Solving the mystery behind a plane crash lies in recovering the wreckage and trying to piece together what happened. When TWA Flight 800 went down only 50 miles from New York City this past July, the National Oceanic and Atmospheric Administration ship *Rude* was one of many vessels that helped map the wreckage site and recover valuable debris .

Sounding the Depths

Mapping the Wreckage of TWA Flight 800

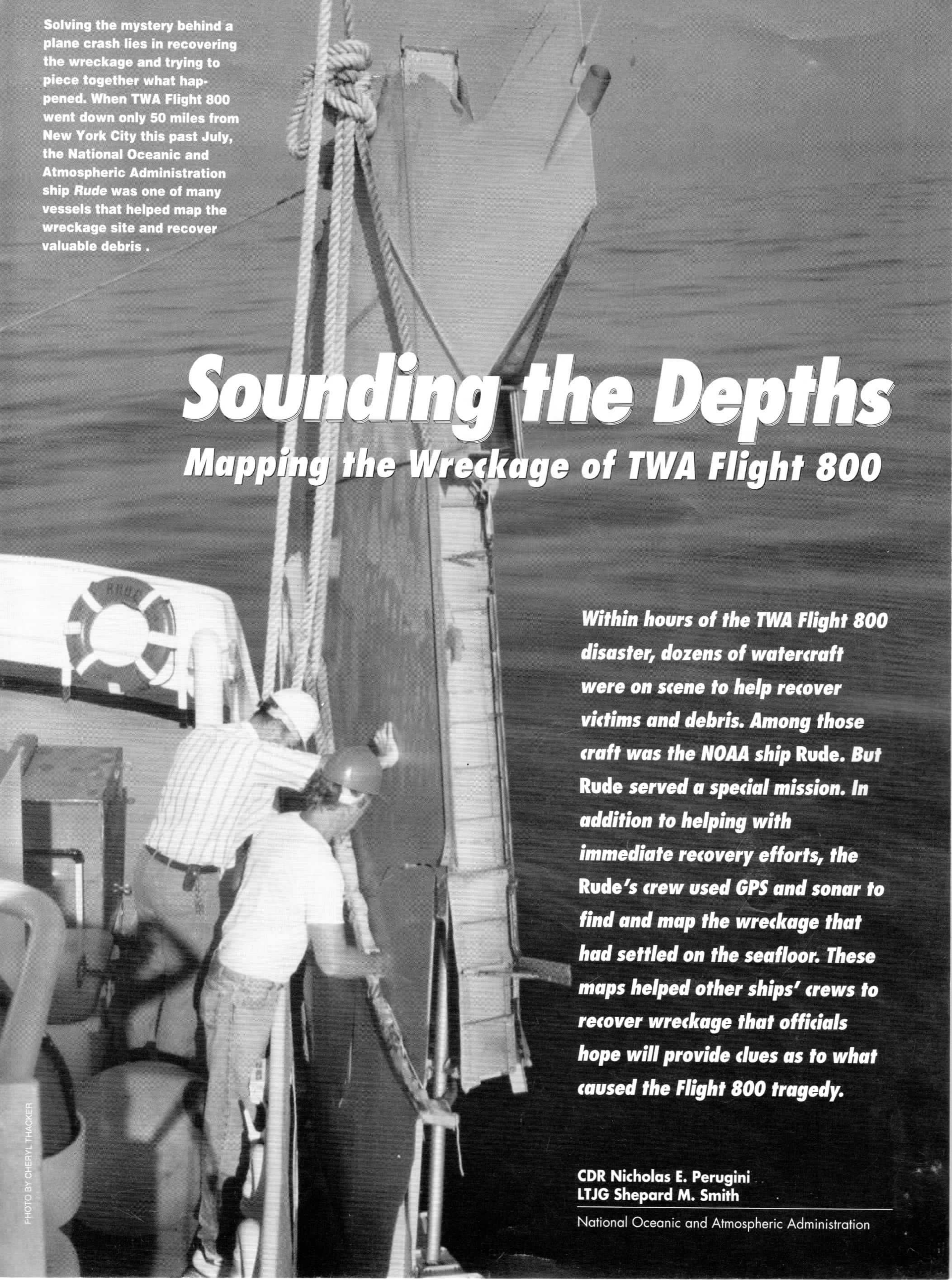

PHOTO BY CHERYL THACKER

Within hours of the TWA Flight 800 disaster, dozens of watercraft were on scene to help recover victims and debris. Among those craft was the NOAA ship Rude. But Rude served a special mission. In addition to helping with immediate recovery efforts, the Rude's crew used GPS and sonar to find and map the wreckage that had settled on the seafloor. These maps helped other ships' crews to recover wreckage that officials hope will provide clues as to what caused the Flight 800 tragedy.

CDR Nicholas E. Perugini
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National Oceanic and Atmospheric Administration

MARK LATHROP

The National Oceanic and Atmospheric Administration ship *Rude* was one of many vessels that helped map the wreckage site and recover valuable debris .

Sometimes the daily life aboard a government charting ship, running long survey lines back and forth over a defined body of water, can become rather mundane. But, in mid-July 1996, the monotony was interrupted for the crew of the National Oceanic and Atmospheric Administration (NOAA) ship *Rude* (pronounced "Rudy") when it became part of one of the most critical underwater mapping projects ever undertaken by the federal government.

On Wednesday, July 17, the four commissioned officers and seven civilian crew members aboard the *Rude* had just finished a nautical charting project in the approaches to New York Harbor, and the vessel was making its way east along Long Island's south shore. By 9 P.M., the 90-foot hydrographic survey ship was anchored off Point Judith, Rhode Island, preparing for a new charting project scheduled to begin the next morning. (See sidebar entitled "NOAA, Hydrography, and DGPS" on page 24.)

At 10 P.M., Commander Sam DeBow, *Rude*'s skipper and a NOAA Corps officer, heard a radio report that TWA Flight 800, carrying 230 passengers, had crashed 8 miles off the coast of East Moriches, New York.

Commander DeBow immediately contacted the U.S. Coast Guard and offered *Rude*'s help with the search for survivors. Within one hour the ship was steaming for the crash site 80 miles away.

RUDE ARRIVES ON SCENE

At daybreak on Thursday, the *Rude* reached its destination. The seas were calm, but the scene was frenzied. Floating wreckage was strewn everywhere. About 30 craft, ranging from the U.S. Coast Guard Cutter *Juniper* to state- and local-government vessels and a variety of pleasure boats, frantically searched the waters for survivors and tried to recover debris. An oil recovery vessel skimmed up fuel, and a tug towing a crane vessel cruised the waters. The *Rude*'s crew immediately joined in the search. (See sidebar entitled "A Commanding View" on page 26.)

At noon, government authorities held a meeting aboard the *Juniper*. All agreed that locating and mapping underwater wreckage was a top priority because it would hasten victim recovery efforts.

Commander DeBow volunteered *Rude*'s services, explaining that no ship was better equipped at the time to handle that task.

Rude has some of the most advanced hydrographic and navigation equipment available, including differential GPS (DGPS), side-scan sonar, echo sounders, and electronic position-fixing systems. The ship has both long- and short-range radio communications abilities and is fully equipped for diving operations to determine the nature of submerged objects.

DeBow explained that the crew could use the ship's sonar devices to find submerged wreckage. The ship's DGPS equipment would enable crew members to precisely determine the positions of these sunken objects. On-scene personnel could use the positions to direct diving and salvage operations, and a NOAA shore team could then generate maps that could help keep the public informed. The shore team could also create a geographic information system (GIS) to help investigators analyze the crash site.

Based on DeBow's description of *Rude*'s capabilities, the crew was soon authorized to begin a limited seafloor survey.

SEARCHING THE SEAS

As the surface debris drifted over an ever-widening area, *Rude*'s crew prepared to conduct a detailed hydrographic survey of the area. Based on the location of floating debris and information from the air-traffic control radar, the crew ascertained the approximate position of the submerged wreckage. Crew members planned the initial search in a 0.5-nautical mile (nmi) radius around a large oil slick in a major floating-debris field.

Using the ship's personal computer (PC)-based data acquisition system to input geographic locations, members first defined a search grid by laying out planned survey lines in a parallel fashion. They determined the spacing between the parallel lines by projecting coverage of the side-scan sonar. This enabled the helmsman to navigate the grid based on a pilot-house display showing the ship's DGPS position in relation to the planned survey lines and the shoreline.

After defining the search area, the crew deployed its sonar array. *Rude* used three devices to accurately determine both position and depth while conducting the survey.

Echo Sounder. Mounted in *Rude*'s hull, the echo sounder is an acoustic instrument that consists of a recorder and a transducer that uses sound waves to precisely measure depths.

The transducer generates a sound wave, which is reflected off the ocean bottom and then returns. The total travel time divided by two is proportional to the depth. *Rude*'s echo sounder has a very narrow beamwidth (7 degrees) enabling it to measure depths to an accuracy of about 0.2 meters.

The narrow beamwidth, however, only ensonifies a small area, or footprint, directly beneath the ship enabling the sounder to accurately measure only feature depths that are directly below the transducer, or the ship's hull. Objects lateral to the vessel's track can remain undetected, and depths between survey lines must be inferred. The crew can address this shortcoming, however, by using the multibeam sonar.

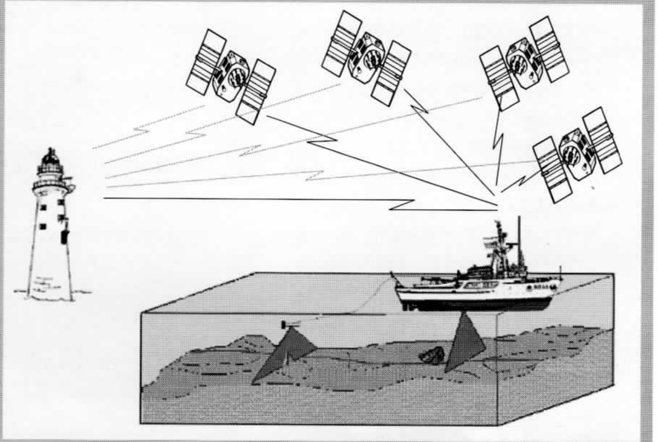
Multibeam Sonar. *Rude*'s shallow-water multibeam sonar can ensonify a swath of about 90 degrees (or twice the water depth) beneath the vessel. Like the echo sounder, the system operates with a transducer fixed to the ship's hull. But, unlike the echo sounder, the multibeam sonar fans out sound waves lateral to the vessel's track.

As the ship moves along the sounding line, the multibeam sonar continuously records depths from 60 beams within a 90-degree swath. In water depths of 10 meters (about 33 feet), the system continuously records a 20-meter swath along the vessel's track.

Side Scan Sonar. The side-scan sonar instrument is complementary to both the echo sounder and the shallow-water multibeam system. Although this instrument cannot measure depths, it can create a shadowy image of the bottom along the sounding vessel's track. This image can help to identify the objects once they are located using any of the sonar devices. The side scan's swath can range from 5–12 times the water depth. (See sidebar entitled "Interpreting Side-Scan

NOAA, Hydrography, and DGPS

A Department of Commerce agency, the National Oceanic and Atmospheric Administration (NOAA) is responsible for producing and maintaining a suite of more than 1,000 nautical charts, which serve as the "road maps" for U.S. coastal waters. Mariners who



operate all types of vessels, including warships, supertankers, freighters, tugboats, and sailboats, rely on these charts for navigation.

NOAA uses hydrographic surveys to develop its nautical charts. A branch of physical oceanography, hydrography deals with measuring and defining the terrain beneath the surface of oceans, lakes, rivers, and harbor areas as well the adjacent shorelines. In simple terms, the elements of a hydrographic survey involve accurately determining both position and water depth.

Rude is one of three hydrographic survey vessels currently owned and operated by NOAA. The ship's mission is to conduct hydrographic surveys in U.S. coastal waters.

Since it began to appear in hydrographic surveying applications about five years ago, differential GPS (DGPS) has revolutionized the offshore positioning process.

Before DGPS, hydrographers relied heavily on radio positioning systems. The intersection of electronic position lines measured from onshore transmitters defined the survey vessel's offshore position. Establishing geodetic shore control and erecting radio-wave transmitters was a laborious and time-consuming, but necessary, part of the survey process.

Today, in U.S. coastal waters, differential corrections from U.S. Coast Guard radiobeacons provide hydrographers, as well as average mariners, with reliable and accurate offshore positioning, and NOAA has incorporated the technology into its hydrographic survey vessels.

Sonar Data" on page 28.)

As the *Rude* began to travel along its survey grid, the systems recorded all sonar contacts and their DGPS-derived positions.

Pinpointing the Wreckage. The DGPS equipment aboard the *Rude* consists of two identical, independent sets of GPS instruments. Each system's main component is a 12-channel, L1, C/A-code GPS receiver built into an equipment drawer in the pilot house. Each receiver attains satellite signals by way of an L-band marine antenna and low-noise amplifier. The antennas are mounted at the top of the main mast, equidistant from the vessel's centerline on the port and starboard.

Two independent beacon receivers gather corrections from U.S. Coast Guard radiobeacons by way of whip antennas. These antennas are mounted on the main mast directly below the GPS port and starboard antennas. The antennas relay corrections to the GPS receiver in RTCM 104 format.

A computer program running on a PC initializes both the GPS sensors and the DGPS beacon receivers. During GPS receiver initialization, the operator selects parameters to optimize horizontal position accuracy. For example, satellites that are lower than eight degrees on the horizon are not used. To initialize the beacon receiver, the operator inputs the desired Coast Guard radiobeacon's frequency and desired parameters. No position is computed using corrections older than 30 seconds.

Surveying the Damage. As the survey began, the system received NMEA 0183 DGPS position messages at 1-second intervals. The messages include geographic position, UTC (Universal Coordinated Time) time, speed and heading of the vessel, and position quality information. The shipboard operator monitored position quality figures, such as the number of satellites being tracked and the horizontal dilution of precision (HDOP), in real time. If

A Commanding View

When the *Rude* arrived at the TWA 800 crash site on Thursday morning, the crew aboard the *Juniper* asked us to help with the search for survivors and debris while we awaited further instructions.

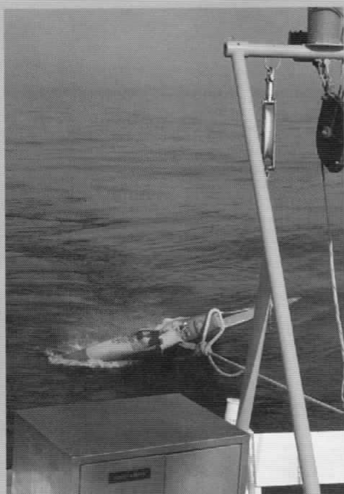
Around 7:15 A.M., we recovered one of the first pieces of floating debris, a three-foot long, charred section of insulation from an inside bulkhead. About 15 minutes later, the *Juniper* crew asked us to help a pleasure craft that was standing by with a piece of wing that was too large for the craft to handle.

When we reached the wing, its tip was bobbing on the surface. We tried to hoist it aboard using the ship's crane. Instead, we learned two important lessons. First, aircraft wings are filled with fuel cells — fuel began spewing everywhere when we attempted to lift it. Second, the wing, which was about 40-feet long, was much too big for us to bring aboard. We kept a line around the wing and towed it slowly to the *Juniper* where Coast Guardsmen hoisted it aboard the vessel. The wing was one of the largest pieces of debris initially recovered.

Next, we launched the *Rude*'s 19-foot Boston Whaler to help recover smaller floating debris. Between the *Rude* and the launch, we recovered many pieces of wreckage, including stabilizers, flaps, and seat cushions.

Later that morning, I met with the on-scene Commander Tim Sullivan aboard the *Juniper* and described the *Rude*'s unique sonar surveying capabilities. Coast Guard Commander Sullivan had put a brand-new, partially crewed, 225-foot buoy tender (which was still on acceptance sea trials) into the eye of this maelstrom. Throughout the operation, he and his crew displayed outstandingprofessionalism.

Sullivan was so impressed with the *Rude*'s capabilities that he immediately sent a message up his chain of command requesting guidance about how to use the *Rude*'s assets. Until this time, we had only been searching for debris that was floating on the surface. First Coast Guard District Commander Rear Admiral Linnon and National Transportation and Safety Board (NTSB) Vice Chair Francis soon authorized *Rude* to begin a limited seafloor survey using only DGPS, the multibeam sonar system, and an echo sounder.



CHERYL THACKER

CHARLES NEELY

Conventional thinking was that the wreck must be directly below the surface oil slick, so that is where we began our search. This assumption proved false, however, because most of the fuel was in the wings, and the wing section we had already retrieved was miles from the first survey location. Our main problem was that, at the time, no one knew for sure where the aircraft had hit the water. The debris field was a good basis for estimation, but surface currents had already drifted wreckage from the original point of impact. Because the multibeam sonar cuts a swath only two times the water depth, we were seeing only a 240-foot-wide portion of the seafloor, and we didn't find any wreckage. After NTSB granted permission to deploy our side scan sonar, the *Rude* began to discover and map wreckage.

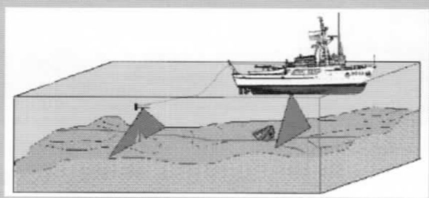
Salvage vessels were soon on site recovering the debris that the *Rude* and her crew had helped to locate. Someday, we hope that the wreckage located and the maps provided by *Rude* and the shoreside NOAA team will provide clues that help investigators solve the mystery of the Flight 800 crash.

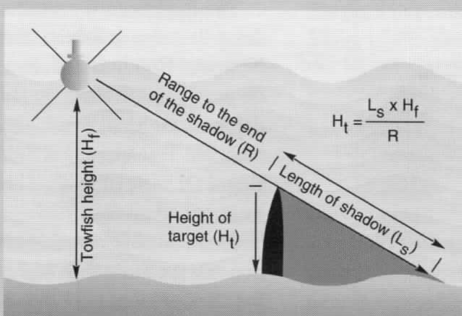
— Commander Sam DeBow
Commanding Officer, NOAA Ship *Rude*

Interpreting Side Scan Sonar Data

The side scan sonar is composed of two major components. The vessel pulls a torpedo-shaped towfish, connected by a cable, underwater at a fixed distance above the bottom.

The towfish has two transducers, one on the port and one on the starboard. Each transducer emits sound waves at regular intervals. As the acoustic energy from an individual pulse strikes the bottom, or a feature above the bottom, a 12-inch paper recorder notes the necessary data in real time. Stronger echoes appear darker, weaker echoes appear lighter. The system also records this information in digital format, which can be viewed in real time or, after post-processing, on a computer monitor.





As the vessel and towfish proceed along a track, the sonar compiles returns from individual pulses to build a shadowy image that is displayed on the recorder.

In general, a hard object will present a very strong return. This appears as a dark mark on the sonar record. If the object is raised off the bottom, acoustic energy is unable to reach the far side of the object. In this case, the return produces a white acoustic shadow. The acoustic shadow's length is proportional to the object's height off the bottom. Consequently, the side scan sonar is a good tool for searching for hard objects or those objects that rise off the seafloor.

In depths of 120 feet (as was found at the TWA crash site), NOAA typically operates the side scan sonar at a 100-meter range scale. This means that the ocean bottom is imaged at swaths 100 meters to port and 100 meters to starboard. Therefore, the system images a total swath of 200 meters along the towfish track.

Although the ship is positioned using DGPS, some accuracy is lost in the process of translating the ship's position in relation to the position of the side scan sonar contact. To compute the contact's position, the crew must first compute the towfish's position. This is done by measuring the fixed distance from the ship's antenna aft to the side-scan towpoint. The side-scan operator slowly lets cable out from the ship trying to maintain the towfish height above the bottom between 8 and 20 percent of the recorder scale. The operator adjusts the fish's height by changing the vessel's speed or changing the cable length out from the side-scan winch. In *Rude*'s TWA operation, the crew maintained the fish's position about 10 meters above the bottom.

Once the fish is "flying" astern of the vessel, the operator makes some simple approximations to calculate a right triangle between the ship and the towfish. The operator determines the water depth beneath the ship's hull using an echo sounder. In addition, the fish's height at any given time is recorded. The height of the towpoint above the bottom minus the height of the fish above the bottom gives one leg of a right triangle. The amount of cable out is multiplied by a factor of 0.9 to account for a catenary or bow in the cable.

Assuming that the towfish is tracking dead astern of the tow point, the crew can compute the towfish's layback. The layback (measured in a forward or aft direction) is the horizontal distance from the transducer, the origin of the vessel's coordinate system. By applying offsets to the GPS antenna, the crew can compute a position for the vessel's transducer. All other positions are ultimately related to that point of origin.

After the towfish position has been determined, the offset, or distance, from the towfish perpendicular to the fish track can be scaled from the sonar record. Therefore, the distance aft from the GPS antenna and the contact's offset from the fish's track can define sonar target's position. Acoustic devices can also be installed on a side scan sonar towfish to accurately determine its position relative to the vessel.

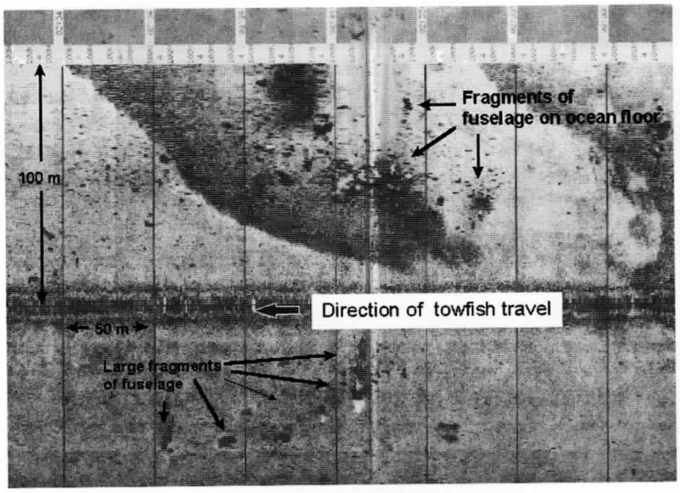
In addition, heading and attitude sensors can minimize errors caused by the uncertainty of the towfish orientation. These instruments are required in deep-water operations when the length of tow is very large (more than 100 meters) and the towfish position cannot be accurately approximated. For short tows (those less than 100 meters), NOAA has been able to consistently establish positions of side scan sonar contacts to an accuracy of about 10 meters. NOAA routinely demonstrates this accuracy aboard its hydrographic vessels. For example, it is quite common for the *Rude* to detect an old abandoned concrete buoy anchor, perhaps 1 meter on each side, sitting on the ocean bottom, 10 miles offshore.

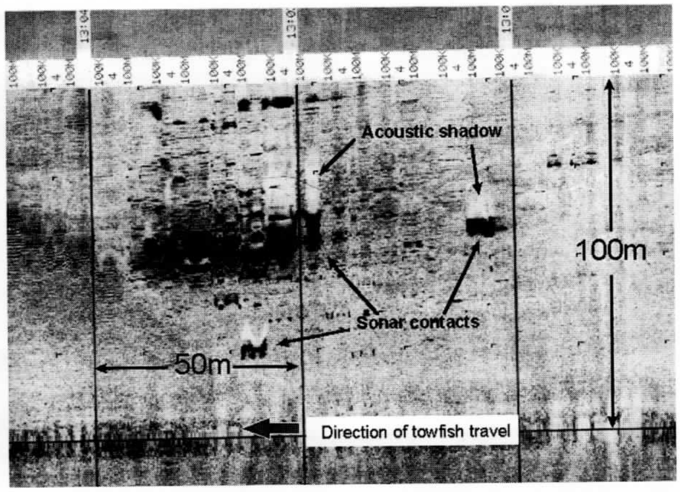
The side scan sonar determines positions so precisely that at any later time, the vessel can return to that position, drop a small float, and divers will be able to locate the feature within 10 meters of the float anchor.

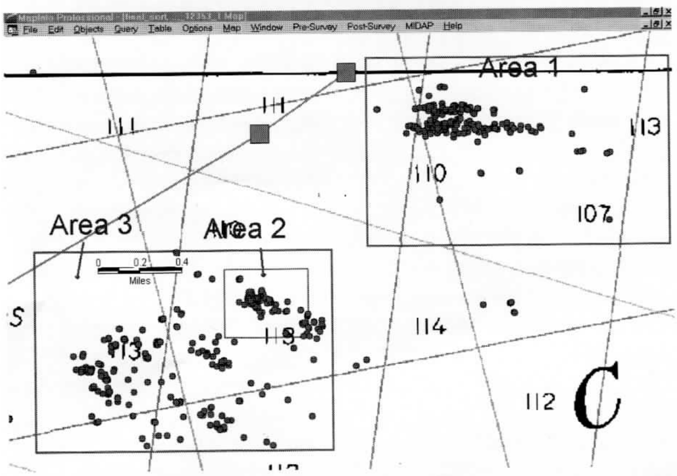
the number fell below four, or the HDOP became greater than the predetermined threshold of 3.3, then the crew ceased survey operations.

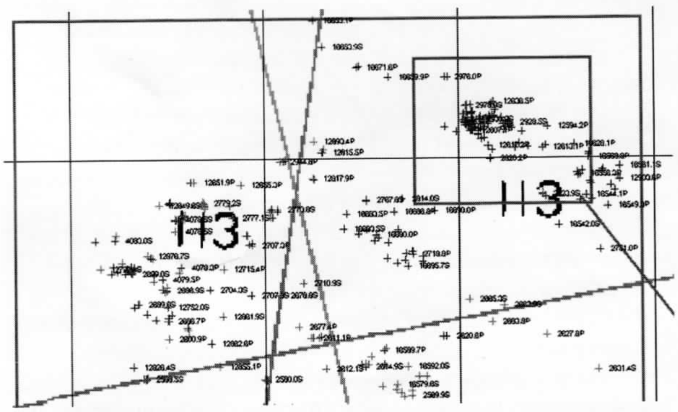
As the ship traveled, the computer's hard drive constantly recorded position and depth data. Using the DGPS updates to navigate, the crew maintained a course within 5 meters of the line that it intended to steer.

The crew monitored and recorded data from both the DGPS units and the depth sensors using the PC-based data acquisition

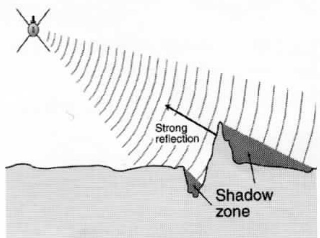








The *Rude* discovered two major areas of wreckage. Top left is a side scan sonar image of the first area; sand waves can be seen on the ocean floor in the upper-left part of this figure. To the right is a side scan image of the second area. Middle left is a GIS display of the flight line and side scan sonar contacts over the nautical chart. To the right is a head-on view of the towfish. The "valleys" and "peaks" on the ocean floor obscure the reflection of the sound pulses, causing acoustic shadows to appear on the sonar record. Bottom image shows the sonar contact names for use by the diving teams.



system. Members then plotted and analyzed the positions, bottom depths, echo soundings, side scan sonar records, and underwater findings to obtain precise DGPS coordinates.

Soon, the crew began discovering concentrations of wreckage. At about 9:45 P.M., only 25 hours after the crash, the ship located and began mapping the first major debris field. At about 3 A.M., it discovered a second debris field. Within 48 hours of the crash, *Rude* had surveyed 2 square nautical miles (70 linear nautical miles) of the seafloor and located most of the major wreckage. The *Rude* was exceeding expectations. Then, the weather turned.

Work Stops. On Friday, two days after the crash, high seas forced a halt to the search. The *Rude* can survey in ocean swells as high as 4 feet. If swells become much larger, the ship's irregular motion begins to affect the stability of the side scan sonar towfish, which must be towed at a constant speed. Friday's rough seas, with 8-foot swells and winds gusting to 25 knots, forced all search vessels to cease operations.

The *Rude*'s crew used this delay to make an 8-hour transit to Newport, Rhode Island, and take on provisions. Before the ship departed the area, it furnished National Transportation Safety Board (NTSB) officials with the locations of all the wreckage it had located. After working nonstop for more than 65 hours, the crew reached port and took a much-needed break.

On July 22, the seas calmed, *Rude* returned to the site to resume its search, and NOAA's shore team arrived.

MAPPING OPERATIONS

NOAA's shoreside representatives for the investigation included a group of five NOAA corps officers and civilians with expertise in GIS. That morning, the team established operations at the East Moriches Coast Guard base about 10 nmi from the crash site.

Each day, the *Rude*'s Boston Whaler, along with Coast Guard vessels, traveled from the search area to the Coast Guard base, shuttling data to the shore team. The first sonar images the *Rude* sent ashore on Monday were stunning, showing two major concentrations of wreckage. A third area, approximately 2 miles up-track (west) of the two concentrated areas, showed a more scattered debris field.

Since beginning the search,

Rude's crew had logged hundreds of sonar contacts and precisely positioned them using DGPS. Using a flatbed scanner, the shore team captured many of the most important contacts and then registered the images in the database to incorporate into the GIS. Using a commercial desktop GIS, team members plotted the location information on the backdrop of a NOAA nautical chart.

Flight-Line Data. By Monday, NTSB had assumed control of the investigation, and the U.S. Navy had been designated the lead agency in the survey and salvage effort. NTSB furnished the NOAA team with TWA 800's flight-line information, which had been generated from shore-based radar. NOAA integrated *Rude*'s GPS contacts with the flight-line information in the GIS.

The team then used the GIS to provide both plots and digital data to Navy and NTSB investigators and those leading the search. NTSB Vice-Chair Robert Francis and Navy senior officer Rear Admiral Edward Kristensen used these charts while conducting their daily press briefings.

In addition, NOAA coordinated with the Coast Guard to define and create maps of the no-fly and surface restriction zones around the crash site. The NOAA team produced both page-size and full-size mylar and paper plots for enforcement personnel and for use at the Coast Guard command center.

Analyzing the Imagery. The GIS proved to be a valuable and versatile tool for decision support and analysis as well as for making maps. In addition to visualizing the relative locations of all the sonar contacts, the NOAA staff used the GIS to perform various data queries.

A query based on the length, width, and height of the contacts helped the team to separate the large contacts, or large pieces of the aircraft, from the smaller ones. In addition, investigators could access the sonar images by clicking on the contact location on the screen. They subsequently used these queries to prioritize salvage operations.

The staff conducted simple spatial analyses to create reports of all contacts that fell in a particular area. Team members then distributed large-scale contact maps and customized charts showing the location of wreckage to dive-platform vessels (see figure on this page).

DIVING OPERATIONS

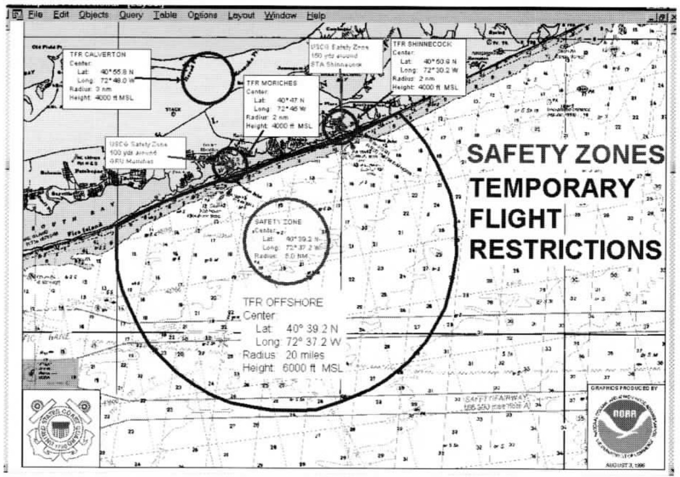
Almost immediately, Navy, Suffolk County, and New York City divers began descending on the positions that *Rude* provided. Many of the dive vessels used the NOAA maps and GPS coordinates to navigate to the wreckage.

For the divers' safety, it was very important that the sonar contact positions be highly accurate. At depths of 120 feet, scuba divers had only about 15 minutes to search, locate, and retrieve the object of their search, if they wanted to avoid getting "the bends," a condition in which nitrogen bubbles form in the blood while the diver ascends from extreme depths.

GETTING A BETTER VIEW

While divers worked valiantly trying to expedite victim recovery, *Rude* continued its side scan sonar work retracing Flight 800's flight line. During the days immediately following the crash, it became apparent that the manner in which the airplane broke up, and what pieces fell off the plane first, might yield clues to the mystery of what had caused the crash.

Knowing that the smallest of pieces might yield a significant clue, the ship's personnel scanned the up-track sonar records with the utmost care. Working five miles west of the known wreckage area, *Rude*'s crew identified about 100 new sonar contacts, but could not immediately determine whether or not these new contacts were part of the plane wreckage because the side scan sonar yielded only shadowy images. To identify them, the crew needed to get a better look at the debris. That's where the Navy contract vessel *Diane G* came in.



NOAA's GIS proved valuable, enabling the agency to produce surface and flight restriction plots, such as the one above, for other recovery teams.

Staffed by personnel from a private scientific consulting firm, *Diane G* used a towed laser-line scan device to investigate the most prominent of *Rude*'s up-track sonar contacts.

Laser-Line Scans. Unlike the side scan sonar, the laser-line scan, can generate a video-like image of the contact, allowing the debris to be identified without using divers.

The laser-line scan investigation of *Rude*'s up-track sonar contacts determined that none of these items were airplane wreckage, thereby enabling divers to concentrate their efforts on the more likely contacts.

Because of its ability to provide a very clear picture of the submerged wreckage, the staff aboard *Diane G* provided laser-line images to divers each day. The staff also created a GIS database of all identified wreckage. (See sidebar entitled "A Sharper Image."

GRASP AND GRAPPLE

The primary focus of overall operation and the divers' tasks remained victim recovery. To retrieve wreckage, the Navy brought in two salvage ships, the *USS Grasp* and *USS Grapple*.

Before the salvage ships reached the crash site, the recovery effort directors used the GPS and sonar contact information gathered by *Rude*'s crew to determine where the ships should anchor to begin recovering wreckage. *Rude* then performed a detailed GPS-controlled microsurvey over each proposed anchor site to ensure that the ships' giant multiple anchors did not disturb the wreckage.

After the crew provided the salvage ships with these geographic coordinates, each ship navigated to and moored over a major debris area so that remotely operated vehicles and hard-hat divers could access the wreckage around the clock.

SAILING FOR HOME

Two weeks after the crash, *Rude* was detached and returned to its charting project in Rhode Island Sound. By this time, the crew had mapped 46 square nmi and acquired 805 side scan sonar contacts. The shore-based processing team stayed an extra week to transfer information to the

Navy and NTSB. The Navy and its contractors continued to lead the search and salvage operation.

For months after NOAA's work was done and *Rude* had departed, Naval crews and contracted personnel worked tirelessly to recover victims and wreckage. On November 1, 1996, the Navy concluded what turned out to be its most extensive salvage operation since that undertaken in the aftermath of Pearl Harbor. Officials estimate the project's cost at more than $8 million, excluding military payroll. Investigators continue to analyze data gathered from the crash site.

Although the cause of the crash is still a mystery, NOAA and *Rude* played a small, but important part in searching for answers to this tragedy. ■

***CDR Nicholas E. Perugini**, has been a National Oceanic and Atmospheric Administration Corps officer for 20 years. He has a B.S. in meteorology from Pennsylvania State University at University Park and an M.S. in hydrographic sciences from the Naval Postgraduate School in Monterey, California. Perugini has served aboard three NOAA hydrographic ships and is former commanding officer of the* Rude. *He is currently chief of NOAA's Atlantic Hydrographic Branch in Norfolk, Virginia.* ***LTJG Shepard M. Smith** attended Deep Springs College in Deep Springs California for two years before transferring to Cornell University where he received a degree in mechanical engineering. After an internship at Los Alamos National Laboratories, he received a NOAA Corps commission in 1993. Smith was assigned to the NOAA ship* Rainier, *where he conducted hydrographic surveys in Alaskan waters for two years. Currently assigned to NOAA's Hydrographic Survey Division at Silver Springs, Maryland, Smith helped the* Rude *crew during the TWA 800 crash investigation.*

A Sharper Image

During the initial search for Flight 800 wreckage, the crew aboard the *Diane G* used a laser-line scan system, towed at 15 feet above the ocean bottom, to image more than 110 million square feet of the seafloor in 16 days. These images were located using DGPS.

As the ship towed the laser-line device, it emitted a narrow beam of laser light (in this case, a blue-green light) in 21-foot wide swaths. By compiling multiple swath lines, the crew generated panoramic, video-quality images with 0.3-inch resolution and 0.15-inch detectability — fine enough to distinguish a luggage tag.

Each morning, we distributed video printouts of these images to individual dive boats and dive teams. This enabled the divers to plan for the size and type of debris to be salvaged. In addition, the divers used the DGPS coordinates we provided to position their boats directly above the debris to be recovered.

We also developed and provided a GIS on CD-ROM that included laser-line scan images, dive reports, and verified wreckage locations overlaid on a search area chart. This allowed divers, project managers, and investigators to quickly access images and the supporting data files for each target. This database eventually cross-referenced every target identified, image generated, and item recovered by three survey vessels, three remotely operated vehicles, two U.S. Navy ARSs (auxiliary recovery ships), and a small fleet of individual dive vessels.

— David Pearson, Assistant Vice-President, Maritime Technology Group, Science Applications International Corporation

US NAVY

The information provided by *Rude* aided the salvage operations of the Navy's *USS Grapple* (photo) and *USS Grasp.*

MANUFACTURERS

During the search, the *Rude*'s crew received differential corrections broadcast from the U.S. Coast Guard beacon stations at Montauk Point, New York, and Sandy Hook, New Jersey. They used **Ashtech** (Sunnyvale, California) GPS Sensor receivers connected to **Leica** (Torrance, California) MX50R beacon receivers. The *Rude*'s sounding equipment includes a SeaBat 9001S multibeam sonar system from **Reson Inc.** (Goleta, California), a DSF-6000N echo sounder from **ODEC** (Ocean Data Equipment Corporation, East Walpole, Massachusetts) and a side scan sonar from **Edge Tech** (Milford, Massachusetts). DGPS and depth sensor data were recorded using PC-based Hypack survey software from **Coastal Oceanographics** (Middlefield, Connecticut) running on Micron Millenia Plus Pentium workstations. To create the GIS and generate maps, NOAA's shoreside team downloaded the GPS data into **MapInfo** (Troy, New York) version 4.0 software running on Pentium and Pentium Pro workstations from **Gateway Computer** (North Sioux City, South Dakota). **Science Applications International Corporation's Marine Systems Operation** (Newport, Rhode Island) personnel staffed the Navy contract vessel *Diane G* and used a **Northrop Grumman** (Annapolis, Maryland) SM-2000 Laser-Line Scan system to generate images of the debris contacts. These images were position-tagged using a **Trimble Navigation Limited** (Sunnyvale, California) 2000S GPS receiver and differential corrections from the Cape May, New Jersey, Coast Guard beacon station.

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