Notes

OPERATION TIRÚA: HYDROGRAPHIC VISION

N.A. Guzmán Montesinos
Naval Hydrographic Engineer
Head of the Information Technology Department
Head of the Chilean Tsunami Warning Center, Chile

Abstract

On 6 October 2013, a small commercial flight with 5 people on board and flying between Mocha Island and Tirúa off the coast of Chile went missing, leaving no traces. The Armed Forces established a search party with personnel and staff from the 3 forces. Considering the possible fall of the plane into the ocean, the Navy deployed several naval and maritime resources with the purpose of finding any signs of it. A number of vessels with hydrographic capacities searched carefully for over 20 days with no positive results. Some parts of the small plane were found 7 months later on the coast on Mocha Island. The hydrographic experiences from this operation provide a number of lessons that can be used in similar operations and to optimize the use of the resources.

Background

A Cessna 172 plane took off from Mocha Island on 6 October 2013, heading to Tirúa, 8th Region of Biobío, with a regular flight time of less than 15 minutes and with 5 passengers on board. The small plane took off at 14:45 with the landing expected sometime around 15:00 hours on the same day. Assuming a possible tragedy, a Search and Rescue (SAR) operation was activated at 18:00 hours later that same day. The Army, Navy and Air Force were part of an operation led by the Air Force. To search the ocean area, the Navy used a series of naval and maritime capabilities, along with help from civilian resources to locate the small plane or its remains underwater. The ocean search used the following technologies:

1. Three platforms fitted with multi-beam systems. This operation used two multibeam systems installed in the naval units, the BMS Merino and the PSG Ortiz and a portable device, which belonged to the Skyring Marine Enterprise, installed onboard a minor vessel. The multi-beam systems consist of small sonars designed to measure the depth of the seabed, with hundreds of beams per second to determine the topography and objects on the seabed. The resolution of the multi-beam system depends on the seafloor depth, vessel speed and the system characteristics. The BMS Merino system is 50 KHz and is designed for medium to deep waters. It also has a theoretical range of operation between 30 and 3,000 meters and sends out 126 beams per second. The PSG Ortiz and of Skyring Enterprise systems are 300 KHz, with a depth range between 0.5 and 150 meters. The 254 beams per second provide a higher discrimination capacity.
2. Three Side Scan Sonar (SSS) systems. SSS detect objects on the seabed (***Figure 1***) and provide good capabilities for this kind of operation. One system belonged to the Navy and the other two systems belonged to the Marine Scope

and Skyring Marine. SSS can be operated from a small rubber boat, so wind, sea state and daylight hours can pose operational limitations.

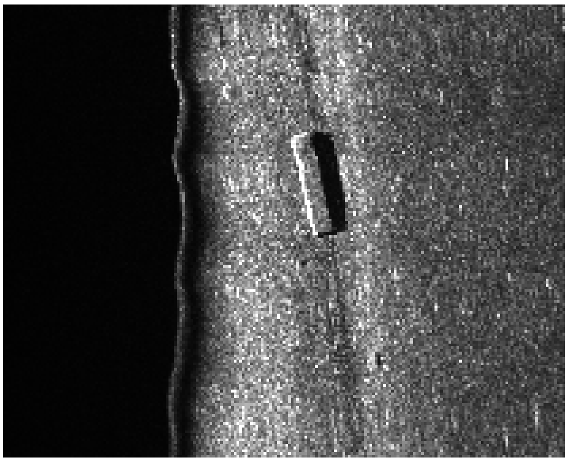

Figure 1. *Container detected by a Side Scan Sonar, sunk in the Bay of Talcahuano.*

3. Two Submarine Scan Robots. The Remotely Operated Underwater Vehicles (ROUV), commonly called Submarine Scan Robots, have the capacity of acquiring images and video of the seabed. This makes them useful for this kind of operation. Its major limitation is visibility determined by the water turbidity. For Operation Tirúa, the visibility was poor and never exceeded two meters, so the ROUVs had a very limited use in this search.
4. Divers. Divers go underwater to recover whatever is necessary once something has been detected by the multi-beam, SSS or ROUV. The limitations of the divers are visibility, depth and time of operation.
5. Naval and Maritime units provided general logistical support and visual scanning for floating objects.

The only previous local experience for this type of search operation, was in the 2011 search for the fighter plane that crashed into the ocean around Juan Fernández Island, killing 21 passengers. Unfortunately, personnel and units engaged in the current search were not part of that previous operation.

The search area's hydrographic and oceanographic conditions determines what sort of vessels are needed, the type of equipment and the skills and experience of professional staff to perform the search efficiently. All the resources were deployed gradually as new information was gathered and more hypotheses developed as to what could have happened and how to find the aircraft.

Description of the Operation

The operational instructions came from the Coordination Center of the FACH (Air Force of Chile) on land and the coordination for searching the ocean was assigned to the BMS Merino. The initial information given for the search was practically zero, since there was no wreckage found or seen, nor witnesses that saw the small plane fall. No photographic or video record of the flight existed to indicate that the aircraft had fallen. There wasn't any certainty that it had even fallen into the ocean. Hence, the first phase of the operation was a visual search with the three branches of the Armed Forces on land, sea and air, to look for any sign that could indicate a way to narrow the search.

Local fishermen informed the search coordinator that they had seen oil slicks. The units checked the area, took some oil samples to be analyzed, but they didn't find any sign of the airplane. The samples were sent to the Chemical Oceanography Laboratory of the Hydrographic and Oceanographic Service of the Navy (SHOA), where an analysis of hydrocarbons was conducted using the gas chromatographer. These returned negative results for aviation oil.

Later information was received about an alleged connection of a cell phone of one of the passengers, who would have had a signal on his or her cell phone for about 6 minutes of the flight. With the speed of the flight, it could be inferred the presumptive distance that the airplane should have flown, if it had fallen after 6 minutes. The problem was that the airplane's speed could have been between 60 and 100 knots, so the distance from the Mocha Island varies significantly, and even worse, the path of the plane was completely unknown.

With the purpose of carrying out a search in a well-planned manner, the search was divided in sub-areas and assigned to the different units and determined their progress.

The assumption that the plane had followed a regular flight route and had fallen into the ocean was taken as a starting point after the exhaustive but unsuccessful search on land. Sounding operations were initiated to search for the plane or its wreckage.

The summary of the hydrographic and oceanographic characteristics of the search area were:

Hydrography

Depth: Shallow waters, between 20 and 30 meters in the area of the alleged plane course. The size of the areas, combined with a shallow depth, lengthened the search. The coverage area of the seabed using multi-beam equipment is three times the depth, meaning the swath of the beam pattern was between 60 and 90 meters wide per each sounding line. The distance between Mocha Island and Tirúa is 17 nautical miles, requiring approximately 420 sounding lines given a coverage area of the multi-beam swath of 75 meters of the bottom.

If a four-mile long sounding line is determined with an average speed of 7 knots for a vessel, which is the appropriate speed to be able to detect an object the size of a small plane, the result is 34 minutes per line. If this is multiplied by the 420 lines, approximately ten days sounding is obtained. This only covered the area approximating the possible track of the plane.

Existing sounding lines: This data was limited and were used to compare any differences to the first sounding lines. In the areas where there were no previous sounding lines, the sounding lines required were between 30 and 45 meters wide. This doubled the sounding time which was originally 20 days.

Oceanography:

Waves: the general wave direction in the area is predominantly from the south-west, 1 to 3 meters high with a period between 12 and 20 seconds. The length grows when there are swells, which happens regularly between March and November. During the search days, tidal waves were evident practically all the time, which made it much more difficult with the sounding operations. Severe movement of the vessel often caused the multi-beam system to crash. This meant that during most of the time, soundings could only be recorded along lines from south to north and not the lines from north to south, further extending the sounding time to 40 days. To cover the total area, considering the detour of the plane and its maximum distance according to the 15 minutes of the flight, it would have taken approximately 3 months of uninterrupted sounding, that is to say 4 months of scheduled hydrographic work.

Currents: the currents between Mocha Island and the continent are predominantly south-west and south-east with modeled intensities that vary between the 0.5 and 2 knots. During the survey, three experimental drifts were deployed with elements monitored by GPS. This equipment provided actual results for comparison against those that were modeled.

Tides: variations of the sea level in the area were minimal with no influence on this operation.

Taking into consideration these conditions, the search operation was established deploying the different units for sounding capture in the search area. The BMS Merino and the PSG Ortiz, which used multi-beam sonars and SSS, both detected what seemed to be a wrecked plane. Small objects, less than 3 meters in length, showed up on the sonar screens, different from what usually is found on the seabed.

The extensive experience of the sonar operators from the Hydrographic and Oceanographic Service of the Navy (SHOA) enables determination of the seabed characteristics and its structure. However, the personnel have not had much experience in the search for sunken wrecks. Many of the new contacts found where fish shoals abundant in this fishing area. The formation of the fish looked similar to a tube and was very close to the seabed, confusing the operators and making them think they had detected something. When they repeated the process, they found that there was nothing in the same spot.

After days of searching and not finding any floating wreckage, oil slicks or any other signs that a plane had crashed in the ocean, it was assumed that the plane had not broken up upon impact with the water and had sunk intact.

The experience of the Skyring Marine personnel in similar searches in other countries, with similar sonars to the one used by the PSG Ortiz, indicated that based on the area's water depth, they expected the multi-beam system to detect the plane almost in its intact form. An example of this type of detection is shown on ***Figure 2*** where a small plane can be seen at less than 30 meters of depth using a 400 kHz multi-beam system.

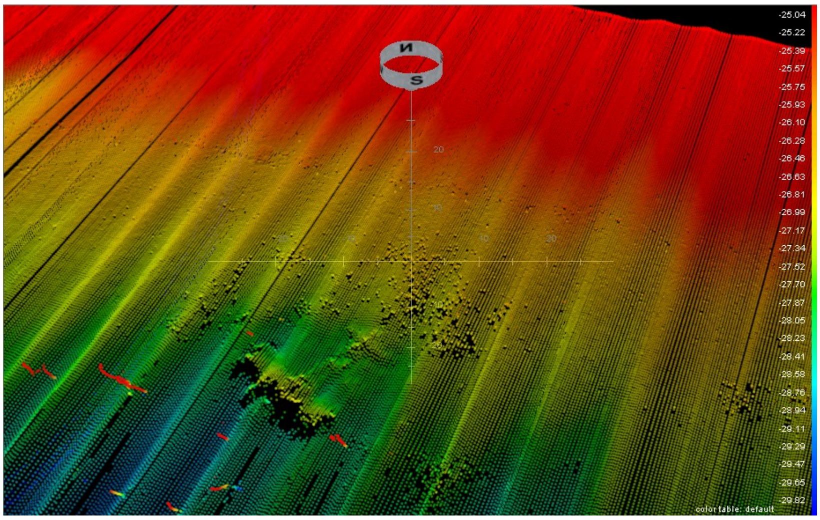

Figure 2: Small plane visualized at less than 30 meters of depth, in Panama.Image provided by Fernando Landaeta, Skyring Marine.

During the search, information was collected from different sources. Several opposing theories of what might have happened also existed. Search vessels with the multibeam systems kept on searching along the alleged flight route, as shown in ***Figure 3***.

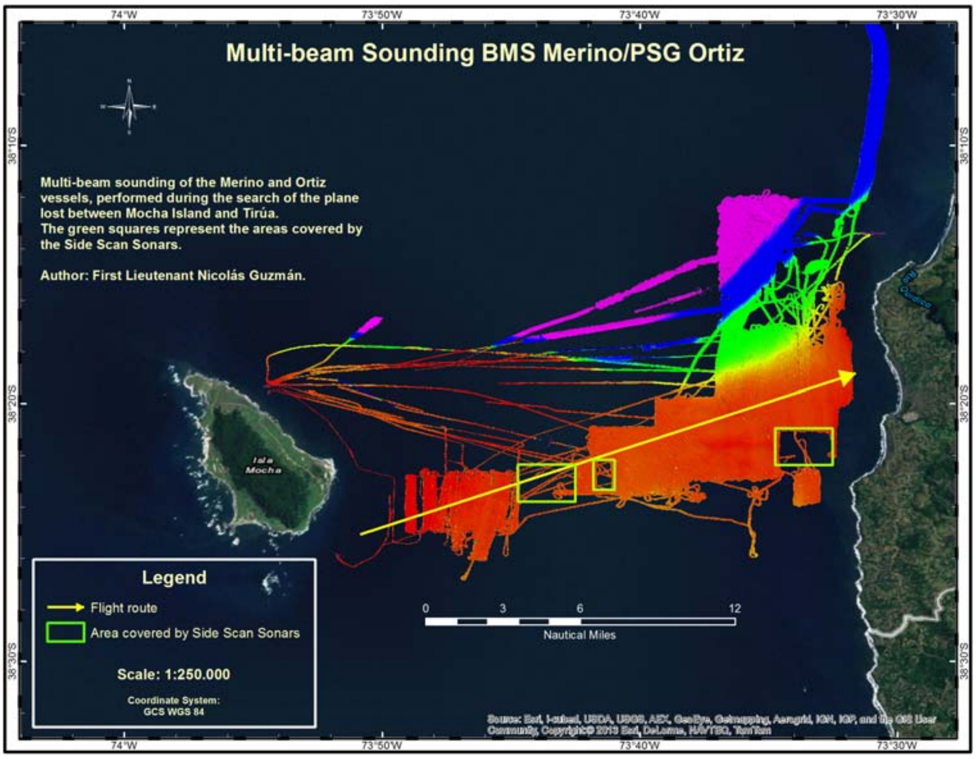

Figure 3*: Sounding performed during the 20 days of search by the BMS Merino, PSG Ortiz and Side Scan Sonars, based in the regular flight track of the plane.*

It needs be pointed out that the searched area only represented a small area, assuming that the plane had problems and could have changed course in any direction.

Conclusions and Recommendations

- The execution time of a search of any sunken object in the ocean will be considerably reduced if evidence that confirms the sinking location is available.
- The hydrographic and oceanographic conditions are the first things to consider in planning the operation; together with the search methodology to be used, such as vessels, sonar equipment, divers, ROV and their respective capabilities and their limitations.
- The sonars to be used include high frequency multibeam systems and Side Scan Sonars (SSS). The use of SSS equipment can be limited to the platform from which they are deployed.
- It is highly recommended to follow a sequential search methodology to maximize technology and human resource efficiency and the likelihood of finding any sunken wreckage: first to search using multibeam and SSS; and after making contact with the object, to deploy the ROUV down and finally the divers, only when video or images confirm the presence of the object.
- Specialized trained personnel are needed to operate the search equipment.

Author Biography

Nicolás A. Guzmán joined the Navy School as a Cadet in 2000 undertaking various Naval assignments. In 2008, he was promoted to Lieutenant and started his studies in Hydrographic Engineering at the Naval Academy. In 2010, he graduated from his "Category A" course at the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA), completing his thesis on wave energy.

The following two years, he was involved in activities related to improve the Chilean Tsunami Warning Center. This included periods of study and further training, specializing in Tsunami's and attending the Early Warning Training Program in Hawaii, at the Pacific Tsunami Warning Center (PTWC). At the end of 2012, he was promoted to Senior Lieutenant.

Since 2011, he has led several Hydrographic and Oceanographic campaigns, in different locations in Chile, including Antarctic. In addition to these operations, he is the current Head of the Information Technology Department, the Head of the Chilean Tsunami Warning Center and has been a Hydrography and Oceanography professor at the Training Center of SHOA since 2012. nguzman@shoa.cl