



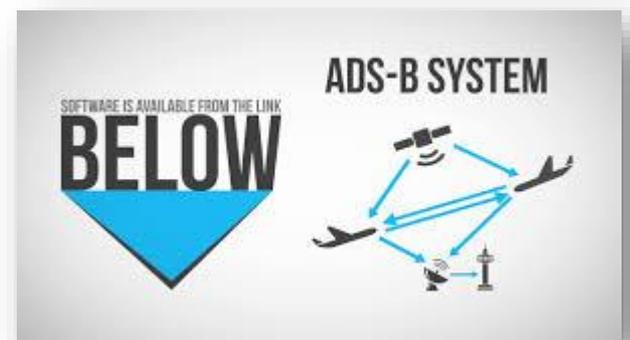
- Casper PA1CJ ADS-B, MLAT en hardware
- Erik PE1RQF Software en tooling
- Gerton PD0G Antennes

Geschatte tijd 60 minuten



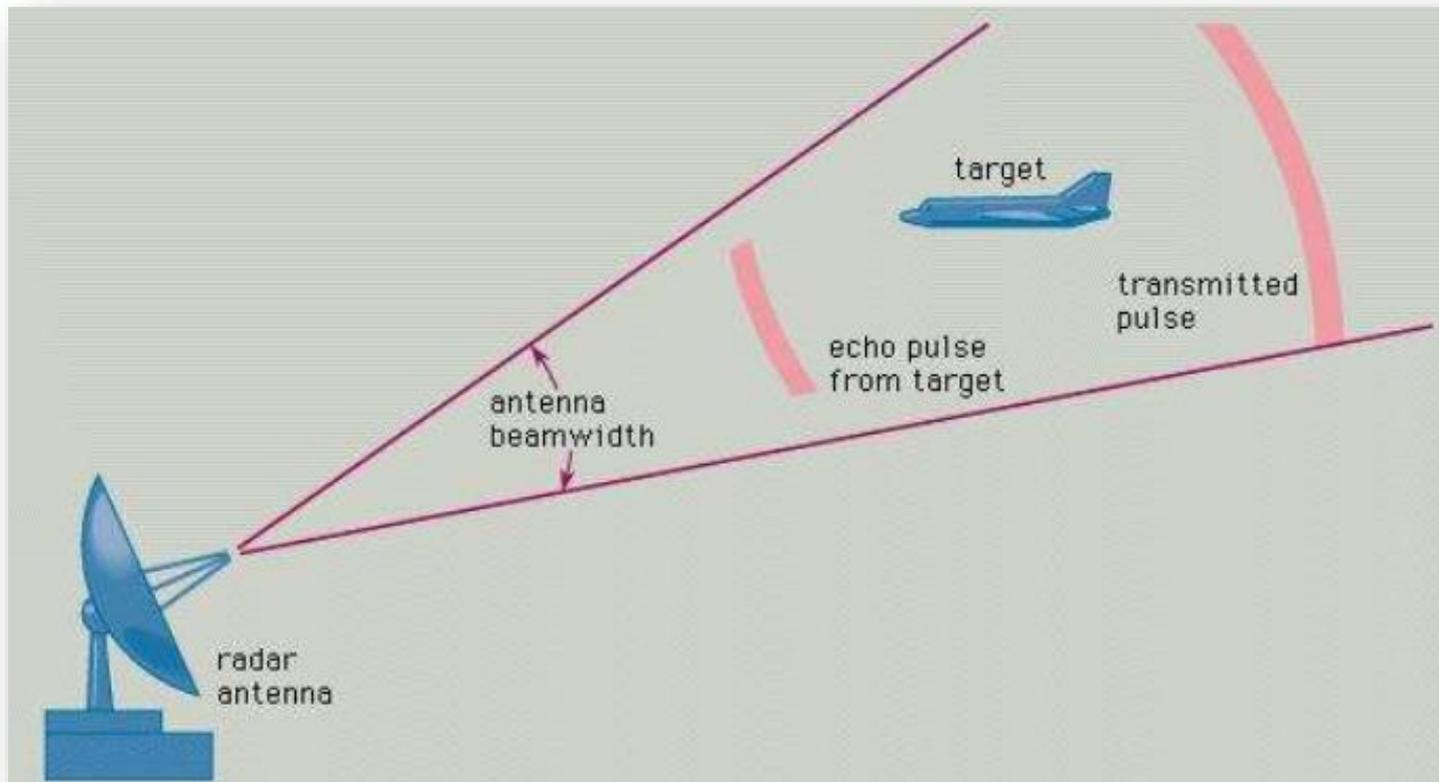
PA100

- Inleiding ADS-B en MLAT
- Hardware



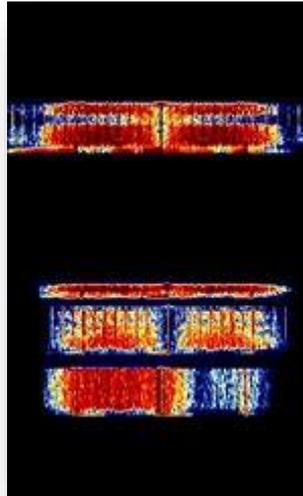
Positie bepaling

- Radar (primaire radar)



Positie bepaling - ACARS

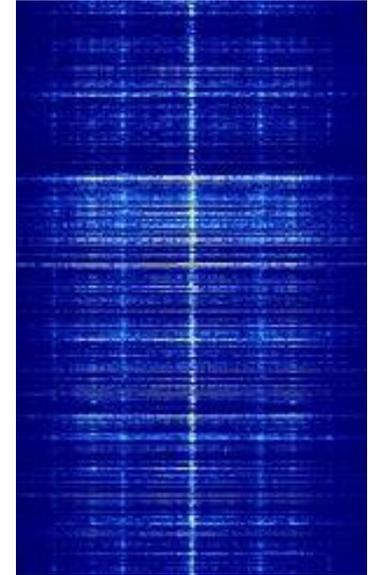
- Aircraft Communications, Addressing and Reporting System
- Short messages sent to and from aircraft
- 137 MHz AM 5KHz



Positie bepaling – ADS-B

- ADS-B (secondary radar)
- Automatic
 - : Verzendt automatisch periodieke informatie.
- Dependent
 - : De positie - en snelheidsvectoren zijn afgeleid van GPS
- Surveillance
 - : Driedimensionale positie en identificatie vliegtuigen of voertuigen.
- Broadcast
 - : Iedereen kan de informatie vrij ontvangen.

ADS-B



- Signaal freq: 1090 MHz AM
- Bandbreedte 50 kHz
- Packets van 112 bits data.

- Mode A: 4-cijferige code, max 4096 codes ICAO
- Mode C: Mode A + hoogte informatie
- Mode S: Mode C + 16 miljoen code's ICAO
- **Mode S + ADS-B: Mode S + additionele informatie (o.a. positie, koers, snelheid en alarmeringen)**

Positie bepaling – MLAT

- MLAT (Multilateration)
- WAM (Wide Area Multilateratie)





Wat is te zien?



- Burgerluchtvaart met ADS-B transponder
- Commercieel verkeersvliegtuigen
- Helikopters
- Particuliere vliegtuigen
- Zweefvliegtuigen



- Ook zonder ADS-B zijn ze zichtbaar met MLAT

Ambulances - MLAT

- Call Sign LIFELN1 Amsterdam
- Registratie nummer PH-HVB
- Flex1600 code 0120901

- Call Sign LIFELN2 Rotterdam
- Registratie nummer PH-ELP
- Type Eurocopter EC135 T2
- Flex1600 code 1420059

- Call Sign LIFELN3 Volkel
- Registratie nummer PH-ULP
- Type Eurocopter EC135 T2
- Flex1600 code 0923993

- Call Sign LIFELN4 Eelde
- Registratie nummer PH-MMT
- Type Eurocopter EC135 P2+
- Flex1600 code ???

- Call Sign MEDIC01 Leeuwarden
- Registratie nummer PH-OOP
- Type Airbus Helicopters H145
- Flex1600 code ???

- Reserve LIFELN?? Lelystad
- Registratie nummer PH-TTR
- Type Eurocopter EC135 P3
- Flex1600 code ???



Brandstof tanken op regionale vliegvelden (ook zonder baanverlichting) als Texel, Ameland, Hoogeveen en Oostwold en Hilversum (test)

Politie - MLAT

- Politiehelikopter 01
- Call Sign ZXP01
- Registratie nummer PH-PXA



- Politiehelikopter 03
- Call Sign ZXP03
- Registratie nummer PH-PXC



- Politiehelikopter 05
- Call Sign ZXP05
- Registratie nummer PH-PXE



- Politiehelikopter 25
- Call Sign ZXP25
- Registratie nummer PH-PXY



- Politiehelikopter 02
- Call Sign ZXP02
- Registratie nummer PH-PXB



- Politiehelikopter 04
- Call Sign ZXP04
- Registratie nummer PH-PXD



- Politiehelikopter 06
- Call Sign ZXP06
- Registratie nummer PH-PXF



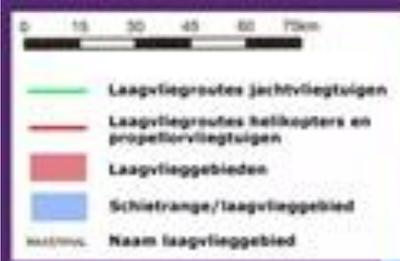
- Politiehelikopter 26
- Call Sign ZXP26
- Registratie nummer PH-PXZ



- Ook bekende onder roepnaam Police01 of Zulu01
- Politiehelikopter zal veelal blijven tanken op haar thuisbasis Schiphol.

Militair - MLAT

- F-16
- Chinook
- Apache
- C-17's
- BE20
- C501



Laagvliegroutes en -gebieden

Drone



Hardware

- USB RTL-SDR Dongle (R820T2 RTL2832U 25MHz-1700MHz)
- Computer (PC of Raspberry PI 3B)
- Coax en/of connectoren.
- Antenne
- Internet verbinding

- PI - 16GB micro SD met software image *
- PI Metalen behuizing *
- PI Voedingsadapter *
- PI voedingskabel *

* Raspberry PI

Deel je data en ontvang extra...

- Flightaware → Enterprise User
- Flightaware deelt data → ADS-B Exchange
- Flightradar 24 → Business account
- Radarbox 24 → Premium user
- Planefinder



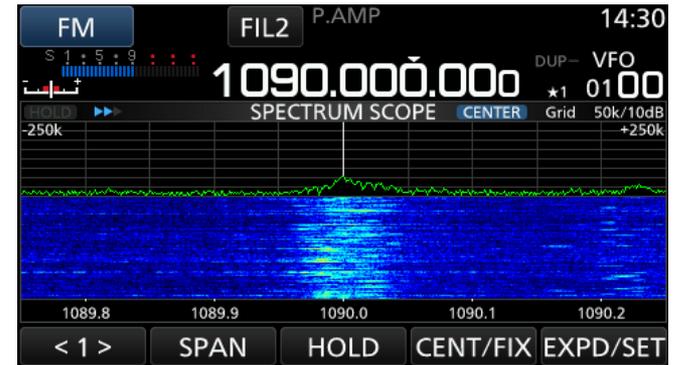
- Software en Tooling

Hardware Ontvanger

RTL-SDR USB Stick universeel



Breedband Ontvanger



RTL-SDR USB Stick speciaal voor ADSB Ontvangst



Hardware Antenne

Collineaire Antenne

$\frac{1}{4}$ Golf Ground Plane

Filter en Versterker



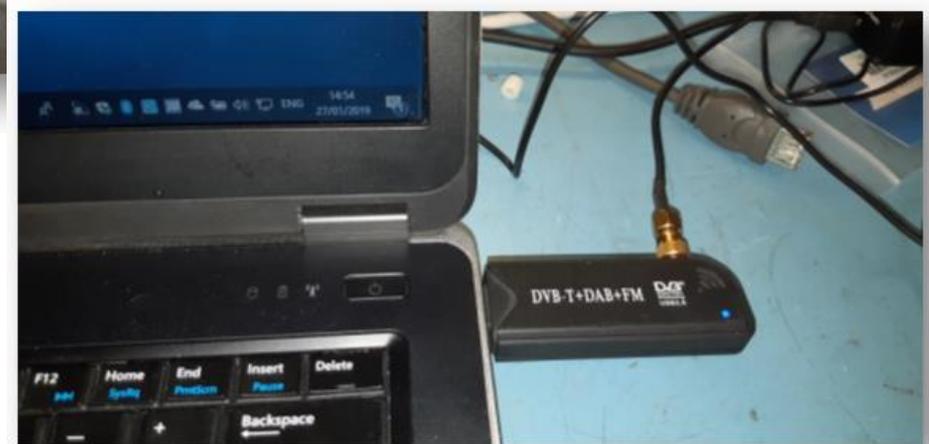
SDR Ontvanger

Hardware computer



Raspberry Pi

Computer
Desktop / laptop

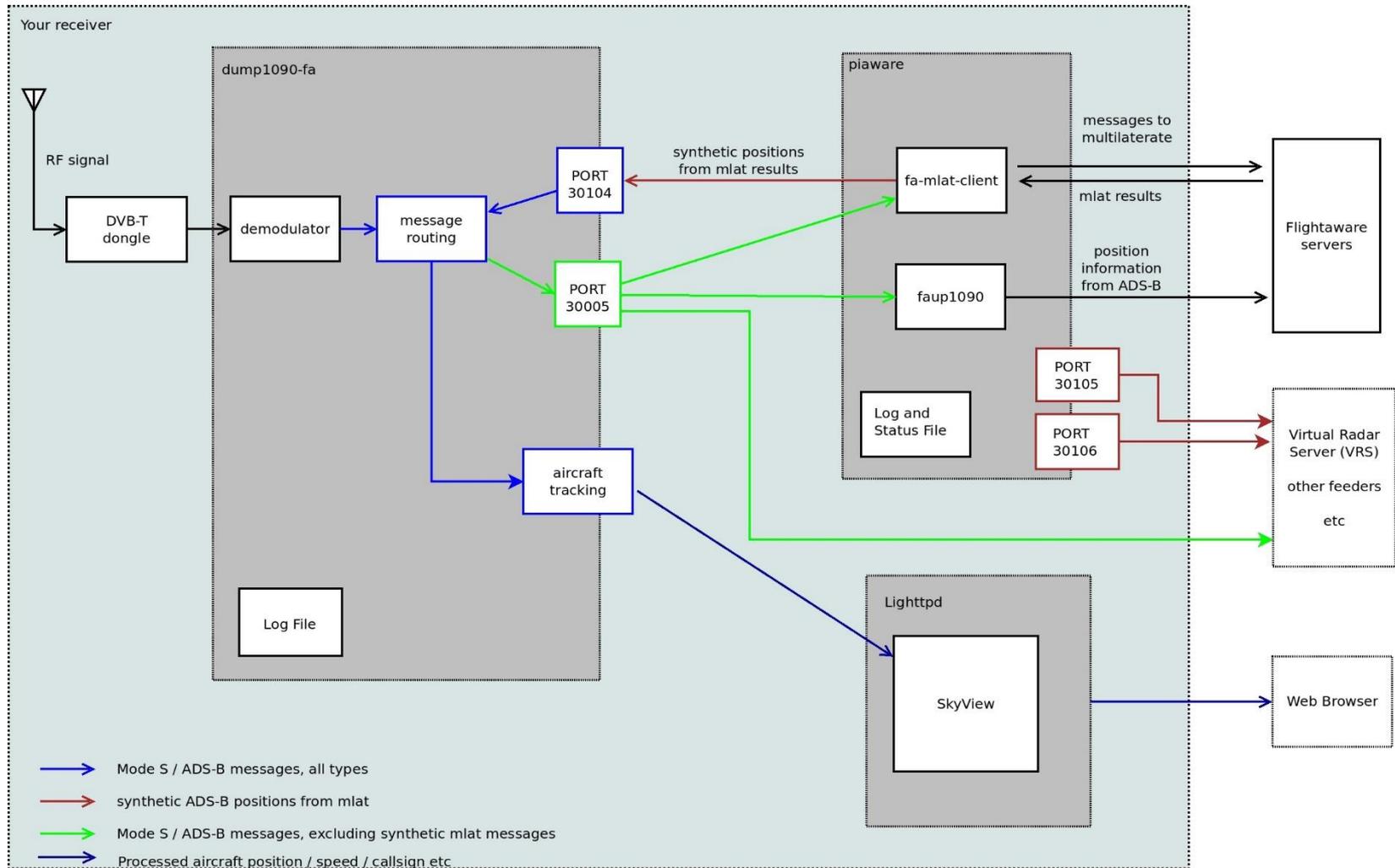


Software om de data te ontvangen

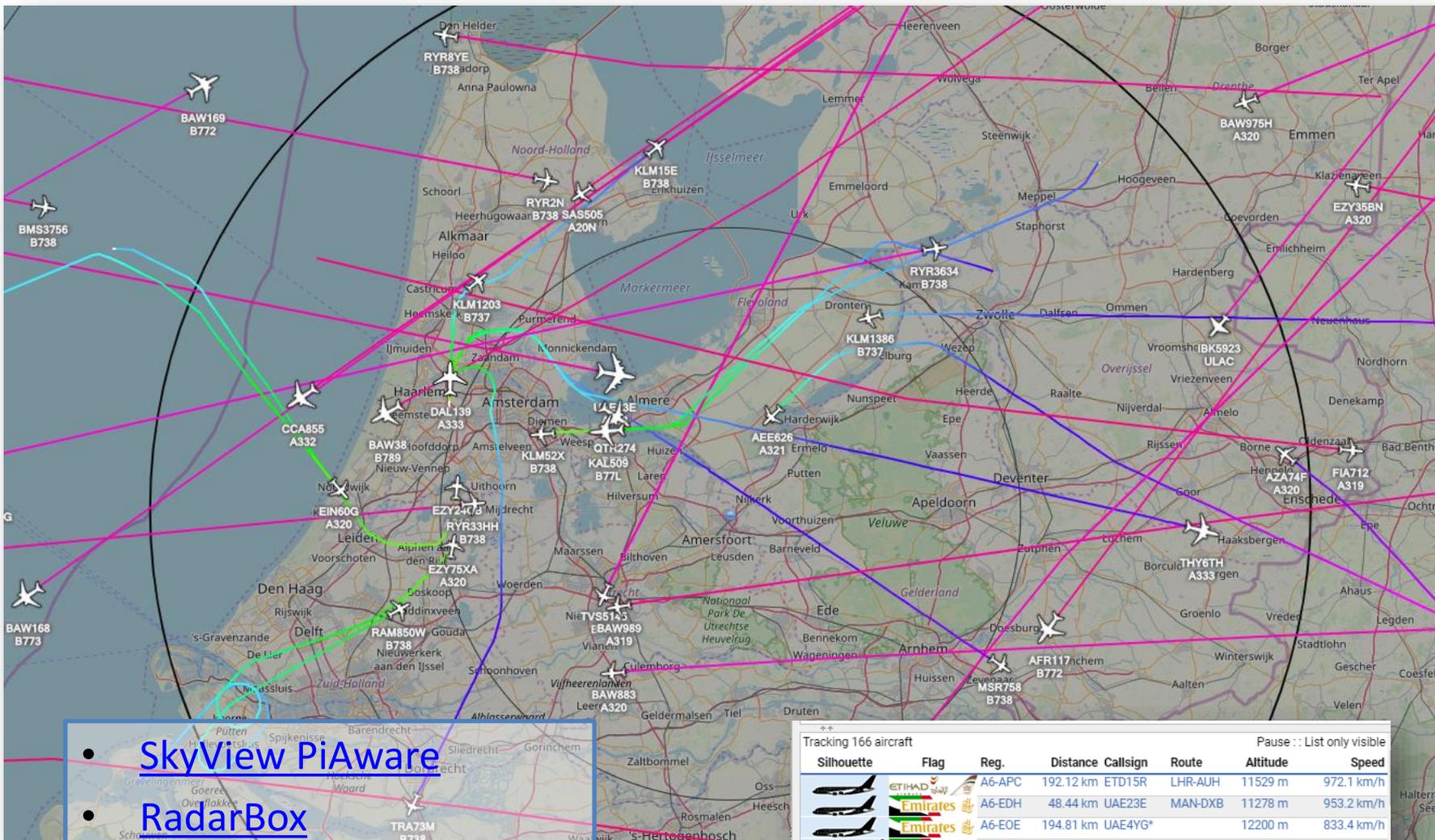
- Raspberry Pi – Piaware lokaal netwerk.
- Windows demoduleren Dump1090, RTL1090.
- Virtual radar server om stream te koppelen.



Voorbeeld routing



Skyview

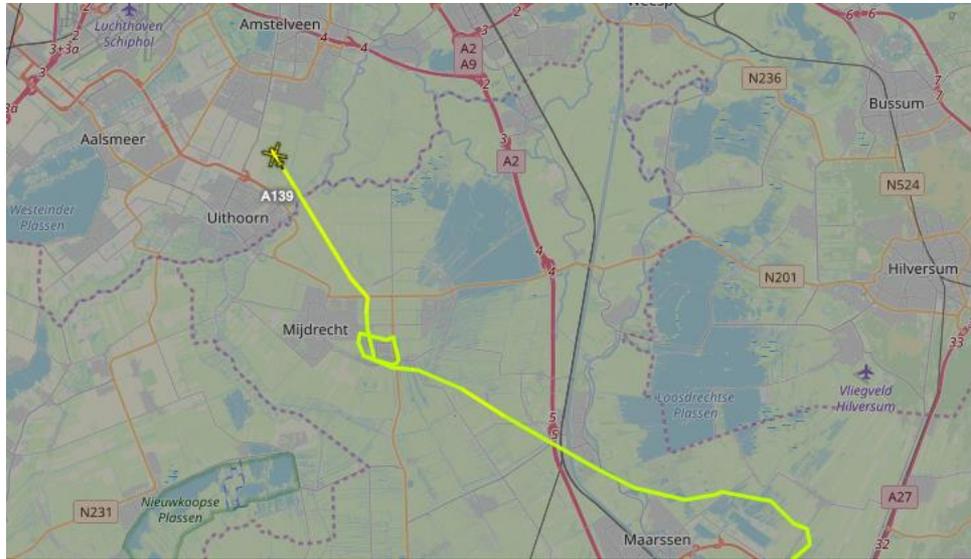


- [SkyView PiAware](#)
- [RadarBox](#)

Tracking 166 aircraft Pause :: List only visible

Silhouette	Flag	Reg.	Distance	Callsign	Route	Altitude	Speed
		A6-APC	192.12 km	ETD15R	LHR-AUH	11529 m	972.1 km/h
		A6-EDH	48.44 km	UAE23E	MAN-DXB	11278 m	953.2 km/h
		A6-EDE	194.81 km	UAE4YG*		12200 m	833.4 km/h
		A6-EPS	163.32 km	UAE28	GLA-DXB	10668 m	944.3 km/h
		A7-ALG	233.85 km	QTR7NB	EDI-DOH	12497 m	979.2 km/h
		A7-ARR	217.04 km			11445 m	950.2 km/h

Skyview Mulilateraal



KLPD Police Aviation Service
Netherlands
AW.139

Civil
A139

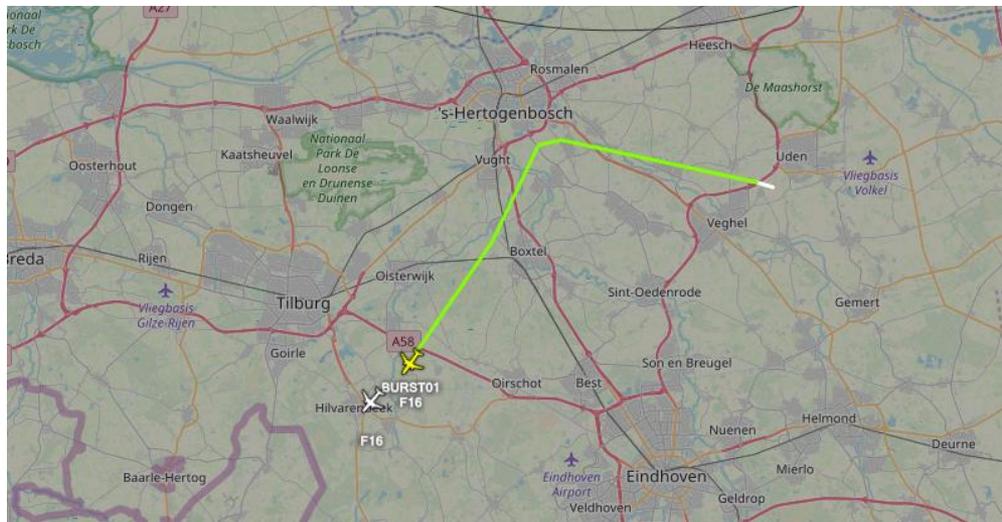
Altitude: 351 m **Vertical Speed:** 20 m/min **Speed:** 190.8 km/h **Heading:** 330.9° **Distance:** 40.08 km **Squawk:**

Engines: Twin turbo **Species:** Helicopter **Wake Turbulence:** Light

Route:
 Aircraft is not transmitting its callsign



www.airport-data.com :: www.airliners.net :: www.airframes.org
 Show on map :: Enable auto-select



Royal Netherlands Air Force
Netherlands
F-16AM Fighting Falcon

BURST01
 Military
F16
 Squawk:

Altitude: 701 m **Vertical Speed:** 20 m/min **Speed:** 855.8 km/h **Heading:** 214.2° **Distance:** 76.80 km

Engines: Single jet **Species:** Landplane **Wake Turbulence:** Medium

Route:
 Route not known



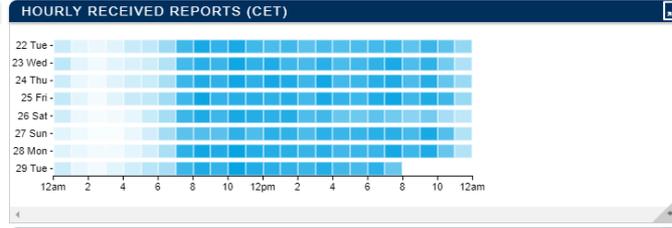
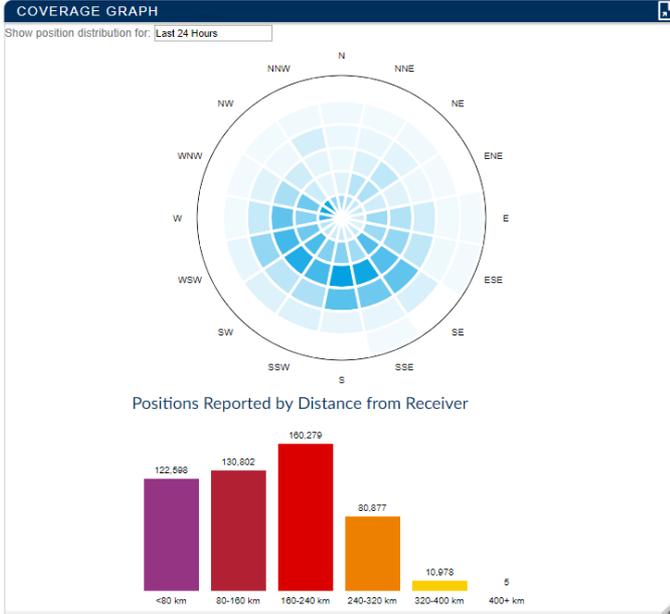
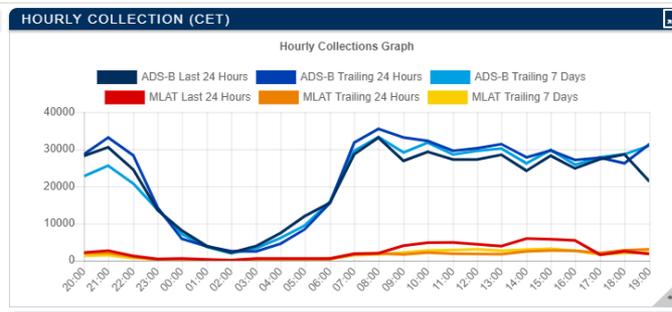
www.airport-data.com :: www.airliners.net :: www.airframes.org
 Show on map :: Enable auto-select :: Submit route



Plattformen

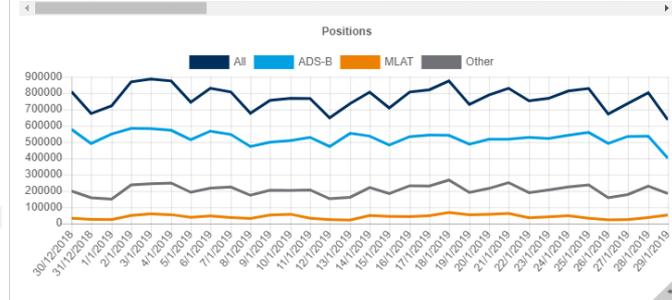


Platformen Statistics



POSITIONS REPORTED

	29/1/2019	28/1/2019	27/1/2019	26/1/2019	25/1/2019	24/1/2019	23/1/2019	22/1/2019
ADS-B	400,541	536,279	534,558	491,080	558,920	541,041	521,580	528,441
MLAT	51,777	36,979	24,375	22,764	32,392	48,425	40,571	35,111
Other	183,678	229,099	177,836	157,606	236,876	223,737	205,590	189,511
Total	635,996	802,357	736,769	671,450	828,188	813,203	767,741	753,062



AIRCRAFT REPORTED

	29/1/2019	28/1/2019	27/1/2019	26/1/2019	25/1/2019	24/1/2019	23/1/2019	22/1/2019
ADS-B	2,168	2,481	2,500	2,426	2,540	2,384	2,332	2,281
MLAT	462	379	268	239	347	454	406	406
Other	122	121	102	80	169	106	111	111
Total	2,752	2,981	2,870	2,745	3,056	2,944	2,849	2,800

Platformen Ranking

HOME > STATION RANKING > NETHERLANDS

RadarBox Stations - Netherlands Ranking

FILTER BY

Netherlands RadarBox XRange2 RadarBox XRange Raspberry Pi Other Receivers

RANK	STATION	COUNTRY	CITY	STATUS	UPTIME	MAX RANGE (NM)	AVG RANGE (NM)	SCORE*
#1	EXTRPI004606	Netherlands	Amstelveen	● Live	██████████ 100%	269	216	26981
#2	EXTRPI000744	Netherlands	Amersfoort	● Live	██████████ 99%	229	196	23700
#3	EXTRPI009373	Netherlands	Emmeloord	● Live	██████████ 100%	236	187	23421
#4	EXTSHA007268	Netherlands	Hoek v Holland	● Live	██████████ 100%	374	155	22981
#5	PGANRB400250	Netherlands	Hellevoetsluis	● Live	██████████ 100%	241	179	22721
#6	EXTSHA007311	Netherlands	Amsterdam	● Live	██████████ 100%	239	179	22681

20,533 sites 16,794 participants Live FlightAware ADS-B Sites: 196 countries represented

Top Sites (30 Days) Top Users Top Countries Top Regions

Showing 1 to 50 of 20,527 entries | Show 50 entries



PE1RQF

Member since: [3 months ago](#)

User last online: [13 hours ago](#)

Language: [English \(UK\)](#)

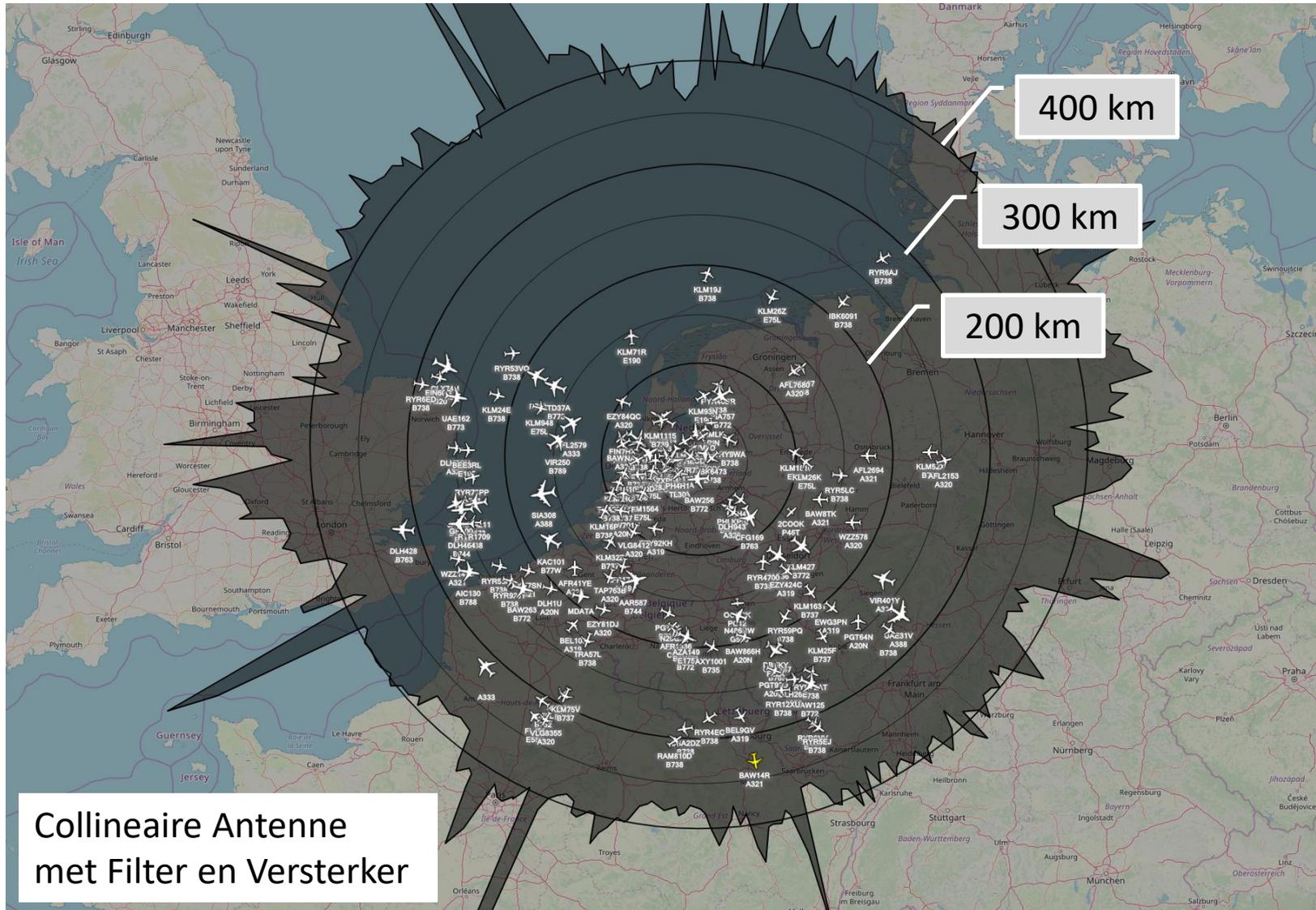
ADS-B feeder since: [20 October 2018](#)

Highest User Ranking Achieved in Last 30 Days: **118**

Polar View Theoretisch bereik



Polar View Bereikt



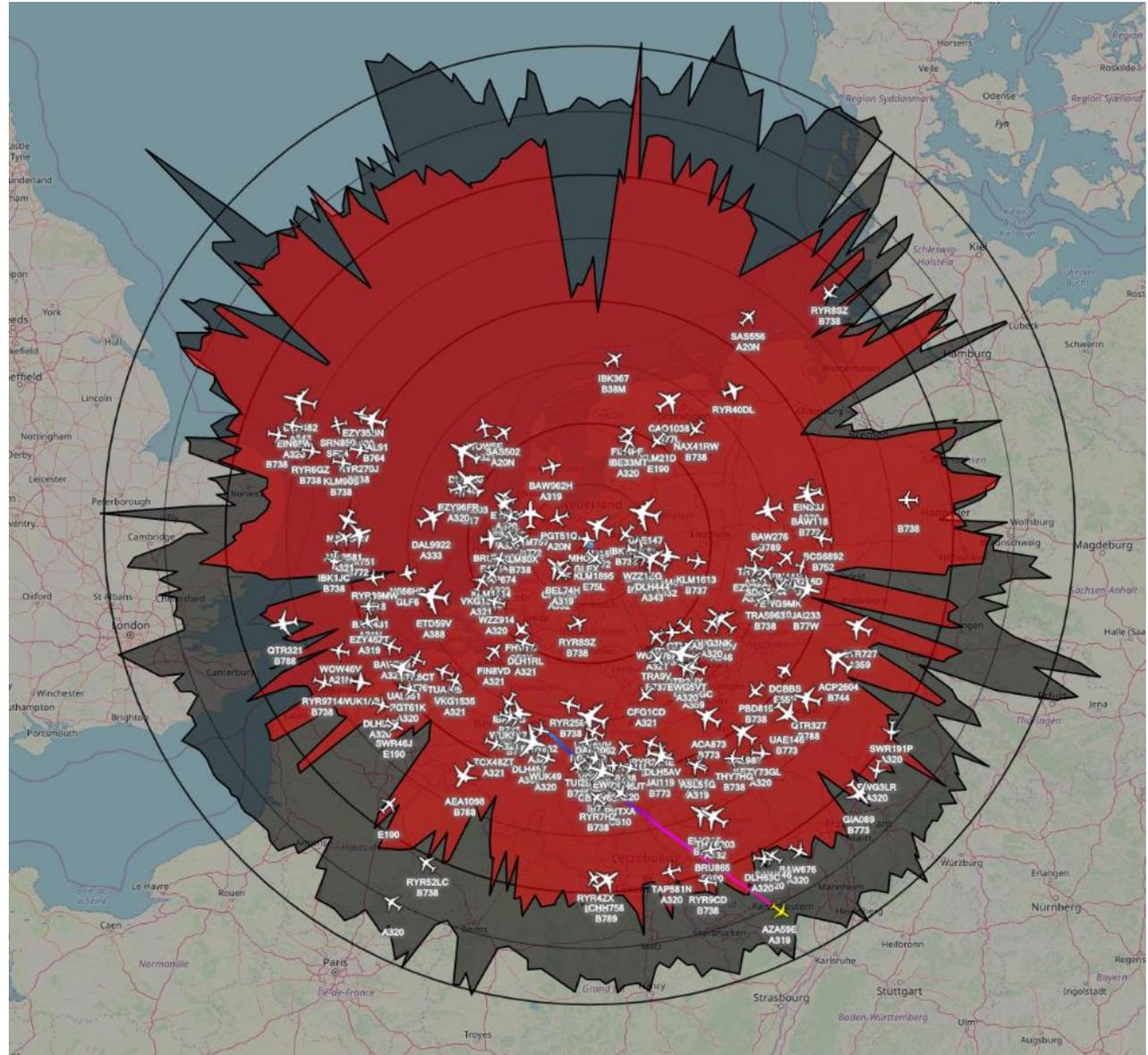
Polar View Bereik

24 uur gemeten tussen de

Collineaire Antenne met
Filter en Versterker

en de

¼ Golf Ground Plane



3D Polar View Bereik (filmpje)





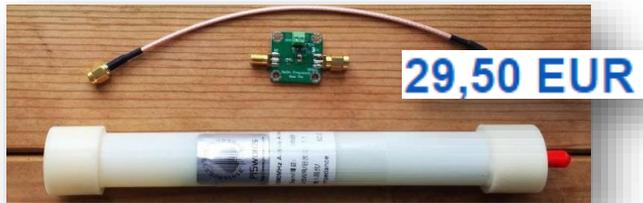
- Antennes

$$\lambda_{\text{meters}} = \frac{299.7925 \times 10^6 \text{ meters/sec}}{f \text{ hertz}} = \frac{299.7925}{f \text{ MHz}}$$

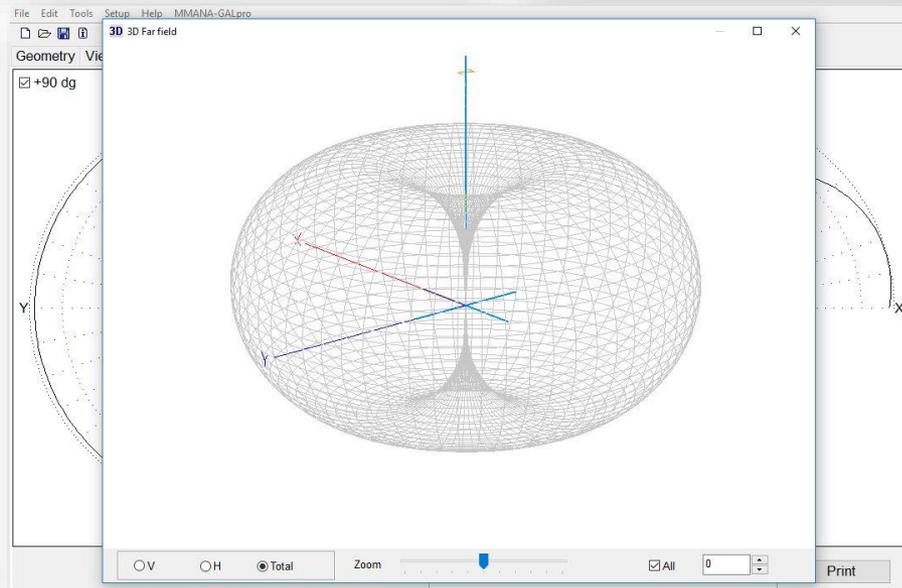
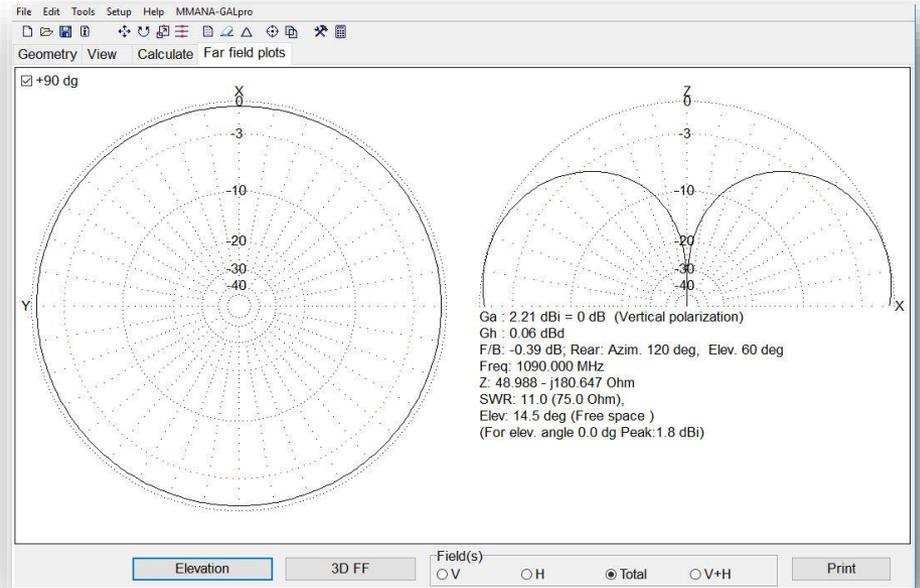
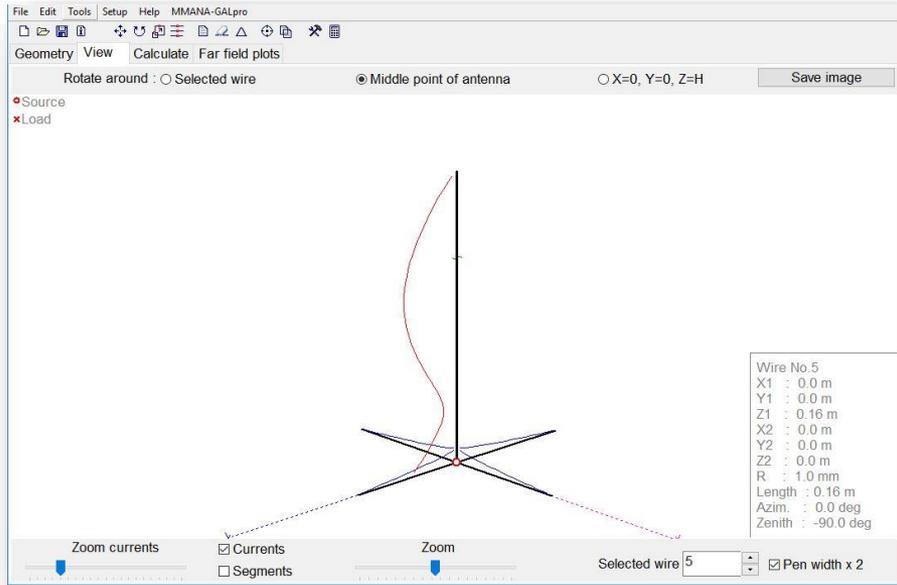
$$\lambda_{\text{meters}} = \frac{299.7925 \times 10^6 \text{ meters/sec}}{f \text{ hertz}} = \frac{299.7925}{f \text{ MHz}}$$

- $300 / 1090 = 0,275\text{cm} / 4 = 6,8\text{cm} \quad \frac{1}{4} \text{ golf}$
- $300 / 1090 = 0,275\text{cm} / 2 = 13,7\text{cm} \quad \frac{1}{2} \text{ golf}$
- $300 / 1090 = 0,275\text{cm} / 8 \times 5 = 17.2\text{cm} \quad \frac{5}{8} \text{ golf}$

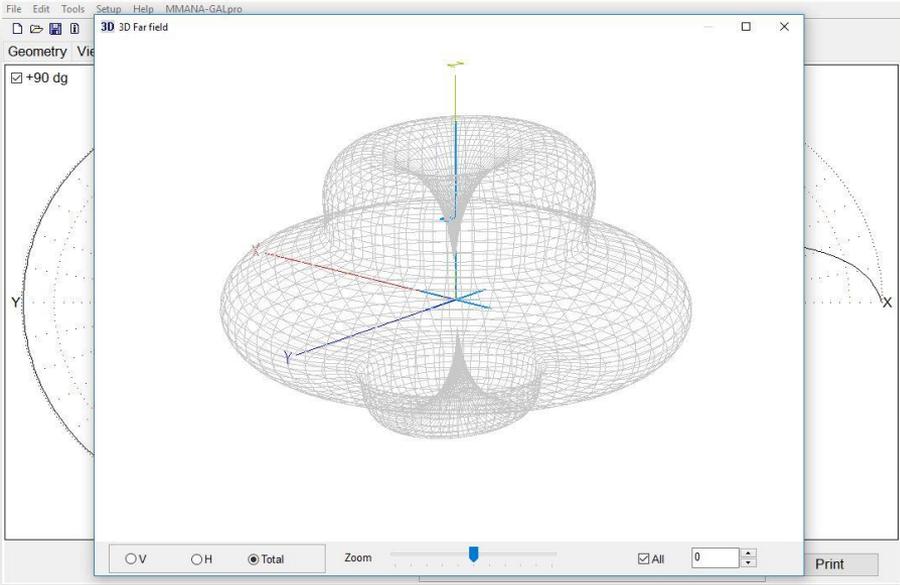
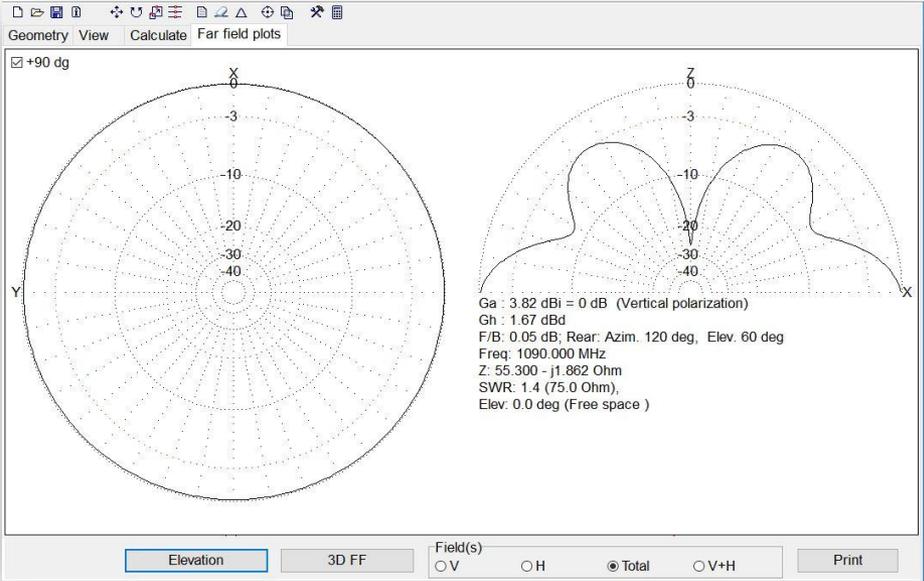
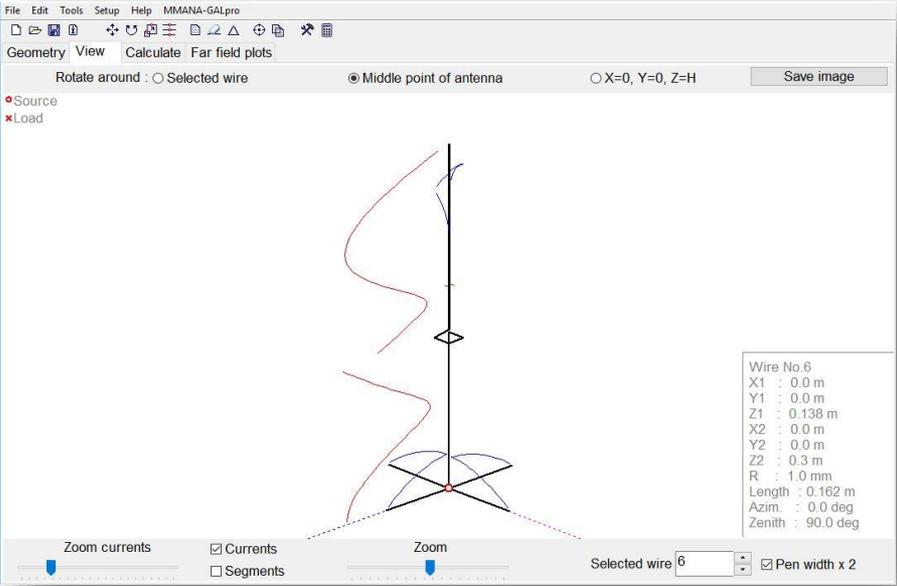
ADS-B antennes



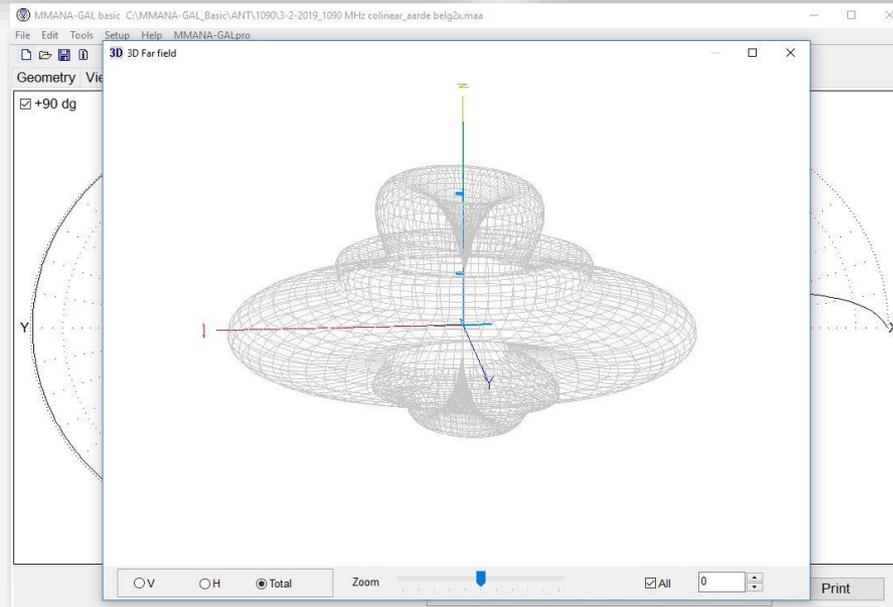
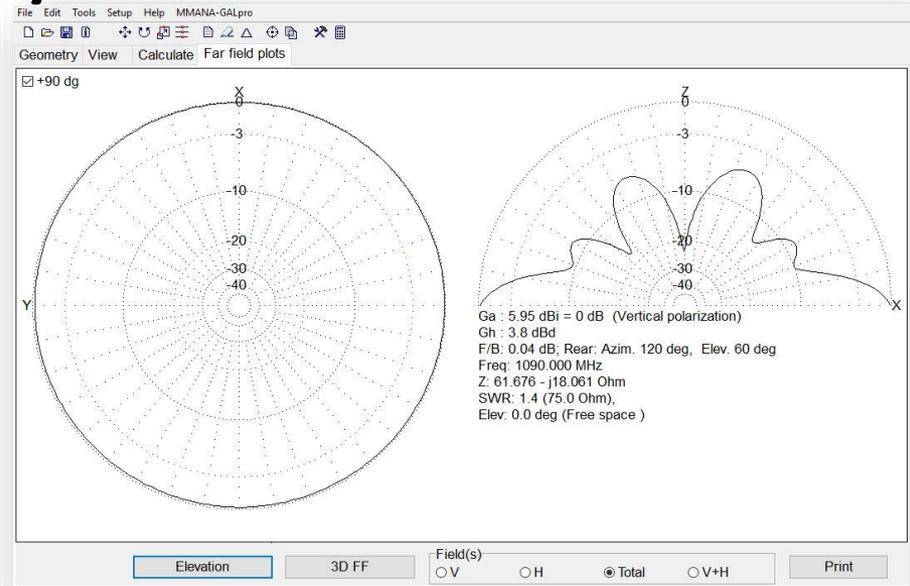
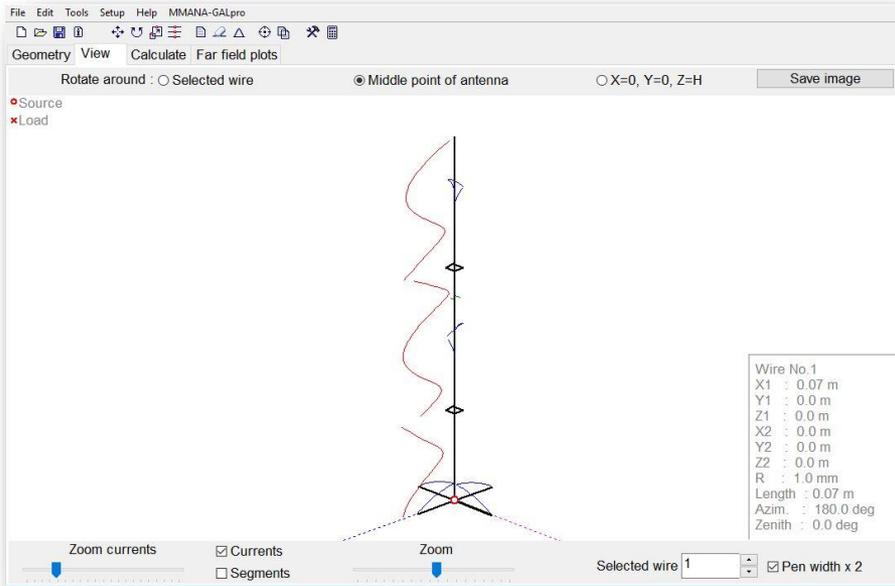
1x 5/8



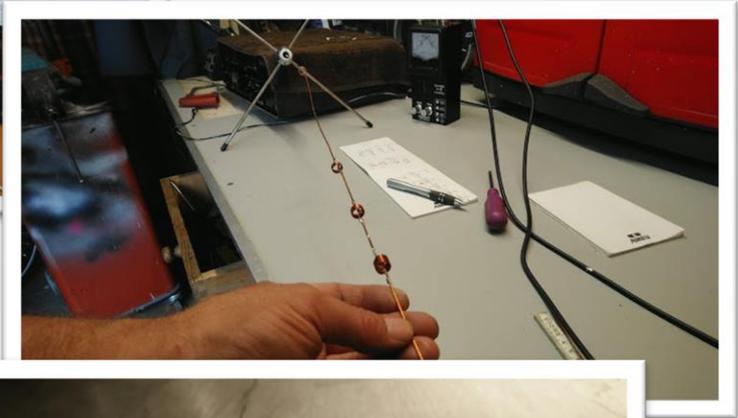
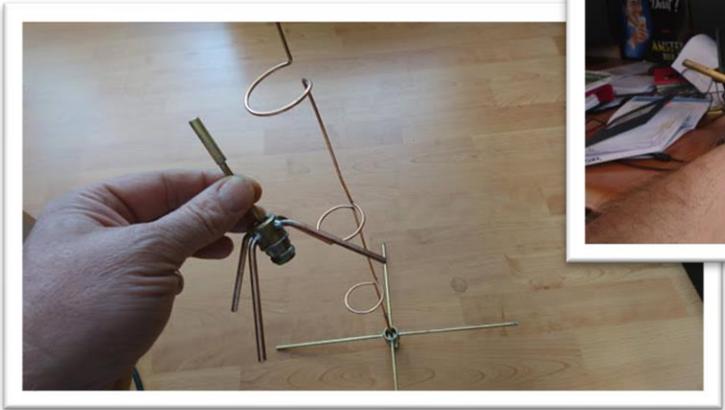
2x 5/8.

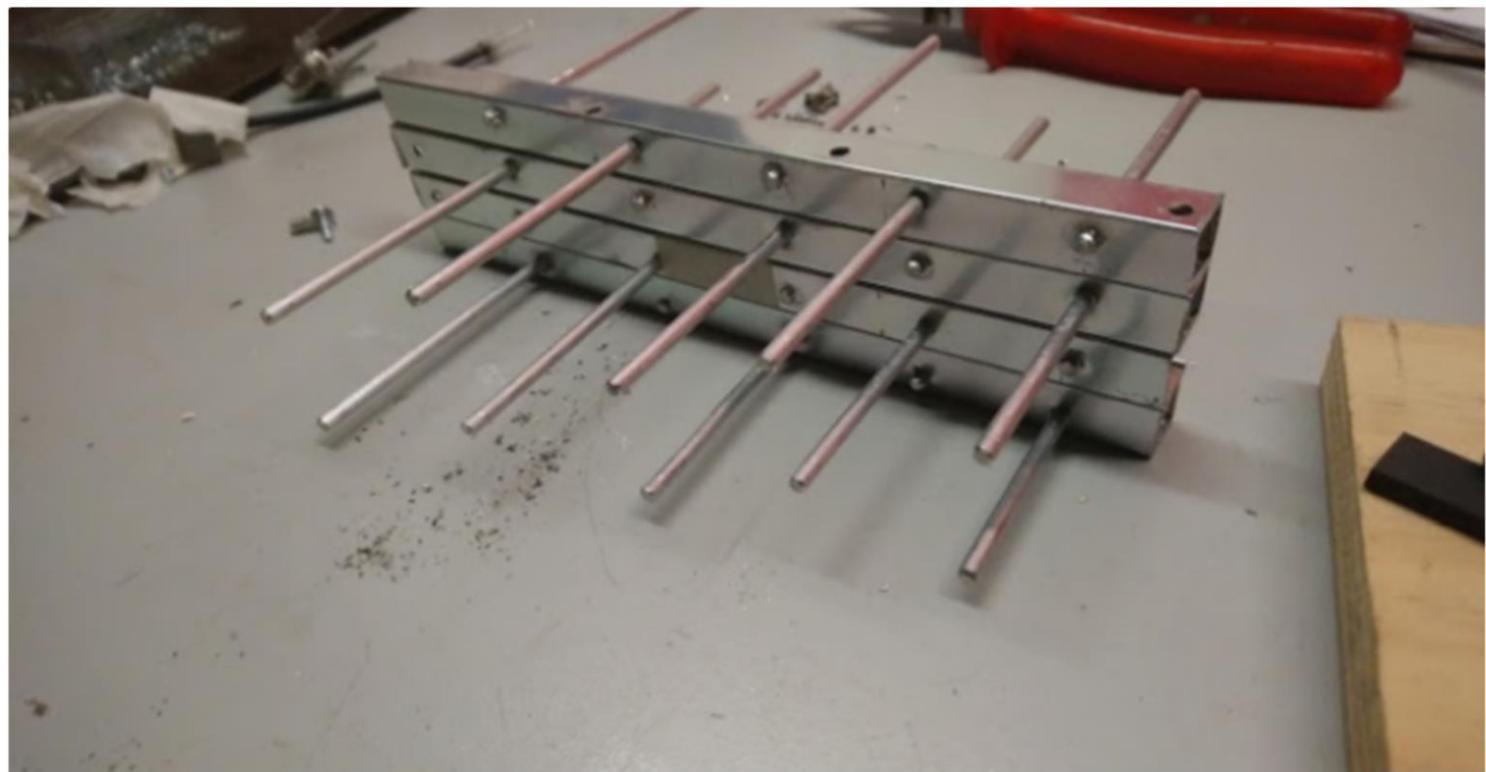
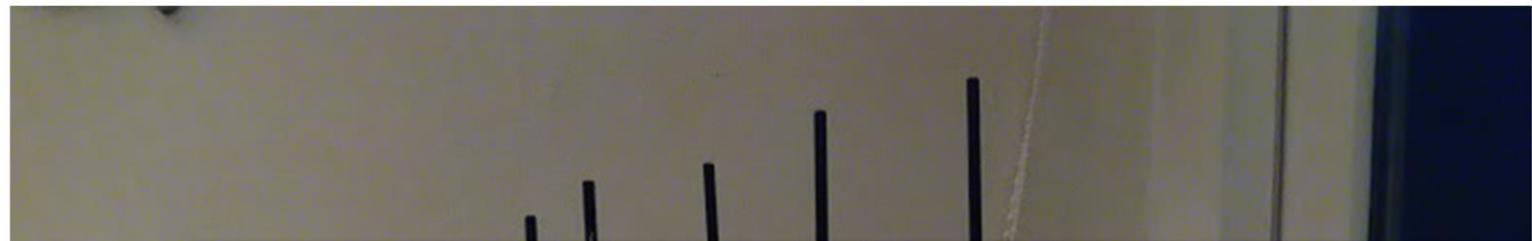


3x 5/8



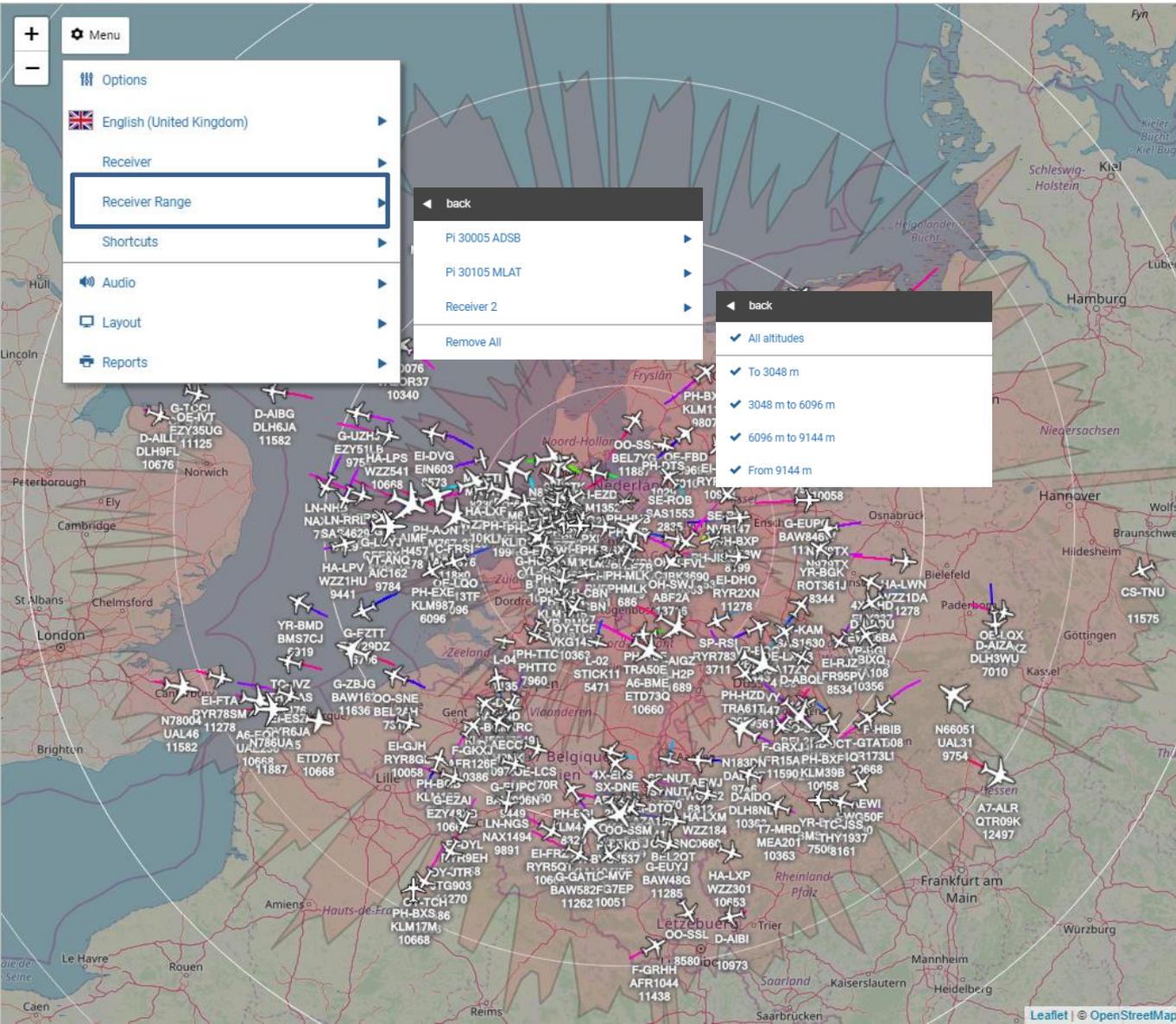
Hoop gemaakt en getest.







Virtual Radar



Menu

- Options
- English (United Kingdom)
- Receiver
- Receiver Range**
- Shortcuts
- Audio
- Layout
- Reports

back

- Pi 30005 ADSB
- Pi 30105 MLAT
- Receiver 2
- Remove All

back

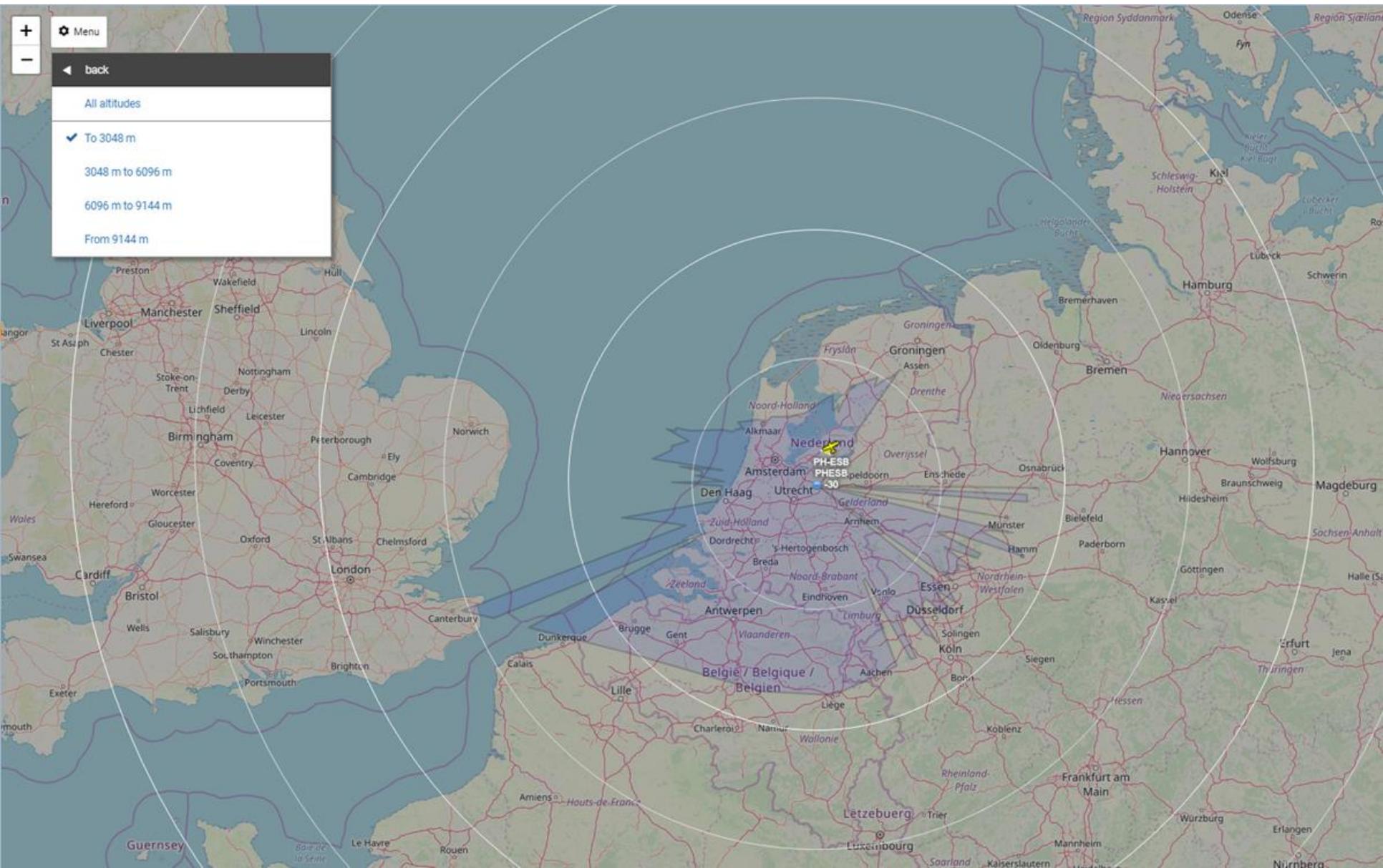
- All altitudes
- To 3048 m
- 3048 m to 6096 m
- 6096 m to 9144 m
- From 9144 m

Disable auto-select

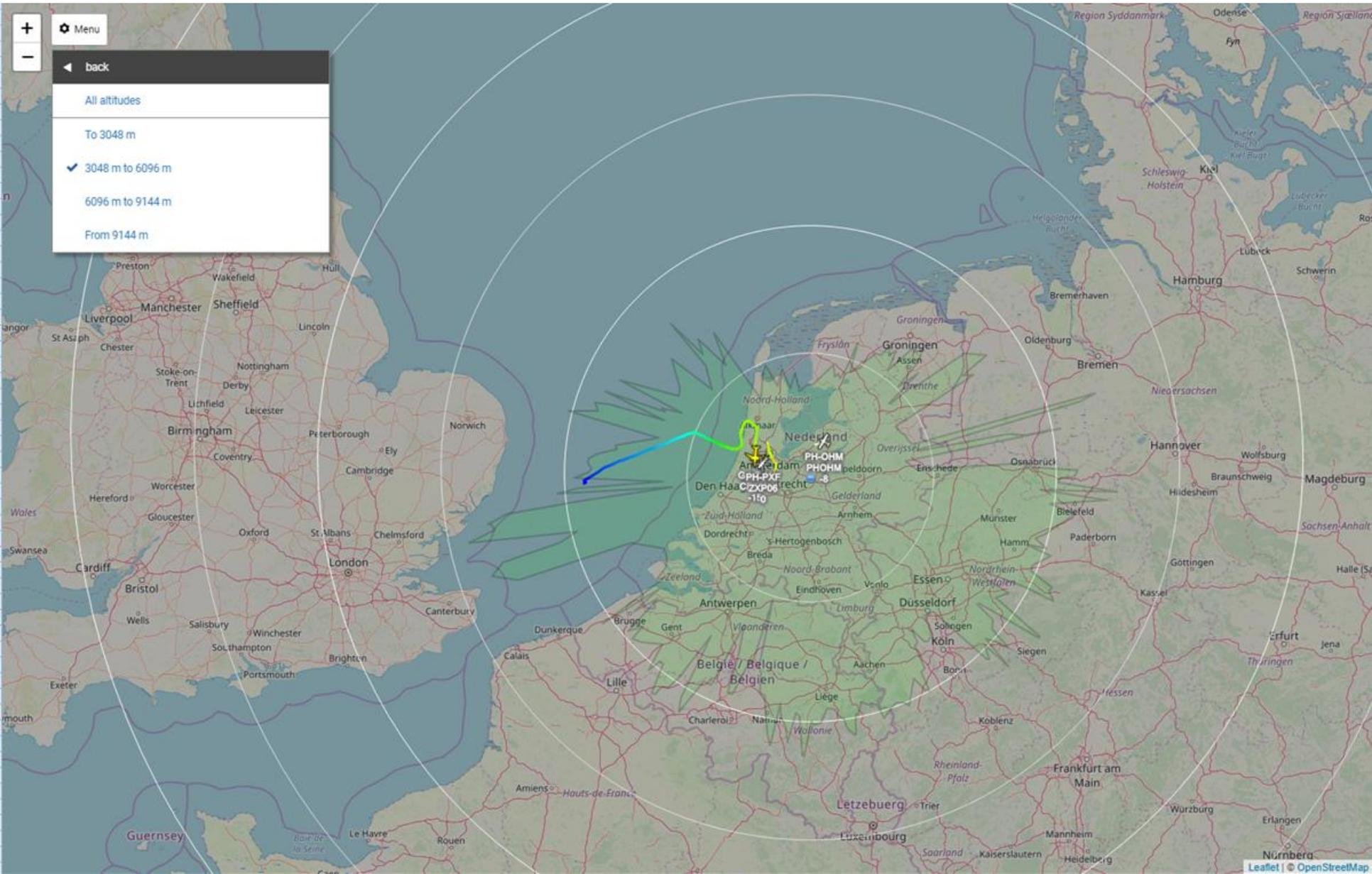
Tracking 199 aircraft Pause :: List only visible

Silhouette	Callsign	Altitude	Speed	Reg.	ICAO	Rou
	QTR09K	12497 m	935.3 km/h	A7-ALR	06A106	EDI
	ZXP25*	23 m	209.1 km/h	PH-PXY	484AC1	
		53 m	454.5 km/h	PH-JIS	484BA8	
	PHPHA	61 m	182.8 km/h	PH-PHA	484CA8	
	ZXP06*	198 m	277.8 km/h	PH-PXF	484A96	
	PHHHB*	244 m	117.8 km/h	PH-HHB	4848FB	
	BAW430	297 m	198.3 km/h	G-NEOS	4075FE	LHF
		373 m	246.3 km/h	PH-BXI	484162	
	PHCBN*	457 m	106.7 km/h	PH-CBN	484655	
		511 m	155.8 km/h	PH-MLQ	484537	
	PHXYZ*	518 m	229.3 km/h	PH-XYZ	4850E3	
	PGT82K	549 m	217.1 km/h	TC-CPG	488E07	SAV
	AAL204	549 m	233.9 km/h	N393AN	A48DFB	MIA
	PHMLK*	686 m		PH-MLK	484534	
	CTN5NL	716 m	260.6 km/h	9A-CTK	501D20	ZAC
	KLM45F*	899 m		PH-EZT	484FC7	AM
	TRA50E	922 m	329.7 km/h	PH-HSF	484F6C	CP
	PH TTC*	960 m	124.3 km/h	PH-TTC	484F4D	
		1029 m	135.6 km/h	PH-DTS	4844FA	
		1135 m	258.2 km/h	L-04	480C24	
		1240 m		DLAANT	304004	

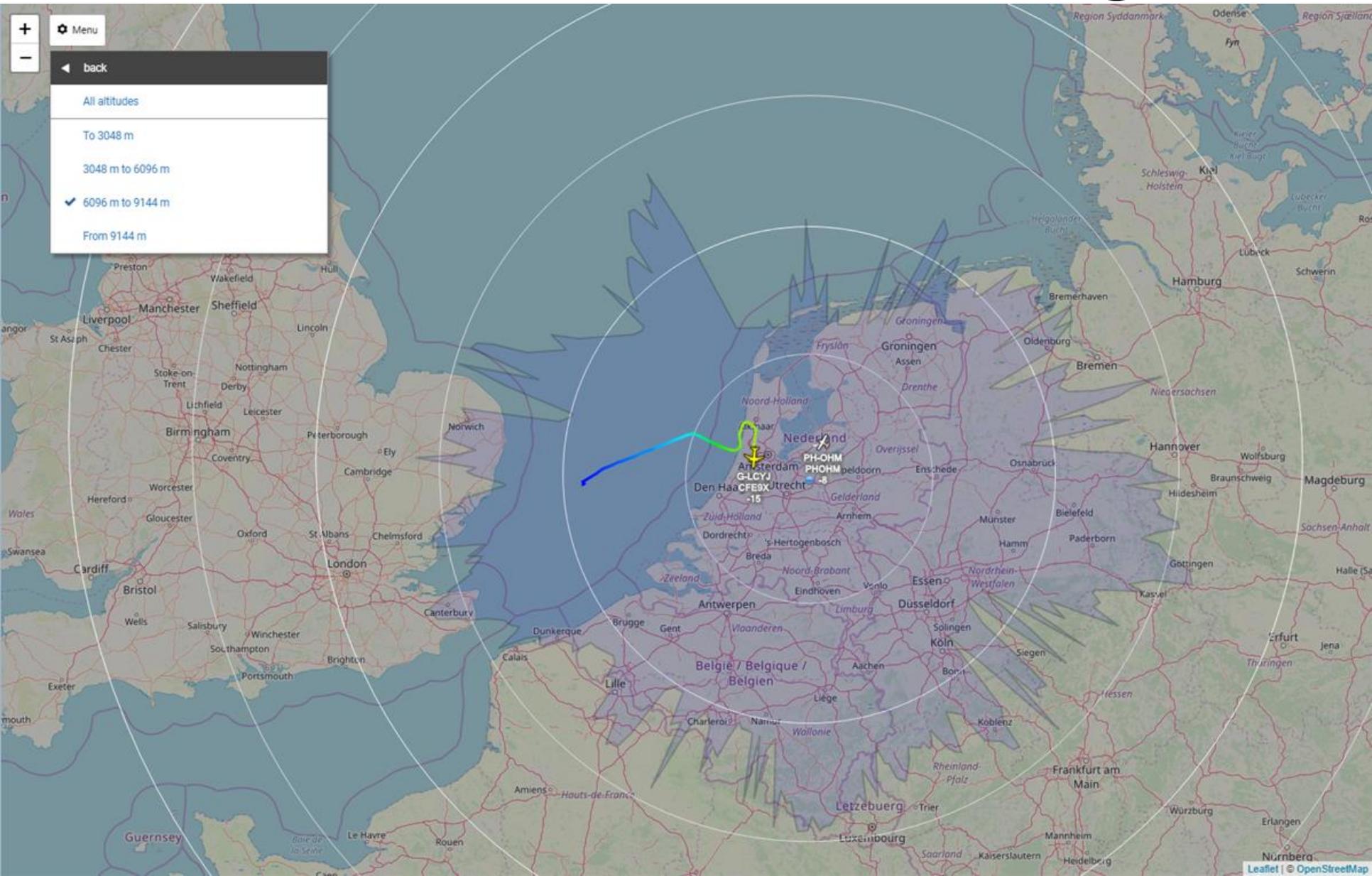
Virtual Radar Receiver Range



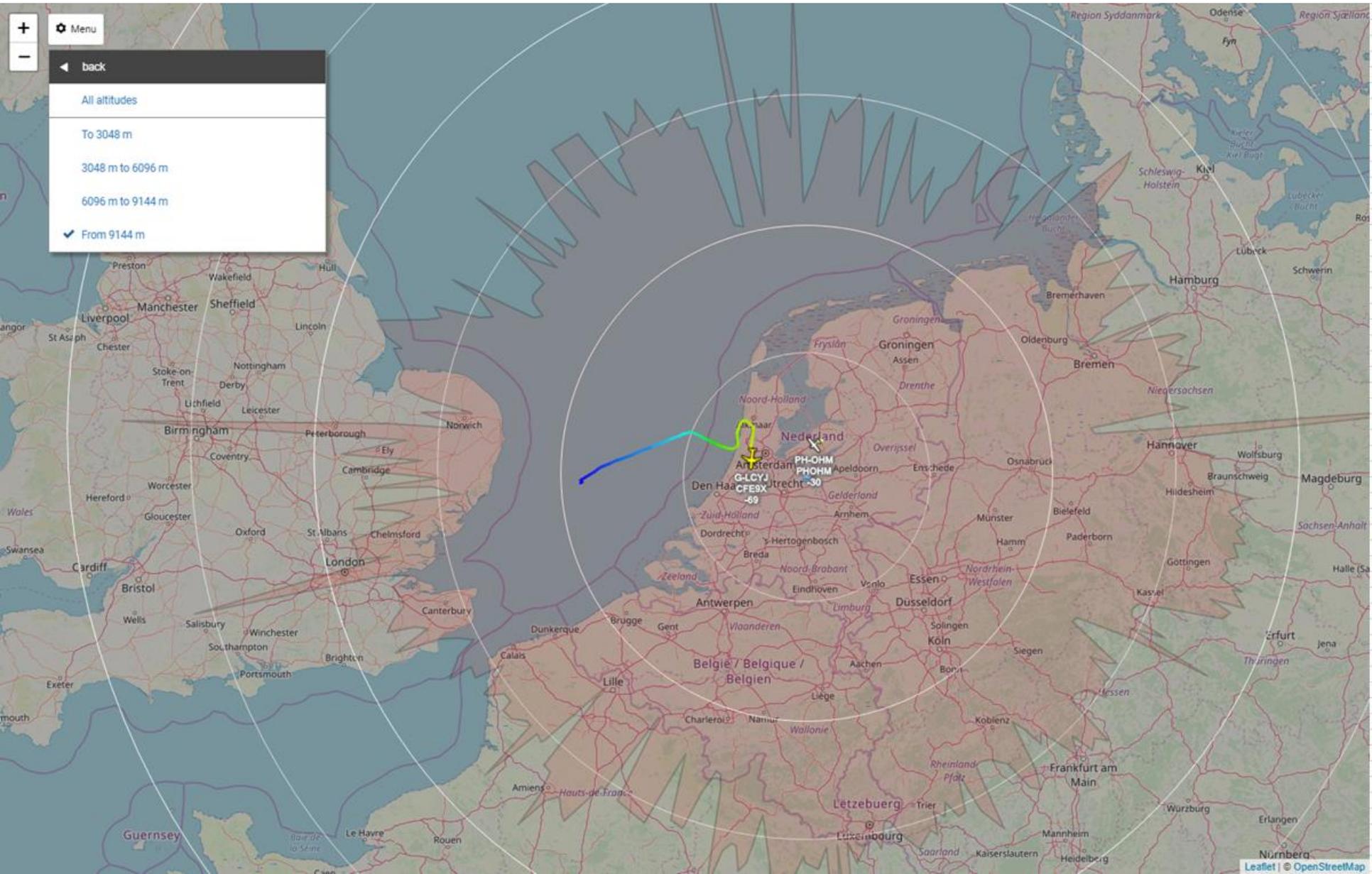
Virtual Radar Receiver Range



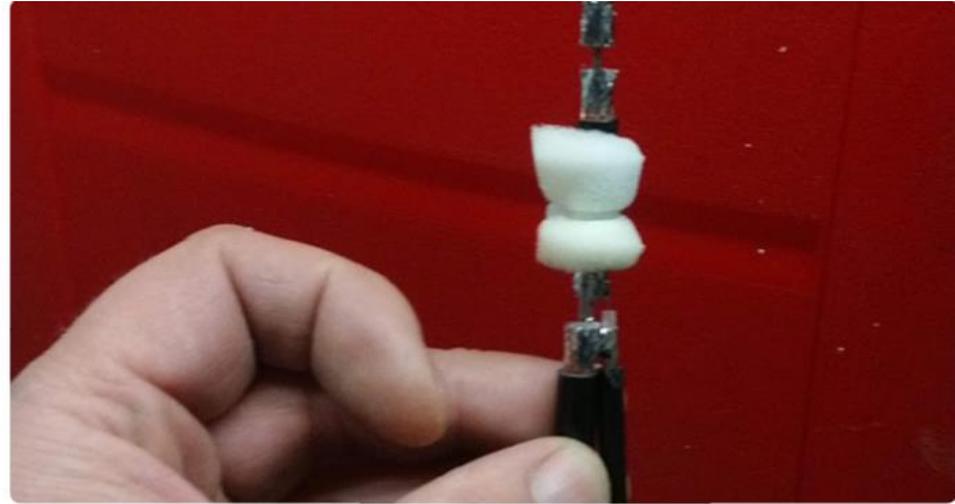
Virtual Radar Receiver Range



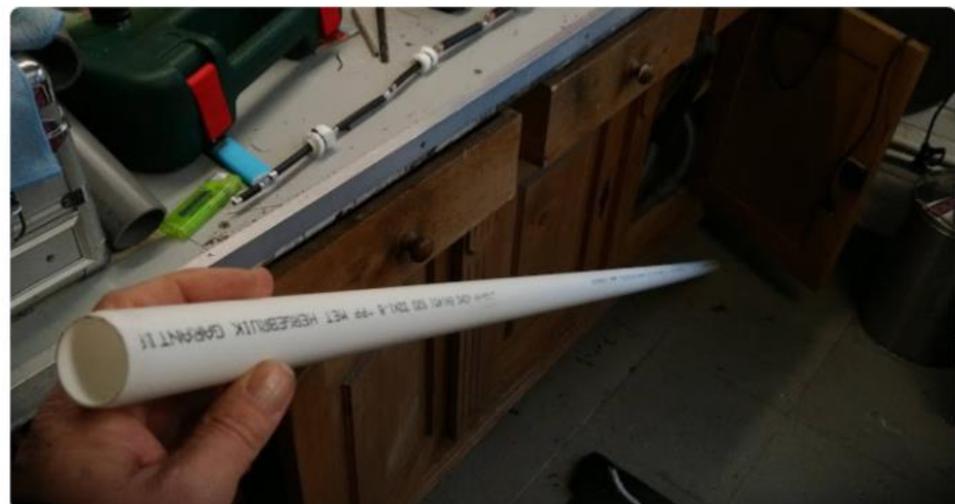
Virtual Radar Receiver Range



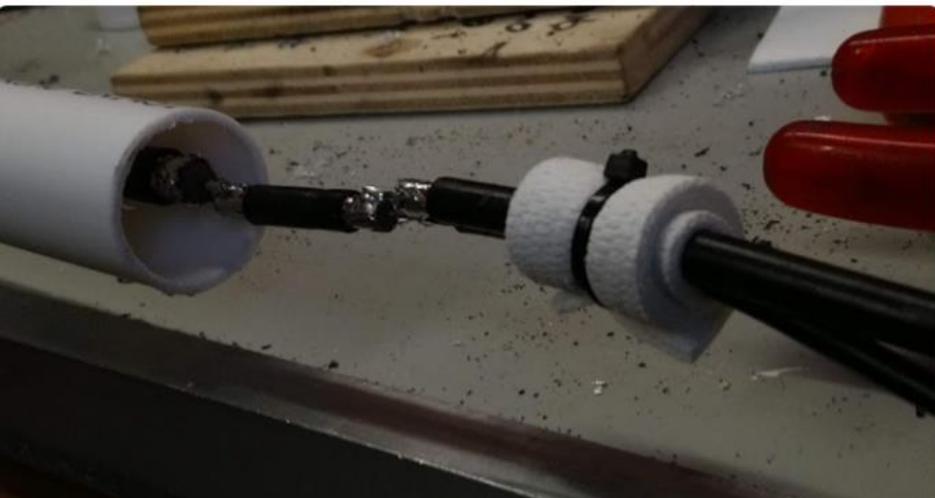
Coaxial Collinear - CoCo



Coaxial Collinear - CoCo



Coaxial Collinear - CoCo



Coaxial Collinear - CoCo



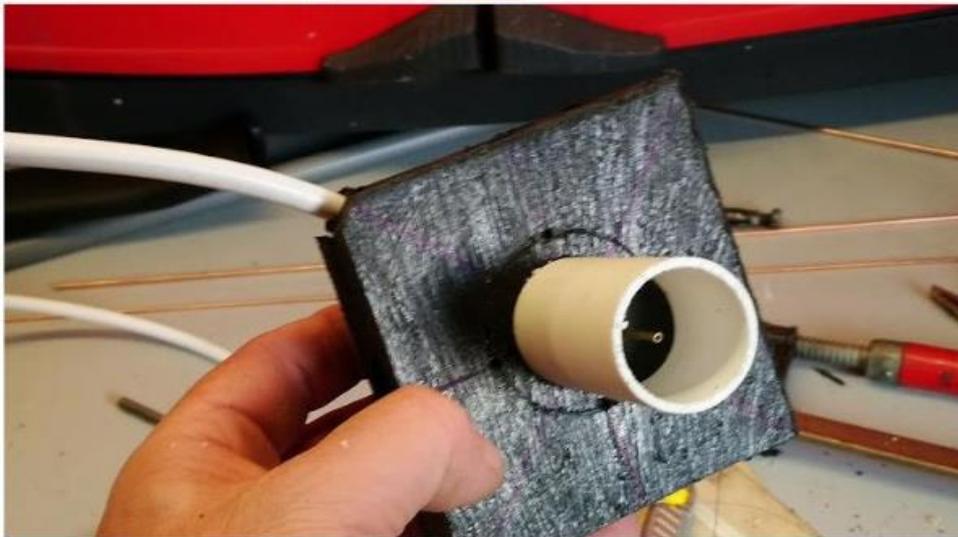
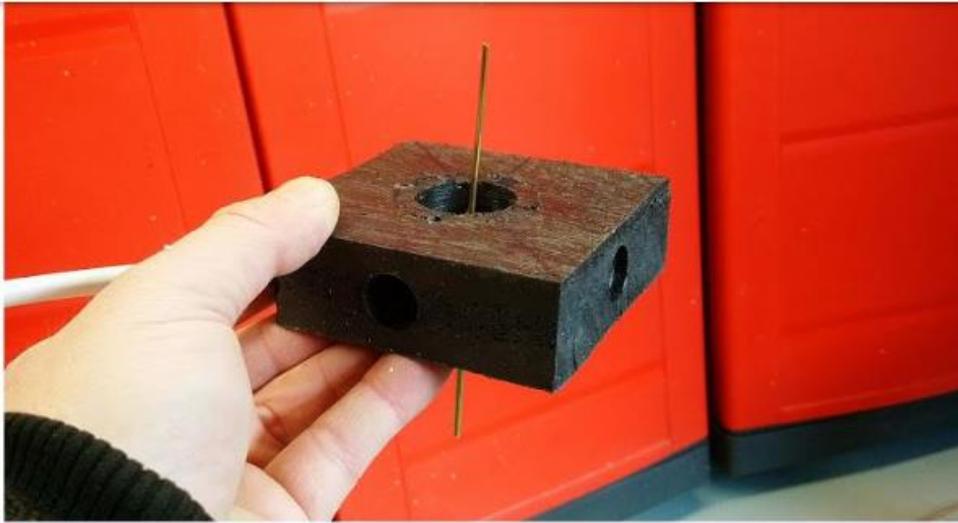
POSITIONS REPORTED

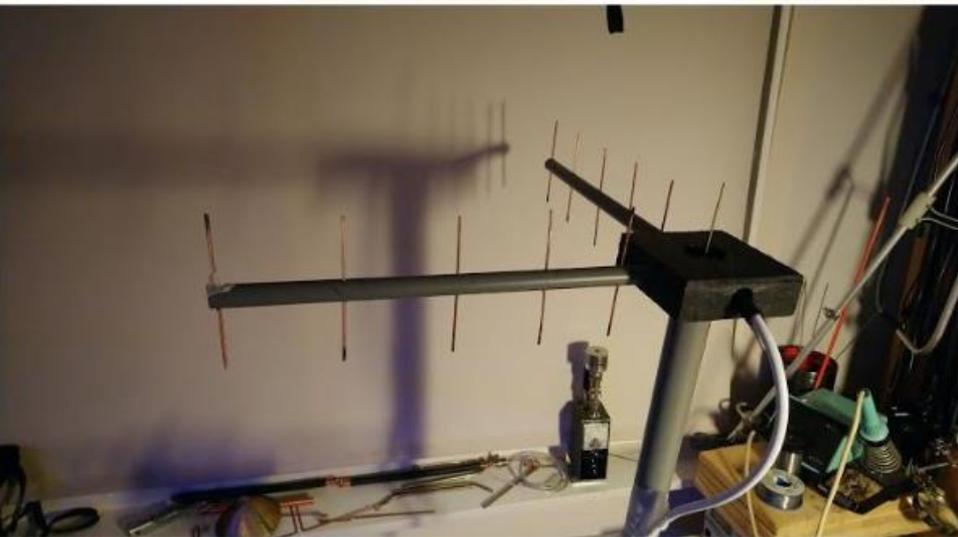
	13/1/2019	12/1/2019	11/1/2019	10/1/2019	9/1/2019	8/1/2019	7/1/2019	6/1/2019
ADS-B	149,863	421,115	496,050	489,201	460,389	433,483	311,994	346,700
MLAT	4,489	19,782	26,035	47,888	39,102	24,520	19,338	26,035
Other	35,739	129,255	201,752	201,373	189,342	147,537	122,060	134,339
Total	190,091	570,152	723,837	738,462	688,833	605,540	453,392	507,100

Positions



Laatste antenne









MMANA-GAL basic c:\mmana-gal_basi\ant\1090\test\4goed 2 kanten op.maa

File Edit Tools Setup Help MMANA-GALpro

Geometry View Calculate Far field plots

Rotate around: Selected wire Middle point of antenna X=0, Y=0, Z=H

Source
Load

Wire No.1
 X1 : 0.0 m
 Y1 : 0.0 m
 Z1 : 0.064 m
 X2 : 0.0 m
 Y2 : 0.0 m
 Z2 : -0.064 m
 R : 0.8 mm
 Length : 0.127 m
 Azim. : 0.0 deg
 Zenith : -90.0 deg

Zoom currents Currents Segments
 Zoom Pen width x 2

Selected wire 1

MMANA-GAL basic c:\mmana-gal_basi\ant\1090\test\4goed 2 kanten op.maa

Tools Setup Help MMANA-GALpro

Geometry View Calculate Far field plots

Ga : 5.87 dBi = 0 dB (Vertical polarization)
 Gh : 3.72 dBd
 F/B: -0.35 dB; Rear: Azim. 120 deg, Elev. 60 deg
 Freq: 1090.000 MHz
 Z: 20.688 - j35.719 Ohm
 SWR: 3.8 (50.0 Ohm),
 Elev. 0.0 deg (Free space)

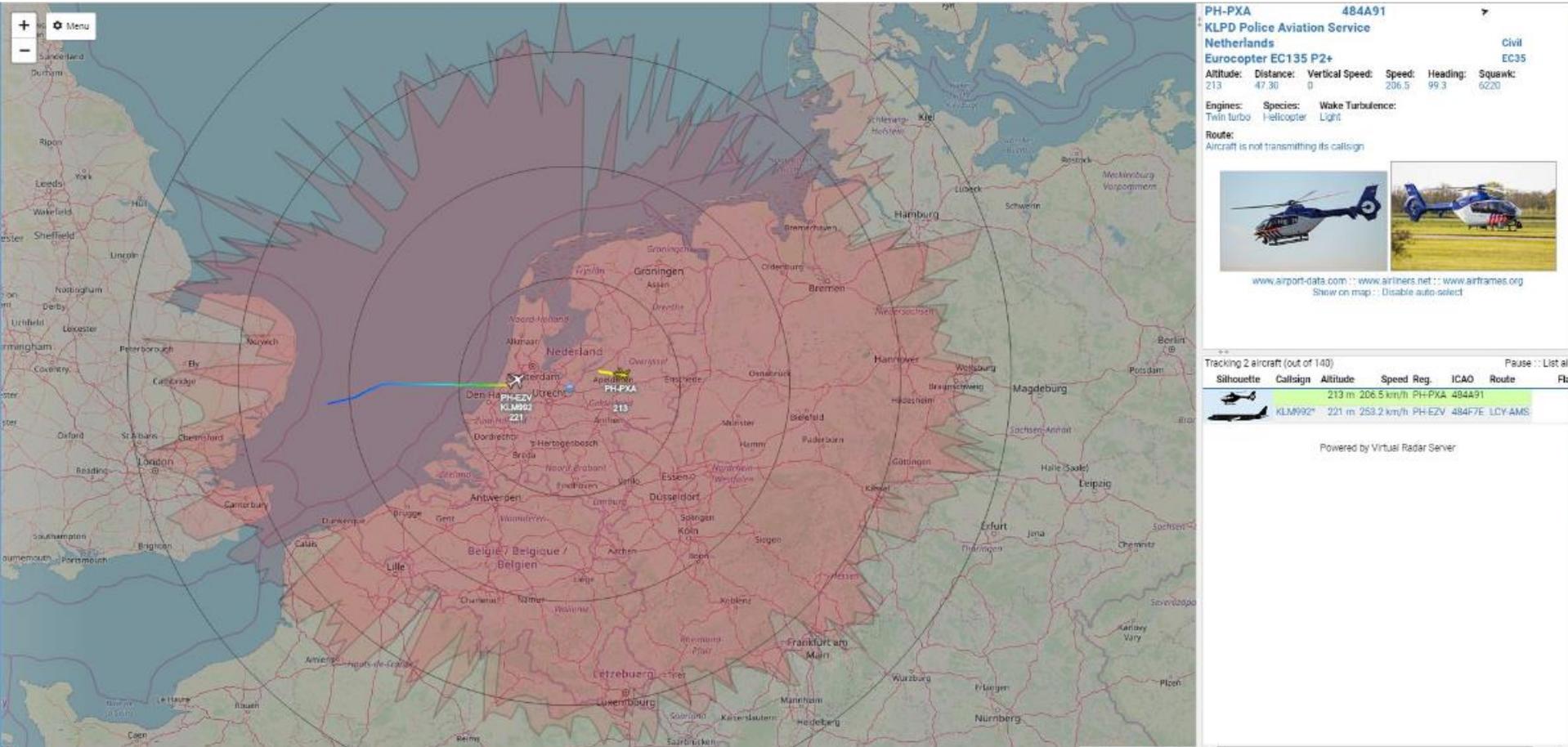
Elevation Field(s) V H Total V+H

Geometry View Calculate Far field plots

3D 3D Far field

V H Total Zoom All 0

Huidige Receiver Range



Schiphol



PH-PXZ 484AC0

KLPD Police Aviation Service
Netherlands
AgustaWestland AW.139

ZXP26*
Civil
A139

Altitude:	Distance:	Vertical Speed:	Speed:	Heading:	Squawk:
-15	42.35	-117	195.4	5.4	6220

Engines: **Twin turbo** Species: **Helicopter** Wake Turbulence: **Light**

Route:
Route not known

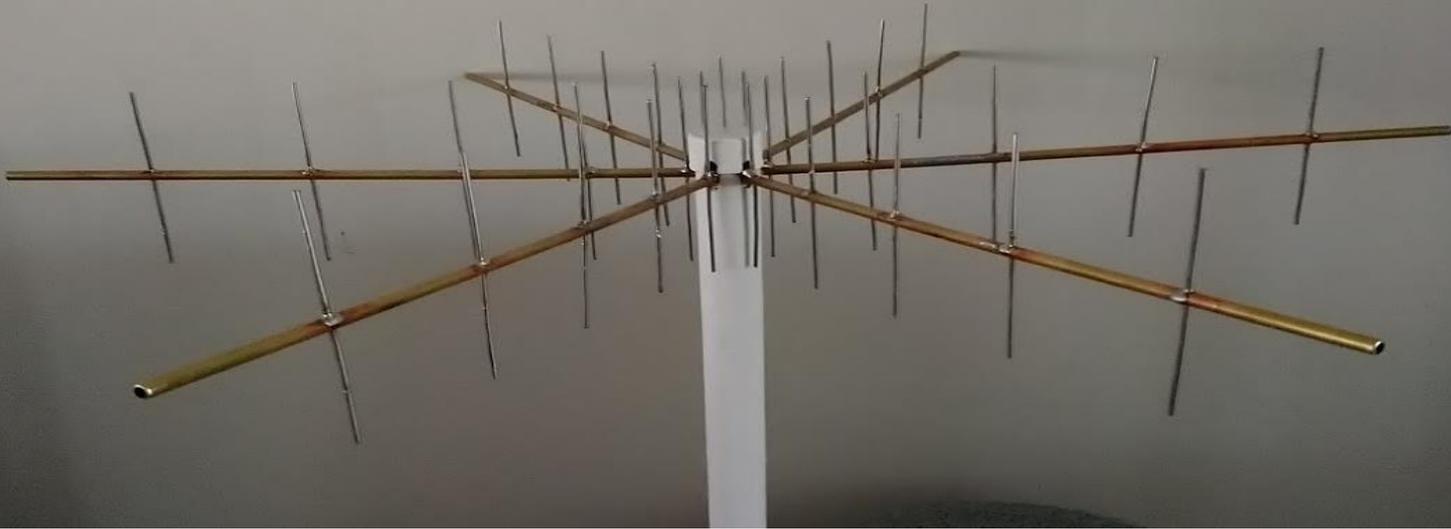



www.airport-data.com :: www.airliners.net :: www.airframes.org
 Show on map :: Enable auto-select :: Submit route

Tracking 26 aircraft (out of 725) Pause :: List all

Silhouette	Callsign	Altitude	Speed	Reg.	ICAO	Route
	SWT7016*	-53 m	210.0 km/h	EC-IMX	342201	HAI*-STN
	BEE84A*	-30 m	215.2 km/h	G-FBJK	406450	
	ZXP26*	-15 m	195.4 km/h	PH-PXZ	4844C0	
	LIFLNT*	GND	235.0 km/h	PH-HVB	484858	
	CFE23X*	8 m	211.3 km/h	G-LCYE	406099	LCY-AMS
	NC603	0 m	202.2 km/h	PH-CGN	484607	
	EZY2159	53 m	212.2 km/h	G-EZUS	406660	LTN-AMS
	SAS1549	53 m	217.2 km/h	OY-KBO	45ACAF	CPH-AMS
	ZXP01*	53 m	67.4 km/h	PH-PXA	484A91	
	BEE2PE*	61 m	213.7 km/h	G-ECOC	405658	MAN-EDI
	BEE7SA*	61 m	213.4 km/h	G-FBJA	40659A	
	WGTB8	69 m	203.7 km/h	D-AGBH	3C9C48	
	EZY78WK	69 m	222.1 km/h	G-EZWY	406891	MAD-EDI
	TRA61P	69 m	243.0 km/h	PH-HZJ	48414E	RTM-S2G
	KLMB0A	69 m	215.0 km/h	PH-BXL	484164	PRG-AMS
	TRA052	69 m	217.2 km/h	PH-HXL	48486E	BFI-AMS
	AZA74F	69 m	232.2 km/h	B-D85Y	4CA757	FCO-AMS
	BAW446	76 m	228.7 km/h	G-EUJL	4809C7	LHR-AMS
	EZY7403	91 m	205.6 km/h	G-UZHH	4074B8	SEN-AMS
	EZ565MN	99 m	230.9 km/h	HB-JXC	4B1A1C	GVA-AMS
	BEE48L*	107 m	204.6 km/h	G-FBJI	406663	BHX-AMS

Mee bezig.....



Vragen!!



**Bedankt voor u
aandacht.**



Beeldmateriaal van: LVNL.nl

Luchtverkeersleiding Nederland