KA-BAND SAR INTERFEROMETRY STUDIES FOR THE SWOT MISSION

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The primary objective of the National Research Council (NRC) Decadal Survey recommended SWOT (Surface Water and Ocean Topography) Mission is to measure the water elevation of the global oceans, as well as terrestrial water bodies (such as rivers, lakes, reservoirs, and wetlands), to answer key scientific questions on the kinetic energy of ocean circulation, the spatial and temporal variability of the world's surface freshwater storage and discharge, and to provide societal benefits on predicting climate change, coastal zone management, flood prediction, and water resources management.

Radar altimetry has been a major achievement in the study of the Earth. Through the missions of TOPEX/Poseidon (1992-2005), and its follow-on Jason (2001-present), and the Ocean Surface Topography Mission (OSTM)/Jason-2 (2008-), a 15+ year data record of the global ocean surface topography has been obtained, which will extend into the future. However, the spatial resolutions of these missions are not sufficient to address fundamental scientific questions such as: (1) the eddy currents of the ocean that contains 90% of the kinetic energy of ocean circulation, and (2) the variability of water storage and discharge over land, which is key to achieve understanding of the global water cycle. SWOT will use a new technique to measure water elevation that will provide an order-of-magnitude improvement in resolution and accuracy that is required to address these scientific questions and to further our current knowledge of oceanography and land hydrology, while establishing a reference standard for future radar altimetry missions.

The core technology for SWOT is the KaRIN instrument, originally developed from the efforts of the Wide Swath Ocean Altimeter (WSOA) [1], [2]. The KaRIn instrument (see Figure 1) will be complemented with the following suite of instruments:: a Ka-band interferometer, a dual-frequency nadir altimeter, and a multi-frequency water-vapor radiometer dedicated to measuring wet tropospheric path delay to correct the radar measurements. The interferometer's concept is as follows: radar pulses are transmitted from each antenna, and the radar echoes from each pulse are received by both. The interferometric phase difference between the coherent signals received by both antennas is essentially related to the geometric path length or range difference to the image point, which depends on the topography. Therefore, the knowledge of the range and the phase difference can be converted into an altitude for each image point. SWOT implements two Synthetic Aperture Radar (SAR) antennas (illustrated in the figure below), each one providing two separate beams at Ka-band (35.7 GHz). As a result, the total swath coverage provided by the interferometer is 120 km, at an unprecedented resolution of 1 km for the ocean (after on-board processing), and 50 m for land water.

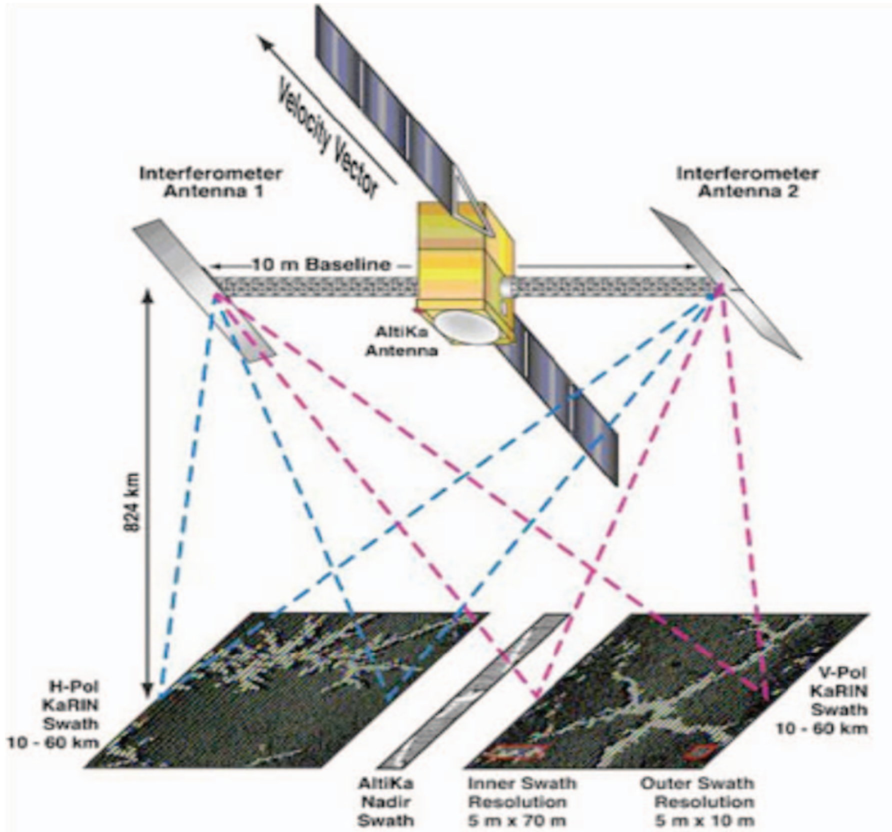

Figure 1. A conceptual picture of the Ka-band radar interferometer.

We are currently funded by the NASA Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP) to reduce the risk of the main technological drivers of SWOT, by addressing the following technologies: the Ka-band radar interferometric antenna design, the on-board interferometric SAR processor, and the internally calibrated high-frequency radiometer. The goal is to significantly enhance the readiness level of the new technologies required for SWOT, while laying the foundations for the next-generation missions to map water elevation for studying Earth. The first two technologies address the challenges of the Ka-band SAR interferometry, while the high-frequency radiometer addresses the requirement for small-scale wet tropospheric corrections for coastal zone applications.

The antenna will employ printed reflectarray technology, consisting of a flat reflectarray aperture of ~5 x 0.20 m with many printed Ka-band patch elements [3]. Two slotted-waveguide feed arrays (one V-pol and the other H-pol) illuminate each aperture to provide two independent beams.

The resulting radar's output data rate is beyond affordable downlink capabilities for global data downlink. Instead, the raw data over land will be downlinked, while the on-board processor with interferometric SAR processing and multi-looking capabilities will decrease the data rate to reasonable limits for data over the ocean before download.

The microwave radiometers carried by previous and on-going altimetry missions do not have the spatial resolution required to resolve the small-scale water vapor features near coastal regions. In order to provide high-resolution coastal altimetry, radiometer channels operating at frequencies of 90 GHz or greater can be added. However, operation at high frequencies without external calibration (that is, without periodic views of hot and/or cold loads), has, to our knowledge, never been flown in space before.

In this paper, we present the overall concept of the SWOT mission, as well as the scientific rational, objectives and development status of the technology items currently under development.

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