Synthetic Aperture Radar Virtual Constellation (SAR-VC)

Implementation Plan v1.1

Introduction

This Implementation Plan provides an overview of the types of activities the Synthetic Aperture Radar Virtual Constellation (SAR-VC) will undertake in the initial period, 2027-2031.

At the third workshop of the International Coordination Group for Spaceborne SAR (ICGS-SAR) in November 2024, the participants developed a set of recommendations. These recommendations have informed the objectives of SAR-VC as outlined in the Terms of Reference, and are the basis for the tasks described below.

Requirements and Specifications

Synthetic Aperture Radar (SAR) is an active remote sensing technique, which observes targets by transmitting a radio wave and measuring the properties of the reflected signal. SAR makes use of the movement of the satellite in orbit, taking repeated observations as the instrument moves along its track, synthesising a much larger antenna and providing detailed, high-resolution images of the ground track.

SAR instruments typically measure in one waveband at a time. The following wavebands are used by current imaging SAR systems:

- P-band (~69.0 cm)
- L-band (~23.5 cm)
- S-band (~9.4 cm)
- C-band (~5.6 cm)
- X-band (~3.1 cm)

SAR systems are calibrated via active transponders or passive reflectors such as trihedral corner reflectors. The WGCV SAR Subgroup coordinates the calibration of these instruments, and has established SARCalNet to promote standardized SAR calibration and facilitate the harmonized implementation of cal/val tasks by a broad SAR community.

Operations of SAR-VC

SAR-VC will endeavour to meet virtually at least quarterly, to review progress on all activities. In-person workshops will be planned at least every two years, or more frequently if deemed necessary. The next workshop will be hosted by DLR, in October 2027. The following workshop will be targeted for sometime in 2029, with the host to be confirmed.

SAR-VC leadership will engage with the Strategic Implementation Team (SIT) Chair regularly, and ensure connection and collaboration with all relevant parts of the CEOS organisation.

Activities

SAR-VC will be broken down into five subgroups, two of which relate to mission coordination, and three of which represent elements that cut across these subgroups. Each group will undertake the following activities.

SG1: Current Mission Coordination

Leads: Takeo Tadono (JAXA), Stéphane Chalifoux (CSA), Nuno Miranda (ESA), Shadi Oveisgharan (NASA/JPL)

The primary goal for SG1 is to support SAR mission coordination for existing or near-to-launch missions to improve collection of spatially gap-free and temporally dense SAR data sets at all available SAR frequency bands. This includes coordinating the tasking of commercial satellites through agency data purchase agreements.

Action SG1-1: A number of organisations have been exploring the possibility of automated disaster response tasking tools for SAR data, to ensure data can be collected as soon as possible after a disaster hits - in particular geological hazards such as earthquakes. The NISAR mission team developed the smart-tasking tool, which automates the coordination of urgent response requests, both through triggered requests from alert feeds such as the USGS PAGER system, and through a graphical user interface available for approved users to submit requests for specific regions, time-frames, and radar modes. SAR-VC will coordinate with WGDisasters to investigate the possibility of expanding this tool to make it accessible by all SAR mission operators.

Action SG1-2: SAR-VC will also support calibration and validation activities, which will involve coordination with the WGCV SAR Subgroup, who focus on Level 1 data. SAR-VC will expand on this by focusing on the calibration and validation of higher level products, to support application areas of interest including agriculture, urban and oceanography. SAR-VC will identify the type of satellite data required alongside suitable models, to develop validation protocols for each use case.

Action SG2-3 (aligned with future mission coordination activities, but also relevant for current mission planning coordination): SAR mission operators often run independent mission planning tools, which help operators in the tasking and planning of acquisitions. A cross-validated tool would help optimize mission plans across agencies to ensure global coverage across all bands to the greatest extent possible. SAR-VC will undertake a cross-validation exercise of all available SAR mission planning tools.

SG2: Future Mission Coordination

Leads: Martin Suess (ESA), Paul Rosen (NASA/JPL), Malcolm Davidson (ESA), Manfred Zink (DLR)

Action SG2-1: SAR-VC will ensure review of all planned SAR missions to identify potential future data gaps. Information exchange will be enabled to allow future mission plans to be shared well in advance of launch to identify possible overlaps and synergies.

To assess the benefits of multi-mission constellations and take advantage of international cooperation, SAR-VC will enable the use of tools for constellation science, applications performance studies, and coverage studies. Capabilities may include a broader range of geophysical parameters to be optimized and their associated error models to address an array of measurement needs common across agencies.

Recommendations of science and applications needs identified by SG3 feed the requirements for future missions. SG2 will analyze those needs and through planning simulations and performance evaluations will develop a CEOS-level strategy for future mission coordination, factoring in the recommendations on techniques and technologies from SG4 and commercial capabilities from SG5.

Action SG2-2: Insights and recommendations originating from SG4 will be leveraged to identify opportunities for integration of SAR Techniques and Technologies into planned or prospective future missions, especially in the area of companion satellites and multi-static missions, which are currently under consideration by many agencies.

Action SG2-3: Mission plans can be quite complex for an individual mission, with multiple stakeholders placing demands on observations. In coordinating many missions across agencies, the problem becomes even more complex. Therefore, SAR-VC will coordinate cross-validation of mission planning simulation tools that can support multiple satellites for coordination of future multi-agency mission constellations.

SG3: Science and Applications Needs

Leads: Ake Rosenqvist (JAXA), Ekaterina Tymofyeyeva (NASA/JPL), Bjorn Rommen (ESA), Magdalena Fitrzyk (ESA), Irena Hajnsek (DLR)

SG3 is a cross-cutting subgroup, developed as an evolution of the ICGS-SAR Thematic Areas on Interferometric and Polarimetric SAR Applications (TA-1/TA-2). Recommendations from the science community were published in *Earth and Space Science* in 2026, in a paper titled *Observation and Coordination Needs for Current, Near-Future, and Next Generation Earth-Observing SAR Systems*.

Action SG3-1: SAR-VC will work with agencies to implement the recommendations outlined in this paper, including:

- Provide open access to more data, even if only contained in archives or acquired for selected areas. For L-band, consider making SAOCOM-1A/B, ALOS, and ALOS-2 global archives open for scientific use.
- Prioritize consistent observation modes over changing modes for systematic monitoring to enable shorter temporal baseline InSAR over longer time scales and more dense time series for change detection in general.
- Coordinate observations for the Arctic, Antarctic, Greenland, and Siberia regions to provide spatially comprehensive coverage with sustained observations at the orbit repeat period. Recently WMO revitalized a polar task group with a similar charter. SAR-VC will provide a representative and work specific technical aspects of the WMO recommendations within the CEOS umbrella.
- Acquire ALOS-4 and SAOCOM-1 wide-swath full-polarimetric observations of global vegetated areas with dual seasonal (summer/winter & dry/wet season) or four-season coverages (this complements NISAR's dual polarization 12-day repeat).
- Coordinate with LiDAR and optical missions for campaigns and supersites.

Action SG3-2: SAR-VC will establish a performance model validation framework to create confidence among Agencies that constellation performance is properly and sufficiently estimated as input to decision-making on international coordination. The VC will develop data sets and ground truth to estimate performance from observations and compare to model predictions.

Action SG3-3: Furthermore, SAR-VC will lead the CEOS Polarimetric SAR (PolSAR) activity, which aims at catalyzing the development of SAR polarimetry. Activities include coordination of the PolSAR Science Team, liaising with contributing CEOS SAR Agencies for the coordination of multi-mission polarimetric observations over PolSAR Reference Sites, and collection of science results.

This subgroup functions as a source of information and requirements for the coordination subgroups 1 and 2.

SG4: SAR Products, Techniques and Technologies

Leads: Stephen Horst (NASA/JPL), Paola Rizzoli (DLR)

Action SG4-1: LSI-VC has been coordinating the development of CEOS Analysis Ready Data (CEOS-ARD) SAR products and specifications since 2018. It has been agreed to transition this activity, which involves the development of new and revised SAR product specifications, to the SAR-VC. Coordination with the development of other CEOS-ARD specifications will be ensured by continued participation in the CEOS-ARD Oversight Group.

Action SG4-2: Interoperability and complementarity of SAR products and services is one of the biggest challenges. SAR-VC will coordinate an assessment of SAR products and services against the CEOS Interoperability Handbook and Maturity Matrix, to inform actions to improve interoperability.

Action SG4-3: Companion satellites for SAR missions are an emerging technique to enable interferometric SAR acquisitions at a lower cost. One example of this is ESA's Harmony mission, which is planned to fly in formation with Copernicus Sentinel-1D. SAR-VC will undertake an activity to review all current plans for similar missions, and develop a white paper highlighting other opportunities.

Action SG4-4: The wavebands used by SAR are regularly under threat by other sectors, in particular communications, and there is a risk that the International Telecommunications Union (ITU) reallocates the wavebands used by SAR to other sectors. SAR-VC will monitor the allocation of radar frequencies, and advocate at an international level for the protection of wavebands for SAR, in particular for scientific research.

Action SG4-5: SAR-VC will also explore developing data analysis techniques, such as the role of Artificial/Super Intelligence and Machine Learning, onboard processing, and foundation models.

This subgroup functions as a source of information and requirements for the coordination subgroups 1 and 2.

SG5: Commercial Data Systems and Providers

Leads: Elizabeth Nuncio (DLR), Leonardo De Laurentiis (ESA), Batuhan Osmanoglu (NASA)

The commercial SAR sector is increasing in size, with more operators launching each year. SAR-VC will track commercial and non-governmental organisations currently operating or planning SAR missions.

Action SG5-1: One of the current impediments to effective use of commercial SAR data is the challenge of matching commercial business incentives with agency-level policies regarding use and redistribution of data for scientific purposes. Commercial companies have demonstrated powerful scientific capabilities, often as a means to promote their systems' capabilities, for specific customers, with limited coverage and distribution rights. Some agencies have pursued data-buy programs with announcements of opportunity for investigators to acquire and use data. However, policies for acquisition and distribution are ad hoc by agency and not coordinated to maximize science return, and typically not coordinated against the landscape of other civil or commercial missions. This activity strives to coordinate commercial policy with agency level usage policies.

Actions SG5-2: Furthermore, the data-buy programs do not always include tasking rights. Agency policies and agreements with vendors should be coordinated such that tasking is possible. The role of the SAR-VC will be to maintain a comprehensive accounting of Agency policies, agreements and practices, assess their effectiveness at CEOS-level coordination of commercial data buys for science activities, and formulate recommendations for improvements.

Schedule

ID	Task	2027	2028	2029	2030	2031
SG1: Current Mission Coordination						
SG1-1	Explore feasibility of an automated tasking tool for disaster applications					
SG1-2	Validation protocols for higher-level products	Ongoing task				
SG2: Future Mission Coordination						
SG2-1	Tracking and exchanging information on agency trends and plans for missions	Ongoing task				
SG2-2	Coordination of multi-static systems and companion satellites					
SG2-3	Cross-validation of mission planning simulation tools					
SG3: Science and Applications Needs						
SG3-1	Implement recommendations from ICGS-SAR Thematic Areas paper	Ongoing task				
SG3-2	Performance model validation framework for vector deformation and other observables					
SG3-3	PolSAR task					
SG4: SAR Products, Techniques and Technologies						
SG4-1	CEOS-ARD SAR product family specifications	Ongoing task				
SG4-2	SAR Interoperability Assessment					
SG4-3	Companion satellite white paper					
SG4-4	Waveband protection advocacy	Ongoing task				

SG4-5	Explore developing data analysis techniques	Ongoing task
SG5: Commercial Data Systems and Providers		
SG5-1	Coordinate commercial policy with agency level usage policies	Ongoing task
SG5-2	Commercial data acquisition policies	Ongoing task

Accreditation and Recognition Metrics

SAR-VC's success over time will ultimately be measured by the availability of consistent global coverage across all SAR modalities (e.g. observation modes, constellation configurations, etc.). Success will also be measured by the operationalisation of new and emerging SAR techniques and capabilities, enabling scientific advancements for societal benefit.

SAR-VC aims to be the international coordination body for all spaceborne SAR aspects, including the agencies' needs of the commercial SAR sector. This can be measured by the number of commercial SAR operators engaging with SAR-VC, with all current and future operators represented within the membership.

Funding

SAR-VC activities will be sponsored by agencies in-kind, on a best efforts basis. CEOS Agency support is requested to host workshops, and allow for travel to hosted workshops and relevant meetings and conferences where coordination with other SAR or CEOS entities are most efficiently conducted.

Two activities have been identified as requiring significant funding:

- SG1-1 (automated tasking tool) - the initial phase will involve exploring the feasibility of such a tool, however will require significant sustained funding to become operational.
- SG3-2 (performance model validation framework) - requires significant funding to be maintained, run on multiple scenarios, generalized for new mission capabilities and concepts, and to add new performance models beyond 3d deformation and biomass.

CEOS Agencies are asked to consider whether either activity is something they would consider funding.