



The COSMO-SkyMed program: VHR modes in the first and second generation

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e-geos
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Agenzia Spaziale Italiana

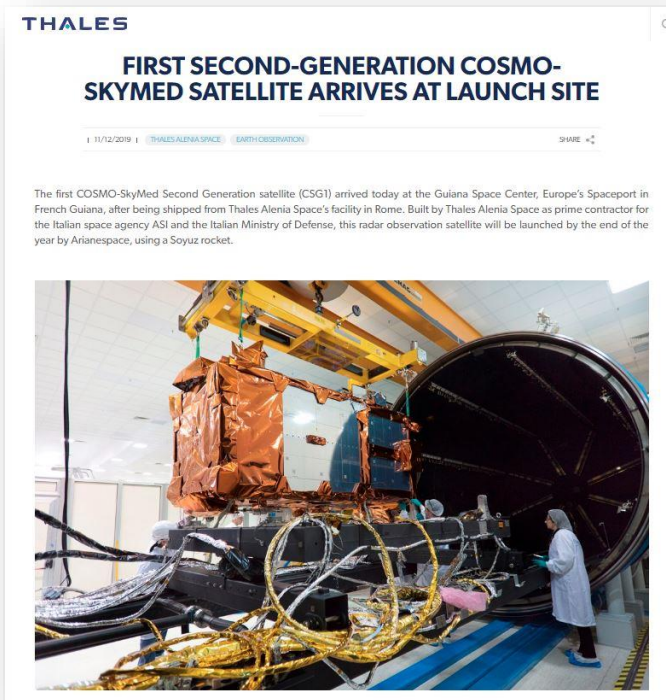
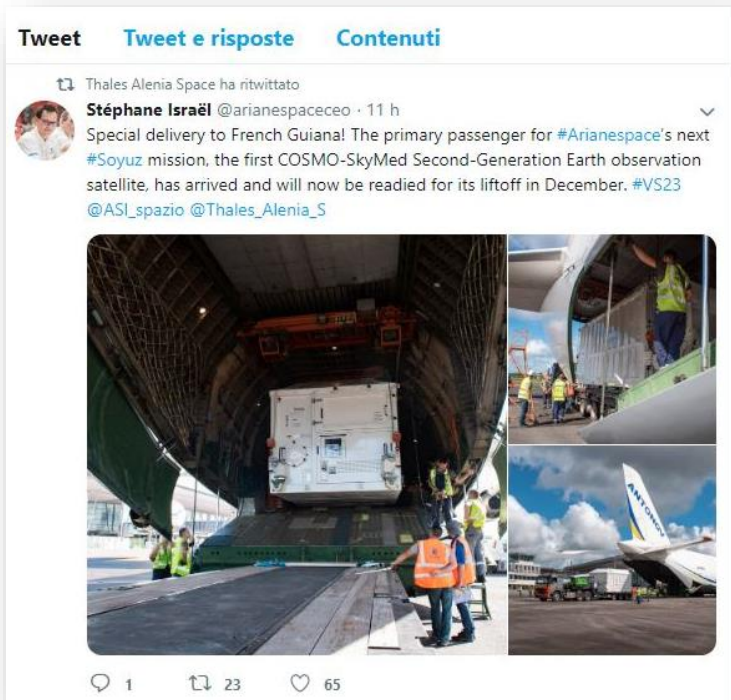
The COSMO-SkyMed program

- 🌐 The first 4 COSMO-SkyMed satellites were launched from the US between 2007 and 2010
 - 🌐 All 4 satellites are still operative, providing unique SAR constellation on the market
 - 🌐 Their technology is still the best on the market, at least in terms of high resolution and image quality
- 🌐 Biggest investment of Italy in the EO domain, with funds coming from
 - 🌐 ASI (previously under Ministry of Education)
 - 🌐 Italian MoD
- 🌐 The mission has a dual use, with a military component that takes advantage in terms of
 - 🌐 Priority
 - 🌐 Resolution
 - 🌐 Geolocation



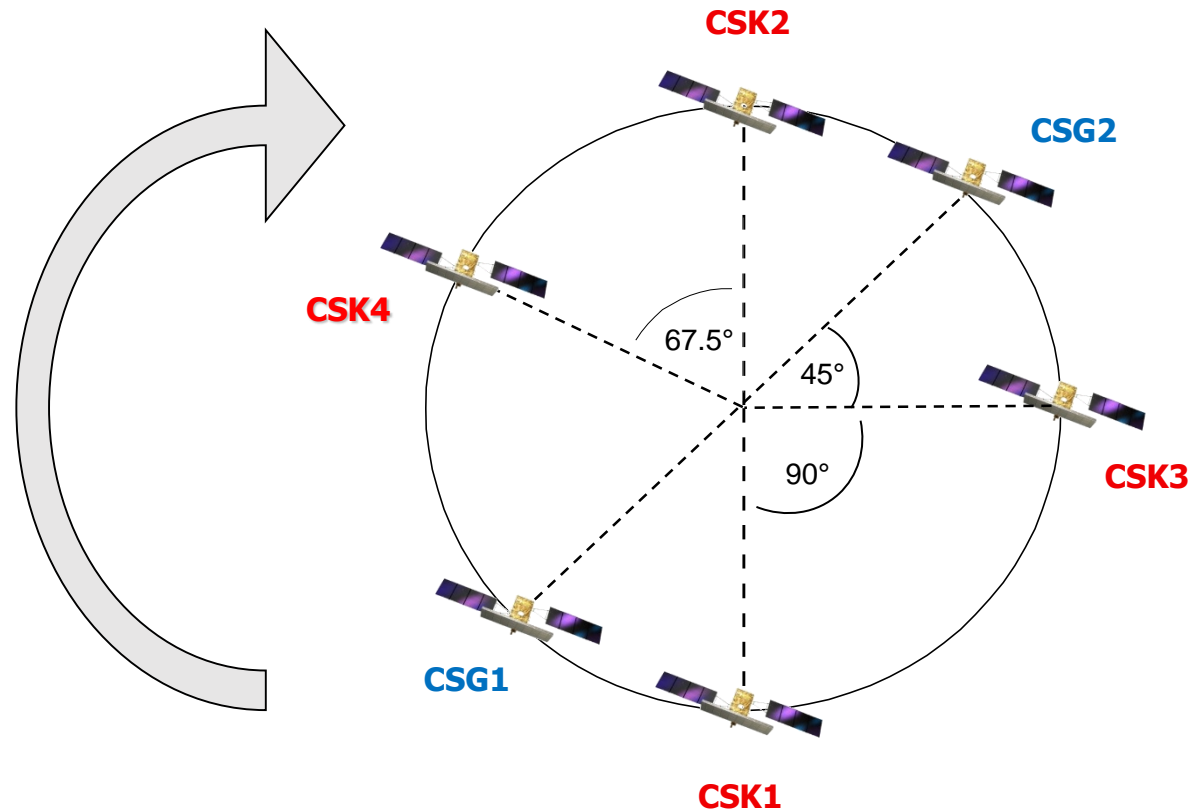
COSMO-SkyMed Second Generation (CSG)

- 🌐 First satellite has been delivered last week to the Kourou launch site
- 🌐 Expected launch December 2019
- 🌐 Second satellite to be launched before end of 2020
- 🌐 Italian Parliament is working for approving investment for the development of 3rd and 4th CSG satellites, to be launched respectively in 2022 and 2023



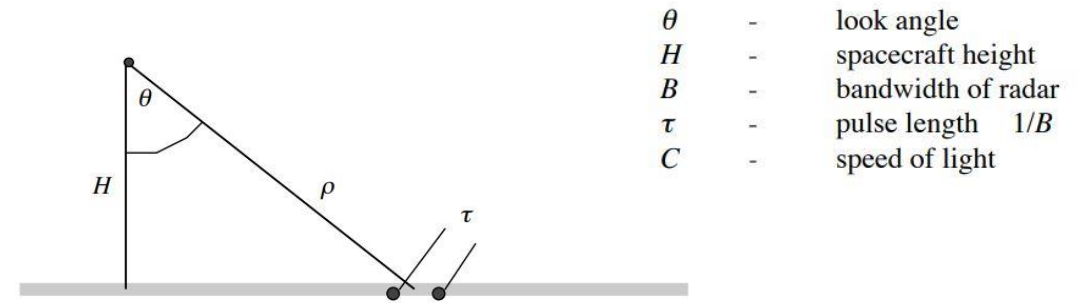
COSMO-SkyMed and COSMO Second Generation

- 🌐 All satellites will be placed on the same sun-synchronous 16-days orbit, in order to guarantee 12 hours revisit and high frequency interferometric revisit
- 🌐 Satellites position on the orbit will be changed according to eventual decommissioning of older satellites



SAR resolution - Range

Resolution in slant range is depending on the SAR bandwidth, as specified by the formula:



$$\Delta r = \frac{C\tau}{2} \quad - \text{ slant range resolution}$$

Currently the COSMO-SkyMed systems provides the highest bandwidth:

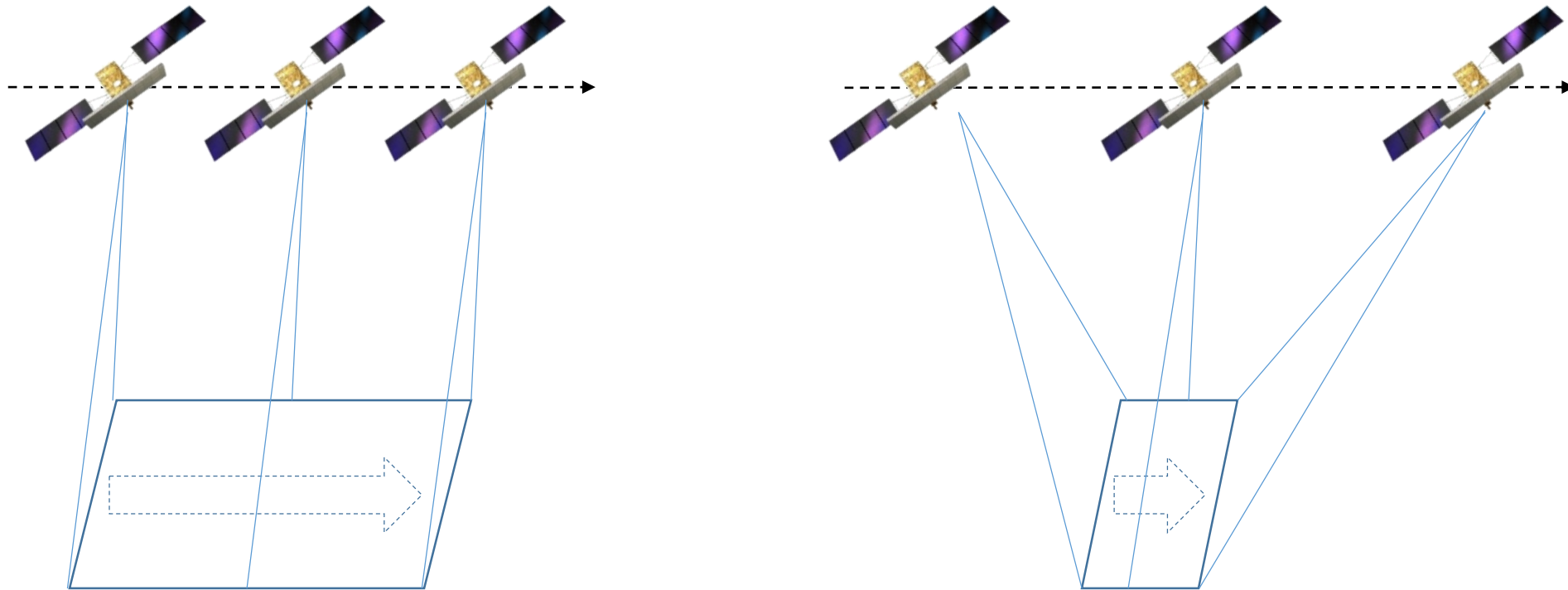
Higher bandwidth does not mean only better resolution, but also the possibility to keep a high resolution on a wider incidence angle range (slant range resolution of the above formula has to be projected as ground range)

Mission	SAR bandwidth
COSMO-SkyMed	400 Mhz
TerraSAR-X	300 Mhz
Radarsat-2	100 Mhz
ICEYE	300 Mhz
COSMO Second Generation	1,100 Mhz

$$R_r = \frac{C\tau}{2} \frac{1}{\sin\theta} \quad - \text{ ground range resolution}$$

SAR resolution - Azimuth

- Resolution in azimuth is depending on the time that the radar is illuminating the same area



- Left the sliding acquisition technique, used for StripMap modes
- Right the staring acquisition technique, used for Spotlight modes

COSMO-SkyMed Spotlight modes

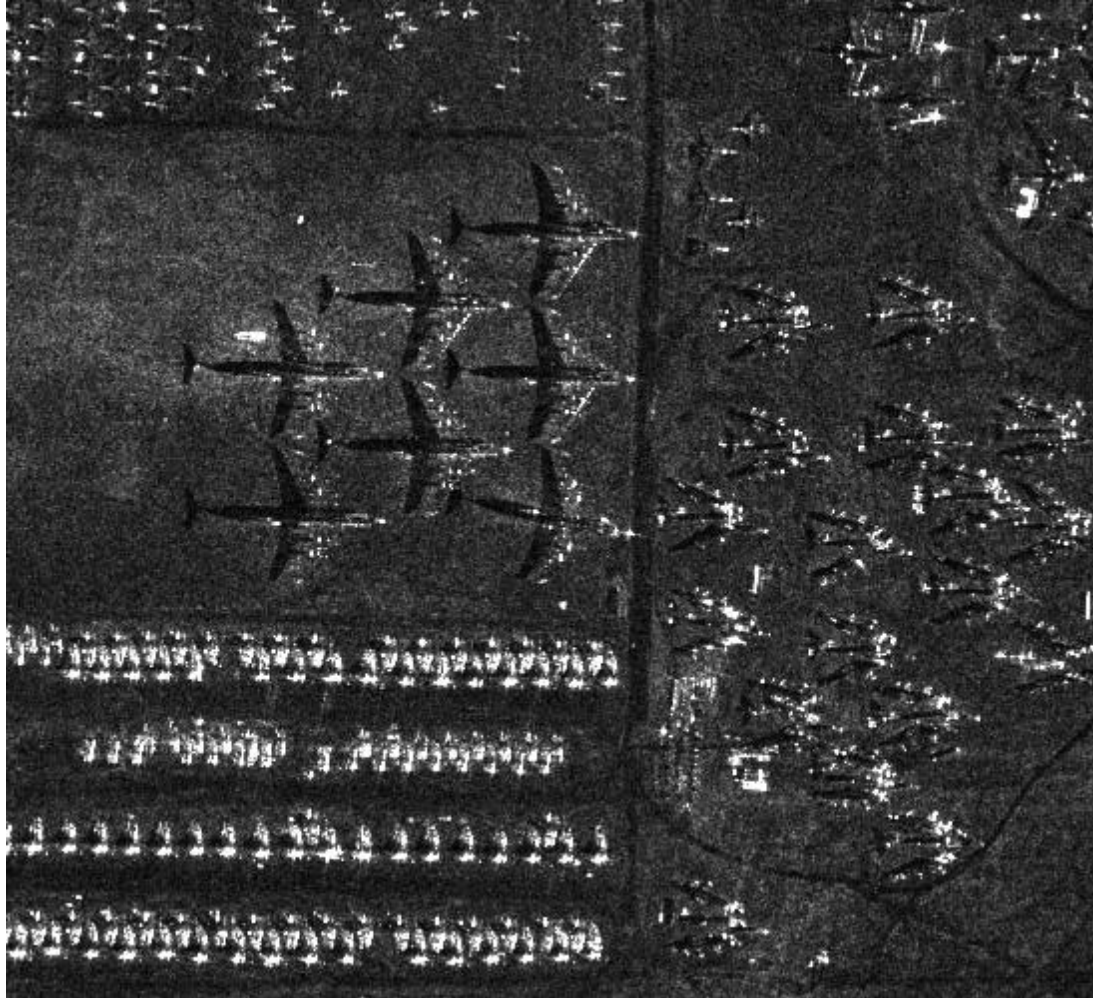
	Spotlight-2	Spotlight-2A
Resolution azimuth	1 m	0,3 m
Resolution range (ground)	1 m	0,7 m
Image size azimuth	10 Km	5 Km
Image size range	10 Km	7 Km
Incidence angles range	20° – 60°	33° – 60°
Illumination time	7 sec	14 sec
Polarization	HH or VV	HH or VV

- Spotlight-2A mode developed in 2016 thanks to e-GEOS investment (available only for pre-authorized Customers)
- Spotlight modes resolution is constant over whole incidence angles range

COSMO-SkyMed Spotlight-2 vs Spotlight-2A - Tucson, AZ



COSMO-SkyMed Spotlight-2 vs Spotlight-2A multi-looked – Tucson, AZ



COSMO-SkyMed Spotlight-2 example – Roma and the Vatican

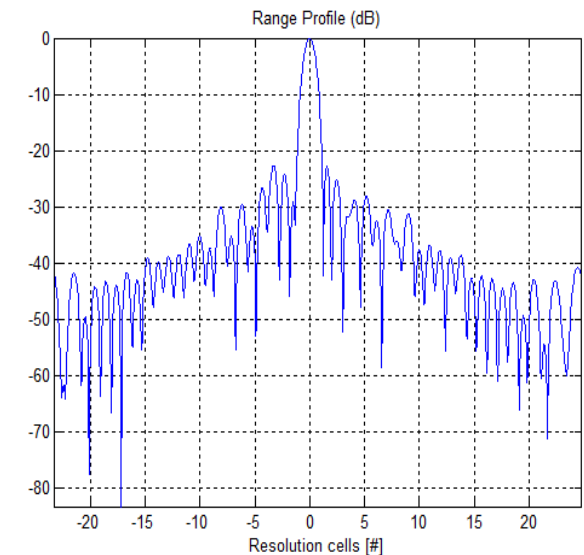
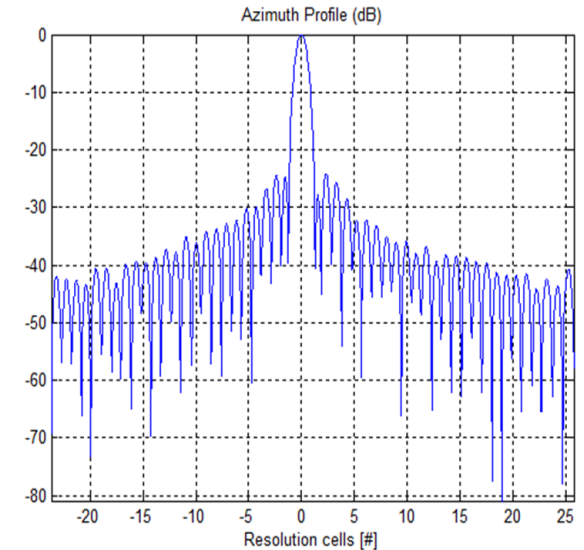


COSMO-SkyMed Spotlight-2A example – Washington, DC



COSMO-SkyMed Spotlight calibration

- 🌐 COSMO-SkyMed data have the following common quality parameters to be achieved for every acquisition mode and every geometry:
 - 🌐 PSLR -22 dB
 - 🌐 ISLR -12 dB
 - 🌐 Azimuth Point Target Ambiguity -40 dB
 - 🌐 Radiom. Accuracy -1 dB (single look)
 - 🌐 Radiom. Linearity -1.5 dB
 - 🌐 Radiom. Stability -1 dB
 - 🌐 Total NESZ -21/-22 dB²/m²
- 🌐 All these imaging modes are monitored and calibrated continuously every month by the COSMO program, using
 - 🌐 Specific corner reflectors located in Italy and in Argentina
 - 🌐 Uniform low signal areas (mainly Amazon forest)



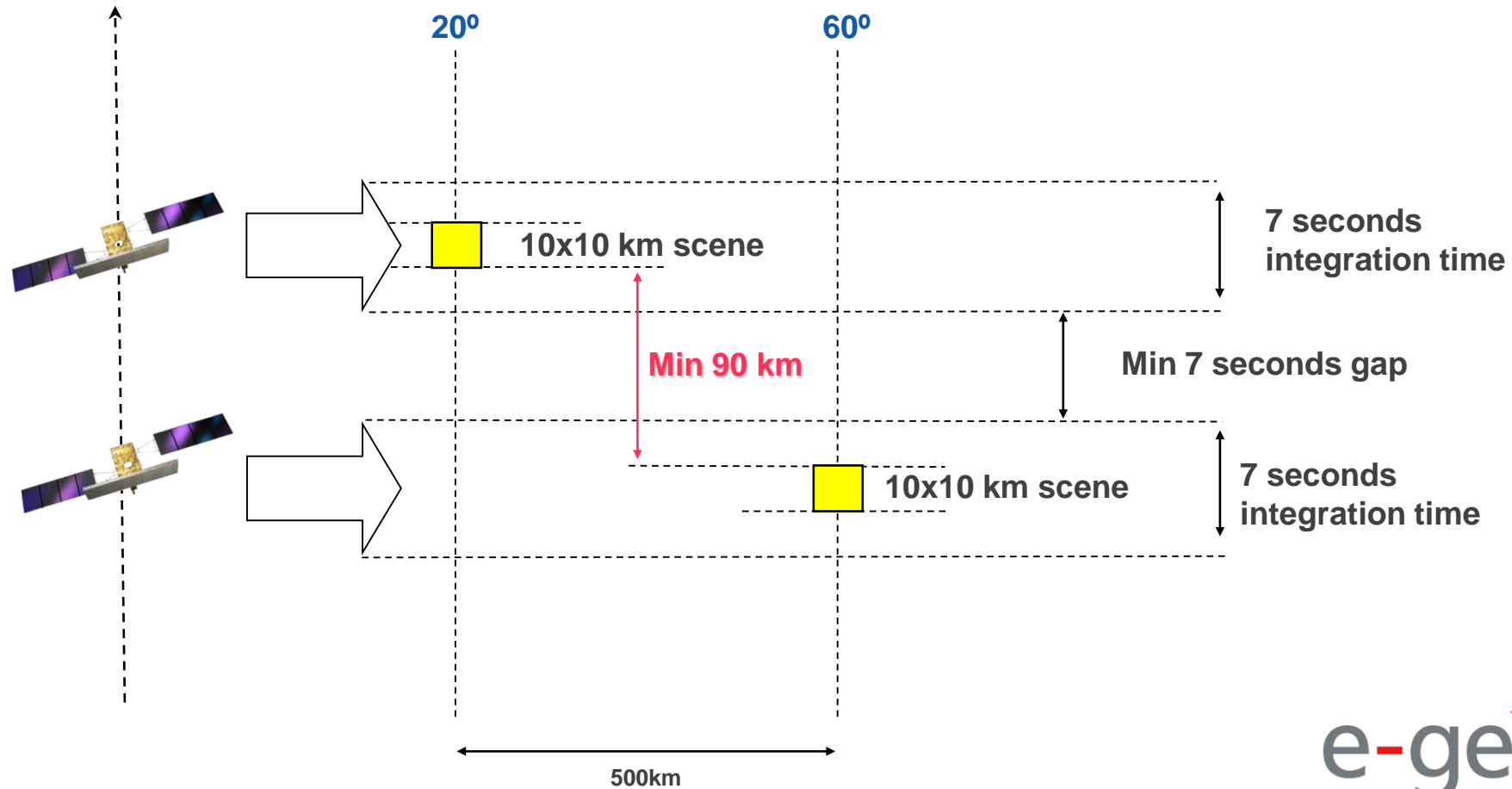
COSMO-SkyMed Second Generation Spotlight modes

	Spotlight-2A	Spotlight-2B	Spotlight-2C
Resolution azimuth	0,3 m	0,6 m	0,8 m
Resolution range (ground)	0,5 m	0,6 m	0,8 m
Image size azimuth	3,5 Km	10 Km	5 Km
Image size range	7 Km	10 Km	10 Km
Incidence angles range	20° – 60°	20° – 60°	20° – 60°
Illumination time	11 sec	9 sec	6 sec
Polarization	HH or VV or HH+HV or VV+VH	HH or VV or HH+HV or VV+VH	HH or VV or HH+HV or VV+VH

- CSG Spotlight-2A: mode with constant SAR bandwidth to optimize the resolution (resolution non-constant in range and non-squared)
- CSG Spotlight-2B: maximum scene size
- CSG Spotlight-2C: minimum resources consumption, i.e. greater number of images per day and a higher probability of acquisition
- Multi-look products are also available

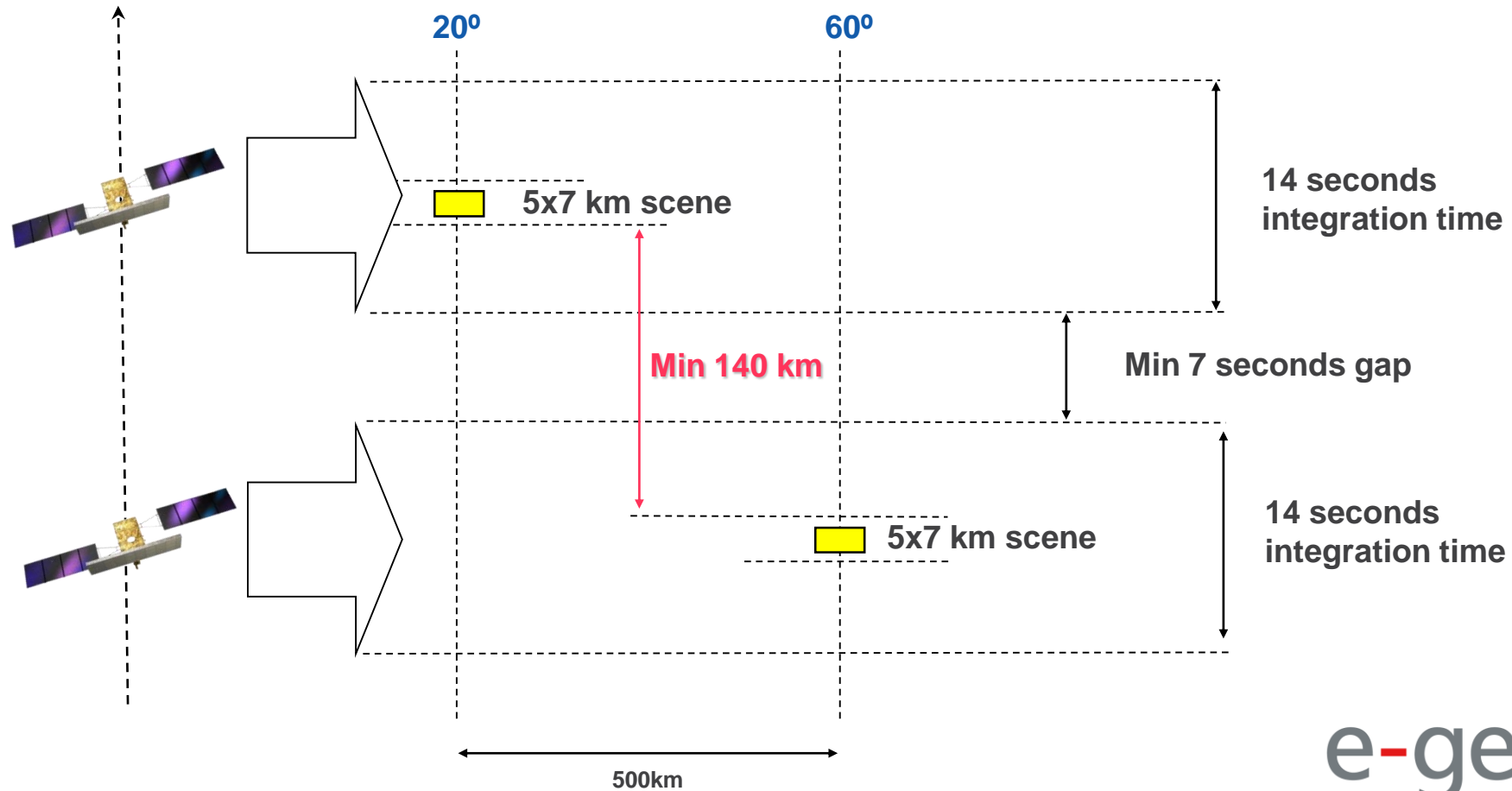
Transition time among Spotlight-2 mode

- 🌐 Limitation to take consecutive Spotlight-2 scenes within a short distance from each other



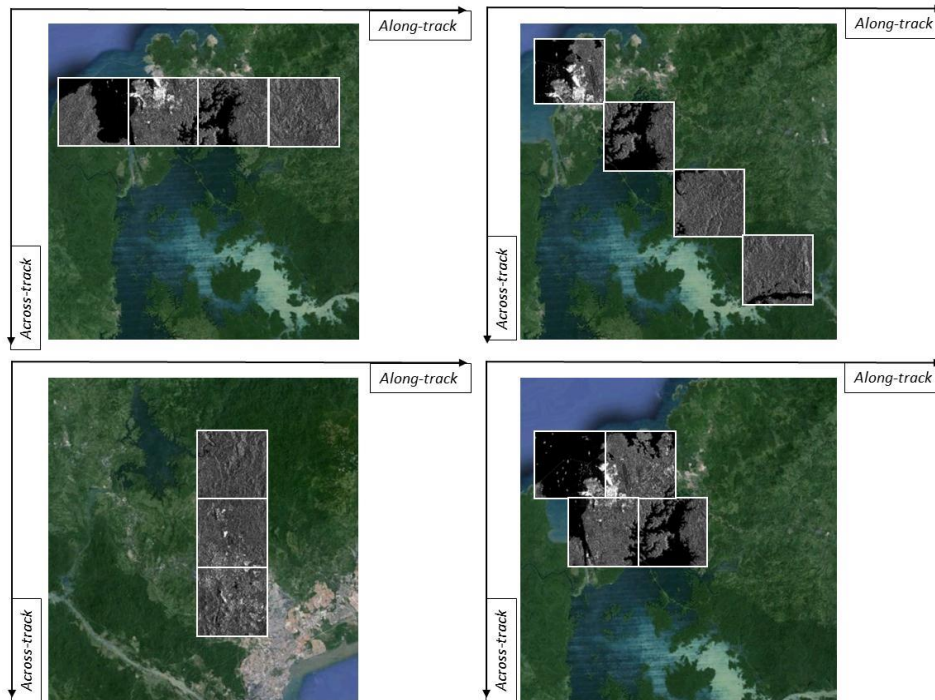
Transition time among Spotlight-2A mode

- 🌐 Limitation to take consecutive Spotlight-2A scenes within a short distance from each other

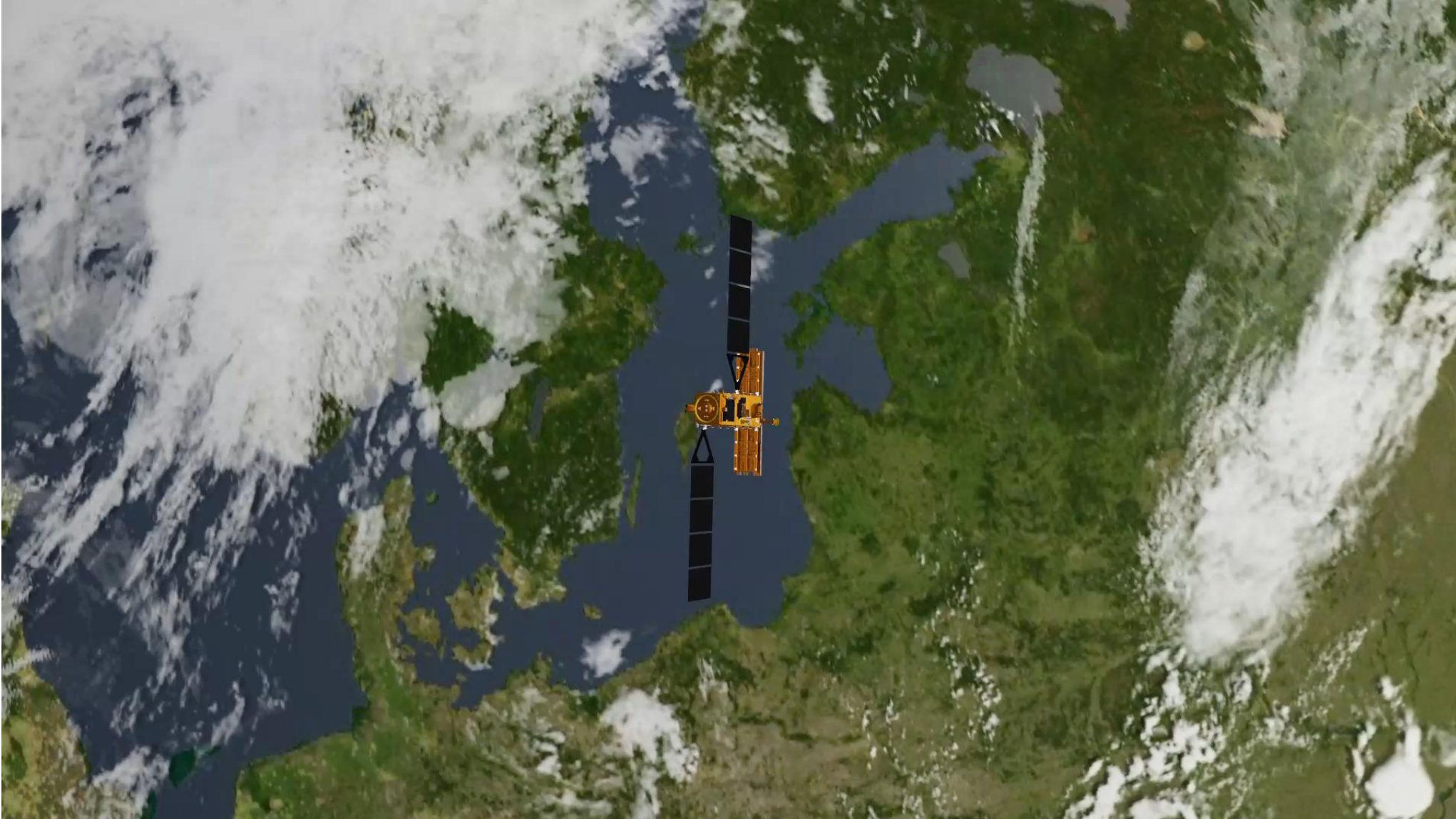


COSMO-SkyMed Second Generation non standard imaging mode

- 🌐 To overcome the limitation of the transition time, Thales Alenia Space Italy developed new imaging mode on CSG, called **Spotlight on theatre**, that performs non-zero doppler acquisitions with a squinted attitude of the platform, taking advantage of the improved platform agility (control moment gyro)
- 🌐 No interferometric possibility and slightly reduced performances, but...
- 🌐 Huge imaging possibilities, almost like an optical satellite



COSMO-SkyMed Second Generation - Spotlight on theatre



*Movie thanks to
Thales Alenia
Space Italy*

Conclusions

- 🌐 The COSMO-SkyMed program is currently providing the best VHR SAR data on the market, both in terms of resolution, image size and quality
- 🌐 The forthcoming COSMO-SkyMed Second Generation will achieve better results, thanks to a unique bandwidth
- 🌐 The defence component of the COSMO-SkyMed program has even better resolutions, making Italy the top technological provider of VHR SAR data
- 🌐 Very important to remember that
 - 🌐 Resolution should be similar in both range and azimuth for all incidence angles, otherwise a highly rectangular pixel will provide distorted images and potential wrong image interpretation
 - 🌐 Resolution is not everything, you need also radiometric quality
 - 🌐 Monitoring of data quality is a primary goal for everyone
 - 🌐 Platform flexibility allows to overcome typical limitation of VHR SAR imaging modes that need a very long illumination time

An aerial Synthetic Aperture Radar (SAR) image of a city. The image is grayscale and shows various urban features like buildings, roads, and a river. A red heart is overlaid in the top-left corner, containing the text "We love SAR". A red rectangular box highlights a specific area in the center of the image, which appears to be a large, dark, textured area, possibly a forest or a large field. The text "We love SAR" is written in white, sans-serif font inside the heart.

We love SAR

A satellite with gold thermal blankets and solar panels is shown in space, orbiting Earth. The Earth's surface is visible with white clouds and blue oceans, and the blackness of space with stars is in the background.

Thank You

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