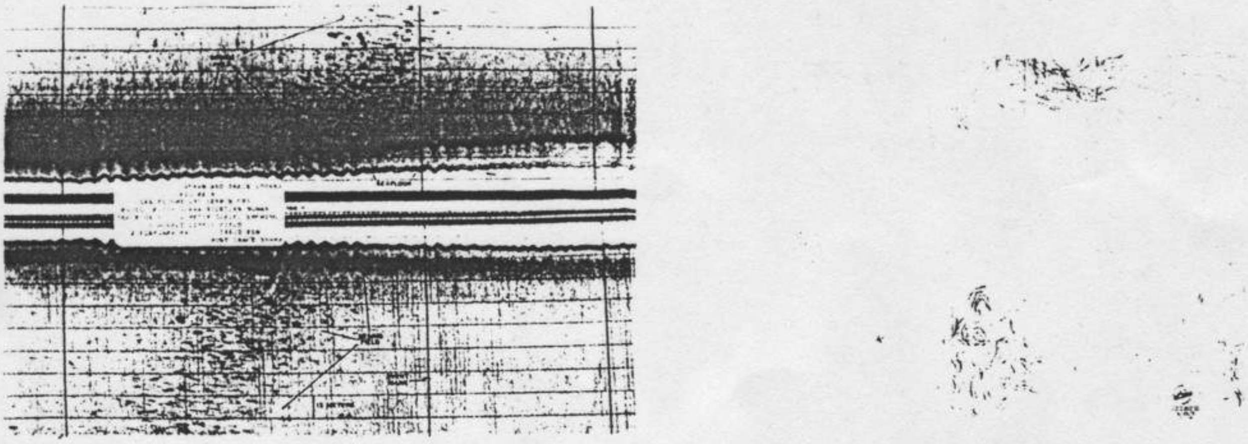
Anatomy of an Underwater Search

Search for the Wreckage of South African Airways' Flight 295 was an International Effort in 4500-Meter Waters—Before Considered Unreachable



A sidescan sonar trace (left) from the Klein "Smartfish" revealed a typical aircraft debris pattern at the 4450-meter water depths. At right, a Sea Beam-generated bathymetric plot provided by the German *R/V Sonne* showed the featureless area of the wreckage site (noted by the aircraft symbol), which was flanked east and west by 700- and 1500-meter seamounts.

By Michael K. Kutzleb
President
Steadfast Oceaneering Inc.

South African Airways Flight 295, enroute from Taiwan to Mauritius, disappeared into the Indian Ocean on November 28, 1987, shortly before its scheduled arrival. The Boeing 747 Combi aircraft, which was carrying passengers as well as cargo, had reported smoke in the aircraft and had just completed an emergency descent to 14,000 feet when communications were lost.

Floating debris was located the following day approximately 135 miles northeast of Mauritius.

Based upon the U.S. Navy's success in locating the pingers from the Air India 747 crash in 1985, the South African government requested assistance from the U.S. Navy's supervisor of salvage (SupSalv). An agreement was signed on December 3 after favorable determination under Section 607 (a) of the Foreign Assistance Act of 1961 and further legal determination that use of U.S. Navy assets for humanitarian purposes would not violate the terms of the comprehensive Anti-Apartheid Act of 1986.

The SupSalv office administers several civilian contracts for the provision of specialized search and salvage services for various projects. For this task, the services of Steadfast Oceaneering Inc., the Navy's prime contractor for underwater search and recovery operations, were required.

Steadfast, with offices in Falls Church, Virginia, and Fort Lauderdale, Florida, is a leader in the field of underwater search and recovery and specializes in deep water operations.

Steadfast was prime contractor for the search for Korean Air Lines' Flight 007, the Air India 747, and the space shuttle *Challenger*.

The first order of business was to identify what assets were required and where to commence the search. Both the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR) on SAA Flight 295 were equipped with Dukane 37 kHz underwater beacons. These beacons are activated upon immersion in water and are designed to survive an aircraft crash and help pinpoint the location of the flight recorders using underwater acoustic locator equipment. With theoretical detection ranges for these beacons of up to 2 miles, large areas can be covered fairly quickly using suitable pinger locator systems.

Listening for Beacons

Based on this, it was decided that phase I of the search would concentrate on listening for the beacons; phase II would involve the use of sidescan sonar either to map the debris if phase I was successful or to continue the search if the pingers were not located during phase I.

The Navy's supervisor of salvage, Captain C.A. Bartholomew, keeps two pinger locator systems in his inventory for use in locating downed military aircraft; his office provided them for use on this task in response to an official request from the South African government.

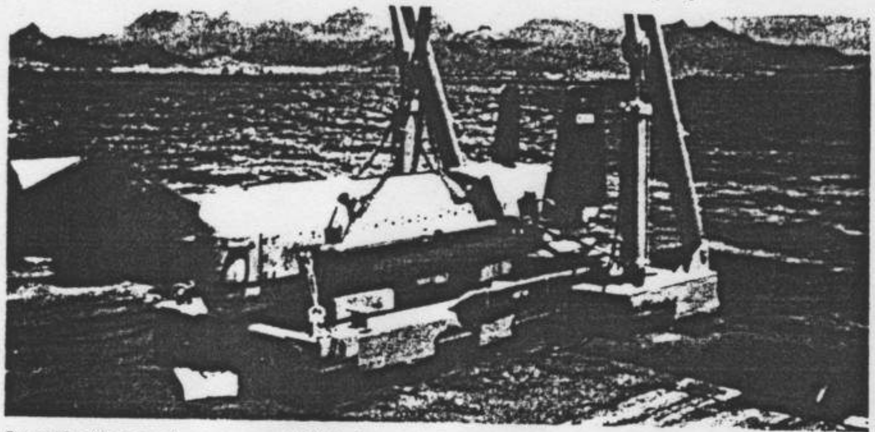
Each system consists of a towed hydrophone, a cable, and a topside processing/display console. The hydrophone and underwater electronics housing are pressure rated to 10,000 psi and could therefore be towed at a sufficient depth to ensure detection of the beacons in the water depths in the search area, which ranged from 2500 to 4500 meters. Previous tests using these locator systems had shown a maximum detection range of approximately 3700 meters under ideal conditions.

A team of U.S. Navy SupSalv and Steadfast personnel, headed by Bartholomew, departed for Mauritius on December 4 to meet with DCA

(Continued on page 38)

and SAA personnel. Bartholomew, along with Tom Salmon and Bill Walker of the SupSalv office, assisted the DCA executive committee in the planning phase of the search.

The writer was in overall charge of the Steadfast project team, together with Dr. Johan Strumpfer of the South African Institute for Maritime Technology. All available loss data was collected for analysis. Using meteorological data and positions of floating wreckage obtained by various search aircraft over a two-day period following the accident, debris set and drift were calculated to derive a projected impact position. This position was then compared to other data, such as the projected flight path, to define a preliminary search area for the phase I search.



Steadfast's search sonar used Klein Associates' dual-frequency "Smartfish" at one end of a 9000-meter coaxial towcable. Multiplexed signals were processed and recorded topside.

An International Effort

The search was truly an international effort. Equipment came in from around the world and had to be cleared through customs, transported across the island to Port Louis, unpacked, set up, and tested. Pinger locator systems, navigation systems, winches, and A-frames were needed for each of the two vessels and had to be ferried to the ships at anchor since all berths in the port were full. Retrieval of floating debris by commercial and South African naval vessels was still an ongoing effort.

Two ocean-going salvage tugs from Pentow Marine in South Africa, the *Wolraad Woltemade* and the *John Ross*, were provided as platforms for the first phase of the search. A German research vessel that was operating in the area, the *Sonne*, was tasked to conduct a bathymetric survey of the search area using a General Instruments Sea Beam survey system. This information proved to be invaluable throughout both phases of the search effort.

The *Sonne* also had a video sled aboard capable of obtaining photos of the seafloor in water depths of up to 6000 meters. The *R/V Africana*, a South African fisheries research vessel outfitted with a hull-mounted acoustic listening system, was also used during the phase I pinger search.

An Argo navigation chain, using shore sites on Mauritius, Rodriguez, and Cocos Island, was set up and operated by Geoteam, a Norwegian survey company. The system could only be used during the day because ranges to two of the sites exceeded the maximum nighttime range of the system. This resulted in the use of GPS satellite positioning during the night after the Argo signals were lost. With the two systems, accurate positioning was possible approximately 18 hours per day.

The *Wolraad Woltmade* got underway on December 11, with the *John Ross* joining the search the following day. A test pinger was dropped near the area in 3600 meters of water, both to test the locator systems used and to serve as a standard to compare with the sounds actually detected during the operation. The *Africana* arrived on scene to assist on December 17.

Trial runs conducted on the test pinger confirmed that the towed locator systems were indeed capable of detecting the pingers in the prevailing water depths. A consistent detection envelope of 1 mile was observed, which resulted in the selection of 1-mile spacing for the search tracks. This gave an overlap of 100% to ensure that all areas were covered.

Phase I continued until January 2, 1988, when we felt that the batteries in the pingers would have been exsquare miles with the three ships during this phase.

Once phase I was completed, the team decided to demobilize all assets and plan for phase II — the sidescan sonar search. All of the data used in the preliminary analysis was reviewed and refined, and new bits of information were added.

During one of the *Sonne's* video runs, newspapers and several pieces of mail were observed on the bottom in one area. This area was along the calculated debris drift axis, coincided with the flight path, and also fit in well with the best estimates of the projected impact position of the aircraft. Based on this information, an area of high probability, measuring 4 x 10 miles, was selected as the primary area of interest for the phase II sonar search.

The search vessels used during the pinger locator phase were not suitable as platforms for a deep sonar search due to their inability to maintain the slow search speeds needed. The *Omega 801*, a 65-meter supply vessel with variable pitch propellers and a large open deck, was chartered to serve as the platform for the sonar search.

Around-the-Clock Reliability

During the break between phases I and II, we decided to replace the Argo navigation system with a system that would provide reliable navigation around the clock. A Geoloc system — owned and operated by CGG, a French geophysical survey company — was contracted to provide the high accuracy positioning required during the phase II sonar search. Geoloc, which is manufactured by Sercel, operates in the 2-mHz band using a spread spectrum technique and has a maximum range of approximately 1000 kilometers. Radiated signal strengths are kept below the ambient noise level to eliminate interference, and the system is immune to the tropospheric and sky wave interferences so common to other medium- and "Smartfish," a dual-frequency (50 or 100 kHz), full-ocean-depth towfish. The signals were multiplexed at the towfish and passed through a 9000-meter coaxial towcable to the Klein topside processing, recording, and display equipment. The winch consisted of a traction unit/power pack and a take-up reel capable of storing up to 14,000 meters of towcable. A hydraulically operated A-frame was used for launch and recovery of the towfish, with an oceanographic sheave for fairleading the towcable over the side.

The search team got underway on January 22 and arrived in the primary area the following morning. High winds and rough seas from a nearby tropical depression prevented the sonar fish from being launched for the next 36 hours, so this time was used to lock in and calibrate the Geoloc navigation system. By Sunday evening, January 24, the weather had abated sufficiently to permit launch of the sonar fish, and the first line was

(Continued on page 40)

...ontinued on page 38)

started just after midnight.

Towing a sonar fish 45 meters off the bottom in 4500 meters of water at the end of a 9000-meter wire is no small feat; thus the first search line was run in an area of relatively flat site itself, the bottom was flat and featureless, which greatly assisted the search team in mapping the area and flying the towfish at the low altitudes required for the high resolution sonar imaging.

> ***"As a gauge to measure the complexity of this task, consider that the deepest location of a lost object to date was the* R.M.S. Titanic *discovery in 1985. [She] was located in less than 4000 meters of water—or over 500 meters shallower than the South African 747."***

topography. This allowed the operators to become familiar with system control and response before tackling the more difficult, central portion of the area where the aircraft wreckage was believed to be located. The Sea Beam charts of this high probability, central area showed several peaks rising 600 to 1500 meters off the seafloor amidst generally rough terrain.

The 50 kHz sonar operating on a scale of 300 meters per side was used for the search. Lane spacing of 300 meters was chosen to give a theoretical overlap of 100%, subject to steering errors, navigation system error, and an anticipated offset in the towfish track relative to the search vessel. This track offset was actually observed to vary from 0 to 200 meters during the course of the search.

Successful Search Line

The second search line was run through the center of the area, and a promising contact was noted on the sonar records. Subsequent runs over the next two days showed a typical aircraft debris pattern, with pieces spread out over a 100 square meter section of the bottom.

News of the discovery was passed to the DCA executive search committee on January 27.

Sonar mapping continued for another week using shorter range scales and the 100 kHz system for higher resolution and greater detail of the various pieces of debris. The largest piece in the debris field measured 40 meters long by approximately 5 meters wide, with most pieces measuring less than 5 meters in overall size.

The water depth at the site where the wreckage was located was 4450 meters. Rocky terrain existed within 2 miles east and west of the crash site, with mountains rising 700 to 1500 meters from the ocean floor. At the

Although the sonar portion of the search was almost immediately successful, it was by no means an easy task. Steadfast personnel had conducted numerous search tasks in water depths ranging from 2000 to 3000 meters but had never searched in depths of 4500 meters.

As a gauge to measure the complexity of this task, consider that the deepest location of a lost object to date was the *R.M.S. Titanic* discovery in 1985. The *Titanic*, close to 300 meters in length, was located in less than 4000 meters of water—or over 500 meters shallower than the South African 747. The entire fuselage of a 747 aircraft measures only 69 meters in overall length, and from previous experience it was predicted that the aircraft would be broken up into numerous small pieces and spread out over the bottom, thus making detection difficult at best.

The wreckage was indeed broken up and spread out as predicted, but the experience of the sonar operators in interpreting the records, as well as the excellent quality of the records themselves, resulted in the successful completion of the task in spite of difficult operating conditions in water depths previously considered unreachable. /st/

Michael K. Kutzleb has been working in the field of underwater search and recovery operations for more than 14 years. He has participated in more than 70 such projects in both deep and shallow waters. Kutzleb previously worked for Seaward Inc. in positions ranging from navigation technician to project manager. He received a bachelor's degree in economics from the University of Virginia.