Study

ON SEA SEARCH OPERATIONS

Accident on 3 January 2004
off Sharm el-Sheikh (Egypt)
to the Boeing 737-300
registered SU-ZCF
operated by Flash Airlines

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
MINISTERE DE L'ECOLOGIE,DU DEVELOPPEMENT ET DE L'AMENAGEMENT DURABLES

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Glossary

BEA	Bureau d'enquêtes et d'analyse pour la securité de l'aviation civile (French accident investigation bureau)
CEPHISMER	Undersea diving group
DP	Dynamic Positioning
DSL	Deep Scattering Layer
CVR	Cockpit Voice Recorder
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FTM	France Télécom Marine
GIB	GPS Intelligent Buoys
GPS	Global Positioning System
kt	Knots
LDA	Louis-Dreyfus Armateurs
NTSB	National Transportation Safety Board
Psi	Pressure per Square Inch
ROV	Remotely Operated Vehicle
SHOM	French Navy hydrographic and oceanographic service
ULB	Underwater Locator Beacon
USBL	Ultra Short Base Line
WGS	World Geodesic System

INTRODUCTION

This document has been produced with the agreement of the Egyptian authorities responsible for the technical investigation. Its aim is to provide an overview of the maritime search operations undertaken by France and Egypt following the accident that occurred to the Boeing 737-300 registered SU-ZCF operated by Flash Airlines on 3 January 2004 off Sharm el-Sheikh. It presents the technical means and strategy employed to search for and recover the flight recorders. The chronology of the search and the mapping of the wreckage, as well as the list of parts brought to the surface, are also detailed. The searches took place between 3 January and 5 February 2004.

The search for possible survivors, then the search for bodies were the rescuers' and investigators' priorities in the first instance. It should be noted that the search efforts were the subject of great media attention in France due to the large number of victims of French nationality, as well as in Egypt, the state of occurrence and of the operator. Rumours about safety (airworthiness of the airplane) and security (terrorist attack) spread while the first results of the technical investigation were awaited. The absence of any emergency distress call contributed to the propogation of these initial rumours. Judicial investigations, coordinated through an international judicial commisssion, were also launched in France and in Egypt following the accident.

All aviation accidents, including the Sharm el-Sheikh disaster, are within the scope of the 1944 Chicago Convention on Civil Aviation, of which Egypt and France are signatories. Annex 13 to this Convention specifies the responsibilities of the States involved in the conduct of a technical investigation. Only the technical investigation led by the Egyptian Commission of Inquiry, with the participation of the United States (NTSB) and France (BEA), was in a position to bring to light elements relating to the causes of this accident.

The searches could not have been undertaken without the contribution of the French and Egyptian navies as well as the LDA, FTM, Comex and ACSA companies. The French Navy in particular sent a large amount of manpower and equipment. Amongst other things, two search ships equipped with submarine ROVs were chartered to complete the force. The search operations required a high level of coordination between the various parties in order to progress as rapidly as possible towards answering the many questions raised by the disaster.

1 - PREPARATORY WORK

1.1 Information Available

Before mobilizing ships, aircraft and equipment for the recovery of elements related to the accident to SU-ZCF, it was necessary to have some indications as to the position of the wreckage. The floating wreckage and witness testimony did not provide sufficiently precise data to locate the airplane wreckage. In addition, the seafloor was little known and featured depths of between 100 and 1,420 metres over short horizontal distances. The chart published by the Naval hydrography and oceanic service (SHOM) is based on occasional soundings of measured depth (see figure 1).

Note: The other charts available are based on the same hydrographic data.

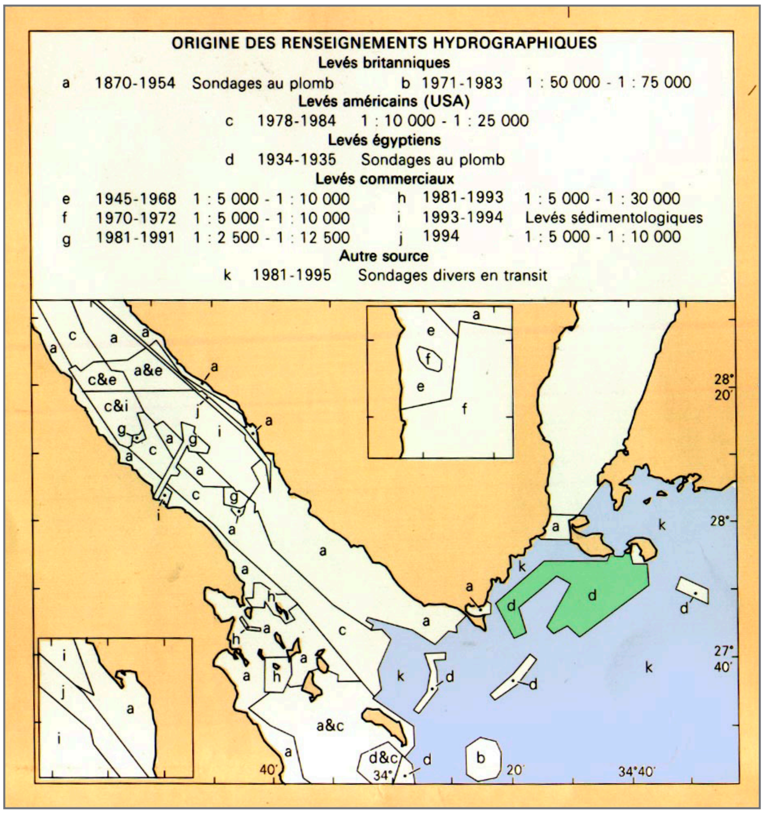


Figure 1: Source of hydrographic data

On arrival at the accident zone, the cable-layer *Ile de Batz* that had been chartered by the French Navy obtained a more precise representation of the seafloor based on various soundings carried out by the French Navy frigate *Tourville*. It also made a number of runs to sound out the area. It should be noted that these soundings gave limited depth values without fully revealing the seabed relief isobaths.

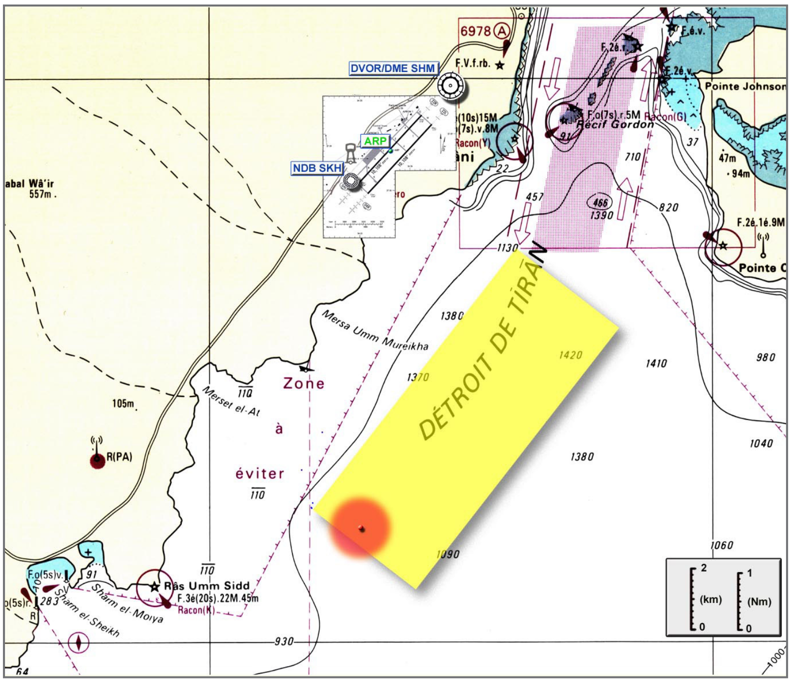


Figure 2: Chart of the area

The zone corresponding to the yellow rectangle represents the surface area in which the floating wreckage was collected by the rescuers. The red circle indicates the last airplane position given by the Sharm el-Sheikh radar. This zone served as the departure point for the underwater searches.

Notes:

- ❒ The forbidden zone corresponds to the protected area for the Presidential residence,
- ❒ The coordinates of the different points used during the mission were based on the WGS84 geodesic system.

1.2 Detection and Localization of Recorders

The recorders, when immersed, can be identified with a portable localization system that allows recognition of pinger signals [(1)] transmitted by the underwater locator beacons (ULB) attached to the recorders. These devices are set off on contact with water and must transmit a signal [(2)] for at least thirty days.

BEA and French Navy equipment was used. The BEA's, a portable multidirectional hydrophone on a pole, could not capture a signal [(3)].

The French Navy (Cephismer) used a light flat-bottomed boat with an acoustic detector mounted on a Helle pole that permitted frequency reception in the range from 7 to 50 kHz. The detector consists of one omnidirectional and one directional antenna, linked to a frequency modifier and listening box. These devices were coupled to a positioning system based on GPS.

(1) Pinger: acoustic device that sends a continuous signal on a given frequency with a given repetition rate

(2) 1 bip/second at 37.5 kHz (± 1 kHz)

(3) The use of a directional hydrophone allows the signal's bearing to be determined and, by making several measurements, this leads by intersections and successive calculations to defining of a geographical point with WGS84 coordinates copied onto a chart for each signal transmitted.

Figure 3: French Navy listening to signals

The first stage involved checking for the presence of signals from the beacons and defining an area approximately with the aid of the omnidirectional antenna. The bearing crosschecks made with the directional antenna confirmed transmissions from two beacons. Since the seabed type was relatively unknown, the localization of the beacons was subject to possible reflections of the sound waves transmitted and possible secondary echoes [4].

The following stage consisted of making numerous measurements to obtain a more precise localization. The following figure illustrates various goniometric plots that enabled the limits of the search zone to be defined.

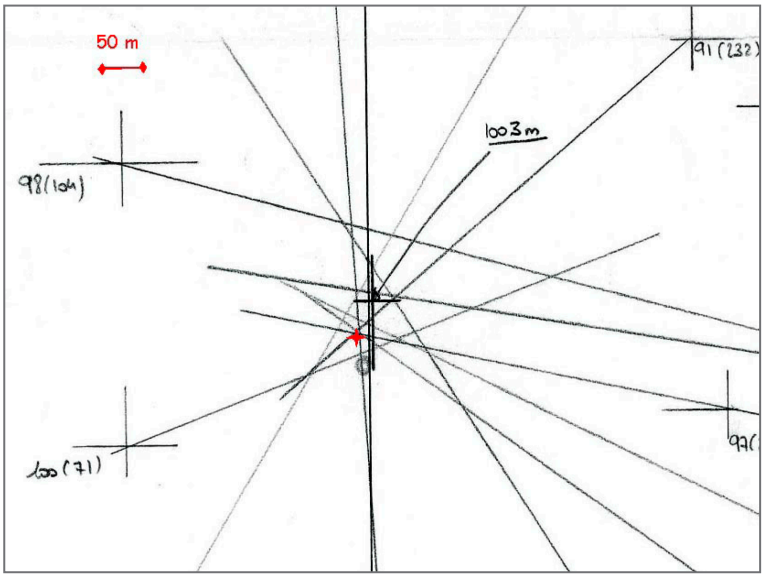


Figure 4: Results of the triangulation

[4] Acoustic waves are used in liquid environments. Their propagation depends on various linked parameters such as salinity and water temperature. These parameters vary in relation the depth. When an acoustic wave propagates in the sea, it is subject to refraction, which generates multiple trajectories. Acoustic waves can thus be deviated in such a way that there is a shadow zone that is never reached by these waves. Further, the more multiple trajectories there are, the more difficult it is to identify them.

These acoustic searches provided information on the possible positions of two beacons: one to the south with what was considered a nominal position but transmitting more feebly than one to the north seeming to transmit more strongly. The measurements and calculations performed showed that the beacons were located at a depth of around one thousand metres.

To confirm these results, the Sonardyne USBL on the *Ile de Batz* was temporarily modified (in coordination with the manufacturer) and adapted to pick up echoes transmitted by the beacon located to the south. The results of this were satisfactory and confirmed the presence of a source of transmission beneath the *Ile de Batz*, which had positioned itself vertically above the estimated location.

To best exploit the beacon transmissions, two strategies were possible:

- The first consisted of using homing, that's to say using the transmission from a beacon as a signal via a directional hydrophone that could move towards the point. This option meant installing a hydrophone on a ROV to obtain, in theory, a direct vector towards the objective. Installing a hydrophone from the submarine Griffon on the Scorpio ROV was mentioned but that would have taken time and thus reduced the ROV's time on zone;

- The second was based on using an absolute positioning system like that offered by ACSA, adapted to the local depth.

1.3 ACSA Positioning System

ACSA (Architecture et Conception de Systèmes Avancés) is specialised in GPS submarine applications. Based on the GPS Intelligent Buoy concept (GIB), ACSA and its partner SERCEL Brest adapted a network of four acoustic receivers to the needs of the investigation to undertake searches at a depth of around one thousand metres.

In order to do this, special cables were ordered from the UK, installed in Brest and delivered to Egypt. 1,800 m of cable were needed to increase the distance between the hydrophones and their corresponding buoys. The hydrophones immersed at 450 m drifted with the current while continuously transmitting information on their relative positions and the signals received (figure 5). An algorithm for offset data processing to subsequently determine the absolute position was used. The results came from triangulation calculations based on acoustic signal propagation time. To render this effective, it is important to have a traingulated zone at the beginning. This device thus complemented the goniometric listening that had previously enabled a precise search zone to be defined.

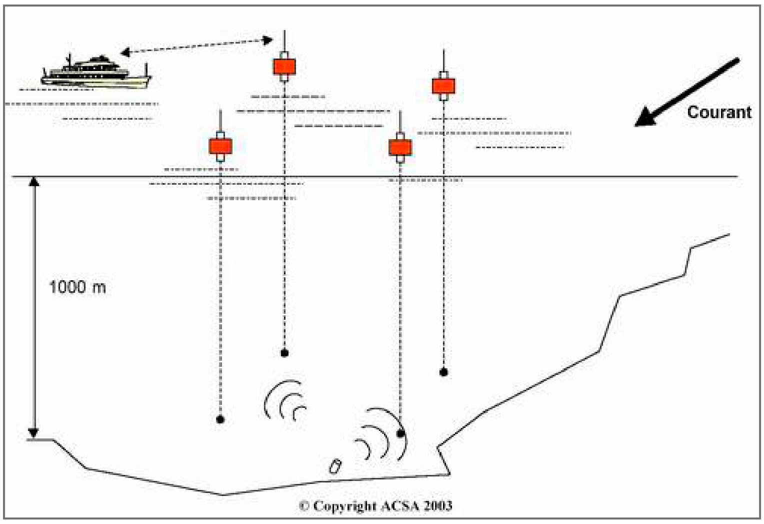


Figure 5: Operating mode of the ACSA system

The ACSA system made it possible to refine the position of the beacon transmission point. This phase proved indispensable in this context because the ROV only had visual equipment without any additional homing information. The buoys were deployed via inflatables belonging to the French and Egyptian navies. In the end, the first beacon was grounded at around seventy metres from the acoustic position estimated by Cephismer (zero point) and twelve metres from the position calculated by the ACSA system.

2 - DEPLOYMENT OF SEARCH RESOURCES

2.1 BHO *Beautemps-Beaupré*

2.1.1 Bathymetry

The French Navy sent the hydrograhic-oceanographic ship the *Beautemps-Beaupré* to undertake the bathymetry [5] of the accident zone (figure 6). With the aid of its multi-bundle sounder, the latter was able to draw up a chart of the submarine depths in isobaths [6] fifty metres apart. This knowledge of the topography of the area facilitated the use of the ROV.

[5] Bathymetry: measurement, by soundings, of marine depths.

[6] Isobath: line linking points of equal depth, underground or undersea.

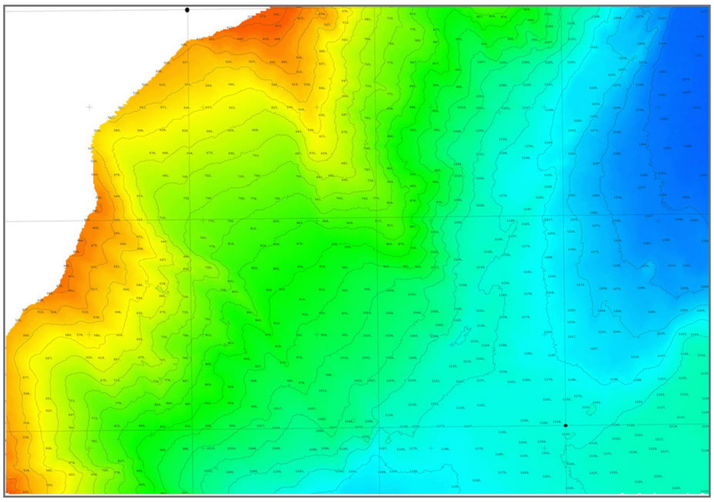


Figure 6: *Beautemps-Beaupré* bathymetry

Neverthless, the bathymetry could not be completed by a three-dimensional mosaic submarine image due to the depth of the wreckage. This would have been possible for shallower depths (down to around two hundred metres) with the aid of a lateral-sweep sonar with which the *Beautemps-Beaupré* is equipped. The fusion of this data with the bathymetry makes it possible to visualize and thus and localize wreckage in shallower waters.

2.1.2 Current measurement

The *Beautemps-Beaupré* also positioned itself in the area for twenty-five hours so as to study current and tide phenomena.

The main results included:

- Absence of currents at a depth of one thousand metres;

- The presence of a reflecting layer fluctuating vertically between depths of one hundred and six hundred metres. This was explained by the nocturnal vertical migration of plankton, associated with a vertical current at a maximum of eight cm/s. This layer can create an acoustic mask for the deeper layers.

Note: On the first few days of operations, the acoustic positioning between the Scorpio ROV and its support ship was lost, probably due to these fluctuations (see chronology of operations in appendix).

The other results show:

- At depths between zero and one hundred metres, a strong permanent current, with an average speed of 25-30 cm/s towards the north-east (040°);
- The layer between zero and five hundred metres has a twice daily tidal current above it, with a maximum modulation of a metre.

The speed of this tidal current is low, about ten cm/s. It creates a variation in the permanent current speed of around twenty cm/s. The speed of the permanent current thus fluctuates, on the surface, between fifteen and fifty cm/s according to the time and the tide.

Further down, between one hundred and seven hundred and fifty metres, the permanent current decreases with depth. It becomes negligible from seven hundred and fifty metres.

The results from bathymetry and current measurements showed that it was unlikely that the recorders would have moved due to the current or the rough terrain.

2.2 Recovery

2.2.1 The *Ile de Batz*

At the time of the accident, the ship was in the Red Sea on the way to a worksite off the coast of Libya. The *Ile de Batz*, a cable-laying ship owned by Louis-Dreyfus Armateurs, is around a hundred forty metres long and is adapted to carry a heavy ROV on its deck with its fifty tons of support equipment. The *Ile de Batz* has an advanced dynamic positioning (DP II) system that allows it to work at a precise position, even with unfavourable meteorological conditions [7]. This ship having been designed to lay cables on the seabed with a one-meter precision, its system for cable tension and runout speed proved very useful for bringing to the surface large and heavy plane parts.

[7] On 20 January, wind conditions of around gale force eight on the Beaufort scale did not disturb the lifting operations.

Finally, since the *Ile de Batz* possessed meeting rooms, cabins and a restaurant, the search operations were based on board. The *Ile de Batz* was thus the support ship for the Scorpio ROV. The movements of the ROV and the ship were coordinated by the survey located on the *Ile de Batz*'s bridge.

2.2.2 Description of the Scorpio 2000 ROV

The Scorpio 2000, operated by France Télécom Marine [8], is a ROV dedicated to undersea cable-laying (workROV).

The Scorpio has the following characteristics:

- Dimensions (in metres): length: 2.90 ; width: 1.50 ; height: 2.50
- Weight: 3.5 tons
- Maximum operating depth 1,200 m (limited by the length of its umbilical cable)
- Maximum speed: 2.5 kt
- Lateral speed: one knot

Figure 7: Photo of the Scorpio ROV

The vehicle has an aluminium structure, on which the propulsion and flotation systems are mounted. The ROV's floatability is adjusted to be slightly positive. Propulsion is ensured via eight hydraulic propulsions systems, four vertical to propel the ROV downwards and maintain it at the desired depth, two in line to ensure forward and backward movement as well as rotation and two mounted transversally to enable lateral movement. An electro-hydraulic power unit provides the necessary hydraulic power for propulsion and the tools.

The Scorpio is equipped with three cameras: a Simrad 1366 colour pilot camera on the vehicle's centreline, a Simrad 1366 swivelling camera with zoom and focus, and a third camera used to control vehicle functions. The swivelling camera provided a width of visual field of around eight metres while the lighting (eight 250 kW lights) enabled about four metres to be illuminated.

Note: The swivelling search camera is located around a metre and a half from the base of the structure.

On its right side the Scorpio ROV has an extending arm with five functions [9]. The maximum opening of its claw (20.3 cm) corresponded to the size of the recorders to be brought to the surface. The claw gripped an object only when the corresponding control button was pushed. The controls are neither

[8] In 1985 France Télécom Marine participated in the recovery of recorders from a Boeing 747 (Air India flight 182) that crashed into the Irish Sea. The operation was carried out with a Scarab type ROV operated from the *Léon Thévenin* cable ship. The recorders were at a depth of about two thousand metres.

[9] The five functions are rotation at the shoulder (up to 120°), raising and lowering of the shoulder (up to 90°), raising and lowering of the elbow (up to 132°) and the rotation of the wrist (up to 360°).

servoed positionally nor powered. To reach and grasp an object, it is thus all or nothing, with available hydraulic pressure of about 2,800 Psi. Finally, the lifting capacity of the claw is around 145 kg taking into account the extension of the arm.

On the front of the vehicle the jetting tool, originally used for telephone cable work was cut off and replaced with a basket for the recovery of elements. This basket, with a double net, was the right size for the recovery of the recorders.

Two types of liaison were used to pilot the ROV:

- An umbilical cable that transmitted the power and the information needed for operations;
- A transponder operating in USBL mode that transmitted information on the position of the ROV in relation to the boat.

A container equipped with the Scorpio control centre was installed on the deck of the *Ile de Batz* near the drum that rolled out the thousand two hundred metres of ROV umbilical cable. The Scorpio was controlled by two teams of three people working twelve hour shifts.

Figure 8: Photo of the control center of the Scorpio

The ROV movements were guided by the lookout on the bridge of the *Ile de Batz* that had a visual of its position via USBL transmissions. The search areas consisted of parallel lines around three metres apart to take into account the width of the visual field of the panoramic camera. This allowed systematic coverage of the predefined search zones.

2.2.3 The *Janus II*

The *Janus II* is a thirty-metre catamaran operated by COMEX and designed specifically for underwater search operations. It was chartered by the French Navy to participate in the sea searches. The *Janus II* sailed to the site of the accident from its home port of Marseille (France) via the Suez canal.

On the rear deck, there is a multi-function winch that can tilt through a hundred degrees with a capacity of between six and ten tons depending on the conditions of use.

Its hydrographic survey system is based on an integrated navigation system that allows for acquisition, follow-up and stocking of all data collected from the onboard sensors. In addition to the data link to the ship, movements by the ROV, the submarine and the divers can be followed through the USBL transponders. The follow-up is performed in real time, on the backdrop of a digitized marine chart.

Apart from the Super Achille ROV, the *Janus II* also had the Remora 2000 oceanographic submarine on board. This was not used at the site since its maximum depth is limited to six hundred and ten metres.

2.2.4 Description of the Super Achille ROV

The Super Achille is an observation ROV (obsROV) dedicated to submarine searches whose main characteristic is its adaptability for different types of submarine activities (wreckage recovery, measurements and sampling, laying explosives charges, etc.).

The *Janus II* carried two Super Achille submarine ROVs to have greater operational availability.

The Super Achille has the following characteristics:

- Dimensions (metres): length: 0.72 ; width: 0.60 ; height: 0.68
- Weight: 110 kg
- Diving depth: 1,100 m
- Maximum speed: 2.5 kt
- Lateral speed: one knot

This light ROV, remotely controlled via cable from the *Janus II*, is placed in a "garage cage" which is lowered beneath the ship by a davit and a deck winch that can descend to one thousand one hundred metres. On reaching its working depth, the Super Achille can leave its cage thanks to a seventy-metre floating leash. This retractable cable linking the ROV to its cage is a coaxial cable through which power, control commands and information received (sonar, video, position) are transmitted. This helps the ROV's mobility, which is thus not limited by the inertial effect of a thousand metres of its main umbilical cable.

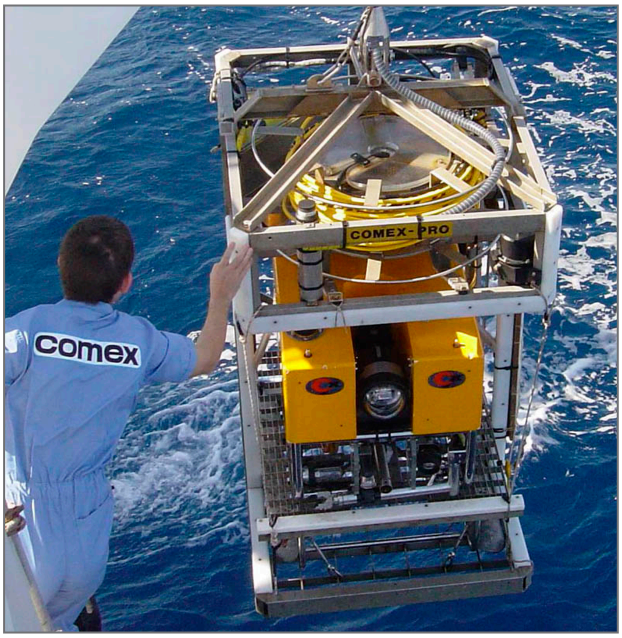


Figure 9: Photo of Super Achille in its cage

The Super Achille, equipped with its transponder (operating with the *Janus II*'s USBL system) can also serve as a dynamic positioning reference and be positioned permanently with geographical coordinates on the integrated navigation system. The chronology of the ROV's movements can be recorded. These positions can be displayed in real time on a digitized marine chart.

Note: The chart used by the *Janus II* was supplied by the French Navy from the bathymetry performed by the *Beautemps-Beaupré*. Comex was thus able to centralize its data on a precise digitized chart (bearing chart).

The Super Achille's swivelling camera is highly sensitive and can transmit high definition colour images like the one below, taken at a depth of around one thousand metres.

Figure 10: Example of photo taken on the seafloor (one of the airplane's manuals)

The Super Achille can be equipped with a standard three-axis arm for the recovery of small debris or with a five-axis hydraulic arm for larger wreckage weighing less than five kilos. These objects can be placed in a basket attached to the cage.

For the recovery of parts over five kilos, Super Achille's agility allows it to perform lifting operations with the aid of lifting cables. Chapter 3.3 gives details of the lifting procedures.

2.3 Role of Technical Investigators

The team that was assembled at Sharm el-Sheikh had additional skills that were required for the rapid identification and localization of wreckage. The Egyptian Commission of Inquiry called on the Egyptian CAA and on advisors from Flash Airlines and Egyptair (airline that also operates Boeing 737's).

As State of Manufacture, the United States, represented by the NTSB was also present at the accident site. Advisors from the FAA and Boeing, specialized in Boeing 737structures and systems, also joined the investigation team. France, represented by the BEA, had asked for the collaboration of an advisor from SNECMA (representing the engine manufacturer CFM International).

The BEA, search coordinator under the auspices of the Commission of Inquiry, could thus call upon:

- Knowledge of the Boeing 737-300 (structure, systems, engines, etc.),
- Specialists in underwater search, protected recorders, etc.

3 - CHRONOLOGY OF MARINE OPERATIONS

Note: Appendix 1 gives details of daily marines operations at the site.

3.1 Undersea Environment

3.1.1 Exploratory Dive

The first dive at the accident site was performed to explore the submarine environment to determine the nature of the seabed and the relief, and to obtain data on the current and the visibility. This dive took place on 12 January, that is to say before the studies undertaken by the *Beautemps-Beaupré*. The depth of around one thousand metres implied pressures around one hundred bars. At this depth, there is no more natural light. Visibility is good only down to around one hundred metres.

The exploration around the ROV's position showed no depth variations and that it consisted of relatively heavy sediment. During the following dives, a progressive burying of some parts was noted.

The current at depth was estimated to be weak or non-existent. The visibility was good, that's to say the depth of the visual field depended directly on the strength of the ROV's lighting.

The technical constraints and the difficulties inherent in working at great depths were thus fortunately not complicated by visibility and current conditions.

3.1.2 Difficulties of working with an ROV at great depth

3.1.2.1 Hyperbaric environment

It should be noted that the difficulties of submarine work increase exponentially as depth increases. Forces due to pressure and the saline environment make it hostile for ROV's. In addition, the distance to the surface makes lifting operations much longer. The descent and ascent took around an hour for the Scorpio and twenty minutes for the Super Achille.

The depth of the wreckage was compatible with the operational envelope of the ROV's sent to the site. The Scorpio and Super Achille ROV's had only a small margin of manœuvre in relation to the length of their respective umbilical cables. Precision positioning of the support ships was in both cases very important to optimize cable length used in order to have the ship supporting the ROV in an optimal position directly above it. The *Ile de Batz* had to coordinate permanently with Scorpio to optimize cable length. The *Janus II* by positioning itself directly above the ROV's cage (itself around ten metres above the seabed) was independent of movements by Super Achille thanks to the system of the floating leash. The Super Achille could thus move freely in a theoretical range seventy metres around its cage (10).

(10) In practice, the Super Achille pilots kept a safety margin of thirty metres.

3.1.2.2 Prehensile ability

The ability of an ROV like Scorpio to pick up objects is limited by the possible movements of its articulated arm and by the all-or-nothing operation of its hydraulic claw. This absence of servo-power for the hydraulic claw made it impossible to grasp soft or fragile objects without risking irreversible damage.

Grasping an object could take several minutes because the following conditions had to be met: position the ROV carefully in relation to the object and turn the camera so that the ROV operator, a thousand feet above, could work by seeing the movements of the articulated arm. The camera provided only a degraded vision of the depth and distance. Its field of vision was around sixty degrees, thus around one third of the human visual field. To ensure permanent and systematic scanning of the zone under observation, it was necessary to have good coordination between the ROV pilot and the panoramic camera operator.

Note: This was especially the case for a workROV like the Scorpio, though less so for an obsROV of the same type as the Super Achille.

3.1.3 Coordination and logistical aspects

3.1.3.1 Coordination between the ROV control room and the investigators

In order to avoid disturbing the Scorpio ROV's team of pilots, it was decided to transfer the images from panoramic camera to the test room on the *Ile de Batz* reserved for technical investigators. A phone line [11] was installed to coordinate the search. This solution also had the advantage of giving the investigators room to access the available documentation (plans, laptops etc.). Coordination discussions could thus take place without disturbing the ROV pilots.

[11] The choice to coordinate via a protected telephone line rather than via radio (portable VHF) was dictated by reasons of confidentiality.

3.1.3.2 Logistical aspects

Every morning and evening, a launch plied between Sharm el-Sheikh port and the *Ile de Batz* and the *Janus II*. Coordination meetings took place every morning on the launch's arrival and before its departure in the evening. This allowed daily briefings and information for new arrivals on the progress of the operations and determine the following steps to take to optimise the means available.

3.2 Several Parallel Objectives

3.2.1 Recovery of bodies

The initial search for survivors, then the recovery of bodies, was the priority for the search teams. The airplane had been smashed by the violence of the impact with the sea and its occupants killed instantaneously. Most of the human remains recovered were found in the first few days after the accident.

They were found on the surface or just below it. At a thousand metres, pressure forces, the fauna, the salinity of the water and the passage of time destroyed what remained of the bodies of the airplane's occupants after its disintegration.

The technical and psychological difficulties added to the pressures inherent in this type of operation [12].

At times, some video images showed shapes associated with human body fragments, but these were in such a fragile state that it was impossible to manipulate them. It was possible to recover some human remains only because they were attached to objects or incrusted in parts.

Despite Comex's [13] experience in this area and the means deployed, in the case of the Sharm el-Sheikh accident, only some rare human remains were able to be recovered despite the efforts made.

(12) The ROV's hydraulic arm was better adapted for grabbing metal parts than fragile elements.

(13) Comex had recovered the bodies of the victims of a Cessna accident off Monaco in 1998 and in 1999 the bodies of helicopter pilots from a Lynx involved in an accident in the Mediterranean, as well as many drowning victims.

3.2.2 Recovery of flight recorders

3.2.2.1 Position of recorders on airplane

The recorders are at the rear of the airplane, in the area indicated in the photo.

Figure 11: Flight recorder installation area

3.2.2.2 Official procedure for handover of recorders

It was important to set up an official procedure for the handover of the recorders between the French and Egyptian authorities since the recorders were recovered from Egyptian territorial waters (Egyptian jurisdiction) and transited via a French warship (French jurisdiction). It was also necessary to satisfy the demand for images from the media. An official photographer took shots as the recorders were lifted out of the water (in both cases at night). These photos were quickly put on line on the BEA's website.

In order not to disturb the search operations, the area was secured by the Egyptian Navy. It was thus agreed that the BEA would hand over the recorders to the Commission of Inquiry in the port of Sharm el-Sheikh in the presence of journalists. The Egyptian judicial authorities were thus able to fix seals before the transfer to Cairo.

3.2.2.3 Recovery of the FDR

One of the initial priorities was to find and recover the flight recorders, the CVR and the FDR. It was planned that they be read out in Cairo.

The Scorpio ROV began its search for the recorders with the aid of its cameras based on the initial fix for localization of the beacon. This position was then refined by use of the ACSA system. This gave a theoretical position with a precision of within about ten metres [(14)]. A square twenty metres by twenty, centred on the theoretical position, was systematically passed over by the ROV. These visual searches finally led to the discovery of the FDR, which was in fact located at around twelve metres from the estimated position.

[(14)] The theoretical precision of the system specially designed for recovery of the flight recorder sis of the order of 1% of the depth, or about ten metres.

3.2.2.4 Recovery of the CVR

The search for the second recorder required a strategic choice. Since the beginning of operations, the echo from the second beacon appeared to be a few hundred metres north of the initial search zones. In between times, the results of the ACSA localization were not yet available.

For accidents resulting from this type of a collision with high ground or the sea, it sometimes happens that the accelerations suffered during impact lead to the beacon being separated from its attachment point on the recorder. This hypothesis was plausible based on the initial evidence gathered.

Two strategies were possible:

- ❐ Wait for the results on the precise positioning of the North echo based on deferred time digital processing,

- ❐ Continue the searches in a recovery zone to be defined from the analysis of the distribution of wreckage, thus supposing that the pinger was no longer attached to the CVR.

The second strategy was adopted. It was decided to limit the search zone to the south at the position of the FDR (see appendix 1 – Saturday 17 January 2004).

The CVR was found around twenty-four hours after the discovery of the FDR, near the square marked by the investigators during a turn by the Scorpio ROV (change of track). Its protective casing was more severely damaged than that of the FDR. The reference and serial numbers on the casing as well as the pinger, had likely been torn off at impact.

The use of a large TV screen connected to the panoramic camera helped in identifying the recorder (see photo). The setup of the work room on board the *Ile de Batz* and the consequent simplified coordination were determining factors in the rapid discovery of recorders.

Figure 12: Photo of the work room

The same handover procedure used the previous day for the FDR was set up for the handover of the CVR.

3.2.3 Wreckage mapping

The exploration of the seafloor was carried out in rectangular zones progressively extended around the central zone. Each zone was then divided into squares with lines spaced by between three and five metres apart (depending on the ROV and of objectives).

During these operations, it was important to have aviation specialists to coordinate these searches and identify the wreckage. The dives by the Scorpio and Super Achille were filmed. On board the *Ile de Batz*, the work room was equiped with a VHS recoder, which allowed some dives to be reviewed, especially during maintenance operations. The Super Achille's video system, which recorded images in a digital format, could also take digital photos of some elements that were thought to be interesting to chart and examine (engines) with inset of parameters such as the coordinates, the depth, the date, time and the bearing on the photo (see figure 13).

Figure 13: Photo of an engine

The various elements found and identified during the dives were entered into a database that is appended to this document. Some parameters such as the date, the position (latitude, longitude), a succinct description, the photo references showing useful information for the investigation were thus able to be used easily (this database contains around four hundred pieces of wreckage located and identified). The following figure represents the mapping of this wreckage within the limits of the search zone.

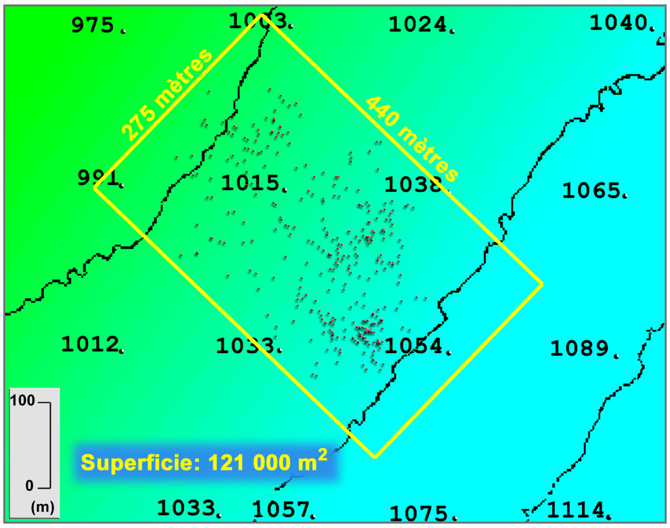


Figure 14: Wreckage mapping

The wreckage was found within a rectangle of around 275 by 440 m and defined by the following coordinates:

North point: N 27°52,559 / E 34°21.933
East point: N 27°52,410 / E 34°22.126
South point: N 27°52,294 / E 34°22.022
West point: N 27°52,450 / E 34°21.817

The multiple explorations confirmed that wreckage was contained within these limits.

3.2.4 Recovery of airplane parts

The strategy to recover airplane parts was based on the first results from the readout of the recorders that took place in Cairo. All the parts associated with the airplane's control surfaces and the onboard systems were given priority.

A procedure was developed to record the description, the dimensions and the coordinates in latitude and longitude of parts recovered by the investigators, as well as their first observations. The description and the coordinates of other parts, studies by the ROV's cameras, were also recorded.

The following categories were made:

- ❒ FW (Floating Wreckage) for the floating wreckage recovered in the first days after the accident;

- SW (Surveyed Wreckage) for wreckage identified;
- RW (Recovered Wreckage) for the wreckage brought to the surface;
- PE (Personal Effects) for the personal effects mainly recovered by the *Janus II*.

In addition to fifty-five pieces of floating wreckage recovered at the beginning, identified and referenced, about fifty further items were recovered and then referenced.

All the parts recovered were conserved in sea water until they were unloaded in the military port at Sharm el-Sheikh and their handover to the Egyptian authorities.

3.2.5 Recovery of personal effects

The objects recovered were mainly watches, bags, wallets etc. Few clothes were recovered. Strips of material frequently blocked the ROV's propulsion system. Their slightly positive floatability made it very difficult to handle and recover them. Some floated out of the recovery baskets during the thousand metres lift.

Some of these objects were recovered in the course of the search operations, then in a second phase the *Janus II* systematically covered the zone in search of personal effects. Its mission came to an end after many sweeps when all recoverable material had been retrieved.

3.3 Recovery techniques and procedures

3.3.1 France Télécom Marine working procedures

3.3.1.1 Inspection of seafloor

The Scorpio moved along the bottom slowly, following the tracks of the lines provided by the "survey" made by the *Ile de Batz* (in coordination with the investigators) and sweeping the zone of visibility on one side then the other of the vehicle. The zone of visibility was around four metres forwards and four metres to the sides.

The lift capacity of the claw made it possible to raise pieces to enable their identification or possibly observe any elements underneath. However, the design of the remote controls made fine manipulation of small or fragile elements impossible.

3.3.1.2 Recovery of parts

The mid-size elements found could be placed in the ROV's basket. When the basket was full, the Scorpio could either be raised or manœuvre towards a bigger basket lowered from the stern of the *Ile de Batz*. For parts weighing less than fifty kilos, the ROV could, by holding the part with its extending arm, move towards the ship's basket to unload it into it. The *Ile de Batz*'s winch then raised the basket containing the unloaded parts therein.

It should be noted that the recovery of elements with neutral or positive flotation were difficult and risky for the Scorpio because these elements tended to float out of the basket during ROV movements or basket raising. Some of them were sucked in by the ROV's propellers, making it impossible to manœuvre the vehicle.

3.3.2 Comex work procedures

In addition to mapping of the seafloor and the direct recovery of parts using its arm, the Super Achille was also able to raise wreckage weighing several tons with the aid of lift cables from the surface. Different line ends adapted to each situation were used: the ROV was able to work with a lasso, a cable, a hook, etc.

Figure 15: Two ships undertaking dynamic positioning work

This type of operation had to be preceded by a close visual inspection of the part to be raised to the surface. The result of this inspection enabled to size of the cable to be determined.

Although the *Janus II* possessed the winches necessary for such recovery, the use of a second ship such as the *Ile de Batz* optimized this type of operation. The Batz being a latest genration cable-layer, it was perfectly adapted it for the positioning and lifting of the lift cables. The use of two ships also provided options for very precise securing and raising operations, which would not have been possible with a single ship. The carrier of the line end was thus able to move several thousand metres away from the part to be recovered while horizontal pulling operations were performed to secure it (see figure 16). During this time, the Super Achille's cameras kept visual contact with the whole operation.

Sizing and production of the line ends was carried out by Comex. They were then transferred to the *Ile de Batz* to be connected to the lifting cables. The operation began when the two ships were vertically above the part to be raised. The *Ile de Batz* and the *Janus II*, both equipped with a dynamic positioning system, could be manœuvred within about ten metres of each other. The *Ile* *de Batz* was placed in a position as close as possible vertically above the object to be raised. The Super Achille ROV was positioned on the seabed close to the part.

The line end, which had neutral flotation, was weighed down for the descent phase with a weight. A transponder was attached to the line to enable the descent to be followed via acoustic positioning. The line was also equipped with reflective strips and a light so as to facilitate the rendezvous at a depth of over a thousand metres.The rendezvous took place about ten metres from the seafloor to avoid the line cable getting twisted together with the ROV's cable and to ensure that the weight didn't catch on the wreckage.

Following the ROV pilot's inputs, the weight was then slowly lowered to the bottom then released by the Super Achille. The line was played out towards the objective. The lift cable was then resting on the bottom and then slowly stretched out. The *Ile de Batz* could then slowly move away from the *Janus II* towards a waiting position while the objective was being hooked up.

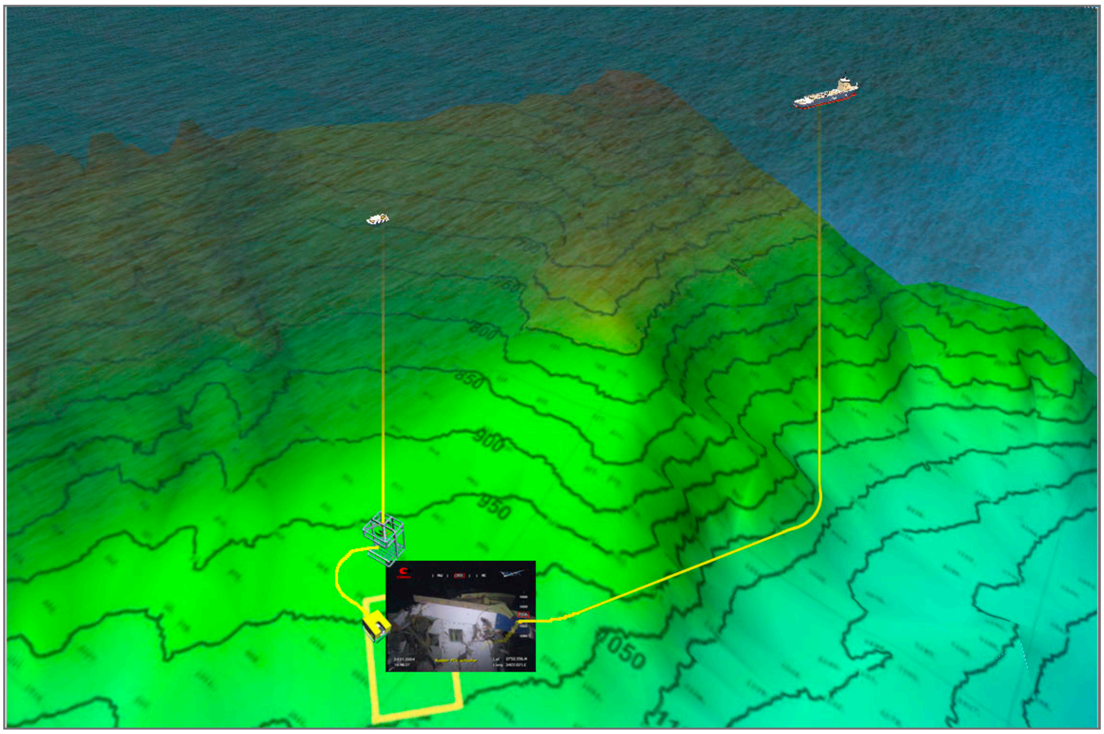


Figure 16: Operation to attach and raise part of the fin

To recover parts such as the rudder and horizontal stabiliser of the airplane, two variations of this method were used:

❒ The line end equipped with a hook

The hook was clipped onto a strong point on the rudder (see figure 17). Following the inputs from the pilot of the Super Achille, who had a full view of the operation on his monitors, the *Ile de Batz* slowly reeled in the cable until the wreckage lifted off the bottom. Once the part was off the bottom, the ROV was withdrawn into its cage while the rudder slowly rose to the surface.

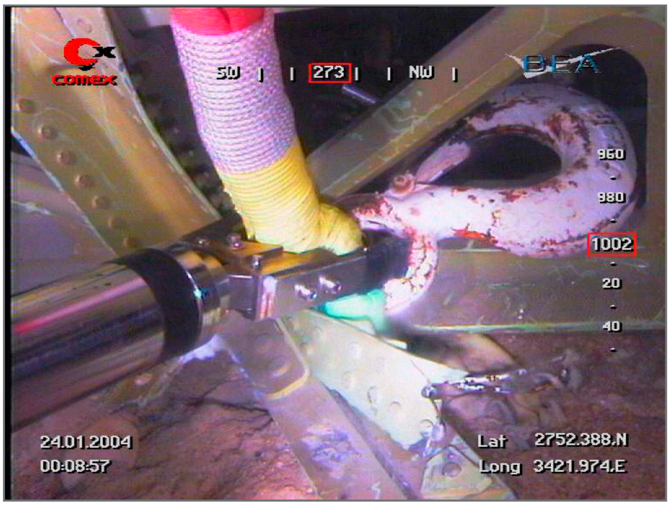


Figure 17: Use of lock hook

❒ The line end equipped with cable

When the part to be raised did not have a lifting point that allowed it to be moved without risk of further damage, the part then had to have a cable wrapped around it. The line end was thus equipped with a long cable and a lock hook. The cable was then wrapped round the part (through previously identified points) then the lock was closed over its own cable. The cable then had to be tightened carefully around the wreckage (this operation involved the rear part of the fin where the servocontrols were situated). This had to be done before lifting so as to avoid the cable slipping off without tightening.

A heavy weight had been placed between the line end and the traction cable. The *Ile de Batz* then laid between two and three kilometres of cable on the seafloor while simultaneously moving on the surface in order to avoid loops that would have disturbed operations. Following the ROV pilot's instructions, the cable was then slowly reeled in. The weight then moved horizontally on the bottom to tighten the line end on the objective.

The *Ile de Batz* could then reposition itself above the part to be raised whilst pulling in the extended cable. This manœuvre had to be performed precisely so as not to damage the part against the seafloor while it was turning (to stress the cable). The video screens allowed the ROV pilot to control the whole manœuvre until the winch on *Ile de Batz* lifted the part on board.

One problematic phase in the lifting operations was lifting parts out of the sea. When a part is lifted out of the sea, Archimedes principle is negated, which can lead to a sudden increase in load. The latest generation winch with which the *Ile de Batz* is equipped made precise speed and tension control possible during part recovery. This helped to avoid damage or loss of elements during this phase.

The parts recovered were loaded onto the *Ile de Batz* and stored in a large hold filled with seawater. The handover of recovered parts to the Egyptian authorities took place in the military port at Sharm el-Sheikh at the end of the *Ile de Batz*'s mission.

Note: The same handover procedure was followed by the *Janus II* at the end of its mission.

4 - RESULTS OF MARINE OPERATIONS

4.1 Complementary nature of equipment used

The means deployed at the accident site allowed large parts (parts of the B 737's horizontal stabiliser) as well as smaller elements (personal effects) to be recovered. The claw of the Scorpio ROV was, for example, well adapted to picking up the recorders. The mobility of the Super Achille ROV made it possible to map the accident site quickly.

The following table shows the area covered by the two ROVs between the 13 and 21 January 2004.

ROVs	Scorpio	Super Achille
Surface covered	8,300 m^2	19,100 m^2
Dive periods	13 to 18 January 2004	18 to 21 January 2004
Daily average	10 h 30 min	19 h

The better operational availability of the Super Achille can be explained by the redundancy of the equipment fielded by Comex. It should also be noted that the Super Achille ROV 's (obsROV) are regularly used for undersea searches while the Scorpio (workROV) is an ROV dedicated to laying undersea cables.

4.2 First Observations

In the context of this investigation, the recovered recorders were quickly found to be readable, which allowed wreckage recovery work to be optimized. Coordination between the investigation teams in Cairo and Sharm el-Sheikh was set up during preliminary readout of the recorders.

The first elements from the FDR suggested an airplane configuration with a nose down attitude of around thirty degrees and a right bank of the order of fourteen degrees. The last recorded heading was 311° while the speed was close to four hundred knots.

These elements were compatible with the first results from the mapping.

A certain number of parts linked to the site and to the wreckage also contributed to the validation of the FDR parameters. The initial observations showed that:

- No parts from the electronics bay (located at the front of the airplane) could be recovered, unfortunately.
- The two engines were found around twenty-four metres apart, which indicates that they were attached to the airplane at the time of the impact.

Note: The initial findings of the technical investigation into the accident to the Boeing 767 operated by Egyptair that occurred on 31 October 1999 off the coast of Connecticut indicated that one engine had detached before the impact with the sea due to the load factors to which it had been subjected.

- The left and right main landing gears were found between the two engines. The grouping together of these heavy components most likely corresponded to the zone where the airplane impacted the surface of the sea. The wreckage distribution was not consistent with a spread typical of an in-flight breakup.

Note: In 2002, the Taiwanese authorities were confronted with two accidents in the sea off the Pengu Islands. In one case, there was an in-flight breakup [(15)] and in the other a collision with the sea [(16)] without any loss of parts. The wreckage distribution spread out in the first case over an area of over 100,000 km^2 and in the second case an area calculated as far less than 60,000 m^2.

- The thrust reverser actuator was brought up and found in retracted position.

- A leading edge slat actuator was brought up and found in retracted position.

- A flap actuator brought up and found in retracted position.

- The shaft of the jackscrew controlling the stabilizer was measured. The position of its nut was 7.5 inches from the end, which corresponds to leading edge nose down position of between two and three degrees or to a trim position of between five and six units [(17)].

These facts indicate that the airplane was probably in a smooth configuration (landing gear, slats, flaps retracted) at the moment of impact, which confirms the information on the FDR.

The first results of the technical investigation resulting from the underwater searches confirmed that the accident was not linked to a terrorist attack.

(15) Accident to the B 747-100 registered B-18255 operated by China Airlines on 25 May 2002 off the Pengu Islands (Taiwan).

(16) Accident to the ATR 42 registered B-22708 operated by TransAsia on 21 December 2002 off the Pengu Islands (Taiwan).

(17) B737-300 Aircraft Maintenance Manual 27-41-00.

4.3 Comparison with Other Accidents

The following table presents some accidents that occurred over the last ten years that required sea recovery operations.

Accident	Place (off)	Wreckage depth	Equipment used	CVR (days)	FDR (days)
B 757 Birgenair (ALW301) 06-02-96	Puerto Plata Dominican Republic	2,200 m	ROV (CURV III)	22	22
B 747 (TWA 800) 17-07-96	Long Island United States	40 m	Various	7	7
MD 11 Swissair (SR 111) 02-09-98	Halifax Canada	55 m	Various	9	4
B 767 Egyptair 990 31-10-99	Connecticut United States	75 m	ROV (Deep drone)	13	9
A 310 Kenya Airways 430 30-01-00	Abdijan Ivory Coast	50 m	Various	26	6
MD 83 Alaska Airlines 261 31-01-00	Los Angeles United States	200 m	ROV (Scorpio)	2	3
B 747 China Airlines (CI 611) 25-05-02	Pengu Islands Taiwan	50-70 m	Various + ROV	24	25
ATR72 TransAsia (GE 791) 21-12-02	Pengu Islands Taiwan	60 m	ROV (Phoenix III)	23	22

In the case the Sharm el-Sheikh accident, the FDR and the CVR were found, respectively, after twelve and thirteen days. These figures can be compared with those of the Puerto Plata accident, which also required operations at great depths.

Each sea recovery presents specific difficulties that can be linked to:

- the depth,
- meteorological conditions,
- mobilisation times (distance in relation to naval bases),
- the political context.

CONCLUSIONS

Despite the difficulties associated with the depth of the wreckage, the distant location of the site and the lack of cartographical information, the recorders were found in under two weeks. This success was mainly due to the preparatory work carried out by the French Navy that allowed the appropriate ships and equipment to be sent to the accident site. The rapid reaction of the other participants (LDA, FTM, Comex, etc.) provided the operational structure that allowed the investigators to define the best strategy to find the recorders as quickly as possible, then to map the wreckage and recover as many personal effects as possible, as well as the parts considered to be potentially useful at the beginning of the investigation.

Logistics played an important part in the success of the operations: the capacity of the *Ile de Batz* and response of its crew helped the team work that was based on optimisation of the many skills that had been gathered.

The decision by the French Navy to deploy the ACSA system contributed strongly to a significant reduction in the search time for the recorders.

The mobility, flexibility and the quality image production of the Super Achille allowed methodical mapping of the accident site to be completed. Comex's experience in this area helped in recovering as many of the personal effects as possible.

The joint work between the *Janus II* and the *Ile de Batz* (both equipped with dynamic positioning) made it possible to recover larger parts such as the rudder.

Finally, experience gained from these operations provides precious feedback on the conduct of underwater searches as well as on the psychological and material preparation of the participants. Discussion with specialists in underwater operations should allow us to optimize and develop new means for undertaking searches.

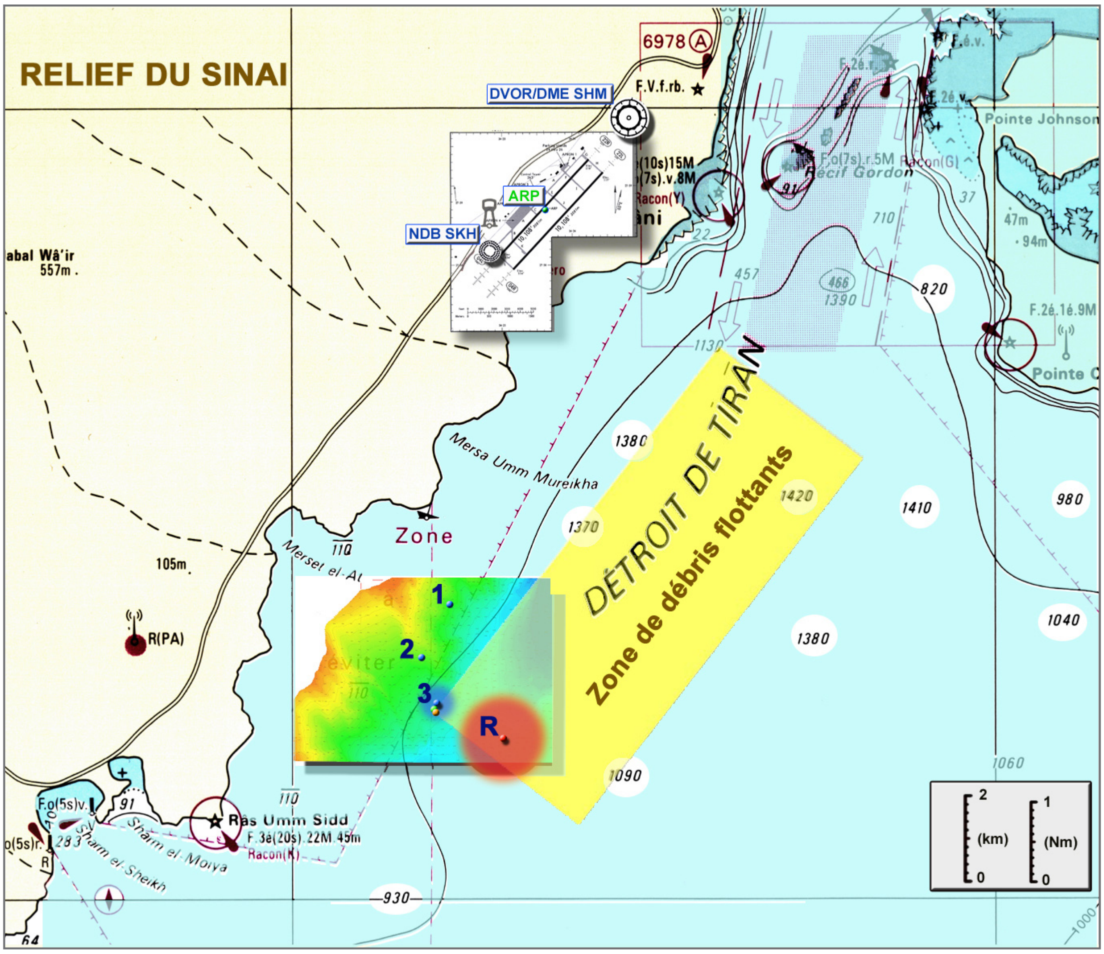
List of Appendices

Appendix 1
Chronology of undersea searches

Appendix 2
Extract from the database used to track search areas

Appendix 3
Examples of referenced submarine photos

Searches from 3 to 6 January 2004



❐ Recovery of floating wreckage in the hours and days following the accident with the help of French and Egyptian air and maritime resources (rectangle representing the wreckage field that was drifting towards the Strait of Tirana).

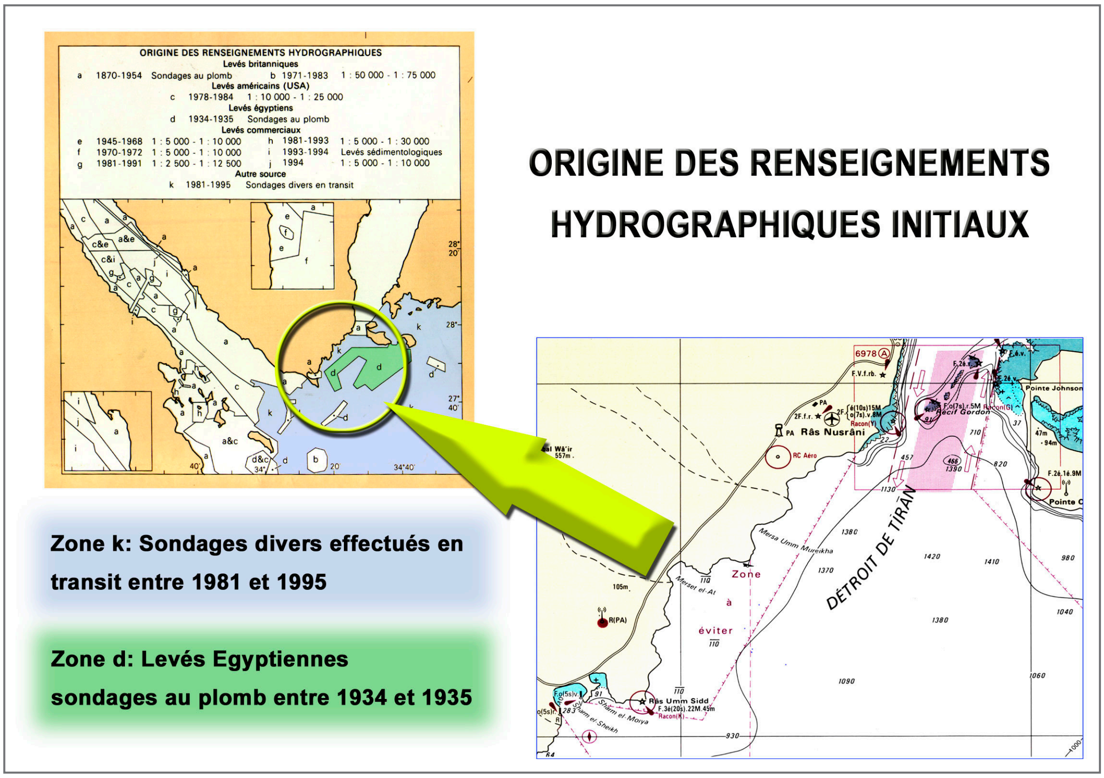
❐ Sunday 4 January:

- arrival of Cephismer with the Helle pole and Achille ROV;
- arrival of BEA with its listening equipment.

❐ Monday 5 January: beginning of underwater search operations undertaken by the French Navy on the supposed area of the accident, based on the information supplied by the Egyptian authorities (last radar blip [see point R] extrapolated from a screen copy). Detection of a very weak signal (not really significant – see point 1).

❐ Tuesday 6 January: detection of a second more significant signal (see point 2). Air search with a Lynx helicopter and a Bréguet Atlantique and sea search by the *Tourville* frigate.

Searches from 7 to 12 January 2004



- ❒ Wednesday 7 January: acoustic beacon anchored at this second point at a depth of 820 m. Arrival of the *Somme*. Press conference.

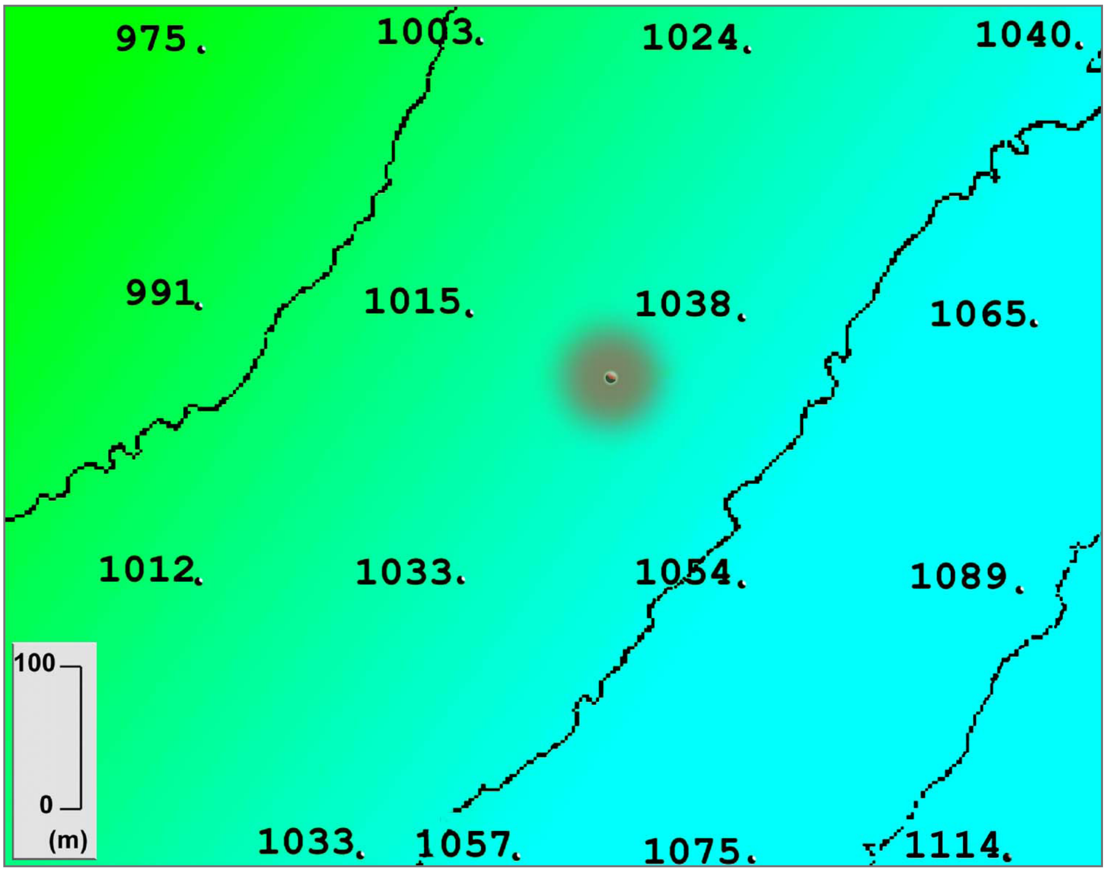
- ❒ Thursday 8 January: ceremonies for the families of victims with the supply tanker the Somme. Departure from Marseille of the *Janus II* chartered by the French Navy.

- ❒ Friday 9 January: runs performed by the frigate *Tourville* to sound the seafloor in this little-mapped zone. Listening for echoes.

- ❒ Saturday 10 January: detection of a nominal echo (audible in all directions) to the south of previous ones (see point 3 on the chart on previous page). Additional readings to detail localization .

- ❒ Monday 12 January: first meeting on board the *Ile de Batz* to decide on the strategy for the searches. Runs in the zone to perform additional bathymetric soundings so as to refine the depth. Fine-tuning of the Scorpio ROV recently embarked in Suez. Preparation of the investigators test room.

Tuesday 13 January 2004



- First launch of the Scorpio ROV (presentation to the press) and initial immersion tests. Establishment of working procedures and coordination between the bridge, the control centre and the investigators' room.

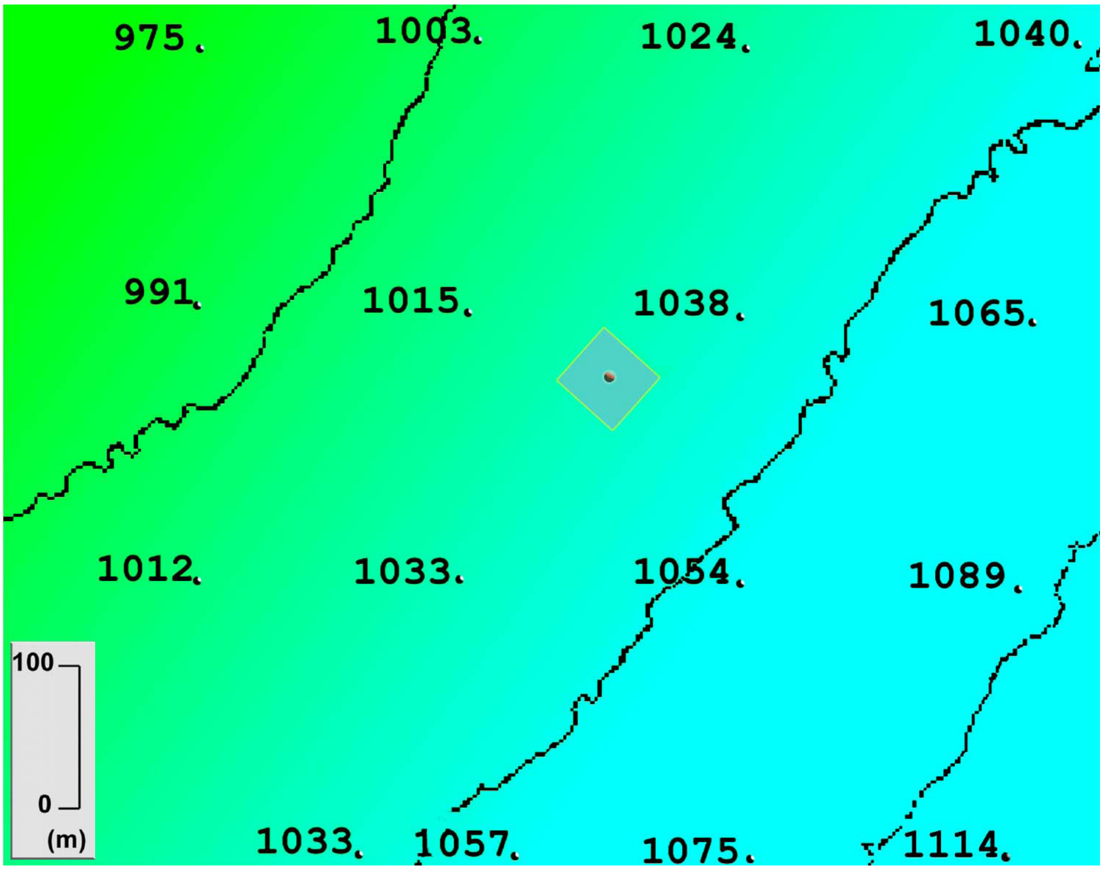
- Definition of a point zero reference point (latitude 27°52'426 N; longitude 034°22'020 E) based on results of latest French Navy triangulation.

- Test dive to evaluate the nature of the seafloor, the currents, the relief, etc. as well as to test the ROV operationally.

- Results of this dive: seafloor at 1,022 m relatively flat with compact sediments, good visibility (limited by lighting), no currents, and visualisation of numerous items of wreckage. Shark observed towards one thousand metres.

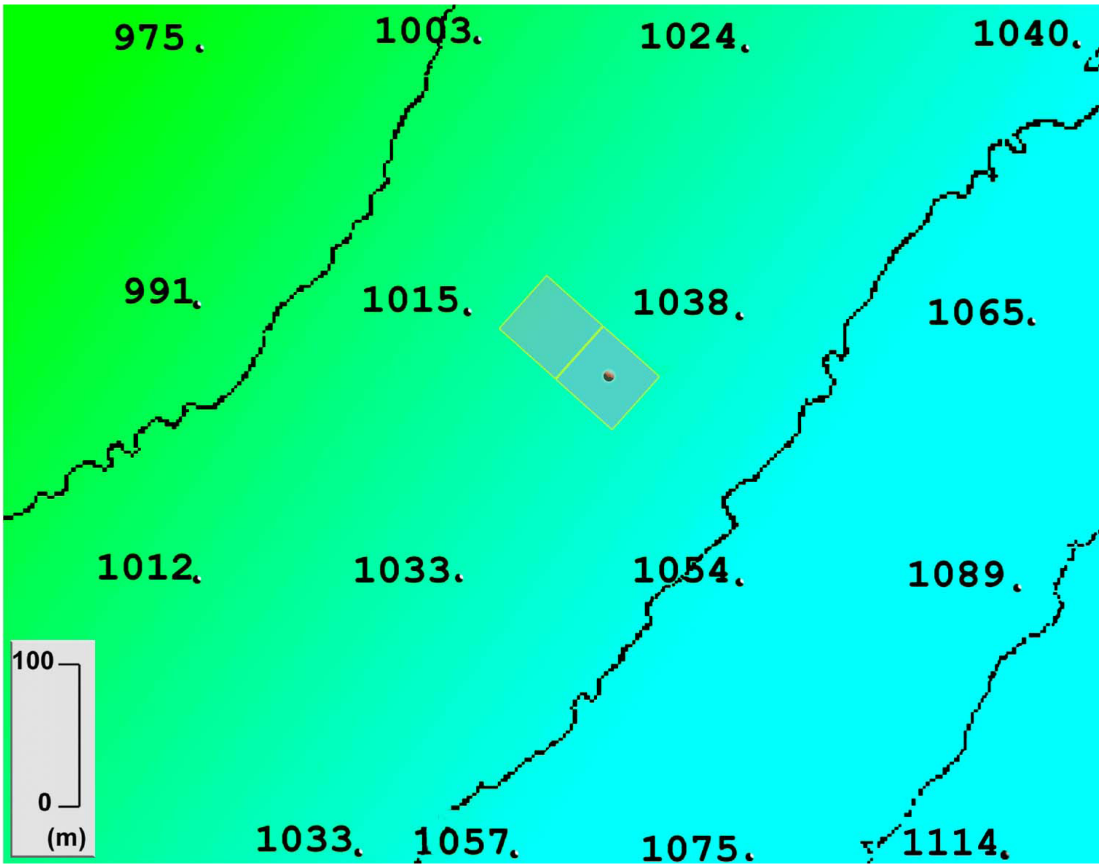
- Departure of the frigate *Tourville*.

Wednesday 14 January 2004



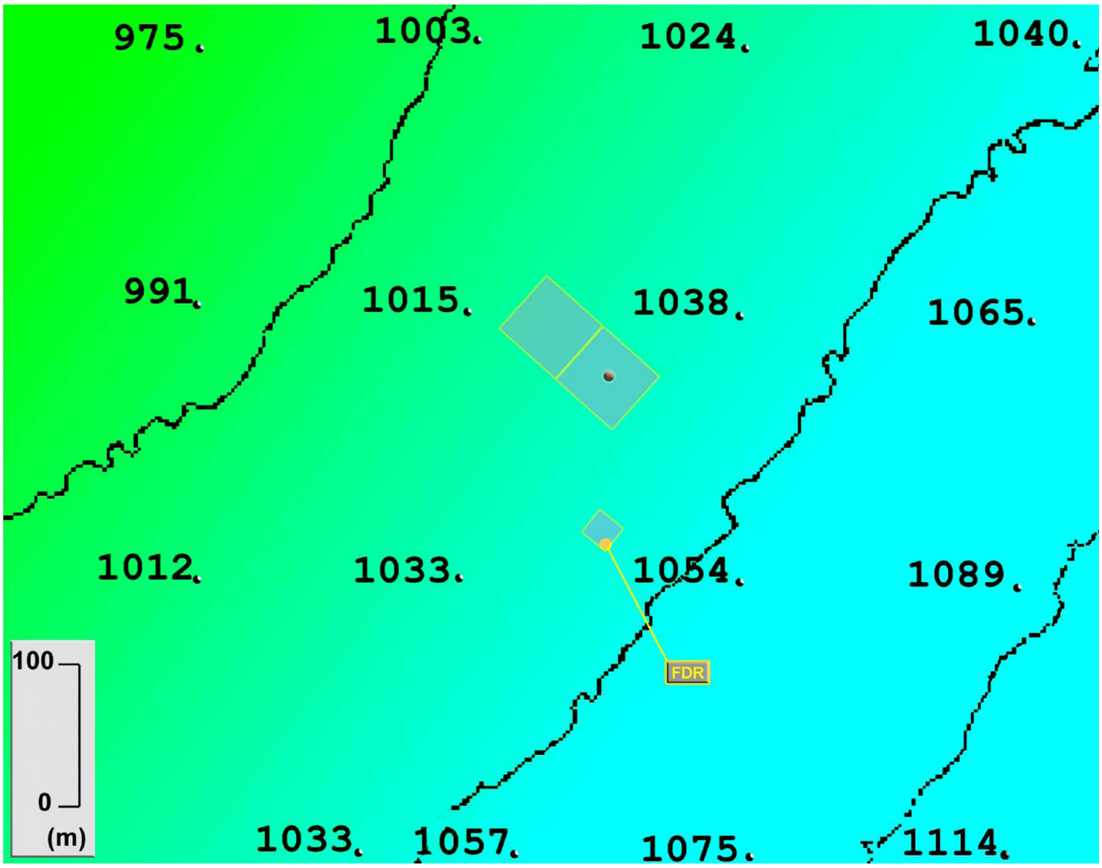
- ❐ Arrival of the ACSA system and conditioning of equipment at the military port. Plan to position the following day.
- ❐ Installation in the work room of a system of re-visualisation of cassettes recorded by the ROV and a large-screen TV.
- ❐ Definition of a search in a fifty by fifty metre square.
- ❐ Loss of the acoustic USBL, interruption of the ROV work.
- ❐ Identification of wreckage (parts of fuselage, engine, etc.)

Thursday 15 January 2004



- Definition of an adjacent search zone (fifty by fifty metres).
- Movement of the *Ile de Batz* to free the zone so as to put the ACSA system drift beacons in place (on the south point).
- Arrival of the *Beautemps-Beaupré* on zone and bathymetric soundings.
- Maintenance operation on the Scorpio after a hydraulic failure.
- Finalisation of the procedure for handing over the recorders to the Egyptian authorities. Decision reached for the BEA to hand over the recorders to the Egyptian Commission of Inquiry at the military port in Sharm el-Sheikh.

Friday 16 January 2004



- Departure of the *Somme* supply tanker.
- Transmission to the *Ile de Batz* of results from the bathymetry performed by the *Beautemps-Beaupré*.
- Dive in the ACSA zone, located around seventy metres south of point zero. Definition of a square twenty metres by twenty.
- Interruptions associated with loss of acoustic signals and hydraulic problems.
- **18 h 45: visual localization of the FDR**
  - **position: 27°52’3602 N / 034°22’0165 E**
- ROV, with the FDR, begins ascent.
- ROV immobilised at one hundred metres while awaiting the arrival on board of Egyptian authorities to formalize the recovery of the recorder.

Saturday 17 January 2004 (1/2)

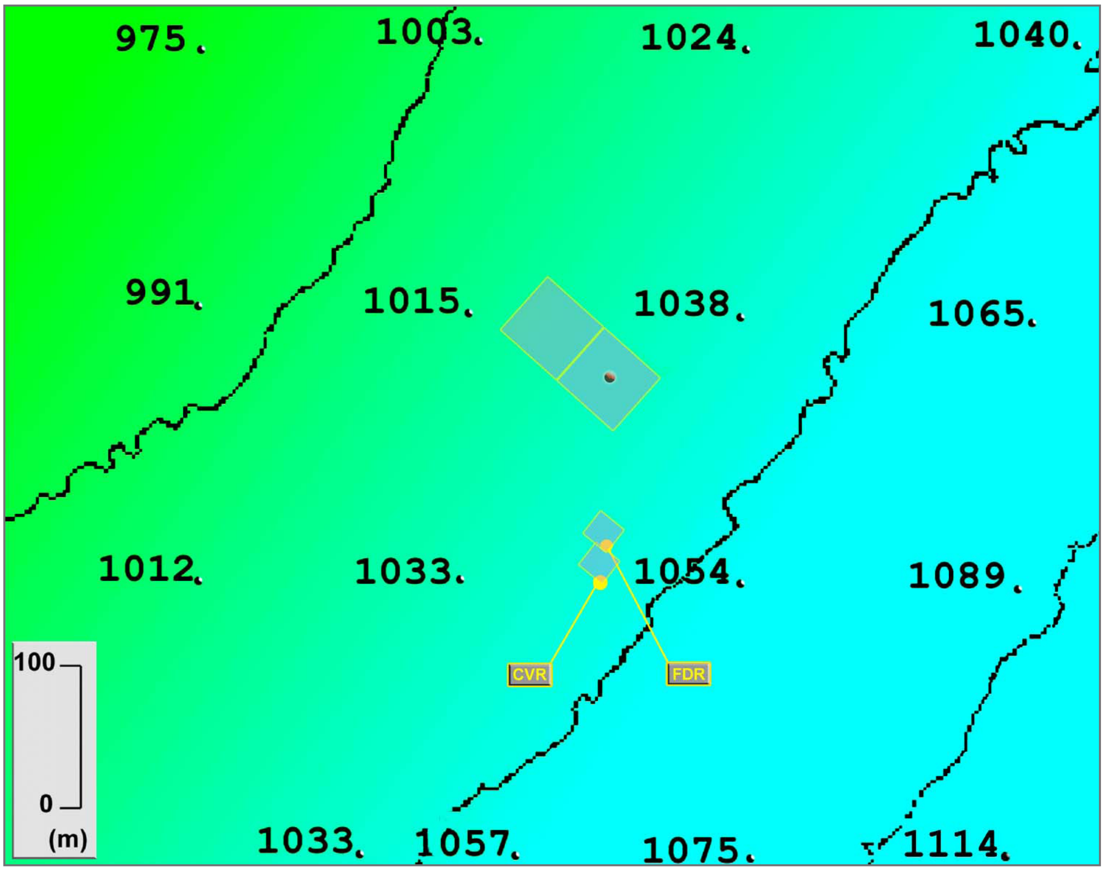
Recovery of the FDR

- 2 h 00 Presence of the Egyptian judicial authorities in the context of the international judicial commission and the commission of inquiry for the ROV surfacing with the FDR in its basket.

- Official handover of the FDR by the BEA to the Egyptian commission of Inquiry in the port of Sharm el-Sheikh via the judicial authorities.

FDR transportation (immersed)

Saturday 17 January 2004 (2/2)



- Maintenance and repairs to the ROV, restart of exploration in the ACSA zone where the FDR was found.
- Probable identification of wreckage of frame of a rear door close to the position of the recorders.
- Strategy meeting on the conduct of the search for the CVR (discussion of two possible options).
- Beginning of exploration of a new twenty by twenty metre square adjacent to the previous one and located further south.
- **20 h 30: visual localization of the CVR**
  - **position: 27°52'3474 N / 034°22'0233 E**
- Recovery of the CVR, more severely damaged than the FDR (ULB beacon missing). Wait for representative officials to arrive before surfacing.
- Arrival of the Comex *Janus II*.

Sunday 18 January 2004

Raising the CVR

- 4 h 30: ROV with the CVR in its basket on the deck of the *Ile de Batz* in the presence of the Egyptian and French authorities (commission of inquiry and judicial authorities).

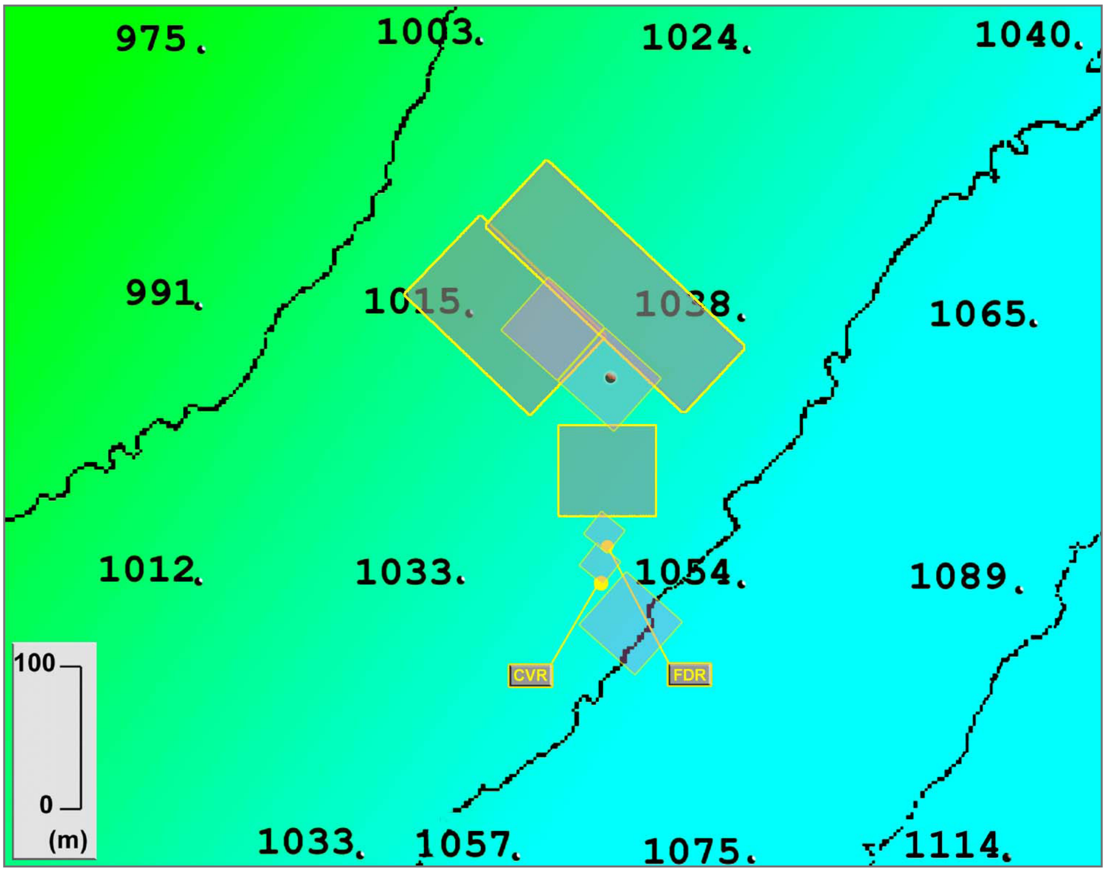
- Distribution of search zones of between the *Ile de Batz* and the *Janus II*.

- Collision involving the *Janus II* and a ship from the Egyptian Navy (consequences: examinations, repairs and Veritas agreement).

- Current measurement from the *Beautemps-Beaupré* over 24 hours from 9 h 30
  - Observation of the vertical structure of the current at a fixed point (27°52.7′ N / 034°21.6′ E)

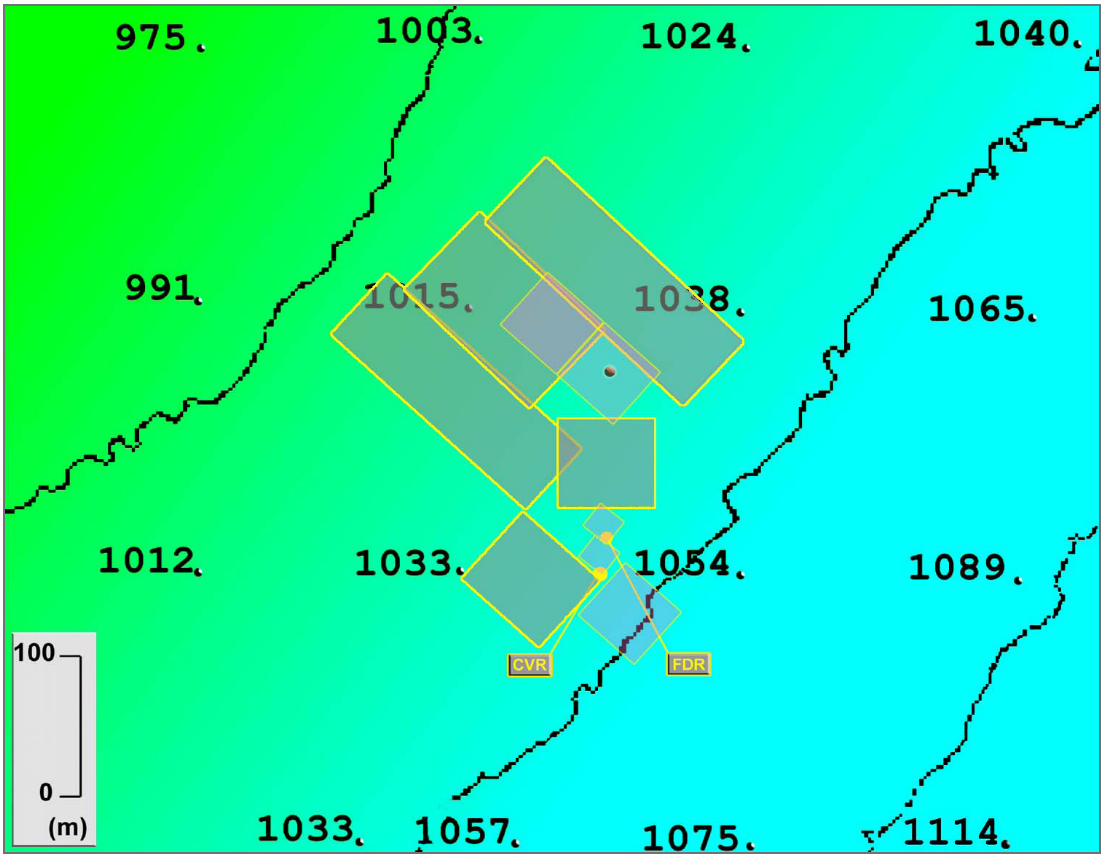
- Test dive by Super Achille to 1,014 m (adjustment of lighting and controls)

Monday 19 January 2004



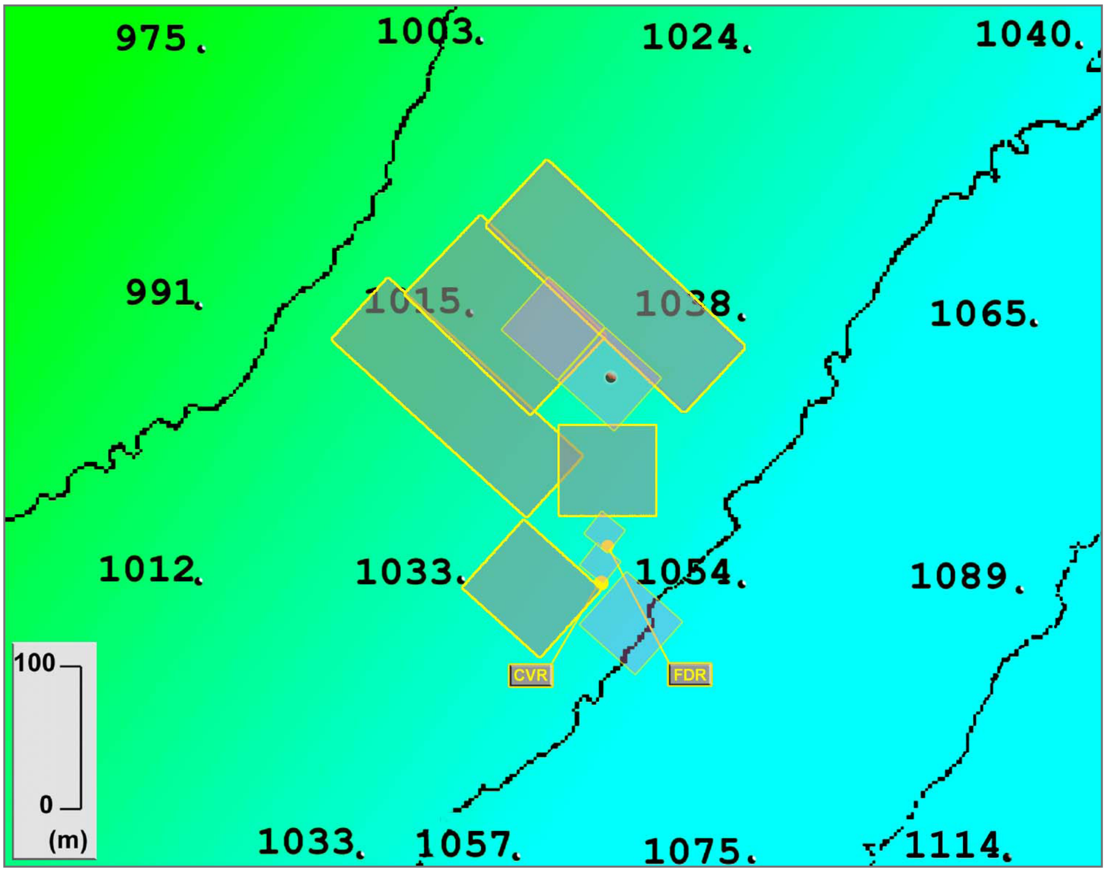
- Work on wreckage mapping by the *Janus* and *Scorpio*.
- Scorpio: south zone.
- Super Achille: north zone.
- Discovery of engines and of the main landing gear to the south of the recorders.

Tuesday 20 January 2004



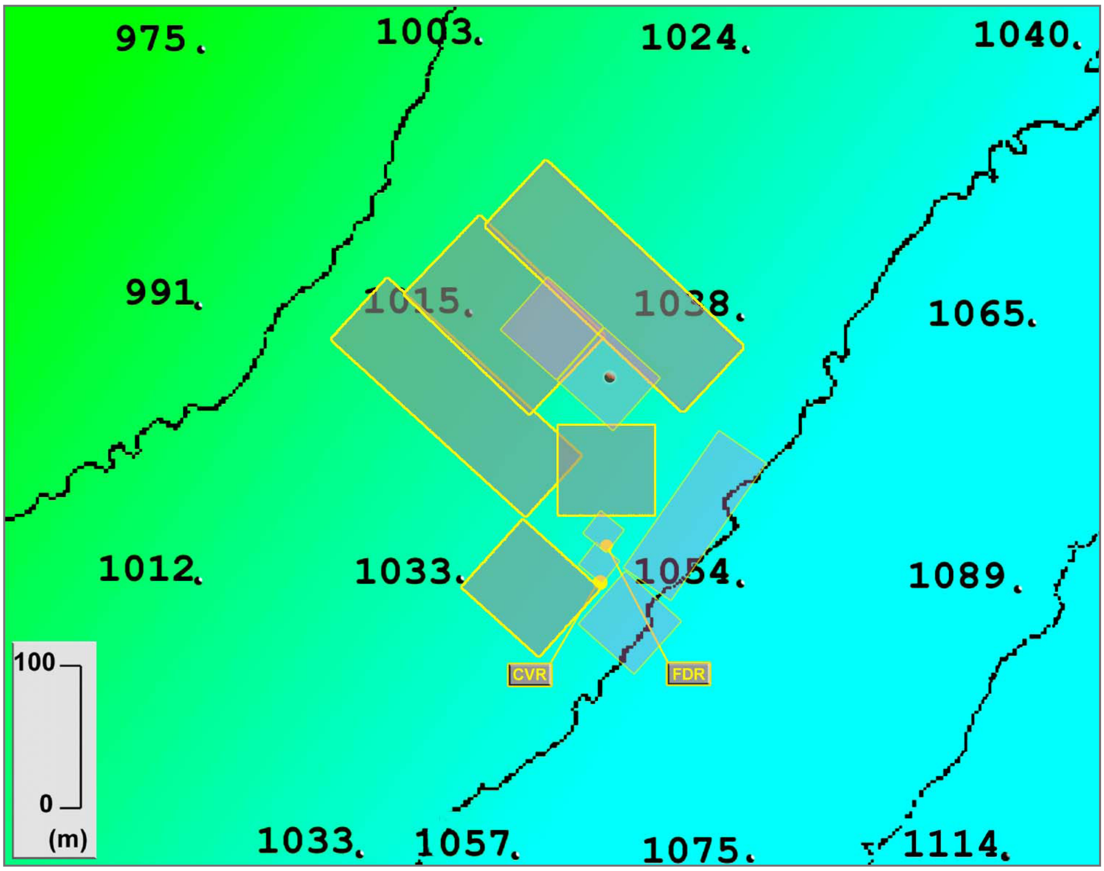
- ❐ Continuation of mapping work by Super Achille (definition of the wreckage zone to the west).
- ❐ Discovery of parts from the controls, of the nose gear, etc.
- ❐ Scorpio: inter-contract situation.
- ❐ Coordination with the investigators in Cairo, readout and preliminary analysis of first data from recorders.

Wednesday 21 January 2004



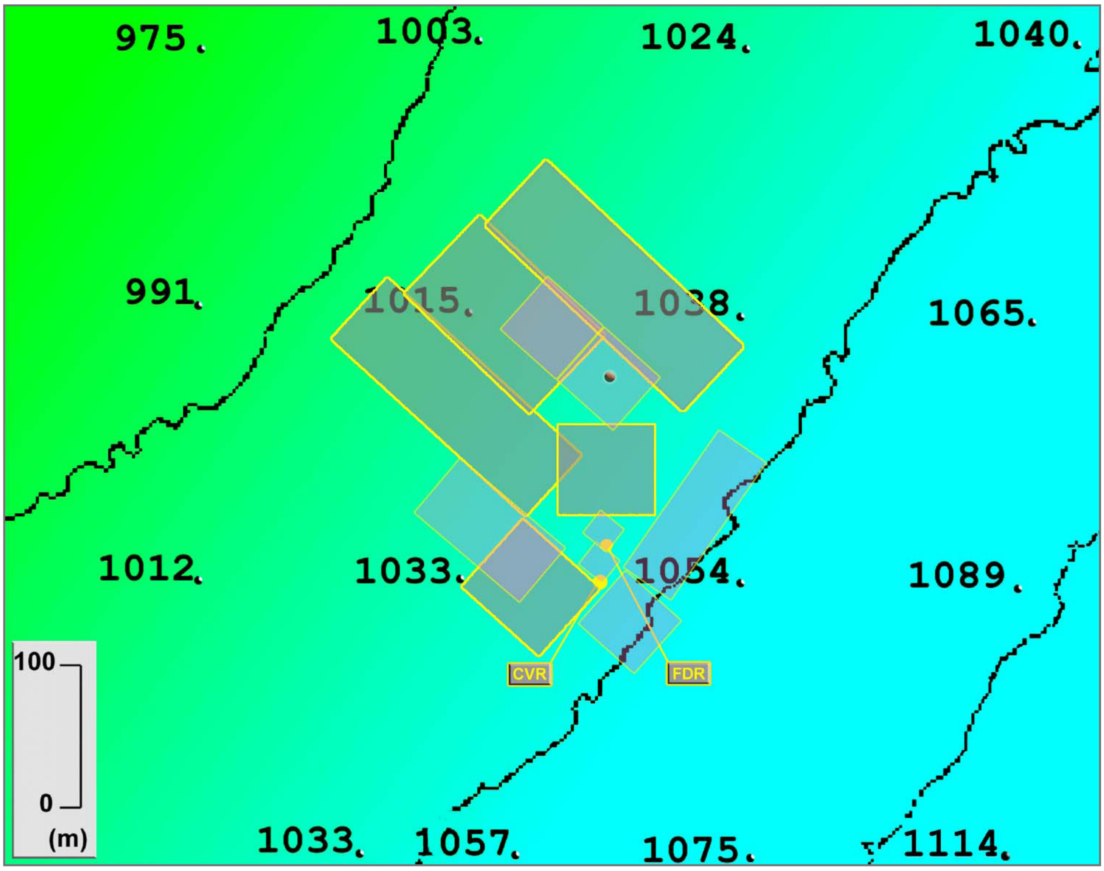
- Definition of the wreckage zone by the Scorpio (fin of the square south).
- Problems with compass and humidity in electronic boxes on the Scorpio.
- Decision to raise the horizontal stabiliser as well as several other airplane parts in coordination with the investigators in Cairo.
- Visit of an official Franco-Egyptian delegation in the context of the International Judicial Commission.
- Repairs on board the *Janus II* following a collision with an Egyptian ship (inter-contract situation).
- Departure of ACSA personnel, GIB equipment and of Cephismer equipment (Achille ROV, Helle pole).

Thursday 22 January 2004



- ❐ Beginning of recovery of parts related to airplane control surfaces.
- ❐ The *Ile de Batz* lowered a recovery basket.
- ❐ Veritas expert on board of the *Janus II* (inter-contract situation).
- ❐ Mapping of the south-east zone by the Scorpio.
- ❐ Departure of the *Beautemps-Beaupré*.

Friday 23 January 2004



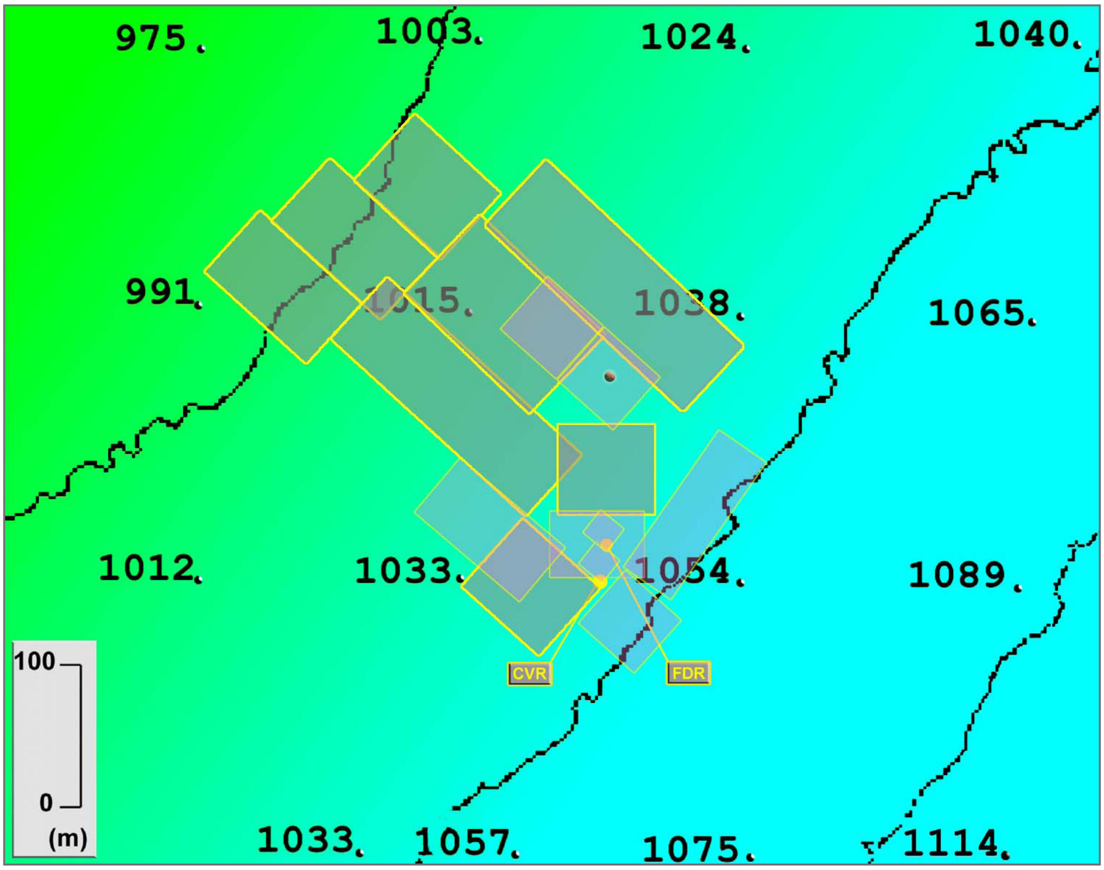
- ❒ Port of Sharm el-Sheikh closed due to sandstorm, no ferries between the port and the *Ile de Batz* (wind around forty knots).
- ❒ Recovery of six parts (RW4 → RW9) raised by the *Ile de Batz* (large basket).
- ❒ Beginning of joint operation by the *Janus II* and the *Ile de Batz* to raise a part of the horizontal stabiliser (four metres long, reference photo T87).

Saturday 24 January 2004 (1/2)

Raising a part of the horizontal stabilizer

Conservation of the part in tanks of seawater

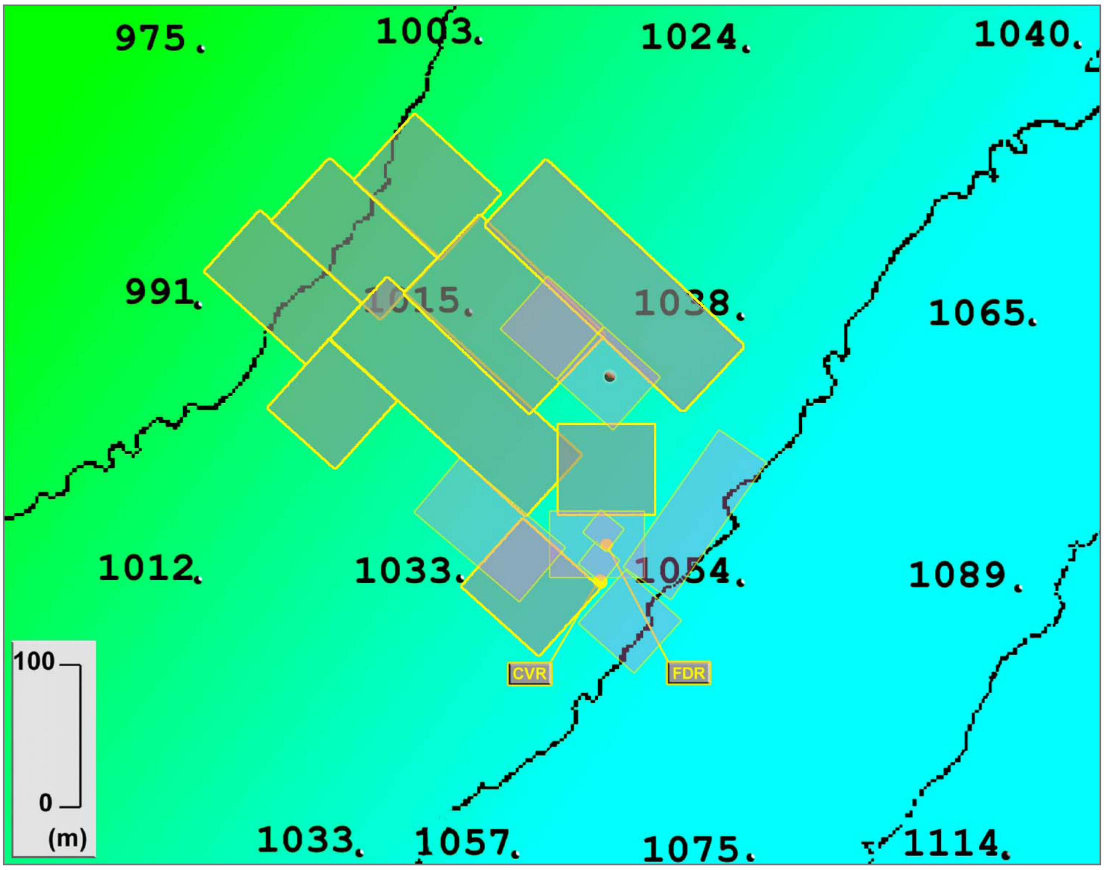
Saturday 24 January 2004 (2/2)



- ❒ Continuation of mapping operations (north-west zone by the Super Achille and central zone by the Scorpio) and of parts raising.

- ❒ Beginning of the recovery of the part of the tail containing the servo-controls (PCU actuator) ;
  - operation started by the Scorpio using its arm but abandoned due to dimensions and weight of the part to be raised.

Sunday 25 January 2004



- Preparation of the equipment required to raise the tail (weights, acoustic beacon, hook, line end, etc.)

- Continuation of the recovery of part of the tail;
  - operation taken over by the Super Achille, using a line end equipped with a cable to attach the part.

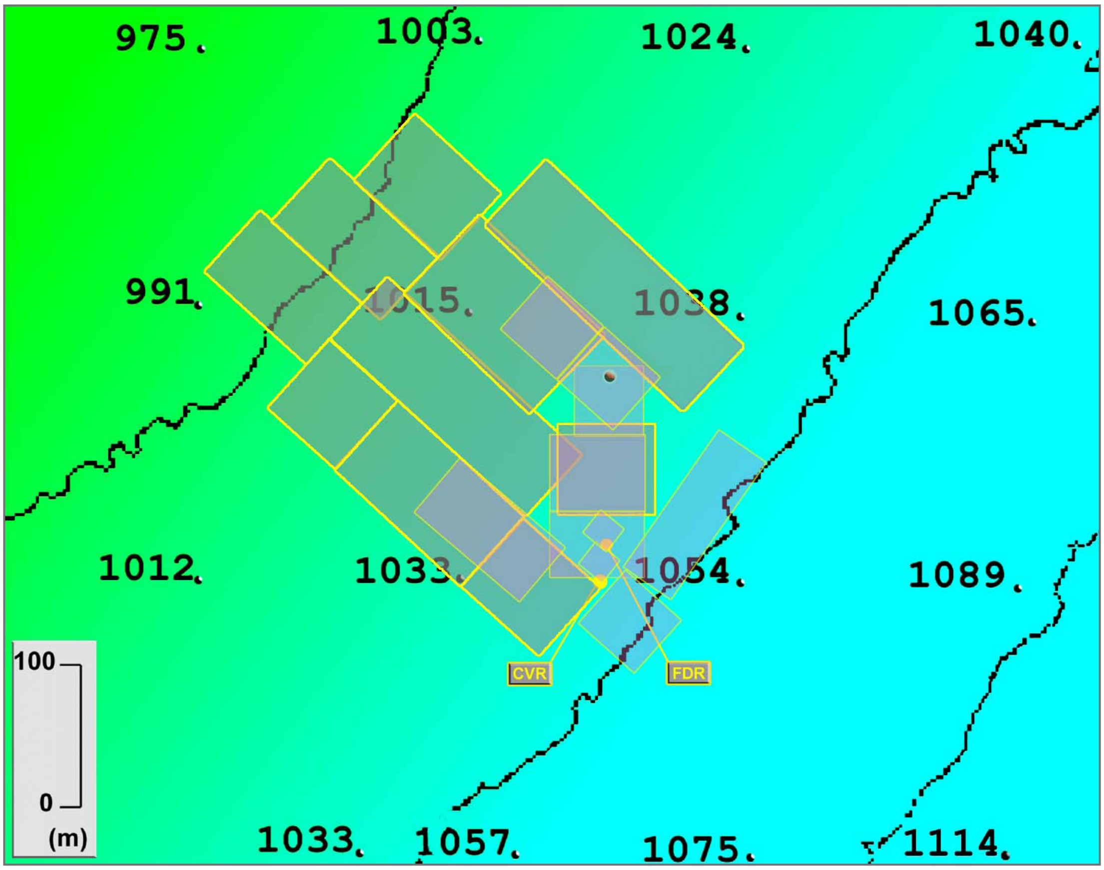
- Transfer of parts raised by the Super Achille and the *Janus II* to the *Ile de Batz* (referencing and conservation of wreckage).

Monday 26 January 2004 (1/2)

Two ships working in close proximity

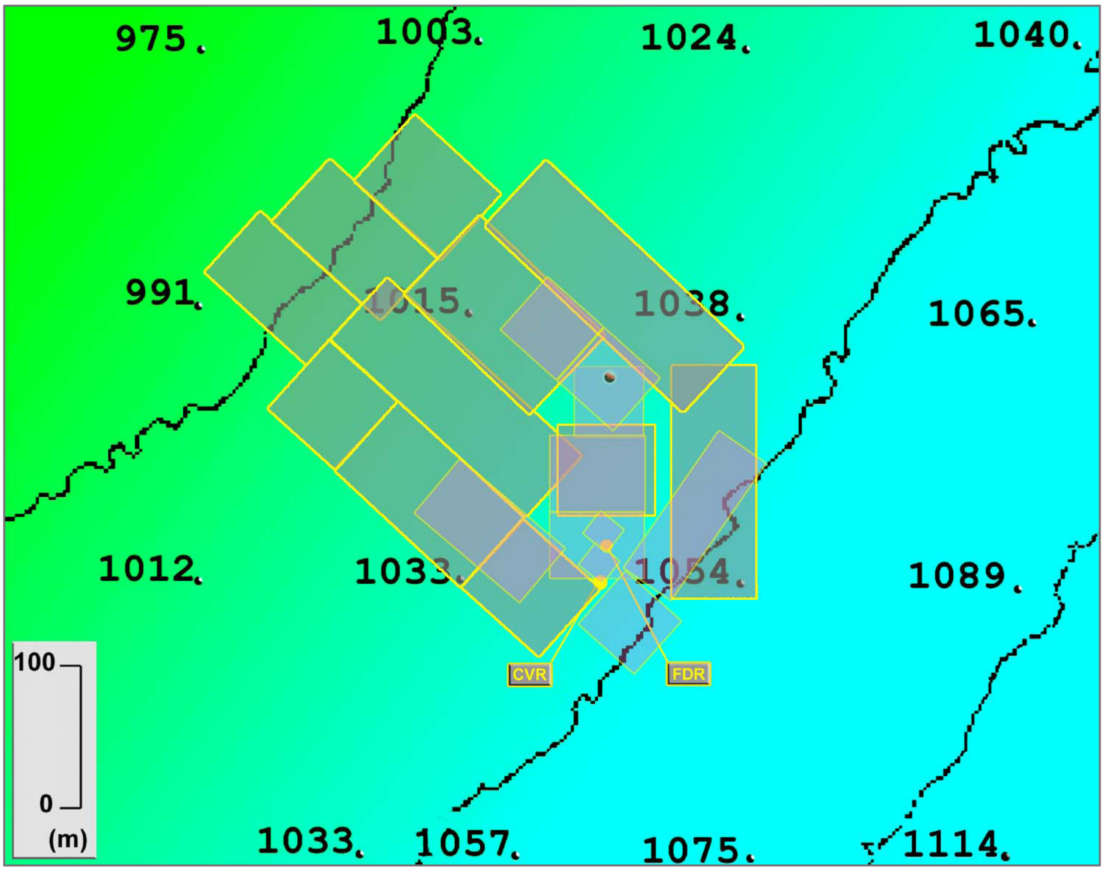
Recovery of the tail

Monday 26 January 2004 (2/2)



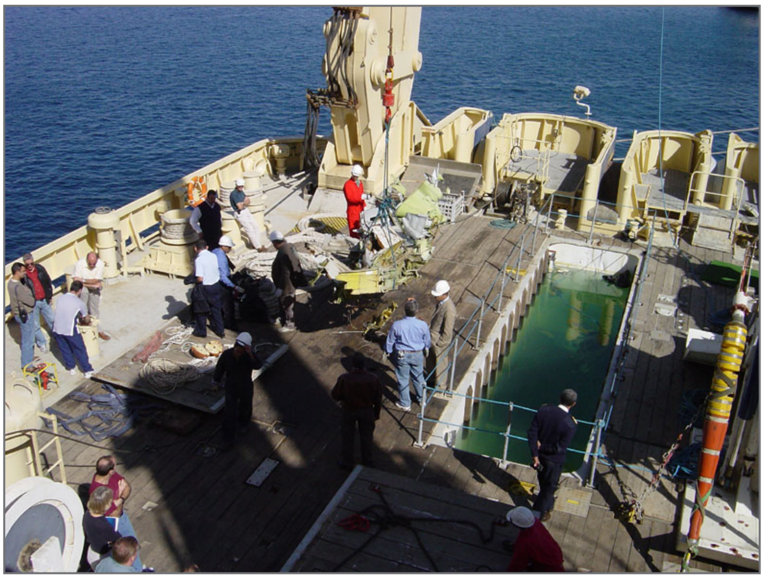
- End of mapping and raising of wreckage in the south-west zone.
- *Janus II* moved to recover the wreckage already found and identified.

Tuesday 27 January 2004 (1/2)



- Transfer of parts from the *Janus II* to the *Ile de Batz*.
- End of search by the *Ile de Batz*, unloading of parts in the military port at Sharm el-Sheikh.
- *Janus II*: continuation of mapping operations and raising parts to the east of the wreckage zone (eastern limits).
- Move to the south for an inspection of the engine zone.

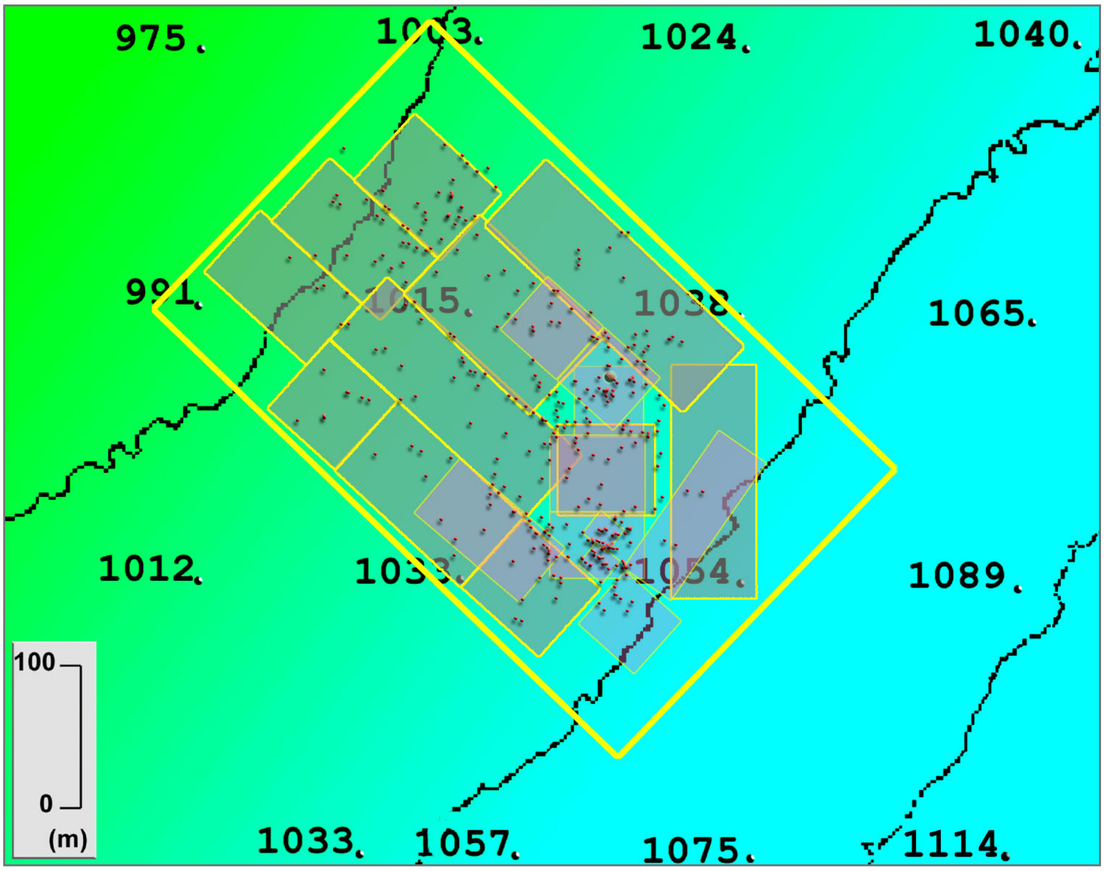
Tuesday 27 January 2004 (2/2)



Parts conservation in tanks

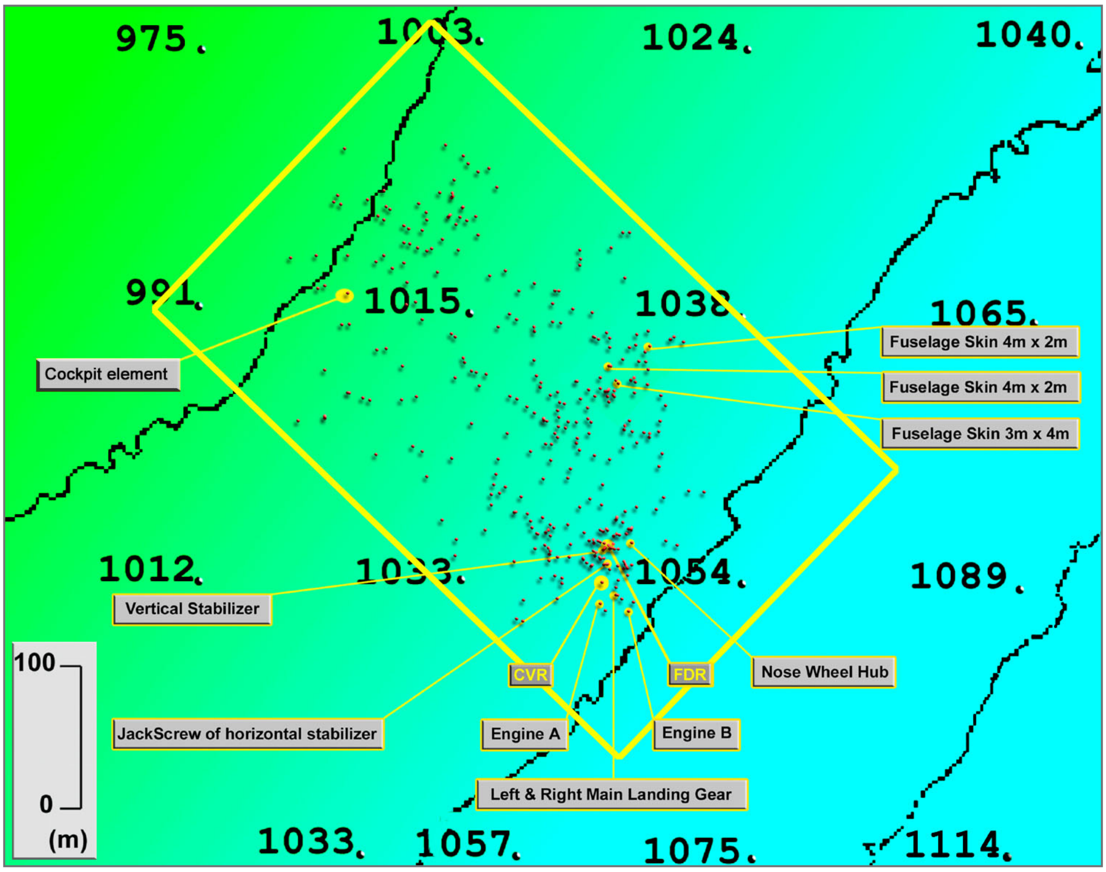
Unloading operations

Limits of the site



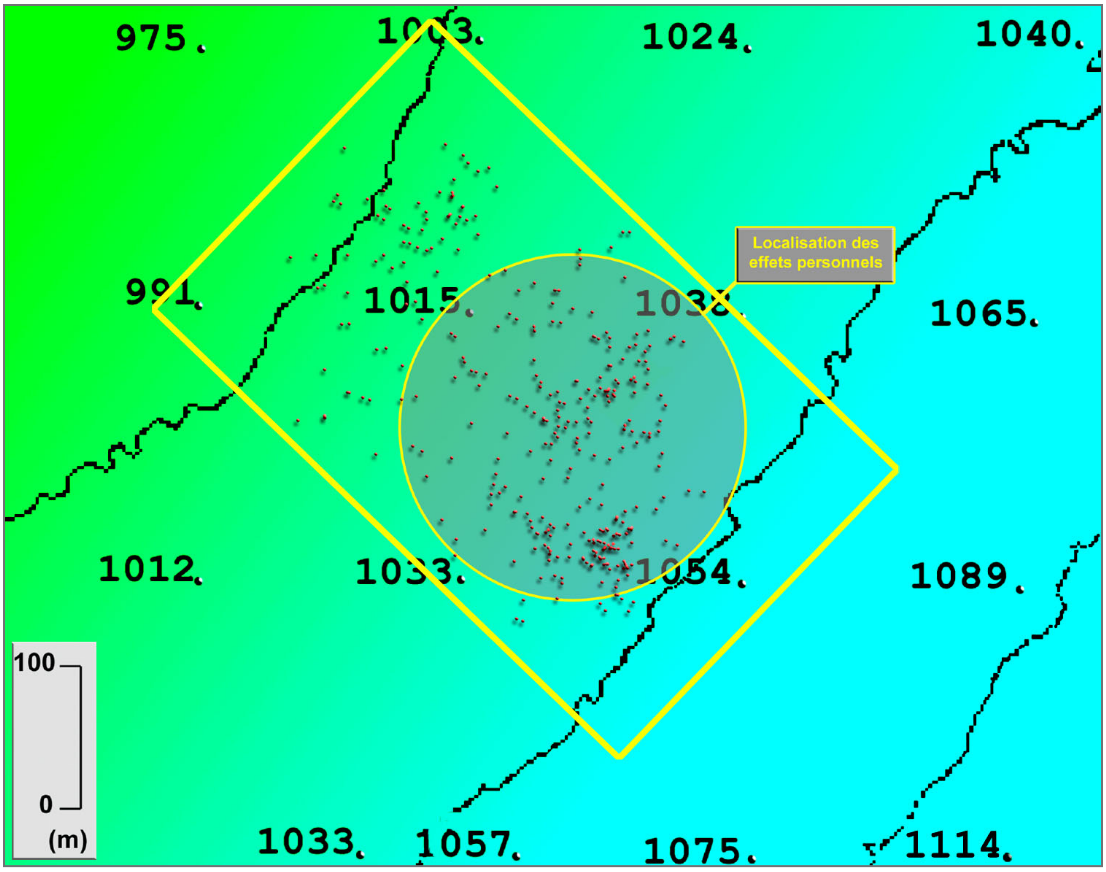
- The site represented a rectangle 275 m by 440 m and an area of around 121,000 m².

Distribution of wreckage



❐ The heavy parts such as the engines and the landing gear found near the point of impact. The lighter wreckage was distributed in relation to the north-east current and the last heading of airplane towards the north-west.

Searches from 28 January to 5 February



- 28 January 2004:

  - Super Achille ROV moved from the site towards the zone located around the ACSA point north of coordinates 27°52.689' N 034° 21.933' E, this zone corresponding in theory to the localization of the CVR's pinger. During this move in visual contact with the seafloor no elements related to the accident were noticed.

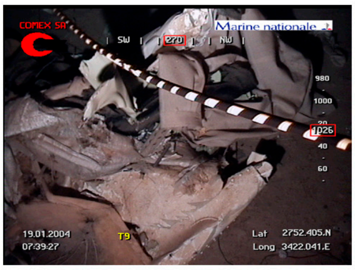
  - From this last point, extension of the exploration towards the point at 27° 53.031' N 034° 21.825' E

- From 28 January to 5 February, additional searches and systematic recovery of personal effects.

Extract from the database used to track search areas

T#	lattitude	longitude	description	action	Janus II photo reference
Prime targets from Janus survey					
n/a	52.4270	21.9890	Pile of electrical wires beside T54	look at	2004-01-19-200844.JPG
n/a	52.4160	21.9390	not ident.	look at	2004-01-20-120103.JPG
T1	52.4090	21.9915	Mid flap	retrieve	
T2	52.4090	21.9900	MLG door mecanisme		
T3	52.4100	21.9900	Passager seat frame		
T4	52.4150	22.0440	Fuselage skin		
T5	52.4090	22.0280	Seat frame		
T6	52.4041	22.0103	Fuselage skin		
T7	52.4055	22.0258	Fuselage skin		
T8	52.4047	22.0293	Mecanisme		
T9	52.4040	22.0369	Safety, life jacket and fuselage	look at	2004-01-19-073927.JPG
T10	52.4047	22.0409	Piece of wing surface		
T11	52.4025	22.0367	Aluminium with blue paint		
T12	52.4043	22.0343	Aluminium and electric cable		
T13	52.4070	22.0260	Piece of wing		
T14	52.4084	22.0044	Frame		
T15	52.4060	21.9998	Piece of passanger seat		
T16	52.4040	21.9951	Fuselage skin / windows		
T17	52.4022	22.0050	Windows frame		
T18	52.3975	22.0057	PSU		
T19	52.3960	22.0425	Skin		
T20	52.3983	22.0253	Lower skin		
T21	52.4002	22.0045	Fuselage skin		
T22	52.4025	21.9963	Seat frame		
T23	52.3997	21.9934	Fuselage Skin		
T24	52.4004	22.0312	Metal Disk (engine)		
T25	52.3954	22.0124	Composite piece. Belt and tissue		
T26	52.3937	22.0193	Metal Piece		
T27	52.3910	22.0410	Fuselage and windows		
T28	52.3936	21.9933	spoiler actuator attached to portion of the wing spar	retrieve	2004-01-19-094158.JPG, 2004-01-20-170624.JPG, 2004-01-20-170615.JPG
T29	52.3840	22.0161	Wing access panel		
T30	52.3750	22.0060	Composity panel		
T31	52.3861	21.9899	Rear part of fuselage		
T32	52.3865	22.0006	Pylon		
T33	52.3750	22.0310	Lower body skin		
T34	52.3788	22.0431	flt. Cont. cable drum	retrieve	2004-01-19-112045.JPG
T35	52.4380	22.0280	Fuselage skin		
T36	52.4400	22.0520	Fuselage skin with "Cut here" indicated		
T37	52.4420	22.0480	look under	look at	2004-01-19-132940.JPG, 2004-01-19-133012.JPG
T38	52.4260	22.0300	Composite panel fixed te Wing pilot		
T39	52.4190	22.0420	handle skin		
T40	52.4420	22.0120	Wing	look at	2004-01-19-160043.JPG, 2004-01-19-155924.JPG
T41	52.4650	22.0260	RIB horizontal stabilizer		
T42	52.4530	22.0030	Fuselage section with "FLASH" text	retrieve	2004-01-19-162335.JPG, 2004-01-19-163724.JPG, 2004-01-19-163717.JPG
T43	52.4830	22.0280	Upper fuselage part		
T44	52.4550	21.9940	Forward entry door frame		
T45	52.4700	22.0060	Part with number		
T46	52.4770	22.0200	Fuselage part with a door cutout		
T47	52.4760	22.0060	Fuselage part "Brew handle must be in down position during taxi, take off, turbulence and landing"		
T48	52.4600	21.9950	Leading edge slat with part of wing	retrieve	2004-01-19-193417.JPG
T49	52.4120	21.9860	Lower wing scan with leading slat panel		
T50	52.4244	22.0042	Skin		
T51	52.4191	21.9929	Skin		
T52	52.4240	21.9890	Leading edge slat with one actuatorattached	retrieve	2004-01-19-195521.JPG
T53	52.4146	21.9826	Nose landing gear assembled		
T54	52.4266	21.9869	Main Equipment Center skin door	look at	2004-01-19-201051.JPG, 2004-01-19-201214.JPG

Example of referenced submarine photos



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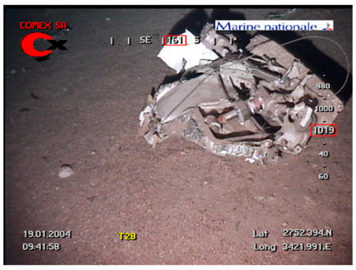

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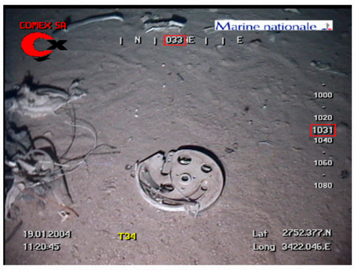

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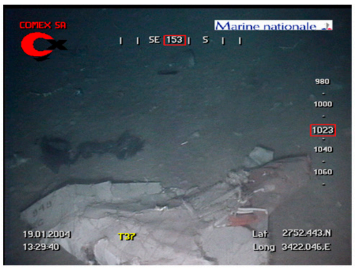


2004-01-19-132940.JPG

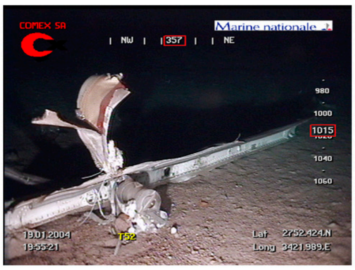
2004-01-19-133012.JPG

2004-01-19-160043.JPG

2004-01-19-163717.JPG

2004-01-19-163724.JPG

2004-01-19-193417.JPG



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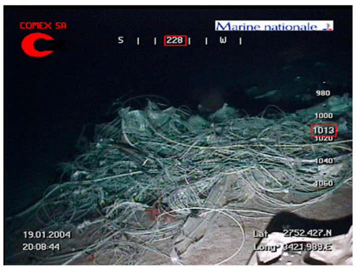
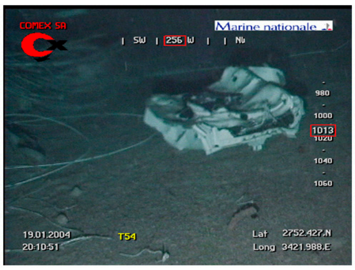


2004-01-19-200844.JPG



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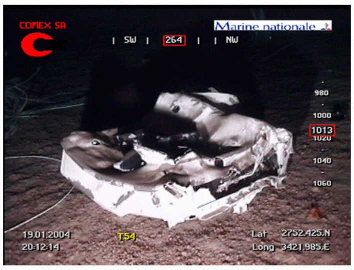
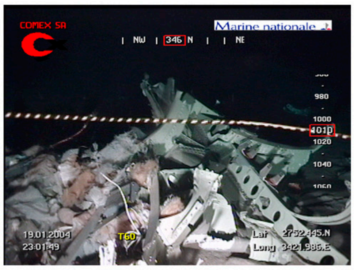


2004-01-19-201214.JPG

2004-01-19-230124.JPG



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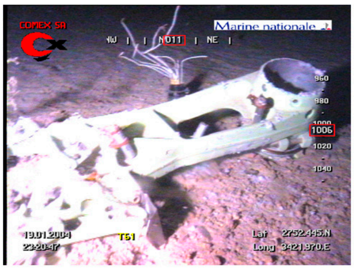

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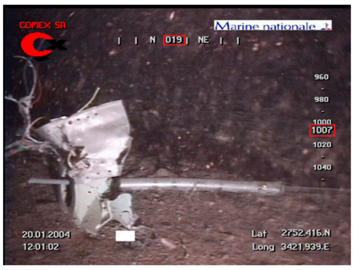

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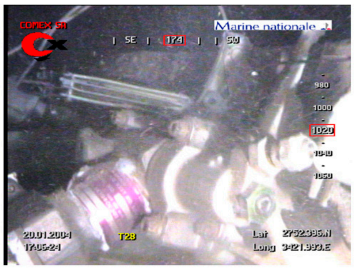

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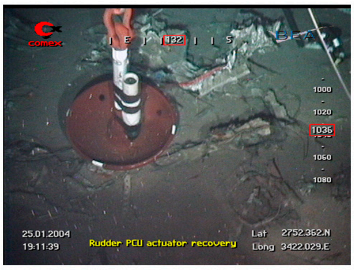

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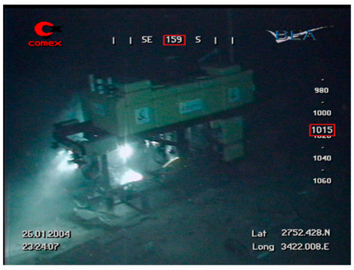

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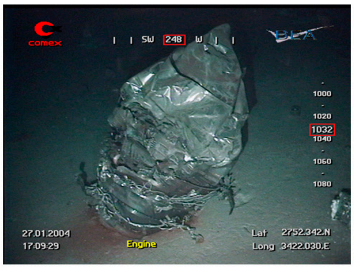
2004-01-26-232443.JPG



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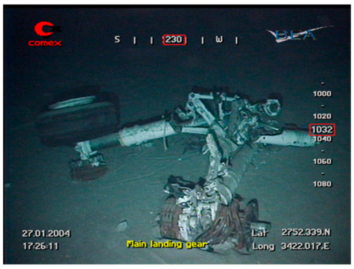

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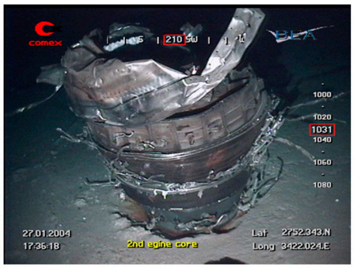

2004-01-27-173619.JPG

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