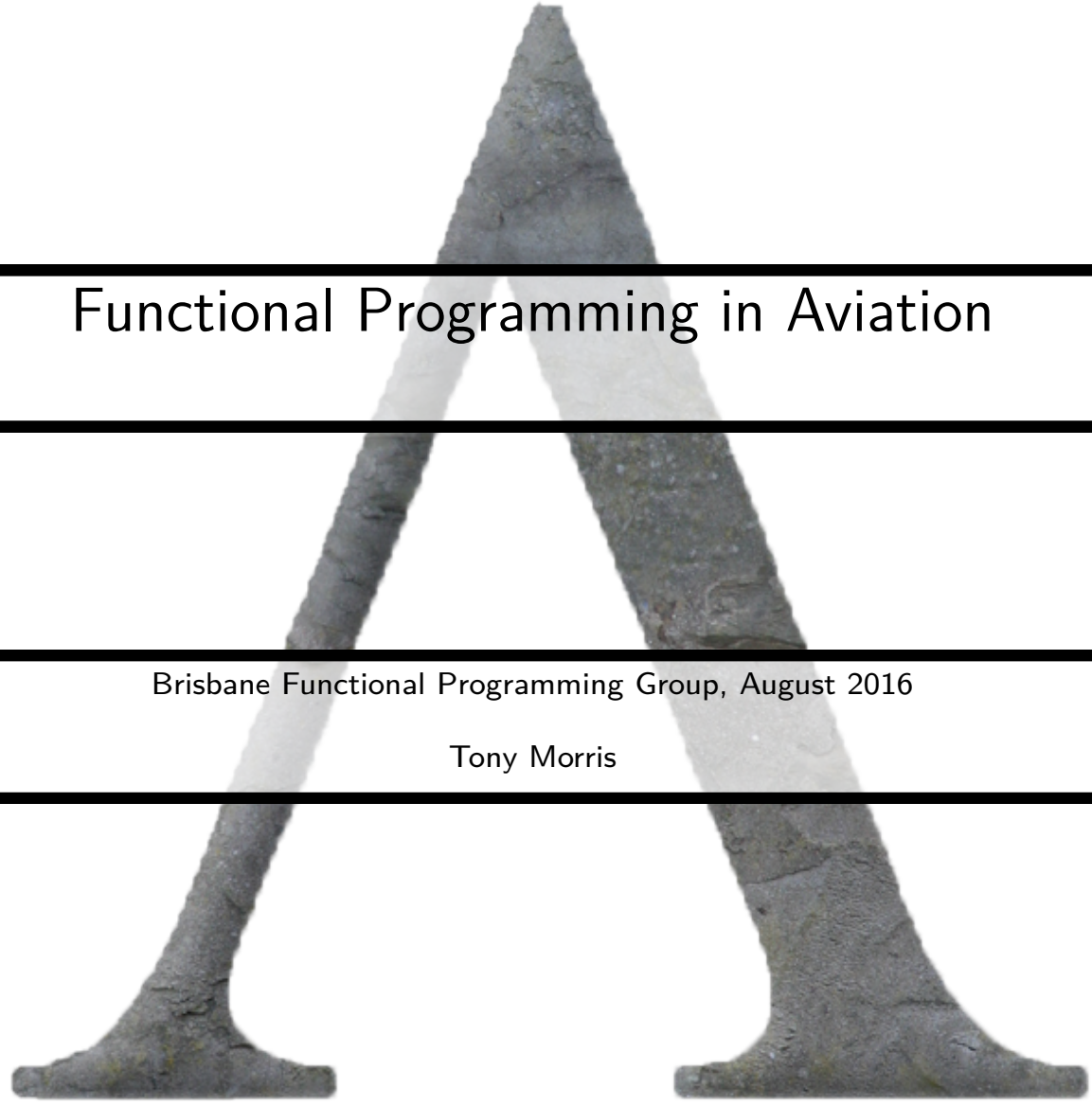


Functional Programming in Aviation

Brisbane Functional Programming Group, August 2016

Tony Morris

Yo BFPG

I haven't given a BFPG talk in quite a while

- My talks are typically about some specific algebraic structure that causes pain in the brain.
- This is not one of those talks.
- This is a fun, gentle story.
- Promise.

Yo BFPG

I haven't given a BFPG talk in quite a while

- My talks are typically about some specific algebraic structure that causes pain in the brain.
- This is not one of those talks.
- This is a fun, gentle story.
- Promise.

Yo BFPG

I haven't given a BFPG talk in quite a while

- My talks are typically about some specific algebraic structure that causes pain in the brain.
- This is not one of those talks.
- This is a fun, gentle story.
- Promise.

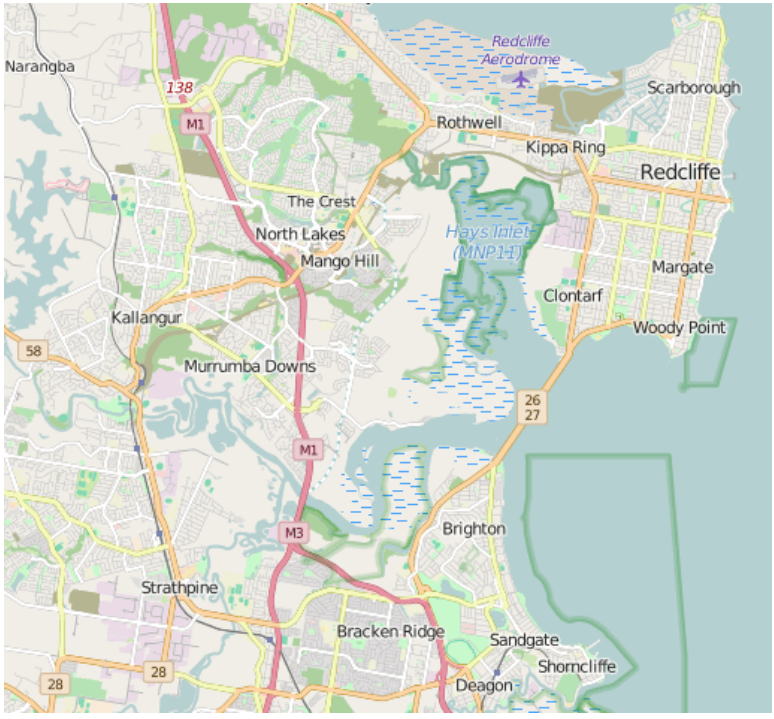
Yo BFPG

I haven't given a BFPG talk in quite a while

- My talks are typically about some specific algebraic structure that causes pain in the brain.
- This is not one of those talks.
- This is a fun, gentle story.
- Promise.

Aviation

I used to live here

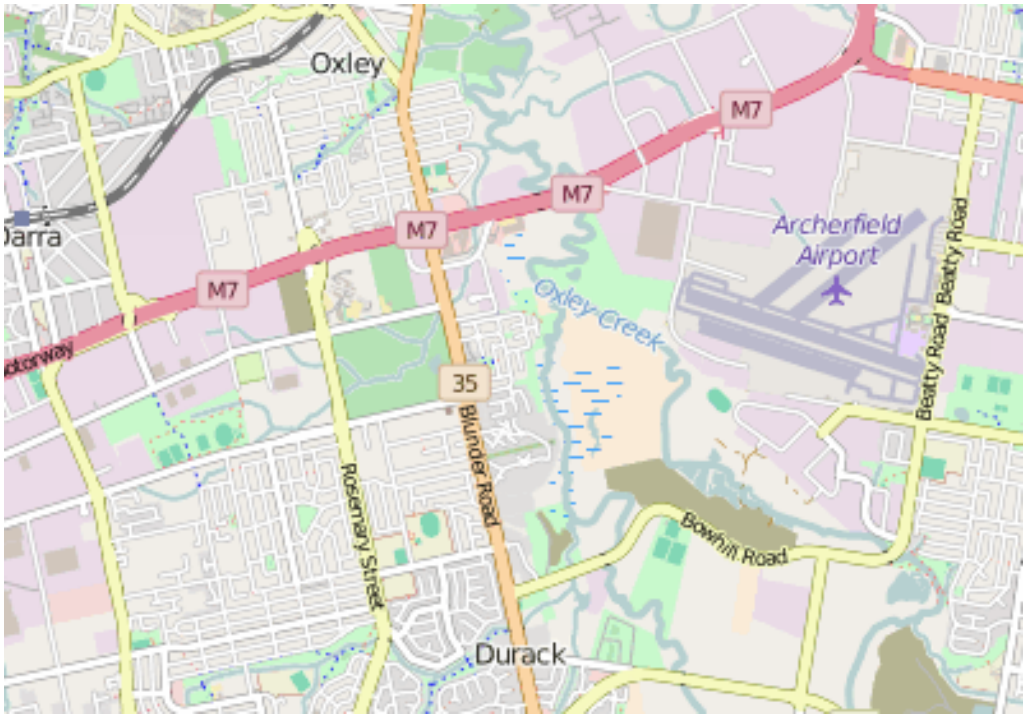


Aviation

and this thought bubble would happen

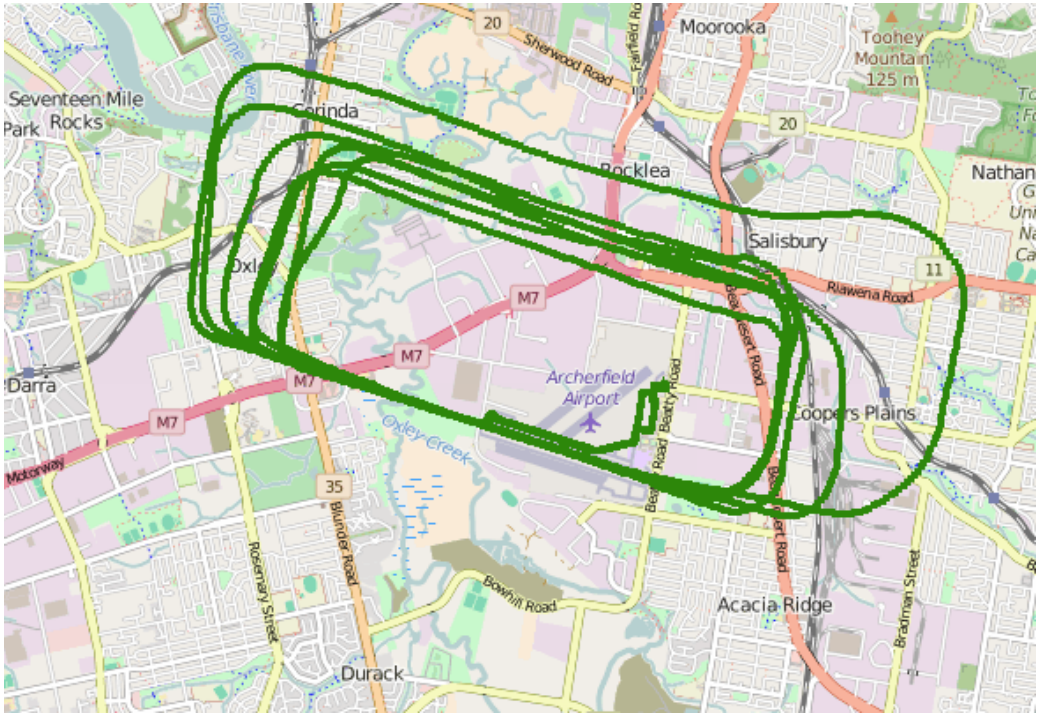
Aviation

and now I live near here



Aviation

This is the 10L/28R circuit pattern for Archerfield (YBAF)



Aviation

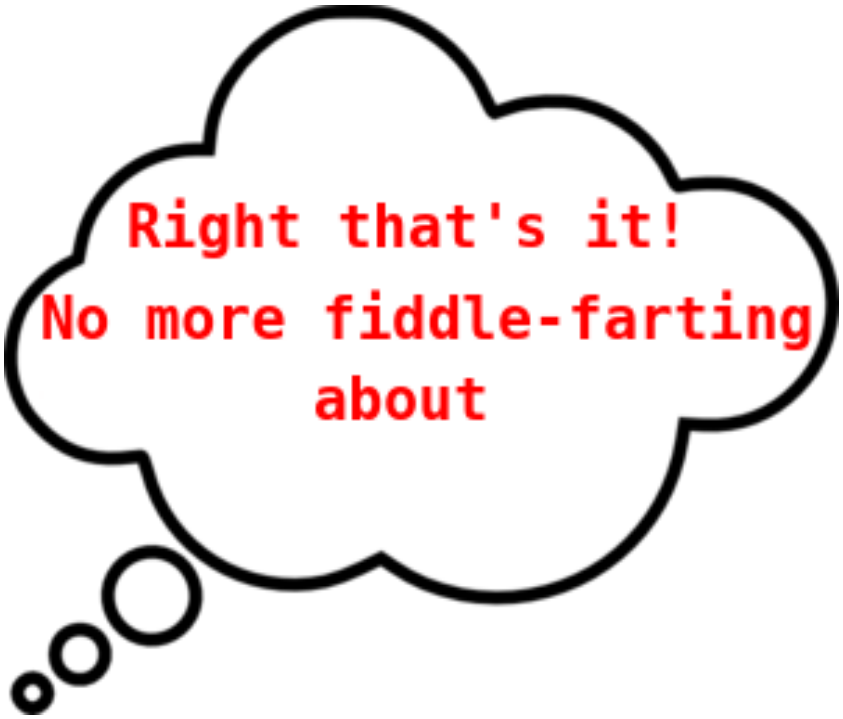
and I'd see this on my way home

Aviation

This is me on my way home

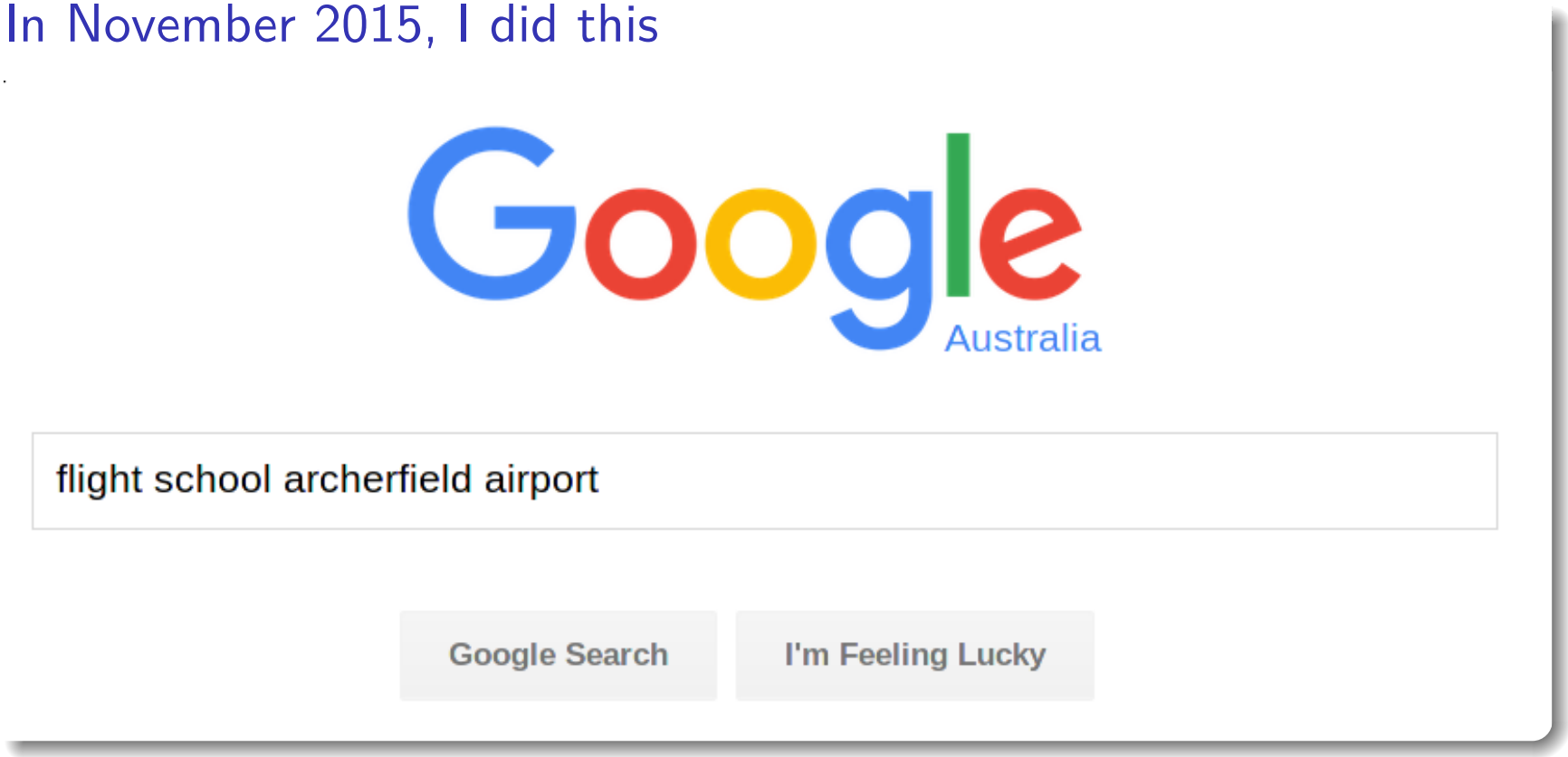
Aviation

and so



Aviation

In November 2015, I did this



A domestic argument ensued

My lovely wife Amanda was like

A compromise was reached

and I was like

The argument was over

and Amanda was like

Today

First CASA flight exam looms

Pilot Personal Log Book

Civil Aviation Safety Regulation 1998 (61.345)

- **Name:** Tony John Morris
- **ARN:** 1007036
- **Total Hours:** 34.2
- **Dual Hours:** 29.4
- **Solo Hours:** 4.8

Aviation

This is a story about some things I have learned about aviation.

Civil Aviation in Australia

- Federally regulated by Civil Aviation Safety Authority (CASA).
- Services, such as weather, provided by Airservices Australia.

Civil Aviation in Australia

- Federally regulated by Civil Aviation Safety Authority (CASA).
- Services, such as weather, provided by Airservices Australia.

Civil Aviation in Australia

and we don't want this to happen

Civil Aviation in Australia

so these also exist

- International Air Services Commission, Australia (IASC).
- International Civil Aviation Organisation (ICAO).

Civil Aviation in Australia

so these also exist

- International Air Services Commission, Australia (IASC).
- International Civil Aviation Organisation (ICAO).

Civil Aviation in Australia

Australian aviation legislation

- Australian Commonwealth, Civil Aviation Act 1988.
- Under CAA1988, is Civil Aviation Safety Regulations 1998.
- The Civil Aviation Regulation 1988 (CAR) is replaced by CASR.

Civil Aviation in Australia

Australian aviation legislation

- Australian Commonwealth, Civil Aviation Act 1988.
- Under CAA1988, is Civil Aviation Safety Regulations 1998.
- The Civil Aviation Regulation 1988 (CAR) is replaced by CASR.

Civil Aviation in Australia

Australian aviation legislation

- Australian Commonwealth, Civil Aviation Act 1988.
- Under CAA1988, is Civil Aviation Safety Regulations 1998.
- The Civil Aviation Regulation 1988 (CAR) is replaced by CASR.

Civil Aviation in Australia

CASR 61.345 *(pilot logbooks)*

61.345 Personal logbooks—pilots

(1) A person who holds a pilot licence, or a certificate of validation of an overseas flight crew licence that is equivalent to a pilot licence, commits an offence if the person does not keep a personal logbook in accordance with this regulation.

Penalty: 50 penalty units.

(2) The person must record his or her full name and date of birth in the person's logbook.

(3) The person must, as soon as practicable after completing each flight, record the following information in the person's logbook for the flight:

- (a) the date the flight began;
- (b) the type of aircraft;
- (c) whether it was a single-engine or multi-engine aircraft;
- (d) the aircraft's nationality and registration marks;
- (e) the take-off and landing points for the flight, and for each segment of the flight;
- (f) the flight time (if any) flown in each of the following capacities:
  - (i) pilot in command;
  - (ii) co-pilot;
  - (iii) pilot in command under supervision;
  - (iv) pilot receiving flight training;
- (g) if the person is a flight instructor—any flight time spent exercising the privileges of his or her flight instructor rating;
- (h) if the person is a flight examiner—any flight time spent exercising the privileges of his or her flight examiner rating;
- (i) whether the flight was by day or night, or both;
- (j) any instrument flight time;
- (k) whether the person conducted an instrument approach operation and, if so, the type of instrument approach procedure.

(4) The person must, as soon as practicable after completing each simulated flight in a flight simulation training device, record the following information in the person's logbook for the simulated flight:

- (a) the date the simulated flight began;
- (b) the type of aircraft represented by the device;
- (c) the simulated flight time (if any) performed in each of the following capacities:
  - (i) pilot in command;
  - (ii) co-pilot;
  - (iii) pilot in command under supervision;
  - (iv) pilot receiving flight training;
- (d) if the person is a flight instructor or simulator instructor—any time spent exercising the privileges of his or her instructor rating;
- (e) whether the flight was conducted in simulated day or night conditions, or both;
- (f) a description of the simulated flight activity.

DATA 61 CSIRO

Civil Aviation in Australia

CASR 61.345 *(pilot logbooks)*

Are electronic logbooks OK?

Civil Aviation in Australia

Yes. CASR 61.365(3)

CIVIL AVIATION SAFETY REGULATIONS 1998 - REG 61.365

Production of personal logbooks

(1) CASA may direct the holder of a flight crew licence or certificate of validation to produce the holder's personal logbook for inspection by CASA.

(2) The holder of a flight crew licence or certificate of validation commits an offence if:

(a) CASA directs the holder to produce his or her personal logbook under subregulation (1); and

(b) the holder does not produce an up to date version of the personal logbook within 7 days after the day the direction is given.

Penalty: 50 penalty units.

(3) If the holder's personal logbook is kept in electronic form, a requirement to produce the logbook is met if:

(a) the holder produces a printed copy of the logbook; and

(b) each page is certified by the holder as a true copy of the logbook records set out on the page.

Pilot logbooks

Introducing the pilot logbook cottage industry

An Excel spreadsheet I made. Free. Coupled with dropbox, works well.

Free copies upon request.

Pilot logbooks

Introducing the pilot logbook cottage industry

I used google sheets from the get go but Logten is pretty sexy.

It may be overqualified for my needs right now but I won't turn back.

Pilot logbooks

Introducing the pilot logbook cottage industry

I switched from a pre-subscription version of LogTen Pro to Foreflight's offering. I still keep a paper logbook, and am only a private, but in my opinion ForeFlight needs a few more features to be competitive. It does just fine for basic logging, it's the reporting side I'd like to see expanded, which they are working on.

Pilot logbooks

Introducing the pilot logbook cottage industry

I personally use Log Ten Pro X! So far it has been great.

Pilot logbooks

Introducing the pilot logbook cottage industry

Hated LogTenPro because of the cost and issues with syncing.

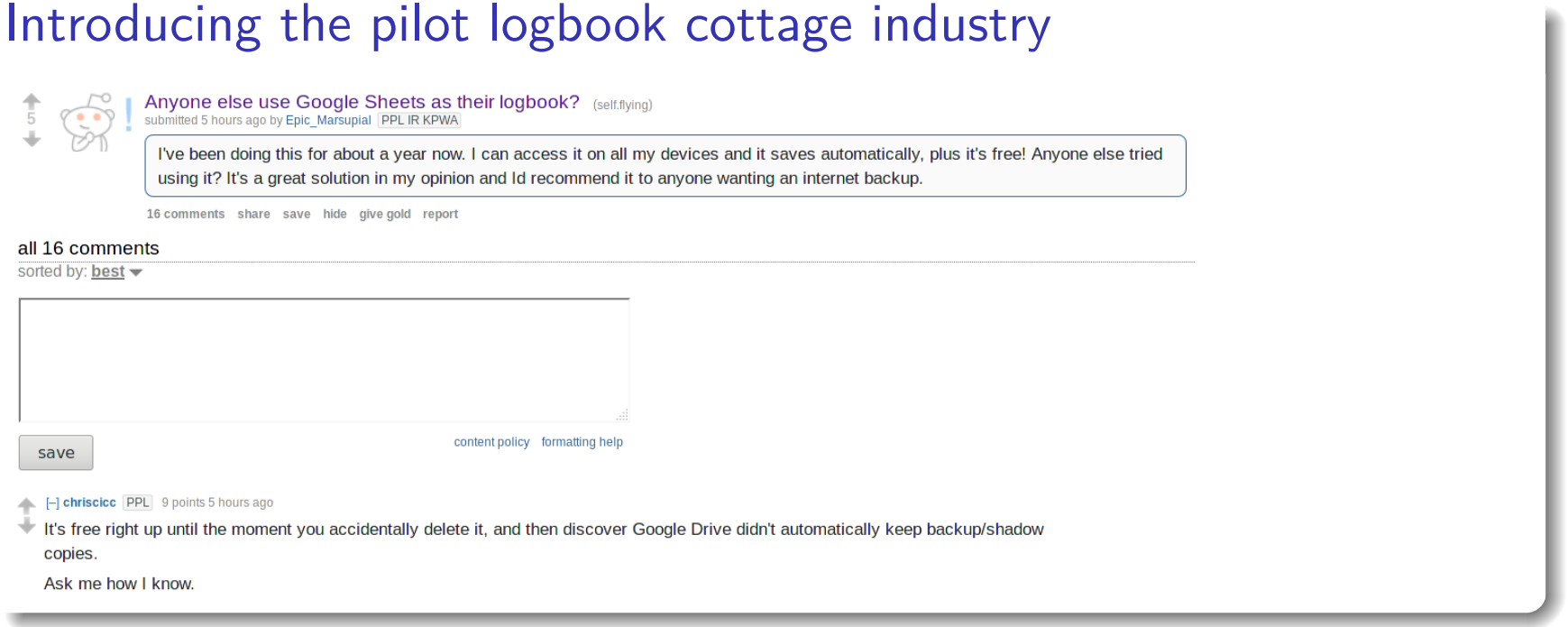
Pilot logbooks

Introducing the pilot logbook cottage industry

We really hate it when our software is not up to snuff. We guessed you might come from New Zealand and we tried to add a flight from New Zealand to Tahiti, crossing the international date line.

Pilot logbooks

Introducing the pilot logbook cottage industry



01 August 2016

Pilot logbooks

This is me, **when not flying**

Pilot logbooks *for responsible pilots*

Pilot logbook requirements

- Data loss impossible, including logbook history, with merge.
- First-class logbook-related values for composition.
- Values that can *close over* other values.
- Ability for *arbitrary* reporting.
- **You can see where I am going, innit?**

Pilot logbooks *for responsible pilots*

Pilot logbook requirements

- Data loss impossible, including logbook history, with merge.
- First-class logbook-related values for composition.
- Values that can *close over* other values.
- Ability for *arbitrary* reporting.
- **You can see where I am going, innit?**

Pilot logbooks *for responsible pilots*

Pilot logbook requirements

- Data loss impossible, including logbook history, with merge.
- First-class logbook-related values for composition.
- Values that can *close over* other values.
- Ability for *arbitrary* reporting.
- **You can see where I am going, innit?**

Pilot logbooks *for responsible pilots*

Pilot logbook requirements

- Data loss impossible, including logbook history, with merge.
- First-class logbook-related values for composition.
- Values that can *close over* other values.
- Ability for *arbitrary* reporting.
- You can see where I am going, innit?

Pilot logbooks *for responsible pilots*

Pilot logbook requirements

- Data loss impossible, including logbook history, with merge.
- First-class logbook-related values for composition.
- Values that can *close over* other values.
- Ability for *arbitrary* reporting.
- **You can see where I am going, innit?**

Pilot logbook

A responsible, CASR 61.x compliant pilot uses

- Haskell data type (sums and products) for logbook.
- Lenses for querying and reporting.
- Pilot logbook zipper for navigating a logbook.
- A pretty-printer to meet CASR 61.365 requirements.
- Revision control (git) for maintaining zero data loss.
- Publishes open-source logbook libraries.

Use-case

Query: Aviation Reference Number (ARN) of logbook owner

```
digitlist :: Prism' Int [Digit]
arn :: Lens' Aviator [Digit]
logbookaviator :: Lens' (Logbook a b c d) Aviator
mylogbook :: Logbook a b c d

λ> mylogbook ^.
       logbook . logbookaviator . arn . re digitlist
1007036
```

Use-case

Modify: Set the digit at index 2 of the ARN to 5

```
arn :: Lens' Aviator [Digit]
logbookaviator :: Lens' (Logbook a b c d) Aviator

λ> :t logbook . logbookaviator . arn %~
      \d -> d & ix 2 .~ x5
Logbook a b c d -> Logbook a b c d
```

Use-case

Modify: Upper-case the surname of the logbook owner

```
logbookaviator :: Lens' (Logbook a b c d) Aviator
surname :: Lens' Aviator String
map toUpper :: String -> String

λ> :t over
       (logbook . logbookaviator . surname)
       (map toUpper)
Logbook a b c d -> Logbook a b c d
```

Use-case

Query: Aircraft from all flights

```
logbookentries :: Lens (Logbook a b c d) (Entries a b c d)
_Wrapped :: Iso' (Entries a b c d) [Entry a b c d]
folded :: Foldable f => IndexedFold Int (f a) a
_AircraftFlightEntry ::
      Prism' (Entry a b c d) (AircraftFlight, a)
flightaircraft :: Lens' AircraftFlight Aircraft
mylogbook :: Logbook a b c d

λ> :t mylogbook ^..
      logbook .
      logbookentries .
      _Wrapped .
      folded .
      _AircraftFlightEntry . _1 .
      flightaircraft
[Aircraft]
```

Use-case

Query: Find first flight in aircraft registration VH-VVO

```
logbookentries :: Lens (Logbook a b c d) (Entries a b c d)
_AircraftFlightEntry ::
      Prism' (Entry a b c d) (AircraftFlight, a)
flightaircraft :: Lens' AircraftFlight Aircraft
aircraftRegistration :: Lens' Aircraft String

λ> :t findOf
      ( logbook .
        logbookentries .
        _Wrapped .
        folded .
        _AircraftFlightEntry . _1)
        ( elemOf
          (
            flightaircraft .
            aircraftRegistration)
          "VH-VVO")
      mylogbook
Maybe AircraftFlight
```

Use-case

Print: pretty-print all exam results

```
_ExamEntry ::
      Prism' (Entry a b c d) (Exam, c)
examResult :: Lens' Exam Int
examResultMaximum :: Lens' Exam Int

λ> mapMOf_
      ( logbook . logbookentries .
        _Wrapped . folded .
        _ExamEntry . _1 .
        runGetter
          ((\x y -> show x ++ " out of " ++ show y) <$>
          Getter examResult <*>
          Getter examResultMaximum)
        )
      putStrLn
      mylogbook
31 out of 40
38 out of 40
38 out of 40
```

Use-case

Query: All aircraft flights as pilot in-command

```
logbookentries :: Lens (Logbook a b c d) (Entries a b c d)
_AircraftFlightEntry ::
      Prism' (Entry a b c d) (AircraftFlight, a)
flightaircraft :: Lens' AircraftFlight Aircraft
aircraftRegistration :: Lens' Aircraft String

λ> :t
      mylogbook ^..
      logbook .
      logbookentries .
      _Wrapped .
      folded .
      _AircraftFlightEntry . _1 .
      filtered
        (elemOf (command . _InCommand) ())
[AircraftFlight]
```

Use-case

Query: Total day hours as pilot in-command

```
λ> foldOf
       ( logbook .
         logbookentries .
         _Wrapped .
         folded .
         _AircraftFlightEntry . _1 .
         filtered
           (elemOf (command . _InCommand) ()) .
         daynight .
         dayDayNight
       )
       mylogbook
TimeAmount {_hours = 4, _tenthofhour = 8}
```

Use-case

Print the entire logbook to a single, printable HTML web page

```
λ> :t htmlLogbook mylogbook
Html ()
```

http://logbook.aviation.tmorris.net/

Use-case

Query of arbitrary obtuseness

All flights where, if the departure and arrival date is the same day (UTC), and that date-of-month is a multiple of 7, unless either there was an intermediate flight path point of YSCN, or the time the logbook owner was PiC for the first three legs of the flight, is between 2.0 hours and the total sum of hours of dual flight in aircraft registered VH-AFR.

code too big to fit on screen

Electronic Flight Bags

Aeronautical Data and Information

Aeronautical Data and Information

Aviation, Navigation and Geodesy

- This part is not technical.
- There is no code here.
- Only whinging.

Aeronautical Data and Information

Aviation, Navigation and Geodesy

- This part is not technical.
- There is no code here.
- Only whinging.

Aeronautical Data and Information

Aviation, Navigation and Geodesy

- This part is not technical.
- There is no code here.
- Only whinging.

CASR 175

What is CASR 175 about?

CIVIL AVIATION SAFETY REGULATIONS 1998 - REG 175.005

What Part 175 is about

(1) This Part establishes standards and requirements for the quality and integrity of data and information used in air navigation.

(2) Subpart 175.B establishes standards and requirements for AIS providers--persons responsible for the publication of aeronautical data and aeronautical information in the Integrated Aeronautical Information Package and on aeronautical charts.

(3) Subpart 175.C establishes standards and requirements for data service providers--persons authorised to publish aeronautical data, aeronautical information or aeronautical charts, or to supply aeronautical data, that pilots may use as an alternative to the Integrated Aeronautical Information Package and aeronautical charts published by AIS providers.

(4) Subpart 175.D sets out requirements for aeronautical data originators--persons responsible for providing aeronautical data and aeronautical information to AIS providers for publication in the Integrated Aeronautical Information Package and on aeronautical charts.

(5) Subpart 175.E contains powers that can be used to gather data about objects and structures that affect aviation safety.

Note: The data gathered under Subpart 175.E will be used in air navigation applications, including the following:

(a) the design of terminal instrument flight procedures;

(b) the calculation of lowest safe altitudes;

(c) aircraft operating limitations analysis;

(d) minimum safe altitude warning systems;

(e) the publication of visual navigation charts.

“(e) the publication of visual navigation charts.”

DATA 61 CSIRO

CAR 233 (1)(h) *moved to CASR 175*

CAR 233 (1)(h)

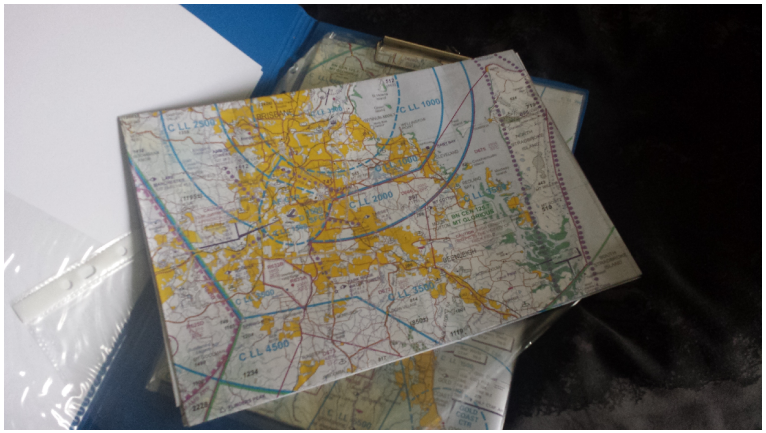
The pilot in command of an aircraft must not commence a flight if he or she has not received evidence, and taken such action as is necessary to ensure, that:

. . .

(h) the aeronautical data and aeronautical information mentioned in subregulation (1A) is carried in the aircraft and is readily accessible to the flight crew.

VTC/VNC

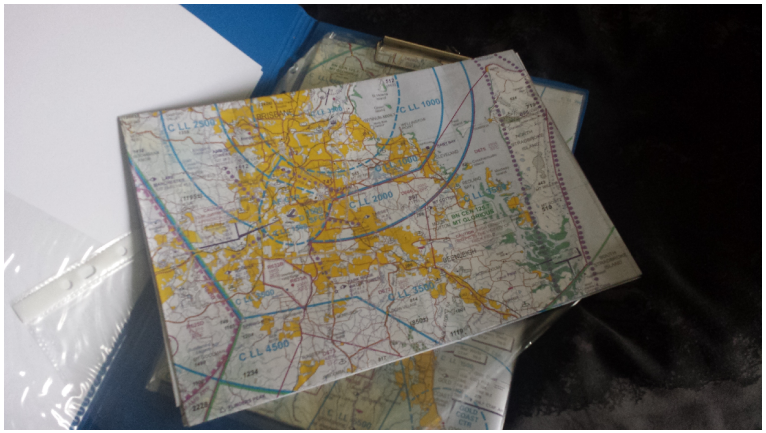
This is a Visual Terminal Chart



- It unfolds out to 500mm x 1000mm.
- Updated every 3 months.
- Similar to another required chart; VNC.

VTC/VNC

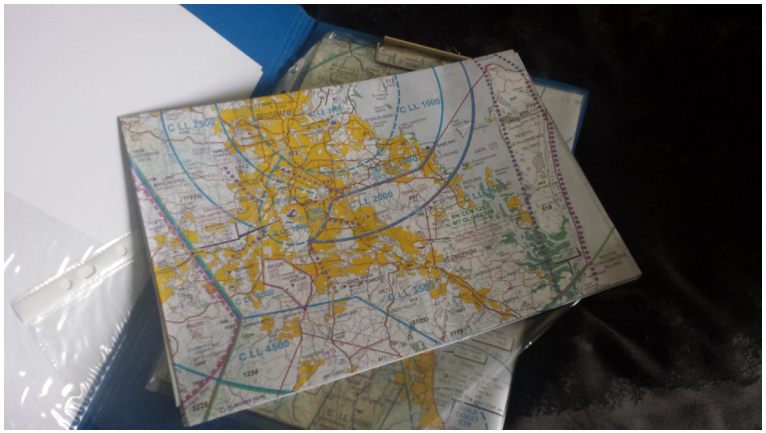
This is a Visual Terminal Chart



- It unfolds out to 500mm x 1000mm.
- Updated every 3 months.
- Similar to another required chart; VNC.

VTC/VNC

This is a Visual Terminal Chart



- It unfolds out to 500mm x 1000mm.
- Updated every 3 months.
- Similar to another required chart; VNC.

VTC/VNC

Surely these exist in electronic format?

Why yes, they do.

VTC/VNC

but

CASR 175.145(1)

AIS providers–publication of aeronautical charts relating to areas etc. outside authority

(1) This regulation applies if an AIS provider publishes an aeronautical chart that includes aeronautical data or aeronautical information that relates to an area, aerodrome, airspace or ATS route not covered by the provider's certificate.

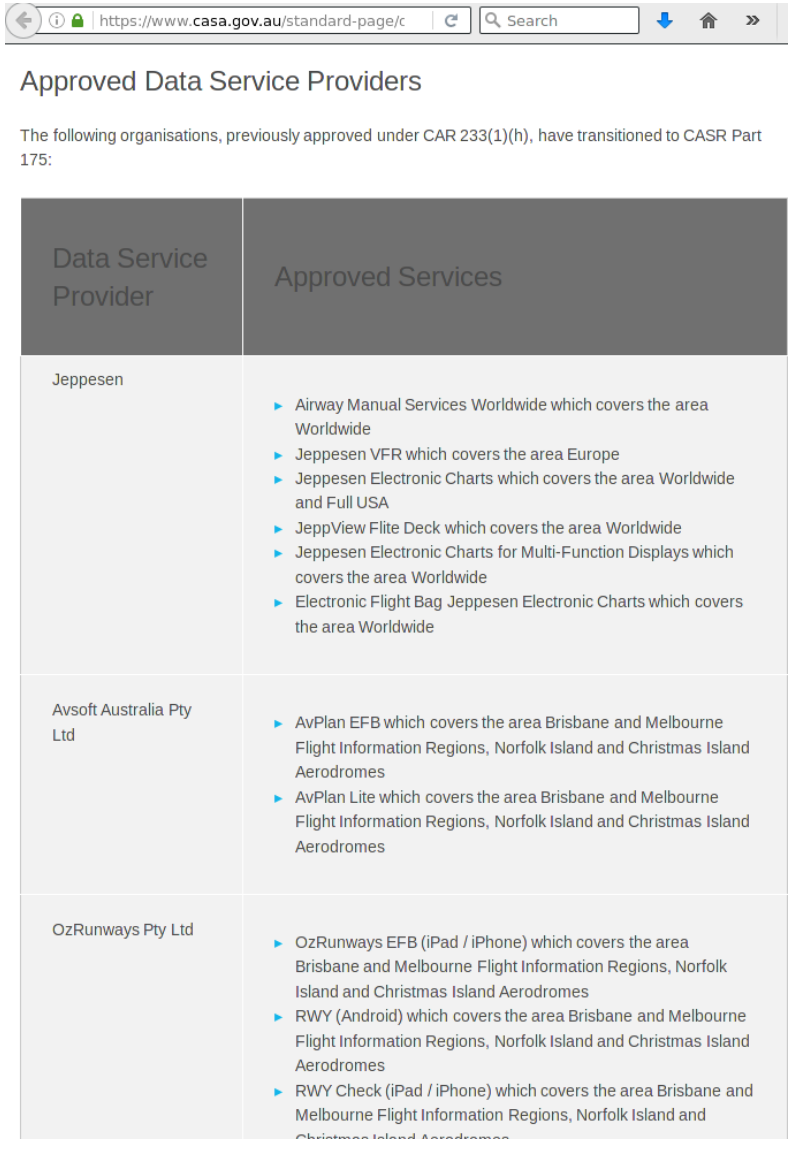
CASR 175.145(1)

No problem.
I will use approved electronic AIS aeronautical charts.

CASR 175.145(1)

but

CASR 175.145(1)



https://www.casa.gov.au/standard-page/c

Search

Approved Data Service Providers

The following organisations, previously approved under CAR 233(1)(h), have transitioned to CASR Part 175:

Data Service Provider	Approved Services
Jeppesen	► Airway Manual Services Worldwide which covers the area Worldwide ► Jeppesen VFR which covers the area Europe ► Jeppesen Electronic Charts which covers the area Worldwide and Full USA ► JeppView Flite Deck which covers the area Worldwide ► Jeppesen Electronic Charts for Multi-Function Displays which covers the area Worldwide ► Electronic Flight Bag Jeppesen Electronic Charts which covers the area Worldwide
Avsoft Australia Pty Ltd	► AvPlan EFB which covers the area Brisbane and Melbourne Flight Information Regions, Norfolk Island and Christmas Island Aerodromes ► AvPlan Lite which covers the area Brisbane and Melbourne Flight Information Regions, Norfolk Island and Christmas Island Aerodromes
OzRunways Pty Ltd	► OzRunways EFB (iPad / iPhone) which covers the area Brisbane and Melbourne Flight Information Regions, Norfolk Island and Christmas Island Aerodromes ► RWY (Android) which covers the area Brisbane and Melbourne Flight Information Regions, Norfolk Island and Christmas Island Aerodromes ► RWY Check (iPad / iPhone) which covers the area Brisbane and Melbourne Flight Information Regions, Norfolk Island and

CASR 175.145(1)

So then

- I first came to terms with my deep resentment of legislated enforcement of proprietary hardware and software.
- . . . in safety-critical applications such as aviation.
- I put aside my expectations of a complete failure.
- I took a deep breath.

CASR 175.145(1)

So then

- I first came to terms with my deep resentment of legislated enforcement of proprietary hardware and software.
- . . . in safety-critical applications such as aviation.
- I put aside my expectations of a complete failure.
- I took a deep breath.

CASR 175.145(1)

So then

- I first came to terms with my deep resentment of legislated enforcement of proprietary hardware and software.
- . . . in safety-critical applications such as aviation.
- I put aside my expectations of a complete failure.
- I took a deep breath.

CASR 175.145(1)

So then

- I first came to terms with my deep resentment of legislated enforcement of proprietary hardware and software.
- . . . in safety-critical applications such as aviation.
- I put aside my expectations of a complete failure.
- I took a deep breath.

CASR 175.145(1)

and I installed ozrunways on a proprietary hardware device.

CASR 175.145(1)

CASR 175.145(1)

I am told that

AvPlan fails at georectification.

Knowingly and with no recourse to correct it.

CASR 175.145(1)

Clearly then

CASR 175.145(1) legislates forced use of unsafe, inferior aeronautical data.

Civil Aviation Advisory Publication 233-1

CAAP 233-1 Electronic Flight Bags *(excerpt)*

APPENDIX B –

AOC Holder's Self Evaluation Checklist for the Introduction of EFB

Has the software application been evaluated to confirm that the information being provided to the pilot is a true and accurate representation of the documents or charts being replaced? Details:	Yes ☐ No ☐ N/A ☐
Has the software application been evaluated to confirm that the computational solution/s being provided to the pilot is a true and accurate solution (E.g. weight and balance, performance etc)? Details:	Yes ☐ No ☐ N/A ☐
Does the software application/s have adequate security measures to prevent unauthorised database modifications and prevention of contamination by external viruses? Details:	Yes ☐ No ☐ N/A ☐

CASR 175.145(1)

Automatic Dependent Surveillance – Broadcast
ADS-B

ADS-B

ADS-B is an electronic system aboard aircraft that broadcasts certain information about that aircraft, to other aircraft, air traffic control on the ground and anyone else who chooses to receive the signal.

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- The ICAO identifier for the airframe.
- The flight identifier e.g. aircraft callsign.
- Aircraft position.
- The integrity of the position report e.g. GPS accuracy.
- Altitude as a function of barometric pressure.
- Altitude as a function of GPS.
- Rate of climb/descent.
- Aircraft ground track.
- Aircraft ground speed.
- Any emergency indicators.

ADS-B

ADS-B

- ADS-B has a revision history in *modes*.
- Mode-S is broadcast on 1090MHz[a].
- Mode-S is most recent and can be received without transmitting[b].
- All IFR aircraft must be Mode-S ADS-B equipped by 2017.

[a] also 978MHz in some countries e.g. USA
[b] unlike Mode-C

ADS-B

ADS-B

- ADS-B has a revision history in *modes*.
- Mode-S is broadcast on 1090MHz[a].
- Mode-S is most recent and can be received without transmitting[b].
- All IFR aircraft must be Mode-S ADS-B equipped by 2017.

[a] also 978MHz in some countries e.g. USA

[b] unlike Mode-C

ADS-B

ADS-B

- ADS-B has a revision history in *modes*.
- Mode-S is broadcast on 1090MHz[a].
- Mode-S is most recent and can be received without transmitting[b].
- All IFR aircraft must be Mode-S ADS-B equipped by 2017.

[a] also 978MHz in some countries e.g. USA
[b] unlike Mode-C

ADS-B

ADS-B

- ADS-B has a revision history in *modes*.
- Mode-S is broadcast on 1090MHz[a].
- Mode-S is most recent and can be received without transmitting[b].
- All IFR aircraft must be Mode-S ADS-B equipped by 2017.

[a] also 978MHz in some countries e.g. USA
[b] unlike Mode-C

ADS-B

ADS-B receive

- We can receive Mode-S ADS-B signals with a SDR.
- Raspberry-pi, DVB Tuner, 1090MHz antenna.
- But we can also do more.

ADS-B

ADS-B receive

- We can receive Mode-S ADS-B signals with a SDR.
- Raspberry-pi, DVB Tuner, 1090MHz antenna.
- But we can also do more.

ADS-B

ADS-B receive

- We can receive Mode-S ADS-B signals with a SDR.
- Raspberry-pi, DVB Tuner, 1090MHz antenna.
- But we can also do more.

ADS-B

You are no doubt wondering

In a talk at the **Black Hat USA conference**, security researcher **Andrei Costin** discussed the possibility of spoofing signals to air traffic control systems in attacks – all courtesy of roughly $1,000 worth of equipment. After his presentation, he sat down with *SecurityWeek* and revealed more details of how attackers could exploit weaknesses in the **Automatic Dependent Surveillance-Broadcast (ADS-B)** technology.

Yes the absence of security in ADS-B has been demonstrated.

ADS-B

We won't be doing that today.
No transmitting of ADS-B.
ADS-B *receive only*.
However, we will be transmitting over TCP **securely**.

Portable ADS-B receiver hardware

Portable ADS-B receiver hardware in prototype stage

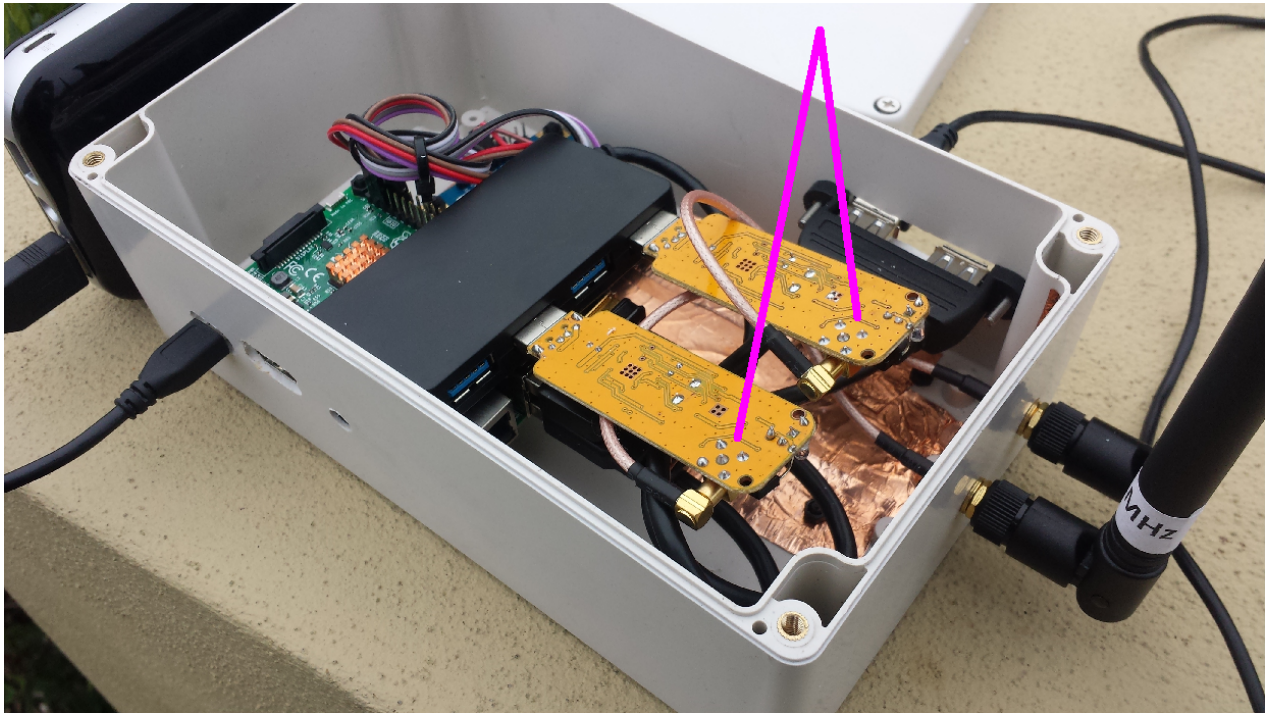
Portable ADS-B receiver hardware

Portable ADS-B receiver hardware in prototype stage

Portable ADS-B receiver hardware

Portable ADS-B receiver hardware

RTL2832U Digital DVB-T (x2)



- RTL2832U Digital DVB-T to receive 1090MHz.
- 2x for either adding 978MHz or redundant 1090MHz.

Portable ADS-B receiver hardware

RTL2832U Digital DVB-T

USB2.0 Digital DVB-T SDR+DAB+FM HDTV TV Tuner Receiver Stick HE RTL2832U+R820T

Item condition: **New: Never Used**

Quantity: 1 More than 10 available / 2,390 sold

Price: **AU $9.88**

Buy It Now

Add to cart

346 watching

Add to watch list

Add to collection

2,390 sold | 148 inquiries | 30-day returns

Portable ADS-B receiver hardware

Dual 1090MHz Antennae

- Copper ground plane can be seen.

Portable ADS-B receiver hardware

1090MHz Antenna

- Tried installing antenna to Amanda.
- No signals were received.

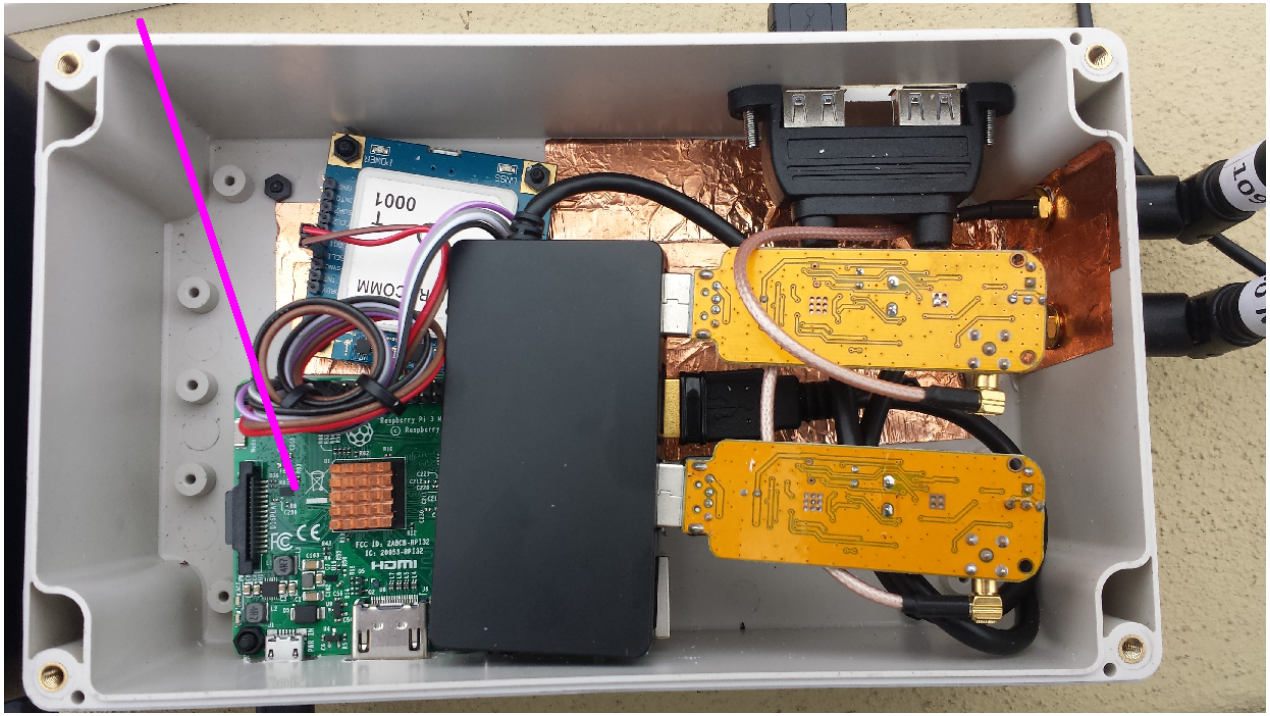
Portable ADS-B receiver hardware

1090MHz Antenna

- Tried installing antenna to Amanda.
- No signals were received.

Portable ADS-B receiver hardware

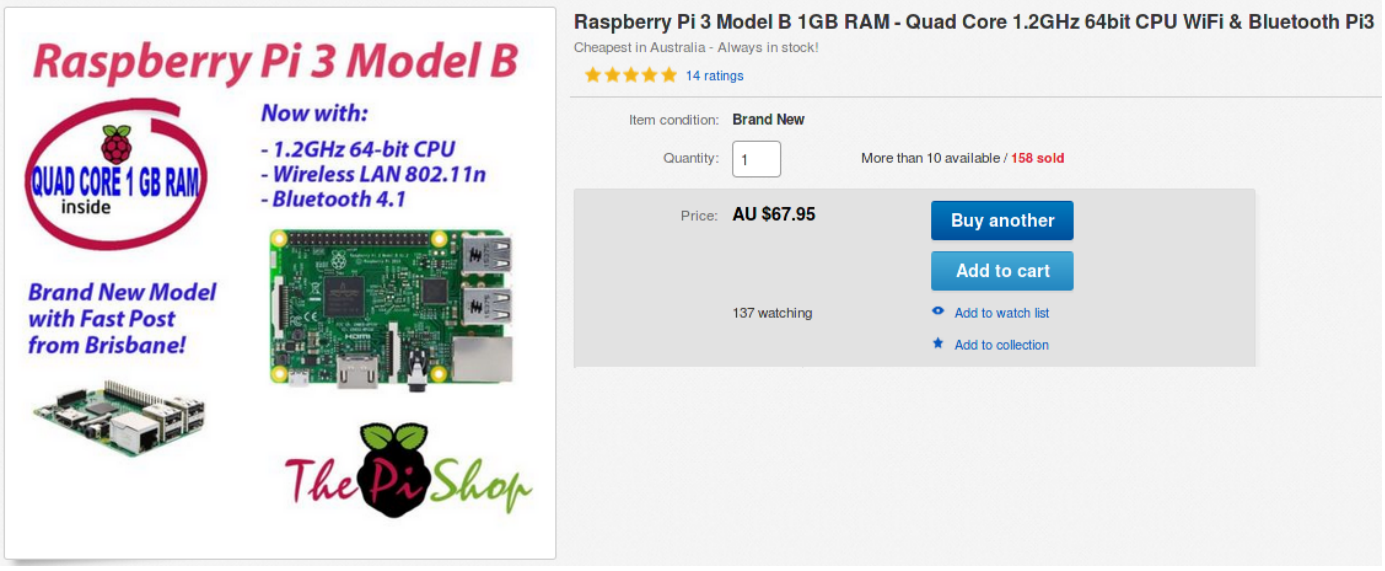
Raspberry Pi 3



- Raspberry Pi 3 with onboard wifi.
- Creates local wireless network.
- Running forked open-source http://stratux.me/

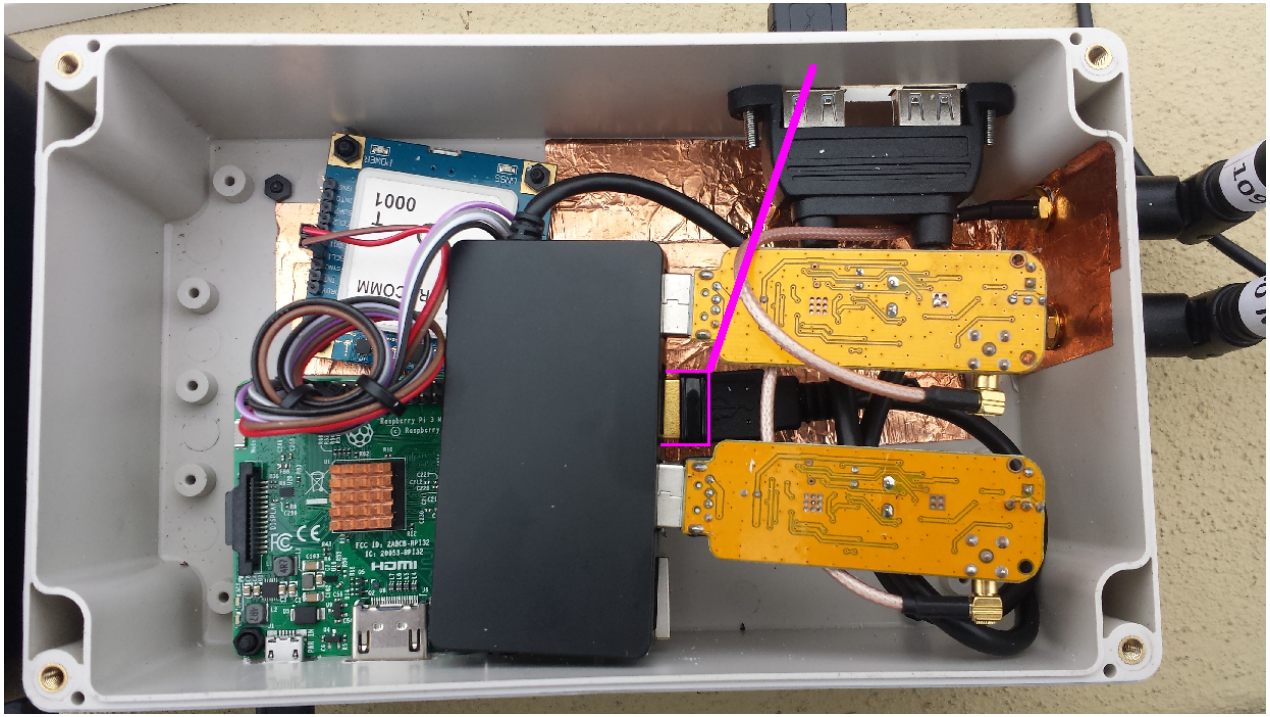
Portable ADS-B receiver hardware

Raspberry Pi 3



Portable ADS-B receiver hardware

Edimax Wifi adapter



- Edimax wifi NIC for wireless client.
- Connects to 4G and opens SSH connection to home server for transmission.

Portable ADS-B receiver hardware

Edimax Wifi adapter

Edimax 150Mbps Wireless Nano USB Adaptor (EW-7811Un) Ideal for Raspberry Pi

3 ratings

Item condition: **Brand New**

Quantity: 1 0 available / 52 sold

Price: **AU $16.95**

Portable ADS-B receiver hardware

VK-162 GPS

- External GPS antenna with magnetic mount.
- Provides track.
- Provides ground speed.

Portable ADS-B receiver hardware

VK-162 GPS

VK-162 GMOUSE USB Interface GPS Navigation Support Google Earth FZ0576

Item condition: **Brand New**

Quantity: 1 — 100 available / 5 sold

Price: **AU $23.25**

Buy another

Add to cart

3 watching

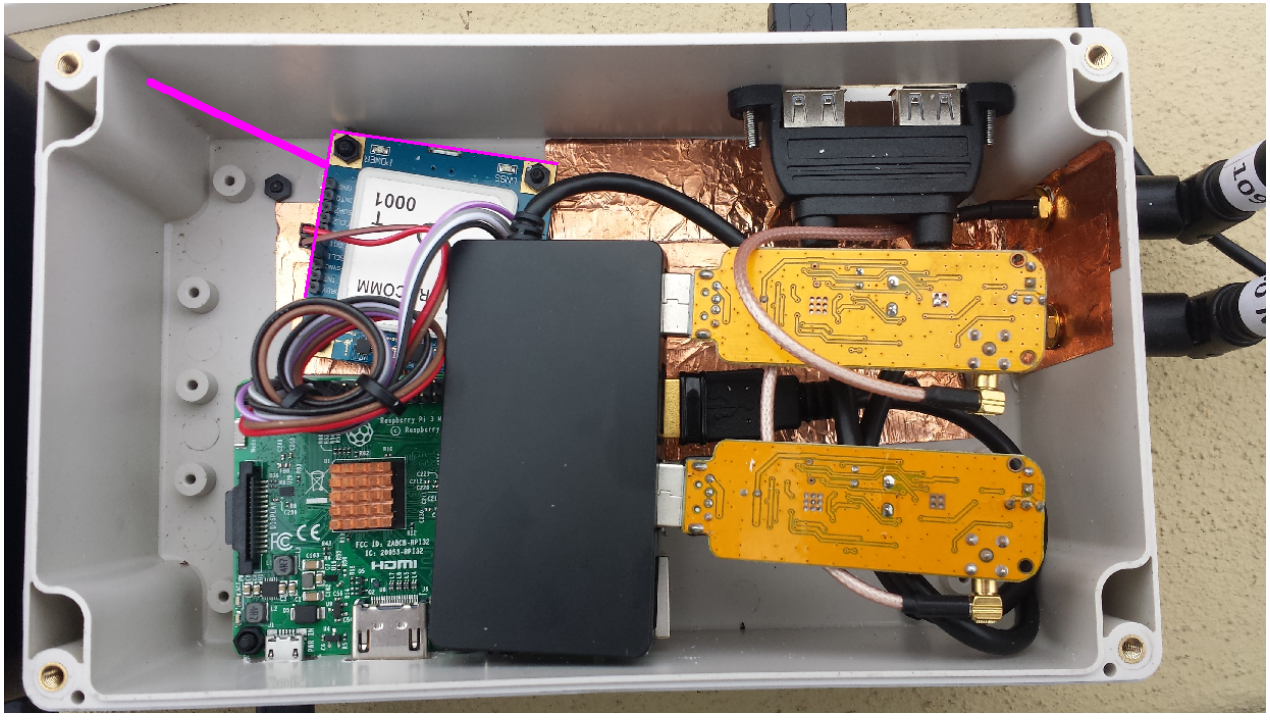
Add to watch list

Add to collection

Free postage | New condition

Portable ADS-B receiver hardware

RY835AI



- Gyrometer providing roll, pitch and yaw.
- Magnetometer provides magnetic heading & lateral orientation.
- Barometer provides air pressure (altitude).
- Thermometer provides outside air temperature.
- GPS (GLONASS) available but not used.

Portable ADS-B receiver hardware

RY835AI

RY835AI 10Hz USB GPS Glonass BeiDou antenna module pressure Compass Gyro sensors

Be the first to write a review.

Item condition: **Brand New**

Quantity: 1 — 975 available / **1,345 sold**

Price: **US $35.00**
Approximately **AU $45.99**

Buy another

Add to cart

305 watching

Add to watch list

Add to collection

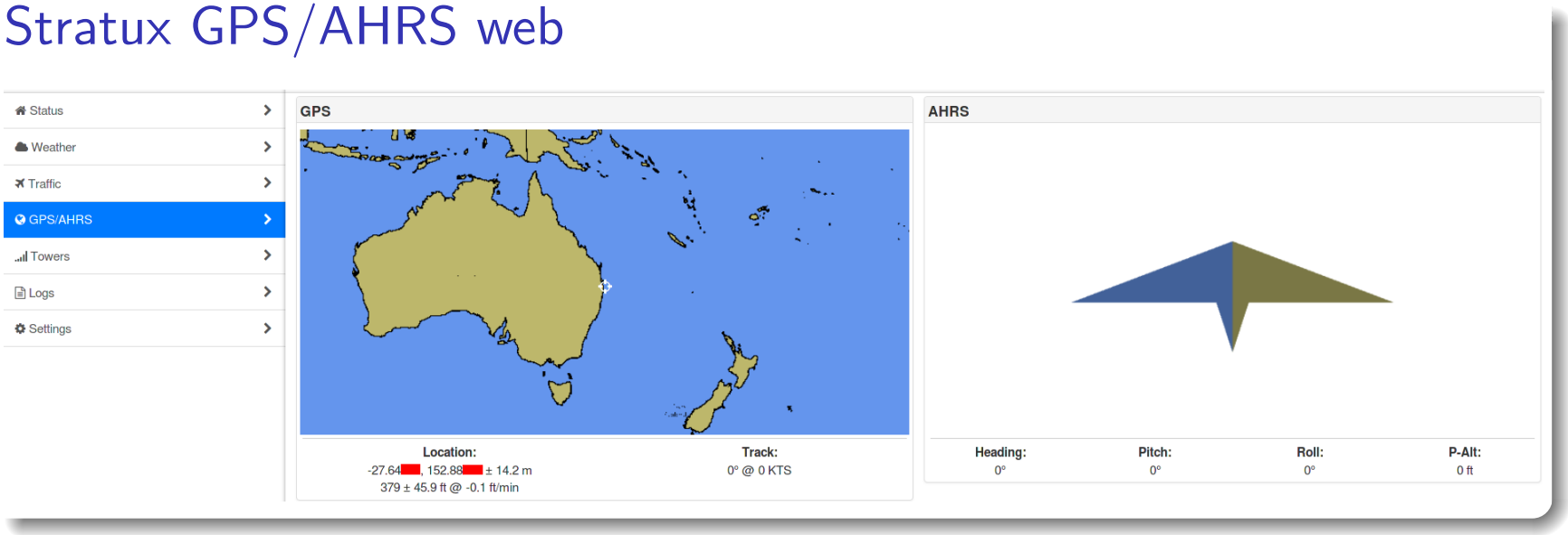
Portable ADS-B receiver hardware

Battery

- USB 5V.
- Tested to provide 11 hours running.

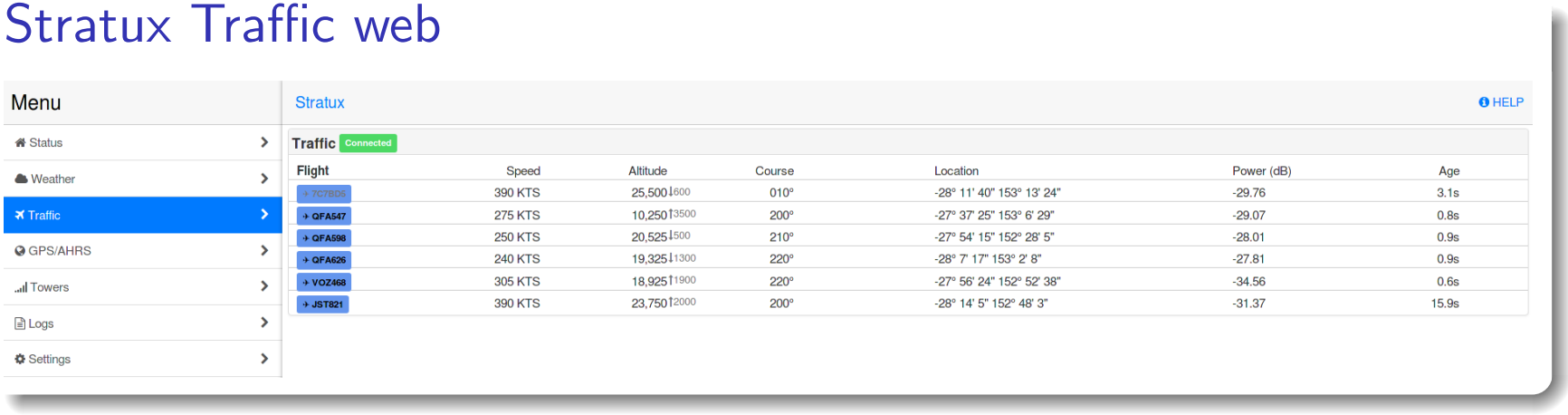
Portable ADS-B receiver software

Stratux GPS/AHRS web



Portable ADS-B receiver software

Stratux Traffic web



Portable ADS-B receiver software

Traffic record data type

Data.Aviation.Stratux.Types.Traffic

Documentation

```
data Traffic
```

Constructors

```
Traffic
  icaoAddrTraffic :: IcaoAddr
  _tail :: String
  _emitterCategory :: EmitterCategory
  _onGround :: Bool
  _addressType :: Int
  _targetType :: TargetType
  _signalLevel :: Double
  _positionValid :: Bool
  _latitude :: Double
  _longitude :: Double
  _altitude :: Int
  _gnssDiffFromBaroAlt :: Int
  _altIsGnss :: Bool
  _navigationIntegrityCategory :: Int
  _navigationAccuracyCategoryForPosition :: Int
  _track :: Int
  _speed :: Int
  _speedValid :: Bool
  _verticalVelocity :: Int
  _timestamp :: UTCTime
  _age :: Double
  _lastSeen :: UTCTime
  _lastAltitude :: UTCTime
  _lastGnssDiff :: UTCTime
  _lastGnssDiffAltitude :: Int
  _lastSpeed :: UTCTime
  _lastSource :: Int
  _extrapolatedPosition :: Bool
  _bearing :: Double
  _distanceToTrafficFromOwnship :: Double
```

Portable ADS-B receiver software

Situation record data type

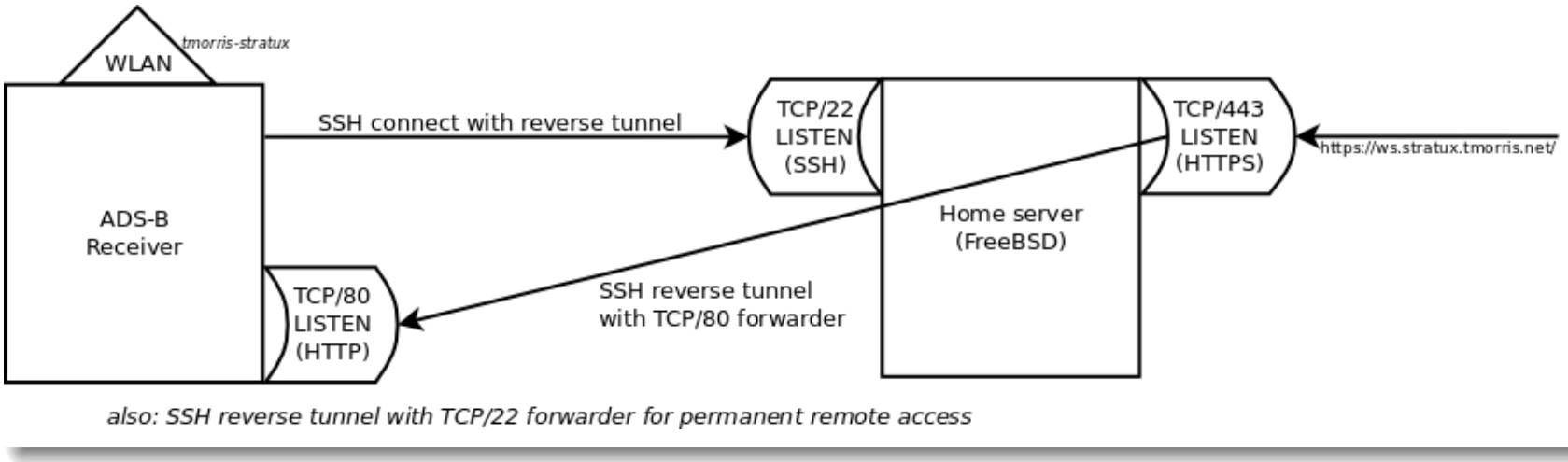
```
data Situation
```

Constructors

```
Situation
  _lat :: Double
  _lon :: Double
  _heightAboveEllipsoid :: Double
  _geoidSep :: Double
  _satellites :: Int
  _satellitesTracked :: Int
  _satellitesSeen :: Int
  _accuracy :: Double
  _nacp :: Int
  _alt :: Double
  _accuracyVert :: Double
  _gpsVertVel :: Double
  _lastFixLocalTime :: UTCTime
  _trueCourse :: Double
  _groundSpeed :: Int
  _lastGroundTrackTime :: UTCTime
  _lastGPSTimeTime :: UTCTime
  _lastNMEAMessage :: UTCTime
  _temp :: Double
  _pressureAlt :: Double
  _pitch :: Double
  _roll :: Double
  _gyroHeading :: Double
  _lastAttitudeTime :: UTCTime
```

Network Traffic Relaying

Connections



If it is to be portable

- We must be able to view status **even at 300kt, 3500ft AGL**.
- We must be able to administer it to and from anywhere.
- **Securely (SSH)**.

Portable ADS-B receiver software

Let's code!