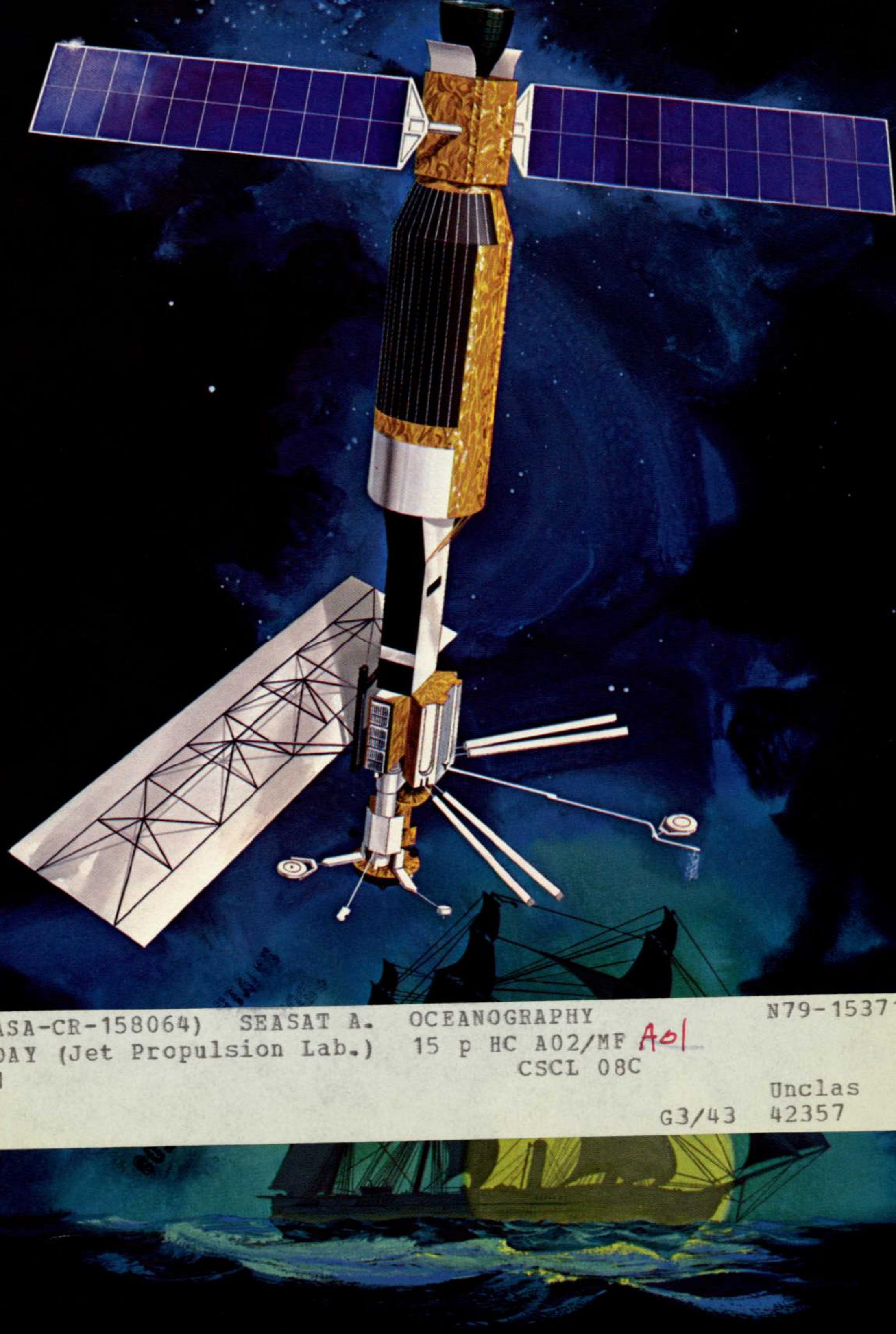
Seasat A

Oceanography Today



Cover: Seasat A, the first spacecraft dedicated to oceanography, with ghost of HMS Challenger, whose trip in the 1870s became the model for oceanographic voyages. Opposite: A fishing boat struggles through high seas as Seasat A monitors progress of the storm.

On a bitter, wet December 21 in 1872 at Portsmouth, England, the crew of HMS Challenger, sullen because they would spend the Christmas holiday at sea and not at home, prepared to weigh anchor on a voyage of tremendous scientific importance. It mattered little to Challenger's grumbling seamen that, when they returned to England in 1876, a new science—oceanography—would be firmly established.

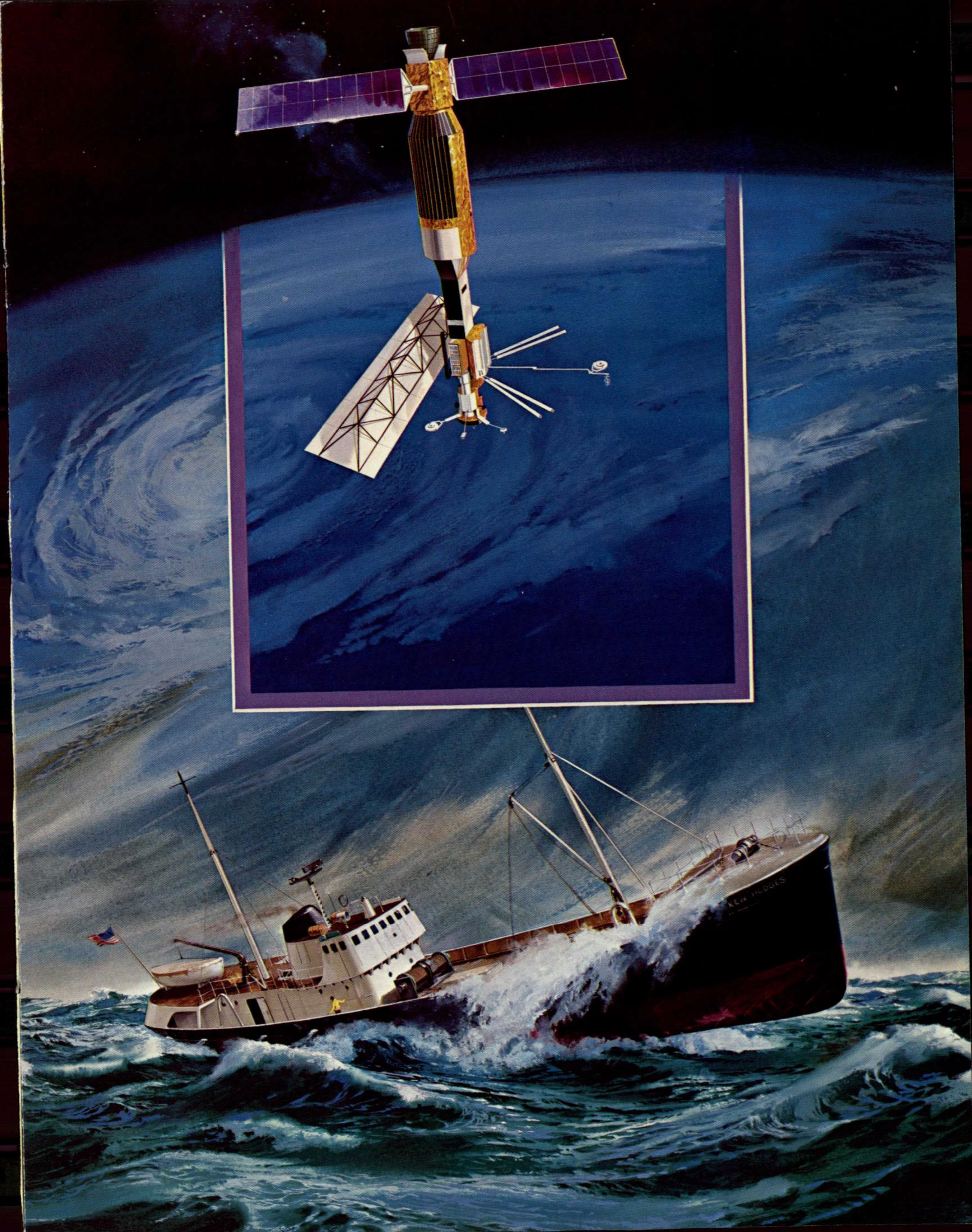
Sir Charles Wyville Thomson, a "damned landlubber" to the sailors, headed a team that was the catalyst for this expedition: Sir Charles was chief scientist on the voyage that would consume three and one-half years, circle the globe, sail 68,000 nautical miles, cross the steaming equator eight times, carry the three-masted corvette into frozen Antarctic wastes, and become the first classic oceanographic research mission.

Challenger's voyage was sponsored by the British government. The Royal Society organized the trip in collaboration with the University of Edinburgh, where the concept of oceanography had recently been born.

As he said farewell to 60 important visitors who had journeyed down to Portsmouth to see Challenger on her way, Sir Charles pondered his Royal charge: "Chart the depths, movement and content of the seas, scour the oceans for marine life, for clues to climatic phenomena, and search for minerals."

Later he would write in his log: "A party of 60 sat down in the handsome wardroom where we now have our general mess. We shall not soon forget the hearty British cheer of encouragement which rang out from a chorus of voices which most influence the destiny of their country and their time."

Challenger's three-and-a-half-year voyage was a resounding success. But, like all oceanographic trips since, it had limitations: "At the end of two years," Sir Charles wrote, "not even the scientists came out on deck to see what was in the dredge. It was always the same."



Opposite: Seasat A will locate ice masses as well as navigable openings to facilitate passage of ocean vessels in ice-covered seas.

Oceanographer, the National Oceanic and Atmospheric Administration's floating laboratory, will lead the program of data collection to verify Seasat A measurements.

More than 105 years after Challenger's pioneering voyage began, scientists are preparing to undertake a new kind of oceanographic voyage of exploration—this time with an unmanned Earth satellite called Seasat A.

Seasat A will cover Challenger's 68,000-mile, three-and-a-half-year trip in its first five hours of flight. It will cross the equator, not eight times in three years, but 28 times a day. It will give oceanographers and meteorologists what sea-going expeditions could never provide: a fast, worldwide look at what is occurring on and just above the surface of the sea.

The National Aeronautics and Space Administration plans to launch Seasat A on its voyage of exploration aboard an Atlas-Agena from Vandenberg Air Force Base, California, in June 1978.

Challenger was, in a way, a voyage to prove that scientists could study the oceans from ships; Seasat A is also a "proof-of-concept mission"—to see if microwave sensors in space can provide clear, accurate, understandable information of direct use to a variety of oceanographic and meteorologic disciplines, and to government and industrial users of the oceans as well.

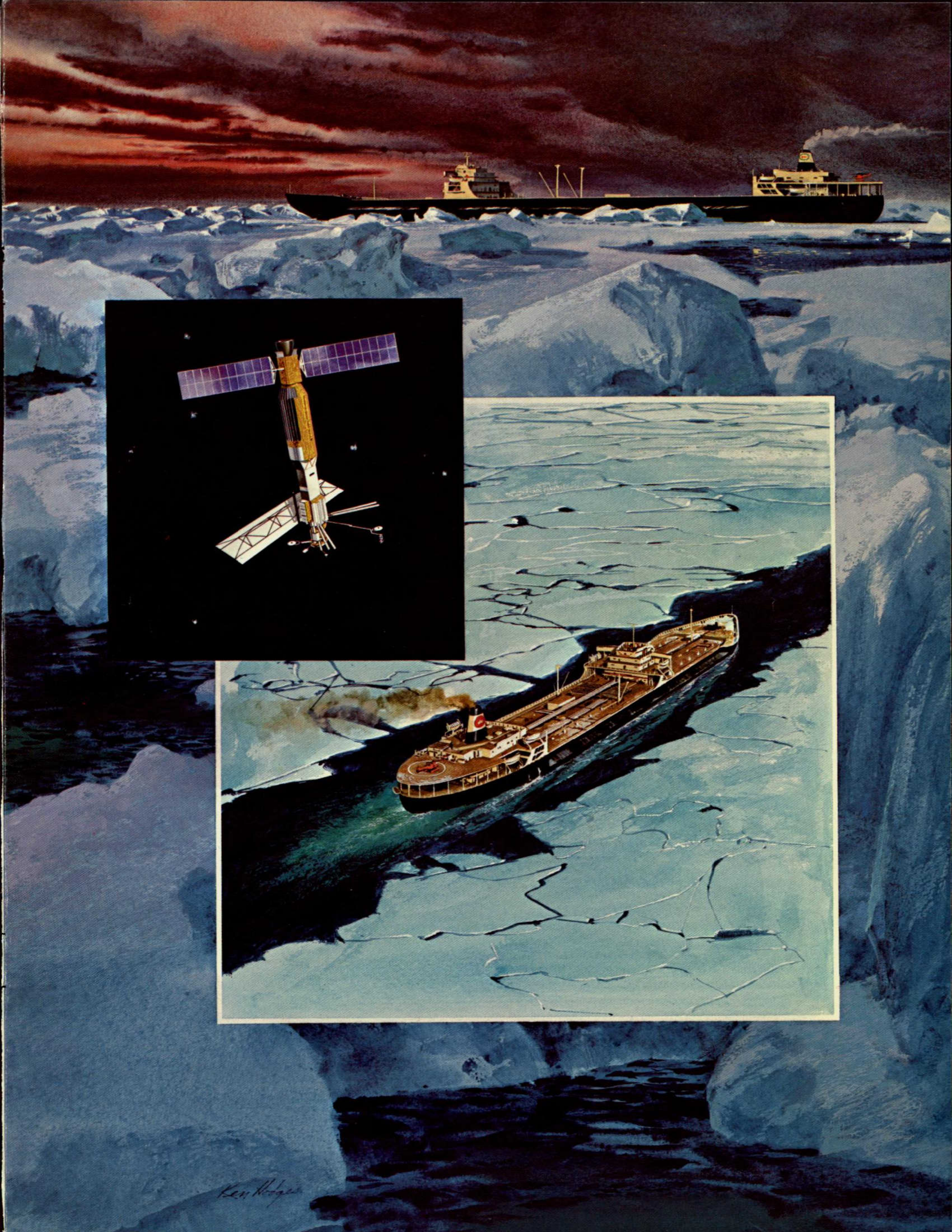
From its 800-kilometer (500-mile)-high, near-polar orbit, Seasat A will point five instruments at the world's oceans as it makes 14 orbits of Earth each day, scanning 95 percent of the oceans every 36 hours. Neither rain, nor sleet, nor dark of night (nor fog) shall stay Seasat A from its appointed rounds—nor obscure its view of the seas: most instruments have all-weather capability and will work as well at night as in daylight.

A portion of Seasat A (engineers call it "the bus") is a Lockheed Agena. The Agena is a three-axis-stabilized spacecraft that has flown more than 300 missions. It carries a sensor module—a specialized section that contains the microwave instruments and other payload-related equipment.

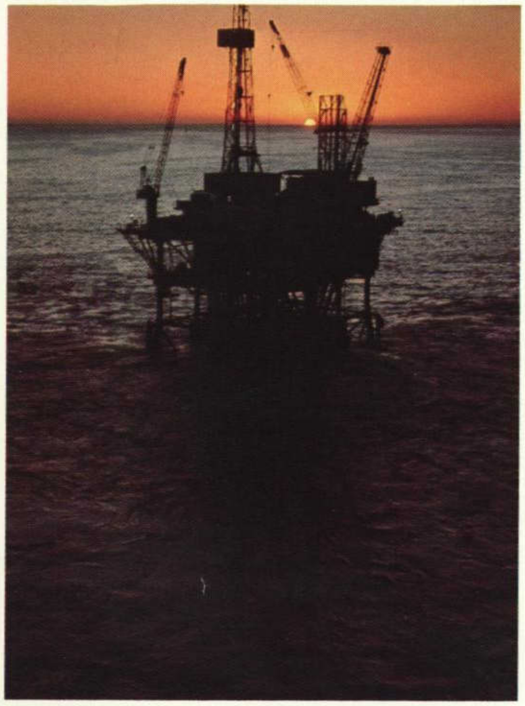
Scientists from several oceanographic and meteorologic fields have formed teams for the mission. Their primary task will be to study information from Seasat's instruments and make an objective judgment about how well they will allow man to study the sea from space.

Four of Seasat A's instruments look at the surface of the sea (and in some cases, the land they pass over) in the microwave region of the spectrum. Just as our eyes see in the visible region (between 4,000 and 7,000 Angstroms), microwave instruments see in a radio portion of the spectrum (between 1,000 and 300,000 megahertz).

The microwave instruments will provide information that can be translated into sea-surface temperature, wind speed, wind direction, and the amount of water in the atmosphere. They will take pictures of



Opposite: Seasat A will aid oil exploration and production by providing timely warnings of threatening storm conditions and resulting high waves.



Offshore oil and gas platforms can be constructed only in calm weather and may suffer costly shutdowns during storms in their vicinity.

ocean waves, ice fields, icebergs, ice leads (linear openings in ice through which ships may navigate), and sea conditions along the coastlines. They will measure what oceanographers call "significant wave height"—the largest third of all ocean waves.

They will also be able to pinpoint Seasat A's altitude above the surface to within 10 centimeters (4 inches) to allow scientists to measure ocean tides, storm surges, and currents.

Seasat A's fifth instrument does not see in the microwave region. It is a radiometer that will take pictures of cloud cover and ocean and coastal features, and will measure sea-surface temperatures. Its main task is to back up the microwave instruments.

Like its predecessor, HMS Challenger, Seasat A has a primary charge: to determine the scientific performance of the instruments and then transfer data-conversion techniques learned in the process to all interested users—government agencies, scientific institutions, and private industry.

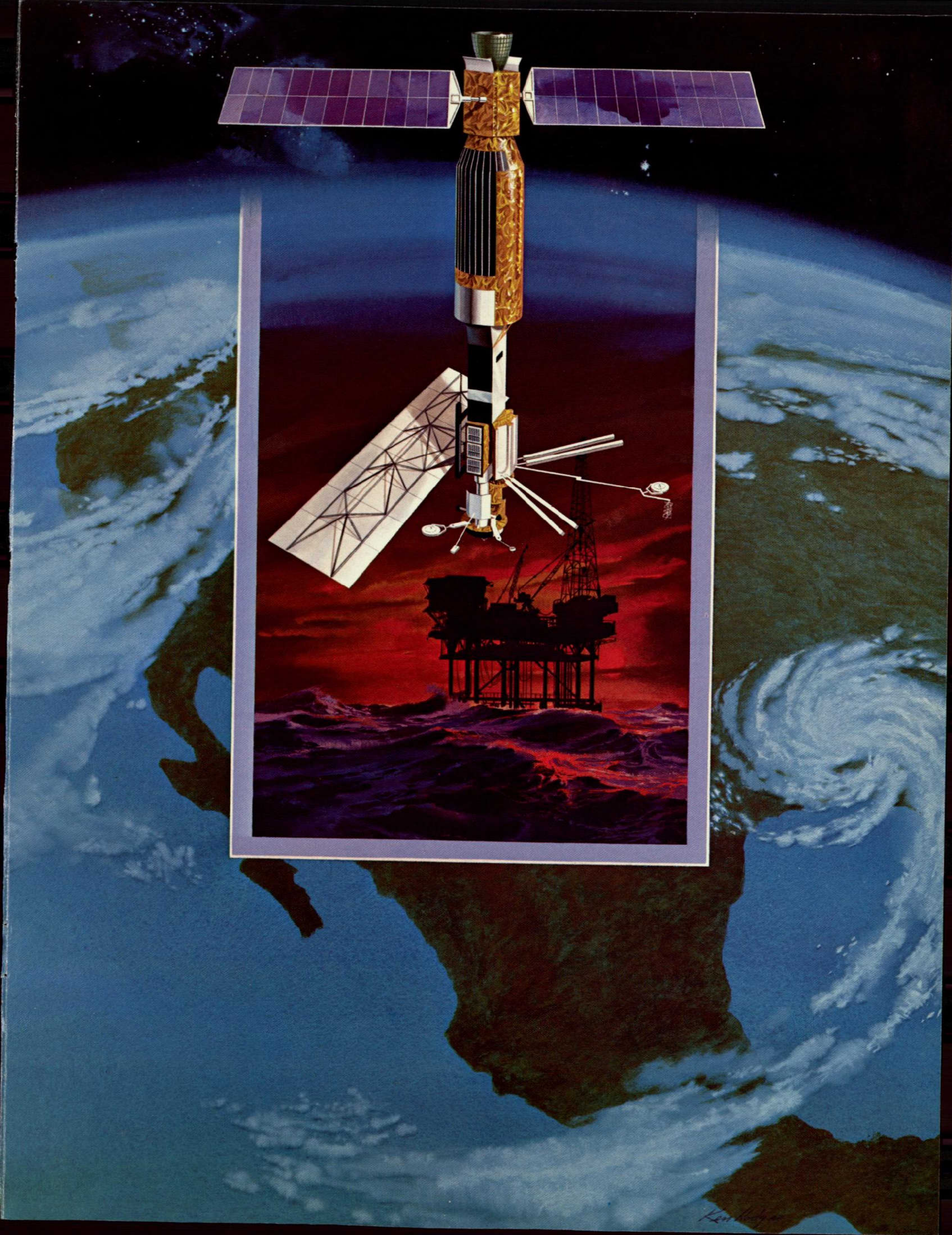
Since the Space Age began, scientists have used remote-sensing instruments to study near-Earth and interplanetary space as well as other planets. Remote sensing instruments on spacecraft have been used to study land areas of Earth and our weather (for example, Landsat and the ITOS weather satellites). But only recently have microwave instruments been developed that can measure Earth's oceans. The problem is both simple and complex: engineers know that microwave instruments can return specific data. But can those engineering measurements be translated into useful scientific information?

The answer to that question will determine the future of the Seasat program. For example, the instrument that indicates wind speed and direction really measures "microwave backscatter" from the sea's surface. Can that backscatter be translated into accurate and real indications of the direction and speed of the wind?

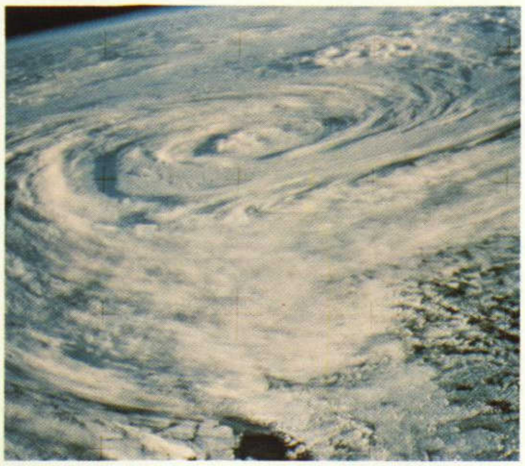
Along with measurements from the spacecraft, scientists plan an extensive "surface truth" program: aircraft, ships, and instrumented buoys will make measurements that will be compared with those from Seasat A to verify the accuracy of its instruments.

Seasat A's mission will extend for at least one year from launch in June 1978; three years' worth of supplies (fuel and other expendables) will be loaded aboard. For the first few months after launch, scientists and engineers will calibrate the instruments—determine how accurately they measure known quantities. During that time, too, computer programs will be tested to see whether they are correctly translating Seasat A's messages.

At the end of those first months, the observation phase will begin in earnest; this will be the real proof of the Seasat concept. Like HMS



Opposite: Outline of Seasat A spacecraft depicts instruments that will measure sea surface winds, temperatures, currents, waves, ice fields, and coastal conditions.



Skylab photograph of Hurricane Ava taken in June 1973 off the coast of Mexico shows kind of destructive storms that develop at sea.

Challenger, Seasat will "Chart the depths, movement and content of the seas, and scour the oceans..."

Near the end of the primary mission, activity will increase sharply. Oceanographers and meteorologists around the world will begin a special observing period for the mammoth undertaking called the Global Atmospheric Research Project (GARP), and instrumented ships and aircraft from many nations will roam the seas and skies. The goal is to have Seasat A participating in GARP, providing global coverage high above the ships and planes.

The sea covers more than 70 percent of our planet. There are regions where man seldom ventures, vast and lonely areas where huge currents flow unseen, storms are born and mature, and fleets of icebergs drift in cold and lonely splendor.

Eighty-seven percent of the fresh water on Earth is tied up in the polar ice caps. Huge schools of fish swarm the seas; some species follow regions where the temperature varies no more than two degrees—a difference that Seasat can detect.

The oceans soak up and store the Sun's energy better than either land or atmosphere. Billions of megawatts lie captive in the sea, and we understand little of how to recover them.

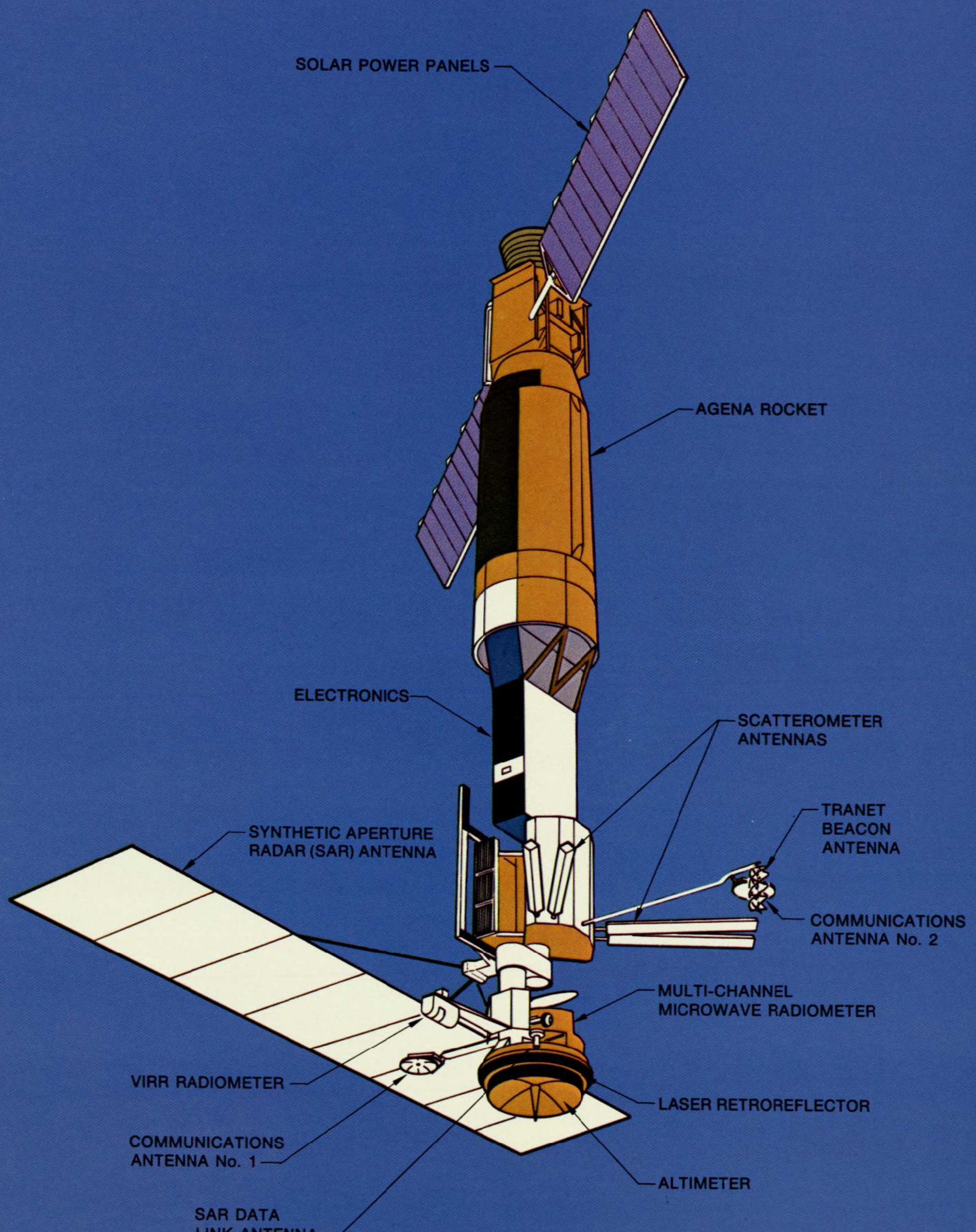
At the same time, the sea gives up prodigious amounts of energy into the atmosphere. That is how weather is created—the sea is an energy storehouse and a huge weather machine.

The U.S. Coast Guard goes to considerable trouble each year to locate and track icebergs, and to warn ships when the bergs approach shipping lanes. Can this be done more effectively and easily from space?

Construction, installation, and operation of offshore oil and gas platforms is an expensive and weather-dependent business. New platforms can be placed only during calm weather, and the task takes many days. Meteorologists push their capabilities to the limits to predict calm periods. During storms (or even the approach of storms), the platforms must often shut down, their pumping gear disconnected and their crews evacuated, to protect drillers and prevent blowouts. Can information about storms and the resulting sea waves help reduce the cost of those operations?

The U.S. Navy's Fleet Numerical Weather Central gathers data from around the globe and issues weather forecasts to ships at sea—military and civilian, foreign and American. Can global monitoring of maritime weather from space, and accompanying rapid dissemination of the data, help improve weather forecasts, allowing ships to move clear of storms and into calmer weather and seas?

Storms take a toll of the world's shipping each year. Storm waves have broken ships in half. Can data from Seasat provide new insight


SOLAR POWER PANELS
AGENA ROCKET
ELECTRONICS
SCATTEROMETER ANTENNAS
TRANET BEACON ANTENNA
SYNTHETIC APERTURE RADAR (SAR) ANTENNA
COMMUNICATIONS ANTENNA No. 2
MULTI-CHANNEL MICROWAVE RADIOMETER
VIRR RADIOMETER
LASER RETROREFLECTOR
COMMUNICATIONS ANTENNA No. 1
ALTIMETER
SAR DATA LINK ANTENNA

Opposite: NASA research aircraft Galileo will be instrumented and flown as part of surface truth program to confirm Seasat A results.

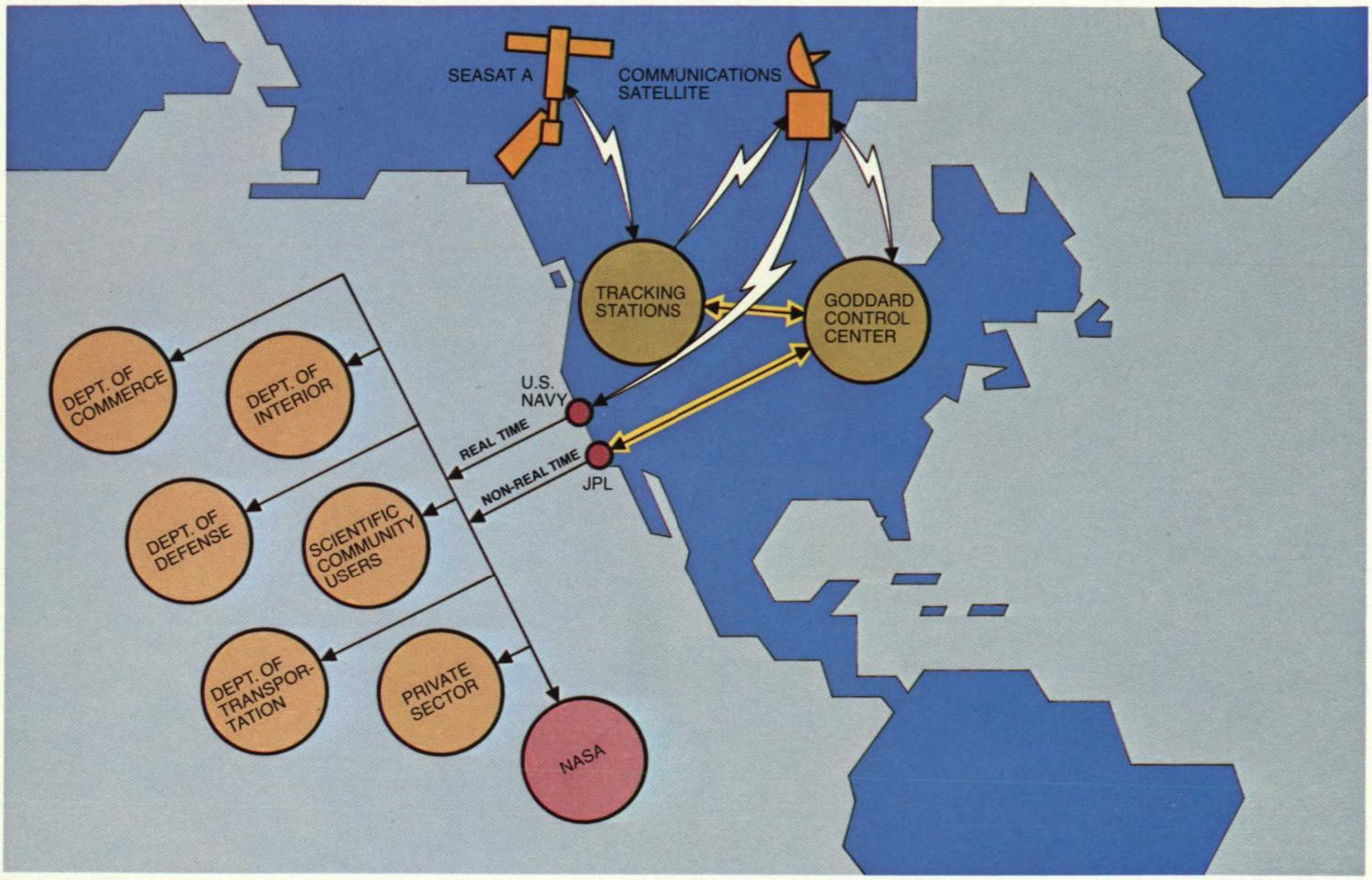


Diagram shows distribution of satellite data via receiving facilities on Earth to various users of oceanographic information; interest in the project is worldwide.

into waves, allowing naval architects and shipbuilders to improve design and construction?

Ocean currents like the Gulf Stream often meander and change course and size. That affects weather, shipping, and fishing. "El Niño" is a warm current that flows south along the coast of Ecuador, usually beginning just after Christmas. In exceptional years, El Niño may extend down the coast of Peru to 12 degrees south latitude. When that occurs, plankton and fish are killed in vast numbers, devastating the fishing industries of many nations. Large concentrations of dinoflagellates (single-celled sea creatures) increase the fish kills, perhaps because of toxins they carry. The water turns a red color similar to the "red tides" along the Southern California and western Florida coasts. Can Seasat help chart the vagaries of such currents and provide useful information to those who need it?

Those are a few of the potential uses for a spacecraft that looks continuously at the world's oceans. Involvement by users of oceano-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C-130, another NASA plane used in Earth survey work, will participate in Seasat A surface truth program.

graphic data, including the industrial community, has expanded since the Seasat program began and is expected to increase even more once the spacecraft is launched.

Two multi-experimenter groups have initiated formal agreements with NASA for the receipt and processing of the satellite's data. These are the Canadian Government's Surveillance Satellite Project (SURSAT) and the European Space Agency-sponsored Seasat A Users Group in Europe (SURGE). Receiving stations are now being equipped at Shoe Cove near St. John's, Newfoundland, and at Oakhanger in Southern England.

More than a century ago, the cold, disgruntled seamen of HMS Challenger began a revolution in man's knowledge that they couldn't have foreseen as they drifted with the outgoing tide from their berth at Portsmouth. Challenger has had a line of distinguished descendants in the years since her first oceanographic voyage. Could Sir Charles Wyville Thomson have predicted that the descendant that launched the fourth great era in oceanographic exploration would do it from the distant reaches of space?

Additional information on the Seasat A program may be obtained by contacting the National Aeronautics and Space Administration's Seasat A Program Office, Washington, D.C. (202-755-1201), or the Seasat A Project Office at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California (213-354-5177).

Seasat A is managed for NASA by the Office of Space and Terrestrial Applications, NASA Headquarters, Washington, D.C. The California Institute of Technology's Jet Propulsion Laboratory manages the project and the satellite system. Lockheed Missiles and Space Company, Sunnyvale, Calif., is prime contractor to JPL for the satellite system.

Surface Truth

The National Oceanic and Atmospheric Administration (NOAA) plans an extensive "surface truth" program to accompany Seasat A. The object of collecting surface truth measurements is to confirm the accuracy of the information gathered by the spacecraft's instruments, and allow improvement and updating of computer algorithms.

The Gulf of Alaska Seasat Experiment will begin in late Summer 1978, and will involve NOAA ships, aircraft, and instrumented buoys, and various Coast Guard and weather-station vessels.

NOAA is responsible for collecting a variety of surface truth data from nondedicated sources—Navy and NOAA ships as well as those from oceanographic institutions, aircraft and surface buoys, and others. These data will be relayed to the Jet Propulsion Laboratory for inclusion in data banks.

The National Oceanic and Atmospheric Administration also will staff the interface between Seasat A and major oceanographic programs such as the Global Atmospheric Research Project.

Proposed Industry Experiments

Beaufort Sea (oil and gas and Arctic operation)	Gulf Oil Canada Ltd., Imperial Oil (Canada), Dome Petroleum (Canada), AOGA/ARC (U.S.A.)
Labrador Sea (oil and gas and sea and ice)	EASTCAN Exploration (Canada), Gulf Oil Canada Ltd., Imperial Oil (Canada), Texaco (U.S.A.)
Gulf of Mexico (oil and gas and pipelines)	AGA/PRC Getty Oil, Texaco
U.S. East Coast	CONOCO et al.
Offshore West Africa (oil and gas and drilling)	Getty Oil et al., Texaco
North Sea (oil and gas)	CONOCO, Union Oil
Equatorial East Pacific (ocean mining)	Kennecott Exploration, Deepsea Ventures
Ocean Thermal Power (thermal resources)	Ocean Data Systems, Inc.
Bering and Chukchi Seas (oil and gas and ice)	AOGA/Bering Sea Task Force on Ice
Optimum ship routing	Sun Shipbuilding and Dry Dock Co.
Ice monitoring for tanker design	Sun Shipbuilding and Dry Dock Co.
Gulf of Alaska (oil exploration)	Ocean Routes, Inc.
Ocean routing and environmental predictions	Ocean Routes, Inc.
North American Goose Nesting Habitat	U.S. Department of Interior Fish and Wildlife
International Ice Patrol—northern survey	U.S. Coast Guard
International Ice Patrol—environment	U.S. Coast Guard
International Ice Patrol—drift	U.S. Coast Guard
Eastern Tropical Pacific tuna fisheries	Inter American Tuna Commission (IATTC)
Salmon—albacore	Oregon State University/ Marine Advisory Program and Humboldt State University/ Marine Advisory Extension Society
Alaskan crab fisheries	Pacific Fishing Vessel Owners Association
Alaskan crab fisheries	Kodiak

Participating Government Organizations

National Aeronautics and Space Administration
- Jet Propulsion Laboratory, California Institute of Technology
- Ames Research Center
- Goddard Space Flight Center
- Johnson Space Center
- Langley Research Center
- Lewis Research Center
- Wallops Flight Center

National Oceanic and Atmospheric Administration, Department of Commerce
- Environmental Research Laboratories
- National Environmental Satellite Service
- National Weather Service
- Environmental Data Service
- National Ocean Survey
- National Marine Fisheries Service

Department of Defense
- Fleet Numerical Weather Central
- Naval Ocean Research and Development Center
- Naval Research Laboratory
- Naval Surface Weapons Center
- Defense Mapping Agency

Department of Interior
- U.S. Geological Survey

Department of Transportation
- U.S. Coast Guard

Institutions Participating in Experiments

City University of New York
Johns Hopkins University/Applied Physics Laboratory
Scripps Institution of Oceanography
Smithsonian Astrophysical Observatory
Texas A&M University
University of Kansas
University of Texas
Department of Energy, Mines and Resources—Canada
European Space Agency

Seasat A
Sensor Measurements

Sensor	Measurement Objectives
Short Pulse Radar Altimeter and Precision Orbit Determination	Significant wave height over the range 1–20 m (3–66 ft) to an accuracy of 10%. Satellite height relative to the sea surface to a precision of 10 cm (4 in.). Satellite ephemeris determinations to less than 2 m (6.5 ft) globally, with a goal of 10–20 cm (4–8 in.) locally.
Wind Field Scatterometer	Sea surface wind speeds over the range 4–20 m/s (13–66 ft/s) to an accuracy of 2 m/s (6.5 ft/s). Wind direction to an accuracy of 20 deg.
Scanning Multifrequency Microwave Radiometer	Sea surface temperature to an absolute accuracy of 2°C (3.6°F). Sea surface wind speeds over the range 7–50 m/s (23–164 ft/s) to an accuracy of 2 m/s (6.5 ft/s) or 10%. Atmospheric attenuation and refraction corrections for the wind field scatterometer and the short pulse radar altimeter.
Synthetic Aperture Imaging Radar	Wavelength and direction for ocean waves greater than 50 m (164 ft) in wavelength. Sea ice, land, and coastal images to a resolution of 25 m (82 ft).
Visual and Infrared Radiometer	Visual and infrared images for feature recognition support to the microwave sensors. Clear air sea surface temperature measurements for comparison with the scanning multifrequency microwave radiometer.

Since the days of Challenger, the science of oceanography has gone through three major periods, each shaped by the instruments available to its practitioners.

In the first, wire cable replaced hemp rope for sounding lines so that great ocean depths could be measured accurately and deep-sea dredges could bring material from the ocean floor, enabling scientists for the first time to catalog the strange creatures living there.

The second stage included the Nansen bottle (a device for taking samples of sea water at selected depths), the reversing thermometer, and accurate analysis of salinity. That period began just before World War I. German and Scandinavian scientists led the way in determining the basic structure of ocean water—the climate of the sea.

The third great period has seen exploration of the sea floor with echo sounders, corers, heat probes, gravimeters, and bottom photographs.

That period began less than 40 years ago, and swiftly led to a new understanding of our planet, its history, and probable future. It climaxed with the verification of the theory of plate tectonics and sea-floor spreading.

Now, with the launch of Seasat A, the fourth great period of oceanography is about to begin.

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