The Surface Water and Ocean Topography Mission

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Abstract— **The SWOT mission is a partnership between two communities, physical oceanography and hydrology, to share high vertical accuracy and high spatial resolution topography data produced by the science payload, whose principal instrument is a Ka-band radar Interferometer. The SWOT mission will provide large-scale data sets of ocean sea-surface height resolving scales of 15km (in wavelength) and larger, allowing the characterization of ocean mesoscale and submesoscale circulation. Present altimeter constellations can only resolve the ocean circulation at wavelengths larger than 200km. SWOT will address fundamental questions on the dynamics of ocean variability at wavelengths shorter than 200km, which encompasses mesoscale and submesoscale processes such as the formation, evolution, and dissipation of eddy variability (including narrow currents, fronts, and quasi-geostrophic turbulence) and their role in air-sea interaction.**

The SWOT mission will also provide measurements of water storage changes in terrestrial surface water bodies and will provide estimates of discharge in large (wider than 100m) rivers, globally. The SWOT measurements will directly measure the surface water (lakes, reservoirs, rivers, and wetlands) component of the water cycle.

The core of the SWOT payload consists of a Ka-band Radar Interferometer (KaRIn) - a dual-antenna synthetic aperture radar specifically designed to make high precision height and backscatter measurements enabling the key oceanographic and hydrology data sets. The SWOT payload also includes: a Nadir Altimeter (NA) system, a radiometer for tropospheric path delay corrections, and a precision orbit determination instrument suite consisting of Global Positioning System-Payload (GPSP), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) receivers, and a Laser Retro-reflector Array (LRA).

SWOT is a partnership mission between NASA, the French Space Agency (CNES), The United Kingdom Space Agency (UKSA), and The Canadian Space Agency (CSA). The spacecraft bus and command & data ground stations are provided by CNES, while the launch vehicle and payload module are provided by NASA/JPL. The SWOT payload module instrument suite consists of the NASA/JPL provided KaRIn instrument, cross-track radiometer, GPS, and laser retroreflector, as well as the CNES provided DORIS and nadir pointing radar altimeter. CNES also provides the Radio Frequency Unit (RFU) sub-system for which the UKSA contributes the Duplexer assembly. The RFU is a key sub-system of the KaRIn instrument. CSA contributes the Extended Interaction Klystron (EIK) which is one of the KaRIn subsystem. This paper describes the mission design, implementation of the Payload, and some of the interface and design challenges.

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1. MISSION DESCRIPTION AND SCIENCE OBJECTIVES

The Surface Water and Ocean Topography (SWOT) mission, recommended by the National Research Council decadal survey "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond", will expand on the multi-year data set begun with the TOPEX/Poseidon mission in 1992, followed by Jason-1 in 2001, OSTM/Jason-2 in 2008, and Jason-3 in 2014.

The mission will generate high vertical accuracy and high spatial resolution topography data produced by the science payload, whose principal instrument is a Ka-band Radar Interferometer (KaRIn), that will be used by the physical oceanography and hydrology science communities.

The SWOT mission will provide data sets of ocean sea-surface height resolving scales of 15km and larger, allowing the characterization of ocean mesoscale and submesoscale circulation. Present altimeter constellations can only resolve the ocean circulation at resolutions larger than 200km. SWOT will address fundamental questions on the dynamics of ocean variability at scales shorter than 200km, which encompasses mesoscale and submesocale processes such as the formation, evolution, and dissipation of eddy variability (including narrow currents, fronts, and quasi-geostrophic turbulence) and their role in air-sea interaction.

The SWOT mission will also provide measurements of water storage changes in terrestrial surface water bodies and will provide estimates of discharge in large (wider than 100m) rivers, globally. Since the early 2000s, NASA has developed and operated missions for the global measurement of the water cycle such as GPM, Cloudsat, SMAP, GRACE, and GRACE-FO. The SWOT measurements will provide a key complement to these measurements by directly measuring global surface water (lakes, reservoirs, rivers, and wetlands) component of the water cycle in a way that has not been previously possible.

The availability of high frequency and high-resolution maps of elevations for surface water bodies and oceans will also present the applications community with unique opportunities to solve numerous societally relevant challenges around the globe. These may include such diverse and far ranging issues as fisheries management, flood inundation mapping/risk mitigation/forecasting, wild life conservation, global data assimilation for improving forecast of ocean tides and weather, reservoir management, climate change impacts and adaptation, and river discharge estimation, just to name a few.

SWOT is a collaborative mission between NASA/JPL and CNES with contributions from the Canadian Space Agency (CSA) and the United Kingdom Space Agency (UKSA). JPL provides four instruments, an X-band payload communication system, a payload module, Payload Integration and Test (I&T), JPL Payload Operations and data processing, and the launch vehicle. CNES provides the spacecraft bus, two instruments, Flight System I&T, SC and CNES Payload Ops and data processing. A summary of the SWOT instrument complement is as follows:

Ka-Band Radar Interferometer (KaRIn)	NASA/JPL
Radio-Frequency Unit (RFU)	CNES
Radio-Frequency Unit (Duplexer)	UKSA
Extended Interaction Klystron (EIK)	CSA
Radiometer	NASA/JPL
Global Positioning System – Payload	NASA/JPL
Laser Ranging Assembly (LRA)	NASA/JPL
DORIS Instrument	CNES
Nadir Altimeter	CNES

The SWOT mission is planned to be launched from Vandenberg Air Force base in 2021 using a SpaceX - Falcon 9 launch vehicle and will operate for a nominal mission of 42 months.

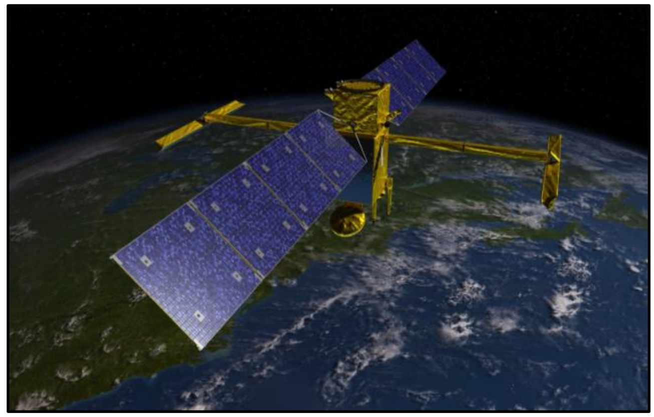

Figure 1 - Conceptual SWOT Spacecraft

The nominal science mission is performed in a near-circular orbit at an altitude of ~891km, with an inclination of 77.6 degrees and a 21-day repeat period in order to minimize tidal aliasing. The baseline mission duration includes 6 months for Launch and Early Operations (LEOP), Flight System (FS) commissioning/checkout and calibration, and a 36-month science phase. At the end of the science mission, the spacecraft will perform a deorbit maneuver to reenter Earth's atmosphere in a controlled fashion to minimize in-orbit debris.

The primary SWOT instrument is the Ka-band Radar Interferometer (KaRIn) used to measure surface elevations. This instrument has a 10-meter antenna baseline, and measures two 50-km wide swaths centered around its along-track direction.

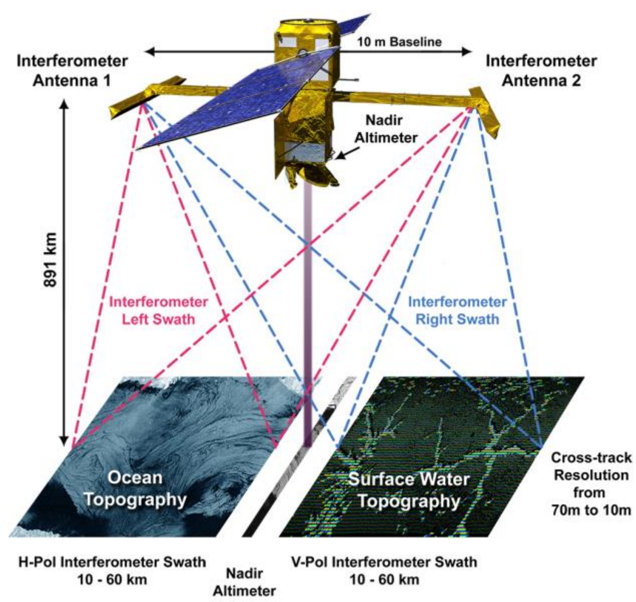

Figure 2 - SWOT Ka-Band Radar Interferometer (KaRIn) and Nadir Altimeter Measurement Concept

Other key instruments include the nadir altimeter similar to prior Jason mission series instrument, which is used for absolute height measurement, calibration at cross-over points, and calibration of the KaRIn instrument. A 2-beam, 3-frequency cross-track radiometer is included to measure atmospheric properties which can affect the KaRIn and altimeter measurements, including wet-tropospheric delay. A suite of Precision Orbit Determination (POD) instruments rounds out the payload, and includes DORIS, GPSP, and LRA. An X-band telecom subsystem is included for high data rate transfer of payload science data.

Table 1. Key Payload Resources

System Resource	Capability
Payload Mass	880 Kg
Payload Orbit Average Power	1407 W
Downlinked science data volume	8.6 Terabits / day

JPL will perform payload operations and science data processing of the JPL-provided instruments and provide science products to the NASA PO.DAAC for data archiving and distribution. CNES performs the analogous functions for the CNES-provided instruments. All payload commands are sent to the CNES spacecraft control center for upload to the spacecraft via the CNES S-band network. Payload science and housekeeping data is regularly (~21 passes/day) downlinked to the CNES X-band network and distributed to the JPL and CNES science data processing centers. The surface height measurements require a combination of KaRIn, altimeter, and POD data, as well as ancillary spacecraft data. This data is shared between the JPL and CNES teams to generate the final science products which are then sent to the institutional science data archiving and distribution centers.

2. Mission Architecture

Observatory Description

The SWOT spacecraft (also called the "observatory") is composed of 2 primary elements: the CNES supplied spacecraft bus (or "platform"), and the NASA/JPL supplied Payload Module (PM). The PM is further split into 2 elements – the Nadir Module (NM), and the KaRIn Module (KM). **Figure 3** graphically shows both the physical configuration and the breakdown of responsibility between the various partner organizations for the delivery of different hardware elements that make up the modules.

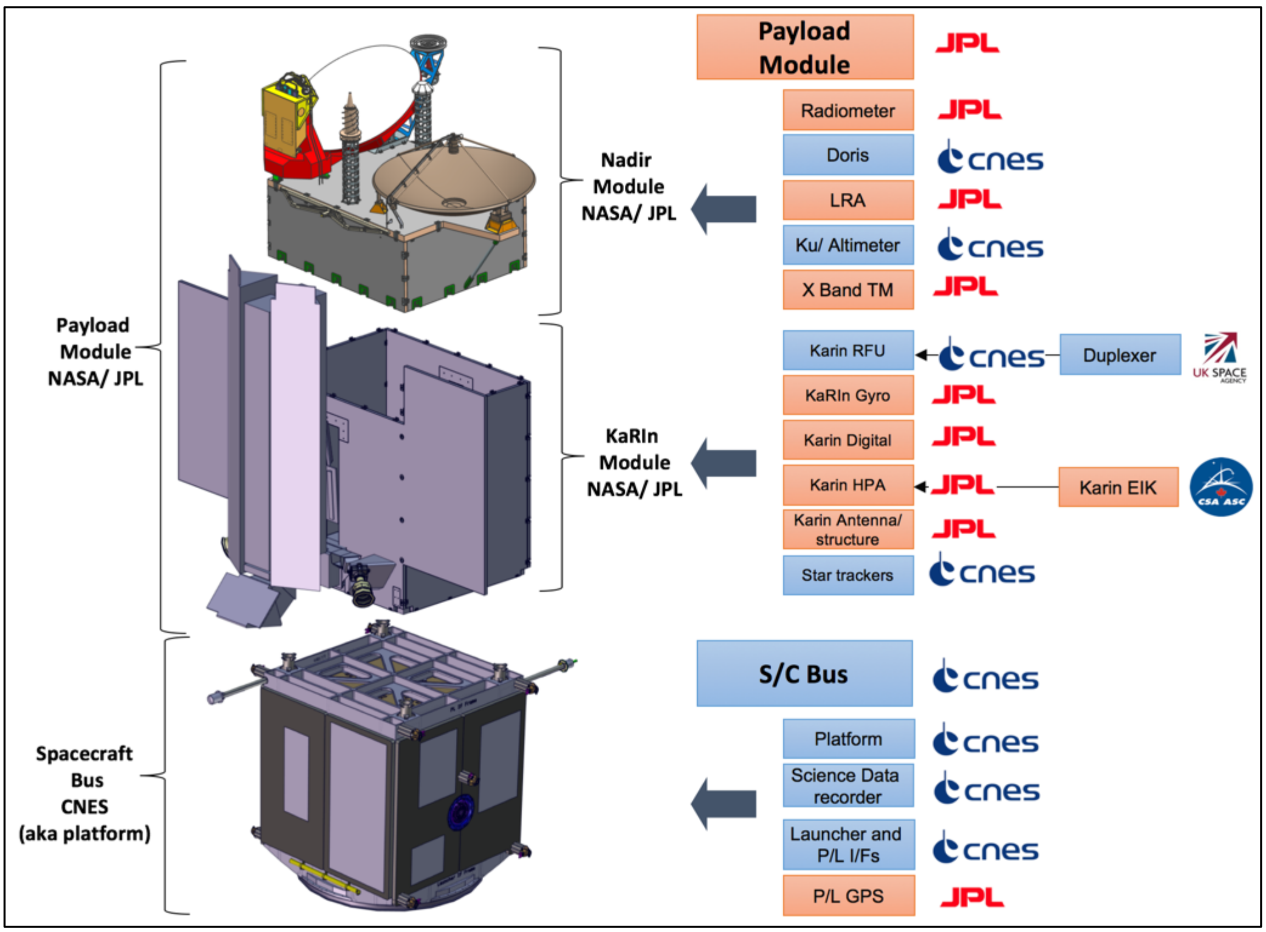

Figure 3. SWOT Observatory by organization

The SWOT Observatory is shown in **Figure 4** in its fully deployed mission configuration. As seen in the figure, the most prominent features of the vehicle are the high power solar panels, the KaRIn dual reflectarray antenna with its 10m baseline, the large +Y facing radiator, and the antenna farm on the nadir deck. The science requirements for the mission require constant data collection by all of the science instrument, resulting in a daily data collection and downlink budget of about 1 Terabytes of data.

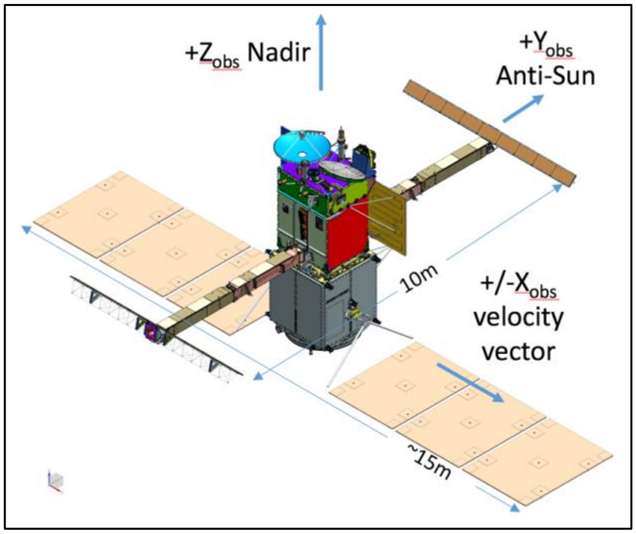

Figure 4. SWOT Observatory in mission configuration

Architectural Drivers

The observatory architecture is driven by the following key factors:

1. **Partner responsibilities**: resulting in the desire to have separate bus and payload modules with clean interfaces.
2. **High spatial resolution for land hydrology measurements:** which drove the large KaRIn interferometric baseline. The 10 m baseline length is limited by the mass/inertia capability of the s/c attitude control system. The offset reflect-array geometry is optimum in terms of mass/inertia for a near nadir viewing geometry.
3. **High data rate & data volume of the radar interferometer:** The high-resolution surface hydrology data results in a raw data rate of approximately 6 gigabits per second (Gbps) from the interferometric radar. In addition, the science requirements are such that all the science instrument are continuously taking data over the life of the mission, over both land and ocean. Because present space qualified storage technology and credible downlink data rate cannot support this data rate continuously, it is necessary to process the KaRIn data onboard prior to storage and downlink. A total of 7 Xilinx Virtex 5 FPGAs are utilized in the data path to do A/D conversion and processing of the raw interferometric I/Q data, bringing the data rate to about 320 Mbps over land, and 15 Mbps over the ocean. The KaRIn instrument is the first mission with this level onboard data processing for a radar developed by JPL.
4. **Stability of the interferometric measurement:** with 3 prime sub-elements
   a. KaRIn electronics thermal stability requirement, together with significant power dissipation, resulting in the need for constant conductance and loop heat pipe taking the heat of the electronics out to large radiators, and the need for those +Y facing radiators to not be exposed to the sun, providing an as-stable-as-possible a sink temperature. A seasonal vehicle yaw flip is executed in order to maintain this anti-sun pointing for the +Y face.
   b. Pointing stability, which drove the need for a near zero CTE composite metering structure and composite antenna booms for KaRIn, as well as low limits on allowable disturbances from the platform to the payload, impacting the reaction wheel selection, placement, and control algorithm. This also necessitated infrequent motion of the solar arrays, contributing to the over-sized arrays to accommodate the resultant cosine losses.
   c. Eliminate moving parts needed during science operations on payload in order to support KaRIn stability -> utilize a low gain antenna (LGA) and high power travelling wave tube amplifier (TWTA) for the X-band science downlink system. Also, no pumped fluid loop was allowed for cooling the payload.
5. **Payload absolute pointing control and knowledge:** The KaRIn instrument and the nadir suite of instruments all need to be pointed accurately at or near Nadir. In addition, the relative pointing of the two KaRIn antenna arrays is crucial for meeting performance requirements. In order to minimize the risk of a static misalignment causing a problem in flight, both antenna reflector arrays have a single degree of freedom alignment mechanism which allows a one beam width change in static pointing of the reflector. In order to meet the end to end pointing control and knowledge requirement, the KaRIn antenna metering structure is used as the key reference, and the attitude control sensors are mounted directly to it:
   a. The 3 for 2 redundant star trackers used by the platform to point the observatory are mounted to a bracket on the +Y face. These are the only pieces of platform equipment mounted to the payload. The star trackers are installed during observatory I&T, after the completion of payload I&T and delivery of the payload to France.
   b. A 4 for 3 redundant ASTERIX-200 fiber optic gyro (FOG) is mounted directly to the metering structure in order to give the highest possible accuracy in sensing the instantaneous pointing of the KaRIn antenna. These high-performance gyros are provided as part of the KaRIn instrument and are for science use only – the data is downlinked to the ground for use in processing of the radar interferometry data. The gyro data is not used on board.

Operations Concept

The SWOT mission timeline includes multiple phases, configurations, and orbits as shown in **Figure 5** The KaRIn antenna is deployed shortly after the LEOP phase while still in the post-launch safe mode attitude (as shown in **Figure 6**). The spacecraft bus and payload then transition to nadir pointing mode and finish their checkout and commissioning phase and transition to instrument calibration phase. The KaRIn instrument drives the duration of the commissioning and calibration activity. This period includes

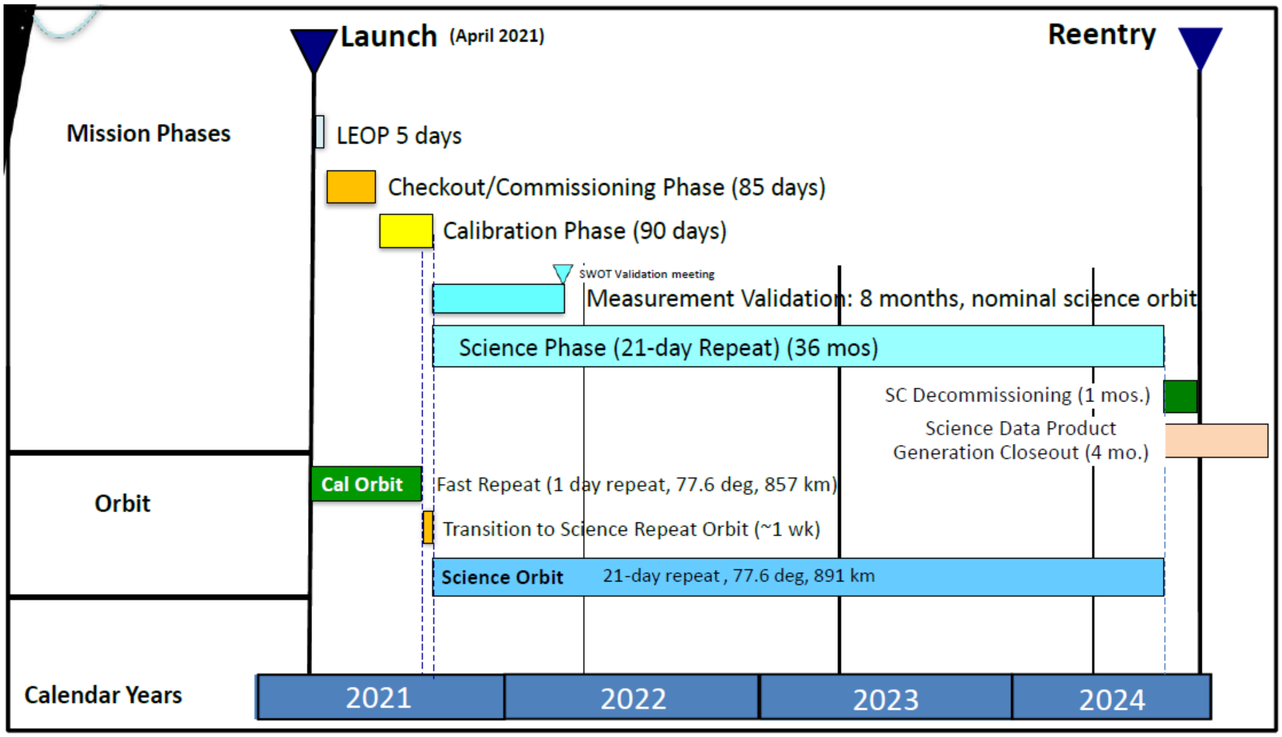

Figure 6. Mission Operations Timeline

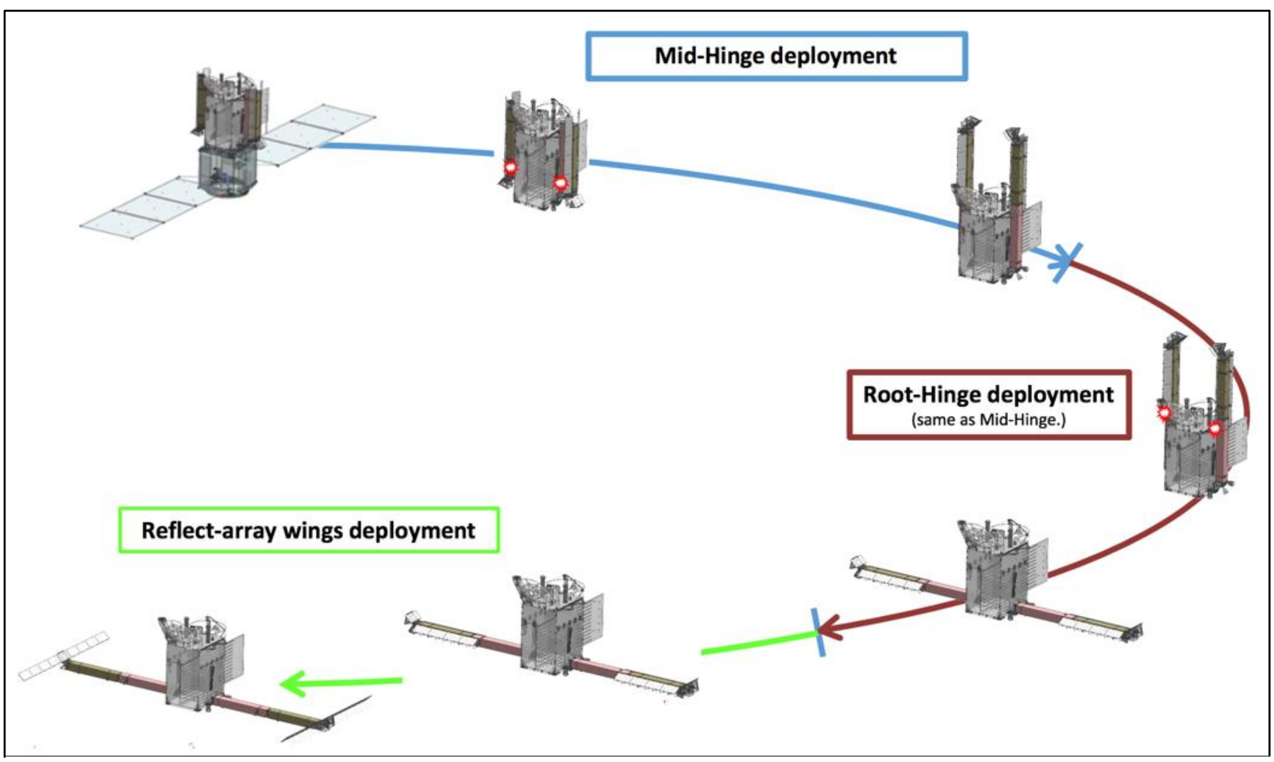

Figure 5. KaRIn Antenna Deployment Sequence

conducting using the onboard alignment mechanism to provide any fine tuning of the static antenna pointing.

Once in nominal science mode, the operations are relatively simple: The payload is continuously on and taking data, so it needs only infrequent commanding. The observatory is flown so that either the +X or –X face is facing its orbital velocity vector (see **Figure 4**), necessitating a seasonal yaw flip maneuver, which on average happens roughly every 70 days. This is done both to ensure the proper radar footprint on the ground as well as ensuring the prime radiator surface on the +Y side of the observatory is facing away from the sun at all times. Beyond the yaw flip, orbital correction maneuvers are required a few times a year to maintain the ground track within 1km of the nominal target value. About 20-21 X-band communications passes are scheduled each day to downlink the science data from the onboard solid-state recorder.

3. Payload Description

Ka-Band Radar Interferometer (KaRIn)

KaRIn is a synthetic aperture ("imaging") radar interferometer operating at Ka-band (35.75 GHz center frequency). The key system parameters are shown in **Table 2**, and a high-level block diagram of the instrument is shown in **Figure 7**.

Table 2. KaRIn Key System Parameters

Parameter	Value
Center frequency	35.75 GHz
TX Bandwidth (average)	200 MHz
TX Pulse length (baseline)	5.7 us
Pulse Repetition Frequency (average)	2 x 4420 Hz
Peak Transmit Power (EOL)	1,500 W
Physical Baseline Length	10 m
Antenna size	5 m x 0.25 m
Boresight Look Angle	+/- 2.65 deg
Polarization, Right Swath	VV
Polarization, Left Swath	HH

KaRIn consists of several subsystems, including:

- The CNES-provided KaRIn Radio Frequency Unit (RFU), including the signal generation, high power transmit-receive switching, phase-stable dual down-conversion, and associated calibration loops;
- The KaRIn High Power Amplifier (HPA) subsystem, including the CSA-provided Extended Interaction Klystron (EIK) amplifiers and the associated NASA-provided High Voltage Power Supplies (HVPS);
- The NASA-provided KaRIn Digital Electronics Subsystem (KDES), including digitization of signals from the interferometric and near-nadir receivers, onboard processing of ocean data, spacecraft command

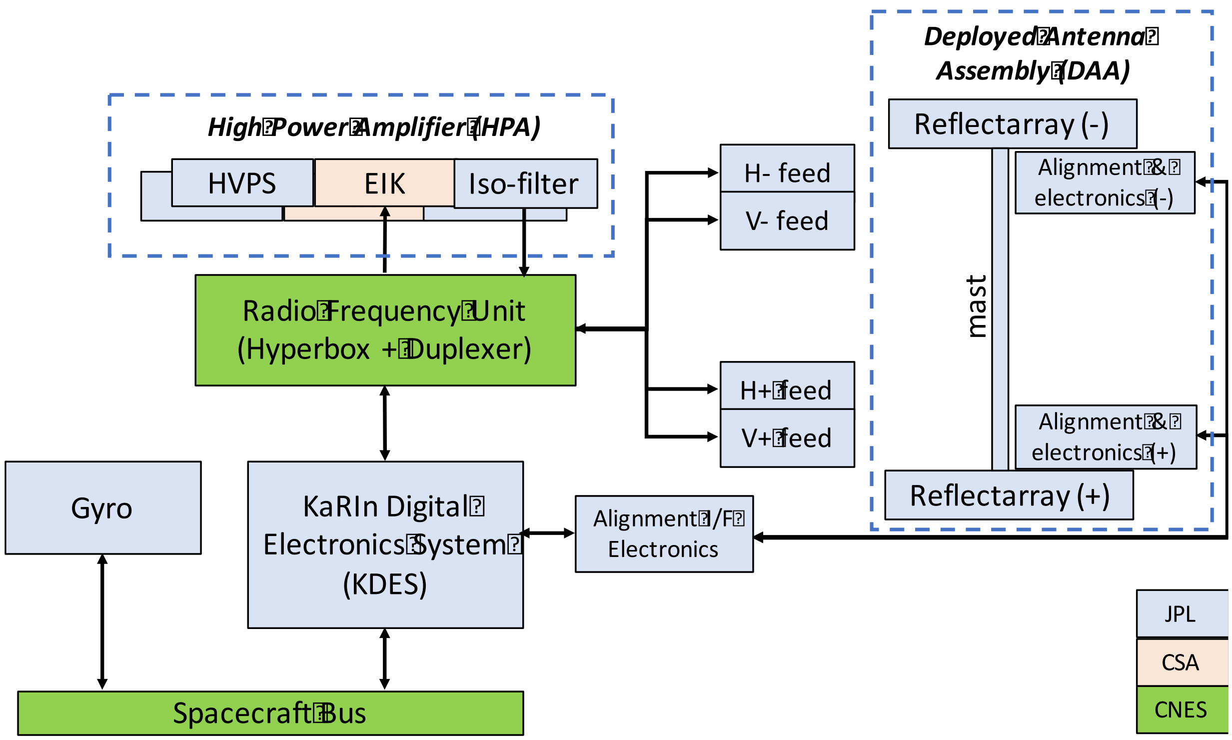

Figure 7. KaRIn high-level block diagram

and control interfacing, packetizing of data into the dedicated solid-state recorder, all instrument timing, and all instrument internal telemetry collection;

- The NASA-provided KaRIn gyro, which collects relative attitude data of the KaRIn mast/reflectarray subsystem;
- The NASA-provided KaRIn Antenna Electrical Subsystem, (KAES) including interferometric reflectarray antennas and their associated slotted waveguide feeds; and
- The NASA-provided KaRIn Mechanical and Thermal Subsystem (KMTS), including deployable antenna support structures and antenna alignment mechanisms; the stable, deployable masts; the thermal control hardware; and the metering structure internal to the payload module.

The antenna subsystem is formed by two 5 m long and ~0.3 m wide deployable antennas on opposite ends of a 10 m deployable boom (which forms the interferometric baseline). While conventional altimetry relies on the power and the specific shape of the leading edge of the return waveform, which is only available for the nadir point, the interferometric technique relies on the measurement of the relative delay between the signals measured by two antennas separated by a known distance (hereafter termed "baseline"), together with the system ranging information, to derive the height for every imaged pixel in the scene. For a given point on the ground, a triangle is thus formed by the baseline B, and the range distance to the two antennas, r_1 and r_2, which can be used to geolocate in the plane of the observation. Using radar pulses transmitted from one of the antennas to form the interferometric pair (this operation mode is commonly referred to as "single transmit antenna"), the range difference between r_1 and r_2 is determined by the relative phase difference φ between the two signals as given by:

$$\varphi = 2kr_1 - k(r_1 + r_2) \approx kB\sin(\theta) \qquad (1)$$

where θ is the look angle, and k is the electromagnetic wavenumber. From the phase measurement, and with precise knowledge of the range distance and the look direction θ, the height h above a reference plane is given by.

$$h \approx H - r_1 \cos(\theta) \qquad (2)$$

The antenna employs printed reflectarray technology, which is basically a flat panel with etched elements on its surface providing the phase change required to collimate the beam, emulating a parabolic reflector. This architecture enables stowage of the antenna to fit inside the launcher fairing, while structurally being low mass, to minimize the tip-mass for best overall baseline system stiffness.

One of the antennas transmits, and both receive the radar echoes. The interferometer is a dual-swath system, alternatively illuminating the left and right swaths on each side of the nadir track. This is accomplished by an offset dual-feed design operating with orthogonal linear polarizations (V and H polarizations), which enables each reflectarray antenna to generate two separate beams scanned ±2.65 deg off boresight, one at each polarization. The instrument's spatial resolution in the direction parallel to the baseline direction (across the swath) is determined by the system bandwidth.

With a 200 MHz transmit bandwidth, KaRIn will achieve ground resolutions in the cross-track direction ranging from approximately 70 m (at the near edge of the swath) down to 10 m (at the far end of the swath). As a synthetic aperture radar (SAR), the spatial resolution in the along-track direction (perpendicular to the baseline direction), is given by the length of the synthetic aperture that can be realized. The highest theoretical resolution that can be obtained is approximately given by half the antenna length, or 2.5 m. In practice, the resolution is determined by a combination of factors, including the antenna pattern, the azimuth bandwidth that is processed to achieve a desired ambiguity level ("contamination" level from adjacent pixels), and other design parameters.

KaRIn's high resolution places high demands on the onboard storage and the downlink needs of the overall observatory. In order to reduce the output data rates and downlink volumes to fit within existing capabilities, KaRIn's digital subsystem performs onboard processing. The KaRIn Onboard Processor (OBP) is integral to the overall functionality of the KaRIn system, performing a double duty for both surface water and ocean measurements. Over land, the instrument performs standard SAR compression techniques: pre-summing by a factor of 2.125, resampling to the system bandwidth (200 MHz), and Block Floating Point Quantization (BFPQ) to 3 bits. The allocated output data rate for this mode is 349 Mbps. Over the oceans, the instrument processes the incoming radar signal from an interferometric channel pair and generates a complex interferogram, as well as amplitude images for each channel, to be downlinked to the ground. The amplitude images for each channel enable estimation of the interferometric coherence on the ground. The onboard processor also performs multi-look averaging to decrease the data rate over the oceans before downlink. The OBP averages down to a resolution of $(500\text{ m})^2$ at 250 m posting, achieving a significant reduction in the data rate. The allocated output data rate for this mode is 17.1 Mbps.

The ocean algorithm implements the following steps for each swath: a pair of received echoes (one echo from each antenna) are first processed independently; each is range compressed (i.e., a matched filter via an FFT in frequency domain), followed by sinc interpolation to co-register in time the echoes from both receive channels, and a spectral filtering to approximately flatten the phase and remove the non-common portion of the two spectra to minimize the coherence loss. This is accomplished by a two-step process: first, an opposite sign phase ramp is applied to each of the interferometric channels in the time domain to induce a frequency spectrum shift that aligns the spectral components of the interferometric channel pair (i.e. flattens the interferometric phase). Second, a FIR filtering is performed to remove the non-overlapping parts between channel spectra. This filtering is slowly adjusted along the orbit to account for mean sea surface (MSS) variations. The algorithm then takes 9 range-compressed lines, which are corner-turned and stored in memory since the next steps will operate in the azimuth direction, processing one range gate at a time. The azimuth processing implements a squinted unfocused azimuth SAR processing for each collection of range gates from a series of consecutive pulses. This effectively divides the real-aperture azimuth beamwidth into 9 separate sub-beams to maintain the number of looks, for an unfocused azimuth resolution of ~250 m. This step is accomplished by performing the complex multiplication of the 9 azimuth samples by 9 separate phase ramps that take into account the Doppler centroid (separately estimated by the algorithm, so as to relax what would otherwise be very stringent S/C pointing control or real-time knowledge requirements), to shift the Doppler spectrum to 9 different Doppler angles. The next stage in the algorithm is to compute the complex interferogram for each one of the 9 output beams by multiplying one channel by the conjugate of the other, as well as the amplitude images for each channel by multiplying each channel by its own complex conjugate. Finally, the algorithm performs multi-look averaging of each interferogram and the images power to achieve the required 500 m (along-track) x 500 m (cross-track) resolution at 250 m x 250 m posting.

Additional SWOT Instruments

In order to meet the required measurement errors, the SWOT mission consists of 6 additional instruments. The altimeter and radiometer provide unique science measurement data, a suite of 3 instruments provide precision orbit determination data, and the telecom system provides the required data downlink.

Nadir Altimeter

The CNES provided Nadir Altimeter is nadir pointed, dual frequency (Ku / C band) altimeter which is based on the heritage Jason-2 and Jason-3 altimeters. The Nadir Altimeter provides range measurements between the SWOT observatory and the sea surface height; enabling sea-surface height measurements for wavelengths greater than 1000 km.

Advanced Microwave Radiometer (AMR)

The SWOT Advanced Microwave Radiometer (AMR) is a cross-track three-frequency microwave radiometer; based on the Jason series microwave radiometers. The SWOT AMR utilizes two independent cross-track beams to measure wet path delay in the troposphere at the center of each KaRIn swath. The radiometer provides a critical assessment of the wet troposphere error in ocean measurement wavelengths around 80 km and larger, in support of the Ocean surface height error.

X-band Telecom

The SWOT Telecom system downlinks at least 7.9 Terabits of science and housekeeping data per day. The telecom system consists of a two channel, dual polarized, X-band frequency design to downlink the mission data to CNES ground stations. Each channel has a 310 Mbps data rate. The system uses an externally corrugated horn LGA to minimize multipath signals.

Precision Orbit Determination Instruments

SWOT utilizes a suite of 3 instruments to determine its orbit to within 1.5 cm. To achieve this level of accuracy the data from the DORIS, GPSP, and LRA are reconstructed and analyzed on the ground. The DORIS and GPSP data is used as generate the orbit ephemeris with the LRA ranging data used to verify the accuracy of the ephemeris.

Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)

DORIS is an orbital determination instrument that operates using high precision Doppler measurements. The instrument utilizes a network of DORIS ground stations to provide on-board and ground-processed orbital determination data. The On-board orbit data is directly provided to KaRIn and the Nadir Altimeter for in-flight operational use. Additional DORIS data is downlinked for ground processing to provide a high precision orbit solution. DORIS has been used on multiple CNES, ESA, and JPL missions with a cumulative on-orbit lifetime of over 115 years.

Global Positioning System – Payload

The GPSP instrument is a GPS positioning instrument that provides SWOT with precise orbital determination data from the GPS constellation. The instrument is heavily based on Jason-3, COSMIC-2 and DSAC designs. GPSP provides high precision orbit determination data via ground reconstruction. All GPSP data is downlinked to the ground for further analysis.

Laser Retroreflector Array (LRA)

The Laser Retroreflector Array (LRA) consists of 9 quartz corner cubes arrayed as a truncated cone. The array operates as a totally passive reflector which utilizes the International Laser Ranging Service (ILRS) network of laser ground stations to determine the range between the SWOT observatory and the selected ground station.

4. SUMMARY

The SWOT mission will address fundamental science questions on the dynamics of ocean variability at wavelengths shorter than 200km and provide first of a kind global measurements of terrestrial water storage changes. SWOT will also enable a broad range of societal applications. SWOT is planned for launch in 2021. The SWOT partnership arrangement between NASA/JPL, CNES, UKSA, and CSA is also a model for close international cooperation towards a shared science objective.

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The authors would like to thank the large international team from JPL/NASA, CNES, CSA, and UKSA whose hard work is making the SWOT mission a reality.

BIOGRAPHY

Parag Vaze received a B.S. in Electrical Engineering from University of Pittsburgh and a M.S in Computer Science from Azusa Pacific University. He has been with JPL for 20 years and is the project manager for SWOT. He has also worked on the TOPEX/Poseidon, Jason-1, OSTM/Jason-2 and Jason-3 projects.

Said Kaki received a BS and MS degree in electronics Engineering from California State University in Sacramento. He has has over 30 years of experience developing space flight hardware and has held key engineering and management positions on several space missions including Cassini, Mars Observer, Mars 98, Microwave Limb Sounder, Jason-1, OSTM/Jason-2, and OCO-2. He is the Deputy Project Manager on SWOT.

Daniel Limonadi is the lead SWOT Payload System Engineer. He has been at JPL for 18 years, and has held system engineering leadership positions on the Curiosity Rover and Mars Exploration Rover projects, and also worked at Hughes Space and Communications on the HS702/Galaxy 11 project. He received his B.S. degree in Aerospace Engineering from the University of California at Los Angeles.

Daniel Esteban-Fernandez received his Ph.D. degree in Electrical engineering from the University of Massachusetts at Amherst. Currently he is the KaRIn Instrument Manager and was the Payload System Engineer for the Jason-3 Mission.

Guy Zohar received a B.S. and M.S. in Aerospace Engineering from California Polytechnic State University, San Luis Obispo in 2013. He has been with JPL for 4 years and is a Payload Systems Engineer on SWOT. He has also worked on JPL Mars Sample Return formulation and R&D.