Sentinel-1 Next Generation: trade-offs and assessment of mission performance

ESA's observation program has a consolidated heritage lasting for more than two decades with C-band Synthetic Aperture Radar Systems (SAR).

In this framework, the current C-band Sentinel-1 observations constitute an essential component of Copernicus program for the monitoring of the Earth characterized by wide-swath systematic global observations of the Earth to build-up a systematic, long-term archive of globally consistent data. The next generation of C-Band Sentinel-1 mission represents the next logical step in ESA's C-band line, conceived to serve more applications and services through increased capabilities, first among the others, the improvement of the mapping capability with wide swath, high resolutions and full-polarimetry.

The possibility of providing simultaneously 400 km wide swath and high resolution of 5 x 5 m^2 single-look resolution represents a factor 5 to 6 improvement with respect to Sentinel-1's IWS mode. A 280 km swath width, with the same single-look resolution but with full-polarimetry enabled, could be thought as even more attractive and highly beneficial for services and scientific applications.

It is well known, however, that wide unambiguous swath coverage and high azimuth resolution pose contradicting requirements on the design of spaceborne SAR systems. Nevertheless, Digital Beam Forming (DBF) techniques, such as Scan-on-Receive (SCORE), and multiple azimuth channels, allow to overcome these fundamental limitations of conventional SAR systems. A multichannel system based on this technique was proposed for a follow-on of the Sentinel-1 system[1, 2]. However, new operational modes allow to reach the same imaging capabilities, both with planar and with reflector-based antennas [3].

The next generation of C-Band Sentinel-1 mission, would ensure a revisit time better than the current one of 6 days for the constellation of Sentinel-1 flying over a 12 days Sun-synchronous orbit at an obit height of 693 km. For the next generation of Sentinel-1 satellites, a mission repeat cycle of 4 days is required, which is achievable when three satellites fly over the same orbit of Sentinel-1 and displaced of 120 degrees. Furthermore, with this configuration and enabling acquisitions with 400m km swath width, daily acquisitions are ensured for higher latitudes (i.e., starting from 45 degrees), as required by several applications, especially those dedicated to the maritime surveillance and sea ice monitoring.

Further solutions in terms of orbits are available, however at the cost of breaking the continuity with Sentinel-1. A first possibility is to deploy two satellites, displaced of 180 degrees, over a 8 days – orbit that with 400 km swath width are able to map the global Earth surface, as in the previous case, in 4 days. In this case however, areas at 45° latitude are observed every 2 days benefiting from swath overlap at higher latitudes. An additional option would be to deploy a constellation of satellites over a higher orbit (in the order of 1000 km - 1300 km), also in this case over 12 days or 8 days sunsynchrous repeat orbits. The great advantage for a higher orbit is the possibility of enabling even a wider swath of 600 km, that allows to fully cover the North Pole, keeping the access range limited, otherwise prohibitive for lower orbits. This means in other words that the instrument is less complex in this case than for lower orbits.

In the final paper a more detailed assessment of the mission performance would be provided

[1] M.Zonno et al. “Performance assessment for the high resolution and wide swath (HRWS) post-Sentinel-1 SAR system”, ESA Living Planet Symposium 2016

[2] P.Lopez-Dekker et al., “Application-level performance and trade-offs for the post-Sentinel HRWS SAR Systems”, proceedings of EUSAR 2016

[3] F. Bordoni et al., “Operational Modes for Sentinel-1 Next Generation C-Band Synthetic Aperture Radar ”, ESA Living Planet Symposium 2019