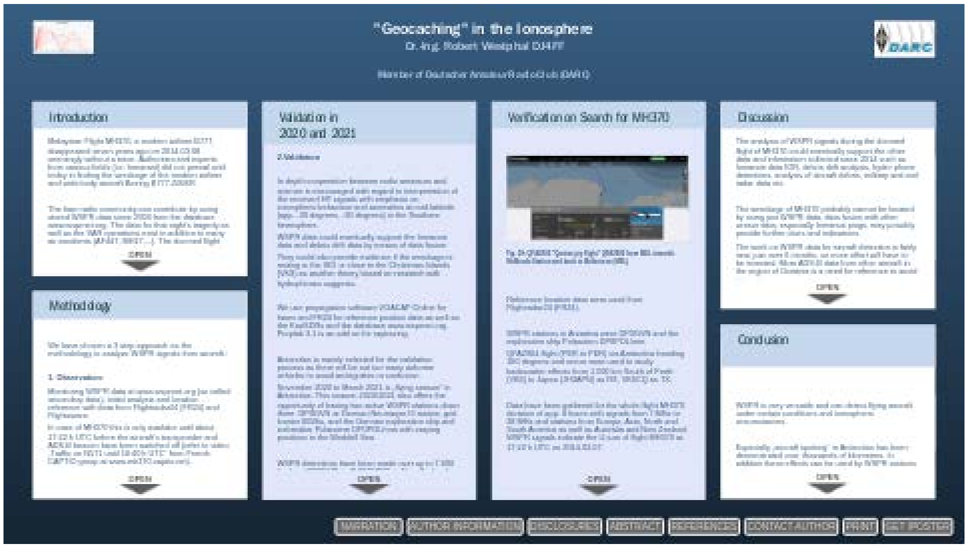
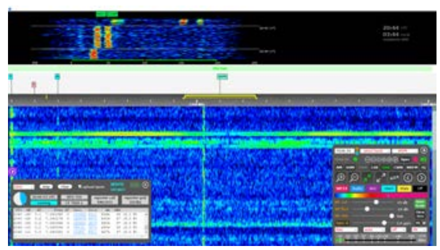
"Geocaching" in the Ionosphere



Dr.-Ing. Robert Westphal DJ4FF

Member of Deutscher Amateur Radio Club (DARC)



PRESENTED AT:

INTRODUCTION

Malaysian Flight MH370, a modern airliner B777, disappeared seven years ago on 2014.03.08 seemingly without a trace. Authorities and experts from various fields (i.e. Inmarsat) did not prevail until today in finding the wreckage of the modern airliner and wide body aircraft Boeing B777-200ER.

The ham radio community can contribute by using stored WSPR data since 2008 from the database www.wsprnet.org. The data for that night's tragedy as well as the SAR operations exist in addition to many air accidents (AF447, MH17,...). The doomed flight happened close to the peak of solar cycle 24 in April 2014.

In 2021 we have detected several aircraft in Antarctica such as a B787-9, two Dassault Falcon 900EX, an Iljuschin IL-76TD and a DC3C commuter airplane by conducting WSPR tests between DP0GVN as TX and ZL2005SWL as RX.

Reference location data were used from Flightradar24. Some radio paths also succeeded from Australia (VK), EA8 and South America.

This kind of research was not possible before the 2nd half of 2020 as there were not enough ADS-B receivers on parts of the shore line of Antarctica in the vicinity for airfields from Neumayer III station QAN, SANAEIV, QAT, QAO, QAP to Australian Davis Station QAD. Wilkins Aerodrome, 70 km Southeast of Casey station does not seem to have an ADS-B receiver linked to the Internet.

WSPR stations in Antarctica were DP0GVN and the German exploration ship and icebreaker Polarstern DP0POL/mm. Qantas joy flights such as QFA2902 to QFA2908 flights to Antarctica heading 180 degrees South and retour were used to study forward scatter (FS) as well as backscatter (BS) effects from Perth (PER, VK6) to Japan (JH3APN).

Testing in Antarctica was prefered in order to avoid ambiguities with other aircraft as it can happen in crowded air space. Detection ranges of more than 7,500 km have been achieved from Antarctica (DP0GVN, DP0GVN-1) to New Zealand WSPR RX (ZL2005SWL).

Additional tests have been done in 2020 with repatriation flight QFA114 between JNB and PER across the Southern Indian Ocean (SIO). Other WSPR testing between ZS and KH6 and daily flights SIA478 and 479 have been conducted by monitoring WSPR data on www.wsprnet.org (secondary data) and www.kiwisdr.com (580 receivers worldwide with raw or primary WSPR data).

In case of MH370 data have been recorded in the WSPR database (www.wsprnet.org) for the whole flight duration of app. 8 hours with signals from 7 MHz to 28 MHz and stations from Europe, Asia, North and South America as well as Australia and New Zealand. WSPR signals indicate the U-turn at 17:22 h UTC and the Final Major Turn (FMT) heading 180 degrees towards the Indian Ocean at app. 19 h UTC.

Midcourse data still have to be analyzed from WSPR stations in Oceania, Asia, Europe, South and North America.

Especially the „end game“ offers a lot of data for Grayline, night and day reception, possible 28 MHz backscatter, short path (SP) as well as long path (LP) propagation. Trajectories have been studied by means of VOACAP Ham online, Proplab 3.1 etc.

METHODOLOGY

We have chosen a 3 step approach as the methodology to analyze WSPR signals from aircraft.:

1. Observation:

Monitoring WSPR data at www.wsprnet.org (so called secondary data), initial analysis and location reference with data from Flightradar24 (FR24) and Flightaware.

In case of MH370 this is only availabe until about 17:22 h UTC before the aircraft‘s transponder and ADS-B beacon have been switched off (refer to video „Traffic on N571 until 18:40 h UTC“ from French CAPTIO group at www.mh370-captio.net).

Monitoring WSPR data at live KiwiSDRs in Oceania at www.kiwisdr.com in mode or extension WSPR (primary data with decodes and non-decodes as waterfall every 2 min. on the screen).

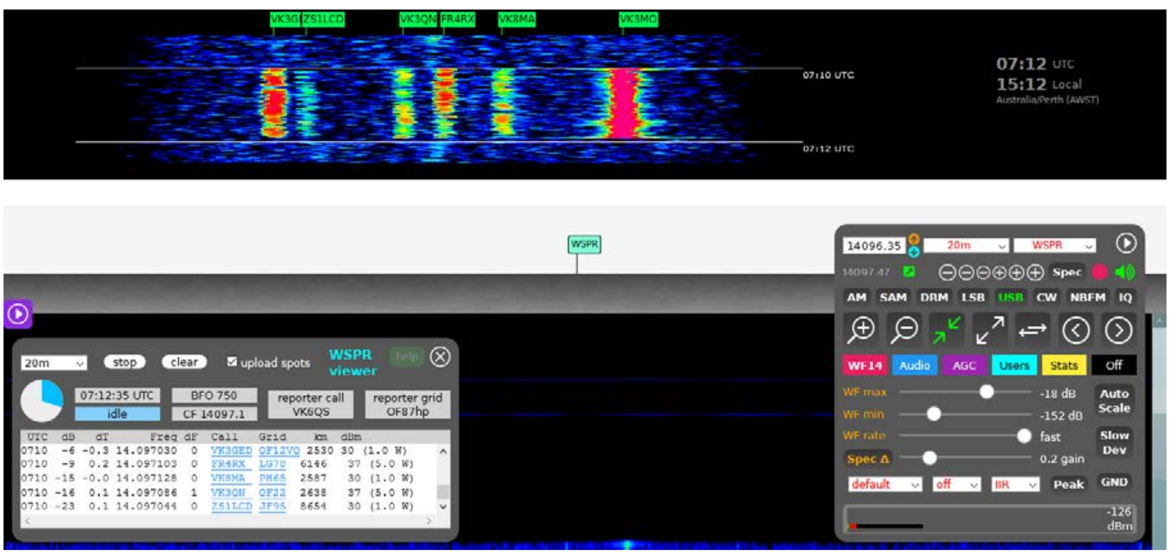


Fig 1. : WSPR waterfall from VK, FR, ZS signals on screen of KiwiSDR at VK6QS in Perth, Western Australia

Military primary radar data exist until app. 18:22 h UTC. After that MH370 was outside of the detection range of those primary radars.

Only 7 pings from Inmarsat satellite IOR show evidence that MH370 was in the air for hours. For background and scientific information on the search for flight MH370 please refer to websites www.mh370search.com and www.mh370.radiantphysics.com.

As the wreckage of MH370 has not been found in seven years the final reports from authorities are of minor help for our activities. Anyway they are publicly available and accessible on the Internet.

By observation of WSPR signals of flying aircraft in 2020 and 2021 we can conclude how the detection process might work by means of WSPR.

Anyway we are in need of a validation process in the presence not in 2014 as www.wsprnet.org just provides stored secondary WSPR data containing less information.

Therefore we use one or more out of app. 580 KiwiSDR all over the world (www.kiwisdr.com).

Live screens provide spectral views on decoded as well as nondecoded (30 % to 80 % of all) WSPR signals. These KiwiSDRs have been located in Australia, Indonesia, Philippines, Maui / Hawaii and New Zealand.

One can easily monitor the influence of flying aircraft on SNR, shape, frequency, etc. of the received WSPR signals which quite frequently will be deformed to be nondecoded but observable WSPR signals (SNR, frequency, shape, locator).

Examples of WSPR signals at KiwiSDRs in Oceania:

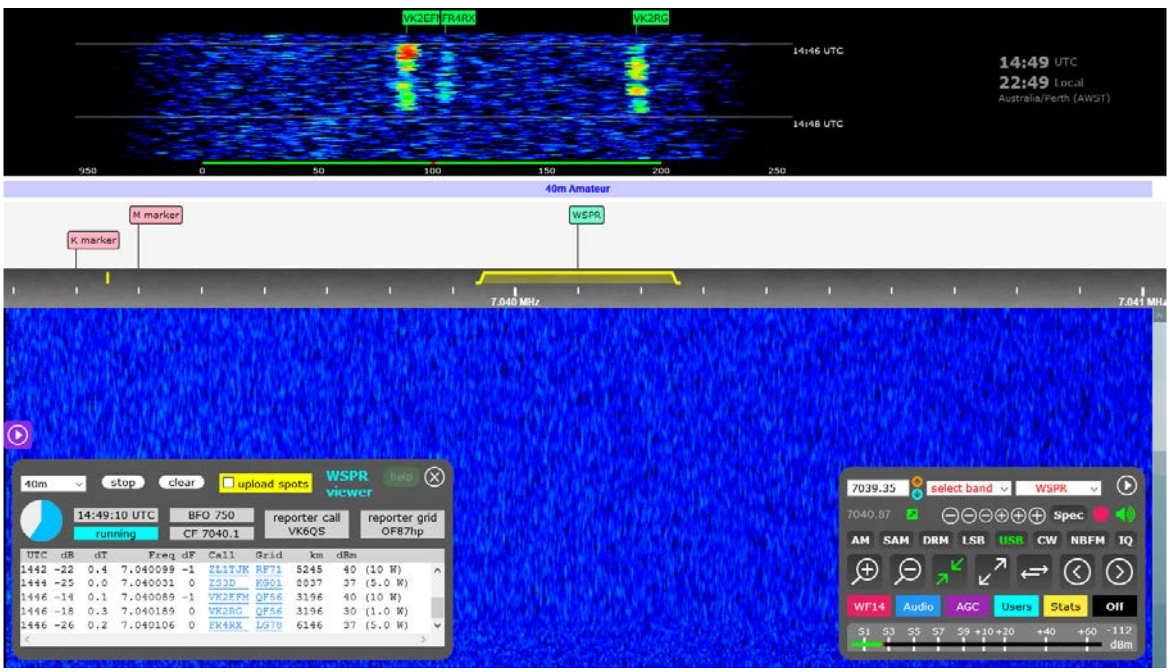


Fig. 2: Strong blip on shape of WSPR signal VK2EFM at screen of KiwiSDR at VK6QS in Perth, Western Australia

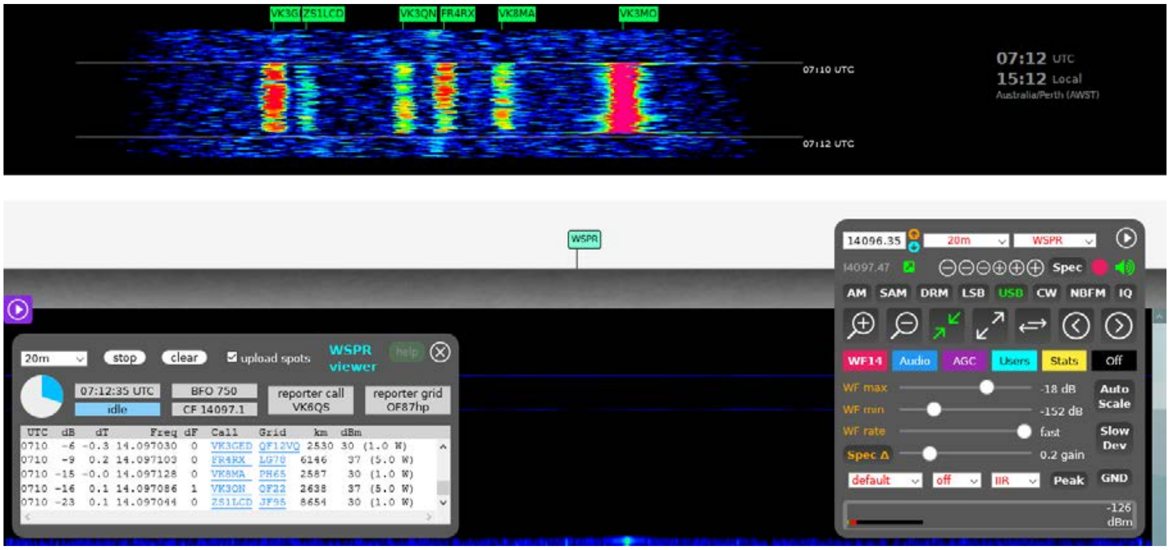


Fig. 3: Very strong WSPR signal of VK3MO due to aircraft scattering at RX VK6QS in Western Australia (Perth)

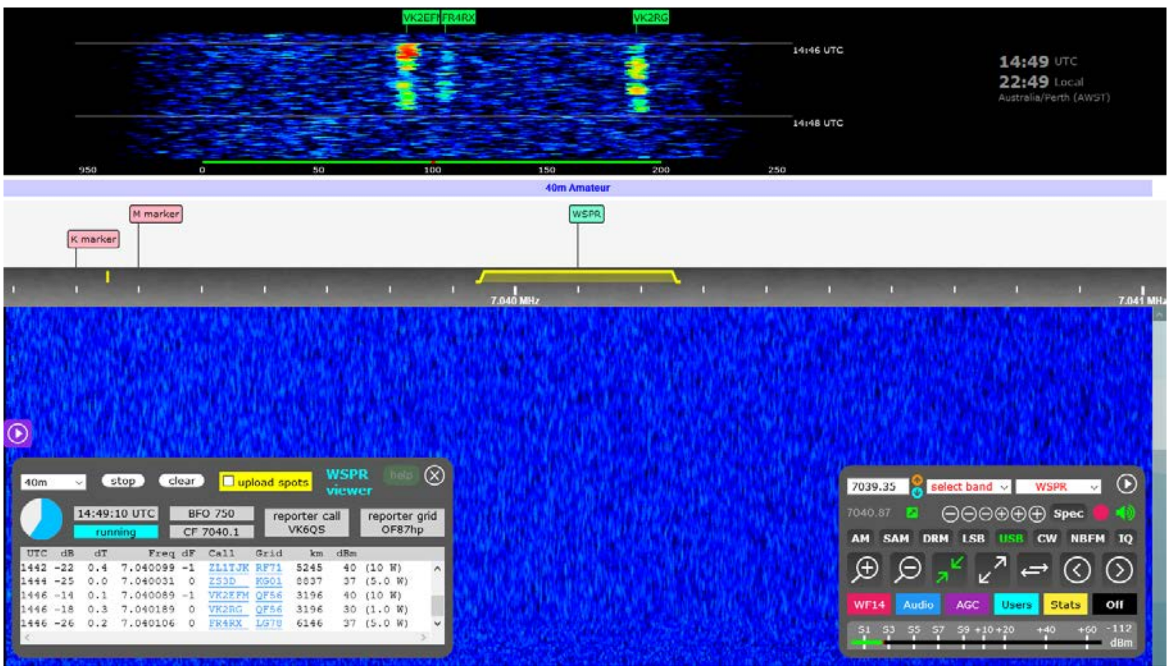


Fig 4.: VK2EFM WSPR signal shape deformation at drift -1 Hz/min due to scattering. FR4RX signal from Réunion as well as VK2RG not effected with drift 0 Hz/min.

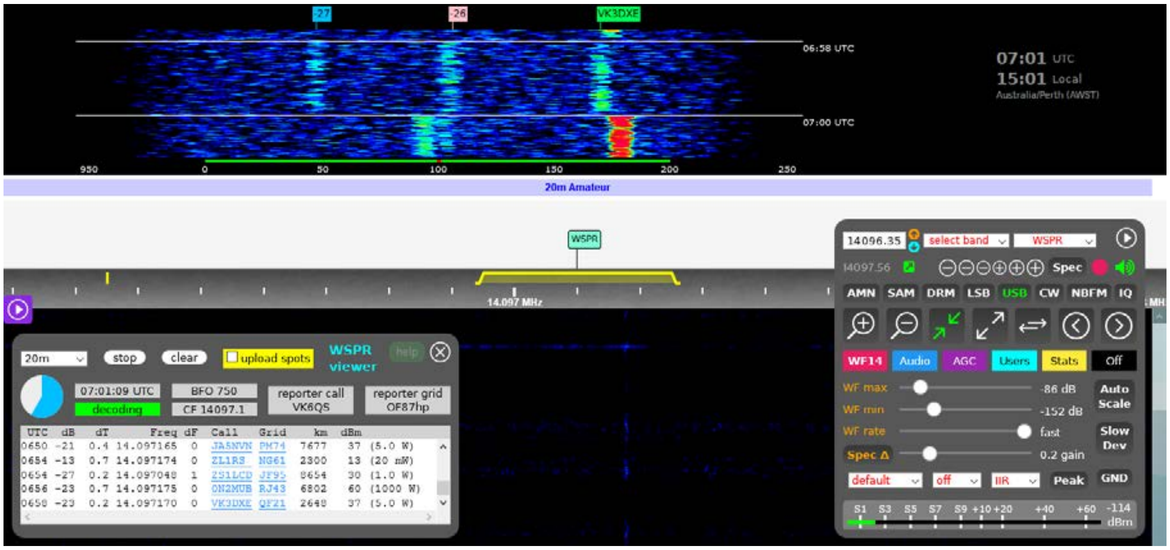


Fig. 5: Two "non decode" WSPR signals with SNR, shape and frequency information left of WSPR Signal from VK3DXE (also on the air on 2014.03.08 flight MH370)

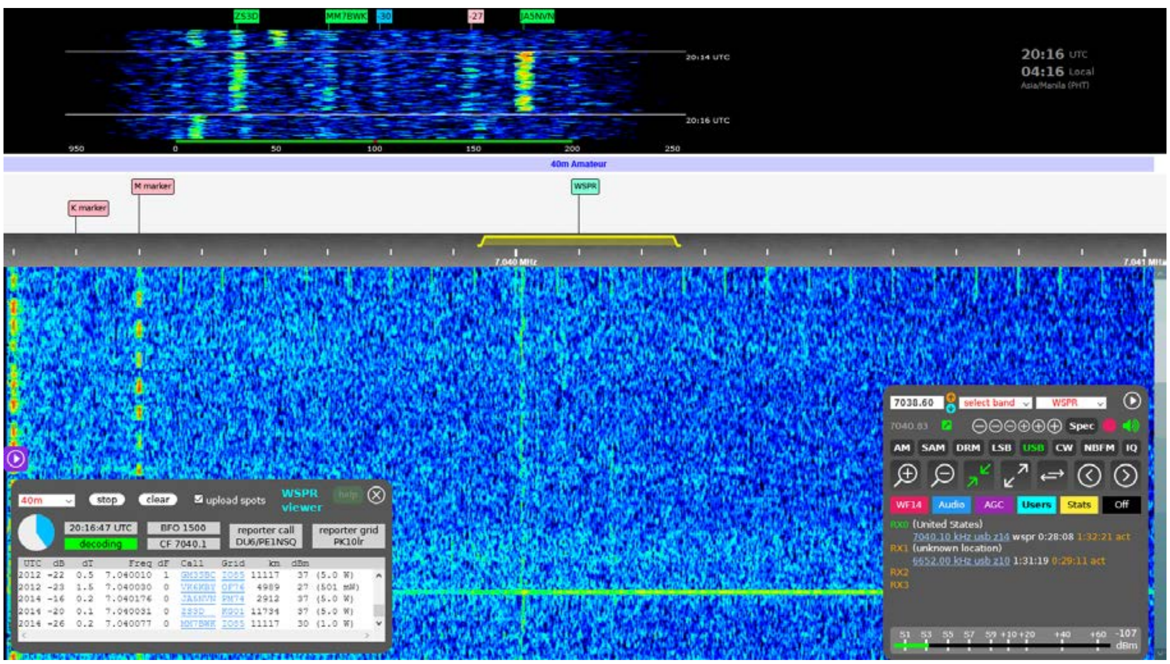


Fig. 6: Non-decode with SNR -27 dB at app. 150 Hz in WSPR band left of JA5NVN will not appear in WSPR database

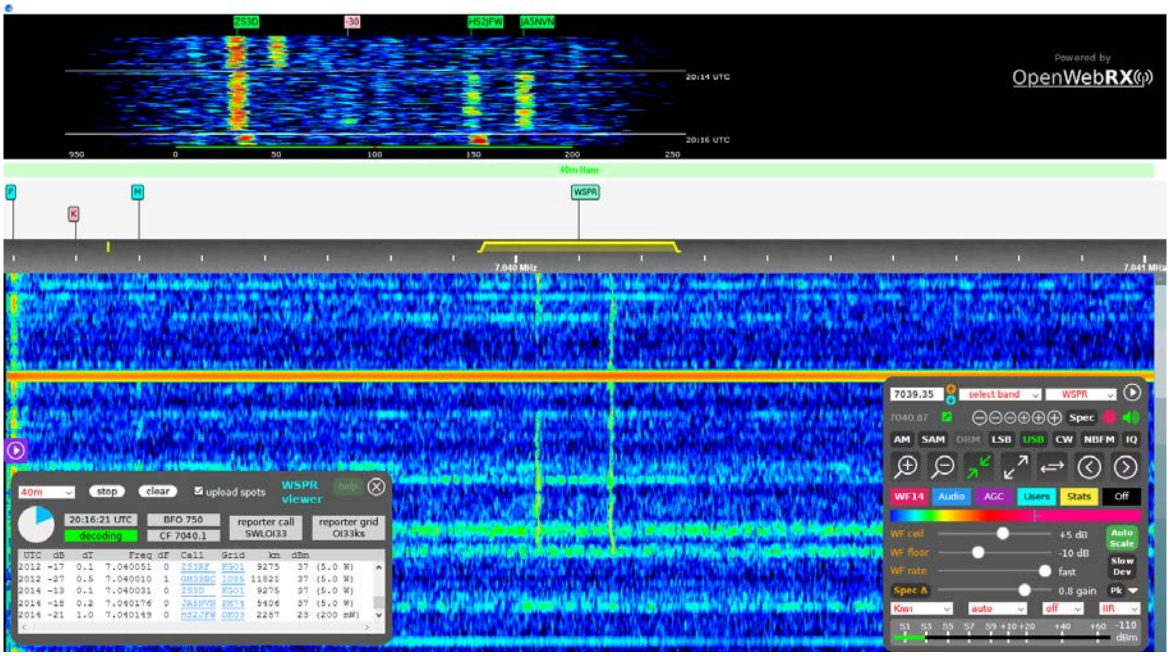


Fig. 7: Bi-/Multilateral reception of WSPR signals in Indonesia and Philippines enables identification of WSPR signal HS2JFW at SWLOI33 close to Jakarta / Indonesia as well as close to Negros / Philippines. This information will be lost in WSPR database (www.wsprnet.org)

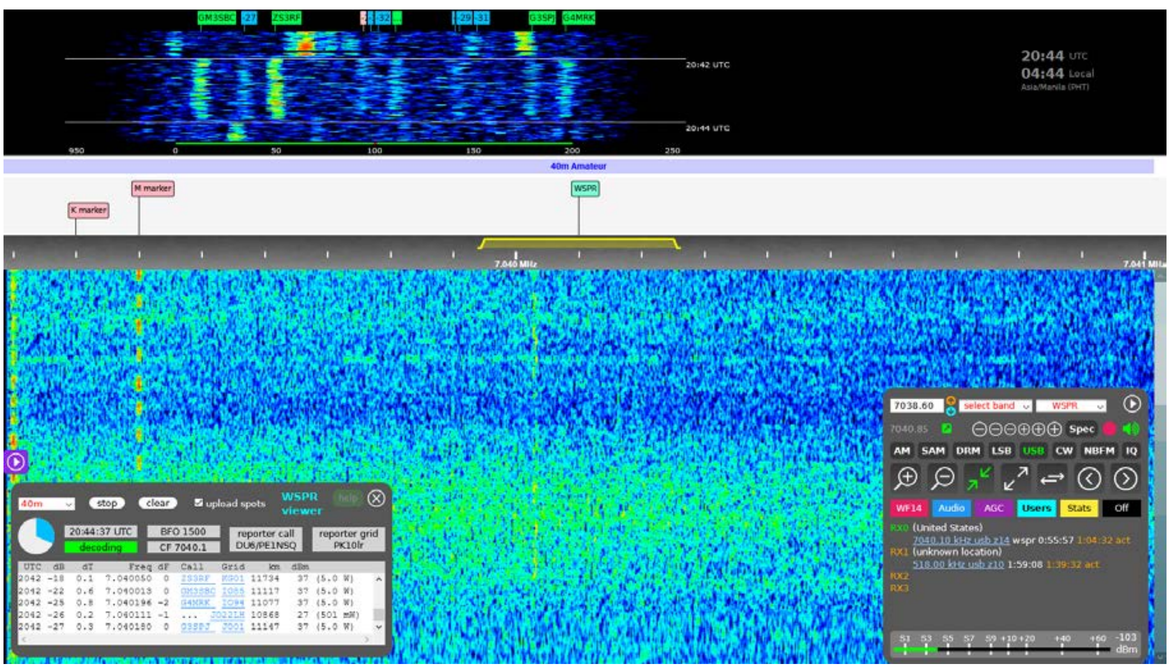


Fig. 8: WSPR signal left of ZSRF is a non-decode at SNR -27 dB at KiwiSDR in Philippines and will not be stored in WSPR database

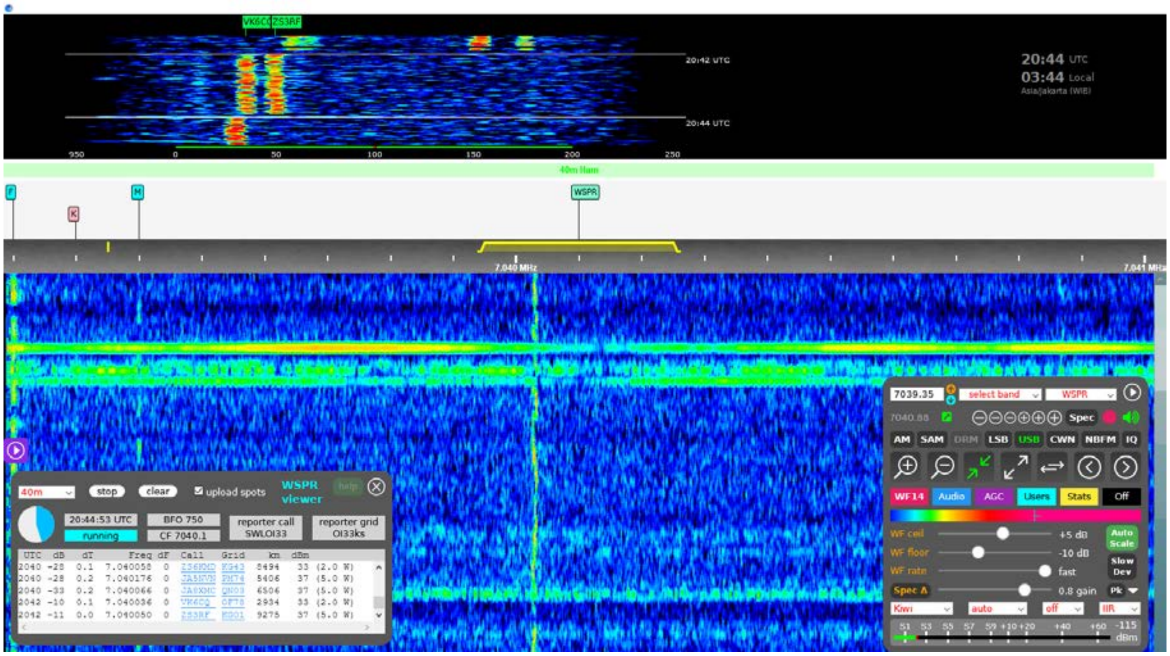


Fig. 9: The non-decode in Philippines is VK6CQ close to Perth well identified by SWLOI33 in Indonesia. So bi/multilateral detection provides more information for WSPR detects. Please notice signal left of VK6CQ is not decoded in Indonesia (GM3SBC decoded in the Philippines)

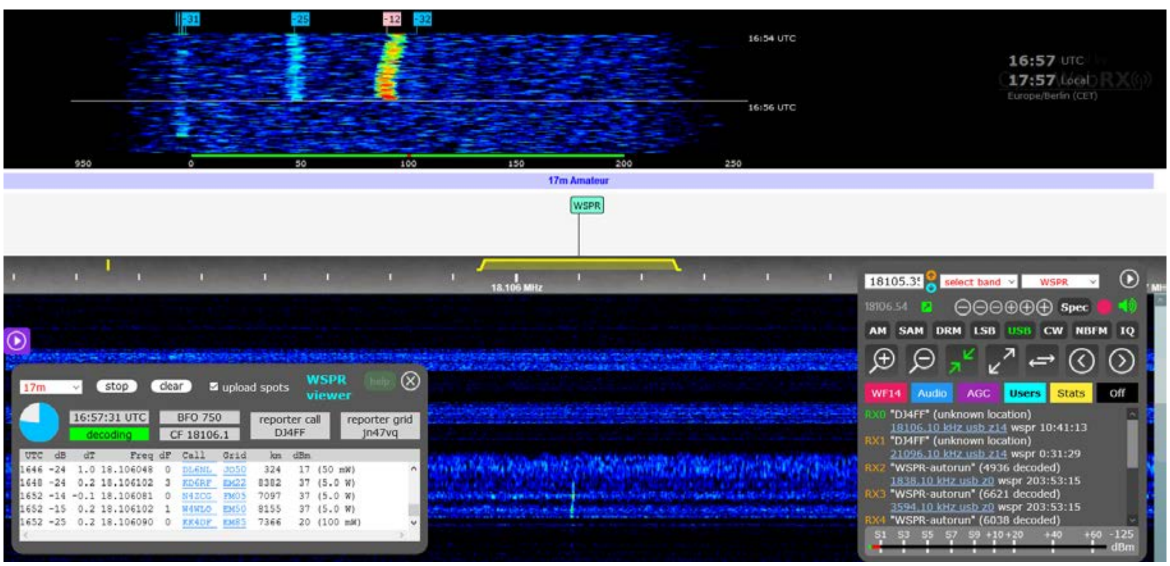


Fig. 10: Strong nondecode with "odd shape" of WSPR signal due to drift > -4 Hz/min

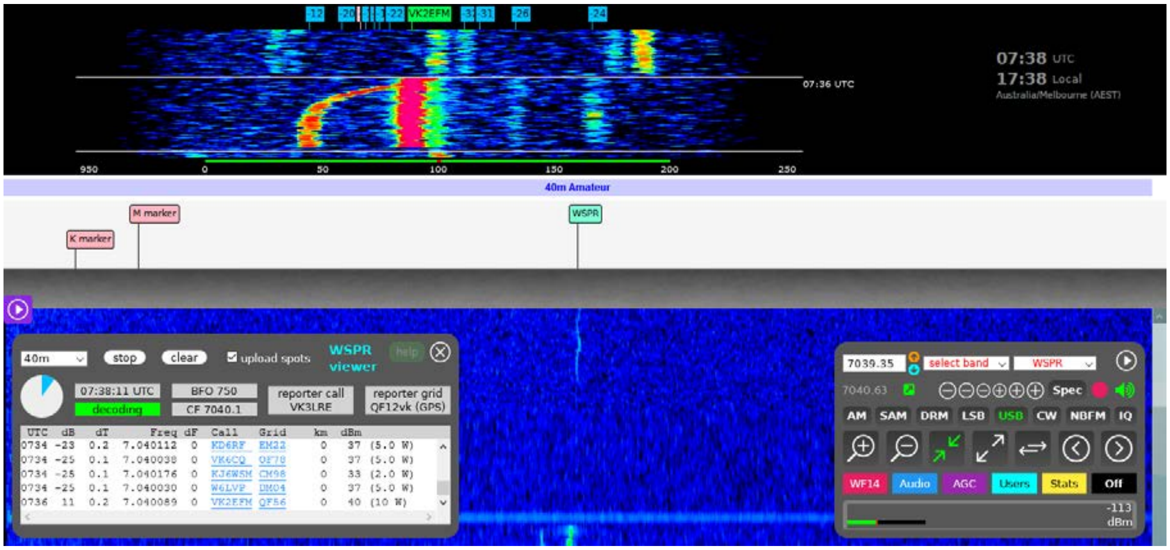


Fig. 11: WSPR Signal with very strong deformation due to air scatter (non decode) probably due to strong banking of aircraft after departure from MEL in Australia.

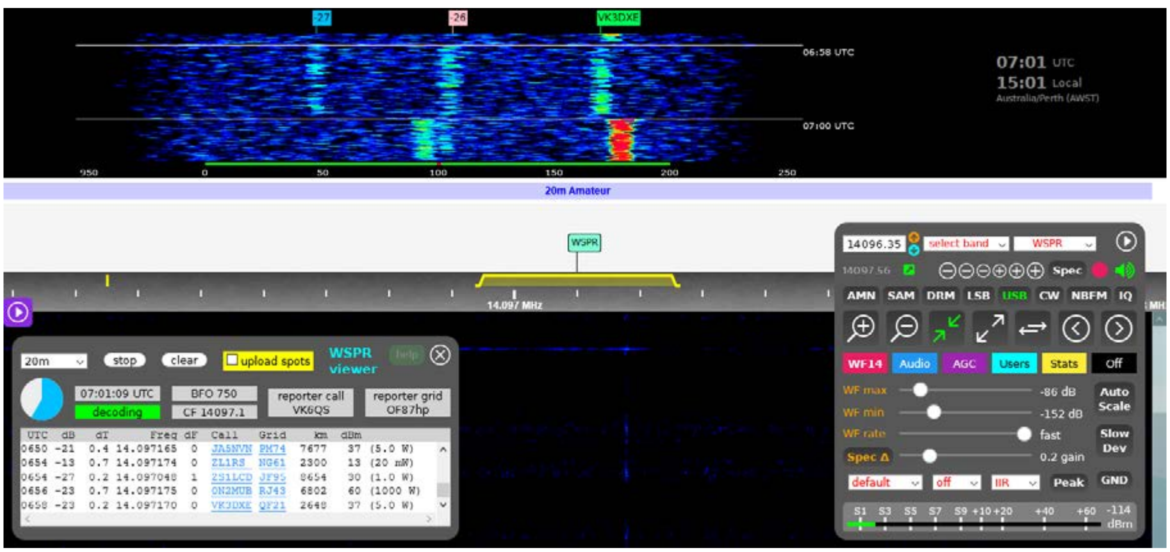


Fig. 12: WSPR signal from VK3DXE at VK6QS as in the night of flight MH370 at VK6ZRY as well as two non decodes with SNR and frequency values. Information lost in database.

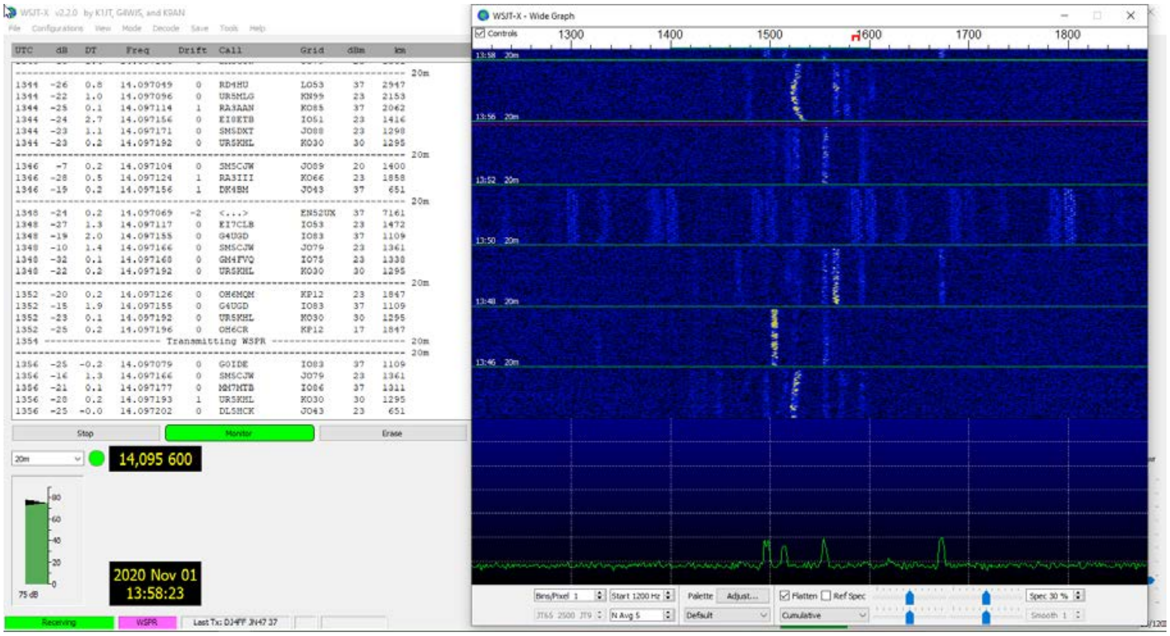


Fig. 13: "Moon shape" WSPR signal due to scatter in WSJT-X

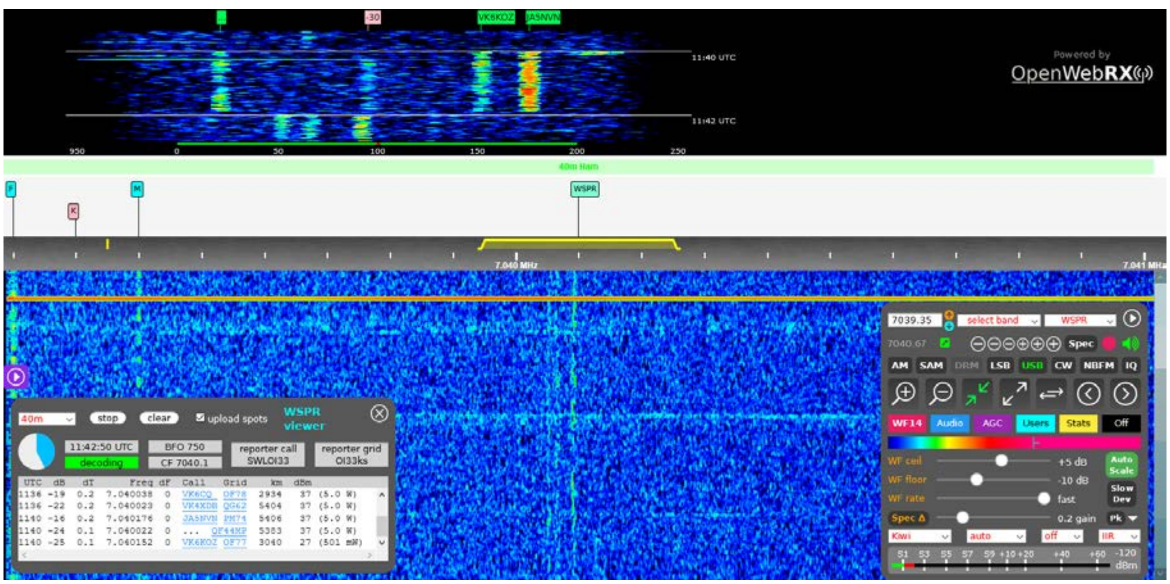


Fig. 14: Non decode on the left, SNR, Frequency and Gridlocator from Eastern Australia enable possible call sign identification

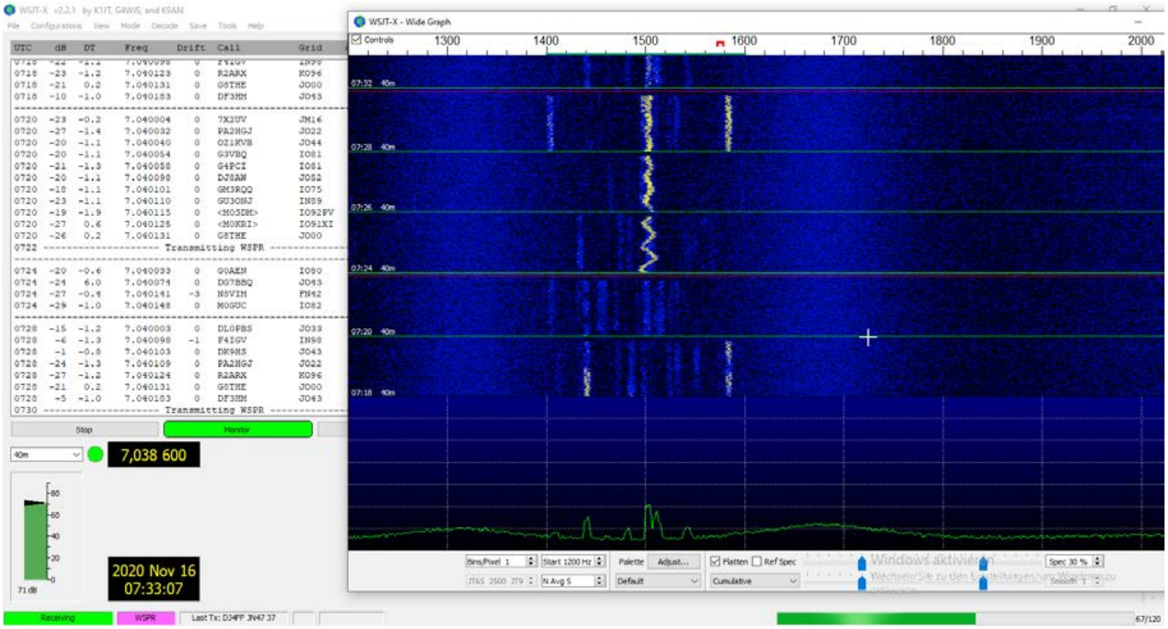


Fig. 15: WSPR signal of French WSPR station in Bretagne deformed to a "snake" in WSJT-X probably due to air scatter between two aircraft

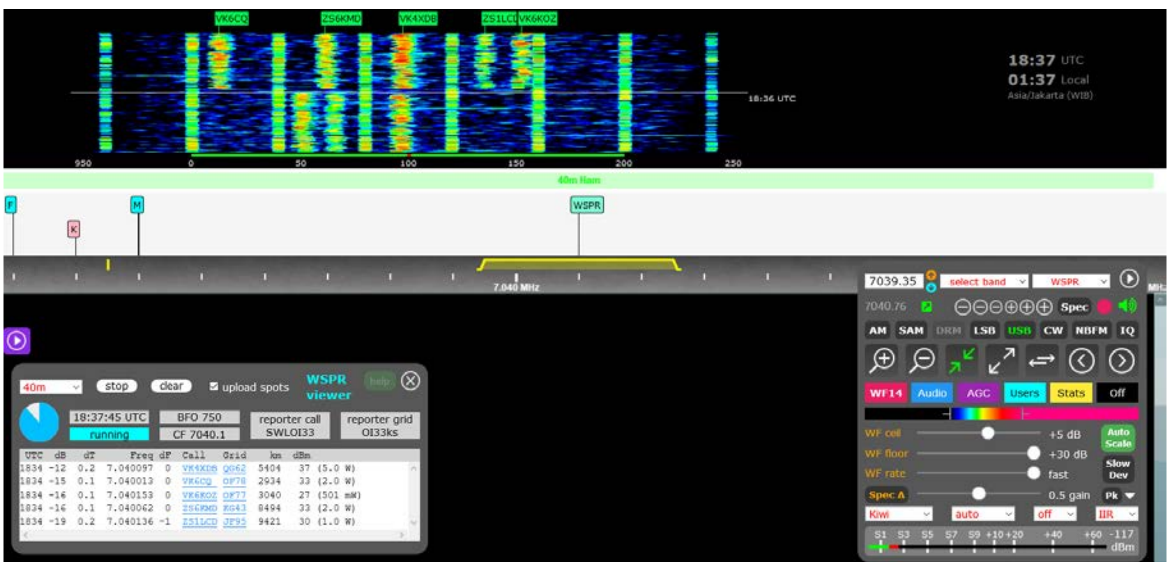


Fig. 16: Numerous WSPR signals received by SWLOI33 in Indonesia with interference by OTH Radar

1.1 Observations aircraft from, to and in Antarctica

Antarctica is mainly selected for the validation process as there will be not too many airborne vehicles to avoid ambiguities or confusion. November 2020 to March 2021 is „flying season“ in Antarctica.

This season 2020/2021 also offers the opportunity of having two active WSPR stations down there. DP0GVN at German Neumayer III station, grid locator IB59iu, and the German exploration ship and icebreaker Polarstern DP0POL/mm with varying positions in the Weddell Sea.

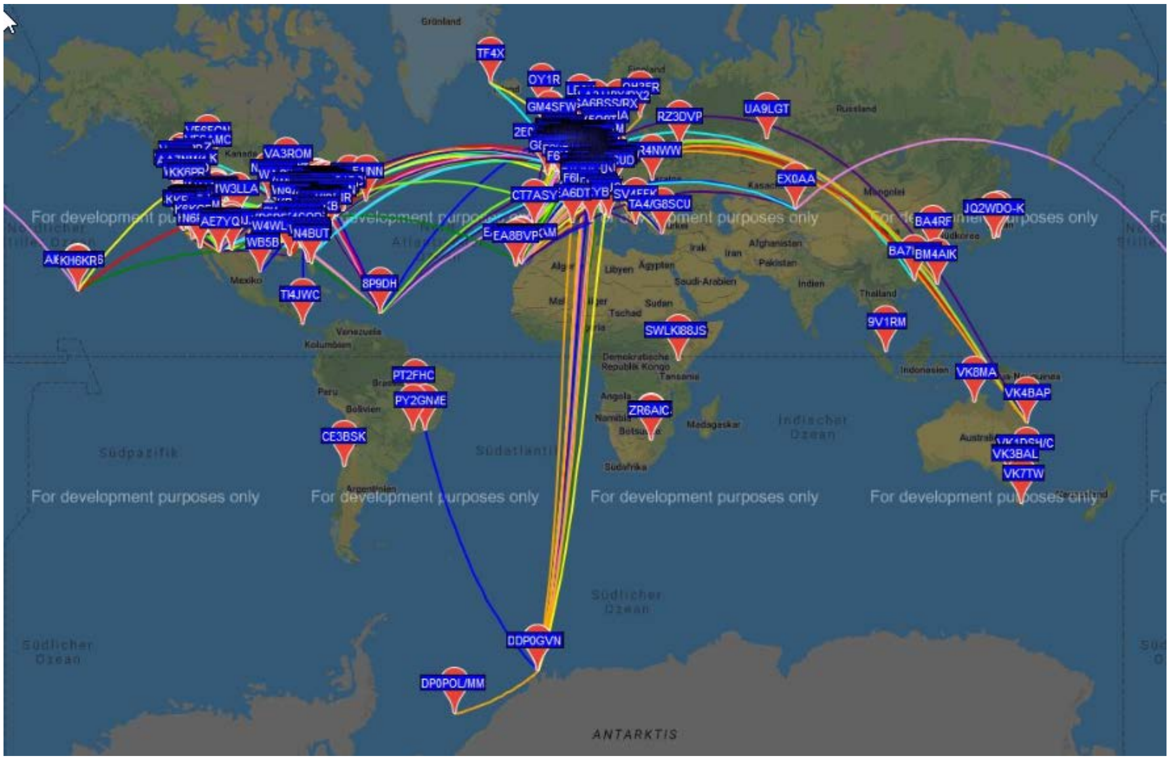


Fig.17 : DP0GVN and DP0POL/mm WSPR signal paths in Map function at www.wsprnet.org

WSPR detections have been made over up to 7.600 km from DP0GVN to ZL2005SWL in New Zealand. Airborne objects have been Iljuschin IL-76TD, Dassault Falcon 900EX, DC3C (Basler), Airbus helicopters H125, Boeing 787-9 and Airbus A319-115 (ER) of AAD. ADS-B data vom FR24

Aviation Entry Points to Antarctica:

ADL, BNE, MEL, PER, SYD: Boeing B787-9 (QFA)

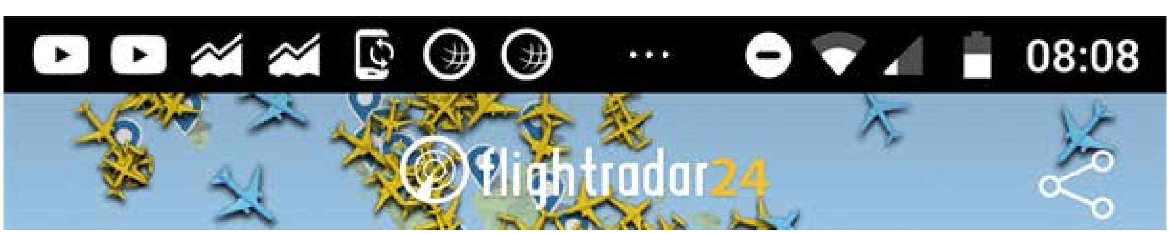
Capetown (CPT): IL-76TD, Falcon 900EX, B767, Gulfstream G550

Tasmania Hobart (HBA): Airbus A319-115ER

CHC in NZ: C130H, C17 A Globemaster III

Rio Gallego (RGA), Argentina: C130 H

Antarctica: helicopters H125, DC3C



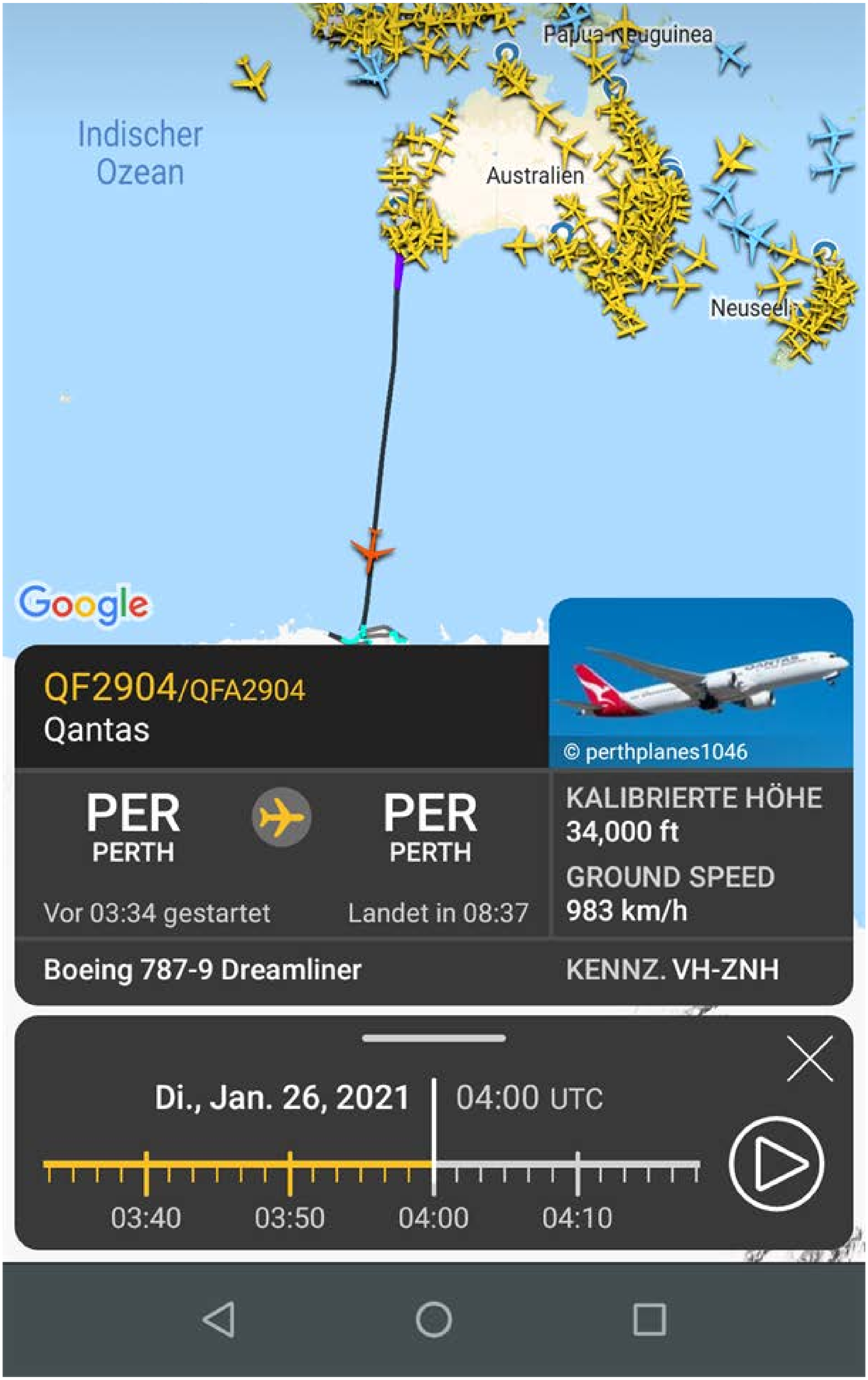


Fig.18: "Joy Flight" QFA2904 PER to PER via Antarctica used for WSPR tests to JH3APN RX and VK6CQ TX up to 1.500 km South of Perth

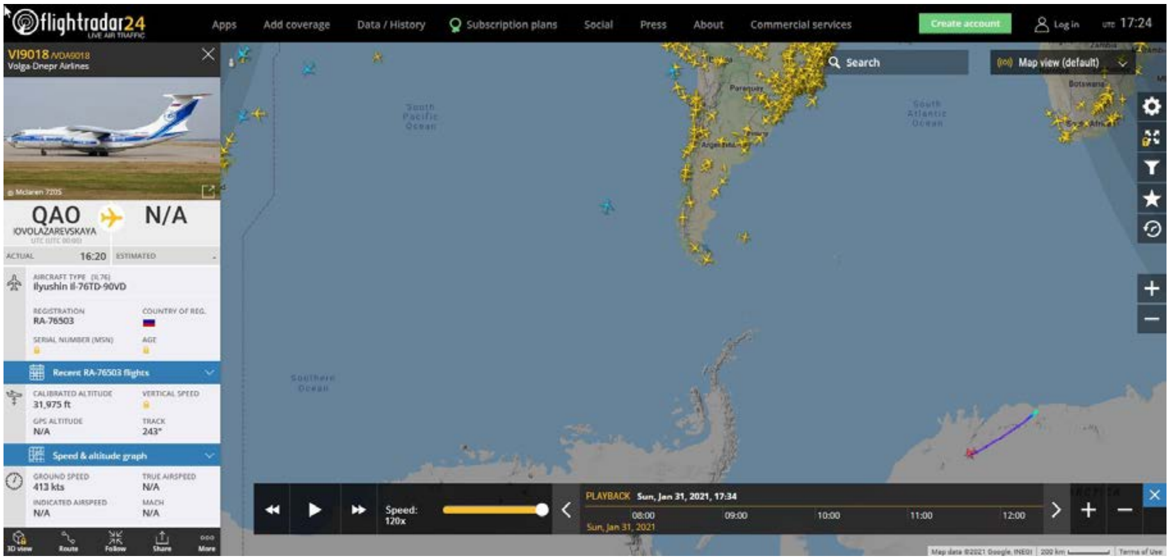


Fig.19: Iljuschin IL-76TD flying in Antarctica from QAO after arrival from Capetown (CPT)

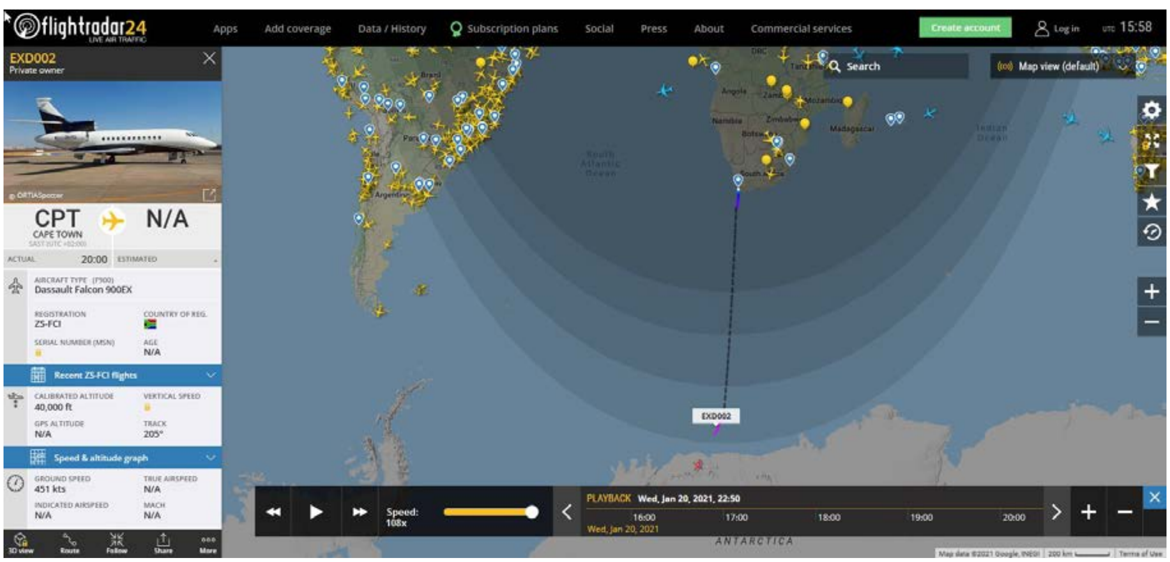
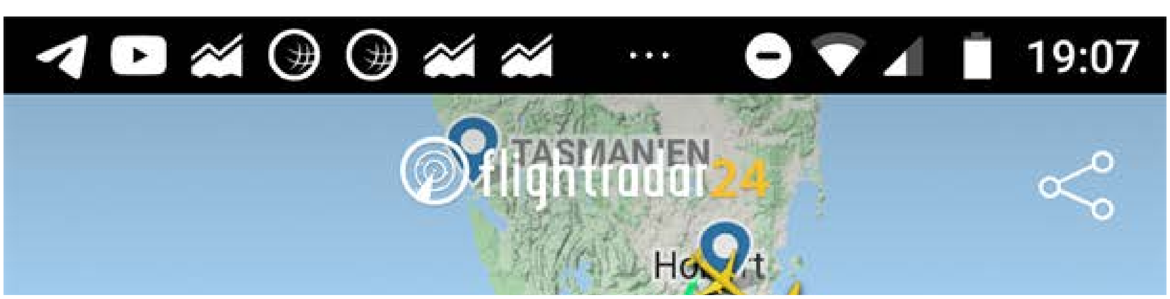


Fig. 20: Dassault Falcon 900 EX from CPT to QAO



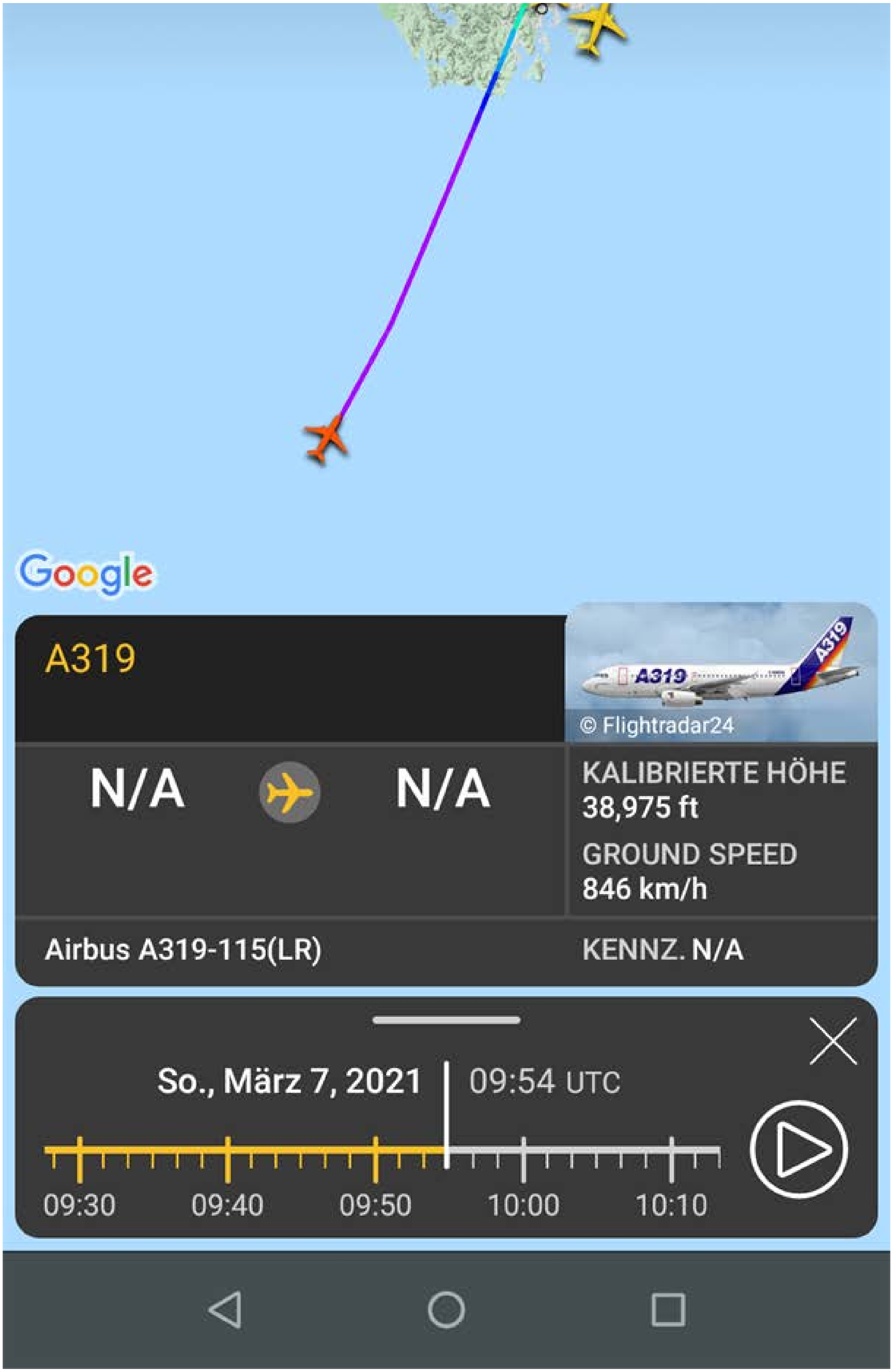
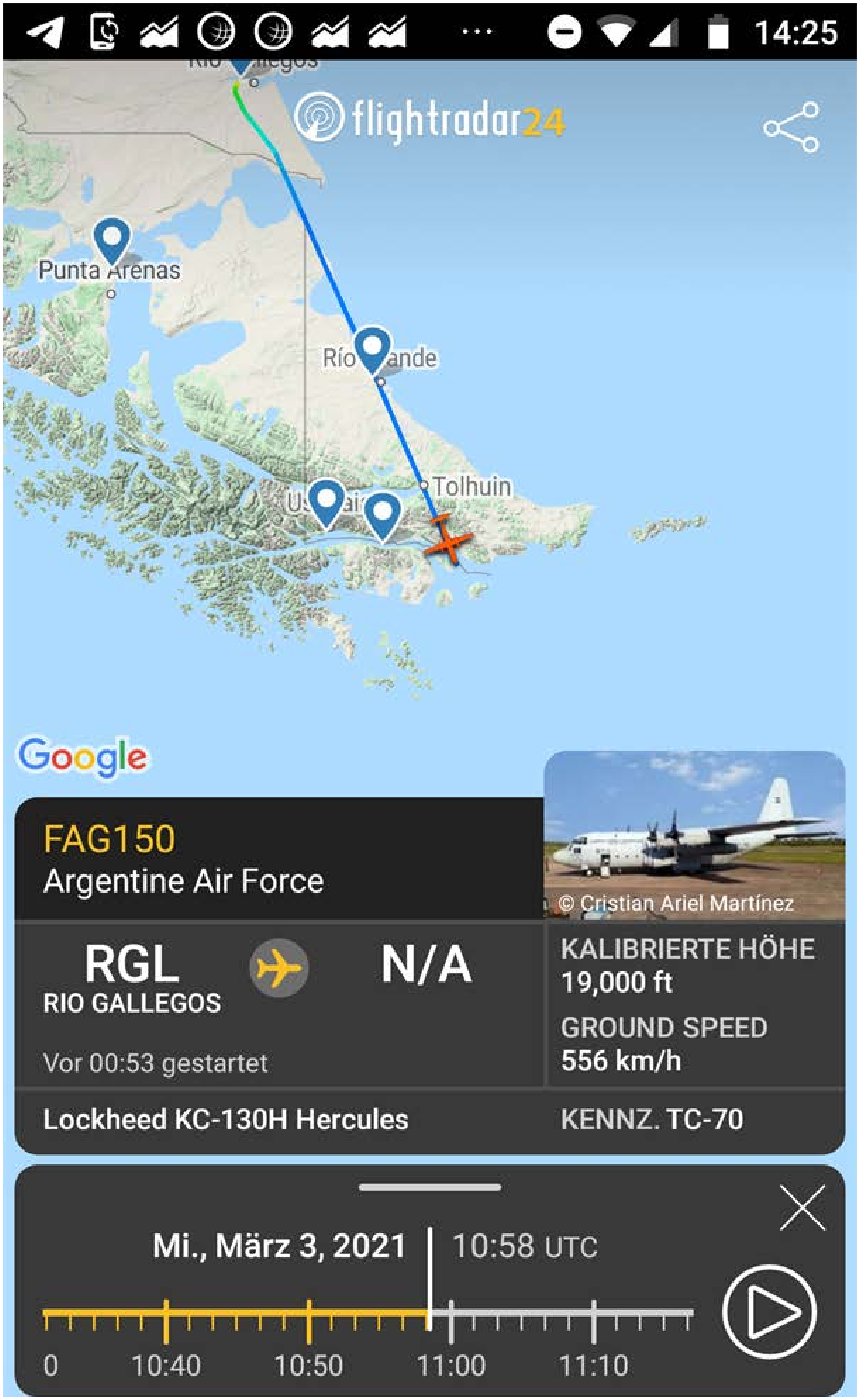


Fig.21: Airbus A319-115 ER from AAD on flight from Wilkins Aerodrome near Casey Station to Hobart (HBA)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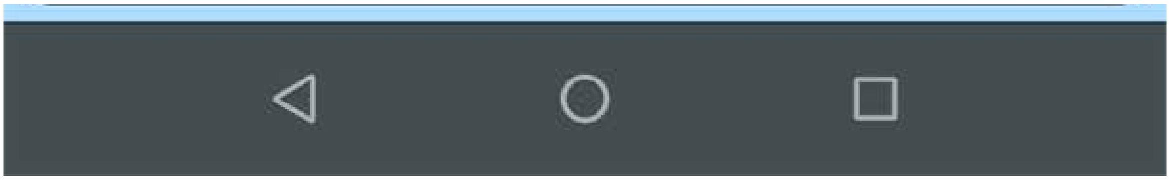

Fig. 22: Lockheed KC-130H from South America to Antarctica

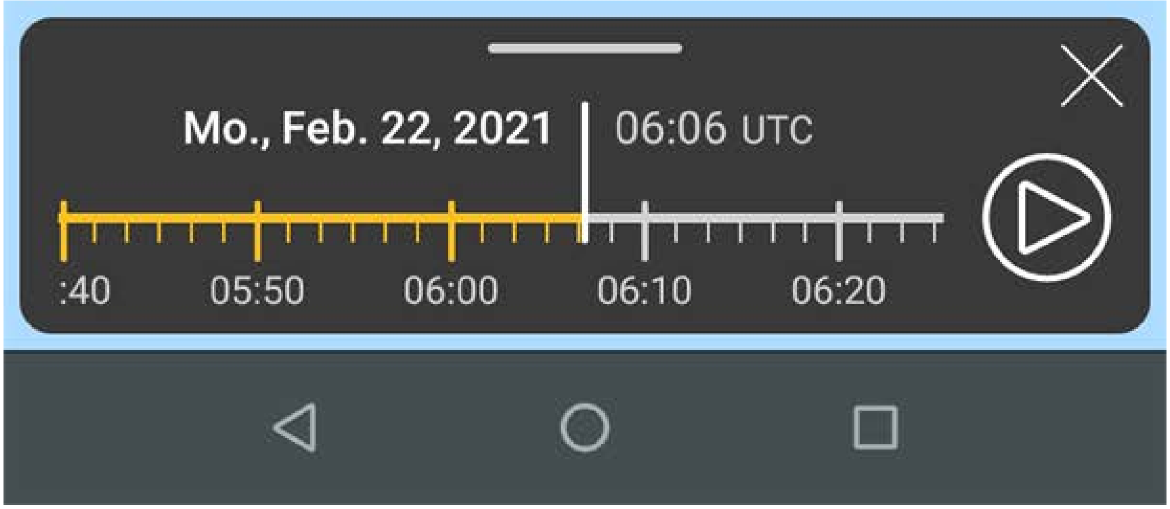

Fig. 23: C-17A GlobemasterIII from McMurdo Station to CHC (Christchurch in New Zealand)

VALIDATION IN 2020 AND 2021

2.Validation

In depth cooperation between radio amateurs and science is encouraged with regard to interpretation of the received HF signals with emphasis on ionospheric behaviour and anomalies at mid-latitude (app. -30 degrees, -90 degrees) in the Southern hemisphere.

WSPR data could eventually support the Inmarsat data and debris drift data by means of data fusion.

They could also provide evidence if the wreckage is resting in the SIO or close to the Christmas Islands (VK9) as another theory based on research with hydrophones suggests.

We use propagation software VOACAP Online for hams and FR24 for reference position data as well as the KiwiSDRs and the database www.wsprnet.org. Proplab 3.1 is an add on for raytracing.

Antarctica is mainly selected for the validation process as there will be not too many airborne vehicles to avoid ambiguities or confusion.

November 2020 to March 2021 is „flying season“ in Antarctica. This season 2020/2021 also offers the opportunity of having two active WSPR stations down there. DP0GVN at German Neumayer III station, grid locator IB59iu, and the German exploration ship and icebreaker Polarstern DP0POL/mm with varying positions in the Weddell Sea.

WSPR detections have been made over up to 7.600 km from DP0GVN to ZL2005SWL in New Zealand.

Airborne objects have been Iljuschin IL-76TD, Dassault Falcon 900EX, DC3C (Basler), Airbus helicopters H125, Boeing 787-9 and Airbus A319-115 (ER) of AAD. ADS-B data vom FR24 have been used as reference.

These many airborne detects clearly demonstrate that the detection of airborne vehicles is feasible depending on the space weather conditions. The physical process of the WSPR detection needs further scientific investigations.

Repatriation flight Qantas QFA114 from Johannesburg (JNB) to Perth (PER) has been analyzed for validation purposes. This was one of the very rare flights across the Southern Indian Ocean (SIO) during the pandemic COVID-19 in the second half of 2020.

The jet passed over the estimated „Last Estimated Position“ (LEP by IG) at app. 22:48 h UTC. WSPR Signal analysis showed numerous West-East as well as East West connections between South Africa (ZR, ZS) and Western Australia (VK6) as well as other parts of Australia (VK3, VK5, VK7,….).

In addition North South links from Costa Rica (TI4), Mexico (XE3) to USA and Canada on great circles have been logged. In 2020 there was much more WSPR traffic than in 2014 so we do not have that many data for flight MH370 as have been documented for Flight QFA114.

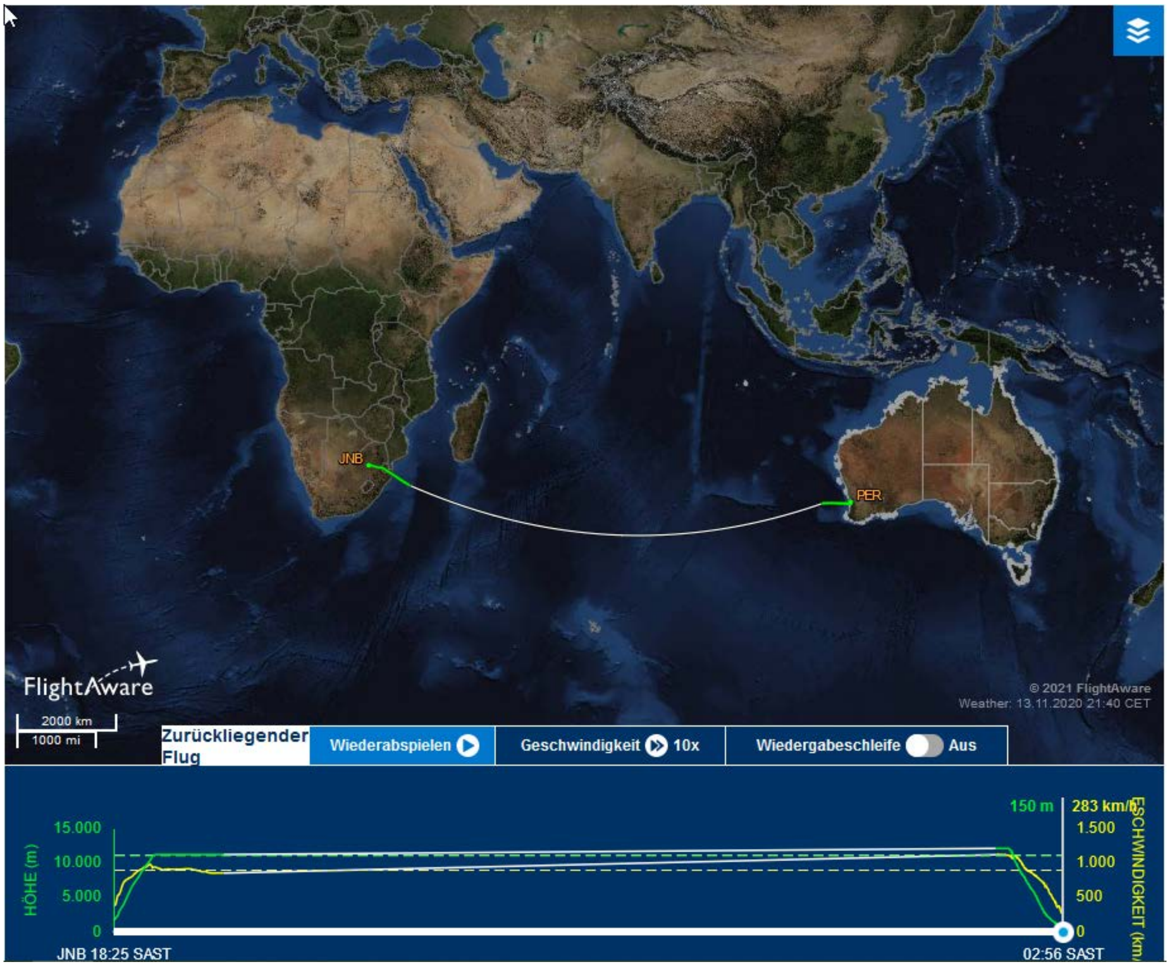

Fig. 24: Flight QFA114 from JNB to PER passing over near IG LEP of MH370 (Flightaware)

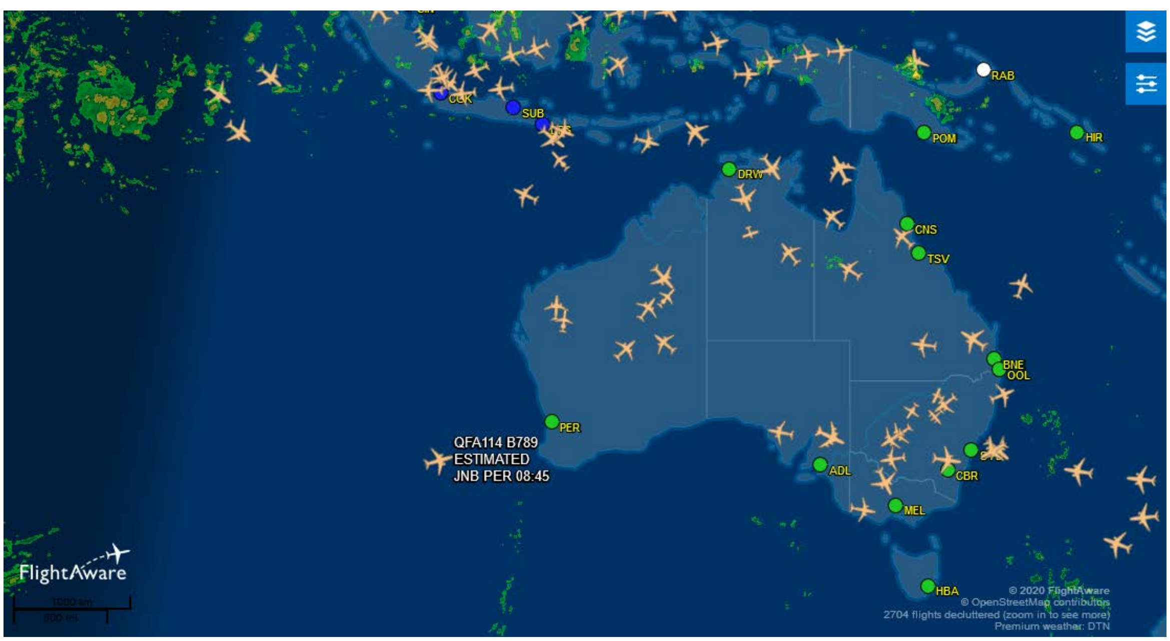

Fig. 25: Flight QFA114 in proximity of IG LEP west of Perth

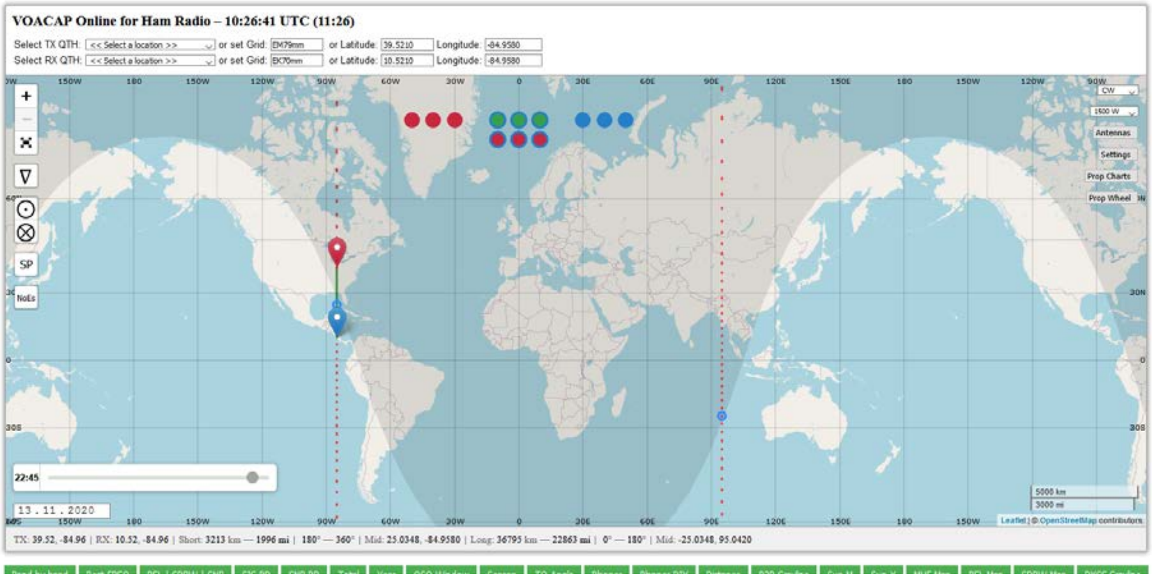

Fig. 26: Great circle for flight QFA114 from Costa Rica (TI4) as RX via Canada, USA (TX) to IG LEP longitude of 93,8 degrees (Illustration VOACAP Ham Online)

Now we can establish guidelines how to approach and conduct a detection process by using WSPR in improve that procedure in the future..

As WSPR has been designed as a „Weak Signal Propagation Reporting System“ it is a very poor detection, location and tracking system. We use it anyway due to the lack of better systems for the search of flight MH370 in 2014.

The following example illustrates the detection of two Airbus H125 helicopters at Australian Davis station by RX ZL2005SWL close to Nelson in New Zealand.

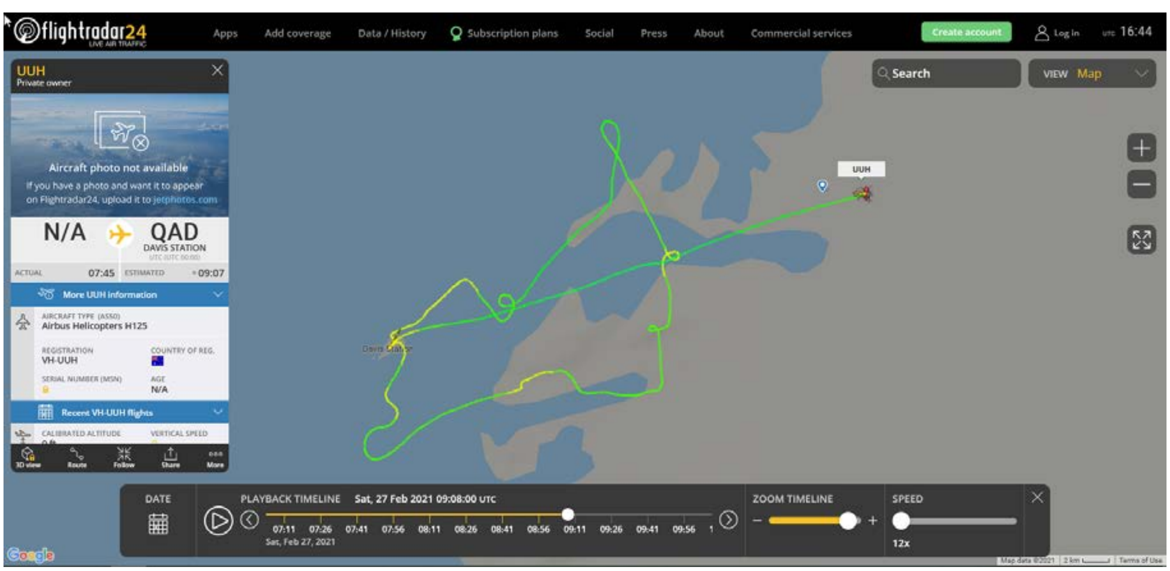

Fig. 27: 2 helicopters Airbus H125 close to Davis Station in Antarctica detected by WSPR

Spot Database

Specify query parameters

6 spots:

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az	Mode
2021-02-27 09:08	DP0GVN	10.140142	-17	0	IB59ui	5	ZL2005SWL	RE68mx	7598	181	2
2021-02-27 08:54	DP0GVN	10.140141	-16	0	IB59ui	5	ZL2005SWL	RE68mx	7598	181	2
2021-02-27 08:24	DP0GVN	10.140141	-13	0	IB59ui	5	ZL2005SWL	RE68mx	7598	181	2
2021-02-27 08:08	DP0GVN	10.140141	-19	0	IB59ui	5	ZL2005SWL	RE68mx	7598	181	2
2021-02-27 04:28	DP0GVN	18.106046	-24	0	IB59ui	5	ZL2005SWL	RE68mx	7598	181	2
2021-02-27 02:28	DP0GVN	18.106046	-20	0	IB59ui	5	ZL2005SWL	RE68mx	7598	181	2

Query time: 0.450 sec

Link to old database interface

Fig. 28: WSPR signals from DP0GVN to ZL2005SWL during flights of the H125 at Australian Davis Station

VERIFICATION ON SEARCH FOR MH370

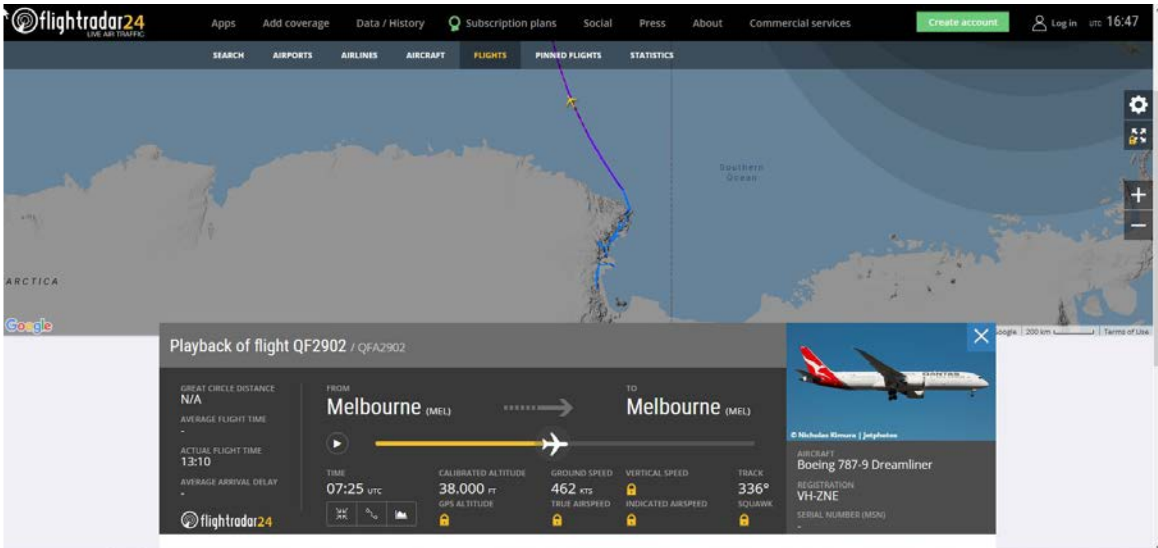

Fig. 29: QFA2902 "Qantas joy flight" QFA2902 from MEL towards McMurdo Station and back to Melbourne (MEL)

Reference location data were used from Flightradar24 (FR24).

WSPR stations in Antartica were DP0GVN and the exploration ship Polarstern DP0POL/mm.

QFA2904 flight (PER to PER) via Antarctica heading 180 degrees and retour were used to study backscatter effects from 1.500 km South of Perth (VK6) to Japan (JH3APN) as RX, VK6CQ as TX.

Data have been gathered for the whole flight MH370 duration of app. 8 hours with signals from 7 MHz to 28 MHz and stations from Europe, Asia, North and South America as well as Australia and New Zealand. WSPR signals indicate the U-turn of flight MH370 at 17:22 h UTC on 2014.03.07.

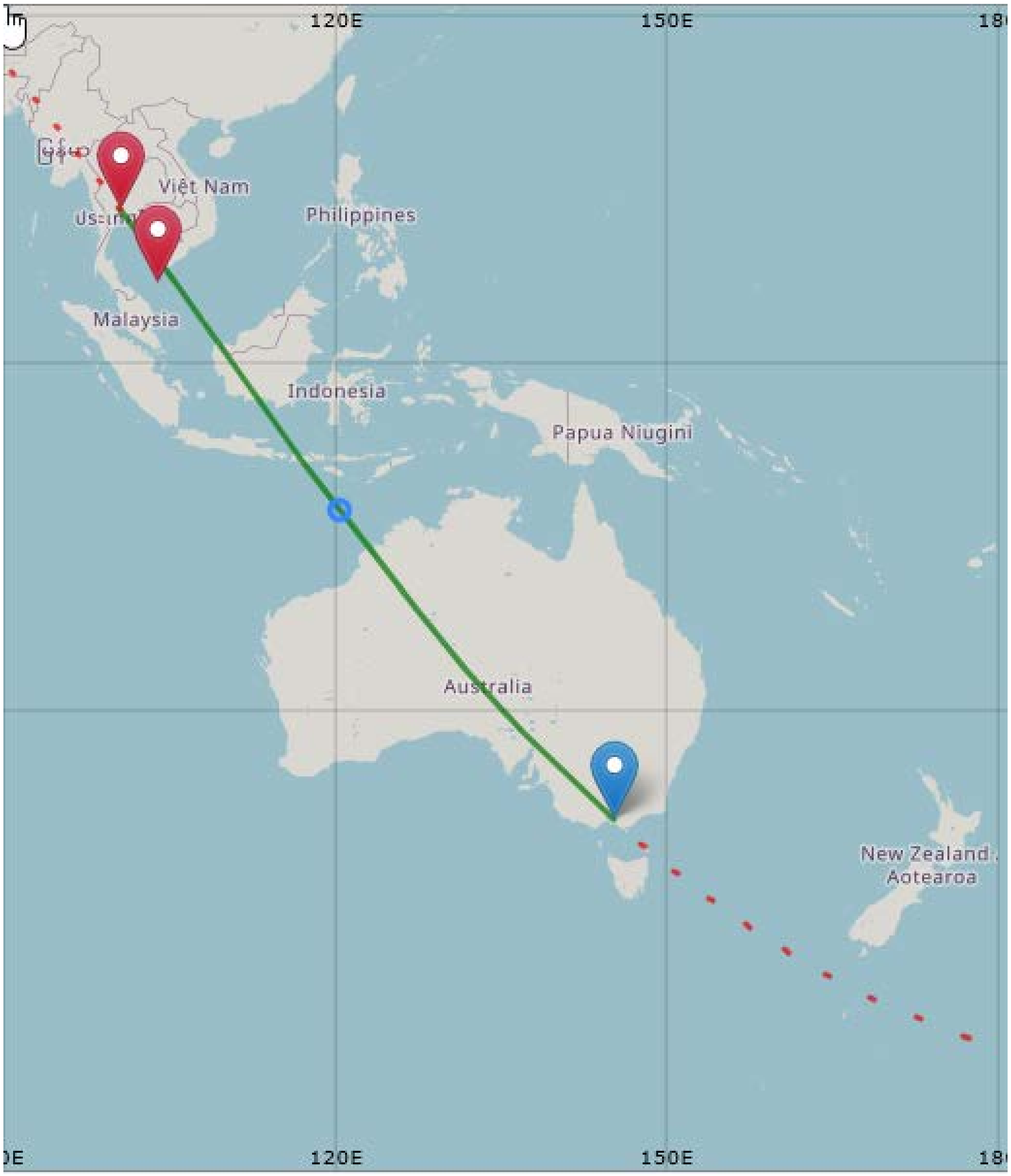

Fig. 30: Position of MH370 at U-Turn (17:22 h UTC) and signal path HS0ZKM TX to VK3DXE RX (in addition VK1CH), both drift rate -1 Hz/min (Illustration VOACAP Ham Online)

Especially the „end game“ or final phase offers a lot of data for Grayline, night and day reception, possible 28 MHz backscatter, short path (SP) as well as long path (LP) propagation. Trajectories have been studied by means of VOACAP etc.

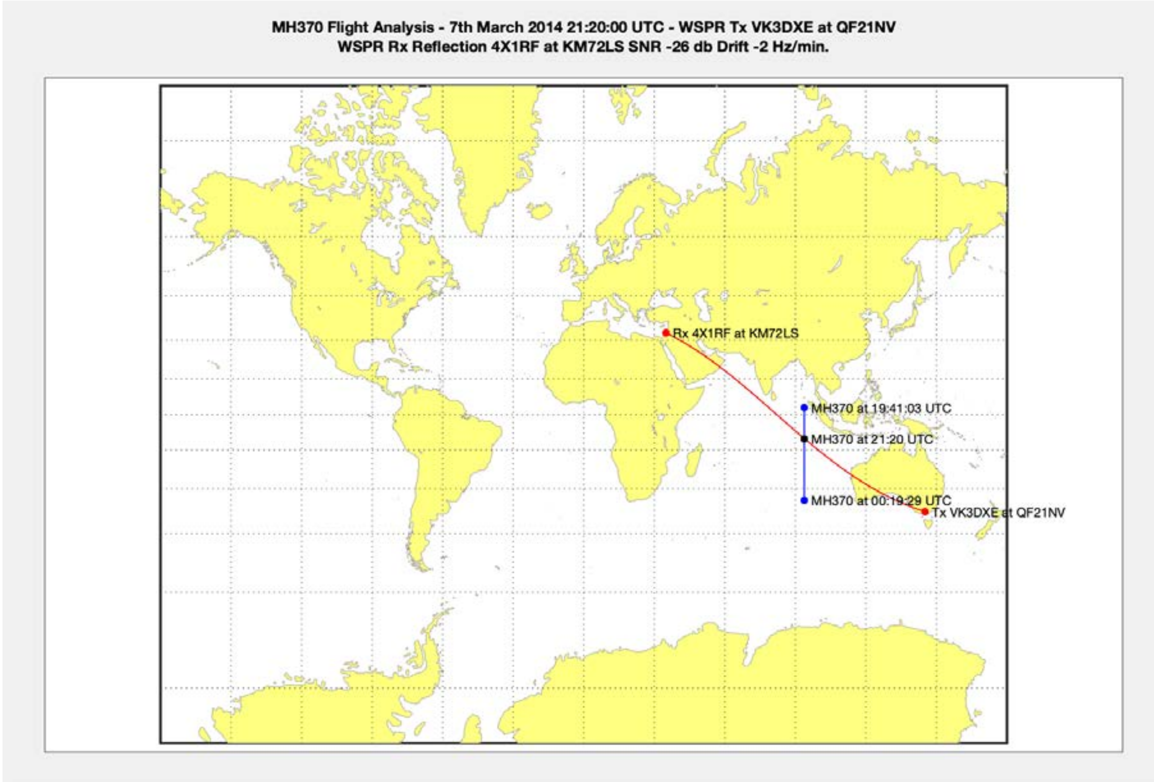

Fig. 31: Midcourse WSPR detection between RX 4X1RF and TX VK3DXE at 21:20 h UTC matched to Inmarsat data (Graphics courtesy of Richard Godfrey)

Fig.32: VK6ZRY as RX, VK7FI as TX and MH370 IG LEP (-34,2 degrees; 93,8 degrees) around midnight of Flight MH370

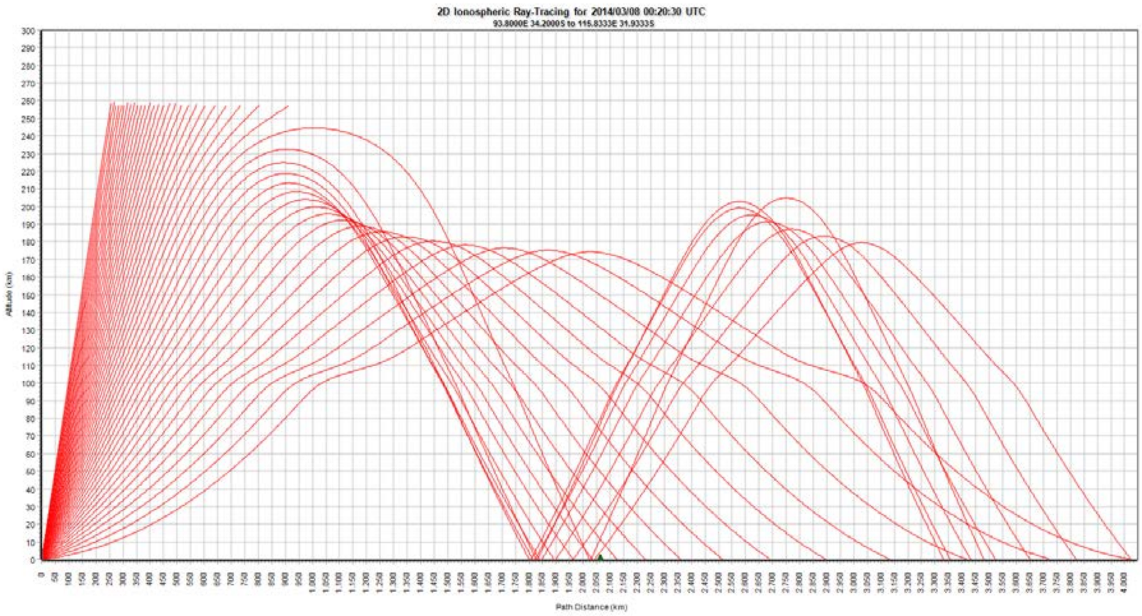

Fig. 33: Ray tracing between IG LEP and VK6ZRY in Perth (Proplab 3.1)

Final Phase of flight MH370

There have been various WSPR signals between midnight and 1 h UTC. VK6ZRY received VK7FI on 14 MHz numerous times as well as HS0ZKM one time at 00:36 h UTC. We have to analyze several clusters.

1. VK6ZRY as WSPR RX station, VK7FI TX, 14 MHz

2. VK6ZRY RX and HS0ZKM rather late (perhaps flight EK425) on 14 MHz?

3. Reception of WSPR signals in VK3, VK7, ZL

4. Analyis of signals on great circles from YV4, CX and ZP in South America passing through IG's LEP

5. Analysis of numerous 28 MHz signals for SP and LP

6. Analysis of "strange" signals from FR5, TJ3, etc.

7. Analysis of signal paths on great circles through longitude of IG LEP (93.8 degrees)

8. Others yet to be identified

In depth cooperation between radio amateurs and science is encouraged with regard to interpretation of the received HF signals with emphasis on ionospheric behaviour and anomalies at mid-latitude (app. -30 degrees, -90 degrees) in the Southern hemisphere.

WSPR data could eventually support the Inmarsat data and debris drift data by means of data fusion.

They could also provide evidence if the wreckage is in the SIO or close to the Christmas Islands (VK9) as another theory based on research with hydrophones suggests.

On the other hand we are in urgent need for more ADS-B reference data on other aircraft than MH370 in the region of Oceania for the whole flight duration of doomed flight MH370.

DISCUSSION

The analysis of WSPR signals during the doomed flight of MH370 could eventually support the other data and information collected since 2014 such as Inmarsat data IOR, debris drift analysis, hydro phone detections, analysis of aircraft debris, military and civil radar data etc.

The wreckage of MH370 probably cannot be located by using just WSPR data, data fusion with other sensor data, especially Inmarsat pings, may possibly provide further clues and indications.

The work on WSPR data for aircraft detection is fairly new, just over 6 months, so more effort will have to be invested. More ADS-B data from other aircraft in the region of Oceania is a need for reference to avoid false alarms.

We have already have enough data from flight MH370 to prove certain conspiracy theories wrong that claim the wreckage of MH370 to be located outside the Southern Indian Ocean (SIO).

MH370 WSPR data might be further analyzed by using SuperDARN data in the Southern hemisphere provided by the Chinese radar ZHO (beam 0) looking North East.

Data for that night of MH370 are in existence. Current slant ranges are app. 2.500 km, that may not be far enough to look at MH370 IG LEP.

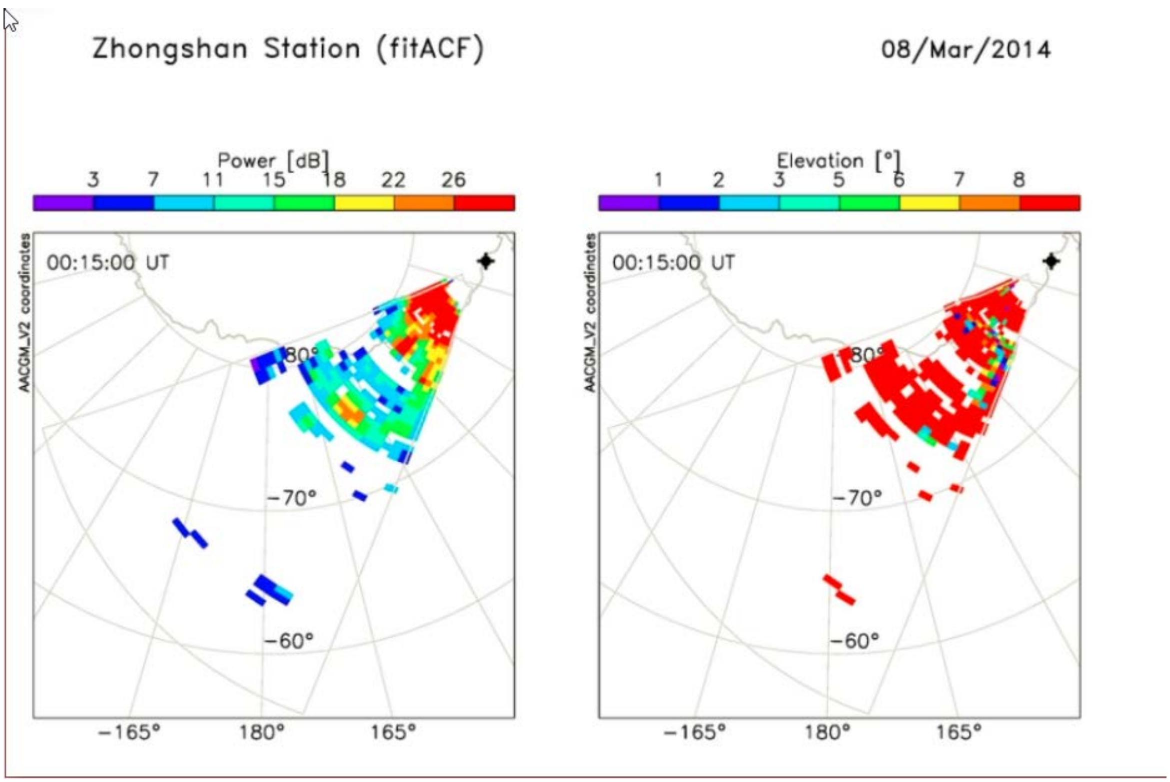

Fig. 34: SuperDARN data Southern hemisphere ZHO at 00:15 h UTC on March 8, 2014 at low elevation angles (Illustration from Virginia Tech SuperDARN website)

WSPR data from the Surface Search flights by ATSB are in existence in the WSPR database wai-ting to be analyzed for any clues on space weather as well as WSPR conditions in March and April 2014 to help locate the wreckage of MH370.

The combination of results from flight QFA-114 with emphasis on great circle detection other than ZS to VK and vice versa, such as from Mexico (XE), Costa Rica (TI) to Canada and USA and others.

Surface Search flights WSPR data in March and April 2014, MH370 WSPR data in the the database www.wsprnet.org and additional ADS-B reference data in the region of Oceania form a big data pool waiting to be analyzed in the future.

CONCLUSION

WSPR is very versatile and can detect flying aircraft under certain conditions and ionospheric circumstances.

Especially „aircraft spotting“ in Antarctica has been demonstrated over thousands of kilometers. In addition these effects can be used by WSPR stations with poor antennas to enhance their radio range in WSPR by scatter via aircraft or ISS.

Aircraft detection by WSPR is also feasible in the past back until March 2008 by adequate use of the WSPR database www.wsprnet.org for various events.

Further investigation regarding ionospheric influence on the process of aircraft WSPR detection is required. Reference data for location such as ADS-B data are highly recommended and more of these ADS-B data are in need for the region of Oceania in March 2014.

Propagation software tools such as VOACAP Online for hams and Proplab 3.1 for ray tracing etc. are helpful and recommended as well.

More intense research on the WSPR data of MH370 in midcourse and final flight phase will have to be accomplished.

Amateur radio can provide a great toolbox in order to achieve faster solutions for possible future cases such as MH370. Air Traffic Control is still not able to detect and track longhaul flights without active location transmitters aboard the aircraft. „Stealth aircraft“ are still unvisible at presence.

WSPR non-detects should temporarily be stored in the WSPR database for 24 hours to one week for optional analysis in the case of a future emergency disappearance of an aircraft such as MH370 in 2014.

Future installations by radio amateurs such as space weather monitoring, remote SDRs globally distributed, ADS-B receivers can be merged to an IARU global system (AAOMS) not only to monitor band intruders but to provide a potent MIMO tool by amateur radio communities in order to prevent another years long tragedy such as MH370 which is still missing after 7 years of Search, the biggest mystery in modern aviation until today.

Monitoring space weather, WSPR reception and a ready to use alert system can be provided in one adequate system for ham radio under the supervision of IARU and deployed in the near future just in time to the 100th anniversary of IARU in April 2025.

Availabitlity of such a global MIMO monitoring system also has the potential to attract younger people to amateur radio in the coming years as it will better fit their habits of gaming, Internet, Smartphones, Geocaching, Software etc..

This will resemble a modern form of "Geocaching" in the ionosphere as well as serving mankind in aviation, space weather, during emergencies and other applications.

In addition this might help amateur radio transitioning from classic ham radio for more than 100 years point-to-point connections towards future mesh connections and MIMO systems being more attractive to modern "Smartphone and Internet" kids.

Science and modern communications will form a web of wireless data fusion and analysis for the years beyond 2025 in amateur radio linked to aviation, space, remote sensing, data fusion and research.

DISCLOSURES

Acknowledgements

I want to express my gratitude to Dr. Karl Herrmann, DL2NGT, for continuous support and assistance with regard to this very special WSPR application and the simulations in Proplab 3.1 as well as Richard Godfrey from the Independent Group who provides valuable advice and support with regard to all the various aspects in the search for MH370. In memory of Dennis Workman, active blogger on www.mh370search.com and www.mh370.radiantphysics.com who unexpectedly passed away end of February 2021.

AUTHOR INFORMATION

Robert Westphal

DJ4FF

radio.scatter370@gmail.com

ABSTRACT

„Geocaching“ in the ionosphere – The Search for MH370 by the amateur radio community

Malaysian Flight MH370, a modern airliner B777, disappeared seven years ago on 2014.03.08 seemingly without a trace. Experts from various fields (i.e. Inmarsat) did not prevail til today.

Maybe ham radio can contribute by using stored WSPR data from the database www.wsprnet.org.

The data for that night's tragedy as well as the SAR operations exist in addition to many air acci-dents (AF447, MH17,...). The doomed flight happened close to the peak of solar cycle 24.

In 2021 we have detected several aircraft in Antarctica such as a B787-9, two Dassault Falcon 900EX, an Iljuschin IL-76TD and a DC3C commuter airplane by conducting WSPR tests between DP0GVN as TX and ZL2005SWL as RX. Reference location data were used from Flightradar24.

WSPR stations in Antartica were DP0GVN and the exploration ship Polarstern DP0POL/mm. QFA2904 flights to Anatarctica heading 180 degrees and retour were used to study backscatter effects from Perth (VK6) to Japan (JH3APN).

Additional tests have been done in 2020 with repatriation flight QFA114 between JNB and PER over the Southern Indian Ocean (SIO). Other WSPR testing between ZS and KH6 and daily flights SIA478 and 479 have been conducted by monitoring WSPR data on www.wsprnet.org (secondary data) and www.kiwisdr.com (570 receivers worldwide with raw or primary data).

Data have been gathered for the whole flight duration of app. 8 hours with signals from 7 MHz to 28 MHz and stations from Europe, Asia, North and South America as well as Australia and New Zealand. WSPR signals indicate the U-turn at 17:22 h UTC. Especially the „end game“ offers a lot of data for Grayline, night and day reception, possible 28 MHz backscatter, short path (SP) as well as long path (LP) propagation. Trajectories have been studied by means of VOACAP etc.

In depth cooperation between radio amateurs and science is encouraged with regard to interpreta-tion of the received HF signals with emphasis on ionospheric behaviour and anomalies at mid-latitude (app. -30 degrees, -90 degrees) in the Southern hemisphere. WSPR data could eventually support the Inmarsat data and debris drift data by means of data fusion. They could also provide evidence if the wreckage is in the SIO or close to the Christmas Islands (VK9) as another theory based on research with hydrophones suggests.

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Websites:

www.mh370search.com

www.mh370.radiantphysics.com

www.370loaction.org

www.mh370-captio.net

Basic Tools:

Libre Office

VOACAP Online for Hams

KiwiSDRs at www.kiwisdr.com in WSPR Mode (rider: extension)

www.wsprnet.org

www.flightradar24.com website and App

www.flightaware.com website and App

Additional Tools:

Proplab3.1 for hop calculation and ray tracing

www.isstracker.com

www.spaceweather.com

Abbreviations:

AAOMS Advanced Amateur Radio Object Monitoring System

ACARS Aircraft Communications Addressing and Reporting System

ADS-B Automatic Dependent Surveillance – Broadcast

AMSA Australian Maritime Safety Authority

ATC Air Traffic Control

ATSB Australian Transport Safety Bureau

BEA Bureau d‘Enquetes et d‘Analyses pour la sécurité de l‘aviation

BFO Burst frequency Offset (Inmarsat)

BS Backscatter

BTO Burst Time Offset (Inmarsat)

CAPTIO Constraints on Alternative Piloted Trajectories in the Indian Ocean for MH370

CVR Cockpit Voice Recorder

DST Defence Science and Technology, Australia

FA Flightaware.com

FDR Flight Data Recorder

FFT Fast Fourier Transformation

FR24 Flightradar24

FS Forward Scatter

GNSS Global Navigation Satellite System (Baidu, Galileo, GLONASS, GPS,….)

GPS Global Positioning Satellite

HamSCI Ham Radio Science Citizen Investigation

HF High Frequency

IARU International Amateur Radio Union

IG Independent Group

Inmarsat International maritime satellite

ISS International Space Station

JNB Johannesburg Airport

KLIA Kuala Lumpur International Airport

LEO Low Earth Orbiting Satellite

LEP Last Estimated Position

LKP Last Known Position

LP Long Path

MART Malaysian Amateur Radio Transmitters Society

MEL Melbourne Airport

O., NL Onderzoeksraad in Netherlands – Dutch Safety Board Aviation

PER Perth Airport

PIC People In Command

RoW Rest of World

RX Receiver, receive

SAR Search And Rescue

SDR Software Defined Receiver

SDU Satellite Data Unit

SIN Singapur Airport

SIO Southern Indian Ocean

SK Silent Key (individual passed away)

SNR Signal-to-Noise-Ratio

SP Short Path

SS Side Scatter

SSR Secondary Surveillance Radar

SWL Short Wave Listener

TAPR Tuscon Amateur Packet Radio

TDoA Time Difference of Arrival

TX Transmitter, transmit

UTC Universal Time Coordinated

VOACAP Voice of America Coverage Analysis Program for HF Propagation Prediction and….

WSPR Weak Signal Propagation Reporter (Radio Mode designed by Nobel laureate K1JT)

WWV Callsign Radio Station time standard Fort Collins, CO, USA

XI Christmas Island (VK9)