Maximize contact availability of smallsat clusters through MSPA technique on GSaaS

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The Mission

Launch date: 07 November 2021

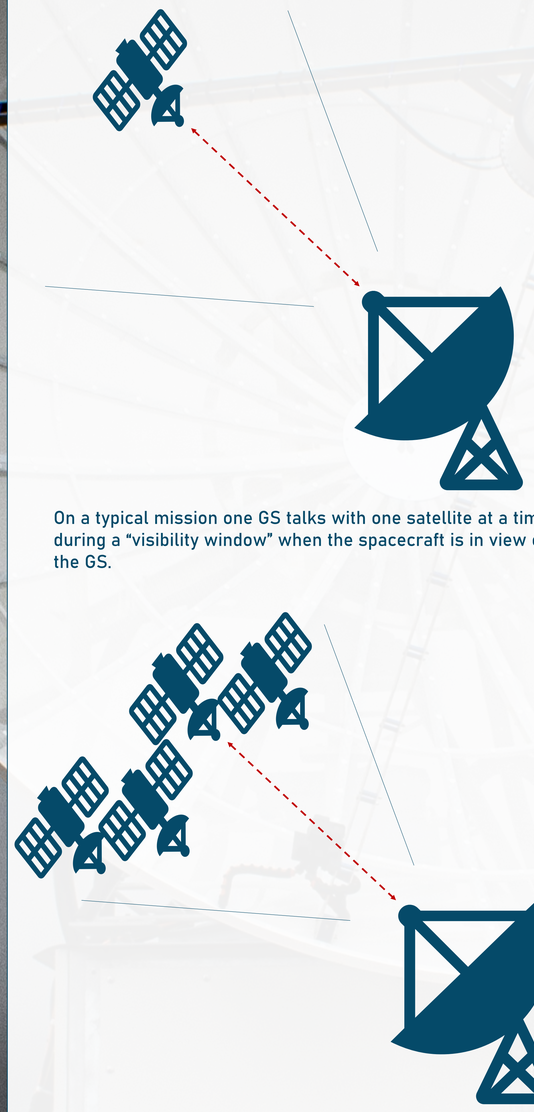
Mission name: KSM1 (Kleos Scouting Mission)
Satellites names: KSM1-A, KSM1-B, KSM1-C, KSM1-D
NORAD-ID: 46912, 46914, 46906, 46907
Application: RF Reconnaissance and Geospatial Intelligence

Mission characteristics:
Kleos Space SA (KSS) Scouting Mission (KSM) first cluster of spacecraft, was launched on the 7th of Novemeber 2021, comprising four 6U cubesat flying in a close formation. The formation maintains the along and across track distance between the four spacecraft, enabling KSS proprietary algorithms to geolocate Radio Frequency transmitters.

GSaaS:

- Leaf Space provides communication through their Leaf Line GSaaS (Ground Segment as-a-Service) with stations in Italy and Spain supporting the mission with UHF

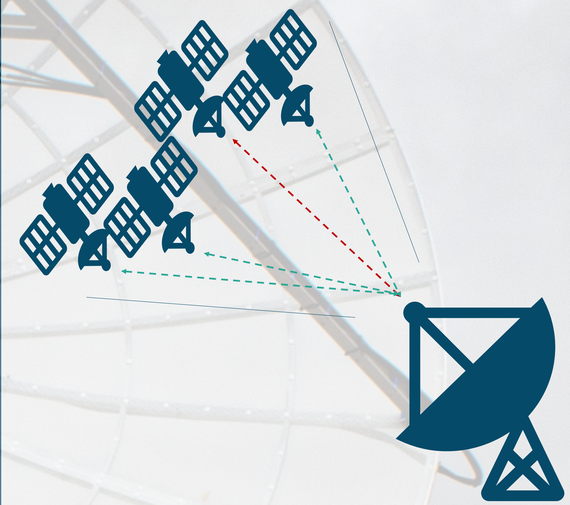
The Challenge



On a typical mission one GS talks with one satellite at a time during a “visibility window” when the spacecraft is in view of the GS.

Spacecraft clusters allow multiple Ground Station contacts in the same cluster visibility window, i.e. more than one spacecraft is in the field of view of the antenna. With standard operations one visibility window can be used to communicate with just one spacecraft, thus reducing the total communication availability for the overall cluster by a factor of four (assuming same GS capacity).

The Solution



Leaf Space supports the KSM1 through the multi-mission Ground Station as a Service (GSaaS) network solution called Leaf Line. The GSaaS exploits the opportunity to maximize the contact time with each spacecraft of the cluster using the Multi Spacecraft Per Aperture (MSPA) technique.

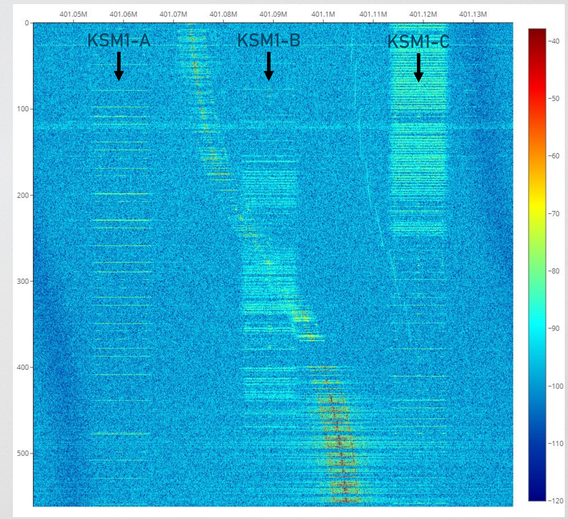
The novel MSPA technique employed by Leaf Space exploits the flexibility provided by the Software Defined Radio (SDR) employed in Leaf Line for rapid reconfiguration (~200 ms) of the uplink and downlink parameters without employing several dedicated modems for each channel. Therefore the satellite operator can seamlessly change through dedicated API the communication configuration (i.e. centre frequency, modcods etc) whenever it is needed always in an automated way without direct interaction with Ground Segment Operators.

In this way, the operations are more effective and the total availability of contact windows with the cluster is similar to the single-satellite case, assuring a high data throughput and higher responsiveness.

Results & Next Steps

Starting from the first available pass after deployment from the launch vehicle, contact has been established with all spacecrafts during the same visibility window, enabling an efficient Launch and Early Operations Phase (LEOP) and optimizing the use of Ground Station access time.
The technique has been used successfully since several months now, providing efficient and effective access to the KSM1 cluster for TT&C communication.

Here after a waterfall plot of a visibility window over one Leaf Line GS is shown. The signals of three satellites are clearly visible, the fourth signal is outside of the reception bandwidth.



Leaf Space is working with Kleos Space in order to apply the same technique also to higher frequency bands like S-Band, where the narrower beamwidth of the antenna make the process more complicated.

The same approach can be applied for X-Band payload downlink, where in this case simoultaneous reception of multiple spacecraft is possible since it is only related to reception. Then increasing the downlinked data amount fourfold employing the same Ground Station Network capacity.

Simultaneous S-Band and X-Band cluster downloads will be tested during the Kleos Space SA Scouting Follow-on (KSF) Mission scheduled to be launched in June 2021 to be integrated as part of nominal operations.