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RESEARCH ARTICLE

Final two MH370 communications suggest controlled eastward descent

Vincent Lyne[†]

University of Tasmania, Hobart, Tasmania, Australia.
Email: vincent.lyne@utas.edu.au
[†]Retired scientist.

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Abstract
Official interpretations of Doppler shifts from the final satellite communications of missing Malaysian Airlines MH370 were based on a motion-decoupled 'Up-Down model'. That model predicted an uncontrolled high-speed gravitationally accelerated dive following fuel starvation. Here, I challenge that model using a more-realistic motion-coupled 'Declination model'. Aerial, satellite and underwater searches failed to find the predicted official violent crash-site near the 7th arc. Meticulous re-examination of debris damage by air-crash investigator Larry Vance concluded that the aircraft glide-landed under power with *extended* wing-flaps. The trailing-edges were then damaged, broke off their mountings, flailing about and *retracted* along the guides to cause the observed wing-flap damage. Larry's conclusions complement interpretations from the 'Declination model' which we demonstrate here with three example flight tracks. Our revised Doppler-shift analyses support the hypothesis of a controlled eastward descent. We conclude that the official theory of fuel starvation and a high-speed dive are fundamentally flawed.

1. Introduction

Malaysian Airlines MH370, a Boeing 777-200ER equipped with the Inmarsat Classic Aero system, went missing on the 8th of March 2014 with 239 people on board (ATSB, 2017). As described by Ashton et al. (2014), the Inmarsat Classic Aero system Satellite Data Unit (SDU) used several different communication frequencies determined by the data rate plus an allowance for environment and instrument errors. The *transmitted frequency* is altered by the SDU which internally compensates for expected *horizontal* Doppler shifts so that signals arrive at the *expected frequency*. However, compensation errors arise from several factors, including the simplified satellite model used, aircraft location, track angle and ground velocity. Importantly, Doppler shifts from vertical motions are uncompensated. Significant remnant discrepancies, after all other factors are accounted for, as found for the last two MH370 satellite communications, may be due to vertical motions – which are the core subject of this paper.

Our aim here is to provide a plausible reinterpretation of Doppler shifts from those two signals. They were so different and uncertain that various conflicting interpretations have been offered. Indeed, as we discuss later, they were *discarded* as erroneous from the Bayesian model used to guide the failed first search. Corrections to uncertainties in those data then led to an official high-speed dive interpretation using a motion-decoupled model. This was used in part to guide the failed second search based on revised fuel loads and drift model studies. However, officials still insist that the model and interpretations are correct. My aim here is to provide context for the official theory so that we have a clear understanding of failures in the theory, model and interpretations. I demonstrate that there is a far more physically

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reasonable interpretation using a motion-coupled model. Three possible tracks for the aircraft are then used to compare and contrast interpretations from these competing models. An underlying key message I want to make is that the wrong MH370 theory led to 'irrational exuberance' by some experts/scientists. Their interpretations, not just for the problem at hand, defy the laws of physics and, in some cases, common sense. At times, I will use the problem at hand to identify how such 'exuberance' was used to justify, what now appears to be, the wrong official theory. There is no defying the Science Principle that analyses purporting to support a wrong theory are most likely also wrong. That was indeed the impetus that led me to this reluctant investigation to set the Science record straight. However, first, let us review the background context for later analyses and comparisons.

As noted in the official report (ATSB, 2017), along its planned fight from Kuala Lumpur to Beijing, MH370 was in normal flight up to the transition between Malaysian and Vietnamese airspaces. The now infamous 'Good Night, Malaysian Three Seven Zero' sign-off by one of the pilots to Malaysian Air Traffic Control (ATC) marks the turning point for the most baffling modern aircraft disappearance. Minutes later, before control passed to Vietnamese ATC, MH370 disappeared from civilian radar screens. Malaysian military radar tracked the aircraft for another hour, as it deviated westwards from its planned flight path and crossed the Malay Peninsula and Andaman Sea. After rounding Penang Island from the east and south – which some interpreted as a hometown 'farewell' by the pilot – it left radar range at 18:22 Coordinated Universal Time (UTC) as it headed north-west along the Malacca Strait. Ground-to-air telephone calls went unanswered, although at the request from Vietnamese ATC, a call from a nearby aircraft heard 'mumbling' and static (Campbell, 2014).

Inmarsat engineers identified regular monitoring 'Log-on Interrogation' communications with the Inmarsat satellite I-3F1 after each hour of inactivity, and two phases of specific 'Log-on Requests' from the aircraft near 18:25 and 00:19 UTC (Ashton et al., 2014). The relative motion between satellite and aircraft caused Doppler shifts in the satellite communication frequency as signals travelled between aircraft, Inmarsat satellite and Perth Ground Station. The aircraft Satellite Data Unit (SDU) compensated Doppler shifts from the horizontal aircraft motion but small biases (from drift and ageing) and a track-dependent error, primarily due to the SDU assuming a geostationary satellite (rather than geosynchronous), remained (Ashton et al., 2014). Following correction procedures by Ashton et al. (2014), Holland (2018. Figure 4) determined aircraft speeds and track angles that minimised this error. Other uncertainties, such as temperature variations within the satellite, and biases, were also carefully calibrated out (Ashton et al., 2014). Detailed analyses of Burst Timing Offset (BTO – distance-based measurement) and Burst Frequency Offset (BFO – relative speed-based Doppler shift measurement between satellite and aircraft) resulted in seven distance-based BTO global arcs (Zweck, 2016) along which the aircraft was located at different times, centred around the Inmarsat satellite undergoing a 'teardrop' shaped geosynchronous orbit; located nominally above the equator at 64·5°E (Ashton et al., 2014).

BFO data from a '*Log-on Request*' at 18:25:27 UTC indicated the aircraft continued along the north-west Malacca track. However, data from an unanswered telephone call at 18:40 UTC suggested that it was travelling south. So, between those communications, the aircraft turned south. A similar request occurred at 00:19:29 UTC at the 7th arc, followed 8 s later by a '*Log-on Acknowledgement*' at 00:19:37 UTC. This was the last communication as there was no response to three handshake requests from Inmarsat at 01:15 UTC (ATSB, 2014).

Signals at 18:25:27 UTC and 00:19:37 UTC were part of a '*Log-on Exchange*' (LOE), whilst other messages were part of a standard '*Log-on Interrogation*' (LOI) asking for a response. Official interpretations of the two LOEs was that the first (18:25:27 UTC) preceded a track change, but the second (00:19:37 UTC) was from the aircraft running out of fuel and crashing. ATSB acknowledged that it could be due to the aircraft being readied for a 'very unlikely' controlled ditching (ATSB, 2017. p. 101). Our revised model and interpretation are that the latter Log-on Requests reflect the aircraft being readied for a controlled descent and later ditching.

Here, we compare BFO interpretations from Holland's motion-decoupled model with our model which couples horizontal and vertical motions. We aim to show that the fuel-starvation model is incorrect

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and that the decoupled model defies physics as it fails catastrophically into a singular solution for finite declinations. Three example flight tracks are used to compare and contrast the models.

In what follows, I describe official interpretations of BFO signals from the last two satellite communications. I then explain why the first official search failed and what went wrong with the second search. These two theories are also differentiated by 'fuel-starvation and flaps-up' (Holland's model) versus 'fuel-available and flaps-extended' (our model and Larry Vance's). Hence, context to the alternate 'controlled ditching' theory is presented in relation to debris damage and flap position by Larry Vance. I then describe the Penang Longitude Theory and controlled ditching which complements the work of Larry. This theory's prediction of MH370 veering eastward and descending by the 7th arc also challenges the official high-speed dive. I first discuss a surprising 'break-through' development (since manuscript submission) of riddles hidden in the Pilot-In-Command (PIC) home simulator track, which were discarded by FBI and official investigators as 'irrelevant' (ATSB, 2017).

The resolved riddles uncovered the probable *very accurately planned* flight track of MH370 (Lyne, 2023b, 2023c). This track is now included belatedly as a third example track for this study. However, it deviates marginally from the 'Adelaide Track' (described later) so conclusions are not critically altered. In yet another follow-up of this study (Lyne, 2022a), I demonstrate that not only is our 'Declination model' capable of explaining the BFO signals, but it also demonstrates that Holland's vertical death-defying gravitational-dive acceleration is nothing more than apparent vertical acceleration from simple rotational changes in declination angle.

Potential flight paths from arc timings and BFO-estimated speeds/directions generally supported a persistent southerly track down to the 6th arc (Ashton et al., 2014; Davey et al., 2016). At the 7th arc, BFO anomalies remained after extrapolation of a statistical fit to previous BFOs (Ashton et al., 2014) and resolved errors (Holland, 2018). However, for the first search, the Bayesian model ignored Log-on Exchange BFOs (at 18:25:27 UTC, 00:19:27 UTC, 00:19:37 UTC) as settling errors could not be resolved and statistically assimilated into their horizontal flight model (Davey et al., 2016. Table 10·1). These deleted communications, particularly the final two, allowed the Bayesian model aircraft to wrongly continue southerly at the 7th arc. This resulted in a 'heat map' crash region about 39°S. Searches of that area failed (ATSB, 2017). Retrospectively (after search failure), the fuel model was also wrong, so Boeing revised the fuel calculations and moved the Second Search further north.

For the Second Search, Holland (2018) (Bayesian-study co-author) carefully bounded errors from power-up settling anomalies. Holland's excellent work should have been used to update the Bayesian flight model (assuming it had the correct flight dynamics that included vertical motions). Instead, Holland used the Inmarsat decoupled BFO (not absolute velocity) model (Ashton et al., 2014) for a solo effort to interpret the last two communications. We are here to challenge these interpretations.

At the 7th arc, discrepancies remained between a predicted BFO of 260 Hz and nominal observed BFOs of 182 Hz and −2 Hz, respectively, at the last two communications 8 s apart (Holland, 2018). Hypotheses on whether the SDU was started up from a power-off-on engine-flame-out event (Hypothesis 1 – fuel-starvation scenario, long cold-start settling behaviour) or a warm-reboot electronic event (Hypothesis 2 – electronic switching, short-reboot settling behaviour as per the log-on BFO at 18:25:27 UTC) led to extended and extreme BFO ranges (Holland, 2018). The extreme range produced unrealistic descent rates, so mid-point values were used for the *assumed-southerly track* at the 7th arc.

Inmarsat's decoupled BFO model (Ashton et al., 2014) assumes remnant anomalies are from uncompensated up-down motions. This led Holland to conclude that, discounting the unrealistic extreme range, a 0·68g (g is Earth's surface gravitation acceleration constant) acceleration took place during the 8 s leading to a nominal high-speed drop of 10,700 fpm (feet per minute). These conclusions, and Boeing-revised fuel-starvation endpoints, *appeared* to be supported by highly promising drift model analyses of recovered debris (Griffin and Oke, 2017; Griffin et al., 2017). However, that 'drift' model was in physically impossible 'sailing' *perpetual motion* in the turbulent open ocean (Lyne, 2023a). Extensive and highly detailed searches around these bounded locations were unsuccessful; with not even a scrap of debris found (ATSB, 2017).

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A significant positive outcome for ocean research was the huge volume of seafloor data collected across 120,000 km^2. Ocean Infinity donated this to the Nippon Foundation–GEBCO Seabed 2030 Project, to update the global ocean seafloor map (Orr & Associates, 2018). It still remains the most intensely mapped seafloor area of our Planet. MH370 was simply not there!

The scenario of powered glide-landing with extended flaps is supported by comprehensive finite-element modelling and simulation analyses by France's MH370-Captio group (MH370-Captio, 2019; Kamoulakos, 2020). These simulations used add-on models of realistic ocean swell, waves and wind. Predictions from these studies matched observed damage to trailing-edges of the flaperon and complement investigations by Vance (2018). These investigations suggest the following evidence-based events at landing.

- During the powered level glide-landing with extended flaps, the right wing contacts a wave, ripping off its engine (as per US Airways 1549 (Lyne, 2024b)).
- The trailing extended edges of the flaps and flaperon were then hydrodynamically damaged (again, as per US Airways 1549).
- Downward crushing forces were created across the wing, and rearward crushing from frontal and upward impact with the wave. The fuselage is breached at the wing root (Vance, 2018), indicating much greater forces at play than US Airways 1549.
- This crushed the inboard-end wing-flap seal-pan with the outboard end of the flaperon.
- The combined crushing forces break off the flaperon and the flap off their supports. As shown previously (Lyne, 2024b), this mimics damage to US Airways 1549 from a 'controlled ditching' – providing further support to interpretations by the Captio-group and Larry Vance.
- The flaperon breaks away but the flap flails about whilst loosely attached to its internal support track.
- Witness marks made by the support track inside the flap-pan suggest that the flap retracted back beyond its fully retracted position before it was pulled back free of the support arm and pulled through the front of the flap.

The thorough and meticulous examination of Larry Vance firmly refutes the incomplete and inaccurate 'flaps up' damage investigation of the ATSB. Further, the opposite finding of 'flaps down' also invalidates the ATSB theory of an uncontrolled crash because the aircraft could only attempt a controlled ditching under full engine power (Vance, 2018) with flaps and flaperon in extended positions; which then damaged the trailing edges (Vance, 2018; MH370-Captio, 2019; Kamoulakos, 2020; Lyne, 2024b). Here, we show that official interpretations of the satellite communications, which hinged critically on a 'flaps-up' 'Up-Down model' and fuel-starvation, are all flawed. I demonstrate this using a much more plausible and realistic alternative 'Declination model' to reinterpret the BFO signals.

Before we describe the MH370 tracks for the demonstration, one track was uncovered recently, hidden in riddles in the Pilot-In-Command simulation track, as shown in Figure 1. Details of these riddles, one set for the northern PIC track and another for the southern, can be found from Lyne (2023b, 2023c). Those tracks were simulated most likely for very careful calculations of fuel consumption (Lyne, 2023c) and to leave riddles to torment investigators; who obliged and discarded the tracks as irrelevant (ATSB, 2017). Resolution of the riddles showed simple waypoints and precise planning. Even the Decoy Tracks were chosen to reflect a fictitious ending not just in Perth but at Perth Airport runway. JORN's corner was cut to save fuel. However, here again, there was knowledge of the three-dimensional (3D) dome nature of JORN's range, because 10 km altitude at that location was above the 3D dome (Harris, 2017). Resolution of the northern PIC track riddle, shown in Figure 1, involved simple measurement of planned and simulated track lengths. An elementary task that could have been accomplished quickly in Google Earth. Admittedly, the southern track riddles were less obvious, but still solvable with critical thought from the world's most eminent analytical minds, who instead threw them all away. Suffice to note that the PIC Track is similar to the 'Adelaide Track' shown in Figure 2. Hence, findings reported originally are not materially altered, but the mastermind careful planning did save ~100 km flight distance.

Two of the three tracks shown in Figure 2 concord with the PL Theory's requirement to stay outside the western boundary of the Australia's Jindalee Over-the-Horizon Radar Network (JORN) (Harris, 2017);

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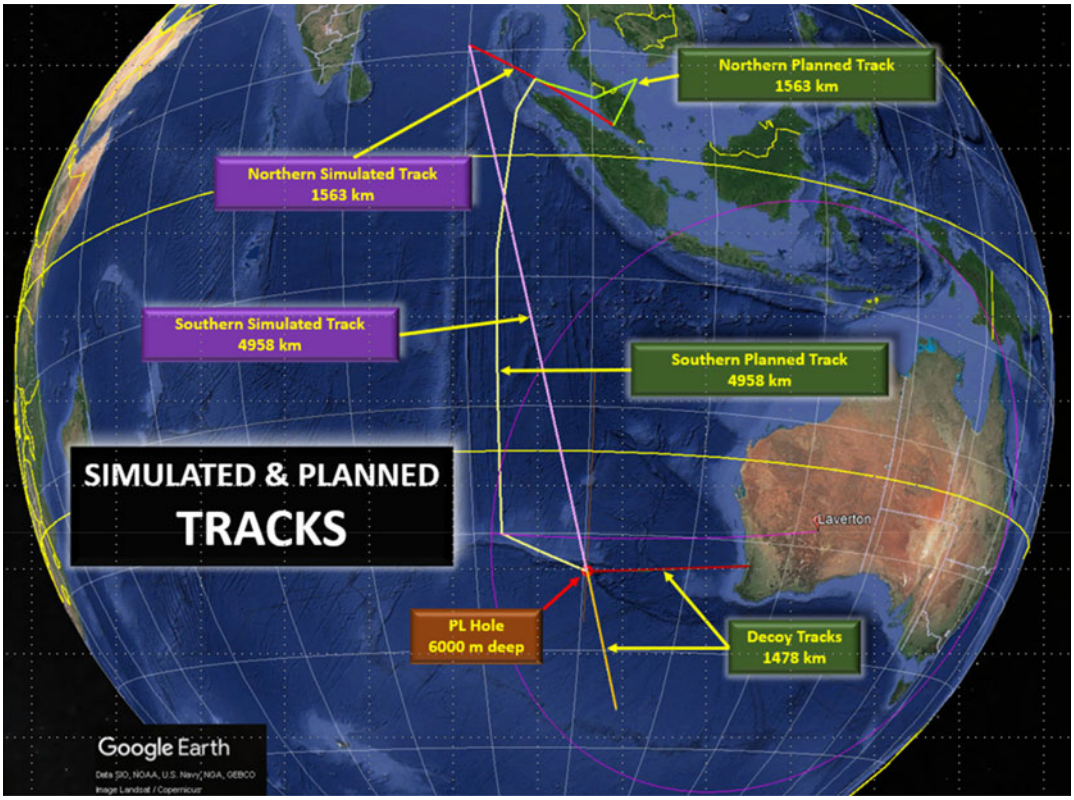

Figure 1. Figure adapted from Lyne (2023c) comparing the respective northern and southern pilot-in-command (PIC) simulated tracks (left-side purple labels) with the planned tracks (right-side green labels). The PL hole is near where the 33°S latitude intersects the longitude of Penang (thin brown vertical line) at a 6,000 m deep hole. The decoy tracks (to Southern Ocean and Perth Airport runway) were not executed but merely to cause confusion. Track lengths are noted in the labelled track boxes. The Jindalee Over-the-Horizon Radar Network (JORN) range and southern boundary from Laverton are drawn in purple. The Decoy Track to Perth is inferred from the other in the simulator track. Note that the map is not in equi-distance projection.

the exception is the South Track. Further, no other theory has an explanation for the inferred southerly tracks other than the utterly unbelievable official explanation of an autopilot track with everyone onboard hypoxic (ATSB, 2017), and with *no* reference to JORN at all. The aircraft had to stay outside JORN range (despite JORN not being on at the time) if it was on a secret mission to not be detected in-flight or found. This implies an eastward descent track at the 7th arc, heading towards the ultra-deep hole at the Penang Longitude (PL) location, which would be filled with sediments many hundreds of meters deep (NCEI, 2021). A ‘perfect’ hiding place.

The example tracks in Figure 2 were derived with simple waypoints. In the ‘Adelaide Track’, Adelaide is chosen as a waypoint past the southern boundary of JORN at (92°E, 31°S). This path crosses precisely over the PL location and minimises distance travelled to avoid JORN. The ‘South Track’ was southerly (up to 6th arc) for compatibility with the fuel-starvation theory southerly tracks. This track cuts deeply into the south-west corner of JORN. The ‘PIC Track’ closely resembles the ‘Adelaide Track’ except the JORN corner-cutting is further east and north (92·5°E, 30°S) and more than 100 km shorter – a mastermind at work saving fuel. Without this ‘safe’ corner cutting (Harris, 2017), the hidden riddles cannot be solved exactly as all planned lengths were very precise. However, for resolving BFO signals, deviations from the Adelaide Track are minor.

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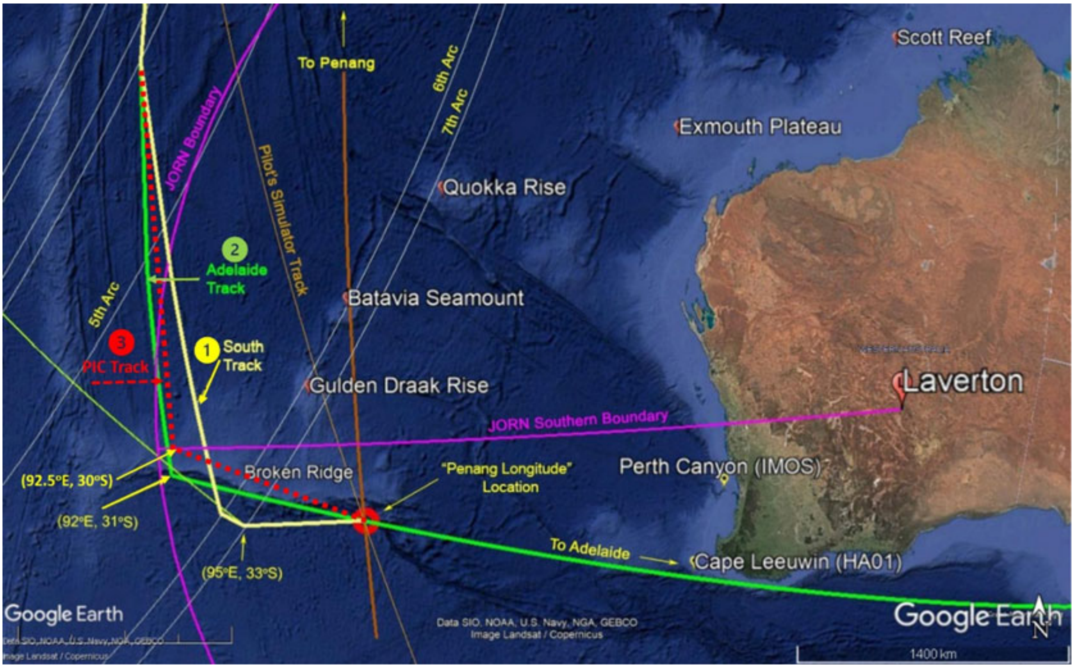

Figure 2. *Map features and example flight tracks. White curves are the 7 arcs. The purple curve and inclined horizontal line are the Jindalee Over-the-Horizon Radar Network (JORN) range boundaries (but ignore the curve past the southern boundary). Three flight tracks are shown: (1) in yellow (1: 'South track') the southerly track intersects the 6th arc near 94°E, then veers to 33°S, 95°E at the 7th arc, and then proceeds east to the 'Penang longitude' location (red circle); (2) in green (2: 'Adelaide track') the southerly path veers east towards Adelaide at 92°E and 31°S; (3) in red (3: 'PIC track'), shown as a dashed red line, is the pilot-in-command (PIC) track where the southerly track along 92·5°E veers south-east once past the JORN southern boundary at 30°S. The bearing to the satellite is shown by the light green northwest line. The light orange line running northwest is one of the simulation tracks from the pilot's home simulator. Other place marks are referred to in the main text or are for general background information.*

For bearings, at the 6th arc, the South Track bearing is less than 6° east from due-south. The BFO residual from a track variation, relative to southerly, of under 6° is under 1 Hz (Holland, 2018) (Figure 4). At the 6th arc, the Adelaide Track and PIC Track veer east and cross at bearings of 108·8° and 116·6°, respectively, which potentially adds ~7 to 5 Hz (respectively) BFO error.

Our analyses will be as per Holland (2018) on the two final 7th-arc BFOs. We focus on alternate explanations for anomalies from the 'warm start' Hypothesis 2. The 'warm start' refers to a warm reboot from a power switching which is more compatible with the PL Theory's prediction that the aircraft was being prepared for descent – which the ATSB acknowledges was possible (ATSB, 2017. p. 101). Precedence for this power-glitch assumption was established by a previous such event (at 18:25:27 UTC) when the aircraft turned south, and clearly did not run out of fuel. We will now analyse interpretations from the respective models.

2. Method

In our proposed analysis, we allow the aircraft track to vary and veer eastwards to the PL Location. This contrasts with the fuel-starvation theory which, by extrapolation, required the aircraft to maintain its southerly track (Ashton et al., 2014). We will also use a motion-coupled flight descent model, where the

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aircraft descends at a declination angle to the horizontal plane. This avoids the trap of assuming that the horizontal motion is compensated for by the SDU and hence need not be further considered. We add the appropriate small BFO differences due to the horizontal deviation from a southerly track at the 6th arc as discussed above.

These changes are incorporated into the standard Doppler shift model of Equation (1) that defines the frequency change observed from a moving electromagnet source:

$$F_o = \frac{C \times F}{(C - V)} \tag{1}$$

where speeds are in kilometres per hour (kph); frequencies are in Hertz (Hz); C is the speed of light (1,079,252,848·8 kph); V is the speed component of the aircraft velocity vector (kph) that is aligned with the vector from the aircraft to the Inmarsat satellite (positive towards the satellite); F is the uplink frequency from the aircraft to the satellite (1,646·6525 MHz); and F_o is the received Doppler-shifted frequency (assuming no compensation).

The magnitude of velocity V was calculated from the aircraft track, heading and elevation to the Inmarsat satellite, and an assumed declination angle according to

$$V = S \times \cos(\theta_e - \theta_d) \times \cos(\theta_s - \theta_a) \tag{2}$$

where heading and track angles are measured clockwise from North in a 3D axis system; S is the ground speed of the aircraft; θ_e is the aircraft to satellite elevation angle from horizontal (positive and set to 38·8° for the 7th arc following Holland [4]); θ_d is the aircraft declination angle (positive for descent); and θ_s and θ_a are heading angles at ground level for the satellite and aircraft, respectively (so 0° is a Northerly track and 180° is a Southerly track).

The calculated velocity magnitude (V) is used in Equation (1) following appropriate sign conventions. The first cosine term in Equation (2) accounts for the satellite elevation angle modulated by the aircraft declination, so when these angles are the same, the frequency offset is at an absolute maximum – because the aircraft is proceeding directly to the satellite or away from it. Likewise, for alignment of the satellite and aircraft headings in the second cosine term. The two equations represent the model we used to calculate expected uncompensated BFOs for various combinations of aircraft track angle (θ_a) and declination angle (θ_d). Other parameters were fixed as listed and referenced in Table 1.

BFO errors at the two times in Table 1 represent the difference between predicted BFO for a frequency-compensated southerly track and measured SDU-frequency-compensated BFO. Previous investigators interpreted the 7th arc mismatch as due to vertical motions, not accounted for in the horizonal compensation by the SDU. This led to the official high-speed descent conclusion (Holland, 2018). By contrast, in the PL Theory, BFO is not directly from vertical motions, but from declination in the vertical plane. This also realigns the aircraft track more closely with the aircraft to satellite direction (positive values imply the aircraft tracking away from the satellite) and also affects the horizontal velocity component (hence SDU compensation – wrongly assumed *fixed* in the decoupled dive model).

Figure 3 schematically portrays motion-coupling differences between the Up-Down model and the Declination model. In the Up-Down model the two components are decoupled based on the assumption that there is no need to be concerned about the motion-compensated horizontal track. However, in the Declination model, for finite declination, the horizontal compensation varies. Therefore, the BFO horizontal-compensation deficit, *plus* the BFO from the vertical motion, must be considered in explaining the overall BFO. Hence, the *fundamental flaw* in the Up-Down model is exposed when the aircraft undergoes declination, unless of course the cruise speed is zero and then we have the valid but *singular solution* of Holland's that depends only on the gravitationally accelerated drop speed. This is the stopping in mid-flight and dropping from the sky 'solution' whose BFO only depends on the elevation angle to the Inmarsat satellite as explained in considerable detail previously (Lyne, 2022a).

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Table 1. *Ancillary parameters for the BFO calculations.*

Parameter	Description	Value
Inmarsat Satellite Location (Ashton et al., 2014)	Ground projected location of the Inmarsat Satellite at 00:19 UTC	0·5°N, 64·475°E
Inmarsat Satellite Elevation (Holland, 2018)	Elevation angle from the aircraft location to the satellite	38·8°
Heading of Aircraft Location to Inmarsat Location at the 7th arc. *(Note, this is not the aircraft track heading)*	Estimated by Ashton et al. (2014)	Location: 34·7°S, 93·0°E Heading: 323·98° from North
	According to the PL Theory	‘**South Track**’ Location: 33·0°S, 95·0°E Heading: 321·6° ‘**Adelaide Track**’ Location: 32·13°S, 96·0°E Heading: 319·8° ‘**PIC Track**’ Location: 31·72°S, 96·59°E Heading: 319·03°
Aircraft speed at 7th arc	In kph	829 kph (Ashton et al., 2014)
First BFO at 7th arc: at 00:19:29 UTC (Holland, 2018)	Predicted for southerly track and observed	Predicted 260 Hz Observed 182 Hz
Second BFO at 7th arc: at 00:19:37 UTC (Holland, 2018)	Predicted for southerly track and observed	Predicted 260 Hz Observed −2 Hz

The uncompensated BFO was calculated by subtracting the compensated horizontal component using Equations (1) and (2) and the declination angle. For a level/horizontal flight with declination angle = 0, this value is zero but with positive (or negative) declination, the component due to horizontal velocity (whose speed is the aircraft speed times cosine of declination angle) is subtracted from the total BFO. Note, as discussed previously, there are BFO discrepancies with track angle due to incomplete horizontal BFO compensation by the SDU. These amounts are to be added to the BFO errors shown in Table 1.

3. Results

BFO changes, compensated for horizontal motion, by track angle and declination angle are shown in Figures 4 and 5. With no declination (horizontal motion only), the difference is zero and increases as the declination angle increases. For any declination, the BFO is maximal at a track angle in-line with the direction of the satellite to the aircraft. These angles are (141·6°, 139·8°, 139·03°) for the tracks (South, Adelaide, PIC). For convenience, the satellite track angle in Figure 4 of 141·6° should be shifted to align with the respective satellite track.

For the South Track, the mismatch at the first 7th arc communication is approximately 80 Hz (80 Hz = Predicted 260 Hz – Observed approximate 180 Hz). The mismatch would require a minimum declination of 6° at the satellite track angle and 8° at the southerly track. There is a slight advantage in veering to the east but, overall, the first BFO mismatch is explainable by a declination of under 8° at the

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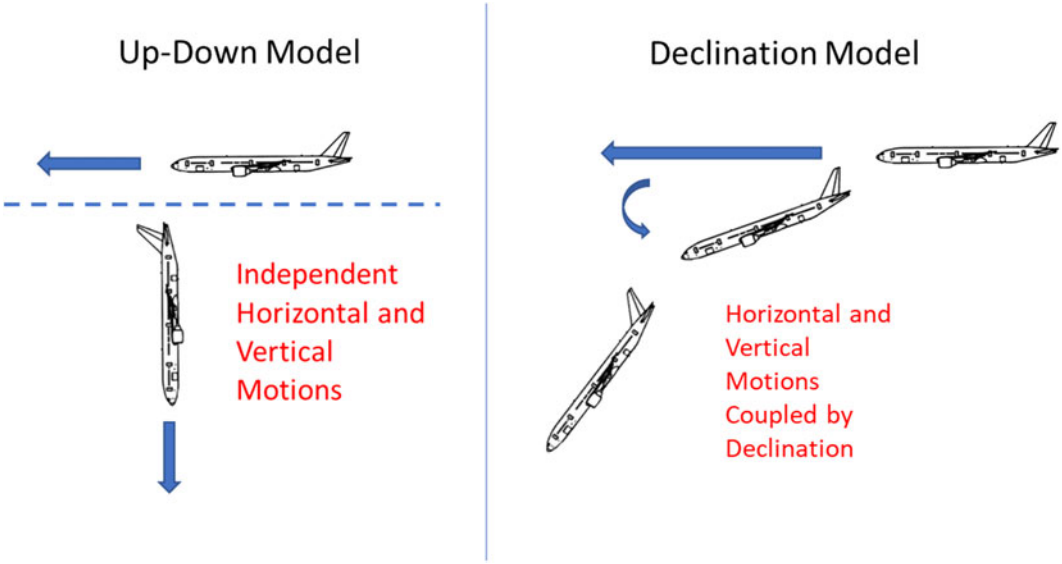

Figure 3. *Comparison of horizontal and vertical motion coupling between the Up-Down model of previous investigators (left model) with the model of coupling between horizonal and vertical via a declination angle from the horizontal (right model). The up-down horizontal Doppler shift is assumed to be compensated by the SDU, so BFOs are attributed solely to the vertical dive motion.*

assumed cruise speed of 829 km/h. The second communication mismatch was nearly 260 Hz and, again, the minimum declination is where the aircraft track is aligned to the satellite direction for a declination of under 19°. The aircraft has veered to a heading of approximately 123° at the 6th arc, so during the 8 s between communications at the 7th arc, it needs 20° of declination to explain the BFO error. This demonstrates clearly that track angle does matter in explaining the 'vertical' component of the BFO changes as evident from the curvature of the BFO contours (Figure 4). In the case of the first BFO error, the track angle effect is small at approximately 2° declination, and it increases to 6° declination for the second BFO error. For the Adelaide Track, the required declinations are 8° and 22° for the first and second BFO errors, respectively, and the PIC Track is slightly less for the first and approximately 20° for the second.

For comparison, at the satellite track, 19° of declination produces 260 Hz BFO decrease – a change that requires 15,300 fpm (280 km/h) downward motion according to Holland's Up-Down model; a speed at which the entire aircraft would obliterate in well under one second. This is higher than the nominal 10,700 fpm estimated by Holland to explain the nominal BFO error at the last 7th arc communication – which requires just 14° declination. Finally, note that the Up-Down model requires the arcs seen in Figure 4 to be straight (horizontal) as vertical motions in that model are independent of horizontal-compensated motions, and BFO error just depends on vertical speed as calculated above. This is clearly not realistic, especially where the track angle is closely aligned to the satellite track. To summarise this point, Figure 6 shows how BFO errors are invariant with track angle, and further that there is difference of almost 75 Hz at the satellite track angle for a declination of 25°.

Differences between the two models are illustrated by variations in the speed factor applied to the horizontal and vertical components in the Declination model, shown in Figure 7. For declinations up to 25°, horizontal speed varies with declination (~10% at 25° declination). For the vertical component, declination contributes over 40% of the cruise speed. In 8 s, the up-down aircraft falling out of the sky at 0·68*g* (Holland, 2018) reaches ~200 km/h, whereas the Declination model has a vertical speed component of 350 km/h at 25° – under controlled descent. Declination, achievable by manipulation of control flaps, *under power*, confers vertical velocities and BFOs more than those achievable by stopping the aircraft in midair and dropping it out of the sky. Further explanations of

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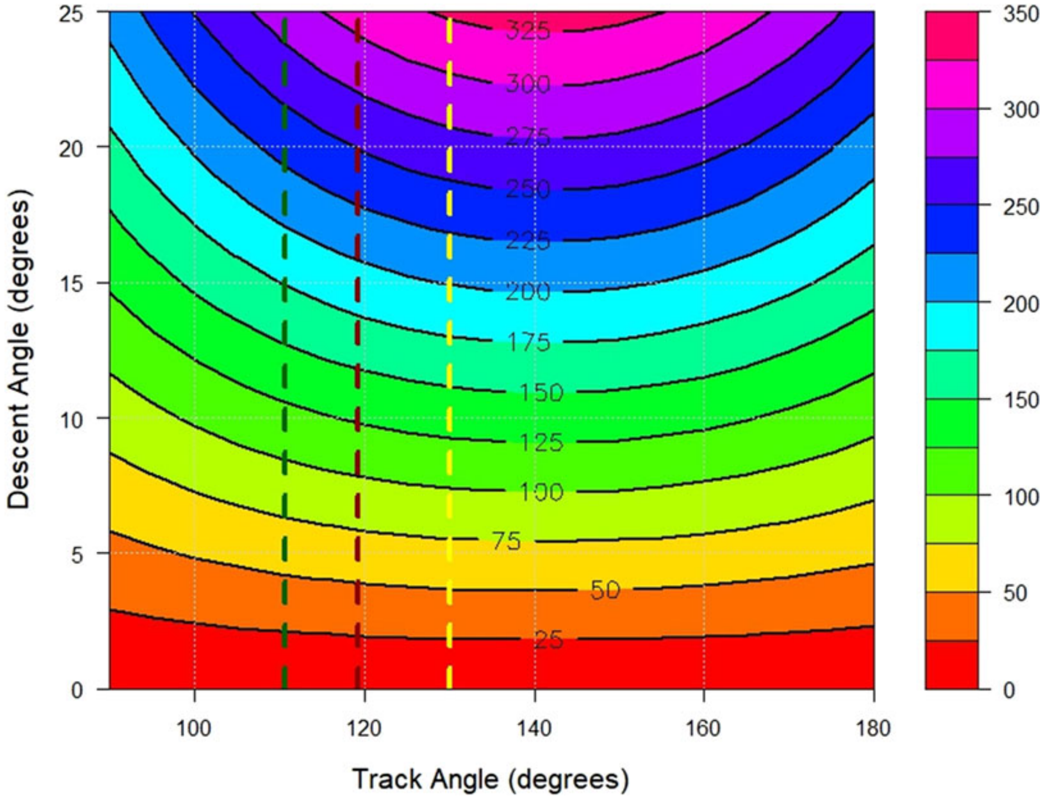

Figure 4. *Variation of BFO error (Hz), compensated for horizontal motion, with track angle in degrees clockwise from north, and declination angle down from horizontal. The approximate aircraft to satellite direction is at 141·6° track angle (and elevation angle of 38·8°) where BFO changes are at a maximum across track angles for any given declination angle. At this track angle, BFO changes of over 325 Hz are possible for a declination angle of 25 degrees. Dashed lines refer to the different tracks in Figure 2: yellow is the 'South track'; green is the 'Adelaide track'; and red is the 'PIC track'.*

the mathematical and physics discrepancies have been detailed previously (Lyne, 2022a), where I show that the 0·68g acceleration is simply explainable as an aircraft in high-speed normal flight undergoing a declination change. This declination rotation results in an *apparent* vertical acceleration of (ω V), where ω is the declination rotation rate and V is the aircraft speed; equivalent to $\omega\ V = 0{\cdot}7g$ for our example (Lyne, 2022a). This approximately matches what Holland derived as 'gravitational acceleration'.

Lastly, the different tracks are of different lengths between the 6th arc (at 00:10:58 UTC) and the final communication (at 00:19:37 UTC). These horizontal lengths are:

Adelaide/PIC Track	113 km
South Track	110 km
Southerly Track	147·5 km (southerly from South Track at 6th arc)

Implying that the horizontal speeds necessary to cross between the arcs are:

Adelaide/PIC Track	783 km/h
South Track	762 km/h
Fuel-starved Southerly Track	1,023 km/h

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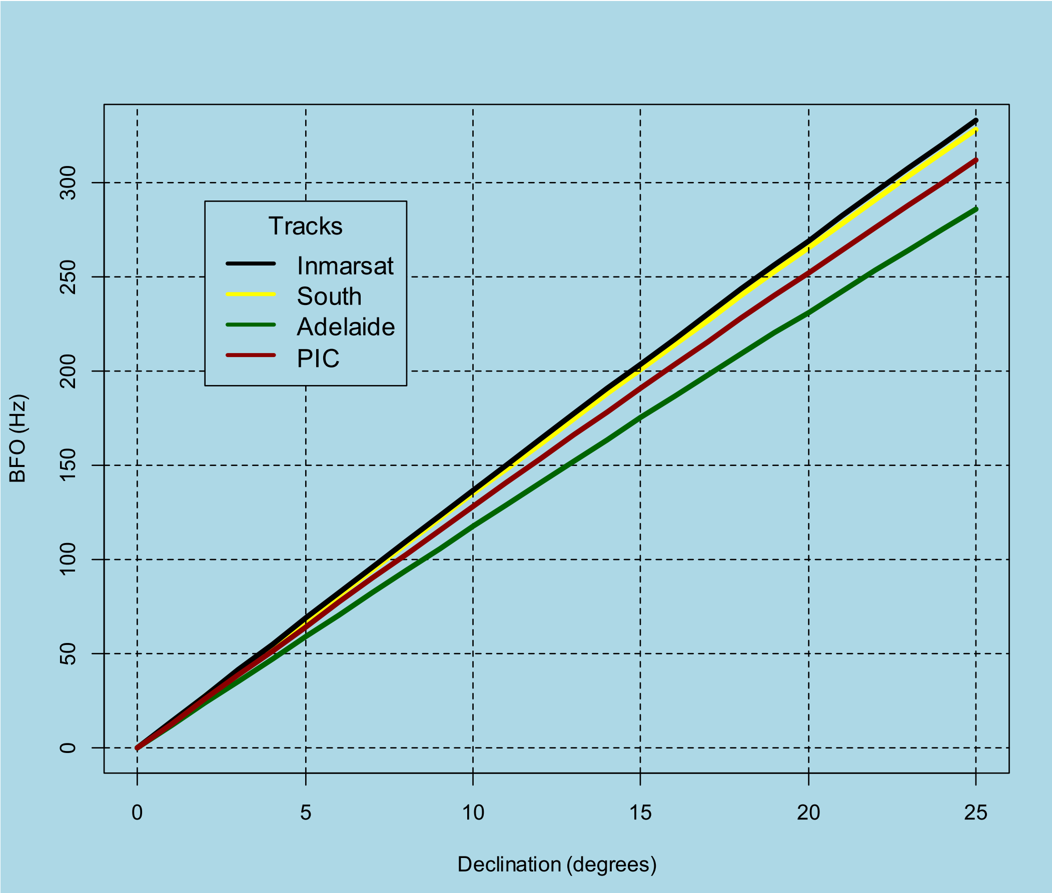

Figure 5. *Variation of BFO with declination angle. Black line is for a nominal flight track heading directly to the Inmarsat satellite – representing the maximum BFO possible by track angle. Other tracks are as shown in Figure 2.*

Both PL tracks have the aircraft slowing down (horizontally) from the previous southerly track cruise speed (necessary to cross the arcs at the right times, but these horizontal speeds will decrease with declination angle – as per Figure 7) of 829 km/h (Table 1). However, the fuel-starvation southerly track requires the aircraft to slow down (horizontally) to undertake the vertical dive, but the track crossing requires the aircraft to in fact speed up to over 1,000 km/h (horizontal) whilst it impossibly runs out of fuel. The only way for the aircraft to decrease its speed is for it to veer east from the southerly track and it still needs a minimum speed of over 750 km/h to cross the arcs at the right times. This compares to a speed of approximately 254 km/h before the aircraft stalls and drops (Marks, 2013). Realistically, this is not the scenario of an aircraft stopping in mid-flight. There is no way for it to achieve that whilst it must cross the arcs at the right times. The evidence is overwhelming that MH370 did not run out of fuel and fall out of the sky. That scenario just simply does not fit the available evidence, nor physics. By contrast, the PL tracks suggest slower horizontal speeds and eastward veering compatible with the predictions of the PL Theory of an eastward turn and descent.

To bring this demonstration to a close, Figure 8 shows the horizontal compensation applied by the SDU model for the Declination model which varies with track and declination angles. As shown previously, the greatest variations and compensations are applied at the satellite track angle. To summarise, the coupled Declination model is a more realistic and accurate model of BFO changes due to changes in

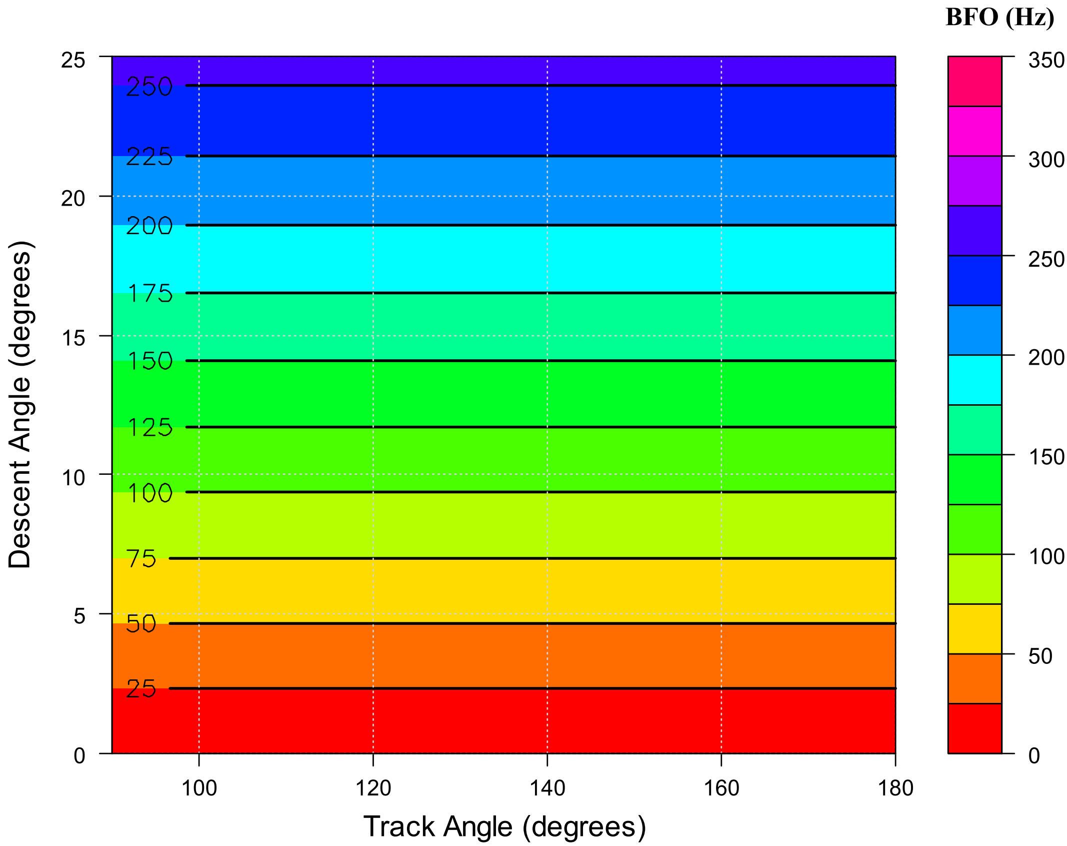

Figure 6. *Variation of BFO (Hz) according to the Up-Down model where horizontal speed is invariant with track angle, and hence horizontal compensation does not vary with track angle. For comparison with the Declination model, we used the horizontal speed at the 180° track (a track angle has to be chosen for comparison as the main point of this comparison is that horizontal compensation in the Declination model does vary with track angle for positive declination angles – Figure 4).*

track and declination angles. Further, we can explain the apparent gravitational acceleration of Holland as merely due to declination rotation and not gravitational high-speed dive.

The PL Theory predicts that at the 7th arc, there is approximately 30 min before landing on an unfamiliar ocean surface where wind, waves and swell need to be monitored carefully to affect a precise controlled ditching. The landing time estimated by Lyne and Lyne (2021a) was approximately 0:53 UTC, and descent at 00:19 UTC was past sunrise estimated at 23:34 UTC (NOAA sunrise calculator: https://gml.noaa.gov/grad/solcalc/sunrise.html). The final track was towards east to southeast on a very cloudy day with limited visibility from standard altitude (Lyne, 2022b). For secrecy the aircraft needed to descend as low as possible to just below, or within, the clouds. In a very recent update, I report the discovery of a 300 km trail of cloud anomalies that align well with the expected final PIC track of MH370 (Lyne, 2024a). These anomalies were visible in five satellite images from three satellite passes. These observations confirm the predictions of our model *and* the PIC Track flight path.

The observations also justify the aggressive nature of the descent predicted at the 7th arc. Although an alternate explanation, proposed previously (Lyne, 2023c), is that it may be near the end of a controlled 'glide phase' to conserve fuel so that, as concluded by Vance (2018), fuel would remain for the *failed* (debris was emitted*)* powered near-level landing attempt in the wild Southern Ocean. This strategy fits a mastermind plan, whereas others would assume the glide occurs at the end. However, in this

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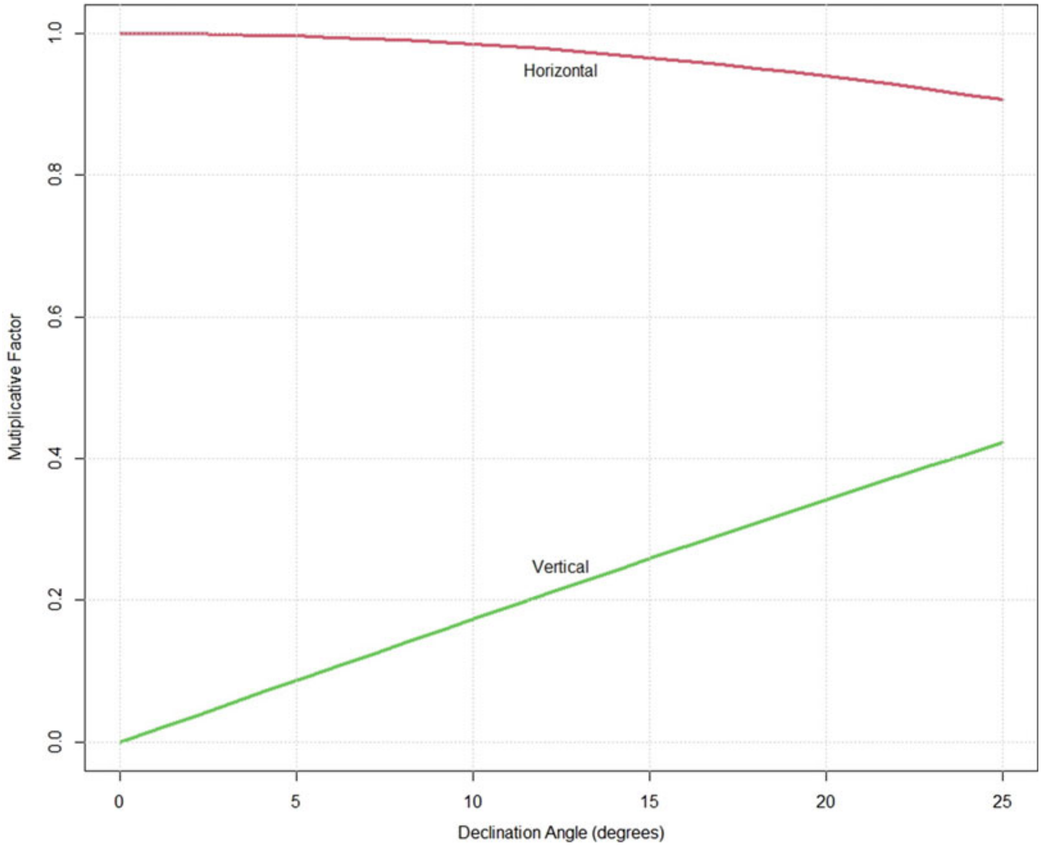

Figure 7. *Variation of the speed multiplicative factor with declination angle. Horizontal speed varies simply as the cosine of the declinaton angle, and vertical speed as the sine.*

case, the lack of fuel and engine power would make a 'controlled' ditching very difficult as the plane must be kept as level as possible, as explained by Vance (2018) and Captain Mike Glynn (*personal communication*).

A summary of the evidence against the high-speed crash and the evidence for the controlled eastward descent is presented in Table 2.

4. Discussion

Our revised model and analyses provide compelling evidence that MH370 did not run out of fuel and fall out of the sky. This assessment is supported by the extensive failed searches that did not find one shred of debris evidence within the hugely extended official crash zone. Instead, careful detailed expert investigations by Vance (2018) confidently suggests a powered, piloted, controlled landing, incompatible with a high-speed nosedive that would have crumpled the leading-edge nose (MH370-Captio, 2019) and obliterated the aircraft into many pieces within the blink of an eye (Vance, 2018). For example, the crash of Swiss Air Flight 111 resulted in over 2 million pieces of small debris – see pictures of such catastrophic devastation in Figure 5 of Larry's book (Vance, 2018).

A controlled landing at the 7th arc is also clearly at odds with the suggested uncontrolled high-speed descent demanded to explain the BFO changes with the fuel-starved theory. Despite the reconciliation of all other evidence by the PL Theory, there were no previous analyses to support the predictions of this theory that MH370 veered eastward at the 7th arc to follow an easterly track. That however changed

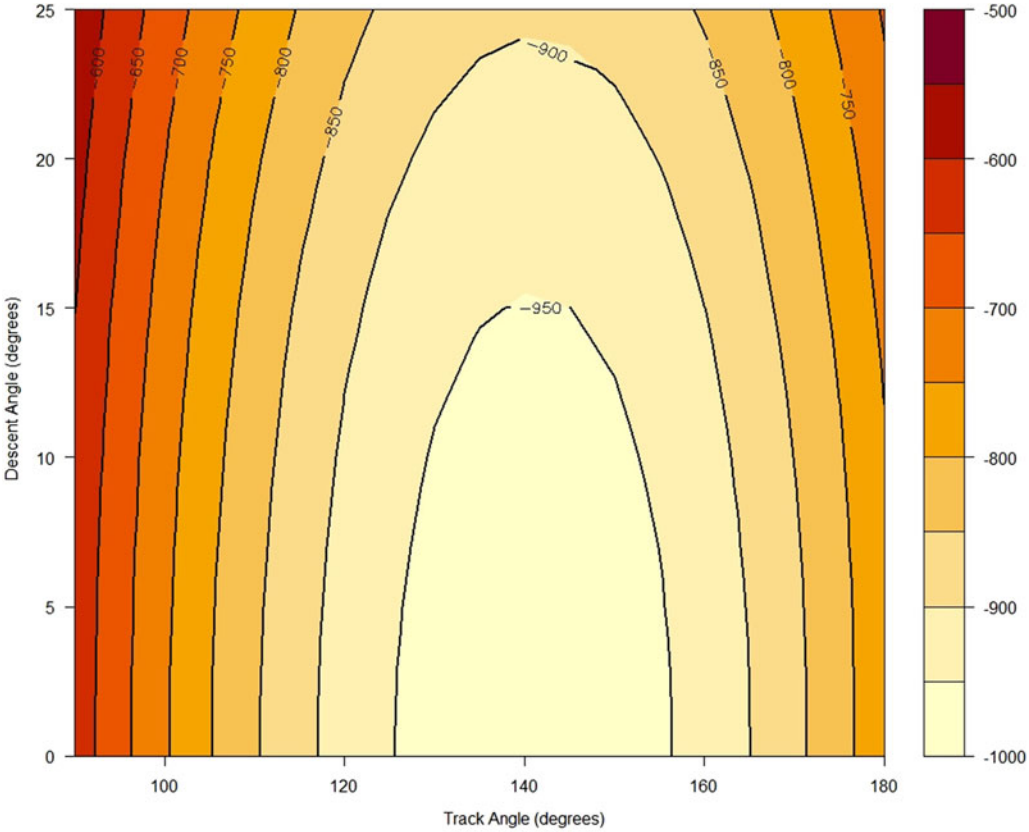

Figure 8. *Variation of horizontal BFO (Hz) compensated by the satellite data unit (SDU) (hence BFOs are negative) for the Declination model. Some variation with declination angle is seen at the south track (180°) but the greatest variation is at the satellite track angle (~141°).*

with the discovery of the hidden riddles in the PIC Track, and more recent discovery of a cloud anomaly trail aligned with the final PIC Track.

Results of our coupled Declination model for the three tracks suggest that the first BFO is explainable with declination under 8° for the first BFO mismatch. The second communication mismatch required a minimum declination of between 19° and 25°. Veering is completed by the 6th arc for all tracks, so changes at the 7th arc were primarily to do with descending for the landing, and possibly the end of a low-fuel-consumption glide-phase.

The Up-Down model decouples horizontal and vertical velocities; hence, it relies on a dropping-from-the-sky vertical velocity to explain BFO changes. However, the Declination model shows that those changes are from a simple declination of the aircraft. We also demonstrate that the track angle does matter, and more so with greater declination – a point entirely missed by the Up-Down model as further demonstrated by Lyne (2022a). This scenario also cannot explain the large horizontal speeds necessary for the aircraft to cross the 6th and 7th arcs at the correct times. We also now have a very plausible explanation for the 'gravitational acceleration' as being simply due to controlled declination rotation of a high-speed aircraft.

The other point to make is that in the most likely situation where the aircraft continued to glide along, the velocity at the last communication will have a much larger component than the vertical speed – perhaps less than the assumed 829 km/h (but not zero) versus 200 km/h vertical. How else can claims be made that the dive model was used to calculate bounds for the 7th arc? This combination, particularly the assumed vertical-drop speed, is unrealistic. Simply put, the aircraft is not a gravitationally accelerated

Table 2. *Summary evidence against high-speed crash (left column) and for controlled eastward descent (right column).*

Evidence Against High-Speed Crash	Evidence for Controlled Eastward Descent
The aircraft did not run out of fuel (Vance, 2018)	Aircraft had fuel until landing (Vance, 2018)
The flaps and flaperon were extended, not retracted, at landing (Vance, 2018)	Aircraft had functional flaps to veer and descend (Vance, 2018)
Minimum stall speed was not reached (Marks, 2013).	Aircraft was travelling at cruise speed eastward and descending at 7th arc
Minimum eastward horizontal speed of 750 km/h required to traverse 6th and 7th arc	Estimated horizontal speeds consistent with aircraft travelling near cruise speed and descending
Eastward veering requires fuel and functional flaps	Controlled eastward veering and descent explains BFO discrepancies
Southerly track requires horizontal speed over 1,000 km/h to traverse arcs with no fuel	Eastward track horizontal speeds consistent with veering and calculated declination angles
Crash speed would be horizontal speed plus approximately 200 km/h vertical speed (min 950 km/h). At those speeds, aircraft disintegrates within 'the blink of an eye' (Vance, 2018)	No debris or aircraft discovered at 7th arc from two extensive searches
Southerly track requires higher vertical speeds than eastward track, but Up-Down model is incorrect and has them the same	Calculated track and declination angles possible in Declination model with fuel and control of flaps
No explanation possible for high-speed crash, or southerly track past 7th arc	Aggressive descent was necessary as sun had risen, or it was the end of a glide phase. Eastward veering once past JORN necessary to reach PL location

lead-weight when it runs out of fuel; despite what a decoupled (BFO) model might lead some to believe. Yes, as far as BFOs are concerned, we do not need to worry about the *compensated* horizontal component, which *changes* because the aircraft is now *descending*, not *diving*. Hence, for an actual *dive* scenario vertical velocity is from momentum (and BFO) transferred from the horizontal cruise speed *plus* gravitational acceleration. As I explain previously (Lyne 2022a), an air-crash in 2022 shows that under such circumstances, which is facilitated by a belly-up dive (otherwise the *controlled* forward dive levels out to a phugoid), speeds can approach supersonic levels, as lift forces are reversed and now act downwards with gravity. We *do not* need supersonic dive speeds to explain the BFOs from MH370, nor does it explain why not one shred of debris was discovered within the expansive 7th arc search zone. However, it is a real worry that students can now read *authoritative* out-of-context claims in an *educational reference* that the diving aircraft simply *slipped without trace* into the ocean (Gregersen, 2021). Let them all prove this 'blink of the eye' disappearance!

There are two elements responsible for this: (1) the assumption that the aircraft ran out of fuel; and (2) the mathematical independence afforded to analysts by the Up-Down model. These two may have been the disastrous pairing that wreaked havoc in the search for MH370. However, the original culprit was the blinded conclusion that the recovered flap was retracted. No, they did not see the obvious trailing-edge damage. Here's a short list of the main potential disasters of these incorrect assumptions and irrationally exuberant attempts by scientists to reconcile evidence to the wrong theory.

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1. Misled the excellent technical analyses of debris drift to a fictitious 7th arc location (Griffin et al., 2017). The official drift model resorted to a misapplied added 10 cm/s *perpetual motion*, to in effect illegally (in Physics) and forcibly 'sail' the recalcitrant flaperon to Réunion Island on time from the 7th arc – as explained previously (Lyne, 2023a). No such mysterious force was required from the PL Location (Lyne, 2023a) using the same model with a standard drift formula (Lyne, 2023d). The implications are obvious.
2. Misled the important hydroacoustic discoveries by Alec Duncan (Butler, 2014) and Usama Kadri (Kadri, 2019). They tried hard but neither could find any 7th arc source using either Duncan's water-borne model or Kadri's novel, and the very clever, hybrid Acoustic Gravity Wave (AGW) model. Anomalous sound data comprised four very accurate atomic-clock timings and two very accurate directions from two Comprehensive Nuclear-Test-Ban Treaty (CTBT) International Monitoring System hydroacoustic stations (HA08: Diego Garcia, HA01: Cape Leeuwin) and two marine-life listening stations of Australia's IMOS program (Perth Canyon, Scott Reef) (Lyne and Lyne, 2021b). Precise resolution (within seconds timing and one-degree direction) of *all* data (4 timings and 2 directions) was only possible from the precise PL Deep Hole location with sound propagating *within* the seafloor (the PL Hole is approximately 1·5 km *below* the general seafloor level at that location) before emerging into the ocean Sound Channel from special seamounts at the end of continental plates (Lyne, 2022b) – the so-called 'MH370 Mechanism' dedicated to MH370 victims. Although for Diego Garcia, the sound appears to have had an uninterrupted path all the way as a seismic signal bouncing off the hard vertical plate structure of Madagascar. Kadri thought Madagascar might have been the actual source, as he did with the Batavia Seamount (using the AGW model). He proposed two separate sources for the conflict. In fact, Batavia was the seafloor exit point for sounds heard at Perth Canyon and Cape Leeuwin, as explained previously (Lyne, 2022b). However, neither Duncan nor Kadri could reconcile the Scott Reef sound which emerged from Exmouth Plateau (shown in Figure 2). Paradoxically, the sound from there to the more distant Scott Reef (at 1:32:49 UTC) arrived *before* the sounds heard at Perth Canyon (1:33:44 UTC) and Cape Leeuwin (1:34:50 UTC). This paradox can only be resolved by the near-double speed of sound in the seafloor compared with the water-borne speed (Lyne, 2022b); a phenomena also noted for the *ARA San Juan* submarine where a precursor implosion-sound propagated within the ice-shelf before exiting to the ocean *20 min before* the arrival of the direct but slower water-borne sounds (Vergoz et al., 2021). Here again, the wrong official theory led to failed interpretations by those contracted to desperately search in vain along the 7th arc.
3. Misled the analyses of other debris damage reported by ATSB (2017) that was corrected by Vance (2018) in his careful, competent and thorough reassessment. Such damage was visibly apparent in the damage to flaps and flaperons from hydrodynamic forces as US Airways 1549 landed on the Hudson River (Lyne, 2024b), after its engines were taken out by a bird-strike (see the film Sully: Miracle on the Hudson). Evidence of ditching damage was there all along, as was Larry's illustration of what a high-speed dive did to Swissair 111. Compare and contrast which theory you would select after seeing those images. Perhaps officials thought they could get away with the no-blame fuel-starvation idea (possibly to minimise grief/trauma), despite obvious evidence to the contrary, and rammed it into failed submission (Lyne, 2023a).
4. Most importantly, misled the second extensive search and stymied hopes of a future search. In science, we make mistakes, but we (some of us anyway) admit those mistakes if we want to move forward with alternate explanations; as I did with my first wayward explanation of the MH370 sound heard at Perth Canyon (Lyne and Lyne, 2021a). No admission, no progress.
5. Quashed other scenarios by insisting that only the official narrative is correct. 'Due diligence' of other theories, or a new search proposal, always finds its way back to officials (my bitter experience). How these failed officials are able to do 'due diligence' credibility assessments on scientists and scientific analyses that go beyond prevailing studies and expertise is beyond comprehension. Here, science journals *must* play a part to set the record straight.

We also note that the short disturbance SDU power after the 6th arc (Hypothesis 2) may have been from preparation for the descent, predicted to be underway by the end of the 7th arc. Whereas the fuel-starvation theory assumes the power-up was from engines flaming out and the cold SDU restarting sometime later – the extreme Hypothesis 1 scenario. Vance (2018) conclusively demonstrates that the aircraft did not run out of fuel, and our calculations also imply that the aircraft was powered to affect the veering and aggressive declination.

To sum up, we can safely, with absolute confidence, say that the fuel-starvation high-speed dive theory is not supported by the available evidence. We can also say that MH370 was most likely in a controlled descent at the 7th arc along a very accurately planned and plausible premeditated PIC Track, to its secret resting place in a deep hole at the PL Location.

5. Conclusions

Whilst valid for horizontal motions only, the official decoupled ‘Up-Down’ model fails comprehensively and catastrophically by attributing vertical velocities from declination as being due to a fictitious ‘gravitational acceleration’ following fuel-starvation. Instead, the baffling BFO changes at the final two communications from MH370 at the 7th arc are more plausibly due to the aircraft veering eastward, in a controlled descent, and undergoing *apparent* vertical acceleration from declination rotation. These revised interpretations accord with predictions by the Penang Longitude theory which also uncovered the precise PIC Track hidden in riddles in the Pilot-In-Command simulator track. These new interpretations of BFO changes provide mutual support for the PIC Track taken by MH370 (presumed, till proven) to its precise mastermind secret final location. We can now safely ditch the very troublesome official 7th arc fuel-starvation high-speed dive theory, and all analyses supporting it.

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References

Ashton, C., Shuster Bruce, A., Colledge, G. and Dickinson, M. (2014). The search for MH370. *Journal of Navigation*, **68**(1), 1–22.

ATSB. (2014). MH370 - Flight Path Analysis Update. Canberra, Australia: ATSB.

ATSB. (2017). The Operational Search for MH370. Canberra, Australia: ATSB. (AE-2014-054). Available at https://www.atsb.gov.au/media/5773565/operational-search-for-mh370_final_3oct2017.pdf.

Butler, D. (2014). Sound clue in hunt for MH370. *Nature*, **510**(7504), 199–200.

Campbell, C. (2014). Search expanded for missing Malaysian airlines flight. *Time Magazine*. Available: TIME. Available at: https://time.com/17184/search-expanded-for-missing-malaysian-airlines-flight/.

Davey, S., Gordon, N., Holland, I., Rutten, M. and Williams, J. (2016). *Bayesian Methods in the Search for MH370. Canberra Australia: Springer Briefs in Electrical and Computer Engineering*. Springer Singapore.

Gregersen, E. (2021). *Malaysia Airlines Flight 370 Disappearance*. Washington DC, USA: Encyclopædia Britannica, Inc. Available at: https://www.britannica.com/event/Malaysia-Airlines-flight-370-disappearance

Griffin, D. and Oke, P. (2017). *The Search for MH370 and Ocean Surface Drift – Part III*. Hobart, Australia: CSIRO Oceans and Atmosphere. Available at: https://www.atsb.gov.au/csiro-mh370-drift-reports

Griffin, D. A., Oke, P. R. and Jones, E. M. (2017). *The Search for MH370 and Ocean Surface Drift – Part II*. Hobart, Australia: CSIRO Oceans and Atmosphere. Available at: https://www.atsb.gov.au/csiro-mh370-drift-reports

Harris, T. (2017). *JORN and the Ionosphere*, Space Weather Users Workshop, University of Sydney. Camperdown Campus, 17-11-2017: Bureau of Meteorology.

Holland, I. D. (2018). MH370 burst frequency offset analysis and implications on descent rate at end of flight. *IEEE Aerosp. Electron. Syst. Mag.*, **33**(2), 24–33.

Kadri, U. (2019). Effect of sea-bottom elasticity on the propagation of acoustic-gravity waves from impacting objects. *Sci Rep*, **9**(1), 912.

Kamoulakos, A. (2020) Aspects of analysis and simulation of a flaperon ditching scenario. In Aiaa Aviation 2020 Forum.

Lyne, V. (2022a). Flawed vertical dive conclusion from MH370 Doppler-shifts. *Researchgate*, **11.** doi:10.13140/RG.2.2.25646.18248/1

Lyne, V. (2022b). There lies MH370: sights and sounds point to iconic deep ocean site. *Researchgate*, **50.** doi:10.13140/RG.2.2.33051.54564/3

Lyne, V. (2023a). *'Drift' Versus 'Sail' of MH370 Flaperon to Réunion Island*. Hobart, Australia. 34. doi:10.13140/RG.2.2.23931.49447/1

Lyne, V. (2023b). MH370 Flight Hidden in Simulated Triple-Twist Riddle [Technical Report]. Hobart, Tasmania, Australia: Researchgate. doi:10.13140/RG.2.2.12350.15685.

Lyne, V. (2023c). MH370 Malacca Track Riddle [Technical Report]. Hobart, Tasmania, Australia: Researchgate. doi:10.13140/RG.2.2.26851.63528/1.

Lyne, V. (2023d). Towelette on Treacherous Australian Coast Escaped from MH370 [Technical Report]. Hobart, Tasmania, Australia: Researchgate. doi:10.13140/RG.2.2.11759.51368/1.

Lyne, V. (2024a). *MH370 Flying in The Clouds*. Hobart, Tasmania, Australia: University of Tasmania. Available at: https://www.researchgate.net/publication/378158549_MH370_Flying_In_The_Clouds.

Lyne, V. (2024b). *Was MH370 Debris Adrift in the Leeuwin Current?* Hobart, Tasmania, Australia: University of Tasmania. https://www.researchgate.net/publication/377782958_Was_MH370_Debris_Adrift_in_the_Leeuwin_Current.

Lyne, V. and Lyne, M. (2021a). Goodbye from MH370 Defines 8th Arc: First of 4 Iterative Reports. Researchgate. pp. 23.

Lyne, V. and Lyne, M. (2021b). Unravelled Cryptic Pathways of MH370-Goodbye and Travel-Path Secrecy Reveals Landing Details and Precise Location. Final of 4 Iterative Reports. Researchgate. pp. 36.

Marks, P. (2013). Why was Asiana jet flying so slowly before crash? *New Scientist Technology*. 8 July 2013. Available at: https://www.newscientist.com/article/dn23831-why-was-asiana-jet-flying-so-slowly-before-crash/#ixzz7LOJbe2qd.

MH370-Captio (2019) MH370: Was Air Traffic Control deliberately misled? RAeS Brussels Branch lecture held at Eurocontrol: Royal Aeronautical Society. Available at: https://www.youtube.com/watch?v{\mathsurround=\opskip$=$}Qk1CxO9XGyQ (accessed October 2021).

National Centers For Environment Information(NCEI). (2021) Total Sediment Thickness of the World's Oceans and Marginal Seas, Version 1, Global Sediment Thickness Map. Available at: https://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html (accessed 20 December 2021).

Orr & Associates, R. (2018). Ocean Infinity donates 120,000 square kilometres of data from search for missing Malaysian airliner to The Nippon Foundation-GEBCO Seabed 2030 Project. The Nippon Fundation-GEBCO Seabed 2030 Project.

Vance, L. (2018). *MH370 Mystery Solved*. Ottawa, Canada: Group of Three Publishing.

Vergoz, J., Cansi, Y., Cano, Y. and Gaillard, P. (2021). Analysis of hydroacoustic signals associated to the loss of the Argentinian ARA San Juan submarine. *Pure and Applied Geophysics*, **178**(7), 2527–2556.

Zweck, J. (2016). Analysis of methods used to reconstruct the flight path of Malaysia airlines flight 370. *SIAM Review*, **58**(3), 555–574.

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