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NASA News

National Aeronautics and
Space Administration

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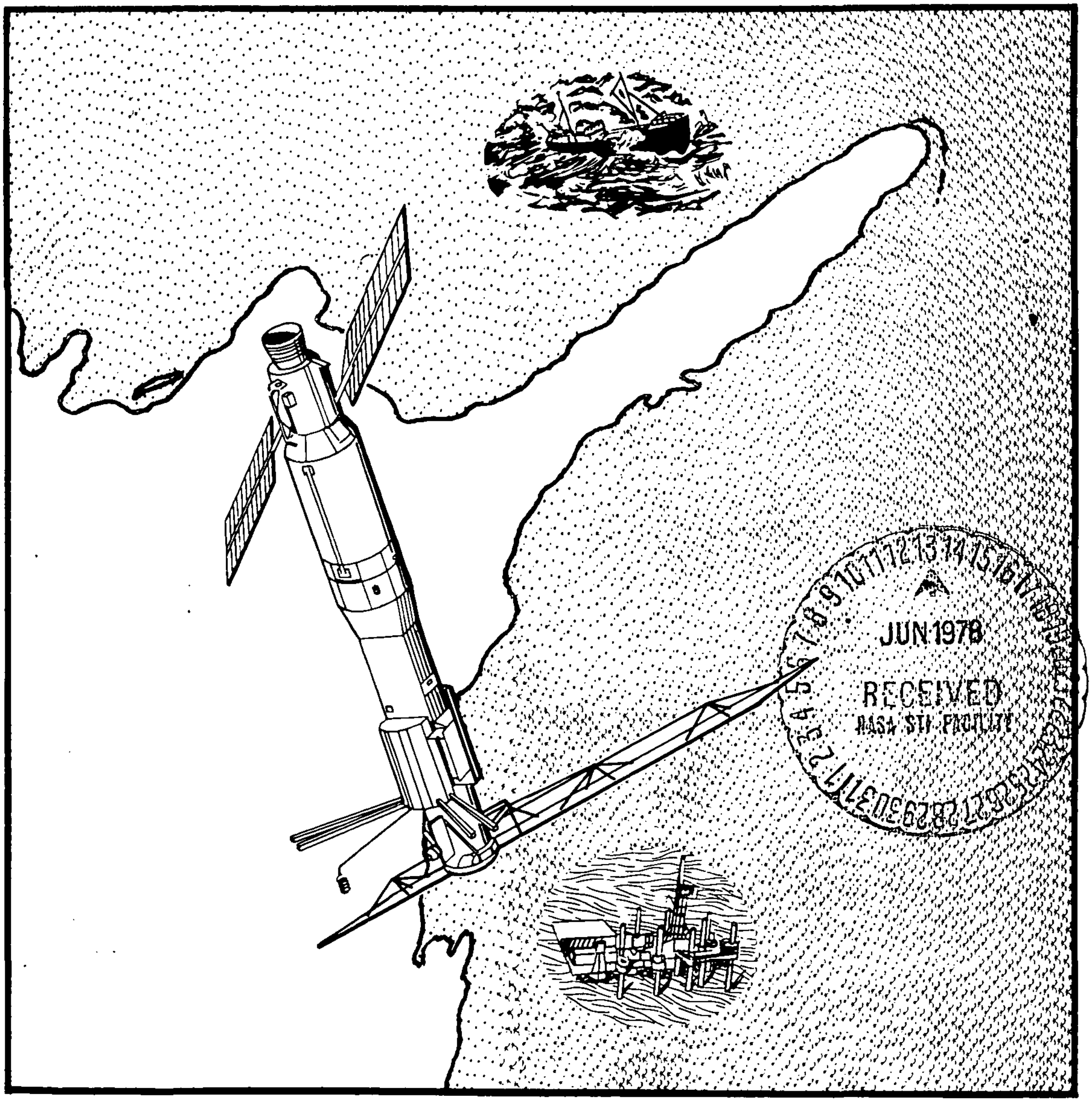
For Release IMMEDIATE

Press Kit

Project Seasat-A

RELEASE NO: 78-77



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May 26, 1978

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IMMEDIATE

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RELEASE NO: 78-77

NASA SATELLITE TO STUDY EARTH'S OCEANS FROM SPACE

NASA will launch Seasat-A, the first satellite to study the world's oceans, from the Western Test Range, Vandenberg Air Force Base, Lompoc, Calif., no earlier than June 24, 1978.

Seasat-A, a "proof-of-concept" mission, will be used to determine if microwave instruments scanning the oceans from space can provide useful scientific data for oceanographers, meterorologists and commercial users of the seas.

The spacecraft will send back information on surface winds and temperatures, currents, wave heights, ice conditions, ocean topography and coastal storm activity.

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An Atlas-Agena launch vehicle will loft Seasat-A into a an 800-kilometer (500-mile) high near circular polar orbit. The spacecraft will circle the Earth 14 times a day and its instruments will sweep across 95 per cent of the oceans' surface every 36 hours, providing oceanographers with their first synoptic, or worldwide, observation of the oceans.

Seasat-A will be used to prove the feasibility of later employing an operational, multiple-satellite Seasat network to monitor the world's oceans on a continuous, near-real-time basis.

Twice daily, such a system could provide ships at sea with detailed charts of routes updated to show latest weather conditions, sea state and hazards. Long-range use of the system could influence ship design, port development and selection of sites for such off-shore facilities as power plants.

Other potential users of Seasat data include commercial fishermen, oil exploration firms, the Weather Service, pollution control agencies, the Coast Guard and Navy and a variety of others.

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The basic part of Seasat-A (engineers call it "the bus") is an Agena that serves as second stage of the launch vehicle and carries a sensor module on which the instruments and related science payload are mounted. Agena is a three-axis-stabilized spacecraft that has flown more than 300 missions.

The spacecraft has all-weather capability, and can see as well at night as in the daytime.

The instrument payload includes four microwave sensors and a visual and infrared radiometer. Experiment teams, drawn from scientists representing various oceanographic disciplines, will determine the geophysical significance of the microwave data.

The four microwave instruments are:

- A scanning multifrequency microwave radiometer. It will measure sea surface temperature, estimate wind speed and detect water in the atmosphere (either vapor or liquid) to help scientists correct other instruments' data. Duncan Ross of the National Oceanic and Atmospheric Administration's Atlantic Oceanographic and Meteorologic Laboratory, Miami, Fla., is team leader.

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- A radar scatterometer will measure sea surface effects that can be converted directly to wind speed and direction. Prof. Willard Pierson of the State University of New York is team leader.

- A synthetic aperture radar (SAR) will provide all-weather high-resolution pictures of ocean waves, ice fields, icebergs, ice leads (linear openings in ice through which ships may navigate) and coastal conditions. (The SAR also can return pictures of conditions on land.) The instrument will be used only when Seasat-A can "see" one of the tracking stations specially equipped to handle its large amounts of data. Dr. Paul Teleki of the U.S. Geological Survey, Reston, Va., is team leader.

- A radar altimeter serves two functions: It will monitor average wave height and "significant wave height" -- a term oceanographers use to designate the largest one-third of all waves -- and the altitude of the spacecraft above the ocean to a precision of 10 centimeters (4 inches). That will let scientists measure sea surface topographic features that relate to ocean tides, storm surges and currents. Dr. Byron Tapley of the University of Texas is team leader.

A fifth instrument aboard Seasat-A -- a visual and infrared radiometer -- will provide data to support information from the microwave sensors. It will measure sea surface temperature in clear weather, and take pictures of cloud patterns and ocean and coastal features. Dr. Paul McClain of the National Oceanic and Atmospheric Administration's National Environmental Satellite Service, Camp Springs, Md., is team leader.

While Seasat-A takes its measurement from space, an extensive program of "surface truth" also will be under way. Low flying aircraft, ships and instrumented buoys will take measurements to corroborate Seasat data.

Seasat-A's primary mission is for one year, but enough fuel and other consumables are being put aboard so the flight can be extended for another two years. For the first month or more after launch, scientists and engineers will calibrate instruments and check out and improve computer programs that have been designed to translate Seasat data into useful information.

After the calibration phase is complete, the observation period will begin.

This will be the primary test for Seasat: can a spacecraft carrying microwave instruments tell scientists useful things about the sea surface and the atmosphere and how they interact?

If Seasat-A lives up to the expectations of those who believe the oceans can be studied from spacecraft, it could lead to a global system that can continuously monitor the oceans.

The Seasat-A program is managed for NASA by the Office of Space and Terrestrial Applications. NASA's Jet Propulsion Laboratory, Pasadena, Calif., manages the project and the satellite system. NASA's Goddard Space Flight Center, Greenbelt, Md., provides tracking, orbit and attitude determination for the mission and the Project Operations Control Center. NASA's Lewis Research Center, Cleveland, Ohio, has management responsibility for the launch vehicle. Launch crew is provided by the U.S. Air Force Space and Missile Test Center. Lockheed Missiles & Space Co., Sunnyvale, Calif., is prime contractor for the satellite system.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

MISSION DESCRIPTION

The launch of Seasat-A is timed so that, once the spacecraft reaches the desired orbit, it will have at least 30 days of full sunlight at the beginning of its mission. The full Sun period will allow engineers to use maximum spacecraft power during checkout and the engineering assessment phase.

Seasat-A will be launched from the Western Test Range at Vandenberg Air Force Base, Calif. The Atlas-Agena launch vehicle will aim for an orbit that is circular, 800 kilometers (500 miles) altitude, has an inclination of 108 degrees and a period of 101 minutes (1 hour, 41 minutes).*

The primary mission is scheduled for one year. Enough fuel and other consumables are being put aboard the spacecraft to allow for an additional two-year-long extended mission.

Seasat-A is a "proof-of-concept" mission with these objectives:

- Demonstrate techniques for global monitoring of oceanographic phenomena and features;
- Provide oceanographic data of use to scientists and to applications users; and
- Determine key features of an operational ocean-dynamics monitoring system.

The major difference between Seasat-A and previous Earth observation satellites is the use of active and passive microwave sensors to achieve an all-weather capability. The geophysical oceanographic measurement capabilities for Seasat-A are shown in Table 1. The altimeter and scatterometer benefit from the atmospheric corrections provided by the microwave radiometer.

The altimeter provides measurements only at the nadir of ground track location. The synthetic aperture imaging radar looks out at a nadir angle of approximately 20 degrees.

*With these trajectory characteristics, sensors with 1,000 km (620 mi.) cross-track coverage will provide global repeat coverage every 36 hours, using both day and night passes to complete the fill-in (Figure 1).

Geophysical Oceanographic Measurement Capabilities for Seasat-A

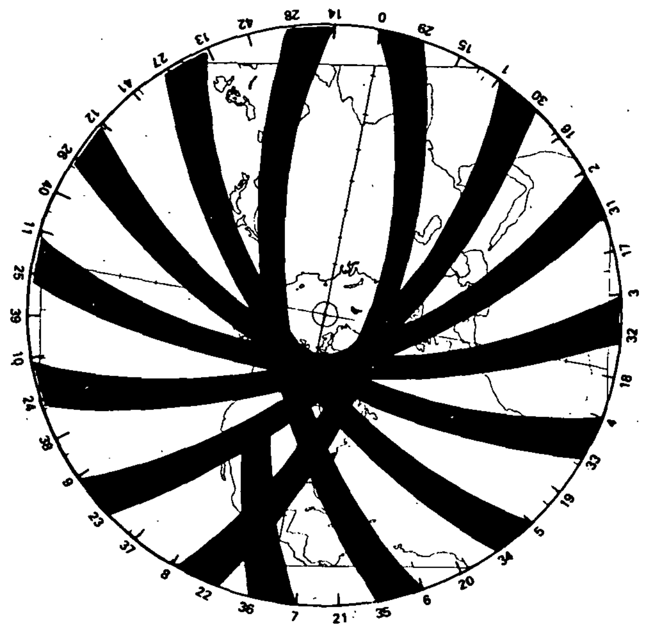
MEASUREMENT			RANGE	PRECISION/ACCURACY	RESOLUTION, km	SPACIAL GRID, km	TEMPORAL GRID
TOPOGRAPHY	GEOID	ALTIMETER	5 cm - 200 m	<± 20 cm	1.6 - 12	~10	LESS THAN 6 MONTHS
	CURRENTS, SURGES, ETC		10 cm - 10 m				
SURFACE WINDS	AMPLITUDE	MICROWAVE RADIOMETER	7 - 50 m/s	± 2 m/s OR ±10%	50	50	36 h TO 95% COVERAGE
		SCATTER-OMETER	3 - 25 m/s	± 2 m/s OR 10%	50	100	36 h TO 95% COVERAGE
	DIRECTION		0 - 360°	± 20°			
GRAVITY WAVES	HEIGHT	ALTIMETER	0.5 - 25 m	±0.5 TO 1.0 m OR ±10%	1.6 - 12	NADIR ONLY	1/14d NEAR CONTINENTAL U.S.
	LENGTH	IMAGING RADAR	50 - 1000 m	±10%	50 m		
	DIRECTION		0 - 360°	±15°			
SURFACE TEMPERATURE	RELATIVE	V&IR RADIOMETER	-2 - 35°C CLEAR WEATHER	1.5°	~5	~5	36 h
	ABSOLUTE			2°			
	RELATIVE	MICROWAVE RADIOMETER	-2 - 35°C ALL WEATHER	1°	100	100	36 h
	ABSOLUTE			1.5°			
SEA ICE	EXTENT	V&IR RADIOMETER		~5 km	~5	~5	36 h
		MICROWAVE RADIOMETER		10-15 km	10-15	10-15	36 h
		IMAGING RADAR		±25 m	25 m		1/14d NEAR CONTINENTAL U.S.
	LEADS		> 50 m	±25 m	25 m		
	ICEBERGS		> 25 m	±25 m	25 m		
OCEAN FEATURES	SHORES, CLOUDS, ISLANDS	V&IR RADIOMETER		~5 km	~5	~5	36 h
	SHOALS, CURRENTS	IMAGING RADAR		±25 m	25 m	25 m	1/14d NEAR CONTINENTAL U.S.
ATMOSPHERIC CORRECTIONS	WATER VAPOR & LIQUID	MICROWAVE RADIOMETER		±25 m	50	50	36 h

Table 1

SEASAT-A

36 HR ORBITAL COVERAGE

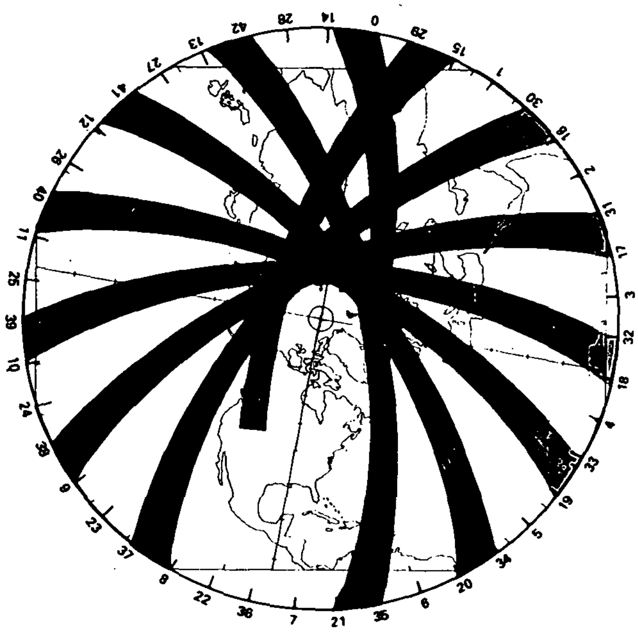
0-12 HRS COVERAGE



SEASAT-A

36 HR ORBITAL COVERAGE

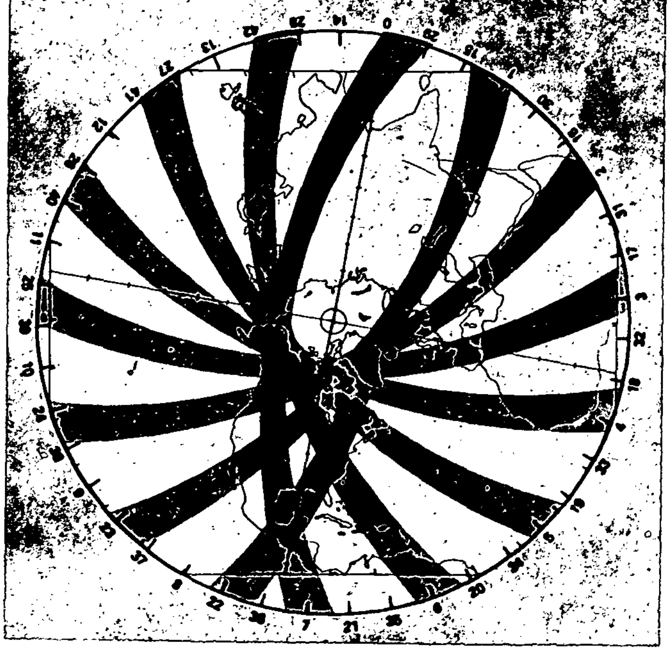
12-24 HRS COVERAGE



SEASAT-A

36 HR ORBITAL COVERAGE

24-36 HRS COVERAGE



The 100-km (62-mi.) swath then allows it to overlap its coverage with the scatterometer wind measurements.

The scatterometer looks out both sides with narrow fan beams. The fan beams, placed 45 degrees forward and 45 degrees back, allow two looks at each piece of ocean separated by 90 degrees, to allow a wind direction assessment. The fan beams extend on the ground from a surface incidence angle of 25 degrees to 55 degrees for the full range of winds (3-25 meters/second), and then to 65 degrees for the higher winds (10-25 m/s). Below 25 degrees, the changes in backscatter from different wind speeds are difficult to differentiate. As a result measurements are not included in those small angles.

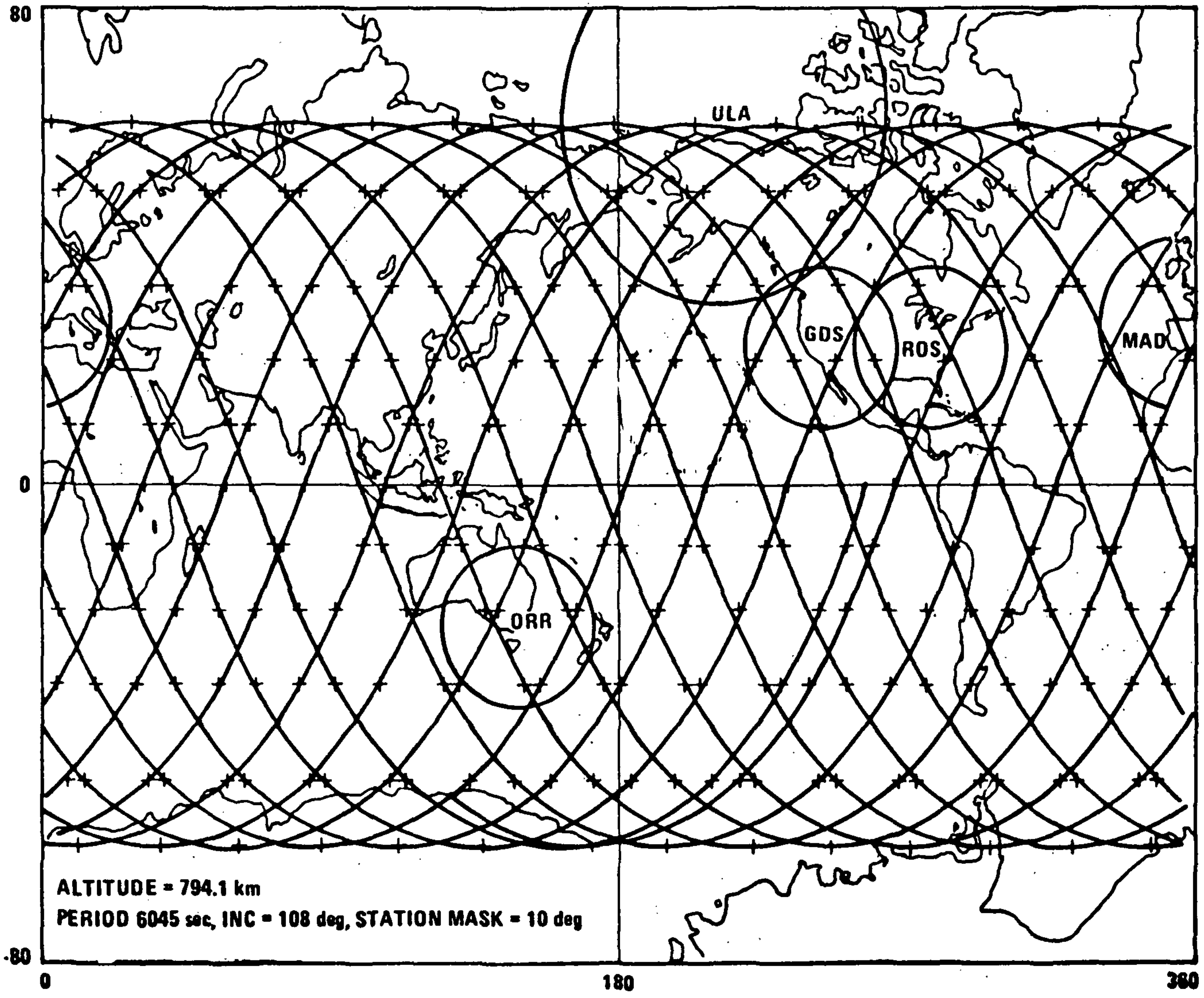
The microwave radiometer scans ±25 degrees across track, with a surface incidence angle of about 55 degrees. The visible and infrared radiometer scans horizon to horizon, but only the middle 70 degrees of scan (or about 1,000 km -- 620 mi.) on the ground produce accurate temperatures. Angular distortions at the higher angles plus increasingly long atmospheric path lengths make accurate interpretation much more difficult.

All of the instruments (except the imaging radar) are expected to be operated continuously during most of the mission to provide global coverage through on-board storage and then dump over one of the five NASA ground stations expected to be active in that period (see Figure 2).

The imaging radar is to operate in real time only when it is over appropriate high-data-rate Satellite Tracking and Data Network (STDN) ground stations. Present plans for the imaging radar use existing stations in Alaska, California and Maryland (at Goddard Space Flight Center) and a new Canadian station at St. John's, Newfoundland, to cover all the coastal waters of the U.S. and the major North American ice fields of interest. A 24-hour ground trace is shown in Figure 3.

SEASAT-A
STATION COVERAGE

Figure 2



ALTITUDE = 794.1 km
PERIOD 6045 sec, INC = 108 deg, STATION MASK = 10 deg

SEASAT-A
24 hour GROUND TRACE

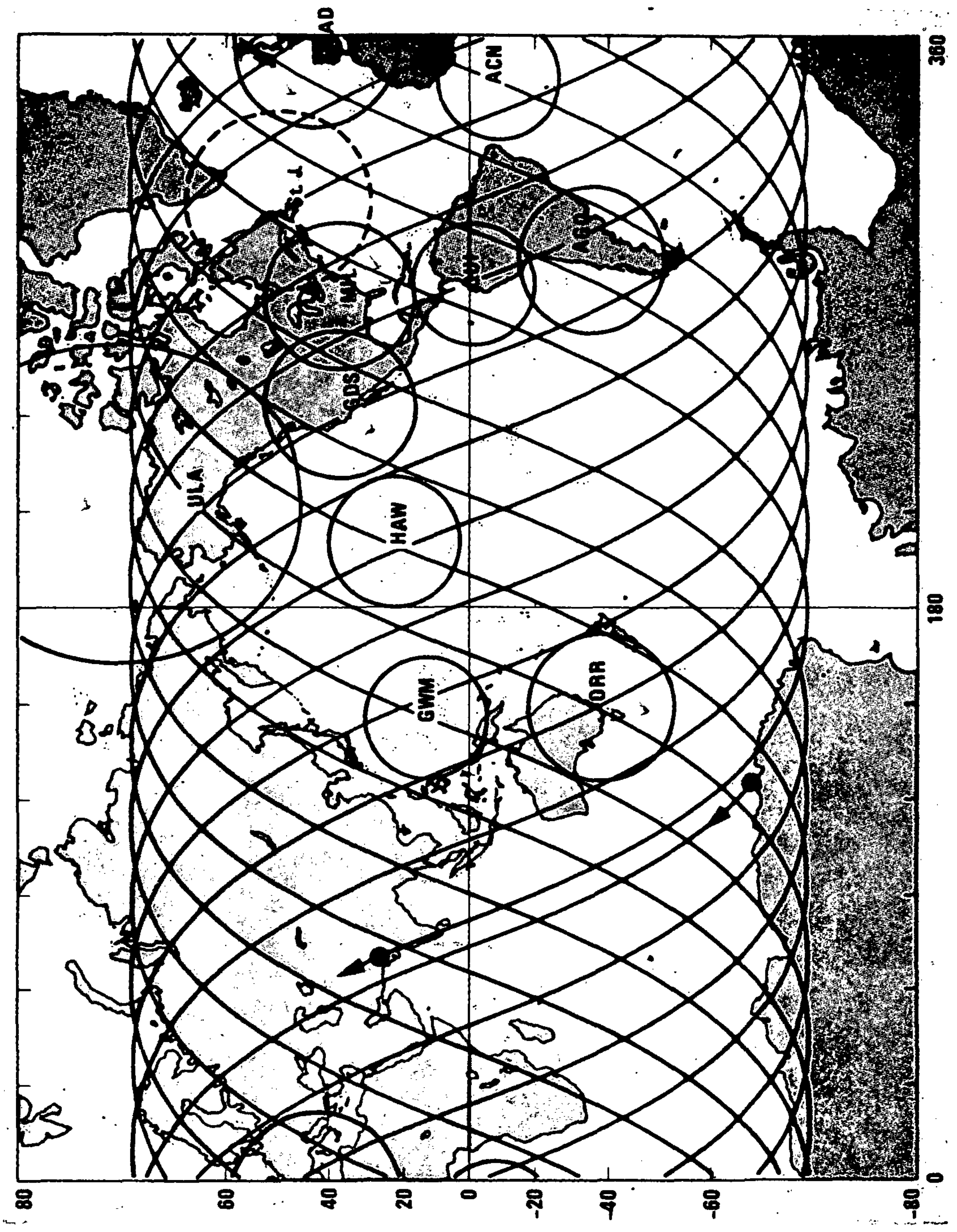


Figure 3

Project engineers and planners have divided the one-year primary mission into several phases:

The Initial Orbital Cruise Phase begins as the spacecraft is acquired by the first ground tracking station of the STDN. It will continue while the spacecraft receives an initial checkout and the orbit is adjusted for launch errors and determined to sufficient accuracy (ultimate altitude accuracy will be a meter (three feet) or less).

The Engineering Assessment Phase will begin when the early checkout is complete. Instruments aboard Seasat-A will be calibrated against prelaunch test information. Algorithms (computer programs) specially designed for Seasat will be checked and updated or improved where needed. During this phase, which could last from 30 to 90 days, the spacecraft, the sensors and the orbit must be checked and made as near ideal as possible, in preparation for the next phase -- the primary purpose of Seasat-A.

The Observation Phase -- the key segment of Seasat's proof-of-concept mission -- is broken down into two parts or subphases. Once the Engineering Assessment Phase ends, experiment teams, whose sole purpose is scientific evaluation of the instruments and computer algorithms, will take data from the spacecraft sensors and other sources and determine how the information can be interpreted. Mission planners refer to this work as geophysical evaluation, and discuss it as different entirely from the engineering evaluation that precedes it.

Once geophysical evaluation is complete, the second phase begins. Now the mission teams will produce Interim Geophysical Data Records and distribute them to experimenters and other users, independent of the evaluation teams. Sensors may be recalibrated in conjunction with surface truth findings throughout this phase.

During the observation phase, data will be taken from all instruments (except the SAR) globally in an uninterrupted stream, stored on the satellite and dumped to a tracking station in three-hour segments.

The Orbit Trim Phase will, from time to time, break into whatever work is going on. Interruptions will be required whenever Seasat-A's orbit must be adjusted. The satellite will be removed from its cruise condition, configured for the orbit trim, the course correction will be made and then the satellite will be returned to cruise.

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Extended Operations -- the final phase -- is being planned. It would begin at the completion of Seasat's first year of flight.

Data from Seasat-A will be made available to users -- after the experiment teams have completed their geophysical evaluation -- in as timely a fashion as required for each user.

When the data become available for everyday use, the U.S. Navy's Fleet Numerical Weather Central at Monterey, Calif., for example, will receive data within a few hours of collection by the spacecraft. The eventual goal is to provide weather data within six hours after it is collected. Data will be distributed by the project to other users -- again, after the evaluation subphase is complete -- from both NASA's Jet Propulsion Laboratory, Pasadena, Calif., and the Navy's computer operations.

The Synthetic Aperture Radar will be used only on a real time basis. Since it collects data at the rate of 110 million bits per second, it can operate only when Seasat-A is within sight of a ground station equipped to handle its data. These stations include Goldstone, Calif.; Merritt Island, Fla.; and Fairbanks, Alaska. The Canadian government is planning to equip a station at St. John's, Newfoundland. The European Space Agency (ESA) is considering similar plans for southern England.

Project planners are setting up a mission plan that reads more like a planetary encounter than an Earth-orbiting flight because mission activity builds with the passage of time to a specific target period. The project aims at support of a worldwide experiment in ocean and atmospheric sampling called the Global Atmospheric Research Project (GARP). Ships and aircraft from many nations around the world will probe the air and sea during special sampling periods in January and February, and again in June and July 1979.

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SCIENCE RATIONALE

The world's oceans play a fundamental role in the dynamics of the Earth's atmosphere and thus profoundly affect the weather and climate of the entire Earth.

The oceans act as a planet-wide heat reservoir that stores, distributes and then releases solar energy; the sea is also the source for most atmospheric moisture. Scientists have estimated that more than 40 per cent of all the heat in the atmosphere comes from condensation of water vapor that enters the atmosphere by way of evaporation from the oceans.

Exchanges between ocean and atmosphere produce large-scale transport of energy on a global scale, usually from lower to higher latitudes, and have a major influence on weather and climate. A large portion of the heat energy that moves from the tropics to higher latitudes is carried by ocean currents.

The enormous quantities of energy involved are dramatically illustrated by hurricanes and typhoons. The source of their energy is heat stored in the oceans.

Scientists believe it is unlikely they will ever be able to make reliable predictions of weather, climate, ocean currents and other oceanographic parameters without the large-scale numerical models of atmospheric and oceanic circulation that are possible only with satellite observations.

A number of ocean science fields should be able to profit, either directly or indirectly, from satellite studies. Satellite oceanography is limited, generally to surface and near-surface measurements in the few tens of meters below and above what scientists call the boundary layer. That constraint is not as severe as it might appear, since data taken from satellites can be used with more conventionally derived information about vertical current and temperature profiles, depth and changes in salinity.

The areas of ocean-related science that can benefit from satellite information are marine geodesy and gravity; physical and biological oceanography; glaciology; boundary layer meteorology; and climatology.

In addition, a number of applications oriented users can benefit from satellite information: shipping, offshore oil drilling and mining, fishing fleets and residents of coastal regions.

It may be possible to monitor location and movement of oil spills from a satellite.

Many Earth satellites have carried sensors with some applications to oceanographic studies. Examples are TIROS, ITOS, Skylab, GEOS, Nimbus and the Applications Technology Satellite (ATS) series. Seasat-A will be the first dedicated test bed for a new class of instrumentation -- microwave sensors -- that can operate independent of solar illumination and without having to cease operations because of overcast.

Seasat-A should add to our understanding of the oceans and the role they play in our lives in these fields:

Oceanography, Meteorology and Climatology

Waves

Seasat-A should reveal the principal features of the dynamic behavior of ocean gravity waves, about which we now have a dearth of quantitative data. Many fundamental questions remain largely unanswered.

A comparison between theory and observation has been difficult to obtain in large part due to the absence of adequate experimental data on waves, especially under storm conditions. Because of this lack, not enough is known about the genesis of waves in response to winds, their changing characteristics as they propagate over the ocean surface, their interactions with other surface wave fields, their generating, in turn, of internal waves, their trapping and refraction by strong currents and their attenuation as they enter shallow waters and suffer major changes in amplitude, speed and direction before finally dissipating their remaining energy in erosive, often destructive assaults on the coasts.

Wave Heights -- The wave height information presently available has been generated largely by ships at sea. The bulk of the information comes from some 1,200 ships, mostly in the northern hemisphere, which report estimated wave conditions in terms of height, period and dominant direction of travel.

Recently the GEOS-3 altimeter has begun to provide wave data from space. Seasat's observations will be more accurate and cover the oceans much more systematically and completely.

Seasat-A will make measurements of significant wave height by means of its short pulse altimeter, the return pulse broadening being a function of the wave amplitude. These measures will be good to 0.5 m (1.8 ft.) or ± 10 per cent in the 1 to 20 (3.8 to 65 ft.) range and will be uniformly distributed over all the world's unfrozen oceans at a measurement density sufficiently great to permit the obtaining of good information about significant spatial variations along the orbital track. Accurate measurements of wave height every 50 km (31 mi.), for example, which is a reasonable operational schedule for Seasat-A, will result in some 7,000 observations per day.

Wave Directional Spectra -- A very few weather ships, four or five in the North Atlantic and a single one in the North Pacific, record the wave height as a function of time at a point. Non-directional frequency spectra can be deduced from such records.

Seasat-A will record wave directional spectra (i.e., wave amplitude as a function of wavelength and propagation direction) at some 500 or 600 locations in both hemispheres, using the coherent imaging radar of the type discussed in the last section. It will thus, for the first time, furnish global, synoptic measures of wave height and directional spectra which, together with the wind field, constitute the most basic quantities needed for open-ocean wave forecasting.

Wave Images -- Where a wave field is not statistically homogeneous, a spectral description is not adequate and wave images are required instead. This is true, for example, of waves generated by intense storms, or in the study of refraction of waves as they enter shallower water, where bathymetric features can lead to large concentrations or dilutions of wave energy.

Wave generation, propagation, interaction and absorption can be studied experimentally for a variety of conditions of wind speed, fetch and duration, using such data. Wave trapping and refraction through encounters with current systems is another phenomenon which can be elucidated by means of Seasat-A wave images. Coupling between surface waves and internal waves can also be studied with the aid of imagery. Evidence has already been presented that effects of internal waves are discernible in Landsat images in the visible and near-infrared regions of the spectrum.

Sea Surface Temperature

The temperature of the ocean's surface, another one of its basic characteristics, is currently mapped over cloud-free portions of the ocean by infrared radiometers operating on Nimbus, NOAA and SMS satellites, with precisions approaching ± 1 degree C(1.8 degrees F.). The temperatures of the remaining beclouded portions of the ocean surface are presently determined only from ships or buoys, however. Seasat-A's multichannel microwave radiometer will map sea surface temperature under conditions of clouds or light rains, albeit with considerably coarser spatial resolution and somewhat lower temperature precision than the infrared instruments. However, the microwave measurements should represent bulk ocean temperatures more closely than the infrared measures do, particularly under conditions where light surface winds result in little surface mixing.

The microwave radiometer, in order to correct the sea temperature measurement for effects of atmospheric liquid and vaporous water and surface foam and roughness, must make independent determinations of these quantities by using several frequencies and two polarizations. The records of the several channels, taken together, form the basis for the determination of sea surface temperature, foam and roughness and hence, high wind speeds, cloud distribution, atmospheric water vapor content and sea and lake ice cover.

Sea temperature is a parameter of considerable importance in oceanic and atmospheric processes, since it reflects the absorption by the sea of that prime mover, solar energy. The difference between active and inactive hurricane seasons may be due to water temperatures in hurricane gestation areas just 2 to 3 degrees C (3.6 to 5.4 degrees F.) lower than average. Ocean temperature is a major factor in determining the tone of weather and climate in coastal regions of the world and indeed, as the North Pacific Experiment suggests, may control short term climate on a continental scale through its influence on the circumpolar jet stream.

Maps of sea surface temperatures are very useful for understanding the dynamics of current systems such as the Gulf Stream or Kuroshio, especially in winter and spring. Furthermore, open-ocean fish such as tuna tend to swim along the lines of constant temperature at certain times in their excursions and thus ocean temperatures assist in marine biological studies. In persistently cloudy areas such as the Intertropical Convergence Zone or the Antarctic Circumpolar Current Region, temperatures derived from a microwave radiometer will be of special value. Knowledge of sea surface temperature will also be important in connection with studies of marine fog.

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Ice Fields and Leads

Ice will be studied in several ways during the Seasat-A mission. The small-scale features of lake and polar ice fields will be sampled frequently by the coherent imaging radar thereby providing data needed to chart ice leads, surface roughness characteristics, and motions of ridges, polynyas and openings in the ice. This information will be of value in studying the structure and dynamics of ice formations. Furthermore, there are indications that the age and thickness of ice may be determined from a properly configured imaging radar.

On a coarser but more nearly global scale, the microwave scanning radiometer should provide images of ice cover that can be used to extrapolate the fine-grained imaging radar coverage. Delineations of the edges of ice packs and glaciers and the general advance and retreat of ice cover should be possible with this device.

The information about the ice leads and openings will also be of value in connection with the all-weather determination of heat transfer into the atmosphere, which proceeds approximately 1,000 times more rapidly across the water than the ice interface. Such data will be valuable for weather and climate studies in the polar regions, where much of the world's weather is spawned.

Sea Surface Topography

The marine geoid is defined as the surface which would be assumed by a motionless, uniform ocean under the influence of the Earth's gravity and rotation, and uniform atmospheric pressure. Thus, it reflects only the effects of gravitational and gross centripetal forces. Departures of the sea surface from the geoid due to tides, currents, coriolis force, wind, pressure and wave-making and other forces are grouped under the term "sea surface topography." These departures, if measurable, can often be used to derive information on the forcing functions themselves.

The general strategy planned for conducting these topographical experiments with Seasat-A includes the focusing of efforts in the Western North Atlantic Quadrangle region defined by Goddard, Bermuda, Grand Turk and Cape Kennedy where laser trackers will yield accurate orbital heights for Seasat-A, and relatively good geoid information is available.

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The aim is to determine the sea surface topography to about a third of a meter in this area, and to one or two meters elsewhere, or about a factor of two or more better than in the case of GEOS-C. In addition, the coverage patterns will be more uniform and complete in the case of Seasat-A.

The Gulf Stream traverses this quadrangle and, in fact, exhibits all its major features in the area, i.e., relatively steady flow, meanders and eddies.

Tides -- The M_2 tidal signal is relatively strong in the quadrangle, and the orbital paths are nearly parallel and orthogonal to the co-range lines there. The complicated, ill-understood transition from deep sea to coastal tides can also be studied here.

The deep ocean tides have amplitudes of the order of a meter. It is anticipated that the determination of the deep ocean tides on a global basis may be attempted by analyzing the entire ensemble of data gathered over a period of a year and solving say,for tidal amplitudes and phases, dissipation parameters and quantities representing the yielding of the solid Earth in response to both the lunisolar gravitational effects and the loading of the ocean tides themselves. Tidal dissipations are thought to occur mainly in regions of broad continental shelves, such as the Patagonian Shelf and the Bering Sea.

Currents and the Oceanic Pressure Gradient -- The movement of water on a rotating Earth leads to a departure of the surface of the ocean from the geoidal equipotential surface due to the balance between the horizontal component of the coriolis acceleration and the resultant horizontal pressure gradient. The steady components of the dynamic topography of the sea surface have an extreme range of the order of 2 meters.

The Seasat-A instrument complement will also include a thermal infrared imager which will aid in identifying and locating ocean features such as currents, and thus facilitate the interpretation of the altimeter records.

The Seasat-A precision altimeter and tracking systems will yield measurements along subsatellite tracks with an equatorial spacing of approximately 2,500 km (1,553 mi.) (and even less at higher latitudes). In three months, the tracks should overlay the equator at about 20 km (12 mi.) intervals. Variable topographic features which have sufficiently long time constants (or are periodic) and are large enough to be sampled with this measurement precision and density should be discernible against spatial variations in the background geoid.

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It is anticipated, for example, that this approach will be used to search for the transient mid-ocean currents, of a spatial scale of the order of 5 degrees, which have recently been seen. Following them over the oceans as a whole will help greatly in the effort to understand how they interact with the mean general circulation of the ocean, and thereby contribute significantly to the solution of the central problem in physical oceanography at the present time.

Tsunamis, Set-Up and Storm Surges -- Other oceanic departures from the geoid should be observable in the altimetric signal if the satellite is overhead at the time and place of occurrence. For example, a seismically excited wave, or tsunami, should be detectable in mid-ocean as a near-periodic topographic ripple of perhaps 50 cm range and a couple of hundred kilometers in wavelength. Since these disturbances last for tens of hours and ultimately traverse the entire ocean basin, there is a reasonable probability of observing one if it should occur during the lifetime of the spacecraft. The amplitude of a deep-ocean tsunami has never been measured.

Similarly, variations in the set-up of water against the coast due to longer term wind stress will be looked for, and the extreme form of this phenomenon, the storm surge, should be observable if the timing and positioning relative to the satellite track are correct. Such an observation of a storm surge is a low probability event but, if obtained, the data would be extremely valuable as checks on storm surge prediction models.

Seasat-A will probably not solve the problems of ocean tides, currents and circulations completely, however, its accurate altimetry will permit important exploratory experiments to be conducted in all these areas. They should yield data which will be of much intrinsic value, and will provide the foundation for planning the next phase of the program in these areas of ocean science.

Meteorology and Climatology

Surface Winds -- Seasat-A will measure surface wind speeds, and to some extent, directions, by means of a scatterometer and a microwave radiometer. The former relies on Bragg scattering from wind-generated capillary waves, while the latter senses the increase in brightness temperature due to foam and roughness. The fraction of the surface covered by the capillaries or the foam and roughness is a function of wind speed.

These instruments have both been operated on aircraft missions and on Skylab.

The Seasat-A surface wind data will be equivalent to some 20,000 ship reports each day, roughly an order of magnitude larger than that presently provided by surface vessels. Again, they will be more or less uniformly distributed over the global oceans, thus filling the major gaps in the meteorological coverage patterns which result from the fact that ships are concentrated in the Northern Hemisphere, largely in the shipping lanes. Using wind data from the spacecraft in conjunction with ship, buoy and island information, it appears possible to define the vector surface wind field throughout the planetary boundary layer every 24 hours, for speeds from 4 to 5 m/sec to perhaps whole gale force or greater, on a relatively uniform grid of approximately 1,400 km (870 mi.) spacing.

The definition of the surface wind over the oceans will be a large step forward in ocean wave forecasting. The wind data, used in conjunction with other surface-derived information and wave directional spectra supplied by Seasat-A as both initial and boundary values of the surface wave field, will allow development of an advanced, computerized global wave forecast model whose potential monetary value to marine interests is immense.

Scientific problems in wind-wave interactions, such as the generation and radiation of waves by intense storms, and in mixing processes in the upper layers of the ocean, may be studied using the enhanced base of global data on winds, waves and ocean temperatures.

The Planetary Atmosphere -- Coming, as they will, at the time of the Global Atmosphere Research Project (GARP)/ First GARP Global Experiment (FGGE) activities, these Seasat-A results will be especially relevant to the science of the atmosphere. The measurements of winds in the tropics and of sea surface temperatures to be made by Seasat-A are expected to be of real value in connection with weather studies in general and the FGGE in particular. Seasat-A is also likely to play a useful role in the longer range studies aimed at the second objective of GARP which is to investigate "the factors that determine the statistical properties of the general circulation of the atmosphere which would lead to a better understanding of the physical basis of climate."

A significant improvement in the quality of the planetary weather forecasts in the one-to-three-day interval is expected to result from the infusion of Seasat-A data into global weather prediction models. The improvement will occur not only over the oceans but also over continental areas, such as the East Coast and the western half of the United States, which are strongly affected by maritime conditions. The data-sparse Southern Hemisphere will benefit especially. The quality of the forecasts there will increase substantially. This will result in both scientific and general gains in terms of our understanding of the atmosphere and the weather, and will permit studies of interhemisphere interactions to get underway in earnest. The fierce meteorological systems surrounding the Antarctic continent will also be susceptible to orderly study on a synoptic scale for the first time.

It is obvious that Seasat-A data will only form a portion of the total meteorological information entering into synoptic or global scale weather and climate studies. However, this expanded data base, containing global measurements of surface wind, waves and sea temperature, will be an important and often unique adjunct to the data obtained from surface sources and from other spacecraft.

Solid Earth Physics

The Ocean Geoid

Although Seasat-A is designed primarily to give oceanic and atmospheric information, it will contribute significantly to solid Earth geophysics as well.

The present knowledge of the geoid is based on observations of gravitational perturbations of satellite orbits, which reflect global features, and surface gravimetry which provides details in some local areas. The satellite altimeter approach offers the best prospect for acquiring high-resolution ocean geoid data on a global basis. It has very large advantages over the conventional surface ship method in terms of the practicalities of achieving worldwide coverage.

The geoid data provided by the altimeter are not attenuated by height. The regular coverage patterns of Seasat-A will improve the spatial resolution of the global geoid. The height resolution is expected to be improved to a scale of the order of a meter.

The fine structure of the geoid to be traced out by the Seasat-A altimeter system is expected to reveal a great deal of information about the structure and dynamics of the Earth's crust. The small-scale undulations of the ocean geoid are manifestations of gravity anomalies which reflect density irregularities of corresponding scale and/or depth. Many of these, in turn, are considered to result from temperature patterns associated with convective flows within the asthenosphere. Upcurrents due to convection are thought to occur at ocean rise crests, and on their volcanic flanks.

Lithospheric dynamics will also be partially elucidated by the high resolution surface gravity mapping obtained from Seasat-A. The understanding of tectonic plate behavior near subduction zones associated with such phenomena as compressive upbuckling will be increased.

A continuing interplay between the oceans and the solid Earth is seen again in the continental shelves and abyssal plains, which are heavily sedimented. The sedimentation process is influenced in significant ways by ocean waves, currents, temperatures and nutrient levels. Thus, this aspect of the solid Earth's structure can be better understood through an increased knowledge of ocean dynamics.

Fine resolution gravity maps will also permit more effective planning of other types of geophysical surveys that use, for example, heat flow probes, dredge hauls, seismic refraction profilometers, drill cores and precision depth sounders.

Solid Earth Tidal Studies

The ocean tidal studies will also yield data on the solid Earth tides. As mentioned earlier, the problem of the ocean tides actually cannot be fully solved without simultaneously determining the elastic behavior of the solid Earth as it responds not only to the lunisolar gravitational attractions but also to the loading due to the ocean tides themselves.

Once the ocean tides are known, intriguing possibilities for detailed probing of the solid Earth can be opened up. For example, the ocean tidal currents flowing in the Earth's magnetic field generate electric potentials which are functions of the conductivity of both sea water and the solid Earth. Once the tides and currents are known, the influence of the solid Earth on the potentials may be estimated, and the corresponding effective conductivity as a function of effective depth in the Earth can be deduced.

Through this route, one may derive information about the temperature distribution within the Earth's upper mantle and draw inferences about the stress fields that may be responsible for seismic activity.

Oceanographic and Geodetic Leveling

Oceanographic and geodetic methods have both been used to determine the positions of the level surfaces along both the east and west coasts of the United States. Mean sea level appears to slope upward from the south to north by nearly a meter, relative to land based spirit leveling. This discrepancy cannot be explained in terms of the estimated accuracies of the two procedures. The Seasat-A mission, with its capability for accurate determination of sea surface topography along the U.S. East Coast, for example, may offer prospects for helping to resolve this long-standing controversy.

Orbital Dynamics

The very accurate tracking and altimetric systems employed in the Seasat-A program will lead to considerable refinements in the science of orbital dynamics. The effects of high-order gravity perturbations will be better understood and accounted for. Non-gravitational perturbations such as those due to solar radiation pressure and residual atmospheric drag will be determined with increased accuracy. One result will be improved orbit determination and prediction models for other Earth-orbiting satellites.

Engineering Science

A high technology system such as a spacecraft and the associated ground facilities always brings along with it a number of important developments in engineering science and technology. While it is difficult to specify exactly what will be the yield of Seasat-A in this regard, it is safe to speculate that in the areas of microwave sensors, in laser and radar tracking technology, and perhaps in data handling and dissemination, significant advances are to be expected. It is likely that other areas in space technology will be upgraded during the program, as well.

-more-

THE SPACECRAFT

The Agena, second stage of the Atlas F/Agena launch vehicle, serves as the satellite bus providing attitude control, power, guidance, telemetry and command functions. The sensor module is tailored specifically for the Seasat-A payload of five microwave instruments and thier antennas. Together, the two modules are about 21 m (40 ft.) long with a maximum diameter of 1.5 m (5 ft.) without appendages deployed. Atop the Atlas booster rocket, the entire satellite is enclosed within a 3-m (10-ft.)-diameter nose fairing which matches the diameter of the Atlas. After burnout of the Agena stage and injection into the 800-km (500-mi.) orbit, Seasat-A weight will be nearly 2,300 km (5,050 lbs.).

Many mechanical elements of the satellite are rigidly restrained against the severe launch vibration during powered flight. Following the launch phase, appendages, which were latched securely within the nose fairing, are deployed to their orbital configuration. The Agena ordnance subsystem actuates pin pullers to release nearly a dozen deployable spacecraft elements including solar panels, antennas and support booms.

In orbit the satellite will appear to "stand on end" (figure 4) like a pencil, the sensor and communications antennas pointing toward Earth and the Agena rocket nozzle and solar panels opposite toward space. Dominant feature of the Seasat is the Synthetic Aperture Radar (SAR) antenna, a 2.1 by 10.7-m (7 by 35-ft.) planar array deployed perpendicular to the satellite body.

Seasat-A is continually stabilized on three axes by a momentum wheel/horizon sensing system to accurately point the sensors at the Earth's surface.

Hot-gas jets provide thrust for adjusting the orbit and for attitude control during Agena burn and orbit adjust periods.

Two 11-panel solar arrays are the primary source of electrical power. Two nickel-cadmium storage batteries are used prior to solar panel deployment and store energy for peak power requirements and during solar eclipse period operations.

Data storage capacity on the satellite is about 350 million bits of information -- the equivalent of more than two full orbits of measurements from all sensors with the exception of the SAR. SAR data is not recorded.

Seasat-A On-Orbit Configuration

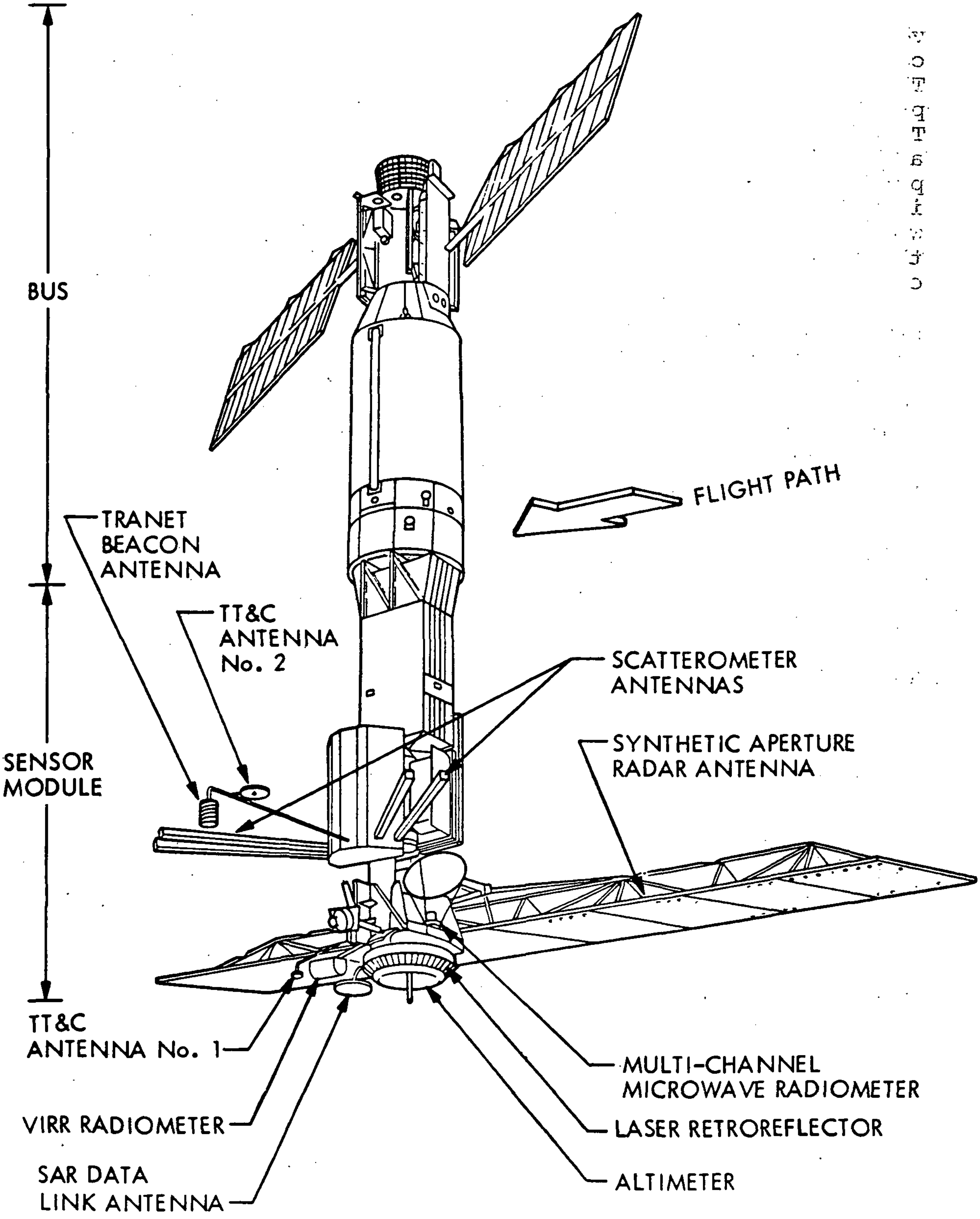

Figure 4

Redundant S-band transmitters and receivers, functioning as transponders, provide the communications link for engineering and sensor telemetry. A separate S-band transmitter provides the SAR downlink.

In addition to the primary tracking information from Seasat's S-band communications system, two independent tracking systems aid in navigation and orbit determination. Laser tracking signals originate from ground sites and are reflected from an array of retroreflectors on the satellite. A dual-frequency beacon transmits ultrastable carriers to a ground tracking network, TRANET.

Power

The Seasat-A power subsystem supplies all electrical power to the satellite by generating, converting and switching the power.

Primary power source is a pair of solar arrays generating about 1,000 watts at the beginning of the mission, varying throughout the mission with a minimum of 700 watts. The panels, rotatable on one axis, support 14.5 square m (156 square ft.) of solar cells.

Two nickel-cadmium batteries, kept charged by the solar arrays, supply all power during ascent to orbit and during solar eclipse periods and augment solar array power during peak loads. Solar eclipse periods occur in about half the orbits during the mission.

A drive system continuously positions the arrays about their central axis to face the Sun as the satellite plys its orbit. The drive system, fed directions by sun sensors mounted on the outboard panel of each array, will rotate the arrays about 5,000 times during the first year of flight.

Normal satellite power requirements can vary from about 500 to 700 watts but can exceed 1,200 watts during brief periods of SAR operations. During emergency conditions, the satellite can be powered down to about 450 watts. Average orbital power load is about 700 watts.

Data System

Communications with Seasat will be S-band radio link between the Earth stations of the NASA Satellite Tracking and Data Network (STDN) and the data system aboard the spacecraft.

The uplink carries commands and ranging signals from ground stations to two redundant receivers. The downlink carrier, from one of a pair of one-watt transmitters, is modulated by ranging signals and real time and stored degital data.

Both receivers are always on, operating at 2106 MHz. Only one transmitter, selected by power-on command, is on at any one time. The transmitters radiate at 2287 MHz. Normally the downlink carrier will be phase-locked to the uplink carrier -- a transmitter and receiver combination functioning as a transponder -- and related in frequency by a known ratio. Two 0.5-m (20 in.)-diameter reflecting disk antennas are used in orbit. A stub antenna will be used during ascent and the period prior to deploying the orbit antennas.

A separate five-watt S-band transmitter, with its own helical antenna, sends all very high rate SAR data in real time to specially-equipped STDN stations. SAR analog wideband data is acquired only when one of these stations is in view of the satellite.

Ground commands, which can be transmitted to the satellite at 2,000 bits per second, are of two types, real time and stored program commands, and provide control of satellite and sensor operations. All commands are 64-bit words decoded on the satellite. Real time commands are sent singly and executed immediately upon receipt. Stored program commands, stored in the command memory for execution of a sequence of events, are formatted into messages of up to 64 commands. Each of two redundant memories stores 768 commands, allowing the Seasat to operate automatically for up to 20 orbits. Commands cannot be stored for execution more than six days after they are loaded into the memory.

During normal operations, command load frequency will be one 256-command load every five to 12 hours. During high-activity periods, more frequent loads may be required.

Data telemetered from Seasat-A will consist of engineering and sensor measurements prepared for transmission by the telemetry formatter.

Encoded information will indicate voltages, pressures, temperatures and other values measured by the spacecraft telemetry sensors as well as payload sensor data which can be translated later into geophysical measurements.

In real time operation, data is sent to one of two tape recorders and to the transmitter, simultaneously, at 25 kilobits per second. During playback, one tape recorder modulates the downlink at 800 kbps while the other recorder is storing data for playback. The 32:1 playback-recorded ratio allows more than two orbits of data (200 minutes) to be played back to a STDN station in less than seven minutes -- easily accomplished in single station pass.

No SAR data is recorded. The SAR operates only 10 to 15 minutes during selected orbits (about 4 per cent of the mission time) as it overflies one of five ground stations which can receive the widebank telemetry stream. The onboard SAR data and transmission systems operate independently of the satellite communications system.

Tracking The Spacecraft

To achieve the desired orbital period, eccentricity and altitude accuracies and to support science data processing, very precise orbit determination is required. Three independent tracking systems provide the necessary measurements.

For the standard Doppler tracking data, the S-band signal with ranging codes inserted is transmitted from the STDN stations, recieved at the satellite changed in frequency by a known ratio and re-transmitted to Earth. It is possible to determine precisely the time delay and the Doppler shift of the received signal, thereby measuring range and velocity relative to the ground station. This is called coherent two-way tracking. Noncoherent one-way tracking is when no uplink signal is received and the downlink carrier frequency is provided by an onboard oscillator.

A ground receiver network, called TRANET, operated by the Department of Defense, receives a dual frequency Doppler beacon from Seasat. The tracking measurements will be used to supplement the STDN S-band tracking for orbit determination. Onboard equipment includes an ultrastable CW transmitter radiating at 162 MHz and 324 MHz. Seasat also will use this frequency onboard as the source for satellite timing.

The third tracking system uses a worldwide network of laser stations, some operated by the STDN and others by the Smithsonian Astrophysical Observatory. Used at selected times for calibration of the radar altimeter, the laser signals, originating at the ground sites, are beamed at the satellites, reflected from "corner cube" retroreflectors and detected on the ground. A ring of quartz reflector cubes about 101 cm (40 in.) in diameter is mounted on the sensor module.

Attitude Control

The ascent portion of the attitude control system provides stabilization of the Seasat after Atlas separation and during two firings of the Agena engine and controls duration of the engine burns.

Following orbital insertion, it also orients the satellite from nose-forward to nose-down and provides stabilization during deployment of antennas and solar arrays. These functions are performed using hydrazine reaction control thrusters for attitude control and a gyro reference unit as one attitude reference, augmented by horizon sensors for a short period prior to nose-down.

A two tank hydrazine supply feeds sets of orbit adjust and reaction control thrusters.
High-mode thrusters, 53.4-newton (12 lb.) are used during ascent. For orbit adjust maneuvers, two 22.2-N (5-lb.) thrusters are mounted in the Agena forward section so that thrust is applied in either direction along the orbital axis. During orbit adjust periods, low mode reaction control thrusters (1.8-N or .4 lb.) maintain satellite attitude. referenced to the gyro unit.

The initial orbit adjust maneuver is designed to correct injection errors and will be conducted about a week after launch when precise orbit determination has been made from an undisturbed satellite. Subsequent orbit trim maneuvers, planned to occur not more than once a month, will be used to compensate for atmospheric drag, solar pressure and other subtle orbit degradations. Propellant allocation has been made for a three-year mission.

During normal operations in orbit, Seasat is three-axis stabilized by momentum wheels and gravity gradient techniques.

Sensor pointing requirements include control to an accuracy of .5 degree in roll, pitch and yaw and telemetered data on satellite orientation to an accuracy of .2-degree in all axes. Scanwheels provide pitch and roll references viewing the Earth's horizon and pitch and roll fine control. Yaw attitude is maintained by gyrocompassing. Sun sensor data is used to determine accurately yaw orientation, but is not used for control. The scanwheels are mounted at the lower end of the sensor module near all of the critical antennas. Pitch momentum wheel and roll reaction wheel are located in a support structure above the sensor module. Excess momentum accumulated in the wheels is removed by providing adjustible torque on the satellite using electromagnets which interact with the Earth's magnetic field.

Sensor Module

The sensor module is a platform for the operation of the five sensors to achieve the mission objectives within the required resolution and accuracy. The sensors are located in positions relative to one another and to the beacon, laser retroreflector and communications antennas so that each has an unobstructed field of view and each achieves the required pointing and scan angle. Mounting positions also were selected to prevent electromagnetic interference between multiple radiating sources.

The sensor module's primary structure is a 25.4-cm (10-in.)-diameter aluminum alloy tubular mast to which equipment mounts are attached.

Two scanwheel assemblies are mounted near the forward end on tubular supports to give each unit a clear view of Earth's horizon.

The Radar Altimeter (ALT) is mounted at the end of the mast structure -- nearest the Earth -- the one-meter diameter reflector antenna and RF unit on the forward end and the signal processor to the side. The ring of corner cube quartz reflectors for the laser tracking system surrounds the altimeter antenna and RF electronics module.

The Microwave Scatterometer (SASS) and Doppler beacon transmitter for the TRANET tracking system are mounted in a support structure on the side of the mast. Four slotted array stick antennas for the SASS are stowed against the structure and each deployed separately. The TRANET antenna is attached to a deployable boom which also supports one of the two S-band communications antennas. The second is deployed on a separate boom.

The Visible and Infrared Radiometer (VIRR) consists of a scanner mounted on a deployable boom and electronics on the mast tube.

The five-channel Scanning Multifrequency Microwave Radiometer (SMMR) is mounted as a single unit on the side of the sensor module structure. The unit includes fixed offset parabolic reflector, scan mechanism and digital processor.

The Synthetic Aperture Radar (SAR) antenna and electronics are installed near the base of the sensor module. The huge SAR sensor antenna is in eight segments, folded during launch and deployed to form a flat rectangular array with an area of 23 sq. m (245 sq. ft.) The SAR downlink transmitter is mounted on the mast and its helical antenna is deployed on a short boom.

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PAYLOAD

Radar Altimeter

The Radar Altimeter traces a 2 to 10 km (1.25 to 6.25 mi.) wide path (dependent on surface roughness), on a line directly below the satellite. The Radar Altimeter measures average wave height to within 10 per cent over a range of 2 to 20 m (6 to 65 ft.) and the height of the spacecraft above the ocean to a precision of 10 cm (4 in.).

The height measurements should allow determination of sea-surface topographic features that correspond to ocean tides, storm surges and currents.

The altimeter generates a 13.56 gigahertz chirp signal at two kilowatts peak power. The signal is radiated to Earth through a 1-m (39-in.) antenna that looks at the sub-spacecraft point.

The reflected signal, when received at the spacecraft, is amplified, converted from analog to digital and processed digitally in the sensor.

That processing includes:

- Acquisition and tracking of the returned signal;
- Development of estimates of altitude and wave state;
- Relaying the onboard measurements and other data for transmission to Earth for additional processing.

The Radar Altimeter uses 177 watts and weighs 93.8 kg (206.8 lb.). Dr. Byron Tapley of the University of Texas is team leader.

Scanning Multichannel Microwave Radiometer (SMMR)

The Scanning Multichannel Microwave Radiometer data are used to derive sea surface temperatures, wind speed and atmospheric water content. It measures absolute levels and relative variations in the microwave radiation it receives from the surface.

The instrument measures surface temperature with a precision of 1 1/2 to 2 degrees Celsius (2.7 to 3.6 degrees Fahrenheit); wind speeds up to 50 meters per second (110 miles an hour); and provides atmospheric correction data to other instruments by measuring water vapor content in the atmosphere.

It observes an area beneath the satellite 690 km (430 mi.) wide.

SMMR uses a scanning 42-degree-offset parabolic antenna to receive the signal from Earth. It measures horizontal and vertical polarization components of microwave radiation at 6.6 gigahertz, 10.69 GHz, 18.0 GHz, 21.0 GHz and 37.0 GHz. The signal is then converted from analog to digital in the instrument and is fed into the satellite telemetry data stream to Earth for final processing.

The Scanning Multichannel Microwave Radiometer uses 59.66 watts of power. It weighs 53.9 kg (118.8 lb.).

Duncan Ross of the National Oceanic and Atmospheric Administration's Atlantic Oceanographic and Meteorologic Laboratory, Miami, Fla., is team leader.

Microwave Scatterometer (SASS)

The Scatterometer measures fine-scale ocean-surface roughness caused by surface winds. The measurements can be converted directly into wind speed and direction.

The Scatterometer measures wind speed from 4 m/s (9 mph) to 48 m/s (107 mph), to an accuracy of 10 per cent or 2 m/s (4.5 mph), whichever is greater, and wind direction to 20 per cent.

The instrument measures wind speed and direction in two surface swaths on each side of the spacecraft, each 500 km (310 mi.) wide. The scatterometer can measure wind speed only for an additional 250 km (155 mi.) on each side of the main swaths.

The SASS generates a 14.6 gigahertz signal at 100-watt peak power that is radiated to Earth through four fan-beam antennas that have vertical and horizontal polarization. The reflected signal is received, amplified and converted from analog to digital within the sensor. It is then routed to the satellite data system for transmission to Earth for processing.

The electronics assembly weighs 59 kg (130 lb.), and each antenna weighs 11 kg (24 lb.) for a total weight of 103 kg (227 lb.).

Professor Willard J. Pierson of the City University of New York is team leader.

Visual and Infrared Radiometer (VIRR)

The Visual and Infrared Radiometer is not a microwave instrument; its primary purpose is to provide supporting data for the four microwave experiments.

The VIRR will provide images of atmospheric conditions, cloud coverage patterns, ocean and coastal features; it will also provide sea surface temperature maps.

Visual image resolution will be 2 km (1.2 mi.); infrared image resolution will be 4 km (2.4 mi.), over a 2,100-km-wide (1,300-mi.) surface swath.

Radiation emitted from Earth is collected by an elliptical-shaped scan mirror that directs it into a dichroic beam splitter. Infrared radiation is sent to a bolometer detector, while visible radiation is sent to a silicon PV detector. The signals are amplified, filtered and sent to the satellite telemetry system as analog signals. They are digitized by the satellite data processing system for transmission to Earth for processing.

The instrument, consisting of an electronics module and a scanner, weighs 8.1 kg (17.85 lb.). It uses 7.3 watts of power.

Dr. Paul McClain of the National Oceanic and Atmospheric Administration's National Environmental Satellite Service, Camp Springs, Md., is team leader.

Synthetic Aperture Radar (SAR)

The Synthetic Aperture Radar will provide all-weather pictures of ocean waves, ice fields, icebergs, ice leads (linear openings in sea ice), fresh water ice, land, snow cover and coastal conditions. It will also provide ocean wave spectra including wave direction.

The instrument produces images with resolution of 25 m (80 ft.) over a swath 100 km (62 mi.) wide. A typical pass with the instrument will last 10 minutes.

The SAR is the first NASA radar system of its kind designed to study ocean wave patterns from orbit. The system consists of a deployable radar antenna 2.1 m (7 ft.) by 10.7 m (35 ft.); a SAR sensor including a solid-state transmitter, low-noise receiver and digital controller and a data link to transmit the radar signal to Earth for processing.

- more -

The sensor generates a 1.275 GHz chirp signal at 1,000 watts peak power that is radiated to Earth by the radar antenna. The reflected signal is received on the spacecraft where it is amplified by the sensor, converted to 2.265 GHz and transmitted to Earth in analog form by the SAR data link. The signal is digitized and stored on tape at the tracking station. The signal is processed into radar images at Jet Propulsion Laboratory's Radar Imaging Processing Facility.

Because of the high data rate of the radar imagery (equivalent to 110 million bps), the SAR, with its special ground equipment, will operate only within line of sight of specific tracking stations equipped to handle the data.

Those tracking stations are located at Goldstone, Calif.; Merritt Island, Fla.; and Fairbanks, Alaska. The Canadian Government is planning to equip a station at St. John's Newfoundland. The European Space Agency is purchasing equipment for a tracking station at Oakhangar in southern England.

The Synthetic Aperture Radar weighs 147 kg (324.5 lb.) and uses 216 watts of power.

Dr. Paul Teleki of the U.S. Geological Survey, Reston, Va., is team leader.

DATA COLLECTION AND PROCESSING

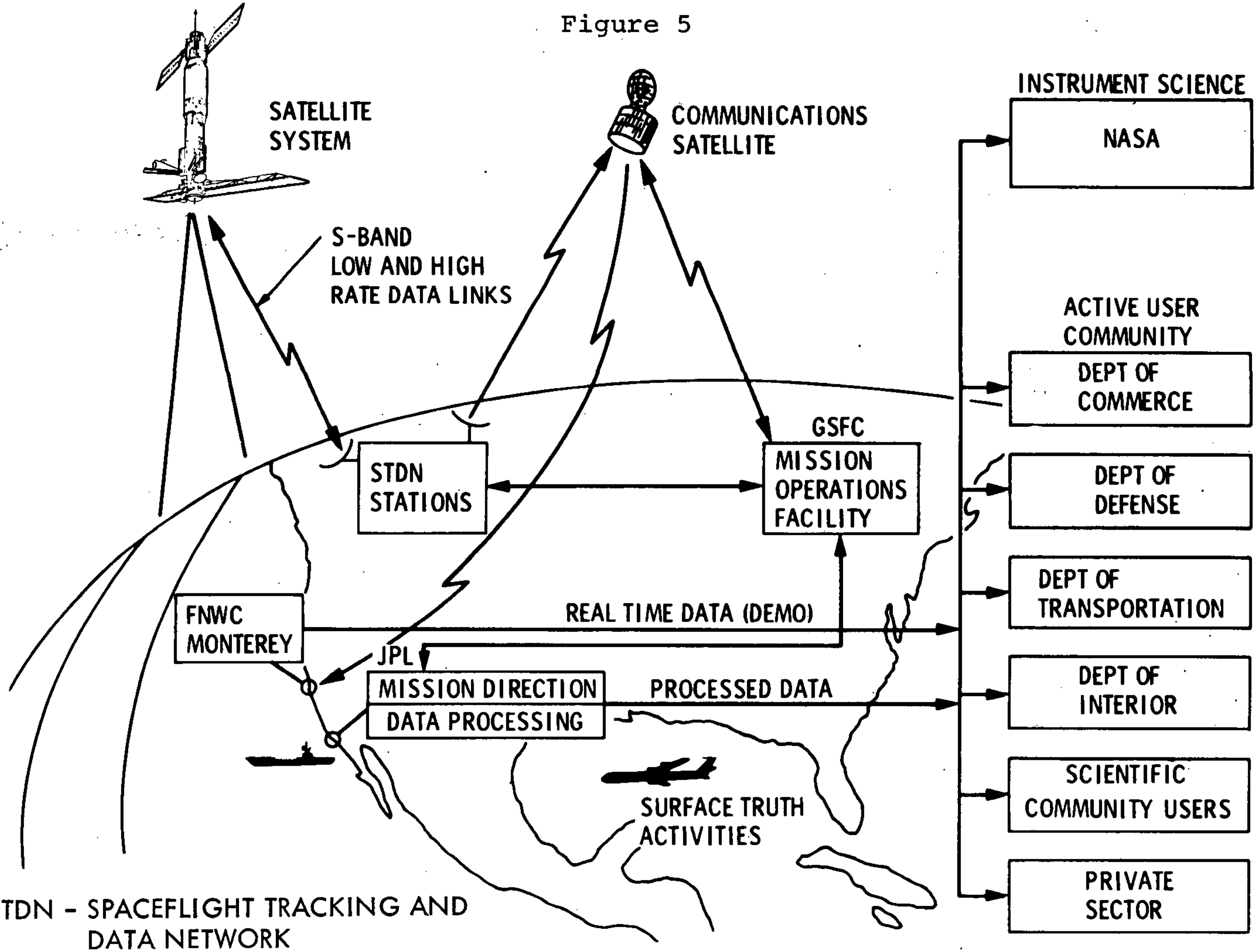
The Seasat-A mission data system embraces all project elements associated with data flow between the satellite and the experimenter-user community on the ground. (Figure 5) An end-to-end system design approach has been adopted and will be implemented by a project data system design team. Consistent with initial program formulation, NASA will establish proof-of-concept engineering and geophysical validation of Seasat data and users will provide the resources required for processing, analysis, dissemination and application of data peculiar to their special interests.

The data products of the Seasat sensors must serve a variety of users in a variety of forms. Weather data is highly perishable; to be of practical value, operationally, they must be processed (e.g., formatted, merged, blended and analyzed) and applied in near real time. Data older than eight hours are of little interest except for climate studies or model development. At the opposite end of the spectrum is the geodesist, whose data are nearly time invariant. The geodesist's approach to analysis is often to fit and refit data by a bootstrap approach, finally achieving a best fit model of the ocean geoid.

SEASAT-A

OCEAN DATA DISTRIBUTION PLAN

Figure 5



STDN - SPACEFLIGHT TRACKING AND DATA NETWORK

GSFC - GODDARD SPACE FLIGHT CENTER

FNWC - FLEET NUMERICAL WEATHER CENTRAL

- USER ANALYSIS
- DATA DISSEMINATION
- ECON. VERIFICATION EXPMTS.

Some of the users will have sizeable ground data systems available to assist them in processing and analysis; others will have only inexpensive terminals with limited processing capability. Some users care only for specific outputs such as wind and wave data for use in ship routing; others, such as university researchers, want as much of the data as available for application to development of advanced prediction models. Thus Seasat's end-to-end data system, consisting of NASA and user facilities equipment and communication networks, must be flexible and dynamic enough to meet the demands of this broad spectrum of currently identified and future user applications.

Data from the satellite will be returned in three separate streams. The real time stream at 25 kilobits per second and the 800 kbps playback stream from the Seasat tape recorders contain all data except that from the Synthetic Aperture Radar (SAR). An analog SAR data stream is obtained in real time only at specially equipped ground stations -- Goldstone, Calif., Fairbanks, Alaska, and Merritt Island, Fla. -- on special wide-band recorders utilizing Seasat-SAR-unique equipment. The data tapes will be forwarded directly to Jet Propulsion Laboratory, Pasadena, Calif., for processing.

The SAR data processing facility at JPL contains unique equipment to correlate the raw radar data recorded at the selected STDN sites and to produce radar images on film. Both processing systems at JPL operate in non-real time, receiving data packages six to 10 days after the data is acquired.

Two non-NASA ground stations also will receive SAR telemetry. SAR data received and recorded at a station in Newfoundland will be processed at JPL and at the Canadian Centre for Remote Sensing. The European Space Agency operates the other station, located in England.

All other spacecraft telemetry data are recorded on either of two on board recorders, 100 per cent of each orbit. Each of 12 STDN stations throughout the world is equipped to acquire playback (tape recorder dump) data. After acquisition, the data are forwarded to Goddard Space Flight Center, Greenbelt, Md., where the data are pre-processed and forwarded to JPL for final processing.

Algorithms, needed to convert the data into information usable by the ocean experimenters, are developed at JPL and applied internally as well as provided to user organizations outside the project.

The tracking station at Fairbanks, Alaska, is committed to provide this same data to the Fleet Numerical Weather Central Facility (FNWC) at Monterey, Calif., within three hours after receipt of each playback acquisition. These data will be forwarded from Alaska to FNWC by commercial satellite link. FNWC desires data less than 6 hours old and will use these data in providing Seasat data products to various users (NOAA, Department of Fisheries, Commercial Weather Forecasters, etc.).

In addition to this 3-hour requirement, other STDN stations will be used to attempt to provide global data to FNWC in a 12-hour time period.

Real time data, approximately once each orbit, will be provided to the Seasat Project Operations Control Center (POCC) at Goddard Space Flight Center (by any STDN station) where spacecraft housekeeping data will be extracted and displayed for use in spacecraft health monitoring and configuration control operations.

The STDN will also provide tracking support, both S-band and laser. Orbit computations support will be provided by the Mission and Data Operations Directorate at Goddard, utilizing these tracking data. The STDN stations are located at: Ascension Island; Santiago, Chile; Bermuda; Goddard; Goldstone; Guam; Hawaii; Madrid, Spain; Orroral, Australia; Merritt Island, Fla.; Quito, Ecuador; and Fairbanks, Alaska. All stations will provide tracking, telemetry and command capabilities.

Both the Navy and JPL will combine ocean measurements from local sources with Seasat data. The "surface truth" data will be obtained from aircraft, ships and instrumented buoys making measurements along the satellite's target path.

The Navy's Fleet Numerical Weather Center (NOAA) will distribute the Navy-processed data. NOAA also will distribute the non-real time data processed at JPL through the Environmental Data Service.

LAUNCH VEHICLE SYSTEM (LVS)

The Launch Vehicle System (LVS) consists of a modified Atlas-F booster, an interstage adapter (ISA), a modified fairing and all associated aerospace ground equipment and facilities. The LVS is 34.6 m (113.5 ft.) overall length and 3.05 m (10 ft.) in diameter. The fairing is 10.2 m (32.8 ft.) in length and 3.05 m (10 ft.) in diameter. The LVS provides the initial boost and guidance to and the aerodynamic protection for, the satellite system. The Agena bus portion of the satellite system provides the injection stage propulsion and guidance functions. A nominal sequence of events is provided below in Table 2. The flight vehicle configuration is shown in Figure 6.

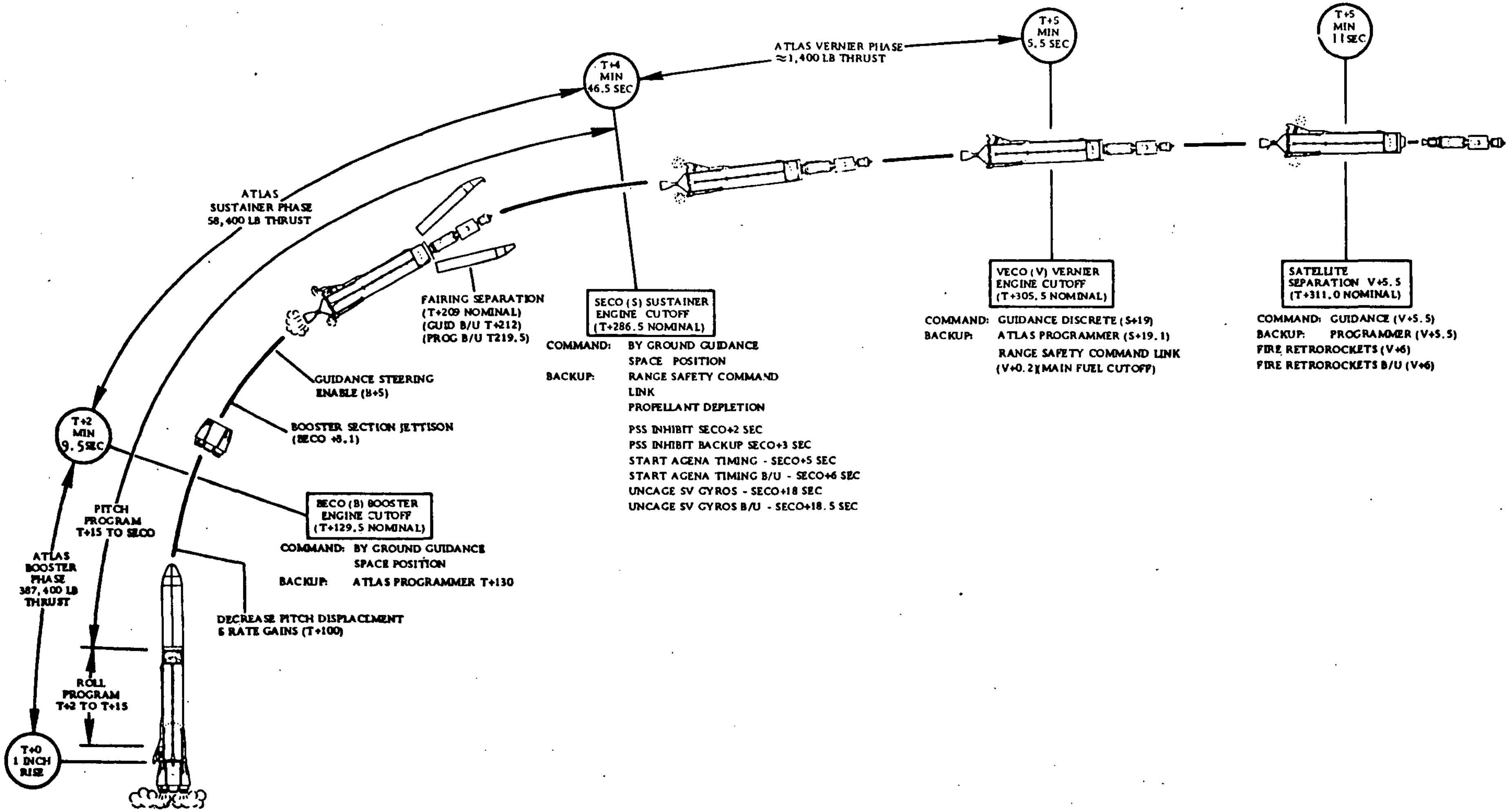
Table 2

MAJOR LAUNCH EVENTS FOR ATLAS F/SEASAT-A MISSION

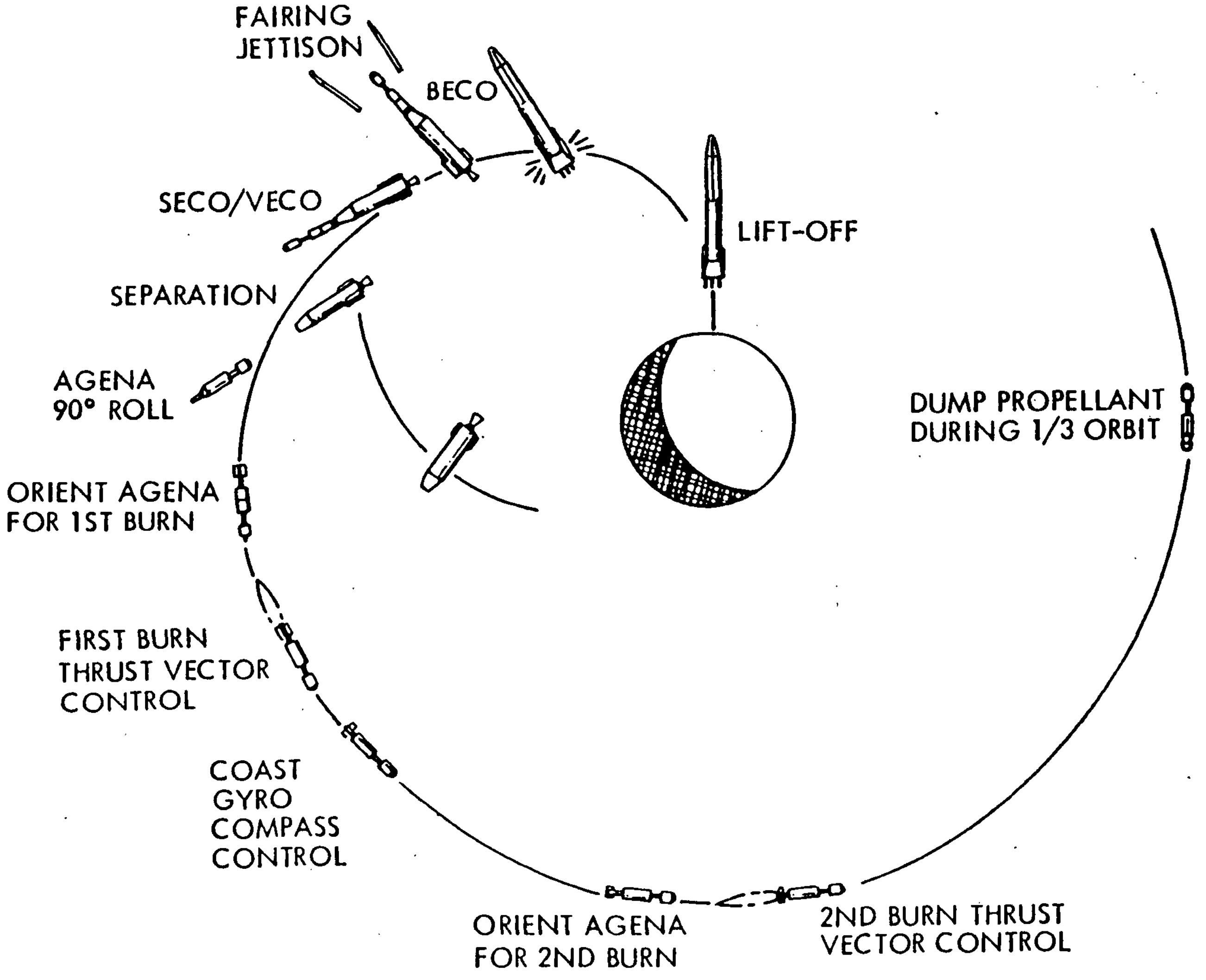
Event	Time	Altitude Kilometers	- Miles
Liftoff	0	0	0
Roll Start	2.0 sec.		
Roll Stop	15.0 sec.		
Booster Engine Cutoff	2 min. 9.5 sec.	45.7	28.4
Booster Engine Jettison	2 min. 12.6 sec.		
Start Guidance Steering	2 min. 27 sec.		
Fairing Jettison	3 min. 27.5 sec.	122.4	76.0
Sustainer Engine Cutoff	4 min. 44.4 sec.	173.5	107.8
Start Agena Programmer	4 min. 49.4 sec.		
Uncage Satellite System Gyros	5 min. 2.4 sec.		
Vernier Engine Cutoff	5 min. 3.4 sec.	185.2	115.3
Satellite System Separation	5 min. 8.9 sec.		
Fire Atlas Retro Rockets	5 min. 9.4 sec.		
Satellite System 90° Roll Start	5 min. 18.4 sec.		
Satellite System 90° Roll Stop	5 min. 54.4 sec.		
Agena First Burn	6 min. 23.4 sec.		
First Burn Shutdown	10 min. 14.5 sec.		
Agena Second Burn	57 min. 28.4 sec.		
Second Burn Shutdown	57 min. 34.6 sec.	790.2	491.0

-more-

SEASAT-A MISSION FLIGHT COMPENDIUM



TRAJECTORY PROFILE FOR THE ATLAS F/SEASAT-A MISSION



Flight Vehicle Configuration

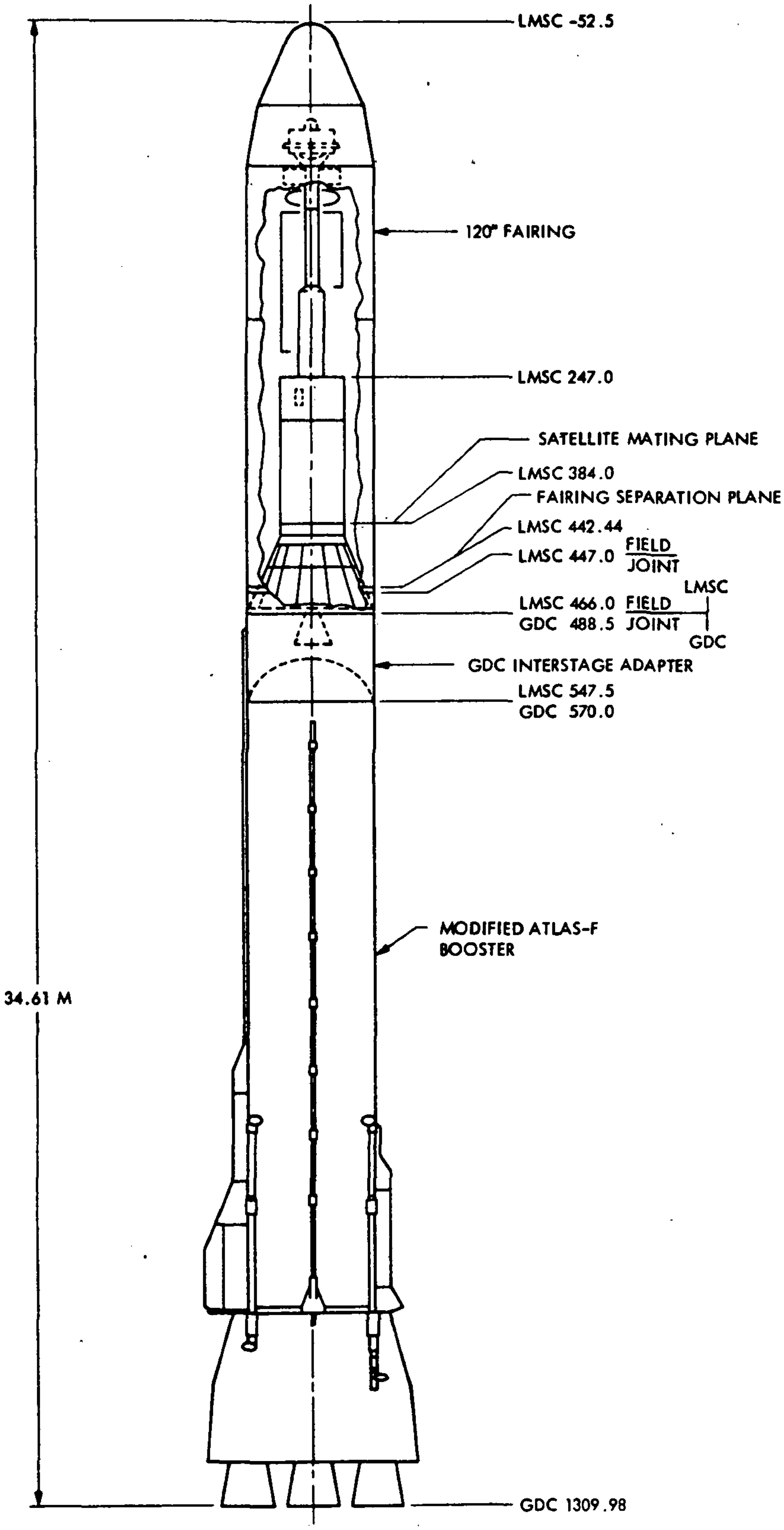


Figure 6

SEASAT-A EXPERIMENT TEAMS

Science Steering Group

James A. Dunne, Chairman	Jet Propulsion Laboratory
John R. Apel	Pacific Marine Environmental Laboratory, NOAA
H. Michael Byrne	Pacific Marine Environmental Laboratory, NOAA (alternate)
Duncan B. Ross	Atlantic Oceanographic and Meteorologic Laboratory, NOAA
E. Paul McClain	National Environmental Satellite Service, NOAA
John W. Sherman III	National Environmental Satellite Service, NOAA
John Wilkerson	National Environmental Satellite Service (alternate)
Samuel L. Smith III	Naval Surface Weapons Center
Vince E. Noble	Naval Research Laboratory
Benjamin Yaplee	Naval Research Laboratory (alternate)
Paul G. Teleki	U.S. Geological Survey
Willard Pierson	City University of New York
Robert Stewart	Scripps Institution of Oceanography
Byron D. Tapley	University of Texas
Rene O. Ramseier	Canadian Department of the Environment

Radar Altimeter

Byron D. Tapley, Team Leader	University of Texas
Craig L. Purdy	Wallops Flight Center
H. Michael Byrne	Pacific Marine Environmental Laboratory, NOAA
J. M. Diamante	Naval Oceanographic Service
Bernard H. Chovitz	Naval Oceanographic Service, NOAA
Bruce Douglas	Naval Oceanographic Service
Pat LeDeonibus	Environmental Monitoring and Prediction, NOAA
Leonard Fedor	Environmental Research Laboratory, NOAA
Joseph T. McGoogan	Wallops Flight Center
George H. Born	Jet Propulsion Laboratory
William Fred Townsend	Wallops Flight Center
Hamilton Hagar	Jet Propulsion Laboratory
Samuel L. Smith III	Naval Surface Weapons Center
Jack Lorell	Jet Propulsion Laboratory
Charles J. Cohen	Naval Surface Weapons Center
Joseph N. Siry	Goddard Space Flight Center
Benjamin Yaplee	Naval Research Laboratory
David E. Smith	Goddard Space Flight Center
E. M. Gaposchkin	Smithsonian Astrophysical Observatory
F. O. Vonbun	Goddard Space Flight Center
H. Jay Zwally	Goddard Space Flight Center
R. J. Anderle	Naval Surface Weapons Center

Synthetic Aperture Radar

Paul G. Teleki, Team Leader	U.S. Geological Survey
Clifford L. Rufenach	Wave Propagation Laboratory, NOAA
Duncan B. Ross	Atlantic Oceanographic and Meteorologic Laboratory, NOAA
John W. Sherman III	National Environmental Satellite Service, NOAA
Frank T. Barath	Jet Propulsion Laboratory
Omar Shemdin	Jet Propulsion Laboratory
Paul E. LaViolette	Naval Ocean Research and Development Activity
Kumar Krishen	Johnson Space Center
Robert Beale	Johns Hopkins University Applied Physics Laboratory
William J. Campbell	U.S. Geological Survey
Bruce Blanchard	Texas A & M University
Richard M. Hayes	U.S. Coast Guard
Robert Shuchman	Environmental Research Institute of Michigan
Robert Stewart	Scripps Institution of Oceanography
Rene O. Ramseier	Canadian Department of the Environment
Frank Gonzales	Pacific Marine Environmental Laboratory, NOAA
Walter E. Brown, Jr.	Jet Propulsion Laboratory

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Radar Scatterometer

Willard Pierson, Team Leader	City University of New York
Ledolph Baer	Environmental Monitoring and Prediction, NOAA
Glenn Flittner	National Weather Service
Peter G. Black	National Oceanic and Atmospheric Administration
Isidore Halberstam	Jet Propulsion Laboratory
W. Linwood Jones	Langley Research Center
Richard K. Morre	University of Kansas
Jack Ernst	National Environmental Satellite Service
W. L. Grantham	Langley Research Center

Visual and Infrared Radiometer

E. Paul McClain, Team Leader	National Environmental Satellite Service
Andrew W. McCulloch	Goddard Space Flight Center
Oscar C. Huh	Coastal Studies Institute, University of Louisiana
Robert L. Bernstein	Scripps Institution of Oceanography
Fred Vukovich	Research Triangle Institute

Scanning Multifrequency Microwave Radiometer

Duncan B. Ross, Team Leader	Atlantic Oceanographic and Meteorologic Laboratory
John W. Sherman III	National Environmental Satellite Service, NOAA
Frank T. Barath	Jet Propulsion Laboratory
Eni Njoku	Jet Propulsion Laboratory
Joseph M. Stacey	Jet Propulsion Laboratory
J. W. Waters	Jet Propulsion Laboratory
Per Gloerson	Goddard Space Flight Center
Thomas T. Wilheit, Jr.	Goddard Space Flight Center
Calvin T. Swift	Langley Research Center
Norden E. Huang	Wallops Flight Center
James P. Hollinger	Naval Research Laboratory
William J. Campbell	U.S. Geological Survey
Vincent J. Cardone	City University of New York
John C. Alishouse	National Environmental Satellite Service

SEASAT-A MISSION TEAM

NASA Headquarters

Dr. Anthony J. Calio	Associate Administrator for Space and Terrestrial Applications
Dr. Lawrence R. Greenwood	Director of Environmental Observations Systems
S. Walter McCandless, Jr.	Program Manager
Norman Pozinsky	Acting Associate Administrator for Space Tracking and Data Systems
John F. Yardley	Associate Administrator for Space Transportation Systems
Joseph B. Mahon	Director, Expendable Launch Vehicles

Jet Propulsion Laboratory

Dr. Bruce C. Murray	Director
Robert J. Parks	Assistant Director for Flight Projects
Walker E. Giberson	Project Manager
Dr. James A. Dunne	Ocean Experiments Manager
John H. Gerpheide	Satellite System Manager
Edwin Pounder	Mission Engineering Manager
Anthony J. Spear	Sensors Manager
Charles A. Yamarone	Information Processing Manager
Richard T. Hayes	Project Operations Manager
Willis G. Meeks	Chief of Mission Operations

Goddard Space Flight Center

Dr. Robert S. Cooper	Director
Albert G. Ferris	Director, Mission and Data Operations
John B. Zegalia	Mission Support Manager

Lewis Research Center

Dr. Bernard Lubarsky	Acting Director
Steven V. Szabo, Jr.	Chief, Seasat Launch Vehicle Office

National Oceanic and Atmospheric Administration

John W. Sherman III	NOAA Project Manager
Dr. John R. Apel	Director, NOAA Pacific Marine Environmental Laboratory

Department of Defense

Capt. Harry L. Bixby, USN	DOD Program Coordinator
Capt. Ron E. Hughes, USN	Commanding Officer, Fleet Numerical Weather Central
Dr. Vincent Noble	Coordinator, Naval Research Laboratory
Dr. Charles Martin	Coordinator, Defense Mapping Agency

Department of Transportation

Richard Hayes	Coordinator, U.S. Coast Guard Programs

Lockheed Missiles & Space Co.

John C. Solvason	LMSC Program Manager

SEASAT-A CONTRACTORS

Satellite

Lockheed Missiles & Space Co., Inc. Sunnyvale, Calif.	Satellite System (bus and sensor modules); Project Operations Support
Ball Brothers Research Corp. Aerospace Division Boulder, Colo.	SAR Antenna
Bell Aerospace, Textron Buffalo, N.Y.	Rocket Engine
Hamilton Standard Division United Technologies Corp. Windsor Locks, Conn.	Thrusters
Ithaco, Inc. Ithaca, N.Y.	Orbital Attitude Control
Motorola, Inc. Scottsdale, Ariz.	Radio Transponder
Odetics, Inc. Anaheim, Calif.	Tape Recorders
Pressure Systems, Inc. Los Angeles, Calif.	Hydrazine Tanks
Schaeffer Magnetics, Inc. Chatsworth, Calif.	Solar Array Drives

Sensor Systems

Aerojet General Corp. El Monte, Calif.	SASS Antenna
Andersen Labs, Inc. Bloomfield, Conn.	ALT Radar Pulse Modulator
Applied Physics Laboratory Johns Hopkins University Laurel, Md.	ALT RF and Sensor Integration and Test, Digital Processing Units and GSE; SAR Data Link

General Dynamics Corp. San Diego, Calif.	SMMR Antenna Reflector
General Electric Co. Valley Forge, Pa.	SASS Sensor
Hughes Aircraft Co. El Segundo, Calif.	SASS Traveling Wave Tube; ALT RF Power Amplifier
Martin Marietta Corp. Denver, Colo.	SAR Power Supply
Microwave Research Corp. North Andover, Mass.	SMMR Antenna Feed
Santa Barbara Research Center Goleta, Calif.	VIRR Instrument Retest and Calibration and Integration Support
Westinghouse Electric Co. Baltimore, Md.	SAR Transmitter
Zeta Labs Mountain View, Calif.	ALT Up-converter

The following are Seasat-A sensor managers:

Keith D. Fellerman Goddard Space Flight Center Greenbelt, Md.	Visible and Infrared Radiometer (VIRR)
Joseph M. Stacey Jet Propulsion Laboratory Pasadena, Calif.	Scanning Multichannel Microwave Radiometer (SMMR)
Fred V. Huber Jet Propulsion Laboratory Pasadena, Calif.	Synthetic Aperture Radar (SAR)
William L. Grantham Langley Research Center Hampton, Va.	Microwave Scatterometer (SASS)
William A. Brence Wallops Flight Center Wallops Island, Va.	Radar Altimeter (ALT)

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