NewSpace and Full-Fledged SAR Missions: A Comparison

Alberto Moreira, Gerhard Krieger, Marwan Younis, Michelangelo Villano and Manfred Zink

German Aerospace Center - DLR
Microwaves and Radar Institute
Wessling/Oberpfaffenhofen, Germany

Abstract - In a changing and dynamic world, high-resolution and timely geospatial information with global coverage and access is becoming increasingly important. Spaceborne Synthetic Aperture Radar (SAR) plays an essential role in this task, as it is the only sensor technology capable of providing high-resolution imagery on a global scale with short revisit times, independent of the weather conditions and sunlight illumination [1], [2], [3]. Today, there are two main trends for the future development of spaceborne SAR systems (see Fig. 1):

- *Full-fledged SAR Missions.* A paradigm shift is taking place in the development of SAR systems, as digital beamforming allows for the implementation of innovative imaging modes with high azimuth resolution and wide swath [4]. For example, ESA's Sentinel-1NG mission, has a SAR instrument specification to achieve a 400 km swath width and 25 m^2 spatial resolution [5], even in full-polarimetric imaging mode. By means of 2 satellites with digital beamforming in azimuth and elevation, a global coverage of the land masses in 4 days is achieved with a much higher performance than it would be possible with conventional spaceborne SAR systems.

- *NewSpace SAR Missions:* Over the past 10 years, NewSpace SAR has driven the development of high-resolution SAR constellations. To complement complex SAR missions with global coverage, low-cost, lightweight systems based on disruptive NewSpace concepts are being implemented to map small areas with a very short revisit time. Notable examples are ICEYE (Finland), Capella (USA), Umbra (USA), Synspective (Japan), iQPS (Japan) and Spacety (China). NewSpace SAR constellations are characterized by an extremely compact SAR system design with the goal of achieving 25 cm x 25 cm resolution for small regions of interest. NewSpace SAR ignited a new era in the commercialization of SAR satellites and imagery.

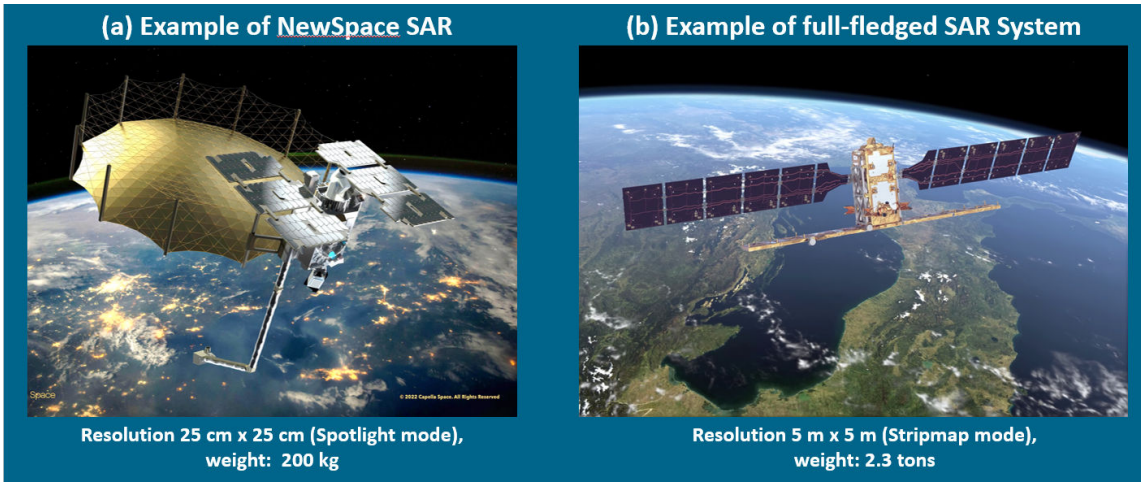

Figure 1 *– a) NewSpace SAR satellite from Capella (USA) b) Full-fledged SAR system from ESA (Sentinel-1). NewSpace SAR constellations offer up to 100 times shorter revisit time, much lower weight and cost per satellite, while full-fledged SAR systems offer global coverage, much higher imaging capacity, better signal-to-noise ratio and image calibration.*

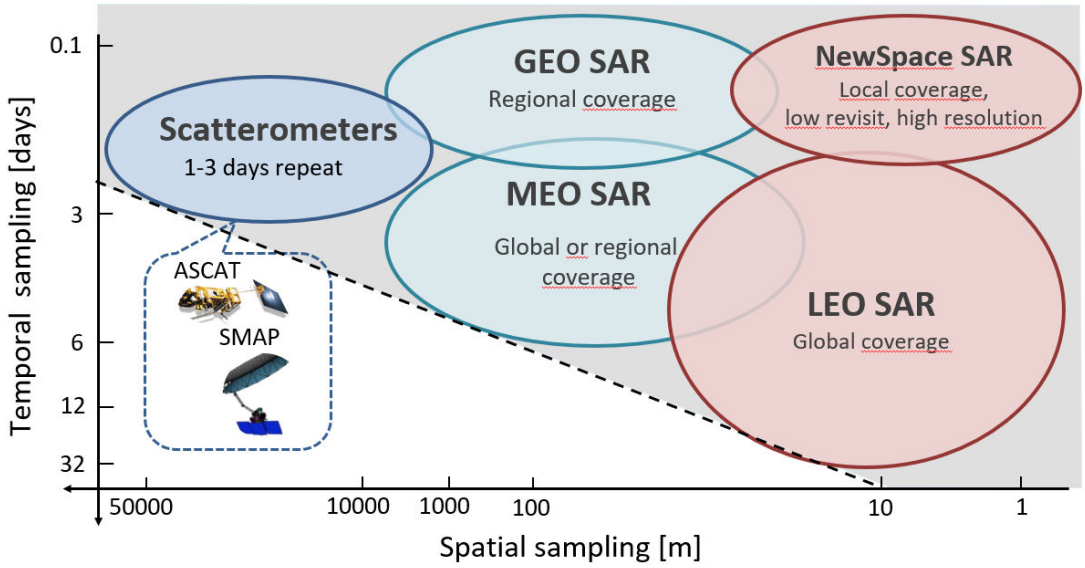

Figure 2 *– Different SAR system realizations: In addition to full-fledged SAR and NewSpace SAR, Medium Earth Orbit (MEO) SAR, Geosynchronous Earth Orbit (GEO) SAR and scatterometers play an important role in fulfilling the user requirements for spatial resolution, coverage and revisit time.*

This talk will first present the state of the art and future developments of full-fledged SAR systems, followed by NewSpace SAR. Next, key parameters such as performance, imaging capacity and quality, revisit time, cost and weight are quantitatively compared, showing the strengths and weaknesses of each system concept. It is concluded that full-fledged SAR systems with digital beamforming are best suited for applications with systematic global coverage requirements, while NewSpace SAR is best placed for agile applications with very short revisit time requirements for regions of interest. Figure 2 compares the typical revisit times and spatial resolutions for different SAR concept realizations. A systematic comparison between the different concepts shows that full-fledged SAR systems offer a much more cost-effective approach for global coverage of the Earth. Finally, the talk shows that the combination of full-fledged SAR systems with disruptive NewSpace SAR concepts offers a wealth of new system approaches for multistatic SAR missions with enhanced imaging capabilities. One example is the High-Resolution Wide-Swath (HRWS) SAR mission with the MirrorSAR concept, which consists of a main X-band satellite and three small receive-only satellites using the MirrorSAR concept of a space transponder [7]. Further opportunities arise from distributed SAR system concepts in a multistatic configuration [8], [9], [10].

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