Version 12.1

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Abbreviations

AAIB Air Accidents Investigation Branch (United Kingdom)
ACARS Aircraft Communications Addressing and Reporting System
AF447 Air France flight 447
AMSA Australian Maritime Safety Authority (Australia)
APU Auxiliary Power Unit
ARAIB South Korean Aviation and Railway Accident Investigation Board
ATSB Australian Transport Safety Bureau (Australia)
AA991 Asiana Airlines flight 991
BEA Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (France)
BFO Burst Frequency Offset
BTO Burst Timing Offset
C2H4 Ethylene
CH4 Methane
CO Carbon monoxide
CSIRO Commonwealth Scientific and Industrial Research Organisation (Australia)
CTBTO Comprehensive Nuclear-Test-Ban Treaty Organization
DST Defence Science and Technology (Australia)
DT Dark Target Aerosol
ELT Emergency Locator Transmitter
FAA Federal Aviation Administration (United States)
FDR Flight Data Recorder
FL Flight Level
FVCOM Finite Volume Community Ocean Model
GDP Global Drifter Program
GEOMAR Helmholtz Centre for Ocean Research (Germany)
H2 Hydrogen
ICAO International Civil Aviation Organization
IFE In-Flight Entertainment
JACC Joint Agency Coordination Centre (Australia)
LANL Los Alamos National Laboratory (United States)
LEL Lower Explosive Level
MODIS Moderate Resolution Imaging Spectroradiometer
NASA National Aeronautics and Space Administration (United States)
NOAA National Oceanic and Atmospheric Administration (United States)
NTSB National Transportation Safety Board (United States)
OSCAR Ocean Surface Current Analyses Real-time
Ppbv Parts per billion volume
SATCOM Satellite Communications
SDU Satellite Data Unit
SO2 Sulfur dioxide
SST Sea surface temperature
UTC Coordinated Universal Time

Contents

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Executive summary

This report details the results of a comprehensive study of thousands of hours of independent research into atmospheric, oceanographic, environmental, meteorological, and aeronautical data tied to the loss of Malaysia Airlines flight 370 on March 8, 2014.

The report provides new satellite and oceanographic data complemented with investigation reports from the Commonwealth Scientific and Industrial Research Organisation, Inmarsat, Boeing, Los Alamos National Laboratory, National Oceanic and Atmospheric Administration, Bureau d'Enquêtes et d'Analyses, plus the Malaysian and Australian government reports. In addition, some of the evidence presented in this report came from unreleased government studies.

The data supports an end-of-flight scenario where MH370 was under pilot control at the time of impact. The overwhelming evidence in the following report shows MH370's debris field is in the Indian Ocean on the seventh arc, 1130 kilometers due west of Coral Bay, Western Australia, within 19 nautical miles of 23.71°S. MH370 did not crash in the southern Indian Ocean.

Introduction

Our investigation began with no predetermined hypothesis, except that the remains of MH370 were somewhere in the Indian Ocean and probably near the seventh arc. However, evidence snowballed after finding the first piece and establishing a logical flight path. Hydroacoustic data, infrared satellite images, and drift modeling data were later uncovered in our research, supporting the impact location and the flight path.

The Australian Transport Safety Bureau (ATSB), the Malaysian government, and independent investigators may have overlooked evidence. For example, some atmospheric, oceanographic, drift, and hydrophone data may have been discounted if it did not fit the narrative that MH370 had crashed in the southern Indian Ocean.

Malaysia and all the countries that lost citizens on MH370 were sent copies of this report. France is the only country with an active criminal investigation into the missing aircraft. New evidence from this report has been sent to the Gendarmerie des Transports Aériens detective in charge of the MH370 investigation.

The Malaysian government has ignored our offers to help fund a new undersea search.

Atmospheric anomalies —Indian Ocean- evidence #1

Our research started by collecting oceanographic and atmospheric environmental data from previous catastrophic aviation accidents occurring at sea dating back to 2009. The goal was to identify similar downwind, and down-current environmental anomalies occurring after the accidents, then match that data to anomalies in the Indian Ocean following the MH370 impact. This data modeling technique has been used before to locate lost commercial and military shipwrecks.

Patterns developed after cross-matching the previous air/sea accidents and corresponding atmospheric anomalies found in the Indian Ocean on March 8, 2014.

High levels of daytime atmospheric carbon monoxide (CO), sulfur dioxide (SO2), aerosol (smoke), and methane (CH4) were detected by two polar-orbiting satellites, NASA's Aqua and Suomi NPP, around seven hours after the time of MH370's impact. The atmospheric anomalies were in a cluster between 21.75°S and 23.30°S in the northern Indian Ocean, drifting northwest, and 7 hours downwind of a possible impact point along the seventh arc between 23°S-24°S (figure1).

Elevated levels of CH4 and CO were also recorded downwind from the impact site of the Asiana Airlines Flight 991 that crashed in the North China Sea. A lithium-ion battery fire was the suspected cause of that 2012 accident. The same elevated levels of CH4 and CO downwind of the MH370 impact site may indicate that some of the 221 kilograms of lithium-ion batteries in the cargo hold were damaged during impact, discharging gases into the atmosphere. More details about lithium-ion battery gas release are on page 9.

Elevated downwind levels of SO2 were observed in the atmospheric data from previous accidents. There is a high sulfur content in jet fuel. Some grades of aviation fuel have up to 1000 ppm of sulfur. Both CO and SO2 are released when jet fuel burns or vaporizes. The downwind SO2 gas cloud from the impact site may indicate that MH370 still had fuel onboard at the time of impact.

Side note: MH370 had 5 tons of mangosteens and 2.5 tons of books in its cargo hold. The mangosteens and the books would have given off carbon monoxide during any type of combustion. In addition, Thiacremonone is a sulfur compound present in mangosteens. So if an explosion or flash fire destroyed the mangosteens during or after impact, the burning mangosteens might have also contributed to the downwind levels of SO2 and CO.

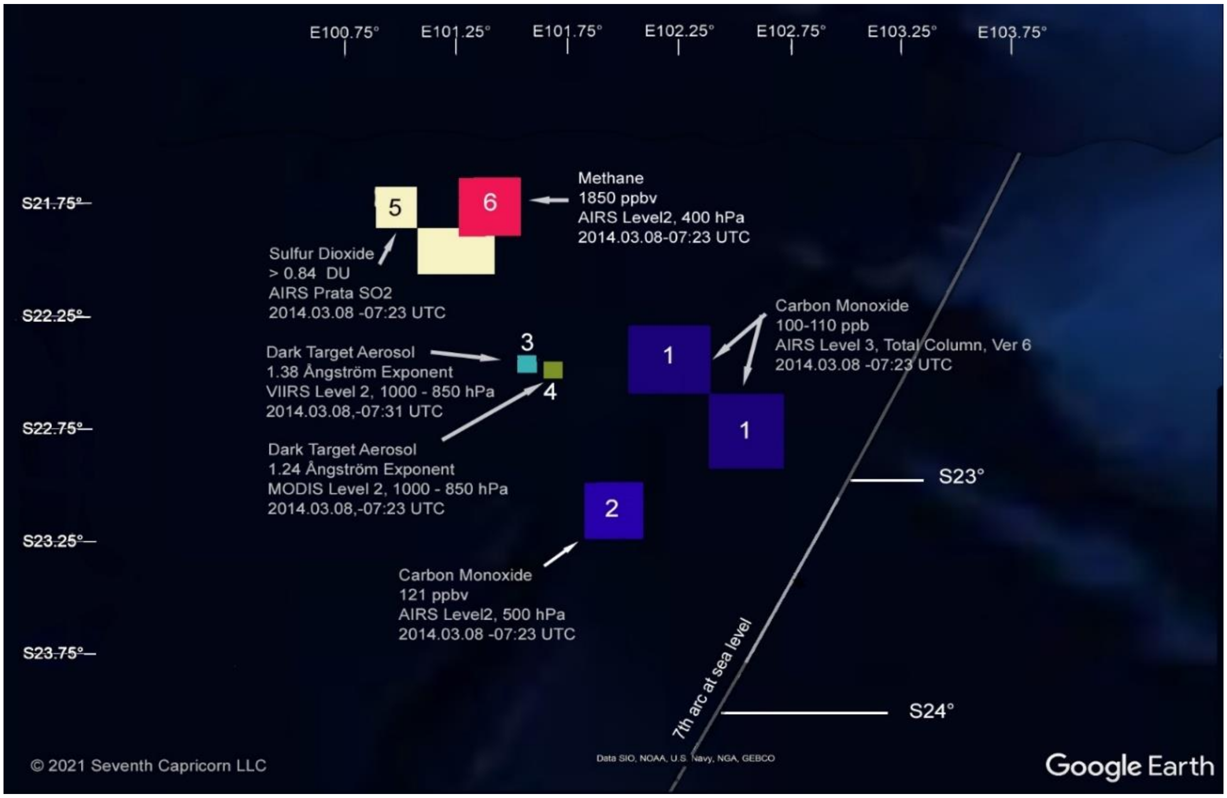

Figure 1. High levels of CO, SO2, CH4, and aerosols in the Indian Ocean on March 8, 2014.

Figure 1 shows the locations of six atmospheric anomalies northwest of the seventh arc. The data is from NASA's Aqua and NOAA's Suomi NPP satellites passing over the northern Indian Ocean between 07:27 and 07:32 UTC on March 8, 2014, seven hours after impact. Here are the data details:

1. Carbon monoxide (CO) near -22.65°, 102.35°. The Aqua satellite's atmospheric infrared sounder (AIRS) Level 3, Ver. 6, recorded a level of 100–110 parts per billion (ppb) in a total vertical column in the atmosphere, a plume. The highest daytime or nighttime levels of CO total column, captured by AIRS Level 3, Version 6, on March 8 for the entire southern hemisphere below 19°S.

2. CO near -23.21°, 101.9°. The Aqua satellite's AIRS Level 2, Ver. 7, recorded a level of 121 PPB volume (ppbv) at pressure level 500 hPa. The second-highest daytime level of CO (500 hPa) within a 1200-kilometer radius.

3. Aerosol, Dark Target (DT) Ocean, near -22.50°, 101.53°. The Suomi NPP satellite's Visible Infrared Imaging Radiometer (VIIRS) recorded a level of 1.36 ÅE. The highest recorded daytime level of aerosol from VIIRS within a 200-kilometer radius. The detection of visual aerosols (smoke) downwind of the impact sight may indicate a fire or explosion after impact.

4. Aerosol, Dark Target (DT) Ocean, near -22.50°, 101.65°. The Aqua satellite's moderate resolution imaging spectroradiometer (MODIS) recorded an aerosol level of 1.17 ÅE. The highest recorded daytime aerosol levels from MODIS within a 350-kilometer radius.
5. Sulfur dioxide (SO2) near -21.80°, 100.90°. The Aqua satellite's AIRS recorded a level of 0.84–0.96 DU (total column) of sulfur dioxide. This reading was the highest level of daytime SO2 within a 1200-kilometer radius. This level of downwind sulfur dioxide is a significant discovery because jet fuel contains sulfur.
6. Methane (CH4) near -21.80°, 101.40°. The Aqua satellite's AIRS Level 2 recorded 1824–1850 ppbv of methane at pressure level 400 hPa. The 1850 ppbv reading was the highest daytime level of CH4 within a 1200-kilometer radius. This elevated level of methane was an important discovery because only one of the previous air/sea accidents displayed high downwind methane levels. It was the 2011 Asiana Airlines Flight 991 crash. Both AA991 and MH370 were transporting pallets of lithium-ion batteries. Hydrogen, methane, and carbon monoxide are the primary gases released when lithium-ion batteries are damaged or punctured. More details on lithium-ion battery gas release are on page 8.

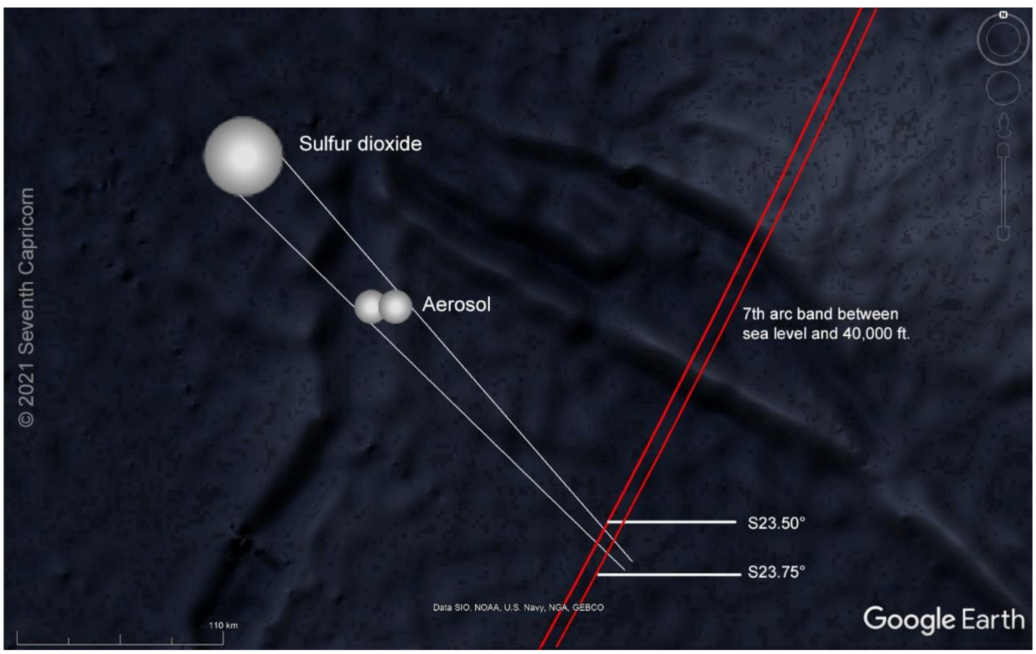

Figure 2. Aqua/AIRS 2014-03-08 daytime levels of SO2 >.084 DU, wind @ 1000 hPa.

The discovery of atmospheric sulfur dioxide and aerosols helped backtrack a path to an impact area. Unlike CH4 and CO that drift into the upper atmosphere, SO2 and aerosols are heavier than air, so they drift in the same direction and the velocity as the wind near sea level (1000 hPa).

Using NOAA's average wind speed (39 km/hr.) and direction (135-140°) at 1000 hPa between 00:30 and 07:30 UTC on March 8, 2014, the SO2 and aerosol clouds can be traced back 7 hours (00:30 UTC) to a location along the seventh arc between 23.50°S and 23.75°S. Figure 2 shows the SO_2 and aerosols position at 07:27-07:32 UTC drifting northwest downwind from an impact point along the seventh arc.

The highest level of SO_2 within a 1200-kilometer radius (over four million square kilometers of the Indian Ocean) was traced to the seventh arc to the exact time of impact.

Figure 3. Daytime CH_4 levels greater than 1850 ppbv on 2014-03-08 in the Indian Ocean.

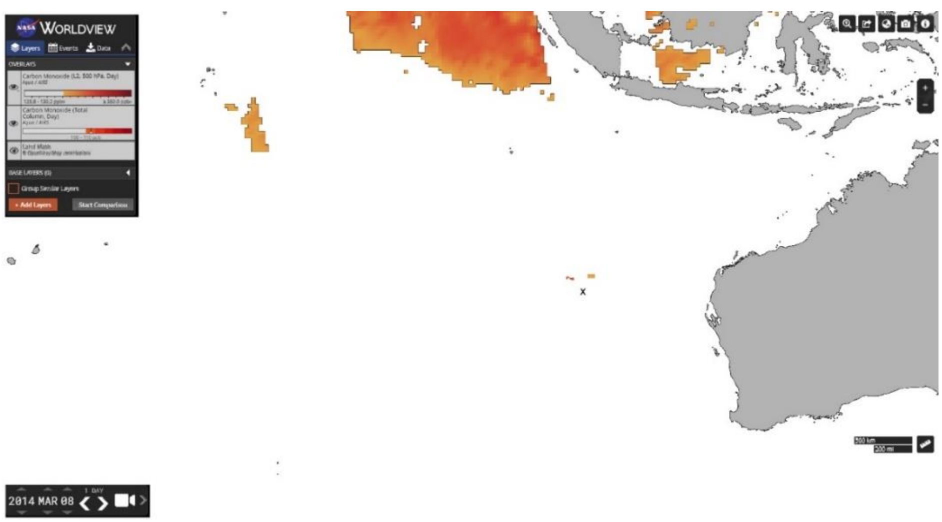

Figure 4. Daytime CO levels greater than 128 ppbv on 2014-03-08 in the Indian Ocean.

Elevated levels of atmospheric CO and CH_4 are rare in the southern hemisphere. Figures 3 and 4 from NASA's Worldview illustrate how rare these anomalies were on March 8, 2014. The maps show the CO and CH_4 levels 7 hours downwind of the estimated impact site (X marks the impact site). Both readings were the highest daytime levels below 12°S in the Indian Ocean for 2014-03-08.

Atmospheric data match — Asiana Airlines flight 991 -evidence #2

Asiana Airlines Flight 991 crashed in the East China Sea on July 28, 2011. The Boeing 747 cargo plane crashed just seven minutes after the crew had contacted air traffic control reporting a fire on board. The South Korean Aviation and Railway Accident Investigation Board (ARAIB) directed the crash investigation. However, due to the loss of both flight recorders, it could only determine that the cause of this accident was a fire that developed near pallets containing 400 kilograms of lithium-ion batteries and other flammable liquids. MH370 was carrying 221 kilograms of the same class of batteries.

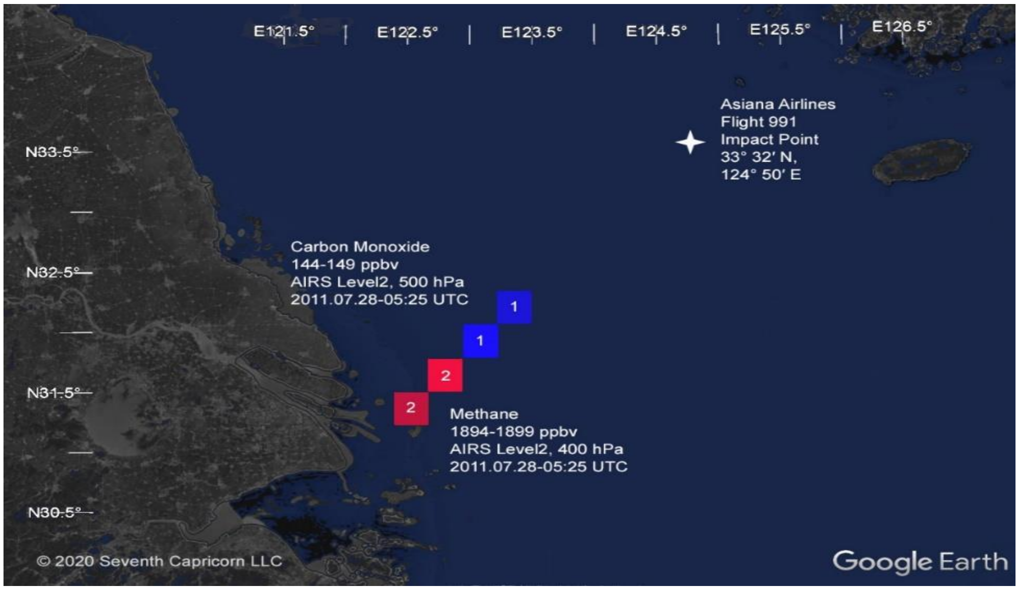

Figure 5. CO (blue) and CH4 (red) in the East China Sea on July 28, 2011, @ 05:25 UTC.

Data from NASA's Aqua satellite over the East China Sea on July 28, 2011, at 05:25 UTC captured elevated levels of CO and CH4 downwind from the Flight 991 crash site. The locations and levels recorded were:

1. CO near 31.93°, 123.03°. The Aqua satellite's AIRS Level 2 recorded 150 ppbv of at pressure level 500 hPa. The highest daytime level of CO within a 600-kilometer radius.
2. CH4 near 31.66°, 122.75°. The Aqua satellite's AIRS Level 2 recorded an 1851 ppbv at pressure level 400 hPa. The highest daytime level of CH4 over open water within a 2000-kilometer radius.

The satellite data from both the Indian Ocean and the East China Sea shows the CH4 drifting downwind from the impact sites faster than the CO. This is because the molecular weight of CO is heavier than CH4. Hence, the lighter CH4 ascended more quickly into the upper-level wind currents.

Lithium-ion batteries

An exothermic chemical reaction (fire) can occur when a lithium-ion battery is punctured, releasing heat and highly flammable and combustible gases. The nearby batteries overheat and release flammable gases, creating an uncontrolled chain reaction called a thermal runaway.

Lithium battery fire tests conducted by the US Federal Aviation Administration (FAA) found Bromotrifluoromethane or Halon 1301 used in almost all cargo hold fire suppression systems was ineffective in suppressing a thermal runaway. Here is the conclusion from the FAA sixty-page report:

"In the event of a thermal runaway, cells shipped in confined spaces such as fire-resistant containers or plastic-wrapped pallets may trap vent gases and lead to explosive conditions. Vent gases generated by a lithium-ion cell in thermal runaway contain flammable hydrocarbons and large amounts of hydrogen gas. The volume of vent gases is a strong function of the state of charge.

The normal Halon 1301 concentration used in Class C cargo compartments is insufficient to suppress an explosion caused by the ignition of lithium-ion vent gases.

A small number of lithium-ion 18650 cells can generate enough gas in thermal runaway that, when confined and ignited, can cause an overpressure in a Class C cargo compartment that will dislodge pressure-relief panels, jeopardizing the benefit of a fire suppression system by allowing for agent leakage and combustion products to spread throughout the aircraft."

The five flammable gases released during a thermal runaway are hydrogen (H2), carbon monoxide (CO), methane (CH4), ethylene (C2H4), and ethane (C2H6). H2 can explode at any point above a 4.0% concentration LEL (lower explosive level). The LEL for CH4 is 5.0%, C2H6 3.0%, C2H4 2.7% and CO 12.5%.

The 221 kilograms (487 lbs.) of lithium-ion batteries were on two plastic-wrapped wooden pallets in the forward cargo bay of Flight 370. If just one of the batteries on a pallet was punctured before or during an attempted ditching, a thermal runaway could have started. The chain reaction of burning batteries would have released substantial amounts of flammable gases, possibly turning the fuselage into a giant pipe bomb.

The United States Department of Transportation banned Lithium-ion batteries as cargo on all US passenger flights in February 2019.

Indonesian radar

There was circumstantial evidence supporting the hypothetical flight path over the tip of Sumatra. The Indonesian military informed Australia and Malaysia that their radar station on Sabang Island did not detect MH370 west of Sabang. So, the only way that MH370 would have avoided that radar was by making a sharp turn to the south shortly after the 18:25 UTC log-on, then flying over Banda Aceh on the backside of the radar's range. But with no visible north-to-south contrails on NASA's infrared images, MH370 likely did not cross over Banda Aceh. Instead, it avoided the Sabang radar by going around and under it.

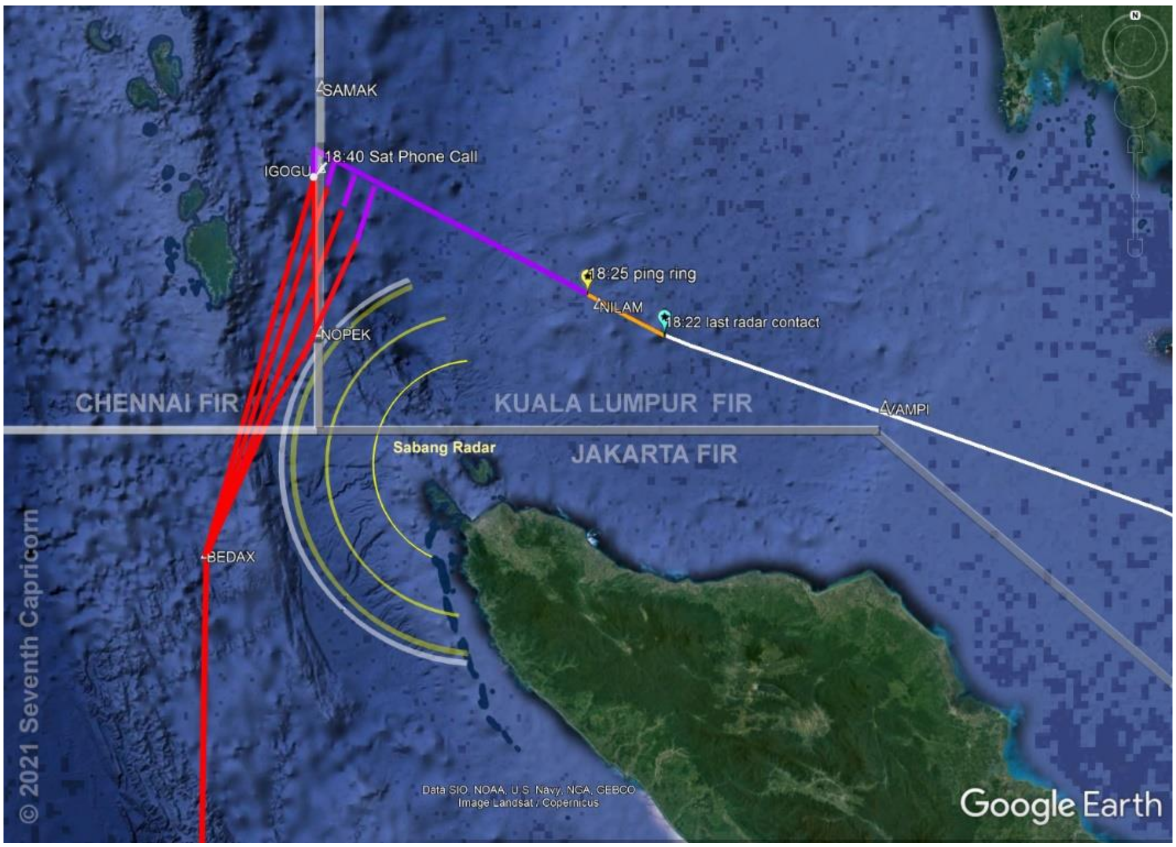

Figure 6. Possible MH370 flight paths that would have evaded Indonesian radar.

After the 18:25 UTC log-on, MH370 continued flying northwest on air route N571 towards the Andaman Sea. The red lines in figure 6 show possible southward flight paths after the turn occurred somewhere near the waypoint IGOGU. After the turn to the south, the aircraft rapidly decreased speed and altitude, as low as 6000 feet if it passed near the waypoint NOPEK, allowing the aircraft to avoid radar detection by flying below the horizon line. After entering the Indian Ocean near waypoint BEDAX, MH370 turned south, increasing speed and altitude.

Reverse flight path – (supporting evidence)

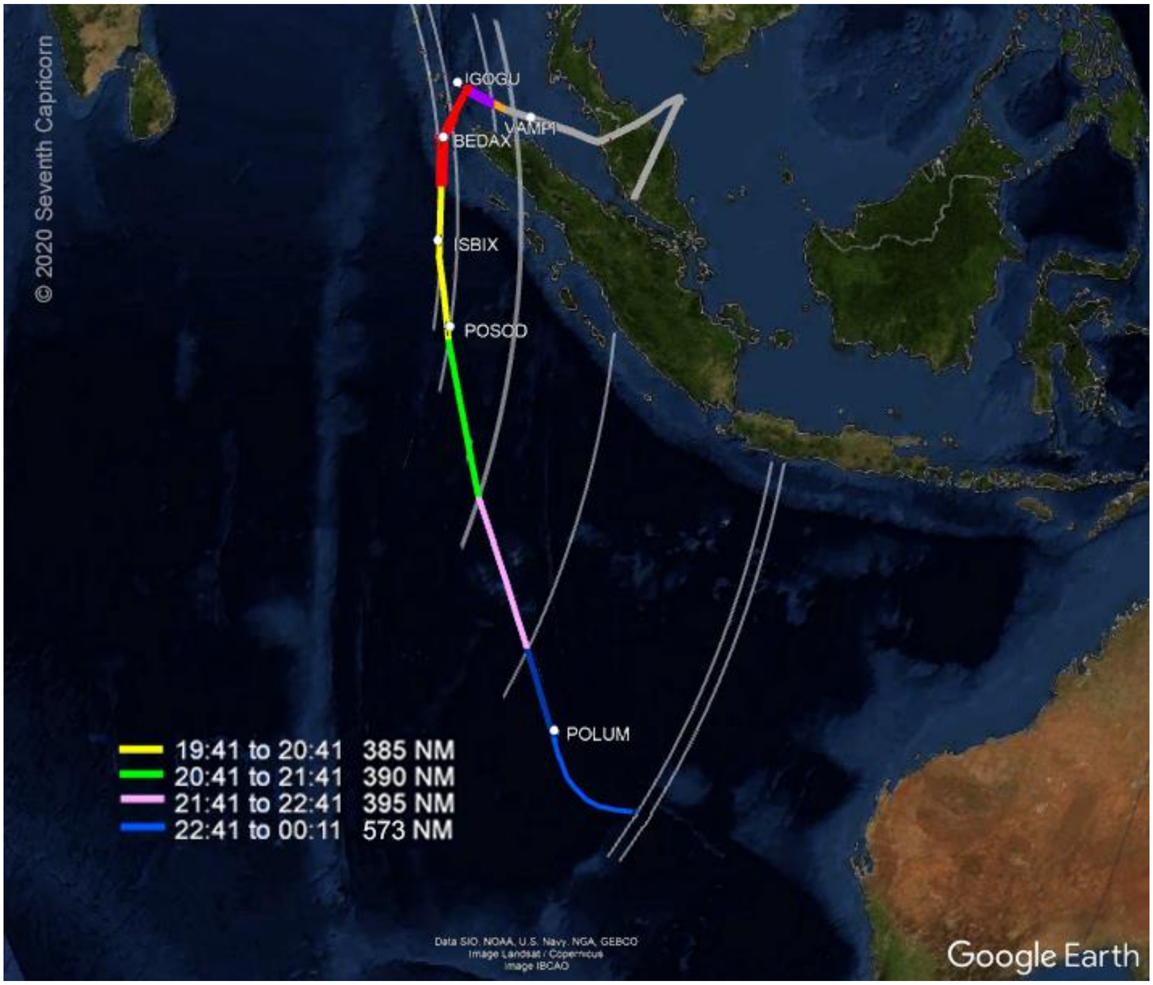

Figure 7. Reverse flight path plotted back from the 7th arc.

Having strong atmospheric data supporting an impact point somewhere between 23°S and 24°S, 80 points were plotted 0.01° apart along the seventh arc between 23.1°S and 23.9°S. The direction, speed, altitude, and rate of descent were adjusted at each point to match the burst timing offset (BTO) and burst frequency offset (BFO) data received from Inmarsat's satellite 3F1. The closest match with the lowest error for 00:19:29 UTC was 23.717 °S, 102.615°E, altitude of 5800 feet, descending at 4070 feet per minute, flying east at 87°. From that point, a reverse flight path was created by finding the lowest error points along the 6th arc, 5th arc, 4th arc, etc. After matching points along the other six arcs to the SATCOM data with the minimum amount of error, a logical flight path developed that unexpectedly followed the waypoints of VAMPI⇨ IGOGU⇨ BEDAX⇨ ISBIX⇨ POSOD⇨ POLUM. Some parts of this flight path could have been programmed into the Boeing 777's flight management system.

Satellite communications data match - evidence #3

Date	Time	Latitude	Longitude	Altitude	Ground Speed	Track	Rate of climb	Calculated BTO	Recorded BTO	Error BTO	Calculated BFO	Recored BFO	Error BFO
	(UTC)	degree	degree	feet	knot	degree	ft/min	µs	µs	µs	Hz	Hz	Hz
3/7/2014	18:39:55.354	7.32	94.47	26247	340	206	-510	11965			88	88	0
3/7/2014	19:41:02.906	3.30	93.74	35105	400	180	0	11500	11500	0	111	111	0
3/7/2014	20:41:04.904	-3.04	94.06	37000	415	175	-100	11740	11740	0	143	141	1.9
3/7/2014	21:41:26.905	-9.47	95.26	37000	400	170	0	12781	12780	-1	169	168	1.5
3/7/2014	22:41:21.906	-15.80	97.25	37000	385	165	0	14539	14540	1	200	204	-3.6
3/8/2014	00:10:59.928	-23.76	101.71	7000	385	87	0	18040	18040	0	252	252	0
3/8/2014	00:19:29.416	-23.72	102.62	5800	173	87	-4070	18399	18400	1	182	182	0

Table 1. Reverse flight path data compared to the SATCOM data.

Table 1 compares the calculated BTO and BFO data produced by the reverse flight path to the satellite communications (SATCOM) data from Inmarsat. For simplification, decimals are rounded up.

The flight path shows MH370 maintained a consistent airspeed around 400 knots at flight level FL370 for at least three hours between the 2nd and the 5th arc. During this time, it was flying close to the minimum operating airspeed for the B777-200ER for that altitude. This slow speed could have been a plan to avoid detection or burn through fuel and time.

The reverse flight path shows the estimated position of MH370 at 00:19:29.416 UTC was at 23.717 °S, 102.615°E, flying east at an altitude of 5800 feet, descending at 4070 feet per minute with a ground speed of 173 knots. If the plane had continued at the same airspeed, direction, and rate of descent, MH370 would have made it to sea level in 76 seconds, traveling 3.7 nautical miles to an ocean impact point near 23.71°S, 102.68°E at 00:20:45 UTC.

The fishhook flight path between the 5th and 6th arc appeared unusual until discovering the displacement trail. Then, the puzzle pieces began to fit together.

Cloud displacement trail - evidence #4

Figure 8. An example of an aircraft flying along the cloud top creates a cloud displacement.

Every airplane generates a wake during flight. Wake turbulence is when an aircraft produces lift by creating a counter-rotating vortex trailing behind the wings. When a plane flies over the top or through a cloud formation, the downwash of air displacement creates a void in the clouds behind the aircraft, cutting a ditch along the top of the cloud. Displacement trails or downwash trails are more visible during sunrise and sunset as the walls of the "ditch" create hard shadows. Figure 8 shows an example of a displacement trail made by an aircraft after sunrise.

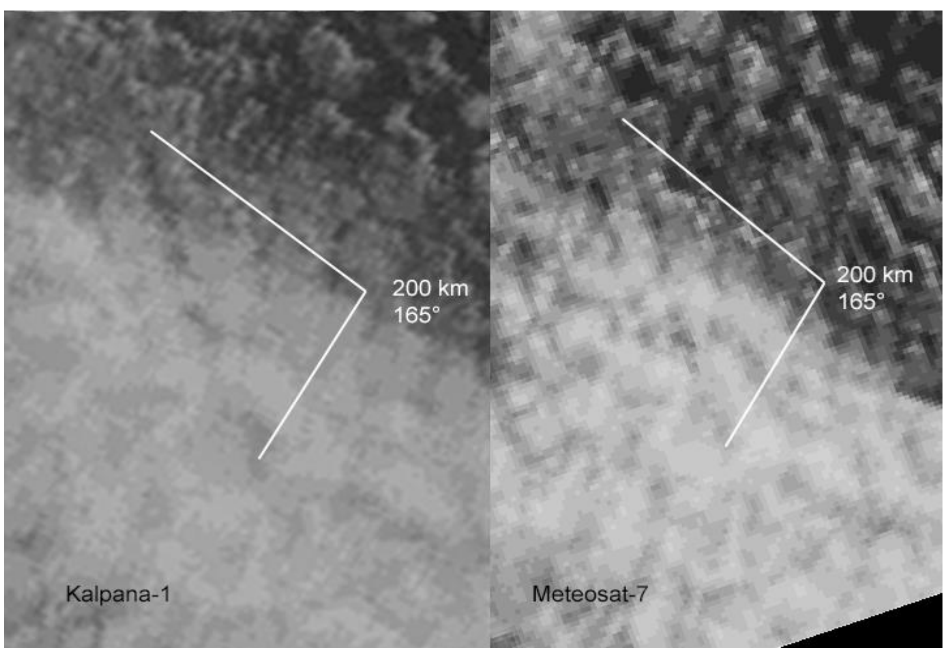

Figure 9. Satellite images of the 200km displacement trail. Images from Kalpana-1 and Meteosat-7.

Two meteorological satellites, Meteosat-7 and Kalpana-1 were positioned over the Indian Ocean on March 8, 2014. The enhanced images in figure 9 were captured between 01:30 and 02:00 UTC. They show a possible 200-kilometer-long cloud displacement. The trail corresponds with the reverse flight path, starting just south of the waypoint POLUM, with the track direction the same as the reverse flight path, 165°. Time-lapse images from Meteosat-7 and Kalpana-1 show the displacement trail slowly drifting west and dissipating as the sun's angle increases. The location, time of day, and altitude, around 7000 feet, match the reverse flight path.

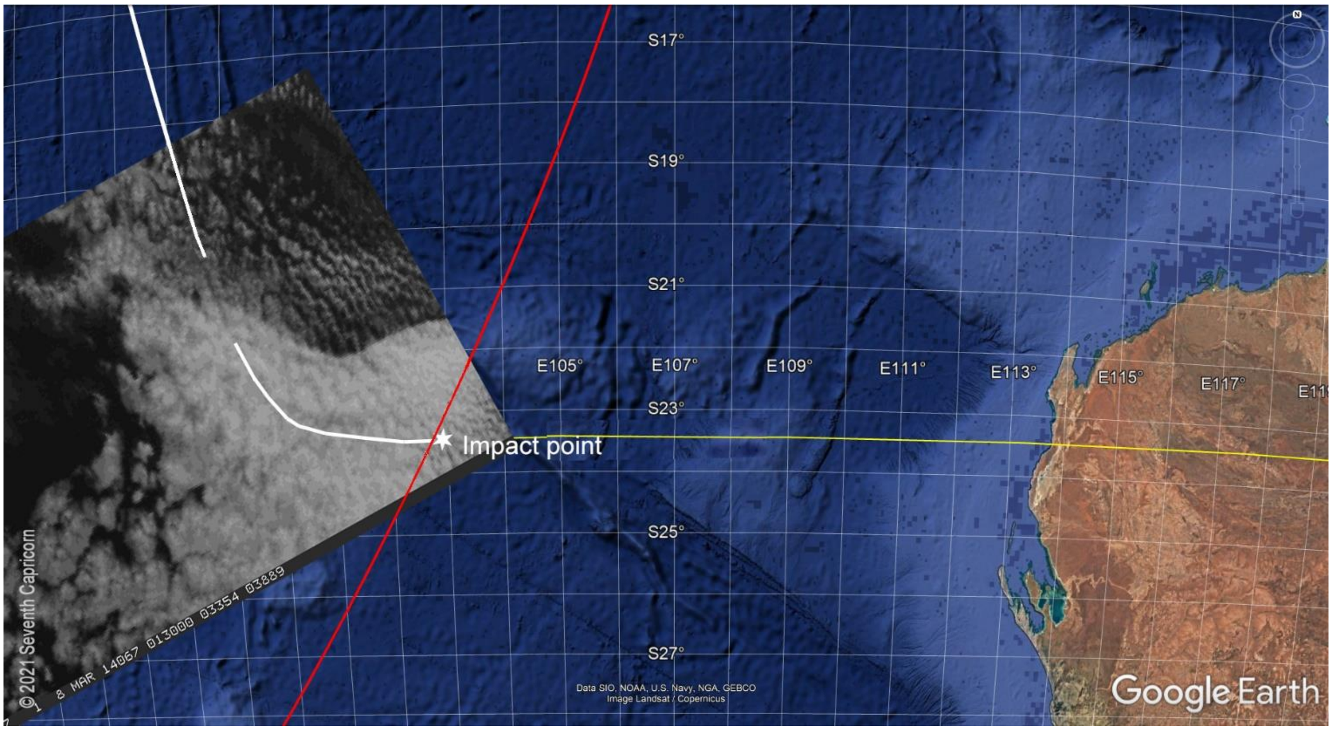

Figure 10. Enhanced satellite image with the reverse flight path (white) and 7th arc (red) overlay.

Near daybreak, the reverse flight path shows MH370 passing near the waypoint POLUM about 23:23 UTC. It has now lost the cover of darkness. South of POLUM, the aircraft dropped to around 7000 feet, flying along or just below the cloud top of a large cumulus cloud bank, most likely to avoid visual detection from military and other aircraft. MH370 was now within the range of the Australian over-the-horizon radar. Still flying below cloud-top around 23:45 UTC, MH370 turned to the southeast. It continues southeast (120°) for another 125 nautical miles before turning east on its final descent.

Oceanographic Environmental Anomalies -evidence #5

Sea surface temperature (SST) anomalies were detected down current from previous air/sea accident impact points. Spilled oil and jet fuel can rapidly disperse across the sea surface after impact, creating a film on the microlayer's surface. However, the accidents had no discernible effect on the actual ocean temperature. The SST information is interpolated satellite data from instruments sampling the ocean's microsurface, about 15 micrometers deep. Just 15 liters of fuel can rapidly spread across the water's microsurface creating 1,000 square meters of film on the surface.

On March 8 at 16:15 UTC, the moderate-resolution imaging spectroradiometer (MODIS) onboard NASA's Terra satellite recorded a 30 km^2 surface temperature anomaly ≥ 0.45°C, located just south of 23°43' S, 102°40'E. That MODIS SST capture was 25.65°- 25.80°C, the 1-day average SST for the same area was 25.05°-25.35°C. The 1-day SST data was from Group for High-Resolution Sea Surface Temperature multi-sensor datasets.

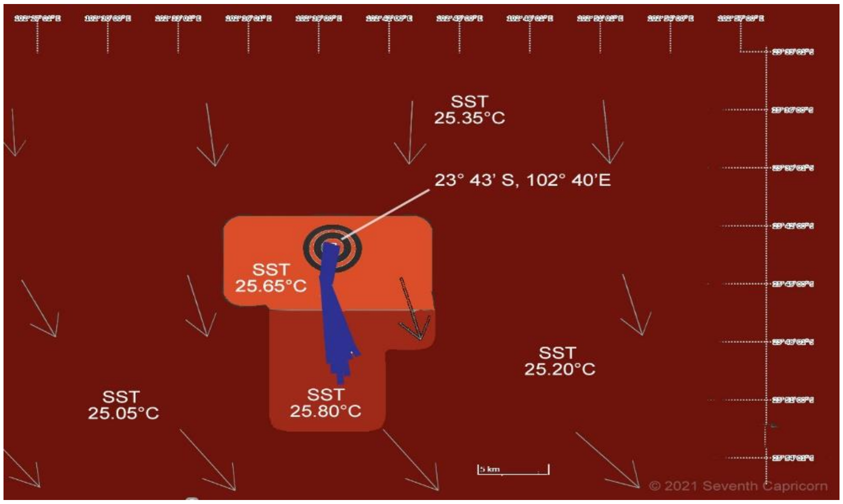

Figure 11. Sea surface temperature anomaly from MODIS, 2014.03.08 16:15 UTC.

The image in figure 11 shows the 16:15 UTC SST anomaly. The arrows indicate the direction of the surface current. The blue lines show a simulated surface drift pattern for 16 hours (0.5-0.7 kilometers per hour) drifting south from a projected impact site of 23°43'S, 102°40'E. The surface current speed and direction are from the 5-day, Level 4 OSCAR data. The impact point was on the edge of a large slow churning ocean eddy. Thus, during the first 24 hours after impact, the debris field and the fuel/oil slick may have only drifted 6 to 9 nautical miles south of the impact site.

The Terra MODIS SST reading at 23.8°S, 102.65°E was the warmest nighttime surface temperature (2014/03/08) in the Indian Ocean below 23.45°S. For a recent example of tracking a fuel spill using sea surface temperature from satellite data, click here.

Air France Flight 447- SST Anomaly (supporting evidence)

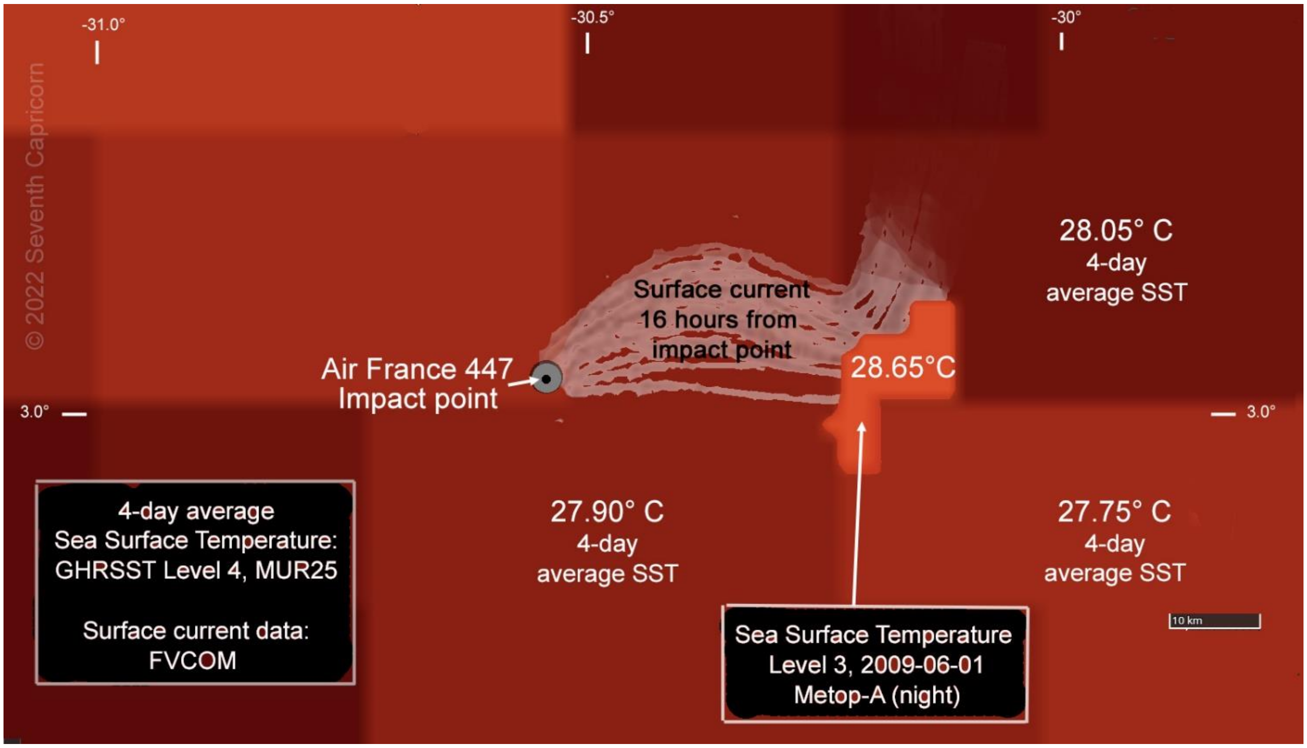

Figure 12. SST data from the South Atlantic Ocean from the night of June 1, 2009.

Air France flight 447 was an Airbus A330 that crashed in the Atlantic Ocean on June 1, 2009, killing all 228 passengers and crew on board. Figure 12 shows NASA satellite data from 2009-06-01 revealing a 230 km² sea surface temperature anomaly 30-35 kilometers down current from the Airbus' crash site. The 28.65°C reading was the warmest SST within 150 Kilometers and 0.55°C-0.90°C warmer than the average 4-day SST. The same down-current SST anomaly of greater than 0.4°C the daily average surface temperature was discovered in four other large aircraft air/sea disasters occurring in open seas. Data source: NASA, NOAA, and FVCOM.

Environmental satellite data indicates MH370 still had fuel onboard at impact. The fuel surface drift started at an estimated impact point near 23.7°S, 102.67E.

An alternative end of flight scenario is that the last log-on from MH370 at 00:19 UTC was not triggered by fuel exhaustion. Instead, the log-on occurred when the left AC bus was turned on to power the fuel jettison pumps. The Boeing 777's Satellite Data Unit (SDU) and the fuel jettison pumps are on the same circuit breaker.

The 2014 Indian Ocean surface search - (supporting evidence of a 23.7°S impact)

Between March 18 and April 27, 2014, military aircraft from multiple countries flew 345 sorties and searched over 4.6 million square kilometers of the Indian Ocean for aircraft debris from MH370. Parts of the Indian Ocean were searched over seven times during the 42-day-mission, but not a single piece of debris was discovered during the search.

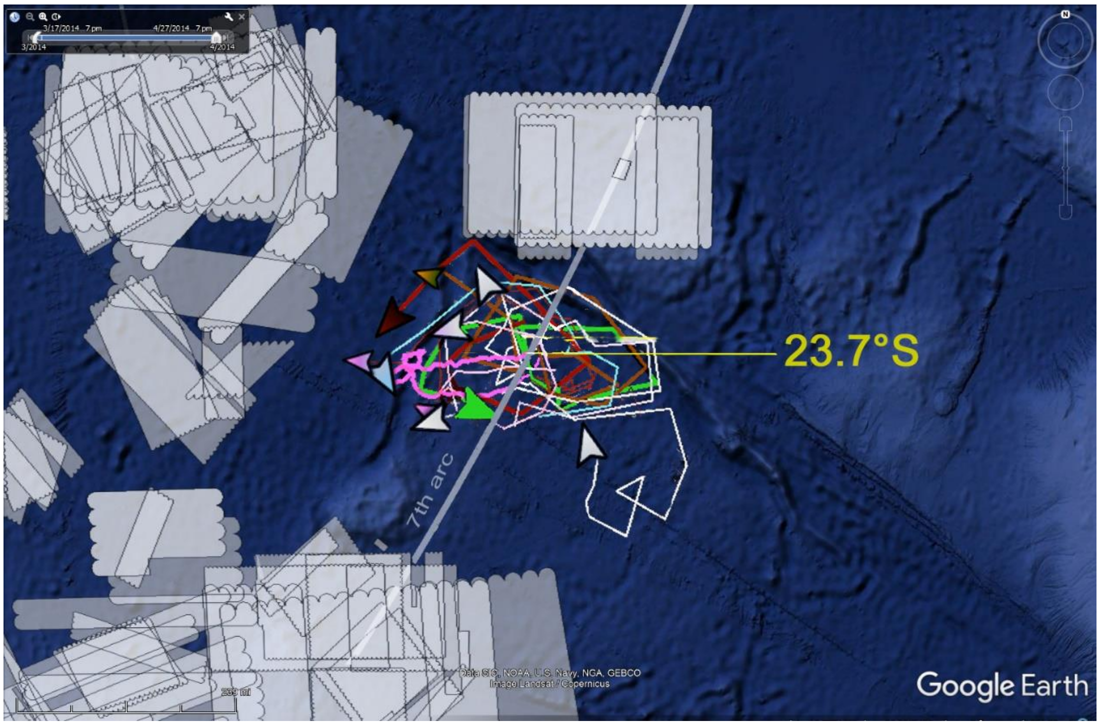

Figure 13. Simulated debris drift paths, starting near the impact location. Data: CSIRO

Figure 13 shows nine simulated 52-day drift models. The simulated drift paths start on March 8 near the seventh arc at latitudes between 23.6°S and 23.9°S. The simulated paths end on April 28, 2014, the last day of the air search. The gray boxes indicate the ocean surface area that was searched by air. The Australian Maritime Safety Authority provided the aerial search data.

If the MH370 impact point were on the seventh arc near 23.7°S, the drifting debris would have been trapped in a series of ocean eddies for months. The probability that the 2014 air search would have detected debris starting from these coordinates was near zero.

Figure 13 is created from the Australian Commonwealth Scientific and Industrial Research Organisation's (CSIRO) data.

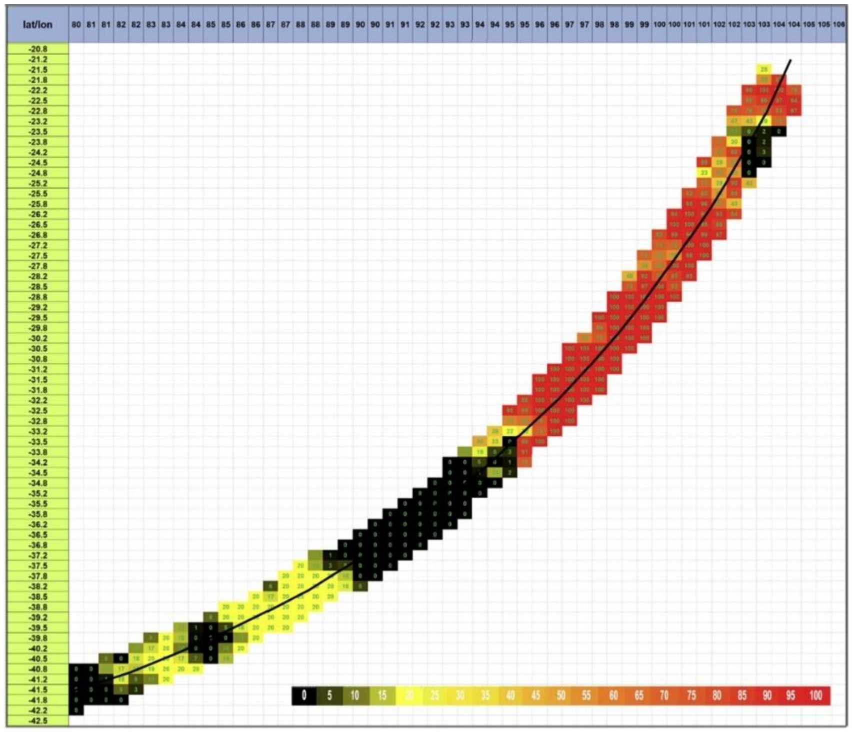

Figure 14. CSIRO's cumulative probability of detection of potential debris. From the March 2020 report The Final Resting Place of MH370 by Bobby Ulich, created from a CSIRO data file, linked to Fig 4.2 of CSIRO's April 2017 The search for MH370 and ocean surface drift-Part II by authors David Griffin, Peter Oke, and Emlyn Jones.

Figure 14 shows CSIRO's simulated drifting debris model for 356 parcels along the seventh arc. The color of each parcel represents the cumulative probability debris from each parcel would have been discovered during the 42-day air search. For example, if the simulated debris path from a parcel passed through two daily air search areas, each with a percentage of detection of 50%, then the cumulative percentage of detection for that parcel would be 75%. The black parcels represent a 0% chance the aerial search would have detected debris, yellow parcels a 25% chance, orange parcels 50% chance, and the red parcels a 100% chance of detection.

Figure 14 shows that the aerial search effectively ruled out most potential impact points north of 32.5°S but was ineffective in searching latitudes south of 33°S. The insert below is from page 34 of the final ATSB report.

> Figure 20 shows that the first few days of the surface search was, with hindsight, fairly ineffective. This was because the number of search assets was low on the first day and because on following days the search was conducted much farther away from the 7th arc than the debris could have drifted, assuming now that the impact was within 25 NM of the 7th arc. In contrast, the northward move of the search on 28 March resulted in a high probability of detecting debris if the impact had been somewhere between about latitudes 26°S and 32.5°S. This phase of the surface search was therefore of high value to the underwater search because it adds to the weight of evidence suggesting that searching the seafloor north of about 32.5°S is unlikely to be successful.

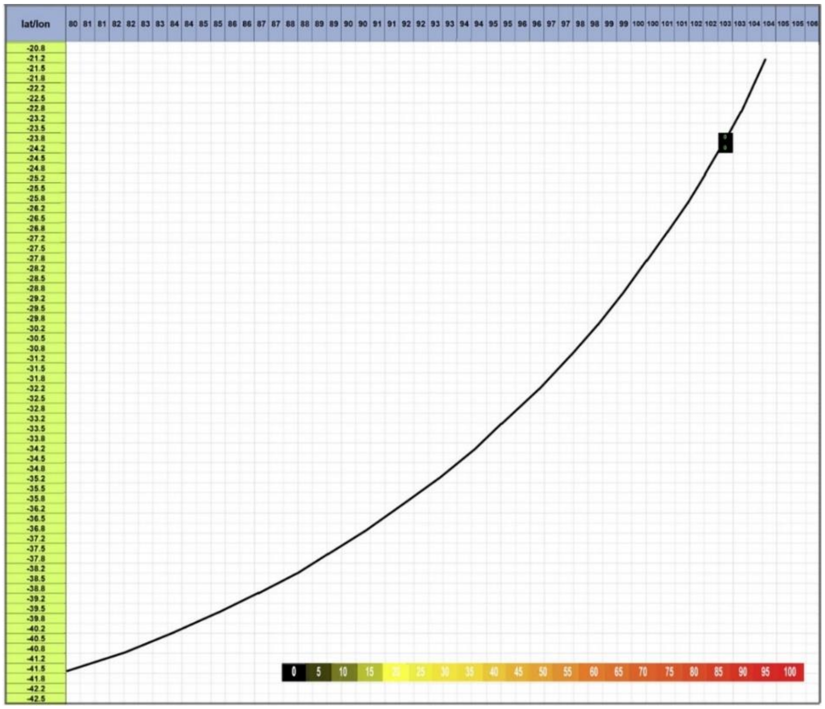

Figure 15. Total efficacy of the search after parcel elimination.

There was an exception north of 32.5°S that was overlooked. Figure 15 shows that eliminating all the parcels with 4% or greater detection during the air search and those covered by the undersea search allowed only two parcels between 23.5°S and 24.2°S along the seventh arc remain. Here is the process of elimination:

1. Eliminate parcels 4% or greater. The aerial search failed to spot the 30+ pieces of recovered debris. The air search overlooked a sizeable floating debris field.
2. Eliminate parcels outside of the fuel-exhaustion range for obvious reasons.
3. Eliminate parcels outside of the 18 +/- nautical-mile band along the seventh arc (again, for obvious reasons, see the side note on page 18).
4. Eliminate all parcels already covered by the undersea searches.

CSIRO's drift data indicated a near-zero probability that debris from impact sites between S23.51° and S24.33° would have drifted east and washed ashore onto Australian beaches. The same simulated drift data reveals that impact sites south of S25.94° show a much higher probability of debris reaching Australia's west coast. No debris from MH370 has been recovered from Australian beaches.

Side note: The probable impact location near S23.7 was in the center of the Joint Investigation Team (JIT) 20,000 km² (red, yellow, and green) most probable impact area between April 3-28, 2014. The lack of debris discovery by the surface search moved the search area to a 60,000 km² "most probable impact area" in the southern Indian Ocean.

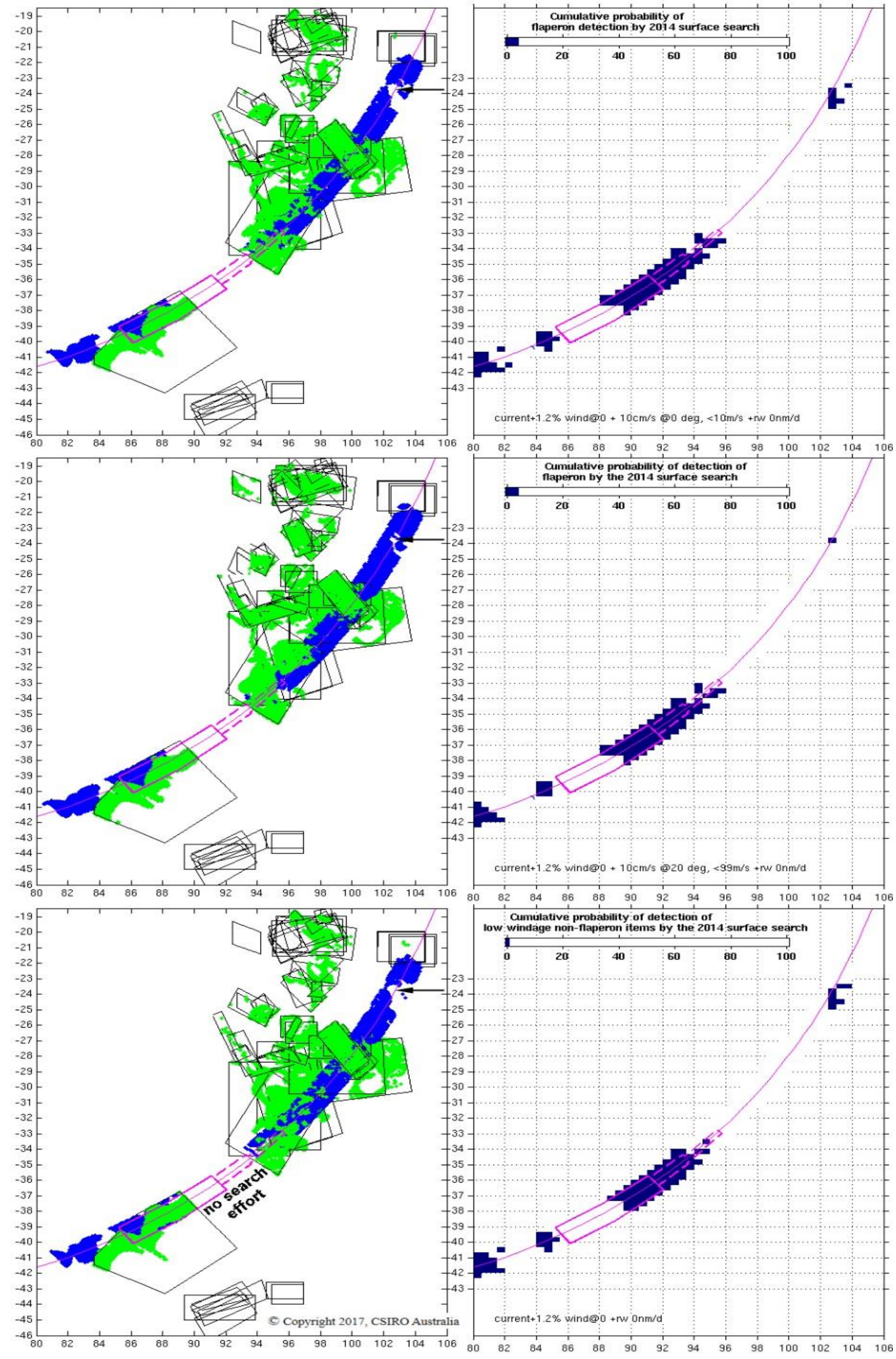

Figure 16. Cumulative probability of the detection of flaperon and non-flaperon debris

Figure 16 shows the probability of detection for the surface search. The three CSIRO plotted maps indicate a near-zero probability (<4%) of the flaperon or low-windage non-flaperon debris would have been detected by the surface search if the impact point was near the 7th arc between 23.7°S and 24.0°S. Source: CSIRO

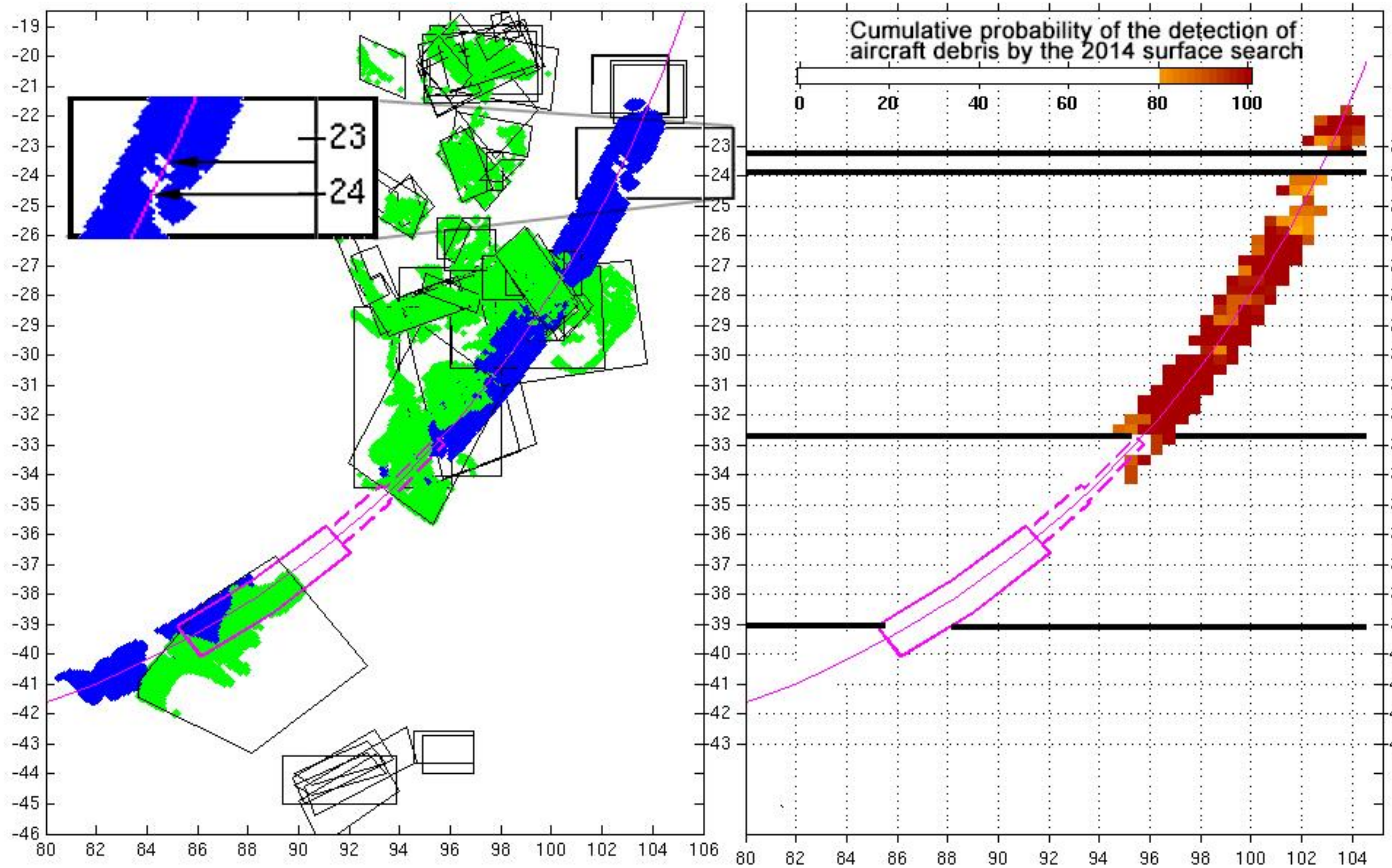

Figure 17. Cumulative probability of the detection of all debris. Source CSIRO.

Figure 17 shows the probability of detection for the 2014 surface search after combining all three layers from figure 16. The map shows a greater than 80% chance debris **would not have been detected** between 23.5°S-24.0°S and south of 32.7°S.

Low windage debris discovery in Africa-

A South African teenager discovered the first non-flaperon piece of debris, part of the horizontal stabilizer from MH370's tail section, on holiday in Mozambique in **December 2015**. In February and March 2016, two more pieces of debris were found, part of MH370's engine cowling in South Africa and a stabilizer panel in Mozambique.

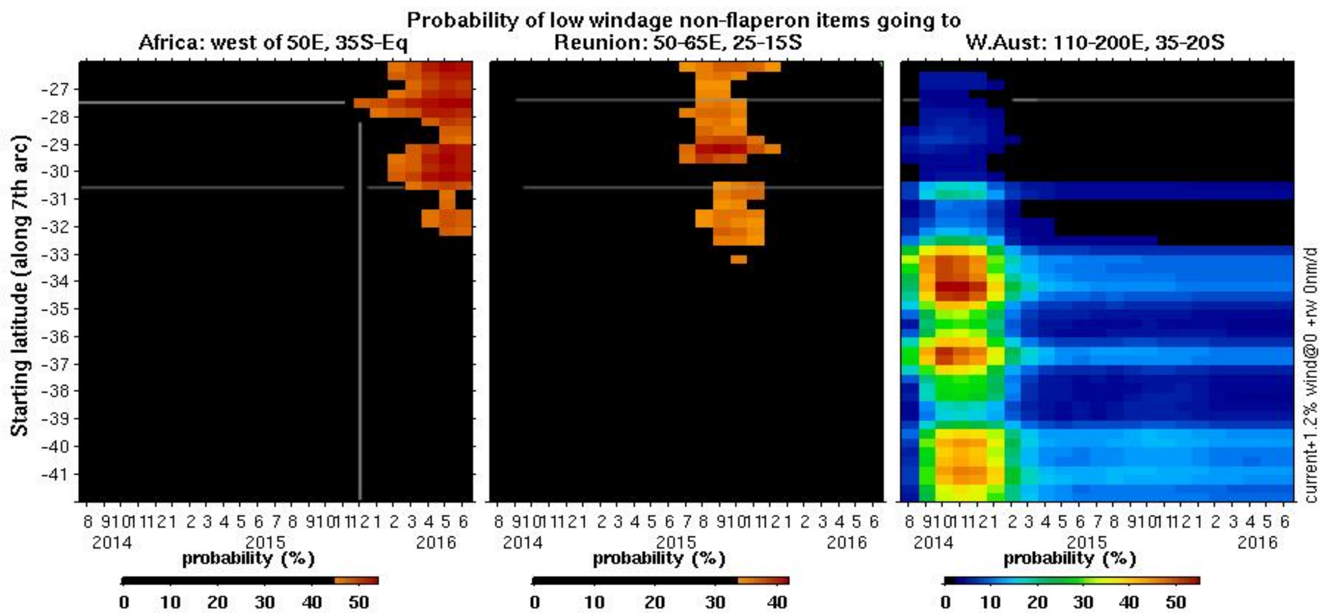

Figure 18. Probability of the discovery of low-windage debris arriving on African shores, 26°-42°S.

Figure 18 above is an enhanced CSIRO graph from page 18 of the December 2106 CSIRO report number EP167888. It shows time-dependent trajectory probabilities for low-windage non-flaperon debris starting between latitudes 26°S to 42°S. Almost all of MH370's debris discovered on African shores was classified as low-windage debris. High-windage debris such as seat cushions may have become waterlogged and sank after a few months in the ocean.

The modeled trajectories from impact points along the 7th arc are by latitude on the y-axis, with three destinations Africa, La Réunion Island, and Western Australia. The timeline from August 2014 to June 2016 is along the x-axis. The color indicates the probable percentage of arrival. The vertical gray line is the **December 2015** discovery of the first piece of debris on African shores.

Example: Low windage debris trajectories starting on the seventh arc between 27.5°S and 30.5°S had the highest probability (45-47%) of reaching Africa west of 50°E, 23°S to the equator sometime between 12/2015 and 3/2016. But, debris trajectories between 27.5°S and 30.5°S also had a 5% probability of reaching Western Australia between 08/2014 and 03/2015. No debris reached Western Australian beaches.
Source: CSIRO

CSIRO data that was not published (supporting evidence)

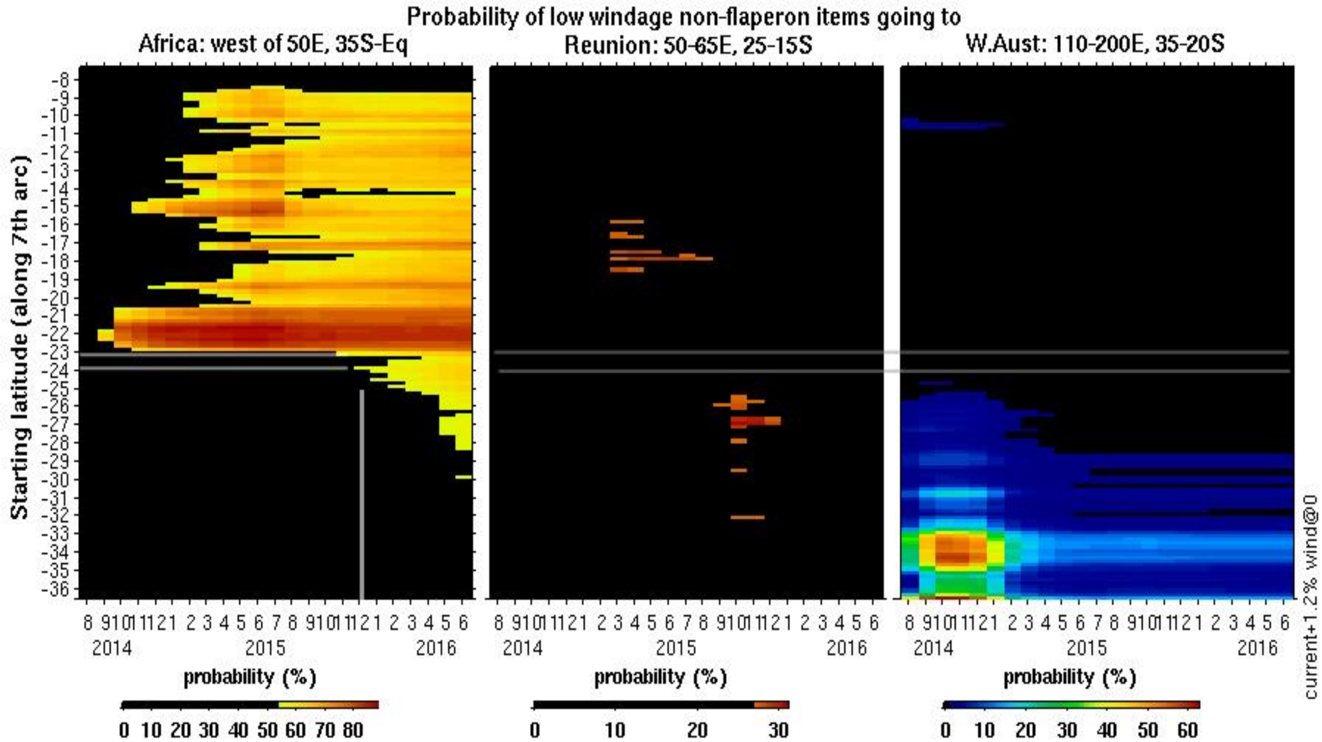

Figure 19. Probability of the discovery of low-windage debris on African shores. Source: CSIRO

The enhanced CSIRO graph in figure 19 was not published. Using the same data as figure 18 but expanding the time-dependent trajectory probabilities for low windage non-flaperon debris north of 26°S up to latitude 7°S. Expanding the latitude north of 26°S shows that **if the impact point for MH370 was anywhere along the seventh arc, the highest percent of probability (56%) of low-wind debris beginning to arrive on African beaches in December 2015 was from debris origin latitudes of 23°S and 24°S.** Conversely, the third panel in figure 19 shows **the likelihood of low-wind debris reaching Western Australia beaches from impact points between 23°S and 24°S was zero.** Only the impact sites north of 24.5°S had a zero probability of WA beaching.

The drift trajectories show that 23°S and 24°S were the most likely (by percent of probability) MH370 impact points along the entire seventh arc for debris to start arriving along the eastern African shores in December 2015. However, this data may have been overlooked because it was needles in a haystack. The CSIRO drift trajectories show if MH370's impact point were just ten nautical miles north of 23.0°S on the seventh arc, the low-wind debris should have arrived on African shores almost a year before. This significant time variance was caused by a series of ocean eddies that could have trapped debris for 10+ months. This series of ocean eddies is confirmed by satellite data from an NOAA global drifter buoy that crossed the seventh arc near 23.6°S on March 8, 2014. Possibly as close as nine nautical miles from the impact site.

NOAA Satellite Buoy – (supporting evidence of a 23.7°S impact)

The Global Drifter Program (GDP) is a branch of NOAA's Global Ocean Observing System that maintains a global array of 1300 satellite-connected buoys in all the world's oceans. These buoys or drifters have a drogue that ensures that the buoys drift with the ocean currents.

A global drifter, number 101703, crossed the seventh arc on March 8, 2014. A piece of evidence that never made it into the thousands of pages of government reports on MH370. By a remarkable coincidence, that global drifter passed within seven nautical miles of the reverse flight path's projected impact point on that day.

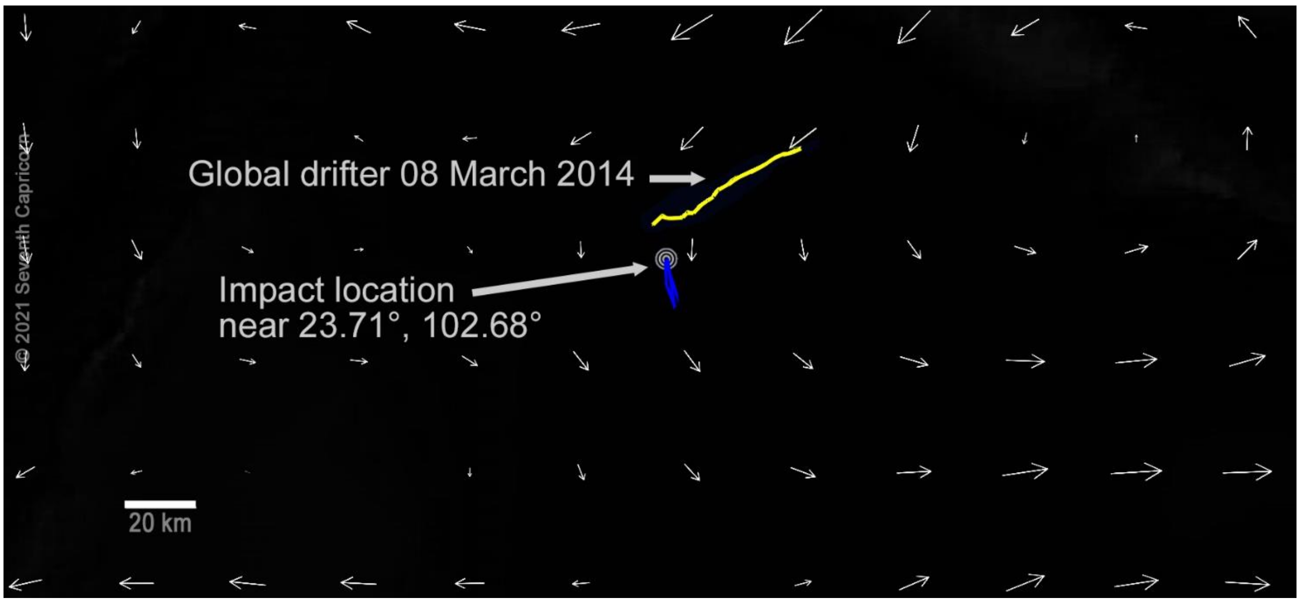

Figure 20. Global drifter #101703 drift path from 00:00 to 23.59 UTC on 2014-03-08 (yellow), MH370 probable debris drift path from 01:00 to 17:00 UTC on 2014-03-08 (blue). Data source: NOAA

Figure 20 shows the drift path of global number 101703 in yellow, plotted for 24 hours of satellite data from March 8, 2014. The speed and direction of the drifter correspond with the OSCAR surface current data. The white arrows are surface current vectors. The blue line is a simulated debris drift path from the impact site, starting at 01:00 and ending at 17:00 UTC. Global drifter 101703 and MH370 debris were pulled into a strong ocean eddy then trapped for months in multiple eddies.

If the impact point had been just 15-20 nautical miles north or west, the possibility that the 2014 aerial search would have discovered debris significantly increases, and MH370's debris probably would have reached African shores months earlier.

The eye of a needle, in a haystack.

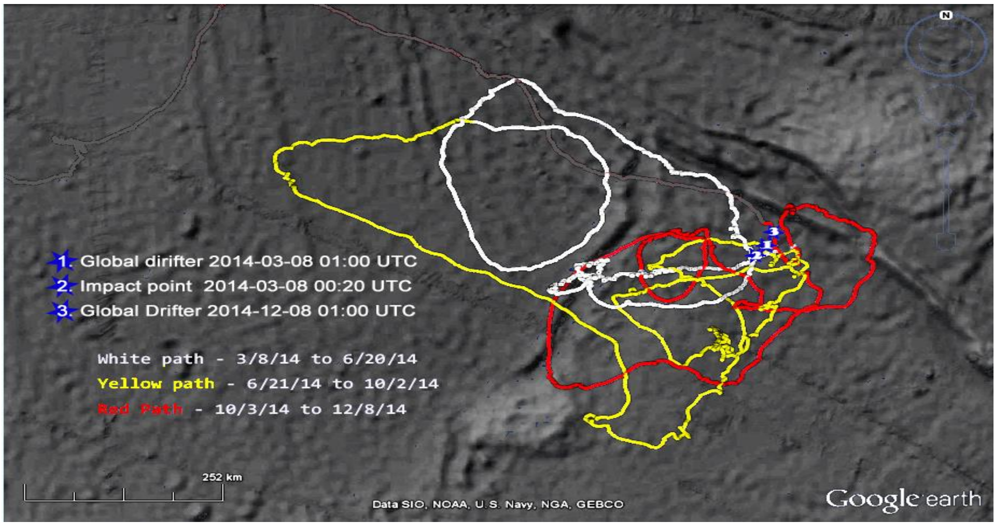

Figure 21. Nine-month drift path for Global drifter #101703, 08 Mar 2014 to 12 Dec 2014. Data NOAA

Figure 21 shows global drifter #101703 was caught in multiple ocean eddies between 21°S and 26°S between March 8 and December 12, 2014. Its path crisscrossed the seventh arc thirteen times during those nine months, eventually breaking free in December 2014, beginning a journey across the Indian Ocean toward Africa.

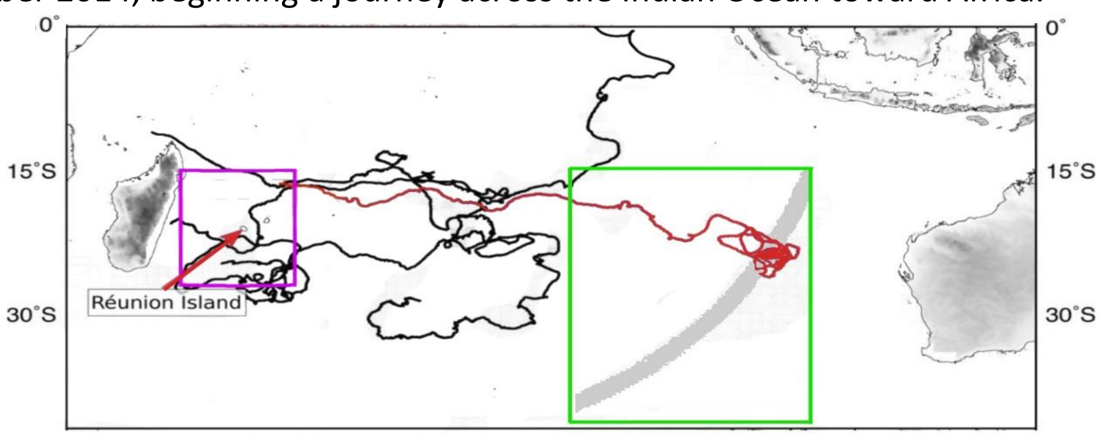

Figure 22. This image is from the study "Analysis of flight MH370 potential debris trajectories using ocean observations and numerical model results" funded by NOAA/OceanWatch and NOAA.

Figure 22 shows four NOAA global drifters trajectories in black (undrogued), and drifter #101703 in red (drogued) entered the purple box around La Réunion island between June and July 2015. Of these four trajectories, one drifter #101703 was the only global drifter in the green box in March 2014. Drifter 101703 crossed the path of the other drifters four times. On July 22, 2015, global drifter #101703 stopped transmitting. Its final position was S16.67619°, E60.05926° near La Réunion Island, where the first piece of MH370 debris was discovered just nine days later. To view the animated path of drifter 101703 from October 3, 2014, to July 22, 2015, click here.

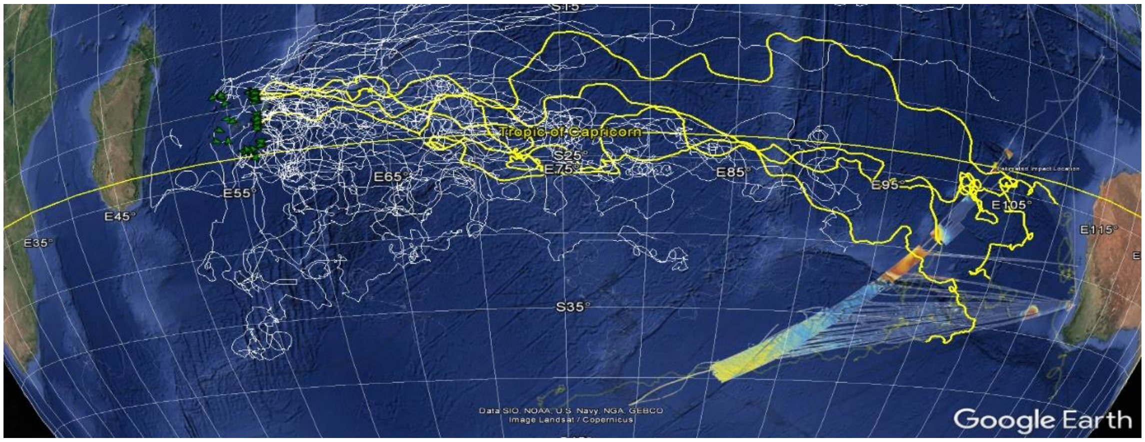

Figure 23. NOAA global drifters passing near La Réunion Island 1985-2015. Data: CSIRO/ NOAA

Thirty years of NOAA global drifter data from the Indian Ocean (1985-2015) showed that only 43 global drifters passed within 300 kilometers of La Réunion Island between April and July (1985-2015). Only 4 out of those 43 drifters could be backtracked to ever crossing the 7th arc. Figure 23 shows the four drifters (in yellow) all traversed the 7th arc north of 30.5°S. The average number of days for those four drifters to reach within the 300 kilometers of La Réunion was 229 days after passing the 7th arc. For comparison, global drifter # 101703 last transmission on 22 July 2015 was 222 days after passing the 7th arc. No reference to the NOAA drifter #101703 crossing the 7th arc on 08 March 2014 was found in any ICAO, ATSB, DST, or CSIRO reports.

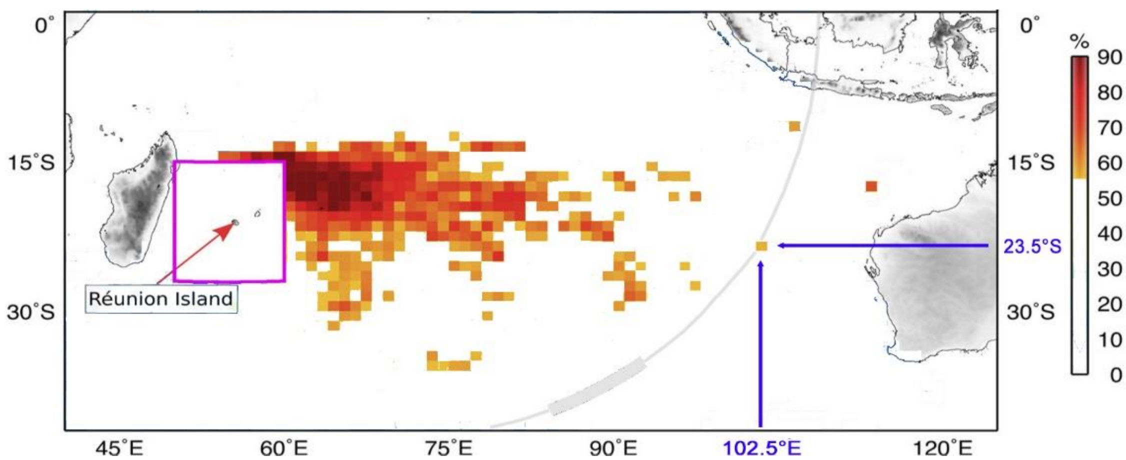

Figure 24. NOAA global drifters probability of passing near La Réunion Island. Journal of Operational Oceanography June 2016, Analysis of flight MH37, Joaquin A. Trinane et al. Data: NOAA

Figure 24 shows the probability by the percentage of an NOAA global drifter reaching the purple box around La Réunion Island. Each parcel represents a 1° x1° area, 12,300 sq. km. The parcel nearest the Inmarsat 7th arc with the highest probability (55%) was between 23-24°S. Figure 24 was created from an NOAA report by Dr. Joaquin Trinane.

Flaperon- reverse drift path - (supporting evidence)

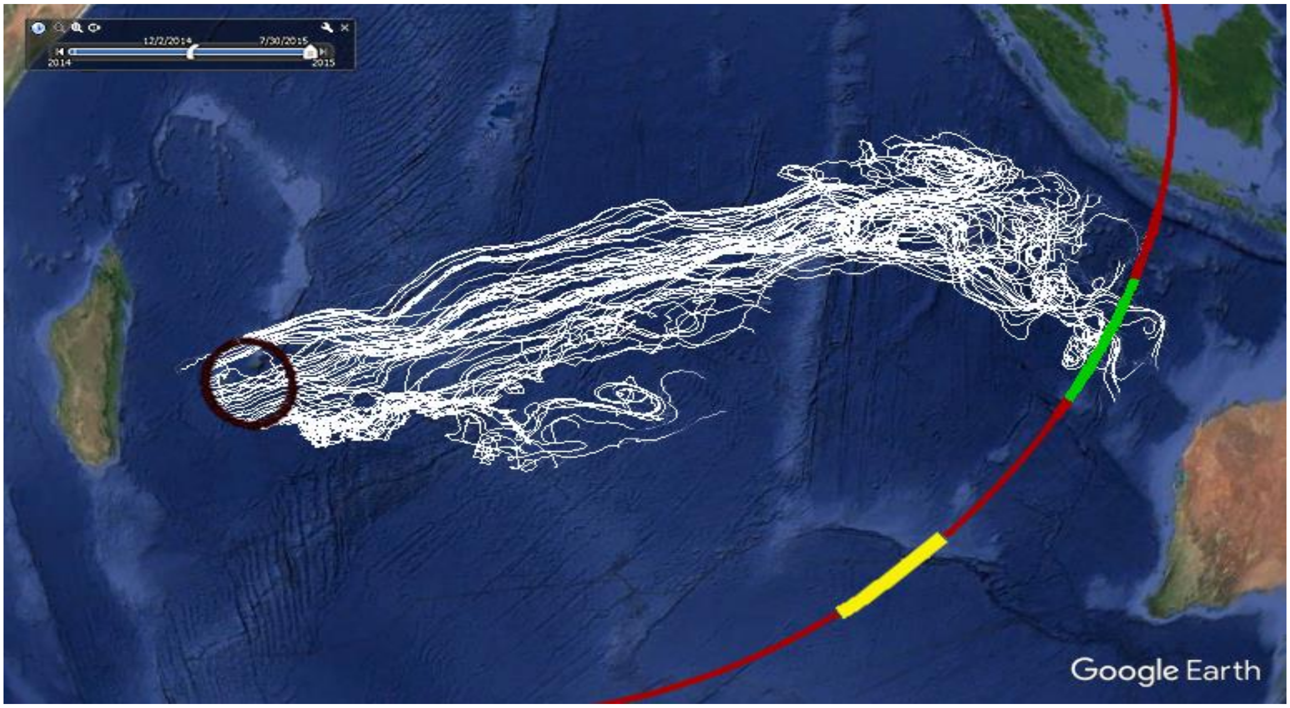

Figure 25. CSIRO's computer-generated reverse drift path. Data source: CSIRO

Just a few days after the discovery of the flaperon on La Réunion Island, Australia's national science agency CSIRO created a computer-generated reverse drift path model. Two hundred starting points (ending points) were plotted around La Réunion Island and backtracked for 502 days (2014-03-08 to 2015-07-30). Figure 25 shows the plotted points adjusted in Google Earth from 2014-12-02 to 2015-07-30. The CSIRO data shows that most simulated flaperon debris paths crossed the seventh arc between November and December 2014 north of 25°S (green). Global drifter #101703 crossed the seventh arc near 23.25°S for the last time on December 8, 2014.

None of the two hundred computer-simulated reverse drift paths crossed the ATSB priority search area (yellow). The CSIRO reverse drift Google Earth file can be downloaded from here. For an animation of the CSIRO simulated drift paths from October 3, 2014, to July 29, 2015, click here. The 502-day reverse backtrack drift model in Figure 25 is not found in any ICAO, ATSB, DST, or CSIRO reports.

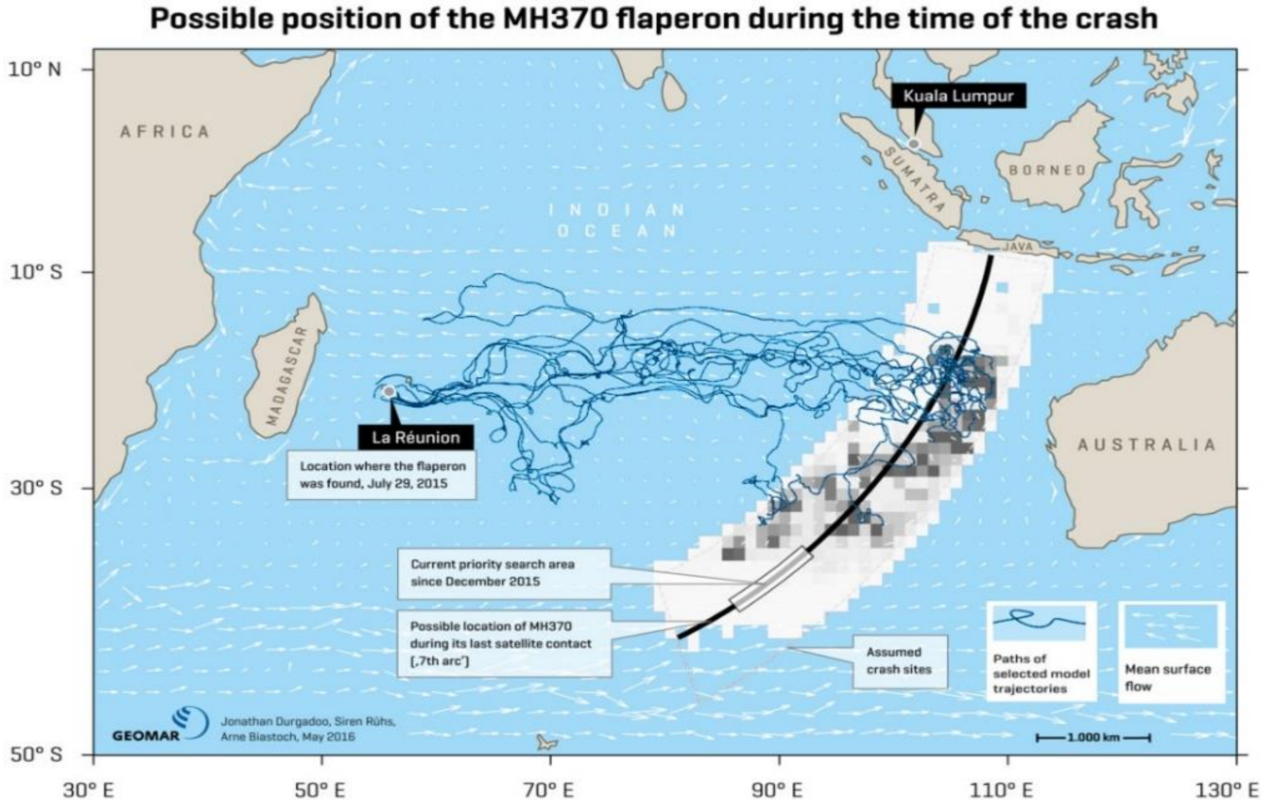

Figure 26. GEOMAR's flaperon reverse drift path.

In May of 2016, the Helmholtz Centre for Ocean Research (GEOMAR) in Kiel, Germany, released a 502-day backtrack flaperon drift model. The result was similar to the CSIRO reverse drift model. Most of the GEOMAR simulated drift paths shown in figure 26 also crossed the seventh arc north of 25°S with no flaperon drift path beginning or ever crossing the ATSB priority search area in the southern Indian Ocean.

When the CSIRO 502-day reverse drift model in 2015 did not match the ATSB search area in the southern Indian Ocean, researchers switched to 30 years of global drifter data. Although between 1985-2015, none of the global drifters that beached on La Réunion Island during that period ever crossed anywhere along the 7th arc.

The GEOMAR drift model was not referenced in any ATSB or Malaysia's ICAO reports.

Fuel exhaustion - (possible supporting evidence)

The search for MH370 was based on the hypothesis that the SATCOM last log-on at 00:19 UTC was triggered by an interruption in the electric supply, which was triggered by fuel exhaustion. The ATSB quote: "*The interruption in electrical supply is highly likely to have been caused by fuel exhaustion*."

Flight Level	True Airspeed (knots)	Mach (*=MRC)	Time (hours)	Range (nm)
FL400	494	0.861	5.0	2491
FL400	475	0.828	5.9	2803
FL400	469	0.818*	6.0	2806
FL400	417	0.727	6.1	2538
FL350	500	0.867	4.7	2356
FL350	475	0.824	5.6	2657
FL350	466	0.824	5.9	2747
FL350	443	0.769*	6.2	2711
FL350	400	0.694	6.6	2624
FL300	500	0.848	4.5	2270
FL300	437	0.742	5.7	2523
FL300	416	0.706*	6.1	2552
FL300	323	0.548	6.8	2181
FL250	471	0.782	4.6	2151
FL250	383	0.642*	6.1	2363
FL250	291	0.483	6.8	1970
FL150	407	0.65	4.5	1835
FL150	333	0.532*	5.8	1923
FL150	250	0.399	6.75	1662
FL030	345	0.535	4.2	1446
FL030	284	0.437*	5.7	1534
FL030	235	0.359	6.2	1464

Table 2. Range capability for Altitude/Speed Combinations from Arc 1.

Boeing researched MH370's fuel exhaustion range for the ATSB. Boeing's aviation engineers created 21 different flight path scenarios for the B777-200ER from Arc 1, using different altitude/speed combinations in the Boeing performance analysis report. Table 2 from the Boeing report shows that 10 out of the 21 simulated flight paths had fuel exhaustion times exceeding 00:19 UTC. For example, two simulated flight paths of FL250/291 knots and FL300/323 knots indicated that MH370 could still have over 10,000 lbs. of fuel at 00:19 UTC, able to fly for another 49 minutes. Those simulated flight paths were flown near the minimum operating airspeed for the corresponding altitude.

The reverse flight path's maximum total distance traveled between Arc 1 and Arc 7 covered 2150-2200 nautical miles, with an average ground speed of 370-380 knots and an average flight level of FL330 with one ascending climb. Thus, most of the flight was flown near the minimum operating airspeed for the corresponding altitude.

Side note: The fuel jettison pumps on the Boeing 777 are on the same electrical left AC bus with the Satellite Data Unit, cockpit door lock, and the cockpit voice recorder.

The Debris Paradox (supporting evidence)
A crash investigation cannot determine the demise of an aircraft with just 30+ pieces of debris, but some of MH370's recovered debris did not match the scenario of a high-speed ocean impact. The questionable debris pieces are in the numerical order of the February 2017 Malaysian Debris Examination Report.

Item 1 – The right flaperon. The leading edge had no compression damage (crushed or dented) from a high-speed vertical impact. However, the trailing edge had damage similar to the water erosion damage of the flaps from US Airways flight 1549, a water landing on the Hudson River in 2009. But forensic evidence shows the flaperon and the flap were retracted at the separation time.
The 94-page flaperon examination report in Appendix 1.12A-2 of the final Malaysian safety report issued by the French DGA/TA, concluded the trailing edge damage was caused by water, and the flaperon did not separate from the aircraft before impact.

*"Taking into account the macroscopic and microscopic observations, the straight trailing edge fracture seemed to have occurred in bending, from the lower surface towards the upper surface****. It appears that the flaperon impacted the water while still attached to the aeroplane and that at the time of the impact,*** *it was deflected"*

Item 5 - Door R1 Stowage Closet. A panel from a stowage closet near the plane's front exit door. This debris piece lacks compression damage, yet it should have received the full brunt of the impact. The same force of a steamroller rolling over it.

Item 18 - Right forward nose landing gear door. There was no compression damage: it was near the impact point. It also should have been crushed.

Item 19 - Right outboard flap. It also had no compression damage. The trailing edge had water erosion similar to the flaperon. Forensic evidence shows the flap was also retracted in the wing at the time of separation. Page 23 of the ATSB debris report revealed contact damage between the flaperon and the outboard flap and bent stiffeners within the seal pan cavity, possibly caused by a lateral force. That enforces the evidence that the flap and flaperon were both retracted in a neutral position at the time of separation. The flap and flaperon would have been extended if a water landing or ditching had been attempted, supporting the ATSB theory that MH370 was not ditched. Logically, the only way that both the French and the

Australian reports could be correct is if the flaperon and flap retracted after a water landing, separating later from the aircraft from a possible fuel tank(s) explosion.

Item 22 - Vertical stabilizer panel. The only recovered piece of debris reported as having compression damage was the front of the vertical stabilizer. This type of damage is unusual because the vertical stabilizer is part of an aircraft that is usually spared from severe damage during a high-speed nose-first ocean impact. For example, Air France Flight 447, Asiana Airlines Flight 991, and Indonesia AirAsia Flight 8501 were almost completely destroyed by ocean impact. But the vertical stabilizers from all three planes sustained minimal damage and were pulled from the ocean almost intact.

The lack of confirmed debris from the fuselage, cargo bay, or center cabin may imply a high-speed ocean impact did not destroy MH370. It may also indicate that large aircraft sections are still intact on the seafloor. There is an end of flight scenario where the debris pieces fit into place.

Possible end-of-flight scenario

What were the hijacker's intentions? Did he plan to ditch the aircraft with minimum damage and minimum debris? Hoping it would sink to the bottom of the ocean and never be found. He picked a location with relatively calm surface conditions with deep ocean depths, taking his time to get there, flying at the minimum airspeed for several hours, arriving an hour after sunrise. Perhaps this was to avoid the Australian over-the-horizon radar, marine or air traffic in the area, or the more favorable wind and sea conditions after sunrise for a water landing.

If the B777-200ER had been successfully ditched, both engines would have been torn off the plane, as designed. Although the APU would have continued running, all the circuits connected to the engines would have tripped. With just the APU running, the electrical management system would have shed all non-essential loads, including the right and left utility busses. The power would have been lost to both the IFE, and SATCOM systems, which is why the IFE set up request at 00:21:06 did not occur. Both the left and right hydraulic systems would have been lost after the separation of both engines. However, the center hydraulic system should have been pressurized and operative, allowing the damaged flap and flaperon to retract into a neutral position after the aircraft was ditched.

The airframe probably suffered significant forward damage but remained intact, floating with the forward section taking on water. The lithium-ion batteries damaged during the rough ditching started to catch fire and explode in a chain reaction creating a thermal runaway, filling the cargo bay with flammable gases. Between 10-12 minutes after touchdown, the concentration of combustible gases would have reached a flashpoint. The aircraft's central fuselage and the fuel tank(s) would have exploded almost simultaneously. Finally, the explosion(s) would have catapulted the forward section of the plane, both wings, and the tail section away from the center of the fuselage, cartwheeling across the ocean surface.

The reverse flight path, impact location, and end of flight scenario answer the questions not explained in over 3,000 pages of government reports.

1. How the flap and flaperon could have water erosion damage on the trailing edge, but both were retracted at the time of separation.
2. How there was contact damage between the flaperon and the outboard flap from a lateral force while retracted. What was the source of that force?
3. How debris from near the front of the aircraft that should have been crushed (compression) in a high-impact crash was torn away (tension) from the aircraft.
4. How the front of the vertical stabilizer sustained compression damage. It was struck by the exploding fuselage moving at 1800 meters per second.
5. Why elevated levels of sulfur dioxide were detected downwind of the impact site.
6. Why some of the highest levels of methane and carbon monoxide in the entire Indian Ocean were detected 7 hours downwind of the impact site.
7. Why none of the CTBTO hydrophone stations in the Indian Ocean detected a high-impact crash.
8. Why none of MH370's emergency locator transmitters were triggered, and no distress signals were received by satellites overhead. Even a rough water landing would not have generated the excessive G-force needed to trigger the ELTs.
9. Why none of MH370's debris has ever washed up on Western Australian beaches.
10. Why the 42-day aerial search in 2014 failed to locate any debris.
11. Why MH370's In-Flight Entertainment system log-on at 00:21:06 did not occur.
12. Why most of the recovered debris has been from the wings, the engines, and tail section, and no confirmed wreckage from the center cabin, cargo bay, or fuselage.
13. Why no wreckage was discovered after undersea searches covered over 230,000 square kilometers of the southern Indian Ocean's seabed.
14. Why Indonesian radar did not detect MH370 flying through Indonesian airspace.

Hydroacoustic data - (supporting evidence of a 23.7°S impact)

Curtin University and the Los Alamos National Laboratory (LANL) conducted hydroacoustic studies for the ATSB's final report. Both studies concluded that acoustic signals received from the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) hydrophones in the Indian Ocean did not detect an acoustic anomaly of a high impact crash near the seventh arc within the ATSB/Inmarsat 89 second window. The CTBTO hydrophone arrays were designed to detect undersea explosions and implosions but have limitations in detecting kinetic surface energy.

But LANL produced a study LA-UR 14-25015 in 2014 intended to brief Boeing executives, *The Mathematical Search for MH370.* That study stated: "The SOFAR signal from an ocean impact might have been detectable. But perhaps not easily noticed unless cued to the approximate signal arrival time and bearing*"*. SOFAR (Sound Fixing and Ranging) is naturally occurring ocean channels that allow sounds to carry great distances.

The analysis in that study showed three cluster groups of low-level but distinct signals that could have originated from the seventh arc within the ATSB/Inmarsat 89 second window. One of the clusters, the group-3 event, lasted for 20 seconds, between 00:39:28 and 00:39:48 (2368 and 2388 seconds after zero-hour).

SIDE NOTE: The ATSB/Inmarsat 89-second impact window is calculated between the last ping from the aircraft at 00:19:37 UTC and the expected but not received In-Flight Entertainment (IFE) system set up request at 00:21:06 UTC. **There is no evidence to doubt this premise, ruling out any glide hypotheses that the underwater search did not discover MH370 because it flew or glided beyond the previously searched bands.** Even under the unlikely event that the aircraft was flying at its maximum physical airspeed as it crossed the seventh arc, it still could not fly more than 15 nautical miles in 89 seconds.

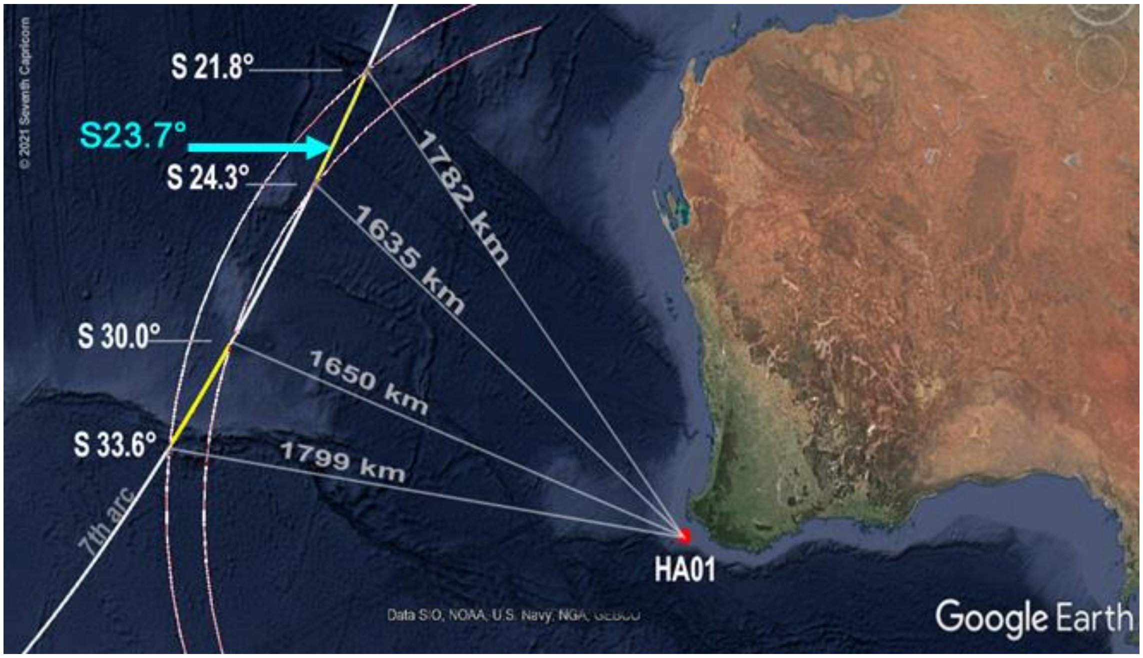

Figure 27. Possible group-3 low-level acoustic events on the 7th arc in the Indian Ocean.

If the source of the acoustic signals from the group-3 event were from a surface impact near the seventh arc during the 89-second window, the impact point would have been between 1635 and 1799 kilometers from the HA01 hydrophone. Figure 27 shows the impact radius intersection of two bands (yellow) along the seventh arc between 21.8°S to 24.3°S and 30.0°S to 33.6°S.

HA01 Hydrophone Event at 00:39:28

Impact Time UTC	Impact Time after 0 hr	Hydrophone Event Time after 0 hr	Travel Time Event time - Impact time		Distance from HA01 Travel Time (sec) x Speed (1.484 km/sec)
hh:mm:ss	Seconds	Seconds	Seconds		Kilometers
00:19:37	1167	2368	1201		1782
00:19:52	1192	2368	1176		1745
00:20:15	1215	2368	1153		1711
00:20:30	1230	2368	1138		1689
00:20:45	**1245**	**2368**	**1123**		**1667**
00:20:55	1255	2368	1113		1652
00:21:06	1266	2368	1102		1635

Sound speed calculated at 22°C average water tempature.

Table 3. The distance sound traveled from the 7th arc in comparison to impact times.

Table 3 shows the travel distances corresponding to different impact times during the 89-second window between 00:19:37 and 00:21:06 UTC using the average sea surface temperature at 27°S latitude.

The reverse flight path calculated an impact time of 00:20:45 UTC and an impact point near 23.71°S, 102.68°E (see page 15). The distance between that location and the HA01 hydrophone array is 1665 kilometers. Therefore, the calculated travel distance for an event to reach the hydrophone array between 00:20:45 and 00:39:28 UTC was 1667 kilometers, just two kilometers difference.

Interpreting hydroacoustic data from a single hydrophone station has limitations. It is difficult to distinguish between events that occurred 1667 or 5000 kilometers away; both could arrive simultaneously from the same direction. The group 3 event could have been an aircraft impact on the seventh arc or an acoustic event off the southern coast of India whose sound waves happened to pass over the seventh arc during the 89-second-window. The ocean is full of natural sound events and acoustic static.

The hydroacoustic data and the LANL study were added to this report as supporting evidence because of a near-exact match to the reverse flight path's impact time and impact location.

The last communication from MH370

In October 2014, Inmarsat, as a technical advisor to the UK Air Accidents Investigation Branch (AAIB), published an updated analysis of the satellite signals received from MH370 in the Journal of Navigation. Two paragraphs taken from that 20-page report are shown below.

3.3. *Log-on Sequence BTO Measurements.* The BTO readings for the signals at 18:25:27 and 00:19:37 UTC are much larger than the other readings, and were not included in the original analysis. However the final signal has special significance as it appears to have been triggered by the aircraft terminal being power cycled, and may indicate the aircraft running out of fuel. The signals at 18:25:27 and 00:19:37 were both generated as part of a logon sequence, contrasting with the other messages which were generated as part of a standard LOI exchange. Each power up sequence starts with a Logon Request message that has been found to have a fixed offset of 4600 μs relative to the LOI message exchange by inspecting historical data for this aircraft terminal. The subsequent messages during the logon sequence were found to have unreliable delay and are believed to be an artefact of the terminal switching channel and frequency during logon and so are not used in this analysis. This means that the BTO data for 18:25:34 and 00:19:37 should be ignored, but that corrected BTO values of 12520 and 18400 μs may be derived from the Logon Request messages at 18:25:27 and 00:19:29 UTC respectively.

5.3. *Refinement of BFO Samples.* Detailed analysis of BFO samples taken from other flights showed a high degree of consistency for the signalling message frequencies, with the exception of those that were performed immediately after the initial logon process. This called into question the BFO measurements after the log-on sequences at 18:25 and 00:19. However it was also determined (by the same method) that the first message transmitted by the aircraft in the logon sequence, the Logon Request message, did provide a consistent and accurate BFO measurement. This means that we can use the Logon Request message information from 18:25:27 and 00:19:29, but it is prudent to discount the measurements between 18:25:34 and 18:28:15 inclusive, and the one at 00:19:37.

MH370 sent two log-on requests to the Inmarsat satellite network after disappearing from military radar. Once at 18:25.27 and again at 00:19:29 UTC. Both times after a presumed power restoration to the satellite data unit. The Inmarsat data in table 4 shows a similar log-on request sequence for both times. A second log-on/log-off acknowledgment followed at 18:25:34 and 00:19:37, seven and eight seconds after the initial logins.

Time	Channel Name	Ocean Region	GES ID (octal)	Channel Unit ID	Channel Type	SU Type	Burst Frequency Offset (Hz) BFO	Burst Timing Offset (microseconds) BTO
18:25 - Log-On Request, initiated from the aircraft terminal. 6.81°N, 95.9°E								
7/03/2014 18:25:27.421	IOR-R600-0-36E1	IOR	305	8	R-Channel RX	0x10 - Log-on Request (ISU)/Log-on Flight Information (SSU)	142 Level flight	12520 (1)
7/03/2014 18:25:28.852	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	0x11 - Log-on Confirm		
7/03/2014 18:25:29.572	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	0x40 - P-/R-Channel Control (ISU)		
7/03/2014 18:25:29.572	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	Subsequent Signalling Unit		
7/03/2014 18:25:30.213	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	0x41 - T-Channel Control (ISU)		
7/03/2014 18:25:30.213	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	Subsequent Signalling Unit		
7/03/2014 18:25:34.461	IOR-R1200-0-36ED	IOR	305	4	R-Channel RX	0x15 - Log-on/Log-off Acknowledge	273 Ascending at 5880 ft/min	51700
7/03/2014 18:25:35.408	IOR-P10500-0-386B	IOR	305	10	P-Channel TX	0x15 - Log-on/Log-off Acknowledge		
00:19:29 - Log-On Request, initiated from the aircraft terminal. 23.72°S, 102.62°E								
8/03/2014 00:19:29.416	IOR-R600-0-36F8	IOR	305	10	R-Channel RX	0x10 - Log-on Request (ISU)/Log-on Flight Information (SSU)	182 Descending 3998 ft/min	18400 (1)
8/03/2014 00:19:31.572	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	0x11 - Log-on Confirm		
8/03/2014 00:19:32.212	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	0x40 - P-/R-Channel Control (ISU)		
8/03/2014 00:19:32.212	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	Subsequent Signalling Unit		
8/03/2014 00:19:32.852	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	0x41 - T-Channel Control (ISU)		
8/03/2014 00:19:32.852	IOR-P600-0-36FC	IOR	305	10	P-Channel TX	Subsequent Signalling Unit		
8/03/2014 00:19:37.443	IOR-R1200-0-36F6	IOR	305	10	R-Channel RX	0x15 - Log-on/Log-off Acknowledge	-2 Descending 14550 ft/min	49660
8/03/2014 00:19:38.407	IOR-P10500-0-386B	IOR	305	10	P-Channel TX	0x15 - Log-on/Log-off Acknowledge		

(1) Modified value, determined by subtracting 4600 µs from measured

Table 4. Inmarsat updated data communication logs. Notations in red

After reviewing the BTO and BFO data, Inmarsat engineers determined that the first logins at 18:25:27 and 00:19:29 were good, but the second logins at 18:25:34 and 00:19:37 were probably corrupt and should be ignored or discounted. The 00:19:37 (corrupt) log-on was the last communication received from MH370. The 18:25:27 (good) BFO data shows the aircraft was flying northwest on a level flight path. The last sighting of the plane by Malaysian military radar captured at 18:22 UTC supports this data point.

After Inmarsat's Journal of Navigation paper was released, the ATSB and Australian Defence and Science Technology (DST) Group continued to use the questionable second data login at 00:19:37 data as "hard evidence" that MH370 was in an uncontrolled dive during the time of the last communication received from the plane. However, the ATSB ignored the questionable second login at 18:25:34 because that data indicated the Boeing 777 went from a level flight to a 5,000 to 10,000 ft/min climb in just seven seconds, not physically possible.

DST Group scientist Ian Holland referenced the Inmarsat Journal of Navigation paper over 20 times in his article, *The Use of Burst Frequency Offsets in the Search for MH370,* and the book *Bayesian Methods in the Search for MH370* he co-authored with four other DST scientists (available on Amazon). But nowhere in the article, the 111-page book or any Australian government report did the DST scientists reference sections 3.3 or 5.3 of the Journal of Navigation paper or ever question the last communication from the aircraft at 00:19:37 as possible flawed data. Nor did they explain why they discarded the 18:25:34 data but kept the 00:19:37 data.

The government hypothesizes that the 00:19 UTC log-on occurred when the SDU restarted after MH370 ran out of fuel, starting the aircraft's auxiliary power. But, the ATSB published no hypothesis for what caused the 18:25 UTC log-on. A specific action by someone controlling the plane could have started both the 18:25 and 00:19 UTC log-ons. The DST Group and ATSB built their investigation and under-sea search around an end-of-flight group of assumptions. First, MH370 was a ghost plane that ran out of fuel. The fuel exhaustion started the auxiliary power unit, which reset the satellite data unit, beginning the 00:19 UTC log-on sequence with the Inmarsat satellite. That log-on created the last set of data pings received from MH370. The following paragraph is from page 101 of the ATSB's final report.

> The ATSB's MH370-Search and Debris Examination Update on the flap analysis also contained the summary of the analysis The Use of Burst Frequency Offsets in the Search for MH370 performed by DST Group scientists on the final two satellite transmissions from the aircraft. This work quantified the range of possible rates of descent based on the burst frequency offsets of the SATCOM transmissions. In summary, the analysis concluded that the aircraft was descending at a rate of between 2,900 ft/min and 15,200 ft/min when the 7th arc was crossed. Eight seconds later the rate of descent had increased to between 13,800 ft/min and 25,300 ft/min[29]. These rates of descent ruled out a controlled unpowered glide with the intent to extend range.
>
> [29] It should be noted that these descent rates were derived assuming the SDU was still receiving valid track and speed labels from the ADIRU at 0019:37 UTC for use in its doppler pre-compensation algorithm.
>
> › 101 ‹

The ATSB inserted a disclaimer in the fine print of the footnote: "these descent rates were derived assuming the SDU was still receiving valid track and speed labels from the ADIRU at 00:19:37". However, the ATSB and the DST Group knew that SDU was most likely not "receiving valid track and speed labels at 00:19:37."

If MH370 were flying due south at 00:19:29, the "useable" BFO shows the aircraft descending at 2,900- 3,200 feet per minute. If the Boeing 777-200ER were flying due east at 00:19:29, the descent rate would have been near 4,000 feet per minute. Depending on the aircraft's starting altitude, the normal idle descent for a Boeing 777 on a landing approach is 1,500 to 2,500 feet per minute. However, a controlled powered descent can reach rates of 6,000 feet per minute in an emergency situation.

MH370 Timeline

Time Event
(UTC)
16:42 Flight 370 takes off from the Kuala Lumpur International Airport.
17:01 The aircraft reaches a flight level of 35,000 ft.
17:08 The aircraft sends the final ACARS data transmission.
17:21 The aircraft disappears from Kuala Lumpur ACC radar near waypoint IGARI. Then, it begins a turn to the left until it is traveling in a southwesterly direction.
17:52 The aircraft reaches the southern end of Penang Island. Flight 370 then turns northwest along the Strait of Malacca.
18:22 The last primary radar contact is made ten nautical miles past waypoint NILAM.
18:25 A log-on request is sent by the aircraft to the satellite communications network.
18:30 The aircraft continues flying along air route N571 towards IGOGU at an airspeed of near 500 knots.
18:37 The aircraft makes a turn south before reaching waypoint IGOGU.
18:39 A ground-to-aircraft telephone call goes unanswered.
18:40 The aircraft begins descending, flying south parallel to Malaysia and India's flight information region boundary.
18:47 The aircraft at FL070 passes near waypoint NOPEK.
19:00 The aircraft passes near the waypoint BEDAX and makes a turn south.
19:15 The aircraft is now beyond Indonesian radar coverage and begins ascending.
19:41 Automated handshake between the aircraft and the satellite communication network.
20:09 The aircraft passes near waypoint ISBIX and turns towards waypoint POSOD.
20:41 Automated handshake between the aircraft and the satellite communication network.
20:45 The aircraft passes near waypoint POSOD with a heading of 169°.
21:41 Automated handshake between the aircraft and the satellite communication network.
22:41 Automated handshake between the aircraft and the satellite communication network.
23:13 A ground-to-aircraft telephone call goes unanswered.
23:23 Near daybreak, MH370 is near waypoint POLUM on a track of 165°. It drops down to or just below cloud-top level, perhaps to avoid detection from possible interceptors.
23:40 The aircraft turned to the southeast, 115 nautical miles south of POLUM.
00:01 The aircraft is still flying along the cloud top as it turns east.
00:11 Automated handshake between the aircraft and the satellite communication network.
00:18 The aircraft starts a final descent; the auxiliary power unit (APU) was started from the cockpit.
00:19:29 The aircraft sends a log-on request to the satellite.
00:20:45 Impact, a semi-successful ditching. Both engines were lost with significant forward damage.
00:20:50 The electrical management system sheds all non-essential loads.
00:21:06 The power was lost to the IFE and SATCOM systems, the IFE set-up request did not occur.
00:21:10 Damage lithium-ion batteries begin to catch fire. A thermal runaway begins.
00:33:15 MH370 was still afloat as hydrogen and methane released by the thermal runaway reached a flashpoint. The center fuselage and possibly the wing fuel tank(s) simultaneously explode.

Conclusion

The overwhelming evidence presented in this report shows the wreckage of MH370 is near the seventh arc between 23.5°S and 23.9°S. The impact point was not a random location where the aircraft ran out of fuel. Instead, it was a well-planned prime location where MH370 may have been successfully ditched. A site where it would have avoided detection and the wreckage would have never been located.

The MH370 hijacker selected this endpoint for several reasons. First, the ocean depths around 23.7°S are over 5000 meters, making it impossible to detect pings from the flight data recorders. Thus, recovery ships could have been directly over the debris field but out of the range of underwater locator beacons on the seabed floor. Second, the location was outside of major shipping lanes avoiding the detection by passing vessels and minimizing the discovery of an oil or fuel slick. Third, the reported ocean conditions near 23.7°S that morning were short swells of moderate height, 1 to 2.5 meters. It was not ideal to attempt a water landing, but it was one of the calmest sea conditions along the seventh arc in the Indian Ocean.

Elevated levels of atmospheric methane, carbon monoxide, and sulfur dioxide gases discovered downwind of the estimated impact site imply an end of flight scenario of a ditching or water landing that may have partially succeeded. However, the rough landing may have damaged the lithium-ion batteries in the cargo hold, starting a thermal runaway that filled the damaged but still floating aircraft with flammable gases, sparking a possible double explosion that destroyed a large part of the center fuselage. The explosion(s) separated the aircraft's wings, front, and tail sections. The end of flight scenario could explain why all of the debris recovered has been from the wings, the front and tail sections with no confirmed debris from the center cabin, cargo bay, or any part of the fuselage.

The explosion(s) may have only destroyed the center part of the aircraft. As a result, large segments of the tail and nose sections may still be intact on the seabed floor.

Some of the supporting evidence in this report originated from published and unpublished government documents. However, that evidence may have been overlooked or discounted because the new evidence did not match the ATSB and DST narrative that MH370 crashed in the southern Indian Ocean.

The initial underwater search failed to locate the June 2009 Air France 447 crash in the Atlantic Ocean. The investigators assumed that the Airbus A330 underwater locator beacons attached to the data recorders were activated by seawater and transmitting signals. So the passive acoustic search area for the beacons was omitted from the 2009-2010 active sonar undersea search. However, when the data recorders were finally recovered in May 2011, tests showed both locator beacons attached to the recorders had failed to activate on ocean impact. The assumption that at least one beacon was working delayed the wreckage discovery by almost two years.

The MH370 search investigators also made some unfortunate assumptions. First, they assumed that the Boeing 777 impact location was south of 32°S because the 2014 surface search had ruled out the 32°S to 25°S segment of the 7th arc. Second, the ATSB end of flight scenario of a ghost plane flying for hours then running out of fuel and crashing into the ocean was not viable for impact points north of 32°S, so most published drift debris analysis focused on impact points south of 32°S. Third, new evidence from BEA, Inmarsat, CSIRO, and independent crash investigators was discounted if the evidence conflicted with the investigation's end of flight narrative.

The Malaysian Transport Ministry and the Malaysian government have abandoned MH370 for either financial or political reasons. Yet they continue to give the next-of-kin empty promises of a renewed search. As more evidence in our investigation has been uncovered, Transportation Minister Wee has received three updates since March 2021, but he has not responded. Despite new evidence and a pinpoint location, Malaysia will not renew the search for the wreckage debris and human remains without international pressure from the media and the other twelve nations that lost citizens on MH370.

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