Questions & Answers
about the MH370-CAPTIO study

Study Report: www.mh370-CAPTIO.net
Video Trajectory: https://youtu.be/Jd_eJIINlBw
Video Debris Drift: https://youtu.be/ZaQYUrjhBCM

A – The ultimate goal of the study

1- Why is it important to find the wreck of MH370?
It is important for the victims' families and friends, as it would deliver them from the psychologically harrowing weight of this mysterious disappearance.
In addition, recovering evidence about the still unknown part of the flight could be used to trigger further investigations, which in turn would help to improve the safety and security of air transport.

2- Why publishing the results of this MH370-CAPTIO study on the web?
We all wished that the Ocean Infinity (OI) led search be successful, but it was not. Thus the next search zone to be considered must be identified soon and proposed to OI or Malaysian authorities in the case they decide to resume the search. The search zone proposed by CAPTIO is highly compatible with all the available data on the MH370 trajectory and the incurred costs would be low compared to previous searches, as it is a small area in tropical waters not far from the coast of Indonesia.

3- Why are the "who" and "why" not discussed by MH370-CAPTIO?
The MH370 trajectory in the first 2 hours and the total flight duration are well known. They clearly show that the multiple changes of route observed were intentional and not caused by any flight-critical failure, but speculating on the "who" and "why" is beyond the scope of our study.

4- MH370-CAPTIO analysis is making the most out of the available information
As no information is available from the aircraft itself (no black boxes, not enough debris…), the analysis is based on all of the relevant data from the official report, the radar data made available after the publication of that report, the Inmarsat data and the output of the scientific community (mainly the Independent Group) and the little information derived from the recovered debris.

B – An actual hijacking

5- Who were the new People in Command, hijackers?
Any people who alter the route of a commercial aircraft without notice nor any compelling flight safety reason can be called "hijackers", be they the pilot(s) in charge or any other people, but their identity and motives remain unknown. Finding the wreck and analysing the flight and voice data recorders might provide some clues.

6- Were the pilot(s) involved?
No clear evidence allows us to ascribe the hijacking to the pilot(s), yet we found no decisive proof that they were innocent either. Also, even if the hijackers were not the pilots, the pilots could have been constrained to act against their own will.

7- How could unauthorised people get into the Main Equipment Center (MEC)?

The B-777 MEC also known as the Electronic Equipment Bay (EEB) is a room located beneath the cockpit which can be accessed via 3 doors: one near the front landing gear, one communicating to the cargo bay and one in the floor of the galley of the passenger cabin just outside the cockpit door. At night, it is easy to get in during aircraft servicing and stay hidden there as it is pressurised. This is where the main circuit breakers of the electrical systems are located.

8- How is it possible for people to get there in spite of airport security?

Airport surfaces are weak points in the security chain. At midnight, it is very easy to access an aircraft at its parking place or gate.

9- What was the reason for the aircraft rerouting 41min after take-off?

The CAPTIO study shows that the geographical area was strategically chosen to perform a hijacking, as it is a delegated zone in between two areas of ATC responsibility. In addition, it is highly unlikely that some major technical failure occurred at this time as recent work by the Independent Group on Kota Bharu radar data concluded that the aircraft might have climbed and accelerated. In case of an emergency, a pilot would do the opposite: descend and reduce the speed. Our interpretation is that the aircraft accelerated to get away from this area as quickly as possible and in the opposite direction after the hijacking.

10- Why not a suicidal action?

The initial part of the flight demonstrates the intention of the aircraft to hide and to avoid the radar coverage in a systematic way. The second part of the flight shows that a number of busy airways where safely crossed and/or avoided. Finally, the analysis shows that the flight lasted until fuel exhaustion i.e. about 7h30. This sophisticated behaviour is not what would be expected from someone taking control of the aircraft merely for committing suicide.

11- Was the cabin depressurised or why the passengers did not react?

No information at all is available to conclude whether the cabin was depressurised or not at a certain stage. The CAPTIO-proposed trajectory shows that the people in command were providing input to the Flight Management System at least until after Arc4. If the hijackers had announced that their intention was to land safely somewhere, the passengers would have had no incentive to attempt a take over; also, if several armed hijackers had been present in the cabin, any rebellion would have been easily neutralized.

C – Low reactivity from Air Traffic Control and radar avoidance by the aircraft

12- Why was the disappearance of the aircraft on the air traffic controller's screen not detected at the time it occurred?

The aircraft was appropriately given the clearance to call the next Air traffic controller on its route via VHF. But no call was placed. The role of the Vietnamese controller was to wait for the MH370 pilot to call him until the time elapsed would lead him to contact the missing aircraft (and other aircraft in the vicinity of the planned MH370 trajectory).

In addition, failures of on-board telecommunication systems are not uncommon. In particular, the transponder might stop answering radar calls for various reasons (system failure or human errors). In such a case, the controller is expected to assume that the aircraft whose identification tag no longer appears on his screen is still following its flight plan.

13- Why the Malaysian authority did not trigger the search and rescue earlier?

After an aircraft is declared missing, the air force can be summoned to intervene, in order to check whether a dangerous situation has arisen and inspect the area.

The SAR (Search And Rescue) operations are usually started only after all of this civil-military coordination activity.

This shows that the zone selected to de-route the aircraft was strategically chosen by the new people in command, as ATC reactivity in such a boundary area is inherently slower than usual providing them with a substantial lapse of time before the aircraft was recognised as missing.

14- Why did the aircraft follow the selected flight levels?

It did so to stay out of the successive radar detection capabilities (with the exception of Military radars and in particular the one in Sabang Island that had the capacity to detect the aircraft during 2h30 at least) and also to cross airways safely by passing below their minimum flight level or above their maximum flight level.

15- Why wasn't the ghost aircraft spotted between the de-routing and the Andaman Islands?

The aircraft hide itself in the traffic, behaving like a normal civilian flight with a non-critical telecommunication system problem.

16- Why wasn't the aircraft detected by the military primary radars?

All radars are monitored by human operators even if they include automated signal processing algorithms for data fusion between civil primary, secondary radar data and military radar data. These human controllers are in charge of evaluating the level of threat of intrusive flights.
Our conclusion is that the level of threat was judged low.
The Sabang military radar should have recorded some traces of the MH370 trajectory. Unfortunately, the Indonesian authorities have released no information.

17- Why wasn't the aircraft detected by the civil primary radars?

The civil radars capable of detecting the aircraft were approach radars helping the controllers to properly sequence the traffic at an airport during the landing phase. Thus En-route traffic like the "ghost" MH370 was not of a concern to them as being out of their responsibility.
In addition, it should be noted that some civil radar data were made lately available at Kota Bharu. Being an approach radar optimised for low altitudes, a cone of silence above it leads to holes in the corresponding track.

18- Did the night time influenced the identification of the flight?

In the middle of the night - it was between about 1 am and 3 am in local time - the military operators or controllers' attention was not attracted by any threatening aspect in the MH370 trajectory, which was deliberately kept within the zone of responsibility of Kuala Lumpur until leaving it and entering the Indian ATC zone of responsibility of Chennai. It is only later that the aircraft performed a quick change of altitude, heading and speed.
Finally, one should be reminded that it is always easier to track an aircraft based on recorded data when one knows what to track.

19- Were the hijackers knowledgeable?

As shown above, the hijack took place in a very well chosen place and the rest of the flight according to CAPTIO demonstrates a very good knowledge of the ATC procedures, rules and of the airspace structure. For example, ATC always extrapolates from the latest trajectory information to predict where to look for a missing aircraft. This explains why MH370 changed so many time its trajectory characteristics at each major turn. This demonstrates the real intention to stay undetected.

D – The choice of the targeted destination

20- Why was Christmas Island the targeted destination?

We assumed that the hijacked aircraft was intended to land safely somewhere in the vicinity of Arc-7, in a place with sufficient runway length, reachable by following waypoints listed in the navigation database flown via direct legs and in coherence with the fuel exhaustion rate corresponding to a flight including a long leg flown at low altitude. We ruled out Java as a possible destination because the known part of the trajectory shows that the hijackers avoided entering the Indonesian airspace directly; The Cocos Islands were obviously excluded because they were too far from the 7th arc.

21- Other possible destinations?

We studied a lot of possible landing destinations. Diego Garcia is simply not compatible with the Inmarsat data. The Australian continent is not reachable because of fuel and even could not be envisioned according to any simulator attempt. Java is incompatible with the visible manoeuvre circumventing Sumatra.

A potential runway could have been Cocos Island, which is in full reach considering the required fuel quantity. But the Inmarsat data, the speed profile and the fuel consumption indicate that Cocos would thus be overshot. In addition, a racetrack-tempering manoeuvre would have had to take place between Arc1 and Arc2, which is in contradiction with a "runaway" aircraft wanting to stay ahead of any potential ATC follower.

E – CAPTIO derived trajectory and the aircraft piloting

22- What are CAPTIO's hypotheses?

The CAPTIO trajectory is derived based on 7 hypotheses:

1. The aircraft was piloted from the beginning till the end by fully capacitated people;
2. The piloting respected the airspace structure and routes as well as the flying rules;
3. The aircraft did not suffer any damage and was just voluntarily and temporarily electrically degraded as electrical power was restored about one hour after its departing from the flight plan;
4. The people in command aimed at landing safely on an adequate runway
5. The trajectory was derived from the capacity of the aircraft automation to select the most adequate flight mode controlling continuously the speed. It was also derived in such a way that as many radars as possible were avoided;
6. No loiter or holding was performed with the view that the aircraft followed the minimum distance strategic path;
7. Because of the small number of debris found, a ditching is highly probable, possibly with a final crash at low speed.

23- Why is the CAPTIO-suggested trajectory plausible and realistic?

The CAPTIO study is not based on any conspiracy theory but on a factual analysis of official and public data as well as of previous scientific work, especially the analyses conducted by the members of the Independent Group (IG). Trajectory compatibility with Inmarsat data is evaluated by means of the signal calculation model validated by the IG.

24- What were the input for the trajectory computation?

The trajectory computation constraints were to maximise the avoidance of civilian and military radar coverage, to safely pass underneath the encountered airways, to let the aircraft automation manage the optimum speed for optimum fuel consumption in a continuous manner, to stay within the flight envelop and to reach a compatible runway with the aircraft type. Official navigation waypoints have been considered, as they were available in the aircraft Flight Management System database. The only human input were the successive flight levels and vertical speed in the MCP to pass properly under the airways when crossing them.

25- What was the flight mode after the first Inmarsat telecom system reconnection?

The Flight Management System (FMS) computes permanently the most efficient speed for fuel consumption depending on the trajectory, the aircraft weight and the meteo. From an altitude of 33 000 ft - or possibly 43 000 ft - (at 02h25 MYT) down to 5 000 ft (at about 05h40), the aircraft performed an economical descent at Indicated Airspeed in Knots (KIAS) setpoint KIAS = 240 kt automatically selected by the FMS considering the aircraft had started its descent. By physical principles, a constant KIAS leads to a slowly varying (decreasing) flying speed according to the decreasing altitude. Consequently, this means an automatically decreasing ground speed.

26- What were the altitude and speed after the descent in the Melbourne ATC zone?

After ~05h50 the Cruise flight mode was selected. As the altitude was levelled at 5 000 ft, this automatically set the KIAS set point equal to 285 knots. This translated to a very slow varying ground speed from about 300 knots as the weight of the aircraft decreased. The aircraft kept these speed and altitude until its final descent just before the attempted ditching.

27- How was the trajectory derived?

The driver for deriving the trajectory was to match the Inmarsat data as closely as possible, respecting the automatically selected flight mode by the aircraft FMS, and the constraints imposed by the airspace structure and the procedures for a safe flight. This leads to a realistic operational trajectory allowing computing simulated satellite data, and then comparing them to the actual Inmarsat data to validate them. It should be noted that the frequency data measured at 23h14 (UTC) were not used to derive the trajectory and were kept as an ultimate validation check only. The human intervention was kept to a minimum: input new altitude targets with a standard vertical speed and switching to cruise flying mode at the end of the descent. The legs between waypoints were direct paths and no holding, loiter or diversion was considered.

27- Why is it not the only possible trajectory?

Considering the large number of potential human interactions, a family of trajectories could be envisioned to reach Arc7 in a piloted trajectory. But the potential solutions are reduced when considering the goal of a safe landing and also considering the necessity to manage the aircraft in a proper flying envelop. Other trajectories could be derived by constantly fiddling with the speed of the aircraft, for example, but this would be irrational.

28- Why such knowledgeable people have failed to manage the fuel shortage?

The CAPTIO study provides no definite answer to this question. There are several elements that the people in command may have missed. Firstly, the right engine was slightly over-consuming (~150kg/h more that the left one) which represents more than a metric ton of fuel missing at Arc7. Secondly, no information is provided by the aircraft manufacturer nor the engines manufacturer about the actual figures of fuel consumption at low altitudes like 5 000 ft for example. Thus the FMS does not provide reliable predictions of fuel at destination during the flight. In our simulations, we have experienced approximate figures, which evolve rapidly towards the very end of the flight leaving little time to react.

In addition, we have no information on the degree of piloting proficiency of the people in command.

Furthermore, it is not known whether there was an additional particular constraint like for example the necessity to follow a time plan or scenario for a timely landing at Christmas at a specific point in time.

F – The debris drift issue

29- What were the input for the CAPTIO debris drift computation?

Our debris drift computation starts from the estimated ditching point and uses real meteo data, in particular with the Cyclone Gillian, for the main part of the drift duration until August 2015. It is not based on retro-drift statistics but it is based on forward drift modelling. The drift computation uses CSIRO model for the flaperon type of debris with a high windage modelled thanks to real data collected with a real replica of the flaperon (cf CSIRO report "The search for MH370 and ocean surface drift – Part II", EP177204 dated 3 October 2017).

A specific report has been produced on this subject (cf. www.mh370-CAPTIO.net).

29- What can be concluded from the debris drift computation?

CAPTIO has performed an analysis to create an illustrative view of the drift of a flaperon starting from End of Flight points located between 9° S and 35° S along Arc7 with a more detailed simulation between 9° S and 24.5° S.

It was not a statistical analysis but several thousands starting points were considered for the

drift paths. A tendency could be derived from the simulated drift paths: the more to the south, the less the debris stayed in warm waters and the faster they arrived on the African coast, and some of them reached La Réunion. Another tendency is also visible for debris departing from the north of 10° S as very few reached La Réunion.

Our conclusions are that for ditching latitudes outside the [10°S, 27°S] interval the probability to reach La Reunion seems low while within this interval the probability seems higher with some peaks around 25° S and 12°S-13°S, which also provides more satisfying arrival dates in respect of the time when the flaperon was found. We know that no wreck was found at 25° S. The estimated time spent by the drifting flaperon in warm tropical waters is also more consistent with the size of the barnacle shells found on the flaperon.

The others studies performed by different institutions lead to some similarities. They do not use the actual meteo data but other sources like buoys, for example, or compute the reverse drift.

In summary, all latitudes between 10° S and 27° S are potentially leading to drift paths arriving at La Réunion. No definitive conclusion can be drawn from the drift studies except that quite a few latitudes are compatible with the debris found so far. These studies cannot be used a priori for discriminating the End of Flight points on Arc7.

G – Past searches

30- What can be concluded from the previous search campaigns which have not found the aircraft?

The previous campaigns (Fugro, Ocean Infinity) are based on the main hypothesis that the aircraft was not piloted and left with its autopilot alone as from about 18H40 UTC. This led to searching for End of Flight locations at the southern end of almost straight-line paths heading around 180°. The underlying concept is that the crew was suddenly incapacitated after 1h40 of skilled piloting. With a caveat concerning the width of the search areas on both sides of Arc7, one can conclude that this straight-line-flying hypothesis must be questioned.

31- Why didn't fishing and cargo boats spot debris in the purported crash area?

First, there was not much debris. Marine currents and wind pushed it in a southerly direction far from maritime routes especially due to cyclone Gillian a few days after the aircraft disappearance. Then, when the surface search was started, these few debris had already moved to the west, far from Arc-7. In addition, maritime traffic density was actually low (see traffic density at https://www.marinetraffic.com/en/ais/home/centerx:111.6/centery:-15.6/zoom:5) and the small size of the debris made it difficult to detect from the bridge of large vessels.

32- Why wasn't any aircraft wreckage detected on satellite images?

On that particular day, the meteo was cloudy in the Christmas Island (CI) area.
People posted comments on Facebook. Participants in the Tomnod project (please see http://blog.digitalglobe.com/crowd/crowdsourcingmalaysianflightthankyou/ for example) reported that no image was available for this area and that equatorial clouds close to CI did not allow conclusive surveys.

33- Why no search has taken place around Christmas Island?

The CAPTIO-proposed End of Flight location has been published too late to influence OI's search. The Australian recommendation (from Mr. Griffin) was more in the South based on the latest drift study results at that time. In addition, the scientific community is still sceptical about human intervention and still believes in an adrift aircraft and an incapacitated crew.
So far we have contacted the major players who are now aware of our results (OI, FAA, Boeing, Rolls-Royce, Malaysian Airlines etc.)
The search area proposed by CAPTIO is worth some inspection and should not be summarily rejected.

H – What is done to avoid that this happens again?

34-Why can we track a mobile phone but not an airplane?

The GSM communication network is a terrestrial network whose antennas are designed and installed to communicate with mobile phones at ground level or so. The antenna beams are oriented downwards. It could possibly happen that a signal from a mobile phone at high altitude be received temporarily and randomly through an antenna beam side lob during a very short time laps, but this would not allow for a connection to be fully established.

35- What is ICAO doing to improve safety?

After AF447 and MH370 losses, ICAO triggered several initiatives staggered over time among which:

- GADSS: Global Aeronautical Distress & Safety System
- NATII: Normal Aircraft Tracking Implementation Initiative
- Flight Data Recording via periodical (satellite) transmission