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Radiocommunication Sector of ITU

Recommendation ITU-R SA.1018-1

(07/2017)

Hypothetical reference system for networks/systems comprising data relay satellites in the geostationary orbit and their user spacecraft in low-Earth orbits

SA Series

Space applications and meteorology

International Telecommunication Union

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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 SA.1018-1

Hypothetical reference system for networks/systems comprising data relay satellites in the geostationary orbit and their user spacecraft in low-Earth orbits

(Question ITU-R 117/7)

(1994-2017)

Scope

This Recommendation provides architecture and characterization of a hypothetical reference system for network/systems comprising data relay satellites.

Keywords

DRS, space-to-Earth, Earth-to-space, space-to-space, forward feeder link, return feeder link

Related ITU-R Recommendations and Reports

Recommendations ITU-R SA.510, ITU-R SA.1019, ITU-R SA.1155, ITU-R SA.1274, ITU-R SA.1275, ITU-R SA.1276, ITU-R SA.1414.

The ITU Radiocommunication Assembly,

considering

a) that communications between the ground and low-orbiting spacecraft and launch vehicles used for space research, Earth exploration and other purposes is essential;

b) that such communications may be required to be continuous or near continuous;

c) that such communications may be required while the spacecraft are passing over specific points on the Earth's surface;

d) that a land-based station has only limited visibility of a low-orbiting spacecraft;

e) that available land-based stations are only able to cover limited portions of any low orbit;

f) that it is not economically or practically feasible to extend networks of land-based stations to provide full or more complete coverage;

g) that a data relay satellite (DRS) in geostationary orbit can provide communications between a single earth station and a low-orbiting spacecraft for more than one-half of its orbit (see description in Annex);

h) that two such DRSs, suitably located in geostationary orbit, with a wide separation angle, can provide communications between two co-located earth stations and a low-orbiting spacecraft almost continuously, with the exception only of a zone of exclusion (ZOE), above the part of the Earth opposite to these earth stations;

i) that two such DRSs, suitably placed in geostationary orbit, can provide fully-continuous coverage between two separate earth stations and a low-orbiting spacecraft;

j) that a DRS system comprising two DRSs can serve several user spacecraft simultaneously, and many more user spacecraft by means of time-sharing;

k) that a DRS system can also serve additional earth stations, either both transmitting and receiving or only receiving signals from user spacecraft;

l) that a DRS must be capable of supporting at least four distinct links:

– an Earth-to-space link in the forward direction, from the earth station to the data relay satellite (known as the uplink or the forward feeder link);

– a space-to-space link in the forward direction, from the data relay satellite to the low orbit spacecraft (known as the forward inter-orbit link);

– a space-to-space link in the return direction, from the low orbit spacecraft to the data relay satellite (known as the return inter-orbit link); and

– a space-to-Earth link in the return direction, from the data relay satellite to the earth station (known as the downlink or the return feeder link);

m) that, for these four links, four separate frequency bands are required, with a guard band between the signals transmitted from and those received by the data relay satellite,

recommends

1 that a hypothetical reference system for data relay satellite network/systems (as shown in Fig. 1) should consist of:

1.1 an Earth-to-space link in the forward direction, from the earth station to the data relay satellite (the forward feeder link); a DRS system can also serve additional earth stations (B1 and B2), either both transmitting and receiving or only receiving signals from user spacecraft;

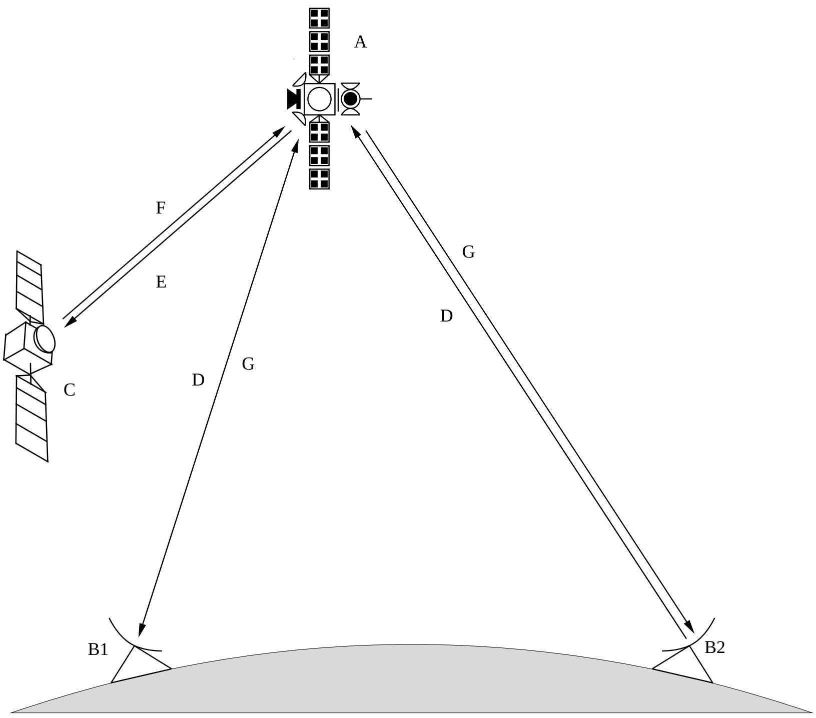
1.2 a space-to-space link in the forward direction, from the data relay satellite to the low-orbiting spacecraft (the forward inter-orbit link);

1.3 a space-to-space link in the return direction, from low-orbiting spacecraft to the data relay satellite (the return inter-orbit link); and

1.4 a space-to-Earth link in the return direction, from the data relay satellite to the earth station (the return feeder link); a DRS system can also serve additional earth stations (B1 and B2), either both transmitting and receiving or only receiving signals from user spacecraft;

FIGURE 1

Hypothetical reference system for data relay satellite network/systems



A: Data relay satellite (DRS)
B1, B2: DRS earth stations using different frequencies
C: DRS user spacecraft
D: Forward feeder link
E: Forward inter-orbit link (IOL)
F: Return inter-orbit link (IOL)
G: Return feeder link

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2 in the forward direction, the input to the circuit should correspond to the input of the earth station modulator carrying out the translation from the baseband to the radio frequency carrier and the output should:

2.1 for the case of a demodulating receiver on board the user spacecraft, correspond to the output of the demodulator on board the user satellite, or

2.2 for the case of a repeater on board the user spacecraft, correspond to the output of the earth station demodulator receiving the return feeder link signal;

3 in the return direction, the input to the circuit should correspond to the input of the user spacecraft modulator carrying out the translation from the baseband to the radio-frequency carrier and the output should correspond to the output of the earth station demodulator carrying out the reverse operation;

4 that links between earth stations and the operations, data processing or other earth-based centres should not be included in this hypothetical reference system.

Annex

1 Introduction

Communication between the ground and low-Earth orbiting spacecraft and launch vehicles used for space research, Earth exploration and other purposes is essential. Such communications may be required to be continuous or near-continuous, or may be required while the spacecraft are passing over specific points on the Earth's surface. Land based earth stations have only a limited visibility and existing stations are only capable of covering a portion of any low-Earth orbit. Moreover, it is not economically or practically feasible to extend networks of land-based stations to provide full or more complete coverage of the low-Earth orbits. In contrast, a data relay satellite (DRS) system including one or more DRS satellites in geostationary orbit has substantially larger visibility of the low-Earth orbits used by these satellites than existing land-based earth stations, and can therefore provide significantly enhanced coverage.

A single DRS satellite in geostationary orbit can provide communications between an earth station and a low-orbiting spacecraft for more than one-half of its orbit. Two such DRSs, suitably located in geostationary orbit, with a wide separation angle, can provide communications between two co-located earth stations and a low-orbiting spacecraft almost continuously, with the exception only of a zone of exclusion (ZOE), above the part of the Earth opposite to these earth stations. Moreover; two such DRSs, suitably placed in geostationary orbit, can provide fully-continuous coverage between two separate earth stations and a low-orbiting spacecraft. A DRS system can also serve additional earth stations, either both transmitting and receiving or only receiving signals from user spacecraft.

2 Description of the data relay satellite network/system

A DRS consists of one or more DRS spacecraft in geostationary orbit and one or more DRS earth stations. The system relays information between the earth station(s) and DRS users, which can include low-Earth orbiting spacecraft, launch vehicles, and even ground based or aeronautical platforms. A DRS system must be capable of supporting at least four distinct links:

– an Earth-to-space link in the forward direction, from the earth station to the data relay satellite (known as the uplink or the forward feeder link);
– a space-to-space link in the forward direction, from the data relay satellite to the low orbit spacecraft (known as the forward inter-orbit link);
– a space-to-space link in the return direction, from the low orbit spacecraft to the data relay satellite (known as the return inter-orbit link); and
– a space-to-Earth link in the return direction, from the data relay satellite to the earth station (known as the downlink or the return feeder link).

In the forward direction, the input to the DRS system reference architecture corresponds to the baseband data provided at the input of the DRS earth station modulator which modulates the feeder uplink carrier.

This baseband data typically consists of command data and (in the case of manned missions) voice and video information. It is provided to the DRS earth station over an external interface (landline communication, RF terrestrial link, etc.) by the Mission Operations Control Center (MOCC) responsible for the user spacecraft. Note that the MOCC and the external interface to the DRS earth station are not part of the reference architecture.

For the case of a demodulating receiver on board the user spacecraft, the output of the DRS system reference architecture in the forward direction corresponds to the output of the demodulator on board the user satellite. For the case of a repeater on board the user spacecraft, it corresponds to the output of the earth station demodulator receiving the return feeder link signal.

In the return direction, the input to the DRS reference architecture corresponds to the input of the user spacecraft modulator carrying out the translation from the baseband to the radio-frequency carrier. This baseband data typically consists of real-time and/or recorded scientific data, or for manned missions, voice and video information. The output of the reference architecture corresponds to the output of the earth station demodulator carrying out the reverse operation.