

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R M.2091-0 (10/2015)

Methodology to calculate spectrum requirements within the frequency bands 1 545-1 555 MHz (space-to-Earth) and 1 646.5-1 656.5 MHz (Earth-to-space) for aeronautical mobile-satellite (R) service communications related to the priority categories 1 to 6 of Article 44 of the Radio Regulations

M Series
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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R M.2091-0¹

Methodology to calculate spectrum requirements within the frequency bands 1 545-1 555 MHz (space-to-Earth) and 1 646.5-1 656.5 MHz (Earth-to-space) for aeronautical mobile-satellite (R) service communications related to the priority categories 1 to 6 of Article 44 of the Radio Regulations

(2015)

Scope

This Recommendation provides a methodology to calculate aeronautical mobile-satellite (R) service spectrum requirements within the frequency bands 1 545-1 555 MHz (space-to-Earth) and 1 646.5-1 656.5 MHz (Earth-to-space). It is intended to be used to quantify the spectrum requirements related to the AMS(R)S priority categories 1 to 6 of RR Article 44, for which the provisions of Resolution 222 (Rev.WRC-12) apply.

Keywords

AMS(R)S; spectrum requirements; priority communications; methodology

Abbreviations/Glossary

AES	Aircraft Earth Station. As defined in RR No. 1.84 an AES is a mobile earth station in the aeronautical mobile satellite service located on board an aircraft
AES Count:	Number of actually operating AESs within the specified area of the satellite network and logged on to that satellite network under consideration in a defined period, in a particular area/beam. Note that the AES count should include only those AES which are expected to make use of the satellite network
AMS(R)S	Aeronautical Mobile-Satellite (route) Service. As defined in RR No. 1.36, the AMS(R)S is an aeronautical mobile-satellite service reserved for communications relating to safety and regularity of flights, primarily along national or international civil air routes
AOC	Aeronautical Operational Control. AOC describes communications required for the exercise of authority over the initiation, continuation, diversion or termination of flight for safety, regularity and efficiency reasons
ATS	Air Traffic Service; ATS is a generic term meaning variously, flight information service, alerting service, air traffic advisory services, air traffic control service (area control service, approach control service or aerodrome control service)
CS	Circuit Switched
Erlang	A unit of traffic intensity. It is a dimensionless quantity expressing voice activity in units of time that would be seen in during some time interval, typically an hour. It is used to determine the number of circuits needed to satisfy circuit voice demand

¹ The Russian Federation had objected to the adoption of this Recommendation for the reasons indicated in the report of the SG 4 Chairman to RA-15, and declares that this Recommendation will be applied only among operators providing services relating to the transmission of AMS(R)S traffic with priorities 1-6 of RR Article 44, contentious issues regarding the determination of spectrum requirements being resolved among the operators.

FEC	Forward Error Correction
GES	Ground Earth Station. The GES is the earth station used for the feeder links of the AMS(R)S system. This is equivalent to an aeronautical earth station, as defined in RR No. 1.82
IP	Internet Protocol
ISDN	Integrated Services Digital Network

Related ITU Recommendations, Reports

Recommendation ITU-R M.1037-0	Bit error performance objectives for aeronautical mobile-satellite (R) service (AMS(R)S) radio link
Recommendation ITU-R M.1089-1	Technical considerations for the coordination of mobile-satellite systems relating to the aeronautical mobile satellite (R) service (AMS(R)S) in the bands 1 545 to 1 555 MHz and 1 646.5 to 1 656.5 MHz
Recommendation ITU-R M.1180-0	Availability of communication circuits in the aeronautical mobile-satellite (R) services (AMS(R)S)

The ITU Radiocommunication Assembly,

considering

- a) that, in the frequency bands 1 525-1 559 MHz (space-to-Earth) and 1 626.5-1 660.5 MHz (Earth-to-space), geostationary mobile-satellite system operators currently use a capacity-planning approach at regional multilateral coordination meetings, under arrangements agreed between their administrations, to periodically coordinate access to the spectrum needed to accommodate their requirements, including the spectrum requirements of the AMS(R)S providing transmission of messages with priority 1 to 6 in RR Article 44;
- b) that the methodologies should first and foremost provide accurate results avoiding overestimation or underestimation of spectrum needs, should reflect as closely as possible the algorithms actually employed by the satellite system under study and should provide a simple, efficient and quick means for determining spectrum requirements;
- c) that only AMS(R)S priority communications 1 through 6 per RR Article 44 supported by the satellite system beam under study should be included in these methodologies to determine the spectrum requirements;
- d) that the methodologies should support the present AMS(R)S environment but take into consideration changes to the environment during the target period, including commencement of new AMS(R)S networks operation, changes in service offerings for the air traffic service (ATS) and aeronautical operational control (AOC), traffic, aircraft equipment, and technology;
- e) that the methodologies should account for the characteristics of the aircraft equipment and the satellite network, and should consider only the services and transmission capabilities afforded by the communication equipment deployed on the aircraft, the ground earth station (GES) and satellite under study;
- f) that the methodologies should avoid double counting of the bandwidth accommodating the communication traffic in areas with overlapping satellite network coverage;
- g) that the information provided for each AMS(R)S satellite network, to be used as input parameters to the methodologies, should, to the extent possible, be independently verifiable;

h) that parameters used in the methodologies should have clear and adequate definition and/or description, as appropriate, avoiding the risk of misinterpretation, to ensure proper determination of AMS(R)S spectrum requirements priority communications 1 through 6 per RR Article **44** associated to each satellite beam;

i) that the methodologies should account for only that portion of the AMS(R)S client's airspace in which satellite communications would be employed such as by excluding airspace corresponding to areas in which VHF and HF communications are employed,

further considering

a) that spectrum needs of an AMS(R)S satellite network with multiple spot beams should be determined to the level of spectrum needs of each spot beam;

b) that proper measures should be taken into consideration where an AMS(R)S satellite system is capable of dynamically configuring its satellite network resources;

c) that proper measures should be taken into consideration where an AMS(R)S satellite network is capable of and support voice compression and/or data compression,

recognizing

a) that WRC-97 allocated the frequency bands 1 525-1 559 MHz (space-to-Earth) and 1 626.5-1 660.5 MHz (Earth-to-space) to the MSS to facilitate the assignment of spectrum to multiple MSS networks in a flexible and efficient manner;

b) that WRC-97 adopted RR No. **5.357A** giving priority to the accommodation of the spectrum requirements for the AMS(R)S providing transmission of messages with priority categories 1 to 6 in RR Article **44** in the frequency bands 1 545-1 555 MHz and 1 646.5-1 656.5 MHz;

c) that Resolution **222 (Rev.WRC-12)** relates to the use of the frequency bands 1 525-1 559 MHz and 1 626.5-1 660.5 MHz by the mobile-satellite service, and procedures to ensure long-term spectrum access for the aeronautical mobile-satellite (R) service;

d) that Resolution **422 (WRC-12)** invites ITU-R to conduct studies on, and develop in one or more ITU-R Recommendations, a methodology, including clear definitions of input parameters and assumptions to be used, to calculate spectrum requirements within the frequency bands 1 545-1 555 MHz (space-to-Earth) and 1 646.5-1 656.5 MHz (Earth-to-space) for AMS(R)S communications related to the priority categories 1 to 6 of RR Article **44**;

e) that systems providing broadband safety services have been developed, and are being considered by ICAO for incorporation into the aviation standards,

noting

a) that AMS(R)S systems are an essential element of the International Civil Aviation Organization standardized communications infrastructure used in air traffic management for the provision of safety and regularity of flight in civil aviation;

b) that, since spectrum resources are limited, there is a need to use them in the most efficient manner within and amongst various MSS networks,

recommends

1 that within the frequency bands 1 545-1 555 MHz (space-to-Earth) and 1 646.5-1 656.5 MHz (Earth-to-space), the spectrum requirements for AMS(R)S communications related to the priority categories 1 to 6 of RR Article **44** to be assigned by bilateral or multilateral

frequency coordination meetings under Resolution **222 (Rev.WRC-12)** should be calculated using the methodology described in Annex 1;

2 that, when the methodology contained in Annex 1 is agreed to be used during a frequency coordination meeting, the participants to this meeting should also agree on arrangements regarding the input parameters required to use the methodology;

3 that, since relevant historical information for new AMS(R)S systems would not be available in advance of the commencement of their operation, established AMS(R)S operators should make available, in a timely manner, at frequency coordination meetings the relevant historical information applicable to the service area of the new AMS(R)S operator, required to determine spectrum requirements for the first year of operation of new systems, using the methodology contained in Annex 1;

4 that any ambiguity in specific parameters of the methodology contained in Annex 1 (e.g. whether messages are related to the priority categories 1 to 6 of RR Article **44**) should be resolved with mutual agreement on assumptions;

5 that any alternative methodologies to determine the spectrum requirements for AMS(R)S communications related to the priority categories 1 to 6 of RR Article **44** to be assigned by bilateral or multilateral frequency coordination meetings under Resolution **222 (Rev.WRC-12)** should be based on the principles and guidelines contained in *considering b) to i)* and *further considering a) to c)*.

Annex 1

Method of calculation of spectrum requirements for the AMS(R)S communications in the 1.5/1.6 GHz bands

1 General

1.1 Introduction

Through RR No. **5.357A**, priority shall be given to accommodating the spectrum requirements of the AMS(R)S satellite networks providing transmission of messages with priority 1 to 6 in RR Article **44**. This Annex contains a methodology which may be used to determine the AMS(R)S spectrum requirements per beam per satellite for AMS(R)S communications.

It should be noted that VHF air/ground/air links are used regularly to provide aeronautical communications services where available but for areas beyond line of sight (BLOS), designated HF channels or satellite communications must be employed. This methodology is intended for calculation of AMS(R)S spectrum requirements for areas where VHF links would not be available.

The methodology described in this Annex is based on the following steps:

- 1) determination of the number of AESs ("AES Count") within a beam;
- 2) calculation of the information volume generated by these AESs for each of a number of different voice and data carrier types;
- 3) calculation of the spectrum requirements for various types of carrier in each beam.

The methodology also includes steps for the calculation of the total AMS(R)S spectrum requirements for a network.

For the established networks, a methodology based on historical traffic records should provide the most accurate results. Also, where historical information is available, the average traffic per aircraft within each satellite beam can be estimated from call and data records. This allows any geographic variability in the average traffic per aircraft to be readily estimated. In addition, since relevant historical information for new AMS(R)S systems would not be available in advance of commencement of their operation, established AMS(R)S operators should make available, in a timely manner, at frequency coordination meetings the relevant historical information applicable to the service area of the new AMS(R)S operator, required to determine spectrum requirements for the first year of operation of new systems, using the methodology contained in this Annex 1.

The procedures in this Annex for the calculation of the spectrum requirements of the AMS(R)S communications are illustrated in the flow chart of Fig. 1.

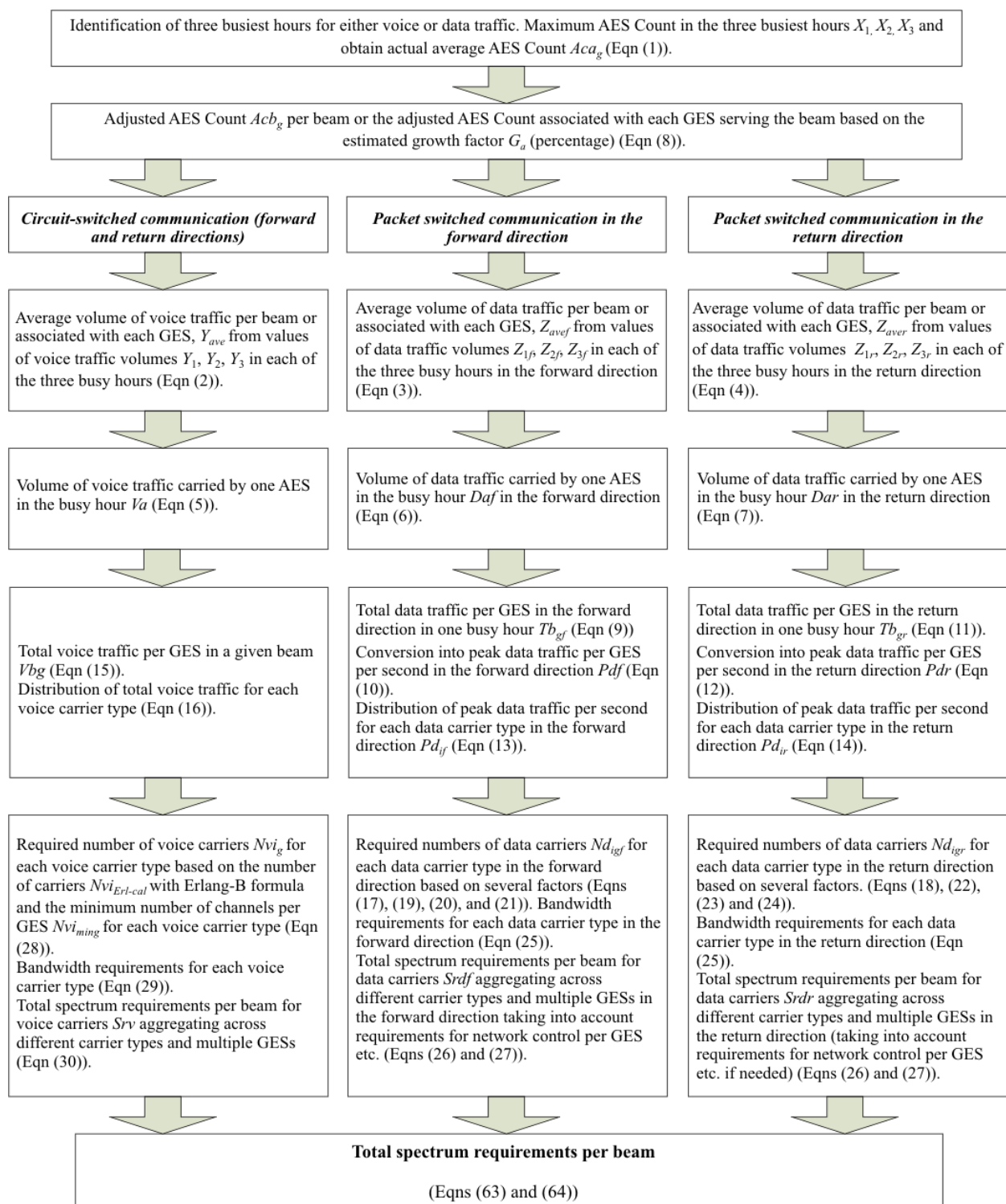
It is generally necessary to determine the spectrum requirements considering a particular time period when traffic is expected to be at its highest. Typically, traffic is assessed for the busy hour of a day and, if there is significant day-to-day variation, it may be necessary to consider the traffic expected on the busiest day of the year.

Calculations are based on the input information of total data/voice traffic of the AMS(R)S communications for all aircraft earth stations (AESs) which are actually operating AMS(R)S applications within the specified service area of the satellite network under consideration.

In some satellite networks, there can be more than one ground earth station (GES) providing AMS(R)S services in a given service link beam. As the service link carriers typically cannot be shared by the GESs, in such a case it is necessary to determine traffic and spectrum requirements of each GES separately. In this case, it is important that the AES count associated with each GES includes only those AESs which operate via that GES.

The total spectrum requirements for a beam served by multiple GESs are determined by summing up the calculated spectrum requirements of the GESs serving that beam.

FIGURE 1

Flowchart illustrating general method to calculate AMS(R)S spectrum requirements

M.2091-01

1.2 Parameters

The following notation is used in the parameter names for the hierarchy and suffixes, for the most part:

- Ground earth station – “*g*”
- Airspace or service area – “*a*”
- Beam for spectrum calculation – “*b*”
- Type of traffic – data: “*d*”; voice: “*v*”; circuit switched voice: “*CS-voice*”; circuit switched ISDN: “*CS-ISDN*”; standard IP: “*StdIP*”; streaming IP: “*StrIP*”
- Requirements or capacity for a specific carrier – “*c*”
- Type of carrier – voice carrier type: “*j*”; data carrier type: “*d*”; circuit switched voice sub-carrier type or circuit switched ISDN sub-carrier type: “*j*”; standard IP sub carrier type or streaming IP sub-carrier type: “*k*”
- Forward and return link – “*f*”, or “*r*”.

The parameters used in the methodology in Annex 1 are shown in Attachment 1.

2 Estimation of AES count and volume of information per AES to be handled with the satellite system under consideration

From an operational and economical point of view, it is generally desired that normal traffic in a wide area be handled by the global beam, and high traffic in congested airspace be handled by spot beams. The advantage of the global beam is that it covers areas that would otherwise not be covered by the spot beams. In a typical deployment scenario a cluster of spot beams may be activated to serve aircraft along the high traffic air routes with the outlying aircraft served by the global beam. Although it is possible for the global beam to provide many of the same services as the spot beams the global beam is likely to be used additionally for broadcast messages, signalling, and logging aircraft on to the network. The spacecraft design may include the adoption of spot beams to provide services where it is more spectrally efficient or power efficient to do so. It is important to know how many AESs are being served by spot beams and global beams during the peak period. As discussed above, the number of AESs (AES Count) within a specified beam to be handled within the satellite system under consideration should be determined. The AES Count is defined as number of actually operating AESs within the specified area of the satellite network and logged on to that satellite network under consideration within a given period and in a particular area/beam. Note that the AES Count should include only those AES which are expected to make use of the satellite network.

The AES Count is a fundamental parameter required for the estimation of the spectrum requirement for the AMS(R)S communications. The approach used to determine this number is based on the assumption that historical data for the total number of logged-on AESs within each beam of the AMS(R)S system within the three highest busy hour periods in a given year is available, and estimates of future requirements may be made based on this historical data, with a suitable adjustment to account for increasing or decreasing demand in the future.

This approach is applicable to established systems and should provide the most accurate estimate of AMS(R)S spectrum requirements.

An AMS(R)S system may consist of several GSO satellites, which may have overlapping beams in some areas. The spectrum requirements are determined separately for each beam within each satellite, and in areas of overlap there is a risk that AESs are double-counted, i.e. assigned to two satellites at the same time. Hence, when determining the AES Count in areas of overlapping

coverage, it is necessary to ensure that the number of AESs is suitably apportioned between the satellites. Such consideration does not apply to situations where one satellite is a backup or hot-standby satellite.

The traffic data for both circuit switched traffic and the packet switched data traffic is typically processed on an hourly basis based on the raw call data records. In such a case, it is possible to gather the following information on an hourly basis for each calendar day of any given month.

- Satellite network/associated GES
- Beam: Global/spot within the satellite
- Calendar day
- Hour (0-23 hours) (NOTE – 1st hour recorded as “0 hour”, 24th hour recorded as “23rd hour”)
- AES identification number communicated with satellite network/associated GES
- Time of start and end of the communication.

The following should also be used to estimate the volume of traffic information, where the traffic consists of the user information and does not include the overheads associated with transmission of the information:

- Traffic unit (kbit/s for packet switched data traffic (forward and return directions) and minutes for circuit switched traffic).
- Volume of traffic (kbit/s or mins).

Based on the above information it is possible to identify three busy hours within a given year for each category of voice and packet data traffic in each beam of satellite network by analysing the call records gathered in the GES serving such a beam. There are occasions where a beam could be served by more than one GES, in which case the busy hour traffic should be determined separately for each GES. Having identified the three busy hours, the AES Count is determined for each of those busy hours and the average value of the AES Count for those three busy hours is used in the further analysis. These steps are undertaken separately for the voice and data traffic so that two values for the AES Count are determined—one applicable to voice traffic and the other applicable to the data traffic. An underlying assumption here is that there is not a significant difference in volume of traffic associated with each of the three busy hours.

The actual average AES Count per beam associated with a given GES is obtained from the following equation:

$$ACa_g = (X_1 + X_2 + X_3)/3 \quad (1)$$

where X_1 , X_2 and X_3 are the number of AESs in each of the three busy hours generating either the highest voice or data traffic in a given year.

Average volume of voice traffic per GES in a given beam in the busy hour:

$$Y_{ave} = (Y_1 + Y_2 + Y_3)/3 \quad (2)$$

where Y_1 , Y_2 and Y_3 are the values of voice traffic volume in each of the three busy hours corresponding to X_1 , X_2 and X_3 .

For the established AMS(R)S satellite networks it is possible to obtain the data traffic information volumes separately in the forward and return directions from the historical traffic data.

The average volume of data traffic per GES in a given beam in the busy hour in the forward direction is given by:

$$Z_{avef} = (Z_{1f} + Z_{2f} + Z_{3f})/3 \quad (3)$$