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OVERVIEW OF REMOTE SENSING APPLICATION FOR SEARCH OF MH370

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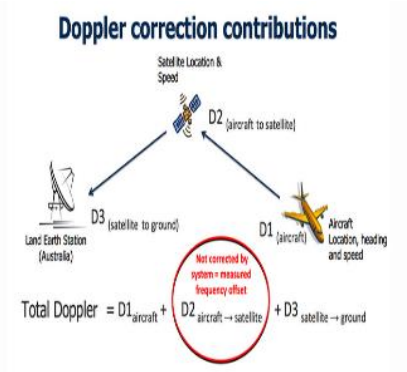
Graphical abstract



Abstract

This paper summarizes some remote sensing technologies in use by different search and rescue operators for the search of the missing Malaysia Airline (MH370). Studies are on-going using detected products and complex imagery. Some of the detected imagery currently does not provide reliable information, though the techniques themselves are promising. The introduction of microwave remote sensing systems will provide the much needed assistance when both visual searches and optical imaging systems do not help. However, under normal atmospheric conditions, airborne or space borne imaging systems are developed to obtain further information. The paper looked into the airplanes, flight data recorder and cockpit voice recorder, as well as the possible path.

Keywords: Remote sensing, MH370, Boeing 777, flight path.

1.0 INTRODUCTION

The research pinpoints some of the vital passive and active remote sensing techniques used by different search operators in the search and rescue of the missing MH370 towards achieving a positive result on the search. Since the search and rescue operation is still on-going, the research may continue to expand by other researchers to point out some necessary and vital future remote sensing steps which will be deemed relevant for the search. Remote sensing has been playing a vital role in the search and rescue mission owing to its importance in different applications.
Microwave imagery using synthetic aperture radar (SAR) systems is also useful for the location of the assumed debris from the airplane. In this paper, the techniques which use both active and passive remote sensing system towards a successful search and rescue operation are discussed. Also suggest the application of optical remote sensing by means of satellite imagery, this will help the search and rescue operators for more useful and faster results. The major objective of this paper is to emphasize on some of the important remote sensing technologies in use for the search and rescue operations of the Malaysia MH370. Other objectives include:

- To analyze the measures used to determine the possible flight paths to the assumed wreck area.
- To discuss the importance of optical remote sensing for search of MH370 on the Ocean surface.

Remote sensing is applicable in many fields of environmental studies, this includes:

- Remote sensing is applicable in meteorology: atmospheric profiling temperature, pressure, water vapor and wind velocity.
- Application in Oceanography: in the areas of sea surface temperature measurement, ocean currents mapping and wave energy spectra.

- Remote sensing application in Glaciology: such as measuring ice sheet volumes, ice stream velocity and distribution of sea ice.
- Application in Geology: in the areas of geomorphology, rock type identification, faults and structure mapping.
- Application in Geodesy: This is applicable in measuring the figure of the earth and earth's gravitational field.
- Application in Topography and cartography: provides improvement in digital elevation models.
- Remote sensing application in agriculture, forestry, and botany: for crops monitoring, biomass of land vegetation, soil moisture mapping and forecasting crop yields.
- Application in Hydrology: for assessment of water resources from snow, rainfall and underground aquifers.
- Application in disaster prediction and assessment: such as monitoring of floods and landslides, volcanic activities etc, as well as assessment of damaged zones caused by natural disasters.
- Remote sensing application in Planning: mapping ecological zones, deforestation, as well as urban land use.
- Crude and other mineral exploration: location of natural oil seeps and slicks, monitoring oil field subsidence.
- Remote sensing application for Military: precise maps for targets planning, military infrastructure, monitoring of ships and movements of troop (used mainly by the US military).

2.0 OVERVIEW OF MH370 AND REMOTE SENSING

Remote sensing is the acquisition of information about an object or phenomenon without being in physical contact with the object or having an in-situ observation. Also, remote sensing generally is the use of aerial sensor technologies for the detection and classification of objects on Earth (which maybe on the earth surface, in the atmosphere or oceans floor) using propagated signals or sounds e.g. electromagnetic radiation [Reddy, 2001]. Remote sensing is divided into active remote sensing (emission of signal from aircraft or satellites) and passive remote sensing (signal emission from sunlight). Remote sensing is playing an active role on the search for the missing Malaysia flight MH370 specifically known as Boeing 777.

2.1 Boeing 777

This is a family of the airplanes characterized by its long-range, wide-body twin-engine developed and manufactured by Boeing Commercial Airplanes [2]. It is the world's largest twinjet, it had onboard 237 passengers from Kuala Lumpur to Beijing. The plane has the ability to cover a range of 5,235 to 9,380 nautical miles (9,695 to 17,372 km). Its other outstanding features include being the largest-diameter turbo-fan engines aircraft; it has a circular fuselage cross-section and also a blade-shaped tail cone. The air plane is equipped with a computerized controls units; being the first overall computer-designed commercial aircraft with a black box (located at the back of the aircraft, built to stay intact in case of any crash) and on it are two individual recorders; the flight data recorder and cockpit voice recorder.

2.2 Flight data recorder and cockpit voice recorder

The Boeing 777's flight data recorder and cockpit voice recorder devices has the underwater acoustic beacons capable of emitting sonar pings, and batteries that can stay up to 30 days after a crash. The beacons can withstand up to 3,400Gs (the measure of gravity), ocean depths of about 20,000 ft., according to Honeywell Redmond (the Black box assembler) [2].

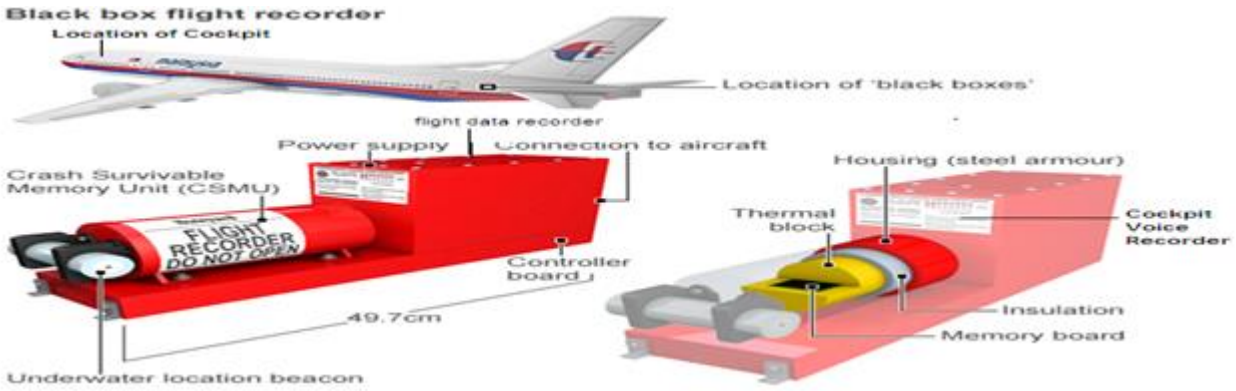


Figure 1 CVR vs. FDR

The Cockpit voice recorder (CVR) can record and retain up-to-date at least two hours conversation and the Flight data recorder (FDR) records 25 hours of data and thousands of parameters for two years.

3.0 METHODS AND RESULTS FOR POSSIBLE FLIGHT PATHS

3.1 Possible Flight Path

Further questions was asked on the authenticity of the information provided leading to the concentration of the search on the southern part of the Indian Ocean;

i. Did the Plane follow the North or South path, whichever,
ii. How Did Inmarsat Deduce Possible Flight Paths?

The International Maritime Satellite Organization (Inmarsat) in conjunction with the British Air Accidents Investigation Branch (AAIB) refined its prediction to reconfirm the authenticity of the possible flight path and after analysis; they came up with the fact of an automatic communication between one of the Inmarsat's satellites and the aircraft, which can be useful to determine possible flight paths. The analysis uses the principle of Doppler Effect. Even though the aircraft's crash position could not be determined, Doppler Effect analysis on SATCOM pings enabled INMARSAT to determine MH370's final route over South Indian Ocean until a final, "partial ping," or handshake' was received 8 minutes after the last known one.

3.2 Doppler Effect

Doppler Effect takes place when wave moves with respect to an observer. It can also be described as the effect produced by a moving source of waves when the frequency increases towards the observer whom the wave is approaching and a decrease in frequency for observers from whom the wave is receding. The Doppler analysis in this case was carried out using the same type of aircraft and the ground receiving station via satellites using the process of handshake (a process whereby the ground station communicates with the aircraft by sending a log on/log off message. The aircraft uses its unique identifier to return a ping to the ground station indicating that it is still logged on). The Doppler technique used by Inmarsat to analyze the difference between the ground stations supposed frequency reception and the actual measured frequency is known as Burst Frequency offset. Burst Frequency Offset may change depending on the location of the aircraft on the arc of possible positions, the flight direction and speed.

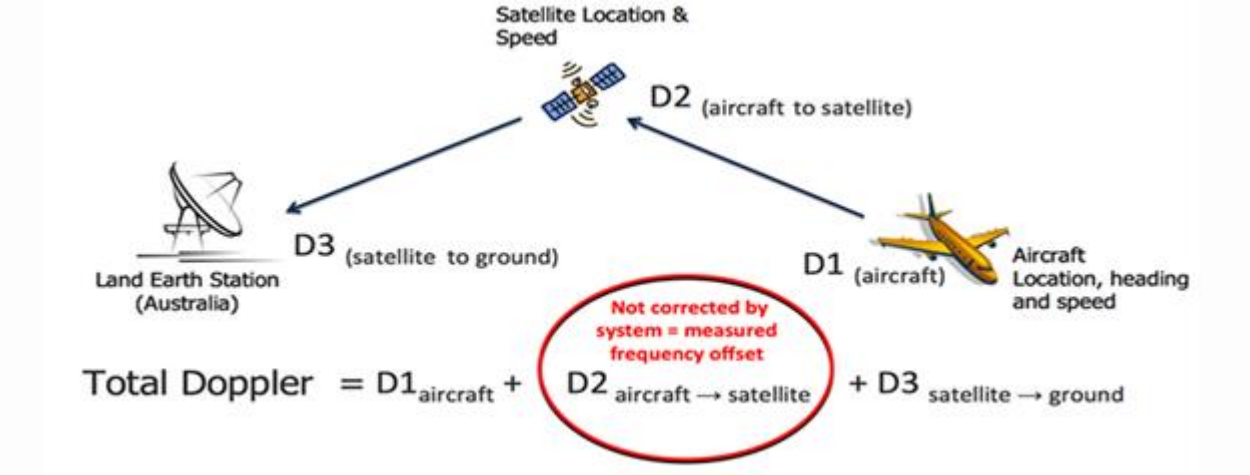


Figure 2 Doppler correction distribution [3]

Inmarsat established confidence of this theory on its analysis using information data from six other B777 aircrafts which flew on the same day in different directions to deduce that the MH370 flew along the southern corridor. While on air, the ground station logged the transmitted and received pulse frequencies at each handshake and noted the systems characteristics and the satellite position. This made it possible to easily determine where on the arc the calculated burst frequency offset best fit.

More so, the satellite position was known, time of signal transmission and reception via the satellite to the ground station was used to establish the range of the aircraft from the satellite. The last complete handshake happened at 0011UTC. The result of the analysis showed poor correlation on the northern corridor and good correlation on the southern corridor. Figure 3 shows that:

- The blue line shows the burst offset at ground station
- The green line shows the predicted burst frequency offset for the southern route, which shows close correlation over the 6 handshakes.
- The red line shows the predicted burst frequency offset for the northern route, which shows poor correlation over the 6 handshakes.

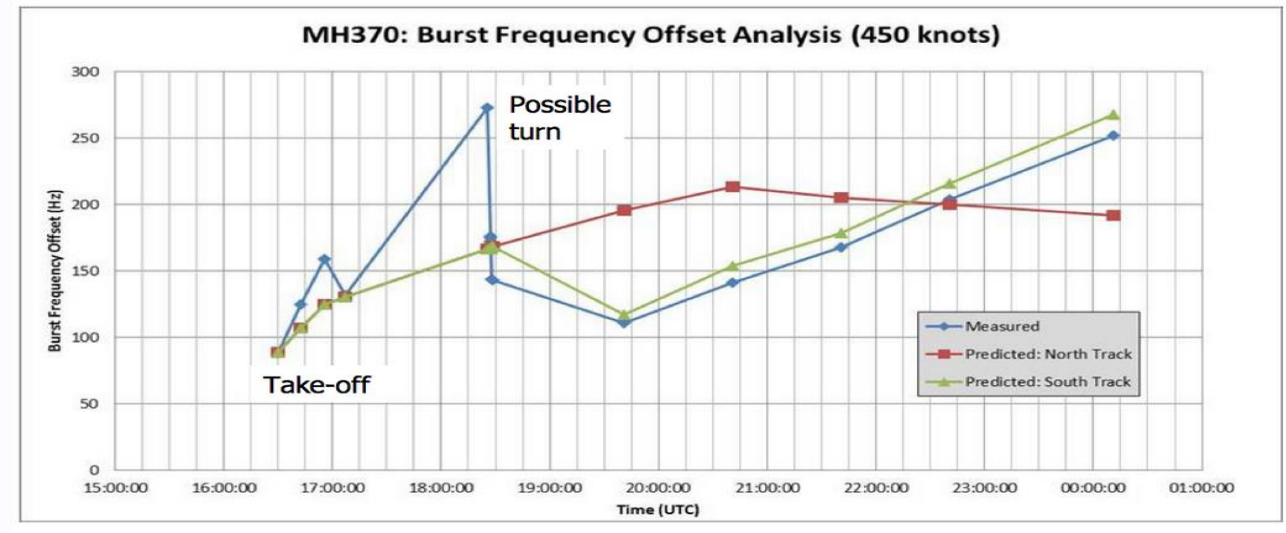


Figure 3 Flight part determination [3]

4.0 METHODS AND TECHNOLOGIES IN USE FOR THE SEARCH OF MH370

Some of the key technologies employed in the search are: The Ocean Shield which has on it; a specialized 'towed pinger locator; that can be lowered deep into the ocean on 6,000m of cable to search for signals, and able to detect pings from the black box. It also has on it the Bluefin-21 autonomous underwater vehicle; an underwater drone equipped with Sonar (active remote sensing system) which can be programmed to dive deep into the ocean floor to search for possible objects or contacts under water using an onboard database and analytical computer.

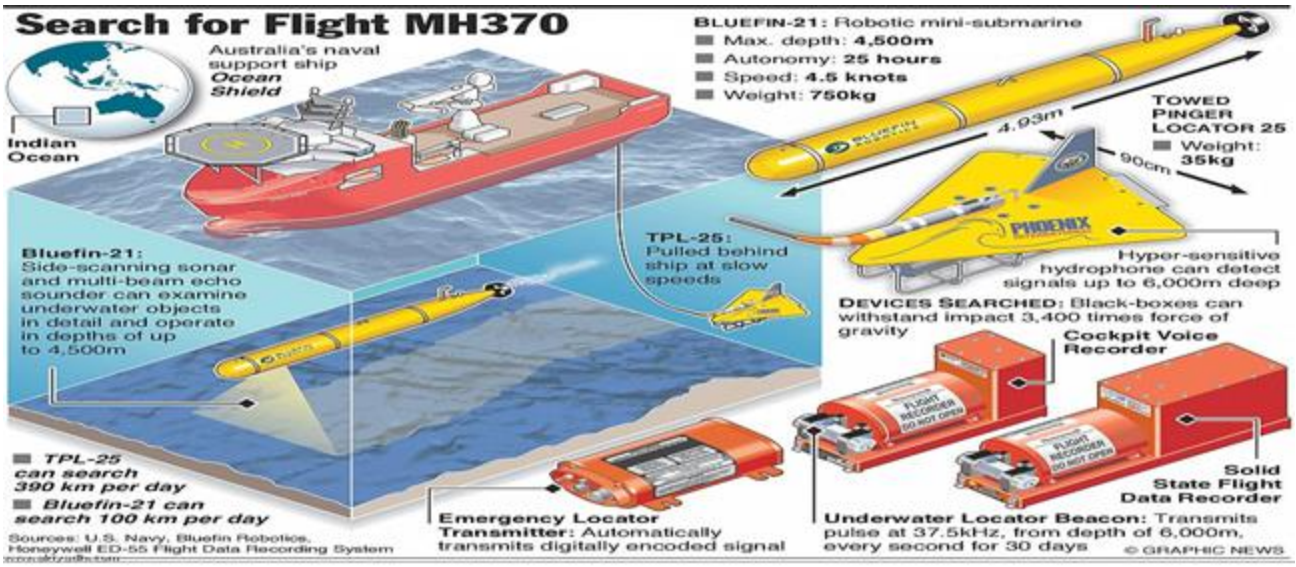


Figure 4 Ocean shield, towed pinger locator and Bluefin-21 Sonar system

Another application takes after the Royal Navy nuclear-powered submarine HMS Tireless; however it can't plunge down to the seabed of Deep Ocean, yet it can work some few meters underneath the surface with its advanced sonar, including its own particular extremely delicate towed array framework which can listen from this depth.

According to [4], "HMS Tireless holds advanced search capabilities, but the task in this deep ocean is a huge challenge as the search area is immense".

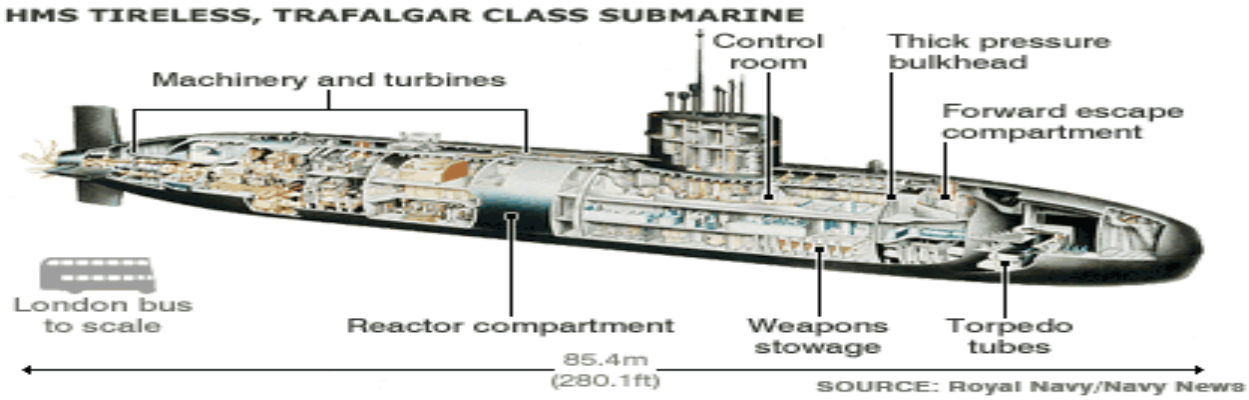


Figure 5 Plymouth Submarine HMS TIRELESS

Also taking part in the search are military surveillance aircrafts of different countries such as the US Navy P-8 Poseidon, Australian, New Zealand, South Korean and Japanese Lockheed Martin P-3 Orion maritime surveillance planes which also played a significant role on the search and discovery of lost Air France 447 which crashed into the Atlantic Ocean in 2009.

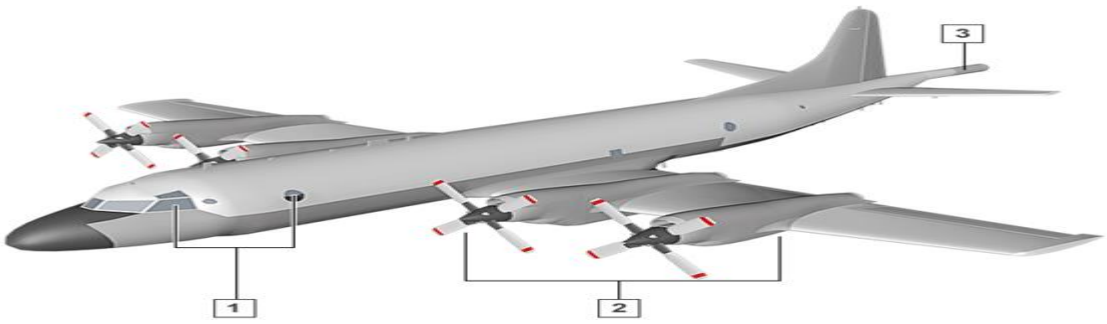


Figure 6 Lockheed Martin P-3 Orion

1. The Lockheed Martin P-3 Orion is equipped with radar and infrared sensors and also observation posts that can distinguish any debris on the sea surface. It additionally has three cameras underneath the landing-gear for zooming in for a more critical look.
2. The four-motor turboprop plane is intended to fly low and moderate to help reconnaissance. When it has come to the search area, maybe a couple external motors can be turned off to save fuel and amplify the surveillance time.
3. The plane is additionally fitted with a magnetic anomaly detector (MAD) - utilized for identifying submarines beneath the ocean. The aircraft also has acoustic identifiers, which have the capacity to detect sound 1,000ft (304.8m) beneath the surface of the ocean [5].

Also are two Chinese Ilyushin Il-76s operating out of RAAF Pearce air base near Perth, and Malaysia's two C-130 Hercules aircraft are also part of the search. As the search goes on but with no positive result yet, and the operation is continuing, more technologies

may be employed on the ocean floor and on the surface for a positive result for the search. Therefore this article talks about the current search and rescue methods and also suggests optical remote sensing system as a more useful and more tactical remote sensing techniques that could yield a positive result on the search.

The search which have been of immense difficulties as a result of some obstacles have introduced a lot of search and rescue techniques both on the ocean surface as regards to tracing some assumed debris from the missing flight, and ocean floor scanning for possible wrecks that may relate to the flight and location of pings from the black box.

5.0 OPTICAL REMOTE SENSING FOR THIS SEARCH

The rapid advance in remote sensing generally makes it easier to detect, measure, record and analyze energy radiated in selected wavelengths of the electromagnetic spectrum. More to its great advantages are its improved synoptic view, vantage points and broadens spectral sensitivity.

Optical remote sensing thus provides good spatial resolution of objects and 3-D perspective. It has the capability of stop action and can also provide, store and retrieve historical records. This system also provides data comparability and enhanced rapid data collection. More to it is its quantitative analysis, measurement of landscape properties and ability to extend ground observations and low cost effective. The system also has its own limitations and challenges which may impact significantly on its data collection accuracy and other derived information. This may include high cost of satellite systems, takes 10 years + to develop, build, test and launch. Another possible challenge is its possibility of single point failure. The panchromatic and multispectral satellites images will indicate clear objects on the water surface. Imaging satellites with 5-meter resolution or more will have the best chance of spotting the aircraft debris.

Director of space and Earth observation at Paris-based Euroconsult, said that some satellites have the capability to see objects that lies below the ocean's surface, "especially satellites with very good blue-band that have the capacity to see in shallow water" [6]. Among the satellites providing optical data collected over the search area, he said DigitalGlobe's Worldview-2 has a very slight advantage. He added that Worldview-2 has several blue bands, and therefore it can filter what corresponds to the atmosphere and what corresponds to the sea or any debris.

6.0 CONCLUSION

Remote sensing classifies extensive regions of Earth's surface by means of image analysis; Search for possible wreck of MH370 on water is not the same as search on land in light of the fact that it doesn't move on land. We thus, utilize numerous images from diverse times, day and night, relies on upon how much you expect things to drift around.

It is easier to search for an abnormality on the water with the idea of remote sensing system, than searching for a piece of wing in a forested or urban area due to the fact that; the ocean surface looks alike on a calm day. In this situation of searching for a wreck that is in water, analyzing the image can be automated by feeding images into a program or software that analyzes the difference between sunlight reflecting off water and metal or other materials.

Human eyes also play an active role in the image analysis; one of the search initiatives been programmed by Tomnod, a crowd-source company that provides coverage in disasters. The satellites' high resolution images aid the public to comb through image after image to look for unusual activities; in this case they're looking for oil slicks or debris from MH370. Thousands of volunteers, including myself, have logged into this platform to find debris and did some image processing using ENVI software.

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