



Underwater Recovery Operations off Sharm el-Sheikh

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Jean-Claude Vital graduated from the School for Test and Acceptance Flight Crews (EPNER), Istres, France. He received a post-graduate degree in Computer from the French National Civil Aviation School (ENAC). In 1997 Jean-Claude joined the Technical department at the BEA as safety investigator, specialized in recorders readout and analysis. He holds a Pilot's license.

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ABSTRACT

On 3 January 2004, Flash Airlines flight FSH604, a Boeing 737-300 registered as SU-ZCF, operating as a chartered flight from Sharm el-Sheikh, Egypt to Paris, France, crashed into the Red Sea approximately six nautical miles southwest of the airport.

This article covers the recovery operations that took place after the accident.

It encompasses several aspects of these operations such as:

- The legal and emotional context of the investigation.
- The difficulties related to the undersea environment (one thousand meter depth).
- The strategies developed by the international investigation team with the assistance of the Egyptian and French navies.
- The use of additional resources (boats, ROVs, etc.) needed to cope with the different steps: pinger location, seafloor mapping, tidal survey, etc.
- The chronology of the operation with priority given to the recovery of bodies and the location of flight recorders (FDR and CVR), while mapping the wreckage.

The wreckage recovery was based on the review of the FDR and CVR data undertaken in Cairo. Teamwork proved to be key in the success of this operation with each contribution improving the effectiveness of this joint effort.

Sharing the knowledge gained during this experience will help other investigators facing the aftermath of an occurrence similar to the Sharm el-Sheikh accident.

INTRODUCTION

Underwater recovery operations were carried out jointly by Egypt and France following the accident on January 3, 2004 off Sharm el-Sheikh to the Boeing 737-300, registered SU-ZCF, operated by Flash Airlines. This article will outline the strategy that was used for the search and recovery of the flight recorders. The chronology of the search, the wreckage mapping as well as the recovery of airplane parts will also be discussed. Recovery operations took place from January 3rd to February 5th, 2004.

The initial search for possible survivors and the recovery of bodies were priorities for the rescue and investigation teams.

The accident triggered a lot of emotion in France because of the large number of French victims¹. The complex international situation and the rather mysterious nature of the accident raised many questions. Speculation on safety (airworthiness of the airplane) and on security (possible terrorist attack) led to intense media coverage while the initial results of the technical investigation were awaited.

Two judicial investigations, coordinated through an international commission of inquiry, were launched in France and Egypt in the aftermath of the accident. Of course, the investigation of a civil aviation accident comes within the framework of the Chicago Convention, to which both Egypt and France are signatories. Annex 13 to this Convention details the responsibilities of the different States involved in the occurrence.

The technical investigation, carried out by the Egyptian Investigation Commission, with the participation of the United States (NTSB) and France (BEA), is charged with finding answers as to why this accident occurred. The investigation team was composed of specialists from the Egyptian CAA, Flash Airlines, the NTSB, the FAA, Boeing, SNECMA and the BEA.

The salvage operation was the first step in the investigation and the underwater recovery operations were undertaken by ships and equipment provided by the Egyptian and French navies. To this end, the French Navy mobilized considerable resources, both human and material. In addition to the frigate *Le Tourville* and the fleet support *La Somme*, two salvage ships (*Île de Batz*, *Janus II*) equipped with underwater robots were chartered by the French government to complete the operation. This required a great deal of coordination between the various parties in order to provide rapid answers to the many questions raised by the disaster.

Preparatory work: finding the wreckage depth and recovering the recorders

Before committing the naval resources, it was essential to get more information on the wreckage site. Parts that were found floating on the surface and the initial witness statements collected were not sufficiently precise to allow the wreckage of the plane to be located. Moreover, the seafloor was not thoroughly charted and varied in depth between 100 and 1,420 meters over relatively short distances.

A flight recorder immersed under water can be located by the signals (1 bip/second with 37,5 kHz (± 1 kHz)) transmitted by the beacon (pinger) attached to the recorder. This pinger starts as soon as it is in contact with water and is designed to transmit this signal for at least thirty days.

¹ On the 148 people on board, 134 passengers were of French nationality. The last two aviation tragedies involving large numbers of French passengers were those at Mont Sainte-Odile (near Strasbourg, with 87 fatalities in 1992) and the bombing of the UTA DC-10 (171 fatalities in 1989).

Equipment from the BEA and the French Navy was used. The BEA's portable equipment, consisting of a directional hydrophone, could not pick up any signals.

The French Navy used an acoustic detector assembled on a pole called "Helle" which tracks signals on frequencies ranging from 7 to 50 kHz. This detector has two reception antennae, one omnidirectional and the other directional. It was connected to an audio system that controlled the frequencies and was coupled with a GPS positioning system.

The first stage in the search consisted of checking signal transmissions and defining an general area using the omnidirectional antenna. The seafloor being uncharted, locating the beacons was complicated by possible reflections from the transmitted sound waves and possible secondary echoes. The next stage consisted of taking successive bearings using the directional antenna so to get a more precise fix.

This acoustic search determined two possible positions for the beacons: one to the south with a position considered as nominal since it could be picked up from all bearings, but which was transmitting more weakly than the one identified further north. The measurements and calculations performed gave an estimated depth of around one thousand meters.

To confirm these results, the USBL (ultra short base line - acoustic positioning) of the *Ile de Batz* (the first recovery ship on site) was temporarily modified (in coordination with its manufacturer Sonardyne) and adapted to the reception of the signals transmitted by the southern pinger. These results confirmed the presence of a transmission source beneath the *Ile de Batz* which had been positioned directly above the estimated position.

USE of a GIB system

To narrow the search area, the French Navy contracted ACSA and its partner ORCA Instrumentation to supply a GIB system (GPS Intelligent Buoys). For the purposes of the investigation, they adapted a network of four acoustic receivers to conduct a search at a depth of around one thousand meters.

The hydrophones, immersed 450 meters down around the initial identified position, drifted with the current while continuously transmitting information on their position and any signals received (figure 1). An algorithm integrated all data to determine the recorder's fixed position.

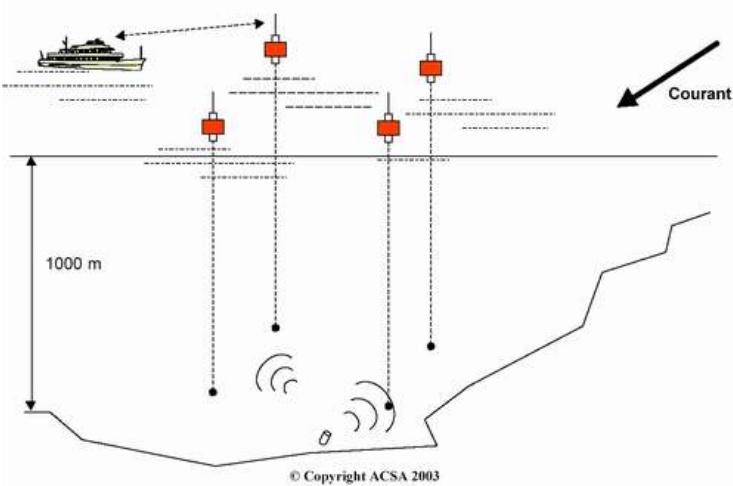


Figure 1: GIB system

The use of a GIB system proved to be essential in this context since the ROV (Remotely Operated Vehicle) only used visual means to search for the recorders and could not be guided by acoustic information to home in directly on the beacons. The FDR was ultimately found in the area defined by the Navy, just twelve meters from the position computed by ACSA.

Bathymetric data

The French Navy sent the oceanographic hydrography ship, the *Beautemps-Beaupré*, to carry out multi-beam sonar bathymetry of the accident area. It drew up a chart of the seafloor with fifty meter isobath. This knowledge of the topography facilitated ROV operations on the seafloor.

Support ships and ROV's

The *Ile de Batz*, owned by Alcatel (LDA), was designed to lay and maintain submarine communication cables, and is ideally suited for this type of search mission. This powerful ship is equipped with Dynamic Positioning II (DP II) enabling it to maintain its position at a given point in spite of adverse weather conditions. The *Ile de Batz* is approximately 140 meters long and can operate at great depths. The Scorpio ROV (work class, see figure 2), provided by France Télécom Marine (FTM), was installed with its fifty tons of equipment on the ship's main deck.



Figure 2: Scorpio ROV operated from *Ile de Batz*

The *Janus II*, owned by Comex, is a thirty-meter aluminum semi-swath catamaran equipped with dynamic positioning. This ship can be used to support the Remora 2000, a twin-seat submarine that can operate down to 610 meters and the Super Achille ROV (observation class), that can operate down to 1100 meters.

The Super Achille is a light unit and can be remotely controlled via its lifting cable from the *Janus II*. A "garage" cage was lowered vertically from the ship by a winch located on the main deck. Once at its working depth, Super Achille exited the cage attached via a seventy meter floating cable, controlled by a winch at the top of the cage (Tether Management System). The ROV was equipped with a transponder acoustic beacon controlled through the *Janus II*'s USBL; it was also used as a DP reference and was continuously positioned on the Integrated Navigation System. A record could thus be kept of the ROV's movements and its position in relation to the garage, which was also equipped with a transponder.

This gave the robot mobility by not hindering its movements through the drag from around a thousand meters of connecting cable.

Procedure for handing over the recorders by the BEA to the Egyptian commission

The readout of the flight recorders was to be undertaken in Cairo, since Egypt had just been equipped with a technical laboratory.

It was important to have an agreed official procedure for handing over the recorders from the French to the Egyptian authorities since the recorders were to be recovered from Egyptian territorial waters (Egyptian jurisdiction) via a ship flying the French flag (French jurisdiction).

It was also necessary to satisfy media requests for images. An official photographer took photographs of the recoveries of the recorders (which in both cases happened at night). The latter were quickly put on line on the BEA web-site.

So as not to hinder salvage operations, the zone had been secured by the Egyptian Navy. The BEA officially delivered the recorders to the Egyptian Commission in Sharm el-Sheikh harbor in the presence of journalists. The Egyptian judicial authorities then affixed seals for their transfer to Cairo.

FDR recovery

The Scorpio robot started searching for the recorders using its cameras based on an initial determination of the position of its beacon. This position was then refined by the ACSA system. That produced a theoretical position with a precision of plus or minus ten meters over one hundred meters.

Squares of twenty by twenty meters were systematically searched by the ROV. While finishing one run, this visual search finally led to the discovery of the FDR, which was in fact located approximately twelve meters from the estimated position.

CVR Recovery

The search for the second recorder required making some further tactical choices. Since the beginning of the operations, the echo from the second beacon had appeared to be located a few hundred meters north of the initial search area. At that time, results from ACSA computations were not yet available.

For accidents with high impact forces, accelerations at the time of the collision may separate the pinger from the recorder case. This assumption was considered plausible on the basis of the initial information gathered.

Two approaches were then possible:

- to wait for the absolute position of the northern echo to be determined on the basis of the ACSA computations processed in deferred time,
- to continue the search in the area where the FDR had been found, supposing that the pinger had been detached from the CVR.

The second option was chosen. On the basis of the initial analysis of wreckage distribution, it was decided to define a zone to the south of the position of the FDR. The CVR was found approximately 24 hours after the discovery of the FDR just outside the search area designated by the investigators. Its case was damaged more than the FDR's, its reference numbers and the pinger had separated.

The use of a large television screen connected to the panoramic camera helped in identifying its position (see figure 3) as the CVR was spotted during a 180 degree turn between search lines. The facilities on board the *Île de Batz*, which contributed greatly to enhanced teamwork and coordination, were a key element in the rapid recovery of the recorders.



Figure 3: investigators' workroom

Mapping the wreckage

Exploration of the seafloor was organized by defining rectangular zones extending outwards from the central area. Each zone was then divided into grids with the side of each square being three to five meters, depending on the ROV used and the specific objectives.

During these operations, it was important to have aeronautical specialists who were able to coordinate the search and identify the debris. Each Scorpio and Super Achille ROV dive was filmed. On board of the *Île de Batz*, the workroom was equipped with a video recorder, which allowed some dives to be reviewed during ROV maintenance.

The digital video system on the Super Achille was also able to take digital stills of the airplane parts considered interesting to map and examine (see figure 4: flight manual) with the still featuring an inset with parameters such as latitude, longitude, depth, heading, etc.



Figure 4: underwater picture taken by Super Achille

The various parts located and identified during the dives were entered in a database. Parameters such as the date, the position, a brief description and photographic references provided useful information for the investigation and could thus be easily accessed (this database contains approximately four hundred located and identified wreckage parts).

The following figure shows the wreckage distribution and the extent of the search area (a rectangle 440 by 275 meters). Super Achille also traveled on the seafloor towards the location of the northern echo, search a hundred by hundred meter square and did not find any pieces of wreckage nor the pinger.

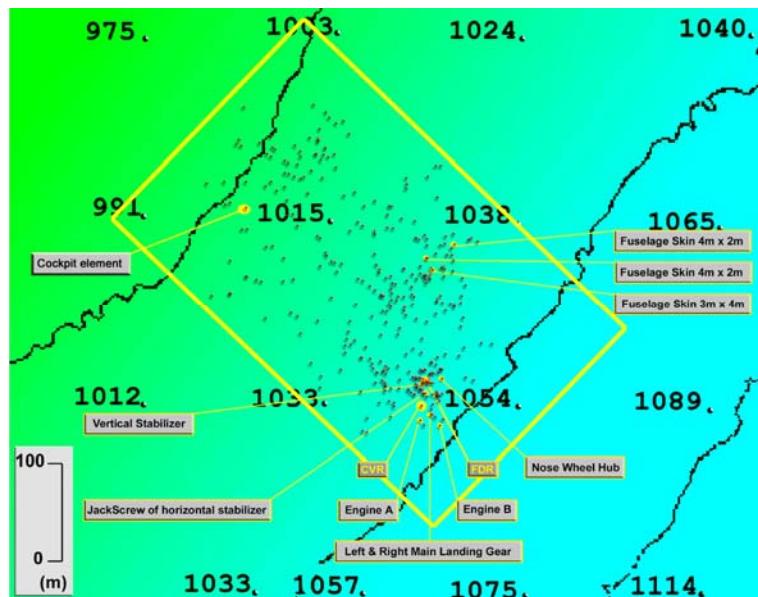


Figure 5: wreckage distribution

The wreckage distribution is compatible with the last recorded heading (311°) and the northeast current measured by the *Beautemps-Beaupré*. The heavy parts (engines and main landing gear) were close to the point of impact whereas lighter debris drifted with the prevailing current during their thousand meter descent.

Recovery of airplane parts

The strategy for airplane parts recovery was developed after initial flight recorder readouts undertaken in Cairo. All parts related to airplane control surfaces, flight systems and flight deck panels were regarded as priorities.

A procedure was developed to record the description, dimensions and co-ordinates of the parts recovered by the investigators, following their first observations. A database made it possible to establish the link between these parts and the photographs taken on the ship's deck or on the seafloor.

A specific nomenclature was also adopted:

- FW (Floating Wreckage) for the floating debris recovered in the first few days after the accident;
- SW (Surveyed Wreckage) for the debris surveyed on the seafloor;
- RW (Recovered Wreckage) for debris recovered;
- PE (Personal Effects) for the personal effects.

Fifty-five items were recovered, identified and referenced as floating debris and around fifty parts were recovered from the seafloor and in turn referenced.

The work performed jointly by the *Janus II* and the *Ile de Batz* (both with dynamic positioning) made it possible to recover large parts such as the rudder and the elevator.



Figure 6: rudder recovery

All salvaged parts were preserved in sea water until unloading at the naval port of Sharm el-Sheikh and handover to the Egyptian authorities.

Recovery of personal effects

Some items of clothing were recovered. On several occasions, they jammed the propellers of both ROVs. Their slightly positive buoyancy made handling and recovery difficult.

Some items fell out of the recovery basket during the thousand meter lift to the surface. Personal effects recovered included watches, cell phones, bags, wallets, etc.

When possible, some personal effects were recovered progressively during the search operations. The majority of these personal effects was then recovered by the *Janus II* which remained at the accident site longer for that purpose.

It covered the central zone where most of the personal effects were located. The *Janus II*'s mission at Sharm el-Sheikh came to an end when everything possible had been recovered.

CONCLUSIONS

The recorders were recovered in less than two weeks although they were in a relatively uncharted area about a thousand meters deep. Figure 7 combines on a maritime map, airfield data, bathymetric data and the airplane track from the FDR readout.

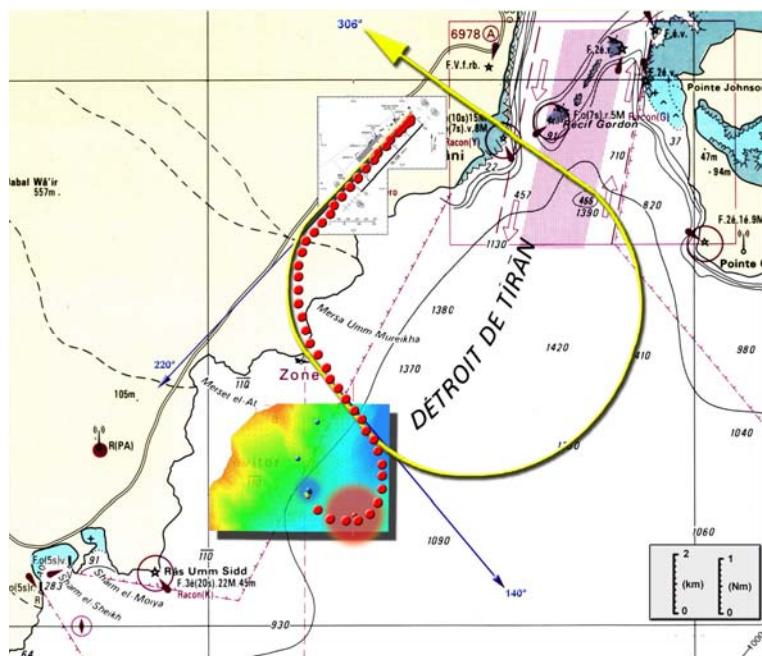


Figure 7: combined data on one map

The success of the operations was mainly due to the preparatory work undertaken by the Navy which meant that appropriate equipment and personnel could be sent to the site quickly. The investigation team was then able to define the most effective strategy to find and recover the recorders in the shortest possible time.

The logistical support was a significant part of the success of the operations. The support ships' adaptability and the hard work of their crew made the joint recovery efforts more complementary and thus more effective. The Navy's decision to deploy the ACSA system also contributed greatly to reducing the amount of time needed for the search. The mobility, adaptability and the image quality from the Super Achille made it possible to cover the site methodically and to recover many personal effects.

Teamwork proved to be key in the success of this operation with each contribution improving the effectiveness of this joint effort. Sharing the knowledge gained during this experience will help other investigators facing the aftermath of an occurrence similar to the Sharm el-Sheikh accident.