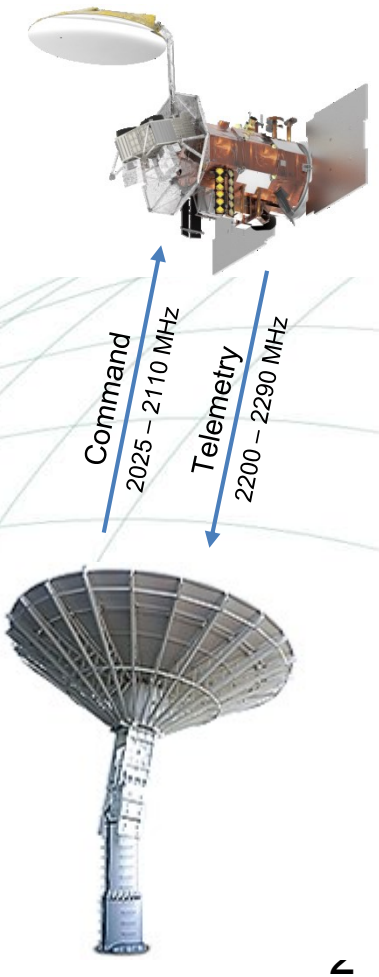
K/Ka Band for Space Operation Services, Pros and Cons

ITU International Satellite Symposium 2017
Ing. Hernan Sineiro

Spacecraft Operation

Historically the S-Band was used for LEO satellite tracking, telemetry and command in spacecraft operation

Allocation to services		
Region 1	**Region 2**	**Region 3**
2 025-2 110	SPACE OPERATION (Earth-to-space) (space-to-space) EARTH EXPLORATION-SATELLITE (Earth-to-space) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (Earth-to-space) (space-to-space) 5.392	
2 200-2 290	SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392	



This band is the most used band for spacecraft operation today

With the LEO satellite applications in continuous expansion and the increase growing of fixed and mobile services (IMT) this band will start to be crowded

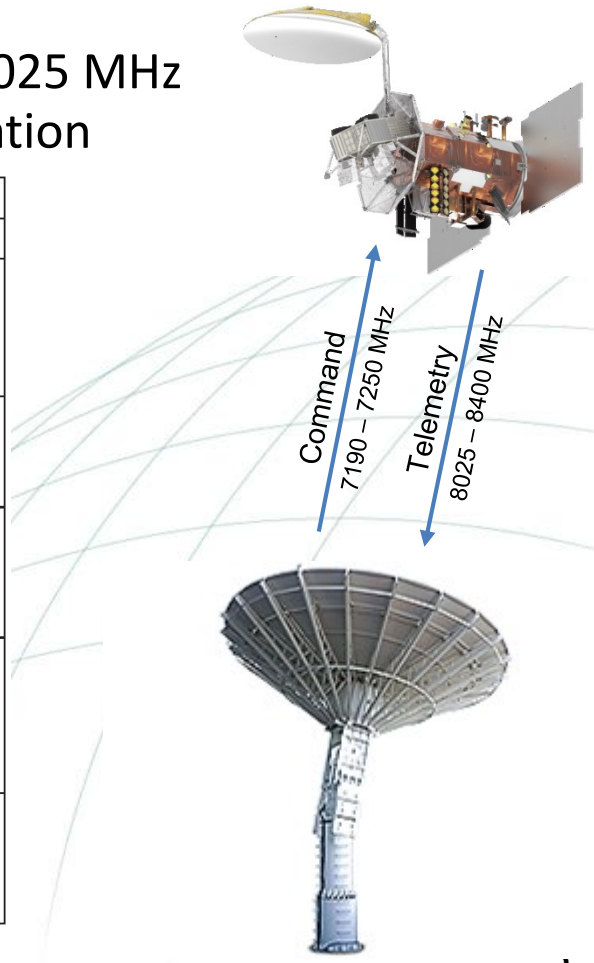
Huge effort is done by the SFCG & ITU through the administrations in WRCs to protect these bands

Spacecraft Operation

Under this scenario after several studies and discussions in the past WRC (2015) was approve the use of 7190 MHz to 7250 MHz band for command in spacecraft operation (by EESS).

This option allows us to use this band jointly with 8025 MHz to 8400 MHz band for telemetry in spacecraft operation

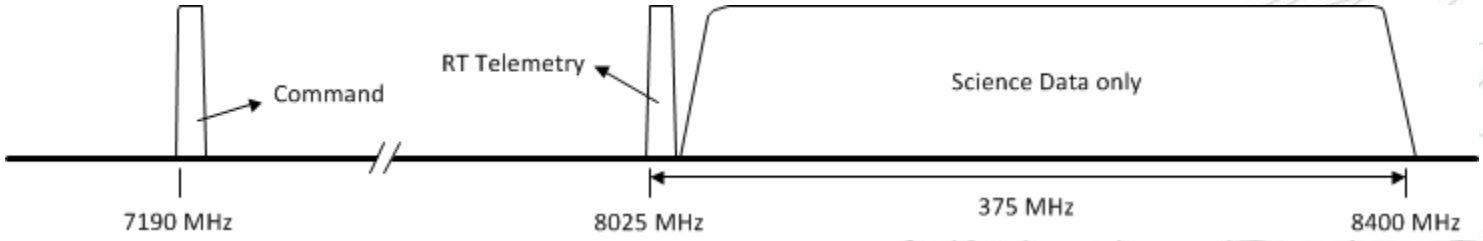
Allocation to services		
Region 1	**Region 2**	**Region 3**
7 190-7 235	EARTH EXPLORATION-SATELLITE (Earth-to-space) 5.460A 5.460B FIXED MOBILE SPACE RESEARCH (Earth-to-space) 5.460 5.458 5.459	
7 235-7 250	EARTH EXPLORATION-SATELLITE (Earth-to-space) 5.460A FIXED MOBILE 5.458	
8 025-8 175	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A	
8 175-8 215	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A	
8 215-8 400	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 5.463 5.462A	



X-band for spacecraft operation

Pros:

- Alleviate of congestion issue in S-band (primary objective)
- Simplification of operational concept
- Important commonality on the RF front-end design (traditionally a LEO satellite needs S-band for TT&C and X-band for Science data downloading, this depend on the amount of science data that needs to be downloaded) that would result in cost reductions on the flight segment



- The technology is already known (components & antenna design)
- There is cross support from some administrations/agencies/Ground stations

X-band for spacecraft operation

Cons:

- A new antenna design is required (but could be a re-design of the actual design for 8025-8400 MHz)
- It seems a temporary solution:

> *Footnote 5.460A (RR-2016): "….Space stations operating in the Earth exploration-satellite service (Earth-to-space) in the frequency band 7190-7250 MHz shall not claim protection from existing and future stations in the fixed and mobile services…"*

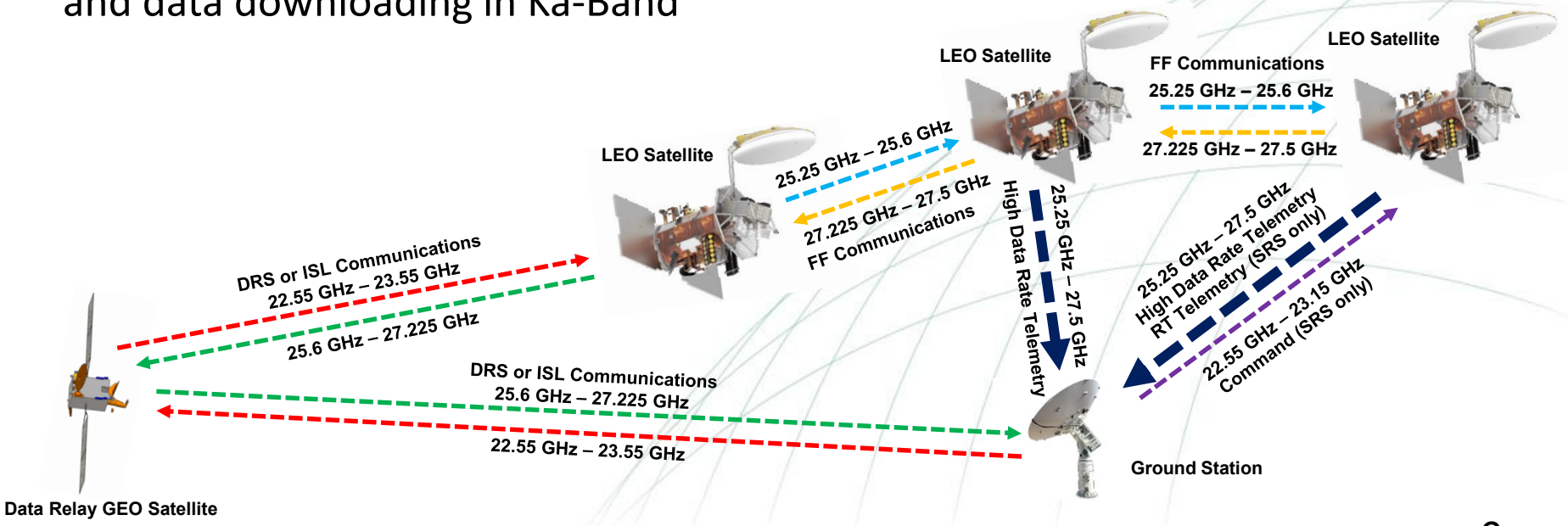
- The turnaround ratios are not defined yet (probably several ones. The command bandwidth is more than 6 times less than telemetry bandwidth)
- The solution go from 85 MHz available for command in S-Band to 60 MHz in X-band.
- A portion on the already use downlink spectrum (8025 MHz to 8400 MHz) needs to be use for real time telemetry (few MHz).
- Around 10 dB more propagation losses

Other future possibilities

The Spacecraft operation in X-band gives a breath over the saturated S-band for several years, but:

- Is this the best solution for manufacturers?
- The space industry push for more capacity
  - Optical instruments with sub metric resolutions
  - Different kind of instruments requiring between 10 to 40 Tb per day

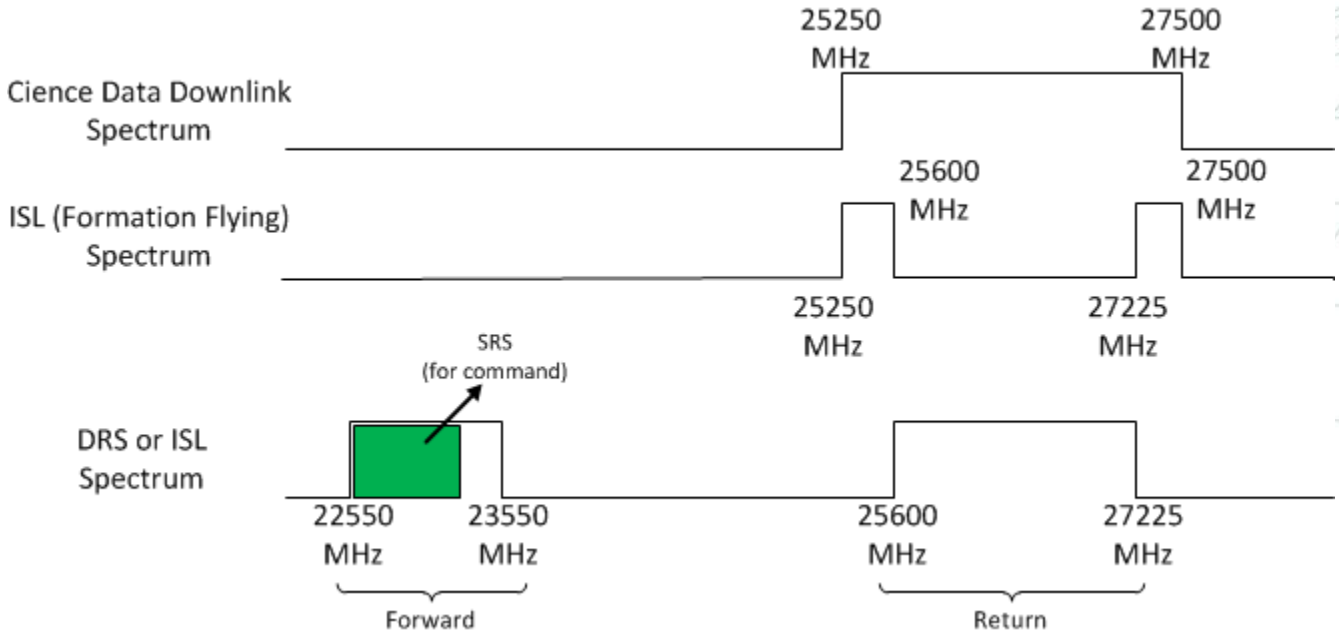
Fortunately there is room for data relaying, formation flying communications and data downloading in Ka-Band



Ka-band for spacecraft operation

As part of WRC-12 was allocated in the DRS FWD band a Space Research Service band for tracking and command purposes for near earth use (LEO satellites)

This complement the already existing bands for ISL and Science Data Downloading



Ka-band for spacecraft operation

Analyses were done to verify compatibility with Fixed, Mobile and ISL services (ITU-R SA.2193)

In most of the ISL cases the interference margin are above 30 dB

Inter-satellite link type	I_{max}/N_0 (dB)	Reference level (dB)	Percent of time (%)	Margin (dB)
GSO-to-non-GSO	–41.1	–10	0.1	31.1
GSO-to-GSO	–41.7	–10	0.1	31.7
Non-GSO-to-GSO	–39.3	–10	0.1	29.3
Non-GSO-to-non-GSO	–43.0	–10	0.1	33.0

Taking into account this scenario, it would be quite beneficial also share this band with Earth Exploration Satellite Services (EESS)

Ka-band for spacecraft operation

Pros:

- Same benefits than X-Band
- The commonality also have the attractiveness of managing ISLs
- More bandwidth available → More capacity @ same spectral efficiency
- Almost the same link margins @ clear sky

Cons:

- Same drawbacks than X-Band
- The technology is relatively new (more in emergent nations)
- The Rain

	S-Band			X-Band			Ka-Band		
Data @ 5° Elevation	**Up**	**Down [LBR]**	**Down [HBR]**	**Up**	**Down [LBR]**	**Down [HBR]**	**Up**	**Down [LBR]**	**Down [HBR]**
FSL Loss [dB]	-167,1	-167,9	-167,9	-177,8	-178,7	-178,7	-187,9	-188,8	-188,8
Total Clear Sky Loss [dB]	-167,8	-168,3	-168,3	-179,1	-179,6	-179,6	-190,4	-190,3	-190,3
Total Atmospheric Loss [dB]	-168,2	-168,7	-168,7	-180,2	-180,5	-180,5	-213,9	-202,2	-202,2
Availability [%]	99%	95%	95%	99%	95%	95%	99%	95%	95%
Throughput Uplink [kbps]	4			4			4		
Throughput downlink (LBR) [Kbps]		4			4			4	
Throughput downlink (HBR) [Kbps]			640			640			640
Data Channel Margin (Clear Sky) [dB]	23,5	16,6	17,1	26,4	17,0	17,5	27,5	14,8	15,3
Data Channel Margin (Worst Case availability) [dB]	23,1	16,2	16,6	25,4	16,2	16,6	4,0	2,9	3,4

Conclusions

The possibility of using Ka-Band for TT&C seems quite beneficial from the flight segment point of view

- Use of similar, if not identical, technology on board reducing NRE costs
- Gives more capacity
- Reduces size
- Allows to build and develop a more cost effective comm payload

The relevance of this topic seems important for development stimulation

Opening the discussion in the following WRCs as well as conducting the necessary studies looking for compatibility with other services in the band seems to be of common interest

Thank you for your attention
Any questions?

/ invap
/ invapargentina
www.invap.com.ar
contact: spacemarketing@invap.com.ar