Network Manager
nominated by
the European Commission

EUROCONTROL

Experience Sharing to Enhance Safety

WS03-2018

Automation, Digitalisation and Cyber – new challenges for Human Factors in complex organisations

"When machine world meets the human world in Air Traffic Management"

27-28 September 2018

Did we learn from MH370? Does Space Based ADS/B prevent a new MH370? Is there anything else that could be done?

Prof. dr. Octavian Thor Pleter, MBA (MBS)

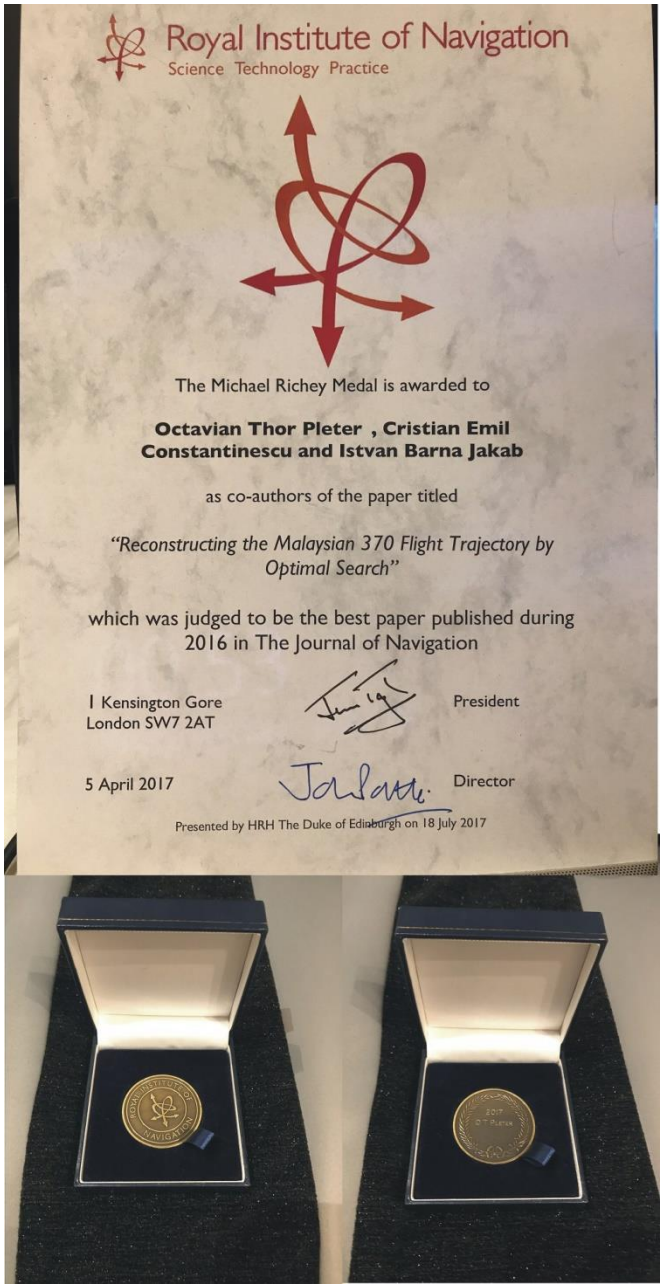
Prof. dr. Cristian Emil Constantinescu, MBA (MBS)

In this presentation, the MH370 case will be analysed to details and all scenarios will be checked against the capabilities of the current and future Space Based ADS/B. Conclusions are surprising. Although the whole effort for satellite surveillance of aircraft was triggered by MH370, such an occurrence would be still left undetected. An aircraft with ADS/B transponders switched off will be invisible by Satellite Surveillance either. The audience is challenged to explore the possible counter measures to unlawful acts from inside the cockpit.

Richey Medal 2017

Royal Institute of Navigation

Best Scientific Paper published in the Journal of Navigation 2017


Royal Institute of Navigation
Science Technology Practice

The Michael Richey Medal is awarded to

Octavian Thor Pleter , Cristian Emil Constantinescu and Istvan Barna Jakab

as co-authors of the paper titled

"Reconstructing the Malaysian 370 Flight Trajectory by Optimal Search"

which was judged to be the best paper published during 2016 in The Journal of Navigation

1 Kensington Gore
London SW7 2AT

President

5 April 2017

Director

Presented by HRH The Duke of Edinburgh on 18 July 2017

THE JOURNAL OF
Navigation
CAMBRIDGE
UNIVERSITY PRESS

THE JOURNAL OF NAVIGATION (2016), 69, 1–23. © The Royal Institute of Navigation 2015
doi:10.1017/S0373463315000570

Reconstructing the Malaysian 370 Flight Trajectory by Optimal Search

Octavian Thor Pleter, Cristian Emil Constantinescu and
Barna Istvan Jakab

(*University Politehnica of Bucharest, 060042 Bucharest, Romania*)

Multidisciplinary approach:

Air Navigation, Flight Dynamics, High Fidelity Simulations, Flight Simulations, Turbine Engines, Flight Management Systems, Automated Flight Control Systems, Power Systems, Meteorology, Geodesy, Satellite Orbital Mechanics, Radio Waves Propagation, Satellite Communications, Air Traffic Control, Radars, Multi-Disciplinary Optimisations, Calculus (Numerical Methods)

Mysteries not acceptable in this stage of science development

Factual Brief of MH370 search in contrast to AF447

Published Results by our team

- BTO s. BFO based strategy
- High Fidelity simulation
- Multimodal optimization total search (38 solutions)
- Glide path of the powerless flight

Search History vs. our Published Results

Lessons learned – lines of action

- Global aircraft tracking euphoria – what to do against a CB cut-off?
- Military (primary) radar coverage / Air policing
- Satellite tranceiver on the essential bus
- Ejectable flash memory

Safety vs. Security

- Safety: avoiding accidents and incidents, reducing risks, mitigating against risks, minimizing consequences, increasing the system resilience (positive safety), just culture

- Security: unlawful interference, the element of intent; vulnerability, security protection

GWI2592
24 March 2015

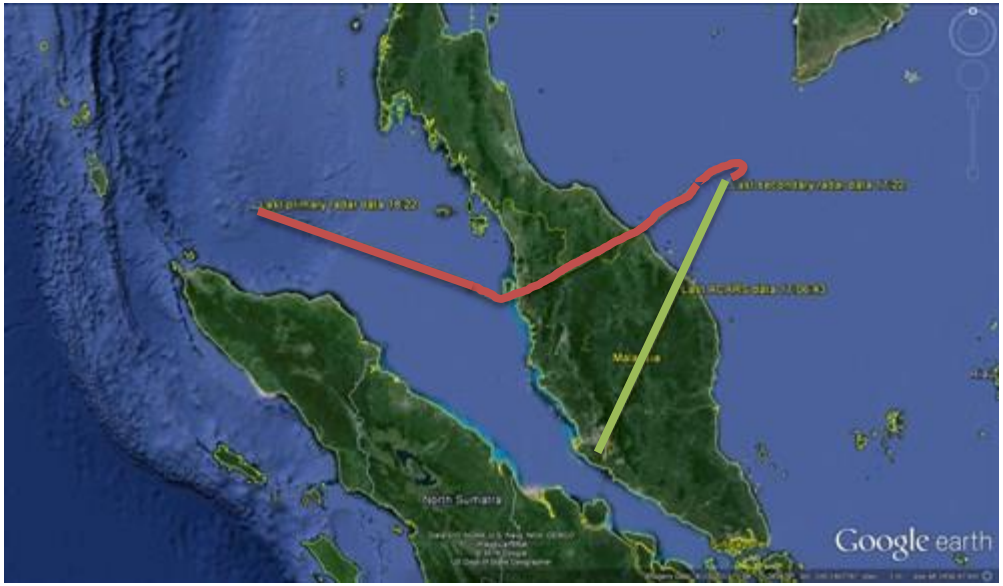
MH370
8 March 2014

MH17
17 July 2014

- ACARS turned off
- ADS/B turned off
- Mode-A/C XPDR turned off
- COM tuned off
- SATCOM calls unanswered
- SATCOM tranceiver on

Last on radar near IGARI point in the Gulf of Thailand South China Sea 8 March 2014

Tracked for **1 hour** by military primary radar in the Malacca Strait, Andaman Sea



6 hours of unknown flight (**2000-2550 NM**)

Debris spotted after **18 months +**

Debris suspected in satellite images taken after **12 days** discovered after **3 years**

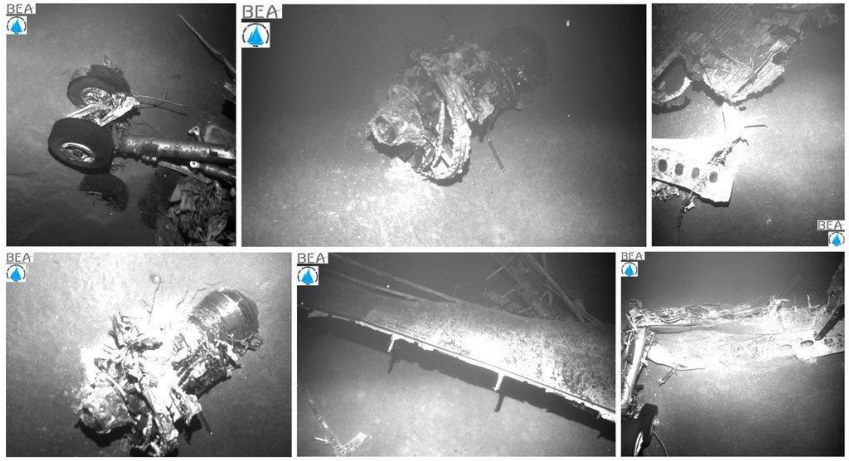
Debris spotted by Brazilian Air Force 2 June (in **36 hrs**)
Debris / bodies recovered 6-7 June (in **6 days**)

Crashed near TASIL point in the Atlantic Ocean 1 June 2009 0214Z

Crash position based on a last **2-10 minutes** ACARS report

Initial search area: **17,000 km^2**

Aircraft wreck discovered 3 April 2011
Underwater search took almost **2 years**



SAFETY INVESTIGATION REPORT

Malaysia Airlines Boeing B777-200ER (9M-MRO)
08 March 2014

By

The Malaysian ICAO Annex 13 Safety Investigation Team for MH370

Issued on 02 July 2018
MH370/01/2018

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370
Email: *MH370SafetyInvestigation@mot.gov.my*

2) Royal Malaysia Police's Report on Flight Simulator of PIC

The Royal Malaysia Police (RMP) seized the PIC's home flight simulator from the residence of the PIC on 15 March 2014.

The RMP Forensic Report dated 19 May 2014 documented more than 2,700 coordinates retrieved from separate file fragments and most of them are default game coordinates.

It was also discovered that there were seven 'manually programmed' waypoint[4] coordinates (*Figure 1.5A* [below), that when connected together, will create a flight path from KLIA to an area south of the Indian Ocean through the Andaman Sea. These coordinates were stored in the Volume Shadow Information (VSI) file dated 03 February 2014. The function of this file was to save information when a computer is left idle for more than 15 minutes. Hence, the RMP Forensic Report could not determine if the waypoints came from one or more files.

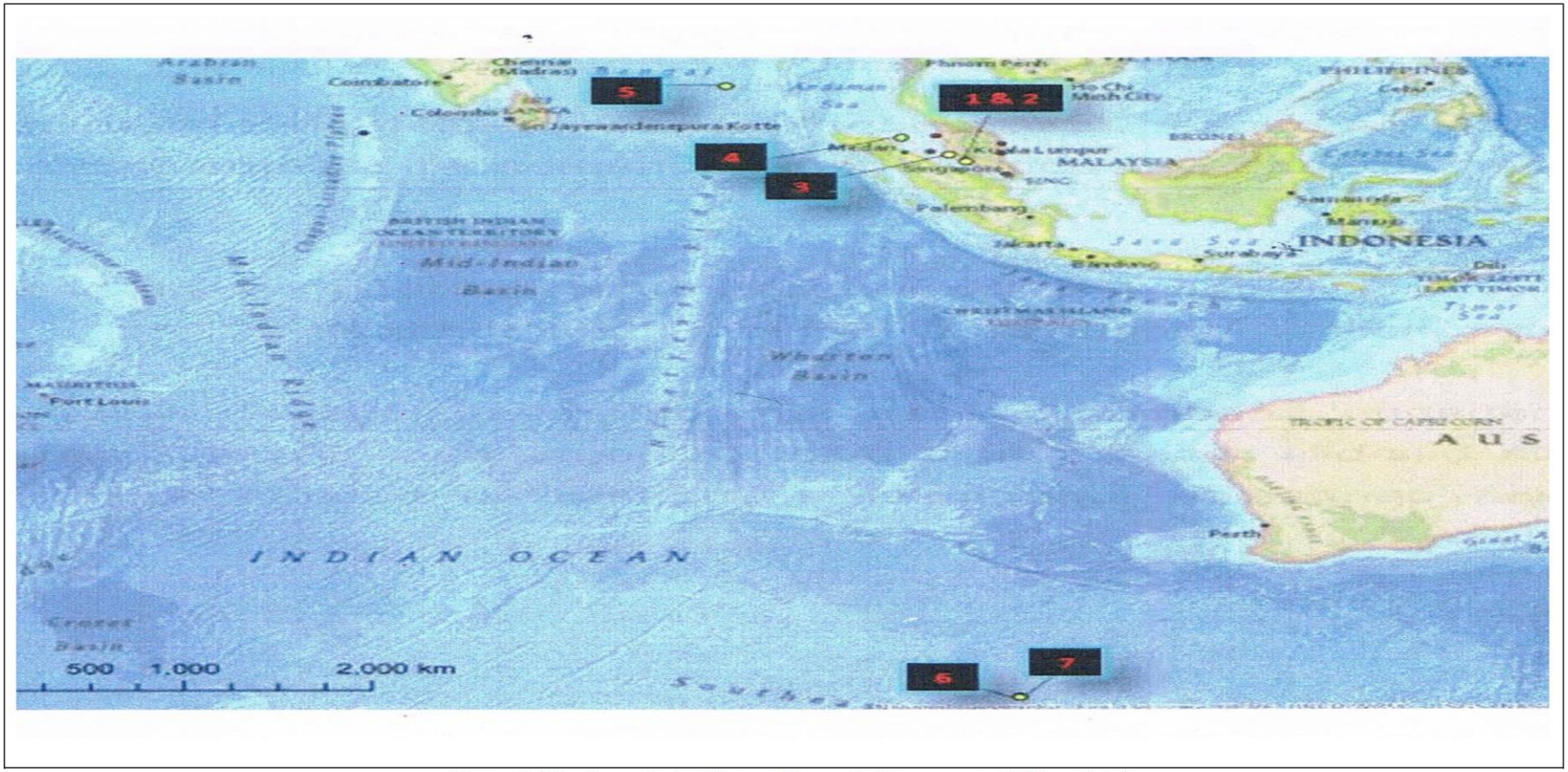
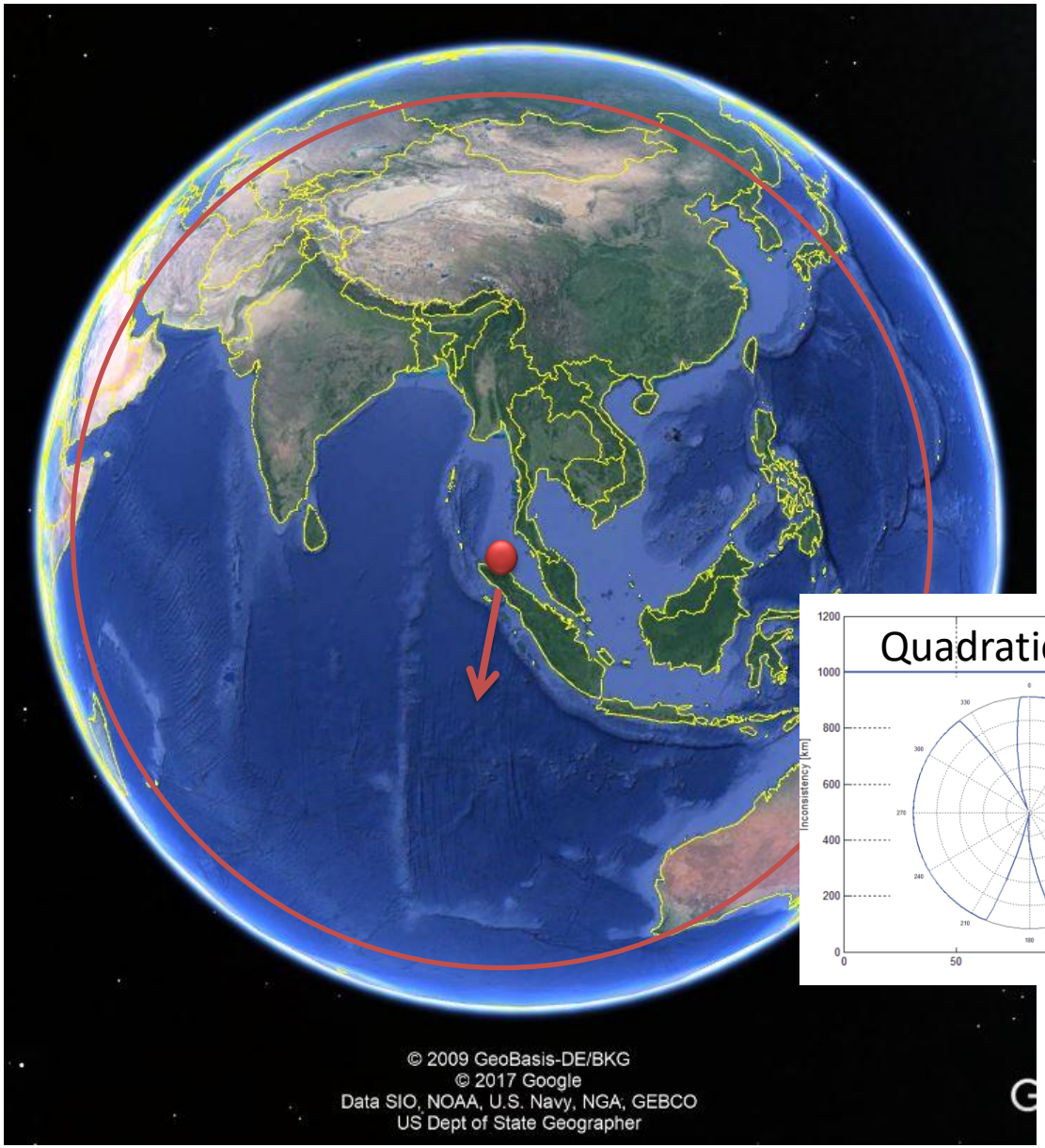


Figure 1.5A - Snapshot of Seven Manually Programmed 'Waypoints'

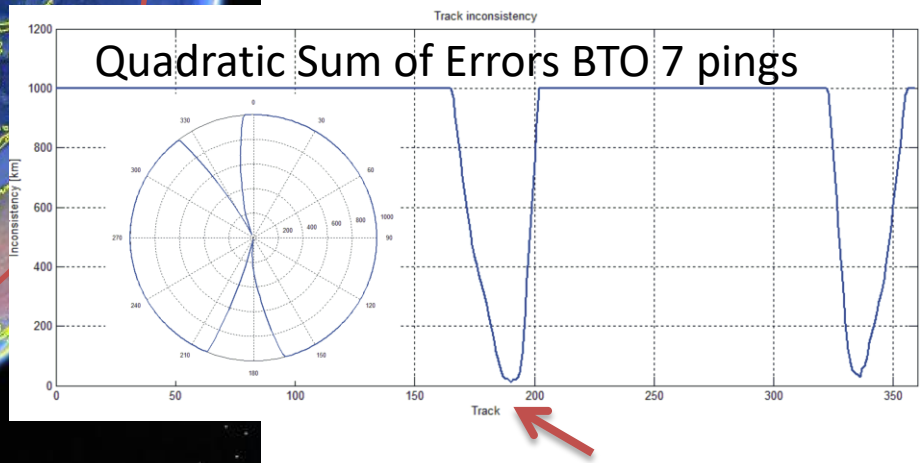
Source: Royal Malaysia Police



6 hrs of flight from the last known position – trajectory / direction unknown

Initial search area **66.9 mil. km²**

7 SATCOM handshake signals (pings) → duration of flight and position relative to the INMARSAT 3-IOR satellite



Searched area **120,000 km²**

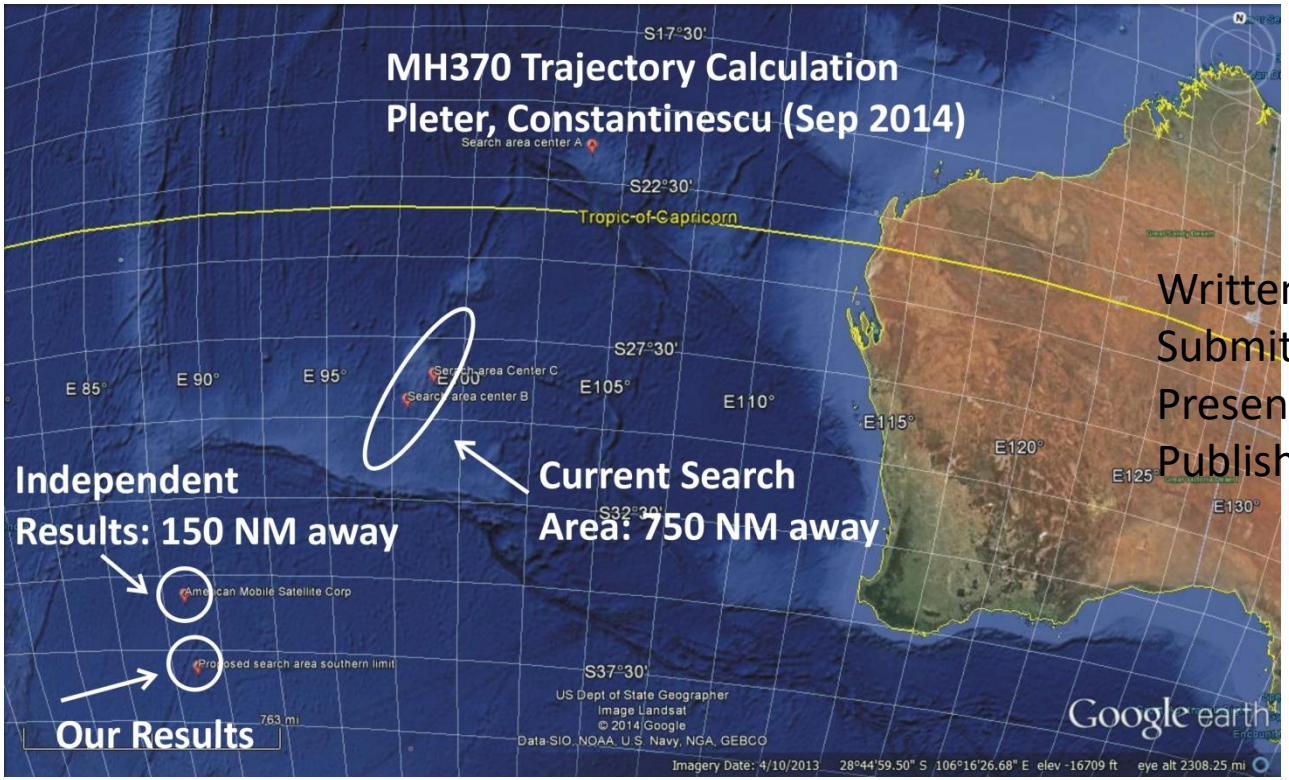
Search operations abandoned after **3 years**

Possible Trajectories of the Flight Malaysian 370

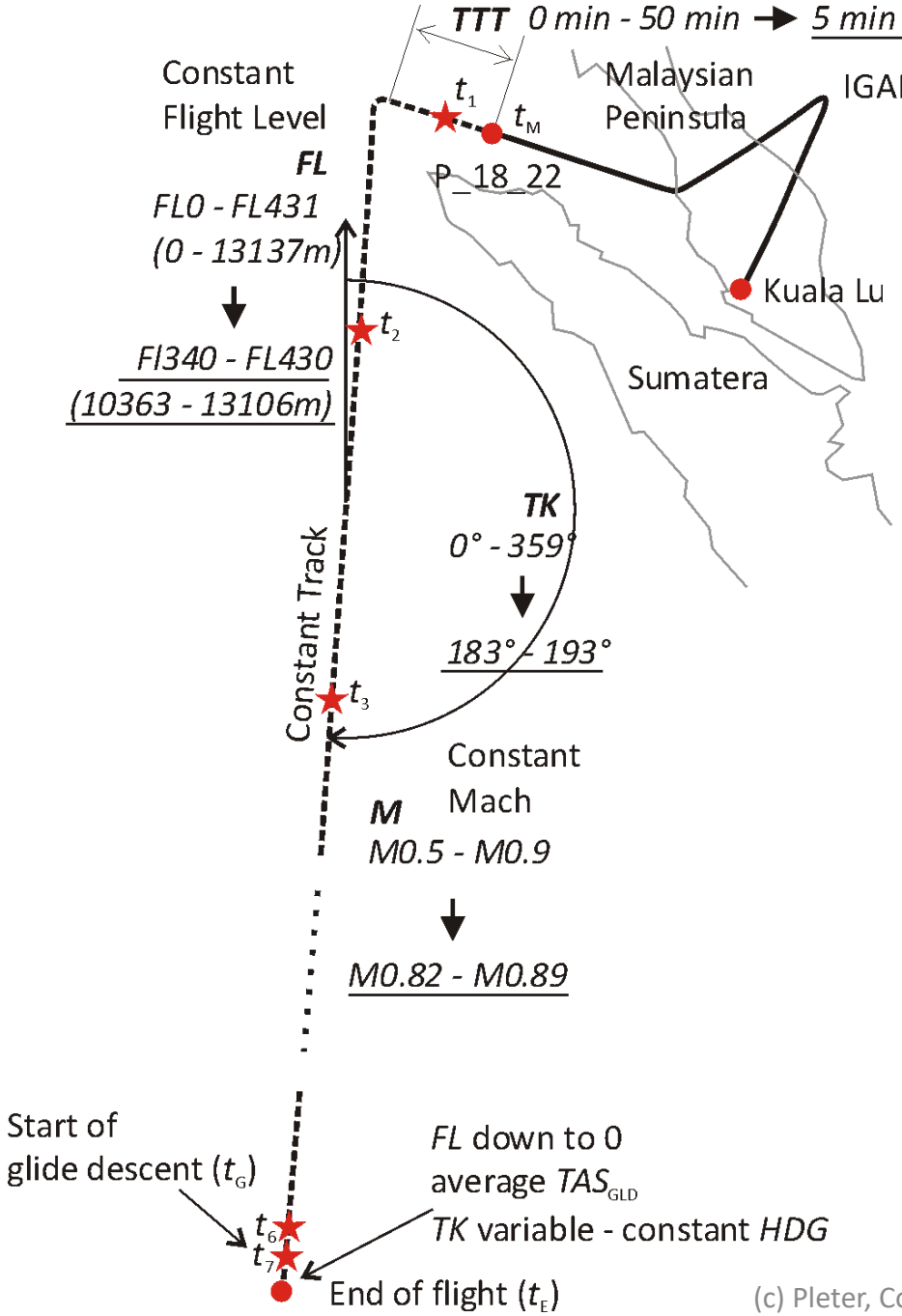
Octavian Thor Pleter, PhD, PhD, MBA (MBS)
Cristian Emil Constantinescu, MScAE, MBA (MBS)
University Politehnica of Bucharest
Faculty of Aerospace Engineering

INCAS – National Institute for Aerospace Research "Elie Carafoli"
(Under the aegis of The Romanian Academy)

International Conference of Aerospace Sciences
"AEROSPATIAL 2014"
18 - 19 September, 2014
Bucharest, Romania



Written: Jun-Aug 2014
Submitted to ATSB: 30 Aug 2014
Presented publicly: 18 Sep 2014
Published: Jan 2015



THE JOURNAL OF NAVIGATION (2016), 69, 1–23. © The Royal Institute of Navigation 2015
doi:10.1017/S0373463315000570

Reconstructing the Malaysian 370 Flight Trajectory by Optimal Search

Octavian Thor Pleter, Cristian Emil Constantinescu and Barna Istvan Jakab

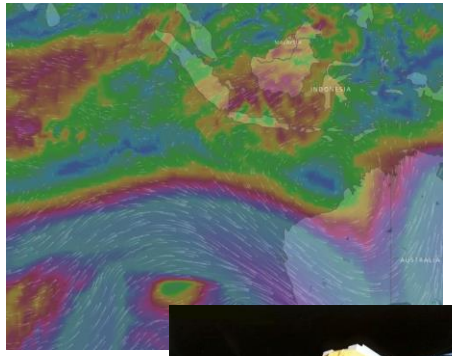
(*University Politehnica of Bucharest, 060042 Bucharest, Romania*)

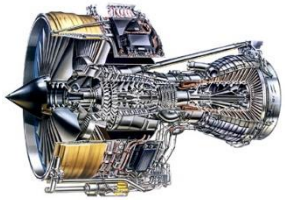
THE JOURNAL OF
Navigation
CAMBRIDGE UNIVERSITY PRESS

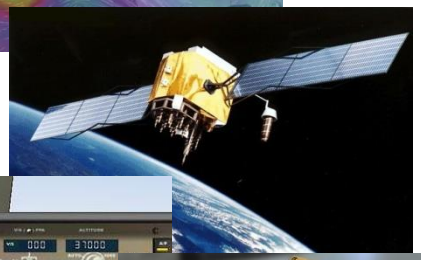
Written: Aug-Dec 2014
Submitted to JN: 13 Jan 2015
Accepted: 1 Jul 2015
Published: 30 Jul 2015

High Fidelity simulation:

- wind vector field at the time and place of flight
- temperature
- pressure
- B772 flight dynamics
- RR Trent 892 engines
- Flight Management System (all modes scenarios)
- Auto Pilot (all modes scenarios)
- Asymmetric engine out at fuel starvation
- Engine-out gliding trajectory
- INMARSAT-3 IOR orbital dynamics
- Ping signal propagation (ionospheric refraction)





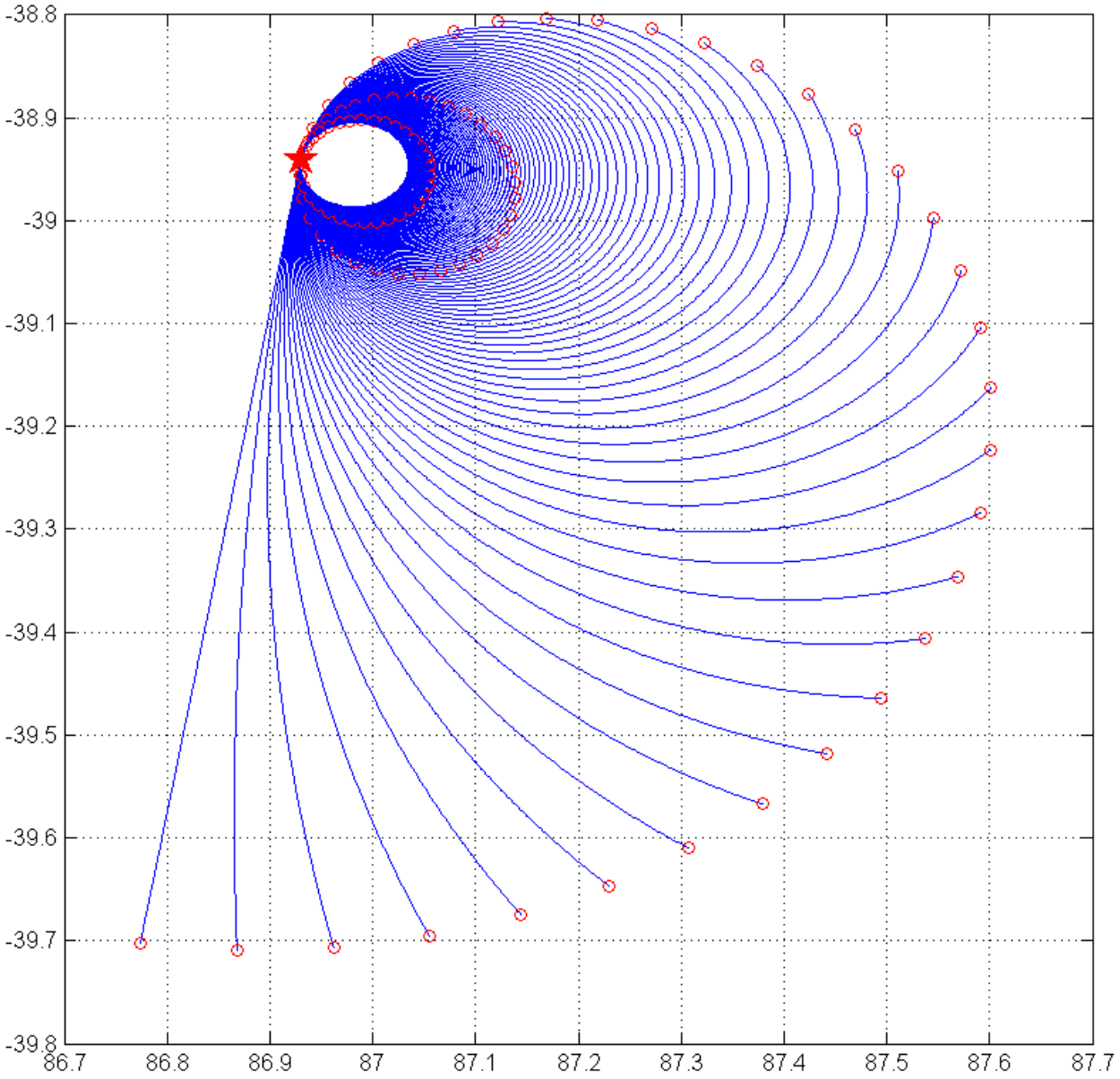


Multimodal optimization - Total search covered **34 mil.** trajectories
Refined search for **42,240** trajectories

$$\varepsilon = \sqrt{\sum_{1}^{6} {d_i}^2} = min$$

38 solutions with Quadratic Sum of Errors **< 25 km** for a 6,000 km flight

Left turn due to asymmetric fuel starvation – glide path seen from above



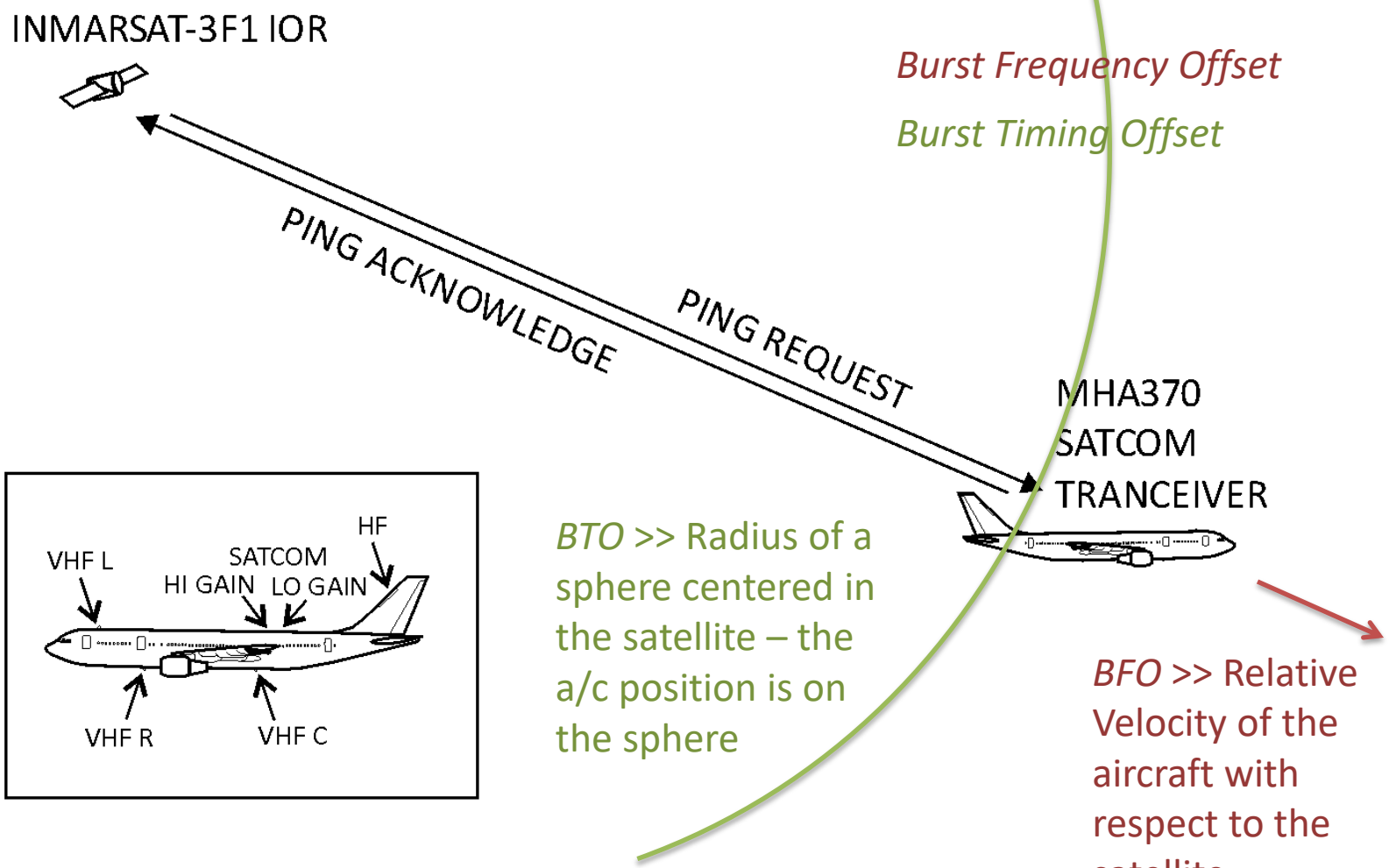
The locus of the end of flight positions for one solution (11 out of 38) considering a constant angular velocity turn during glide descent

The circles represent the possible points of impact for each respective angular velocity

The star is the Ping 7 position (flame out of the 2nd engine, end of powered flight)

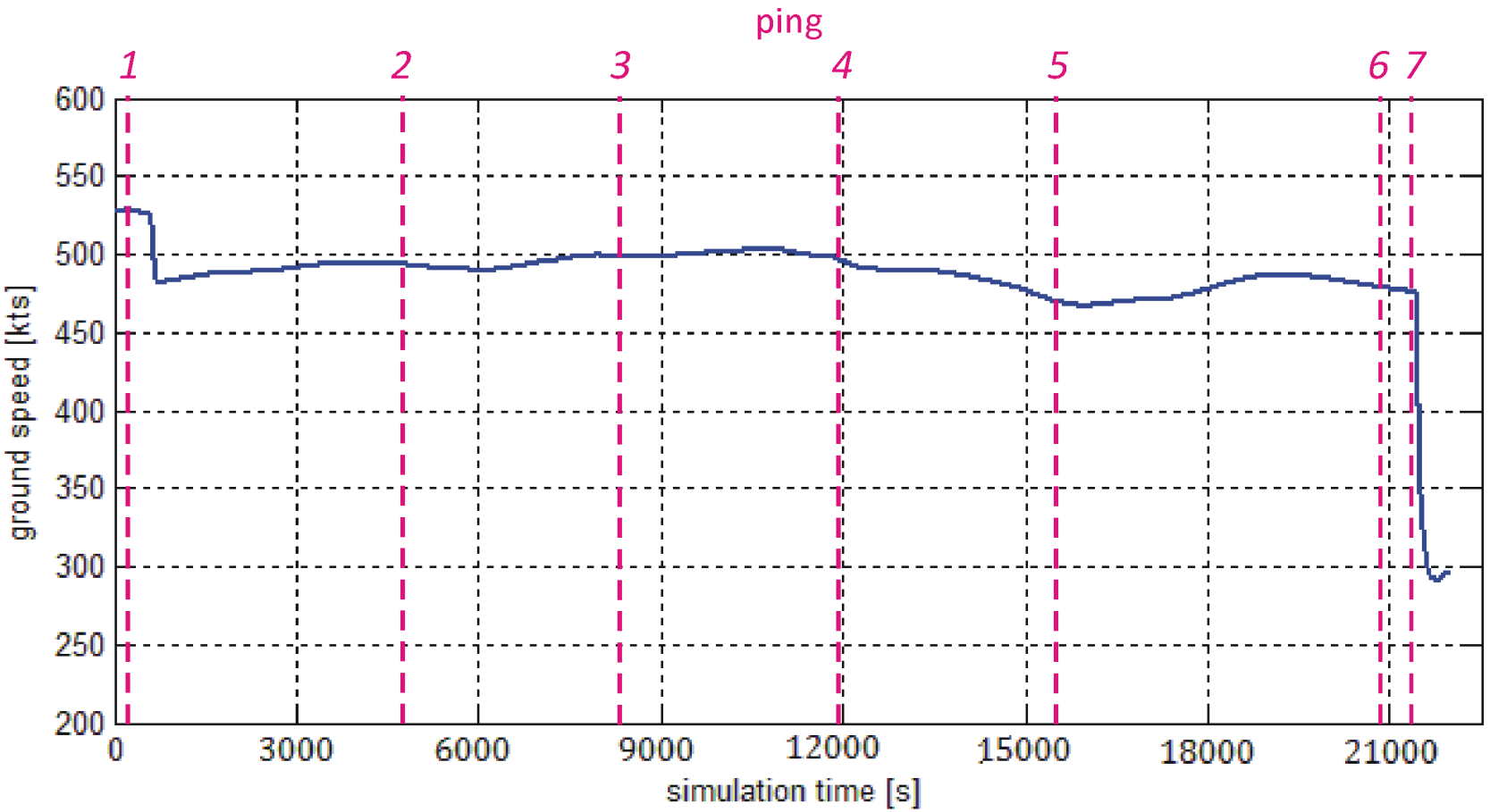
All trajectories have the same length

Just the 7 **BTOs** were used in our calculations, not the **BFOs**!
The problem of the relative speed between satellite and aicraft is geometrically **ill-conditioned**

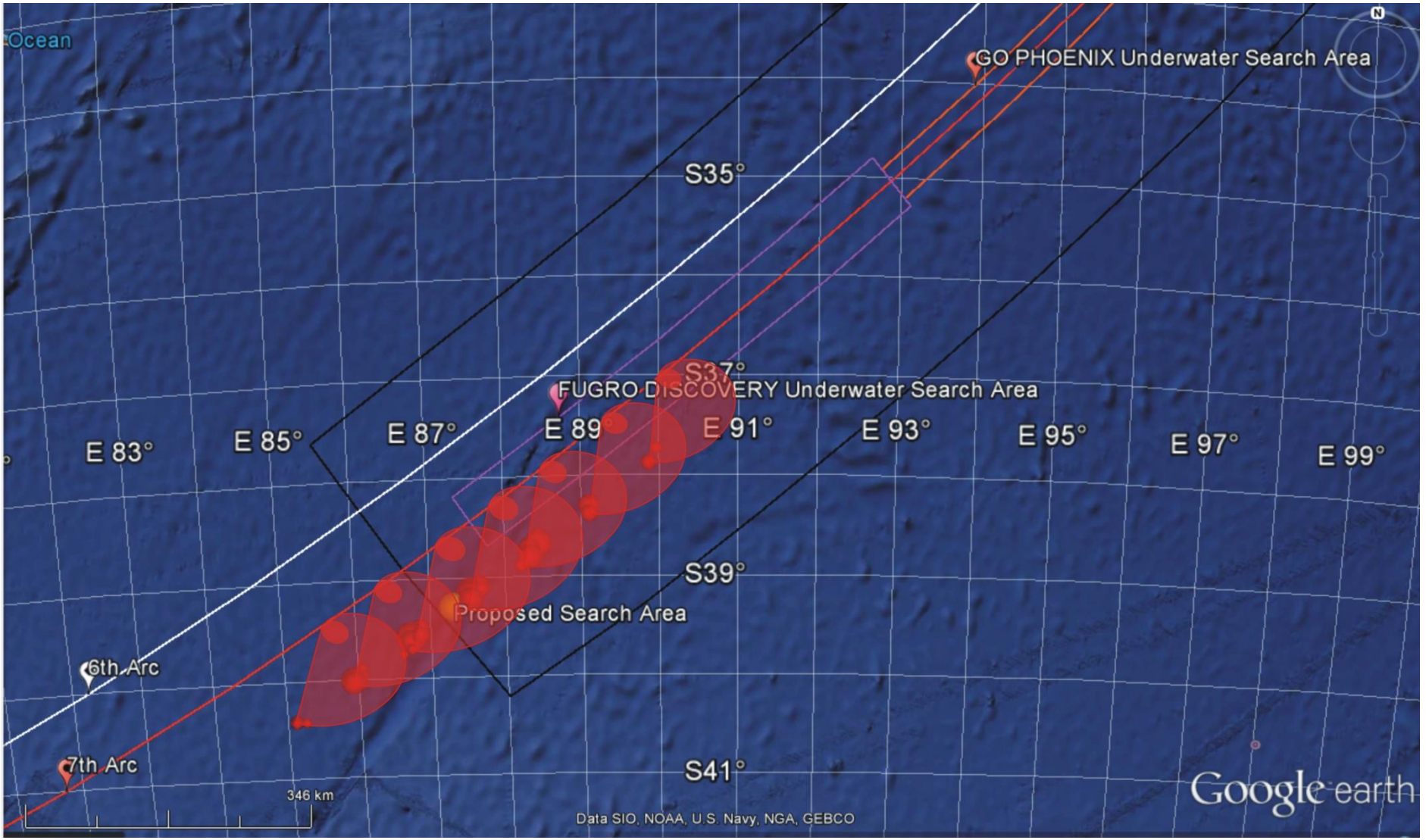


Ground Speed (solution 11 out of 38)

What are the odds the Ground Speed were constant?

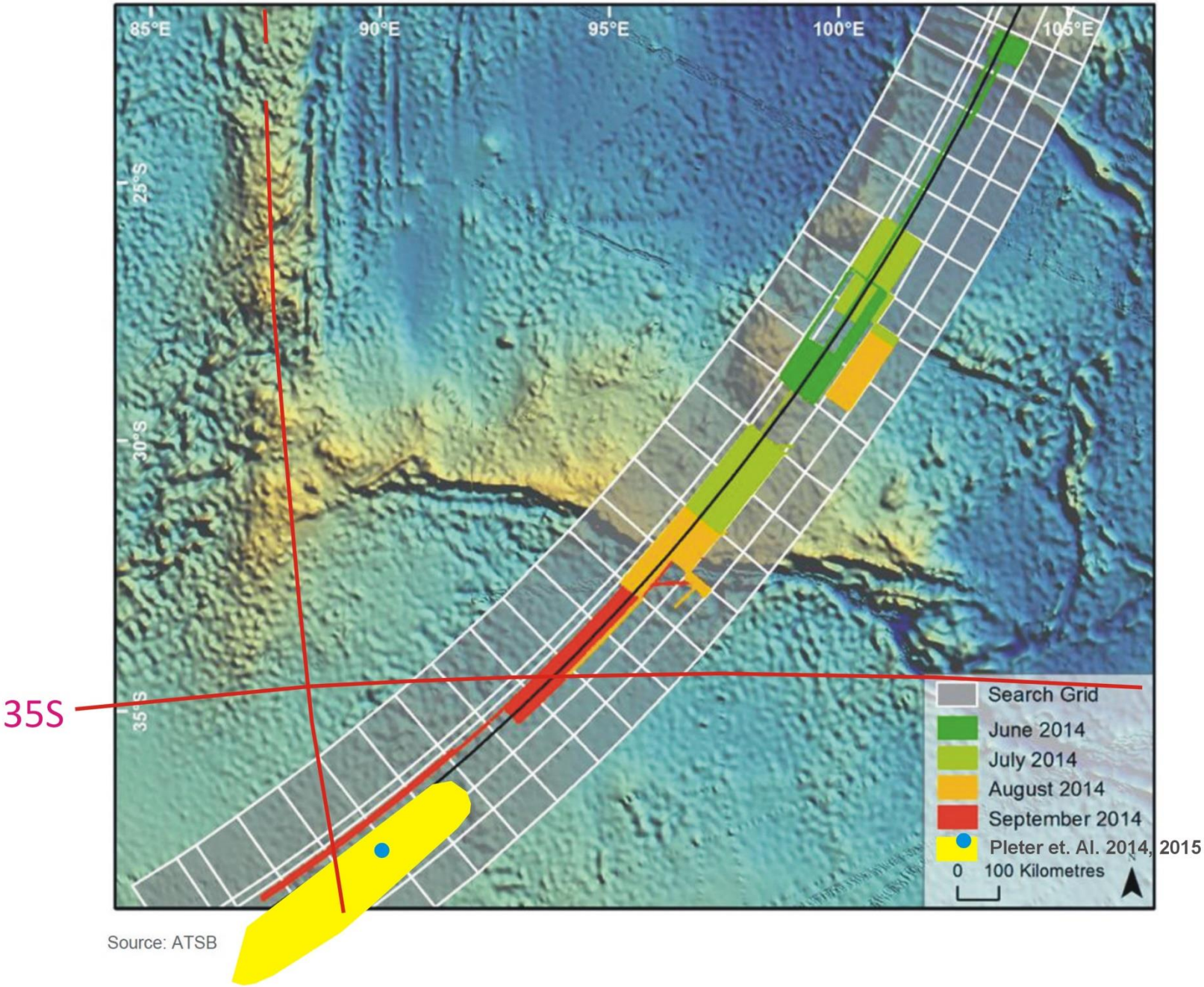


Envelope of our 38 solutions with Quadratic Sum of Errors **< 25 km** for a 6,000 km flight



87.5E

Envelope of our 38 solutions vs. June-September 2014 search



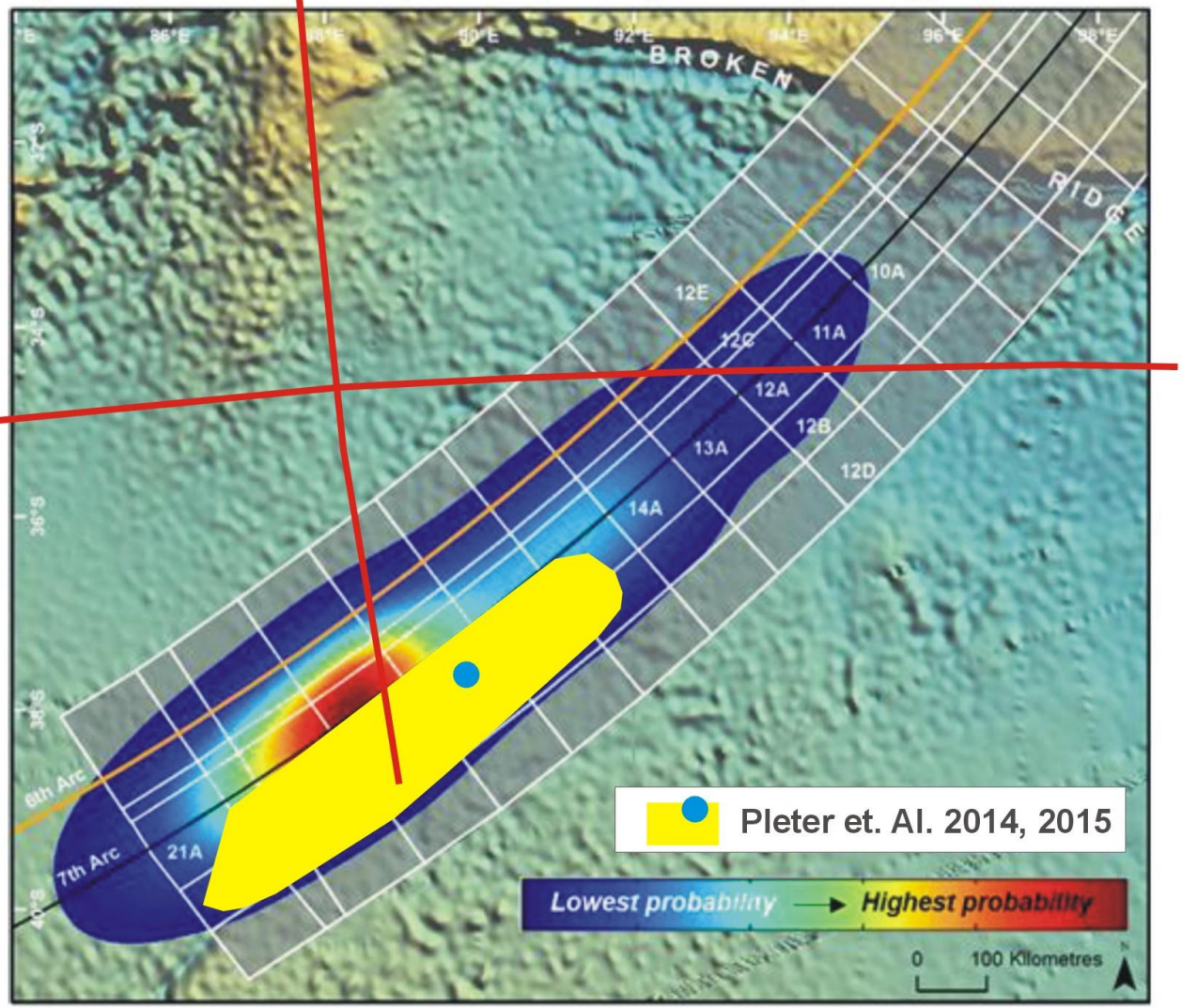
Envelope of our 38 solutions calculated **Dec 2014**
vs.
Nov 2015 heatmap (ATSB)

(Impact North of 7th Arc disregards the 1st Law of Newton)

87.5E

35S

Figure 56: Two dimensional probability density function (heatmap), November 2015



Source: ATSB, using DST Group data

The Anti-Medal

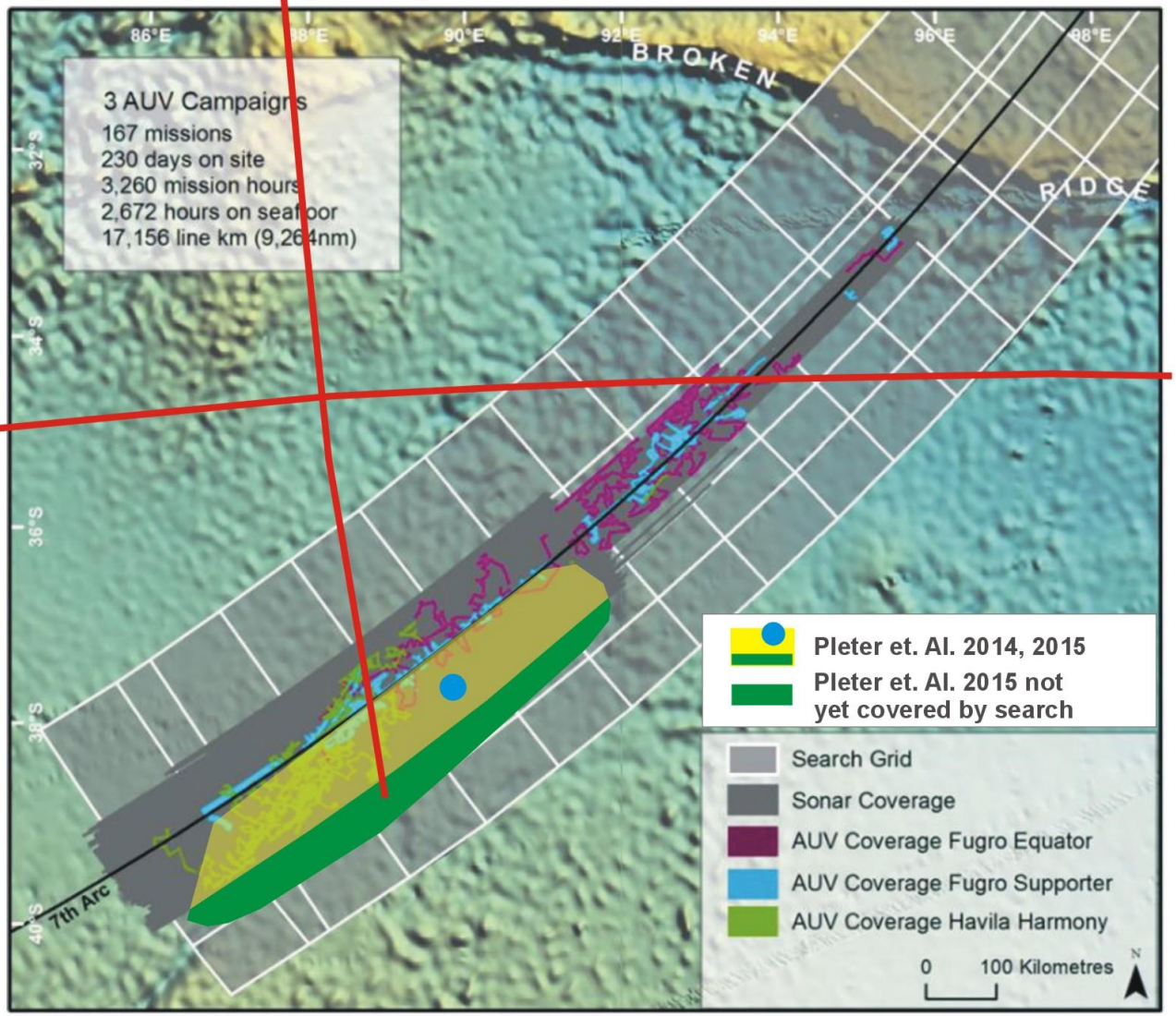
Envelope of our 38 solutions vs. final search chart (ATSB)

The green is what we calculated but has never been searched

87.5E

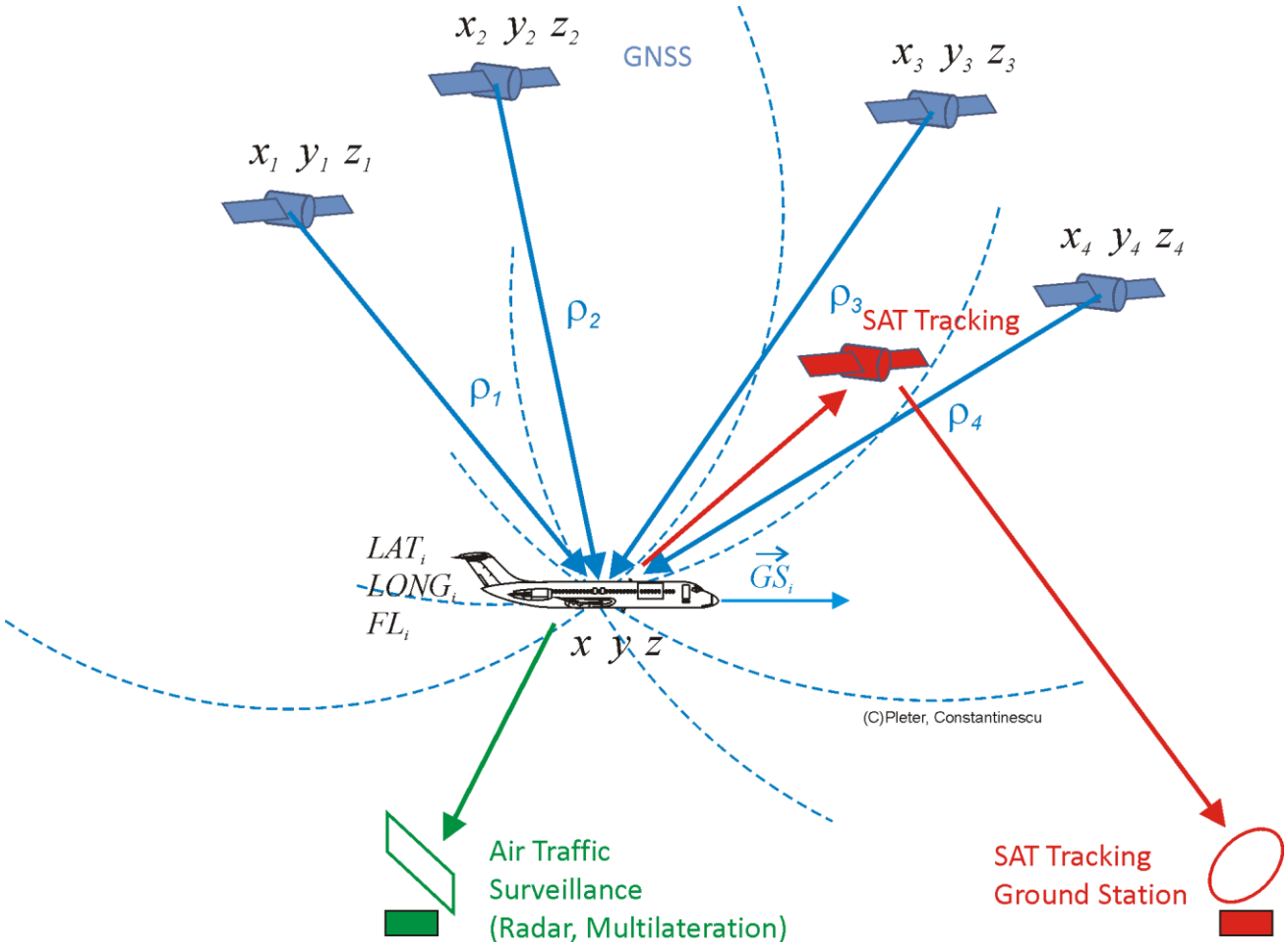
35S

Figure 65: Map showing coverage of AUV missions and statistics



Source: ATSB

Global ATC Surveillance Tracking via Satellite seems the natural answer to the requirement put forward by ICAO in 2015
Aireon fully functional in 2019



Lessons learned – lines of action

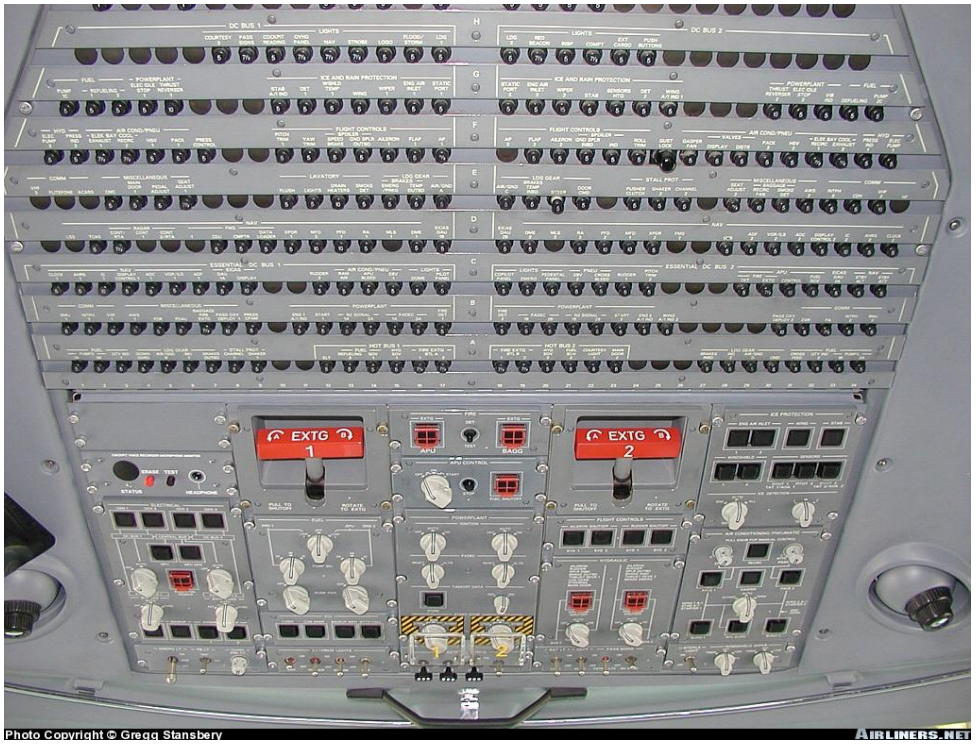
1) Global aircraft tracking euphoria – what to do against a CB cut-off?

There is consensus among experts that MH370 was an **intentional act**

ACARS Circuit Breakers were cut off

Any piece of equipment on board has a CB and may be switched off if so desired from within the cockpit

Nothing can be done against a person with knowledge and bad intentions who gets control of the cockpit



9/11 Security door sometimes keeps good people outside the cockpit
(see also GWI 2592)

Lessons learned – lines of action

2) Military (primary) radar coverage / Air policing

If the unknown flight detected by the Malaysian military PSR would have been intercepted within the 1 hour time frame, the fate of MH370 would have been the same, but at least known

Secondary radars and ADS/B satellite surveillance are for *safety*

Security depends on **primary surveillance radars**

Immediate military interception of civilian flights who do not comply, have no functional transponder or cannot be contacted by radio

(NATO in Europe is a good example)

Lessons learned – lines of action

3) Satellite tranceiver on the essential bus

The last Ping was only a Half Ping because the satellite tranceiver has *no back-up power*.

RAM Air Turbine only supplies essential / flight critical instrumentation with electricity and hydraulics.

The satellite tranceiver *is not yet considered critical*.

After MH370 **it should**. Satellite tranceiver could provide invaluable data to SAR, let alone the possibility for a SATCOM call from anywhere on the planet

Lessons learned – lines of action

4) Ejectable flash memory

For aircraft impacting deep water, as well as terrain:

Flight parameters should be continuously written to a flash memory.

In case of impact (based on g-force) the memory should be **ejected** from the tail of the aircraft using a pyrotechnic cartridge.

The memory should have its own GPS tracker and could respond to SAR interrogations. It will retain the **exact place of impact** although it may drift for days until found.

It will **float** so it stays active on radio frequencies.

Lessons learned – lines of action

5) Tracking of Aircraft by Satellite Infrared Sensors

Source: Andreea Sfia, Satellite Based Air Traffic Surveillance Based on Thermal Detection, Diploma Project, UPB Faculty of Aerospace Engineering 2018

- Fix object

- Slow moving object (ship)

- Fast moving object (aircraft)