

# ADSB op Raspberry Pi

*secondary surveillance radar voor 80 euro*



Dick van Harten  
*3 oktober 2016*

Raspberry Pi projecten:  
Weerstation,  
Domotica/IOT (verlichting, weersensoren),  
Controle en instelling CV

Toekomstige Raspberry Pi projecten:  
Controle en beveiliging/bewaking huis,  
Domotica (zonne-energie)  
Audio

# Overzicht

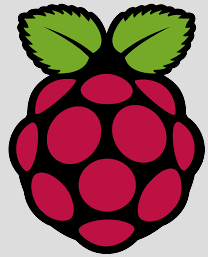
## Onderwerpen

- PCGG: Personal Computer Gebruikersgroep
- Raspberry Pi : een 25\$ creditcard computer
- ADSB: Automatic Dependent Surveillance - Broadcast
- ADSB op Raspberry Pi
- ADSB services
- Afsluiting
  - Demo
  - Vragen

# Raspberry Pi

## Geschiedenis Raspberry Pi

- Initiator: Eben Upton
  - Cambridge University
  - later Chip Designer Architect Broadcom
- Bedoelingen:
  - Jeugd in het Verenigd Koninkrijk:  
'need to create a generation of producers, not consumers'
  - Teach, Learn, Make
  - Betaalbare computer voor ontwikkelingslanden



# Raspberry Pi

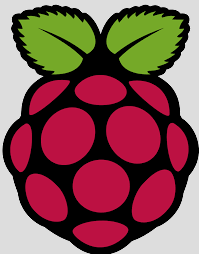
## Geschiedenis (vervolg)

- Inspiratie:
  - (1981) BBC A, B,
  - (1985) ARM (Acorn/Advanced RISC Machine)  
RISC=Reduced Instruction Set Computing
- Verwachte Productie grootte: 10000
- Raspberry Pi Typen:
  - A, B, A+, B+, 2B, Compute Module, Zero, 3
  - Gemiste kans: versie 3.14, release 14 maart, 22 juli



Acorn 

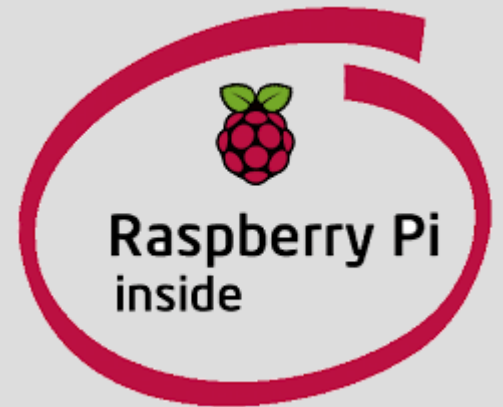
ARM<sup>®</sup>



# Raspberry Pi

## Bestelde aantallen

- 28 feb 2013: 100,000 (eerste dag)
- Okt 2013: 2 miljoen
- Feb 2015: 5 miljoen
- Aug 2016: 10 miljoen
- "Thanks to you, we've beaten our wildest dreams by three orders of magnitude," says Upton.  
"And we're only just getting started."



# Raspberry Pi

## Raspberry Pi Types

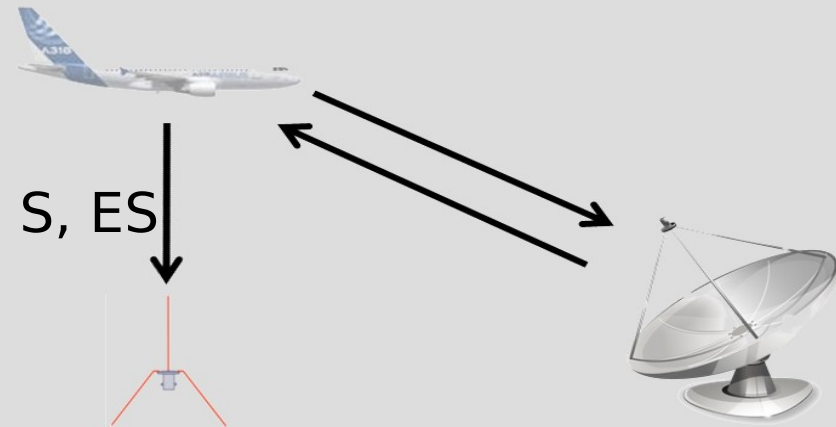
Variant	Raspberry Pi 1				Raspberry Pi 2		Raspberry Pi 3	Compute Module*	Raspberry Pi Zero	
Model	Model A	Model A+	Model B	Model B+	Model B	Model B	N/A	PCB v1.2	PCB v1.3	
Release date	February 2012	November 2014 <sup>[39]</sup>	April–June 2012	July 2014 <sup>[40]</sup>	February 2015 <sup>[13]</sup>	February 2016 <sup>[14]</sup>	April 2014 <sup>[41]</sup>	November 2015 <sup>[42]</sup>	May 2016	
Target price	US\$25	US\$20 <sup>[43]</sup>	US\$35 <sup>[44]</sup>	US\$25 <sup>[45]</sup>	US\$35	US\$35	US\$30 (in batches of 100) <sup>[41]</sup>	US\$5 <sup>[42]</sup>	US\$5	
Architecture	ARMv6 (32-bit)				ARMv7 (32-bit)		ARMv6 (64/32-bit)	ARMv6 (32-bit)		
SoC	Broadcom BCM2835 <sup>[11]</sup>				Broadcom BCM2836		Broadcom BCM2837	Broadcom BCM2835 <sup>[41]</sup>		
CPU	700 MHz single-core ARM1176JZF-S <sup>[11]</sup>				900 MHz 32-bit quad-core ARM Cortex-A7		1.2 GHz 64-bit quad-core ARM Cortex-A53	700 MHz single-core ARM1176JZF-S	1 GHz ARM1176JZF-S single-core <sup>[42]</sup>	
GPU	Broadcom VideoCore IV @ 250 MHz (BCM2837: 3D part of GPU @ 300 MHz, video part of GPU @ 400 MHz) <sup>[46][47]</sup> OpenGL ES 2.0 (BCM2835, BCM2836: 24 GFLOPS / BCM2837: 28.8 GFLOPS) MPEG-2 and VC-1 (with license), <sup>[48]</sup> 1080p30 H.264/MPEG-4 AVC high-profile decoder and encoder <sup>[11]</sup> (BCM2837: 1080p60)									
Memory (SDRAM)	256 MB (shared with GPU)		512 MB (shared with GPU) as of 4 May 2016. Older boards had 256 MB (shared with GPU) <sup>[49]</sup>			1 GB (shared with GPU)		512 MB (shared with GPU)		
USB 2.0 ports <sup>[50]</sup>	1 (direct from BCM2835 chip)		2 (via the on-board 3-port USB hub) <sup>[50]</sup>		4 (via the on-board 5-port USB hub) <sup>[29][40]</sup>			1 (direct from BCM2835 chip)	1 Micro-USB (direct from BCM2835 chip)	
Video input	15-pin MIPI camera interface (CSI) connector, used with the Raspberry Pi camera or Raspberry Pi NoIR camera <sup>[51]</sup>							2× MIPI camera interface (CSI) <sup>[41]</sup> <sup>[52][53]</sup>	None	MIPI camera interface (CSI) (rev 1.3) <sup>[54]</sup>
Video outputs	HDMI (rev 1.3) composite video (RCA jack)		HDMI (rev 1.3), composite video (3.5 mm TRRS jack)	HDMI (rev 1.3), composite video (RCA jack)		HDMI (rev 1.3), composite video (3.5 mm TRRS jack)		HDMI, 2× MIPI display interface (DSI) for raw LCD panels, <sup>[41][53]</sup> <sup>[55][56]</sup> composite video <sup>[52][57]</sup>	Mini-HDMI, 1080p60, <sup>[42]</sup> composite video via GPIO <sup>[58]</sup>	
Audio inputs	As of revision 2 boards via I <sup>2</sup> S <sup>[59]</sup>									
Audio outputs	Analog via 3.5 mm phone jack; digital via HDMI and, as of revision 2 boards, I <sup>2</sup> S							Analog, HDMI, I <sup>2</sup> S	Mini-HDMI, stereo audio through PWM on GPIO	
On-board storage <sup>[50]</sup>	SD, MMC, SDIO card slot (3.3 V with card power only)		MicroSDHC slot <sup>[40]</sup>	SD, MMC, SDIO card slot		MicroSDHC slot		4 GB eMMC flash memory chip, <sup>[41]</sup>	MicroSDHC	
On-board network <sup>[50]</sup>	None <sup>[60]</sup>				10/100 Mbit/s Ethernet (8P8C) USB adapter on the USB hub <sup>[50]</sup>		10/100 Mbit/s Ethernet, 802.11n wireless, Bluetooth 4.1		None	
Low-level peripherals	8× GPIO <sup>[61]</sup> plus the following, which can also be used as GPIO: UART, I <sup>2</sup> C bus, SPI bus with two chip selects, I <sup>2</sup> S audio <sup>[62]</sup> +3.3 V, +5 V, ground <sup>[46][63]</sup>		17× GPIO plus the same specific functions, and HAT ID bus	8× GPIO plus the following, which can also be used as GPIO: UART, I <sup>2</sup> C bus, SPI bus with two chip selects, I <sup>2</sup> S audio +3.3 V, +5 V, ground. An additional 4× GPIO are available on the P5 pad if the user is willing to make solder connections		17× GPIO plus the same specific functions, and HAT ID bus		46× GPIO, some of which can be used for specific functions including I <sup>2</sup> C, SPI, UART, PCM, PWM <sup>[64]</sup>	40× GPIO ("unpopulated header") <sup>[42]</sup>	
Power ratings	300 mA (1.5 W) <sup>[65]</sup>	200 mA (1 W) <sup>[66]</sup>	700 mA (3.5 W)		600 mA (3.0 W) <sup>[40]</sup>	800 mA <sup>[67]</sup> (4.0 W) <sup>[68]</sup>	200 mA (1 W)	~160 mA <sup>[42]</sup> (0.8 W)		
Power source	5 V via MicroUSB or GPIO header									
Size	85.60 mm × 56.5 mm (3.370 in × 2.224 in), not including protruding connectors		65 mm × 56.5 mm × 10 mm (2.56 in × 2.22 in × 0.39 in), same as HAT board	85.60 mm × 56.5 mm (3.370 in × 2.224 in), not including protruding connectors					67.6 mm × 30 mm (2.66 in × 1.18 in)	65 mm × 30 mm × 5 mm (2.56 in × 1.18 in × 0.20 in)
Weight	31 g (1.1 oz)	23 g (0.81 oz)		45 g (1.6 oz)		7 g (0.25 oz) <sup>[69]</sup>				9 g (0.32 oz) <sup>[70]</sup>
Console	Micro-USB cable <sup>[60]</sup> or a serial cable with optional GPIO power connector <sup>[71]</sup>									
Model	Model A	Model A+	Model B	Model B+	Model B	Model B	N/A	PCB v1.2	PCB v1.3	
Variant	Raspberry Pi 1				Raspberry Pi 2		Raspberry Pi 3	Compute Module*	Raspberry Pi Zero	



## ▣ ADSB: Automatic Dependent Surveillance - Broadcast

### ADSB, SSR en IFF

- IFF: militaire 'Identification Friend or Foe' technologie, ontwikkeld gedurende de tweede wereldoorlog
- SSR: Secondary Surveillance Radar gebaseerd op IFF, daarom nog steeds compatible
- ADSB: een vorm van SSR
  - Frequentie: 1030/1090 Mhz
  - Berichten: A, B, C (altitude), D, S, ES
  - Bericht: S ook unsolicited
  - Bericht: ES (ADSB info)

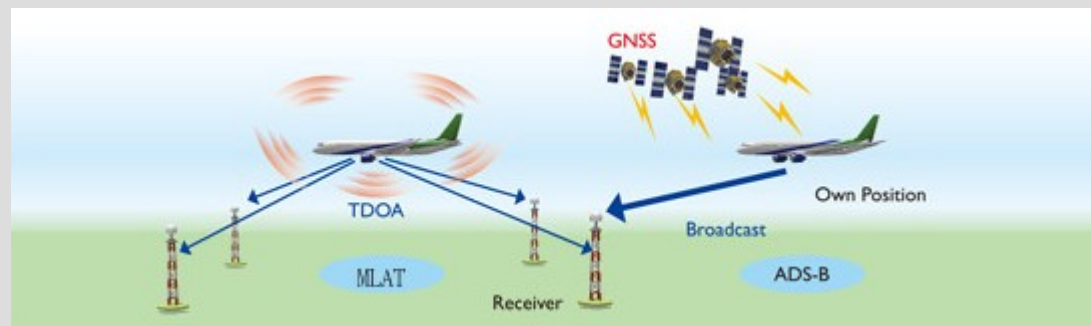




# ADSB Multilateration (MLAT)

## Multilateration

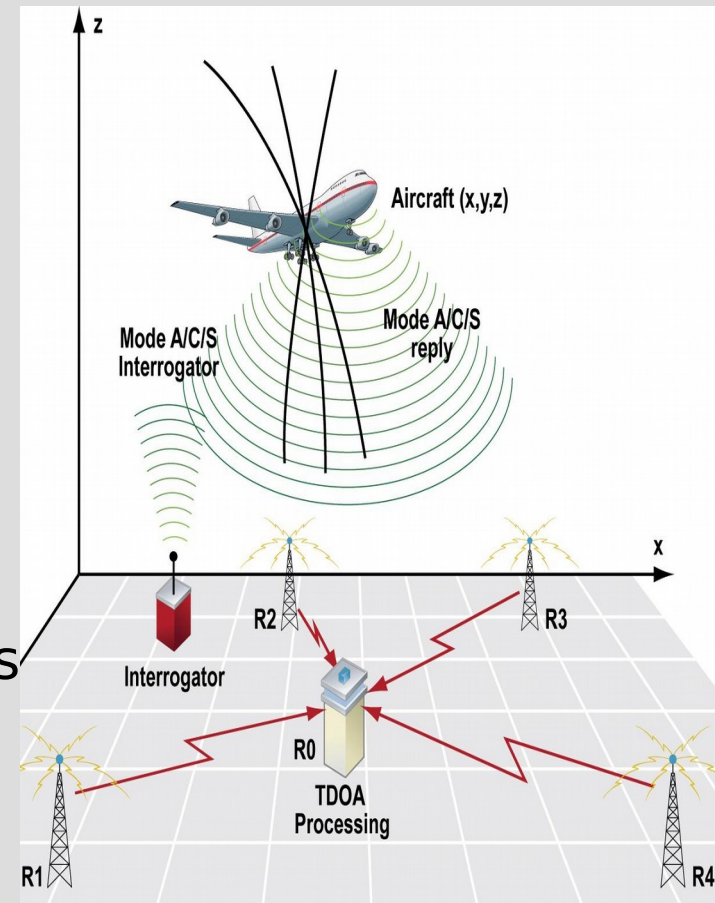
- Positiebepaling zonder dat positie ontvangen wordt.
- Techniek:
  - Ontvangt Mode S transponder signalen
  - Gebruikt ontvangst-tijd-verschillen bij meerdere ontvangers
  - Methode: time difference of arrival (TDOA)



# ADSB Multilateration (MLAT)

## Multilateration (toegift)

- Bijv. 4 ontvangst stations
- Time of Arrival (1,2,3,4)
- TDOA(12, 13, 14, 23, 24, 34)
- Meerdere hyperbool snijpunten (3 vergelijkingen, 3 onbekenden)
- Evt. verwijderen 'foute metingen'
- Complexiteit: tijdoplijning ontvangers
- Centrale (server) positie berekening
- 1 micro seconde = 300 meter



# ADSB op Raspberry Pi

## Ontvangststraat

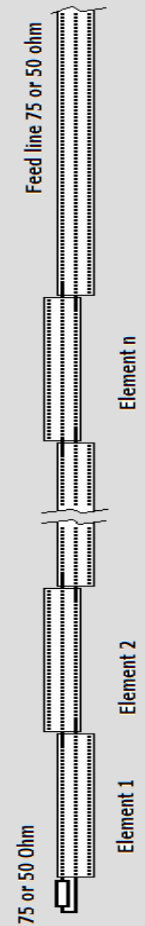
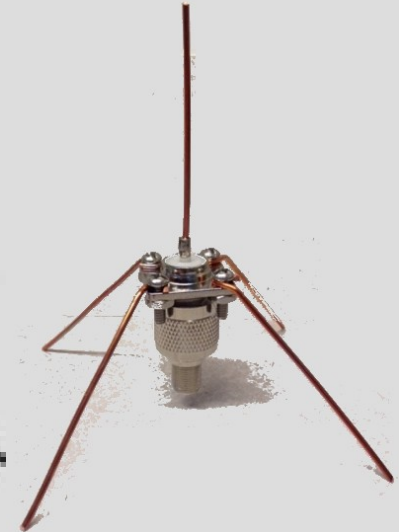
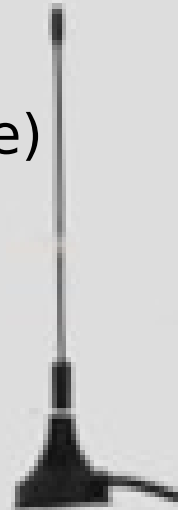
- Ontvangst antenne
- Bandfilter (optioneel)
- Ontvanger (software defined radio, china, 8 euro, dab, fm, etc.)
- Processor (Raspberry pi)
- Software



# ADSB op Raspberry Pi

## Ontvangst Antenne

- Antenne type (gain: tot tien keer meer ontvangen posities)
- Antenne positie (voorkeur: hoog, 'zicht' op veel vliegtuigen)
- Correcte aanpassing (impedantie)
- Types, o.a.:
  - Spriet
  - Groundplane
  - Coax Collinear Antenna



# ADSB op Raspberry Pi

## Bandfilter

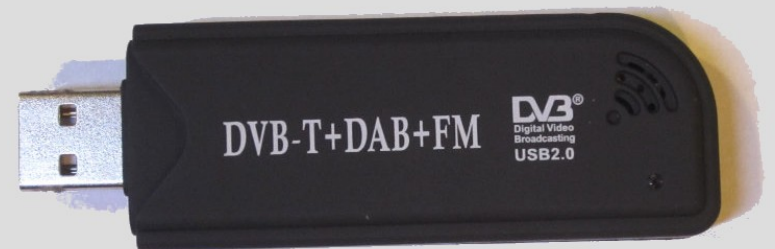
- Bandfilter alleen met gevoelige ontvanger
- Voor:
  - onderdrukking van stoorsignalen
  - tegen gaan van ontvanger-oversturing



# ADSB op Raspberry Pi

## Ontvanger (RTL-SDR)

- Hooggevoelig (Amazon, \$16)
- Normaalgevoelig (Aliexpress, \$8)
- RTL-SDR (RTL2832U)
  - Frequency range :  
24 → 1760 MHz (direct sampling: 100 KHz - 24 MHz)
  - Toepassingen:  
ADSB, DVB-T, DAB, FM receiver, spectrum analyzer



# ADSB op Raspberry Pi

## Processor (Raspberry Pi)

- Bijv. Raspberry Pi 3
  - 1 Gbyte RAM
  - Quad Core, 1.2 GHz
  - 4 x USB2
  - Ethernet, Wifi,
  - Bluetooth 4.0 LE
  - HDMI
  - 2 a 3 Watt
  - Computing power: ~Pentium 2 GHz



# ADSB op Raspberry Pi

## Software

- 2016-09-23-raspbian-jessie.img
  - Windows10
  - Win32DiskImager
  - micro sd card
- Dump1090
  - <https://forum.planefinder.net/threads/raspberry-pi-b-plus-and-model2-installation-instructions-for-raspbian-dump1090-data-feeder.241/>
- Of, voor PiAware:
  - <https://flightaware.com/adsb/piaware/build>





# Internet Services

- Dump1090 (ontvanger in Haaksbergen)  
<http://www.hetweer.nu:9090>
- FlightAware (met o.a. multilateration):  
<http://nl.flightaware.com/adsb/stats/user/dickvanharten>
- FlightRadar24
- ADS-B Exchange  
<http://global.adsbexchange.com/VirtualRadar/desktop.html>
- Virtual Radar Server
- Let op: 'free premium account', filteren, aanleveren,

# Afsluiting

## Vragen

## Demo

- Dump1090 is operationeel
- Effect standaard antenne vs. 'afgestemde' groundplane antenne
- Effect hooggevoelige ontvanger met bandpass filter en hooggeplaatste groundplane antenne
- ADS-B Exchange

## Vragen