

# Communicating with SRS and EESS Satellites

Bradford A. Kaufman (USA)

Deputy Director, NASA Spectrum Policy  
and Planning

Chairman ITU-R WP 7B

# Definitions



**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)

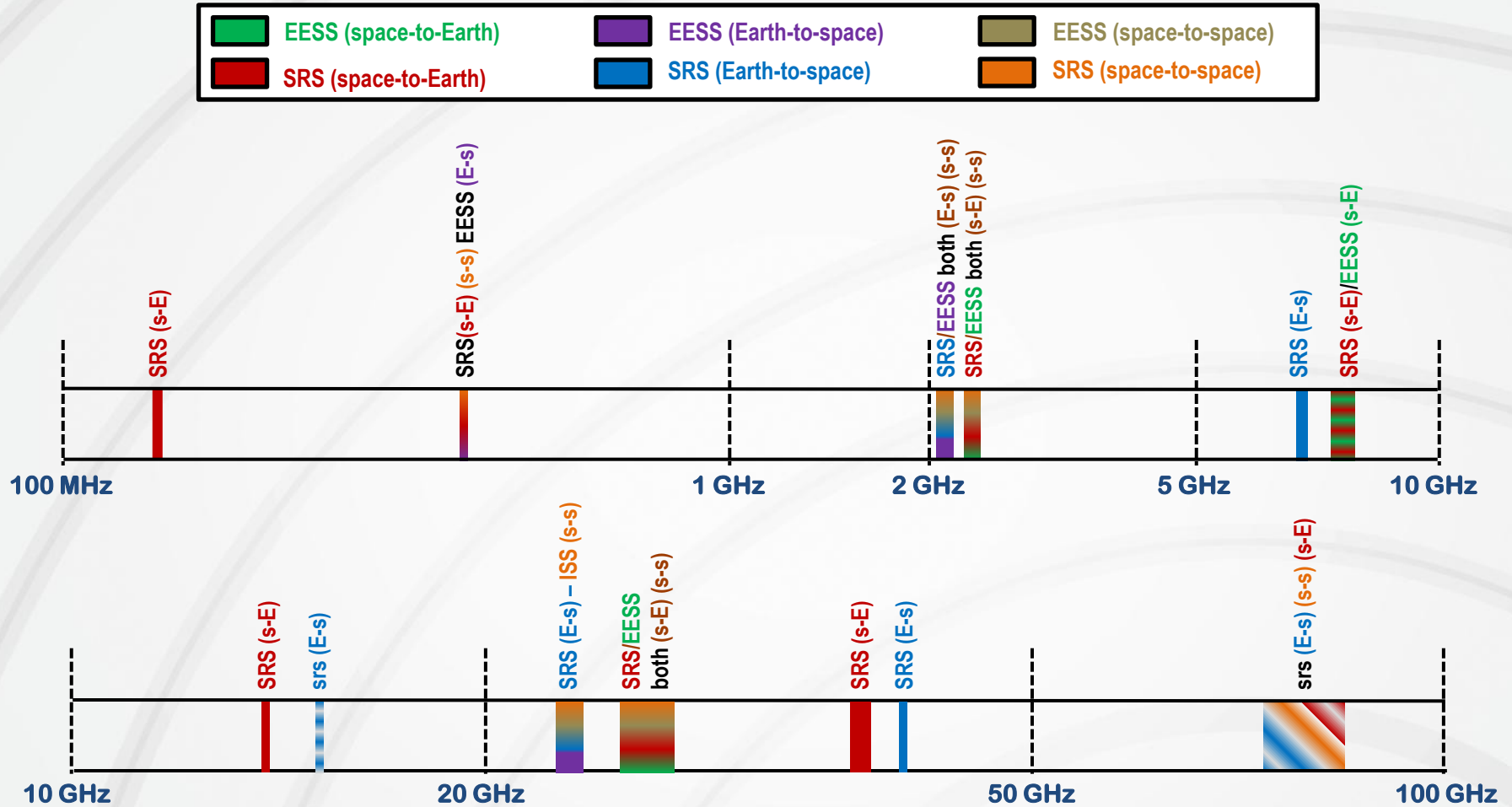
**SA.1162** - Performance criteria for service links in data collection and platform location systems in the Earth exploration- and meteorological-satellite services

**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

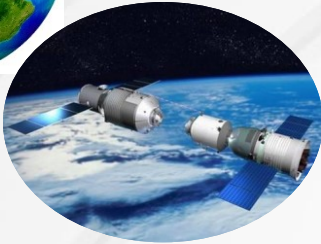
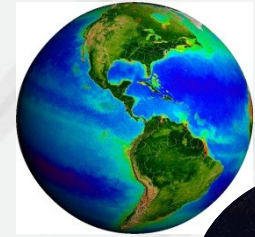


# SRS and EESS Communications Spectrum Use



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

# Purpose of SRS and EESS Communications



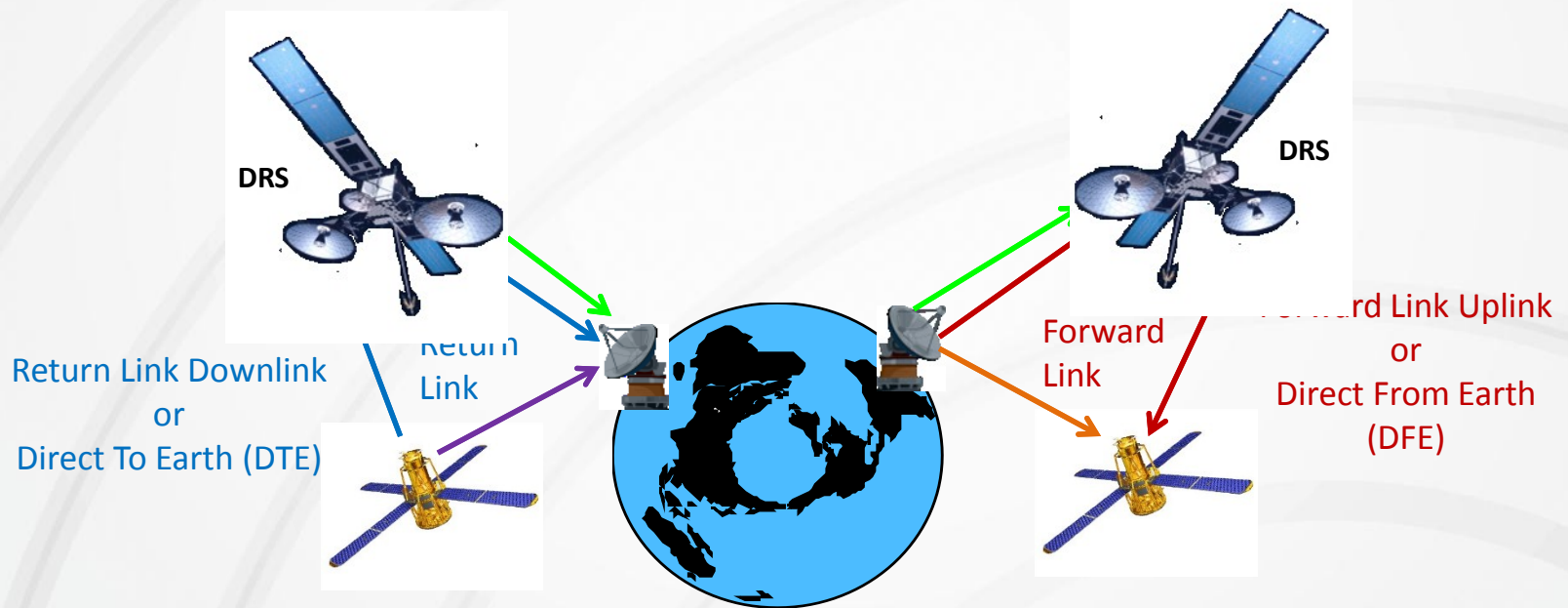
- **Transfer of scientific data** from spacecraft to earth station
- Rendezvous and docking operations with co-orbiting vehicles for cargo or personnel transfers
- **Telemetry data, tracking data and commands (TT&C)**
  - Data to/from spacecraft (s/c) to the mission ground system
  - Location of the 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).

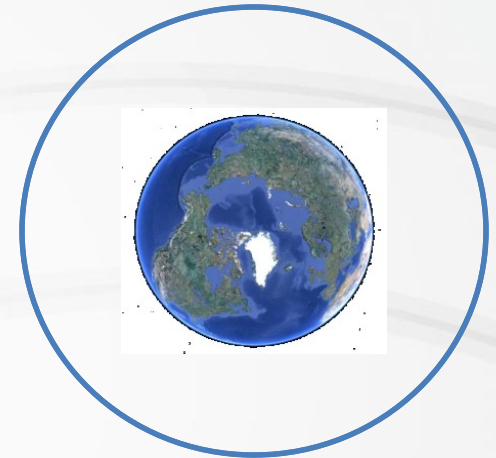
**Sequence** – A set of commands with information about when and what to execute.

# SRS and EESS Orbits

## Circular

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

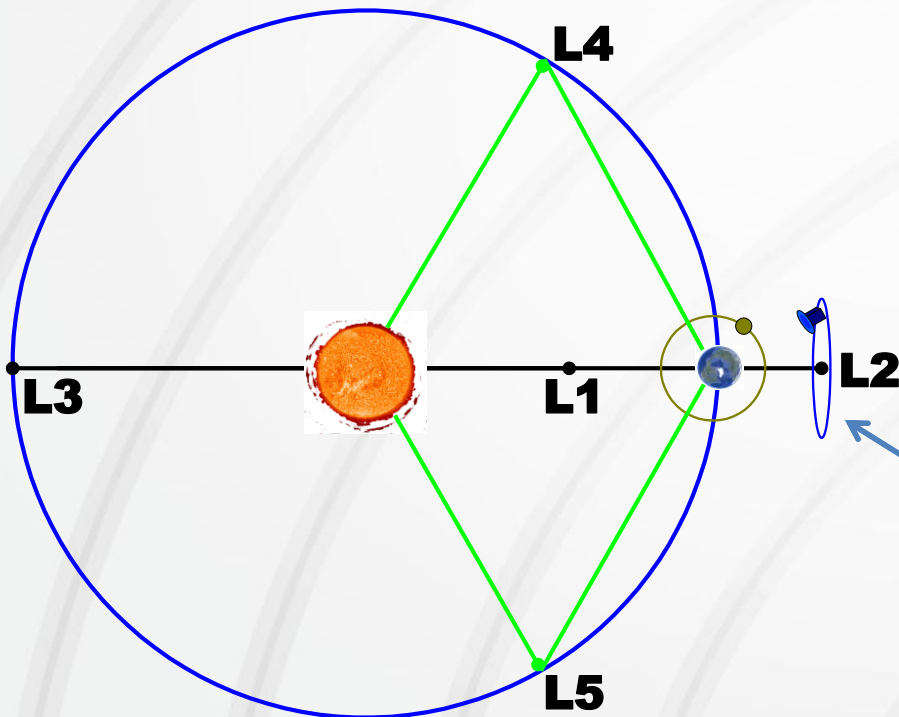
- **Low Earth Orbit (LEO)** approximately 200 – 2,000 km orbit altitude
- **Medium Earth Orbit (MEO)** approximately 1,000 km to GEO
  - MEO is referred to as intermediate circular orbit (ICO)
- **Geostationary Orbit (GEO)** = 35,786 km
- **High Earth Orbit (HEO)** > GEO



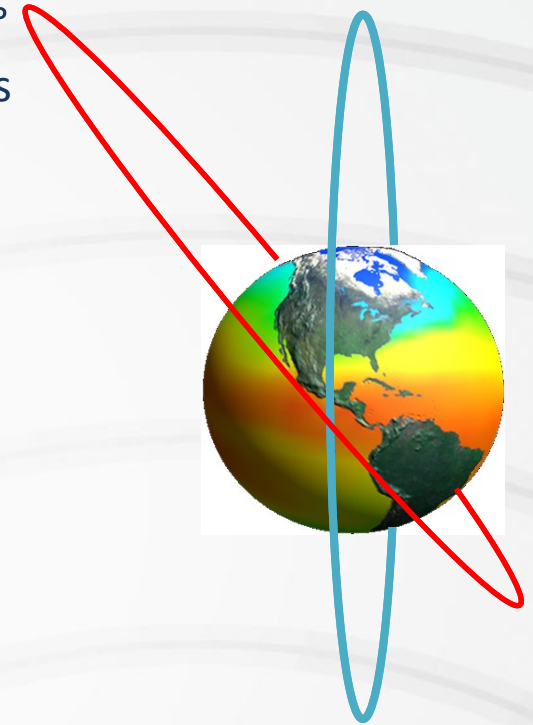
# SRS and EESS Orbits

## Other Types

- **Polar orbits** are circular orbits with inclinations near  $90^\circ$ 
  - **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)

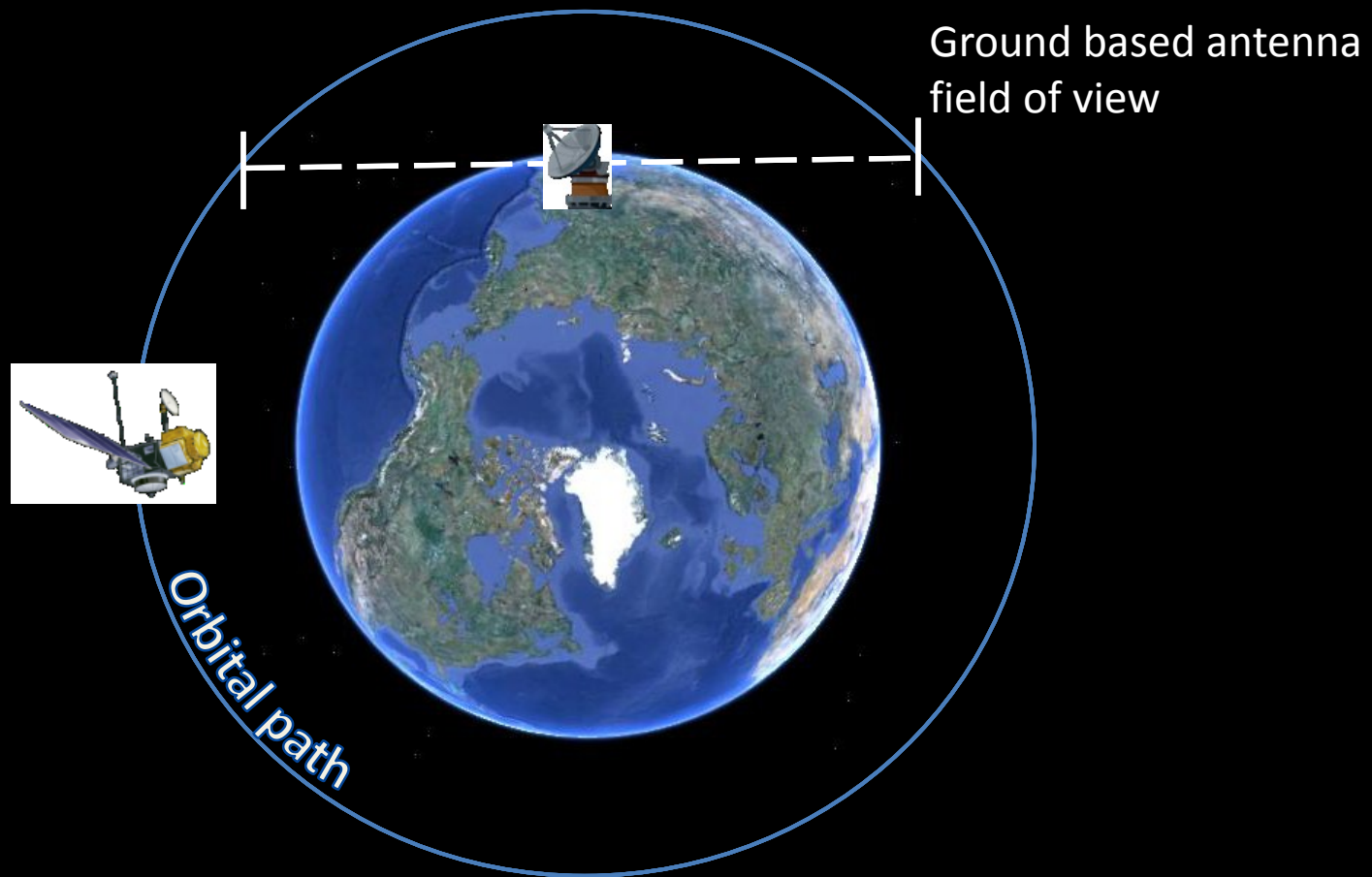


**Halo orbits** are orbits about an equilibrium point (Lagrange) between two celestial bodies





# 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

**Alaska Satellite Facility**  
Fairbanks, Alaska



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



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



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



**Kongsberg Satellite Services**  
Svalbard, Norway



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



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



**USN Australia**  
Dongara, Australia



**Satellite Applications Center**  
Hartebeesthoek, Africa



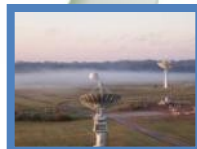
**White Sands Complex**  
White Sands, New Mexico



**USN Hawaii Station**  
South Point, Hawaii



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



**Wallops Ground Station**  
Wallops, Virginia



**University of Chile**  
Santiago, Chile

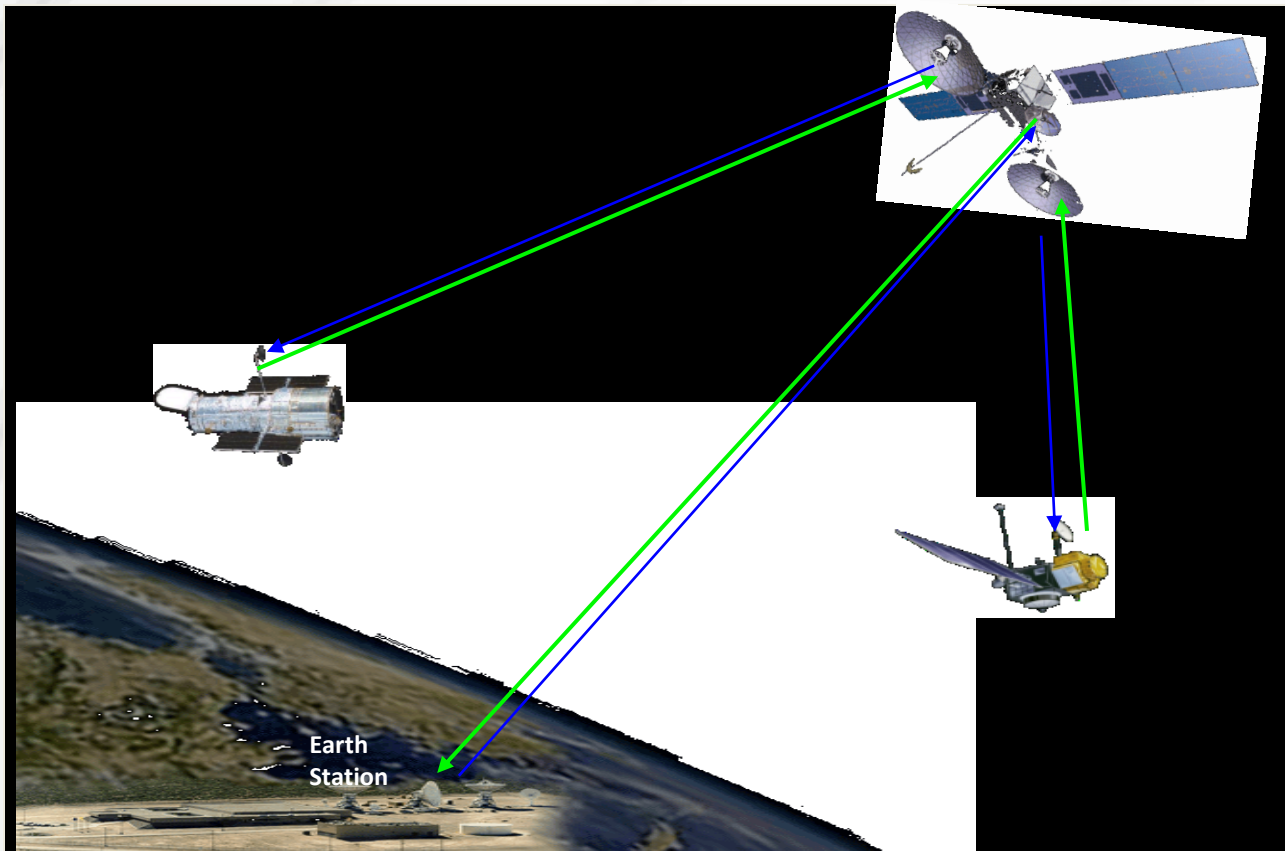


**McMurdo Ground Station**  
McMurdo Base, Antarctica



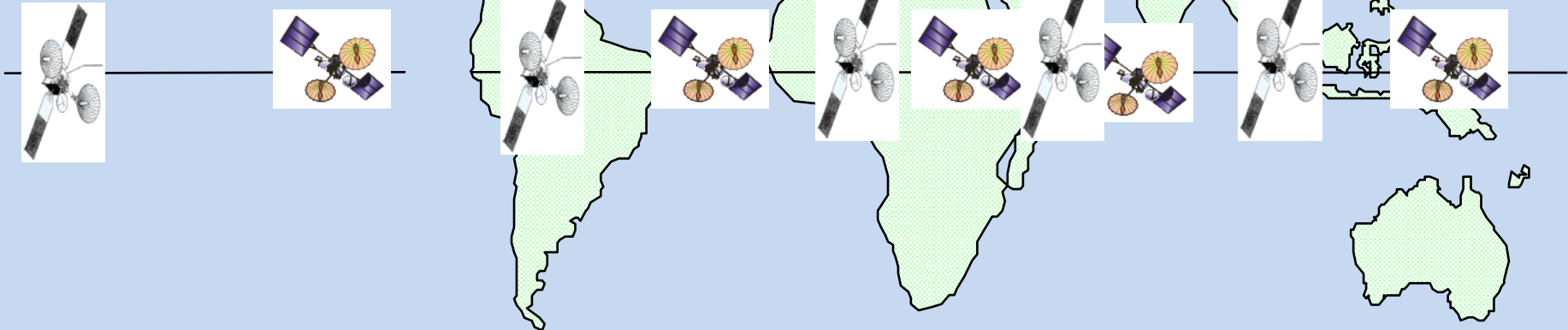
# Data Relay Satellite

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

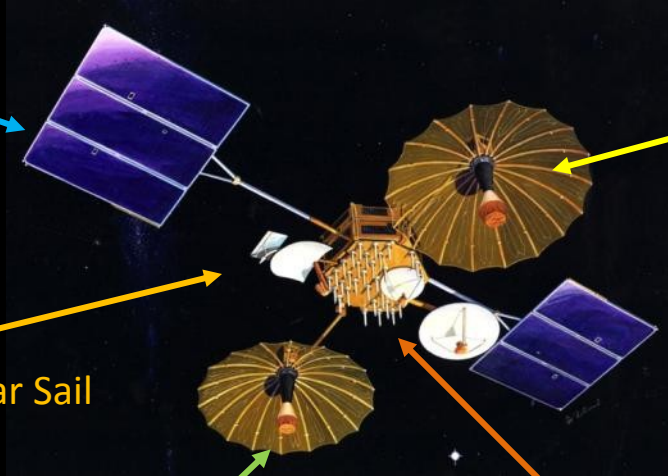
# Data Relay Satellite Systems



186°	281°	311°	328°	10.6°	21.5°	47°	77°	113°	160°
189°	298°	314°	344°	16.4°		59°	80°	121°	171°
190°		316°	348°	16.8°			85°	133°	176.8°
200°		319°					89°		177.5°
221°							90.75°		
							95°		

# Anatomy of a Data Relay Satellite (notional)

Solar array for  
Power



**Omni Antenna and Solar Sail**

2025-2110 MHz FWD  
2200-2290 MHz RTN

**Space-to-Space Access Antenna**  
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

**Space-to-Ground-Link Antenna**

DRS downlink  
2.0 meter parabolic reflector  
Two axis gimbaled

**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

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

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

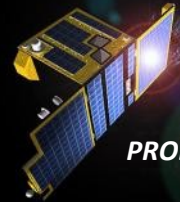
# Near Earth SRS Satellites have Many Missions



*RHESI*



*SAMPEX*



*PROBA*



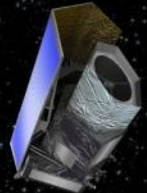
*HST*



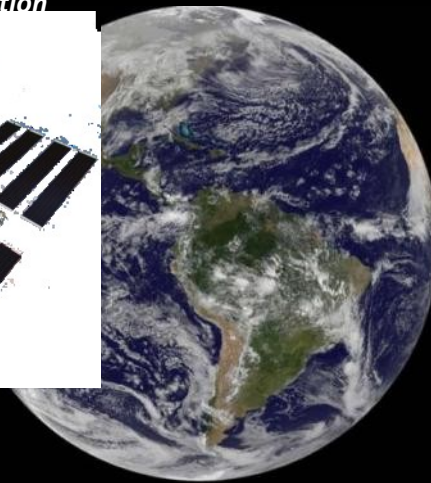
*International Space Station*



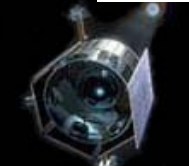
*Suzaku*



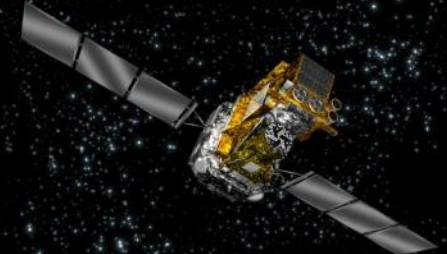
*EUCLID*



*GRAIL*

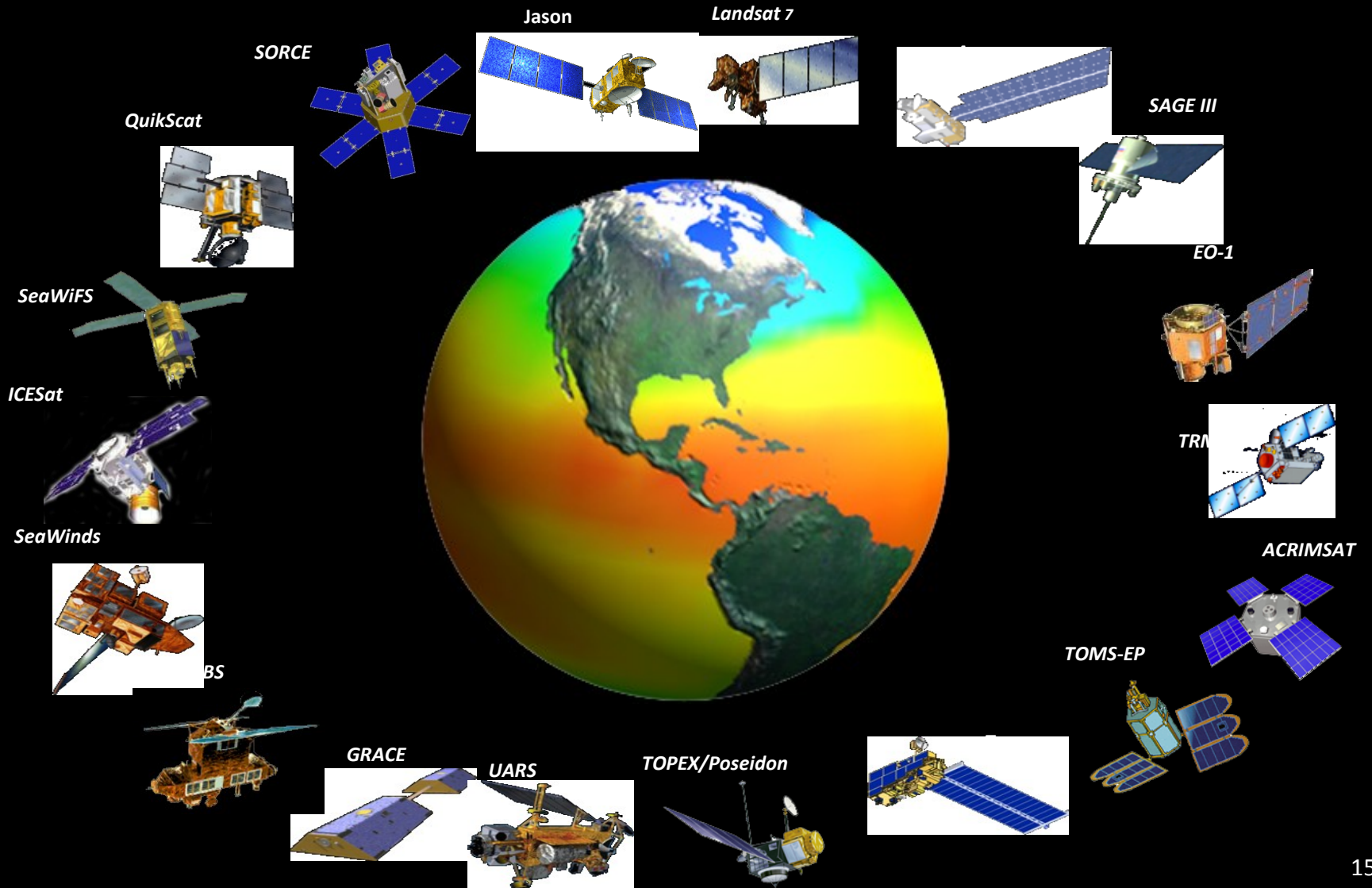


*LCROSS: Moon*



*INTEGRAL*

# Remote Sensing Satellites



# Importance of Satellite Science Data



The World Now has Capability to Study the Earth as a System with the aid of Satellites



**Questions**