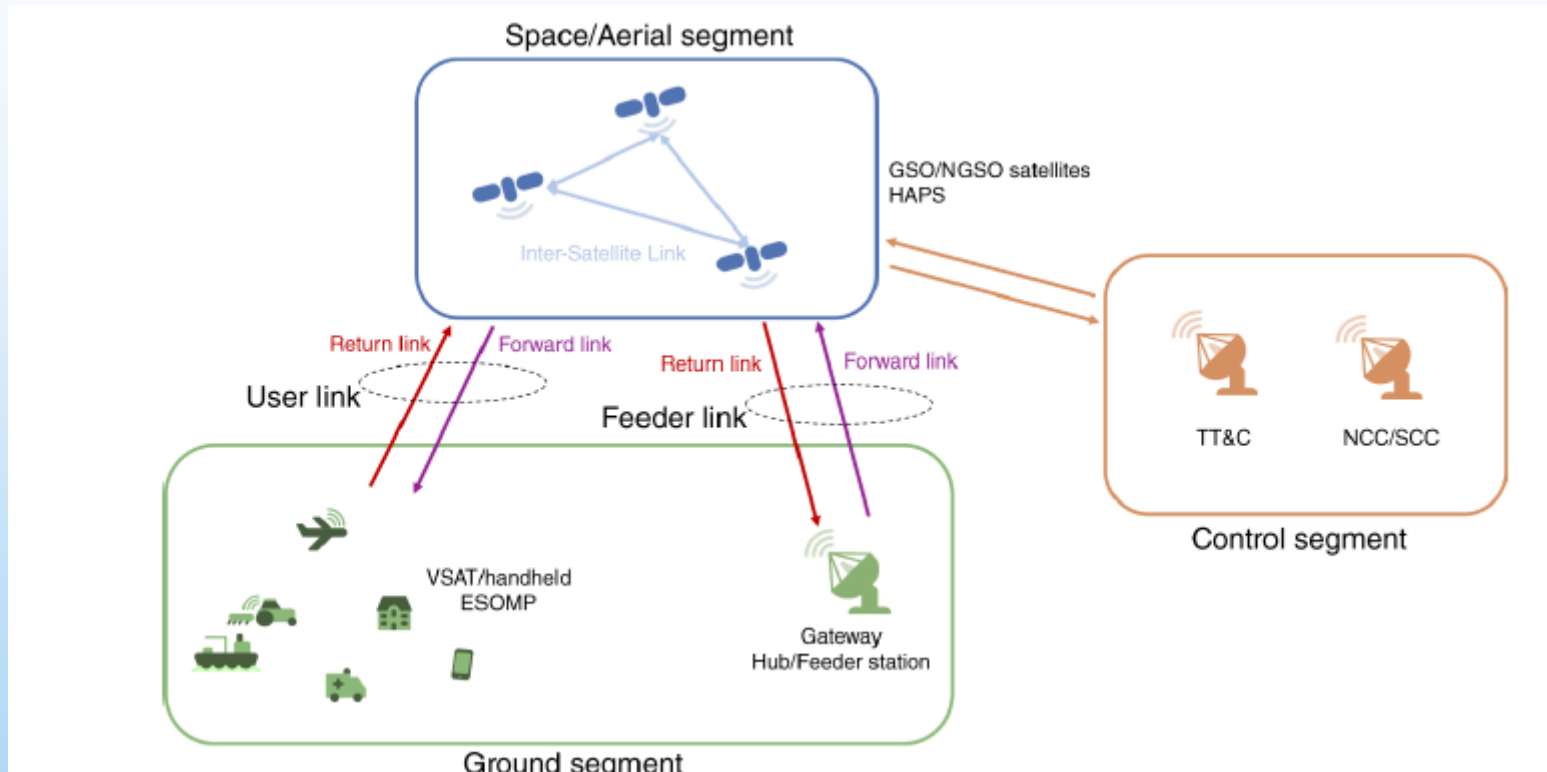# Elements of a Satellite Communications System

Elements

- Elements of Satellite Network

- Alessandro Vanelli-Coralli, Nicolas Chuberre, Gino Masini, Alessandro Guidotti, Mohamed El Jaafari, "5G Non-Terrestrial Networks: Technologies, Standards, and System Design", Wiley-IEEE Press, 2024

Segments and Links

- Telecommunications satellites and Non Terrestial Networks (NTN) provide an information transfer service (telephony, radio broadcasting, TV broadcasting, data transmission, ...) via links between satellite and Earth station (space wave), between two satellites (intersatellite link), or via double Earth station-satellite and satellite-Earth station links (satellite radio link).

- As shown in the figure, a Satellite Communications system is composed of several segments:
  - The Space/Aerial segment.
  - The Control segment.
  - The Ground segment.

- The communication links in the NTN can be classified as follows:
  - The User Link.
  - The Feeder Link.
  - The Inter-Satellite Links (ISL).

The Space/Aerial segment

- The Space/Aerial segment includes one or more satellites/High-Altitude Platform Stations (HAPS).

- More precisely, the space segment includes one or more satellites, while the aerial segment, if present, includes the HAPS.

- The satellites in the space segment are typically organized in a constellation orbiting around the earth.

- The network elements in the space segment perform all the communication functions in the sky. Each element in the space/aerial segment includes:
  - a payload, consisting of the receiving/transmitting antennas and all the electronic equipment supporting the telecommunications operations;
  - a platform, consisting all of the subsystems allowing the payload to perform its operations.

- The payload can further be classified as
  - transparent, acting as a radio repeater by implementing filtering, frequency conversion, and amplification operations;
  - regenerative, when the satellites/HAPS are equipped with an On-Board Processor (OBP) that allows to perform advanced operations, including modulation/demodulation and error control.

Transparent vs Regenerative

- The advantage of the transparent architecture is the independency on the radio waveform, so any amendments in other segments do not require changes in the spaceborne station. The disadvantages are the amplification of noise because the satellite does not perform any channel equalization or noise cancellation, the vulnerability against jamming attacks and the lack of ISL connections for traffic steering.

- The advantage of the regenerative architecture is the reduction of latency. However, buffer management, link control or retransmissions need to be implemented in the regenerative mode satellite and this increases the complexity aspect.

The Ground segment

- The Ground Segment, consisting of all of the Earth stations communicating with each other through the services provided by the space/aerial and control segments. These stations include:

  - the user terminals, which, depending on their size and characteristics, can be Very Small Aperture Terminals (VSAT), handheld terminals, or Earth Station on Moving Platform (ESOMP);

  - hub/feeder stations, collecting and distributing the information to/from the other user terminals;

  - gateways (GW), which provide the connectivity between the user terminals and the terrestrial infrastructure.

The Control segment

- The Control Segment, which is composed of all of the on-ground elements aimed at monitoring and tracking the elements in the space/aerial segments and at guaranteeing the proper functioning of the overall system.

- This segment may include

  – Telemetry Tracking and Control (TT&C), which tracks the position of the satellite(s)/HAPS(s) and telemeters and commands the on-board functions.

  – NTN Control Center (NCC) or System Control Center (SCC), which performs several operations, including the user configuration management, capacity management, channel allocation, and user access management.