GNSS repeaters is to permit GNSS receivers to keep tracking satellites so that they will be able to function immediately on restoration of direct line of sight to the GNSS satellites. The repeater will only allow GNSS receivers to generate the position of the GNSS repeater's receiving antenna. This repeated signal would allow many emergency services or aircraft in hangars to lock their navigation systems to the relevant satellites as soon as a mission has been initiated. It takes time for a receiver to provide an accurate position fix.

Such usage represents a small, but not mass-market demand for indoor coverage, notably for GNSS equipped rapid response vehicles located in parking garages, hangars or stadiums. Emergency services would benefit from GNSS indoor coverage since they require a quick and accurate time to first fix (TTFF) i.e. the calculation of their first position, as every second counts in knowing the location of vehicles deploying in emergency operations.

3.3.2 Testing embedded GNSS receiver performance

A GNSS repeater would also allow the production testing of handheld/embedded GNSS receivers (i.e. handhelds or those integrated in cars or other products). These usually have little or no antenna access.

3.3.3 Other Applications

Some additional uses include meteorology, where Radiosondes use GNSS position (including height) to help measure the propagation performance of radio waves. The Radiosondes determine useful meteorological information from identified propagation changes due to atmospheric effects. Another is for use in Intelligent Transport. The EU Intelligent Transport Directive indicates that GNSS can be used if required in such systems. Therefore, it is important to note that there are public trust issues concerning road tolling positioning data.

3.4 Equipment types and availability

GNSS repeaters are active amplifier devices designed to re-transmit any signal entering their frequency of operation, but especially Global Positioning Satellite (GPS) or other Global-navigation satellite system (GNSS) signals, such as Galileo. These can be described as simple re-broadcast systems, whereby the GNSS signals are received, amplified and re-transmitted on the same frequency into an area where there are no GNSS signals, thereby allowing GNSS receivers to maintain relevant satellite ephemeris and other data. Repeater devices are not intelligent and do not demodulate or actively process the received signals for re-transmission.

GNSS repeaters in their simplest form, can be constructed of sub-components purchased separately, each being R&TTE compliant. Such "ad-hoc" systems represent the greatest potential for harmful interference, as persons with little or no regulatory or engineering knowledge routinely construct these systems; almost universally designed with excessive radiated power. Improper installations are prone to oscillation and spurious emissions if the amplifier gain exceeds the propagation losses between the transmit and receive antennas. The lack of a reasonable and effective regulatory policy results in a far greater potential for harmful interference due to the employment of such "ad-hoc" systems.

Other technologies can address indoor accuracy shortcomings by providing additional ranging signals and by improving geometry. These include pseudolites (Pseudo-satellites), which are ground based radio transmitters that transmit a GNSS-like navigation signal. However, ordinary GNSS-receivers cannot use these signals without changes to their internal processing software. It is then possible to extend the satellite navigation technology to difficult environments like indoors with high accuracy and cost effectiveness.

Pseudolites and their technical compatibility with GNSS and other services is the subject of a separate report, ECC Report 128. There will be a separate ECC Report on the regulatory framework for GNSS Pseudolites.

4 COMPATIBILITY BETWEEN GNSS REPEATERS AND OTHER SERVICES/APPLICATIONS

The ECC has adopted ECC Report 129 on the subject of GNSS repeater compatibility. The Report offers technical requirements for the use of the equipment and sets some basic parameters for ETSI to develop harmonised standards. Its main conclusions on co-frequency and adjacent frequency compatibility are described in the following sections.

4.1 Co-frequency compatibility with GNSS

GNSS receivers are incorporated in many applications including the new generation of mobile phones. If not managed, GNSS repeaters have the potential to cause degradation of the accuracy of these position location devices if they are able to simultaneously receive satellite and a GNSS repeater's re-radiated signals. This could result in incorrect operation of GNSS devices in both civil and military applications. Therefore, it is essential that GNSS repeater devices and/or their transmitting antennas are appropriately separated from areas where normal GNSS reception is possible.

For some administrations there will be additional national considerations due to the potential to interfere and jam GNSS services –some Government departments (Transport and Defence, for instance) might need evidence that the use of these devices will not cause harmful interference.

4.1.1 *Compatibility with other co-frequency or adjacent band services*

In addition, a GNSS repeater is likely to re-radiate signals from any other services operating in or adjacent to the GNSS bands. Such services include radar and aircraft DME systems. In order to limit these re-radiated signals ECC Report 129 proposed that the maximum output power for an input of non-GNSS like signals be restricted to -20 dBm.

The RNSS band 1215-1300 MHz, is also used by radar, the Earth Exploration Satellite Service (EESS) and Wind Profiler radar. Re-radiation of these signals by the GNSS repeaters may cause effects inside a radar clutter zone or enhance the signals to EESS satellites. This would not be the case if the maximum output power capability of the system is restricted to -20 dBm as stated above.

Galileo and GPS both use the band 1215-1300 MHz for secure services as well as providing additional signals to help correct ionospheric propagation effects. CEPT administrations should review the technical compatibility studies report in ECC Report 129, together with the proposed regulatory provisions outlined in this report

Aeronautical Distance Measuring Equipment (DME) uses the RNSS band, 1164-1215 MHz. The analysis indicates that there should be no cause for concern in the use of repeaters if they incorporate suitable filtering and output power capability as stated previously (see Section 9 of ECC Report 129). To have an impact on DME the analysis section of ECC Report 129, would have had to make large errors in its assumptions. However, aviation authorities are still concerned that no tests have been performed to verify continued DME performance when GNSS repeaters are situated near to DME equipment. Aviation also intends to use GNSS as a precision landing aid in this band. The aviation authorities are therefore concerned with the potential interference that GNSS repeaters could cause to DME and their safety critical use of GNSS. CEPT administrations should review the technical compatibility studies report in ECC Report 129, together with the proposed regulatory provisions outlined in this report.

For the band 1559-1610 MHz, there are no other apparent sharing services and the main protection should be provided by a geographic protection distance. CEPT Administrations can protect GNSS operation in this band by providing suitable gain/power limitations in any licence for these devices. Aviation will also use RNSS landing systems in the band 1559-1610 MHz. In the GPS L1 band, GNSS repeaters are more likely to be deployed as there are already illegal GNSS repeater products available for this band. CEPT administrations should review the technical compatibility studies report in ECC Report 129, together with the proposed regulatory provisions outlined in this report.

4.1.2 *Consideration of fixed, portable and mobile operations*

There is a considerable risk in the mobile use of these GNSS repeaters since uncoordinated use will increase the potential risks to normal GNSS receiver operation and therefore mobile use should not be considered.

5 OPTIONS FOR AUTHORISATION OF GNSS REPEATERS

5.1 Equipment compliance and standards

An ETSI technical standard EN 302 645 for GNSS repeaters has nearly completed the ETSI approval process. When this is available, an administration could use this as an informative standard under the R&TTE Directive, for any national licensing process

When this standard is approved, it will provide minimum technical standards for operation of GNSS repeaters, the standard includes such factors as:

- An installed GNSS repeater is limited to a total gain of +45 dB maximum (including antenna gains) or alternatively 48 dB (the maximum of the antenna gain, amplifier and an assumed maximum feeder loss of 3 dB.). The 45 dB gain equates to a GNSS protection distance of around 10 metres for a -160 dBW GNSS signal
- GNSS repeaters, when subject to high levels of adjacent or in-band signals are limited to a maximum saturated output power of -20 dBm.
 - The level of the GNSS output signal is limited to about -77 dBm which would be achieved with the maximum GNSS repeater gain of +45 dB and a typical GNSS received signal level of -155 dBW (= -125 dBm). If signals are received from more than one GNSS system the total GNSS-related output power would be increased accordingly.
 - GNSS signal is about 20 dB below the GNSS receiver noise floor and can not be separated from the GNSS receiver noise. There is no simple method to measure the GNSS signal level -77 dBm in the GNSS repeater output, but it is possible to measure and define the GNSS repeater receiver noise floor amplified by repeater gain (45 - 48 dB), which now is also the maximum e.i.r.p of GNSS repeater and of the order of -57 - -60 dBm.
- The GNSS repeater system should have band edge filters, and bandwidths sufficient to pass civil, and public regulated and military signals as applications dictate (i.e. single & multi-band variants). The devices shall have filter responses at various band edges - 1164, 1215, 1300, 1559 and 1610 MHz. To protect DME operation in bands below 1164MHz, at 1151 MHz, the GNSS repeater maximum output power shall be limited to -27 dBm for any out of band input from Non-GNSS like signals below 1164 MHz.

5.2 Placing equipment on the market and national restrictions

For EEA countries, the R&TTE Directive is the appropriate regulation applicable to placing radio equipment on the market.

Any Member State can prohibit placing equipment on its national market in accordance with the relevant article of the RTTE Directive (in particular Art. 9) when “radio equipment, including types of radio equipment, which has caused or which it reasonably considers will cause harmful interference, including interference with existing or planned services on nationally allocated frequency bands”.

The Commission then decides whether the measure taken is justified or not.

For non-EEA countries, the decision to prohibit placing equipment on its national market is a national decision.

The equipment must meet certain technical standards and be suitably deployed and operated. These aspects include:

- Ensuring equipment compliance for the safe and non-interfering operations through the R&TTE Directive (99/5/EC) equipment authorization process, by certification and/or self-certification against the agreed technical standard (e.g., emission limits, frequency, bandwidth, fixed antenna, etc.)
- Potentially restrict the purchase and operation of the devices to a limited class of eligible users
- Ensuring proper installation and operation only at the authorized sites
- Enforcement

6 FREQUENCY AUTHORISATION

If GNSS repeaters are available on the market, there are two options related to rights of use of radio frequencies, as defined in the Authorisation Directive:

- including conditions for usage of radio frequencies in a general authorisation;
- Make the use of such radio frequencies subject to the grant of individual rights of use.

6.1.1 Consideration against general authorisation regime for GNSS repeaters

If CEPT administrations issued general authorisation for GNSS repeaters, this would raise a number of issues:

- Free market circulation and mass-market sales with no individual regulatory control could cause a potential increase in the risk of interference caused to nearby GNSS receiver applications.
- A general authorisation regime could increase the likelihood of an unknown GNSS repeater operating to other legitimate GNSS uses.
- Aviation users are particularly concerned as unknown GNSS repeaters operating close to aircraft could cause errors or stop the aircraft acquiring and tracking GNSS before leaving the an airport gate.
- Government users are also concerned that uncontrolled use of these devices might negate the trust in the use of GNSS and therefore undermine the regulatory basis of any location-based applications.

With these factors in mind, this Report does not recommend general authorisation regime for these devices.

6.1.2 Limitation to professional uses

Within the EU, a licensing process based on general authorisations would allow the free use by any person. However, GNSS repeaters should if possible be subject to additional restrictions on licensing eligibility e.g.

- Government associated agencies, including law enforcement, fire and rescue organizations and the contractors supporting them.
- Companies in the military and civilian aviation industry, including aircraft and avionics manufacturers and relevant maintenance facilities
- Manufacturers of GNSS chipsets and integrators of such chipsets into other equipment
- Manufacturing, production and test facilities where GNSS is an integral part of the finished product
- Operators of indoor parking facilities where emergency services need to continue tracking GNSS where it is otherwise unavailable.

6.1.3 Site licences and implementation

As stated above, licences for GNSS repeaters should ideally be restricted to applications listed above for use of such a device. Any request for licensing should explain that need. The licence should be site specific and provide specific guidance for installation, such as:

- The GNSS repeater transmit antennas should be located as close as possible to the GNSS application's receiving antenna so that the re-radiator can operate at the minimum EIRP level necessary to perform the intended function. It would be preferable to provide RF attenuation or shielding for directions away from the area required for the re-radiated GNSS signals.
- Users should direct any re-radiating antenna away from any large open apertures which would increase signal levels in places accessible by the general public or other GNSS operations
- The repeater design and connections should ensure that it is difficult to include additional amplification above 45 dB.
- Finally, the licensee must take all necessary additional measures to ensure that installed GNSS repeater does not affect the accuracy of GNSS receivers located outside the building, in places accessible by the general public or by other GNSS operations.

7 CONCLUSIONS AND RECOMMENDATIONS

This report considers the regulatory factors of GNSS repeaters and provides some technical and other licensing conditions that could be applied to the operation of GNSS repeaters.

7.1 General technical conclusions

It is suggested that GNSS repeaters should be limited to the bands 1164-1215 MHz, 1215-1300 MHz and 1559-1610 MHz.

The GNSS repeater maximum system gain should also be limited to a value of 45 dB and that the e.i.r.p of any amplified GNSS signal should not exceed -77 dBm. Because the amplified GNSS signal is below the GNSS repeater noise floor, there is no method to measure the GNSS signal level. It is possible to measure and define the GNSS repeater receiver noise floor (abt. -105 dBm) amplified by repeater gain (45 - 48 dB), which now is also the maximum e.i.r.p of GNSS repeater and of the order of -57 - -60 dBm. The maximum output power of the system when subject to non-GNSS input signals should be restricted to - 20 dBm.

That chaining two or more GNSS repeaters to increase overall system gain above +45 dB should be avoided as this would increase the risk of harmful inference to unacceptable levels.

The GNSS repeater should incorporate filtering in accordance with Section 9.4 of ECC Report 129.

7.2 Additional considerations to the authorisation regime

The report concludes that GNSS repeater installations should be for justified needs, such as given in section 6, subject to national considerations.

The report also concludes that any authorisations or licences for GNSS repeater installations should include guidance for reduction and reasonable checking of the potential to cause interference.

The report identifies that other general recommendations related to the authorisation regime may apply such as:

- that installation within airport boundaries may require clearance from the local aviation authorities, even though they might not own the airport.
- Military or other government authorities might impose particular site limitations.

8 RECOMMENDATION

The Report recommends that operation of GNSS repeater devices should be subject to individual licensing and that licence exempt operation should not be permitted.

The Report recommends that administrations should not permit mobile use of GNSS repeater.

The Report recommends specific technical and operating conditions that should be included in any authorisation and guidance given for installation.

ANNEX 1: GNSS REPEATER SCENARIOS

This section outlines scenarios where GNSS repeater has been used and the expected distances for repeater operation. This distance is distinct from, but related to, the protection distance. Given an expected -10 dB difference between the wanted signal and the maximum interference level, the operational distance will be 0.32 times the defined protection distance, based on free-space loss $20 \log(d)$. Industry supplied these scenarios as examples of potential uses.

SCENARIO 1 - SEMICONDUCTOR TEST LAB WHICH UTILISES GNSS AS A TIMING REFERENCE

Lab sizes: about 8 metres square by about 2.5 m high. There is a conventional suspended ceiling and the roof above is tiled with aluminium. The floor is solid concrete. There are four small windows facing south, with internal glass partitions to other rooms on the north side. The building has slightly larger windows on the north side. The sidewalls are brick.

Without the GNSS repeater, the signal strength inside the building is never great enough to allow operation of a GNSS device. The building envelope is a good signal attenuator. This attenuation will apply towards the outside of the building as well, even when the repeater is operating

Expected Operational Distance ~up to 8 metres

SCENARIO 2 - TETRA RADIO TEST LAB IN A CONTROLLED ENVIRONMENT

A lab located in a heavy concrete building of cold war origins with foot thick walls, floors and roof. There is no usable GNSS signal in the lab area. To overcome this, the GNSS signal is distributed on coax around a number of systems within the lab from an outside aerial. This application is the type approval of Tetra hand held radio terminals for use by emergency services and other approved users. Most modern terminals have inbuilt GNSS receivers, with no external antenna connection. It is required to prove this functionality under controlled conditions. It is presently proving to be very difficult, without use of a local GNSS repeater within the lab. Size of the lab is approx 30 m x 10 m.

Expected Operational Distance ~up to 10 metres

SCENARIO 3 - TELEMATICS EQUIPMENT PRODUCTION LINES

Test on ground floor or certainly sky-obscured situations of up to 20 units, at any one time, on soak or intermittent test when new products are introduced.

In this situation, it is obviously advantageous to be able to use a repeater and standard antennas. Given the attenuation of the GNSS signals into the test areas, it is reasonable to expect a similar attenuation of any re-radiated signal to the outside

Expected Operational Distance Unknown – Assumed same as Tetra up to 10 metres.

SCENARIO 4 - TEST AND TYPE APPROVAL OF PRODUCTS WITH GNSS CAPABILITY AT EMC LABS

All tests conducted in a properly designed EMC chamber.

Required Operational Distance Compliance with R&TTE is needed, however no requirement for a an individual authorisation is assumed as system is not free radiating.

SCENARIO 5 - TEST FACILITY FOR GNSS RECEIVERS USED IN OFF-SHORE OIL EXPLORATION

Dimensions of room where re-radiator required (high up in one corner) is 10x10x3 meters. Receivers used are latest hand-held devices so may have newer higher sensitivity type.

Expected Operational Distance ~up to 10 metres

SCENARIO 6 - RADIO TRAINING FACILITIES

Sizes of the classrooms used for training are:

- 10m x 8m
- 12m x 8m
- 15m x 9m
- 20m x 10m

Required Operational Distance ~up to 10 or 20 metres

SCENARIO 7 - TESTING PASSENGER JET GNSS RECEIVERS WHILST IN MAINTENANCE HANGARS

Large passenger aircraft and jets with sometimes multiple GNSS receiving antennas located at different positions on the airframe. A hangar of dimensions 67m x 40m x 15m, with steel roof trusses at a height of around 10m. Minimum coverage of around 3m x 3m in 3 different locations in each hangar.

The aircraft GNSS receivers pick up no GNSS signal when the hangar doors are closed.

Expected Operational Distance ~up to 15m

SCENARIO 8 - IN-CAR GNSS IN A MOVING PRODUCTION LINE ENVIRONMENT

Many new cars are now fitted with GNSS as standard, which needs to be tested in the final stages of production line. Typically, the production line is 200/300m in length and the required GNSS testing area is 30/50m in length. Testing typically needs to be carried out at the minimum signal strength in order to test the performance of the wiring loom from antenna to receiver.

Factories are typically metal structures with a pitched roof at about 15m max above the production area. Cars move under a metal screen to stop random items falling and damaging the car roofs. Two types of repeater systems have been identified – individual antennas or leaky feeders.

An industry view is that a leaky feeder system was the preferred solution along the track. The feasibility of this is unknown. A protection distance limit in this instance would probably be set at 15 metre from any point on the cable, for a leaky feeder system. However, the aggregate power across the total length could exceed expectations and therefore, leaky feeder systems might need to be forbidden, and spot radiating points preferred, and limited to a maximum number at any specific location.

- i) One view from industry was that the required operational distance of ~up to 15 metres, another view was that the Expected operational distance ~up to 30 metres

SCENARIO 9 - OPERATIONAL VEHICLES - CONTINUOUS TRACKING OF GPS GNSS SIGNALS

This requirement comes from a need for a vehicle to have its GPS GNSS receiver readily available with a current position fix, so that when it exits the storage or parking area it can get an immediate position fix. This it often automatically reports back to a central resource management unit. We provide below, an example-building outline.

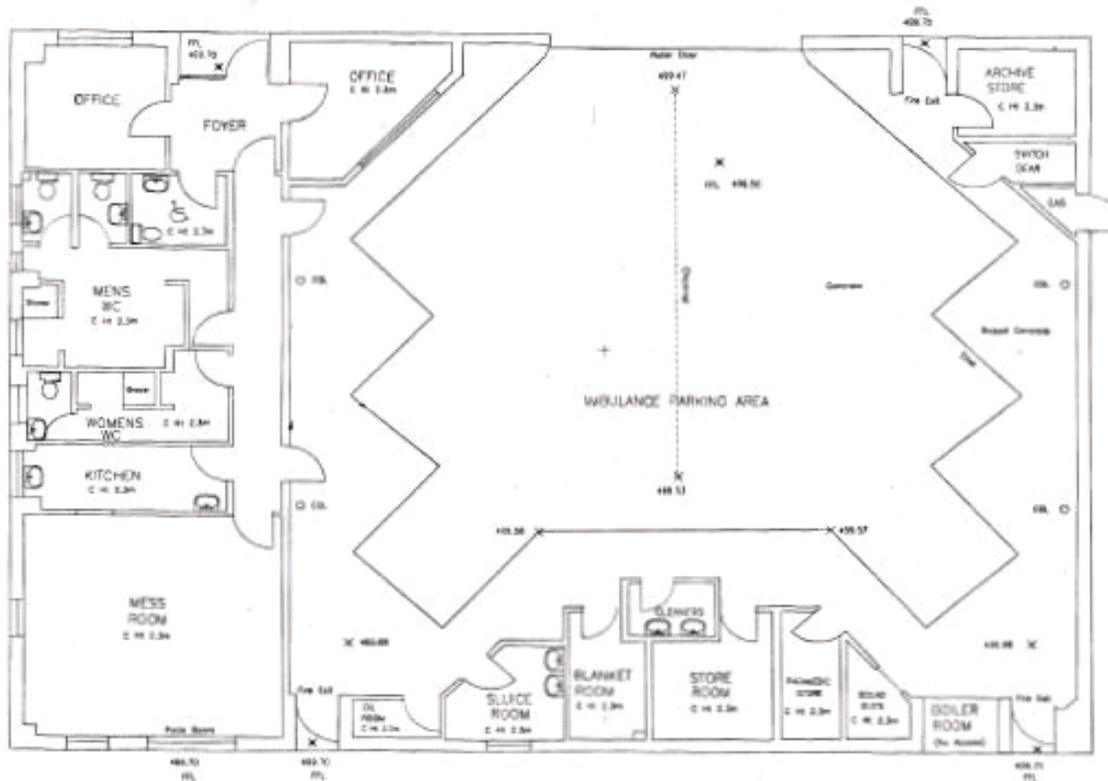


Figure 1: Example Operational vehicle storage location

Required Operational Distance ~up to 15 metres

SCENARIO 10 - USE OF REPEATER IN A MOBILE VEHICLE

This is an application of GNSS repeaters in mobile vehicles to assist in protection of “lone worker” working practises. Staff has body worn GNSS receiver which is updated by a GNSS repeater mounted in the cab of a vehicle, such as an ambulance, to allow a location fix on the staff member when they would otherwise have been out of sight of the satellite constellation.

The risk of mobile use of these devices in an uncoordinated manner will increase potential risks to normal GNSS (GPS) receiver operation.

ANNEX 2: REFERENCES

ECC Report 128	Compatibility studies between pseudolites and services in the frequency bands 1164-1215 MHz, 1215-1300 MHz and 1559-1610 MHz
ECC Report 129	Technical and operational provisions required for the use of GNSS repeaters.
ETSI EN 302 645	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Global Navigation Satellite Systems (GNSS) Repeaters; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive”