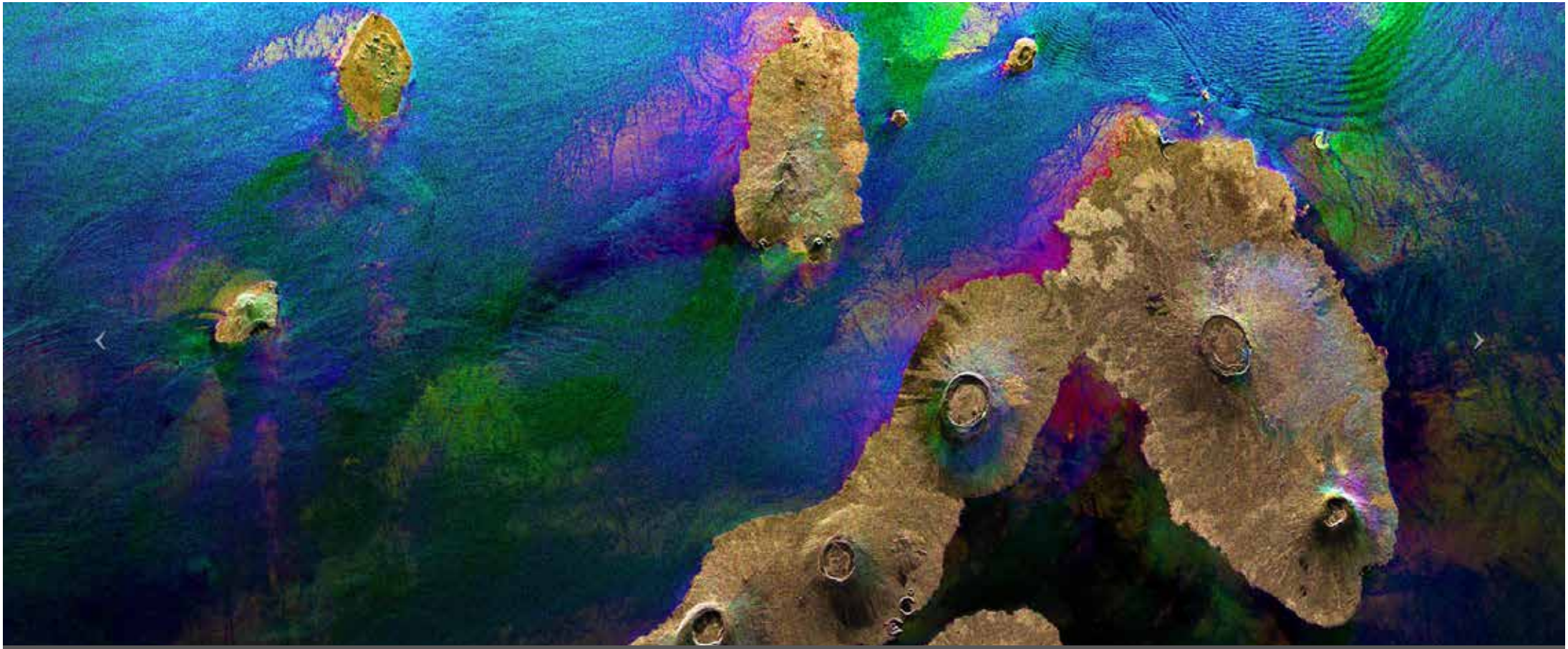


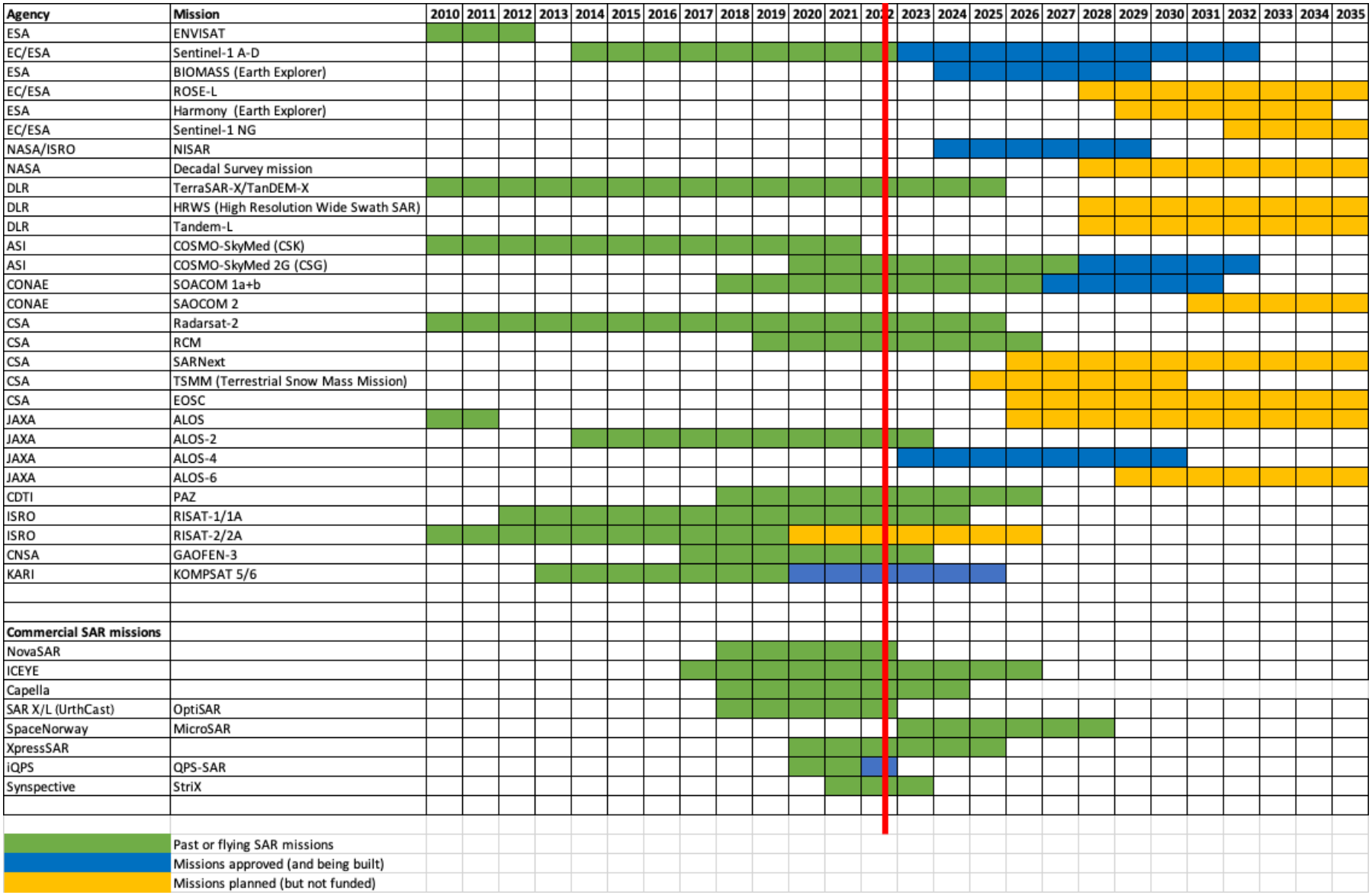
Overall Progress Since the First Workshop in 2018

Charles Elachi

Second Workshop on International Coordination for Spaceborne SAR missions
28 September2022, ESA/ESRIN

International Coordination for Spaceborne Synthetic Aperture Radar Data Acquisition, Processing and Analysis for Earth Science and Applications

- First workshop held on 30 May – 1 June 2018 at Caltech, USA
- Explore the interest in and value of a more coordinated approach among the different organizations flying or planning spaceborne SAR missions to achieve higher value for the science and application user community
- Workshop was attended by 60 scientists and engineers from almost all the agencies/countries flying spaceborne SAR's and from the commercial sector


Agency
Mission
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
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2024
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2026
2027
2028
2029
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2033
2034
2035
ESA
ENVISAT
EC/ESA
Sentinel-1 A-D
ESA
BIOMASS (Earth Explorer)
EC/ESA
ROSE-L
ESA
Harmony (Earth Explorer)
EC/ESA
Sentinel-1 NG
NASA/ISRO
NISAR
NASA
Decadal Survey mission
DLR
TerraSAR-X/TanDEM-X
DLR
HRWS (High Resolution Wide Swath SAR)
DLR
Tandem-L
ASI
COSMO-SkyMed (CSK)
ASI
COSMO-SkyMed 2G (CSG)
CONAE
SOACOM 1a+b
CONAE
SAOCOM 2
CSA
Radarsat-2
CSA
RCM
CSA
SARNext
CSA
TSMM (Terrestrial Snow Mass Mission)
CSA
EOSC
JAXA
ALOS
JAXA
ALOS-2
JAXA
ALOS-4
JAXA
ALOS-6
CDTI
PAZ
ISRO
RISAT-1/1A
ISRO
RISAT-2/2A
CNSA
GAOFEN-3
KARI
KOMPSAT 5/6
Commercial SAR missions
NovaSAR
ICEYE
Capella
SAR X/L (UrthCast)
OptiSAR
SpaceNorway
MicroSAR
XpressSAR
iQPS
QPS-SAR
Synspective
StriX
Past or flying SAR missions
Missions approved (and being built)
Missions planned (but not funded)

Recommendation 1: Archival, present and future data should be easily and electronically accessible with a standard and common format, at little or no cost.

- All agencies flying spaceborne SAR systems either provide all of the data free of cost, or subsets of data for specific purposes and to support interagency agreements.
- While a single format may not be suitable for all SAR data, there is a strong consensus that a good degree of harmonization is warranted and possible, through the clear and common definition of metadata quantities, and creation of standard lookup tables to serve as Rosetta Stones translating among legacy formats.

Recommendation 2: Develop a mechanism to coordinate future data acquisition and coverage by present and planned systems, as well as ground reception and processing approaches for mutual benefit.

- Coordination among systems has led to significant benefit, particularly for polar ice studies (Polar Space Task Group) and rapid characterization of natural hazards (International Disaster Charter and Sentinel Asia). Expanded coordination will greatly benefit applications that rely on expanded coverage, shorter repeat time, long term monitoring and multiple frequency/polarized observations.
- Information on acquisition plans for each mission should be available to all to facilitate better coordinated between the agencies.

Recommendation 3: Take an optimized systems approach to the overall constellation of planned and proposed missions to explore the possible mutual benefit of the total constellation coverage and capabilities.

- Each organization, *understandably*, optimizes its system for its needs within its limitations. By evaluating the global constellation of missions as a coordinated system, there are opportunities for enhanced or new capabilities, while meeting individual agency requirements. Some examples:
  - Better filling of gaps and higher repeat coverage by slight adjustment of orbit, node crossings or local crossing time.
  - Quick response for time critical applications.
  - Better continuity of observations over a long period of time (multi decadal).
  - Enable new multiple system capabilities such as bistatic observations and multi interferometric observations.
  - Left / right imaging coordination to overcome shadowing

Recommendation 4: Coordinate and share common test sites and sites for calibration and validation.

- Calibration and validation sites are essential to be able to use the radar data for most applications. Each mission team establishes such sites to serve individual systems, with a few cases of common site utilization.
- Mutually agreed on common test sites and "Supersites" for calibration and validation of all currently flying and planned systems would provide great value. *This would significantly enhance the value of the data from multiple systems, save significant financial resources and encourage international collaboration.*
- Given the large number of SAR missions and the diversity of mission architectures (e.g. frequency, antenna, pattern, resolution, polarization, etc...), there is a recognized benefit to calibrating/validating all SAR missions over a number of "Super-Sites".
- Public availability of data from all missions and associated ground based observations would facilitate inter-mission comparisons and fusion. These sites should be defined, developed, and supported by international teams, under multi-agency agreements.
- The validation and thematic sites should involve relevant user agencies, so that validated data are easily understood and used, and that data products can be widely applied by non-experts.

WG-1 Present and Future Data

1. Compile survey results of three main target area (virtual observation constellation, tasking and data sharing)

- Compiled information about number of satellite systems into two tables.
- Found that all agencies flying spaceborne SAR systems either provide all the data free of cost, or subsets of them for specific purpose or by entering into inter agency agreements.
- Found that their value will be significantly enhanced If all the data has standard geometric and radiometric formats.

2. Discuss and coordinate way forward to enhance the current cooperative framework for virtual observation constellation, tasking and data sharing.

a) Virtual constellation

- Need to establish a scheme to have multi-agencies / organization virtual constellations? (A-Train type framework, GPM or ACCP?) for what?

b) Tasking and observation planning

- Do we need enhance emergency observation tasking beyond international disaster charter or sentinel Asia (what is a value / advantage of SAR emergency observation? Night / bad weather? And other reason?
- Mechanism of observation plan sharing (just KML?)

c) data sharing

- How to enhance / improve data and information sharing and for what? Need to have a pilot / demonstration projects (- cooperation with CEOS and/or GEO to specific theme?) to provide valuable outcome (e.g. Carbon STK – Biomass, sea ice monitoring, etc.)
- Data format standardization with CEOS WGISS or WGCV?

WG -2 : Future imaging systems

- Identify a set of global science measurements of interest to many/most countries with space agencies, which can be addressed by SAR (possibilities depicted at right)
- Consider specific inter Agency coordination scenarios
  - *e.g.* multi-lateral partnerships, federations, CEOS/GEO-centric initiatives
  - Identify potential opportunities and roadblocks
  - Factor in the role commercial SAR

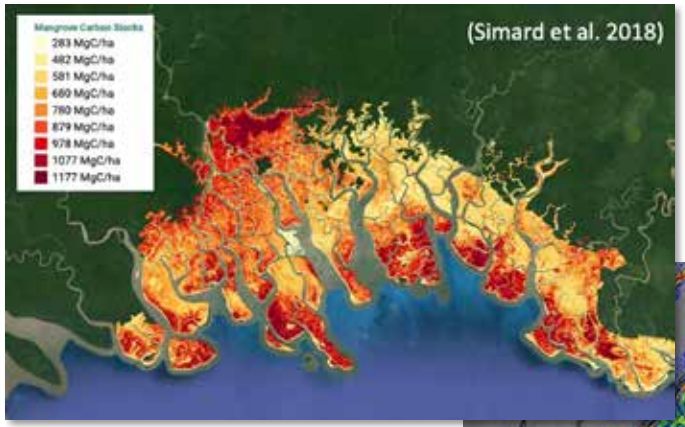
TA-1: Polarimetric and multi-frequency SAR applications

Key application areas

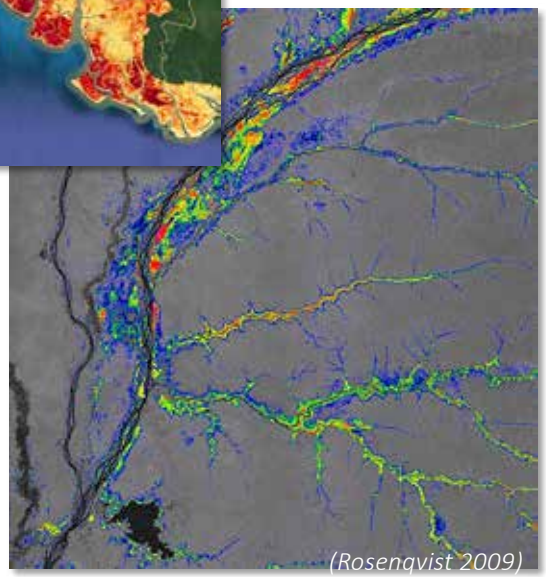
- Forest & Land Cover
- Vegetation structure & Above-Ground Biomass
- Wetlands extent and inundation
- Agriculture & Soil Moisture
- Ocean & Sea Ice

Challenges

- Ionospheric and tropospheric effects
- Lack of consistent data at regional-global scales:
  - Time-series data at several radar frequencies
  - Coincident multi-frequency datasets
  - Polarimetric time series
  - Bi-static data for R&D
- Temporal noise & Signal saturation



Mangrove carbon stocks [SRTM]

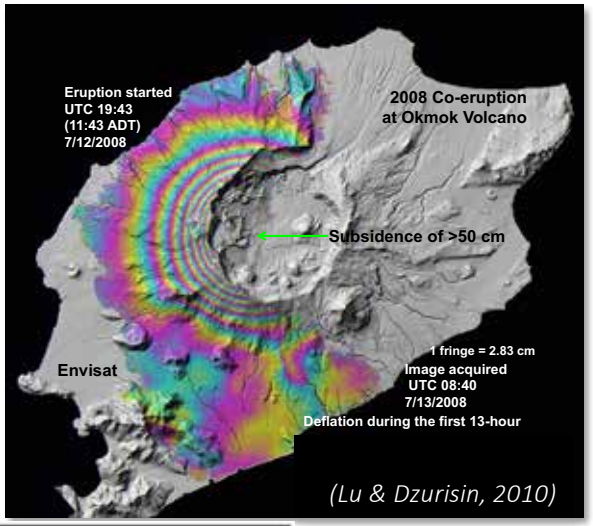


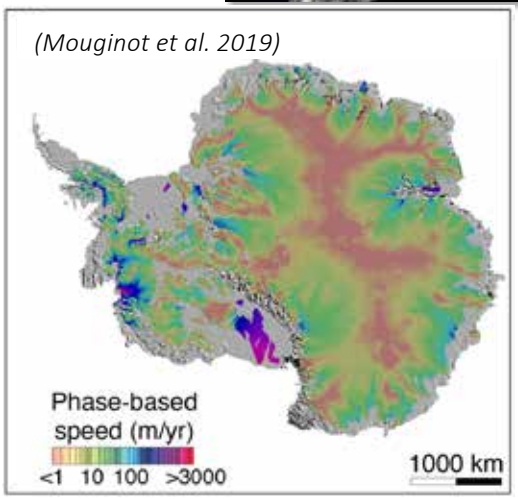
Wetland inundation [ALOS PALSAR]

TA-2: Interferometric SAR applications

Key application areas

- Crustal deformation, subsurface magma migration, aquifers
- Earthquakes, volcano eruptions, landslides, subsidence
- Velocity of glaciers, ice caps, and ice sheets
- Glacier grounding line mapping
- Applications related to Climate Change, e.g., relative sea level rise, increased occurrence of natural disasters





Challenges

- Temporal revisit
- Temporal decorrelation
- Ionospheric and tropospheric delay
- Spatial resolution
- Line-of-Sight (LOS) diversity
- Accessibility & latency in data delivery

Working Groups (WG)

WG1	WG2	WG3
Present and future data-Visibility and access (L0-L2)	Future imaging systems- Goals, plans, challenges and opportunities	Data exploration-Cal/Val, fusion and assimilation (L3-L4)
Co-Chair's Sobue, Bawden, Kroupnik, Potin	**Co-Chair's** Suess, Zink, Rosen	**Co-Chair's** Chapman, McNairn, Frulla, Engdahl

Thematic Areas (TA)

TA1	TA2	TA3
Polarimetric and multi-frequency SAR applications	Interferometric SAR applications	Program and mission coordination
Co-Chair Rosenqvist, Scipal	**Co-Chair** Jones, Rommen	**Co-Chair** Bawden, Davidson

Input for today Workshop

- With more than 25 spaceborne SAR systems currently flying and an additional 25+ being built or planned, tremendous opportunity to cooperate and coordinate among space agencies and industry actors:
  - Data harmonisation and standard
  - Coordinate future data acquisition and coverage
  - Optimized systems approach to the overall constellation of planned and proposed missions
  - Coordinate and share common test sites and sites for calibration and validation
- WG's and TA' put in place to address these topics
- Strong desire from space agencies to work together in order to offer the best synergy among SAR missions to the users community
- Wish to include commercial SAR data providers in the overall approach