Communicating with SRS and EESS Satellites

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No. 1.51 - **Earth exploration-satellite service (EESS):** A radiocommunication service between earth stations and one or more space stations, which may include links between space stations, in which:

- information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, is obtained from active sensors or passive sensors on Earth satellites;
- similar information is collected from airborne or Earth-based platforms;
- such information may be distributed to earth stations within the system concerned;
- platform interrogation may be included.

This service may also include feeder links necessary for its operation.

No. 1.55 - **space research service (SRS):** A radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes

No. 1.177 - **deep space:** Space at distances from the Earth equal to, or greater than, $2 \times 10^6$ km

No. 1.184 - **orbit:** The path, relative to a specified frame of reference, described by the centre of mass of a satellite or other object in space subjected primarily to natural forces, mainly the force of gravity
ITU-R Publications

- Space Research Communications Handbook
- Earth Exploration-Satellite Service Handbook
- SA series: 54 Recommendations and 15 Reports

Some selected ITU-R SA Recommendations:

**SRS Related:**
SA.364 - Preferred frequencies and bandwidths for manned and unmanned near-Earth research satellites
SA.609 - Protection criteria for radiocommunication links for manned and unmanned near-Earth research satellites
SA.1019 - Preferred frequency bands and transmission directions for data relay satellite systems
SA.1154 - Provisions to protect the space research (SR), space operations (SO) and Earth exploration-satellite services (EESS) and to facilitate sharing with the mobile service in the 2 025-2 110 MHz and 2 200-2 290 MHz bands
SA.1155 - Protection criteria related to the operation of data relay satellite systems
SA.1414 - Characteristics of data relay satellite systems

**EESS Related:**
SA.514 - Interference criteria for command and data transmission systems operating in the Earth exploration-satellite and meteorological-satellite services
SA.1024 - Necessary bandwidths and preferred frequency bands for data transmission from Earth exploration satellites (not including meteorological satellites)
SA.1162 - Performance criteria for service links in data collection and platform location systems in the Earth exploration- and meteorological-satellite services
SA.1163 - Interference criteria for service links in data collection systems in the Earth exploration-satellite and meteorological-satellite services
SA.1627 - Telecommunication requirements and characteristics of EESS and MetSat service systems for data collection and platform location
SRS and EESS Communications Spectrum Use

Representative SRS and EESS Communication Spectrum Use (100 MHz – 100 GHz)
Purpose of SRS and EESS Communications

- **Transfer of scientific data** from spacecraft to earth station
- Rendezvous and docking operations with co-orbiting vehicles for cargo or personnel transfers
- **Telemetry data, tracking data and commands (TT&C)**
  - Data to/from spacecraft (s/c) to the mission ground system
  - Location of the spacecraft, its movement and direction
  - Commonly transmitted over the SRS/EESS communication links (use of single radio saves weight/power)
- **Extra-vehicular activity (EVA)** - manned spacewalks conducted outside of habitat, either in orbit or on the surface of a planet.
- **Emergency communications** – humans/spacecraft
- **Science use of the communication system**
- **Manned vehicles** have additional audio and video requirements

Minimize spacecraft communications resources ➢ maximize throughput
Communication Links

- **Telemetry and Science data**
  - *Return Link* – spacecraft to ground (can be through relays).
  - *Downlink or Direct to Earth (DTE)* – Direct connection from spacecraft to ground.

- **Commanding and Software uploads**
  - *Forward Link* - Send information to the spacecraft from the ground (can be through relays)
  - *Uplink or Direct From Earth (DFE)* – Direct connection ground to spacecraft

**Telemetry** – ‘Measurement at a distance’ – commonly refers to non-science data.
**Command** – Instructions sent to the spacecraft (DRS commands on uplink).
**Sequence** – A set of commands with information about when and what to execute.
SRS and EESS Orbits
Circular

Most frequent orbit-type used for both SRS and EESS missions

- **Low Earth Orbit (LEO)** approximately 200 – 2,000 km orbit altitude
- **Medium Earth Orbit (MEO)** approximately 1,000 km to GEO
  - MEO is referred to as intermediate circular orbit (ICO)
- **Geostationary Orbit (GEO)** = 35,786 km
- **High Earth Orbit (HEO)** > GEO
**SRS and EESS Orbits**

**Other Types**

- **Polar orbits** are circular orbits with inclinations near 90°
  - **Sun-synchronous orbits**: the satellite ascends or descends over a fixed point with respect to the sun

- **Elliptical orbits** are characterized by having one portion of the orbit close to the Earth (a small perigee and a large apogee)

**Halo orbits** are orbits about an equilibrium point (Lagrange) between two celestial bodies
Single Earth Station - Support Limits

Can only support small fraction of spacecraft orbit

- Many orbits go unsupported or have very limited support.
- Options: Data Loss, Store and forward, Cross-support or DRS
Major Earth Station Sites for Near Earth Missions

- **McMurdo Ground Station**
  - McMurdo Base, Antarctica

- **Wallops Ground Station**
  - Wallops, Virginia

- **Kongsberg Satellite Services**
  - Svalbard, Norway

- **USN Australia**
  - Dongara, Australia

- **USN Alaska (1)**
  - Poker Flat, Alaska

- **USN Alaska (2)**
  - North Pole, Alaska

- **Partner Station: NOAA CDA Station**
  - Gilmore Creek, Alaska

- **University of Chile**
  - Santiago, Chile

- **Merritt Island Launch Annex**
  - Merritt Island, Florida

- **USN Hawaii Station**
  - South Point, Hawaii

- **USN Alaska (2)**
  - North Pole, Alaska

- **Swedish Space Corp. (SSC)**
  - Kiruna, Sweden

- **German Space Agency (DLR)**
  - Weilheim, Germany

- **Satellite Applications Center**
  - Hartebeesthoek, Africa

- **White Sands Complex**
  - White Sands, New Mexico

- **Alaska Satellite Facility**
  - Fairbanks, Alaska

- **McMurdo Ground Station**
  - McMurdo Base, Antarctica
Data Relay Satellite

Provide communications, data relay, and tracking services for Low Earth Orbiting (LEO) satellites, Human Space Flight, Space Shuttle, ISS, Expendable Launch Vehicles (ELV), and Scientific Customers.

Data Relay Satellites (DRS) provide a radio relay platform located in space.
Data Relay Satellite Systems

186° 189° 190° 200° 221°

281° 298°

311° 314° 316° 319°

328° 344° 348°

10.6° 16.4° 16.8°

21.5° 47° 59°

77° 80° 85° 89° 90.75° 95°

113° 121° 133°

160° 171° 176.8° 177.5°
Anatomy of a Data Relay Satellite (notional)

**Forward (FWD):** link from DRS Ground Station through DRS to Spacecraft

**Return (RTN):** link from Spacecraft through DRS to DRS Ground Station

**Communications and tracking functions:**
- 2025-2110 MHz FWD
- 2200-2290 MHz RTN
- 22.55-23.55 GHz FWD
- 25.5-27 GHz RTN

**4.9 meter shaped reflector assembly**
- Two axis gimbaling

**Multiple Access Antenna**
- 30 helices:
  - 12 diplexers for transmit
  - 30 receive body mounted
- Single commanded beam, transmit
- 20 adapted beams for receive
- Ground implemented receive function

**Space-to-Ground-Link Antenna**
- DRS downlink
- 2.0 meter parabolic reflector
- Two axis gimbaled

**Space-to-Space Access Antenna**
- Omni Antenna and Solar Sail
  - 2025-2110 MHz FWD
  - 2200-2290 MHz RTN

**Solar array for Power**

**Solar array for Power**

**2025-2110 MHz FWD**

**2200-2290 MHz RTN**

**22.55-23.55 GHz FWD**

**25.5-27 GHz RTN**
Near Earth SRS Satellites have Many Missions
Remote Sensing Satellites
The World Now has Capability to Study the Earth as a System with the aid of Satellites
Questions