Reports

Seasat Mission Overview

Abstract. *During some 3 months of orbital operations, Seasat collected a unique set of global synoptic data on ocean winds, waves, temperature, and topography. All indications from a preliminary analysis of these data are that most of the mission's proof-of-concept objective—the demonstration of nearly all-weather microwave surveillance of the world's oceans—will be met.*

On 28 June 1978, the United States, through the National Aeronautics and Space Administration's Jet Propulsion Laboratory, launched Seasat, the first satellite dedicated to establishing the utility of microwave sensors for remote sensing of the earth's oceans. The spacecraft carried five sensors on-board the 2290-kg platform in a nearly circular orbit with an inclination angle of 108° at an altitude of 800 km. Seasat circled the earth 14 times each day, covering 95 percent of the global oceans every 36 hours with two of its wide-swath sensors. Data transmitted to the earth included information on sea-surface winds, sea-surface temperatures, wave heights, internal waves, atmospheric water, sea ice features, ocean topography, and the marine geoid.

On 10 October 1978, Seasat failed in orbit as a result of a massive short circuit in the electrical system. Fortunately, during some 3 months of orbital operations, the satellite returned a unique and voluminous set of data on the earth's oceans.

The concept of a microwave oceanographic satellite grew from the recognition by ocean scientists that the data available to them on winds, waves, tides, and currents was sparse, fragmentary, and often unreliable. This situation was recognized by participants at the Williamstown conference on remote-sensing techniques in 1969 (*1*), who postulated that satellite technology could provide the mechanism for monitoring the world ocean on a scale appropriate to the requirements of the physical oceanographer. This group identified radar altimetry as an important technique for the acquisition of data on ocean circulation, storm surges, tides, and wind-driven, sea-surface tilts. These researchers further recognized that satellite radar scatterometer (a device for measuring ocean surface winds) data could provide information on surface winds on a scale and resolution otherwise unattainable, leading to important advances in weather forecasting. The concept was advanced of a passive microwave radiometer for the measurement of sea-surface temperature on a global scale along with a microwave imaging system to provide a capability to monitor ocean waves and sea ice.

After extensive discussions with the user community and after system feasibility studies had been completed, the satellite was designed to carry five sensors including a radar altimeter (ALT), a Seasat-A scatterometer system (SASS), a synthetic aperture radar (SAR), a visible and infrared radiometer (VIRR), and a scanning multichannel microwave radiometer (SMMR). The satellite (Fig. 1) was a modified version of the Agena system which has been extensively used for earth-orbiting missions (*2*).

A short-pulse (3-nsec), nadir-viewing altimeter (ALT) operating at 13.5 GHz was the first instrument selected to be incorporated into the satellite. The instrument swath width varies from 2.4 to 12 km, depending on sea state. The precision of the height measurement was expected to be 10 cm (root-mean-square) for sea state less than 20 m. The estimate of significant wave height was expected to be accurate to ± 0.5 m or 10 percent (whichever is greater) for seas less than 20 m.

The SASS, an active microwave wind sensor, was selected next. The SASS illuminates the sea surface with four fan-shaped beams (two orthogonal beams, each 500 km wide, on each side of the Seasat ground track). The transmitted frequency is 14.6 GHz, with the returned energy shifted slightly because of Doppler effects. The Doppler shift aids in establishing a spatial resolution of 50 km over a region of 200 to 700 km on either side of the spacecraft. As a goal, surface winds were to be determined to ± 2 m/sec in magnitude and ± 20° in direction for winds ranging from 4 to 26 m/sec.

The VIRR, which was nearly identical to the National Oceanic and Atmospheric Administration (NOAA) scanning radiometer, was used for feature identification. The VIRR operated with both a visible channel (0.49 to 0.94 μm) providing information on cloud conditions and an infrared channel (10.5 to 12.5 μm) providing information on surface and cloud-top temperatures.

The SAR, imaging in the L-band (1.275 GHz), looked to the starboard side of the subsatellite track with a swath 100 km wide centered 20° off nadir. The length of the SAR image track was deter-

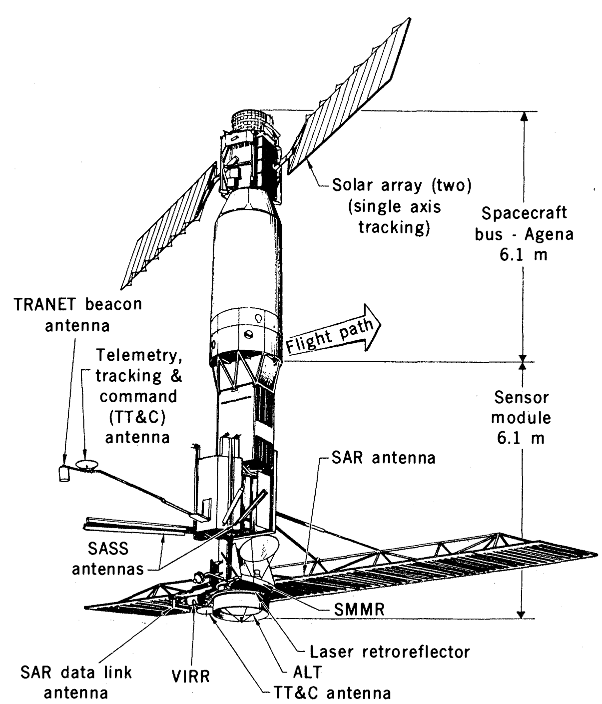

Fig. 1. The Seasat satellite in-orbit configuration; *TRANET*, Tracking Network (U.S. Navy).

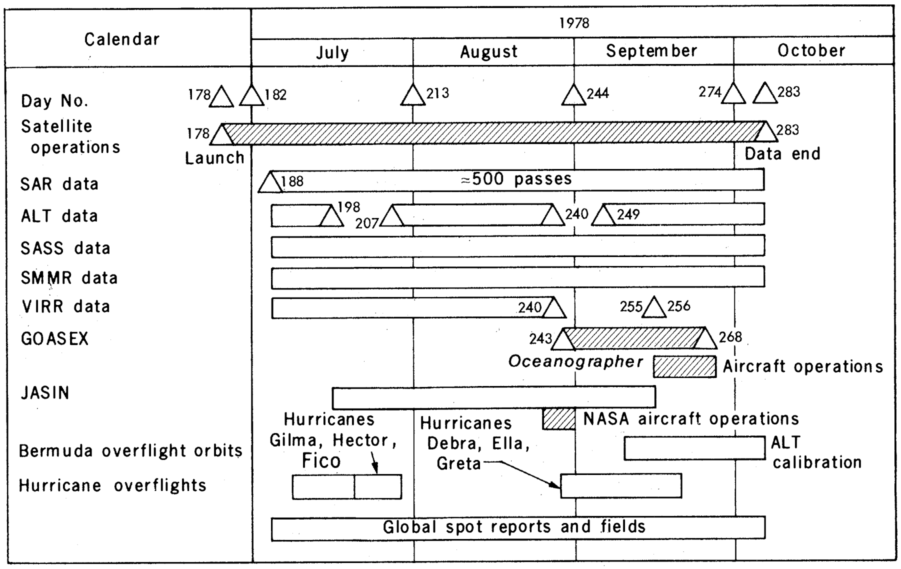

Fig. 2. Summary of mission data.

mined by the view duration of the receiver station, with about 4000 km being the maximum. The spatial resolution of 25 m, needed for wave analyses, required a very high rate of data acquisition so that on-board recording was not viable. The goal was to measure waves and wave spectra to oceanic wavelengths of 50 m or greater, and in addition to recognize sea ice features and to detect icebergs and water-land interfaces, and to penetrate to the surface through major storms such as hurricanes.

The SMMR, which operated at frequencies of 6.6, 10.7, 18, 21, and 37 GHz with both vertical and horizontal polarizations, was carried primarily to observe sea-surface temperatures. The spatial resolution of the SMMR ranged from about 100 km at 6.6 GHz to about 22 km at 37 GHz. The aft-viewing SMMR scanned the starboard side of the spacecraft, with a swath width of about 600 km. Two parameters obtained from SMMR data were sea-surface temperature (SST) and surface wind magnitudes. Liquid water and water vapor were also measurable, and these values could be used to formulate path length and attenuation corrections for the ALT and SASS, respectively. The absolute accuracy of the SST was expected to be ± 2°K with a relative accuracy of 0.5°K. The accuracy of the wind speed measurements was expected to be ± 2 m/sec for winds ranging from 7 to about 50 m/sec.

The National Aeronautics and Space Administration and the Jet Propulsion Laboratory cooperated in two major surface observation experiments which were supplemented with routinely collected data. The first was the independently organized, multinational Joint Air-Sea Interaction Experiment (JASIN), which was conducted in the eastern Atlantic near Scotland in July and August 1978; JASIN produced a set of high-quality surface observation data which will be used in the Seasat validation. The second was the Gulf of Alaska Seasat Experiment (GOASEX), which was dedicated to the early validation of Seasat data (*3*). This experiment, which monitored oceanographic and atmospheric parameters during September 1978, was supported by research vessels, weather ships, data buoys, and aircraft. The U.S. Navy's Fleet Numerical Weather Central (FNWC) and NOAA's National Climate Center provided global surface reports for the lifetime of the mission. In addition, FNWC provided selected field data for the duration of the mission. Some 200 overpasses of the JASIN area and about 60 overpasses of the GOASEX area were made. In addition to overpasses of ships and buoys, numerous overpasses of hurricanes, typhoons, and tropical storms were also obtained.

The Seasat sensors were turned on during day 10 of orbital operations and were operated as discussed below until the spacecraft failure on day 105. The SASS and SMMR operated almost continuously throughout the mission. The VIRR operated nearly continuously until it experienced a failure on day 62. The ALT operated intermittently, with a total of approximately 70 days of data collected. The SAR collected data on about 500 passes, with an average pass duration of 5 minutes. Data were collected by SAR only when within view of a tracking station at Rosman, North Carolina, Goldstone, California, or Fairbanks, Alaska, within the United States or Shoecove, Canada, or Oakhanger, England. Figure 2 summarizes acquisition times for sensor and surface truth data during the mission.

In October 1978 it was decided that the most expeditious evaluation of Seasat data would be obtained in a workshop setting. In this way, appropriately structured panels could intercompare the sensor and surface observation data from GOASEX. A planning meeting was held in December 1978, and the workshop convened at the Jet Propulsion Laboratory in January 1979. Seven panels, each comprising six to eight people and representing expertise on the sensors, data-processing, the surface observation data, and the interpretation of geophysical phenomena met for 5 days. The final report of this workshop was published in April 1979 (*4*). Two other workshops were held concurrently with the GOASEX workshop. One was the ALT height measurement calibration workshop, which used data taken during direct overflights of the laser tracking station on Bermuda. The other was the VIRR workshop, which concentrated on comparing Seasat data with data from other NOAA satellites and from surface spot reports off the east coast of the United States taken during July 1978.

Partial releases of interim Seasat data records will be made available to the user community by the NOAA Environmental Data Information Service in 1979. Final data records should be available in late 1980 (*5*).

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References and Notes

1. W. M. Kaula, Ed., *The Terrestrial Environment: Solid Earth and Ocean Physics* (NASA CR 1579, National Aeronautics and Space Administration, Washington, D.C., 1970).
2. The spacecraft was built by Lockheed Missiles and Space Company, Inc., Sunnyvale, Calif. Sensor managers were located as follows: (i) ALT, Wallops Flight Center; (ii) SASS, Langley Research Center; (iii) VIRR, Goddard Space Flight Center; and (iv) SAR and SMMR, Jet Propulsion Laboratory.
3. GOASEX was planned and conducted by NOAA, including the Pacific Marine Environmental Laboratory, the National Environmental Satellite Service, the Atlantic Oceanographic and Meteorological Laboratory, the Wave Propagation Laboratory, and the National Data Buoy Office.
4. G. H. Born, D. B. Lame, J. C. Wilkerson, Eds., "GOASEX Workshop Report" (Report 622-101, Jet Propulsion Laboratory, Pasadena, Calif., 1979) (internal document).
5. The first release of interim ALT and SASS geophysical data has already been provided to the NOAA Environmental Data and Information Service, from which the content and format of these data records are available.
6. The research described in this report was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under NASA contract NAS7-100.

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