ECAC Group of Experts on Aviation Accident Investigation (ACC)

Workshop on Underwater Recovery Operations

Dubrovnik, 10-12 June 2009

Report

The ECAC Secretariat wishes to thank all participants who kindly put their photos at our disposal, many of which are used to illustrate this report.

INTRODUCTION

On 10-12 June 2009, European experts in aircraft accident investigation came together in Dubrovnik for a workshop on the special challenges around the location and recovery of aircraft and flight recorders lost beneath water. This was the latest in a series of workshops organised by ECAC's Group of Experts on Accident Investigation (ACC), under the chairmanship of PAUL-LOUIS ARSLANIAN, Director of the French *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile* (BEA).

In any accident investigation, access to the site of the accident and to the wreckage is a first priority. When the aircraft comes down in the sea, or in difficult desert, jungle or mountain terrain, this question of access can become problematic in itself, calling for a well-planned and rapid response, coordinated amongst many parties, if important evidence of the cause of the accident is not to be lost. The costs of location and recovery operations in such circumstances may well exceed the normal budget of the investigating authority, presenting a further challenge.

The objective of the Dubrovnik workshop was to provide participants with a comprehensive overview of the procedures and equipment needed for an effective response to aviation accidents with an underwater dimension, through the sharing of learning and personal experience, and through practical exercises. The workshop had been prepared over a period of almost a year by a small Steering Group established for the purpose. It enjoyed excellent support from the Croatian Ministry of the Sea, Transport and Infrastructure's Accident Investigation Body, from the French BEA, and from the Air Accident Investigation Branch of the UK Department for Transport. The practical element also involved the welcome participation of professional divers from Croatia and Hungary.

It was no more than a coincidence that the Dubrovnik workshop took place soon after the tragic loss of Air France 447 in the mid-Atlantic, although that inevitably lent the event a special poignancy. The particular focus of the workshop was the location and recovery of flight recorders and aircraft wreckage lost in relatively shallow waters. Such operations when conducted in deep water naturally require the use of rather different kinds of equipment and techniques.

Organisation of the Workshop

The agenda for the workshop is at Appendix 3. The first day saw a briefing on aircraft accident investigation in Croatia, followed by a series of presentations by ACC members and observers on past examples of underwater recovery, including cases involving location and recovery from lakes and rivers, as well as from the sea.

The second day was then devoted to practical exercises at sea, organised around a scenario involving a mid-air collision between a passenger airliner and a small general aviation aircraft. During these exercises, flight recorders and a substantial piece of aircraft wreckage, previously positioned, were searched for and successfully located and raised.

The final day of the workshop saw further presentations on past underwater recovery operations, discussion of the insurance option for the funding of expensive investigations, and a detailed de-briefing on the exercises. It was the Expert Group's intention to consider further the learning from the exercises at its next meeting, in Lisbon in November 2009, where it was hoped that some of this could be captured through the development of, for example, check lists dealing with the preparation for an underwater recovery operation, and for its handling on the spot.

Involvement of ECAC Partners

The ACC was pleased to welcome to the workshop colleagues from Singapore, Hong Kong, the United States and Tunisia, who added their own experiences and perspectives.

Mr Chow W. Chong, Senior Investigator at the Singapore Air Accident Investigation Bureau, took the opportunity to brief the meeting on the International Accident Investigation Forum due to take place on 21/23 April 2010 at the Singapore Aviation Academy. Invitations to this event, the agenda for which would include AIG 2008 follow-up, the sharing and protection of safety information, bird-strike, international cooperation and input from manufacturers, would be issuing in due course, and papers invited.

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FIRST DAY OF THE WORKSHOP: JUNE 10

Chairman's Opening Remarks

As chairman of the ACC, Mr Arslanian welcomed all participants to the workshop. He expressed his gratitude to the Croatian authorities for having invited the group to the beautiful and historic city of Dubrovnik, and for all the hard work which they had done over the past many months to ensure that the workshop was successful. He asked the head of Croatia's air accident unit Mr Dinko Vodanović to transmit the ACC's thanks to all concerned, and acknowledged in particular the part played by Mr Vodanović himself, through his enthusiasm, efficiency and dedication to aviation safety, and as an experienced investigator and active member of ACC.

Mr Arslanian noted that the workshop was the fifth to be organised by ACC, under the auspices of ECAC, in order to address an aspect of accident investigation. In 2000 a symposium had been held in Tallinn on assistance to the victims of aviation accidents and to their families. In 2002, ACC had reviewed in Nicosia the national implementation of aircraft accident and incident investigation regulations and guidance. In 2005, in Bucharest, the Group had addressed the communication aspects of accident and incident investigation and in 2006, in Athens, the drafting and issuing of safety recommendations.

Mr Arslanian observed that poor preparation and poor management of an accident in any problematic location had the potential to degenerate into a crisis on a national or even international scale, not to mention the probable loss of crucial evidence. He noted some of the critical factors in underwater recovery operations:

- the tools and other necessary resources for an underwater operation, and the way in which they are organised, will differ according to a number of parameters, of which the depth of the water was only one;

- the first step was to reach as precise an understanding as possible of the environment, together with a good knowledge of the tools available and other potential resources;

- information contacts, feedback loops, coordination with every potential partner (for example military and foreign affairs, or colleagues from abroad) should be established as soon as possible; and

- most States had the resources to handle the first days following an accident on land, but when the aircraft was under water the position changed. Identifying the budget and other resources for the operation became a serious challenge, especially when the role of each actor cannot be determined in advance.

Mr Arslanian noted that the ambitions for the workshop were set very high, and that not all would be met over its course. ACC would return to the issues at its next meeting. Consideration could also be given then to possibly mounting in 2010 another workshop on underwater recovery, in order to continue to exchange experience and undertake common training, for example in the use of remotely operated vehicles (ROVs) where operations in deeper waters were needed.

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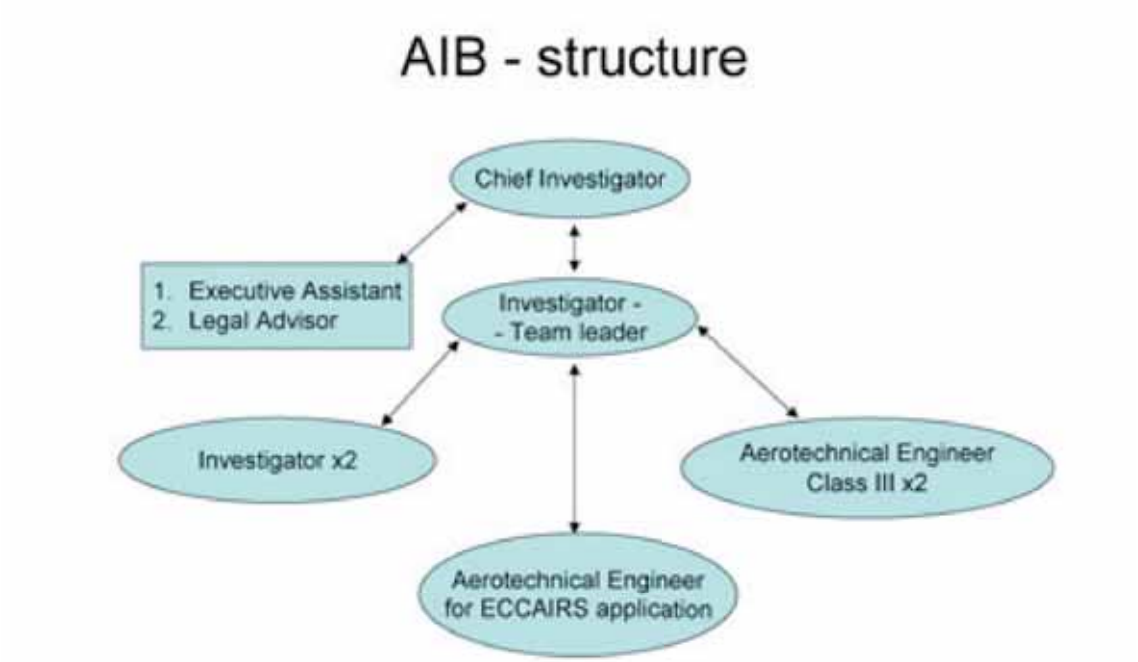
"Air Accident Investigation in Croatia"

A presentation by Mr Dinko Vodanovic
Croatian Accident Investigation Board, Ministry of the Sea, Transport and Infrastructure

Air accident investigation in Croatia, as laid out in the Air Traffic Act, followed the provisions of EU Directives 94/56/EU and 2003/42/EU, and of Annex 13 of the Chicago Convention. The Croatian arrangements had undergone an ICAO audit in 2003. The Board was presently implementing the ECCAIRS programme for the collection and analysis of events relating to safety threats, accidents and serious incidents, in line with EU Directives 1321/2007 and 1330/2007.

Recent accidents investigated by the Croatian AIB included the loss of two of eight general aviation aircraft flying together towards the Adriatic, with four fatalities; the loss near the island of Unije of a Cessna C-172, which had needed to be salvaged from a depth of 15 metres by a specially equipped salvage vessel (pictured below); the belly-landing of a Piper PA-44 at Zadar, in the northern Dalmatian region of Croatia, owing to a micro-switch failure; and a bird strike during an Airbus 310 take-off at Zagreb Airport which had left only one undercarriage tyre undamaged. For the past three years, human error had been identified as an increasingly frequent factor in aviation accidents and incidents.



Participants were then given a series of presentations on aspects of underwater recovery.

"LOCATING THE AL SALAM BOCCACCIO 98, RED SEA, FEBRUARY 2006"

A PRESENTATION BY ADRIAN BURROWS
AIR ACCIDENT INVESTIGATION BRANCH, UK DEPARTMENT FOR TRANSPORT

On 2 February 2006, the Al-Salam Boccaccio 98, an Egyptian Roll On/Roll Off passenger ferry, sank in the Red Sea en route from Duba, Saudi Arabia, to Safaga in southern Egypt. Its last known position was 100 km from Duba. The ship was carrying some 1,300 passengers and about 100 crew, cargo and about 27 vehicles. Only 388 people survived.

The Al-Salam Boccaccio 98 was equipped with a Voyage Data Recorder (VDR) of British manufacture that was fitted with an underwater acoustic beacon, as found on all aircraft flight recorders. Because of its British manufacture, the International Maritime Organisation sought assistance from the UK's Marine Accident Investigation Branch, which in turn approached the UK's AAIB to assist with the location of the vessel. The beacon emits a pulse of 10 milliseconds, each second, for a period of at least 30 days, after which the signal fades. The AAIB brought to Safaga its Underwater Beacon Location (UBL) System, comprising a hydrophone array, connecting cables and detector unit. The UBL system could be towed behind vessel, travelling at approximately 5 knots, and was capable of picking up a signal 2.5 kilometers away, if present. The water in the area in which the Al-Salam Boccaccio 98 was believed to have been lost was some 900 metres in depth.

A search area was indentified that reflected estimates of the vessel's last known position from various sources, and where items from the ferry had been recovered. The

search area was split into a grid of eight parallel tracks one nautical mile apart and five nautical miles long, which would take about 10 hours to search. However, no signal was detected in this area, so a second search grid was formed alongside the first, along the route the ferry would have been taking. The signal was soon detected in the new search area and an attempt was made to "box" the signal (ie detect from four sides which bounded the signal in a box), so that a best estimate of its position could be made. Due to deteriorating weather conditions, this "boxing" of the signal became increasingly difficult ; however, a best estimate of position was made, at the centre of a 1x1 kilometer square.

Several days later, once the weather had improved, the investigative team returned to the search area aboard the vessel MV Scandi Bergen equipped with an ROV and crane to be used to recover the VDR from the ferry. The one kilometer square was split into 21 parallel tracks (ie 50 meters apart) for the ROV to follow. It was hoped that the cameras and sonar equipment on board the ROV would quickly detect the ferry, but problems with the sonar, unknown to the operators, meant that nothing had been found after 20 of the 21 tracks had been run. There was then an electrical problem aboard the vessel, making it necessary to use handheld UBL detection equipment from the side of the stationery vessel, to try and get a better fix on the signal.

The signal was again detected (towards the end of the 21st track) and the vessel's safety boat was launched so that the handheld equipment could be used to home in on the signal from the surface. A new estimate of position was then identified, within 85 meters of the actual position. The ROV (now fully functional) was manœuvered towards this position and soon detected the ferry. The ROV was then used to survey the site and guide cables from the crane to be attached to the VDR. This was subsequently pulled free and recovered to the surface.

A number of lessons were drawn by the AAIB from the experience of searching for the Al Salam Boccaccio 98. These included:

- a dynamic search (ie using equipment that is towed) is very efficient but not particularly accurate, so refinement of position is needed;

- towing the hydrophone array at a speed of 5 knots, with a track spacing of 1 nautical mile, is effective for a 900 meter depth and flat sandy sea bed;
- it is preferable that the towing vessel be equipped with a working autopilot so that the search grid is more accurately followed;
- the hydrophone array is able to be deployed to good effect in less than perfect sea conditions;
- a good working relationship between the search team and the captain of the host vessel is extremely important; and
- the AAIB's UBL system, while effective, is relatively bulky, labour intensive to use and not especially sea-worthy. [1]

"Search and Recovery of the 2007 Agusta Westland A109 Accident near Giglio's Island"

A presentation by Mario Colavita
Agenzia Nazionale per la Sicurezza del Volo, Italy

On 24 November 2007, an Agusta 109S helicopter departed from Grosseto Hospital for Giglio's Island, in the Tyrrhenian Sea off the coast of Tuscany, part of the Province of Grosseto. This was a night flight, with two pilots, a doctor and a nurse aboard. Visibility was excellent and the seas slight. During the final approach to Giglio's Island, the aircraft experienced strong vibration, losing altitude and becoming out of control. It hit the sea with a slight downward pitch and a minor bank to the right. The cabin immediately flooded and the helicopter turned upside down. All four persons on board were able to escape with minor injuries, and were rescued after about 40 minutes in the water.

On 3 December the search for the wreckage began, on the basis of information from eyewitnesses and those involved in the rescue. Its position was first detected by side-scan radar, and a small ROV was sent down. The helicopter was discovered on 20 December on the seabed, upside down at 105m. It was decided to film the wreck in situ, with a view to determining how best it might be recovered. On 13 and 15 February 2008, two movies were shot by deep divers.

Between 3 and 9 April, the divers returned to the site with a working boat and attached cables to the three undercarriage legs of the inverted helicopter. Low pressure "parachute" balloons were also attached to the wreckage to help keep the structure under consistent tension during the recovery operation and so prevent further damage. On 16 April, the working boat winched the wreckage to within a few feet of the surface, at a rate of 5 metres per minute, before relocating to nearer the coast into shallower (30 metres) and calmer waters.

1 Since its use in the Red Sea in 2006, the AAIB's UBL system has been upgraded through the digitalisation of its signal, which enables the "listening" to be done by a computer rather than a human operator.

At this point, three of the four rotor blades were cut off by divers, and the fourth aligned with and strapped to the tail fuselage. A strong band was then passed through the rear windows of the cabin and attached to a separate winch on a second working boat. By winching in this band and at the same time loosening the cables fixed to the undercarriage legs, the helicopter, still in the water, was slowly turned the correct way up. It was then hoisted out of the water onto the deck of the working boat, after 144 days in the water. Having been washed down on deck with fresh water, the helicopter was taken into dock, and lifted aboard a flatbed truck, before being taken away for examination by Italian air accident investigators.

The Agusta recovery was undertaken by Explorer Team Pelicano on behalf of the Agenzia Nazionale per la Sicurezza del Volo. The team had deployed a total of twenty-two divers during the recovery: eight certified for deep diving to more than 100m, four in support of the deep compression operations, six in support of the medium compression operations, and four in support of the low decompression operation. The movie shot by Explorer Team Pelicano will in due course be available on the BEA and ECAC Web sites.

"Comparison of Underwater Recovery in Lakes and Rivers"

A presentation by Edmund Klich
State Commission of Aircraft Accident Investigation, Poland

On 1 September 2008, an ultralight aircraft Aeroprakt A-22L was seen to stall during low level flight and to crash into Lake Dworackie, near Olecko. The aircraft was located following a two day search using sonar aboard an inflatable vessel provided by the local fire brigade. The area of search was able to be kept confined, thanks to the eyewitness statement.

The aircraft wreckage was located on the bed of the lake, at a depth of 8 metres. After having been raised to the surface using inflatable rubber pontoons, the wreckage was towed to the bank. The entire operation was accomplished in twelve hours, with two teams each of two divers.

In July 2005 an Mi2 helicopter engaged in a firefighting operation near Police stalled and crashed into Lake Piaski, when the bucket it had lowered in order to take up water became overloaded with mud. There was immediately an ecological problem, as the helicopter (pictured opposite) contained some 400 litres of fuel. The wreckage had to be surrounded by special protective curtains during the operation to pump out the fuel. It could then be towed to the bank of the shallow lake, and recovered.

In September 2007, Cessna 150M (SP-KCP) engaged on a training flight in the Warsaw-Babice area lost power due to carburetor icing. Owing to the built-up nature of the land, the pilot had to ditch the aircraft in the River Vistula, where the water level was very high as a result of flooding. After the aircraft had been carried about 150 metres downstream it was abandoned by the pilot, who sadly drowned in the turbulent and dirty waters. The pilot's body was recovered a week after the crash, and the aircraft, which had drifted another 100 metres downstream before sinking, was located from the air the following day.

The first attempt to recover the aircraft, using ropes deployed from the bank by the fire service, did not succeed. A second attempt, again using ropes but deployed from a barge, also failed. There followed a reconnaissance of the wreckage by divers, who had been briefed on the aircraft type, and an attempt to recover it using inflatable rubber pontoons positioned under the wings and engine. This, too, proved unsuccessful, when the sharp metallic edges of the wreckage punctured the pontoons.

The next recovery attempt was made by four boats over a period of twelve hours, and used large sealed metal tubes (pictured below) which together had twice the displacement of the aircraft, inserted under its wings. Owing to the weight of sand which had by this time - some seven weeks after the accident - collected in the wreckage, which made it three times heavier than normal, this attempt, too, failed. However, a further attempt using the same metal containers succeeded, after sand had been sucked out of the wreckage. This operation took twenty hours, with four boats assisting, in seriously adverse weather conditions (rain, snow, air temperatures of 2-5 degrees C). The aircraft was then towed very slowly to the bank of the river, in an upside down position, before being hoisted out of the water.

The lessons drawn by the Polish accident investigation authorities from the Cessna 150M operation included the following:

(i) recovery action should be taken as soon as possible;

(ii) one may well need more robust equipment than seemed likely at the outset;

(iii) the depth of water in a river and the volumes of mud and sand are important factors;

(iv) breaking off an operation mid-way will probably mean starting from scratch again when one recommences; and

(v) back-up logistics are very important (shelter, food, hot drinks etc).

"Underwater Localisation and Recovery Strategies"

A presentation by Olivier Ferrante
Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile, France

Mr Ferrante described a number of underwater recovery operations which the French BEA had led or in which it had participated. They included among other cases the loss in January 2004 off Sharm el-Sheikh of Boeing 737-300 SU-ZCF, the Armavia A320 accident off Sochi in May 2006, and the DHC6-300 off Moorea in August 2007. In the case of the Tupolev 154M lost in the Black Sea in October 2001, the depth of the wreckage, the volume of sediment and the lack of suitable equipment had prevented the local authorities from recovering the recorders. The lessons learned from the Sharm el-Sheikh recovery operation were applied successfully by the Russian authorities to the 2006 Sotchi accident, which also occurred in the Black Sea, the recorder from which had at first been considered by those authorities to be irrecoverable. Mr Ferrante referred participants to relevant reports available on the BEA Web site.

A review of the events of recent years showed fatal accidents with an underwater dimension to be recurring very regularly, with the loss of Air France 447 only the most recent example, albeit an especially costly one in terms of lives lost. This latest case was demonstrating the exceptional challenges which investigators faced when the probable crash location was remote and unknown, with difficult and little-understood bathymetry, and a variable seabed composition.

The BEA had established some general principles to govern its investigations: body recovery must take priority over that of wreckage, and speed in sending on site the appropriate equipment was of the essence where environmental conditions were not favourable.

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SECOND DAY OF THE WORKSHOP: JUNE 11

The second day of the workshop was devoted wholly to practical exercises conducted from aboard vessels very generously made available by the Croatian Navy, namely SB-51 FAUST VRANCIC (mine-hunter, pictured opposite), SB-73 KORKULA (salvage ship), and a number of fast inflatable craft.

For the purposes of this practical component of the workshop, a scenario, had been developed involving a mid-air collision over the sea immediately north-west of Dubrovnik, between an airliner inbound to Dubrovnik Airport and a small general aviation aircraft. In advance of the exercise, a flight deck recorder had been deposited in the sea at one location, and a large piece of general aviation wreckage at another. It was assumed that eyewitness reports had provided a very general indication of where each might be found.

The first exercise saw the deployment from the FAUST VRANCIC of the UK AAIB's towed hydrophone array (pictured opposite), to "box" the general location of the Flight Recorder. A search grid was drawn up on the basis of the eyewitness reporting, and the ship then followed this pattern, traveling at 5 knots and completing a series of parallel two-mile tracks, each with one mile of separation from the next. During this period, workshop participants aboard the FAUST VRANCIC were able to handle and use in real conditions the hand-held hydrophones which would be deployed later in the exercise, and to view the signals from the towed array as shown on the laptop computer to which it was linked.

Once the signal from the Flight Recorder had been detected and its general position estimated, an inflatable craft was deployed by the FAUST VRANCIC to enable the signal's location to be identified with greater precision with the use of hand-held hydrophones held over the side. By means of triangulation, the recorder was found and (having been discreetly buoyed) was able to be recovered to the inflatable craft and then transferred to KORCULA.

In the second exercise, the two Croatian navy vessels relocated to the second site, further offshore where the water was some 80 metres in depth. The wreckage of the general aviation aircraft was searched for and successfully located using side-scanning radar aboard the KORKULA, to which some of the workshop participants had

transferred. Divers provided by the Croatia and Hungarian authorities were then deployed from the FAUST VRANCIC aboard inflatable craft. Diving on the wreckage, they attached to it a number of "parachutes" (centre picture below), able to be inflated with compressed air carried in tanks taken down by the divers. Once inflated, these "parachutes" brought the aircraft wreckage to the surface, where it was made fast to the salvage crane fitted on the KORCULA.

In the final exercise, the wreckage of the general aviation aircraft was carried by the KORKULA to the FAUST VRANCIC, and lifted aboard the latter's aft deck space, care being taken to ensure that this operation inflicted no additional damage on the aircraft.

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THIRD DAY OF THE WORKSHOP: JUNE 12

The final day of the workshop opened with a de-briefing on the previous day's practical exercises. There then followed further presentations on issues associated with underwater recovery. Mr Arslanian having had to return to Paris, this last day was chaired in his place by Mr Peter Kirk, Deputy Executive Secretary of ECAC.

De-brief on Practical Exercises

The debriefing was led by Olivier Ferrante and Jean-Claude Vital (BEA), and Adrian Burrows (UK AAIB).

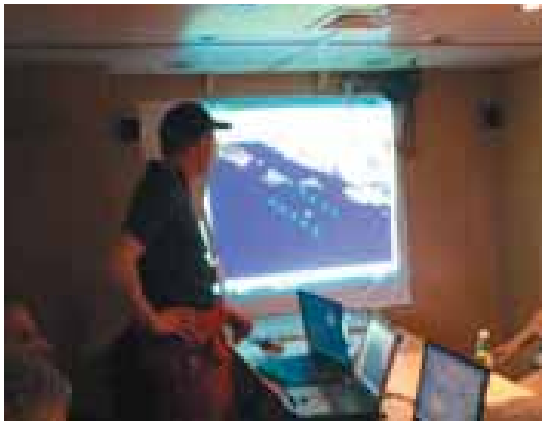
It was noted that the exercises had mirrored real-life operations faithfully, in having included the unexpected and in sometimes requiring plans to be changed quickly on the spot. This was the particular value of such practical exercises.

Particular points registered in discussion were as follows:

(i) the working environment at sea presented constant challenges for any delicate operations, owing for example to the noise and movement of the vessel itself, the confined and sometimes less than laboratory-clean spaces available for working, the threat to electronics posed by water, and the length of time taken at sea simply to travel from point to point, turn, launch and recover inflatable craft, deploy divers safely etc;

(ii) the time constraints imposed by the exercise timetable had echoed those which typically bore on an actual investigation;

(iii) the winds during the early part of exercise had been stronger than anticipated, and had been at 90 degrees to the search grid used for the towed array. This had made the FAUST VRANCIC's track-keeping very difficult, underlining the value of using an autopilot for such an activity;



(iv) the currents had also been stronger than anticipated, which had made the flight recorder drift a considerable distance from its original location;

(v) in retrospect, the one mile separation between each parallel run by the FAUST VRANCIC may have been too great, as the signal from the flight recorder had been heard on one pass but missed on the next leg;

(vi) given the volume of background noise heard in shallow waters, the signal 'spike' shown when the "pinger" was detected was not very prominent, and so quite easily missed;

(vii) the need to avoid damaging the "parachutes" on the sharp metal edges of the aircraft wreckage had meant that their attachment had taken some considerable time and care on the part of the divers;

(viii) water being very heavy, there was always a risk of further damage and loss of evidence when aircraft parts are being lifted from the sea, and the loading upon them altered suddenly. An aircraft being recovered from water by the Irish authorities in 1964 had broken wholly into pieces at this point;

(ix) the value of redundancy in equipment provision had been demonstrated, when one of the hand-held hydrophones had failed but a second had been available for use. Such redundancy would be even more important in a operation conducted many hundreds of miles off shore;

(x) the importance of orderly stowage of equipment after use was demonstrated including the washing off of salt water, so that it was immediately fit and ready for use on the next occasion;

(xi) great merit was seen in establishing as much commonality as possible in the specifications of equipment and software used by different European States, so that such resources could be loaned and used with ease, and shared ownership synergies realised; and

(xii) the difficult realities of underwater search had borne in strongly on participants of the exercises, for some of whom the image of "looking for a needle in a haystack" had been well confirmed. These difficulties led some participants to wonder whether the future lay in the continuous and automatic downloading of data from aircraft in flight, making unnecessary the recovery of recorders after an accident.

Further Presentations

"RECOVERY IN EXTREMELY LOW VISIBILITY CONDITIONS"

A PRESENTATION BY MARTIN PUGGAARD
AIRCRAFT ACCIDENT INVESTIGATION BOARD FOR CIVIL AVIATION, DENMARK

In October 2000, a Robinson R44 with three persons aboard crashed in the large (42 sq kilometers) and shallow Lake Arresoe, the only wreckage found on the lake surface being a seat cushion. The lake had an average depth of 3 metres, and was only 6 metres at its deepest point. Visibility in the waters of the lake at that time of year was typically 3.8 cm.

A surface search by helicopters, the dragging of the lake by two surface vessels, and a search using metal detectors mounted on inflatable craft failed to locate the wreckage. At this point, the Danish AIB were offered assistance by MARIDAN, a company which had developed a small robot submarine for use in gold mining operations in South Africa. This UAV, 'MARTIN', was equipped with side scan sonar, GPS and an inertial navigation system. Its preparation and launching had taken some six hours, after which it was controlled from a small surface vessel equipped as a control centre. It was directed to follow a defined search programme, on completion of which it surfaced and uploaded its findings to the control centre. In due course 'MARTIN' located the wreckage of the Robinson R44, which was subsequently recovered using a hoist erected between two small barges. The subsequent investigation revealed no technical deficiencies on the R44. Factors considered to have contributed to the accident were the poor visibility (mist and fog), and the lack of visible references as the aircraft crossed the eastern shore of the lake, leading to spatial disorientation. The aircraft's low altitude gave the pilot no time to recognize the situation and recover. No recommendations were made arising from the investigation.

MARIDAN, subsequently merged with the Atlas Corporation, had since developed more sophisticated AUVs, including the Mk 1 and Mk 2 SEA OTTER, capable for example of

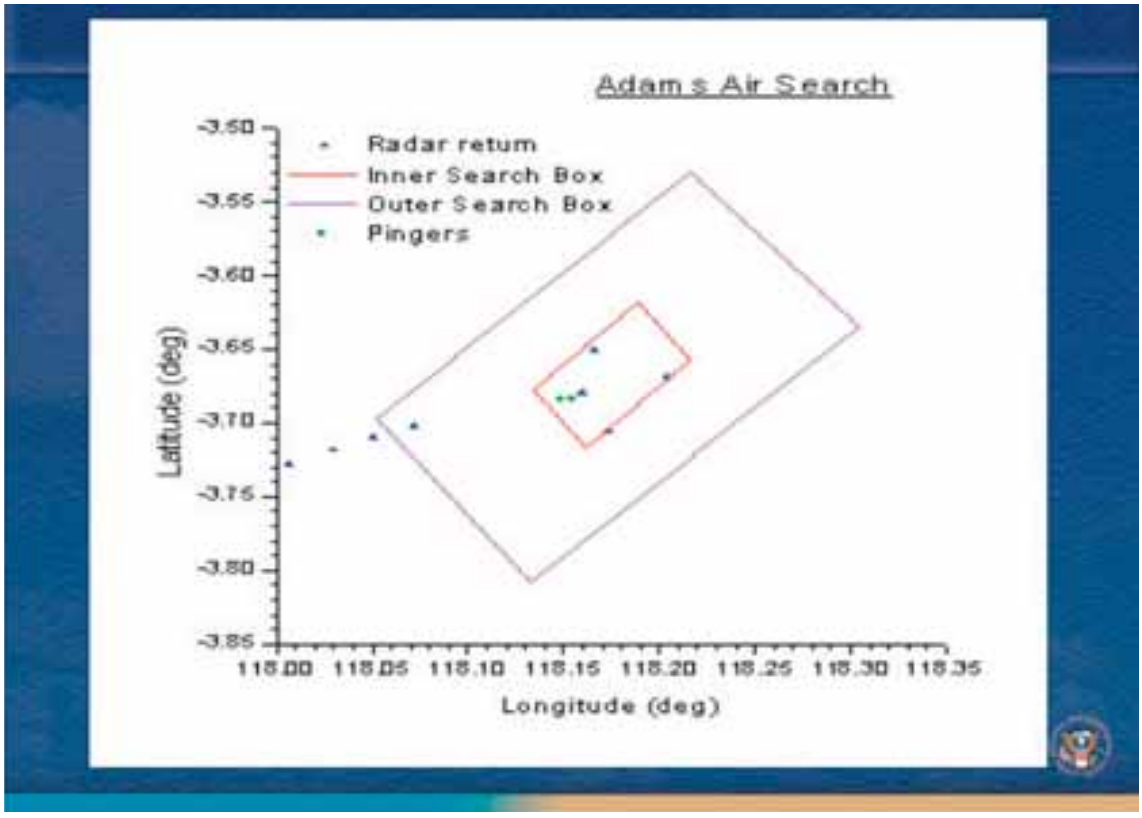
"hovering" and automated obstacle avoidance, and of being operated with only a four-person operating crew. Further technical details are in the slides in Annex 1 to this report.

"Review of Adam Air Search and Recovery"

A presentation by Frank Hilldrup
National Transportation Safety Board, USA

On 1 January 2007, Adam Air flight 574 from Surabaya to Manado, Indonesia, possibly experiencing inertial reference system problems, descended vertically from 3,500 feet into the Makassar Straits, at that point some 1,800 metres deep. All 102 people on board were killed.

The search for the Boeing B737 aircraft and its recorders was hampered by some initial mistaken reporting, and by the washing ashore of floating debris at different points on the shore of the island of Sulawesi. The US Navy assisted in locating the flight recorders in January 2007, and Adam Air contracted with the marine services company Phoenix International, which in late August 2007 deployed a vessel to undertake sonar searching within an outer and later an inner search box (see below). Despite some initial difficulties with the vessel's dynamic positioning system, two "pinger" GPS locations were identified, and a ROV sent to each of them. No debris was discovered on these dives, but on 27 and 28 August both the Flight Data Recorder and the Cockpit Voice Recorder were discovered at points between the two GPS locations. The remaining days of the mission were then spent mapping the debris field.



"Lessons Learned from Two North Sea Aircraft Recoveries

A presentation by Tor Norstegard
Norwegian Accident Investigation Board

In September 1997, Super Puma helicopter LN-OPG fell into the North sea en route from Bronnoysund to the oil platform 'Norne'. The flight, with ten passengers and two crew on board, was being conducted under IFR outside radar coverage. A sudden loss of engine power and flight controls resulted in an uncontrolled descent from 2,000 feet. No emergency messages were sent, and there were no survivors.

The helicopter was equipped with a Penny & Gils Combined Voice and Flight Data Recorder, with a Ducane DK100 "pinger" transmitting at 37.5kHz. The helicopter's Automatically Deployable Emergency Transmitter was destroyed on impact. A primary search area was established on the basis of the expected flight path, last known position, wind and sea conditions and floating debris, and four vessels commenced a search. An ROV was used to investigate sonar findings, and a towed hydrophone was used, deployed 80 metres behind the towing vessel at a depth of 30 metres and speed of 4 knots, on a search grid whose parallel legs were 1 nautical mile apart.

The hydrophone detected the 'pinger' and with it the helicopter wreckage after 24 hours, at a depth of 385 metres on a muddy but level sea bed. After nine days of 24 hour operations, 90% of the wreckage had been recovered using four ROVs. Sea conditions delayed the recovery, the helicopter's total loss of structural integrity made it difficult to raise major sections, and the CVR/FDR was almost lost in the muddy sea bed. The total cost of the recovery operation was 2.7m euros.

In June 2008, a twin-engined Fairchild SA226-T(B) Merlin with three persons aboard stalled and fell some 6,000 feet into the North Sea. It was followed by radar down to about 900 feet, and hit the sea surface "flat". Oil and some aircraft parts were subsequently found in the area. The Norwegian AIB was able on the day of the accident to deploy the Subsea Support Vessel (POLAR PRINCE) with Dynamic Positioning capability, two ROVs and good crane lift capacities. The police were invited to join the search operation, but care was taken by the AIB to retain overall control of the operation.

Signals from the Merlin's Underwater Locator Beacon were detected 41 hours after the crash by the POLAR

PRINCE's HiPAP system, an integrated part of its Dynamic Positioning System, capable of operating in the 37,5 kHz range. An ROV then found the wreckage at a depth of 316 metres. 90% of the wreckage had been lifted onto the ship's deck within two hours of the detection of the ULB signal (pictured opposite). The total cost of the operation was 155,000 euros.

The Norwegian AIB drew a number of lessons from these two recovery operations:

- o experienced personnel should be used;
- o check lists are useful for planning purposes, but no two accidents are identical, and the detailed planning will be event-specific;
- o effective equipment is expensive, but can nonetheless reduce total costs;
- o it is important to have access to hydrophones for listening at 37.5 kHz;
- o it is also important to know where you can find subsea vessels, of which some 50-80 are available at any one time in the North Sea;
- o advice should be taken from eg police, military, coastguard – but overall control of the operation should be retained by the investigator; and
- o one should be prepared for any operation to take a long time.

"Air Accident Investigation – The Insurance Option"

A presentation by Jurgen Whyte
Irish Air Accident Investigation Unit
and John Barry
Willis Dublin

Work on the financing of very large accident investigations was initiated by ICAO AIG as long ago as 1999, but the group tasked with this work had no progress to report to AIG 2008.

At the ACC's meeting in Vienna in November 2008, Mr Jurgen Whyte, Chief Inspector of Air Accidents in the Irish Air Accident Investigations Unit (AAIU) briefed colleagues on their Unit's insurance policy which covers the costs associated with conducting a large air transport accident investigation. The AAIU has held such cover for some ten years, conscious that Ireland has very deep waters in close proximity to its coasts, that some 98% of transatlantic air traffic passed through its airspace, and that the several hundred commercial aircraft on the Irish register operated all over the world. For 2008, the AAIU acquired insurance cover of €100m for any one accident. The policy has an excess of €1m and 10% self-insured.

Mr John Barry, spoke on behalf of Willis Dublin, part of the global Willis Group, the largest insurance broker in the aviation sector. It had written the 2008 insurance policy, unique in Europe, for the AAIU, covering costs arising from aviation accident investigation (aircraft wreckage recovery and storage costs, technical testing, reconstruction and simulation costs, etc.) The policy does not cover the costs associated with the search and rescue operation of survivors or victims. The very high potential costs of such investigations, which in the case of a major investigation into an aircraft lost at sea might be in the region of 80-100m euros, were considered by Willis Dublin to make insurance an appropriate option. A policy of that magnitude would be underwritten by a group of insurance companies, each taking a part of the risk, rather than by a single firm. It currently covered losses attributable to any cause except terrorism. Policies might be of the "stand alone" kind, as held by the Irish authorities, or of a "group" or "pooled" type. Typical indemnity limits would be 25-100m euros, but higher limits could be considered. The costs of such policies could only be determined on a case-by-case basis.

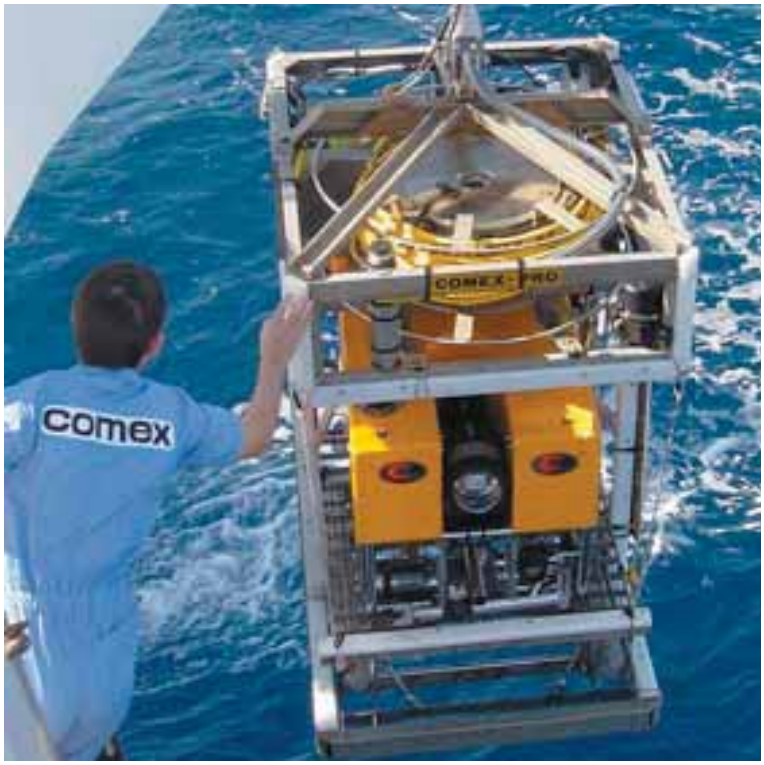
The control of any claim made under such a policy remained with the party insured, rather than being taken over by the insurer (as was more usual in other circumstances). In practice, the insurers made the money available, and the insured party drew upon it as necessary. The policy provides for 10% of the total cost to be borne by the claimant, under a self-insurance retention, to incentivise it to incur only reasonable costs, and there is a 1m euro deductible, although variations could be considered.

"Dealing with Human Remains"

A presentation by Olivier Ferrante
Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile, France

Mr Ferrante described some of the issues raised by the need there would sometimes be in the course of an accident investigation to deal with human remains, which posed special technical and psychological difficulties.

The recovery of bodies must be the first priority in any fatal accident investigation. This principle was important for the families of those aboard the aircraft, as well as for security and safety reasons.



If the aircraft had been lost in deep water, an ROV may be the only means of access to the bodies. Unlike in the case of crashes on land, where those leading on the recovery of bodies were typically emergency service personnel well used to this task, the operator of an ROV would be wholly inexperienced in encountering human remains, and would need careful briefing and management.

It was also important to control very carefully access to any data, including photographs, relating to human remains. The French BEA had established procedures, which provided for photographs of human remains to be filtered out of the general investigation data and reserved for post-mortem purposes.

Conclusion of Workshop

Speaking on behalf of Mr Arslanian, and also of ECAC as co-organiser of the workshop, the Acting Chairman Mr Kirk confirmed the general feeling of ACC that the event had been very successful, with good presentations and valuable and educative practical exercises.

Mr Kirk recalled Mr Arslanian's prediction, that not all lessons would have been identified by the end of the workshop, and said that the opportunity would be taken at ACC's next meeting, in Lisbon in November, to review what had been learned and to begin to turn this learning into tangible products, including checklists. In the meantime, a CD would be circulated containing all of the presentations made at the workshop, and the BEA would be taking the lead in preparing even fuller documentation, possibly to be placed on the ECAC Web site.

Mr Kirk noted that all present were conscious that the workshop had addressed only some of the issues and challenges around underwater operations. The Lisbon meeting would provide an opportunity to discuss what other elements the group should address, including consideration of the factors around recovery operations in deeper water.

The aim would continue to be to achieve a consistent and high quality of investigation capability across all of Europe. The tragic events of recent weeks had been a reminder that an accident could happen at any moment, and that readiness was everything. This was the particular value of the work which ACC had done together in the present workshop, and of the further work it would be doing, first in Lisbon and then continuing from there.

Mr Kirk reminded the group of the value, in this context of the sharing of expertise, of the ACC "Code of Conduct on Cooperation in the Field of Civil Aviation Accident and Incident Investigation", and invited those States which had not yet signed up the Code to consider doing so.

On behalf of Mr Arslanian and of ACC as a whole, Mr Kirk thanked the Croatian authorities, including and through Mr Vodanovic, for the excellence of the arrangements for the workshop, both on land and sea. There was he believed general agreement that the exercise component had been extraordinarily successful. The facilities had been excellent, and the cooperation of so many parts of the Croatian government first class.

Thanks were also due to Hungarian colleagues for providing divers, to Adrian Burrows and his colleagues at the UK AAIB, and in particular to the French BEA. It was testimony to the BEA's commitment to the sharing of expertise, said Mr Kirk, and to its strong sense of the importance of European accident investigators working together as a community, that despite the very heavy pressures on the BEA at this time they had continued to support the workshop strongly and help make it a success.

Speaking on ACC's behalf, Mr Kirk said how glad the group had been to have with it this week, bringing their own expertise and perspectives, professional colleagues

and friends from Singapore, Tunisia, Hong Kong, and the United States. Their very real contributions had been much appreciated

In closing the workshop, Mr Kirk re-emphasised that it had marked the beginning, not the end, of the group's work on underwater recovery. There were many more aspects to the subject, which ACC would explore in future meetings.

❑❑❑

ANNEX 1

SLIDES USED IN WORKSHOP PRESENTATIONS

1 ***Air Accident Investigation in Croatia***
by Dinko Vodanovic, Croatian Accident Investigation Board, Ministry of the Sea, Transport and Infrastructure

2 ***Locating the Al Salam Boccaccio 98, Red Sea, February 2006***
by Adrian Burrows, Air Accident Investigation Branch, UK Department for Transport

3 ***Search and Recovery of the 2007 Augusta Westland A109 Accident near Giglio's Island***
by Mario Colavita, Agenzia Nazionale per la Sicurezza del Volo, Italy

4 ***Comparison of Underwater Recovery in Lakes and Rivers***
by Edmund Klich, State Commission of Aircraft Accident Investigation, Poland

5 ***Underwater Localisation and Recovery Strategies***
by Olivier Ferrante, Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile, France

6 ***Recovery in Extremely Low Visibility Conditions***
by Martin Puggaard, Aircraft Accident Investigation Board for Civil Aviation, Denmark

7 ***Review of Adam Air Search and Recovery***
by Frank Hilldrup, National Transportation Safety Board, USA

8 ***Lessons Learned from Two North Sea Aircraft Recoveries***
by Tor Norstegard, Norwegian Accident Investigation Board

9 ***Air Accident Investigation — The Insurance Option***
by Jurgen Whyte, Irish Air Accident Investigation Unit, and John Barry, Willis Dublin

10 ***Dealing with Human Remains***
by Olivier Ferrante, *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile*, France

ECAC • CEAC

WELCOME

Ministarstvo mora, prometa i infrastrukture
Ministry of the Sea, Transport and Infrastructure

Accident Investigation Board

Legal regulations

Introduction of regulations according to Directive 94/56/EU
at the beginning of EU negotiations
- Council Directive 21/11/1994 -

Legal regulations

Air traffic Act

Regulations on reporting and investigating of aircraft safety threats, accidents and serious incidents

EU Directives 94/56/EU and 2003/42/EU

ICAO Audit

Audited by ICAO
(International Civil Aviation Organization)
in 2003

International obligations

Accident Investigation Board is obliged to comply with Directive 2003/42/EC, Article 5

Board is currently implementing ECCAIRS program for collection and analysis of events related to aircraft safety threats, accidents and serious incidents (EU Directives 1321/2007 and 1330/2007)

Authorities

Government
Republic of Croatia

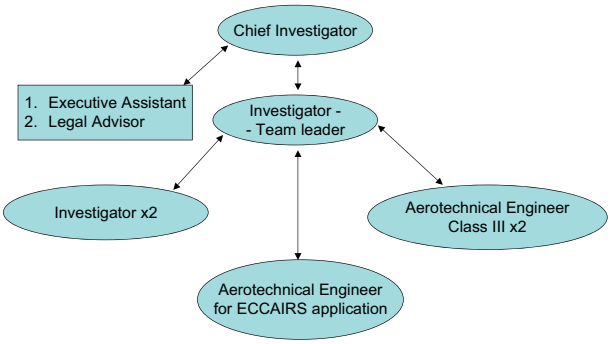
↓

Ministarstvo mora, prometa i infrastrukture
Ministry of the Sea, Transport and Infrastructure

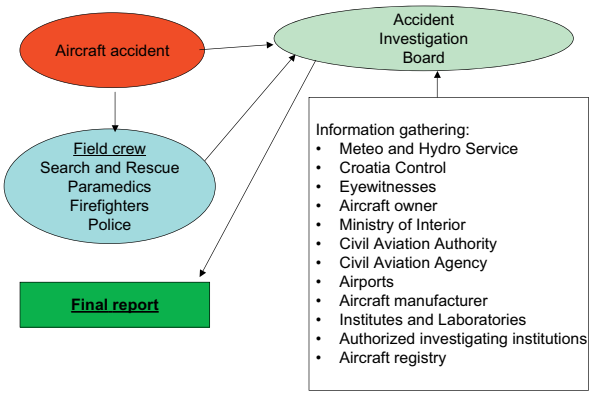
↓

Accident Investigation Board

AIB - structure



Accident investigation workflow



Group flight of 8 aicraft towards Adriatic – 2 a/c crashed, 4 fatalities

Accident near island of Unije – - C-172 immediatly after the accident

Specially equipped salvage ship brought the aircraft from depth of 15 m

PA-44 belly landing at Zadar

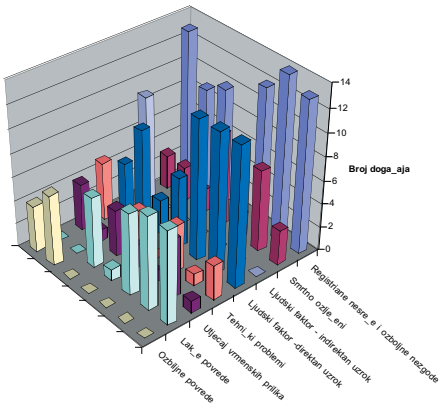
Cause of the PA-44 accident:
micro switch failure

DA-20 canopy unlocks and open mid-flight:
seat cushion jammed in canopy frame

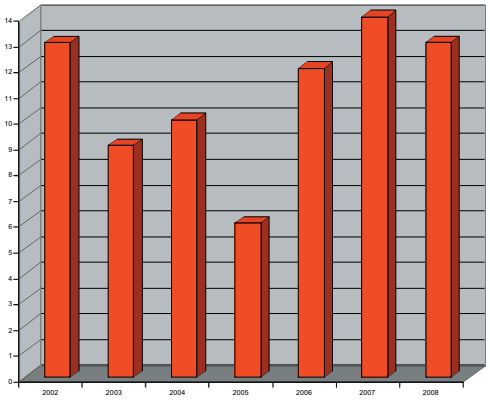
Airbus 310 bird strike at LDZA during take off run
- only one tire left after immediate breaking

Another bird strike on LDZA Zadar
Airbus 319

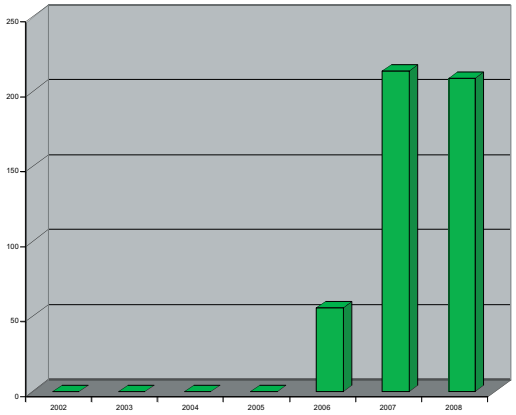
Accident Analysis



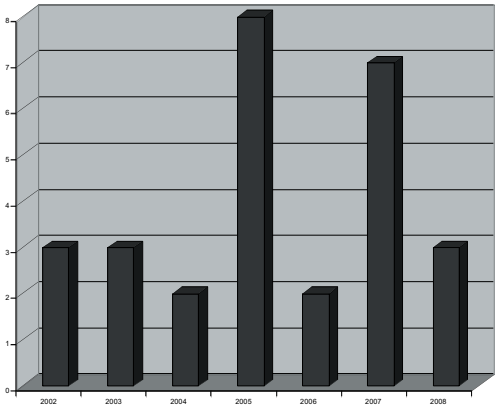
Registered Accidents



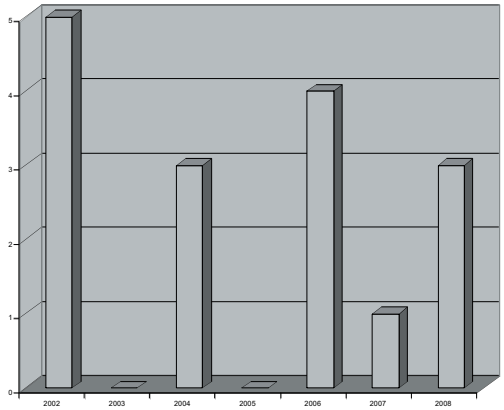
Special Occurrences



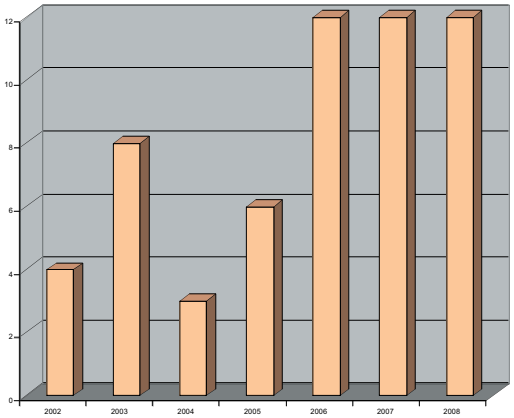
Fatalities



Technical Problems



Human Error



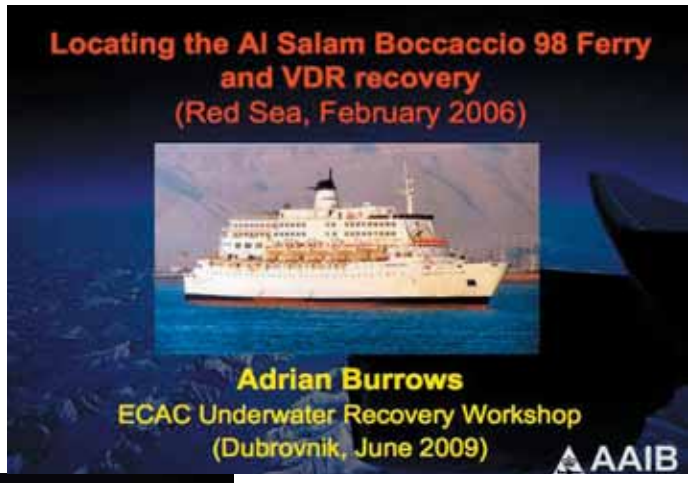
International Airports and Local Airfields

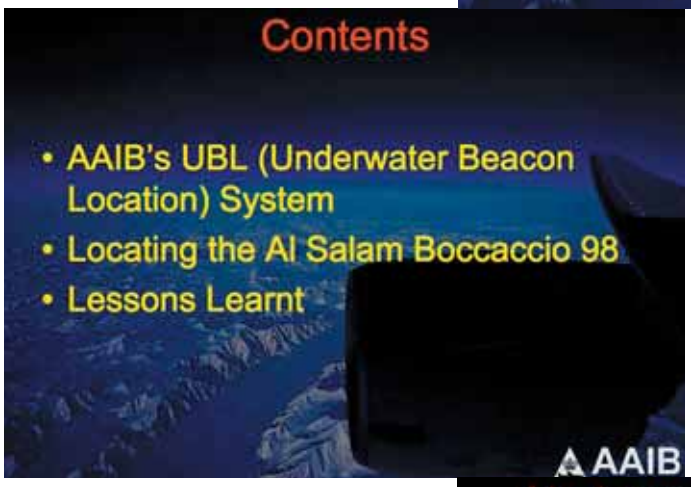
Phone numbers

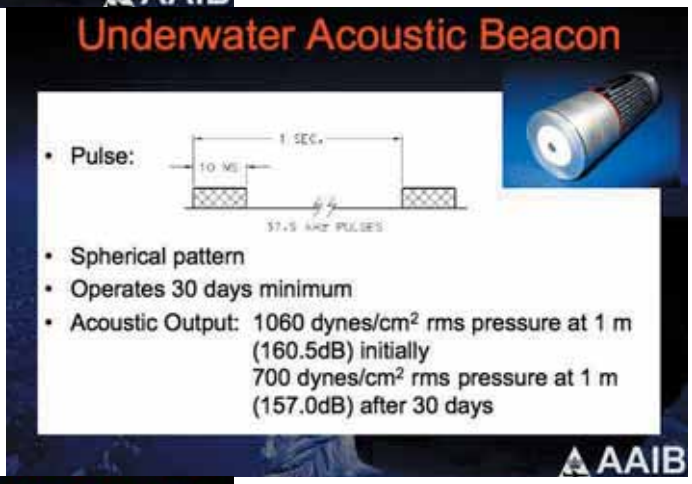
24-hour availability: +385 98 255849

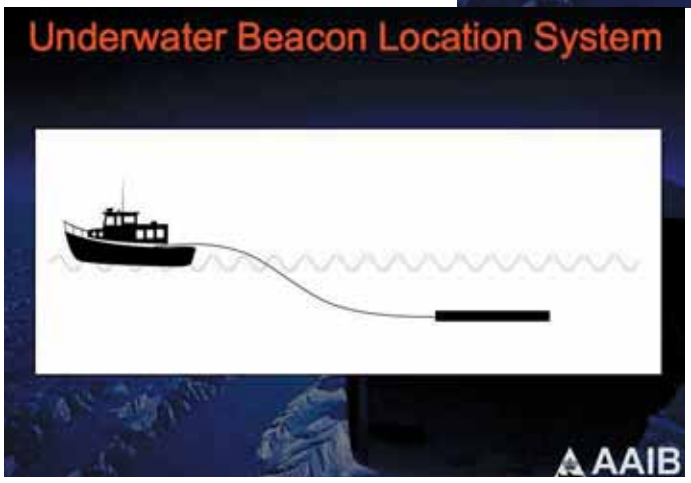
Office: +385 1 616 91 68

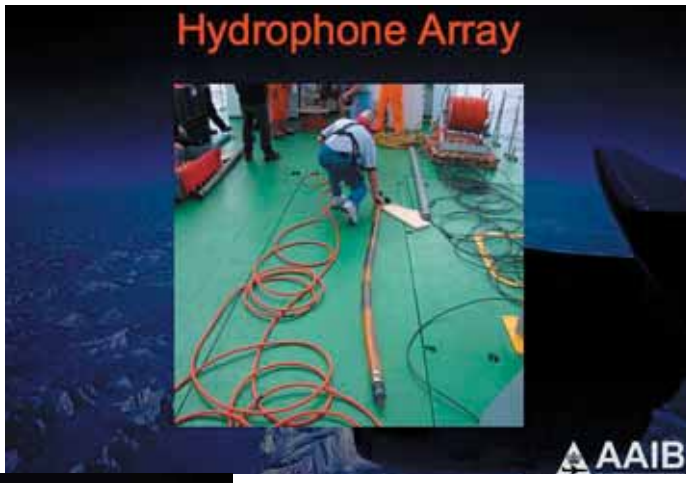
Fax: +385 1 616 90 68


Locating the Al Salam Boccaccio 98 Ferry and VDR recovery
(Red Sea, February 2006)
Adrian Burrows
ECAC Underwater Recovery Workshop
(Dubrovnik, June 2009)
AAIB

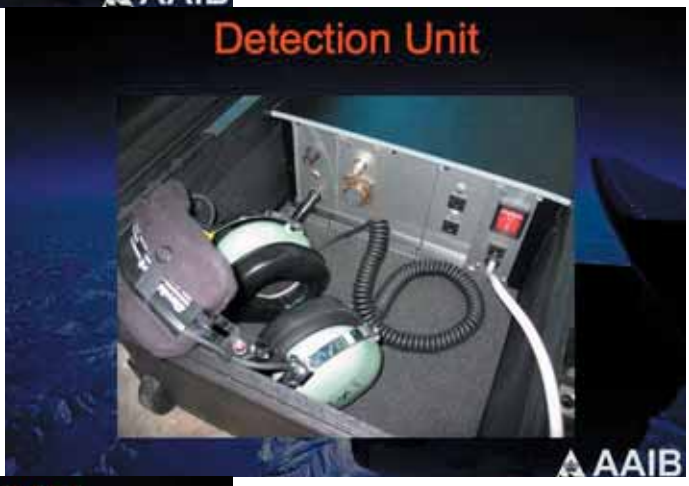

Contents
• AAIB's UBL (Underwater Beacon Location) System
• Locating the Al Salam Boccaccio 98
• Lessons Learnt
AAIB

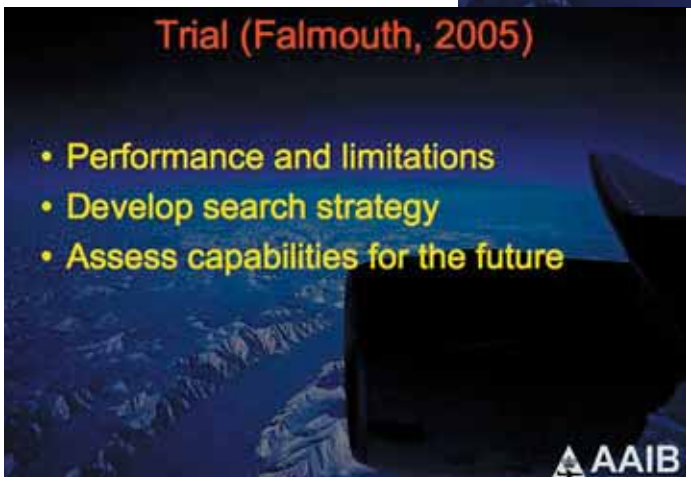

Underwater Acoustic Beacon
• Pulse:
1 SEC.
10 MS
37.5 KHZ PULSES
• Spherical pattern
• Operates 30 days minimum
• Acoustic Output: 1060 dynes/cm² rms pressure at 1 m (160.5dB) initially
700 dynes/cm² rms pressure at 1 m (157.0dB) after 30 days
AAIB

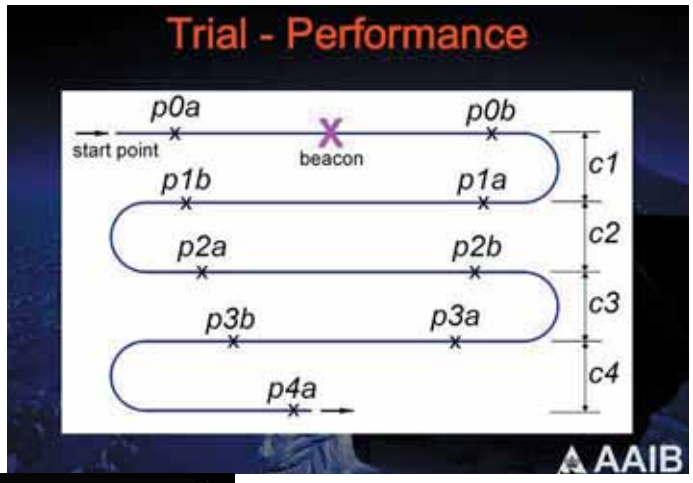

Underwater Beacon Location System
AAIB

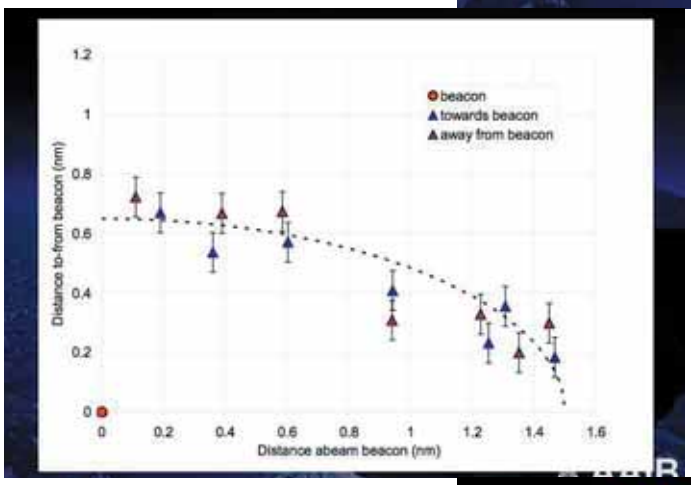

Hydrophone Array
AAIB

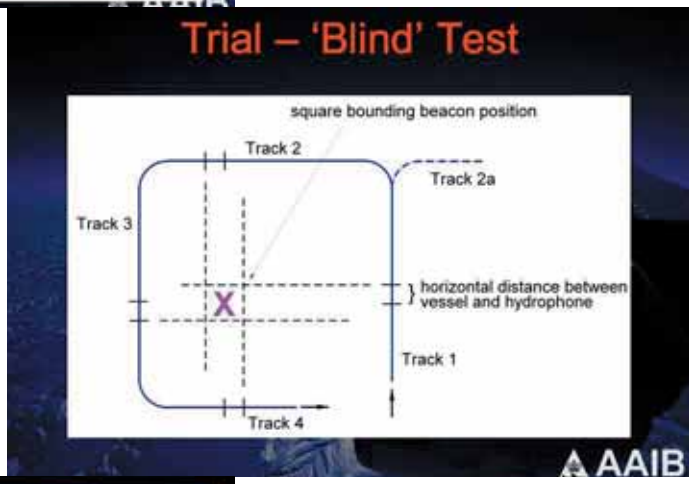

Cables
AAIB


Detection Unit
AAIB

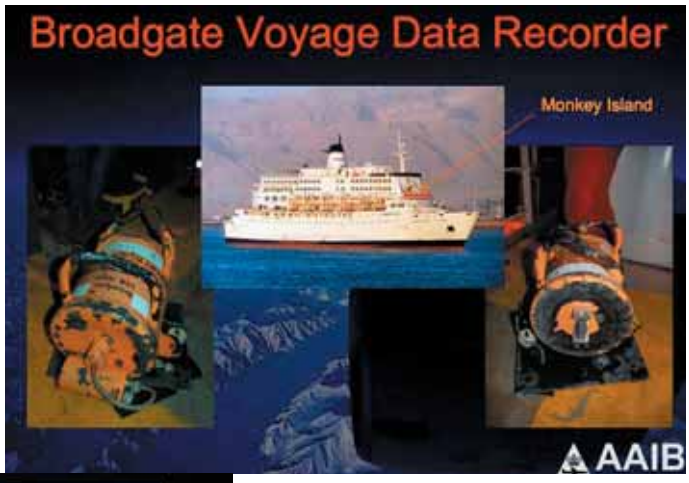

Trial (Falmouth, 2005)
• Performance and limitations
• Develop search strategy
• Assess capabilities for the future
AAIB


Trial - Performance
p0a
p0b
start point
beacon
p1b
p1a
p2a
p2b
p3b
p3a
p4a
c1
c2
c3
c4
AAIB

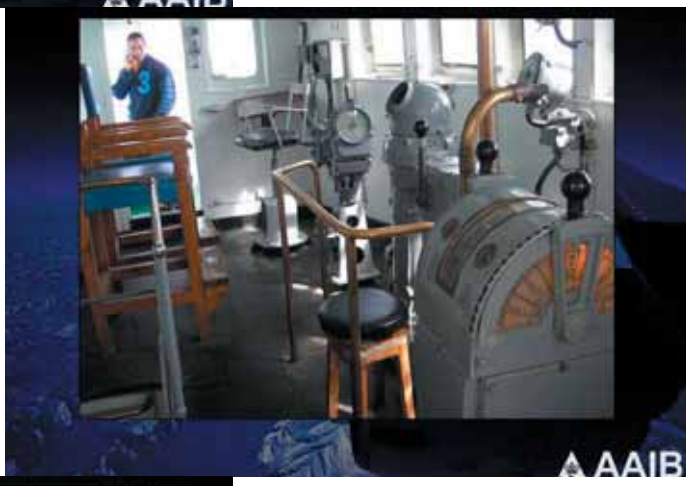

beacon
towards beacon
away from beacon
Distance to-from beacon (nm)
Distance abeam beacon (nm)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Trial – 'Blind' Test
square bounding beacon position
Track 2
Track 2a
Track 3
horizontal distance between vessel and hydrophone
Track 1
Track 4
AAIB

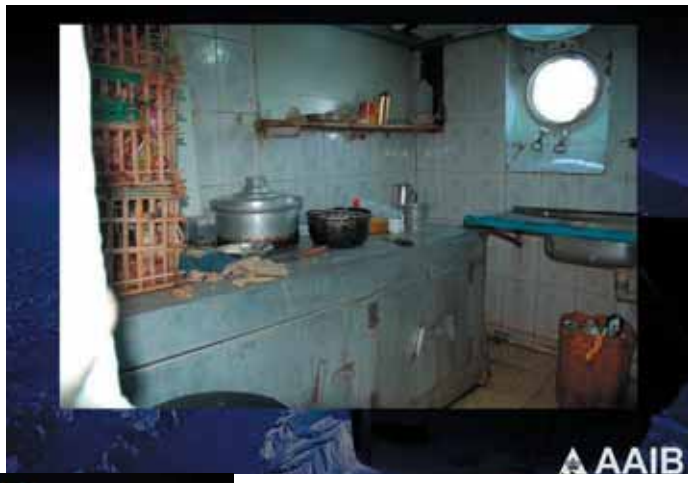

EGYPT
IRAQ
SAUDI ARABIA
Jeddah
SUDAN
Ship sank in this area
Dubai ferry left 1900*
Safaga ferry due 0300*
*Local time
- 1319 passengers & 97 crew
- 22 cars, 5 trucks, 6 x 40' containers, 9 trailers
- 76 tonnes of general cargo
- weather was 6 to 7 on the Beaufort scale
(strong breeze to near gale)
AAIB


Broadgate Voyage Data Recorder
Monkey Island
AAIB


AAIB


AAIB


AAIB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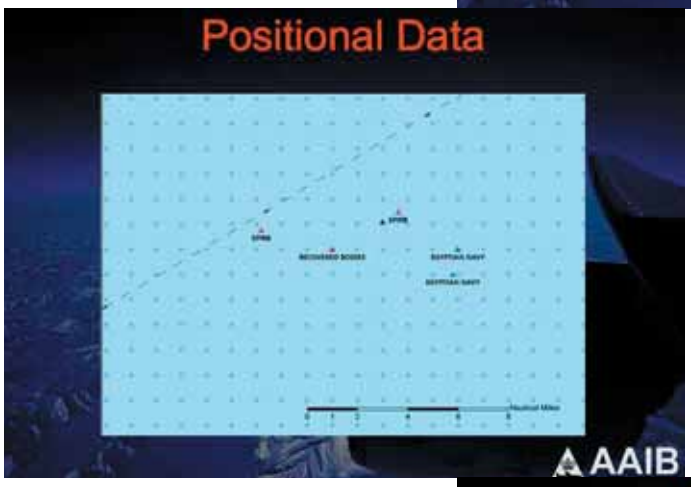
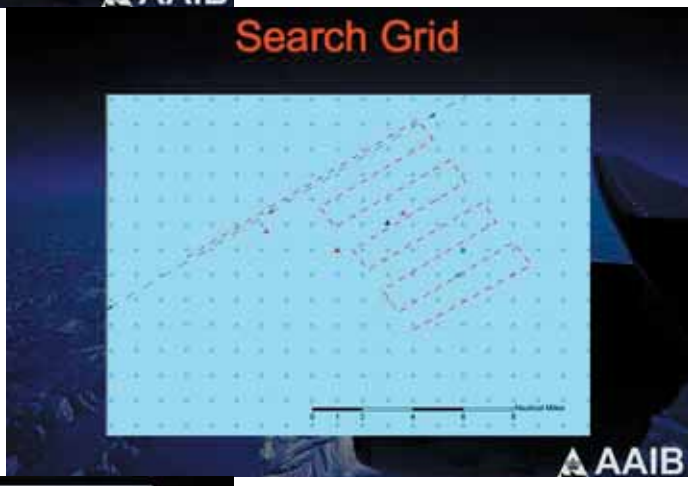
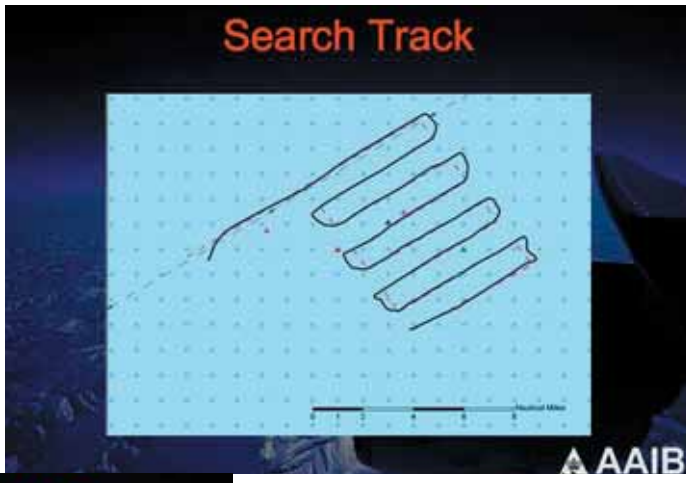
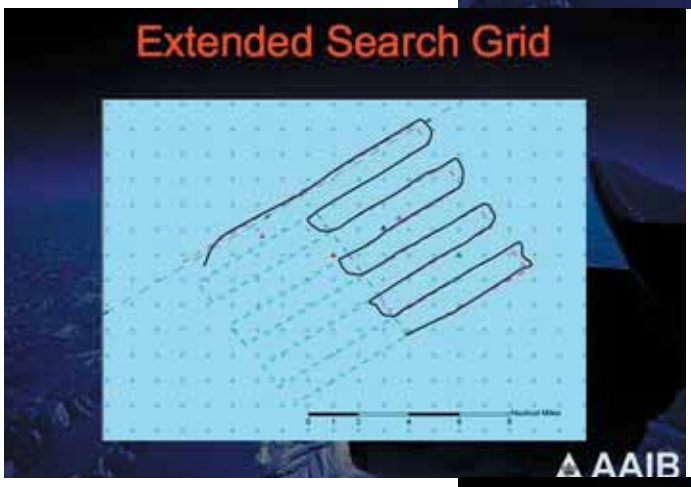
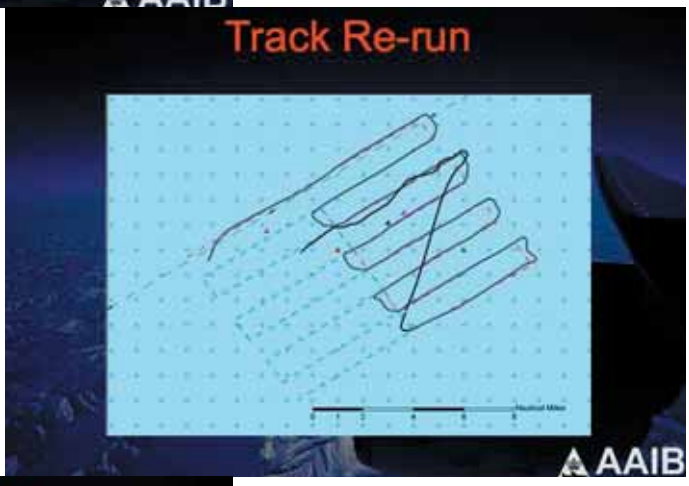

Positional Data
AAIB

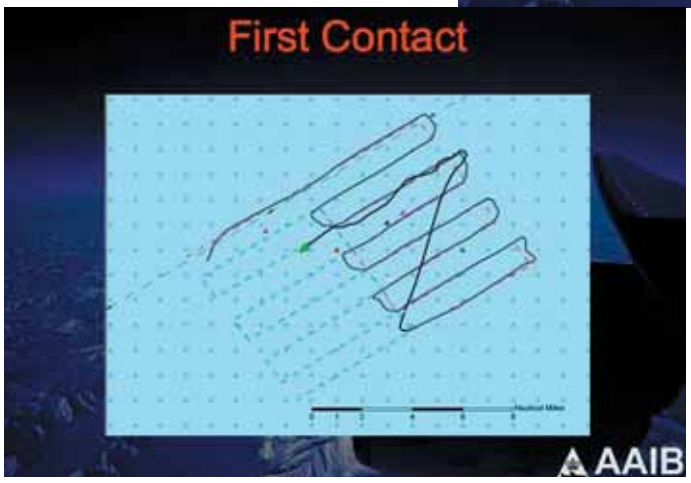

Search Grid
AAIB

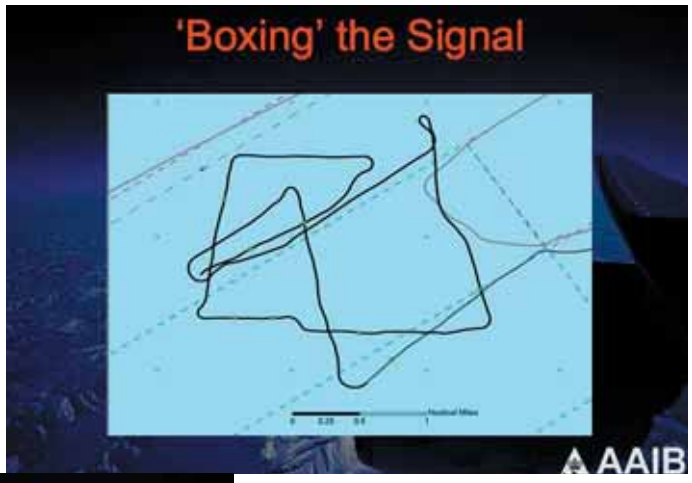

AAIB


Search Track
AAIB


Extended Search Grid
AAIB


Track Re-run
AAIB

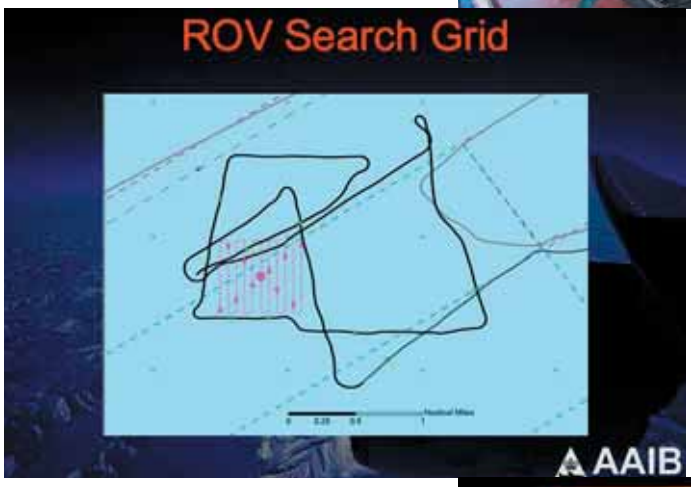

First Contact
AAIB

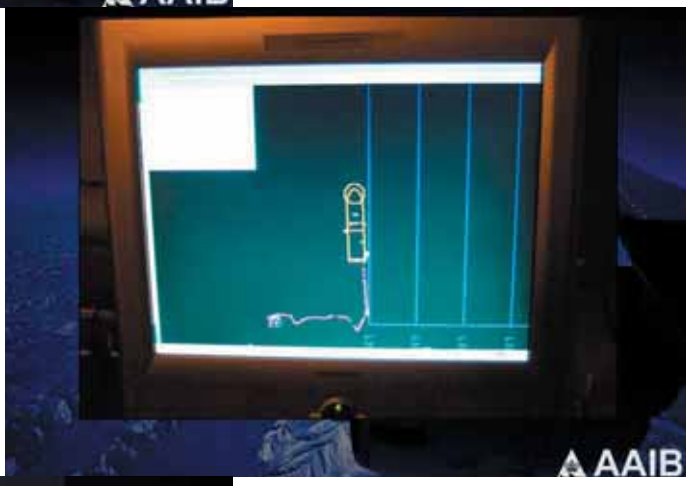

'Boxing' the Signal
AAIB


Best Estimate
AAIB


AAIB

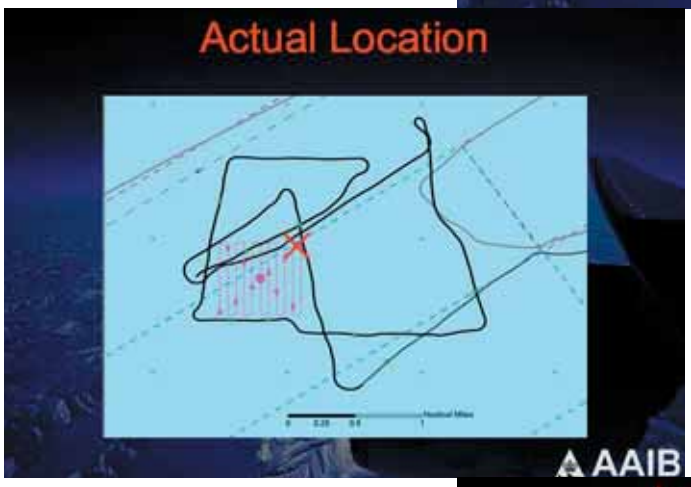

AAIB

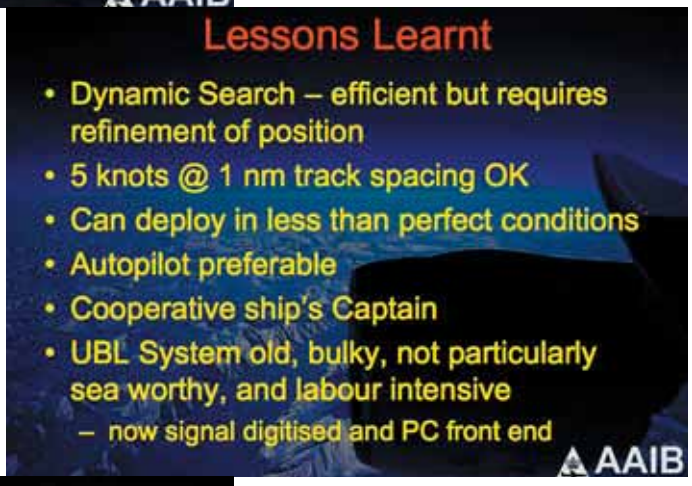

ROV Search Grid
AAIB


AAIB


AAIB


AAIB


Actual Location
AAIB


Lessons Learnt
• Dynamic Search – efficient but requires refinement of position
• 5 knots @ 1 nm track spacing OK
• Can deploy in less than perfect conditions
• Autopilot preferable
• Cooperative ship's Captain
• UBL System old, bulky, not particularly sea worthy, and labour intensive
– now signal digitised and PC front end
AAIB


Questions?

COMPARISON OF UNDERWATER RECOVERY IN LAKES AND RIVERS

Edmund Klich AAIB Poland

ACCIDENT 1 – September 2008

ULTRA LIGHT
Aeroprakt A-22L

LOW LEVEL FLIGHT

LOSS OF SPEED

STALL

CRASHED ON LAKE

EYEWITNESS STATEMENT

Crash area

Fire brigade boat with sonar
2 days searching, very limited area thanks eyewetness statement

Wreckage located on floor 8 m deep. After using rubber pontoons to recover the aircraft was towing to the bank.

Operation lasting 12 hours
2 teams of 2 divers

Accident 2 - July 2005

Helicopter Mi-2 during fire operation was taking water to bucket and took the water with mad and overloaded. Stalled and crash to the lake. Pilot survived.

Located in shallow lake

Ecological problem - about 400 l of fuel.
During pumping out the fuel wreckage was surrounded by special protection (curtains)

After pumping out of the fuel wreckage was towing to the bank

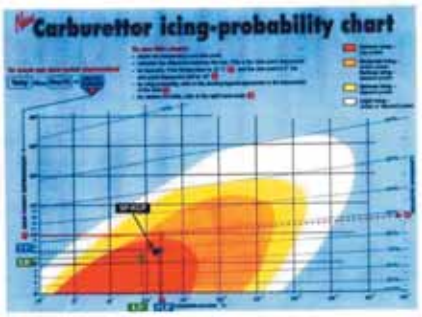
Accident 3 - training flight Cessna 150 M in area Warszawa-Babice (EPBC)

Carburetor icing – loss power.
No place for force landing due to urban Warsaw area.

Accident 3 - training flight Cessna 150 M in area Warszawa-Babice (EPBC)

Pilot decision to ditch on Vistula river.
Very high level of water due to flood.

Aircraft was descending in intensive icing area



(Australian Transport Safety Bureau)

Accident area

Sequences of events

•Accident (15.09.2007 r.) – 477 cm

•Pilot abandoned aircraft and tried to swim. Drowned after about 20 seconds due to waves whirls, and dirty water;

•Rescue action unsuccessful;

•Pilot body recovery (22.09.) – 199 cm;

•Location the aircraft (in overturn position) (23.09.) – 184 cm;

Sequences of events cont.

•First attempt of recovery – 23-24.09. from bank by using ropes (fire brigade) – failed;

•24.09. – 07.10. 2007 r. – financial problem – failed recovery from barge using crunch;

•09.10. – reconnaissance with the divers;

•10.10. – briefing drivers about aircraft.

Attempt by using pneumatic pontoons – 11.10.2007 r.

First attempt to recover by using rubber pontoons (banana shape) under wings and engine failed due to puncture the pontoons by sharp edges of aircraft

First attempt by using metal pontoons – 3-4.11.2007 r.

Attempt to recover by using metal containers under wings between fuselage and struts failed due to heavy aircraft full of sand (3 times heavier) and the stream. Action was taken 12 hours with using 4 boats. Containers had 2 times bigger displacement than aircraft.

Second successful attempt by using metal containers – 7-8.11.2007 r.

Preparing action
- sand washing, sucking of the sand;
- time - 20 hours, 4 boats

Very slow towing in overturn position

Crunching the aircraft

Recovery conditions'

- aircraft in overturn position;
- Vistula wild river – no barge with crunch;
- high stream;
- sand mine;
- problem with binding containers;
- Two big boats with 3 anchors each;
- two divers working;
- first attempt – no movement;
- any longer brake - more mud and sand;
- very bad weather: rain, snow, temp. 2-5°C, water temp. 6-7°C.

Aircraft – sand everywhere magneto

Aircraft – sand everywhere wings

Conclusions

- Take recovery action as soon as possible;
- Use stronger equipment then you expect;
- Consider high stream;
- Consider sand and mud;
- You need at least 2 or more boats;
- Don't take long brake – you will start the job from the beginning;
- Prepare good logistic (shelter, food, hot drinks)

BEA

ECAC Workshop
Underwater Recovery Operations

10 – 12 June 2009 DUBROVNIK, CROATIA

Underwater Localization & Recovery based on Recent Events

Disseminating and Sharing the Lessons Learned

http://www.bea.aero

BEA

Armavia A320 Accident - Sochi

- 3 May 2006
- Sochi (Russia)
- Investigation by Russia with France and Armenia

- The previous Flash Airlines Recovery Operation Report helped in allocating resources for the underwater search

BEA

Previous Black Sea Accident

- ✓ 4 October 2001, Sibir Airlines,
- ✓ Tupolev 154M, registered RA-85693
- ✓ Depth (approx 1000 m), sediment and lack of equipment prevented the recovery of the recorders
- ✓ (Aircraft shot by a Ukrainian missile)

BEA

Sotchi Accident

✓ Adapted tools

✓ Homing




BEA

Capitalization of Lessons Learned

✓ Simulation exercise

- French navy
- BEA
- International underwater recovery workshop in Dubrovnik (June 10-12, 2009)
- Sharing experience and equipments


BEA

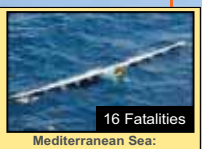
Recent Underwater Recovery Operations


148 Fatalities
Red Sea: Jan 3, 2004

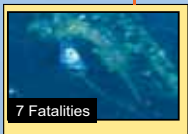

113 Fatalities
Black Sea: May 3, 2006


20 Fatalities
Moorea (Tahiti): Aug 9, 2007

2004 2005 2006 2007 2008


16 Fatalities
Mediterranean Sea: Aug 6, 2005


102 Fatalities
Indonesia: Jan 1, 2007

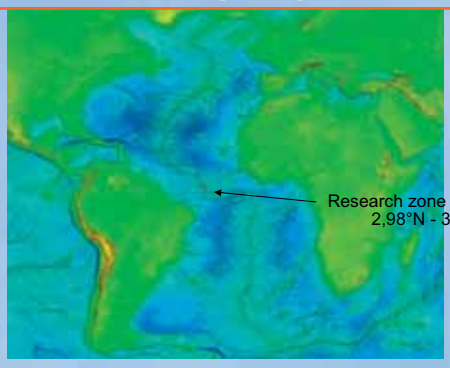

7 Fatalities
Perpignan (France): Nov 27, 2008

BEA

The Sea Search of Flight AF447

BEA

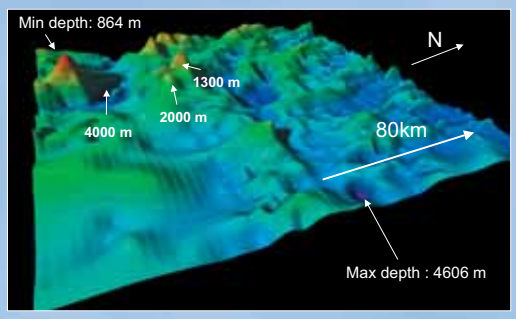
General Bathymetry of the Zone



Source: SHOM

BEA

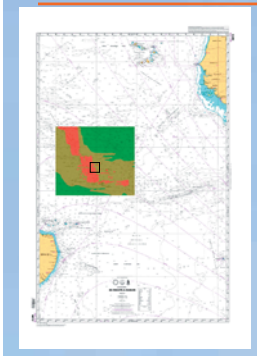
Bathymetry: Limited Knowledge of the Zone



Source: SHOM

BEA

Composition of the Seabed



Source: SHOM

In red: rocks

In green and brown: mud

Chart based on existing sediment data

BEA

Vessels deployed by France

Six vessels including a submarine

- BEA :
  - IFREMER - Le Pourquoi Pas?
  - Two tugboats (LDA) :
    - Fairmount Glacier
    - Fairmount Expedition
- Marine nationale :
  - Frégate Ventôse
  - SNA Emeraude
  - BPC Mistral

BEA

Means on the Pourquoi Pas ?

-ROV Victor
(Remotely Operated Vehicle)
-Submarine Nautile
-AUV
(Autonomous Underwater Vehicle)
-Towed hydrophone

BEA

Acoustic Means

- **2 Towed Pinger Locator (TPL) - US Navy**
  - **> One on each tugboat**
  - **Range 1 NM**
  - **Operating depth 20000 ft**
  - **Frequencies 5 to 60 Kz**

TPL System

- **Side Scan Sonar (range 500 m, 7000 ft depth)**
- **Several ROV homers adapted on IFREMER's means**
  - 4000 m
  - 12000 m (titanium)

ROV homer

BEA

BEA

To be continued…

Underwater Recovery Operations

R44 recovery with extremely low visibility conditions

An ECAC Workshop

Dubrovnik
10-12 June 2009

Presentation given by

Martin Puggaard
AIB Denmark

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

History of Flight

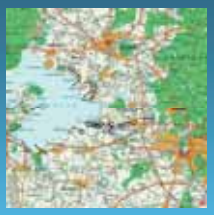
Date and time:	13 October 2000 @ 1500 UTC
Type of flight:	General Aviation – Pleasure
Occupants:	3 persons

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

History of Flight

Weather after cast	
Clouds	2/8 of ST in 500 – 800 ft OVC in 5.000 ft
Visibility	BWT 4 – 8 km
High humidity with the tendency of mist in periods	



Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Location of a seat cushion

Facts about Arresoe

Surface area	Approx. 42 km²
Average depth	3 m
Max. depth	6 m
Average visibility year 2000	3,8 cm

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Methods tried in order to locate wreckage:

- Surface search from helicopters
- Dragging the bottom of the lake with two small surface vessels
- Search with metal detectors mounted on zodiacs

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Then MARIDAN offered their service with the AUV "MARTIN"

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

MARIDAN's AUV "MARTIN" was 2nd generation of their AUVs.

The AUV was at that time equipped with side scan sonar, GPS and inertial navigation system.

The preparation and launching phase took approx. 6 hours.

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Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

After launching the AUV in the water, all systems was check and tested.

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

A surface vessels was equipped as control center and the operation was managed from this.

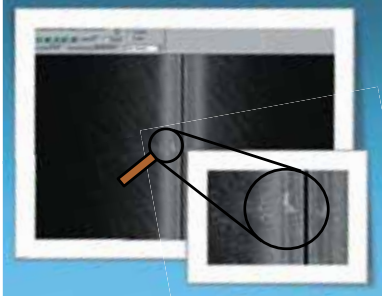
Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

When a search was defined, programmed and sent to the AUV,
it submerge,
did its survey,
surfaced and survey data was uploaded to the control center.

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions



Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Today:

- MARIDAN has been merged with the ATLAS Corporation
- AUVs has been developed further

The models are now SeaOtter Mk I (3rd G) and Mk II (4th G)

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Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Facts about ATLAS MARDIAN's AUV operations

- currently 3 3rd generation AUVs "SeaOtter MK I" system in operation around the world
- launching 4th generation AUV "SeaOtter MK II" system based on the heritage of previous generations technology and operations

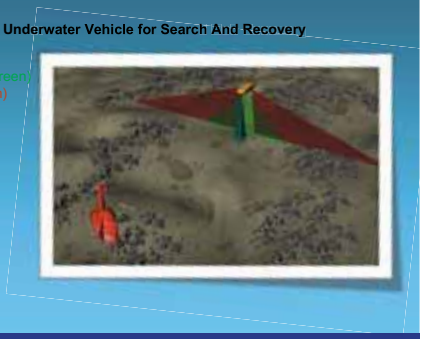
  Some of the new capabilities of 4th G are
  - Hovering for inspection
  - Obstacle avoidance
  - Extreme adaptability to payload
  - Small operating crew (4)

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

SeaOtter MK II Autonomous Underwater Vehicle for Search And Recovery

- Side Scan Sonar (red)
- Multibeam Echosounder (green)
- Sub Bottom Profiler (brown)
- Camera (blue)
- Magnetometer
- Pinger Locator



Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

SeaOtter Mk II Specifications

Parameter	Value	Note
Dimensions	Length	3,5 m
	Width	0,98 m
	Height	0,48 m
Weight	Weight in air	1300 kg
Speed		Max. 8 kn
	Vertically	0,5 kn
Manoeuvrability	Turn Radius	< 10 m at 4 kn
Hovering	DP capability	≤ 2 kn
Depth	Operational range	600, 1500 m
Range / Endurance		> 90 nm at 4 kn speed
		~ 24 h at 4 kn speed
Temperature		-5°C - +32°C
	On deck	-30°C - +45°C
Operation	Sea State	Max. 4
Navigation	Pos. accuracy on line survey	0,1% of travelled distance
	Pos. accuracy on site survey	0,03% of travelled distance
	External navigation updates	- LBL
		- USBL
		- SLBL

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Chartering, costs and readiness

Contact for chartering:

Jesper Peter Menne Baunsgaard
Marketing & Sales Manager

ATLAS MARIDAN ApS
Agern Alle 3
DK-2970 Hørsholm
Denmark

Phone: +45 4576 4050
Cellphone: +45 6163 0408
Email: jpb@maridan.dk
Website: www.maridan.dk

Costs and readiness

Costs

Initial costs — 3 mill €

Incurring costs — Depends on
- urgency
- Location
- scope of work

Readiness

Depending on travel form
- If transported with GPS active ~ 1 hour
- If transported with GPS inactive ~ 12 hour

Accident Investigation Board Denmark — The Aviation Unit

Underwater Recovery Operations
R44 recovery with extremely low visibility conditions

Presentation given by

Accident Investigation Board Denmark

Martin Puggaard
Chief inspector of Air Accidents
Deputy Director of the Danish AIB

E-mail: aib@aib.dk

Website: http://www.aib.dk

Accident Investigation Board Denmark — The Aviation Unit

NTSB National Transportation Safety Board

Office of Aviation Safety

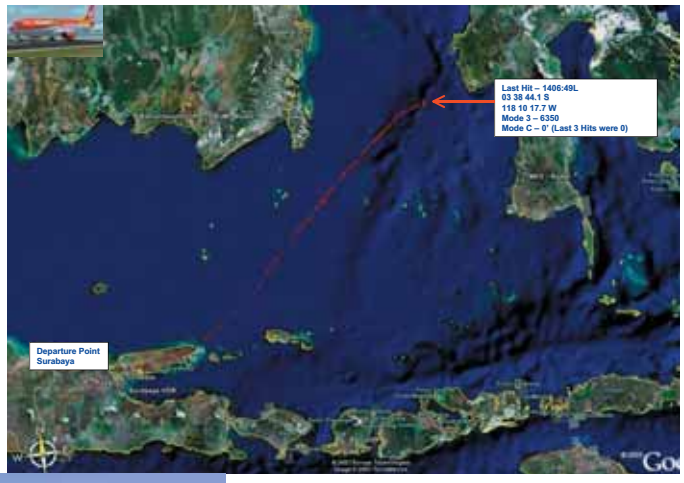
Review of Adam Air Search and Recovery

Frank Hilldrup
International Investigations

Adam Air 574, B-737

- January 1, 2007
- Surabaya to Manado, Indonesia
- FL 350, IRU problems
- Vertical descent
- Impact in Makassar Straits
- Water depth approx 1800 m

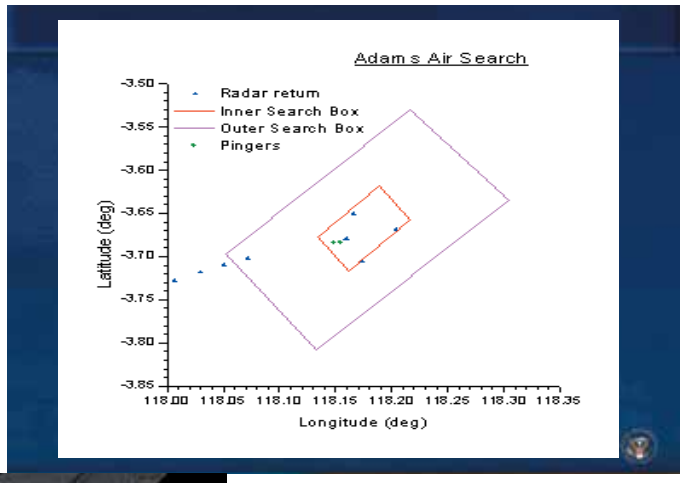
NTSB

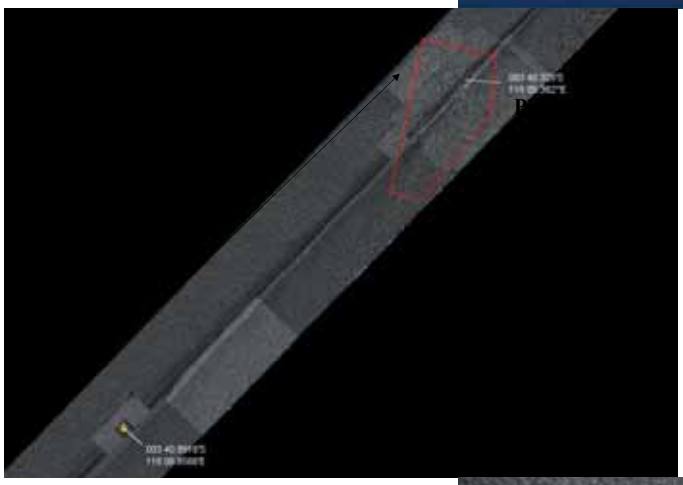


Mobilization for Underwater Search

- Phoenix Intl (via USN contract)
- 6/13-14: crew + two TPLs, SS sonar, and two winches (7K & 23K cable) depart military & commercial
- 6/18: equipment installed on USNS Mary Sears
- 6/19: Tested/repaired equip.
- 6/20-21: TPL runs
- 6/24: SS runs
- 6/25-27: return and demob.

NTSB





Recovery Operation

- 8/24-25: 15-hr transit from port to site
- Early equipment & Dyn Pos problems
- 8/25-26: ROV dove on both pinger GPS locations
  - no debris seen
- 8/27-28: FDR then CVR found between GPS loc's (2/3 days after search began)
- Remaining days spent mapping debris

NTSB

Lessons Learned from two North Sea Aircraft Recoveries

Presented to the Underwater Recovery Workshop, Dubrovnik 2009

by Inspector of Accidents
Tor Nørstegård

aibn

Localization and Recovery of Super Puma, LN-OPG

10 – 19 September 1997

- 2 crew and 10 passengers enroute from Brønnøysund to the oil production vessel "Norne".
- IFR flight outside radar coverage.
- No emergency message from crew.
- Sudden loss of engine power and flight controls resulted in an uncontrolled fall from 2000 ft.

aibn Inspector of Accidents Tor Nørstegård

Localization

- Equipped with Penny & Gils Combined Voice and Flight Data Recorder (CVFDR) with Ducane DK 100 acoustic transmitter (Pinger). Transmitts at 37.5 kHz.
- ADELT destroyed on impact.
- Two fatalities and parts found floating.
- Expected track, last known position, speed, wind condition, sea current and debris used to establish primary search area 12 x 10 NM (100 NM West-Northwest of Brønnøysund).

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Search

- 4 vessels engaged in the search.
- Sonar – on vessel and at ROV.
- Objects (rocks) found by sonar was checked visually with ROV.
- Hydrophone (on loan from and operated by AAIB, UK) towed 80 m behind Subsea Support Vessel "Rockwater 1". Depth: 30 m, speed: 4 kt, distance between lines: 1 NM.
- Wreckage found by hydrophone in the primary search area after 24 hrs.
- Muddy but level sea bed.
- 385 m depth.

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Recovery

- 4 ROVs involved from Subsea Support Vessels "Rockwater 1" and "Seaway Pelicane".
- Wreckage mainly concentrated, but not limited to an area 100 x 100 m.
- Approx. 1 kt current.
- Operation limited to 6 m wave height.
- CVR/FDR nearly lost in muddy sea bed.
- Difficult to raise major sections.
- 24 h operation, 9 days.
- All vital parts and approx 90% of wreckage recovered.
- Total cost 2.7 mill. Euro.

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Localization and Recovery of Fairchild SA226-T(B) Merlin, LN-SFT

21 – 22 June 2008

- 3 persons performing a Type rating Skill Test.
- Entered a stabile deep stall situation and fell about 6000 ft in 30 sec +
- Followed by radar down to about 900 ft ("live" data available).
- Hit the sea surface "flat".
- Oil and aircraft parts found in the area.

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aibn Inspector of Accidents Tor Nørstegård

PLANNING

- Useful maritime section within AIBN.
- Financial backing from DoT.
- Equipment to home at the 37.5 kHz pinger.
- 2 x ROV's
- Deck working area.
- Workshop on board (to modify tools if necessary).
- Crane capacity (for ROV's and tools/wreckage).
- Take full control (but invite the police on board).
- Contracted Subsea Support Vessel "Polar Prince" the same day as the accident happened.

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Polar Prince

- DP2 Subsea Support Vessel
- Length: 94 m
- With: 22 m
- DWT: 4554 tons
- Work deck area: 1152 m²
- ROV: 2 x Magnum
- Dynamic Position System: Kongsberg Simrad SDP21 including Hydrodynamic Position Responder (HPR) and HiPAP capable of receiving 37.5 kHz.
- Vessel and ROV crew on the actual operation: 42

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In short

- Signals from the ULB was detected 41 hours after it crashed.
- A ROV found the wreckage at a dept of 316 m 82 m from the last radar plot 30 minutes later.
- The wreckage was pulled through the sea surface with extreme care.
- 95% of the A/C was on the ship deck 43 hours after it crashed.
- 98% of the wreckage was found within 48 hours.
- Total cost 155,000 Euro.

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Inspector of Accidents Tor Nørstegård

Lessons Learned

- Use experienced personnel.
- Make a good check list for planning. However, no accidents are identical and must be planned individually.
- Expensive equipment are effective and can reduce the total costs.
- Know where you can get hydrophones for 37.5 kHz.
- Know where you can get Subsea vessels.
- Keep yourselves in charge of the operation, but take advice from the military, coast guard, police etc.
- Be prepared for time consuming operations.

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Pre-arrangements

AIBN has an agreement with ship broker Fernley Offshore Supply AS, including:

- Standard bid format
- Bimco Supplytime 2005, AIBN modified
- Standard scheme for evaluating offers

There are at any time 50 – 80 Subsea Support Vessels present in the North Sea area.

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aibn

Bimco Supplytime 2005

Inspector of Accidents Tor Nørstegård

aibn

Standard scheme for evaluating offers

Inspector of Accidents Tor Nørstegård

Air Accident Investigation – The Insurance Option

Underwater Recovery Operations Workshop
Dubrovnik, Croatia 10th - 12th June 09.

Willis

Willis

- 400 Offices in Nearly 120 Countries
- Offices throughout Europe
- Largest Aviation Broker Worldwide
- Clients in 190 Countries Worldwide
- Global Team of 20,000 Associates

Willis
Grand Mill Quay
Barrow Street
Dublin 4

Tel: +353 1 639 6305 - John Barry
Tel: +353 1 639 6408 - Thomas Byrne
Web: www.willis.com/ireland

1 Willis

Duties/Obligations

Legal background – obligations under the Chicago Convention

Social/Political Obligations

2 Willis

Likely Financial Exposures

Cost of Recovery
Land based resources
Marine based resources
Specialist Contractors

Cost of Investigation/Recovery
Comply with Chicago Convention
Comply with National Legislation (if any)
Meet Social/Political Requirements

Likely Cost: €80m to €100m

3 Willis

The Insurance Option

- Costs of Air Accident Investigation
- Recovery or attempted recovery of wreckage.
- Indemnity Limits - €25,000,000 to €100,000,000.
- Higher Limits can be considered.
- 10% Self Insured Retention
- Deductible €1,000,000 – variations may be considered.
- Terrorism Excluded

4 Willis

Cover Options

- Stand Alone Policy on an individual country basis.
- Subscription to a Group arrangement.

5 Willis

Claims Handling

- Control of Claims
- Loss Adjusters
- Claims Fund

6 Willis

Information Required

- Estimated Annual Flights – Commercial Airliner
- Number of Aircraft Registered
- Choose an Indemnity Limit
- Email details to john.barry@willis.ie or thomas.byrne@willis.ie

7 Willis

Questions

8 Willis

BEA

ECAC Workshop
Underwater Recovery Operations

10 – 12 June 2009 DUBROVNIK, CROATIA

Dealing with Human Remains

Outline

- ✓ Generalities
- ✓ Case of Flight AF447 Investigation
- ✓ Discussion

BEA

Generalities

- ✓ Priority
  - Body recovery before wreckage
  - Time pressure (environmental conditions)
- ✓ Important for families, security and safety reasons
- ✓ Technical investigation

Factual Information
- ICAO Report Section 1.13
- Medical and pathological information
  - ✓ *Brief description of the results of the investigation undertaken and pertinent data available therefrom.*

BEA

Different Situations

✓ Crash Site	✓ Body State
On land	Bodies
On water	Body parts
Easy access	Human remains
ROV access	

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ROV Operations

- ROV only link to the crash site in deep waters
- ROV operators (generally) not used to dealing with human remains
- Technical & psychological difficulties

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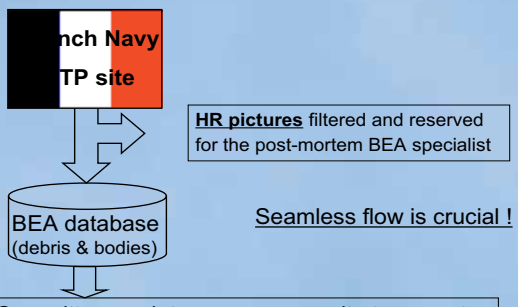
AF447 Investigation

✓ Human remains data management



BEA

Conclusions

✓ Each situation is different

✓ Preparation is key

BEA

ECAC • CEAC

ANNEX 2

WORKSHOP PARTICIPANTS

COUNTRY		NAME
Albania		Genci Resuli Hrvoje Lazic
Bosnia and Herzegovina		Ilija Savatic
Bulgaria		Anatas Kostov Yavor Petrov
Croatia		Mario Bradov Dinko Vodanovic Renato Pavicic Stjepan Dehin Davor Mistric Elvira Pankasz Zoran Benic Josko Vlasic Vlaho Lujo
Cyprus		Ioannis Loizou
Czech Republic		Pavel Strubl Stanislav Suchy
Denmark		Martin F. Puggaard
France	(Chairman)	Paul-Louis Arslanian Olivier Ferrante Jean-Claude Vital
Germany		Thomas Kostrzewa
Greece		Akrivos D. Tsolakis Nikos Pouliezos
Hungary		Laszlo Meszaros Lorand Kugyela Ferenc Pataki amas F. David
Ireland		Jurgen Whyte Thomas Moloney John Barry Thomas Byrne
Italy		Mario Colavita
Latvia		Ivars A. Gaveika
Lithuania		Kestutis Povilonis
Luxembourg		Marc Determ

Netherlands	Michiel Schuurman Peter Verheijen
Norway	Tor Norstegard Inge S. Arnesen
Poland	Adrzej Pussak Edmund Klich
Portugal	Antonio Barros Arthur Pereira Fernando Lourenço
Romania	Mircea A. Ciuca Eugen Suciu
Slovenia	Roman Rovansek
Spain	Manuel Fernandez Francisco J. Hernandez Sanz
Sweden	Agne Widholm
Switzerland	Christian Gerber
United Kingdom	Adrian Burrows

OBSERVERS

Hong Kong	Jimmy Leung Simon Li Victor Liu
NTSB	Frank Hilldrup
Singapore	Chow W. Chong Wing K. Chan David Lim
Tunisia	Khélifa Ezzine

SECRETARIAT

Peter Kirk — Deputy Executive Secretary
Monique Inizan — Assistant

ANNEX 3

WORKSHOP PROGRAMME

ECAC-CEAC AGENDA 10-12 June 2009 President Hotel, Dubrovnik, Croatia

Wednesday 10 June 2009

13:00 **Registration desk open**

13:30 **Welcome**
Dinko Vodanović, Chief Investigator, Croatia AIB

13:35 **Objectives of the Workshop**
Paul Louis Arslanian, Chairman of the ECAC Accident Investigation Group (ACC)

13:50 **Locating the Al Salam Boccaccio 98 Ferry Red Sea February 2006**
Adrian Burrows, AAIB UK

14:10 **Search & Recovery of the 2007 Agusta Westland A109 Accident near Giglio's Island**
Mario Colavita & Giancarlo Cagnoni, ANSV Italy

14:30 **Comparison of Underwater Recovery in Lakes and Rivers**
Edmund Klich, AIB Poland

14:50 **Underwater Localization & Recovery Strategies Based on Recent Events**
Jean-Claude Vital & Olivier Ferrante, BEA France

15:10 **Question & Answer session**

15:30 **Coffee Break**

16:00 **Briefing, Scenario of the On-Site Exercise & Logistics**
Steering Committee

16:45 **End of briefing**

17:00 **Bus departure for the social event**
Guided visit of old Dubrovnik

Thursday 11 June 2009

Day of the on-site exercise

The exercise will be dependent on the weather conditions. It may be replaced by backup presentations if sea conditions prevent the exercise from taking place.

Lunch will be provided on board
Participants need to wear their badges to access the Croatian navy vessels, a cap, sunglasses, trousers (no shorts), tennis shoes or other type of shoes with good grip on wet surfaces.

Timeline of the Day
Transfer from hotel to port by bus
Exact time will be provided during the Wednesday afternoon briefing
Safety exercise drill/briefing during transit to exercise zone

1st stage: Towing the arrays to make first contact and "box" the location

2nd stage: Demonstrating the omni-directional hydrophone

3rd stage: Triangulation using handheld directional hydrophones

4th stage: Sending divers to recover flight recorder using handheld directional hydrophone

5th stage: Side scanning for wreckage

6th stage: Recovery phase

20:00 Sponsored Dinner
Valamar President Hotel. Hosted by the Ministry of the Sea, Transport and Infrastructure of the Republic of Croatia

Friday 12 June 2009

8:30 **Debriefing the On-Site Exercise**
Steering Committee presentation of material and websites (ECAC, CIRCA)

9:30 **Coffee Break**

10:00 **R44 Recovery in Extremely Low Visibility Conditions**
Martin Puggaard, AIB Denmark

10:20 **Underwater Site Survey in Shallow Water**
Yann Torrès, BEA France

10:40 **Underwater Recovery Process and Significant Events**
Frank Hilldrup, NTSB USA

11:00 **Lessons Learned from two North Sea Aircraft Recoveries**
Tor Nørstegård, AIBN Norway

11:20 **Air Accident Investigation Costs - The Insurance Option**
John Barry, Willis Dublin

11:40 **Dealing with Human Remains**
Olivier Ferrante, BEA France

11:50 **Question & Answer session**
Discussion on general recommendations

12:20 **Closing Remarks**
Paul Louis Arslanian, Chairman of the ECAC accident investigation group (ACC)

12:30 **End of the Workshop**

Ministry of the Sea, Transport and Infrastructure
Accident investigation body

Workshop on Underwater Recovery Operations