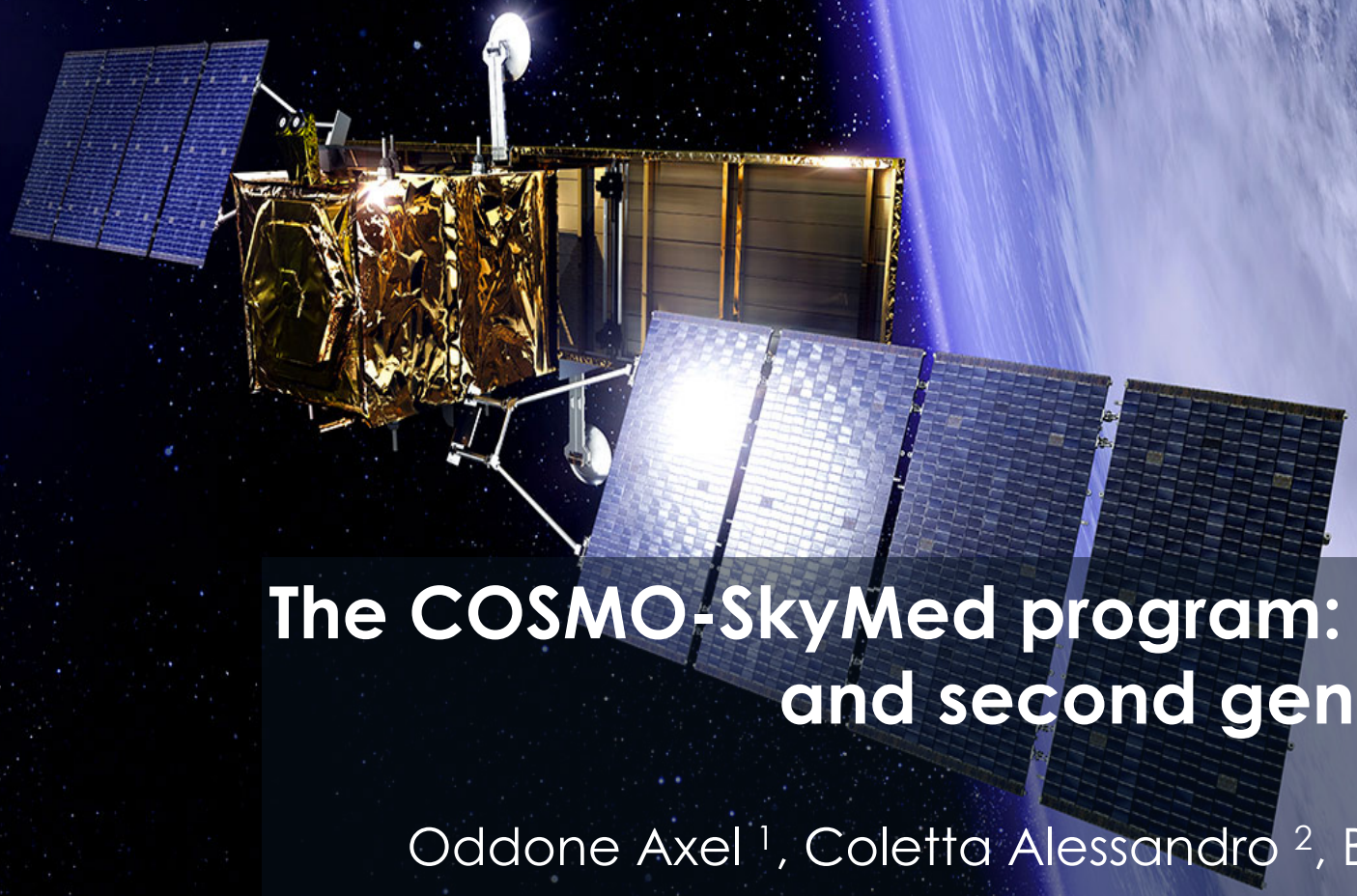

The COSMO-SkyMed program: VHR modes in the first and second generation

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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

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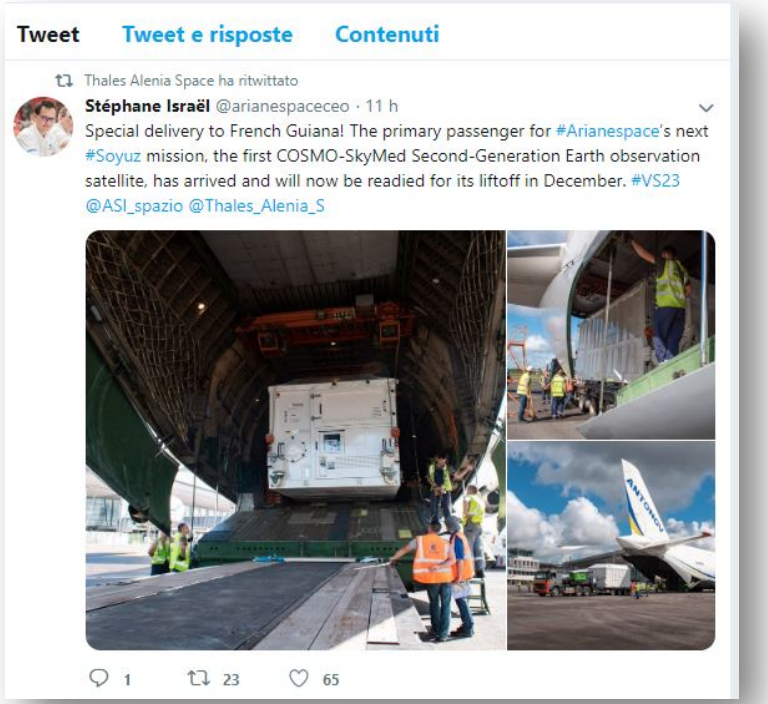
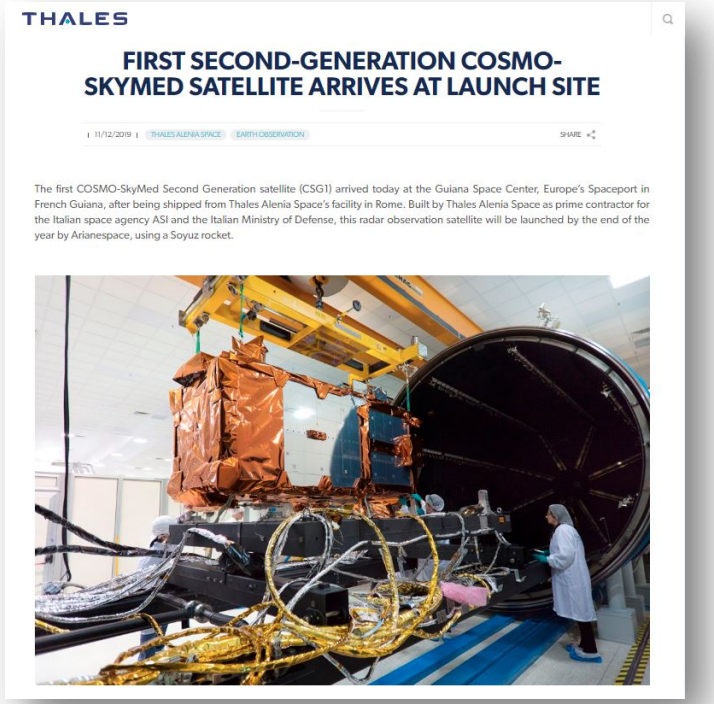
COSMO-SkyMed Second Generation (CSG)

- 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 recently approved investment for the development of 3rd and 4th CSG satellites, to be launched respectively in 2022 and 2023





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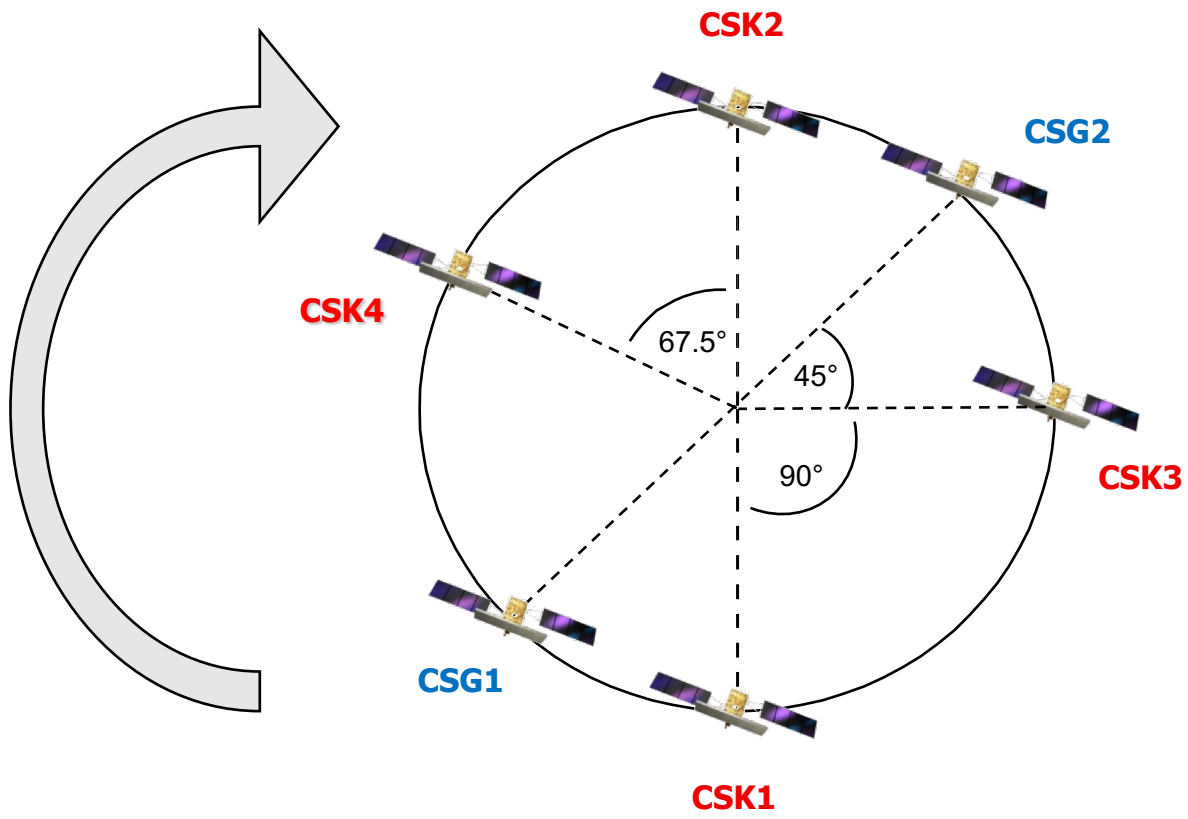
COSMO-SkyMed and COSMO Second Generation

- 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 decomissioning of older satellites



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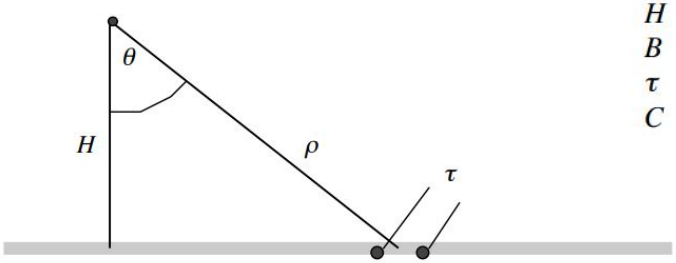
SAR resolution - Range



θ - look angle
H - spacecraft height
B - bandwidth of radar
τ - pulse length $1/B$
C - speed of light

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

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

- Currently the COSMO-SkyMed systems provides the highest bandwith:

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

- Higher bandwith 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)

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

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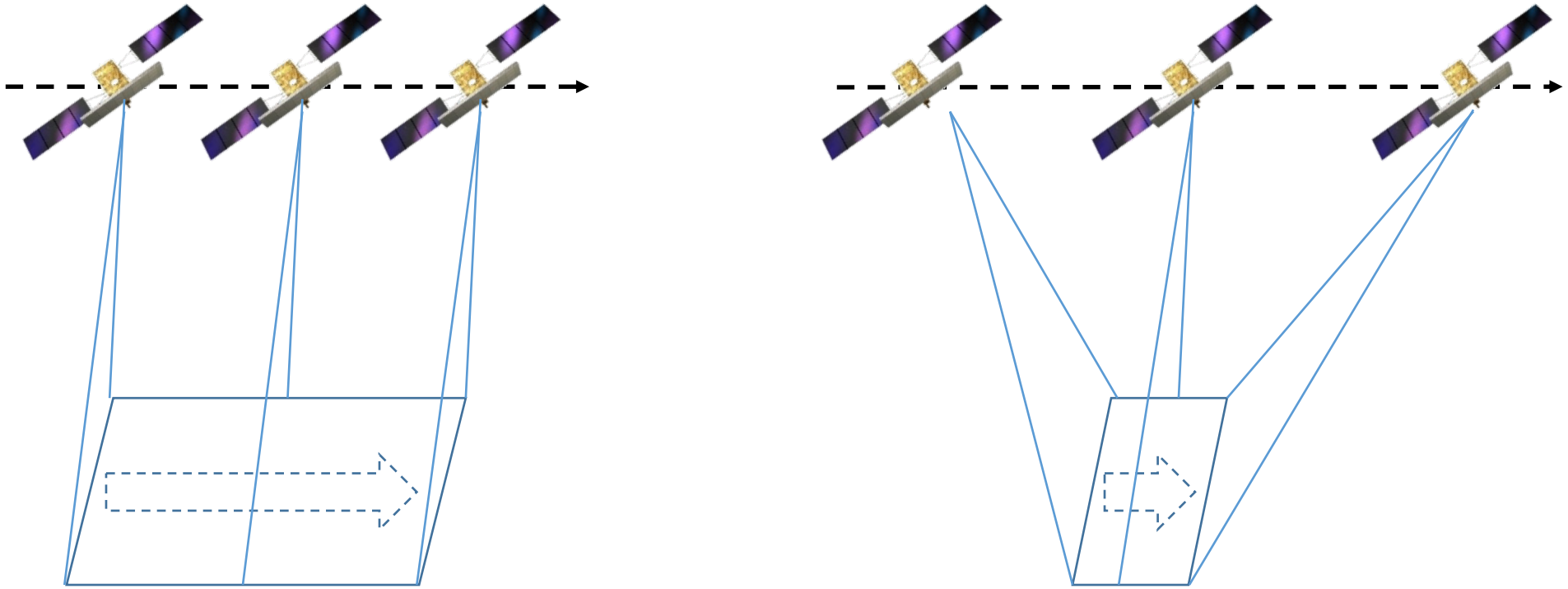
SAR resolution - Azimuth

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



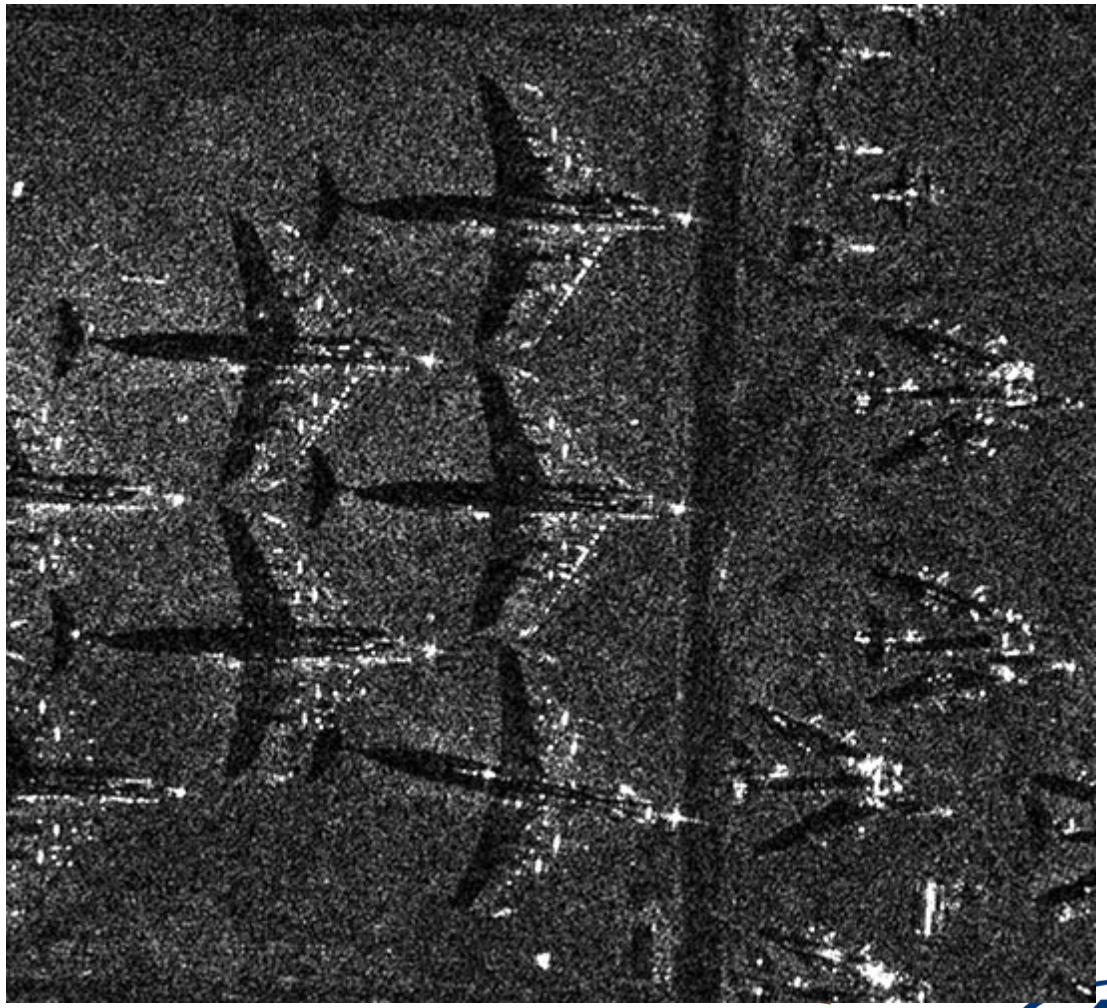
- Left the sliding acquisition technique, used for StripMap modes
- Right the staring acquisition technique, used for Spotlight modes

COSMO-SkyMed Spotlight modes

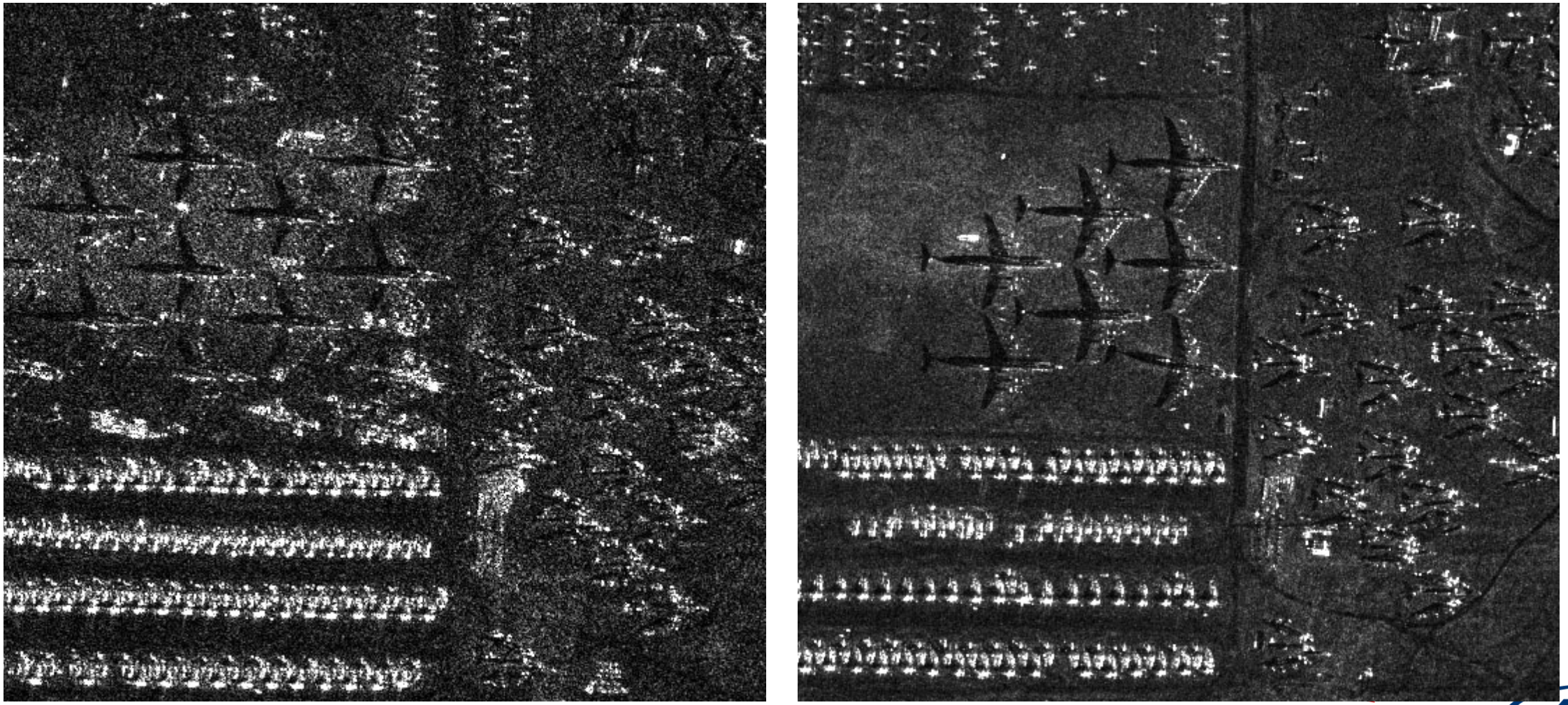
	Spotlight-2	Spotlight-2A
Resolution azimuth	1 m	0,3 m
Resolution range (ground)	1 m	0,7 m
Image size azimuth	10 Km	5 Km
Image size range	10 Km	7 Km
Incidence angles range	20° – 60°	33° – 60°
Illumination time	7 sec	14 sec
Polarization	HH or VV	HH or VV

- 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



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

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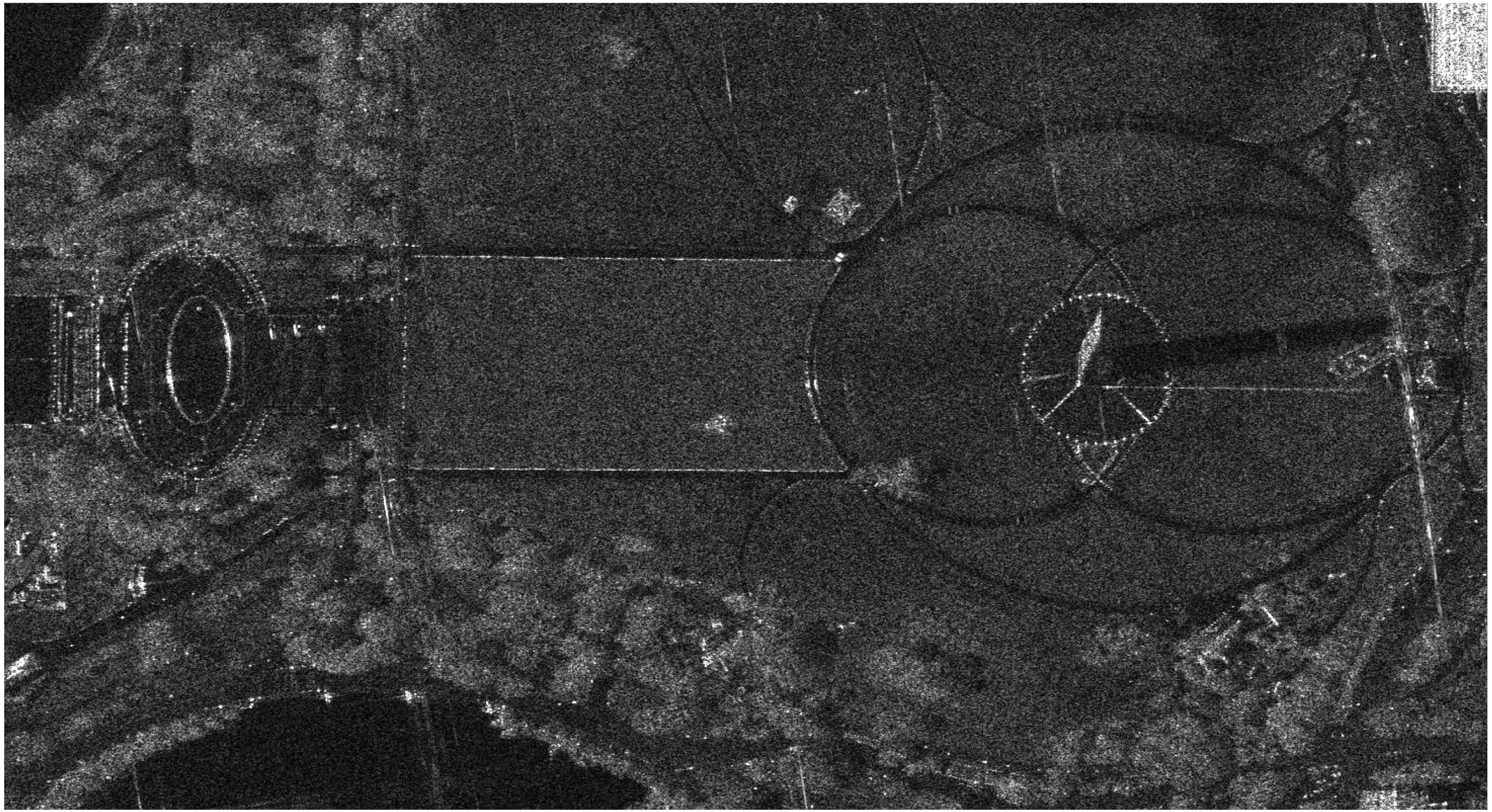
COSMO-SkyMed Spotlight-2A example – Washington, DC



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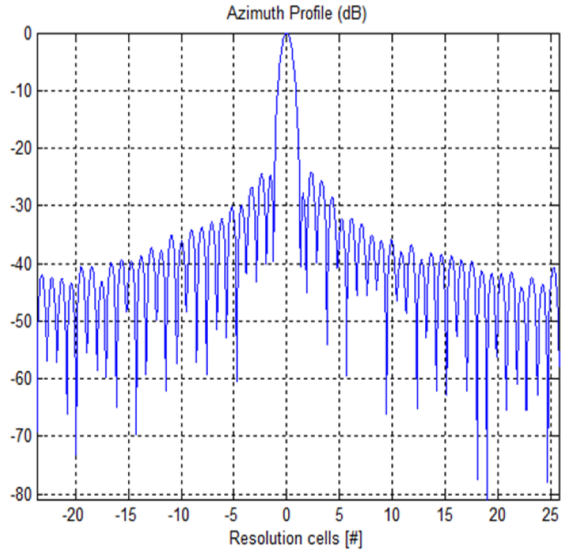
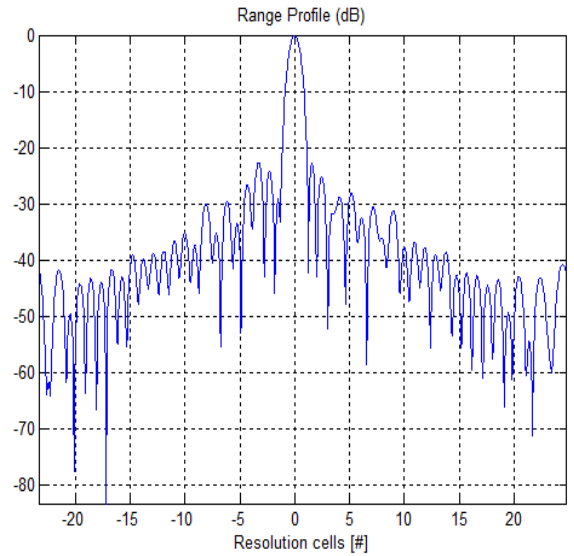
COSMO-SkyMed Spotlight calibration

- 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)





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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

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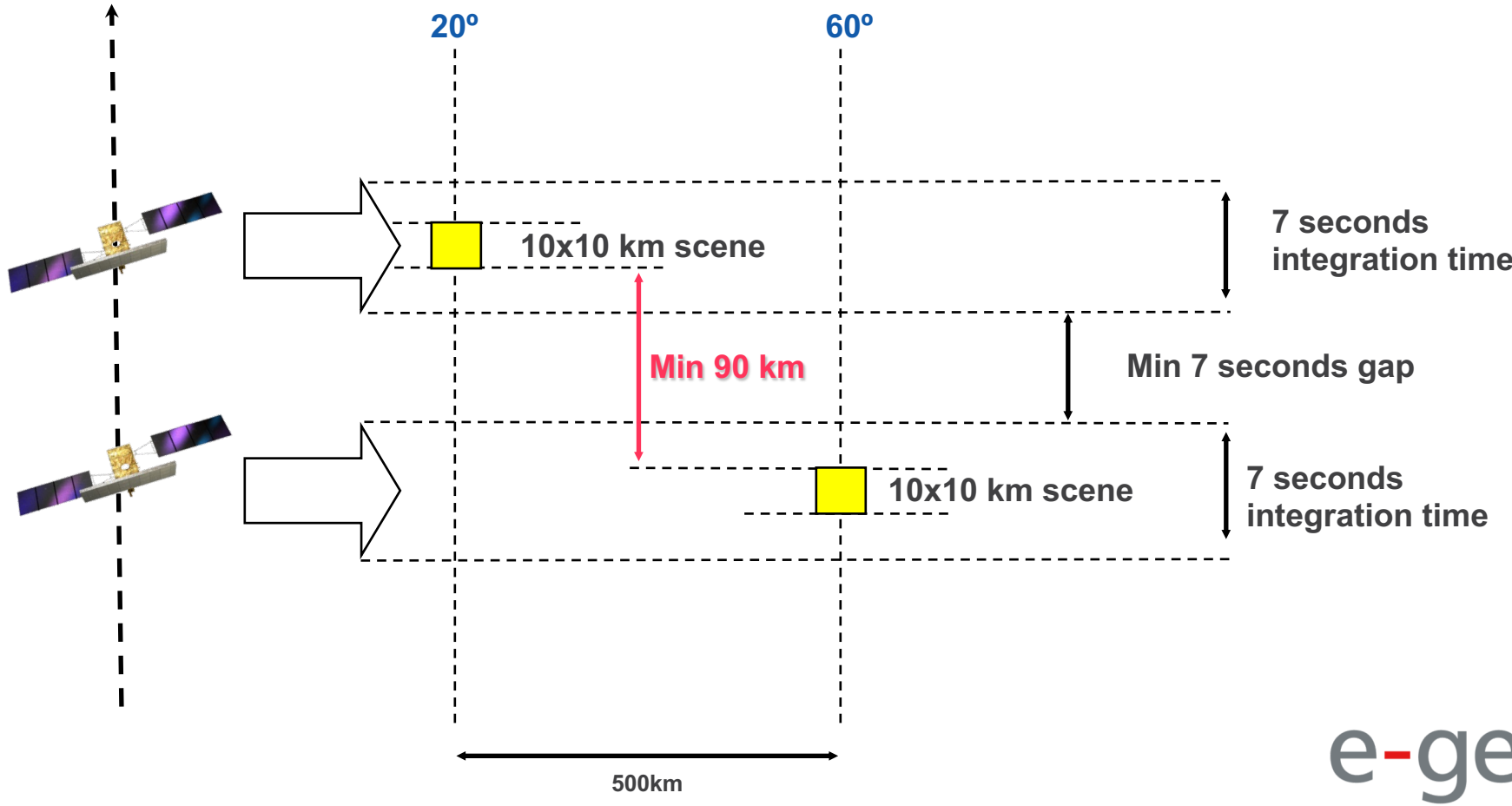
Transition time among Spotlight-2 mode

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



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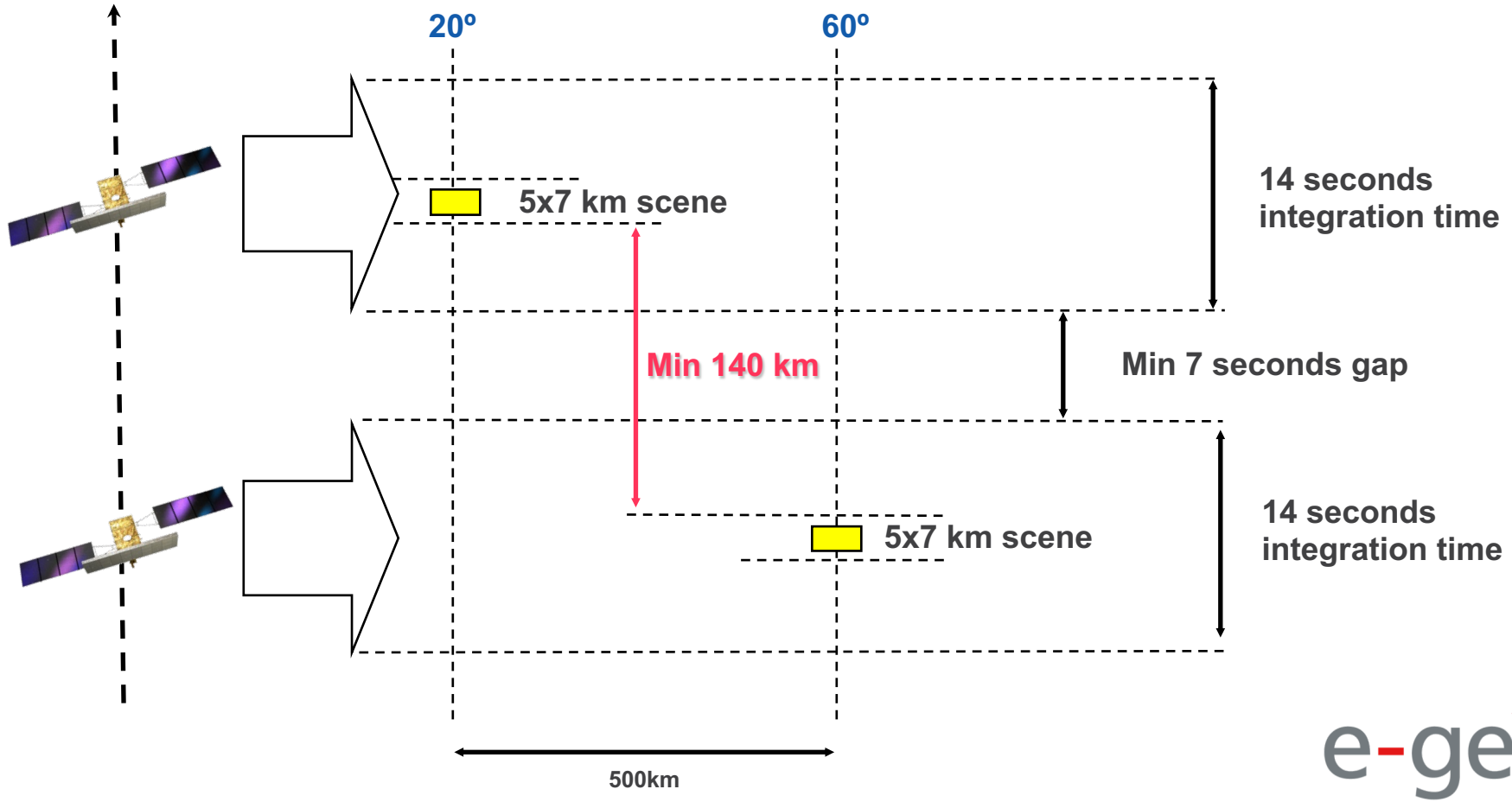
Transition time among Spotlight-2A mode

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



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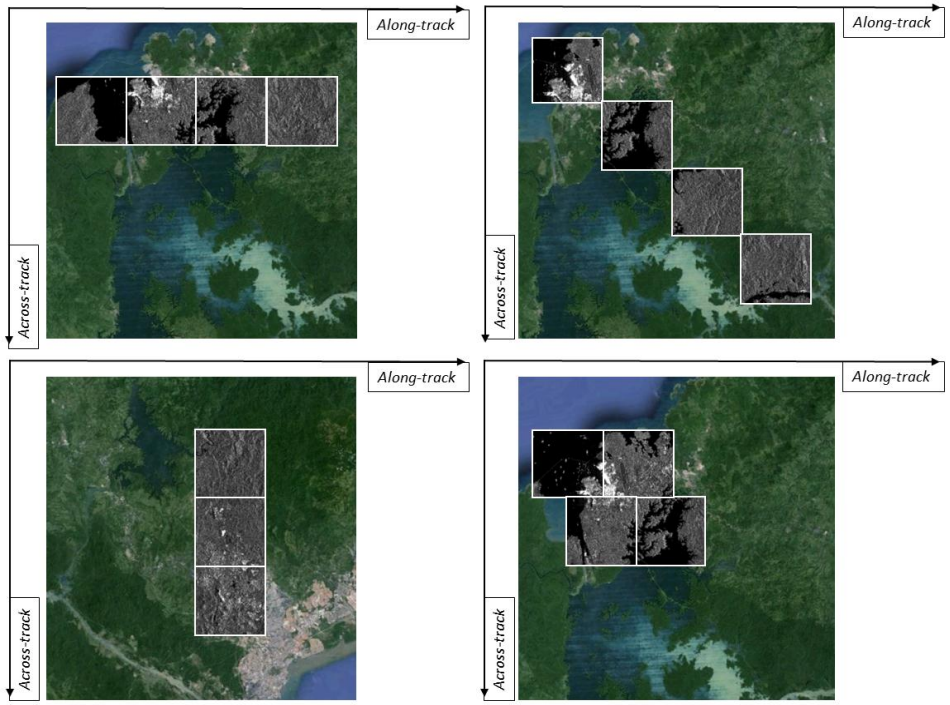
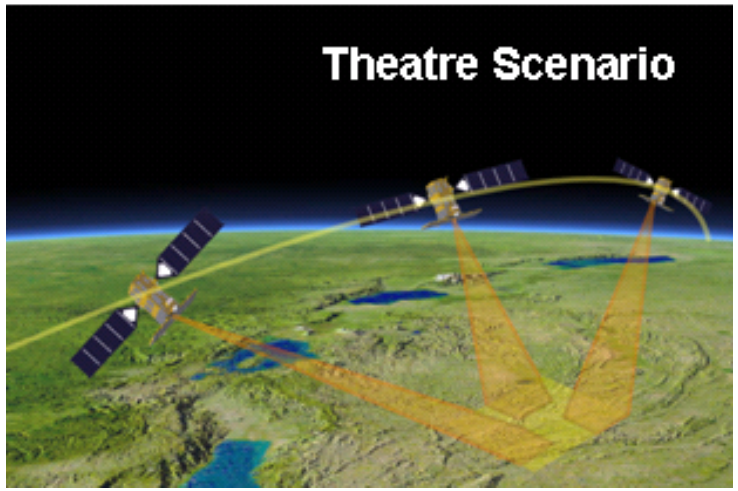
COSMO-SkyMed Second Generation non standard imaging mode

- 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





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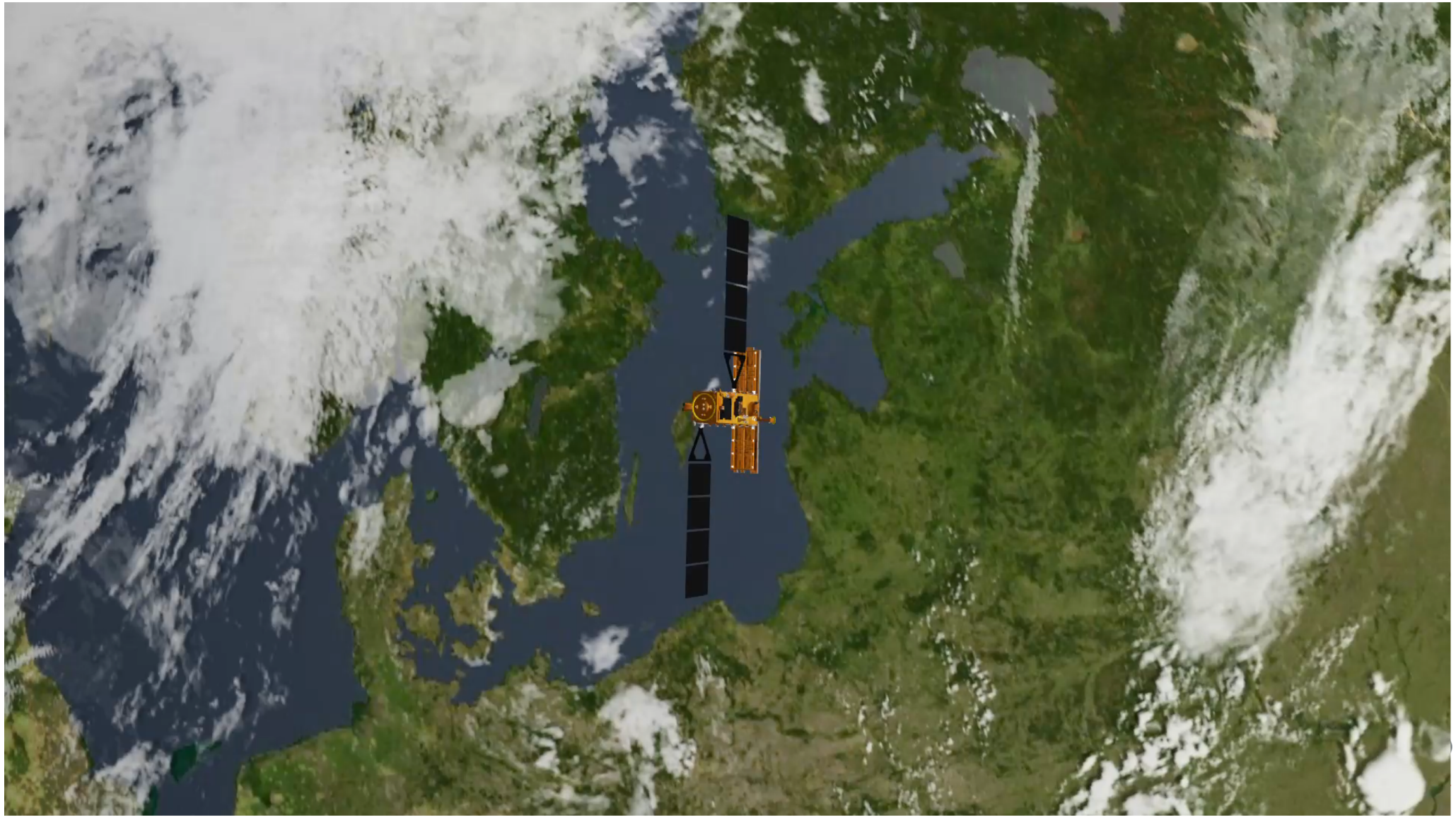
COSMO-SkyMed Second Generation - Spotlight on theatre



Movie thanks to Thales Alenia Space Italy

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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


We love SAR

Thank You

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