The search for Malaysian Airlines flight MH370

An article by MELANIE BARTH

Even today, hydrographic surveys can reach the boundaries of what is technically possible, and project sizes as presented in this case study will push our ingenuity. The size-challenge can be defined by the extent of the project area, the water depth, the number of vessels/equipment involved, the data volume or all of the above. On 8 March 2014 the Malaysian airplane MH370 scheduled on a flight from Kuala Lumpur to Bejing with 239 people on-board went missing. This tragedy started a marine search and rescue mission, which turned later into the largest aircraft accident investigation in history. This case study presents a summary of the underwater search of this investigation. The mainly uncharted search area in the southern Indian Ocean of 120,000 square kilometres reaches water depths of up to 6,000 metres. The operation was planned in three phases: a deepwater multibeam survey to map the seafloor and enable a detailed search, the detailed survey to find the aircraft, and at last a recovery survey.

aircraft search | ultra-deep survey | deep-tow system | Indian Ocean

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1 Introduction

On 8 March 2014 the Malaysian airplane MH370 scheduled on a flight from Kuala Lumpur to Bejing went missing. On board the aircraft were 239 people. A marine search and rescue mission was started shortly after the disappearance, which turned later into an aircraft accident investigation to understand the circumstances leading to the tragedy and hopefully bring closure to the families.

The case study will present a summary of the underwater search of this investigation.

2 Project overview

2.1 The search area

The Australian Transport and Safety Bureau (ATSB) is leading the search and recovery operation in the southern Indian Ocean. One of the first steps of the investigation was the identification of the most likely location of the missing aircraft. Available information and simulations were studied and produced a probability heat map of the aircraft location (Fig. 1), which was used to specify the search area.

The underwater search area is in a remote location approximately 1,000 to 1,500 nautical miles west of Freemantle, Australia; a sailing time of four to six days at 10 knots to reach the location by survey vessel.

The size of the search zone measures 120,000 square kilometres with water depths up to 6,000 metres. The morphology of the seafloor was relatively unknown previous to the search operation. Satellite radar altimetry data gave an indication of the expected water depth and aided with the planning.

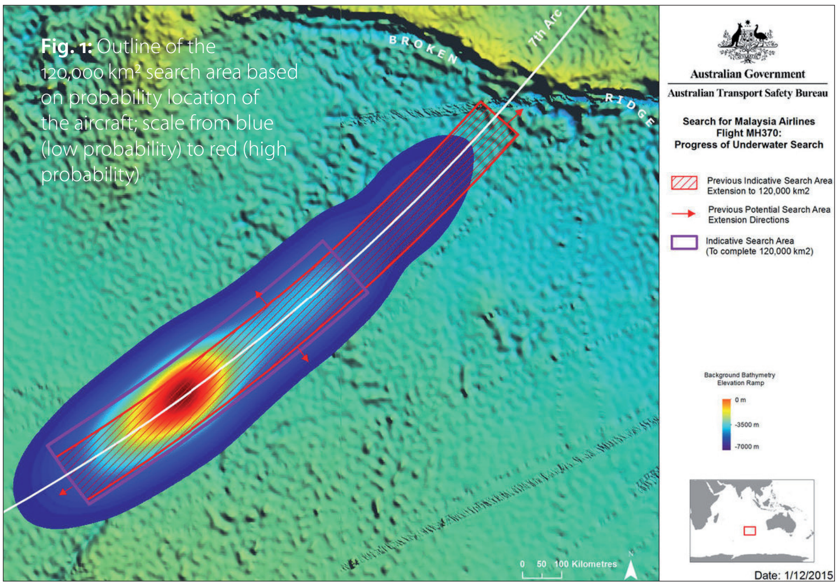


Fig. 1: Outline of the 120,000 km² search area based on probability location of the aircraft, scale from blue (low probability) to red (high probability)

2.2 Search parameters

From previous aircraft accidents it is understood that an aircraft can break up on contact with the water surface, e.g. the accident of the AF447 flight in June 2009 revealed a debris field of 600 metres by 200 metres on the seafloor with one of the turbine engines as the largest located piece (BEA 2012). This experience was used to specify the parameters for the MH370 search. The operation had to be designed to identify debris fields with individual maximum target size of two square metres, while full coverage of the entire priority search area was required.

2.3 The survey

The operation was split into three phases (see table) and started with the deepwater multibeam echo sounder investigation to map the seafloor with a hull-mounted Kongsberg EM302 system of the »Fugro Equator«, which was later joined by three further Fugro vessels. The bathymetry revealed a challenging morphology with underwater volcanoes and canyons, e.g. at the Greelvink Fracture Zone an up to ten kilometre wide canyon

Survey phases	Method	Coverage rate
Map the seafloor to enable save mission planning for detailed search	Deepwater multibeam survey with hull-mounted echo sounder	1,200 km²/d, cross track resolution: 104 m
Detailed survey to identify the aircraft and map/ photograph the debris field	Deep-tow (DT) & AUV survey; with multibeam echo sounder, side-scan sonar, sub-bottom profiler, camera, USBL positioning	DT: 133 km²/d, cross track resolution: 0.7 m; AUV: 17 km²/d, cross track resolution: 0.1 m
Find and recover (phase not started yet)	ROV survey	24 km²/d, cross track resolution: 0.1 m

was observed with an almost one kilometre high perpendicular wall.

Based on the bathymetry the detailed survey plan was designed. The deep-tow system was selected as primary solution for the second phase. The altitude of the deep-tow system was set at 150 metres above the seafloor to ensure the required resolution and maximal possible coverage. This resulted in a towed distance of approximately nine kilometres behind the vessel (Fig. 2), which limited the manoeuvrability of the spread.

As secondary system an AUV (»Echo Surveyor VII«, a Kongsberg Hugin 1000) was selected to cover the areas that could not be reached by the deep-tow system and for detailed inspections of recorded targets of interest. The AUV was deployed from the stern of the vessel on pre-programmed missions flown at 100 metres altitude, hence the necessity of the high-resolution bathymetry from the first phase of the project.

The deep-tow systems as well as the »Echo Surveyor VII« were depth rated to 6000 metres. The systems were equipped with state-of-the-art sensors: Edgetech 75 kHz side-scan sonar, Kongsberg EM2040 multibeam echo sounder, Edgetech sub-bottom profiler, cameras, hydrocarbon sniffer (only at the beginning of the investigation) and positioning systems such as Doppler Velocity Log (DVL), altimeter, sound velocity sensors, HAIN motion sensors and Ultra Short Baseline (USBL) systems (HiPAP 101 for the deep-tow systems, HiPAP 501 for the AUV respectfully).

Data from the deep-tow system was transmitted directly via an umbilical to the vessel, while the data on board the AUV was recorded on board the vehicle and uploaded after each mission. Missions were limited by battery power to approximately 30 hours. Data was copied immediately to a secondary server system for backup and then transmitted via satellite systems to shore in near real time to enable access to the authorities to all information and allow coordination and control of the operation. Processing of the data was split over various processing centres to increase efficiency. The data was reviewed by minimum of four independent geophysicists (ATSB and Fugro) to ensure that no target was missed.

3 Implication of the remote location

It was mentioned before that the search area was defined in a remote location. There are two main challenges with the remote location: number one is the distance to the nearest port and hence long sailing times, number two is that so little is known about the investigation area.

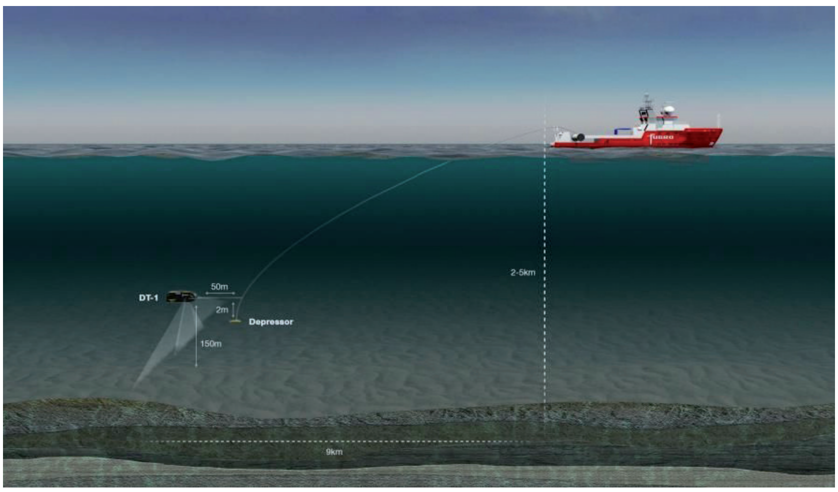
3.1 Distance to shore and sailing time

Vessel mission periods are limited by the fuel consumption and food supplies that a vessel can carry. During the MH370 search operation Fugro vessels with a length between 65 and 93 metres were involved in the project. Even though missions were usually planned for maximum duration of each vessel, effective survey time was always limited by the sailing time from and to the search area, which averaged ten to twelve days per mission. Using up to four survey vessels attempted to minimise this impact on effective survey time.

The long distance to shore also has an impact on each interruption of the operation. It was clear that unplanned mission breaks had to be avoided. Therefore, all vessels had a doctor on board and remote tele-medicine to reduce the likelihood of medical emergency breaks. Even though the medical risk was considered it could not be totally avoided. In the two years operation there were two emergency port calls due to illnesses, though no injuries.

Another risk was exposure to weather extremes. The risk was mitigated by six-hourly weather forecasts to ensure safe mission planning. Though equipment could be recovered on board in time,

Fig. 2: Schematic representation of the deep-tow system of the »Fugro Equator«



References

ATSB (2015): ATSB Transport Safety Report – MH370 - Definition of Underwater Search Area, AE-2014-054, 3 December 2015

BEA (2012): Final Report – On the accident on 1st June 2009 to the Airbus A330-203 registered F-GZCP operated by Air France flight AF 447 Rio de Janeiro – Paris (Update: 27 July 2012)

there was no shelter close by and therefore the vessels had to stay out at sea. During the project there were four tropical cyclones at the search area which resulted to largest recorded wave heights of 17 metres, and wind up to 78 knots (~150 km/h).

Not only weather extremes were a limitation to the survey also standard wave heights in the Indian Ocean had an impact on the operations as the AUV had to be launched and recovered on a regular basis. When wave heights increased above the safe operation limits missions had to be postponed until safe operations were possible again. During the project a new launch and recovery system was installed on board one of the vessels used during the survey, the »Harvila Harmony«, which increased the AUV weather window to wave heights of up to 3.5 metres.

3.2 Unknown of the investigation area

Even though hydrographic surveys have been carried out for centuries the main research areas of interest are near to shore in national territories or along popular shipping routes. In general, the further the operation area is away from shore the less information is available. Although satellite radar bathymetry becomes more and more available the details of the collected data reduce with increasing depths. The MH370 search area is not only located far away from shore, but also in deep water, which resulted in sparse available information before operations started. This made it necessary to commence the operations with the mapping of the survey, before the detailed search could start to reduce the likelihood of losing the survey equipment.

4 Close-out

Flight MH370 has not been located yet. The authorities have indicated that the search will be suspended after completion of the priority area until new information becomes available which warrants continuation of the search. Until such time, the tragedy remains a mystery.

However, data that was collected during the search mission will be made available and might support future studies on tectonics or other earth science topics and increase our understanding of the earth, especially of the seafloor of the Indian Ocean.

Experiences gained during the operation will assist in future projects, e.g. the newly designed launch and recovery system will make operations safer and remote processing becomes a common practice. ⚓