Notes and links in PDF comments on each slide

All Your RFz Are Belong to Me: Hacking the Wireless World with Software Defined Radio

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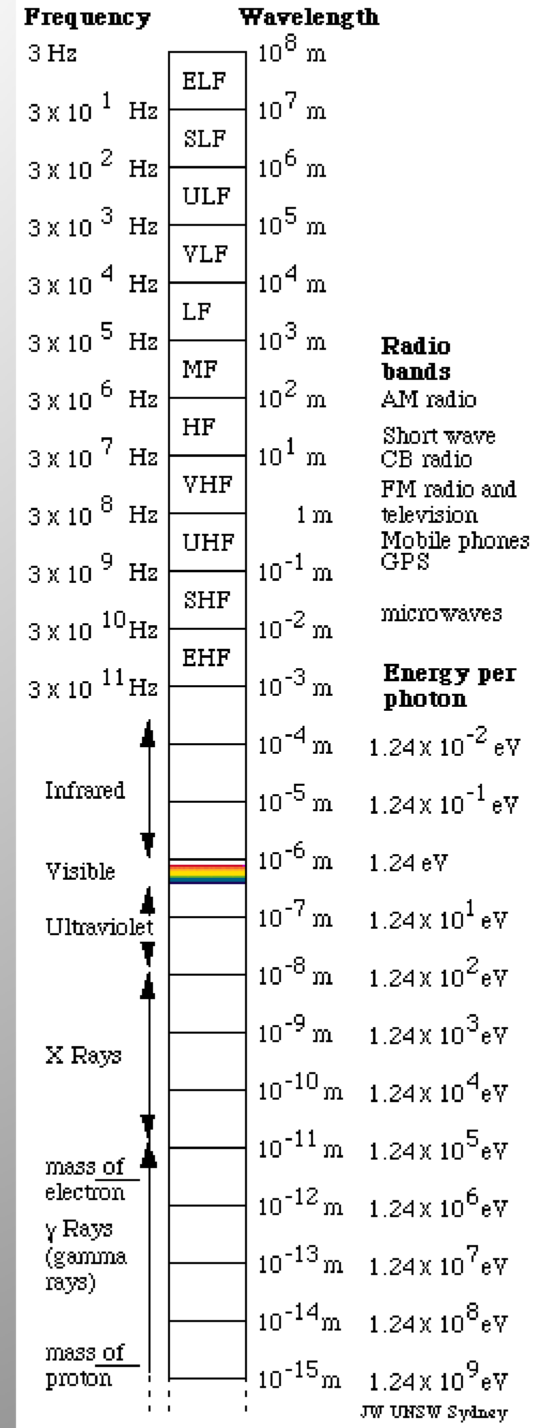
Ettus Research

Overview

- RF 101
- The journey into Software Defined Radio
- Hospital pager systems
- Tracking planes
- Decoding satellite-downlink traffic
- Direction Finding

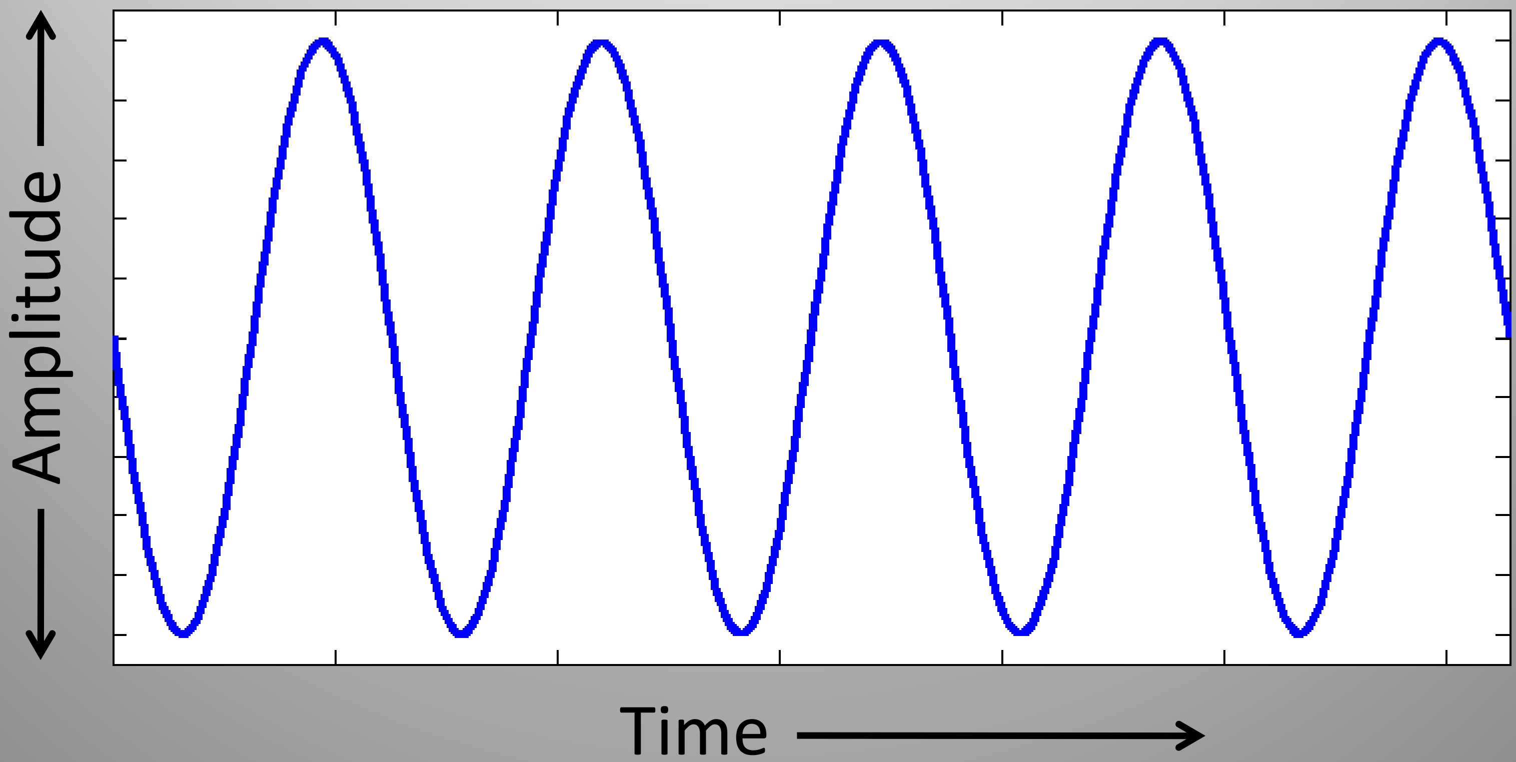
The Electromagnetic Spectrum

- Electromagnetism: one of four universal forces
- Radio wave exists due to energy being propagated at a particular frequency
- Can create and receive radio waves using electronics



Transmitting Data

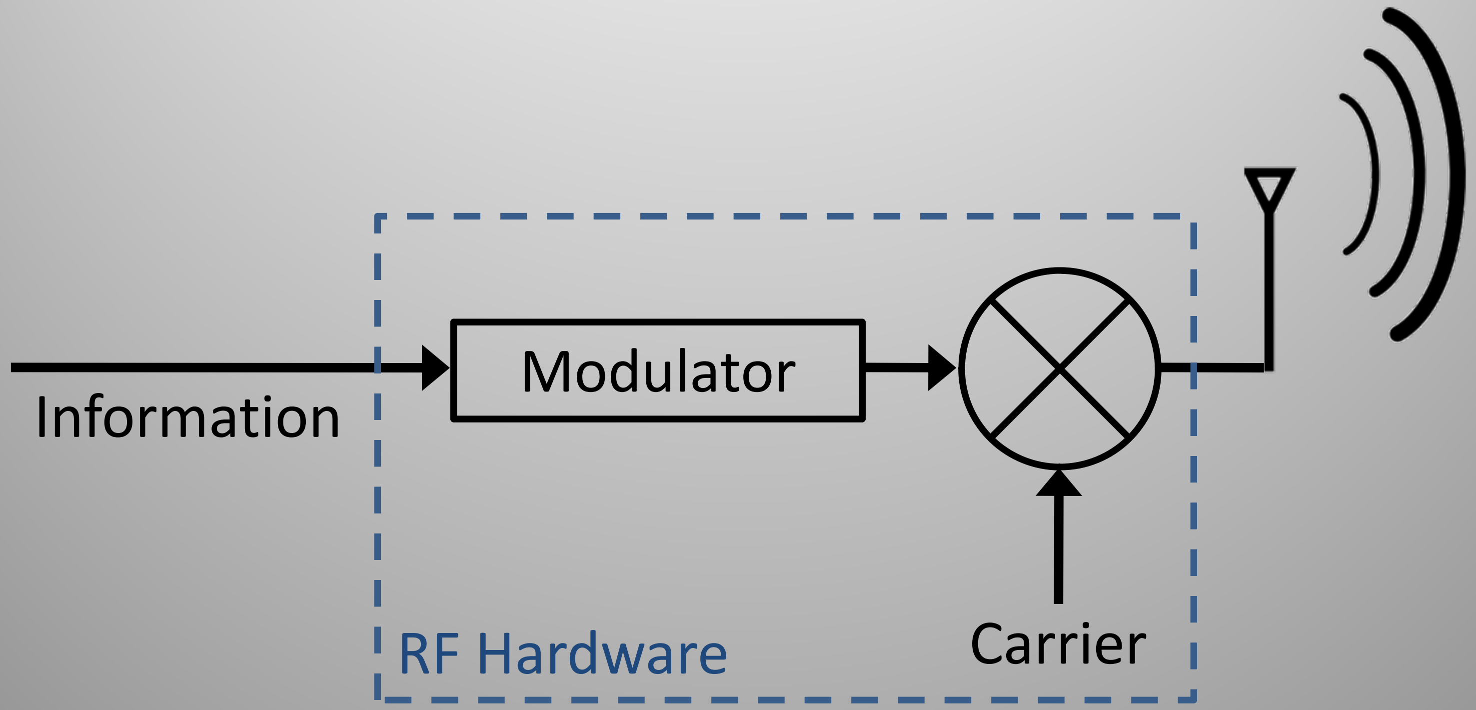
- Radio (carrier) wave must be modulated to convey information



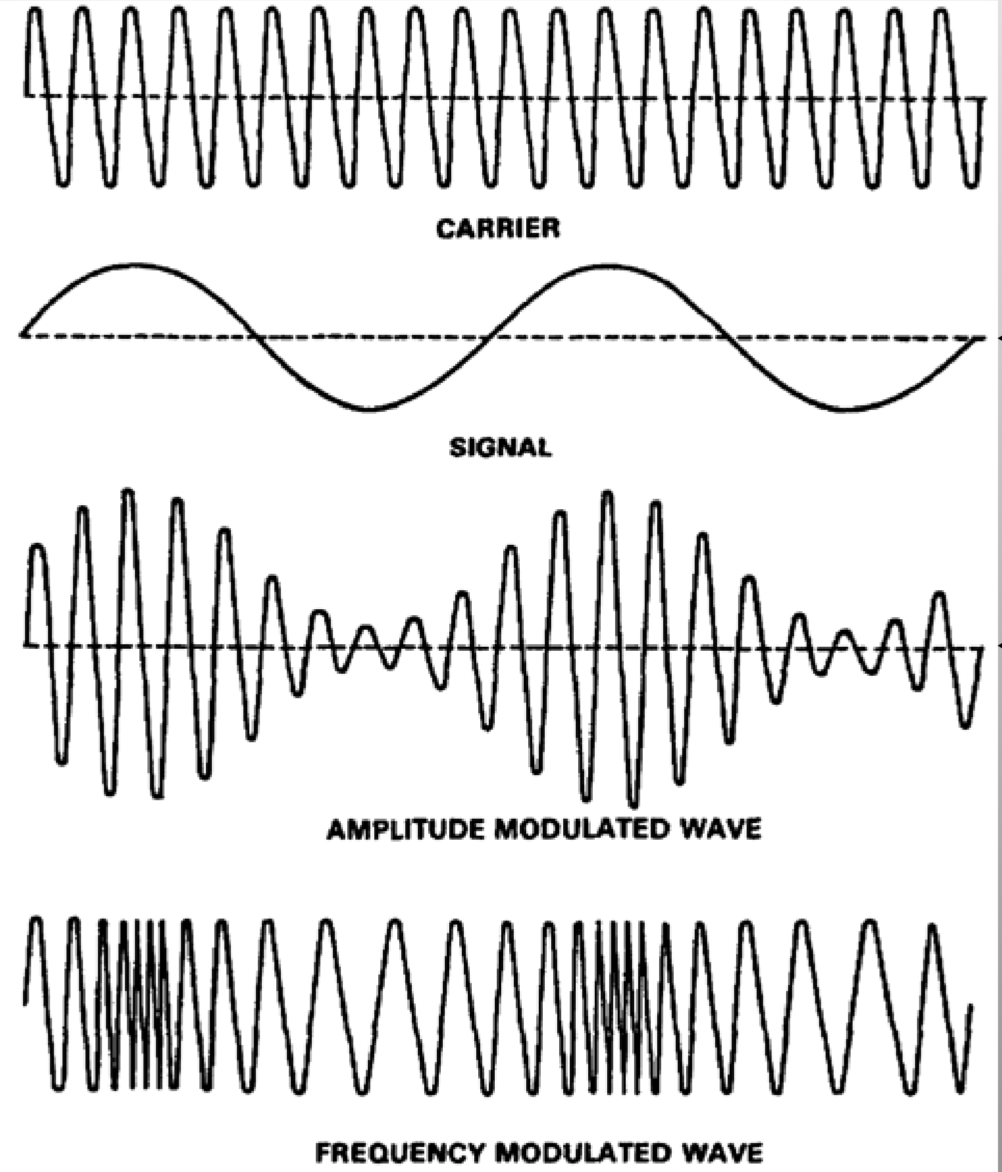
Transmitting Data

- Radio (carrier) wave must be modulated to convey information
- OOK (**O**n-**O**ff **K**eying)
  - Presence/absence of a signal
- COFDM (**C**oded **O**rthogonal **F**requency-**D**ivision **M**ultiplexing)
  - WiFi, DVB, DAB, WiMAX, UWB, 4G, ADSL, PLC

Transmitting Data



AM & FM: In the Time Domain

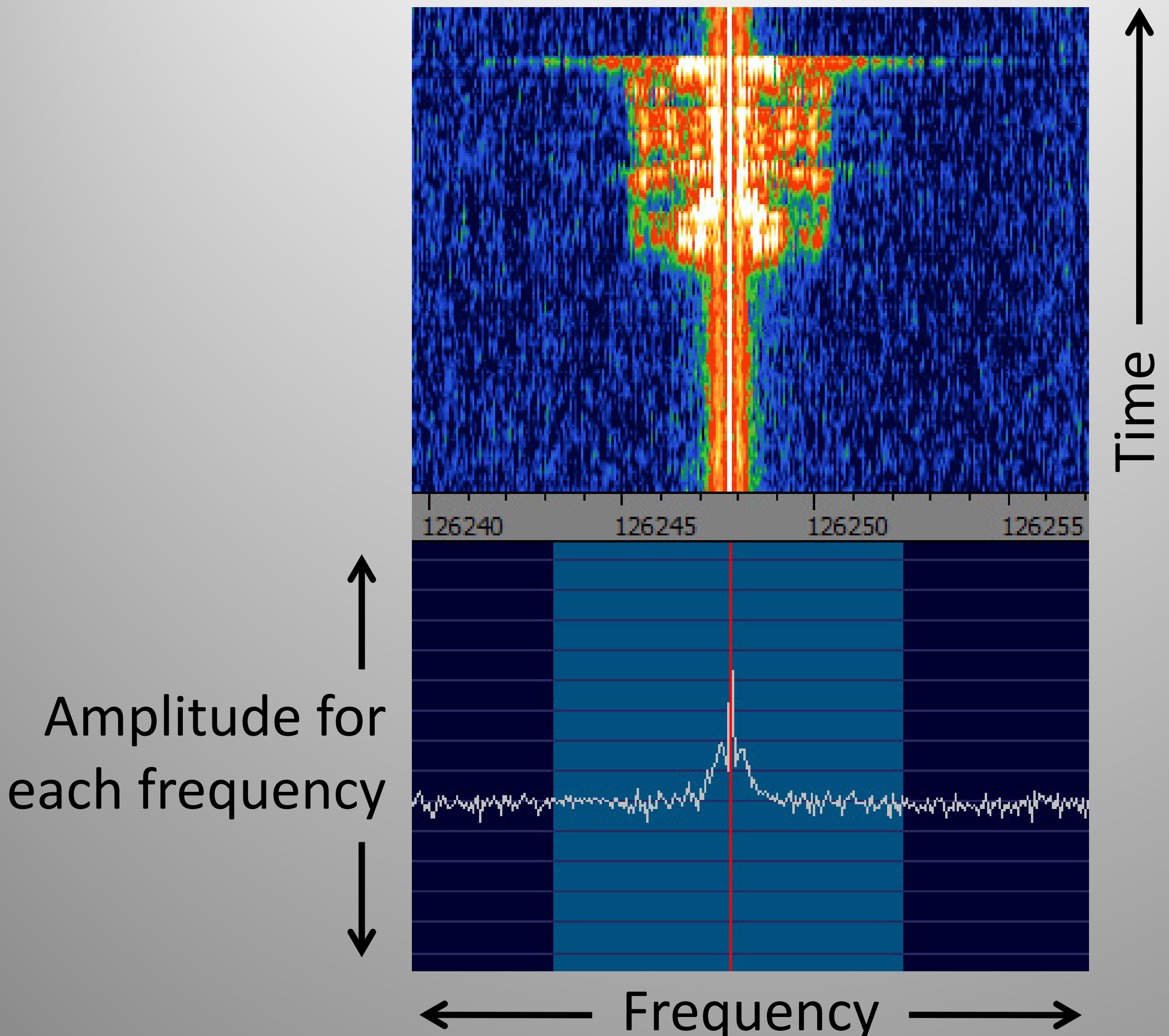


Analog or digital information

Constant frequency

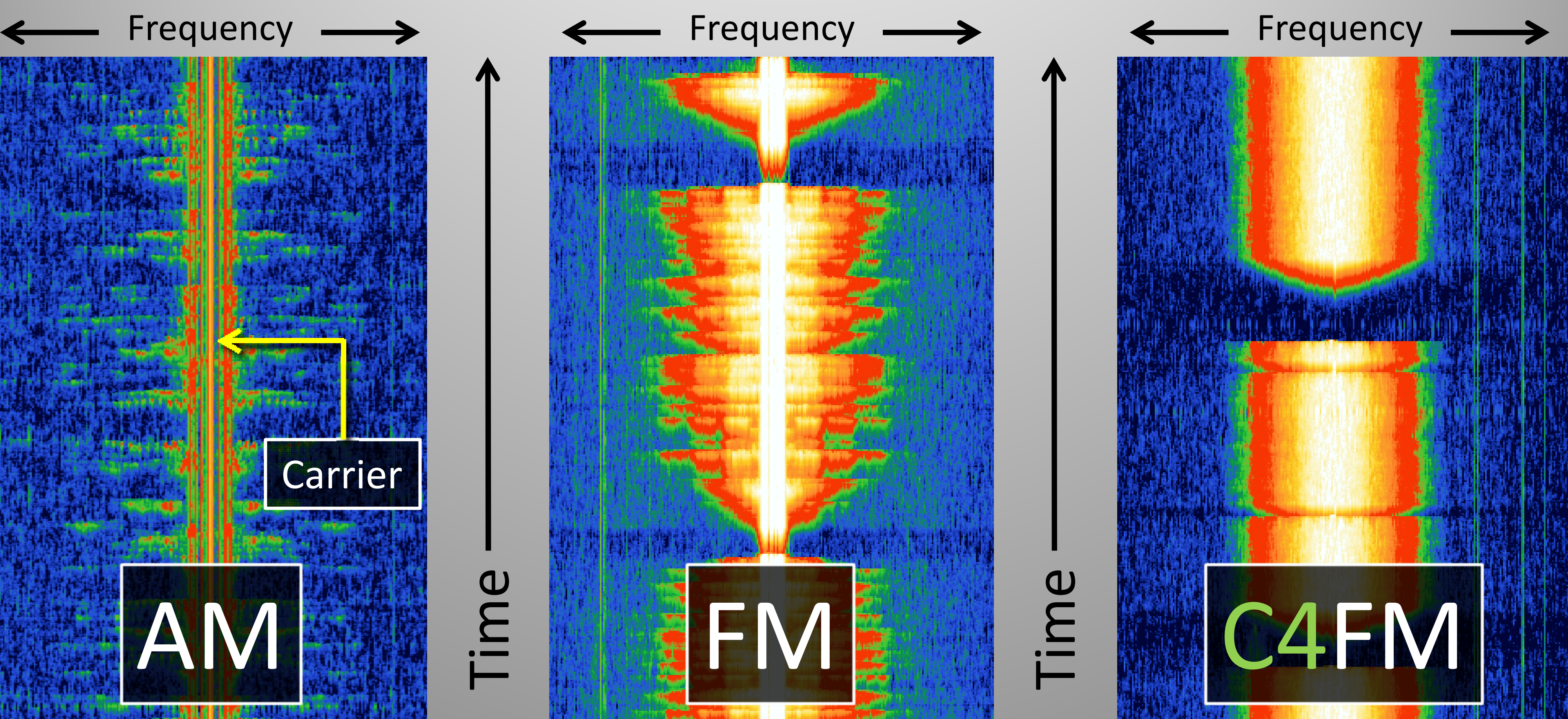
Constant amplitude

In the Frequency Domain



Modulation

- Modulation technique defines how the signal will look on the spectrum



Hardware

- Crystal set receiver
  - Powerful AM transmissions

Hardware

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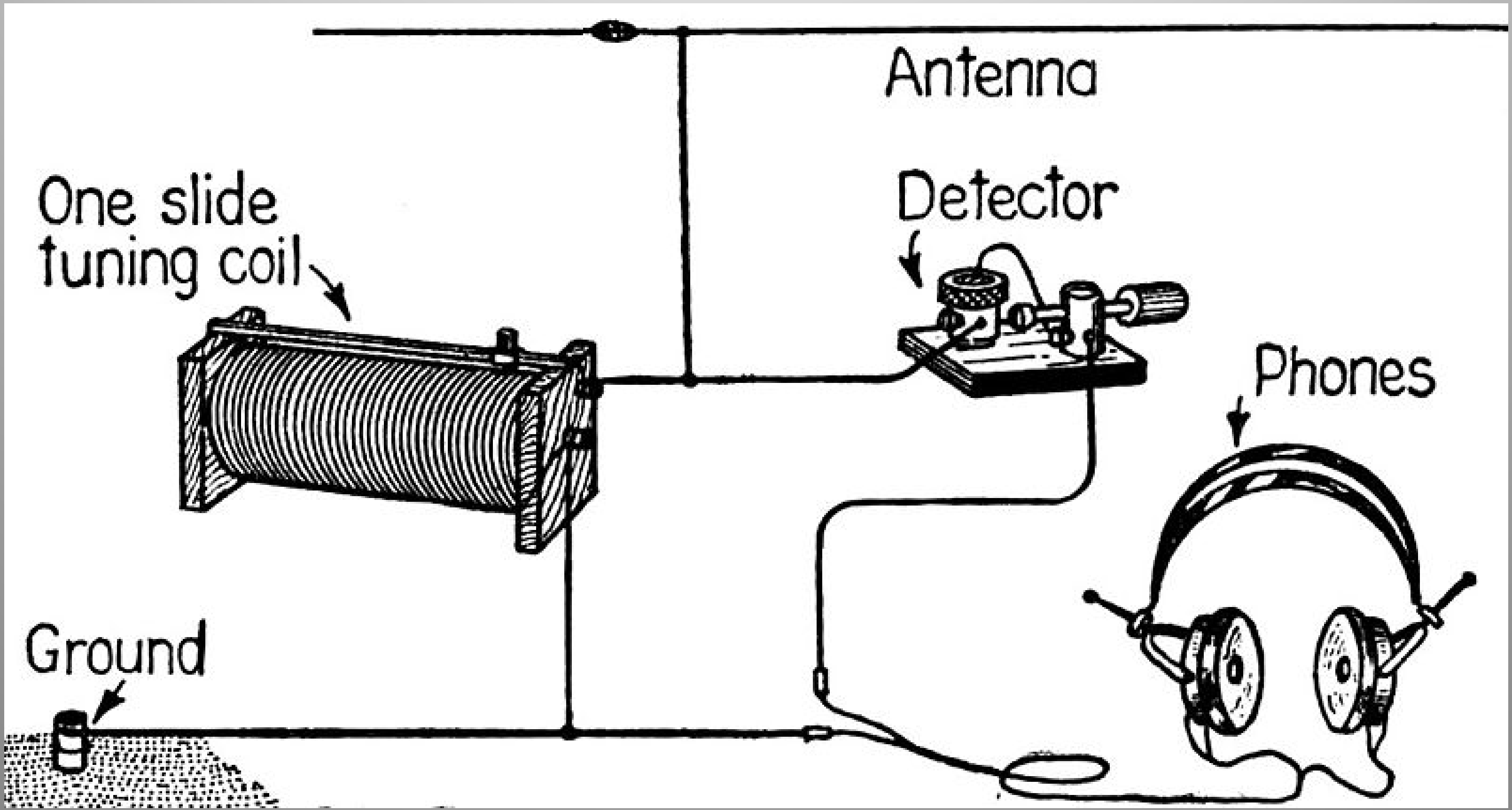
  - Powerful AM transmissions

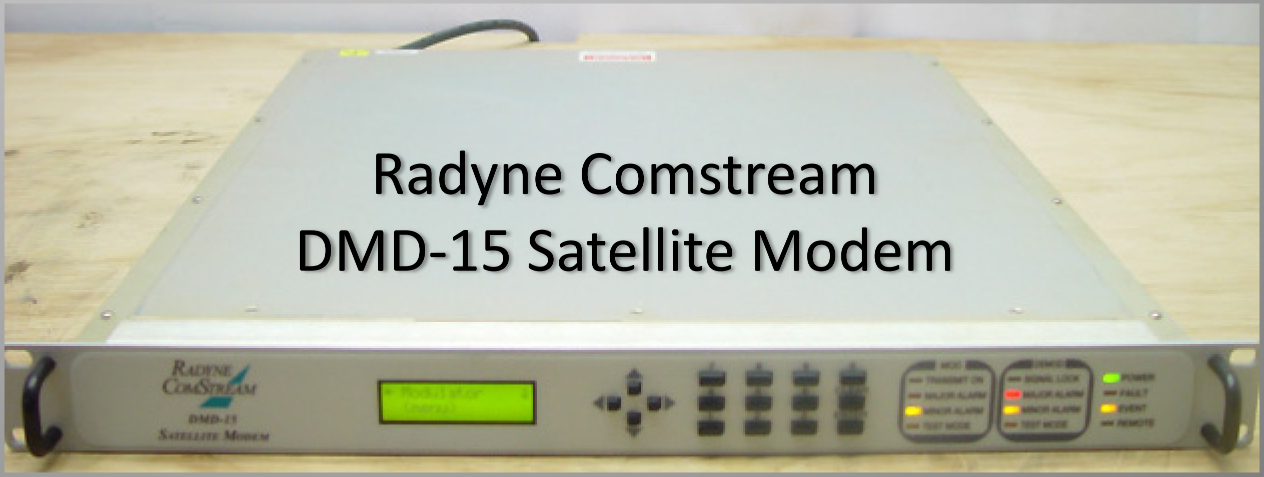


Hardware

- Crystal set receiver
  - Powerful AM transmissions
- More advanced hardware to handle increasingly complex modulation schemes
  - FM, stereo FM, microwave, digital…

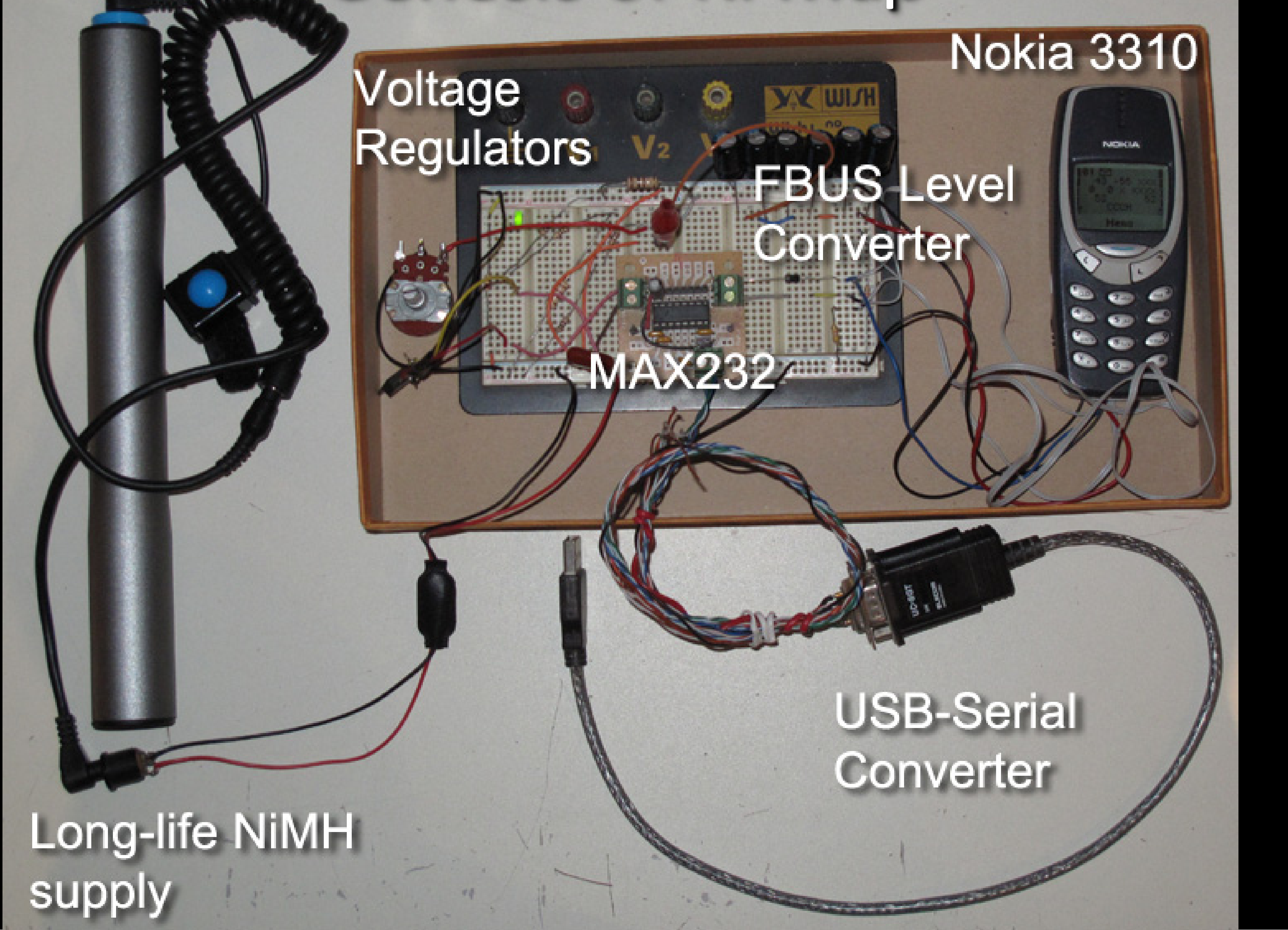
Modulation in Hardware

- **MO**dulation and **DE-M**odulation traditionally performed in hardware
- ‘Black box’ implementation
  - Not re-configurable
- Modern digital hardware allows more flexibility

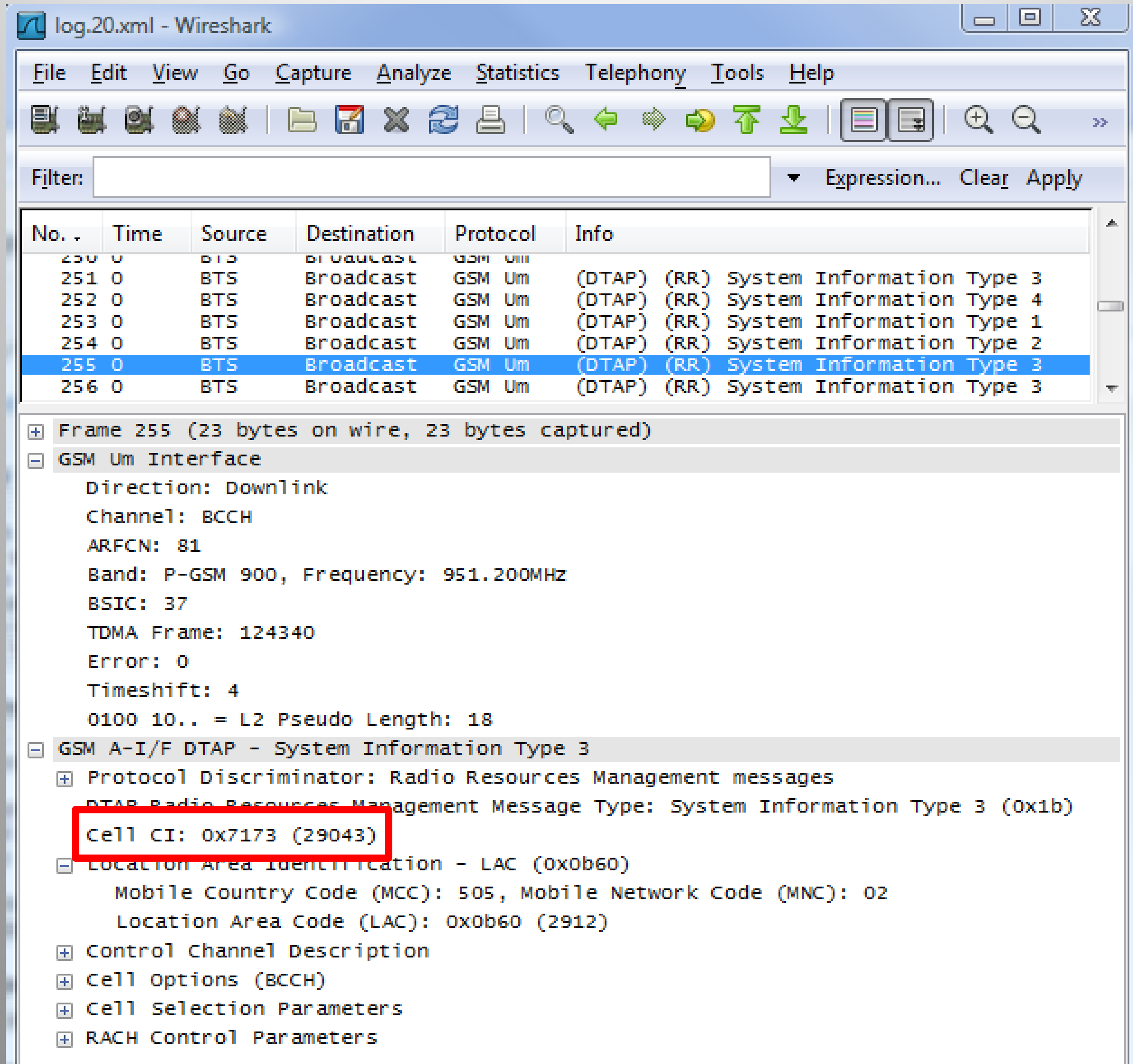


The journey begins…

Genesis of RFMap

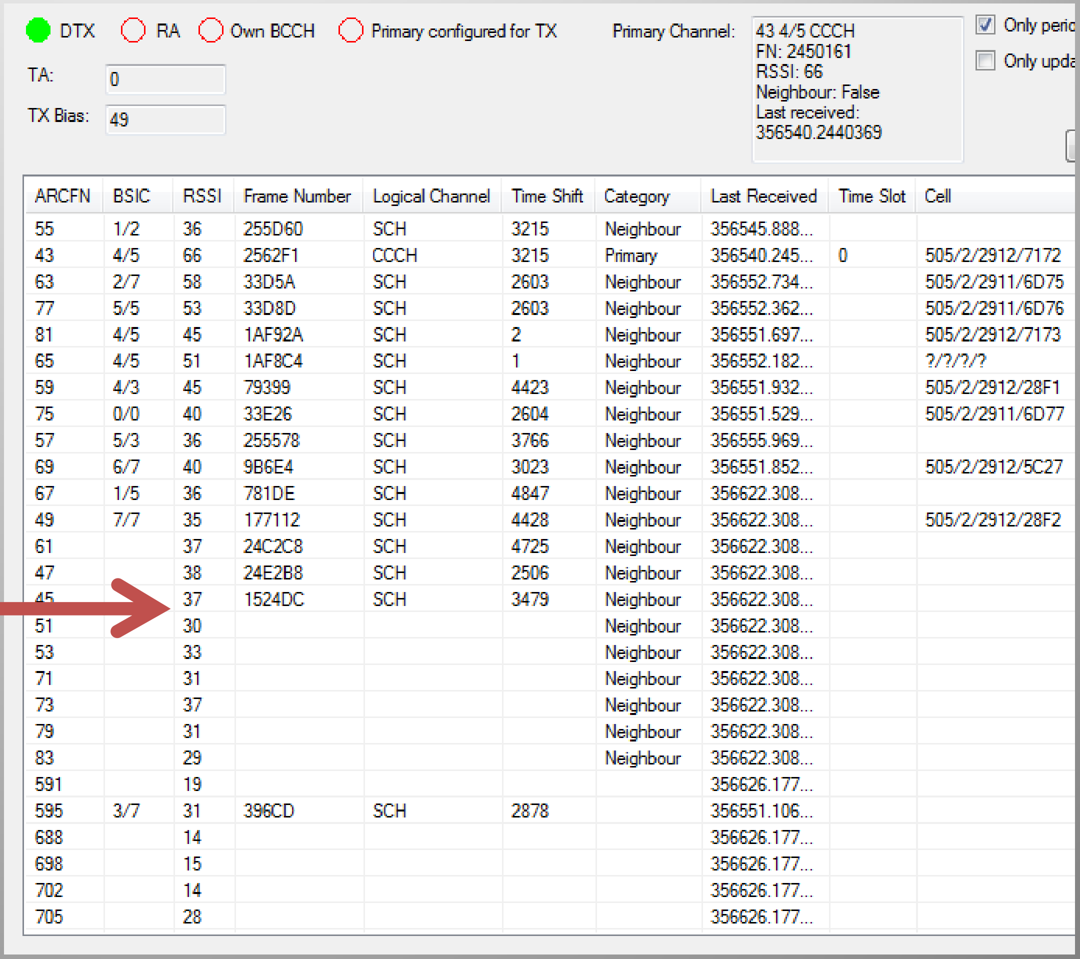


GSM + Gammu + Wireshark



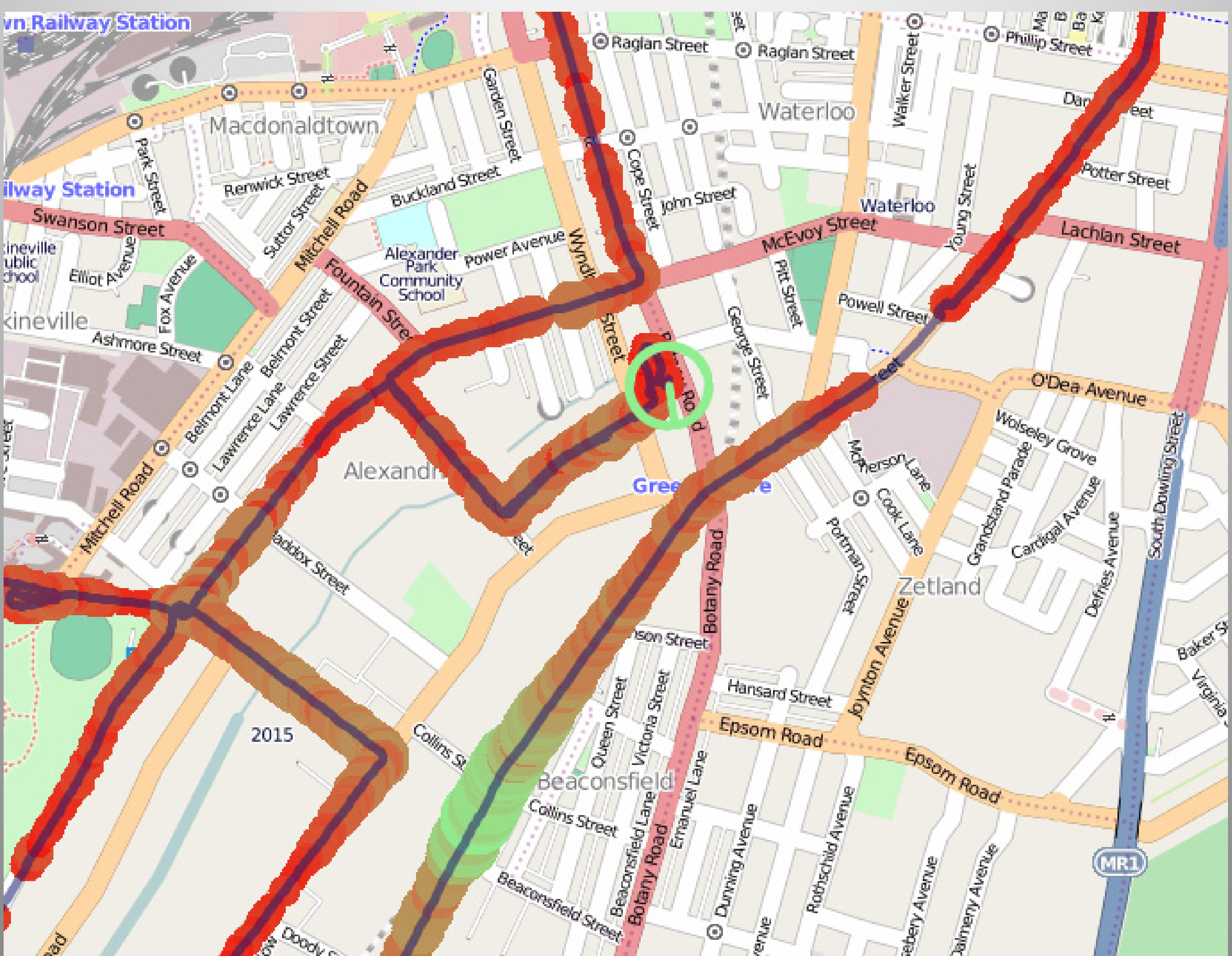
Field Test Mode

<1983> MDI:d2m/RSSI_RESULTS t=0afe nr=73: D 83:
00 00 b1 b1 00 65 ab a3 b1 a0 a0 a6 9d a1 80 a4 80 80 80 80 80 80 80 aa

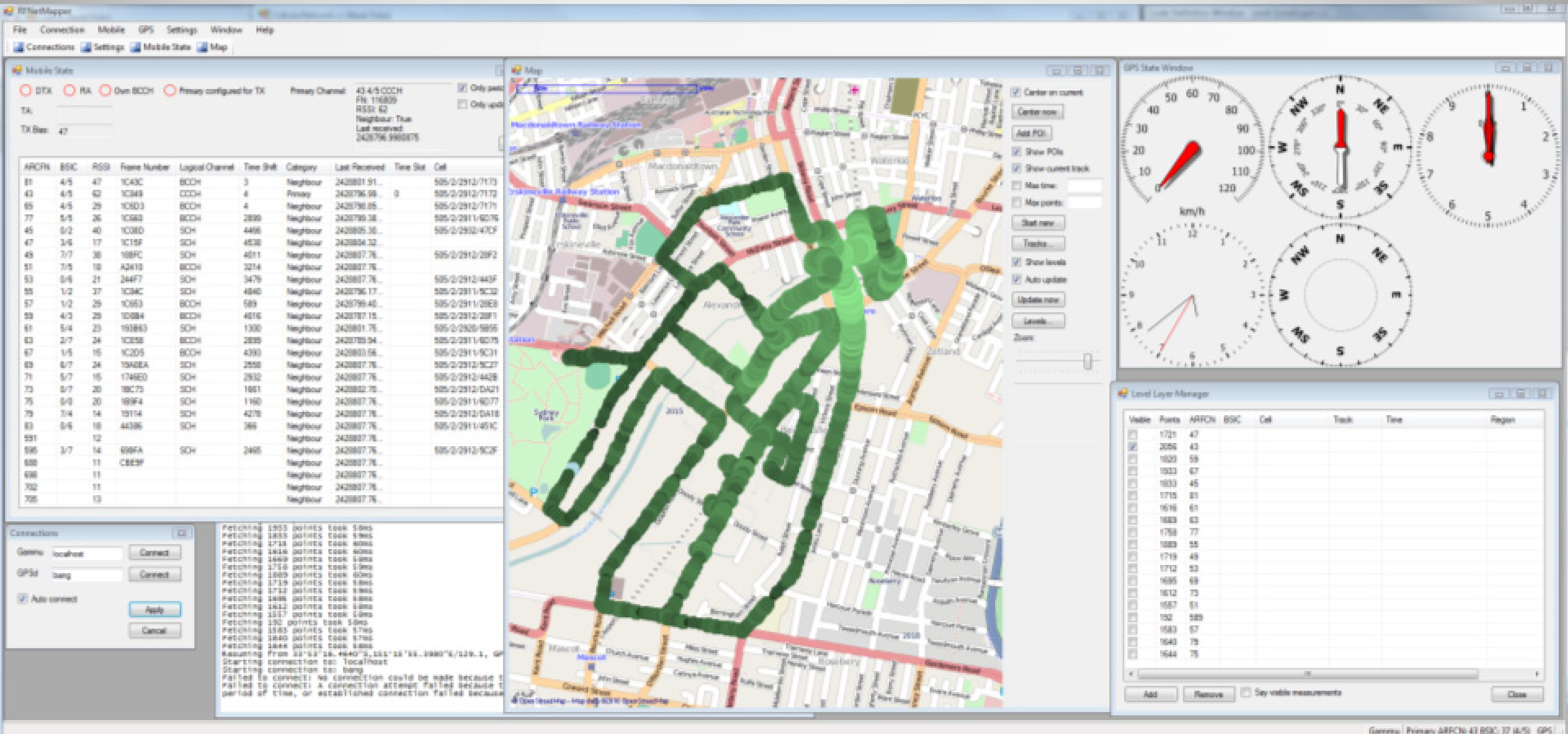


ARCFN	BSIC	RSSI	Frame Number	Logical Channel	Time Shift	Category	Last Received	Time Slot	Cell
55	1/2	36	255D60	SCH	3215	Neighbour	356545.888...		
43	4/5	66	2562F1	CCCH	3215	Primary	356540.245...	0	505/2/2912/7172
63	2/7	58	33D5A	SCH	2603	Neighbour	356552.734...		505/2/2911/6D75
77	5/5	53	33D8D	SCH	2603	Neighbour	356552.362...		505/2/2911/6D76
81	4/5	45	1AF92A	SCH	2	Neighbour	356551.697...		505/2/2912/7173
65	4/5	51	1AF8C4	SCH	1	Neighbour	356552.182...		?/?/?/?
59	4/3	45	79399	SCH	4423	Neighbour	356551.932...		505/2/2912/28F1
75	0/0	40	33E26	SCH	2604	Neighbour	356551.529...		505/2/2911/6D77
57	5/3	36	255578	SCH	3766	Neighbour	356555.969...		
69	6/7	40	9B6E4	SCH	3023	Neighbour	356551.852...		505/2/2912/5C27
67	1/5	36	781DE	SCH	4847	Neighbour	356622.308...		
49	7/7	35	177112	SCH	4428	Neighbour	356622.308...		505/2/2912/28F2
61		37	24C2C8	SCH	4725	Neighbour	356622.308...		
47		38	24E2B8	SCH	2506	Neighbour	356622.308...		
45		37	1524DC	SCH	3479	Neighbour	356622.308...		
51		30				Neighbour	356622.308...		
53		33				Neighbour	356622.308...		
71		31				Neighbour	356622.308...		
73		37				Neighbour	356622.308...		
79		31				Neighbour	356622.308...		
83		29				Neighbour	356622.308...		
591		19					356626.177...		
595	3/7	31	396CD	SCH	2878		356551.106...		
688		14					356626.177...		
698		15					356626.177...		
702		14					356626.177...		
705		28					356626.177...		

Geolocation with GSM



RFNetMapper



Determine accuracy by comparing to ground truth: where are the base stations?

ACMA RadCom Web Interface

acma.gov.au

Register of Radiocommunications Licences

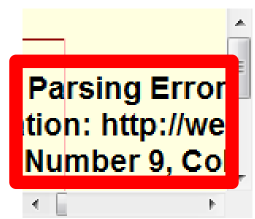
Found **10526** sites within about a **200 kms** radius of: **Latitude: -34 17 47.782 Longitude: 150 56 20.778**.
Coordinate Projection: Australian Geodetic Datum 1966 [AGD66]
[List Nearby Sites] [New Site Search]

Pan 3 4 5 6 Zoom IN OUT

Site:
Approx distance:

Refine Search

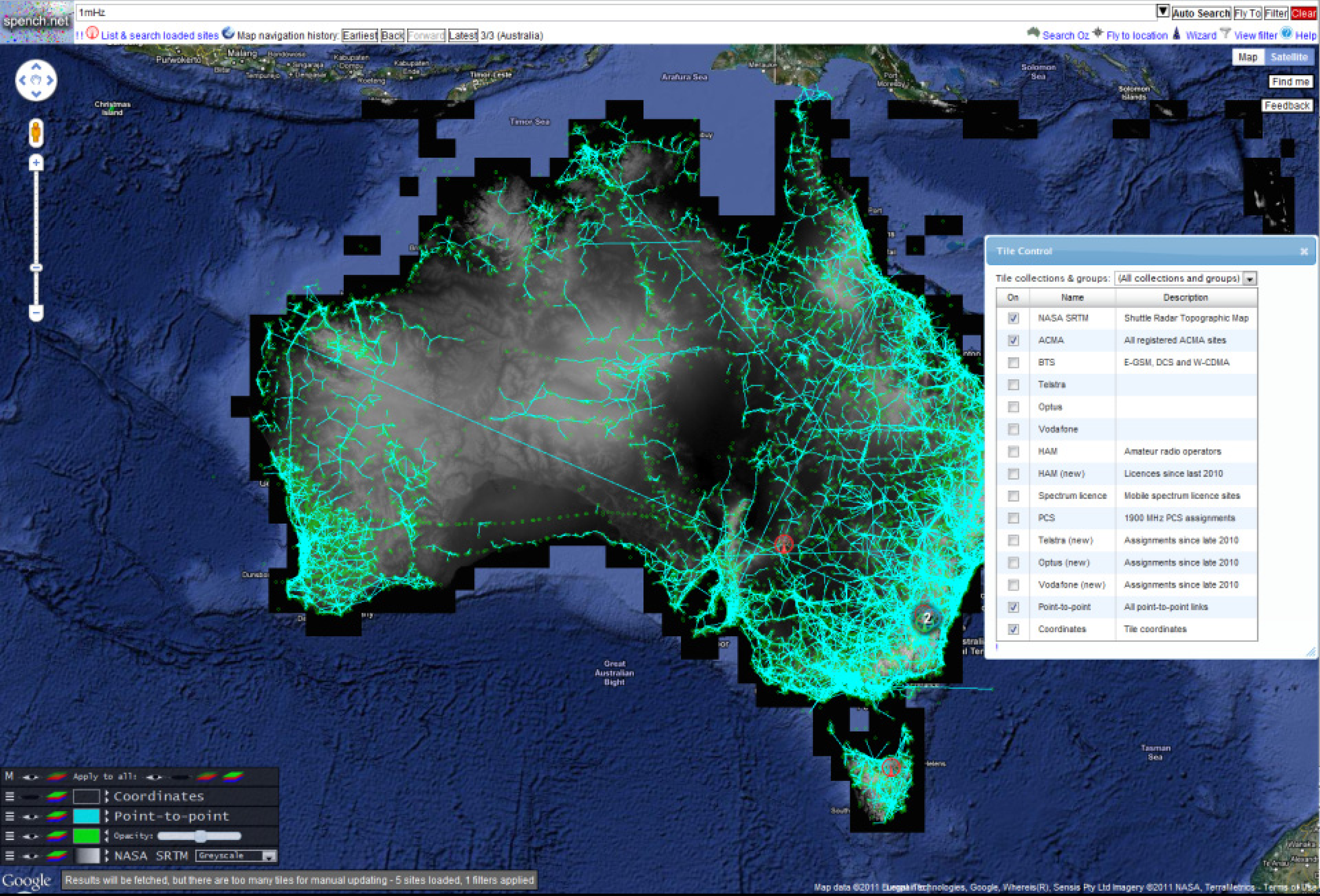
Show Site names	☐		
Show ACMA mapgrid	☐		
Radius/Zoom	200 kms		
Latitude	D -34	M 17	S 47.782
Longitude	D 150	M 56	S 20.778
Go	[Use Degrees Decimal]		



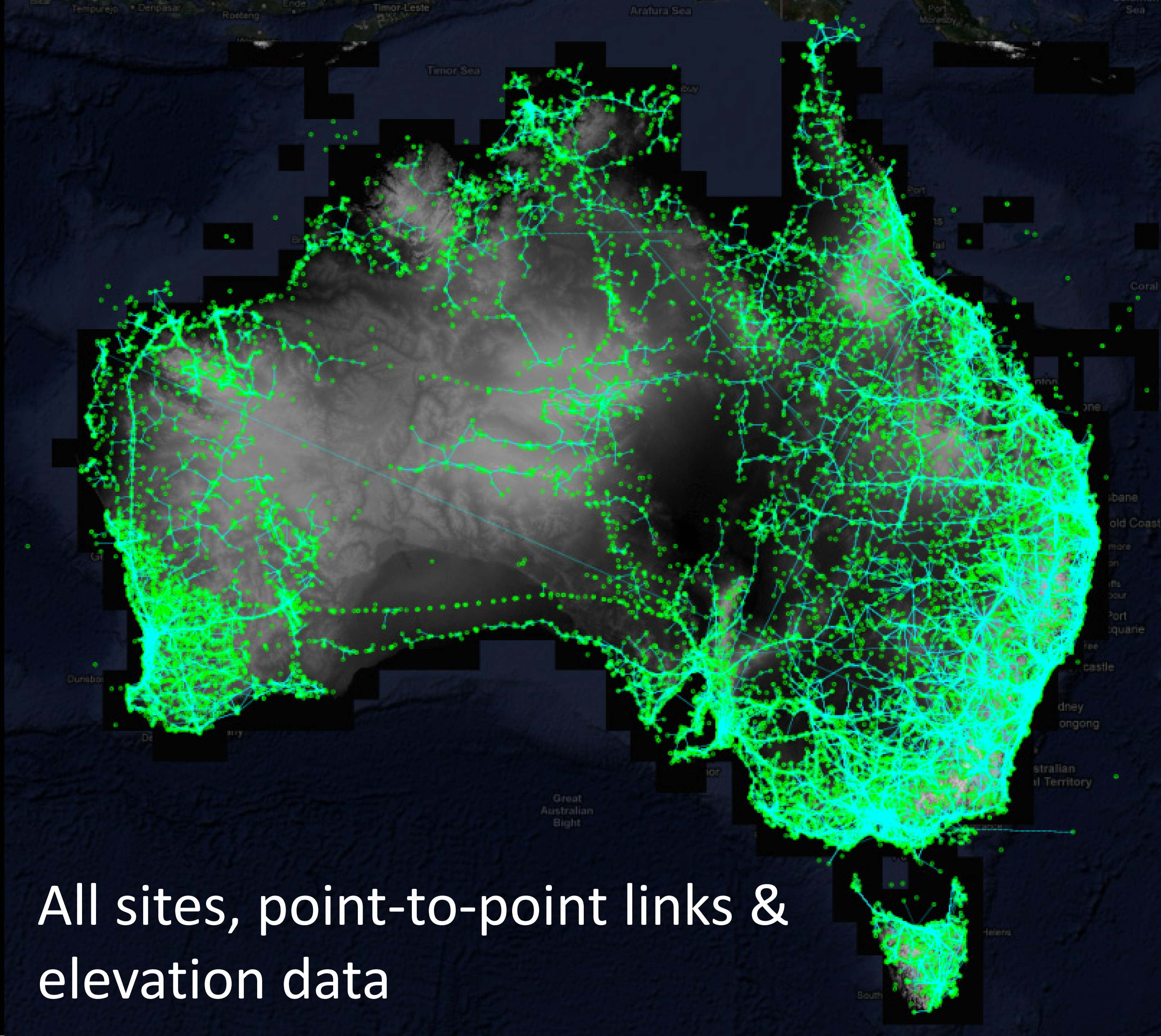
Site proximity usage notes;

- Map display accuracy within 10 metres.
- Distances shown are approximations only (they are not latitude compensated).
- To view images correclty, browser's must be able to accept both Javascript and compressed SVG content.
- You can **download** the SVG viewer Ver 3.0 from Adobe to view site search results.
- If you do not wish to install the SVG viewer, the List Nearby Sites link will display the results in table format.
- Use right mouse button for additional SVG pan and zoom functions.
- GMDA 1M 2001 and MAPDATA-2.5M data © Commonwealth of Australia (AUSLIG) 2001.

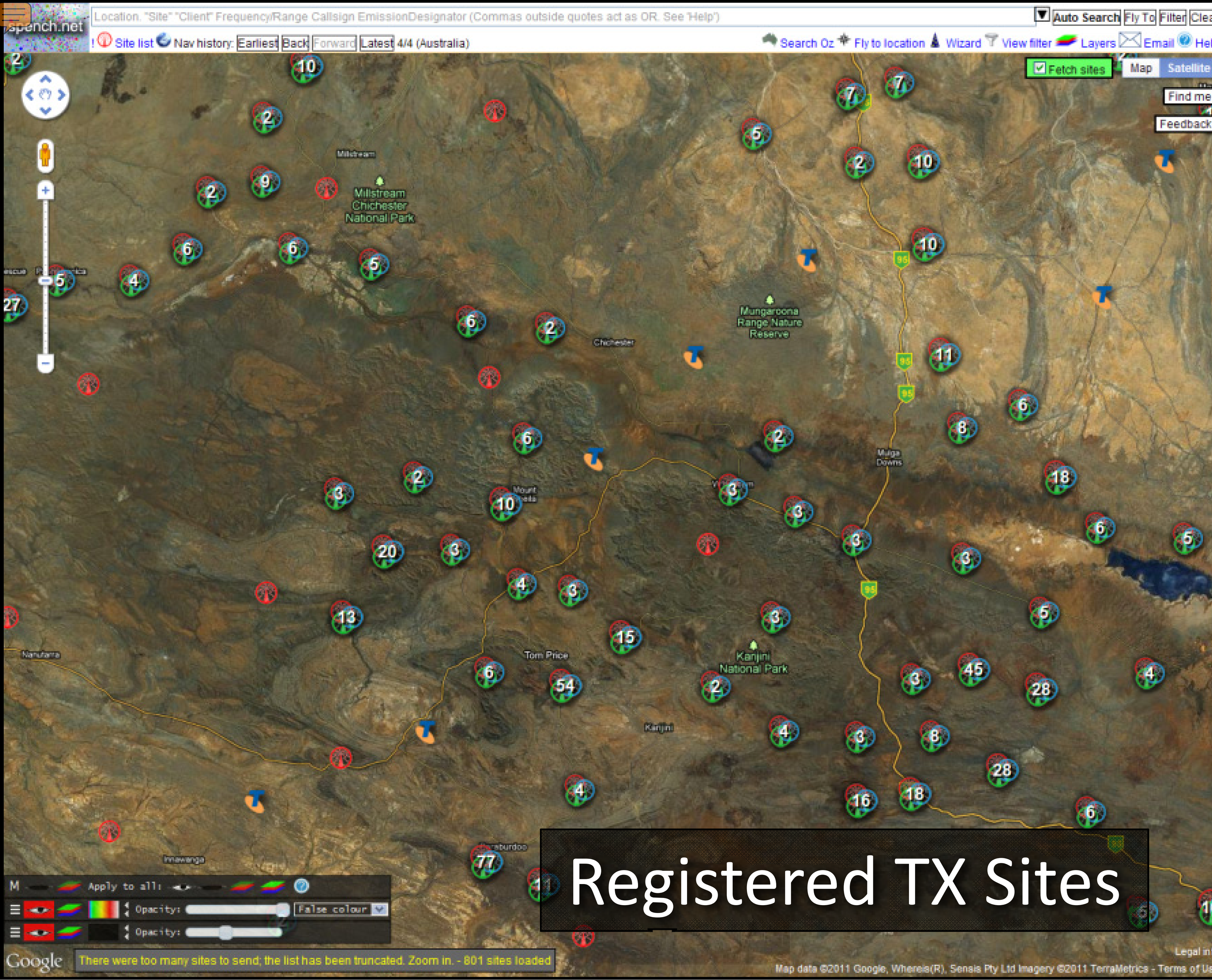
Enter RFMap…



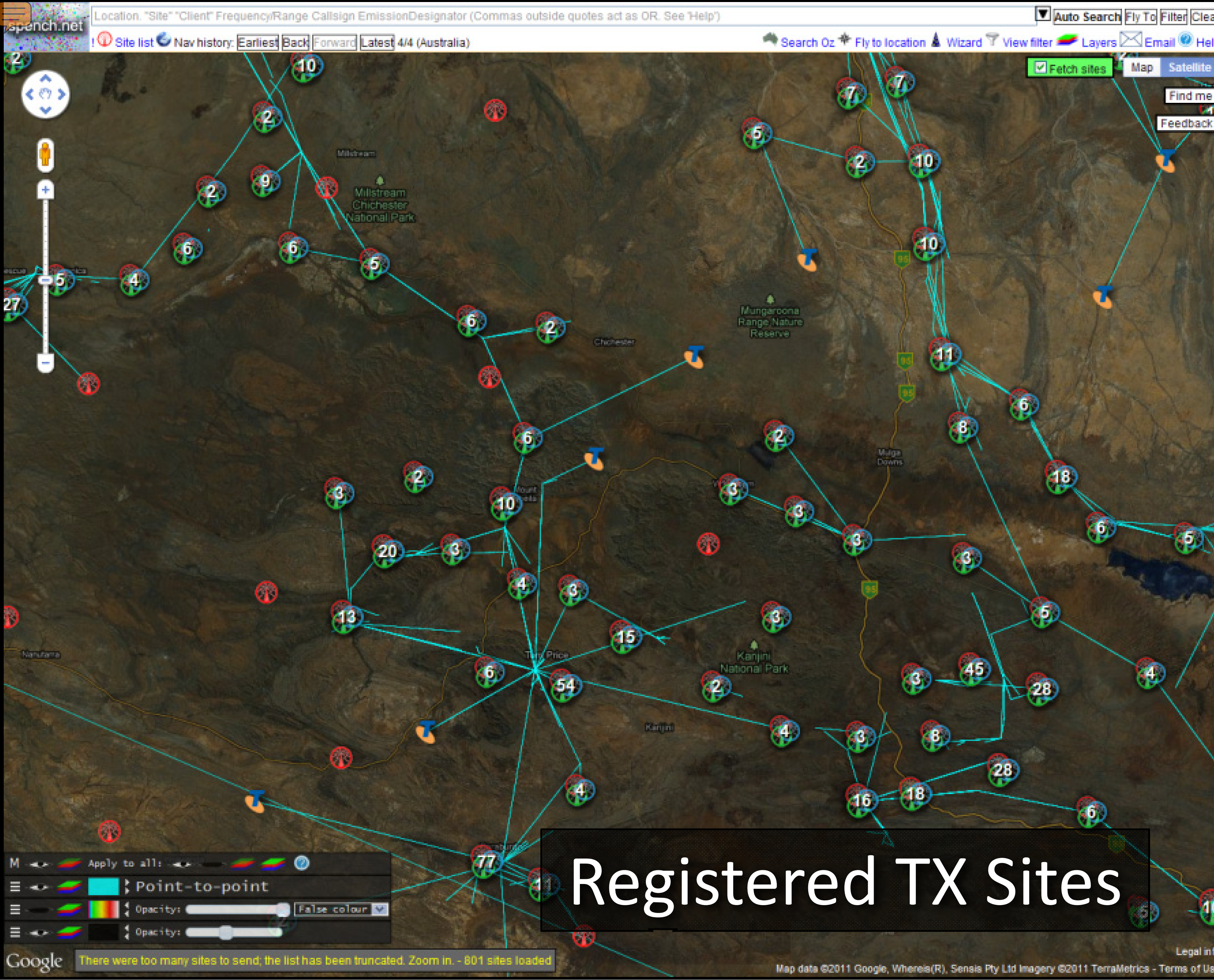
The RFMap web interface



All sites, point-to-point links & elevation data

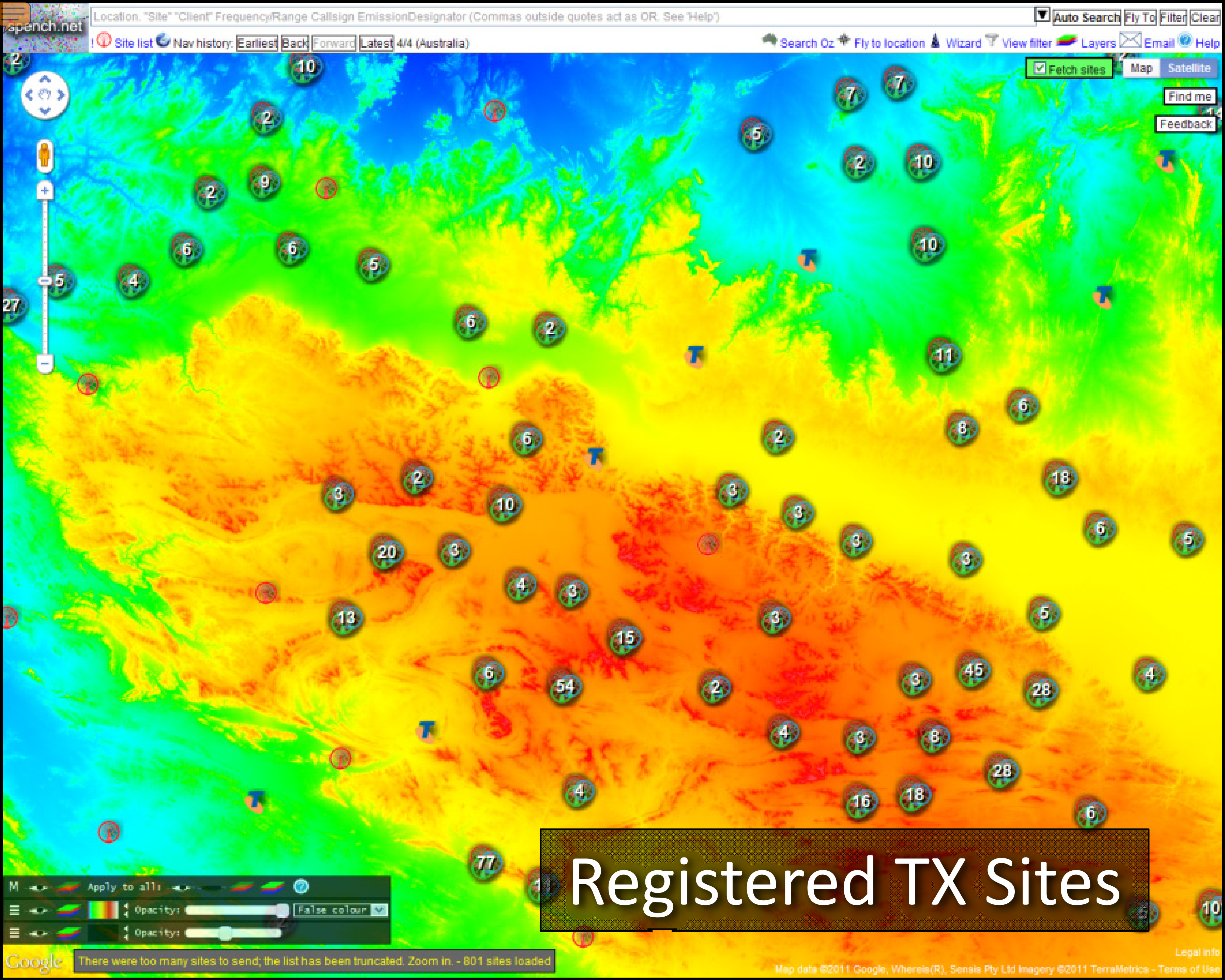


Registered TX Sites

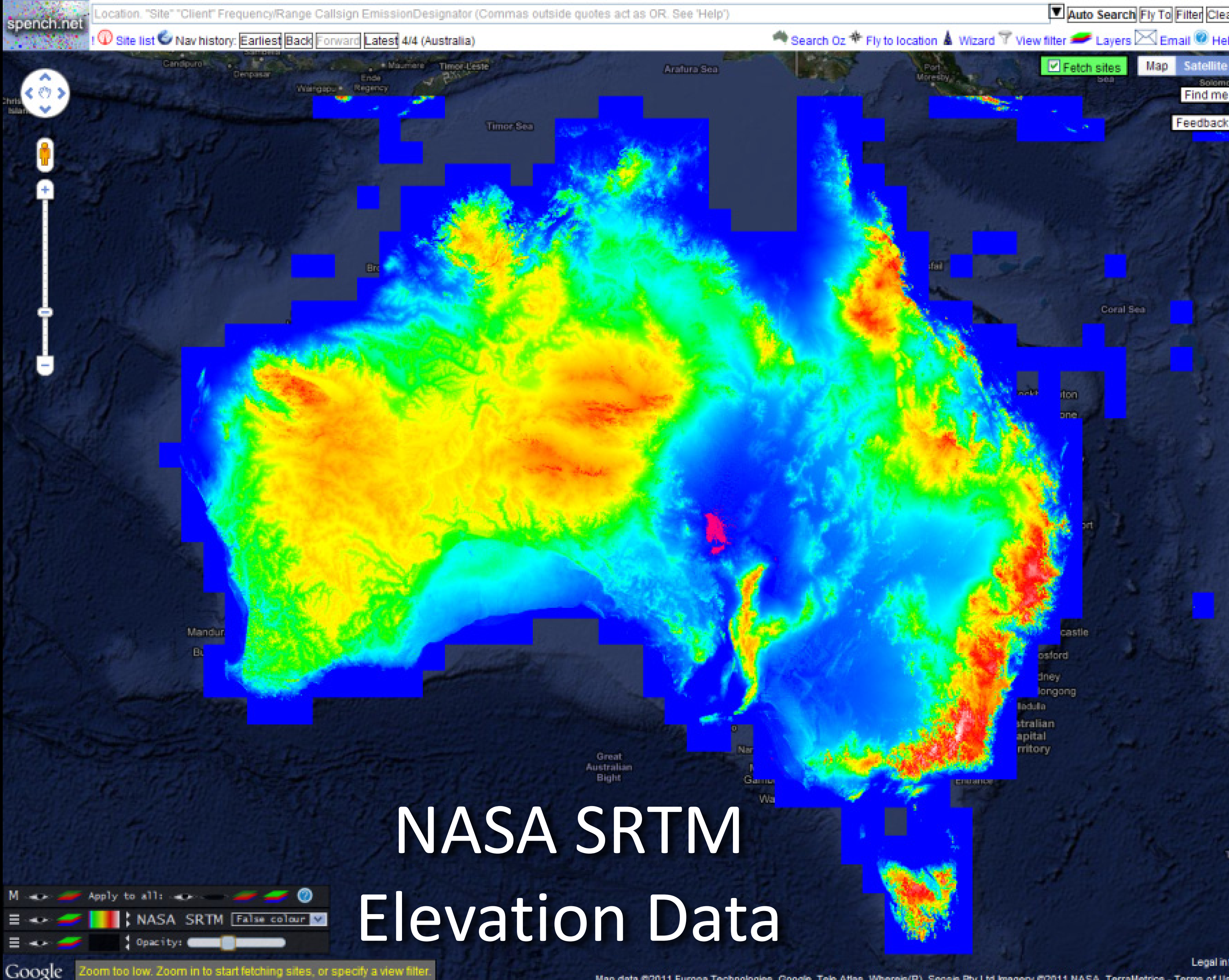


Registered TX Sites

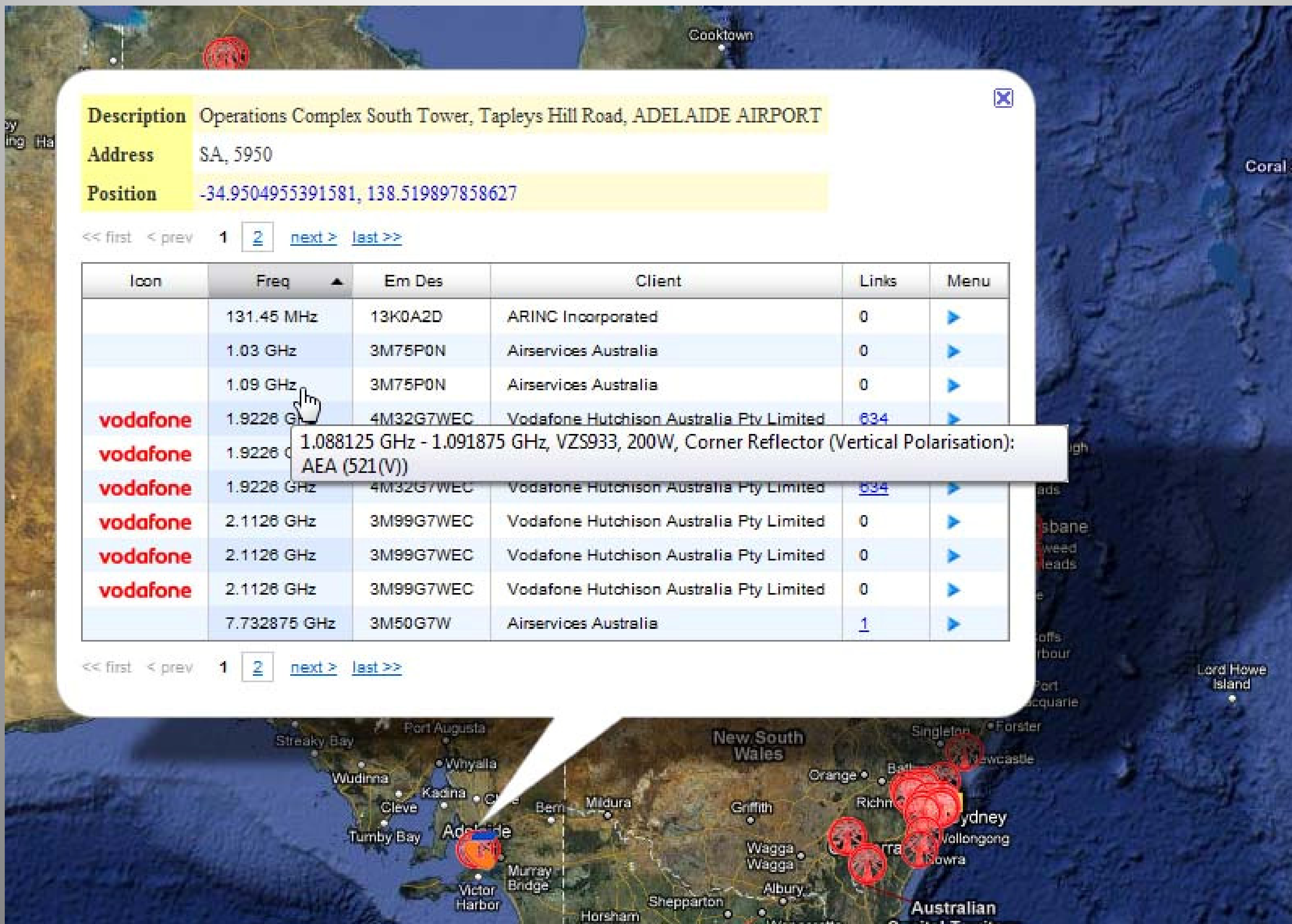
Registered TX Sites



NASA SRTM Elevation Data



Site details: frequency assignments



Description	Operations Complex South Tower, Tapleys Hill Road, ADELAIDE AIRPORT
Address	SA, 5950
Position	-34.9504955391581, 138.519897858627

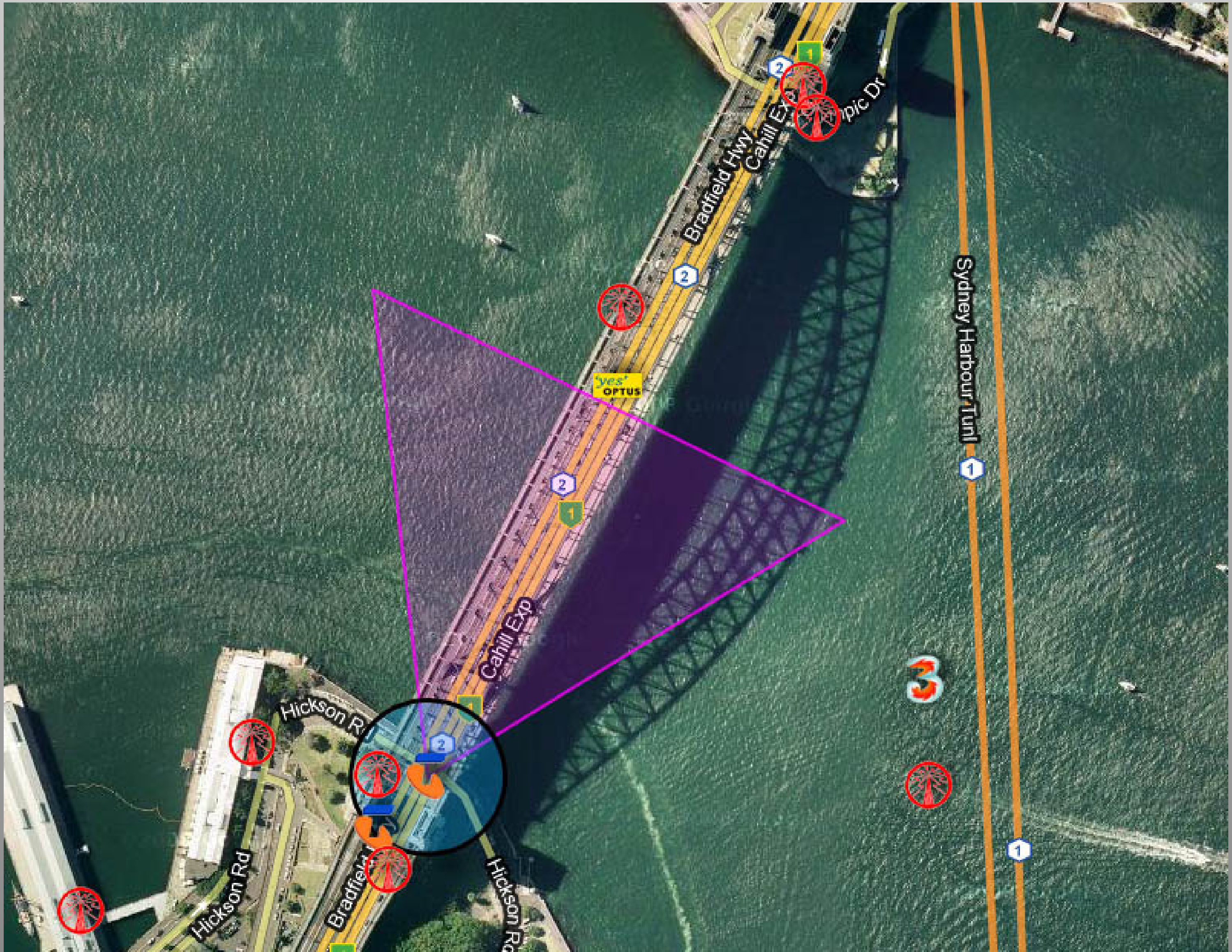
<< first < prev 1 2 next > last >>

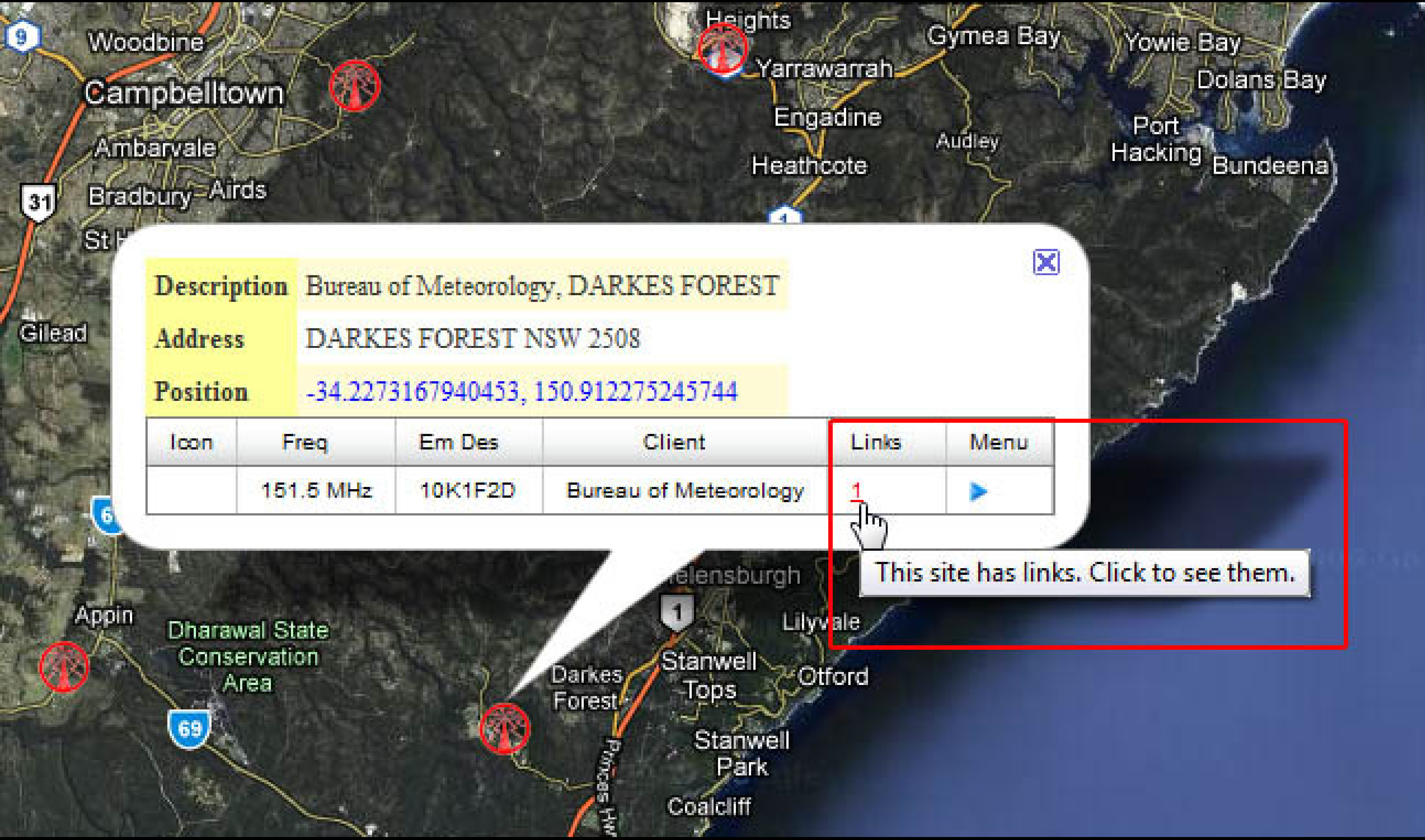
Icon	Freq	Em Des	Client	Links	Menu
	131.45 MHz	13K0A2D	ARINC Incorporated	0	▶
	1.03 GHz	3M75P0N	Airservices Australia	0	▶
	1.09 GHz	3M75P0N	Airservices Australia	0	▶
vodafone	1.9226 G	4M32G7WEC	Vodafone Hutchison Australia Pty Limited	634	▶
vodafone	1.9226 (				
vodafone	1.9226 GHz	4M32G7WEC	Vodafone Hutchison Australia Pty Limited	634	▶
vodafone	2.1126 GHz	3M99G7WEC	Vodafone Hutchison Australia Pty Limited	0	▶
vodafone	2.1126 GHz	3M99G7WEC	Vodafone Hutchison Australia Pty Limited	0	▶
vodafone	2.1126 GHz	3M99G7WEC	Vodafone Hutchison Australia Pty Limited	0	▶
	7.732875 GHz	3M50G7W	Airservices Australia	1	▶

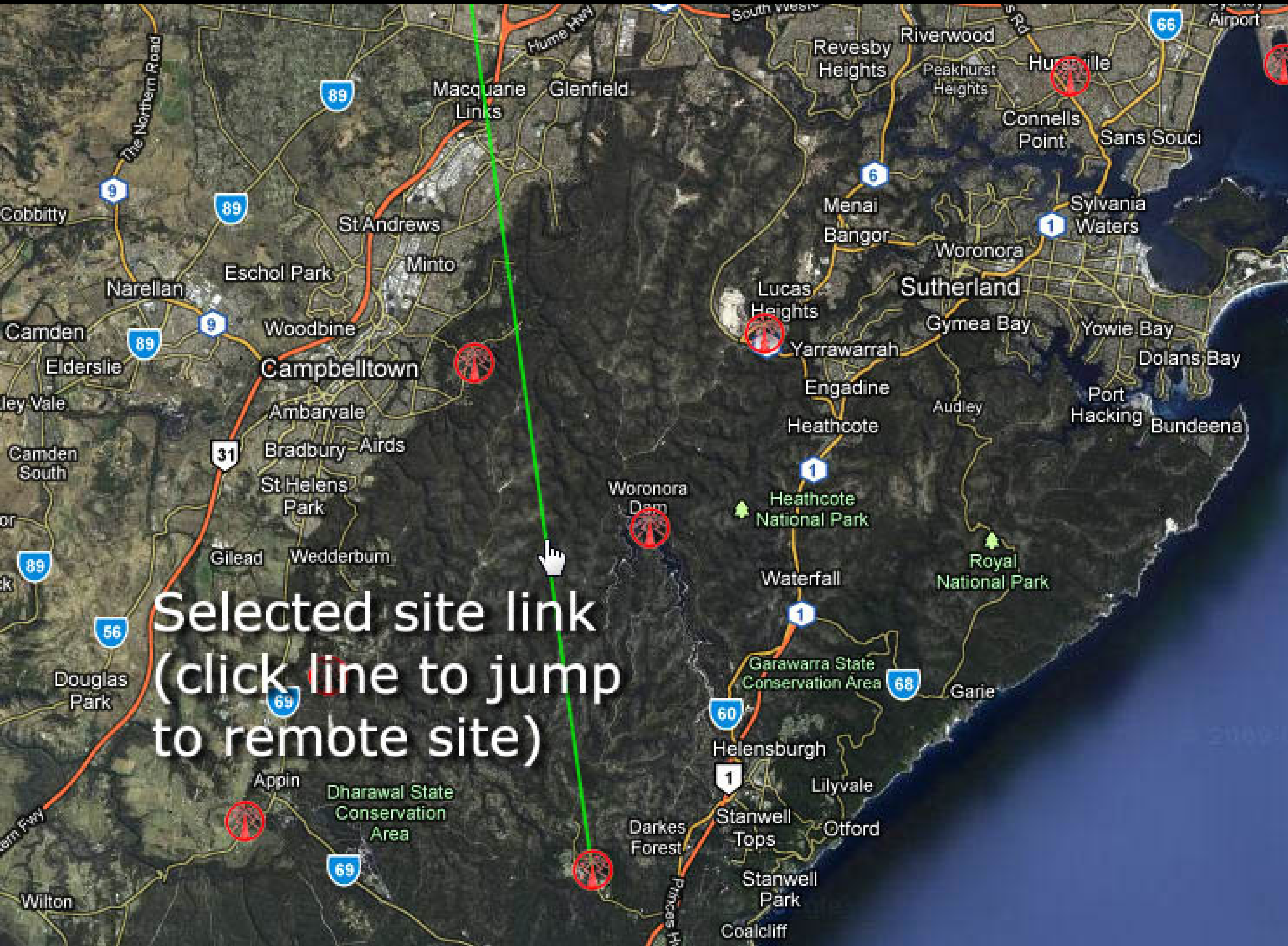
1.088125 GHz - 1.091875 GHz, VZS933, 200W, Corner Reflector (Vertical Polarisation): AEA (521(V))

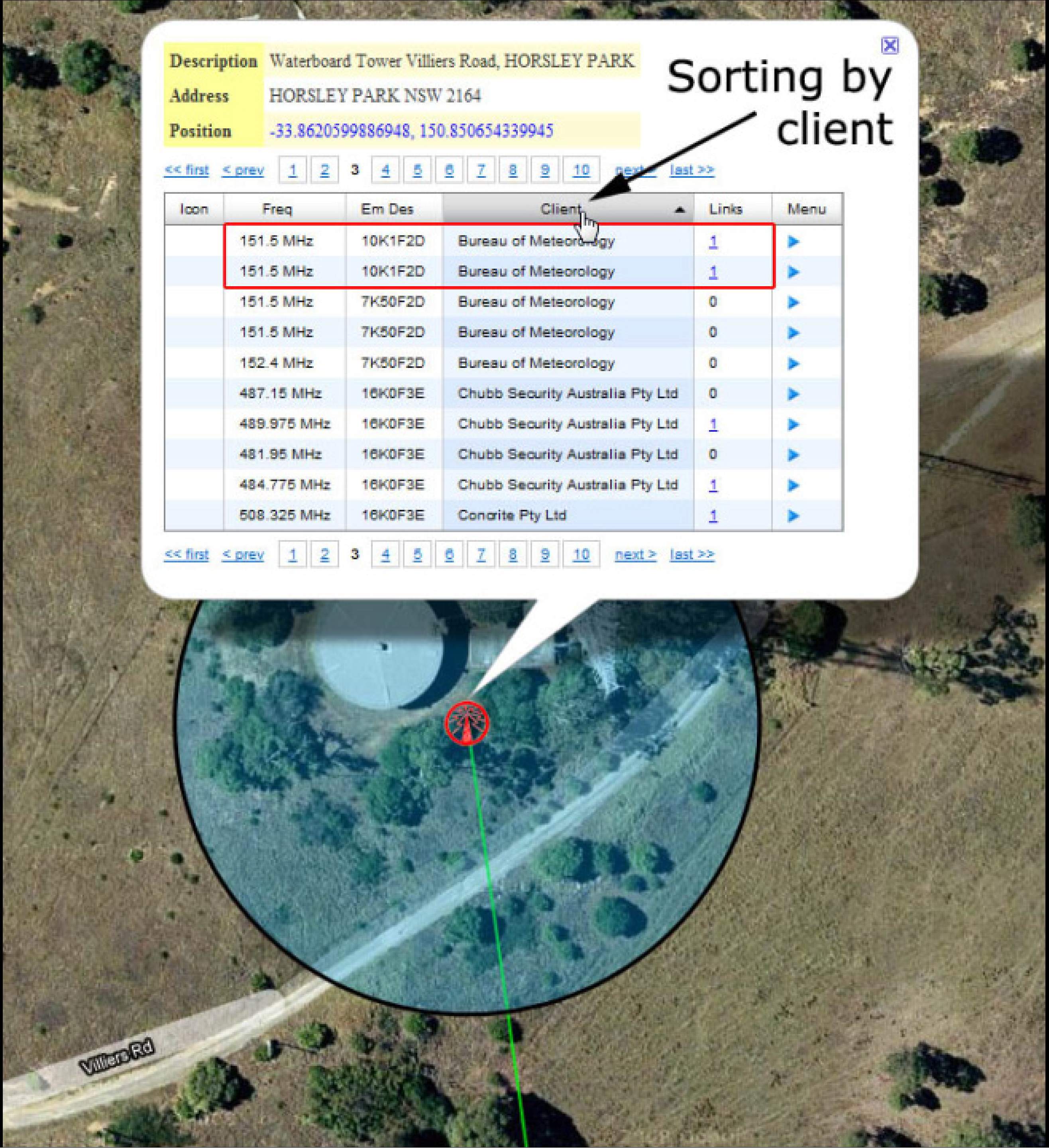
<< first < prev 1 2 next > last >>

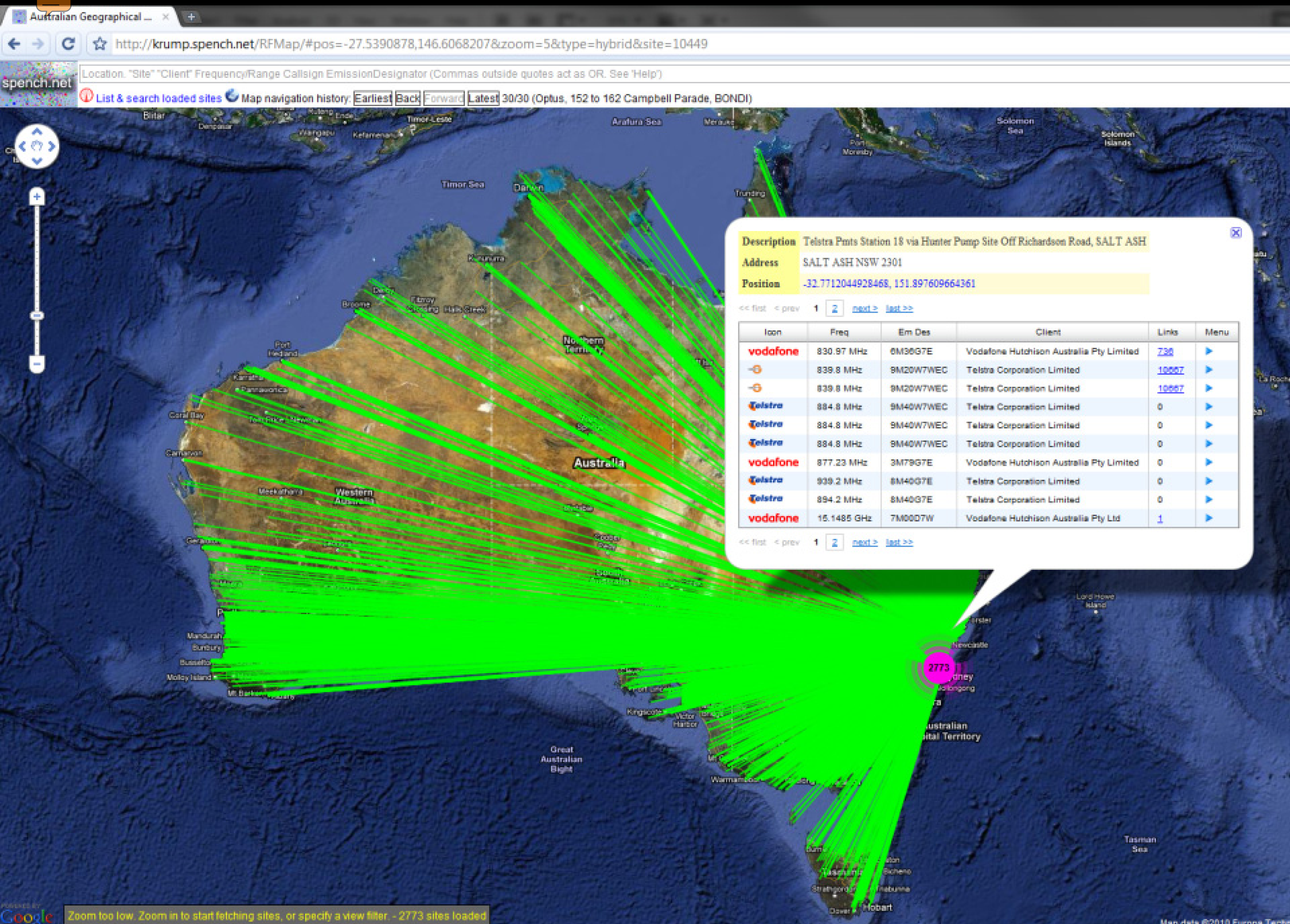
Antenna radiation pattern*




Description Bureau of Meteorology, DARKES FOREST
Address DARKES FOREST NSW 2508
Position -34.2273167940453, 150.912275245744
Icon
Freq
Em Des
Client
Links
Menu
151.5 MHz
10K1F2D
Bureau of Meteorology
1
This site has links. Click to see them.
Woodbine
Campbelltown
Ambarvale
Bradbury
Airds
Gilead
Appin
Dharawal State Conservation Area
Heights
Yarrawarrah
Gymea Bay
Yowie Bay
Dolans Bay
Engadine
Audley
Heathcote
Port Hacking
Bundeena
Lilyvale
Darkes Forest
Stanwell Tops
Otford
Stanwell Park
Coalcliff


Selected site link
(click line to jump
to remote site)
Macquarie Links
Glenfield
Hume Hwy
Revesby Heights
Riverwood
Peakhurst Heights
Connells Point
Sans Souci
Airport
The Northern Road
Cobbitty
St Andrews
Menai
Bangor
Woronora
Sylvania Waters
Eschol Park
Minto
Narellan
Lucas Heights
Sutherland
Camden
Woodbine
Gymea Bay
Yowie Bay
Yarrawarrah
Dolans Bay
Elderslie
Campbelltown
Engadine
Audley
Port Hacking
Bundeena
Ambarvale
Heathcote
Camden South
Bradbury
Airds
St Helens Park
Woronora Dam
Heathcote National Park
Gilead
Wedderburn
Waterfall
Royal National Park
Douglas Park
Garawarra State Conservation Area
Garie
Helensburgh
Appin
Dharawal State Conservation Area
Lilyvale
Darkes Forest
Stanwell Tops
Otford
Stanwell Park
Wilton
Coalcliff
Princes Hwy


Description Waterboard Tower Villiers Road, HORSLEY PARK
Address HORSLEY PARK NSW 2164
Position -33.8620599886948, 150.850654339945
Sorting by client
<< first < prev 1 2 3 4 5 6 7 8 9 10 next > last >>
Icon Freq Em Des Client Links Menu
151.5 MHz 10K1F2D Bureau of Meteorology 1
151.5 MHz 10K1F2D Bureau of Meteorology 1
151.5 MHz 7K50F2D Bureau of Meteorology 0
151.5 MHz 7K50F2D Bureau of Meteorology 0
152.4 MHz 7K50F2D Bureau of Meteorology 0
487.15 MHz 16K0F3E Chubb Security Australia Pty Ltd 0
489.975 MHz 16K0F3E Chubb Security Australia Pty Ltd 1
481.95 MHz 16K0F3E Chubb Security Australia Pty Ltd 0
484.775 MHz 16K0F3E Chubb Security Australia Pty Ltd 1
508.325 MHz 16K0F3E Concrite Pty Ltd 1
<< first < prev 1 2 3 4 5 6 7 8 9 10 next > last >>
Villiers Rd



Australian Geographical ...
http://krump.spench.net/RFMap/#pos=-27.5390878,146.6068207&zoom=5&type=hybrid&site=10449
spench.net
Location. "Site" "Client" Frequency/Range Callsign EmissionDesignator (Commas outside quotes act as OR. See 'Help')
List & search loaded sites
Map navigation history: Earliest Back Forward Latest 30/30 (Optus, 152 to 162 Campbell Parade, BONDI)
Description Telstra Pmts Station 18 via Hunter Pump Site Off Richardson Road, SALT ASH
Address SALT ASH NSW 2301
Position -32.7712044928468, 151.897609664361
<< first < prev 1 2 next > last >>
Icon Freq Em Des Client Links Menu
vodafone 830.97 MHz 6M36G7E Vodafone Hutchison Australia Pty Limited 736
839.8 MHz 9M20W7WEC Telstra Corporation Limited 10667
839.8 MHz 9M20W7WEC Telstra Corporation Limited 10667
Telstra 884.8 MHz 9M40W7WEC Telstra Corporation Limited 0
Telstra 884.8 MHz 9M40W7WEC Telstra Corporation Limited 0
Telstra 884.8 MHz 9M40W7WEC Telstra Corporation Limited 0
vodafone 877.23 MHz 3M79G7E Vodafone Hutchison Australia Pty Limited 0
Telstra 939.2 MHz 8M40G7E Telstra Corporation Limited 0
Telstra 894.2 MHz 8M40G7E Telstra Corporation Limited 0
vodafone 15.1485 GHz 7M00D7W Vodafone Hutchison Australia Pty Ltd 1
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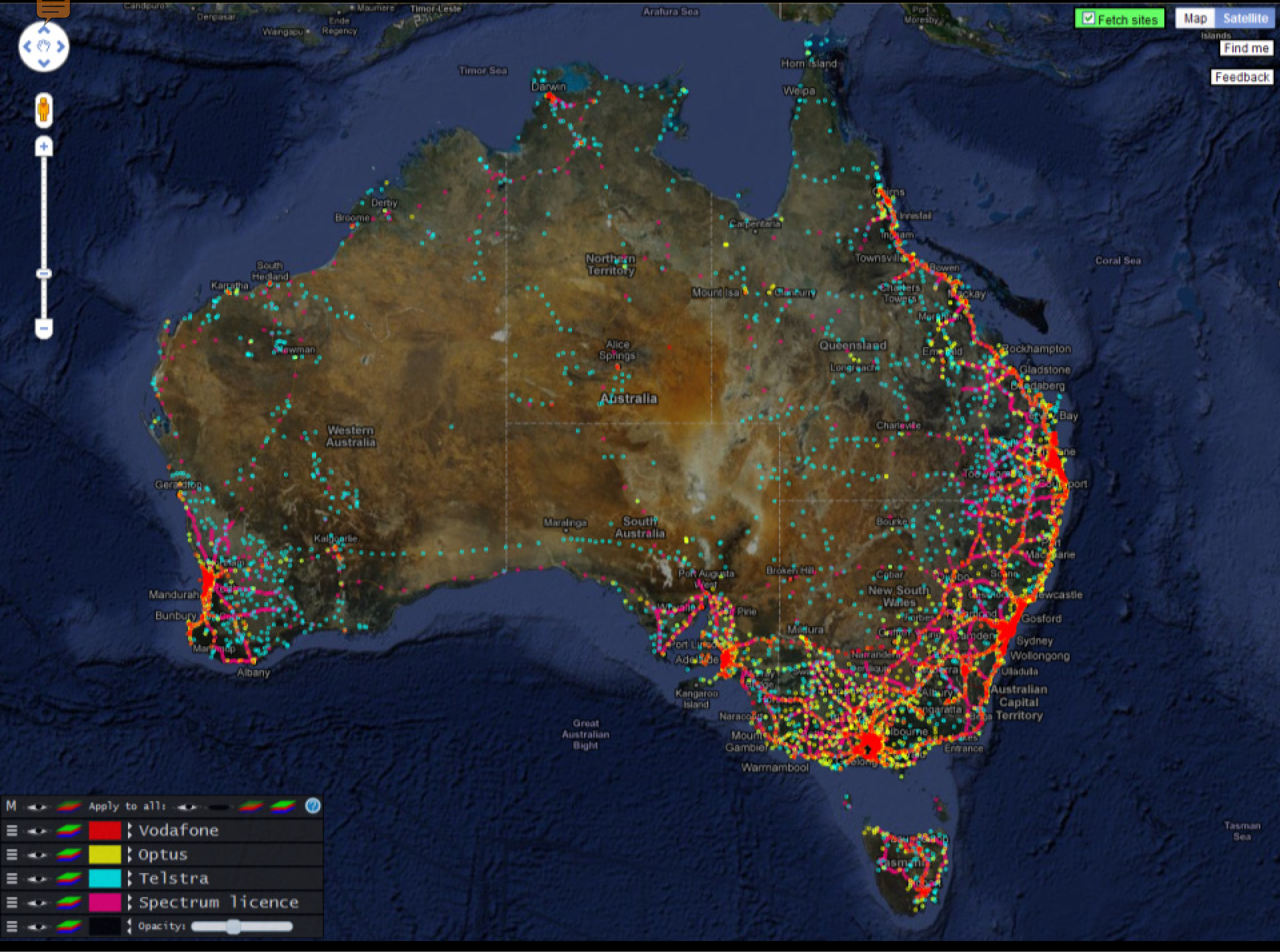
2773
Australia
Western Australia
Northern Territory
Timor Sea
Arafura Sea
Great Australian Bight
Tasman Sea
Darwin
Broome
Hobart
Zoom too low. Zoom in to start fetching sites, or specify a view filter. - 2773 sites loaded
Map data ©2010 Europa Techn



Fetch sites
Map
Satellite
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Arafura Sea
Timor Sea
Darwin
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South Hedland
Karratha
Northern Territory
Mount Isa
Cloncurry
Charters Towers
Newman
Alice Springs
Queensland
Longreach
Rockhampton
Gladstone
Australia
Charleville
Western Australia
Geraldton
Maralinga
South Australia
Kalgoorlie
Bourke
Port Augusta
Broken Hill
New South Wales
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Bunbury
Mildura
Newcastle
Gosford
Sydney
Wollongong
Ulladulla
Albany
Adelaide
Kangaroo Island
Australian Capital Territory
Great Australian Bight
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Mount Gambier
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Tasman Sea
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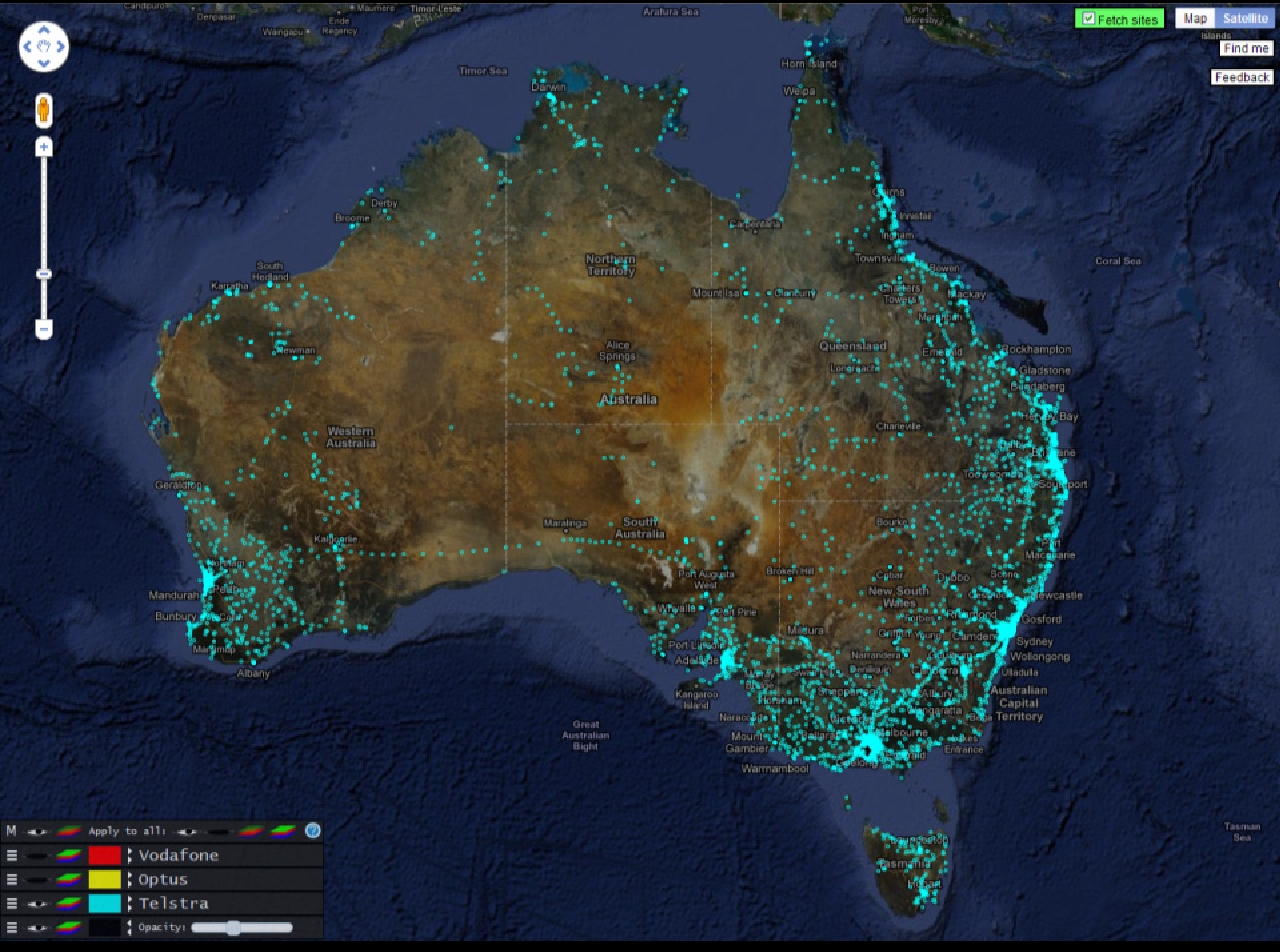
Opacity:



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Cairns
Innisfail
Ingham
Townsville
Bowen
Mackay
Charters Towers
Mount Isa
Cloncurry
Queensland
Longreach
Emerald
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Gladstone
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Hervey Bay
Charleville
Brisbane
Toowoomba
Southport
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Broome
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Kalgoorlie
Maralinga
South Australia
Mandurah
Perth
Bunbury
Albany
Port Augusta West
Port Pirie
Whyalla
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Kangaroo Island
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Bourke
Cobar
Dubbo
New South Wales
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Port Macquarie
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Sydney
Wollongong
Ulladulla
Mildura
Griffith
Young
Canberra
Australian Capital Territory
Shepparton
Albury
Wangaratta
Naracoorte
Mount Gambier
Warrnambool
Ballarat
Melbourne
Geelong
Lakes Entrance
Great Australian Bight
Tasmania
Hobart
Tasman Sea
Apply to all:
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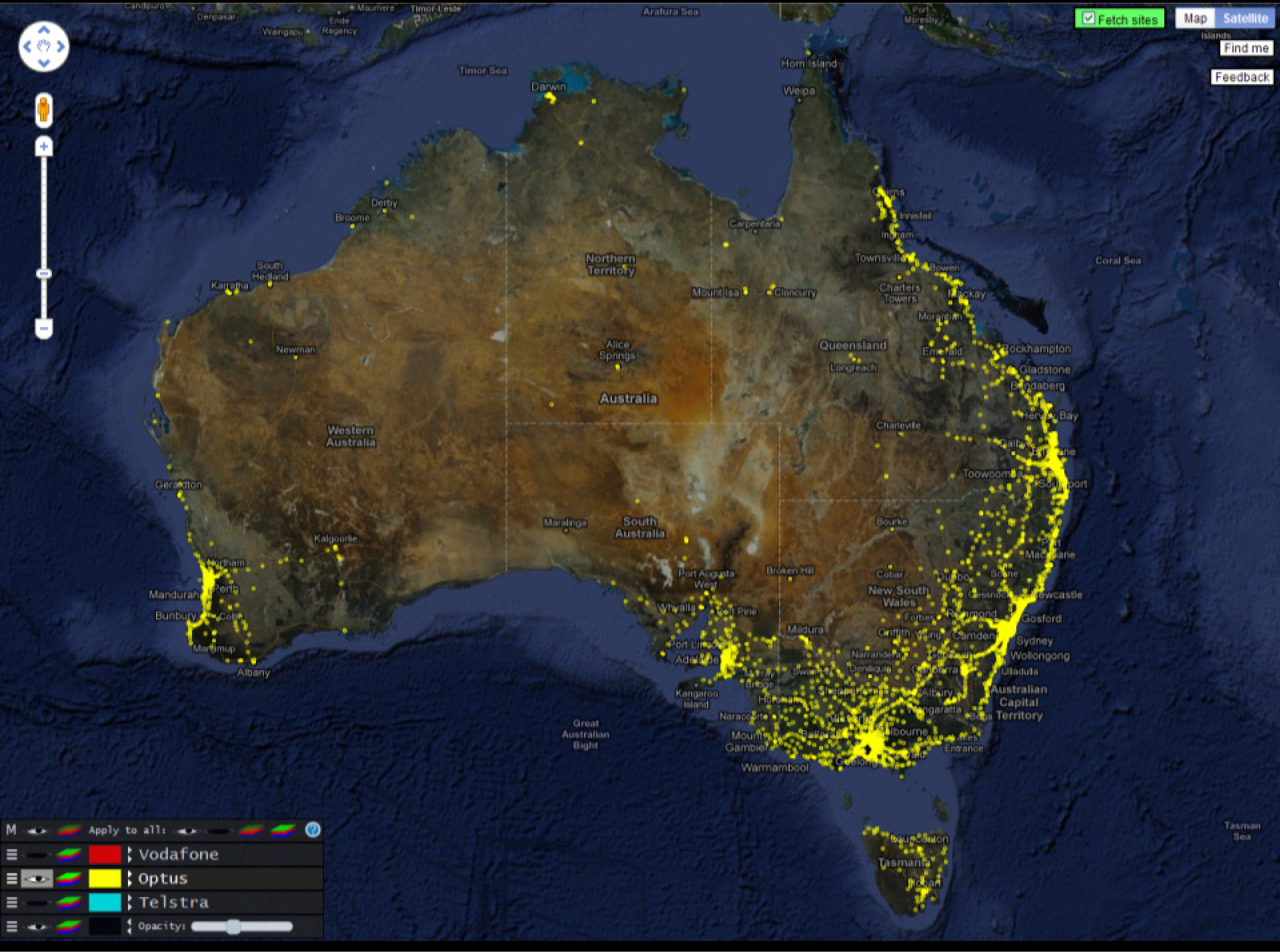
Telstra
Opacity:


Fetch sites
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Timor Sea
Arafura Sea
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Northern Territory
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Newman
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Rockhampton
Gladstone
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Hervey Bay
Longreach
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Griffith
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Albany
Great Australian Bight
Mount Gambier
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Australian Capital Territory
Tasmania
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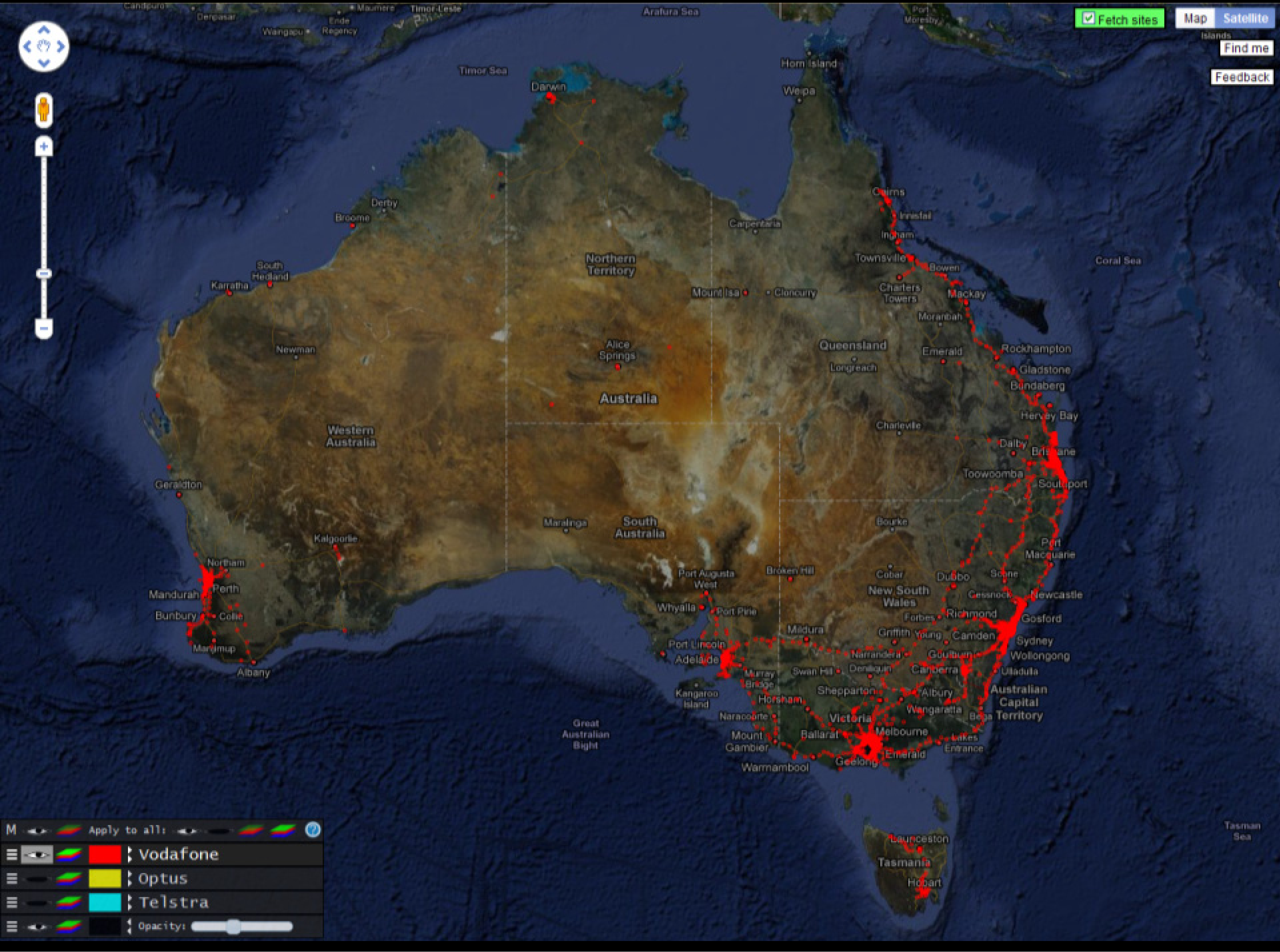
Opacity:



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Toowoomba
Southport
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Geraldton
Maralinga
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Bourke
Port Macquarie
Kalgoorlie
Northam
Perth
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Bunbury
Collie
Manjimup
Albany
Port Augusta West
Whyalla
Port Pirie
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Cobar
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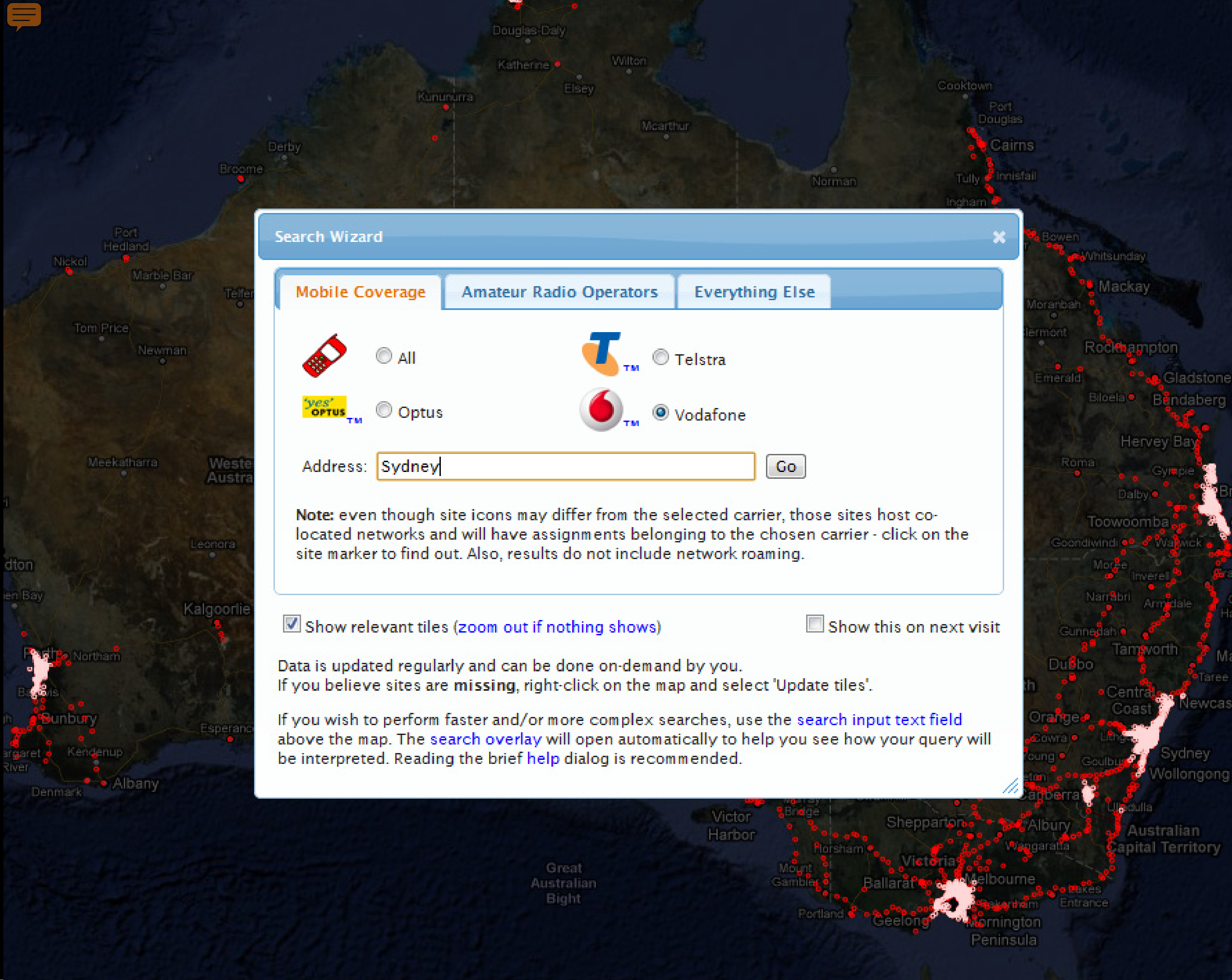
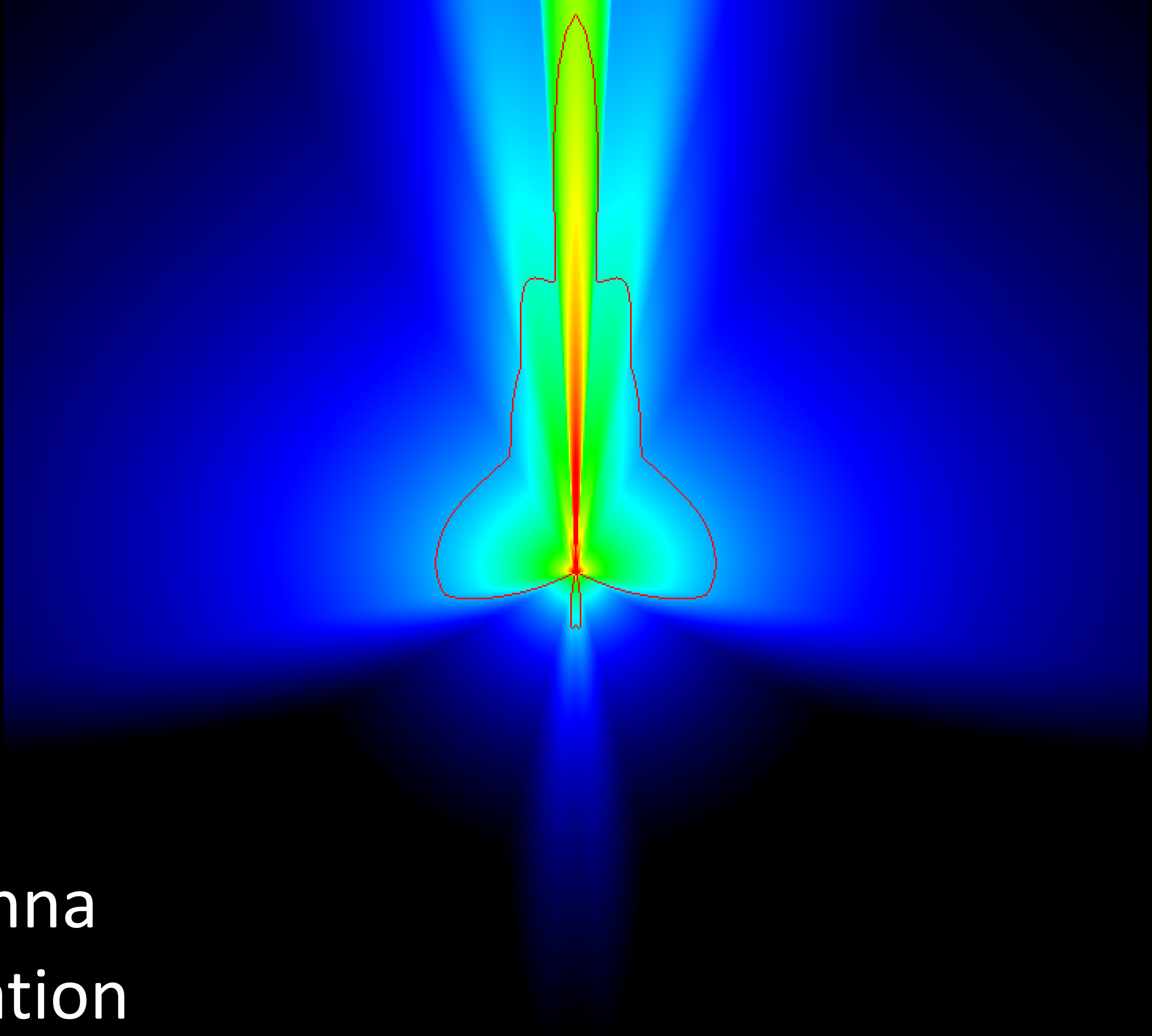
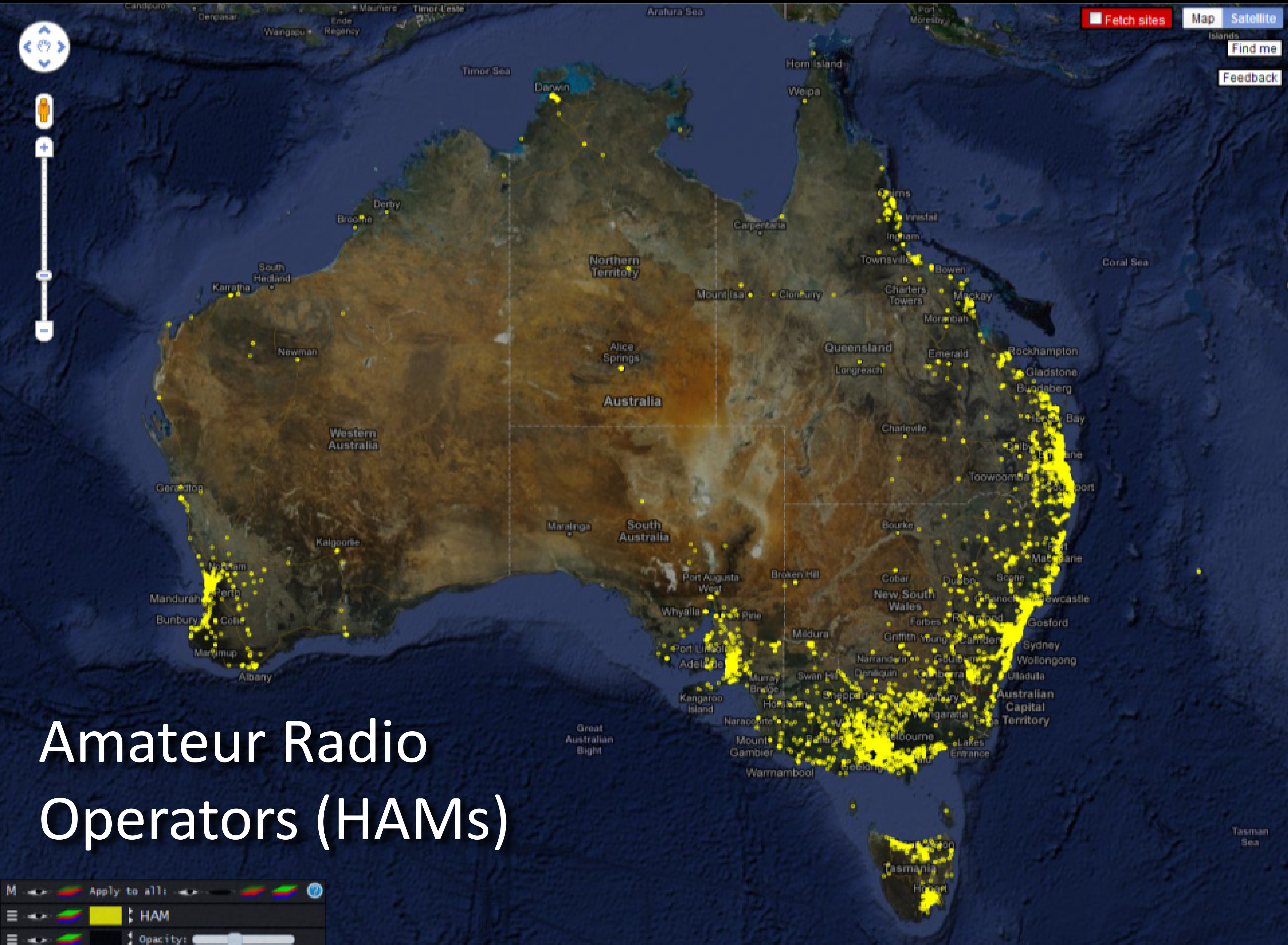
Dubbo
Scone
Cessnock
Newcastle
Forbes
Richmond
Gosford
Mildura
Griffith
Young
Camden
Sydney
Wollongong
Port Lincoln
Adelaide
Murray Bridge
Narrandera
Goulburn
Swan Hill
Deniliquin
Canberra
Ulladulla
Kangaroo Island
Shepparton
Albury
Australian Capital Territory
Horsham
Wangaratta
Naracoorte
Victoria
Bega
Great Australian Bight
Mount Gambier
Ballarat
Melbourne
Lakes Entrance
Geelong
Emerald
Warrnambool
Launceston
Tasmania
Hobart
M
Apply to all:
Vodafone
Optus
Telstra
Opacity:


Search Wizard
Mobile Coverage
Amateur Radio Operators
Everything Else
All
Telstra
Optus
Vodafone
Address: Sydney
Go
Note: even though site icons may differ from the selected carrier, those sites host co-located networks and will have assignments belonging to the chosen carrier - click on the site marker to find out. Also, results do not include network roaming.
Show relevant tiles (zoom out if nothing shows)
Show this on next visit
Data is updated regularly and can be done on-demand by you.
If you believe sites are missing, right-click on the map and select 'Update tiles'.
If you wish to perform faster and/or more complex searches, use the search input text field above the map. The search overlay will open automatically to help you see how your query will be interpreted. Reading the brief help dialog is recommended.

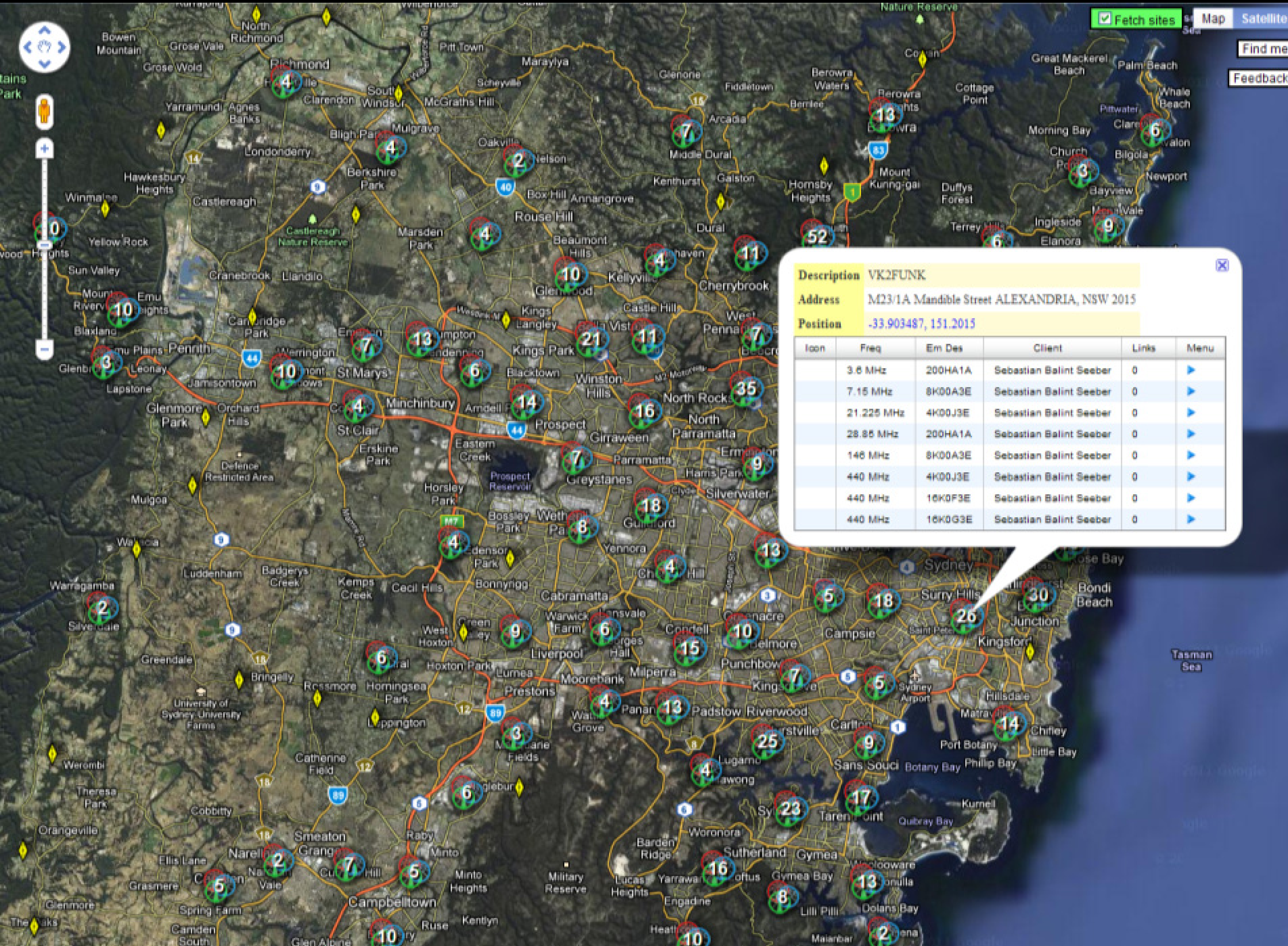


Antenna
Radiation
Envelope

Radiation Heatmap

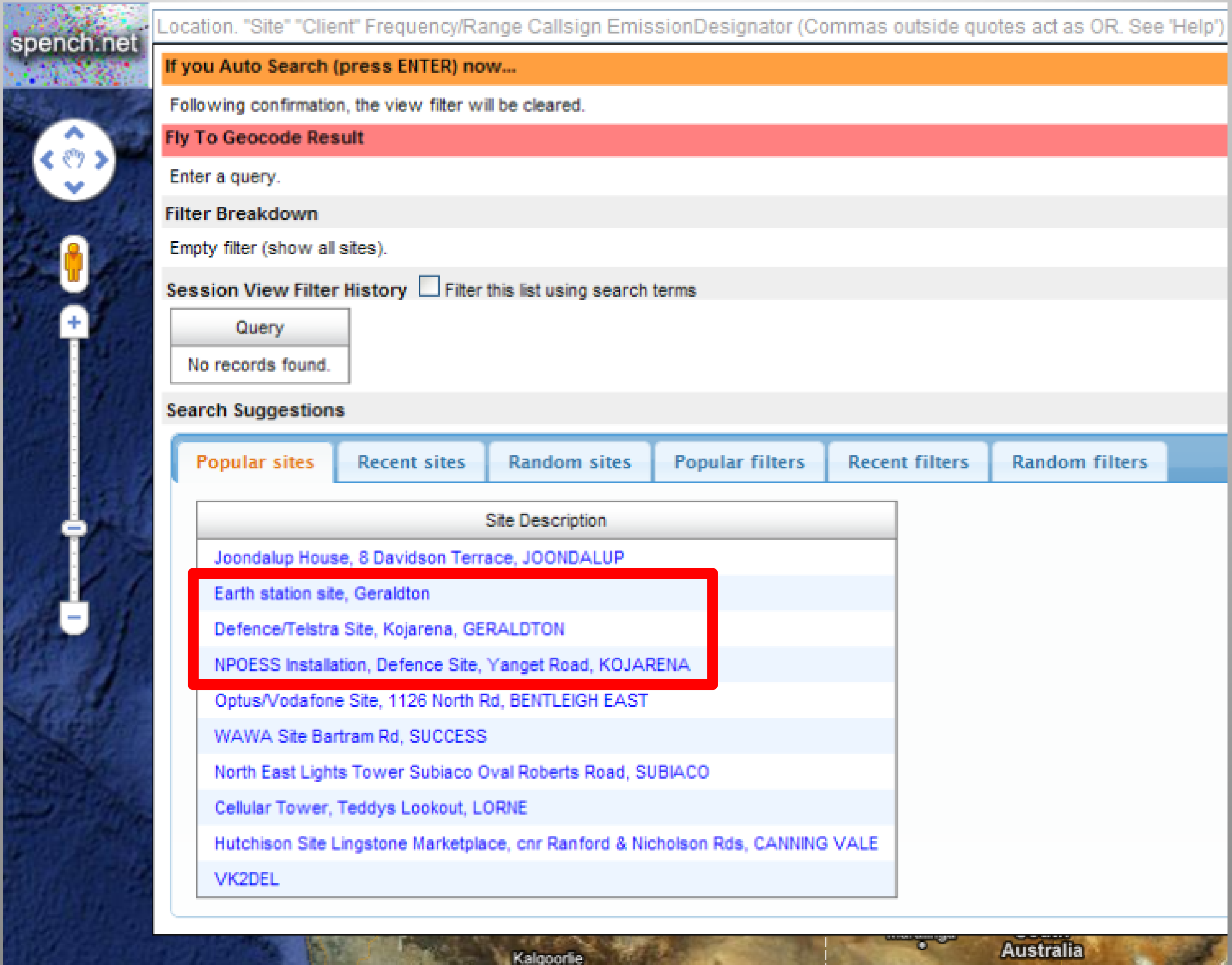


Amateur Radio Operators (HAMs)



Fetch sites
Map
Satellite
Find me
Feedback
Description VK2FUNK
Address M23/1A Mandible Street ALEXANDRIA, NSW 2015
Position -33.903487, 151.2015
Icon | Freq | Em Des | Client | Links | Menu
3.6 MHz | 200HA1A | Sebastian Balint Seeber | 0
7.15 MHz | 8K00A3E | Sebastian Balint Seeber | 0
21.225 MHz | 4K00J3E | Sebastian Balint Seeber | 0
28.85 MHz | 200HA1A | Sebastian Balint Seeber | 0
146 MHz | 8K00A3E | Sebastian Balint Seeber | 0
440 MHz | 4K00J3E | Sebastian Balint Seeber | 0
440 MHz | 16K0F3E | Sebastian Balint Seeber | 0
440 MHz | 16K0G3E | Sebastian Balint Seeber | 0
Sydney
Parramatta
Penrith
Campbelltown
Liverpool
Bondi Beach
Botany Bay
Tasman Sea

Most popular sites



Defence & ECHELON

"Joint Space Defence Research"


Fetch sites
Map
Satellite
Find me
Feedback
Google
Fetching sites... - 5 sites loaded
Legal info
011 Google, Whereis(R), Sensis Pty Ltd Imagery ©2011 Cnes/Spot Image, DigitalGlobe, GeoEye - Terms of Use
Upset ADIRU of QF68/71/72 & JQ7 ?

Side note

Bolivia


MICHELANGELO
BIBLICAL ART
RENAISSANCE
GAUDI
Othello
Twelfth Night
Romeo and Juliet
King Henry V
JAMES DAY
MUMMY
YAESU
FRA-7700
YAESU FRT-7700
YAESU
FRG-9600
REALISTIC
300 CHANNEL PRO-2004
VOLUME
SQUELCH
YAESU
COMMUNICATIONS RECEIVER
FRG-8800
POWER
PHONES
SQUELCH
TONE
AF GAIN
ATT

The Mystery Signal

Rate at which 'messages' were transmitted varied throughout the day:

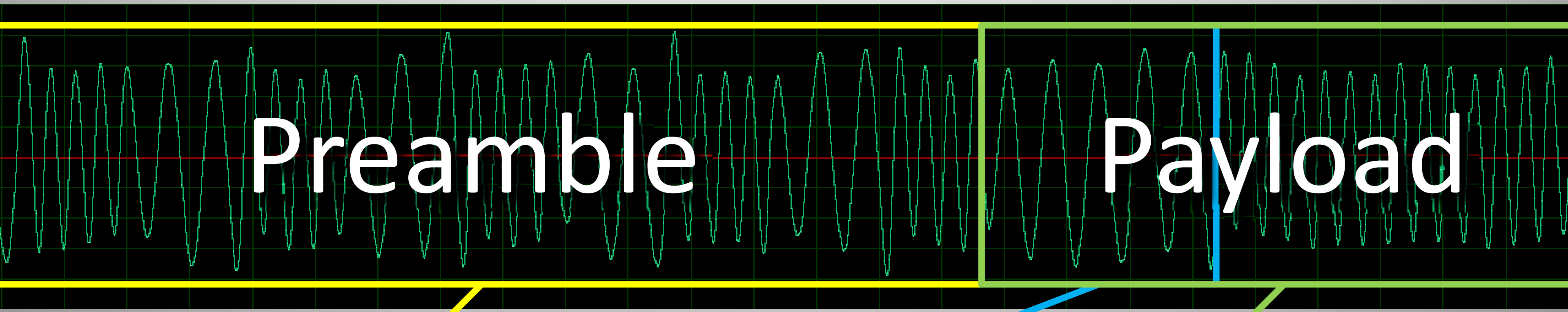
correlates with increased daytime activity.

Received RF signal → audio → sampled by soundcard → streamed across network

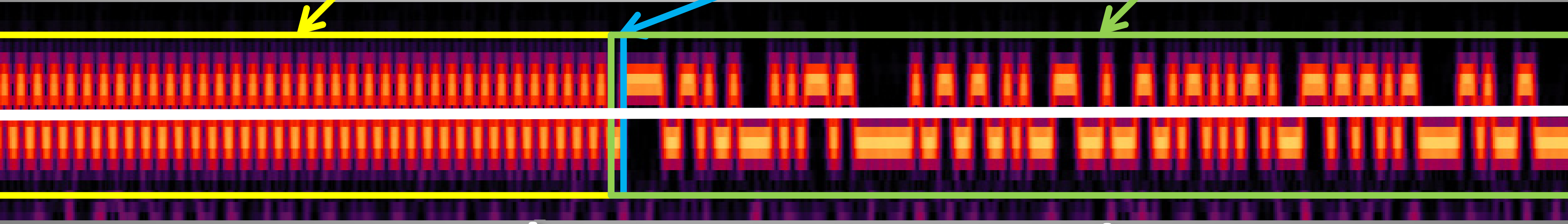
Step One: Look at the signal

Radio is already set to receive N-FM (narrowband frequency modulated signal)

Signal in the time domain (voltage vs. time):

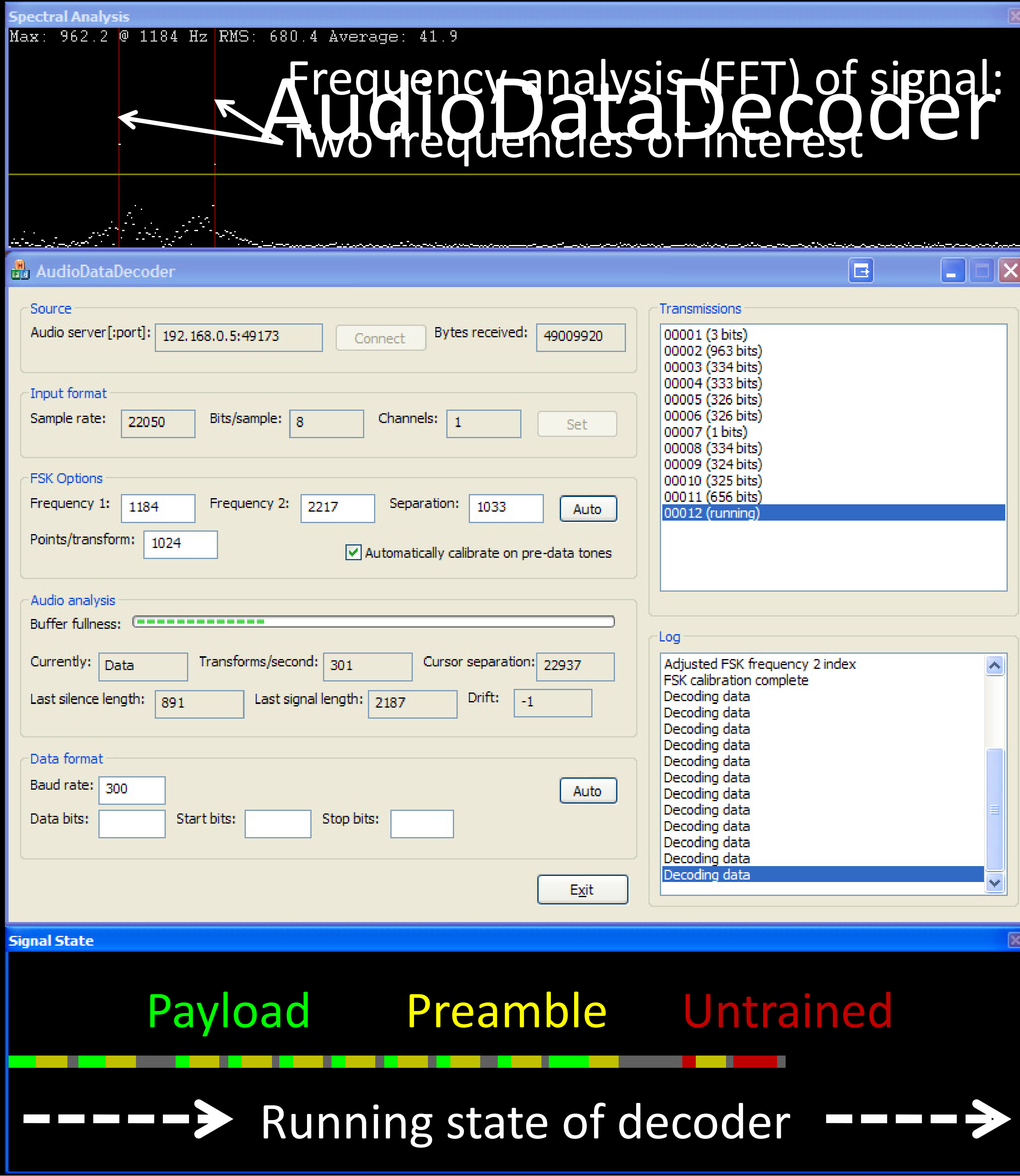


Signal in the frequency domain (intensity of frequency bins vs. time):



IT'S SLICER TIME!

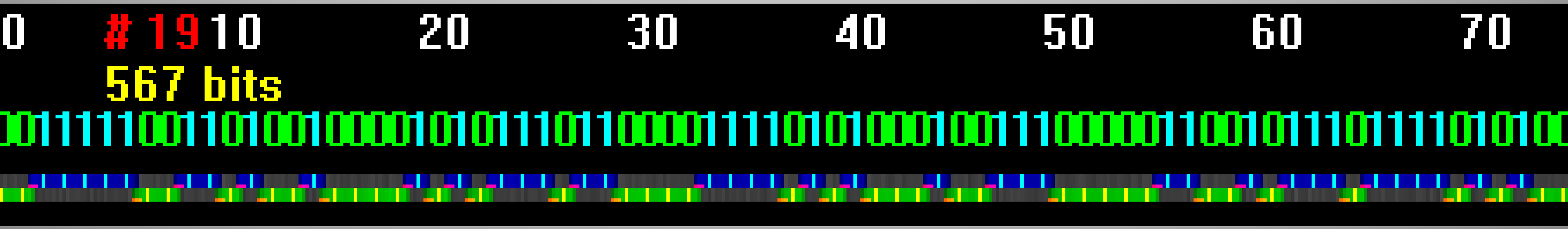
AudioDataDecoder



Step Two: FFT of 2FSK → Bitstream

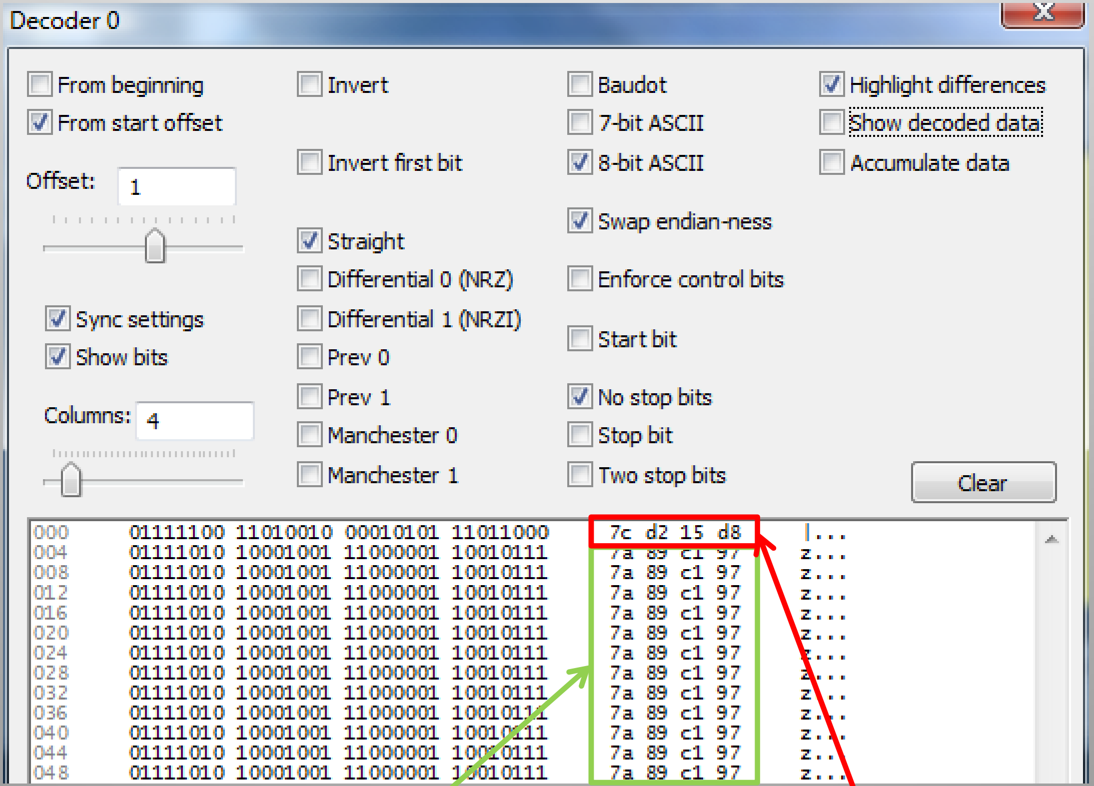
- Lock on two frequencies (**F**requency **S**hift **K**eying)
- Sample intensity of each at regular interval (baud rate)
- Pick which is the strongest:

low = 0 bit, high = 1 bit



Step Three: Data → Information

- The most difficult part, so try all combinations



Wikipedia says:

Code words are transmitted in batches that consist of a sync codeword, defined in the standard as 0x7CD215D8, followed by 16 others containing the data. Any unused code words are filled with the idle value of 0x7A89C197. In practice other values are sometimes used to indicate sync and idle.

POCSAG!

- "**P**ost **O**ffice **C**ode **S**tandardization **A**dvisory **G**roup"
- Standard decoding software didn't work
- Key: recognisable sequence of bits when idle

→Look for known codewords/repeated bit strings

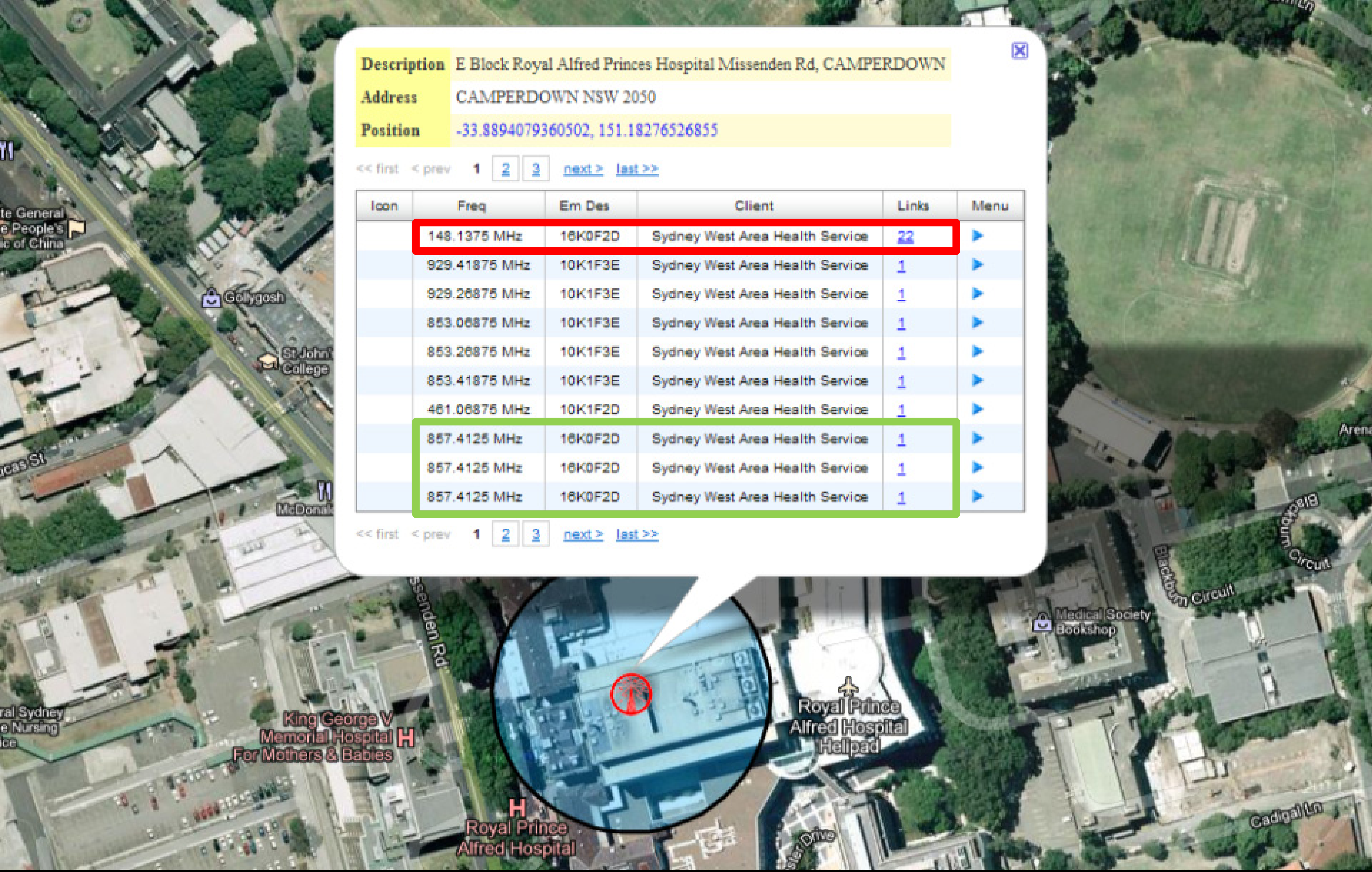
Hospital Pager Systems

- High power, better penetration than mobiles
- Personnel carry small pagers, each with ID mapped to **R**adio **I**dentity **C**ode
- Mostly numeric pages with phone extension
- Sent via software on any computer at hospital
- Address to multiple recipients, automatically sent to each once
- Delivery not guaranteed

Frequencies

- Shared frequency: 148.1375 MHz (standard)
- Private systems in 800/900MHz band:

  Non-standard FSK ignored by decoders


Description E Block Royal Alfred Princes Hospital Missenden Rd, CAMPERDOWN
Address CAMPERDOWN NSW 2050
Position -33.8894079360502, 151.18276526855
<< first < prev 1 2 3 next > last >>

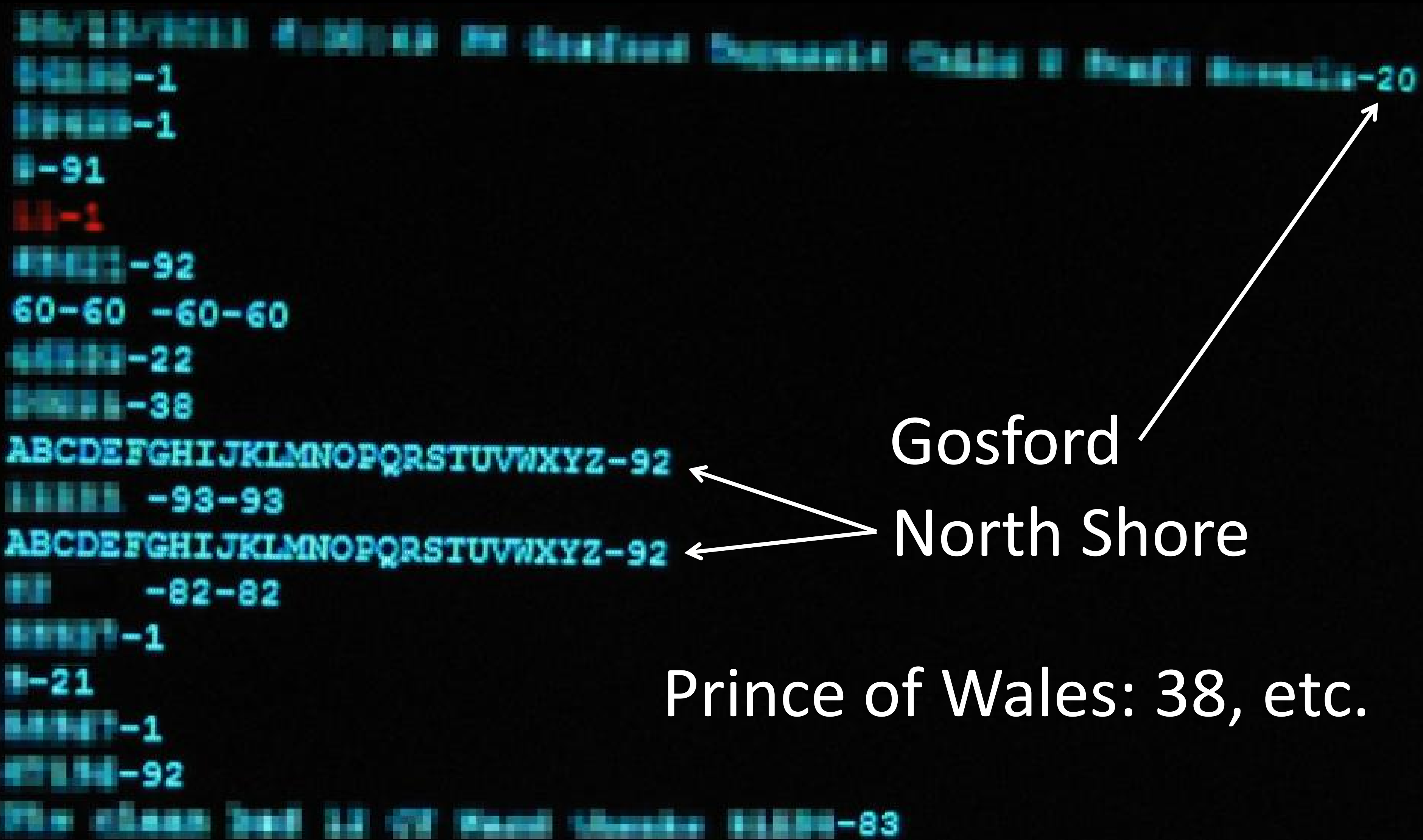
Icon	Freq	Em Des	Client	Links	Menu
	148.1375 MHz	16K0F2D	Sydney West Area Health Service	22	
	929.41875 MHz	10K1F3E	Sydney West Area Health Service	1	
	929.26875 MHz	10K1F3E	Sydney West Area Health Service	1	
	853.06875 MHz	10K1F3E	Sydney West Area Health Service	1	
	853.26875 MHz	10K1F3E	Sydney West Area Health Service	1	
	853.41875 MHz	10K1F3E	Sydney West Area Health Service	1	
	461.06875 MHz	10K1F2D	Sydney West Area Health Service	1	
	857.4125 MHz	16K0F2D	Sydney West Area Health Service	1	
	857.4125 MHz	16K0F2D	Sydney West Area Health Service	1	
	857.4125 MHz	16K0F2D	Sydney West Area Health Service	1	

<< first < prev 1 2 3 next > last >>
Gollygosh
St John's College
McDonald's
King George V Memorial Hospital For Mothers & Babies
Royal Prince Alfred Hospital
Royal Prince Alfred Hospital Helipad
Medical Society Bookshop
Blackburn Circuit
Cadigal Ln
Missenden Rd

On RFMap

Sydney West Area Health Service

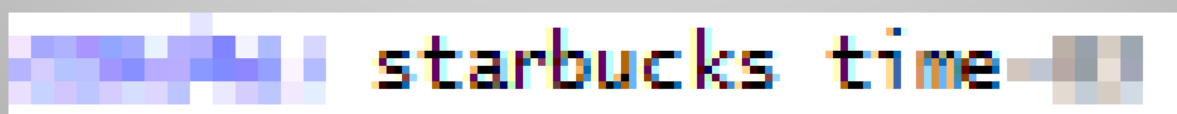
Hospital ID Postfix

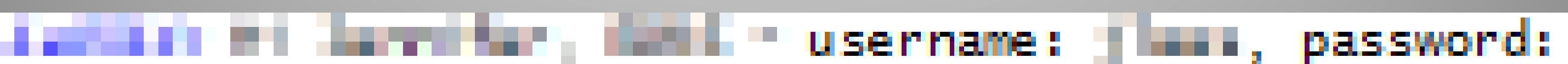


Gosford
North Shore

Prince of Wales: 38, etc.

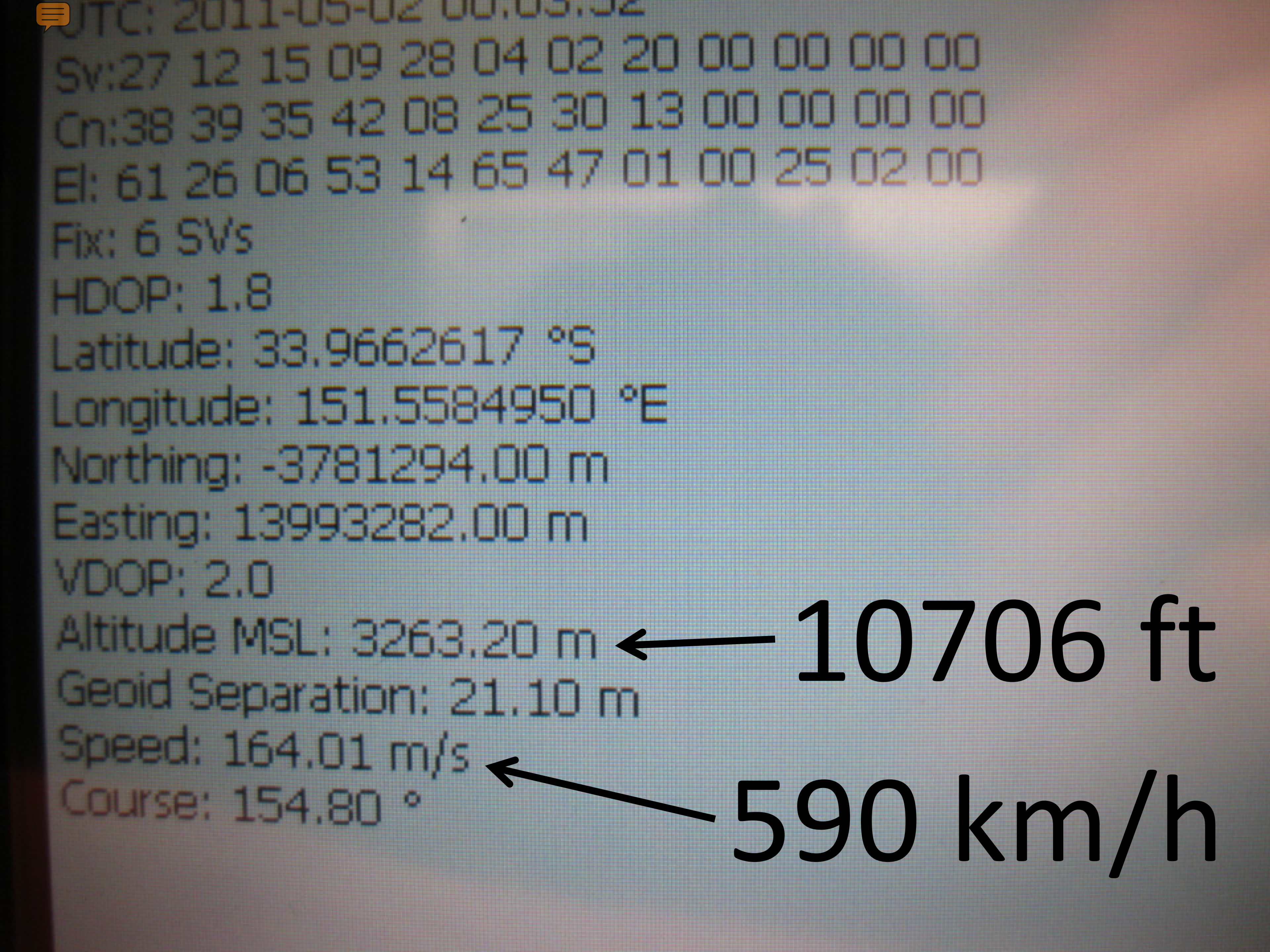
Sensitive Information





AviationMapper

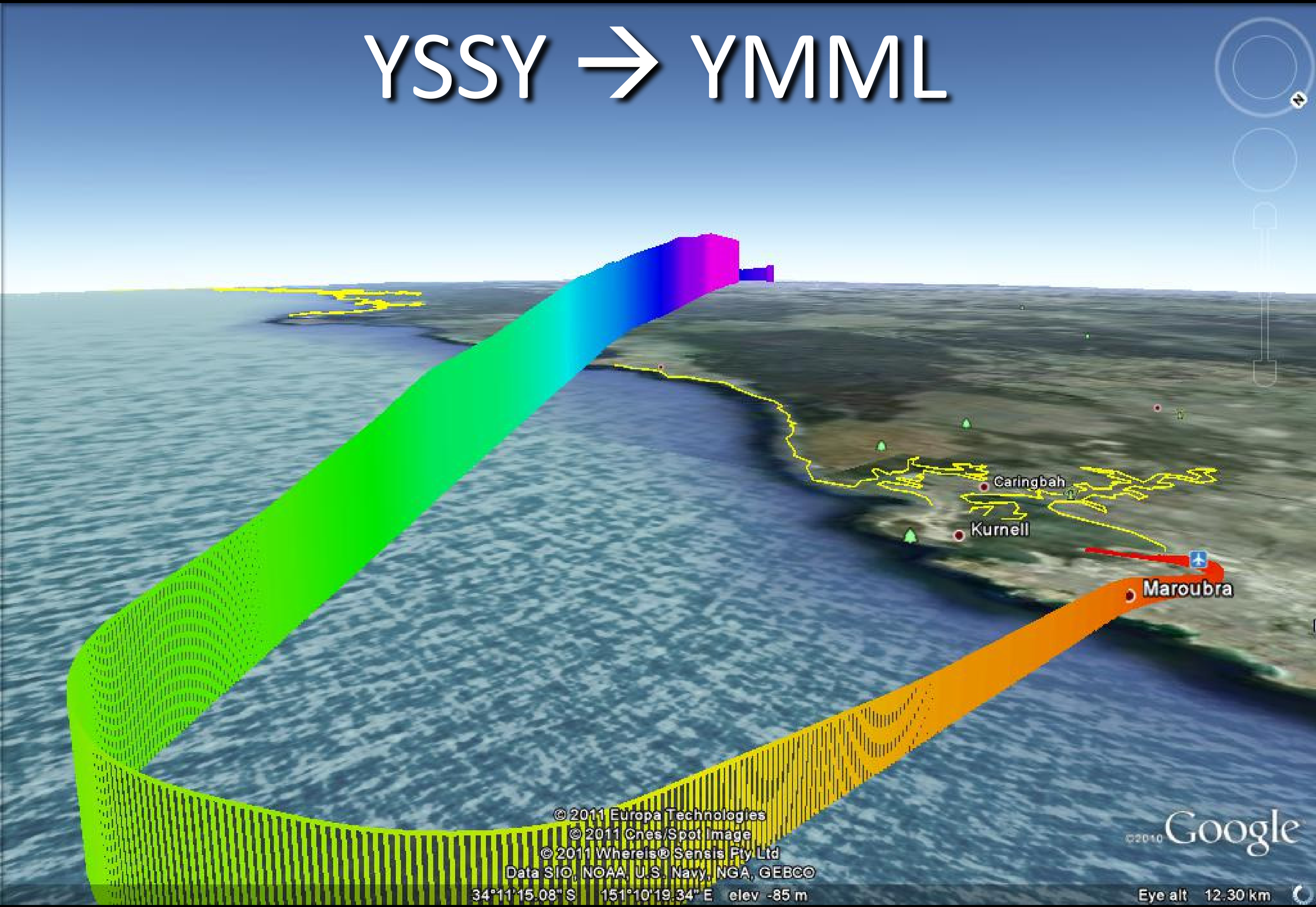
Image by Oscar De Lellis


Sv:27 12 15 09 28 04 02 20 00 00 00 00
Cn:38 39 35 42 08 25 30 13 00 00 00 00
El: 61 26 06 53 14 65 47 01 00 25 02 00
Fix: 6 SVs
HDOP: 1.8
Latitude: 33.9662617 °S
Longitude: 151.5584950 °E
Northing: -3781294.00 m
Easting: 13993282.00 m
VDOP: 2.0
Altitude MSL: 3263.20 m
Geoid Separation: 21.10 m
Speed: 164.01 m/s
Course: 154.80 °
10706 ft
590 km/h

YSSY → YMML

New South Wales
Sydney
Wollongong
Canberra
Victoria
Melbourne
French Island
Montague Island
Raymond Island
Snake Island
Norman Island
Anser Island
Rodondo Island
Gabo Island
Hogan Island
Curtis Island
Erith Island
Deal Island
Craggy Island
122 km
© 2011 Whereis® Sensis Pty Ltd
© 2011 Europa Technologies
© 2011 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
lat -36.473525° lon 148.276967° elev 1056 m
©2010 Google
Eye alt 559.39 km

YSSY → YMML



Caringbah
Kurnell
Maroubra
© 2011 Europa Technologies
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
34°11'15.08" S 151°10'19.34" E elev -85 m
©2010 Google
Eye alt 12.30 km

9:13 am
Satellite
Excellent
Accuracy
21 ft
Stopped Time
2m 16s
Moving Time
22m 40s
Moving Avg
244.4 Mph
Avg Speed
222.2 Mph
Distance to End

Time Travelled
24m 56s
Current Speed
481.1 Mph
Elevation
30700 ft
Heading
125°
Bearing

11:19 am
United State
N
Time to Next

Accuracy
26 ft
Conroe
Houston
© 2012 Cnes/Spot Image
Image © 2012 TerraMetrics
© 2012 Google
© 2012 INEGI
lat 30.210870° lon -96.043489° elev 82 m
Eye alt 71.37 km
Google

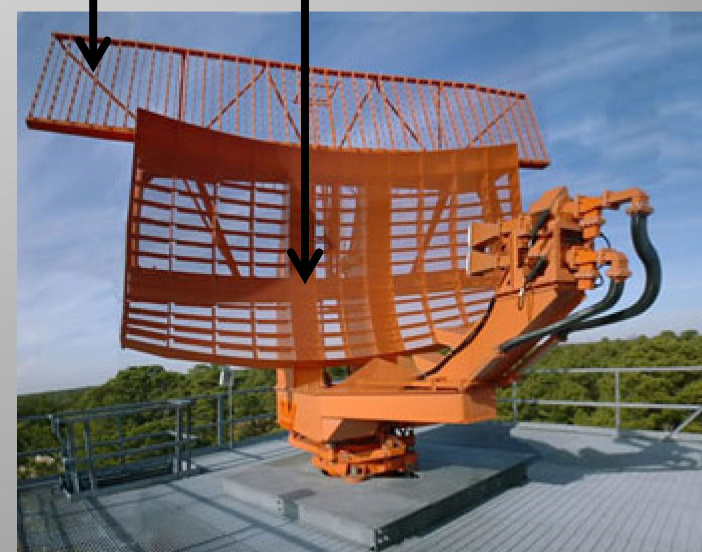
ATCRBS, PSP & SSR

- **A**ir **T**raffic **C**ontrol **R**adar **B**eacon **S**ystem
  - – **P**rimary **S**urveillance **R**adar
  - – **S**econdary **S**urveillance **R**adar

Primary:
- Traditional RADAR
- ‘Paints skins’ and listens for return
- Identifies and tracks primary targets, while ignoring ‘ground clutter’
- Range limited by RADAR equation ($\frac{1}{d^4}$)

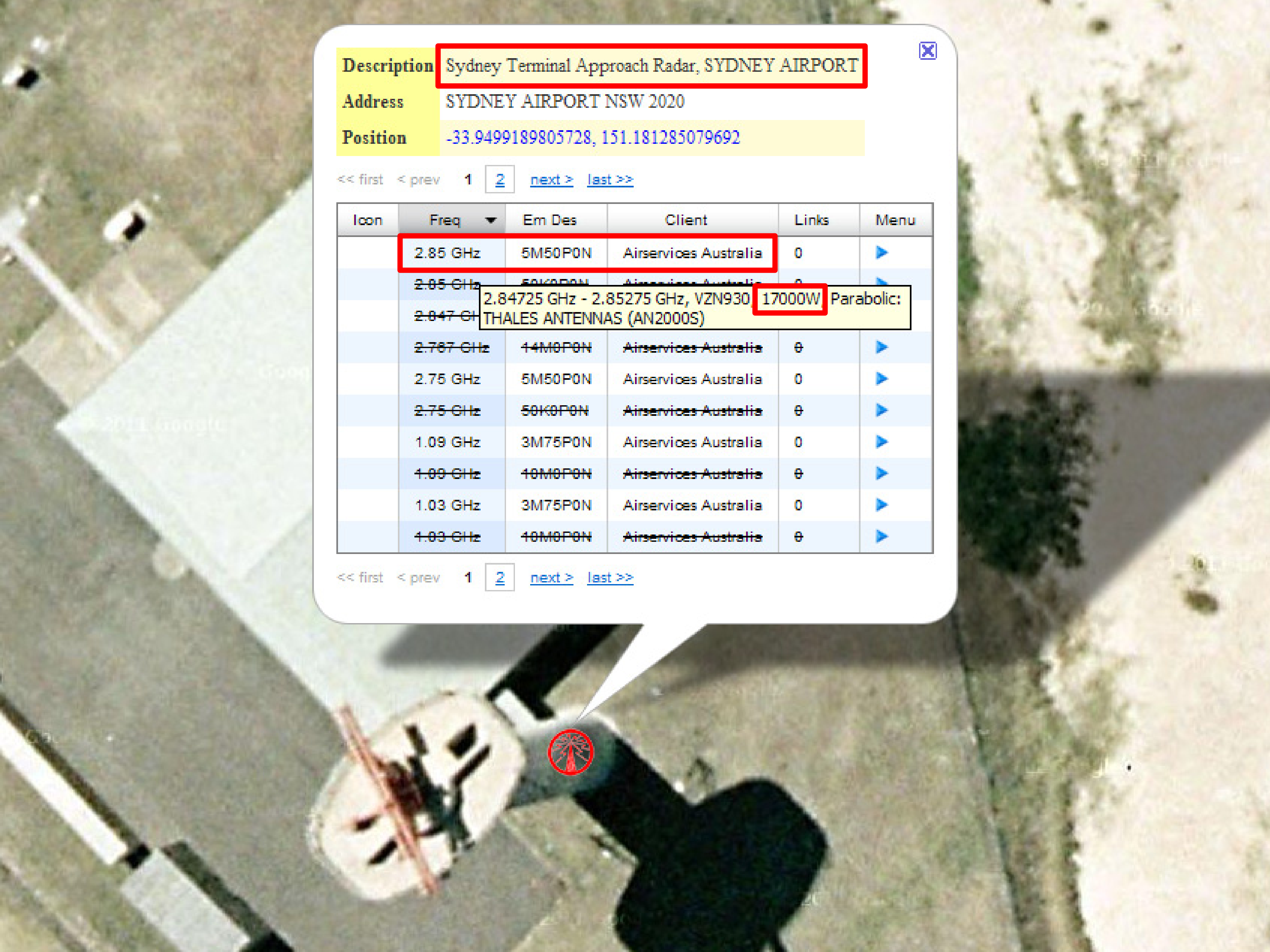
ATCRBS, PSP & SSR

- **A**ir **T**raffic **C**ontrol **R**adar **B**eacon **S**ystem
  - **P**rimary **S**urveillance **R**adar
  - **S**econdary **S**urveillance **R**adar

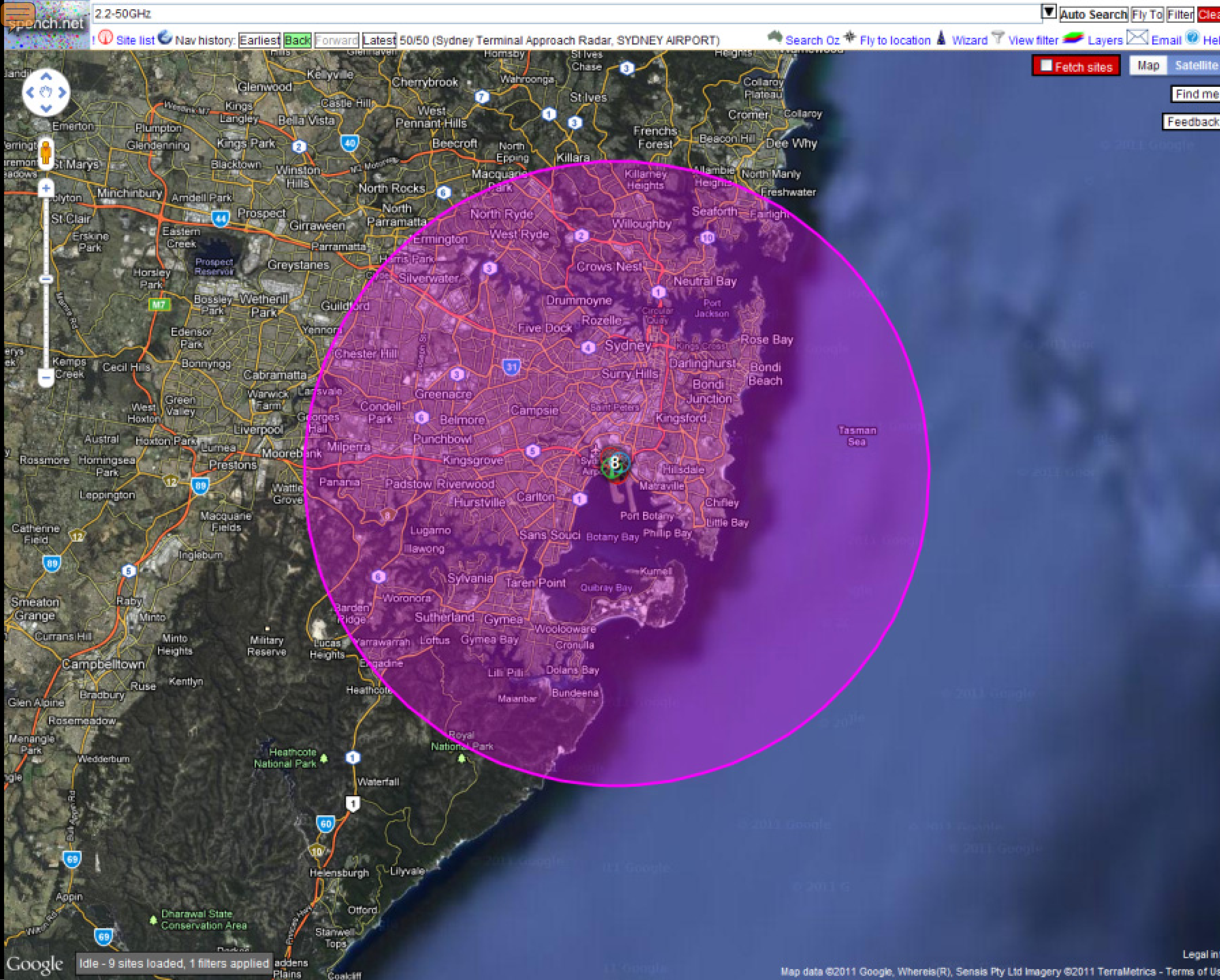


Secondary:

- Directional radio
- Requires transponder
- Interrogates transponders, which reply with squawk code, altitude, etc.
- Increased range ($\frac{1}{d^2}$)



Description
Sydney Terminal Approach Radar, SYDNEY AIRPORT
Address
SYDNEY AIRPORT NSW 2020
Position
-33.9499189805728, 151.181285079692
<< first < prev 1 2 next > last >>
Icon
Freq
Em Des
Client
Links
Menu
2.85 GHz 5M50P0N Airservices Australia 0
2.85 GHz
2.847 GH
2.84725 GHz - 2.85275 GHz, VZN930, 17000W Parabolic:
THALES ANTENNAS (AN2000S)
2.767 GHz 14M0P0N Airservices Australia 0
2.75 GHz 5M50P0N Airservices Australia 0
2.75 GHz 50K0P0N Airservices Australia 0
1.09 GHz 3M75P0N Airservices Australia 0
1.09 GHz 10M0P0N Airservices Australia 0
1.03 GHz 3M75P0N Airservices Australia 0
1.03 GHz 10M0P0N Airservices Australia 0
<< first < prev 1 2 next > last >>



spench.net
2.2-50GHz
Auto Search
Fly To
Filter
Clear
Site list
Nav history:
Earliest
Back
Forward
Latest
50/50 (Sydney Terminal Approach Radar, SYDNEY AIRPORT)
Search Oz
Fly to location
Wizard
View filter
Layers
Email
Help
Fetch sites
Map
Satellite
Find me
Feedback
Glenwood
Kellyville
Cherrybrook
Wahroonga
St Ives
Castle Hill
West Pennant Hills
Kings Langley
Bella Vista
Emerton
Plumpton
Glendenning
Kings Park
Beecroft
North Epping
Killara
Frenchs Forest
Cromer
Collaroy
Beacon Hill
Dee Why
St Marys
Blacktown
Winston Hills
North Rocks
Macquarie Park
Killarney Heights
Allambie Heights
North Manly
Freshwater
Minchinbury
Arndell Park
Prospect
St Clair
Eastern Creek
Girraween
North Parramatta
North Ryde
Seaforth
Willoughby
West Ryde
Ermington
Erskine Park
Parramatta
Prospect Reservoir
Greystanes
Harris Park
Crows Nest
Neutral Bay
Horsley Park
Silverwater
Drummoyne
Port Jackson
Bossley Park
Wetherill Park
Guildford
Rozelle
Five Dock
Edensor Park
Sydney
Rose Bay
Chester Hill
Bonnyrigg
Cecil Hills
Kemps Creek
Cabramatta
Surry Hills
Darlinghurst
Bondi
Bondi Beach
Bondi Junction
Greenacre
Green Valley
Warwick Farm
Condell Park
Campsie
West Hoxton
Liverpool
Georges Hall
Belmore
Kingsford
Austral
Hoxton Park
Punchbowl
Milperra
Moorebank
Rossmore
Horningsea Park
Prestons
Kingsgrove
Tasman Sea
Hillsdale
Panania
Padstow
Riverwood
Matraville
Leppington
Wattle Grove
Hurstville
Carlton
Chifley
Macquarie Fields
Port Botany
Little Bay
Catherine Field
Lugarno
Sans Souci
Botany Bay
Phillip Bay
Ingleburn
Illawong
Kurnell
Sylvania
Taren Point
Quibray Bay
Smeaton Grange
Raby
Woronora
Barden Ridge
Minto
Sutherland
Gymea
Woolooware
Currans Hill
Minto Heights
Military Reserve
Lucas Heights
Yarrawarrah
Loftus
Gymea Bay
Cronulla
Campbelltown
Engadine
Lilli Pilli
Dolans Bay
Kentlyn
Ruse
Heathcote
Bundeena
Maianbar
Glen Alpine
Bradbury
Rosemeadow
Royal National Park
Menangle Park
Wedderburn
Heathcote National Park
Waterfall
Helensburgh
Lilyvale
Appin
Otford
Dharawal State Conservation Area
Stanwell Tops
Google
Idle - 9 sites loaded, 1 filters applied
Legal info
Map data ©2011 Google, Whereis(R), Sensis Pty Ltd Imagery ©2011 TerraMetrics - Terms of Use

The Modes

- **A**: reply with squawk code
- **C**: reply with altitude

SSR

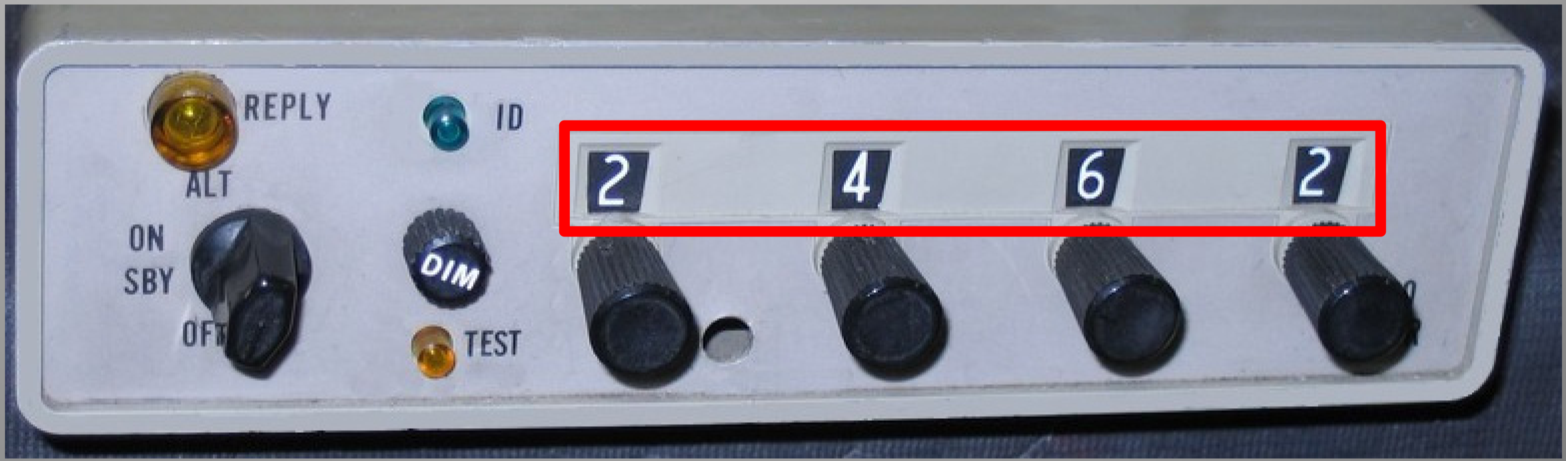
- **S**: enables **A**utomatic **D**ependant **S**urveillance-**B**roadcast (ADS-B), and the **A**ircraft/**T**raffic **C**ollision **A**voidance **S**ystem (ACAS/TCAS)

- Mode S not part of ATCRBS, but uses same radio hardware (same frequencies)
  – Increasing problem of channel congestion

The Modes

- **A**: reply with squawk code
- **C**: reply with altitude
- **S**: enables **A**utomatic **D**ependant **S**urveillance-**B**roadcast (ADS-B), and the **A**ircraft/**T**raffic **C**ollision **A**voidance **S**ystem (ACAS/TCAS)

SSR



Position

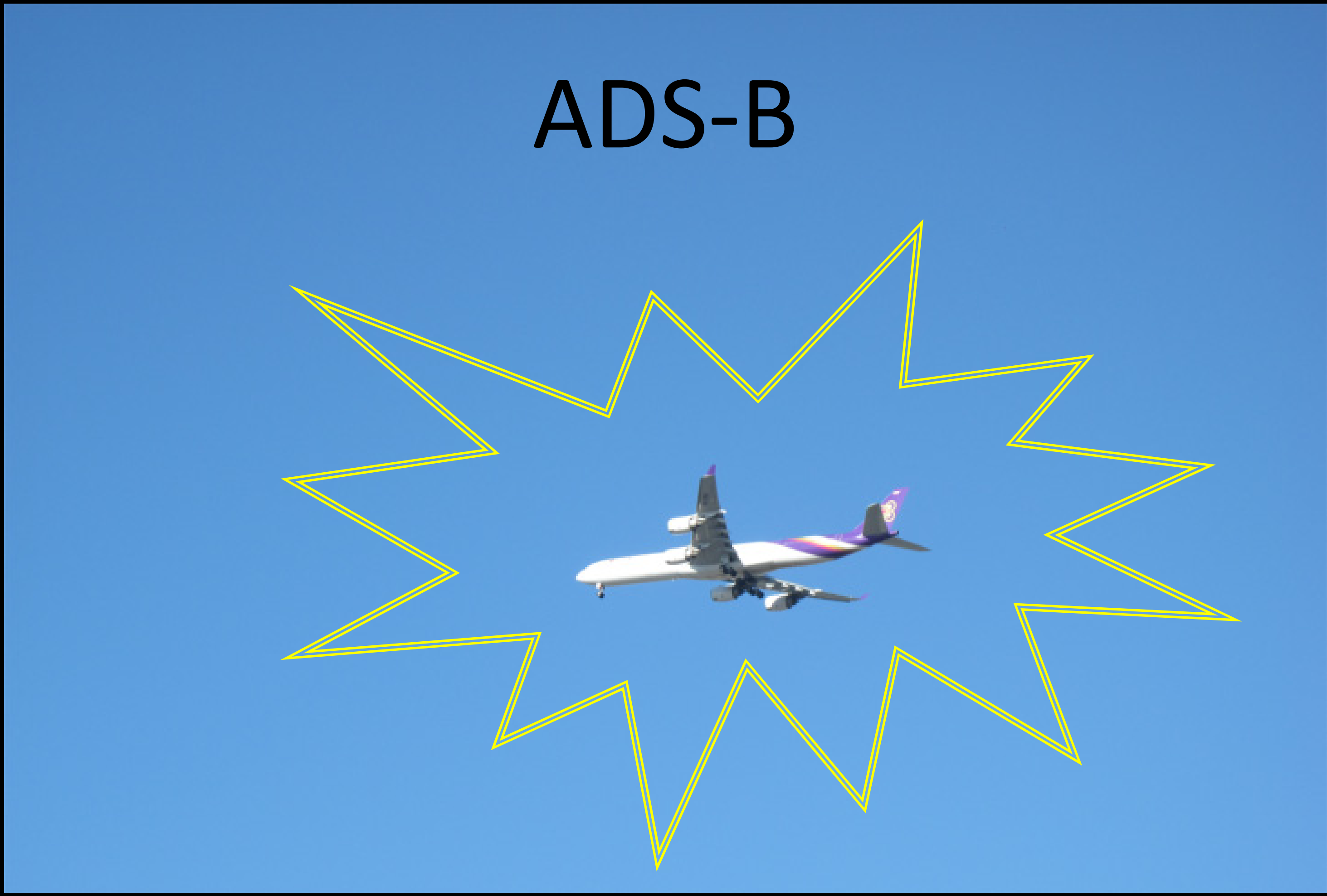
Heading

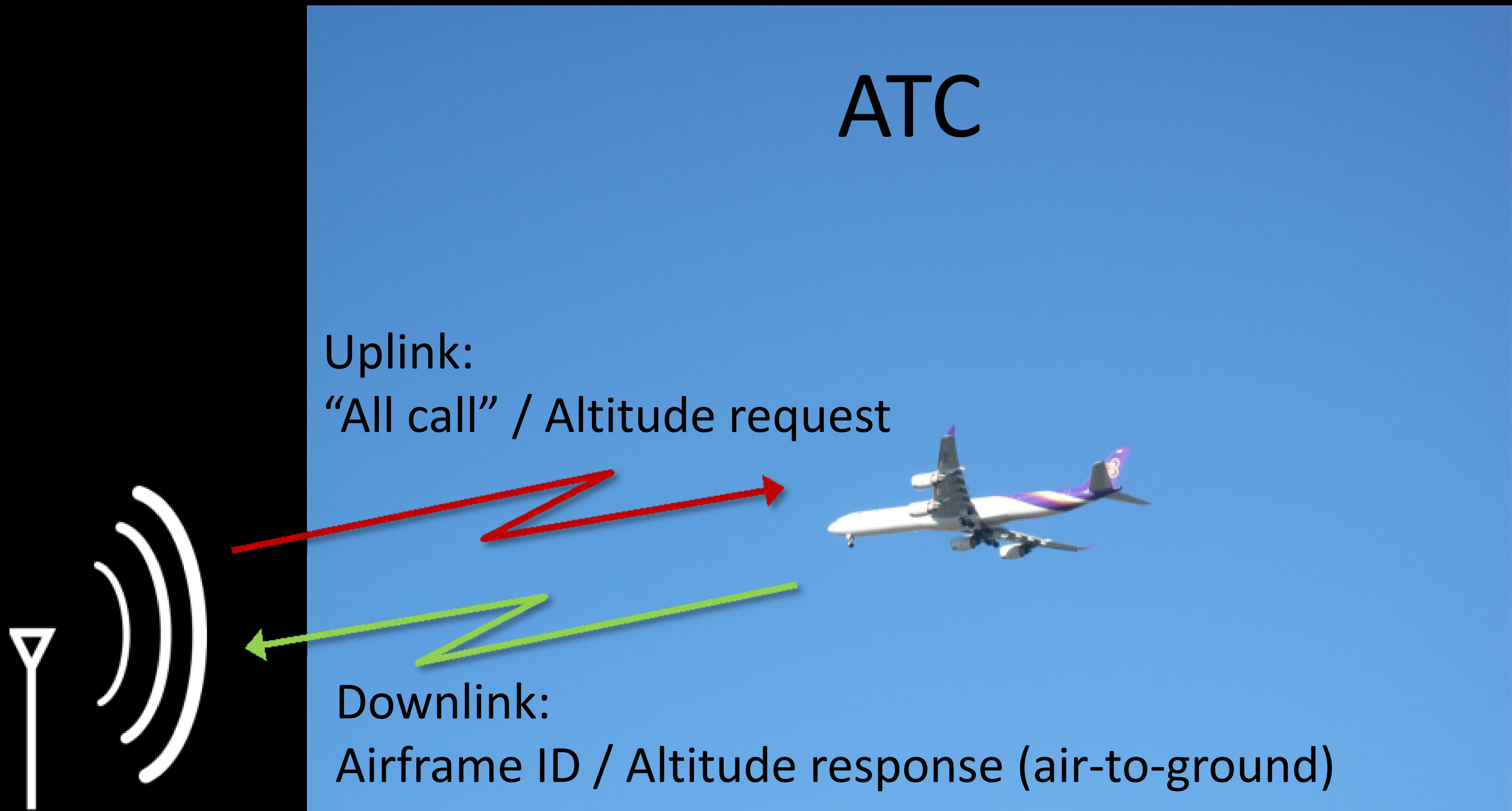
Altitude

Vertical rate

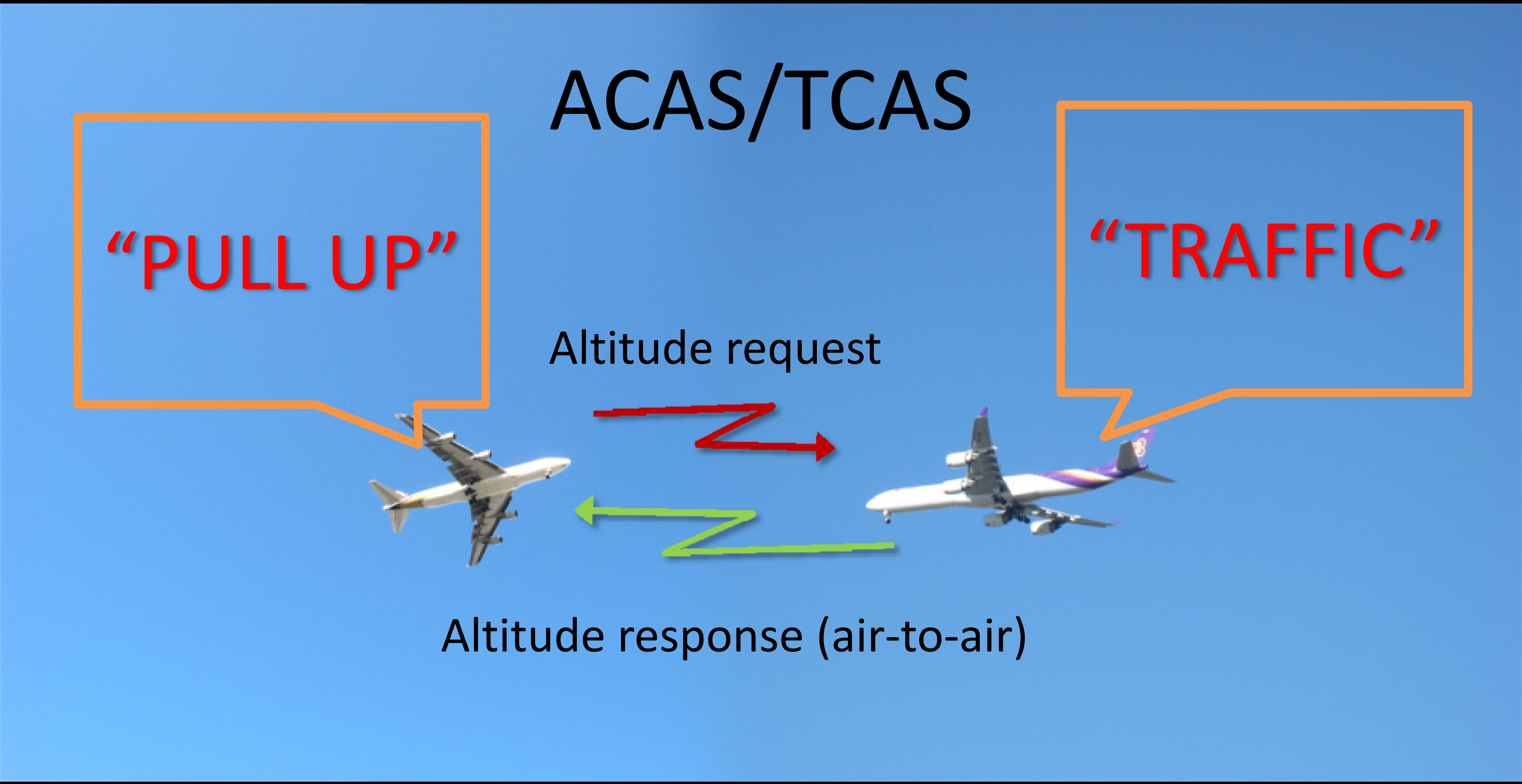
Flight ID

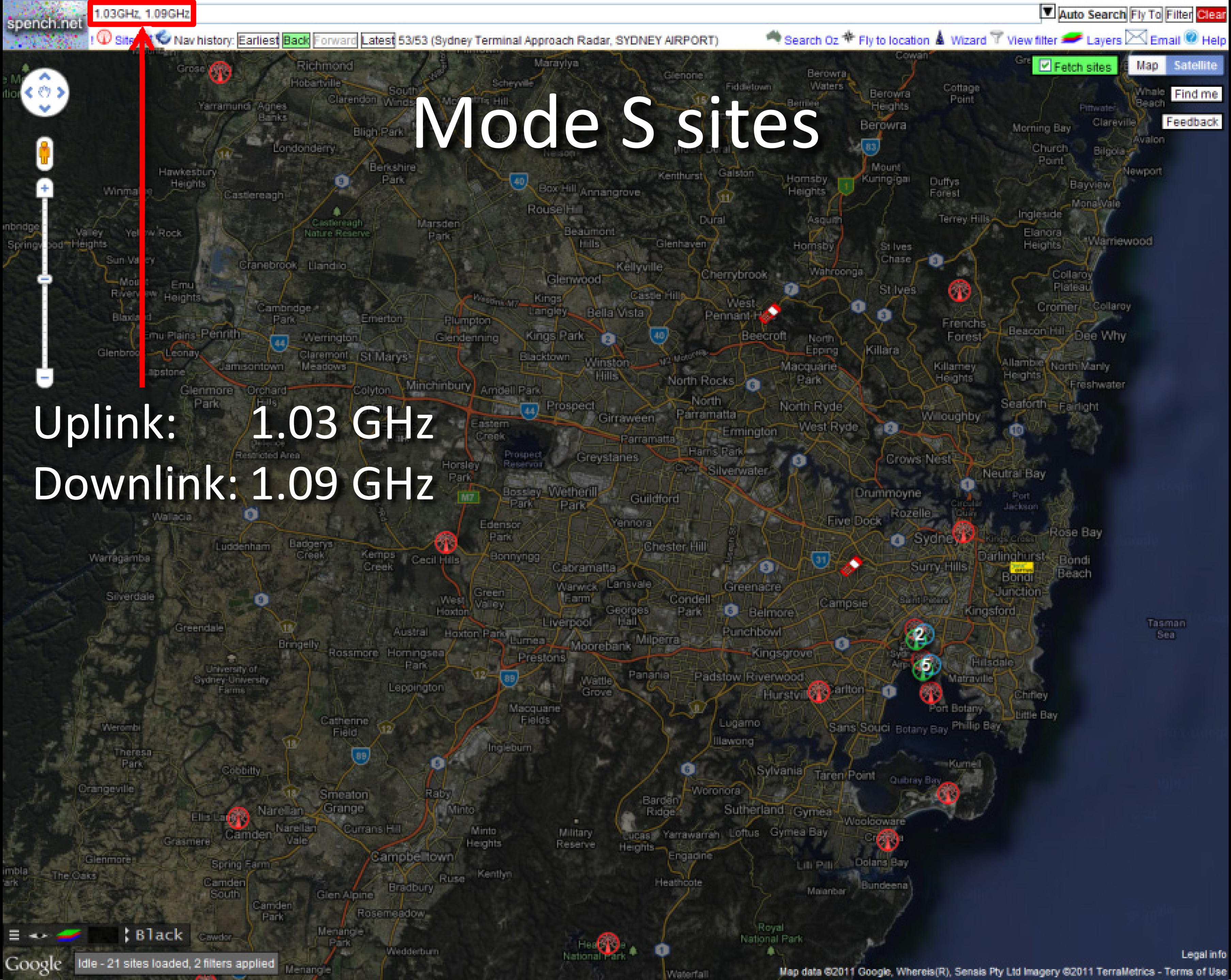
Squawk code



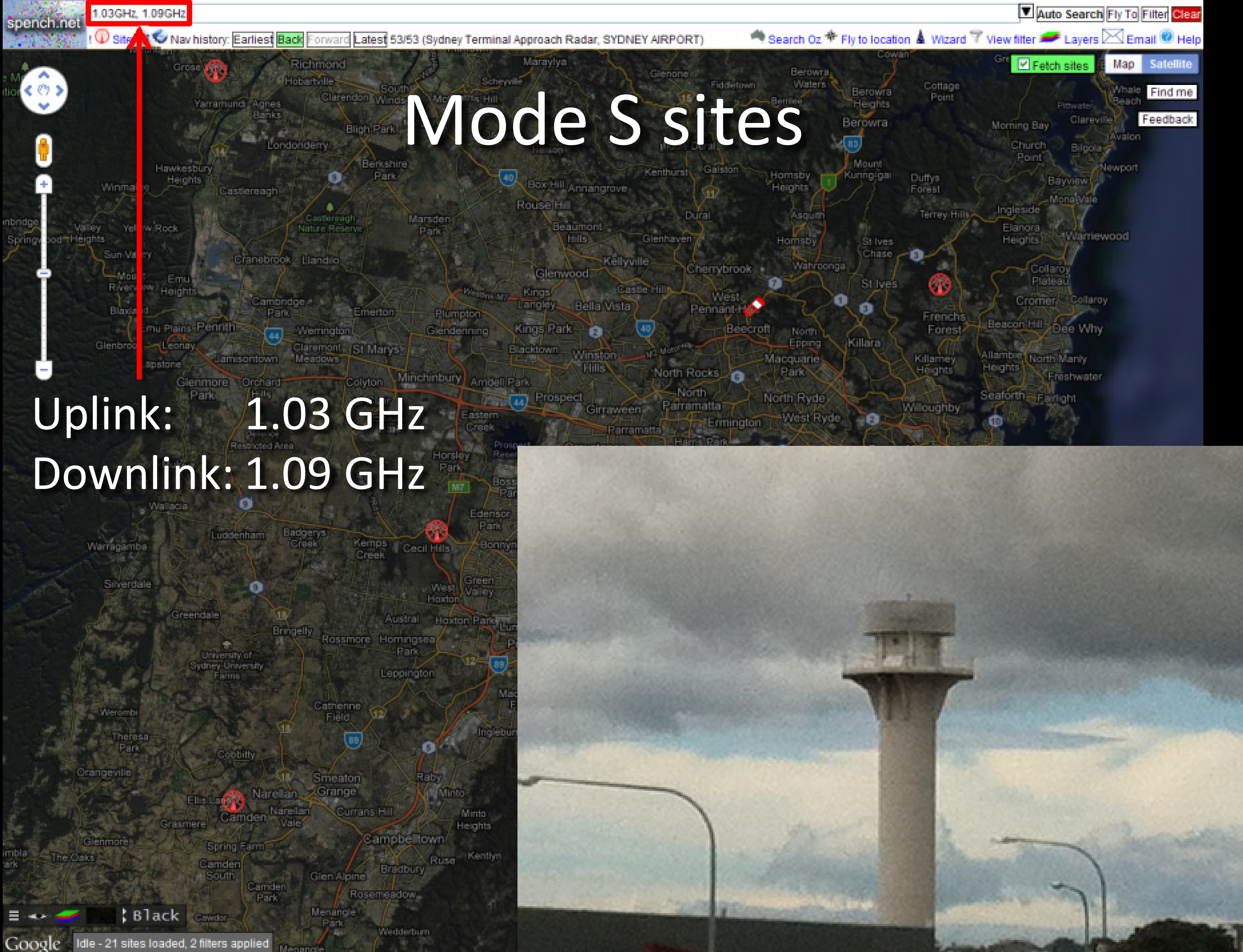


Mode S TX/RX: Linked to ATC (can be at airport, or remote)


ACAS/TCAS
“PULL UP”
“TRAFFIC”
Altitude request
Altitude response (air-to-air)


Mode S sites
Uplink: 1.03 GHz
Downlink: 1.09 GHz
spench.net
1.03GHz, 1.09GHz
Auto Search
Fly To
Filter
Clear
Nav history:
Earliest
Back
Forward
Latest
53/53 (Sydney Terminal Approach Radar, SYDNEY AIRPORT)
Search Oz
Fly to location
Wizard
View filter
Layers
Email
Help
Fetch sites
Map
Satellite
Find me
Feedback
Black
Idle - 21 sites loaded, 2 filters applied
Legal info
Map data ©2011 Google, Whereis(R), Sensis Pty Ltd Imagery ©2011 TerraMetrics - Terms of Use

Mode S sites

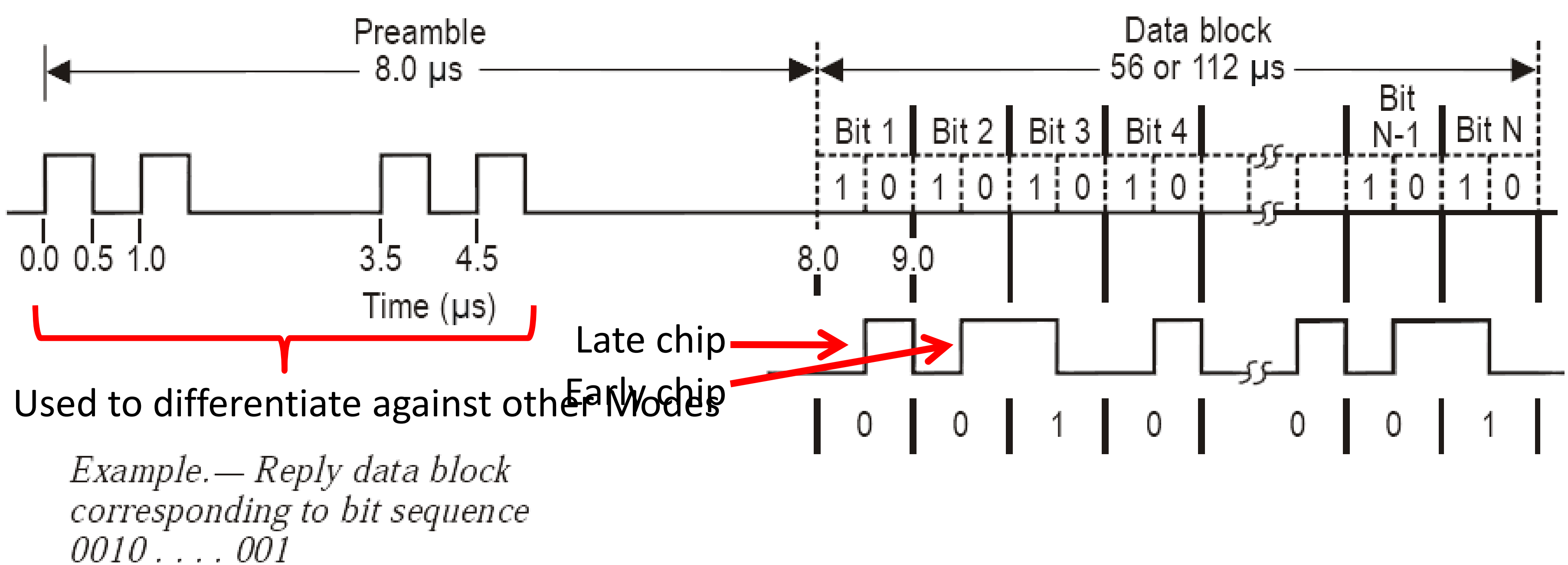


Uplink: 1.03 GHz

Downlink: 1.09 GHz

Response Encoding

- Data block is created & bits control position of pulses sent by transmitter



Pulse Position Modulation (AM)

Pulse Position Modulation

- Pulse lasts 0.0000005 seconds (0.5 μs)
- Need to sample signal at a minimum of 2 MHz (assuming you start sampling at precisely the right moment and stay synchronised)
- Requires high-bandwidth hardware and increased processing power
- Ideally, oversample to increase accuracy

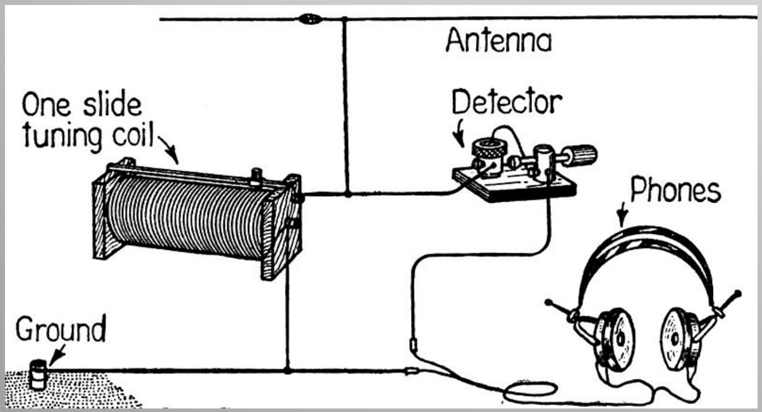
Enter **S**oftware **D**efined **R**adio…

SDR: Digitise the baseband

- Hardware is sophisticated, but purpose is simple: capture a chunk of the RF spectrum and stream it to your computer
- Computer is responsible for doing something useful with baseband data
- Instead of designing RF hardware, write it in software!
- Increased complexity/bandwidth requires more CPU power (pretty cheap)

Software **D**efined **R**adio

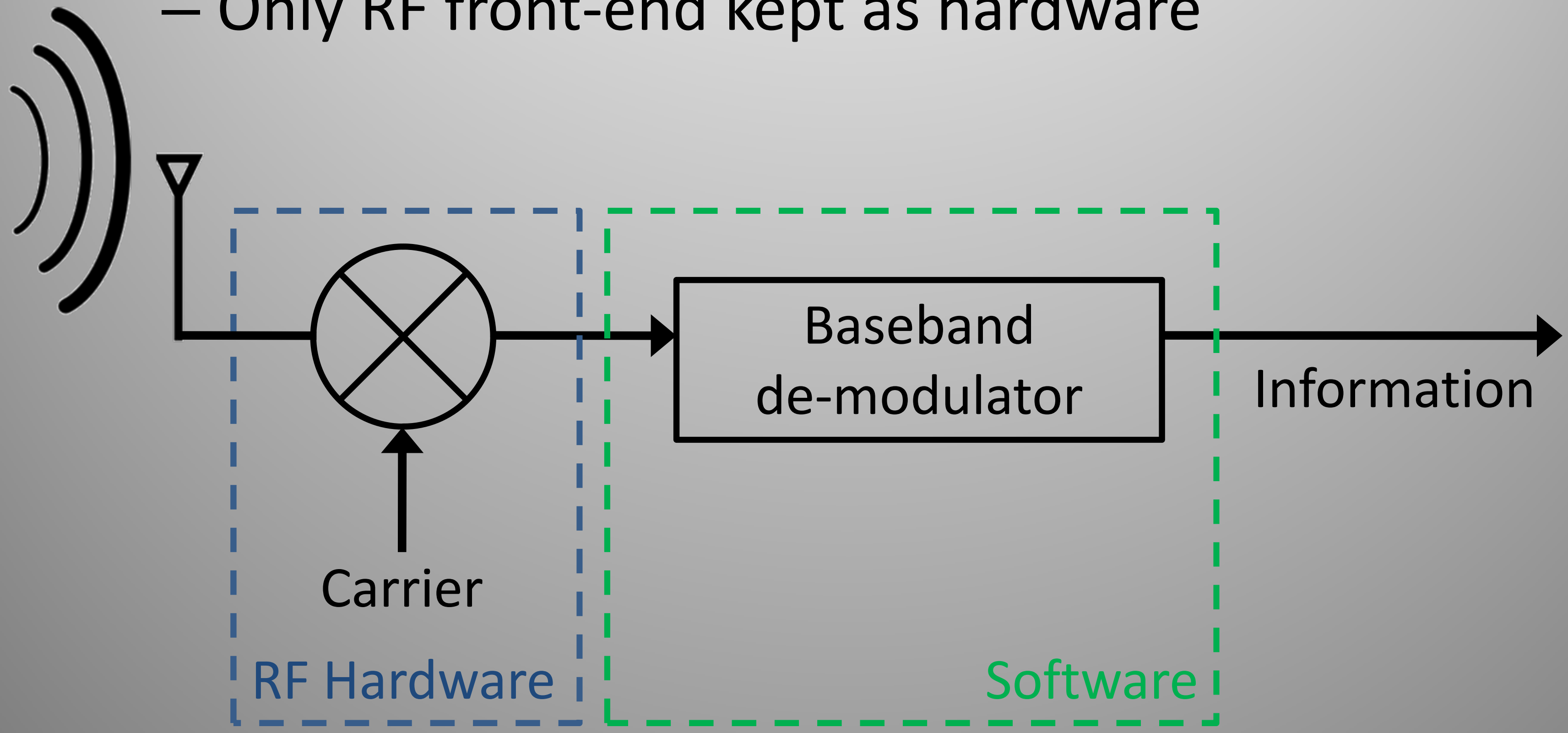
- Hardware → software representation
  - Completely re-configurable
  - Only RF front-end kept as hardware



$$\rightarrow \sqrt{I^2 + Q^2}$$

Software Defined Radio

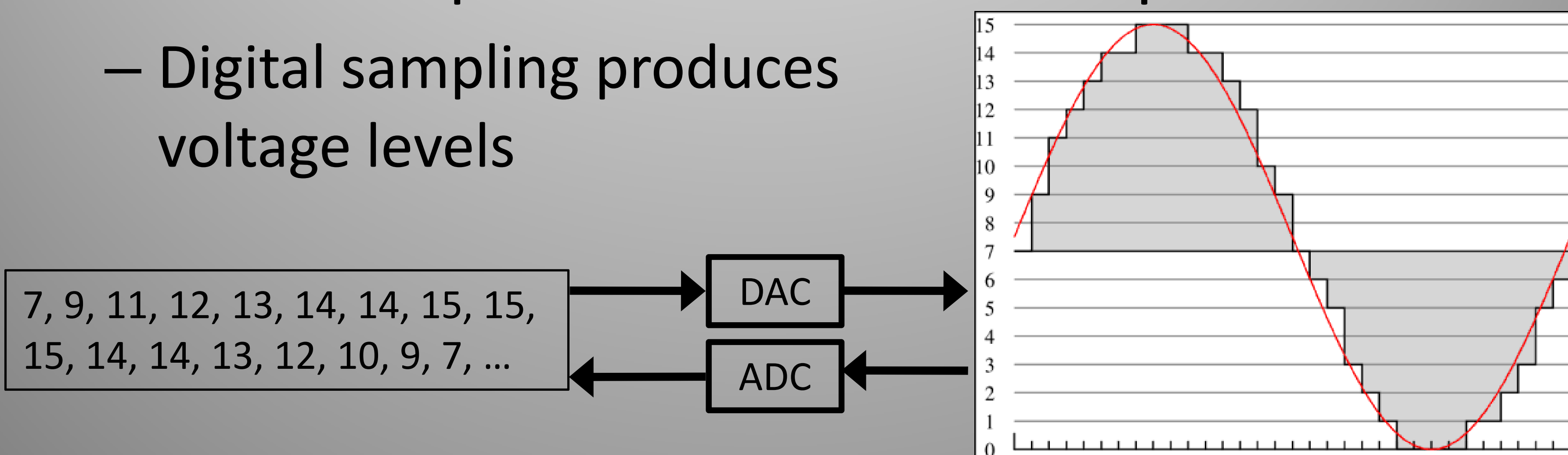
- Hardware → software representation
  - Completely re-configurable
  - Only RF front-end kept as hardware



Software Defined Radio

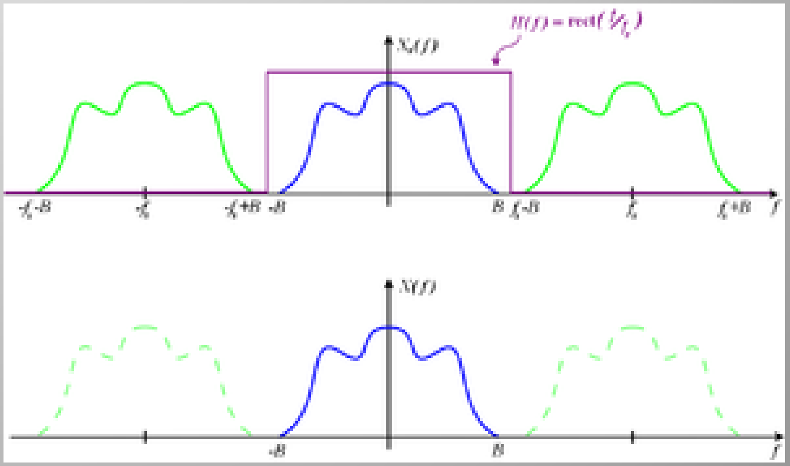
- Hardware → software representation
  - Completely re-configurable
  - Only RF front-end kept as hardware

- Continuous process → discrete & quantised
  - Digital sampling produces voltage levels



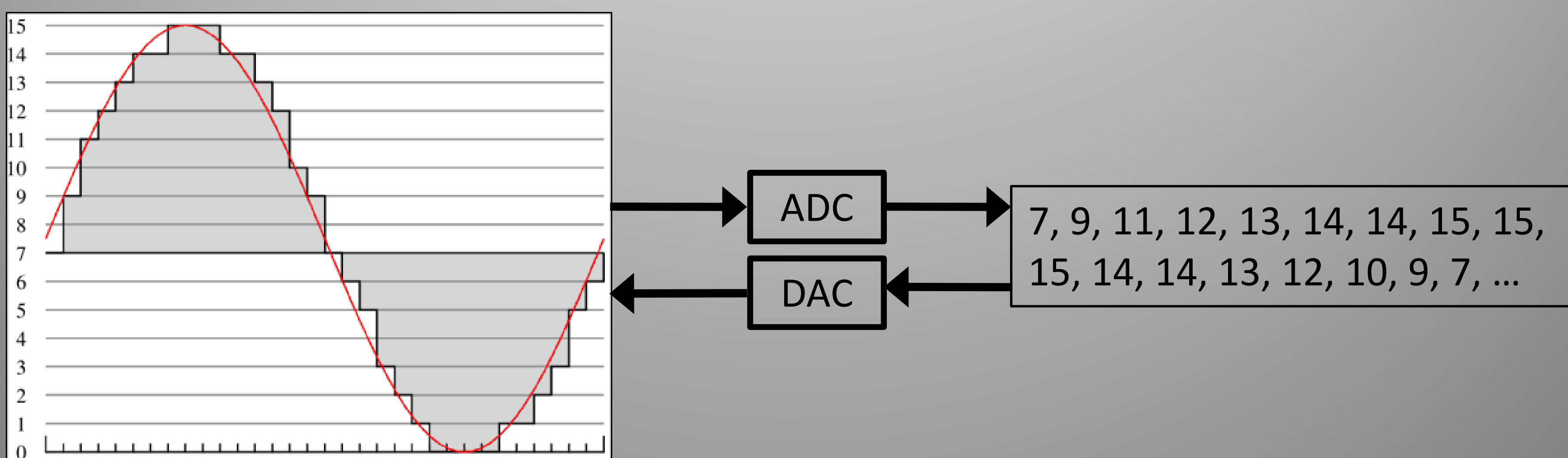
Sampling

- Nyquist-Shannon Sampling Theorem:
  - “Sample at twice the highest required frequency”
  - Avoid aliasing of signal



Sampling

- Nyquist-Shannon Sampling Theorem:
  - "Sample at twice the highest required frequency"
  - Avoid aliasing of signal
- **A**nalog-to-**D**igital **C**onverter (RX)
- **D**igital-to-**A**nalog **C**onverter (TX)



Sampling

- Nyquist-Shannon Sampling Theorem:
  - “Sample at twice the highest required frequency”
  - Avoid aliasing of signal
- **A**nalog-to-**D**igital **C**onverter (RX)
- **D**igital-to-**A**nalog **C**onverter (TX)
- ADC/DAC rate determines bandwidth*

Reception

- RF front-end down-converts signal to baseband
  - Zero IF receiver
- Sample & quantise baseband signal
- Simple approach would be to sample voltage level (amplitude)
  - Sound card

Real vs. Analytic Signals

- Real signal:
  - Amplitude for each sample
  - One ‘real’ number
- Analytic signal:
  - Amplitude and phase
  - ‘Real’ and ‘imaginary’ components (negative frequency)
  - Encode more information

Quadrature Modulation

- Analytic signals can be sampled by having two ADCs
- Baseband must first be separated into quadrature components (real and imaginary parts)
- Mix baseband with:
  - In-phase local oscillator (I channel)
  - Quadrature-phase LO (Q channel)

Sample Rate

- Analytic signal has two components
  - I & Q samples per sample time
- Negative frequency
  - Double the bandwidth
- Re-apply Shannon's sampling theorem:
  - Sampling rate directly determines bandwidth
- Produce a stream of complex stream (I/Q samples pairs) at sample rate

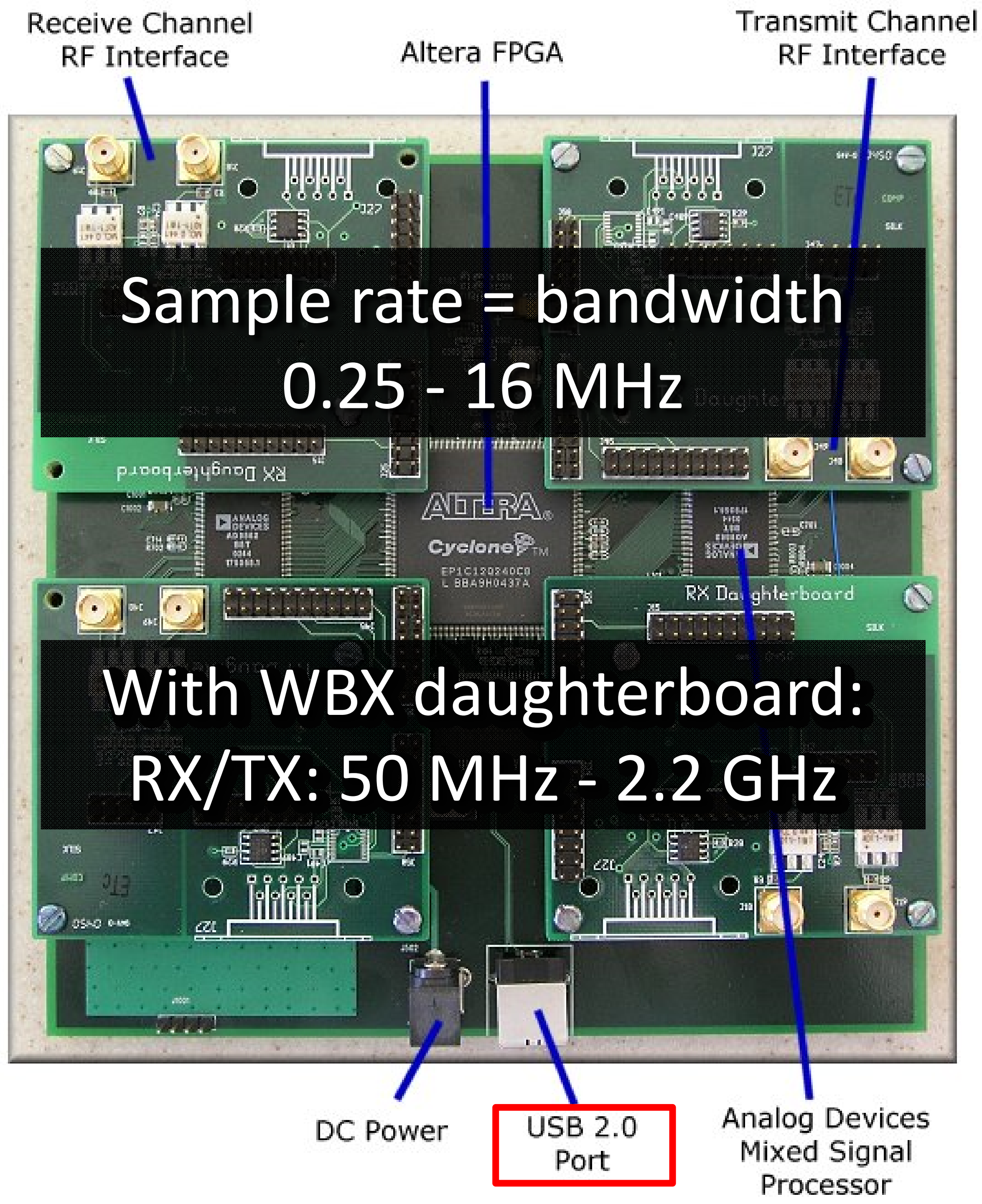
SDR (De-)modulation

- Complex stream passed through mathematical functions and state machines

The

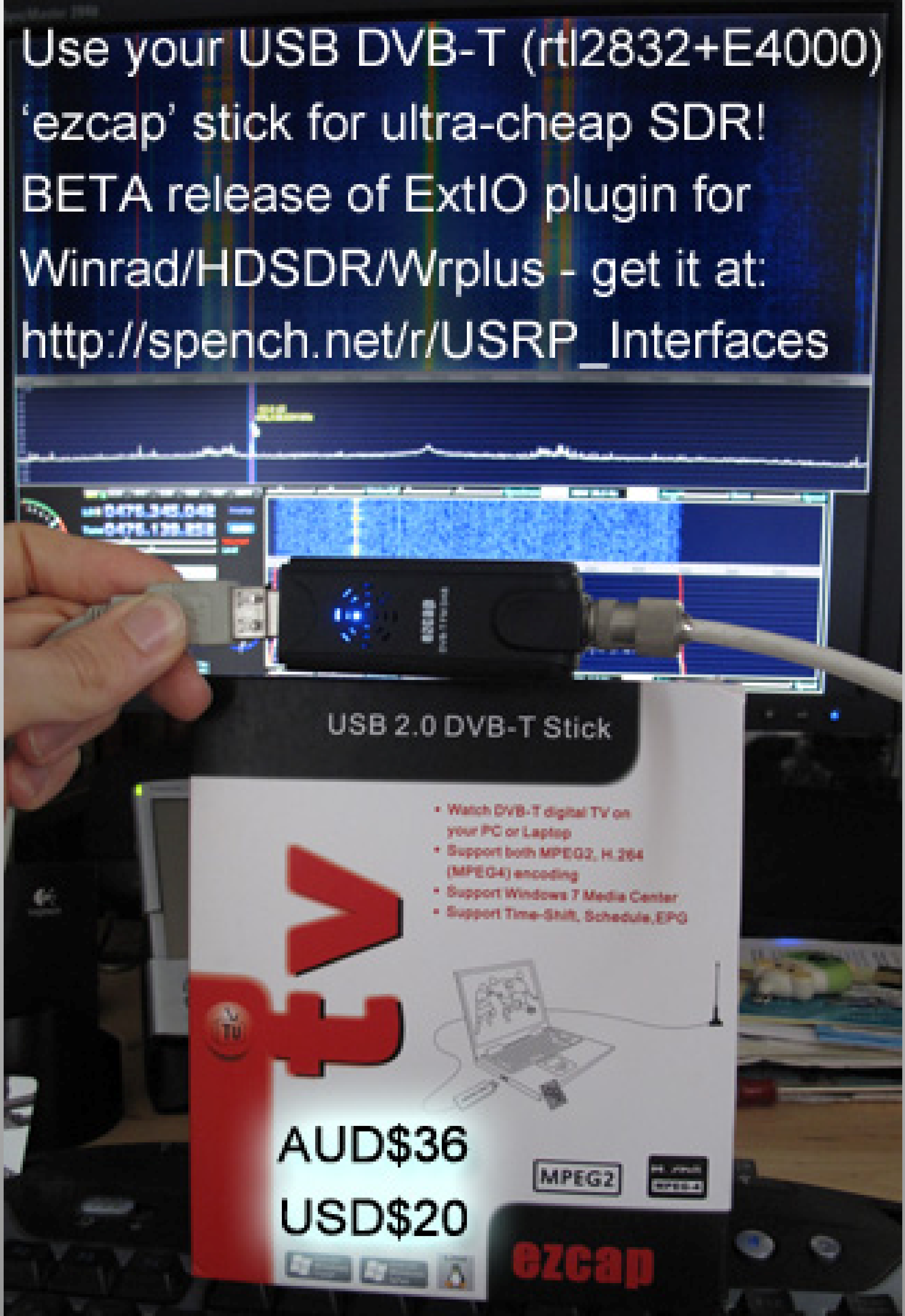
Universal
Software
Radio
Peripheral

(USRP 1)




CLOCK
CLOCK
ALTERA
Cyclone

The FUNcube Dongle



Use your USB DVB-T (rtl2832+E4000)
'ezcap' stick for ultra-cheap SDR!
BETA release of ExtIO plugin for
Winrad/HDSDR/Wrplus - get it at:
http://spench.net/r/USRP_Interfaces
USB 2.0 DVB-T Stick
AUD$36
USD$20
MPEG2
ezcap

Host Software

- Receive/transmit baseband samples
  - Analyse & display
  - (De-)modulate
  - Encode/decode (extract information)

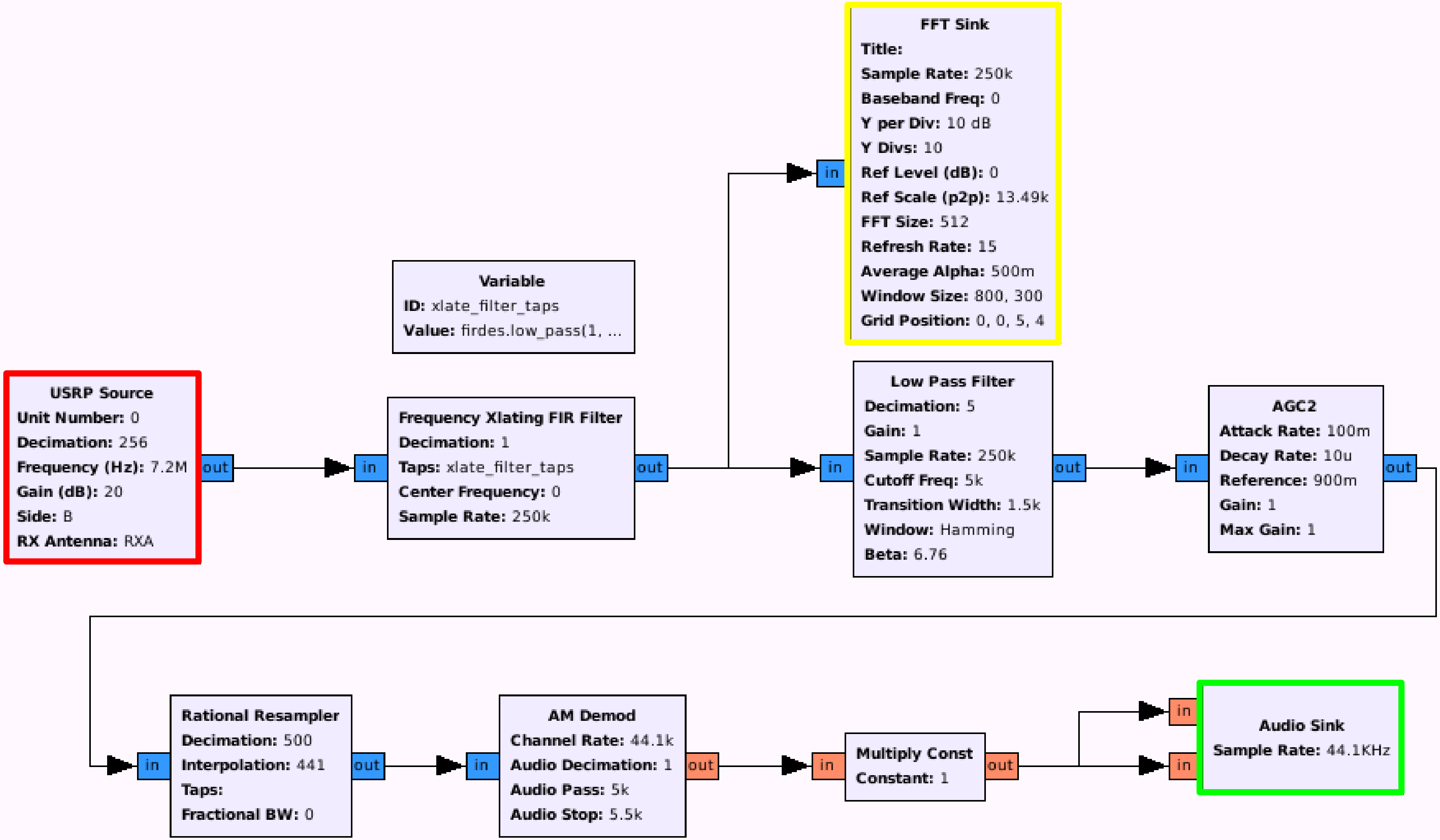
- Well-known platforms/programs:
  - LabVIEW
  - MATLAB Simulink

  Open source? **No.**

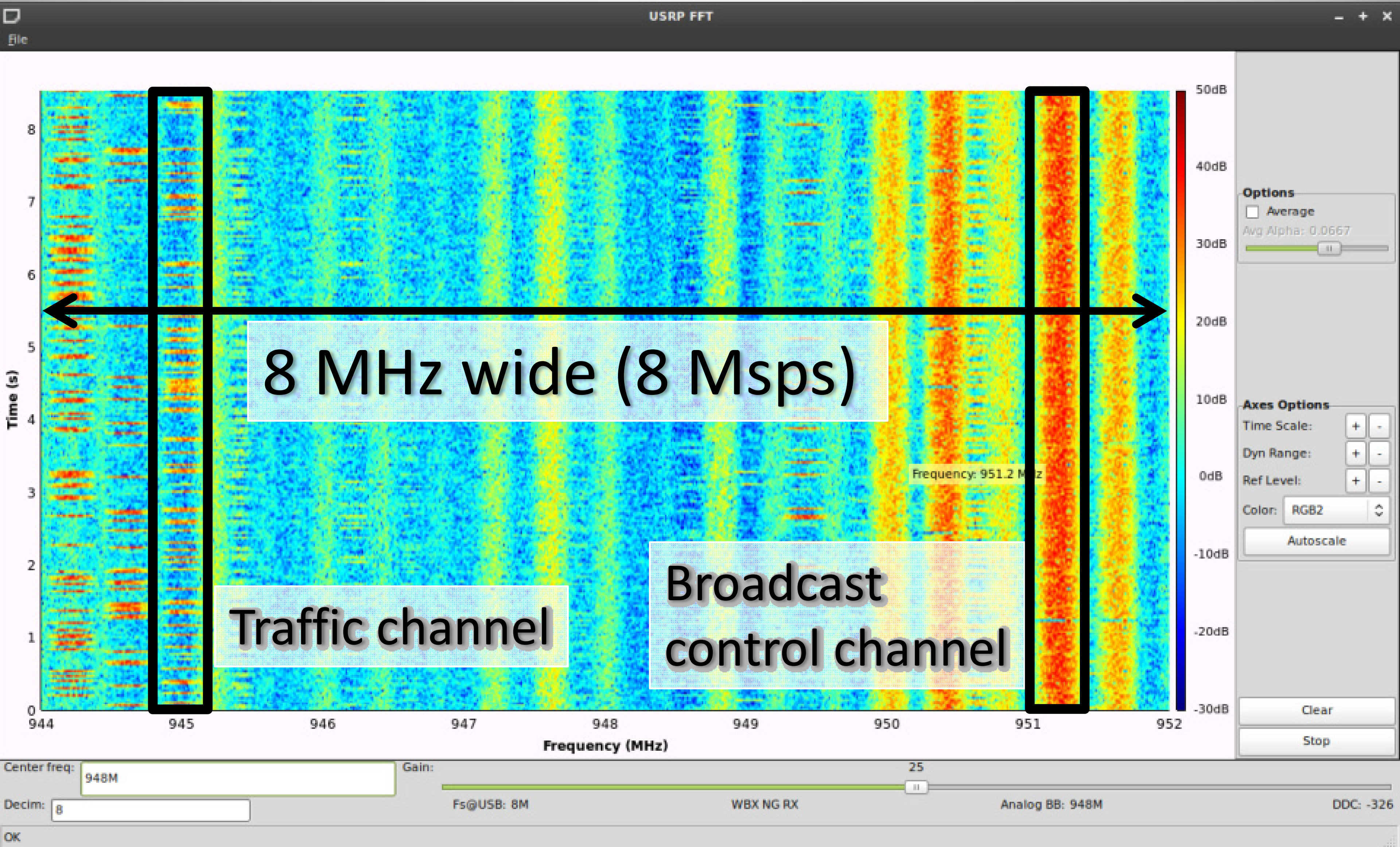
GNU Radio

- Open source signal processing toolkit
- Data flow paradigm
  - Signals flow from sources to sinks
- Intermediary blocks operate on signals
  - Sources & sinks: USRP, sound card, file, network
  - Visualisation: FFT, waterfall, scope
  - Signal types: complex, float, integers
  - Filters: traditional building blocks used in analog and digital RF hardware
- Completely extensible (Python: high level, C++: grunt)

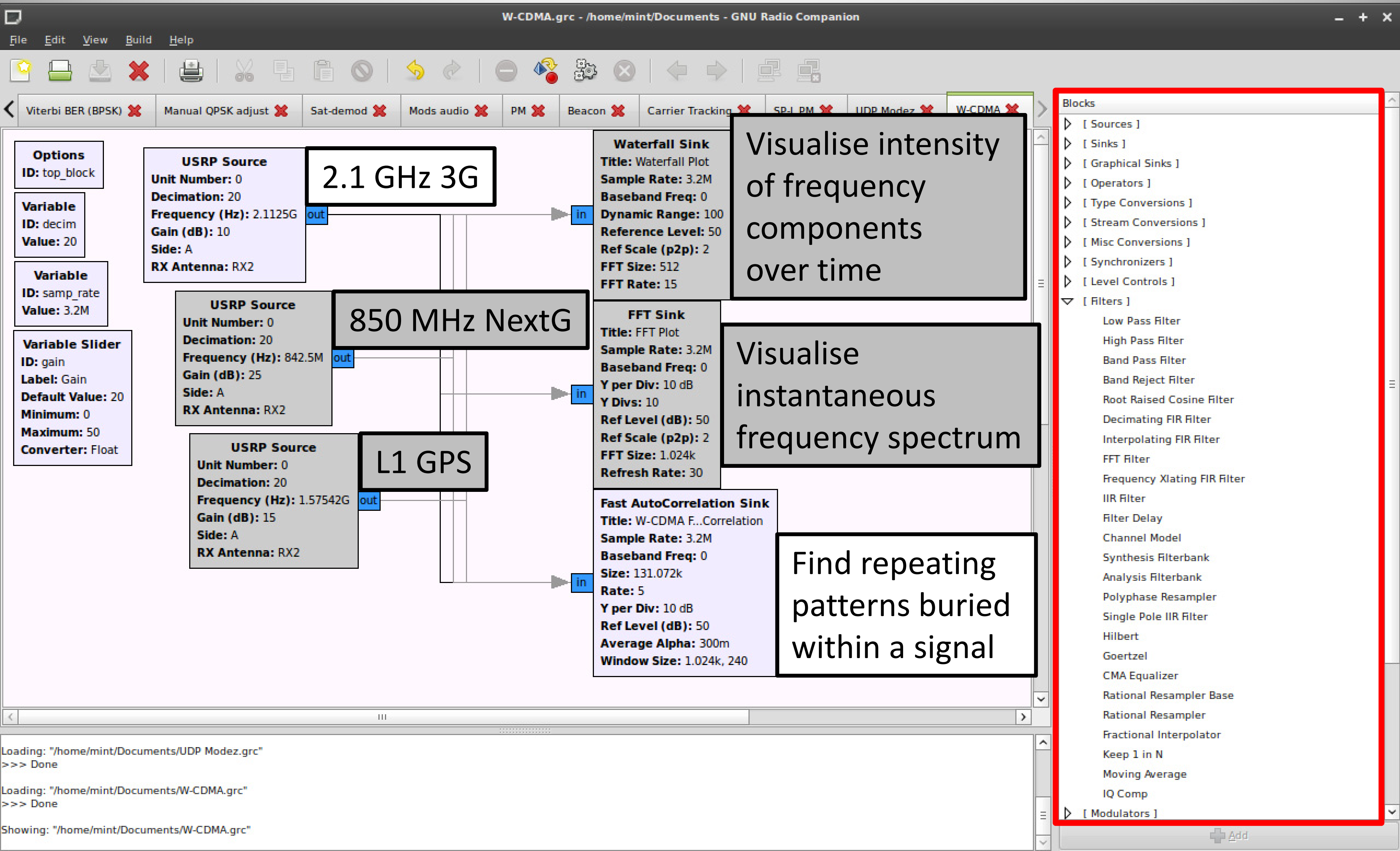
GNU Radio Companion



2G GSM Waterfall

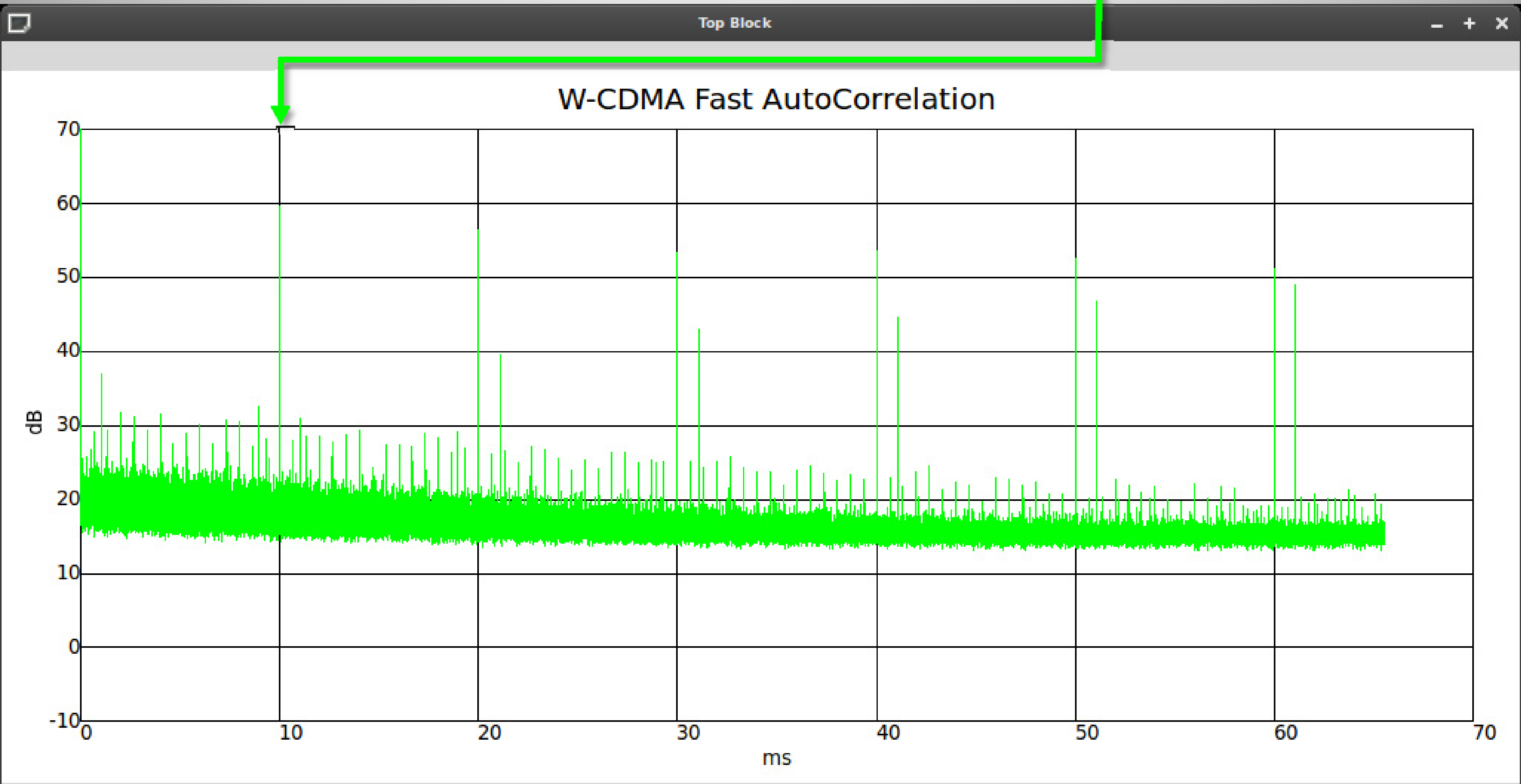


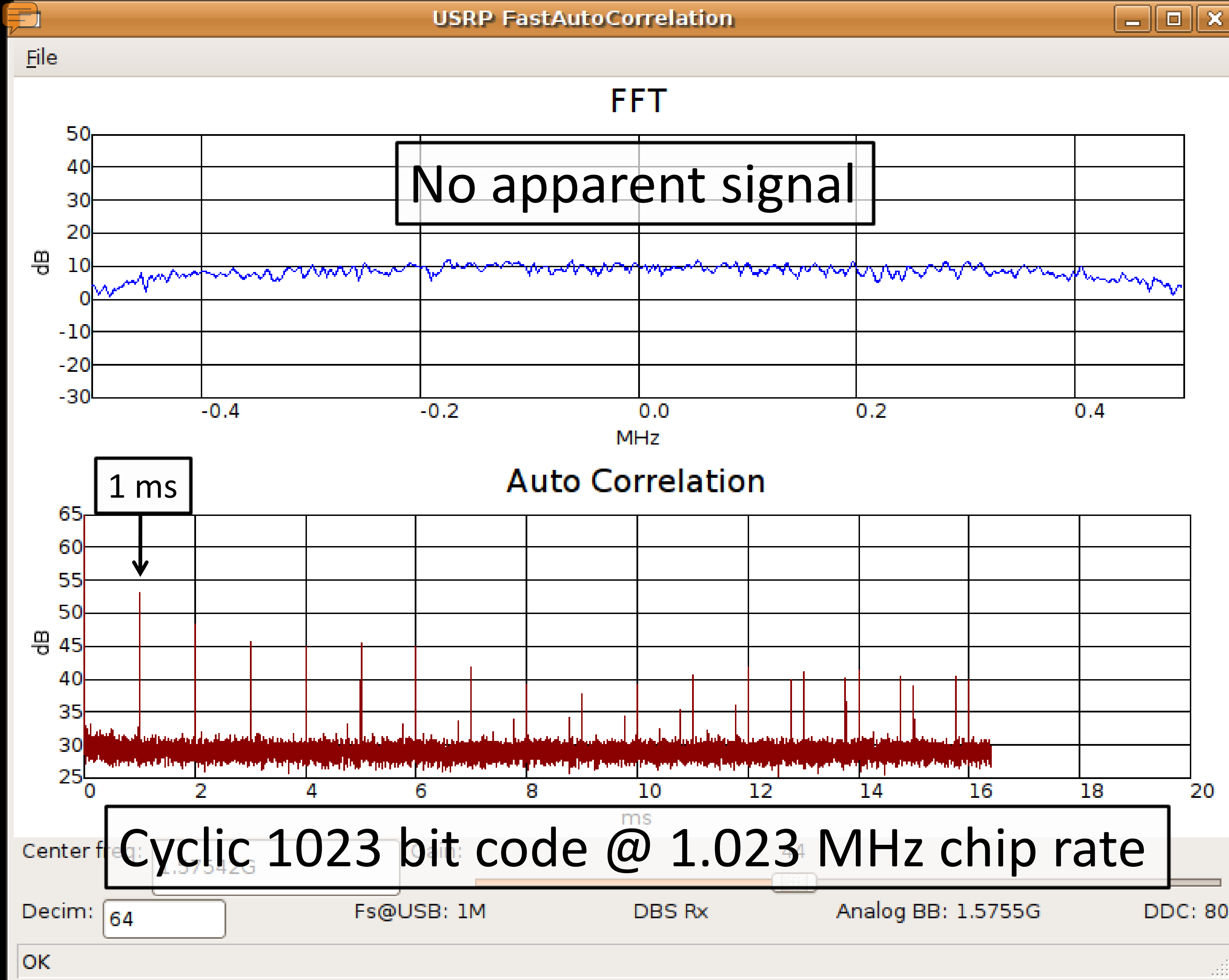
CDMA Detection with GRC



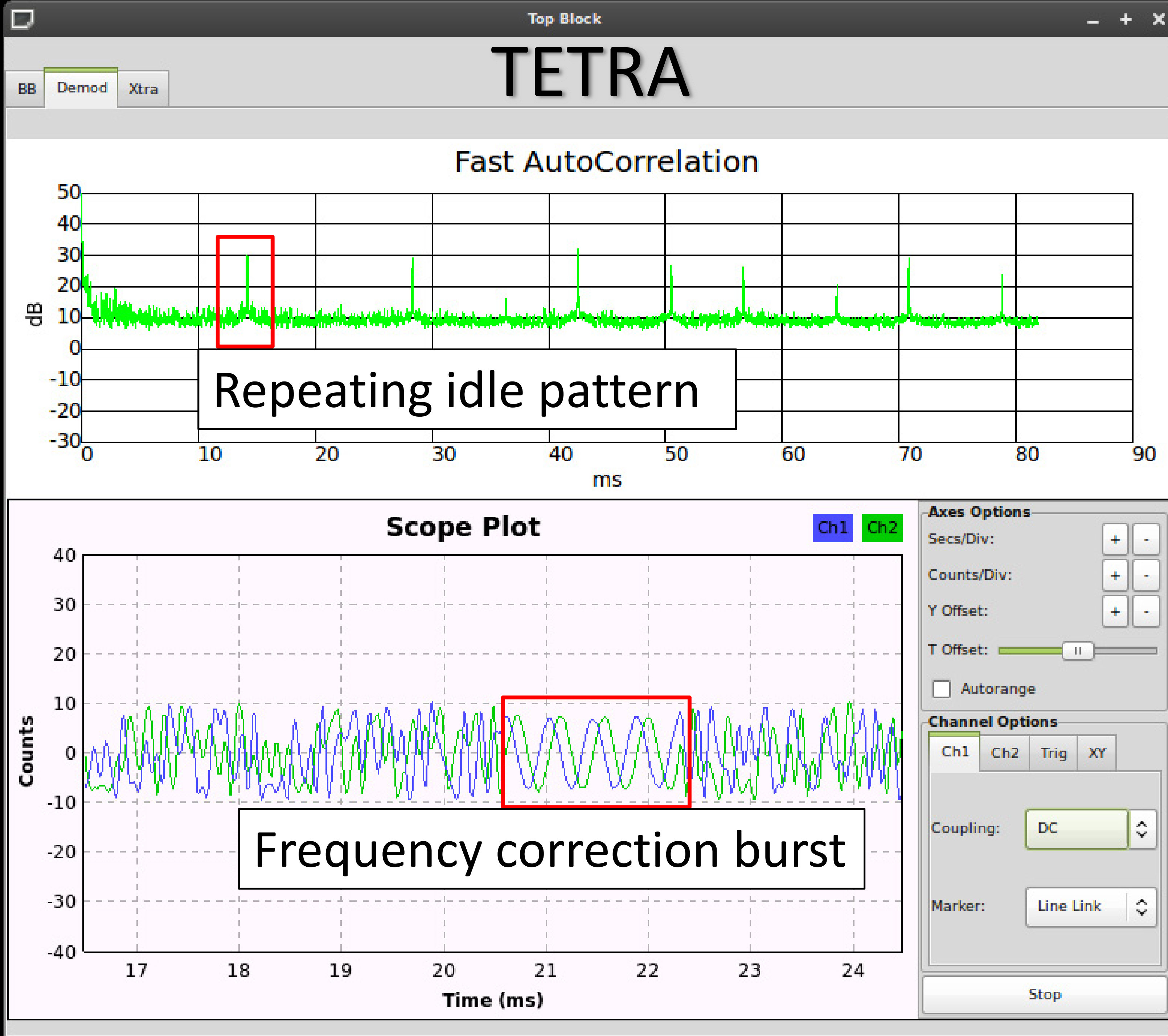
3G W-CDMA

Signature of UMTS: repeating data in CPICH at 10 ms intervals

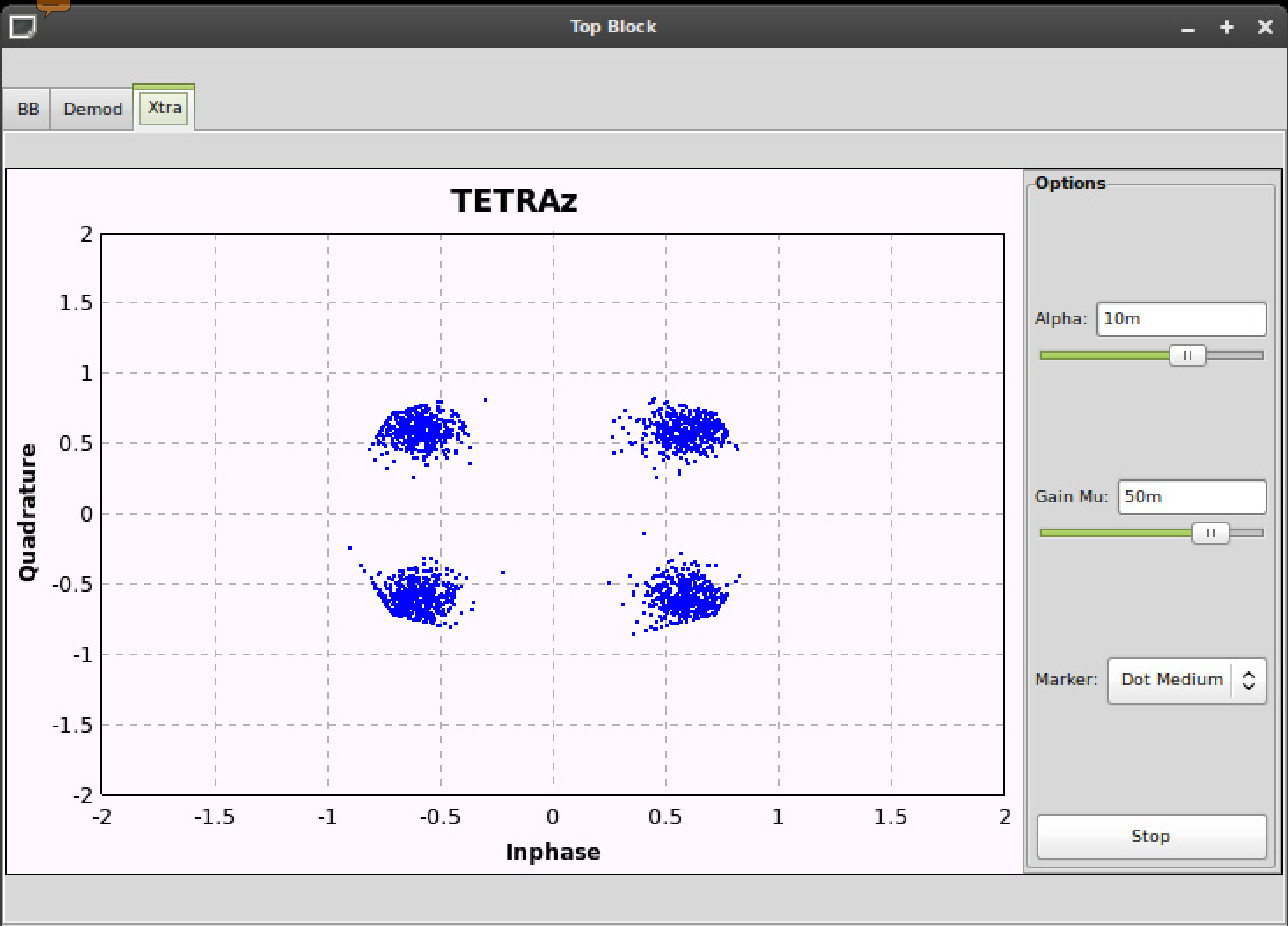



USRP FastAutoCorrelation
File
FFT
No apparent signal
50
40
30
20
10
0
-10
-20
-30
dB
-0.4
-0.2
0.0
0.2
0.4
MHz
1 ms
Auto Correlation
65
60
55
50
45
40
35
30
25
dB
0
2
4
6
8
10
12
14
16
18
20
ms
Cyclic 1023 bit code @ 1.023 MHz chip rate
Center freq:
Decim:
64
Fs@USB: 1M
DBS Rx
Analog BB: 1.5755G
DDC:
OK

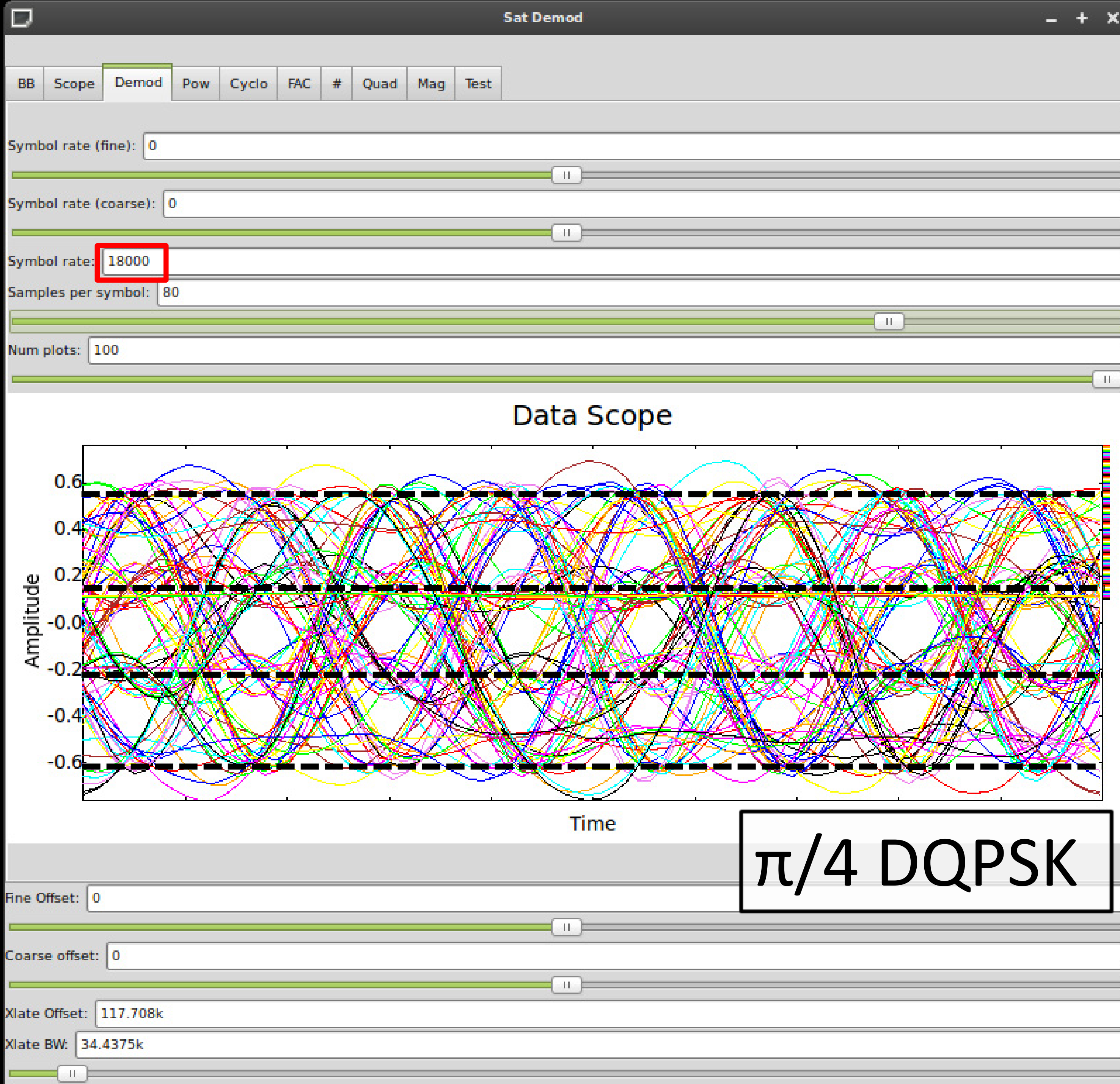
TETRA



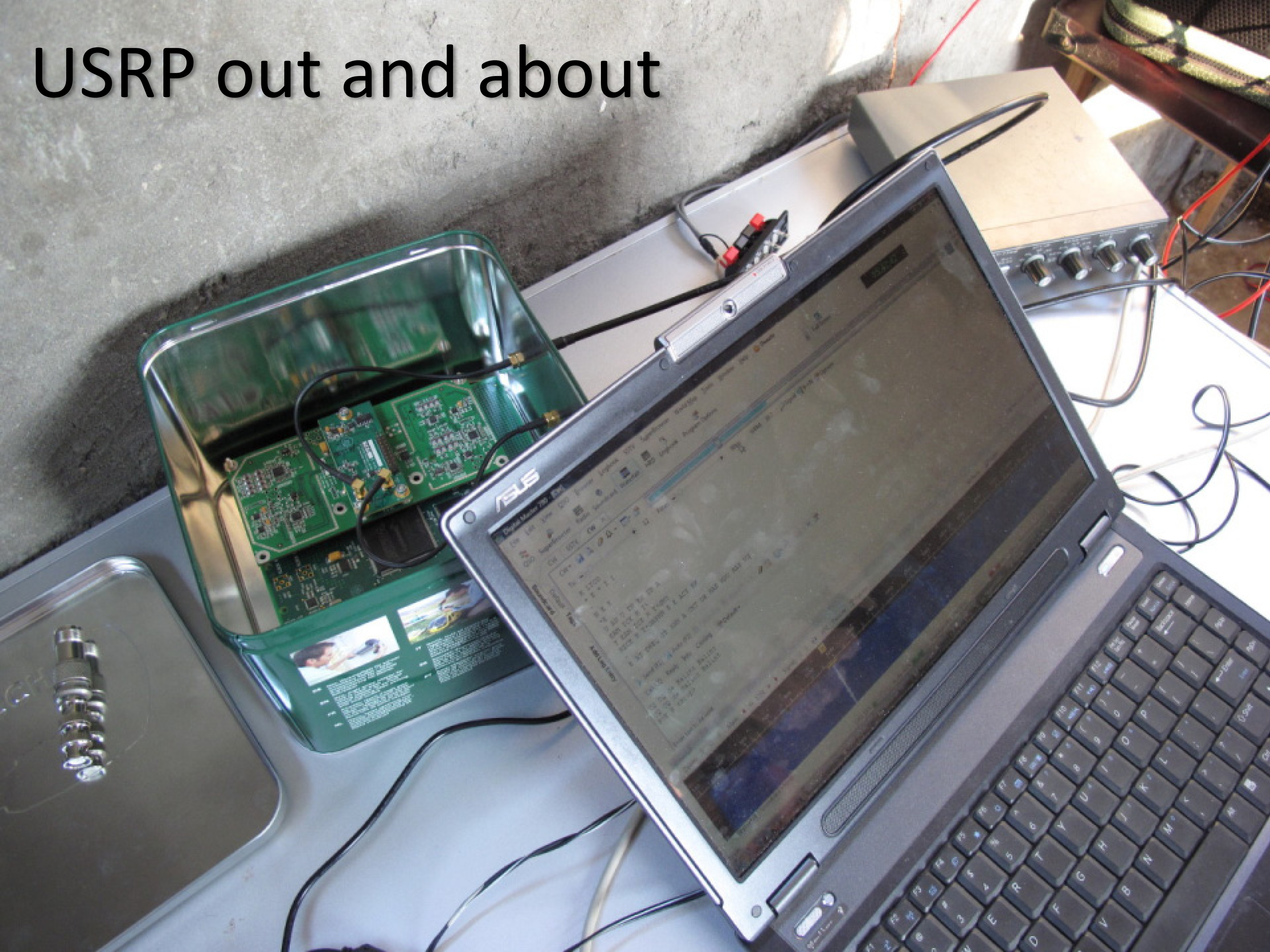
Top Block
BB
Demod
Xtra
Fast AutoCorrelation
dB
ms
Repeating idle pattern
Scope Plot
Ch1
Ch2
Counts
Time (ms)
Frequency correction burst
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
Autorange
Channel Options
Trig
XY
Coupling:
DC
Marker:
Line Link
Stop

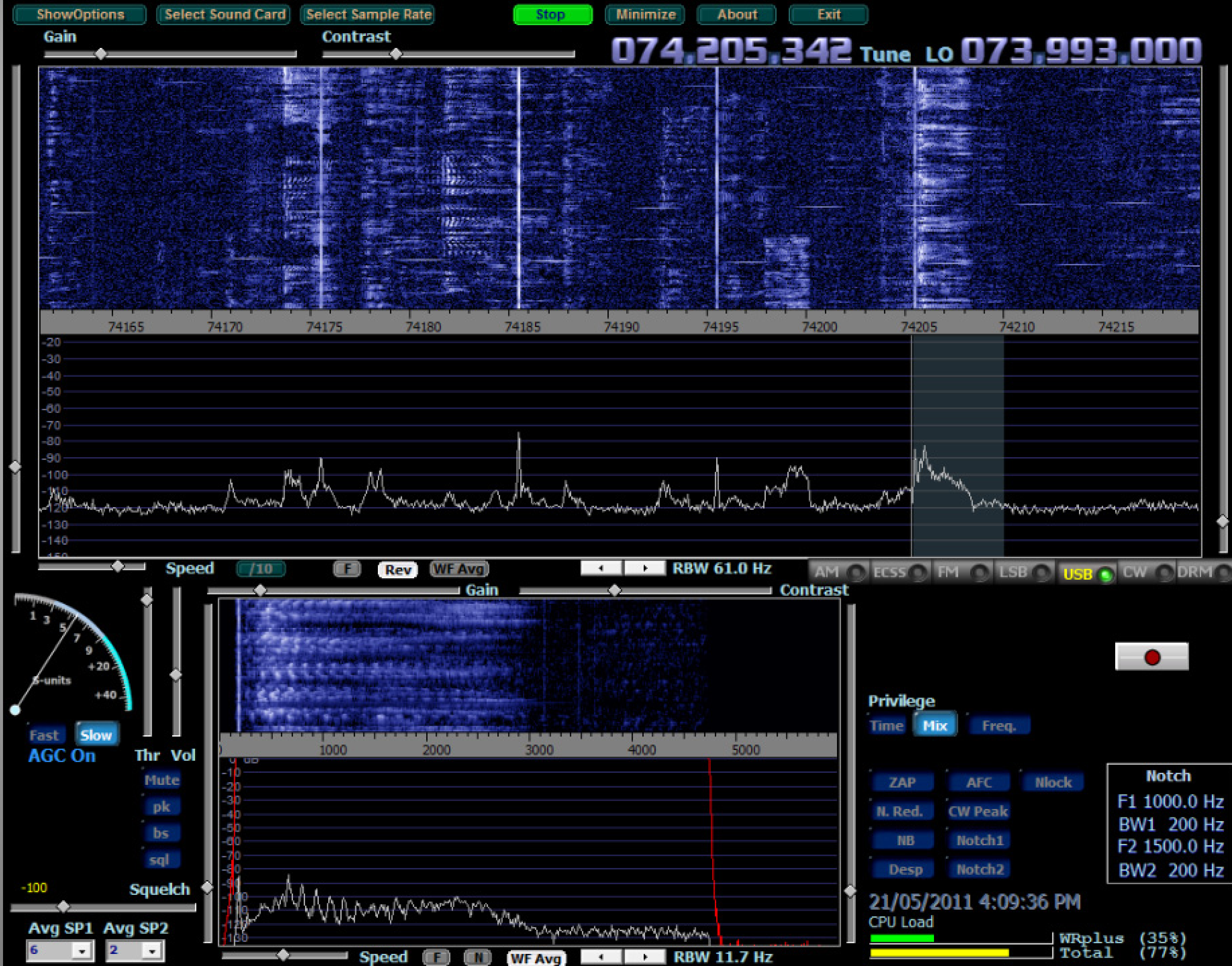

Top Block
BB
Demod
Xtra
TETRAz
Quadrature
Inphase
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Options
Alpha: 10m
Gain Mu: 50m
Marker: Dot Medium
Stop

TETRA

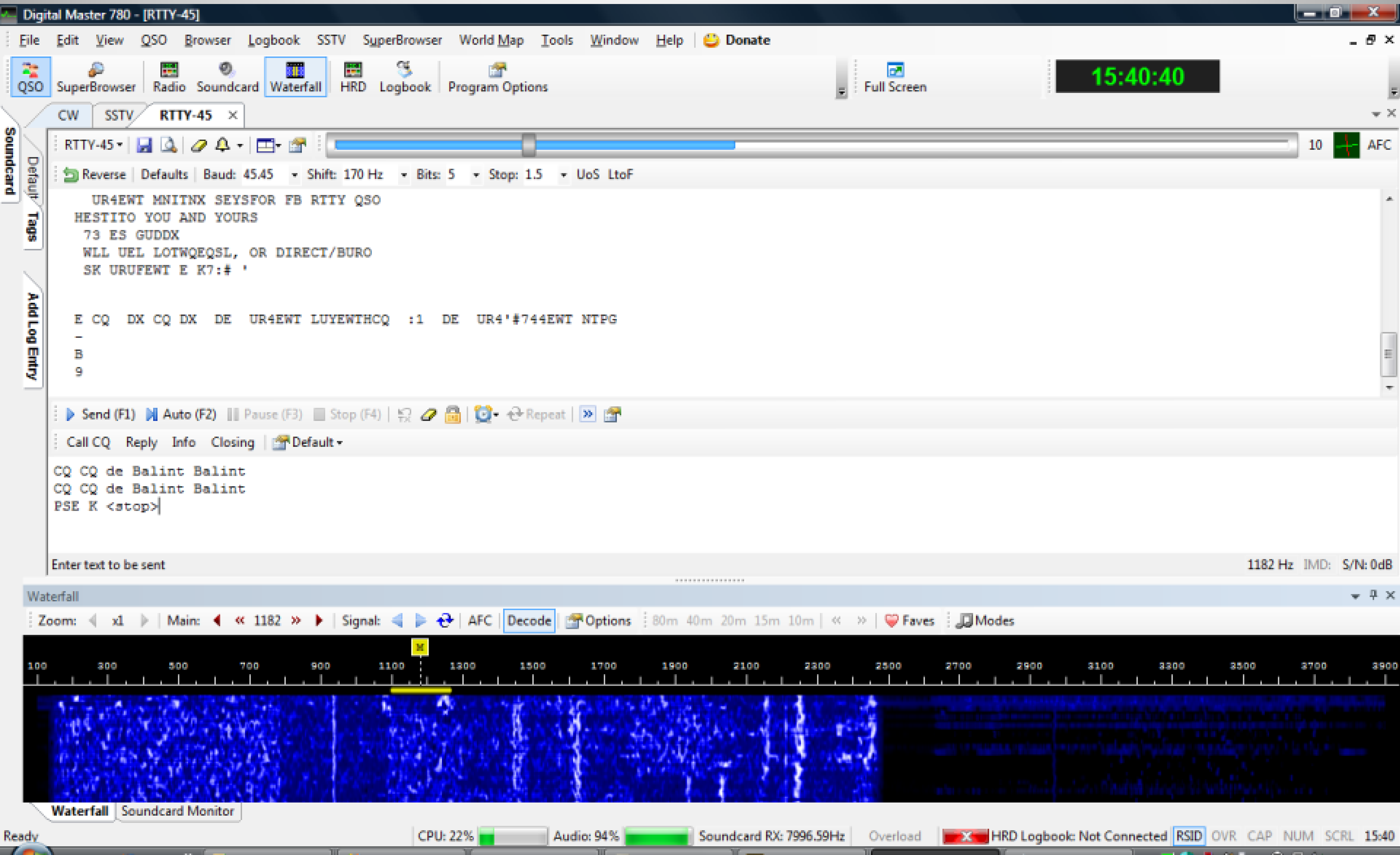

Sat Demod
BB
Scope
Demod
Pow
Cyclo
FAC
#
Quad
Mag
Test
Symbol rate (fine): 0
Symbol rate (coarse): 0
Symbol rate: 18000
Samples per symbol: 80
Num plots: 100
Data Scope
Amplitude
0.6
0.4
0.2
-0.0
-0.2
-0.4
-0.6
Time
Fine Offset: 0
Coarse offset: 0
Xlate Offset: 117.708k
Xlate BW: 34.4375k
π/4 DQPSK

USRP out and about

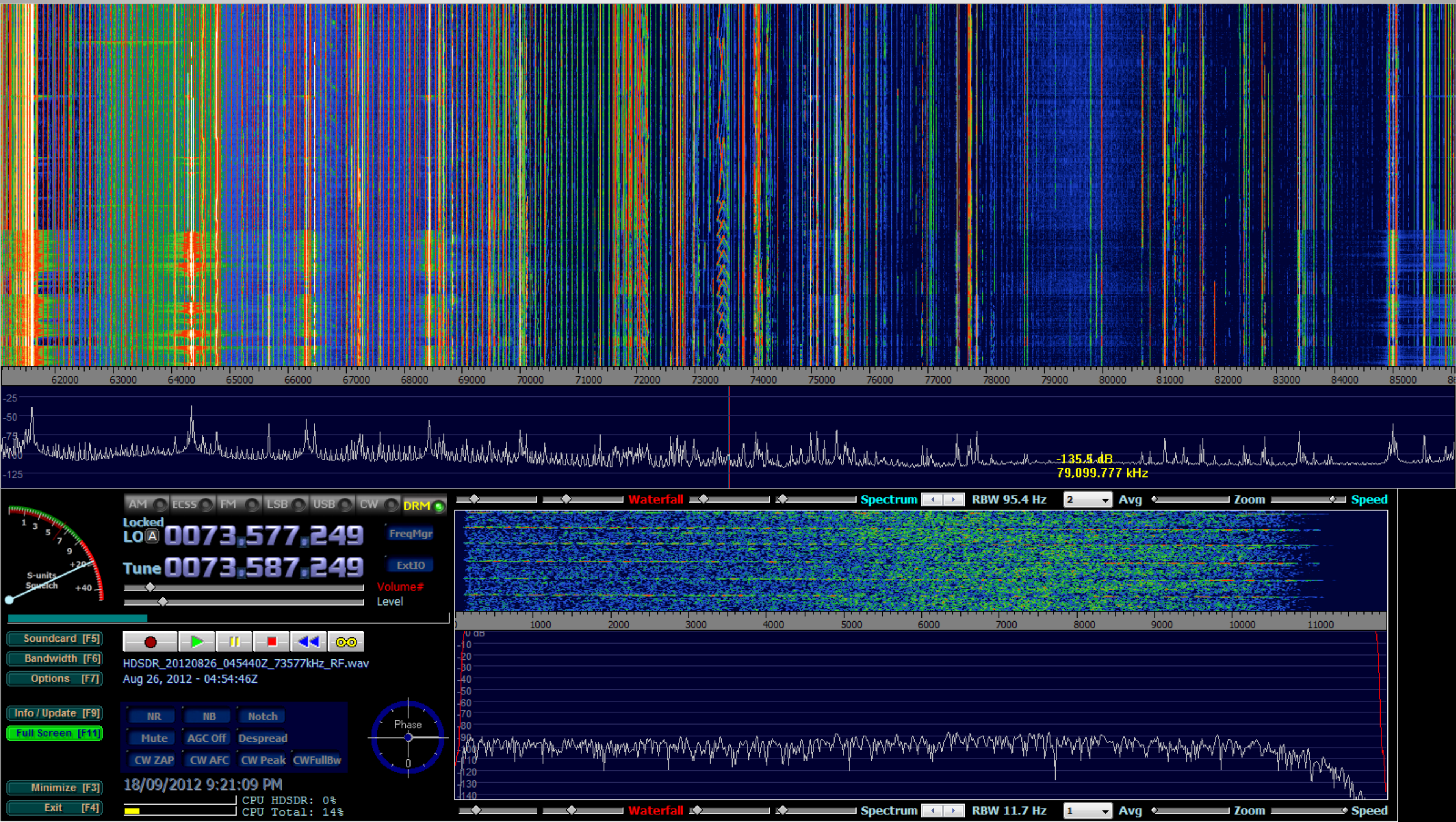



ShowOptions
Select Sound Card
Select Sample Rate
Stop
Minimize
About
Exit
Gain
Contrast
074.205.342 Tune LO 073.993.000
74165 74170 74175 74180 74185 74190 74195 74200 74205 74210 74215
-20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140
Speed
/10
F
Rev
WF Avg
RBW 61.0 Hz
AM
ECSS
FM
LSB
USB
CW
DRM
Gain
Contrast
S-units
+20
+40
Fast
Slow
AGC On
Thr
Vol
Mute
pk
bs
sql
-100
Squelch
Avg SP1
Avg SP2
6
2
1000 2000 3000 4000 5000
Speed
F
N
WF Avg
RBW 11.7 Hz
Privilege
Time
Mix
Freq.
ZAP
AFC
Nlock
N. Red.
CW Peak
NB
Notch1
Desp
Notch2
Notch
F1 1000.0 Hz
BW1 200 Hz
F2 1500.0 Hz
BW2 200 Hz
21/05/2011 4:09:36 PM
CPU Load
WRplus (35%)
Total (77%)

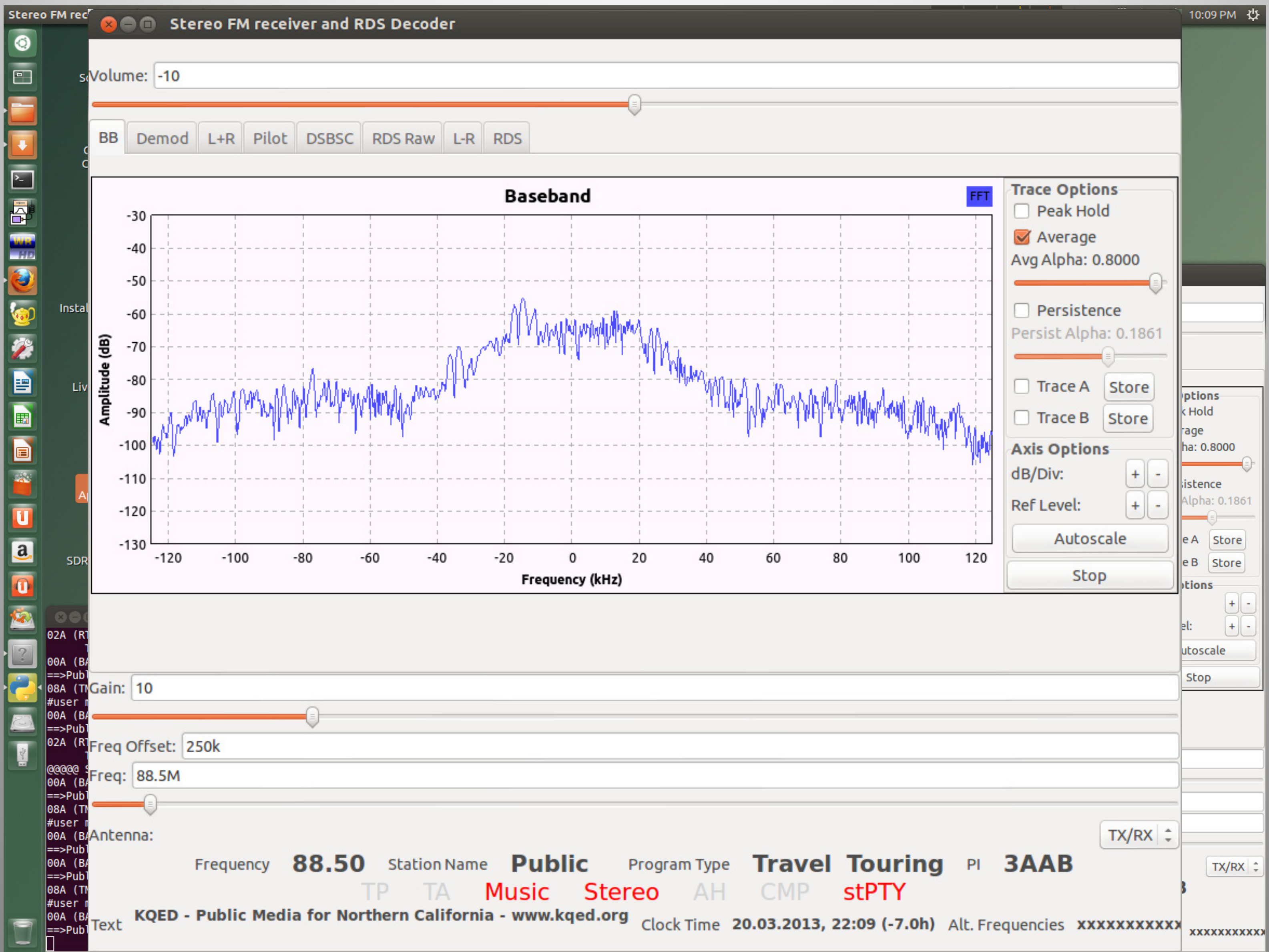
Amateur Digital Modes



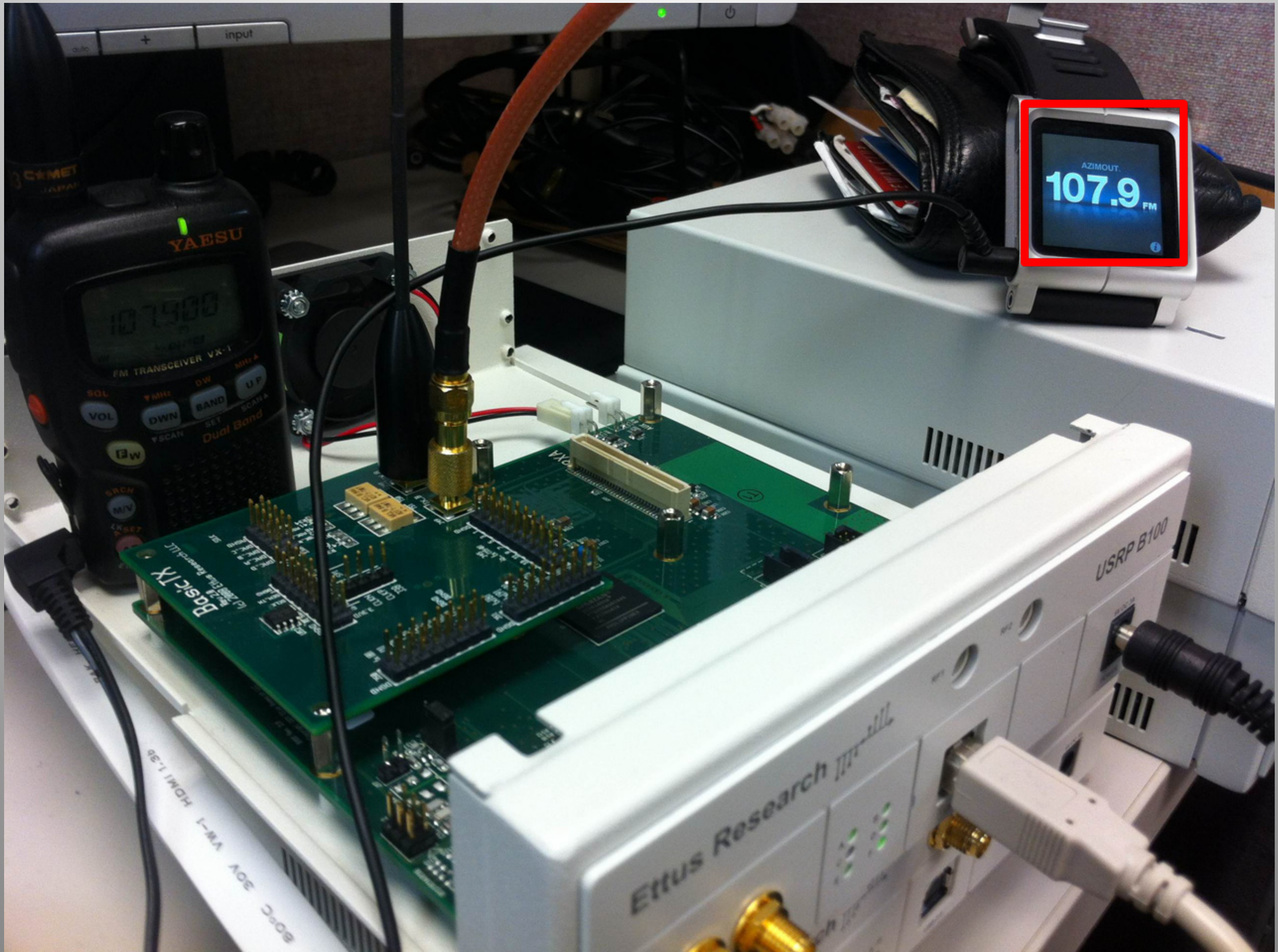
The Entire HAM Band



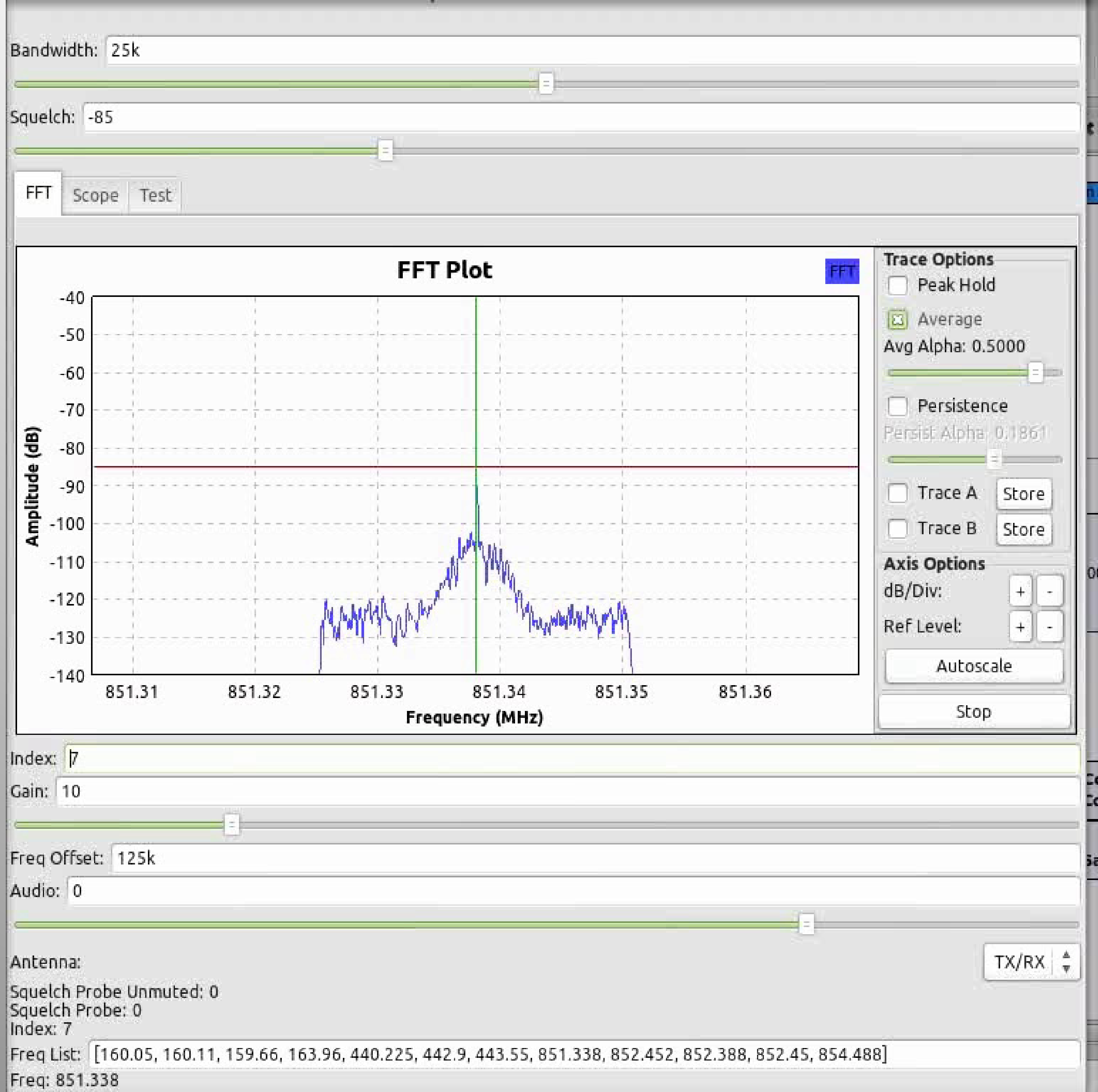
Stereo FM with RDS: Receiver



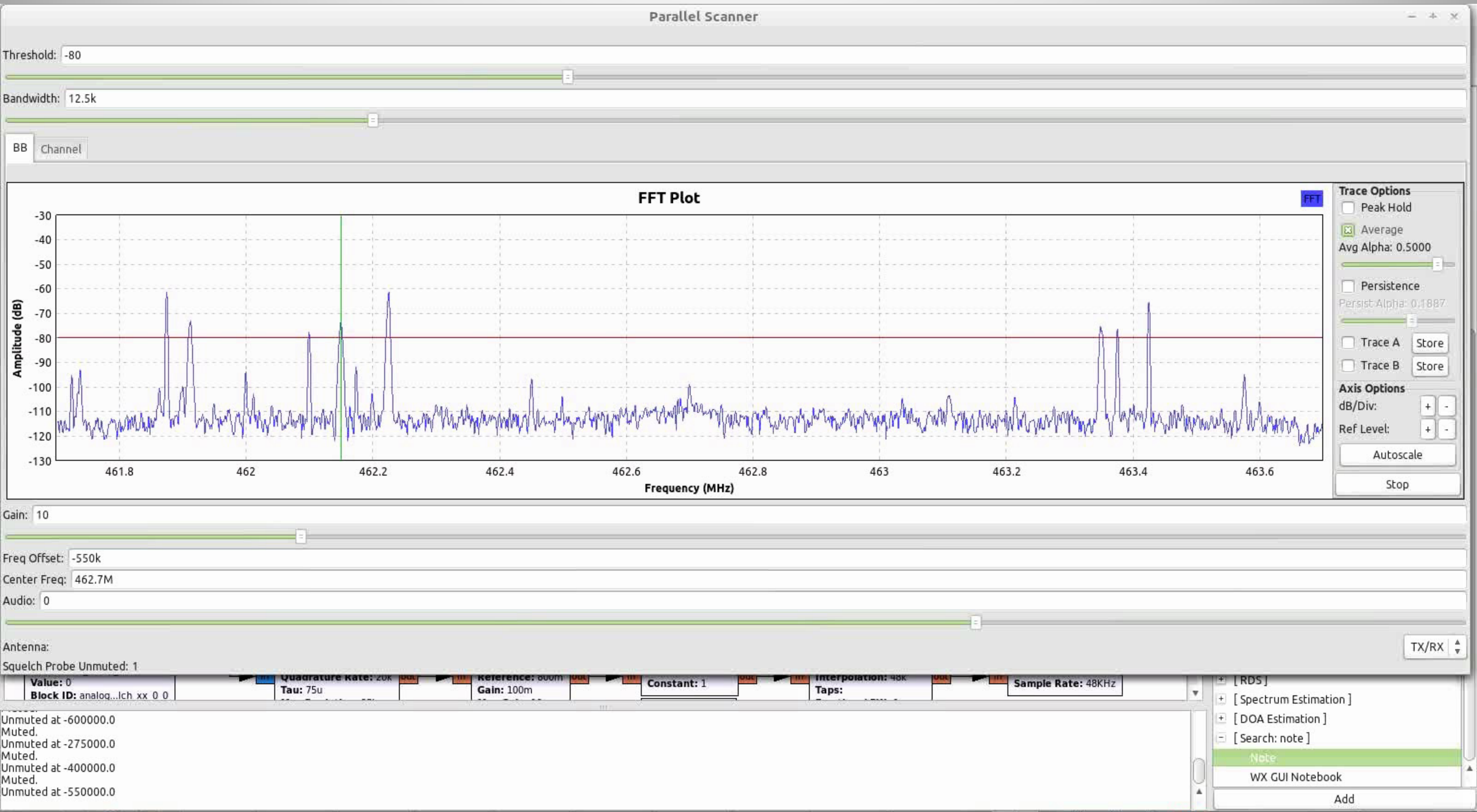
Stereo FM with RDS: Transmitter



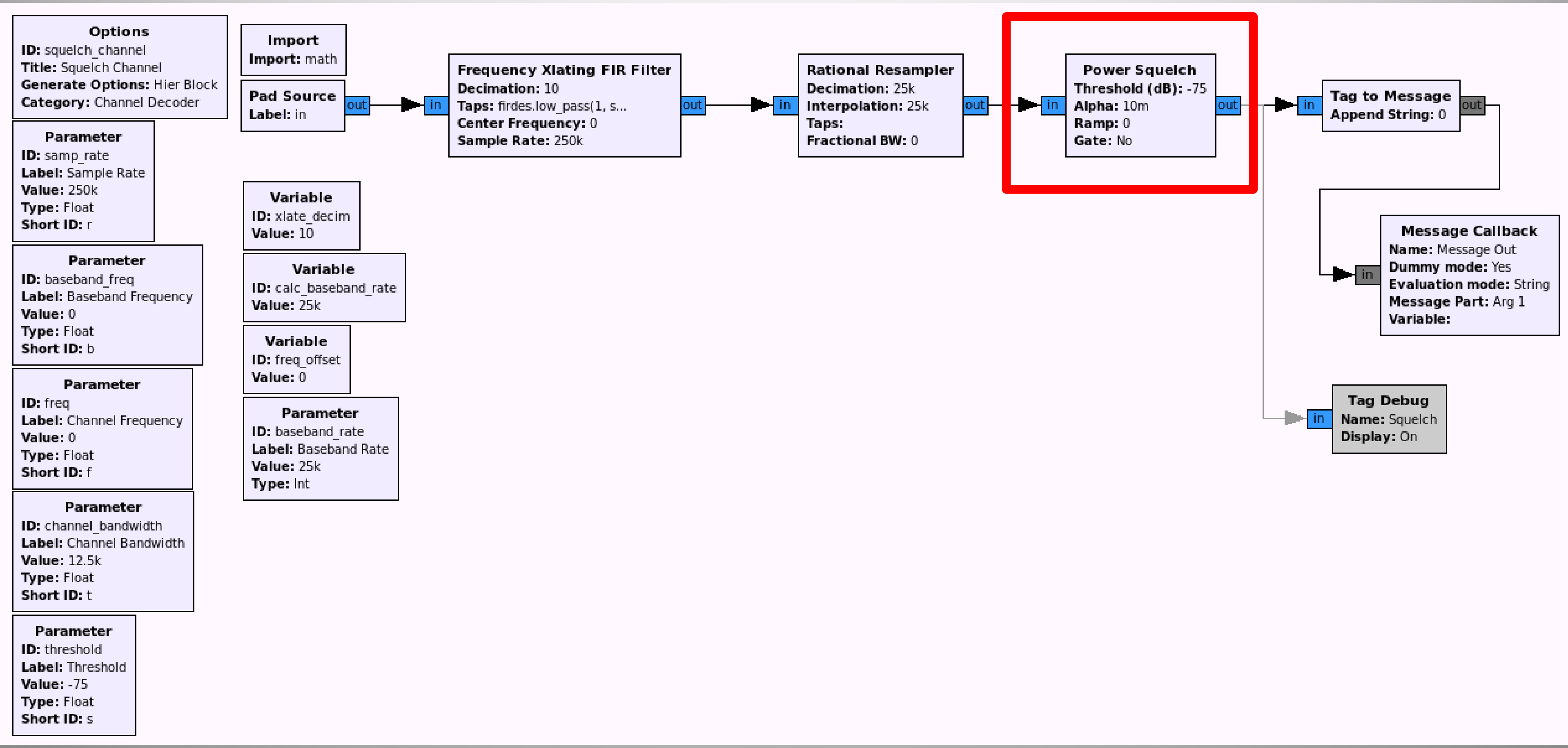
Sequential Scanning



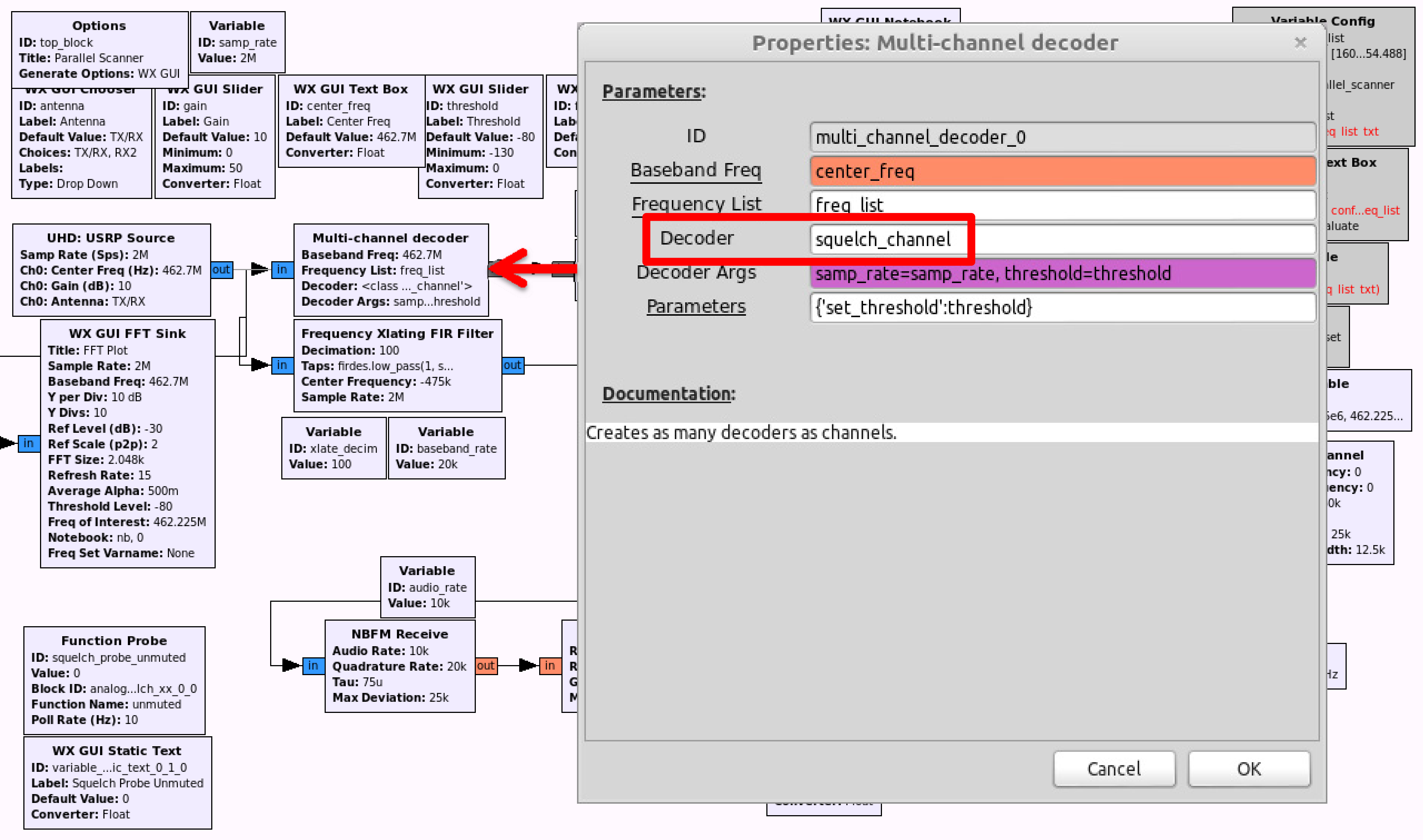
Parallel Decoding



Parallel Decoding: 1

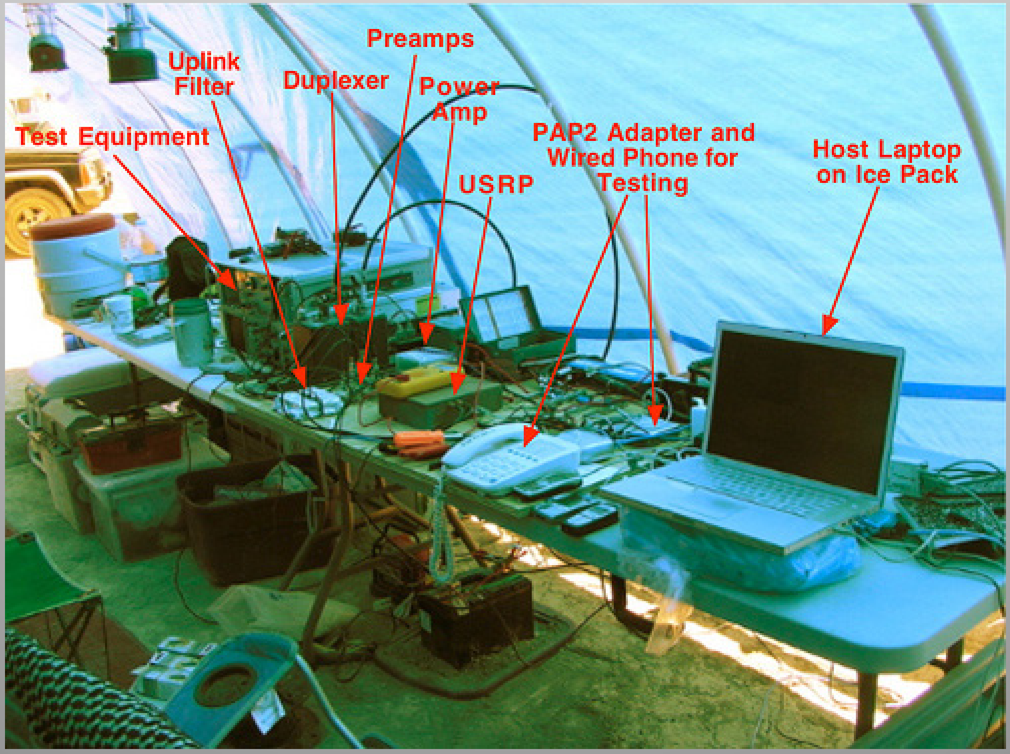


Parallel Decoding: N



OpenBTS

- Open-source 2G GSM stack
  - Asterix softswitch (PBX)
  - VoIP backhaul



802.11agp decoding

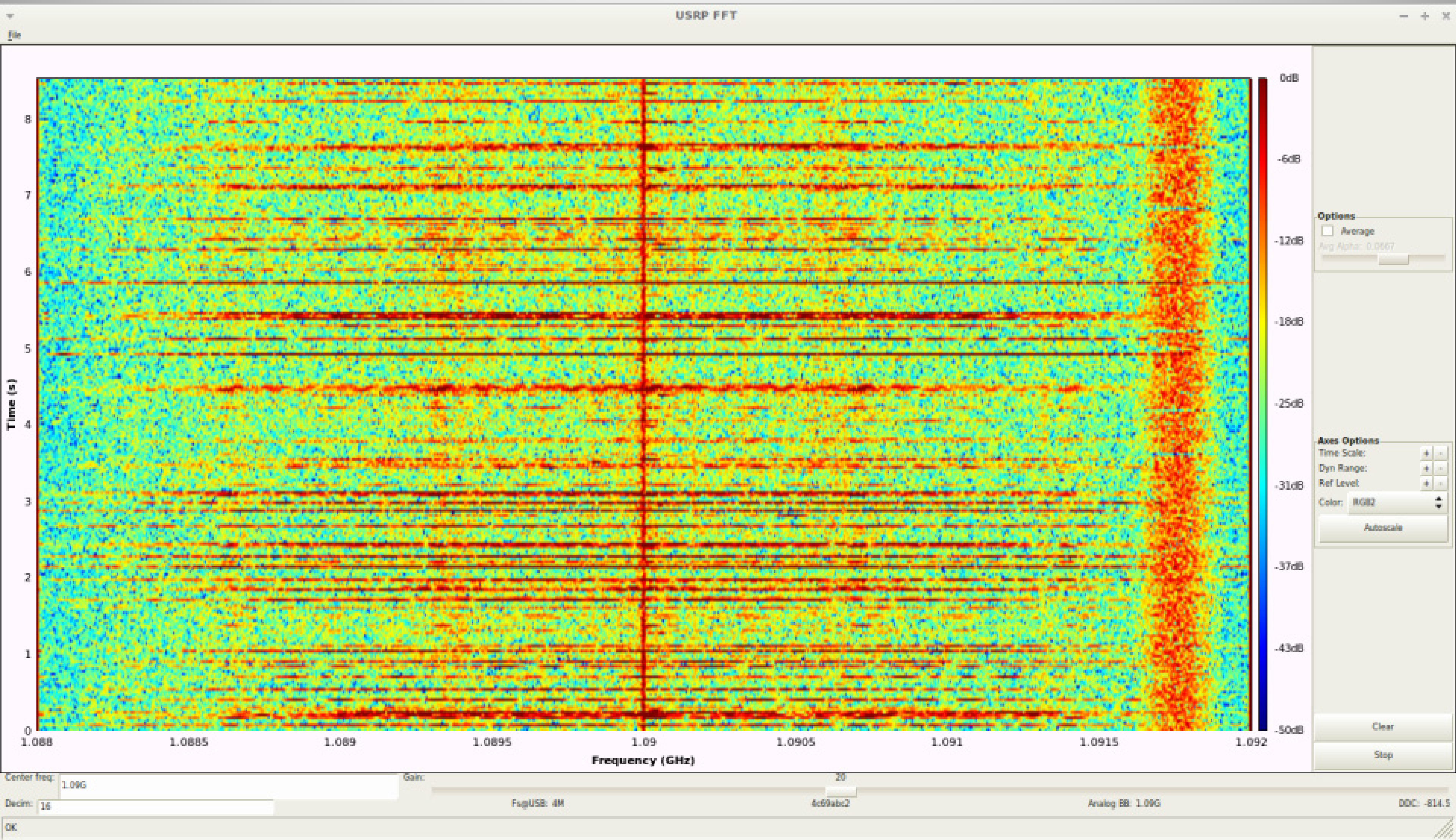
- 10/20 MHz OFDM
- gr-ieee-802-11
- BPSK & QPSK

Other Applications of SDR

- Radio astronomy
- Passive radar
- DVB-S decoder
- Tracking pedestrian foot traffic in shopping malls

- Much more…

Mode S Waterfall



Frank's Fantastically Fabulous

radiorausch

recreational! raw! rutabagas! riveting! random! rdlap! ridiculous! redundant!

radio related rambling

Four Level FSK & Motorola RD-LAP: Perhaps you have an interest in some of the following topics:

- Technical characteristics of Motorola's RD-LAP wireless data transmission protocol (same protocol as used on DataTAC networks).
- A real world example of TCM (Trellis Coded Modulation). For a nice introduction to TCM please see tutorial 23b at complextoreal.
- MDTs (Mobile Data Terminals) / MDCs (Mobile Data Computers), especially as related to public safety and police use in the greater Huntsville, Alabama area.
- The FBI's NCIC database system
- Security aspects of such systems vis a vis the scanner radio enthusiast
- A delightfully stimulating application of the Ettus Research USRP and the GNURadio based SDR

1090 MHz Aviation Transponders & The USRP

Illustration 1: Sample Mode S Transponder Squawk received on 1090 MHz with 3.2MHz sample rate.

Equipment used:

All from Ettus Research (http://www.ettus.com/custom.html):

- USRP With DBSRX 800 MHz – 2.4 GHz Daughterboard
- LP0926 Log Periodic Antenna

The sampling rate was selected at 3.2MHz (USRP decimation 20) to avoid DBSRX or computer generated frequency spurs that appear at ±2 MHz relative to 1090 MHz. Aviation transpond
selected bandwidth is thus sufficient to catch each individual pulse.

MODE S Data Example:

The data from the illustration above is sliced at a level of about 250 A.U. and then processed into a stream of 0.5 µS pulses. After the 8 µS Mode S header we have a stream of data bits en
for a '0' bit; the data bit rate is 1 megabit / second. With received data highlighted in yellow the above example becomes:

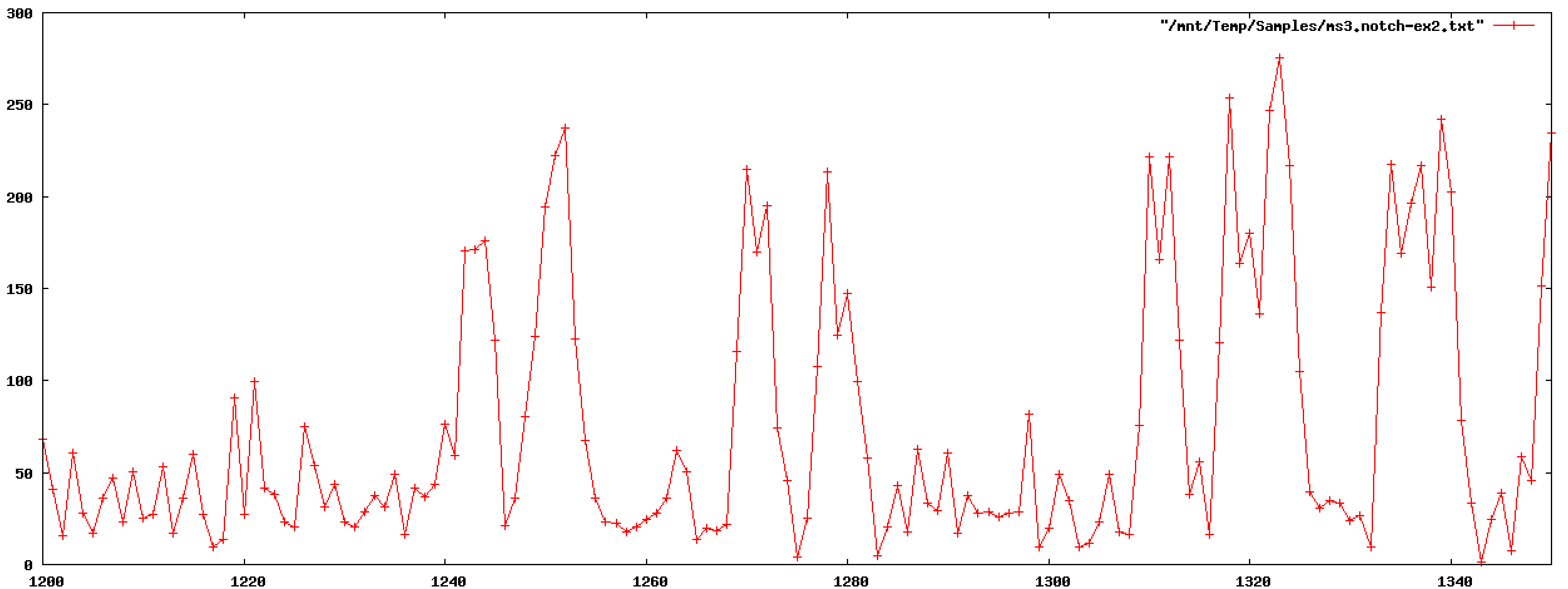
1010000101000000	MODE S Header: Pulses at 0, 1, 3.5, and 4.5 µS
0110011010 0 1 0 1 1	Format Number: DF = 11; (ALL CALL REPLY)
100110 1 0 1	Capability
100110010110011010100110100110100110010110101001 1 0 1 0 0 1 0 1 1 1 0 1 1 0 1 1 0 1 0 0 1 1 1 0	MODE S Address: Hex A5DB4E (or 51355516 octal)
101010100110011010101010011010100110010101010101 1 1 1 1 0 1 0 1 1 1 1 1 0 1 1 1 0 1 0 0 0 0 0 0	Parity

Downlink format (DF) 11 does not include altitude information. However, just with the MODE S address we may go to web pages such as http://www.airframes.org/ and learn more abou
number N477CA, type, owner, et cetera.

Receivable 1090 MHz Traffic:

MODE C	Traditional aircraft squawk codes
MODE S	Traditional aircraft squawk codes

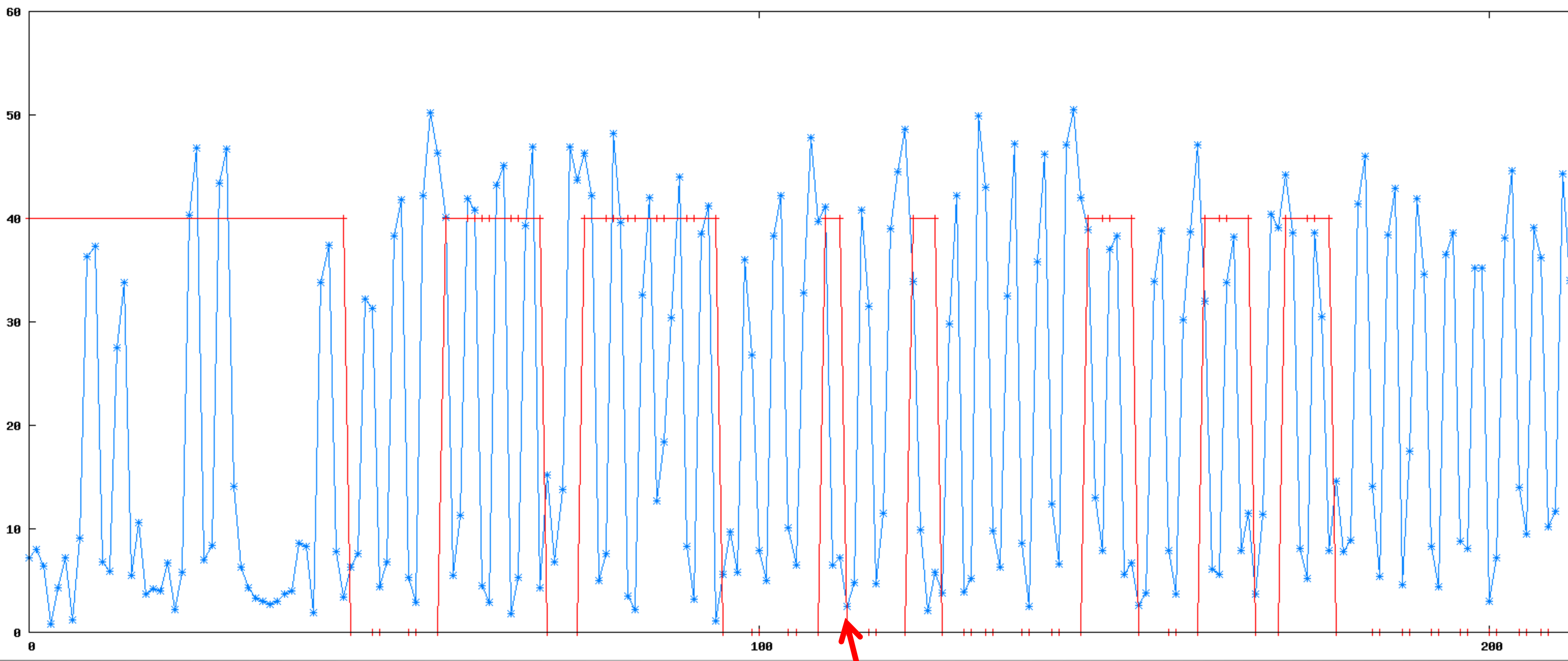
Time Domain



Preamble

Frame →

Time Domain

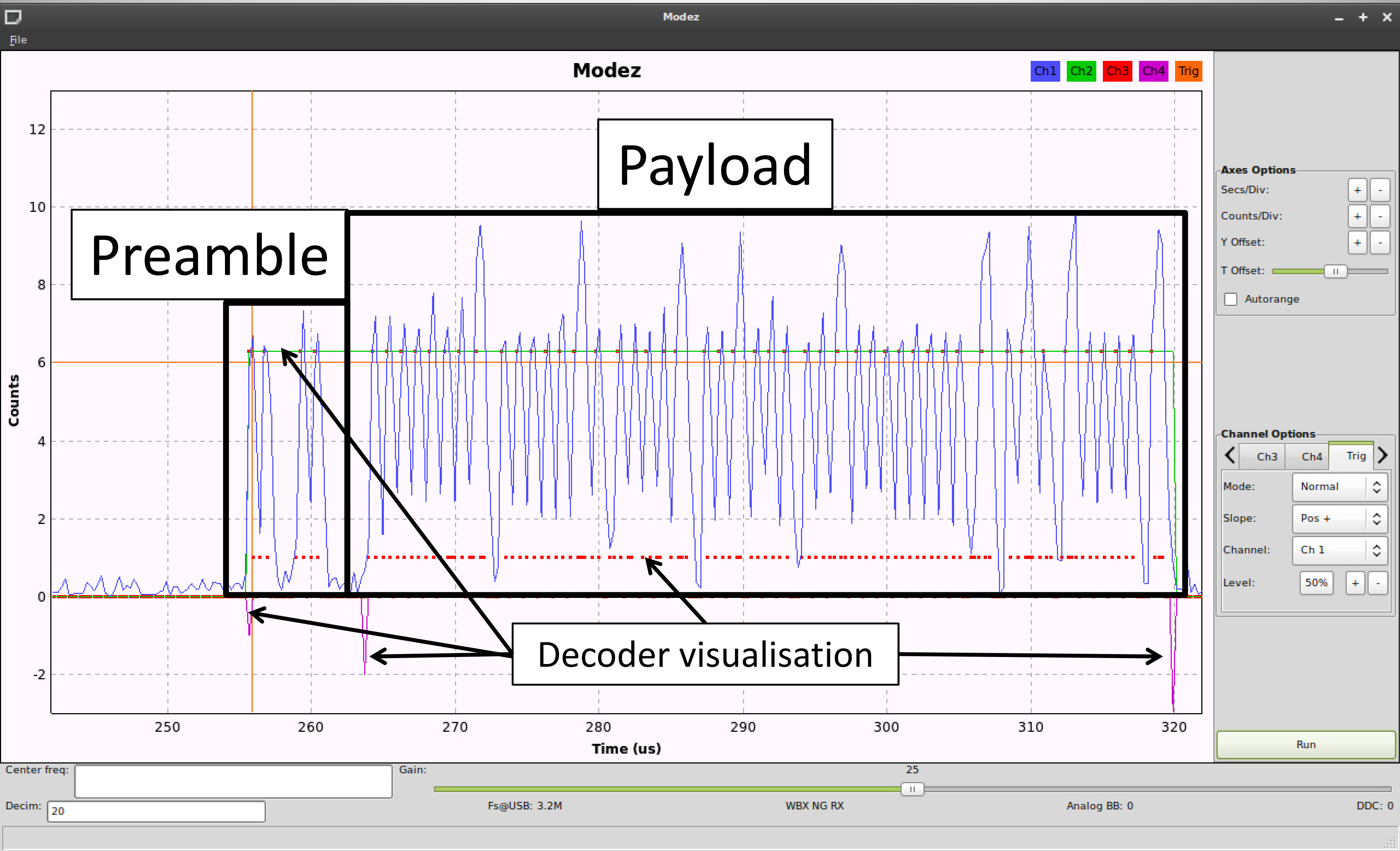


Preamble Frame → Data bits from early/late chips

Starting Points

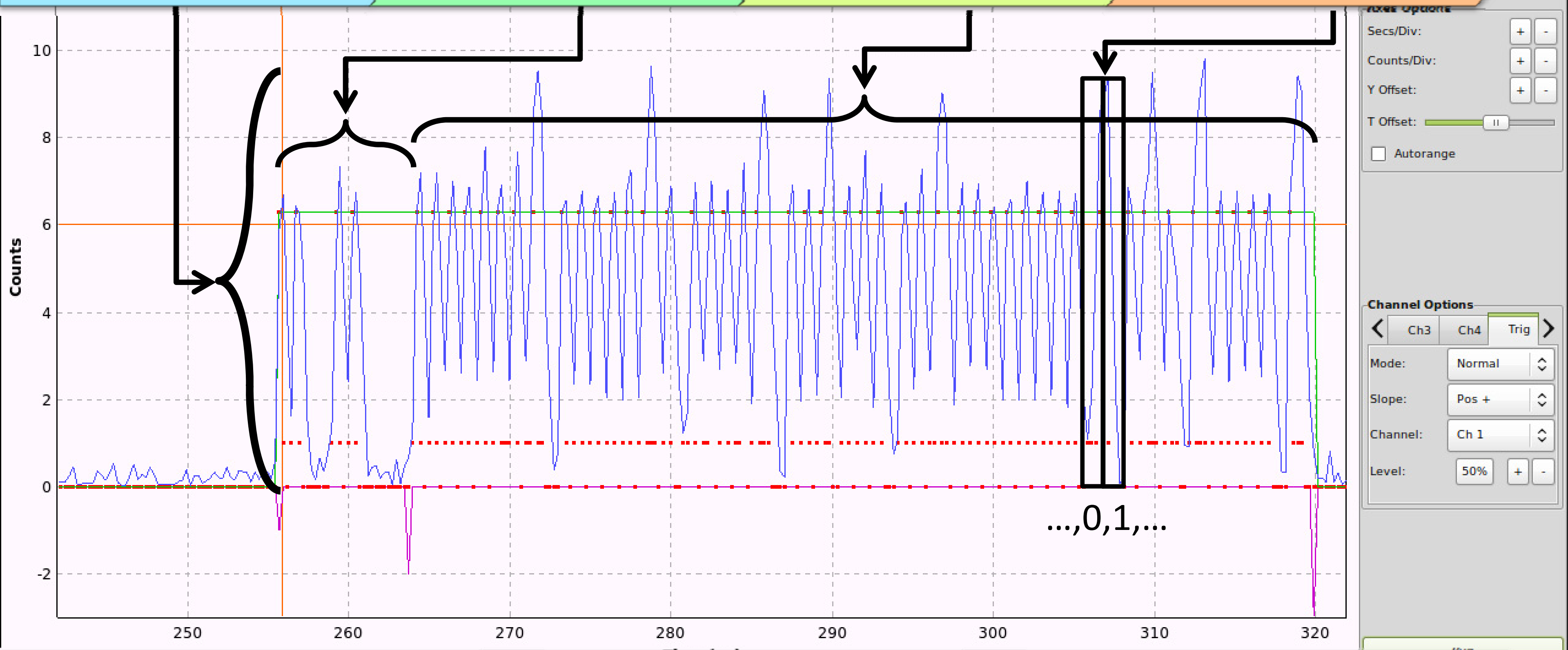
- gr-air by Eric Cottrell
  - Separates processing into several different GR blocks which detect/decode:
    1. Pulses
    2. Mode S preamble
    3. Frame length
    4. PPM chips/bits
- gr-air-modes by Nick Foster
  - Less complex (fewer steps) → better performance
  - Less overhead by using PMTs instead of passing state structs as 'samples' through GR runtime

Mode S Response: AM signal



Mode S Decoder Structure

Pulse detect → Preamble detect → Frame length detect → PPM demod



Frame parser → Error correction → Sanity check

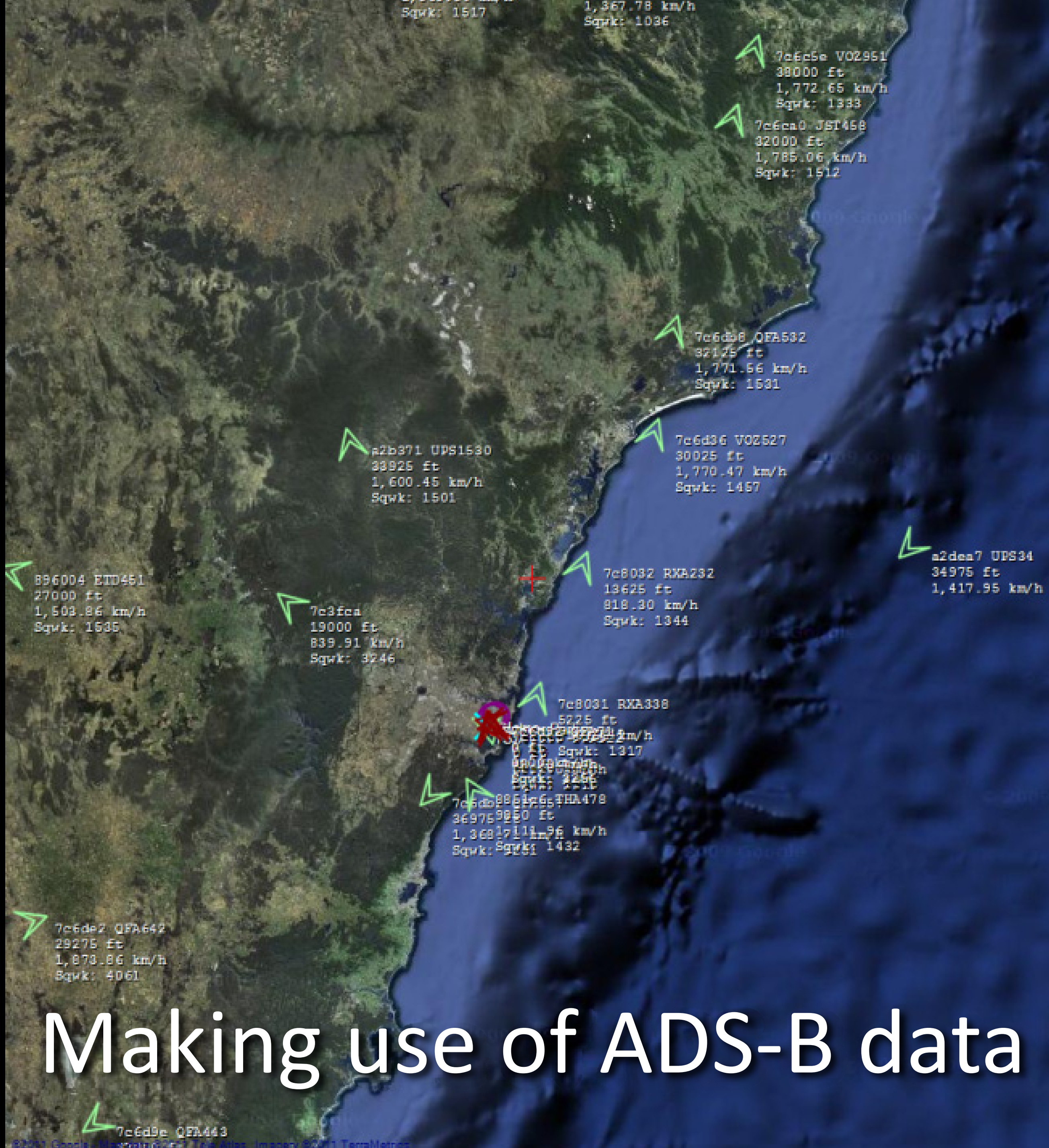
Mode S Frame Types

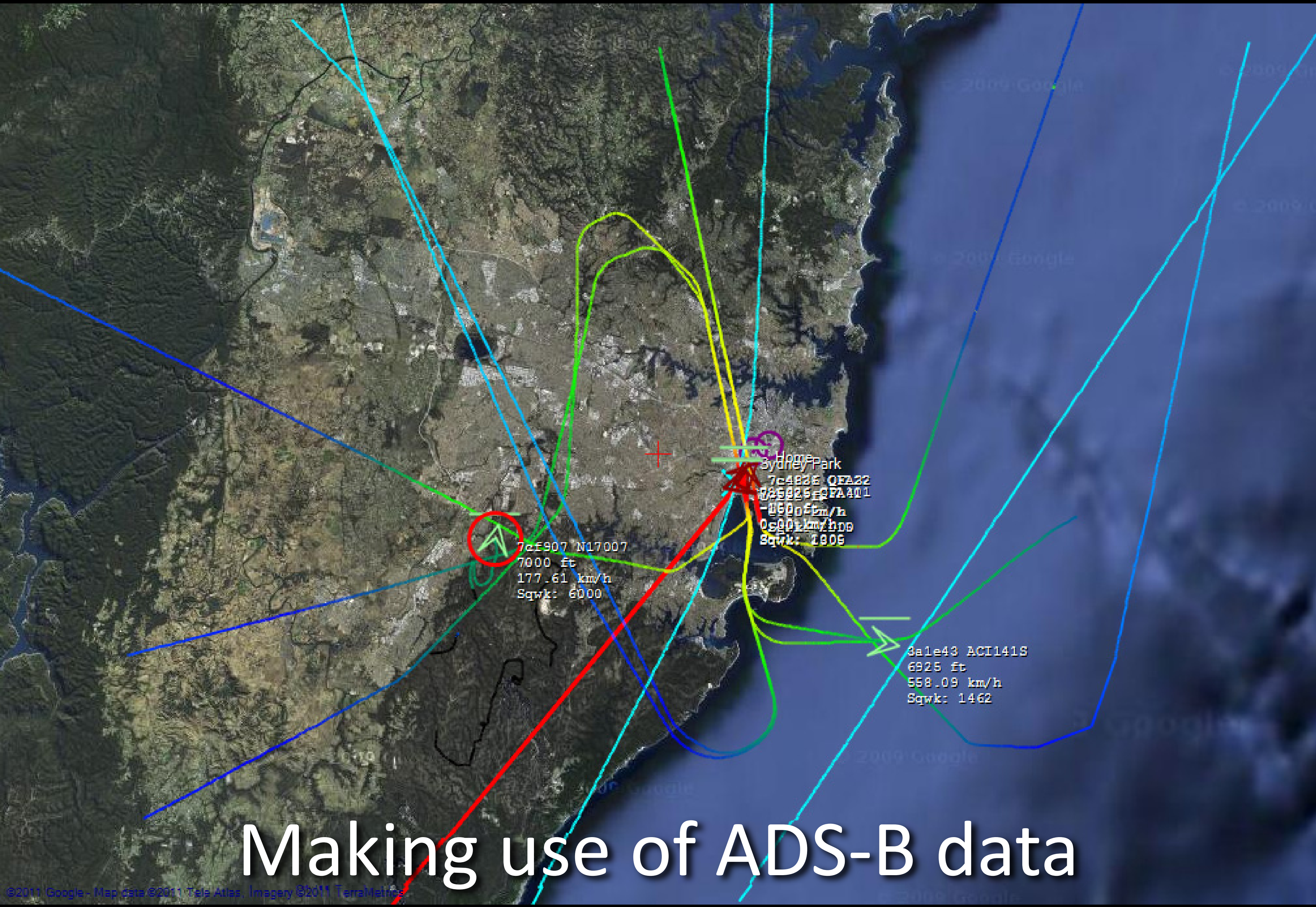
- Several **D**ownlink **F**ormats (DF)
  – Short/long frames (56/112 bits)
- Contains **A**irframe **A**ddress (AA)
  – 24-bit transponder address allocated by ICAO
- Appended CRC
  – 'Normal' mode (syndrome = 0)
  – Address overlaid mode (syndrome = AA)
- DF 11: All call, 5/20: Identity (squawk code), 0/4/16/20: Altitude…

ADS-B: **E**xtended **S**quitter

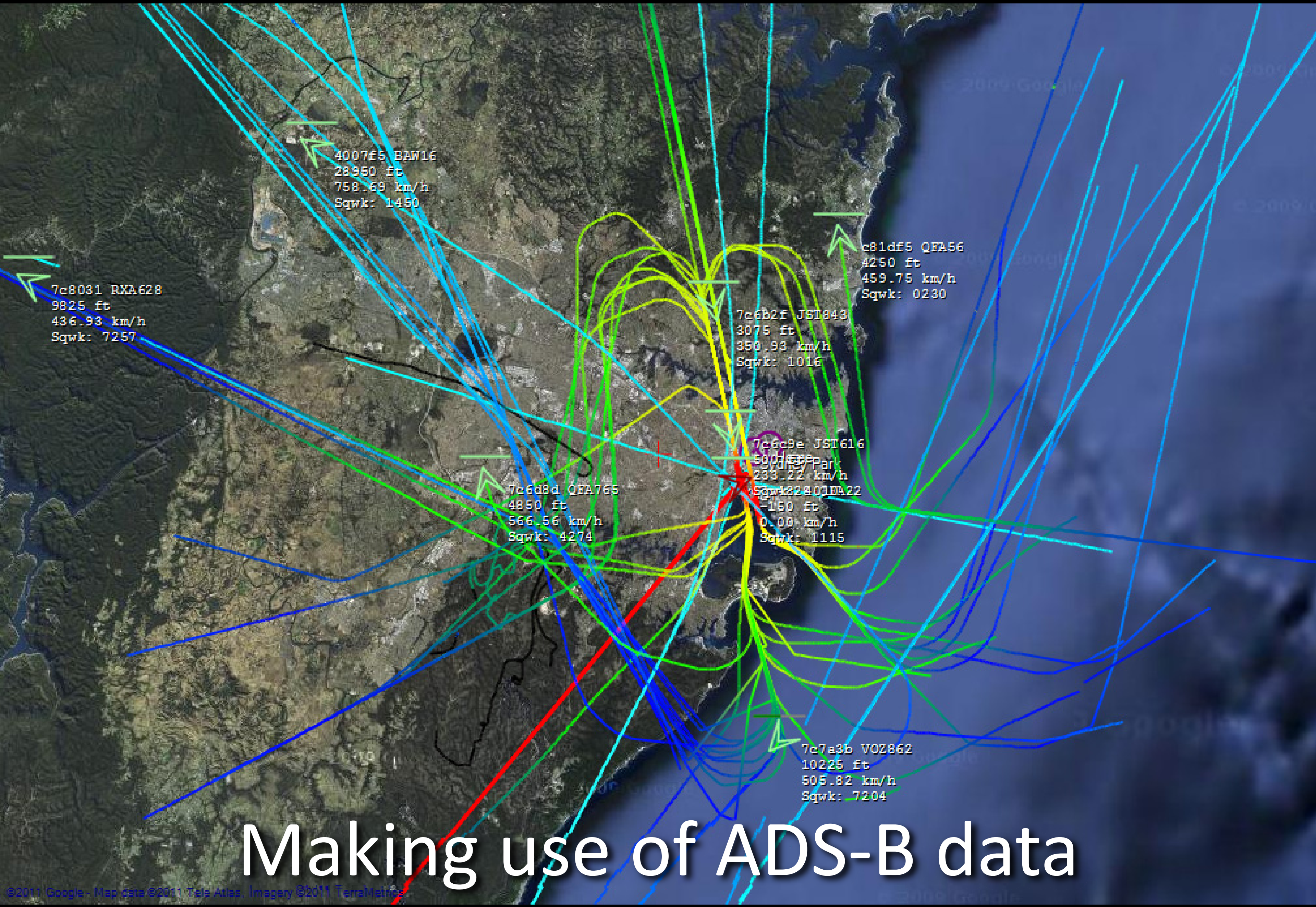
- Several ES types (DF 17):
  - Standard: position, altitude, heading, vertical rate, flight ID, transponder code
  - System information
  - Aircraft capabilities/status (e.g. autopilot enabled)
  - Aircraft intent
  - Traffic information
  - TCAS resolution advisories (“Pull up!”)

Making use of ADS-B data

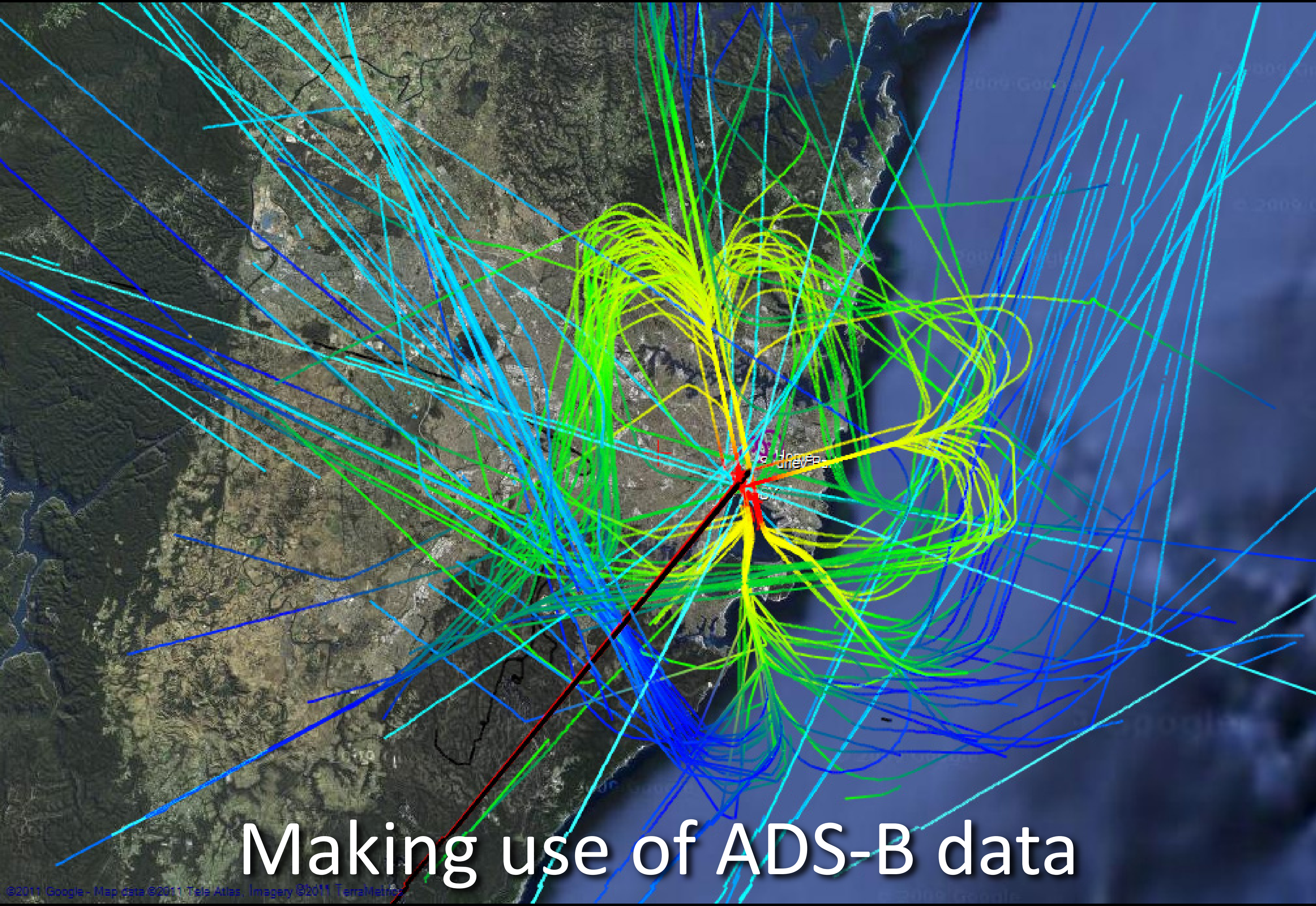




Making use of ADS-B data



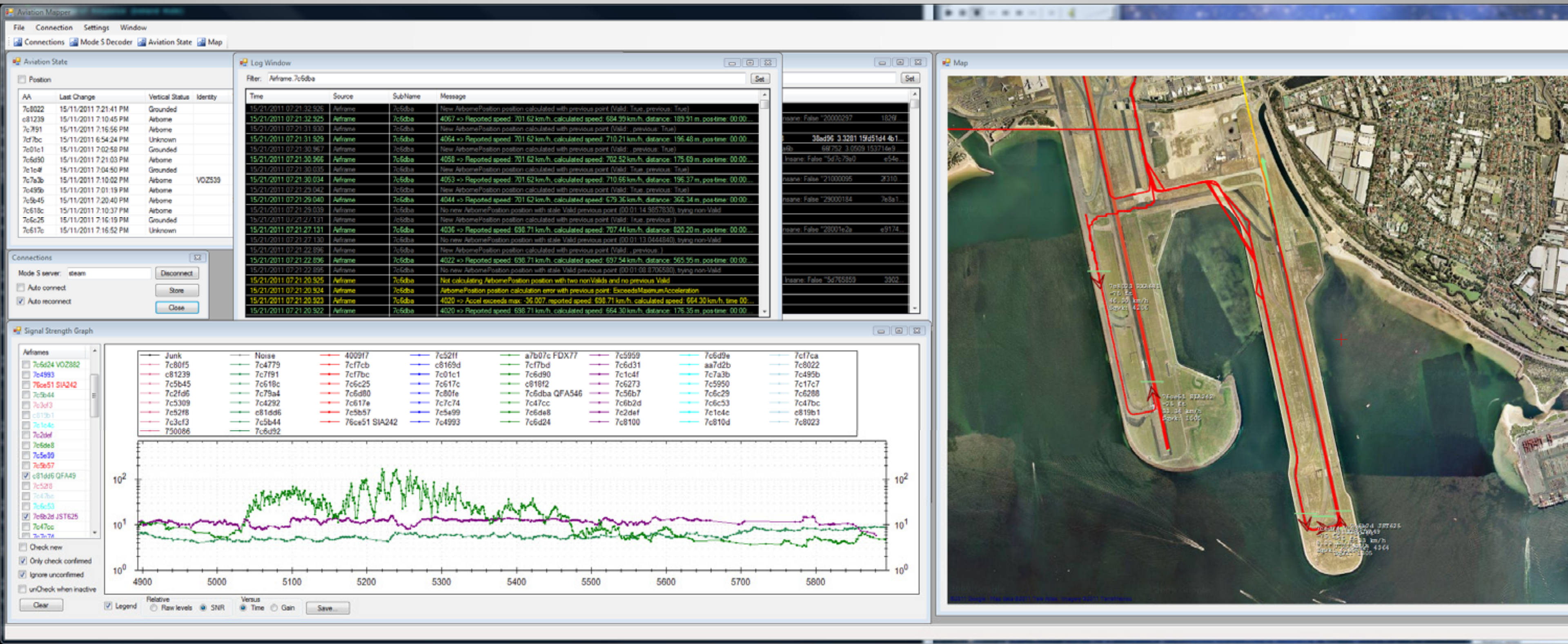
Making use of ADS-B data

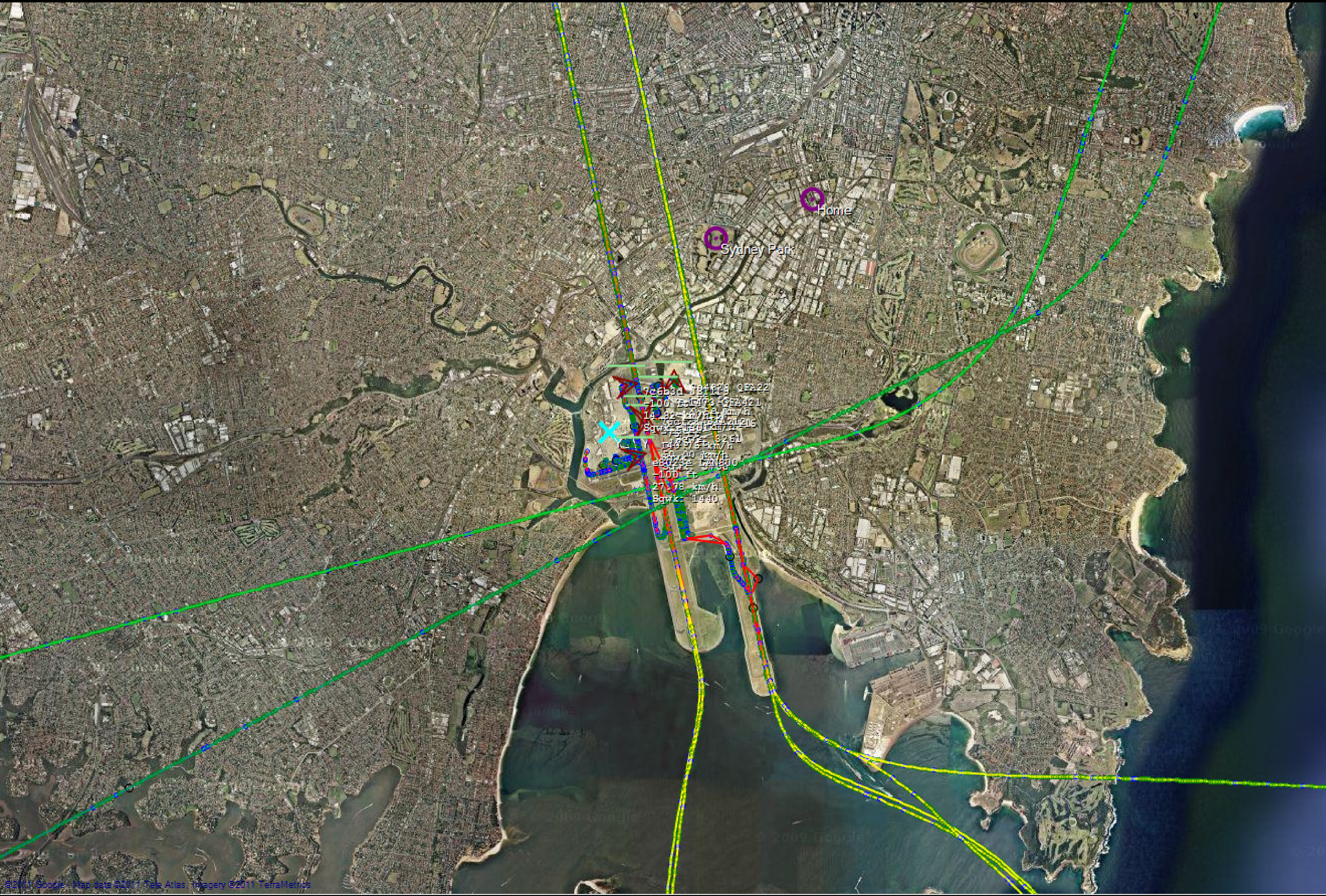


Making use of ADS-B data

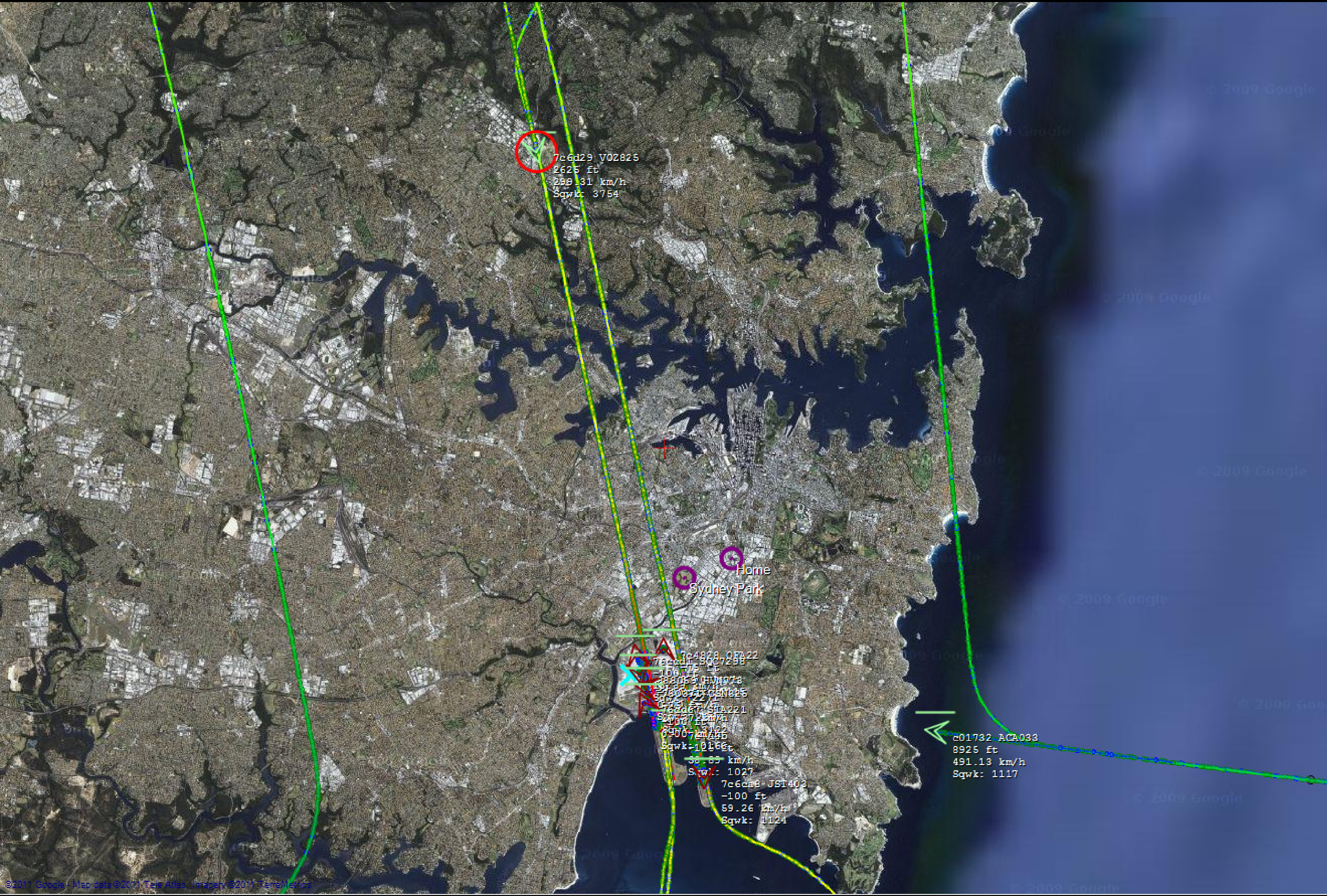
AviationMapper

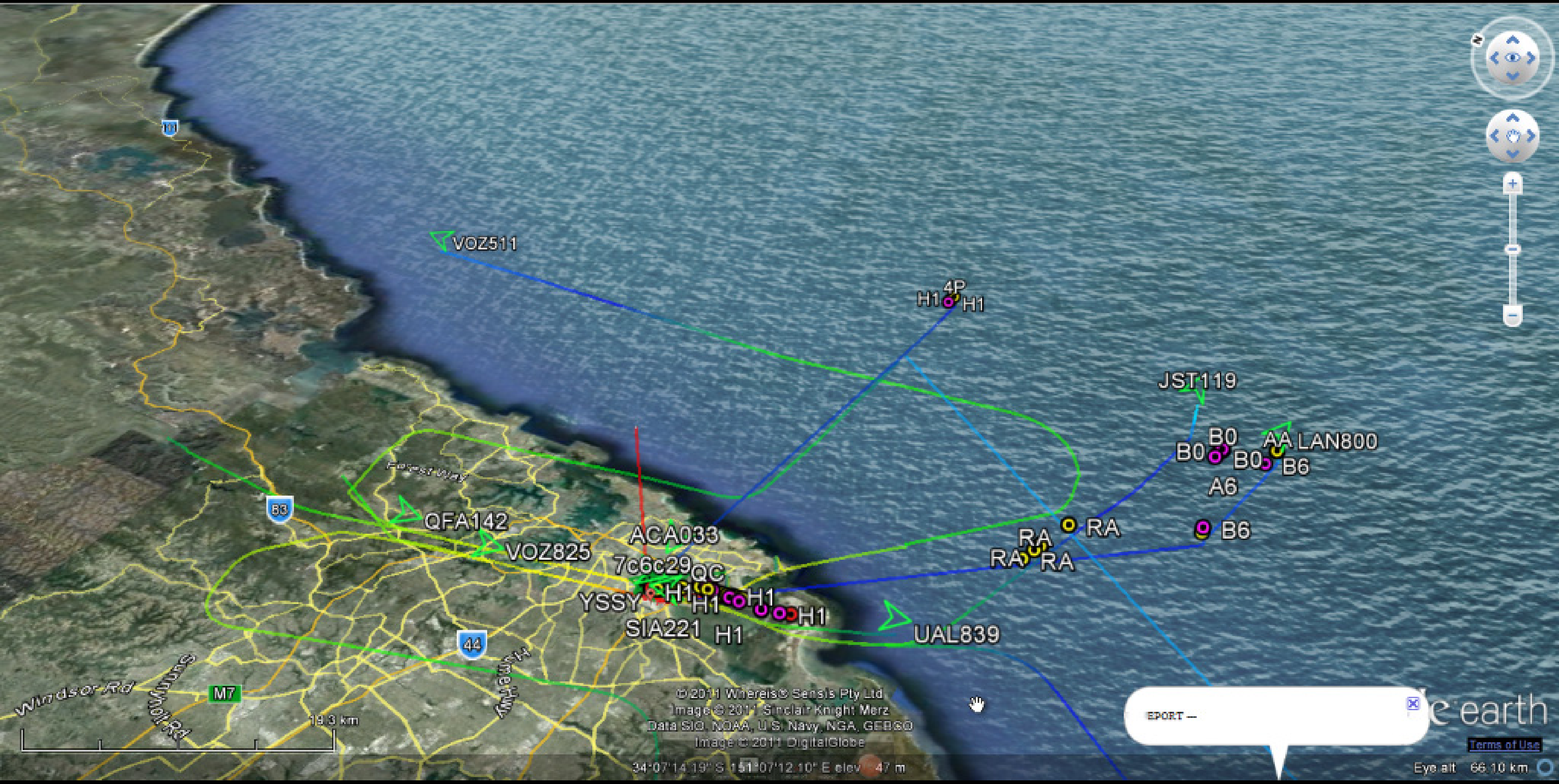
- Connects to Mode S decoder server
- Tracks & plots airframes, collects statistics
- Provides state server for web streaming

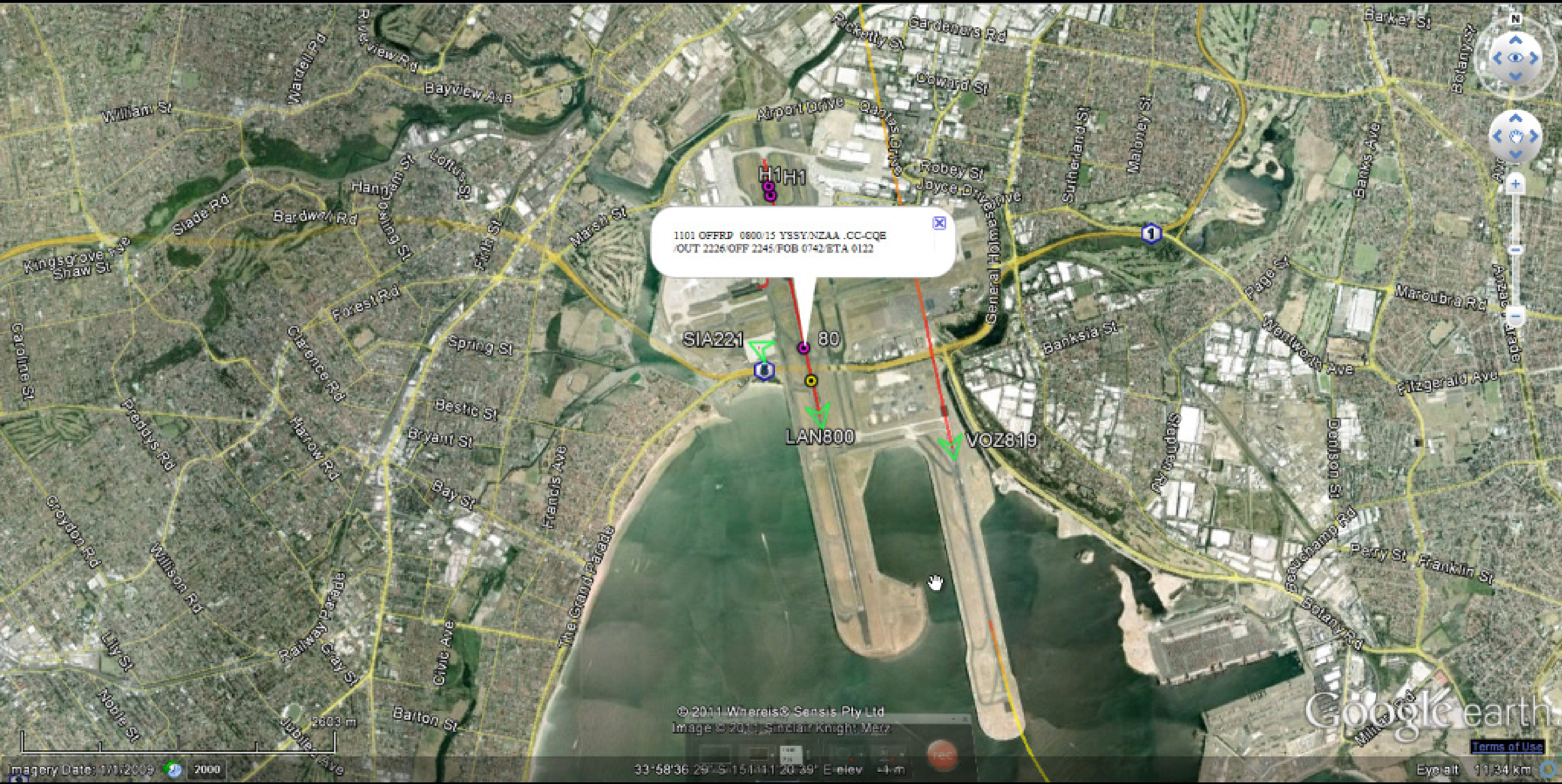


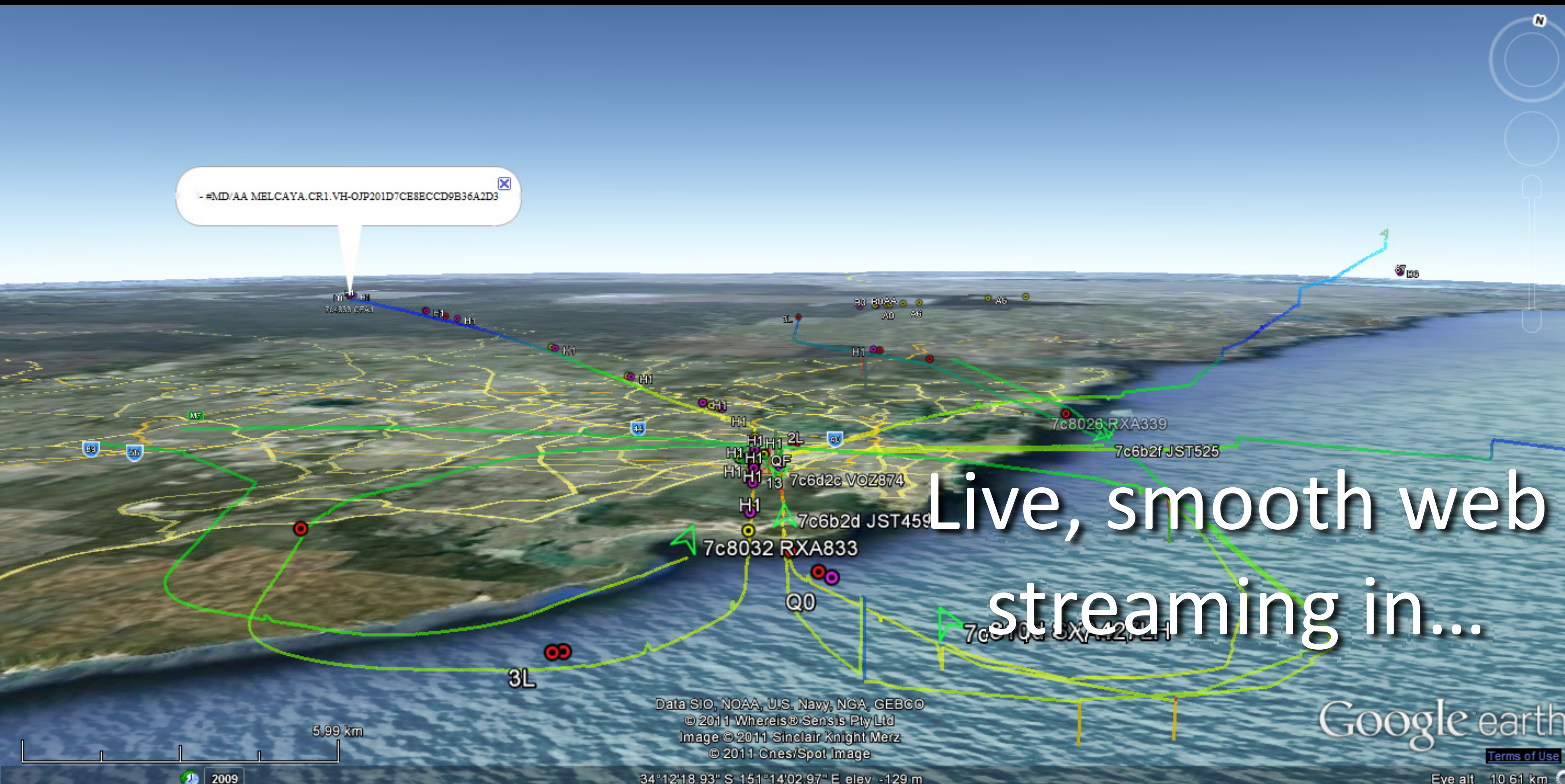


Home
Sydney Park
QFA22
-100 ft
27.78 km/h
Squawk: 1440
©2011 Google - Map data ©2011 Tele Atlas, Imagery ©2011 TerraMetrics


7c6d29 VOZ825
2625 ft
298.31 km/h
Sqwk: 3754
Home
Sydney Park
c01732 ACA033
8925 ft
491.13 km/h
Sqwk: 1117
7c6ca8 JST403
-100 ft
59.26 km/h
Sqwk: 1124
©2011 Google - Map data ©2011 Tele Atlas, Imagery ©2011 TerraMetrics


VOZ511
4P
H1
H1
JST119
B0
B0
B0
AA
LAN800
B6
A6
RA
B6
RA
RA
RA
QFA142
VOZ825
ACA033
7c6c29
QC
H1
H1
H1
H1
YSSY
SIA221
H1
UAL839
Windsor Rd
M7
19.3 km
© 2011 Whereis® Sensis Pty Ltd
Image © 2011 Sinclair Knight Merz
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2011 DigitalGlobe
Eye alt 66.10 km
Terms of Use


1101 OFFRP 0800/15 YSSY/NZAA .CC-CQE
/OUT 2226/OFF 2245/POB 0742/ETA 0122
H1H1
SIA221
80
LAN800
VOZ819
© 2011 Whereis® Sensis Pty Ltd
Google earth



Live, smooth web streaming in...


Modez Mk I
EXIDE

Modez Mk IIpoint5

Modez Mk III


7c8031 RXA674
0 ft
61.20 km/h
Sqwk: 3707
7c810d RXA339
0 ft
64.80 km/h
Sqwk: 1041
7cf3d1
42350 ft
111.60 km/h
7c6d38 VOZ973
0 ft
0.00 km/h
Sqwk: 1452
Ground vehicle with Mode S!
(inspecting perimeter?)
©2011 Google - Map data ©2011 Tele Atlas, Imagery ©2011 TerraMetrics

7c6c32 TGW343
35000 ft
803.38 km/h
Sqwk: 1041
7cf85c REGL1
38800 ft
851.12 km/h
Sqwk: 1425
7c6dd8 QFA922
18875 ft
740.69 km/h
Sqwk: 1432
7c7a3b VOZ321
38000 ft
835.71 km/h
Sqwk: 1355
76ccd0 SQC7290
36000 ft
936.74 km/h
Sqwk: 0161
7c80fb
7700 ft
516.56 km/h
Sqwk: 4002
497.62 km/h
Sqwk: 3740
89611b UAE418
27200 ft
933.50 km/h
Sqwk: 1545
7c6d31 VOZ411
23850 ft
910.08 km/h
Sqwk: 3726
7c6c92 JST747
31850 ft
852.10 km/h
Sqwk: 4265
©2011 Google - Map data ©2011 Tele Atlas, Imagery ©2011 TerraMetrics

Aviation State

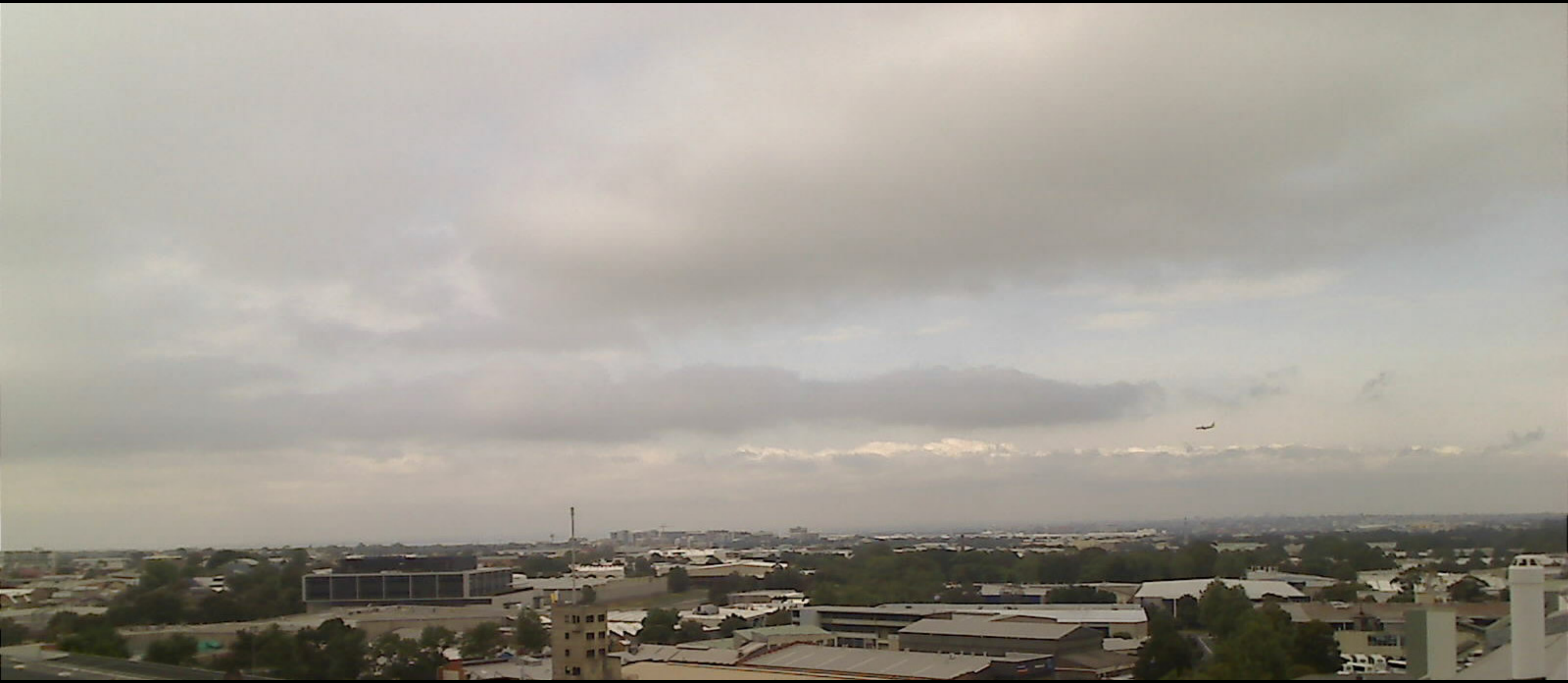
☐ Position

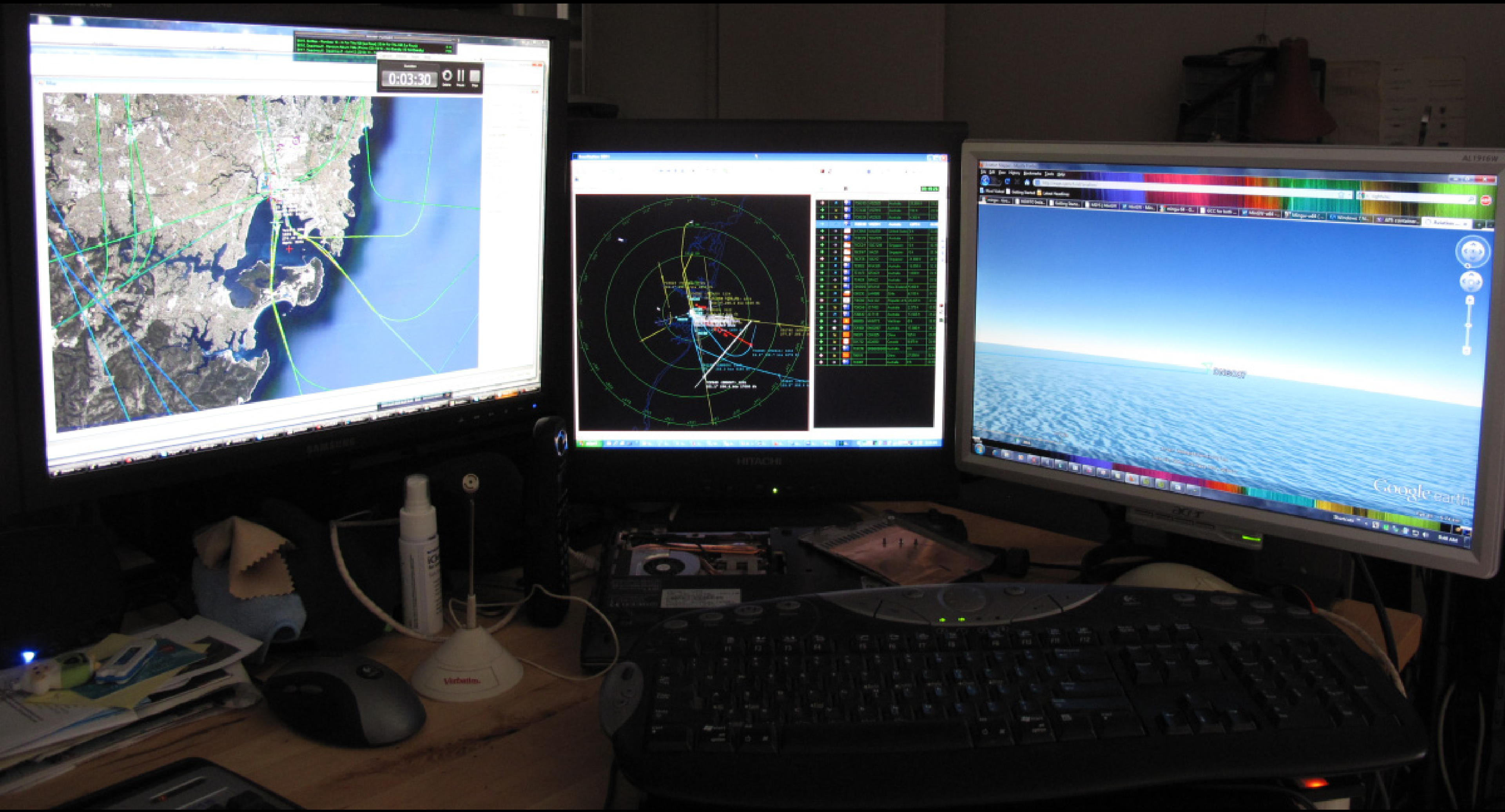
AA	Last Change	Vertical Status	Identity	Transponder	Altitude	Rate	Position	Speed	Heading	Distance
7c6289	16/11/2011 2:55:53 PM	Airborne			725					
7c6a7e	16/11/2011 1:29:35 PM	Airborne								
7c5310	16/11/2011 2:54:13 PM	Grounded		4253	-150					
7cf7cb	16/11/2011 2:49:52 PM	Grounded		7722						
780236	16/11/2011 2:56:58 PM	Grounded	CPA101	2000	-150	0	33°56'14.7095"S,151°10'08.5533"E	0.00 kts	253.1250°	4.81 km
7c80f5	16/11/2011 2:41:54 PM	Grounded			-125					4.60 km
7c52fa	16/11/2011 2:24:15 PM	Grounded			-125					
7c6d2b	16/11/2011 2:25:52 PM	Grounded		4361	-125					63.82 km
7cf8f3	16/11/2011 2:55:53 PM	Airborne	PLUTO07	2501	31000					
8a02b7	16/11/2011 1:37:10 PM	Airborne		1354		2432		362.40 kts	288.3350°	87.73 km
76cd64	16/11/2011 2:43:08 PM	Grounded	SIA231	2221	-125	0		0.00 kts	295.3125°	5.15 km
7c6d80	16/11/2011 2:40:56 PM	Airborne		7212	24375					
7cf7be	16/11/2011 2:50:46 PM	Unknown			29000					
7c6d96	16/11/2011 2:56:28 PM	Grounded				0		0.00 kts	98.4375°	
7c81d2	16/11/2011 2:52:15 PM	Airborne		3646	30075					
7c7a38	16/11/2011 1:36:33 PM	Grounded		3760	-175	0	33°56'18.9551"S,151°10'57.7963"E	13.50 kts	348.7500°	4.26 km
7c6d37	16/11/2011 2:43:32 PM	Airborne			13125					54.98 km
7c6d2c	16/11/2011 2:53:49 PM	Airborne	VOZ1421	1372	27800	1280	33°29'19.1607"S,150°44'38.2874"E	416.43 kts	345.9638°	62.59 km
7c6c5b	16/11/2011 2:45:53 PM	Airborne			22925					50.02 km
7c6c9e	16/11/2011 2:55:18 PM	Airborne			32500	1984		426.43 kts	233.7751°	70.44 km
3a1e43	16/11/2011 2:56:00 PM	Airborne	ACI141S	1462	125	2176	33°57'12.3486"S,151°10'40.1397"E	152.78 kts	169.0578°	5.95 km

AA	Last Change	Vertical Status	Identity	Transponder	Altitude	Rate
a74647	28/05/2011 8:27:51 AM	Airborne				
a9b40d	28/05/2011 8:27:37 AM	Airborne		1717	11875	
a78dd7	28/05/2011 8:27:15 AM	Airborne				
a59b5e	28/05/2011 8:28:23 AM	Airborne			15100	
acdde3	28/05/2011 8:28:21 AM	Airborne			6825	
a733b4	28/05/2011 8:27:55 AM	Airborne			1800	
a2e28f	28/05/2011 8:28:18 AM	Airborne			32000	
a096cd	28/05/2011 8:28:22 AM	Airborne		3725	11600	
a83951	28/05/2011 8:28:22 AM	Airborne			2125	
ab4151	28/05/2011 8:28:19 AM	Airborne			3875	
a1b1bc	28/05/2011 8:27:58 AM	Airborne			19575	
ac7f4e	28/05/2011 8:28:13 AM	Airborne			65800	
ab4c15	28/05/2011 8:28:22 AM	Airborne	2246		13825	3712
aae233	28/05/2011 8:28:22 AM	Airborne			10300	
a22426	28/05/2011 8:28:21 AM	Airborne	SCOTSUXX		9775	-128
acae9a	28/05/2011 8:28:06 AM	Airborne			9800	
ab473a	28/05/2011 8:28:15 AM	Airborne			6775	
ad0119	28/05/2011 8:28:18 AM	Airborne			18225	
a72b6b	28/05/2011 8:28:22 AM	Airborne			18825	
100000	28/05/2011 8:27:37 AM	Airborne				
a699a6	28/05/2011 8:27:32 AM	Airborne				
a1a2e0	28/05/2011 8:27:59 AM	Airborne			3800	
a3ca18	28/05/2011 8:28:20 AM	Airborne			17050	
a6dd66	28/05/2011 8:28:23 AM	Airborne			2000	
3c7202	28/05/2011 8:27:59 AM	Airborne	BER7393		6525	2432

Next Level Modez


ELECTUS
PLUS



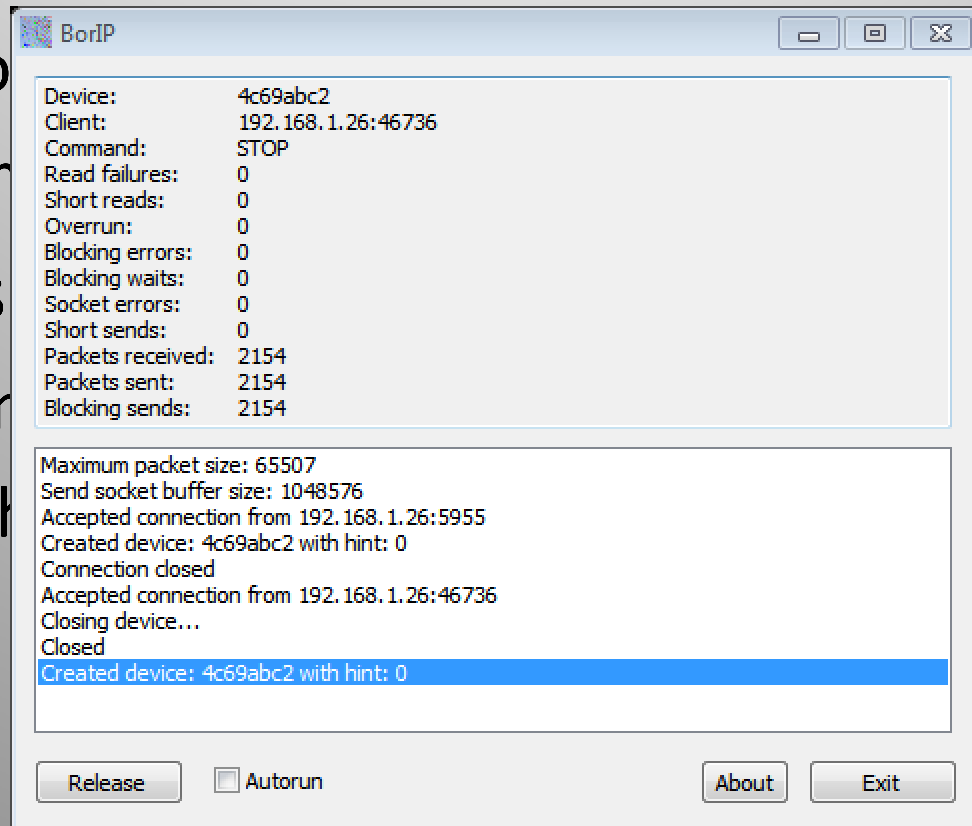

0:03:30

BorIP

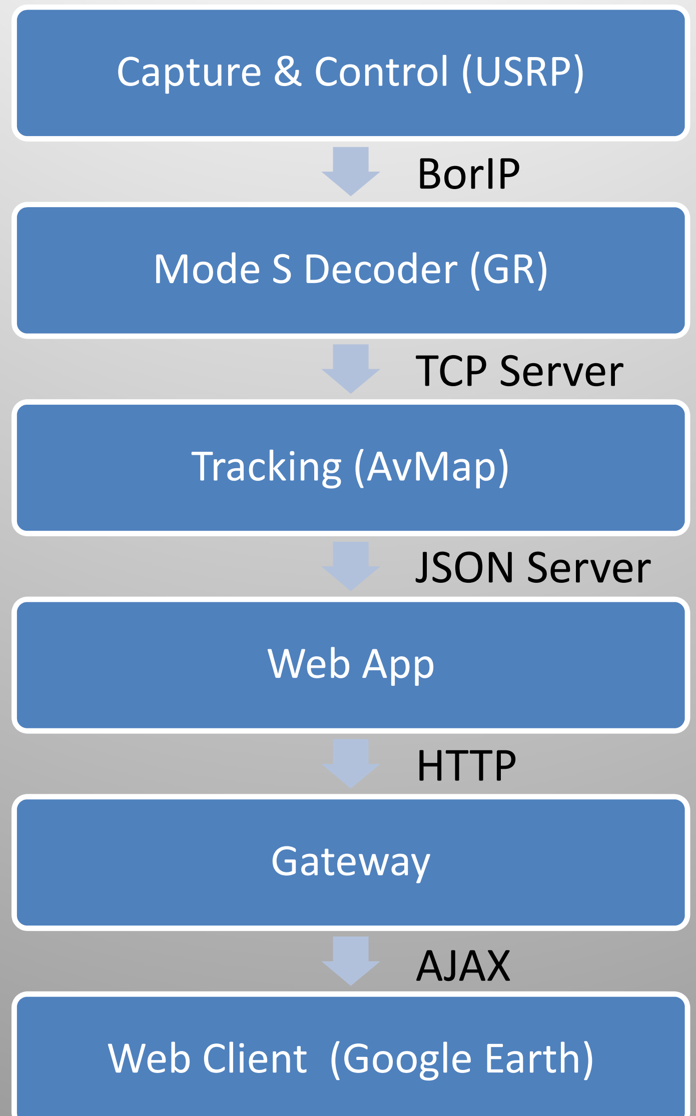
- Allows USRP 1 and computer to be separated by LAN
  - Control radio via TCP
  - Stream baseband via UDP
- Seamless drop-in for GR
  - If it can’t find a local device, try remote
  - Everything just works (USRP Source, GR, etc)

BorIP

- Allows USRP 1 and computer to be separated by LAN
  - Contro
  - Stream
- Seamles
  - If it car
  - Everyt R, etc)



Antenna to Google Earth

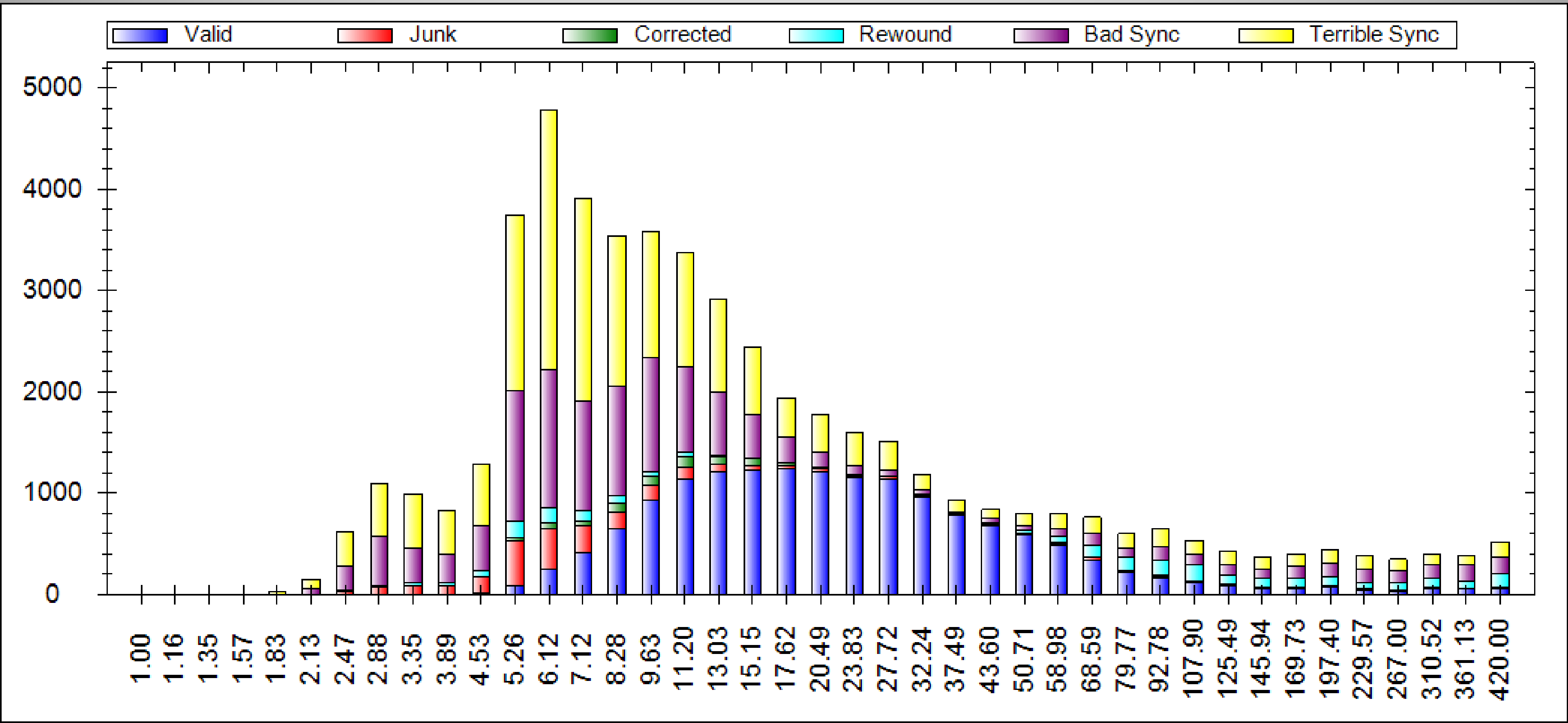


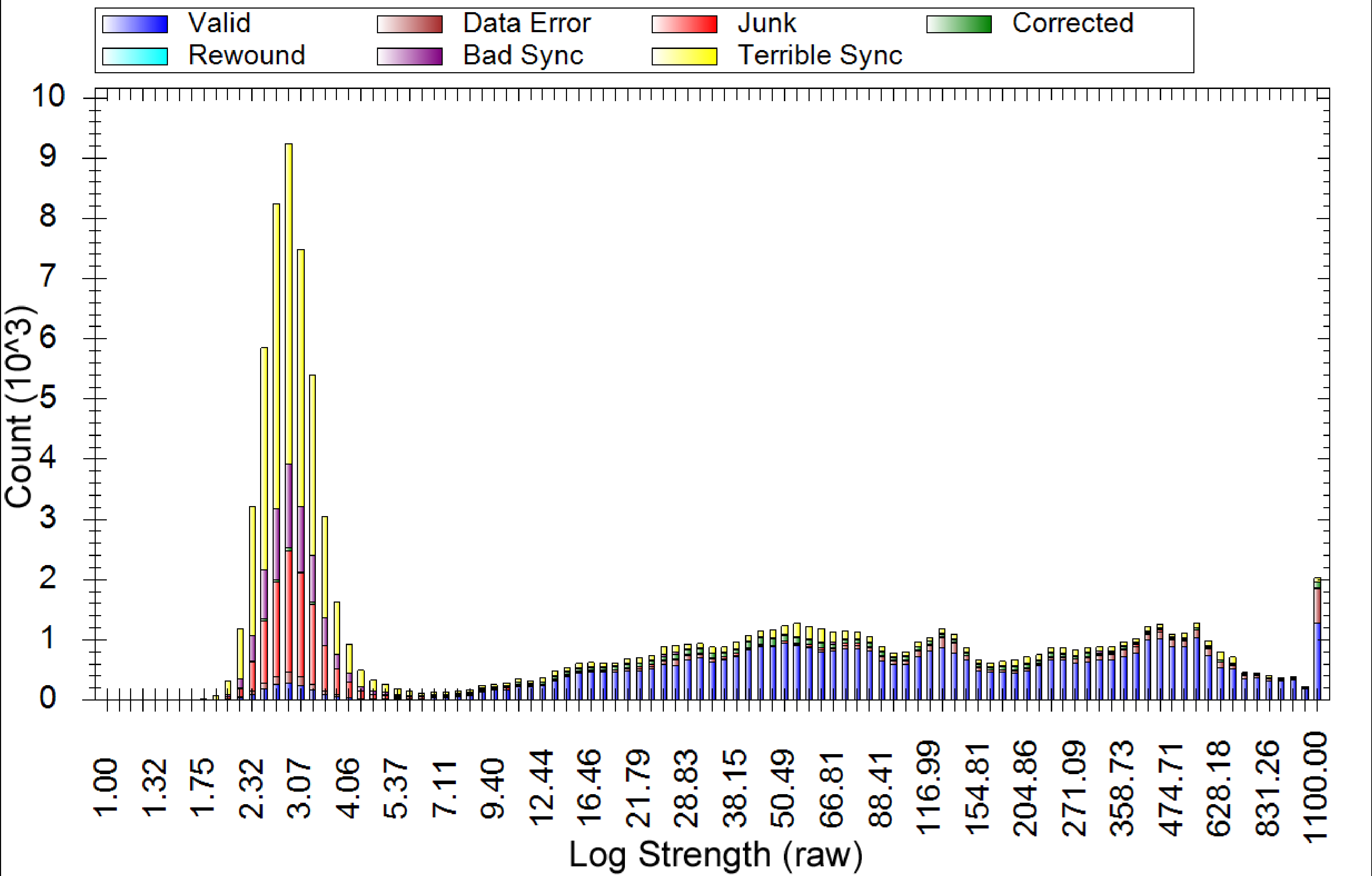
Modez Evolution

- Goal is to increase SNR
  - Increase gain: tuned antenna
  - Drop noise floor: front-end filter (GSM is nearby) & optimal sample rate to avoid artifacts (spurs)

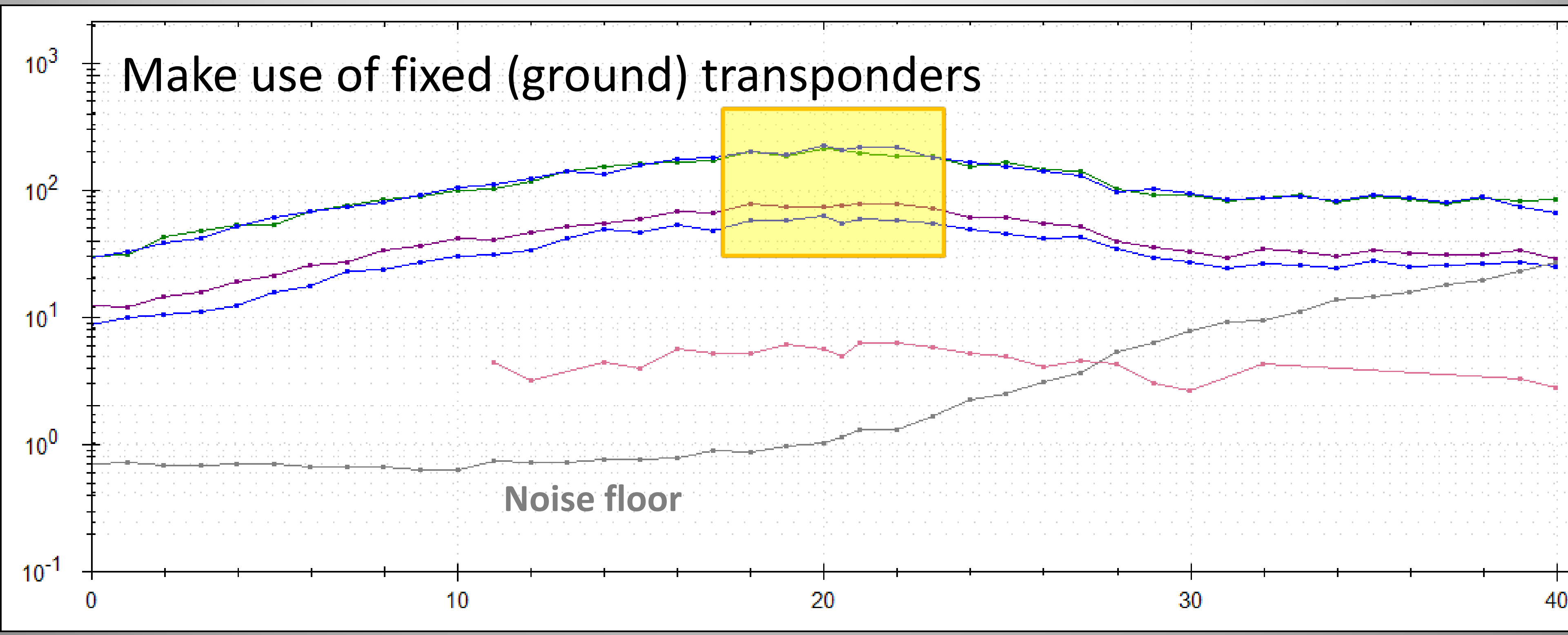
Signal Strength Distribution

- Evaluate how well decoder is doing



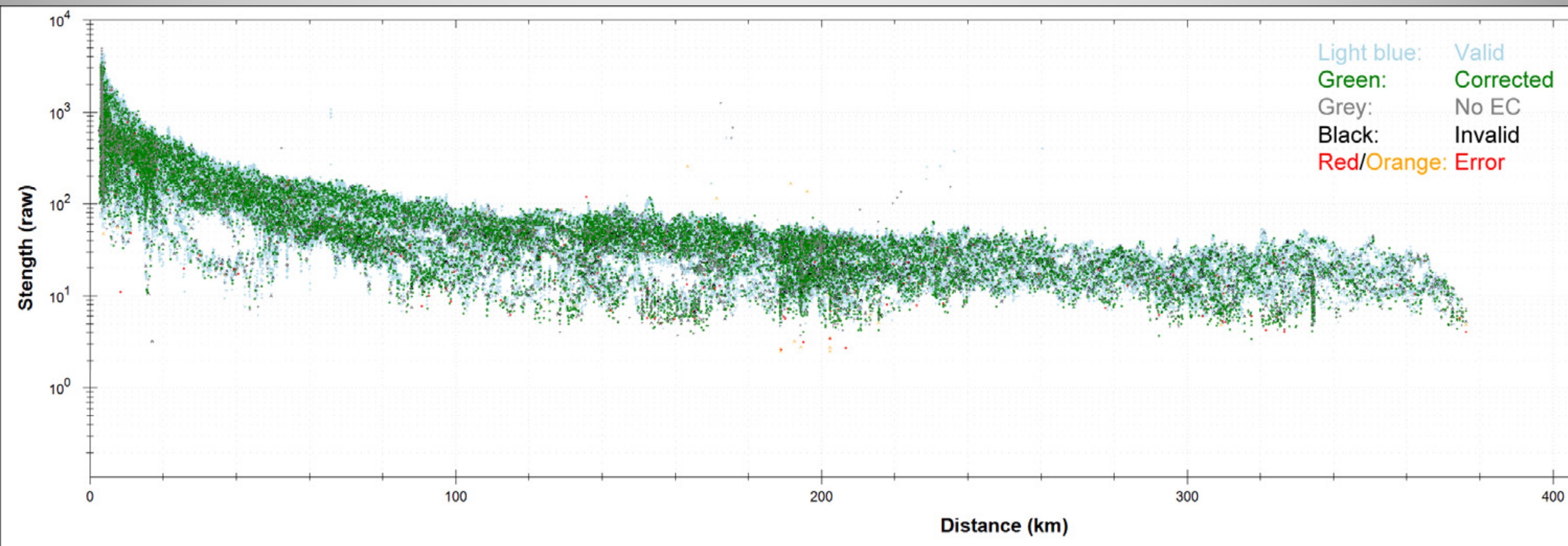

Valid
Data Error
Junk
Corrected
Rewound
Bad Sync
Terrible Sync
Count (10^3)
0
1
2
3
4
5
6
7
8
9
10
1.00
1.32
1.75
2.32
3.07
4.06
5.37
7.11
9.40
12.44
16.46
21.79
28.83
38.15
50.49
66.81
88.41
116.99
154.81
204.86
271.09
358.73
474.71
628.18
831.26
1100.00
Log Strength (raw)

SNR vs. Gain

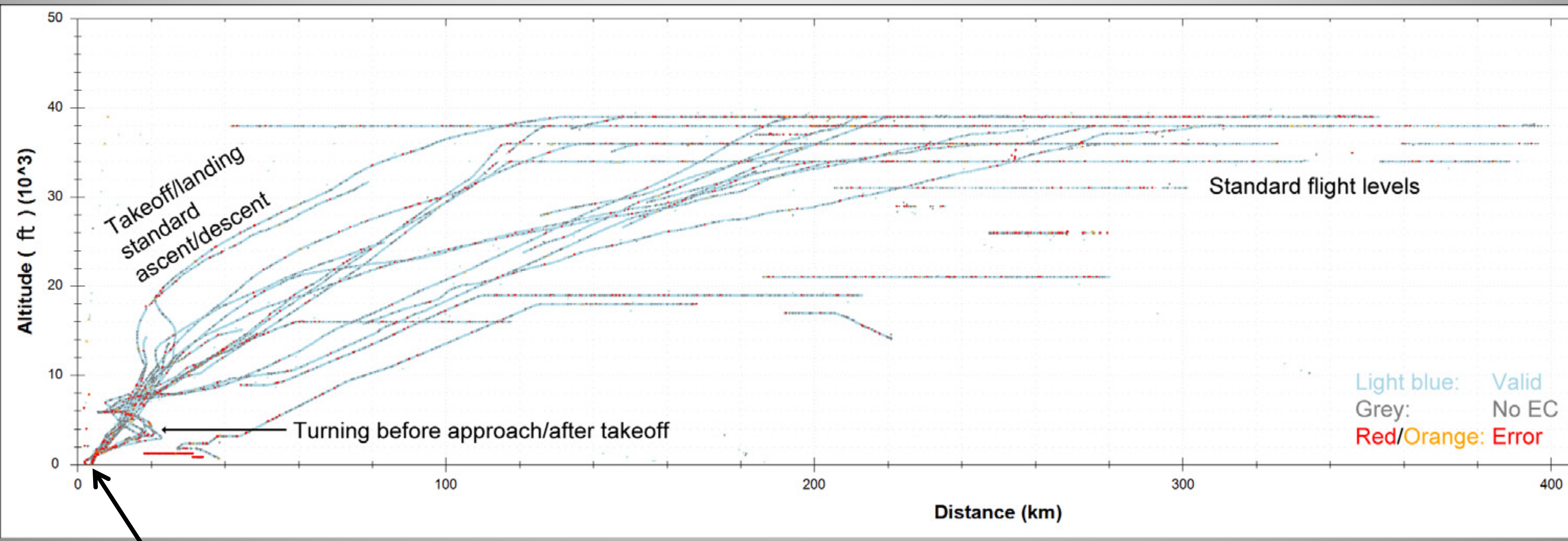


Change USRP/WBX gain

Strength vs. Distance

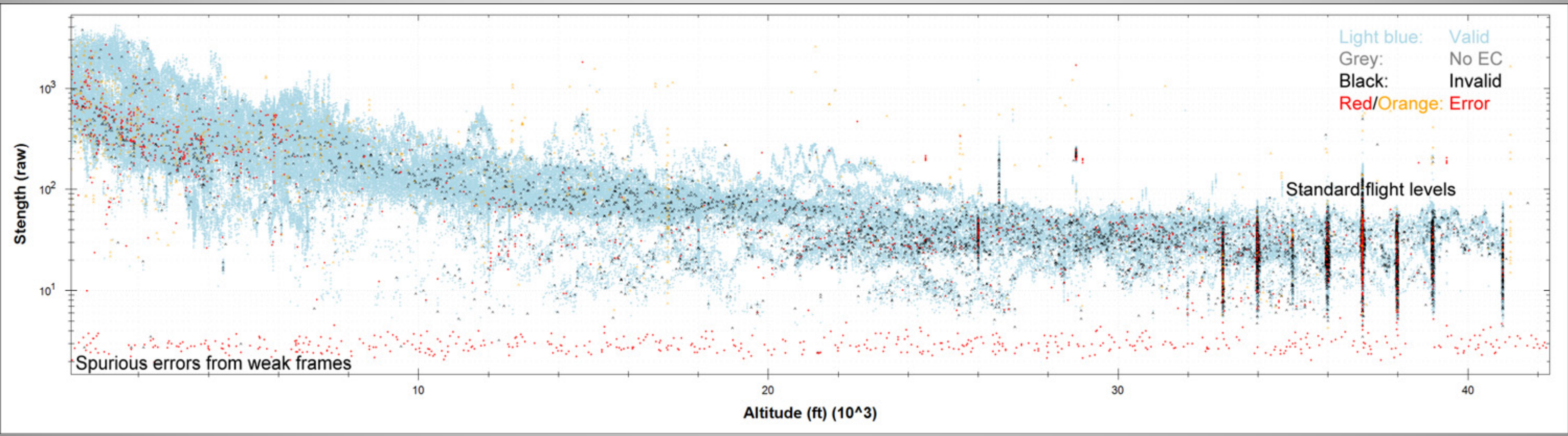


Altitude vs. Distance



Helps to live close to the airport

Strength vs. Altitude




- #MD/AA MELCAYA.CR1.VH-OJP201D7CE8ECCD9B36A2D3
7c8026 RXA339
7c6b2f JST525
7c6d2c VOZ874
7c6b2d JST459
7c8032 RXA833
7c810d SXA427LH
Q0
3L
QF
2L
13
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2011 Whereis® Sensis Pty Ltd
Image © 2011 Sinclair Knight Merz
© 2011 Cnes/Spot Image
5.99 km
2009
34°12'18.93" S 151°14'02.97" E elev -129 m
Google earth
Terms of Use
Eye alt 10.61 km

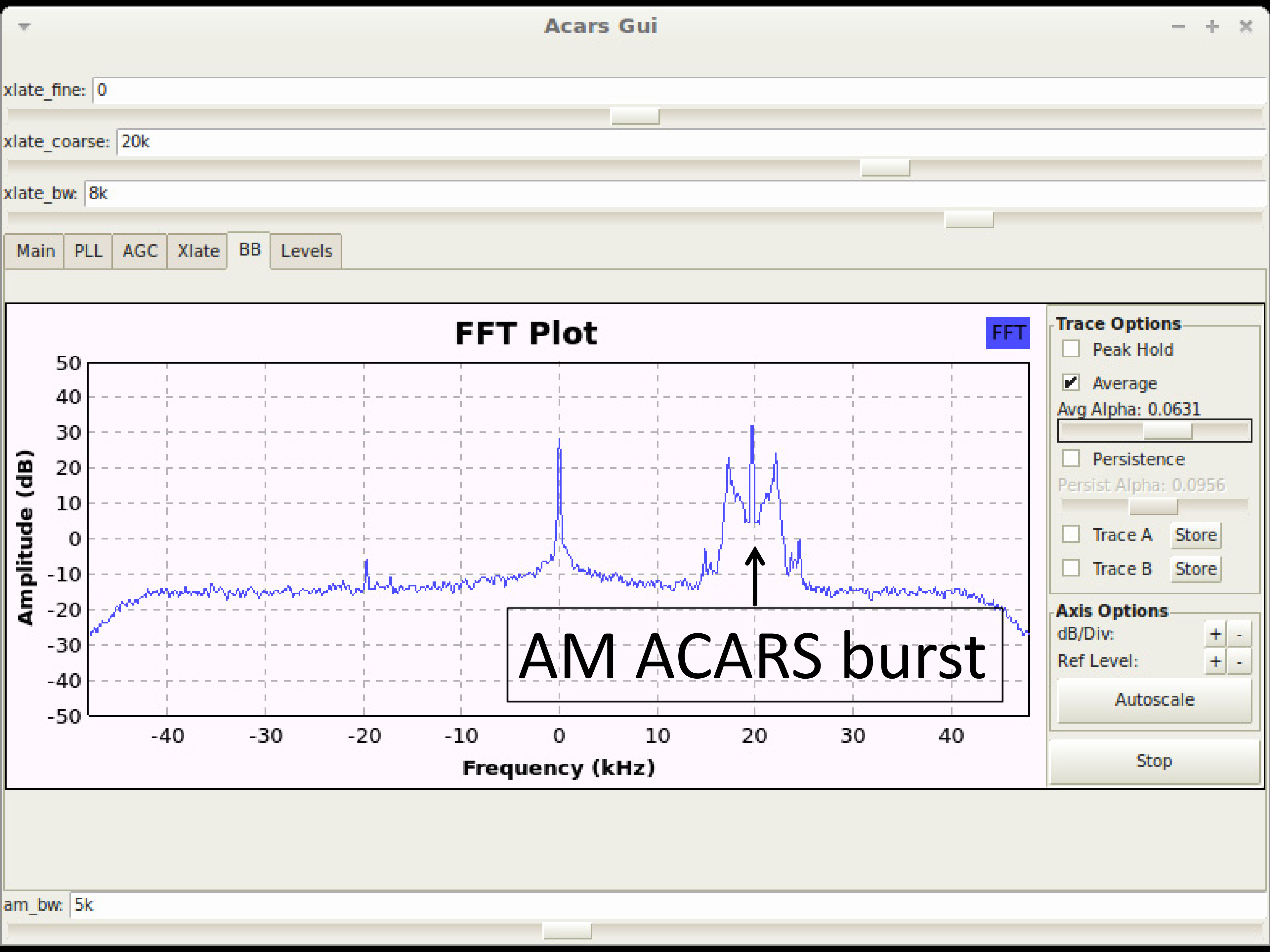
ACARS

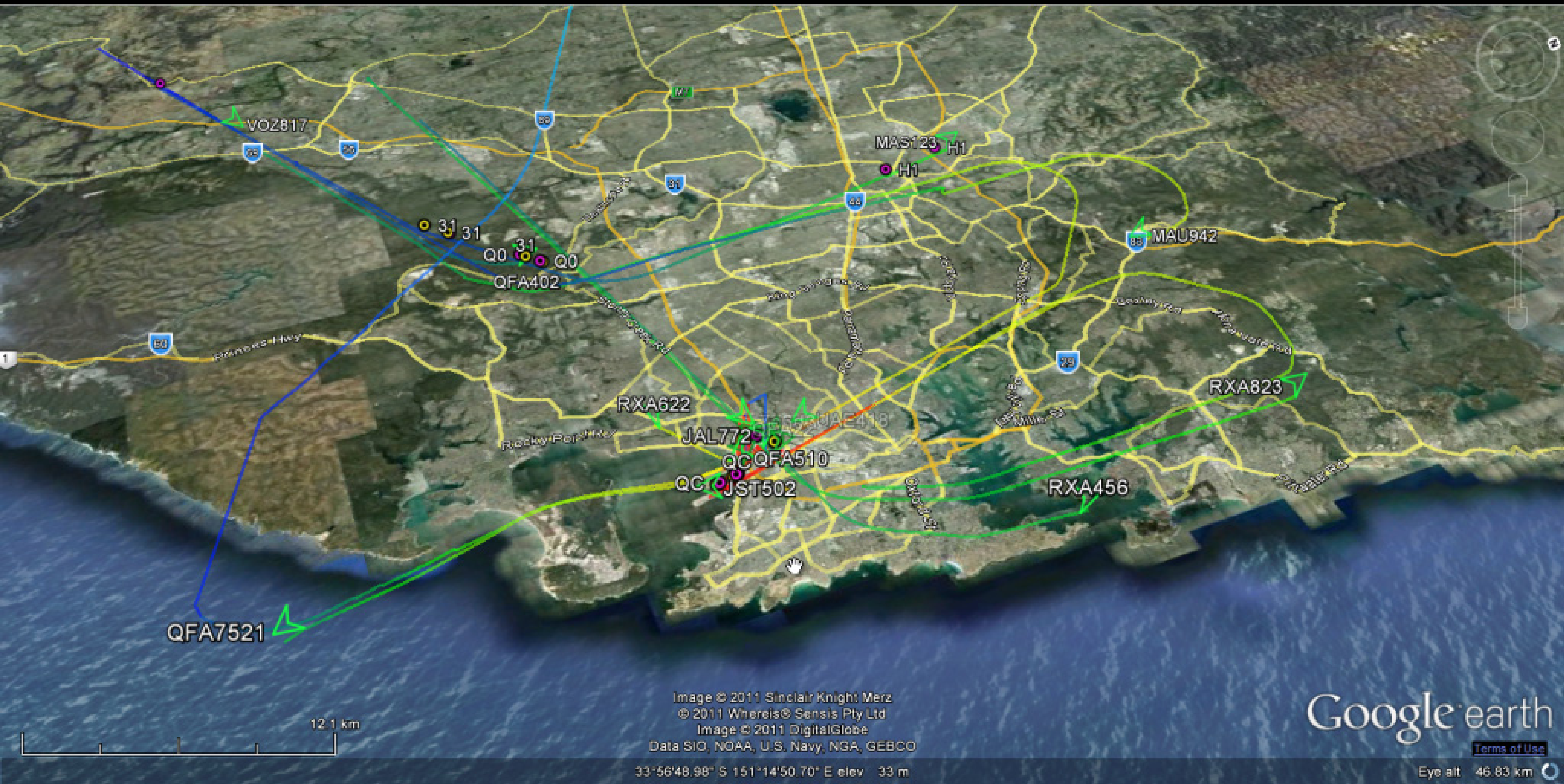
- **A**ircraft **C**ommunication **a**nd **R**eporting **S**ystem
- ‘Text messaging’ for aircraft
- Wide-reaching network
  - VHF ground stations
  - HF datalink
  - SATCOM
- Manual and automated messages between:
  - Cockpit, ATC, airline ops & airport ground staff
  - Avionics/engines, airline maintenance & equipment (engine) manufactures

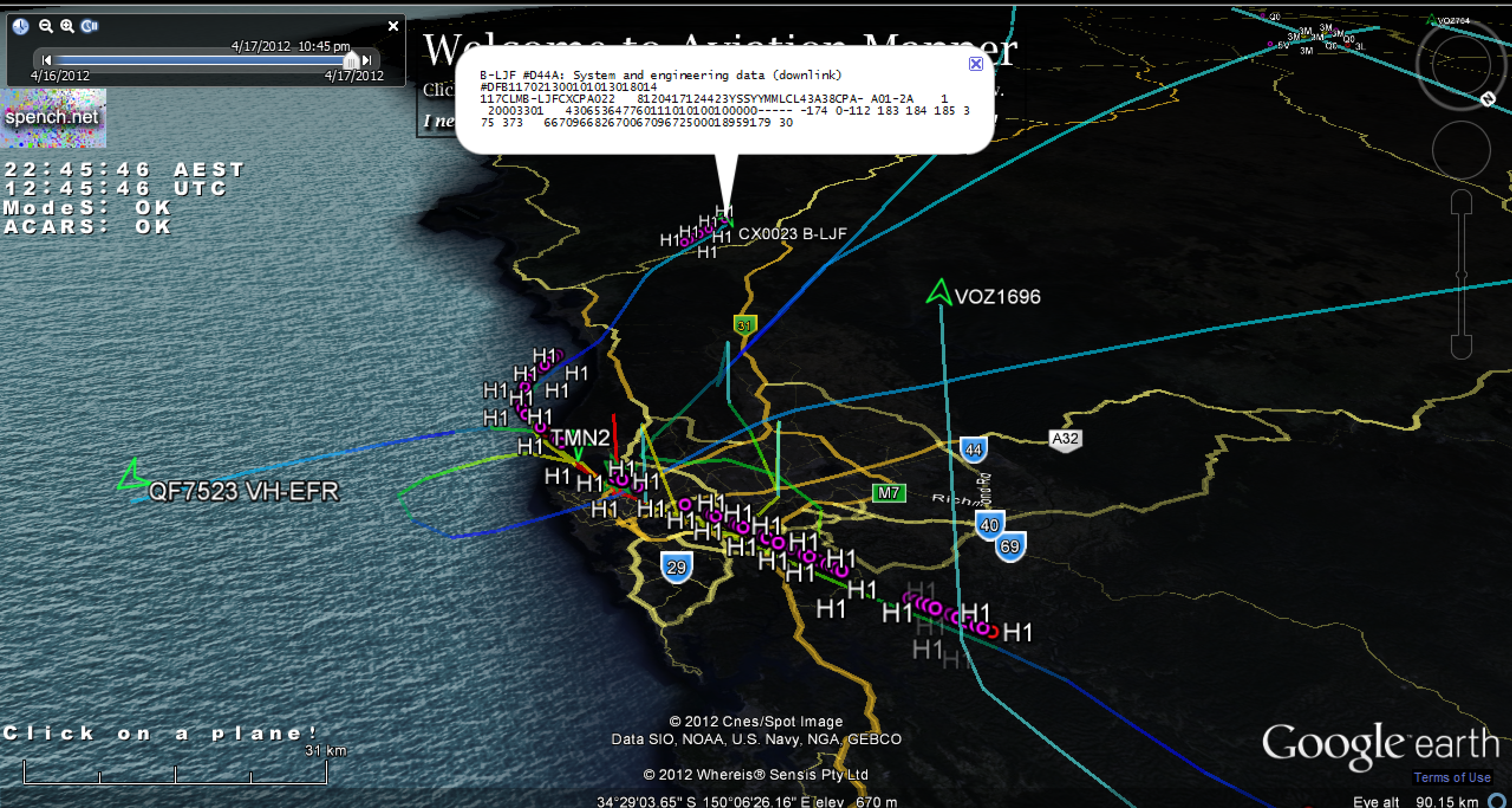
Streaming

- Listening to primary & secondary frequencies
- Decoded, combined, JSON-ified & served

```
Time:        2011-11-15 22:42:17.894000
Station:     Home
Frequency:   131.55 MHz
Mode:        S (downlink, LCN: 19)
Address:     VH-OJD
Ack:         NAK
Label:       H1: System and engineering data
Block:       6
Message #:   C15A
Flight ID:   QF0021
#CFB/BLVBOCR.


 A RPT20 PG1  L-APU REAL
 B VH-OJD 15NOV11 1142 QFA21   YSSY/RJAA 685-2270-011 RR-508 ES


 1  489 100.0  92.8
 2  GND
 3    OPEN
 4  OFF 0.83
 5  OFF 100
 6   ON  ON 226 226
 7


Time:        2011-11-15 22:42:18.111000
Station:     Home
Frequency:   131.55 MHz
Mode:        s (uplink, LCN: 19)
Address:     A6-ECV
Ack:         7
Label:       _<DEL>: General Response (Demand Mode)
Block:       P


Time:        2011-11-15 22:42:22.203000
Station:     Home
Frequency:   131.55 MHz
Mode:        S (downlink, LCN: 19)
Address:     VH-OJD
Ack:         NAK
Label:       H1: System and engineering data
Block:       7
Message #:   C15B
Flight ID:   QF0021
#CFB  NORM 14.1
 8    OPEN  20
 9   ON  28
 10  ON 202
 11     MES 32 32
 12 NORM  70  70
 13   OPEN  53  53
 14 102
 15    94  61   0
 16  2266 CHG  2
 17  1760 27
 18 15NOV11 11:42:13
 19
```


Acars Gui
xlate_fine: 0
xlate_coarse: 20k
xlate_bw: 8k
Main
PLL
AGC
Xlate
BB
Levels
FFT Plot
FFT
Amplitude (dB)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-40
-30
-20
-10
0
10
20
30
40
Frequency (kHz)
AM ACARS burst
Trace Options
Peak Hold
Average
Avg Alpha: 0.0631
Persistence
Persist Alpha: 0.0956
Trace A
Store
Trace B
Store
Axis Options
dB/Div:
Ref Level:
Autoscale
Stop
am_bw: 5k


VOZ817
MAS123
H1
H1
MAU942
31
31
31
Q0
Q0
QFA402
RXA622
RXA823
JAL772
QFA510
QC
QC
JST502
RXA456
QFA7521
12.1 km
Image © 2011 Sinclair Knight Merz
© 2011 Whereis® Sensis Pty Ltd
Image © 2011 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
Terms of Use
33°56'48.98" S 151°14'50.70" E elev 33 m
Eye alt 46.83 km


4/17/2012 10:45 pm
4/16/2012
4/17/2012
spench.net
22:45:46 AEST
12:45:46 UTC
ModeS: OK
ACARS: OK
B-LJF #D44A: System and engineering data (downlink)
#DFB117021300101013018014
117CLMB-LJFCXCPA022   8120417124423YSSYYMMLCL43A38CPA- A01-2A   1
 20003301   430653647760111010100100000----- -174 0-112 183 184 185 3
75 373   667096682670067096725000189591 79 30
CX0023 B-LJF
VOZ1696
TMN2
QF7523 VH-EFR
Click on a plane!
31 km
© 2012 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Whereis® Sensis Pty Ltd
34°29'03.65" S 150°06'26.16" E elev 670 m
Google earth
Terms of Use
Eye alt 90.15 km

Examples

```
Time:      2011-11-16 09:12:24.073000
Station:   Home
Frequency: 131.55 MHz
Mode:      s (uplink, LCN: 19)
Address:   9M-MPO
Ack:       NAK
Label:     31: Airline Defined Message
Block:     W
S
1. TOILET CC1-INOP
2. ROW 30-31 DEFG-CARPET FLOOR VERY WET
2. GALLEY 3-CART LIFT FLOODED
```

Examples

```
Time:       2011-11-16 09:49:00.255000
Station:    Home
Frequency: 131.45 MHz
Mode:       2 (either)
Address:    VN-A375
Ack:        NAK
Label:      H1: System and engineering data (downlink)
Block:      4
Message #: C12A
Flight ID: VN0773
#CFB.1/MPF/ANVN-A375/FIHVN773
/DM11115224900NOV1514042244PFR1/DAVVTS/DSYSSY/FR383141VSC
1,,,,,,,LAV 37,HARD,140505;237346CIDS1  1,,,,,,,DEU A
(200RH2),HARD,140505;383141VSC    1,,,,,,,LAV 53,HARD,174906;
```

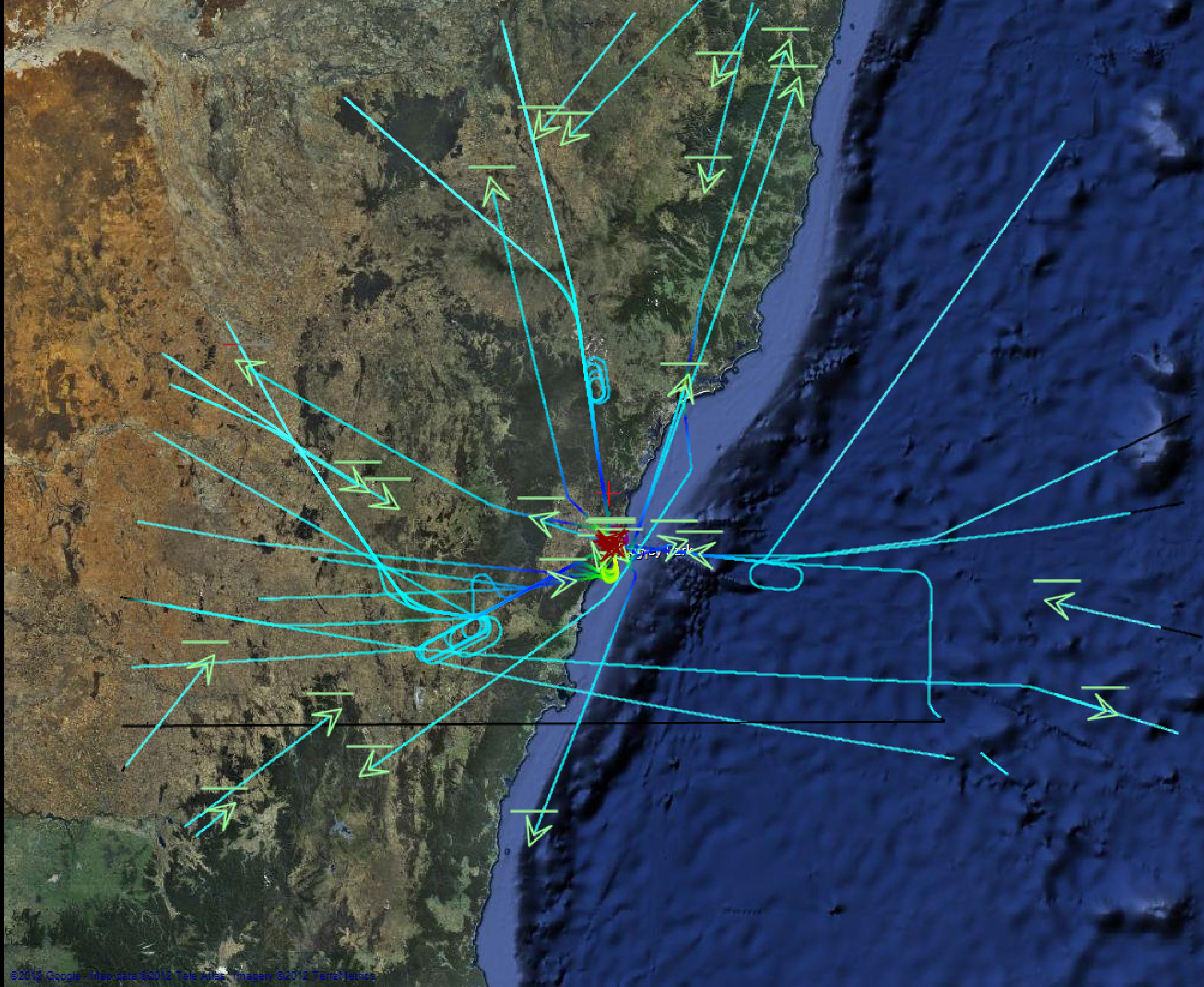
Examples

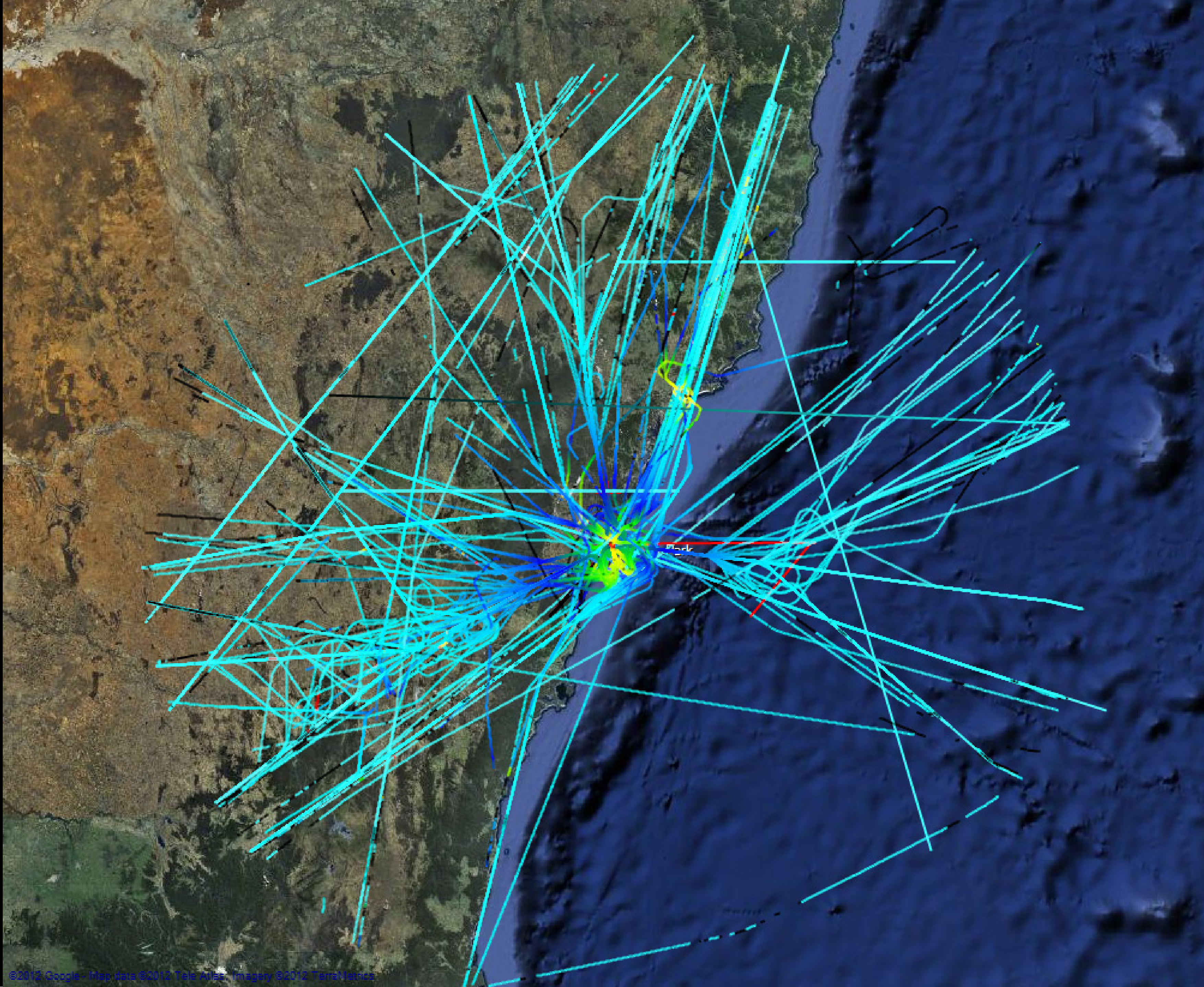
```
Time:       2011-11-16 09:49:06.844000
Station:    Home
Frequency:  131.45 MHz
Mode:       2 (either)
Address:    VN-A375
Ack:        NAK
Label:      H1: System and engineering data (downlink)
Block:      5
Message #:  C12B
Flight ID:  VN0773
#CFB383141VSC    1,,,,,,,LAV 61,HARD,202806;344137WXR2
1,,,,,,,WXR MOUNTING TRAY (5SQ),INTERMITTENT,203506,EOR
```

4/13/2012
2012
2012
spench.net
Welcome to Aviation Mapper
Click here for info, feedback and to share – if you like this, let me know.
I need to find a new receiver site near the airport ASAP - please help!
Barrier Hwy
Mitchell Hwy
ModeS: OK
ACARS: OK
BANDA
CORKY
BULGA
LV-ZRA #C71C: System and engineering data (downlink)
#CFBAULT,212606;2128455MAINTENANCE STATUS CRG VENT,213006/FR212300VC X2
,,,,,,,,GALY LAV DUCT CLOGGED,HARD,,EOR
PRAWN
PRAWN
H1
H1
H1 'System and engineering data' regarding the (failure of) toilets?
Hume Hwy
RAZZI
http://maps.spench.net/aviation/
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
© 2012 Whereis® Sensis Pty Ltd
Click on a plane!
181 km
Google earth
Terms of Use
33°51'01.32" S 151°24'46.54" E elev -60 m
Eye alt 786.43 km


4/15/2012 9:45 pm
4/14/2012
4/15/2012
spench.net
Welcome to Aviation Mapper
Click here for info, feedback and to share – if you like this, let me know.
I need to find a new receiver site near the airport ASAP - please help!
21:02:32 AEST
11:02:32 UTC
ModeS: Terminated
ACARS: OK
http://maps.spench.net/aviation/
International &
cross-country
flight paths
sent as flight plans
using IFR waypoints
GUTEV
IGOPO
GATOR
ROBIN
NERTI
DUMAV
EGORE
MONIC
MELBO
TIMET
RUVAP
NORMA
DOTAP
TASHA
FORMA
SARIK
TAVEV
NONET
VILOL
AKLET
ONIVI
MACLA
UNDER
GRABL
DUNDA
HECTO
FLAKE
FILET
FAGIN
ACTIN
BLACK
MAXEM
POINT
Click on a plane!
2709 km
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
© 2012 Whereis® Sensis Pty Ltd
Google earth
Terms of Use
Waiting for krump-dev...
3°56'15.16" N 93°48'49.69" E elev -1305 m
Eye alt 5231.14 km

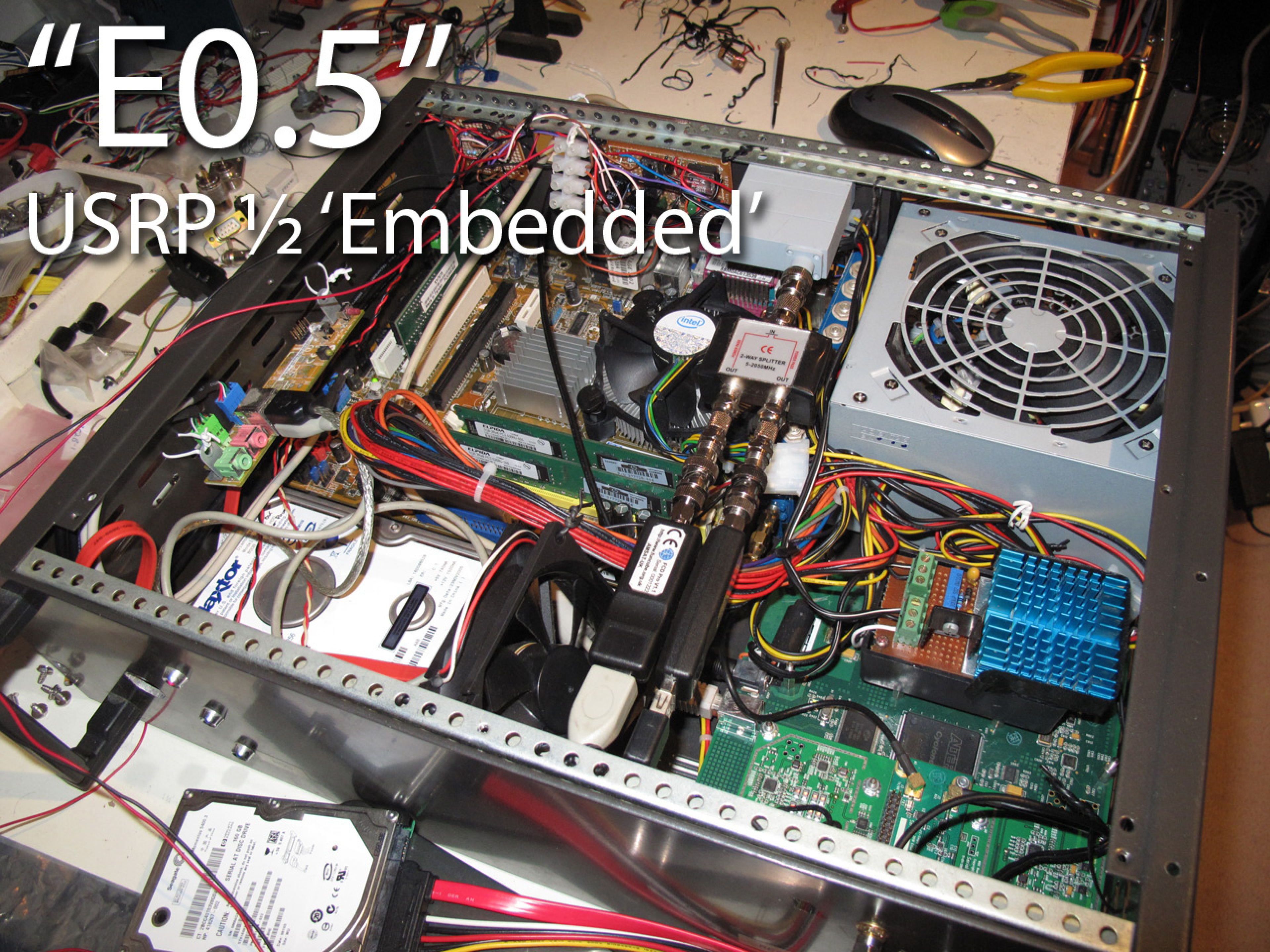
4/27/2012 5:06 pm
Welcome to Aviation Mapper
Click here for info, feedback and to share - if you like this, let me know.
I need to find a new receiver site near the airport ASAP - please help!
spench.net
15:46:23 AEST
05:46:23 UTC
ModeS: OK
ACARS: OK
Auto Balloons
Trails
Trails need more CPU
QF0012 VH-OJM
Click on a plane!
164 ft
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth
Terms of Use
Imagery Date: 1/1/2009
2000
33°56'03.95" S 151°10'05.37" E elev 25 ft
Eye alt 760 ft

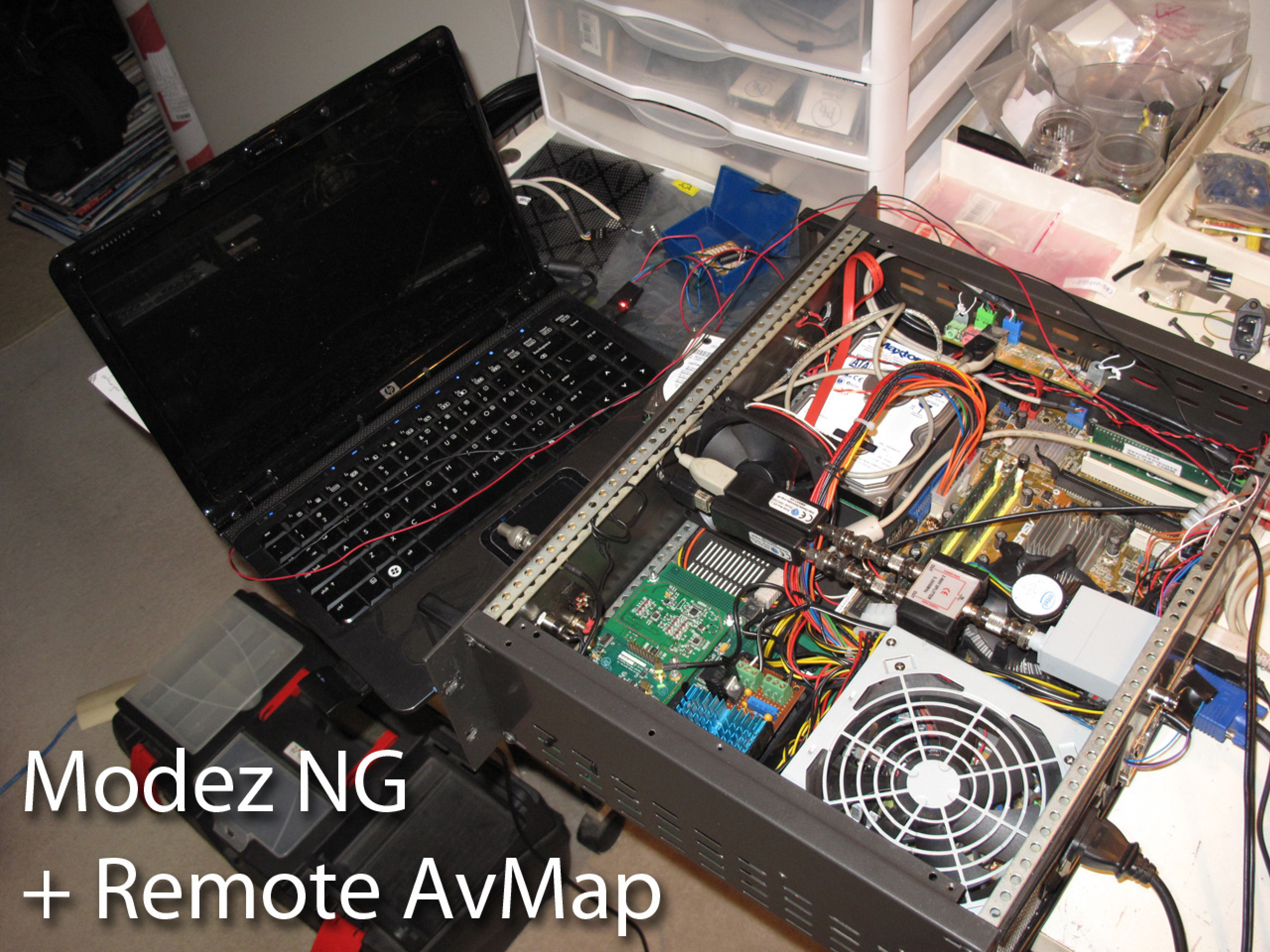

©2012 Google - Map data ©2012 Tele Atlas, Imagery ©2012 TerraMetrics


©2012 Google - Map data ©2012 Tele Atlas, Imagery ©2012 TerraMetrics

“E0.5”

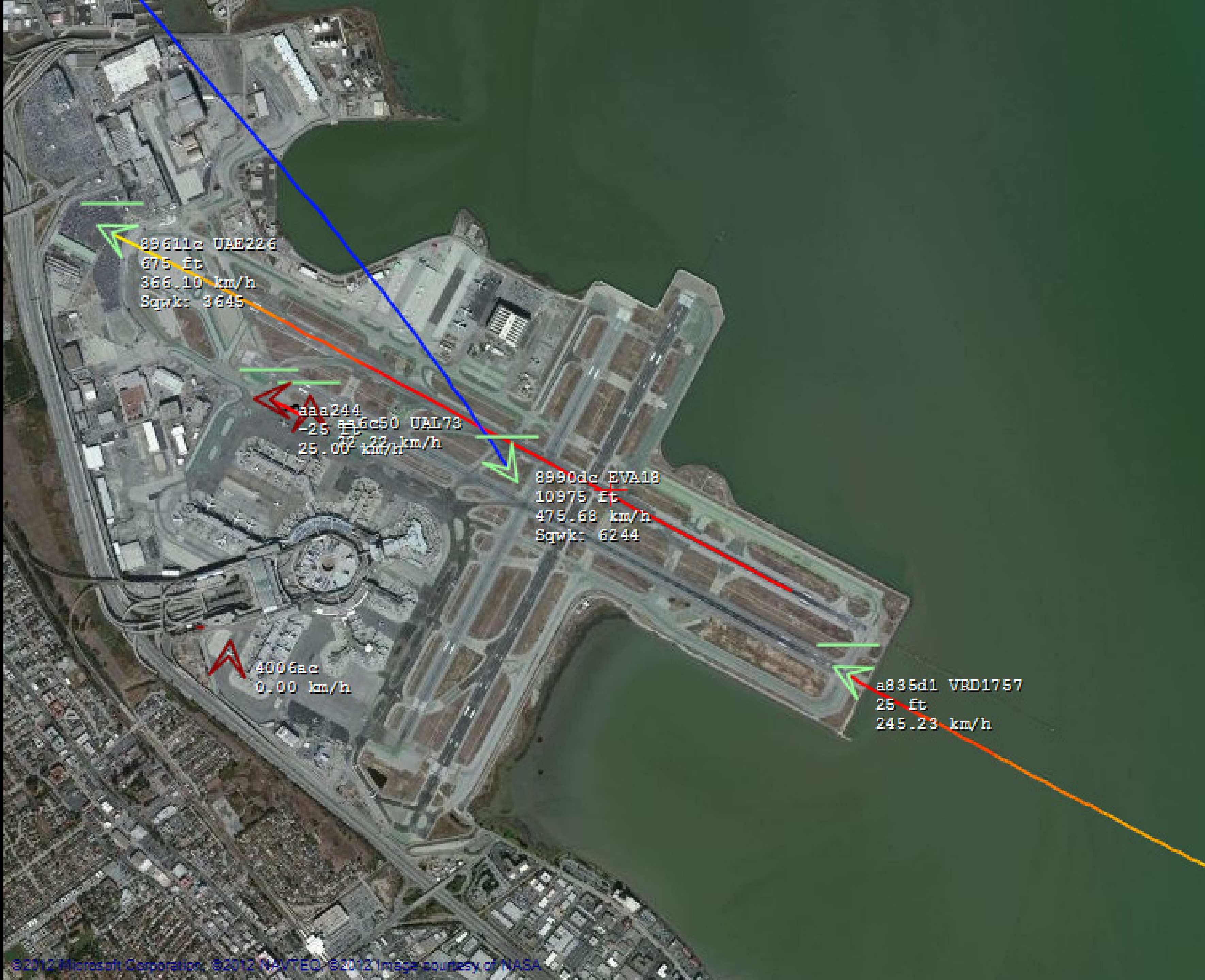
USRP ½ ‘Embedded’

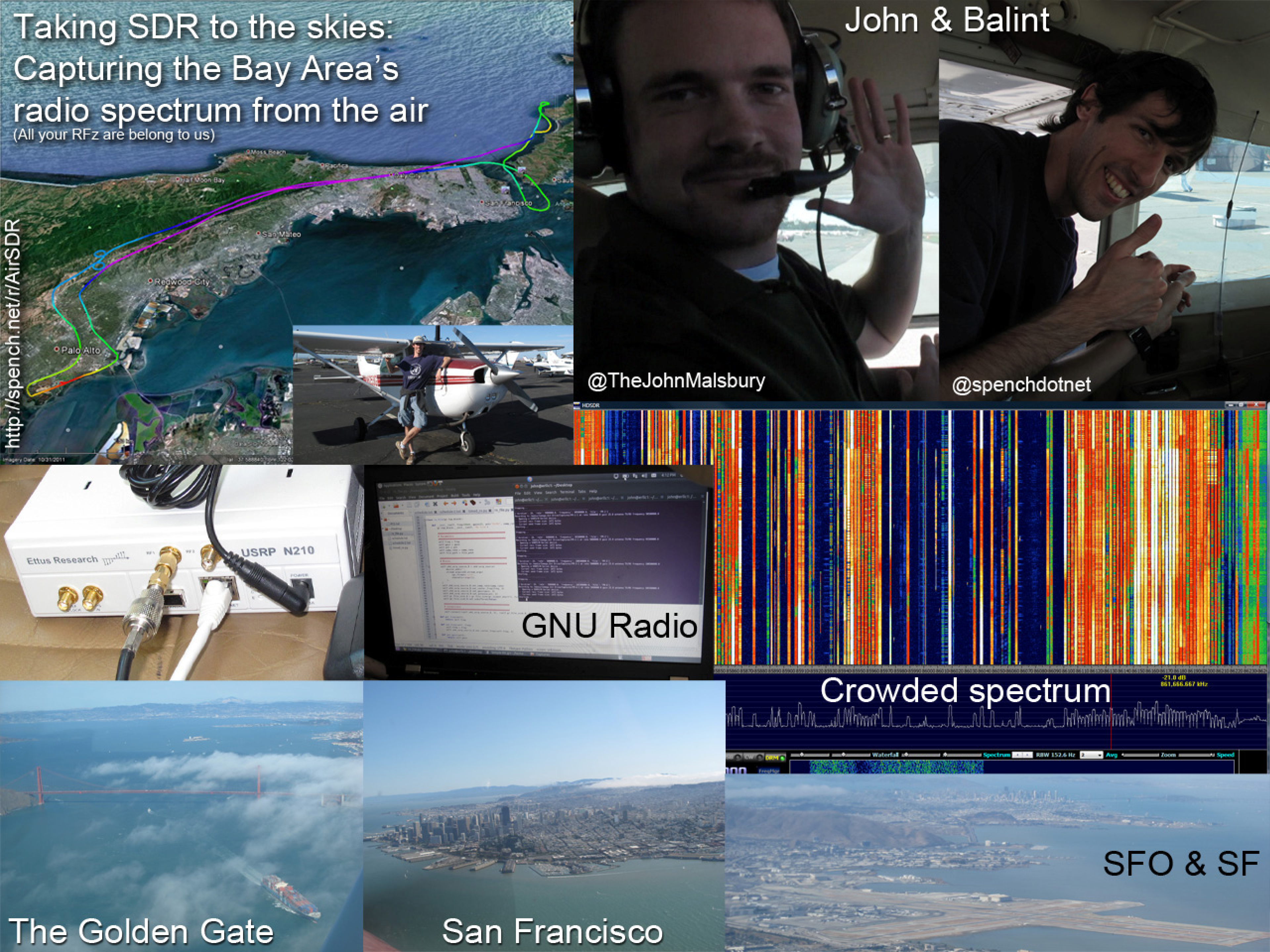



Modez NG
+ Remote AvMap

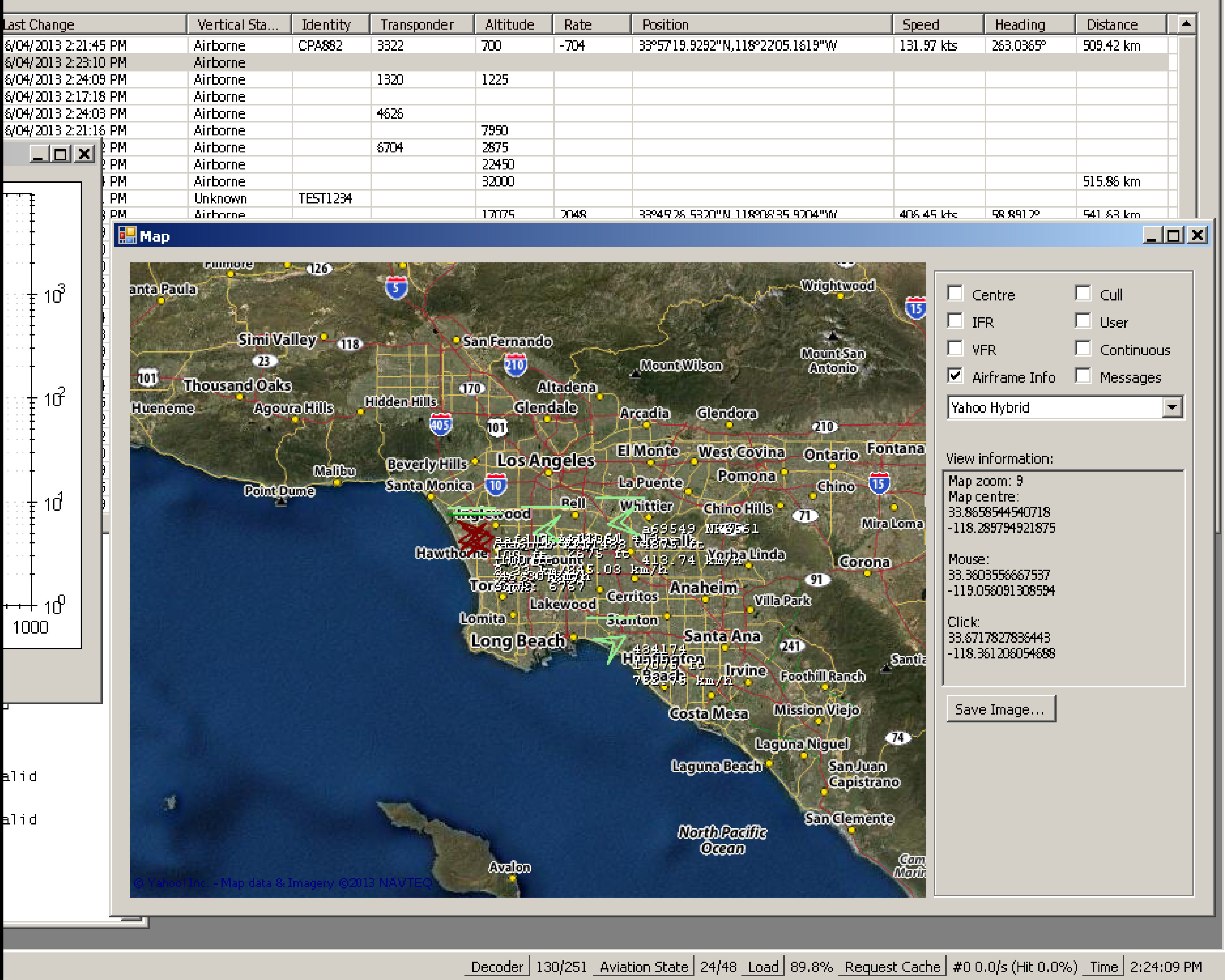

Modez NG
AvMap's view:


a835d1 VRD1757
30600 ft
795.21 km/h
a47557 AAL73
34000 ft
779.22 km/h
Sqwk: 5676
NoiseBridge
Sqwk: 3641
Ettus
ab856c VRD958
31575 ft
848.60 km/h
©2012 Microsoft Corporation, ©2012 NAVTEQ, ©2012 Image courtesy of NASA


89611c UAE226
675 ft
366.10 km/h
Sqwk: 3645
aaa244
-25 ft
25.00 km/h
UAL73
8990dc EVA18
10975 ft
475.68 km/h
Sqwk: 6244
4006ac
0.00 km/h
a835d1 VRD1757
25 ft
245.23 km/h
©2012 Microsoft Corporation, ©2012 NAVTEQ, ©2012 Image courtesy of NASA



Taking SDR to the skies:
Capturing the Bay Area's
radio spectrum from the air
(All your RFz are belong to us)
http://spench.net/r/AirSDR
San Mateo
Redwood City
Palo Alto
John & Balint
@TheJohnMalsbury
@spenchdotnet
Ettus Research
USRP N210
GNU Radio
Crowded spectrum
The Golden Gate
San Francisco
SFO & SF



Last Change
Vertical Sta...
Identity
Transponder
Altitude
Rate
Position
Speed
Heading
Distance
6/04/2013 2:21:45 PM Airborne CPA882 3322 700 -704 33°57'19.9292"N,118°22'05.1619"W 131.97 kts 263.0365° 509.42 km
6/04/2013 2:23:10 PM Airborne
6/04/2013 2:24:09 PM Airborne 1320 1225
6/04/2013 2:17:18 PM Airborne
6/04/2013 2:24:03 PM Airborne 4626
6/04/2013 2:21:16 PM Airborne 7950
PM Airborne 6704 2875
PM Airborne 22450
PM Airborne 32000 515.86 km
PM Unknown TEST1234
Map
Centre
Cull
IFR
User
VFR
Continuous
Airframe Info
Messages
Yahoo Hybrid
View information:
Map zoom: 9
Map centre:
33.8658544540718
-118.289794921875
Mouse:
33.3603556667537
-119.056091308594
Click:
33.6717827836443
-118.361206054688
Save Image...
Simi Valley
Thousand Oaks
San Fernando
Los Angeles
Glendale
Santa Monica
Beverly Hills
Malibu
Long Beach
Anaheim
Santa Ana
Irvine
Pomona
Ontario
Costa Mesa
Laguna Beach
San Clemente
North Pacific Ocean
Avalon
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1000
Decoder 130/251 Aviation State 24/48 Load 89.8% Request Cache #0 0.0/s (Hit 0.0%) Time 2:24:09 PM

HFDL

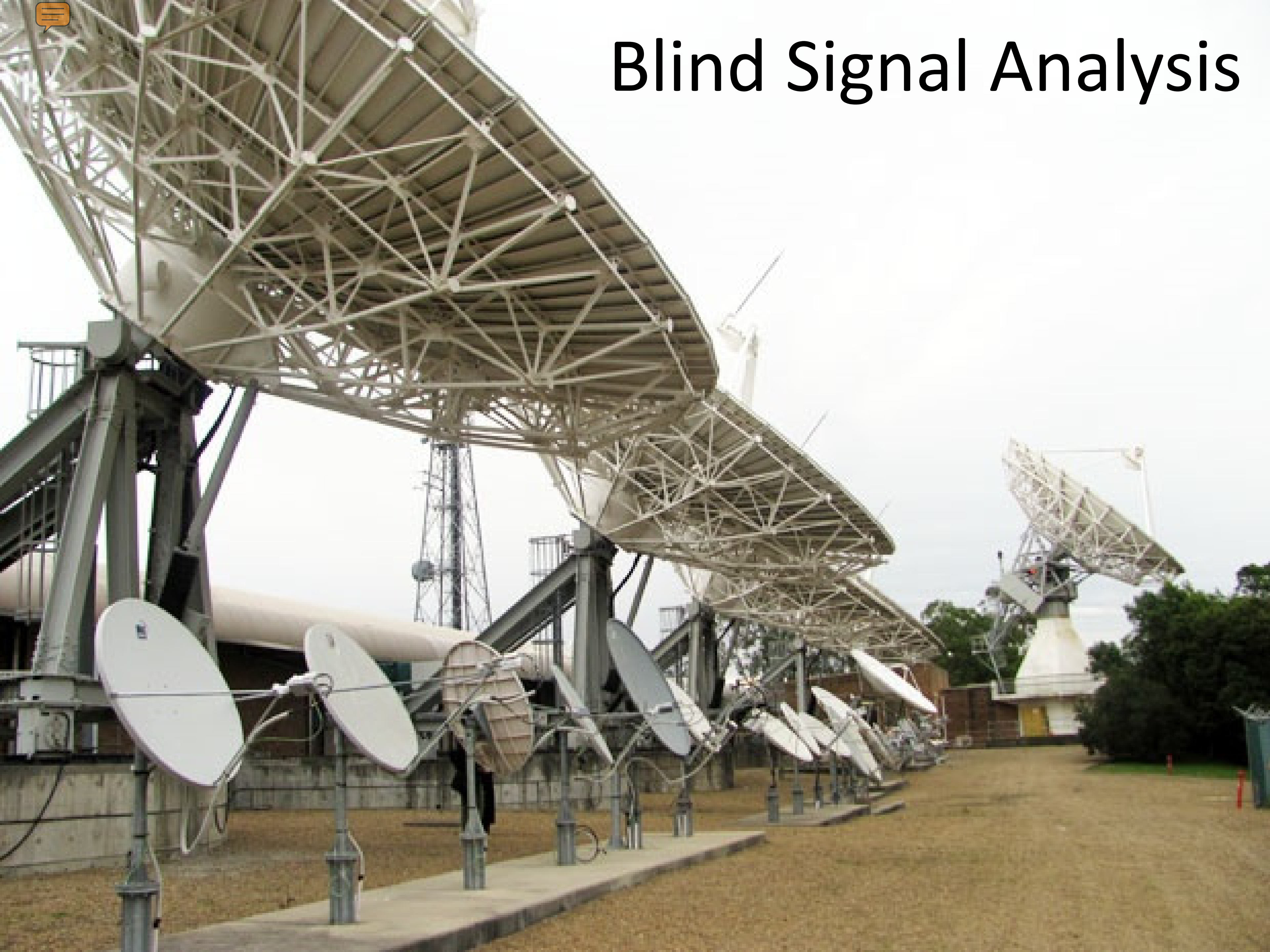
PC-HFDL

UP0009
CES514
CES233
China
CCA150
CCA410
3U8548
CCA451
CCA450
3U8931
5655
CSN309
Taipei
3U8869
Taiwan
CI0931
Hong Kong
Macau
Nepal
Kathmandu
Bhutan
IGO257
IGO212
Bangladesh
IGO245
IGO348
UP0021
IGO318
IGO041
India
Myanmar (Burma)
Hà Nội
SLK972
Laos
Naypyidaw
Philippines
Manila
Vientiane
Paracel Islands
IGO266
IGO377
6E0275
OMA811
6E0339
IGO276
Thailand
Vietnam
VJC838
IGO436
Bangkok
Cambodia
Phnom Penh
US Dept of State Geographer
© 2012 Google
© 2012 Tele Atlas
© 2012 Mapabc.com
lat 26.040498° lon 98.494735° elev 3003 m
Eye alt 4407.20 km
©2010 Google

What about no ADS-B?

- No position reports
- Signal is high bandwidth
- Multiple remote USRPs can be sync’d with GPSDO
- Perform multilateration on non-ADS-B (‘plain old’ Mode S)
- Calculate position from TDOA

Blind Signal Analysis



Recap

- Lots of different types of satellites
- Variables:
  - Purpose: comms, weather, MIL, amateur
  - Payload: transponders, cameras/sensors
  - Orbit: **L**ow **E**arth **O**rbit, geostationary (geosync)
  - Frequencies: uplink, downlink, beacon, command
- Two categories:
  - **Intelligent**: communication with on-board systems
  - **Dumb**: relay information with linear transponders

Wide-area re-broadcast

- RF megaphone (e.g. satellite TV)
- Single dish sends beam on uplink to satellite

Wide-area re-broadcast

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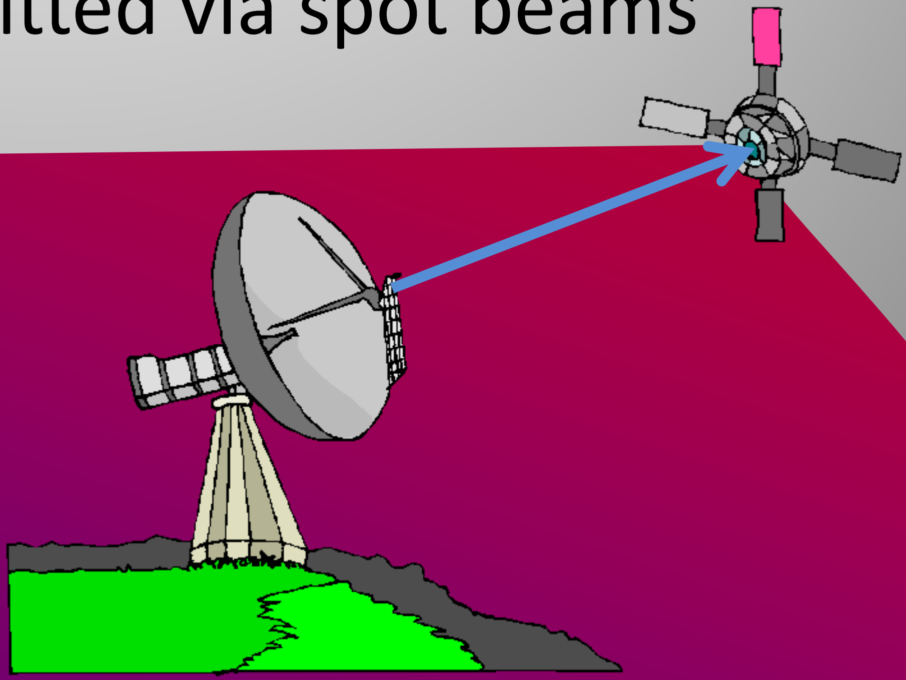
- Linear transponder shifts raw RF to downlink frequency, re-transmitted via spot beams



Wide-area re-broadcast

- RF megaphone (e.g. satellite TV)
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- Cover any entire country

Wide-area re-broadcast

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- Single dish sends beam on uplink to satellite
- Linear transponder shifts raw RF to downlink frequency, re-transmitted via spot beams
- Cover any entire country

- Linear transponders are **dumb**: re-broadcast anything onto coverage area

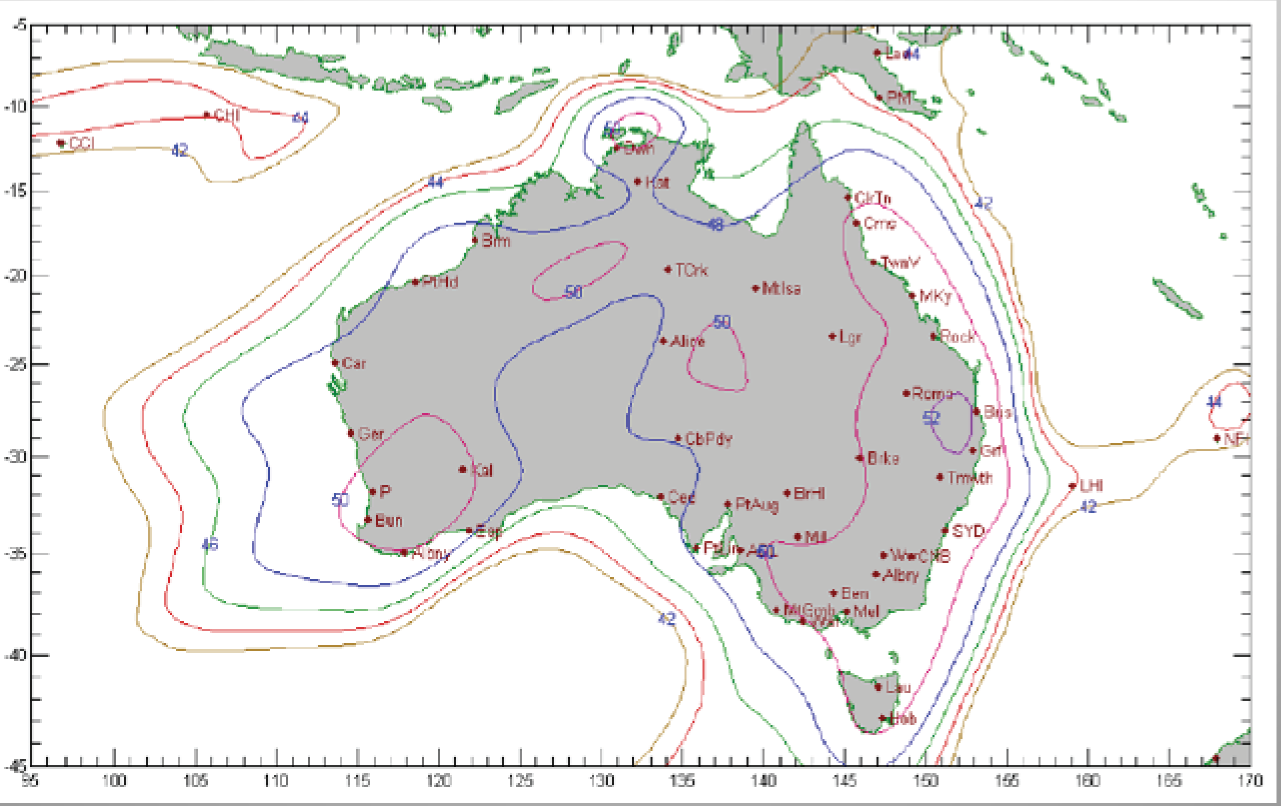
TT&C and UPC

- **T**elemetry, **T**racking and **C**ommand
- Need to be able to send commands to satellite
  - Change payload configuration
    - Multiplexing
    - Switch between redundant systems
    - Orbit
- Check on health of satellite/payload
  - Beacon + telemetry
- Measure affect of weather (combat rain fade)
  - **U**plink **P**ower **C**ontrol
  - Turn up transmitter power (keep at min. = save $$$)

Optus D1

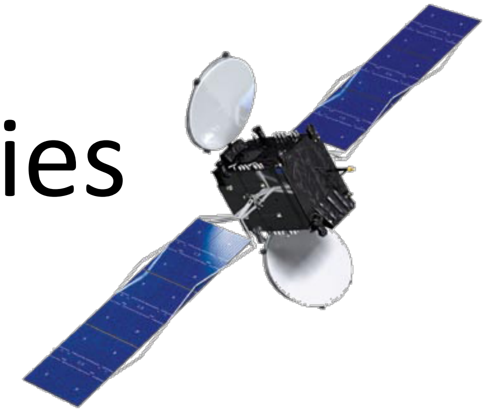
- 24 Ku band transponders
  - Multiplexed spot beams service Aus and NZ
  - Uplink: 14.0 - 14.5 GHz
  - Downlink: 12.25 - 12.75 GHz
  - Bandwidth: 54 MHz
- Mainly TV (wideband DVB-S)
  - ABC, SBS, Se7en, Nin9, SkyNZ
- Some other (narrowband) things…

FNA Beam Coverage

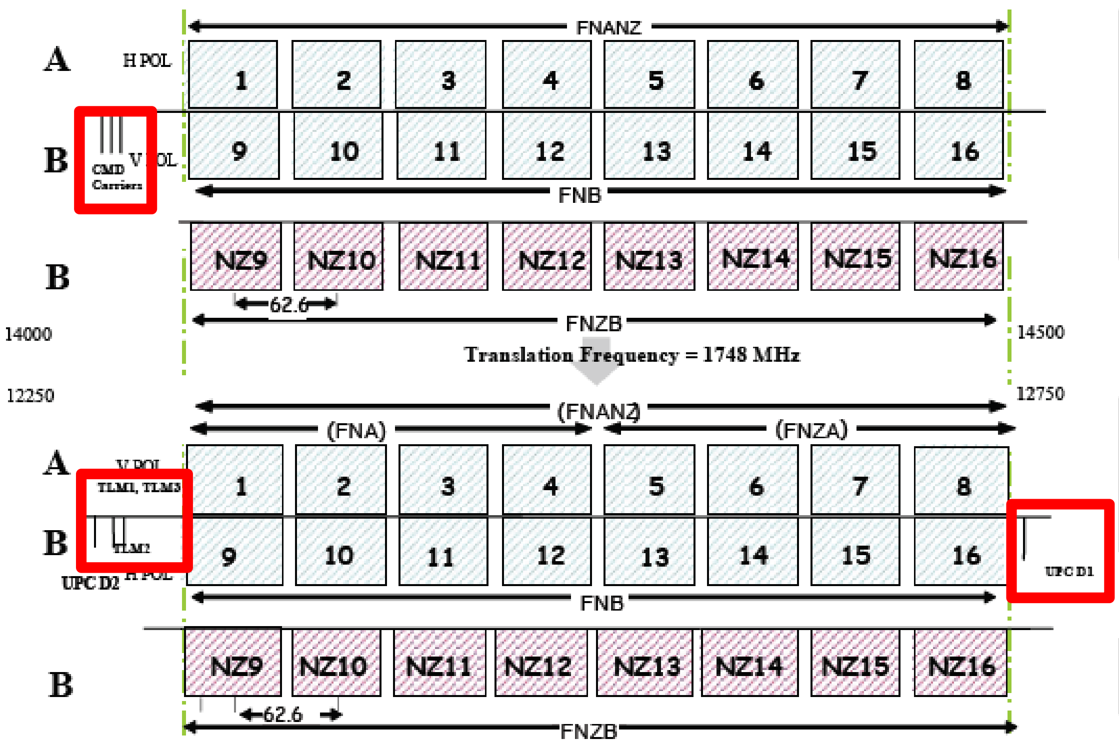


Effective **I**sotropic **R**adiated **P**ower (EIRP)

D1 Channel Frequencies



Uplink

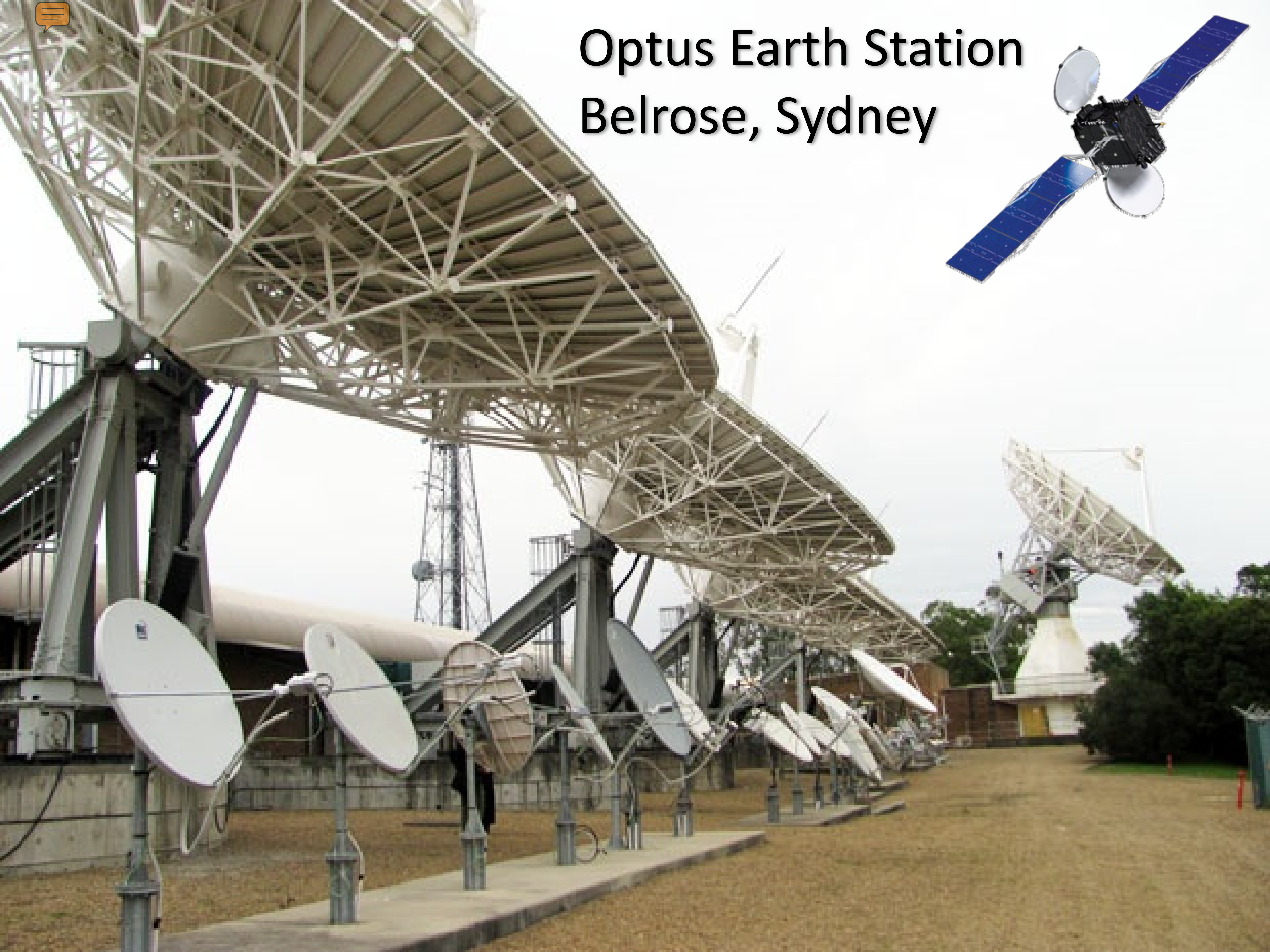


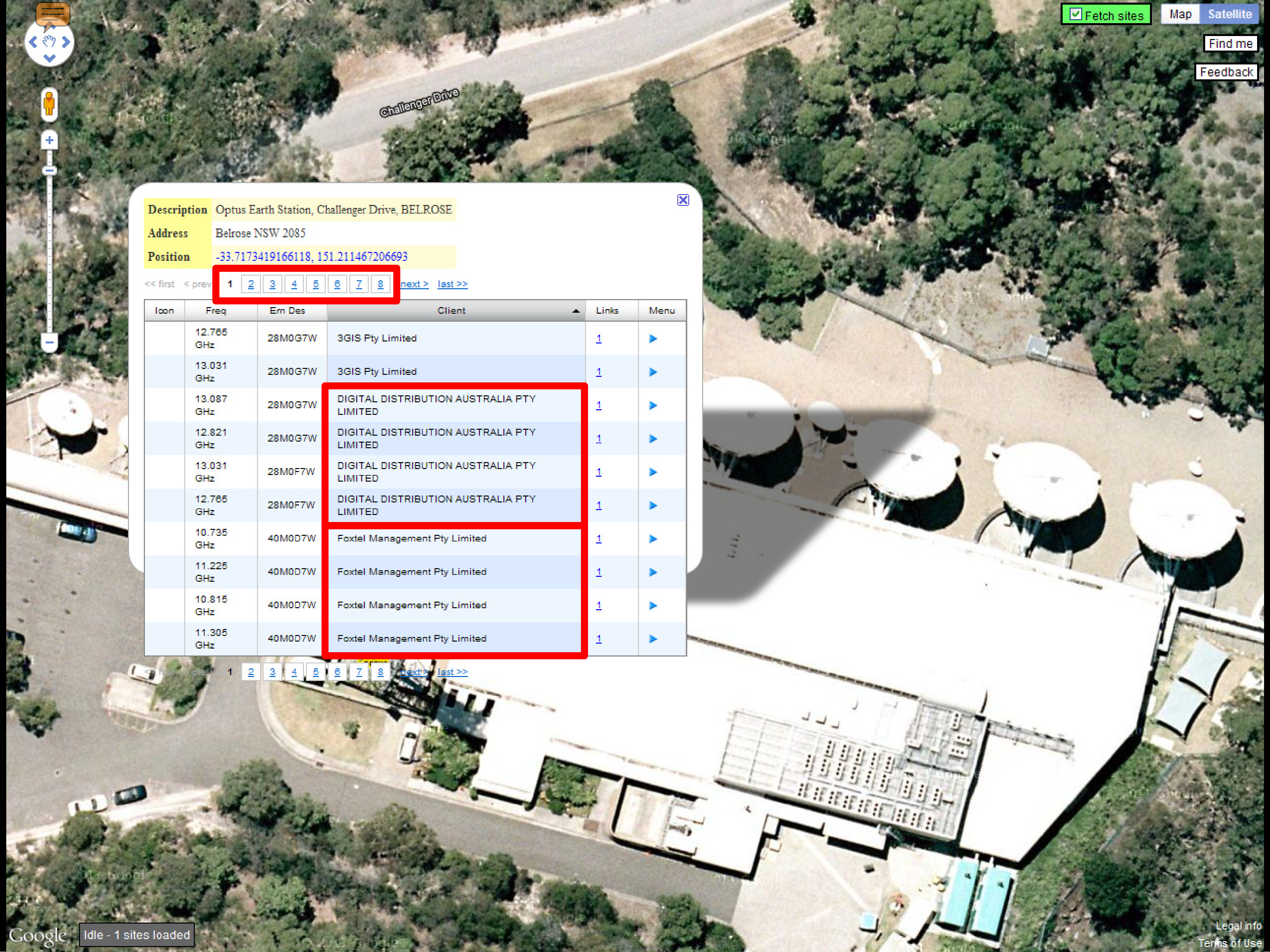
Downlink

FSS Australia Centre Frequencies (MHz)		
Channel	Uplink	Downlink
1	14029.90	12281.90
2	14092.50	12344.50
3	14155.10	12407.10
4	14217.70	12469.70
5	14280.30	12532.30
6	14342.90	12594.90
7	14405.50	12657.50
8	14468.10	12720.10
9	14029.90	12281.90
10	14092.50	12344.50
11	14155.10	12407.10
12	14217.70	12469.70
13	14280.30	12532.30
14	14342.90	12594.90
15	14405.50	12657.50
16	14468.10	12720.10
TLM1		12243.25
TLM2		12245.25
TLM3		12243.25
UPC		12749.50

D1

FSS NZ Centre Frequencies (MHz)		
Channel	Uplink	Downlink
NZ9	14029.90	12281.90
NZ10	14092.50	12344.50
NZ11	14155.10	12407.10
NZ12	14217.70	12469.70
NZ13	14280.30	12532.30
NZ14	14342.90	12594.90
NZ15	14405.50	12657.50
NZ16	14468.10	12720.10


Optus Earth Station
Belrose, Sydney



Description	Optus Earth Station, Challenger Drive, BELROSE
Address	Belrose NSW 2085
Position	-33.7173419166118, 151.211467206693

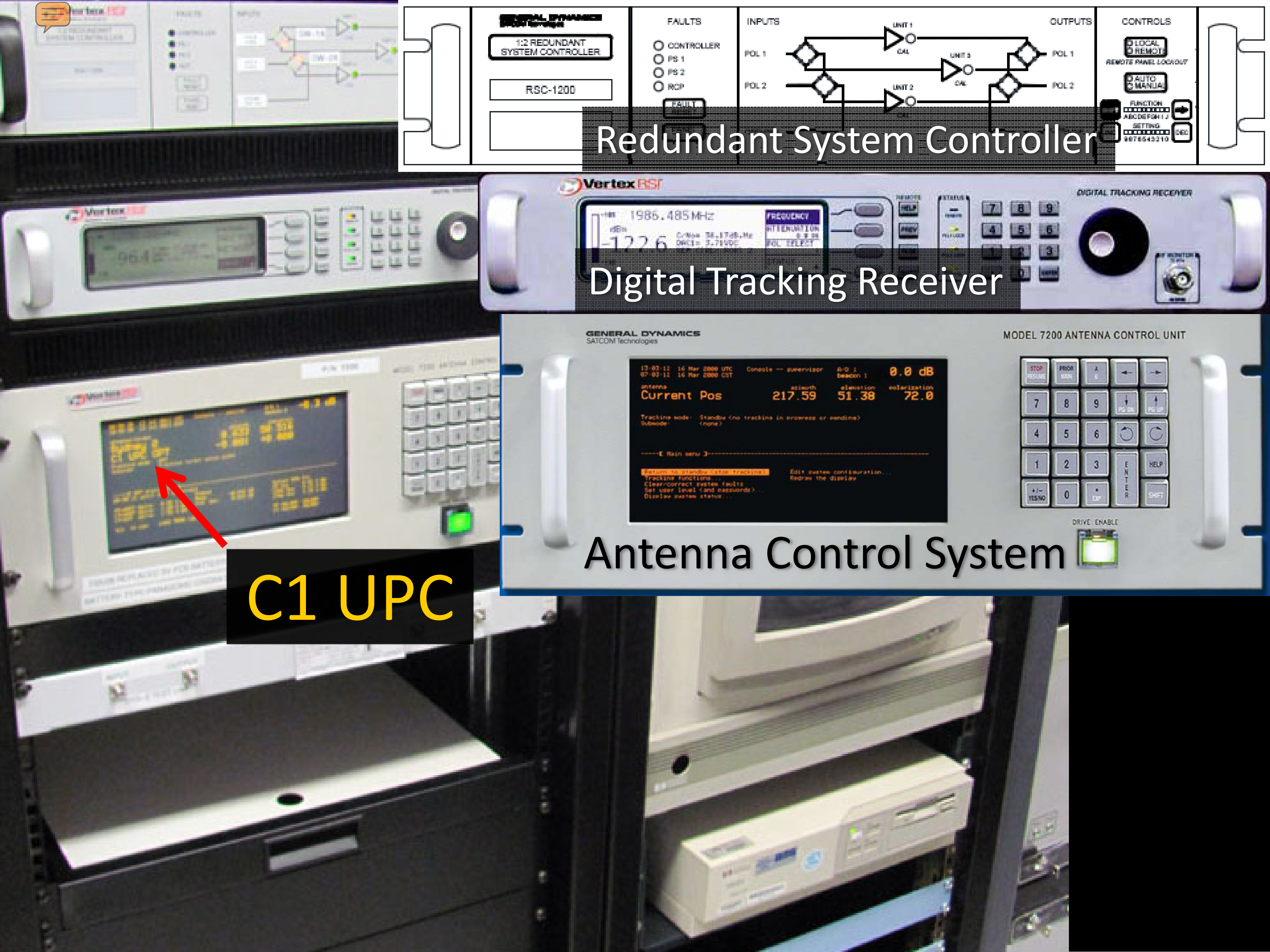
<< first < prev 1 2 3 4 5 6 7 8 next > last >>

Icon	Freq	Em Des	Client	Links	Menu
	12.765 GHz	28M0G7W	3GIS Pty Limited	1	▶
	13.031 GHz	28M0G7W	3GIS Pty Limited	1	▶
	13.087 GHz	28M0G7W	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED	1	▶
	12.821 GHz	28M0G7W	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED	1	▶
	13.031 GHz	28M0F7W	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED	1	▶
	12.765 GHz	28M0F7W	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED	1	▶
	10.735 GHz	40M0D7W	Foxtel Management Pty Limited	1	▶
	11.225 GHz	40M0D7W	Foxtel Management Pty Limited	1	▶
	10.815 GHz	40M0D7W	Foxtel Management Pty Limited	1	▶
	11.305 GHz	40M0D7W	Foxtel Management Pty Limited	1	▶

<< first < prev 1 2 3 4 5 6 7 8 next > last >>

Spot the satellite modem

Radyne Comstream
Satellite Modem
DMD-15

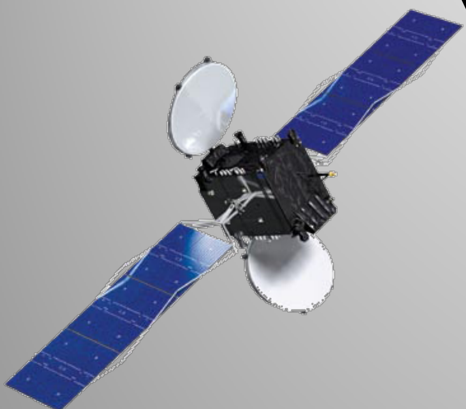


1:2 REDUNDANT SYSTEM CONTROLLER
RSC-1200
FAULTS
INPUTS
OUTPUTS
CONTROLS
Redundant System Controller
DIGITAL TRACKING RECEIVER
Digital Tracking Receiver
GENERAL DYNAMICS
SATCOM Technologies
MODEL 7200 ANTENNA CONTROL UNIT
Current Pos
Antenna Control System
C1 UPC

What you need

Dish + LNB + power injector + USRP + GNU Radio

(set-top box with LNB-thru)



Low Noise Block down-converter

Subtract 11.3 GHz from downlink frequency: 950 - 1450 MHz

Ku Band High Power TM Transmitters

Applications

- Satellite TC&R subsystems
- Telemetry and ranging transmission and modulation

Main features

- Ku Band
- Compatible with most of bus interfaces (command & telemetry formats)
- Power supplies 22 to 100V
- High power output, 8W EOL, 10W BOL (through SSPA)
- Flight Proven design
- Modulation Index selection
  - By Command
  - Automatic according to modulating tones number

Technologies

- Microwave Integrated Circuit
- Surface Mount Printed Circuit Board
- Thick Film Hybrid

Background

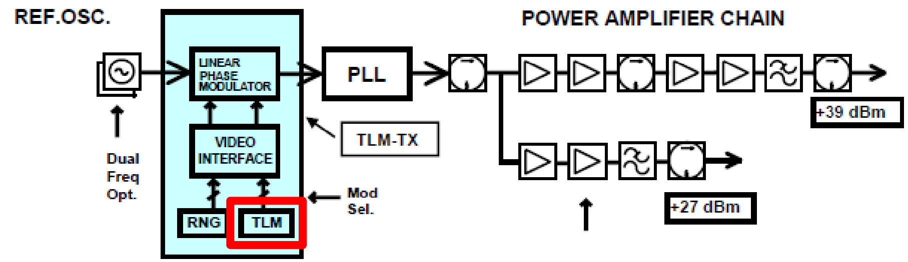
- AMC 14 - AMC 15 - AMC 16
- BSAT 2 A - BSAT 2 B
- BSAT 2 C
- BSAT3A
- ECHOSTAR 10
- ECHOSTAR 7
- GE 2A (NIMIQ2)
- HORIZON 2
- JCSAT 10
- JCSAT 11
- JCSAT 9
- NEWSKIES 6
- NEWSKIES 7
- OPTUS D1
- OPTUS D2
- Panamsat 11
- RAINBOW
- Thor2

Technical Description

- The unit consists of two modules:
  - MPLL module
  - Baseplate module

- The baseplate module houses the DC/DC converter board, which supplies the power voltages to the RF section, and the telemetry interface board, and the Solid State Power Amplifier (SSPA).
- The MPLL module includes all the microwave and RF circuitry to generate and modulate the Ku-band carrier. The modulation inputs interface is implemented on the Telemetry Interface board that is usually tailored on customer's requirements
- The reference crystal oscillator generates a frequency at about 100 MHz, depending on the exact transmitter frequency. The design is based upon a grounded-base configuration with an AT-cut quartz crystal resonator, oscillating in overtone mode. An analog thermal compensation network is implemented.
- Modulation indices may be selected by commands or, as option, automatic selection may be implemented. In this case a specific circuit keeps constant the total power of the modulation signal in presence of one, two or three input signals, in whatever combination
- The signal level emerging from the loop is about +10dBm. The following medium power Ku-band amplifier chain provides +27 dBm power level; it composed by three single ended stages using GaAs FET devices. The following SSPA, delivering 8W E.O.L. power level, is a single ended design, based on two power GaAs FET devices
- As an option, the unit can be equipped with an extra, independent amplifier chain, having an output power up to 0.5 W E.O.L. In this case the transmitter unit can operate in two functional modes: low power mode (0.5W), with high power output isolated (<-30dBm) and high power mode (8W), with low power output isolated (-15dBm)

Ku Band High Power Telemetry Transmitter Block Diagram



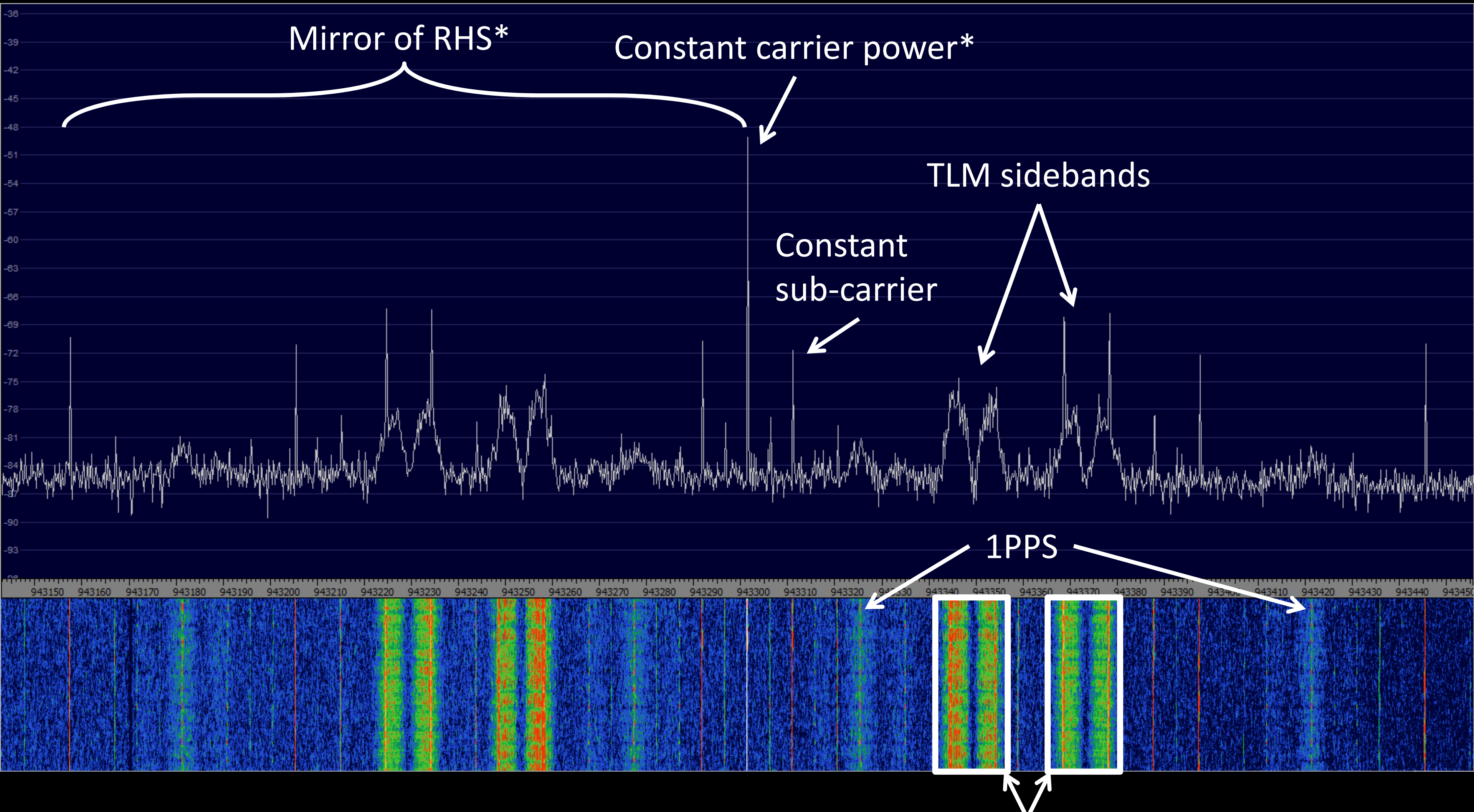
Main Performances

Output Frequency	10.7 – 12.7 GHz
Frequency Stability	± 10 ppm Std Stability Opt ± 5 ppm High Stability Opt
Output Power Level Extra Output	≥ 38.5 dBm (7W) EOL, up to 40dBm (10W) BOL (25C) ≥ 27 dBm EOL Dual Power Opt
Output Phase Noise	< 4 deg_{rms} @ 10 Hz to 1 MHz
PM modulation index	Up to 2.4 radpk
Mod.Index Selection	By command Automatic according to mod.tones number
Modulation Linearity	± 3%
Modulation Op.Mode	TM1, TM2, RNG1, RNG2, RNGS + TMs
DC/DC converter	55/71V – 22/43V (16Vpp max in the range for best efficiency)
Command Interface	HLC
Qualification Temp. Range	-25 / +65 °C

Mass, Dimensions and Consumption

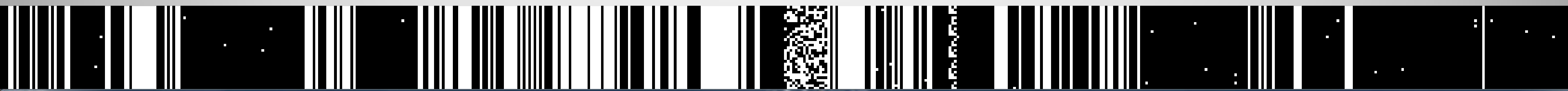
DC Power Consumption	High power mode <55W Low power mode <18W (Dual Power Opt)
Mass Properties	< 2 kg
Outline Dimensions	250 x 130 x 80 mm

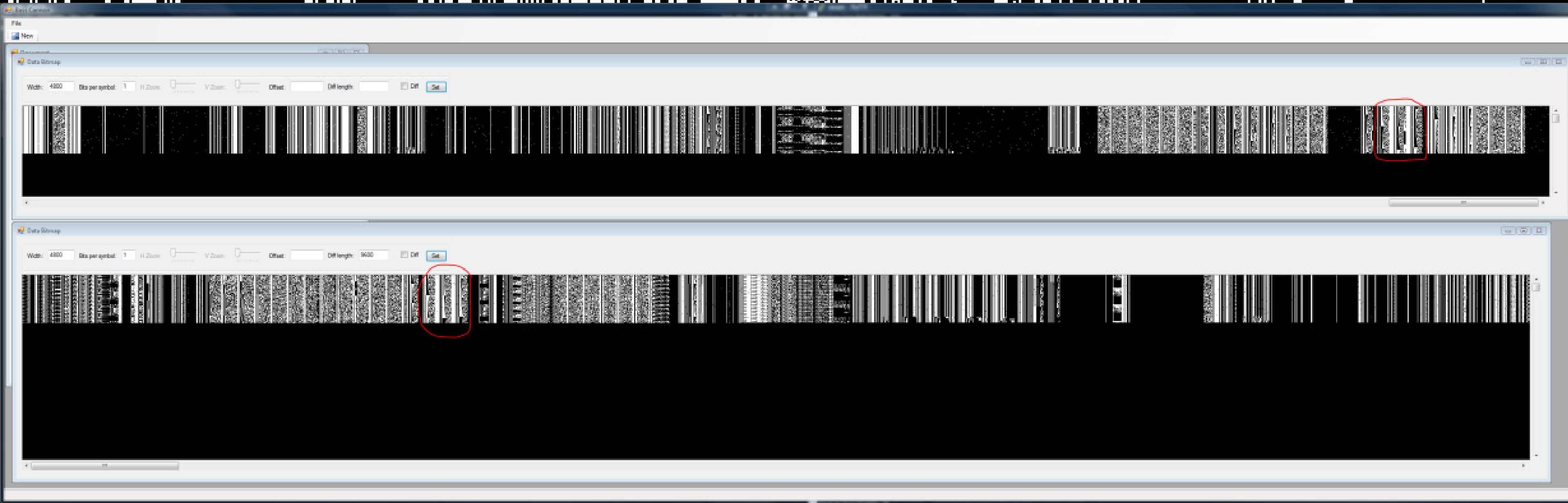
D1 TLM1: 12243.25 MHz

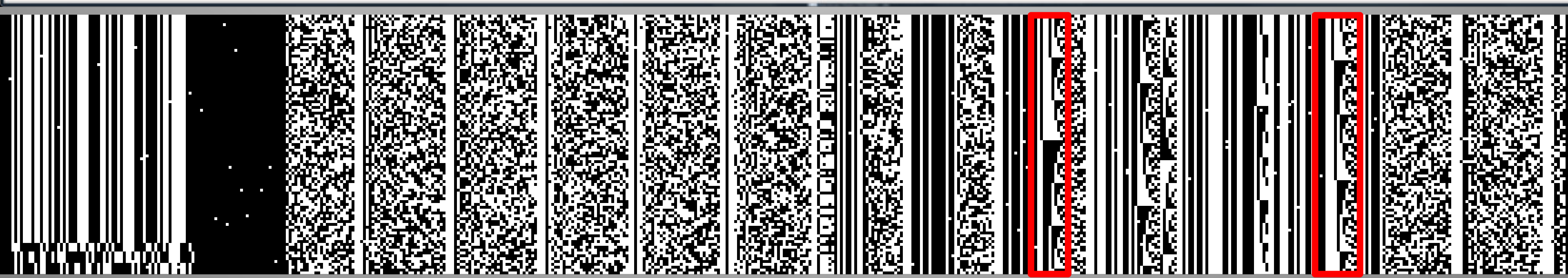


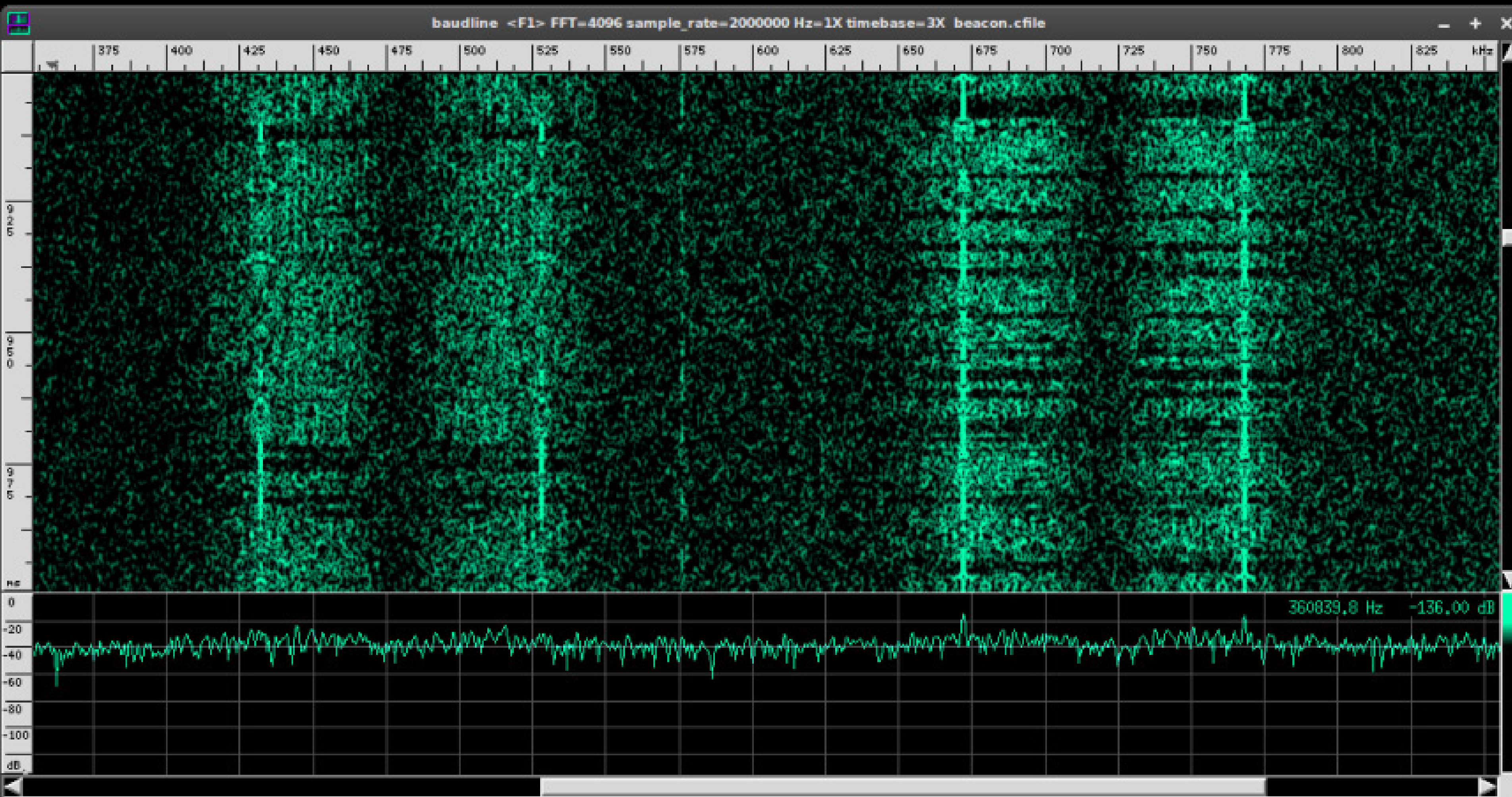
Beacon with **P**hase **M**odulation* (PM): 1PPS and two telemetry streams (sidebands)

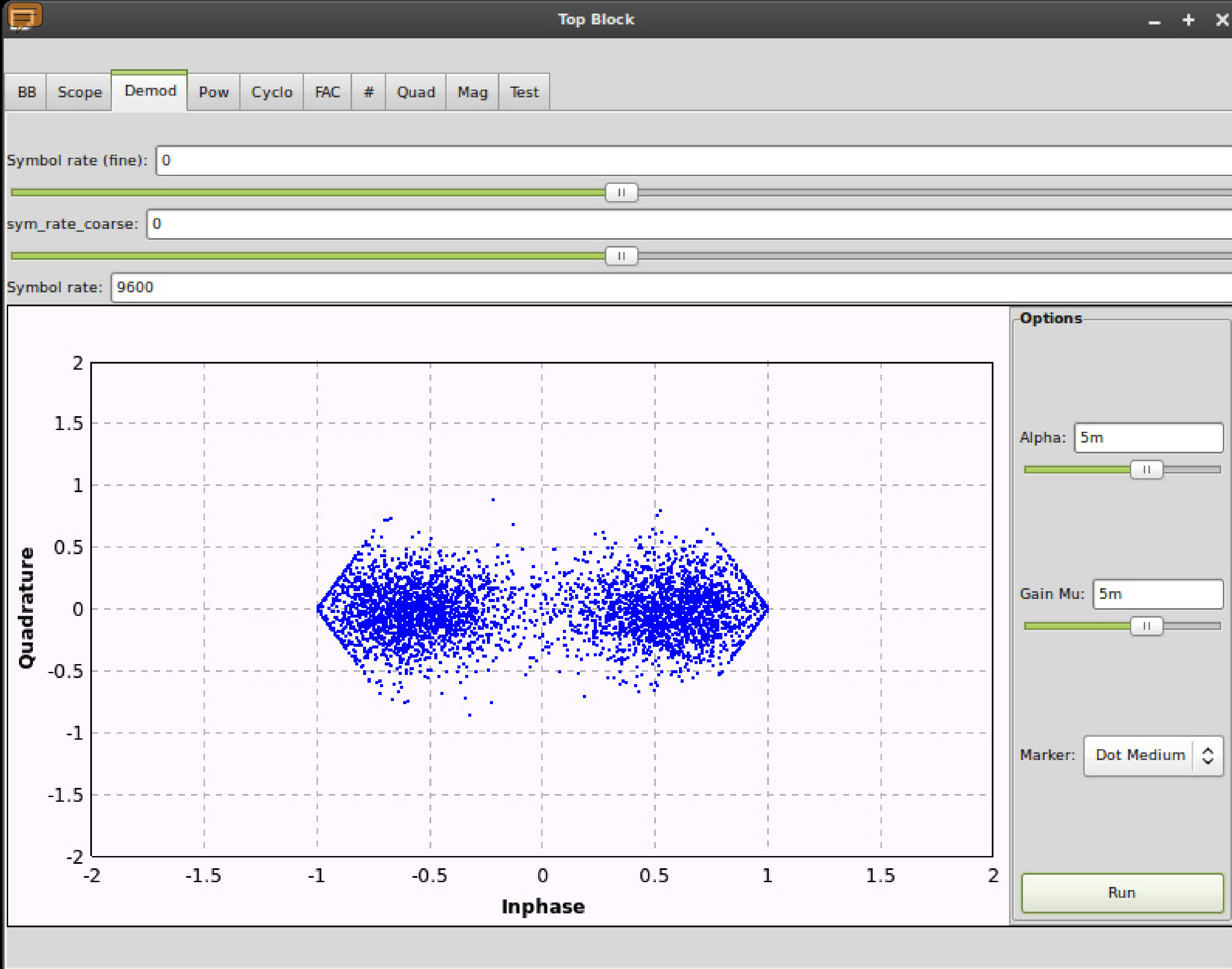
Visualisation



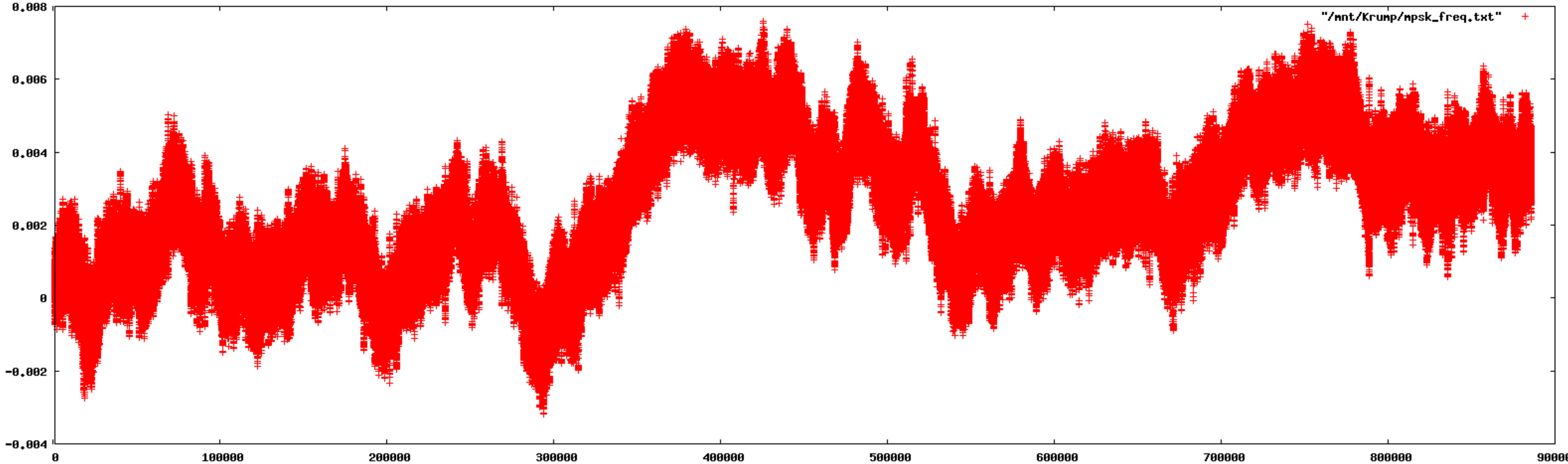


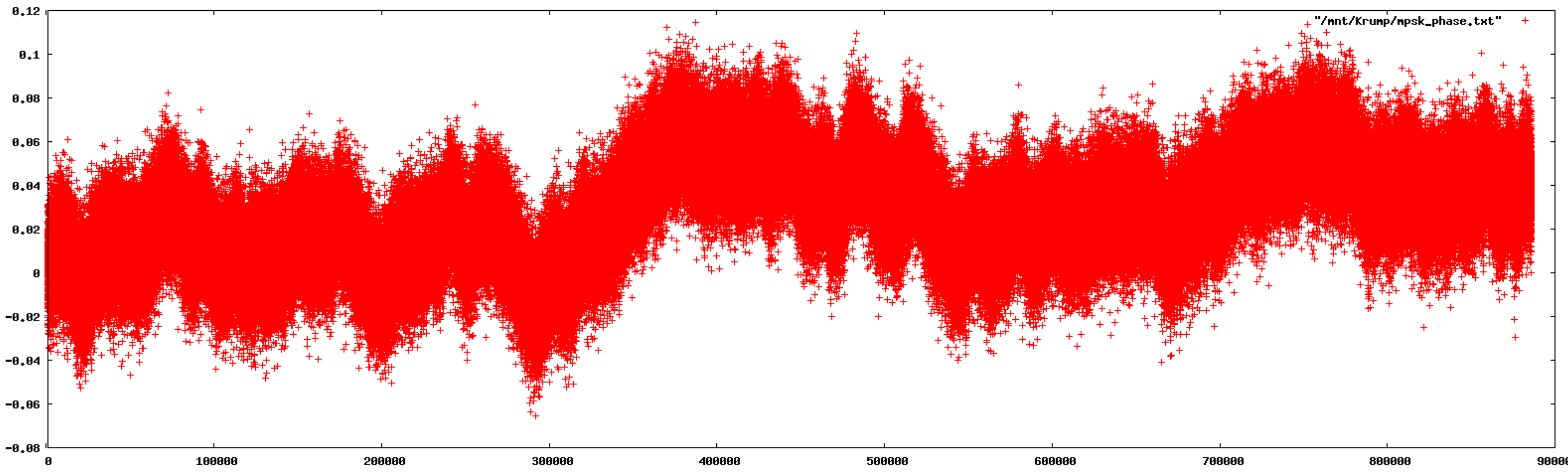



baudline <F1> FFT=4096 sample_rate=2000000 Hz=1X timebase=3X beacon.cfile
375 400 425 450 475 500 525 550 575 600 625 650 675 700 725 750 775 800 825 kHz
925
950
975
ms
0
-20
-40
-60
-80
-100
dB
360839.8 Hz -136.00 dB


Top Block
BB
Scope
Demod
Pow
Cyclo
FAC
#
Quad
Mag
Test
Symbol rate (fine): 0
sym_rate_coarse: 0
Symbol rate: 9600
Options
Alpha: 5m
Gain Mu: 5m
Marker: Dot Medium
Run
Quadrature
Inphase
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2

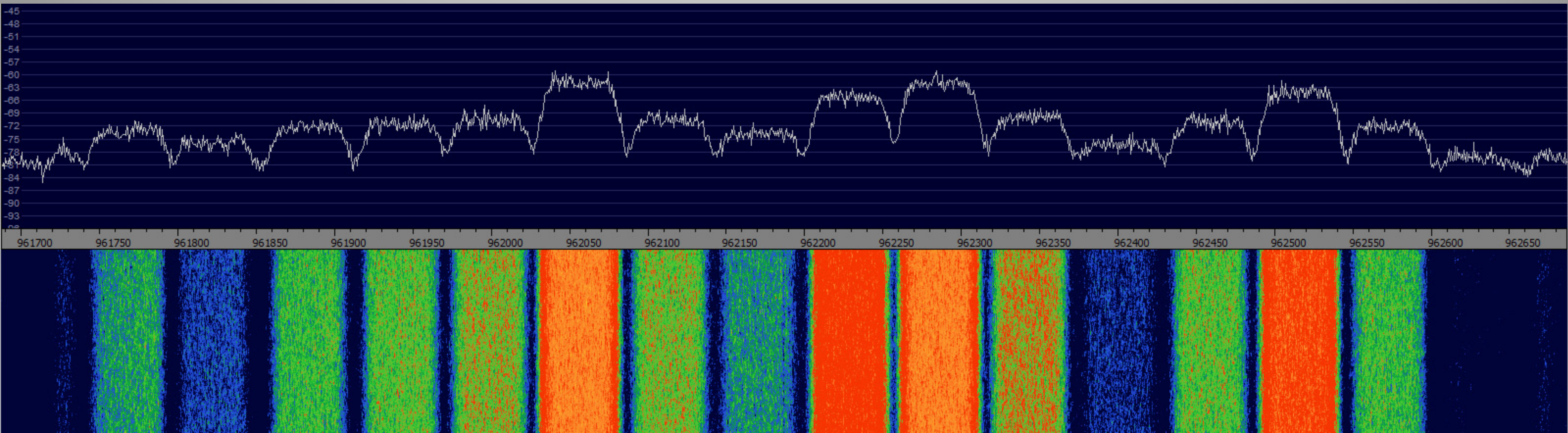
PSK Debug Output





Data Streams

- All sorts of continuous streams of varying bandwidth
- Streams created by manipulating raw data to optimise for transmission over long distance
- Receiver must be able to lock on and decode

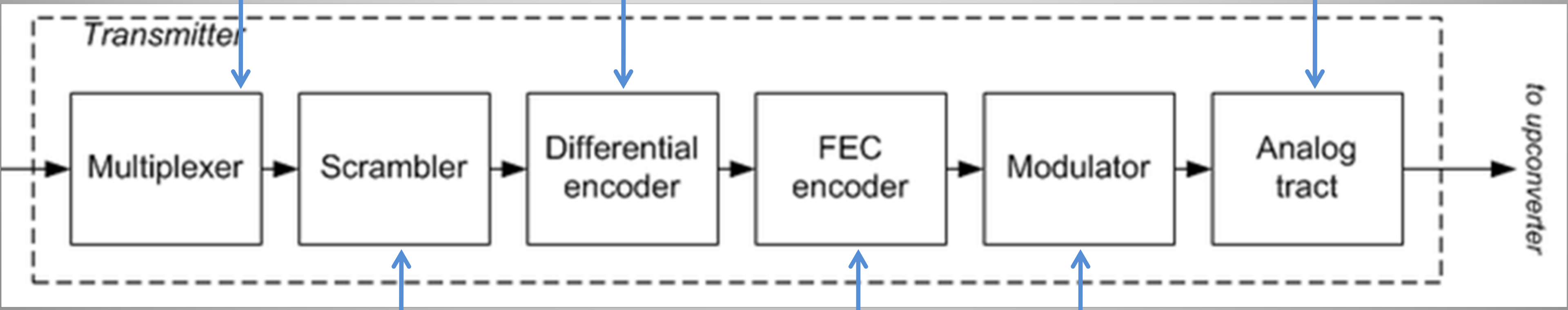


Modulation: pick your parameters

Support multiple data streams, drop-and-insert

Encode changes in data (receiver can be non-coherent)

Create signal suitable for uplink



Make data appear random (increase entropy of structured data)

Turn binary into symbols for baseband RF (0/1 → combinations of waves)

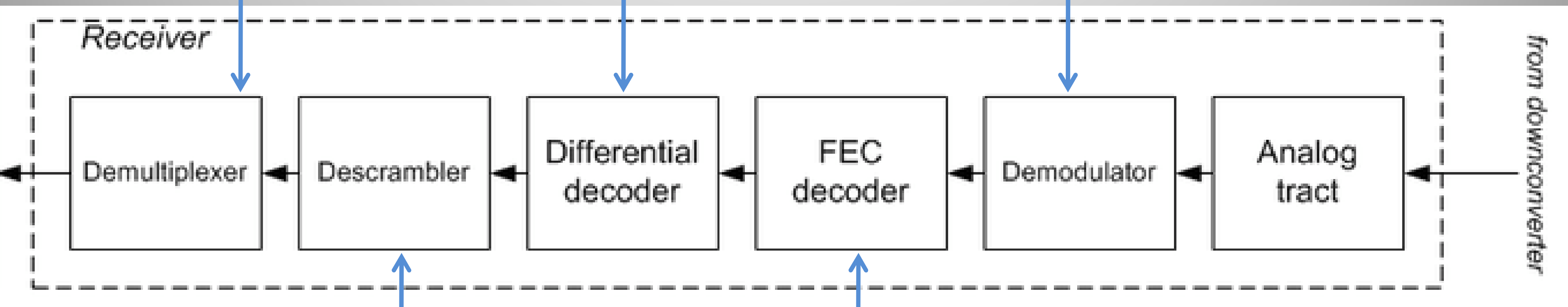
Protect integrity of data (corruption from noise on channel)

Demodulation: easy when you know

What is the modulation?
Symbol rate? Require coherence?
What is the phase difference?
Need to conjugate complex plane?

Are there multiple streams?
How are they multiplexed?

Is it differential, or
what defines a 0/1?



Possible to determine if it is scrambled
(calculate stats), but what is the scrambler?
Is it additive or multiplicative?
How is it synchronised?

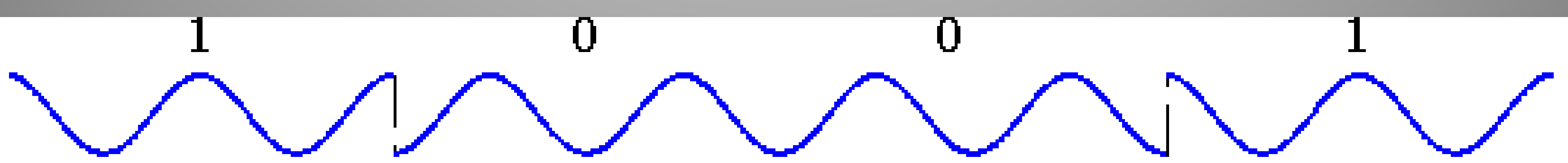
Which FEC(s) is used?
Is it a concatenated code?
What is the code rate?
What is the block size?
How is it synchronised?

If you don’t know…

- Try the most common/default options (RTFMM):
  - Modulation: **P**hase **S**hift **K**eying (BPSK, QPSK)
  - Convolutional code: NASA, K=7 (Voyager Probe)
  - Scrambler: IESS-803 (**I**ntelsat **B**usiness **S**ervice)
- Still need to try each combination of:
  - Differential decoding, synchronisation offset, symbol mapping
- Best option is to try every permutation automatically
- Assuming decent SNR, low **B**it **E**rror **R**ate is an indicator you’re heading the right way!

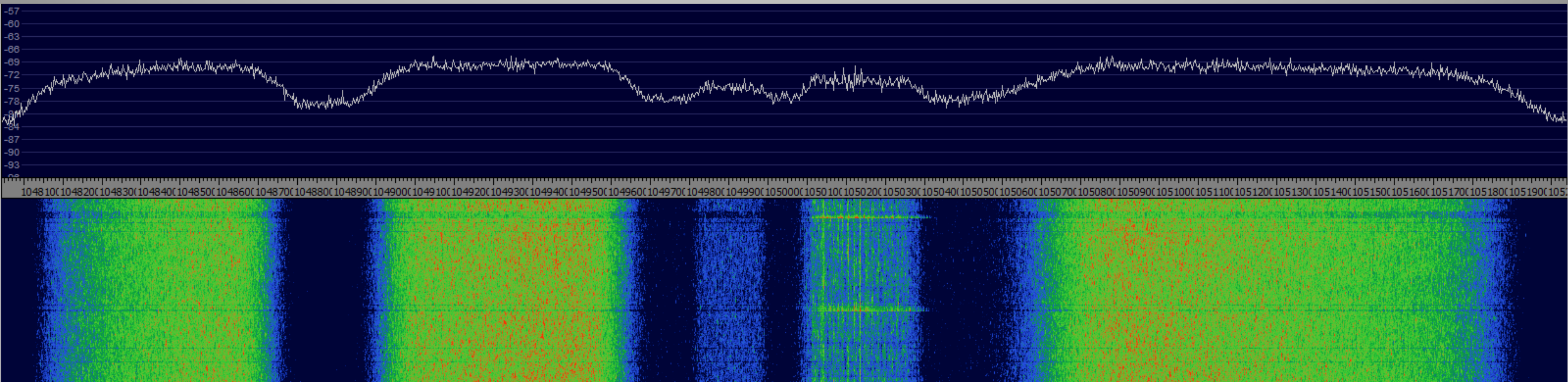
Aside: PSK, Symbols & Bits

- PSK uses changes in phase of a signal (carrier) to convey data
- Demodulator detects phase changes and outputs symbols
- Order of PSK determines # bits in 1 symbol
  - Many bits/symbol thanks to imaginary numbers (I/Q)
- Raw bit rate = symbol rate x (# bits/symbol)
  - Binary PSK (BPSK): 1 bit/symbol
  - Quaternary PSK (QPSK): 2 bits/symbol
  - 8PSK: 3 bits/symbol, etc…

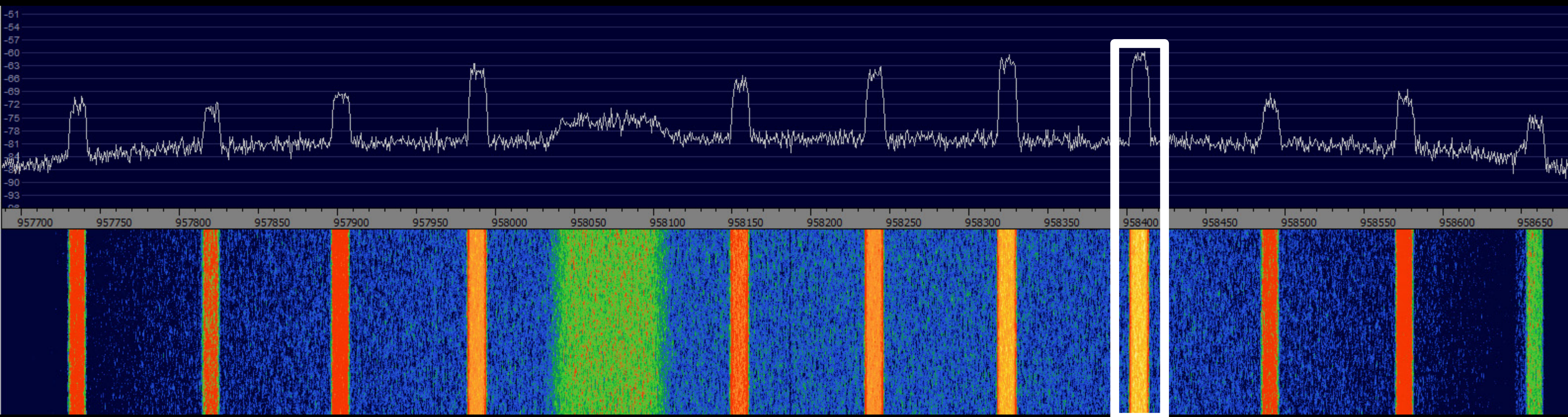


Determining modulation & rate

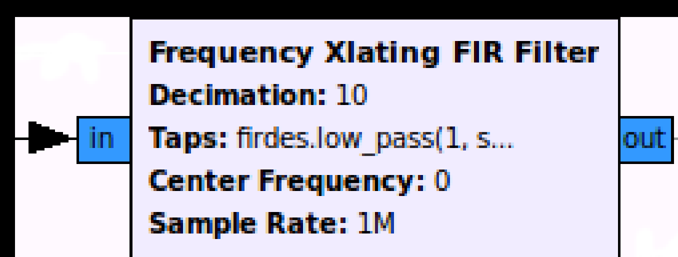
- Assuming PSK, easy to determine:
  - Modulation order: multiply the signal by itself
  - Symbol rate: multiply the signal by a lagged version of itself (cyclostationary analysis)
- Only a few GR blocks required do this



Let’s try one…

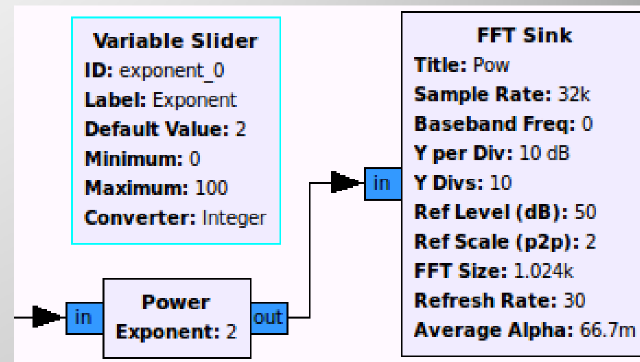


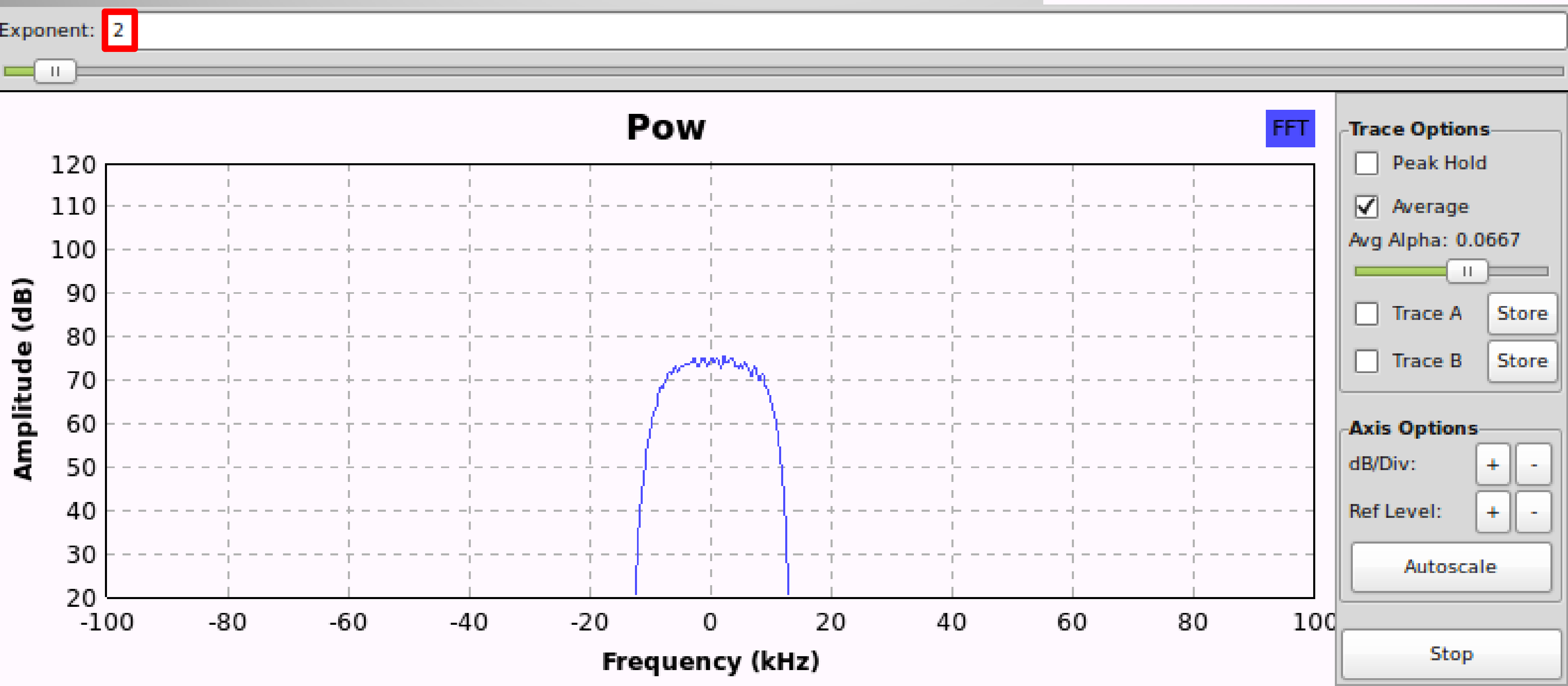
- Feed entire baseband spectrum into GR
- Perform ‘channel selection’ to isolate stream of interest (create new baseband
  centred on stream)



Determine PSK order

- Start at 2 and go up
- Stop when spike appears





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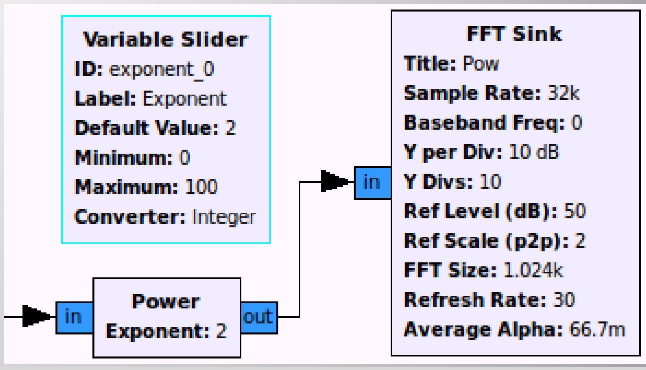
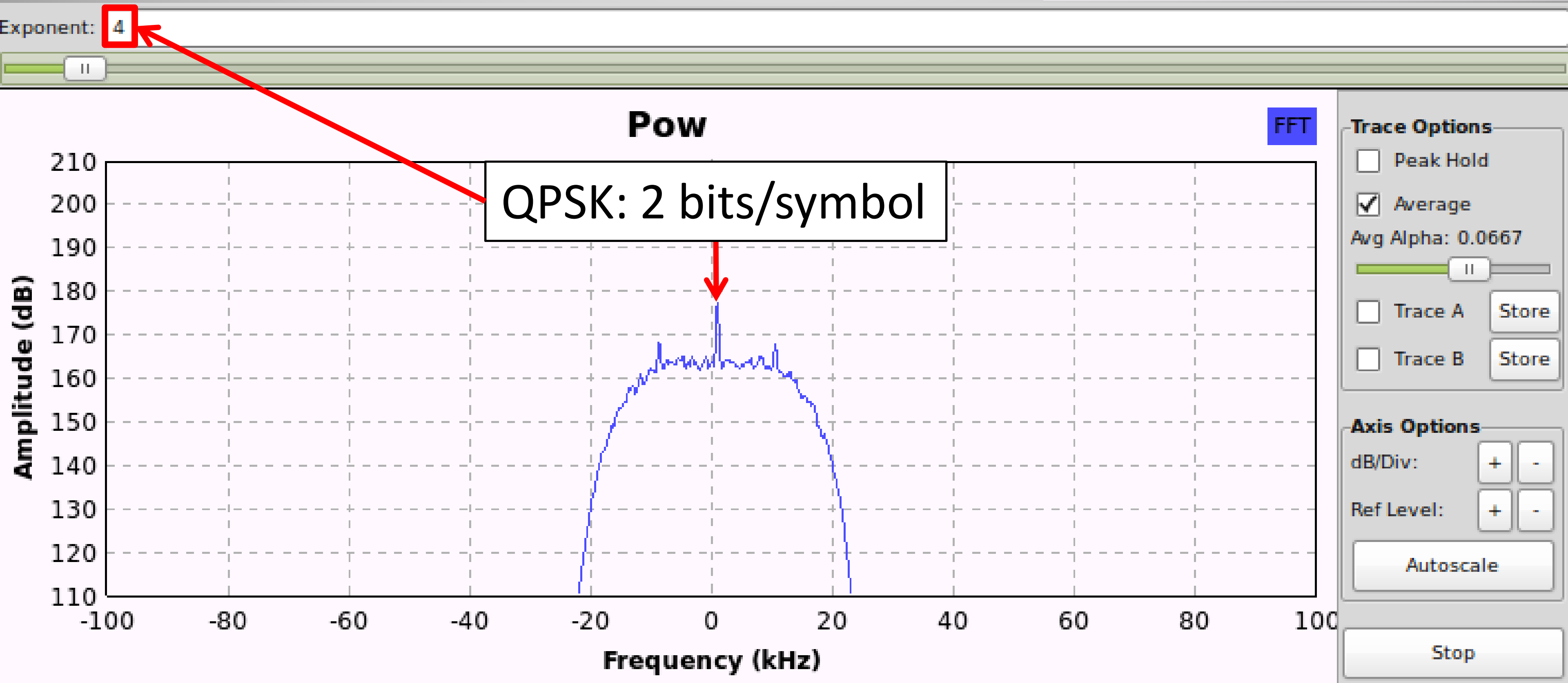
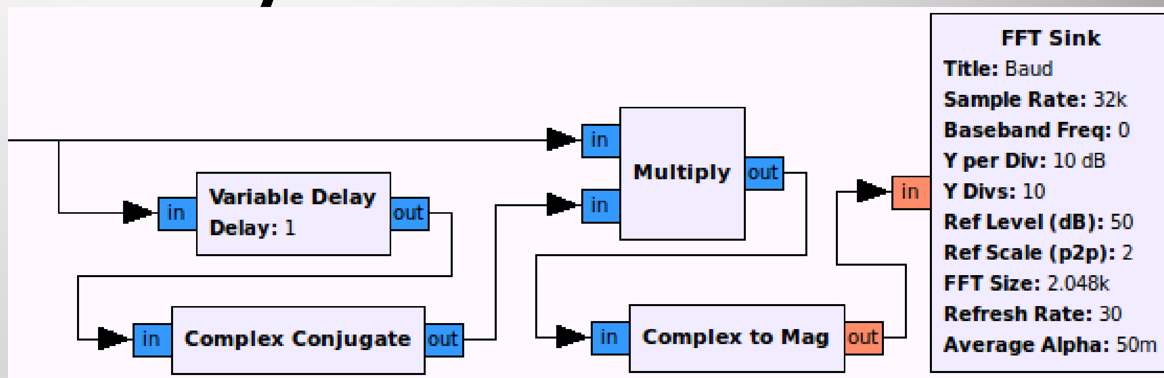
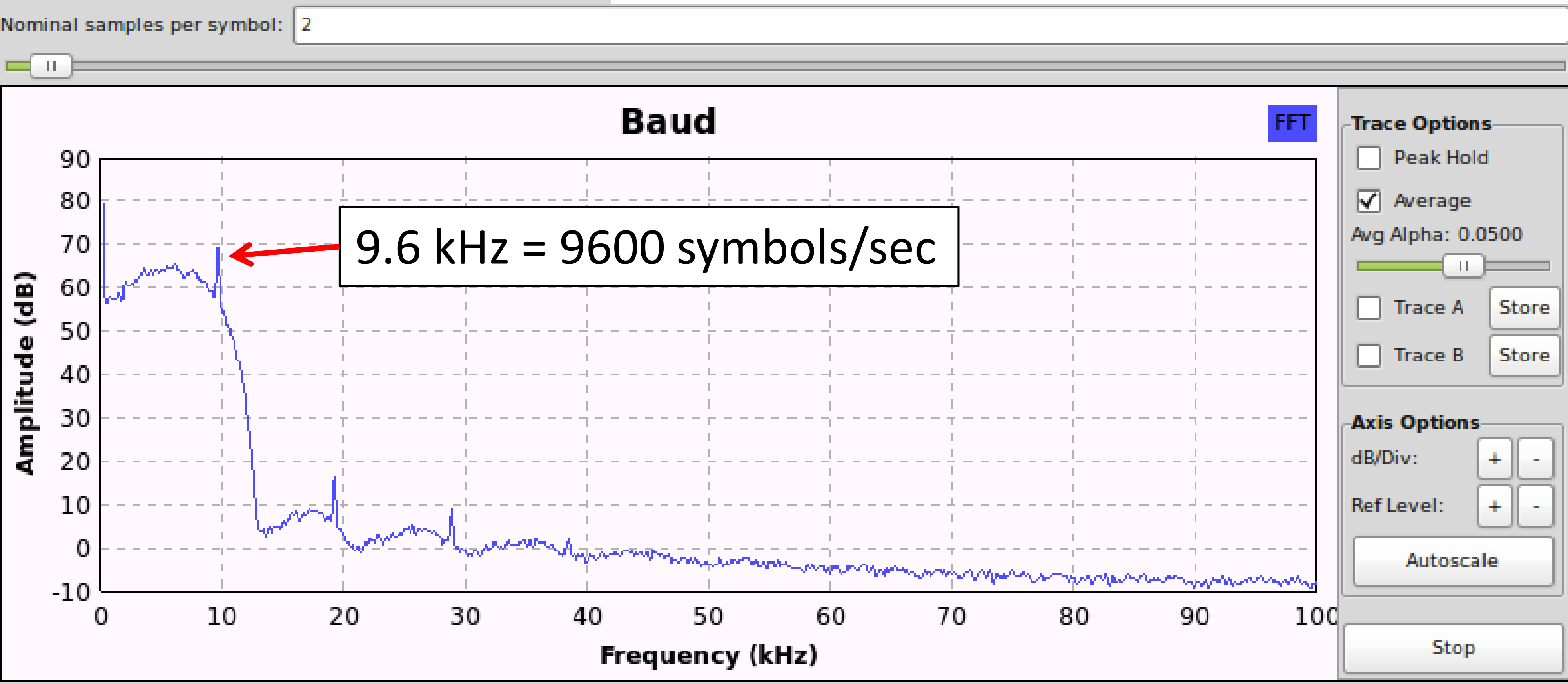




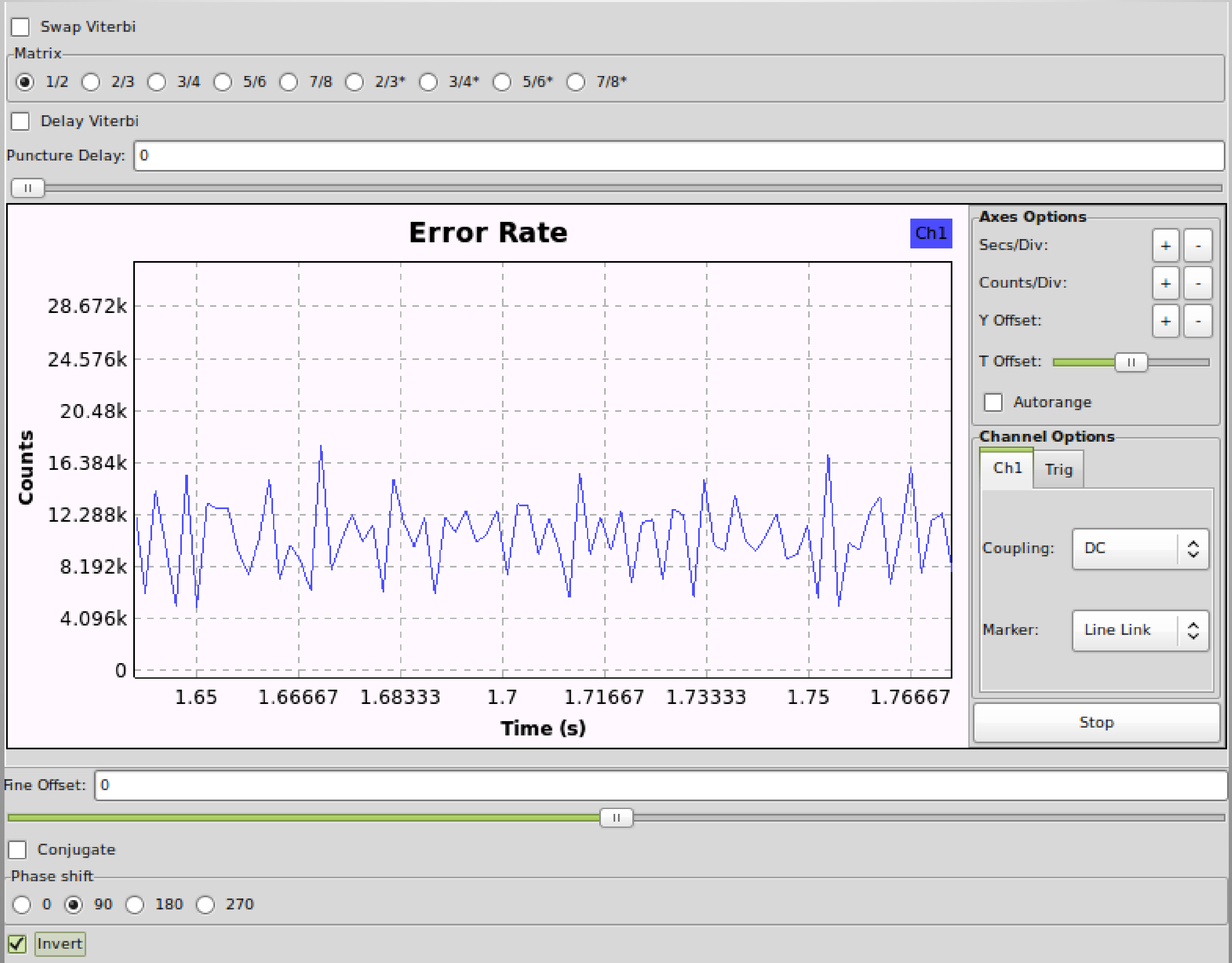
Determine Symbol Rate

- Find first peak

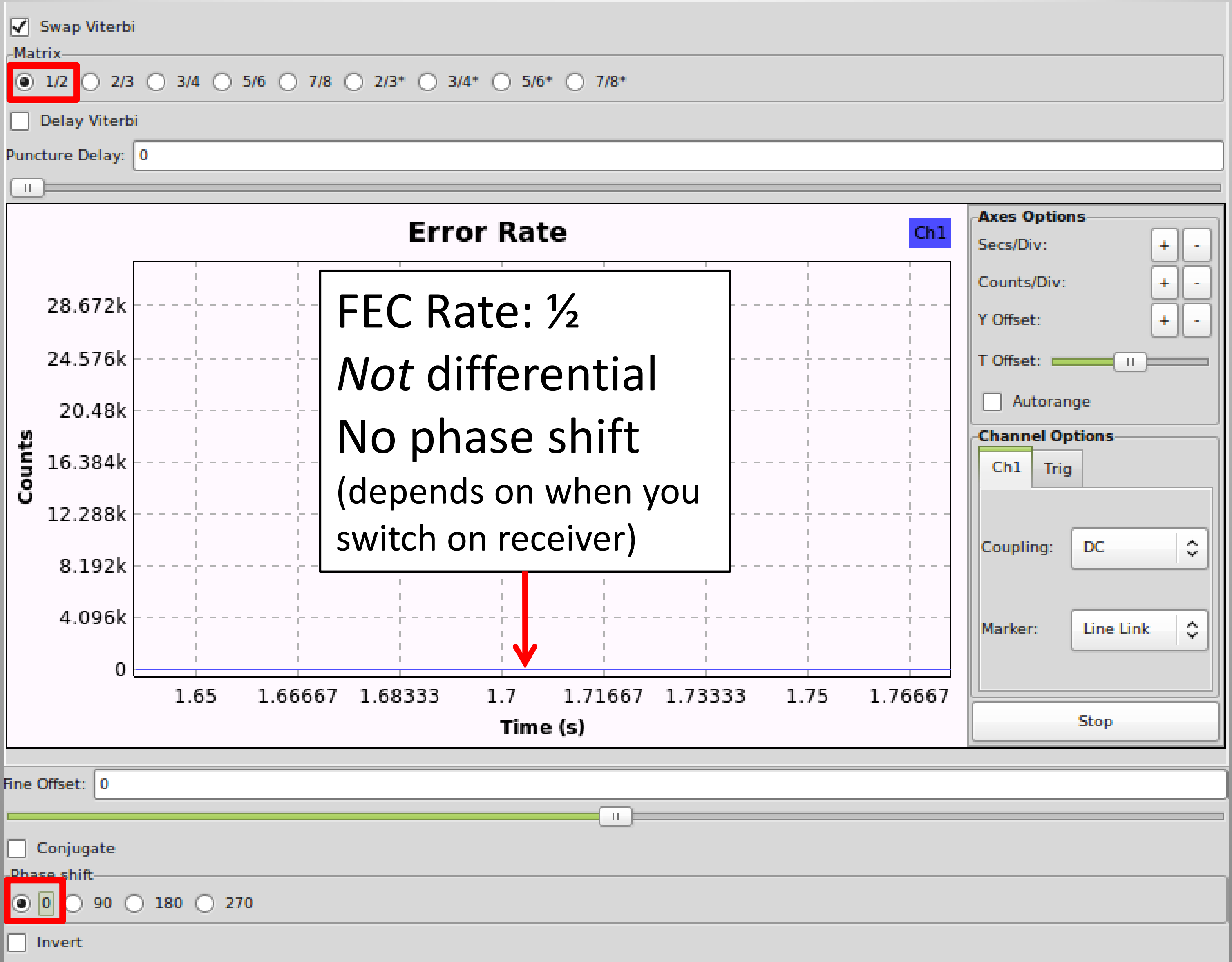


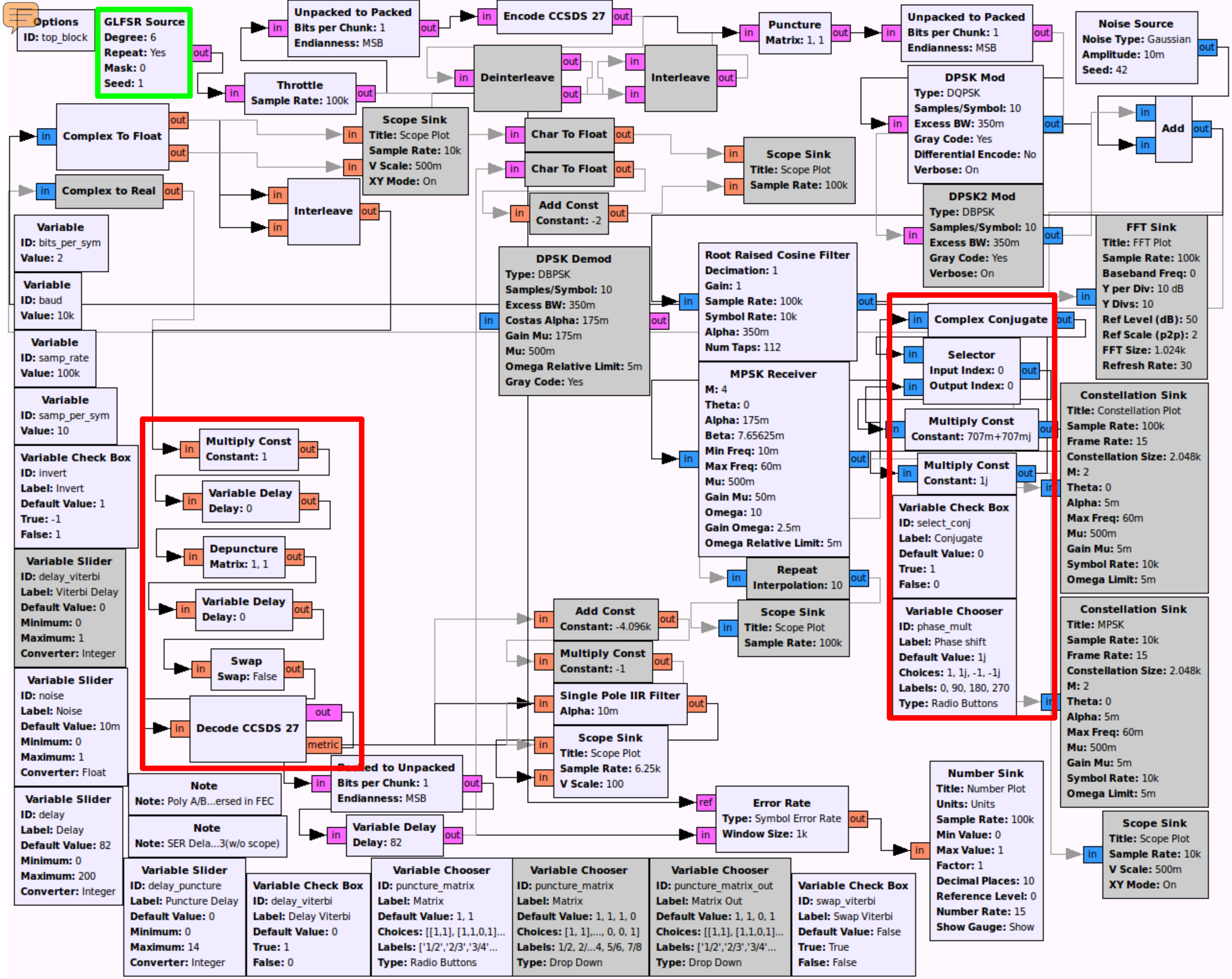


Try synchronisation & FEC

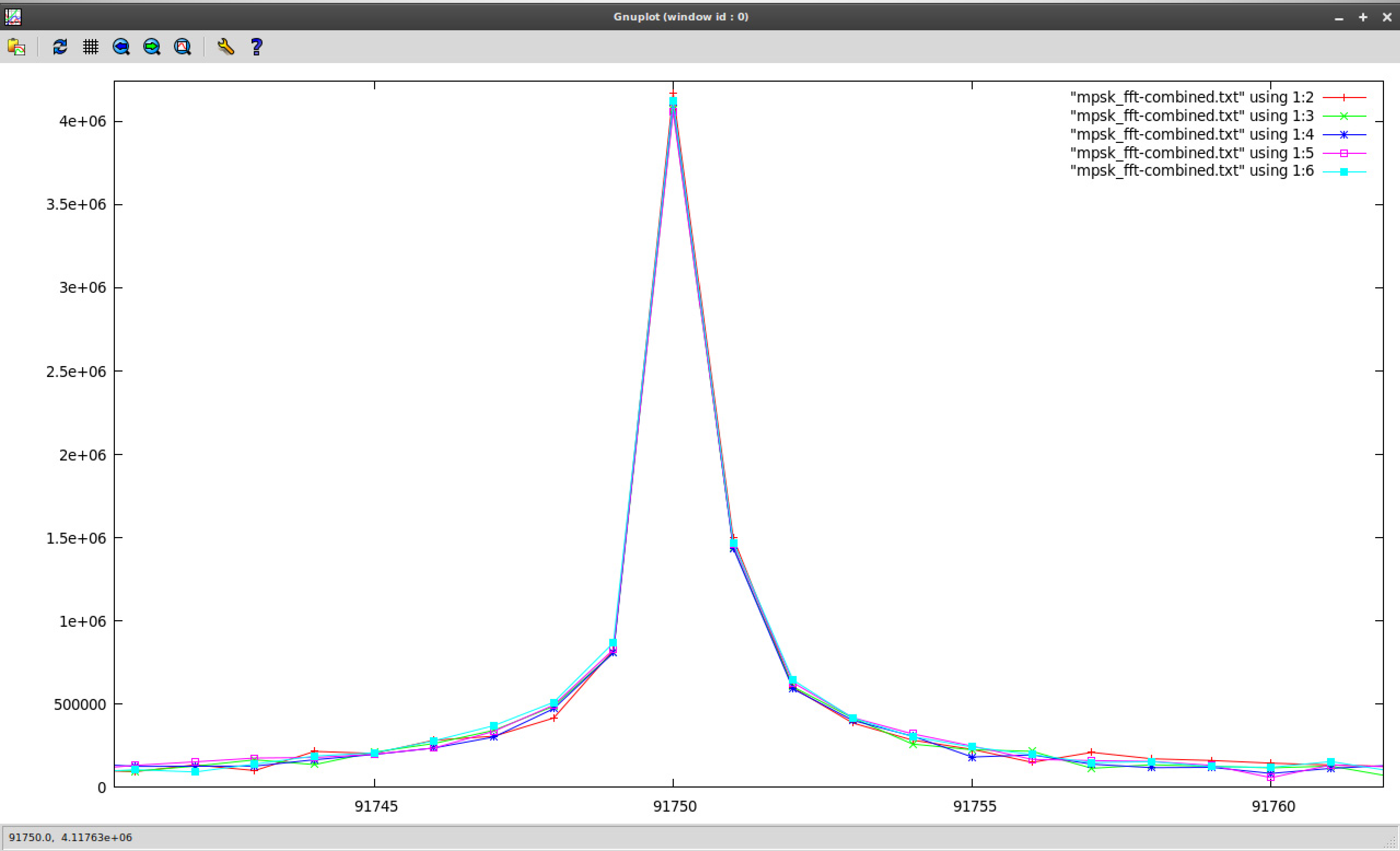


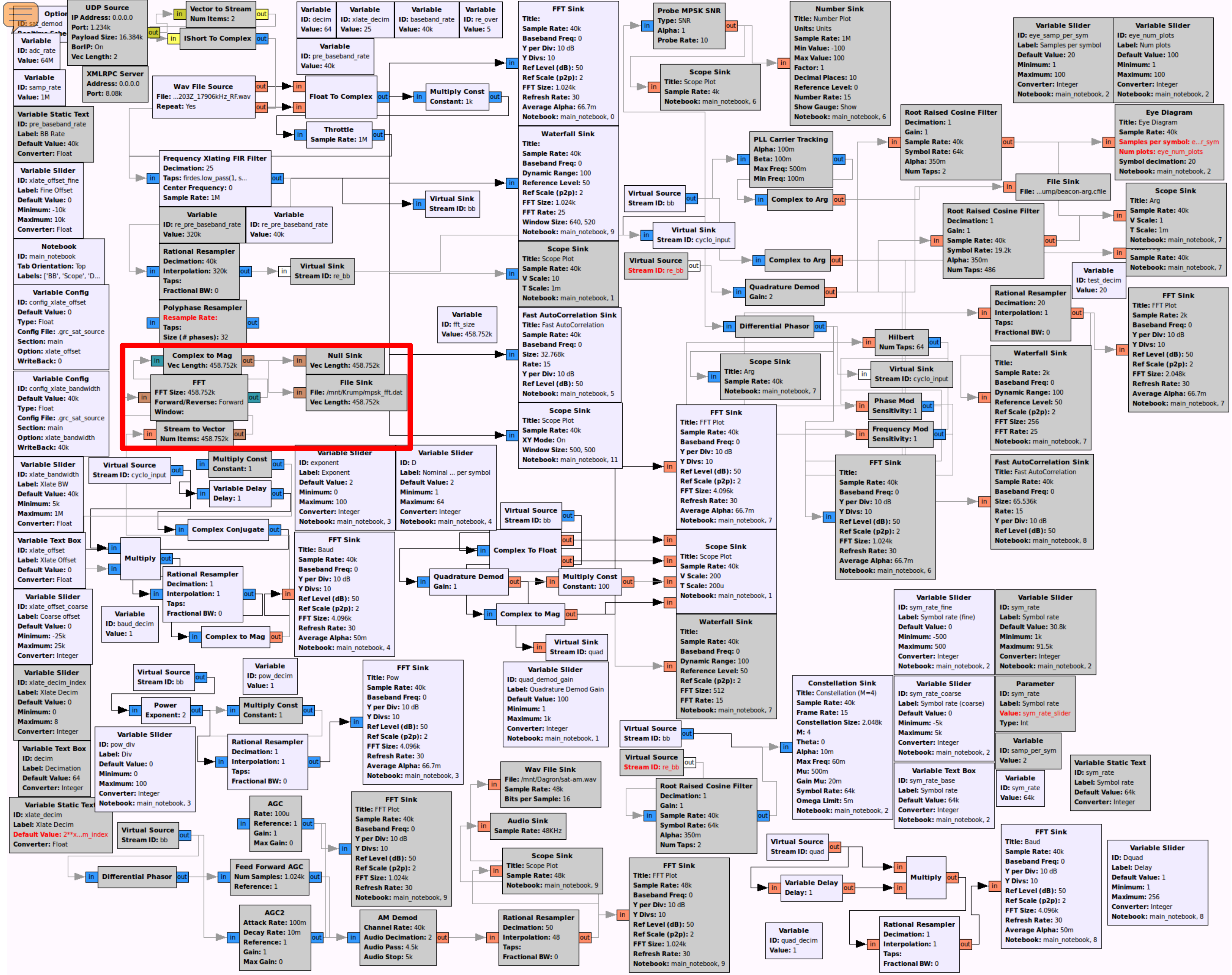
Try synchronisation & FEC



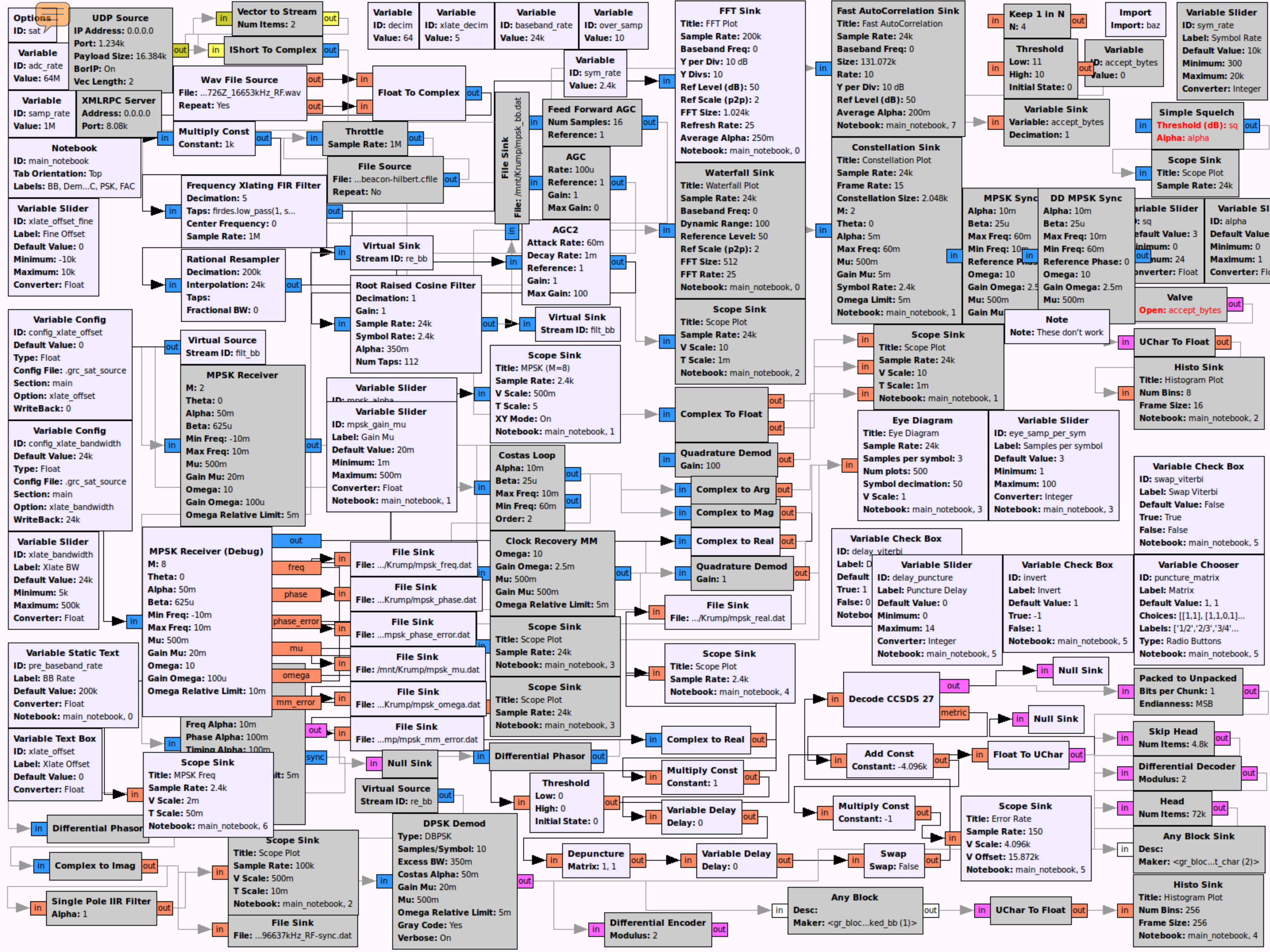

Options
ID: top_block
GLFSR Source
Degree: 6
Repeat: Yes
Mask: 0
Seed: 1
Unpacked to Packed
Bits per Chunk: 1
Endianness: MSB
Encode CCSDS 27
Puncture
Matrix: 1, 1
Unpacked to Packed
Bits per Chunk: 1
Endianness: MSB
Noise Source
Noise Type: Gaussian
Amplitude: 10m
Seed: 42
Throttle
Sample Rate: 100k
Deinterleave
Interleave
DPSK Mod
Type: DQPSK
Samples/Symbol: 10
Excess BW: 350m
Gray Code: Yes
Differential Encode: No
Verbose: On
Add
Complex To Float
Scope Sink
Title: Scope Plot
Sample Rate: 10k
V Scale: 500m
XY Mode: On
Char To Float
Char To Float
Scope Sink
Title: Scope Plot
Sample Rate: 100k
Complex to Real
Interleave
Add Const
Constant: -2
DPSK2 Mod
Type: DBPSK
Samples/Symbol: 10
Excess BW: 350m
Gray Code: Yes
Verbose: On
Variable
ID: bits_per_sym
Value: 2
FFT Sink
Title: FFT Plot
Sample Rate: 100k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
DPSK Demod
Type: DBPSK
Samples/Symbol: 10
Excess BW: 350m
Costas Alpha: 175m
Gain Mu: 175m
Mu: 500m
Omega Relative Limit: 5m
Gray Code: Yes
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 100k
Symbol Rate: 10k
Alpha: 350m
Num Taps: 112
Variable
ID: baud
Value: 10k
Complex Conjugate
Variable
ID: samp_rate
Value: 100k
Selector
Input Index: 0
Output Index: 0
MPSK Receiver
M: 4
Theta: 0
Alpha: 175m
Beta: 7.65625m
Min Freq: 10m
Max Freq: 60m
Mu: 500m
Gain Mu: 50m
Omega: 10
Gain Omega: 2.5m
Omega Relative Limit: 5m
Variable
ID: samp_per_sym
Value: 10
Constellation Sink
Title: Constellation Plot
Sample Rate: 100k
Frame Rate: 15
Constellation Size: 2.048k
M: 2
Theta: 0
Alpha: 5m
Max Freq: 60m
Mu: 500m
Gain Mu: 5m
Symbol Rate: 10k
Omega Limit: 5m
Multiply Const
Constant: 1
Multiply Const
Constant: 707m+707mj
Multiply Const
Constant: 1j
Variable Check Box
ID: invert
Label: Invert
Default Value: 1
True: -1
False: 1
Variable Delay
Delay: 0
Variable Check Box
ID: select_conj
Label: Conjugate
Default Value: 0
True: 1
False: 0
Depuncture
Matrix: 1, 1
Variable Slider
ID: delay_viterbi
Label: Viterbi Delay
Default Value: 0
Minimum: 0
Maximum: 1
Converter: Integer
Repeat
Interpolation: 10
Variable Delay
Delay: 0
Add Const
Constant: -4.096k
Scope Sink
Title: Scope Plot
Sample Rate: 100k
Variable Chooser
ID: phase_mult
Label: Phase shift
Default Value: 1j
Choices: 1, 1j, -1, -1j
Labels: 0, 90, 180, 270
Type: Radio Buttons
Constellation Sink
Title: MPSK
Sample Rate: 10k
Frame Rate: 15
Constellation Size: 2.048k
M: 2
Theta: 0
Alpha: 5m
Max Freq: 60m
Mu: 500m
Gain Mu: 5m
Symbol Rate: 10k
Omega Limit: 5m
Swap
Swap: False
Multiply Const
Constant: -1
Variable Slider
ID: noise
Label: Noise
Default Value: 10m
Minimum: 0
Maximum: 1
Converter: Float
Decode CCSDS 27
Single Pole IIR Filter
Alpha: 10m
Scope Sink
Title: Scope Plot
Sample Rate: 6.25k
V Scale: 100
Packed to Unpacked
Bits per Chunk: 1
Endianness: MSB
Note
Note: Poly A/B...ersed in FEC
Number Sink
Title: Number Plot
Units: Units
Sample Rate: 100k
Min Value: 0
Max Value: 1
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 15
Show Gauge: Show
Variable Slider
ID: delay
Label: Delay
Default Value: 82
Minimum: 0
Maximum: 200
Converter: Integer
Error Rate
Type: Symbol Error Rate
Window Size: 1k
Note
Note: SER Dela...3(w/o scope)
Variable Delay
Delay: 82
Scope Sink
Title: Scope Plot
Sample Rate: 10k
V Scale: 500m
XY Mode: On
Variable Slider
ID: delay_puncture
Label: Puncture Delay
Default Value: 0
Minimum: 0
Maximum: 14
Converter: Integer
Variable Check Box
ID: delay_viterbi
Label: Delay Viterbi
Default Value: 0
True: 1
False: 0
Variable Chooser
ID: puncture_matrix
Label: Matrix
Default Value: 1, 1
Choices: [[1,1], [1,1,0,1]...
Labels: ['1/2','2/3','3/4'...
Type: Radio Buttons
Variable Chooser
ID: puncture_matrix
Label: Matrix
Default Value: 1, 1, 1, 0
Choices: [1, 1],..., 0, 0, 1]
Labels: 1/2, 2/...4, 5/6, 7/8
Type: Drop Down
Variable Chooser
ID: puncture_matrix_out
Label: Matrix Out
Default Value: 1, 1, 0, 1
Choices: [[1,1], [1,1,0,1]...
Labels: ['1/2','2/3','3/4'...
Type: Drop Down
Variable Check Box
ID: swap_viterbi
Label: Swap Viterbi
Default Value: False
True: True
False: False

Find Precise Symbol Rate

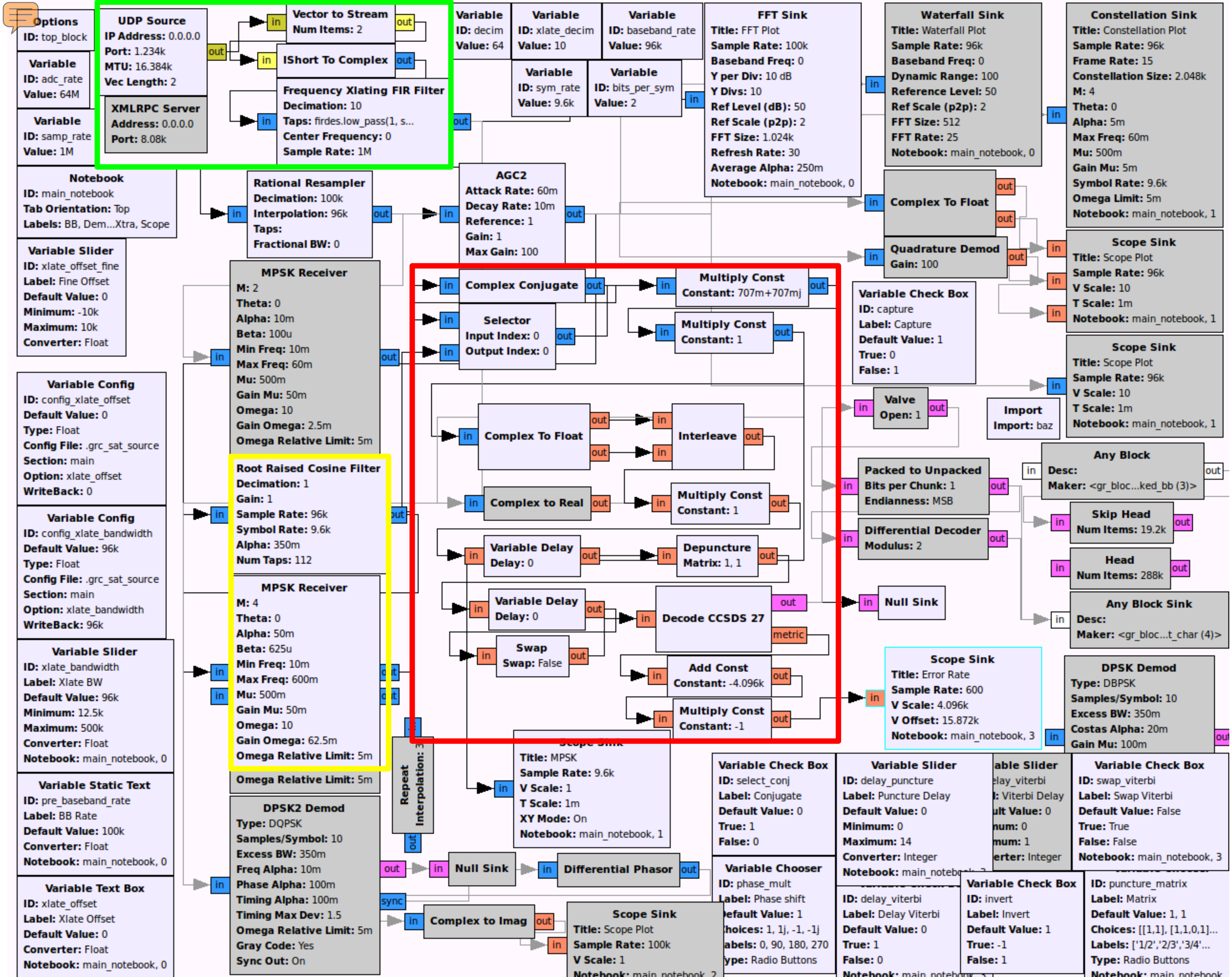




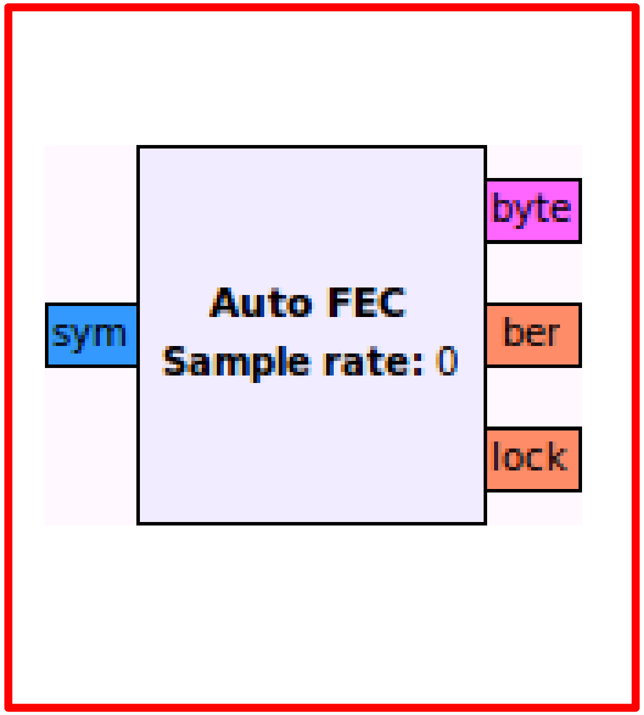
UDP Source
IP Address: 0.0.0.0
Port: 1.234k
Payload Size: 16.384k
BorIP: On
Vec Length: 2
Variable
ID: adc_rate
Value: 64M
Variable
ID: samp_rate
Value: 1M
XMLRPC Server
Address: 0.0.0.0
Port: 8.08k
Vector to Stream
Num Items: 2
IShort To Complex
Variable
ID: decim
Value: 64
Variable
ID: xlate_decim
Value: 25
Variable
ID: baseband_rate
Value: 40k
Variable
ID: re_over
Value: 5
Variable
ID: pre_baseband_rate
Value: 40k
Wav File Source
File: ...203Z_17906kHz_RF.wav
Repeat: Yes
Float To Complex
Multiply Const
Constant: 1k
Throttle
Sample Rate: 1M
Variable Static Text
ID: pre_baseband_rate
Label: BB Rate
Default Value: 40k
Converter: Float
Variable Slider
ID: xlate_offset_fine
Label: Fine Offset
Default Value: 0
Minimum: -10k
Maximum: 10k
Converter: Float
Frequency Xlating FIR Filter
Decimation: 25
Taps: firdes.low_pass(1, s...
Center Frequency: 0
Sample Rate: 1M
Virtual Sink
Stream ID: bb
Variable
ID: re_pre_baseband_rate
Value: 320k
Variable
ID: re_pre_baseband_rate
Value: 40k
Notebook
ID: main_notebook
Tab Orientation: Top
Labels: ['BB', 'Scope', 'D...
Rational Resampler
Decimation: 40k
Interpolation: 320k
Taps:
Fractional BW: 0
Virtual Sink
Stream ID: re_bb
Variable Config
ID: config_xlate_offset
Default Value: 0
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_offset
WriteBack: 0
Polyphase Resampler
Resample Rate:
Taps:
Size (# phases): 32
Variable
ID: fft_size
Value: 458.752k
Complex to Mag
Vec Length: 458.752k
Null Sink
Vec Length: 458.752k
FFT
FFT Size: 458.752k
Forward/Reverse: Forward
Window:
File Sink
File: /mnt/Krump/mpsk_fft.dat
Vec Length: 458.752k
Stream to Vector
Num Items: 458.752k
Variable Config
ID: config_xlate_bandwidth
Default Value: 40k
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_bandwidth
WriteBack: 40k
Variable Slider
ID: xlate_bandwidth
Label: Xlate BW
Default Value: 40k
Minimum: 5k
Maximum: 1M
Converter: Float
Virtual Source
Stream ID: cyclo_input
Multiply Const
Constant: 1
Variable Delay
Delay: 1
Variable Slider
ID: exponent
Label: Exponent
Default Value: 2
Minimum: 0
Maximum: 100
Converter: Integer
Notebook: main_notebook, 3
Variable Slider
ID: D
Label: Nominal ... per symbol
Default Value: 2
Minimum: 1
Maximum: 64
Converter: Integer
Notebook: main_notebook, 4
Complex Conjugate
Variable Text Box
ID: xlate_offset
Label: Xlate Offset
Default Value: 0
Converter: Float
Multiply
Rational Resampler
Decimation: 1
Interpolation: 1
Taps:
Fractional BW: 0
Variable Slider
ID: xlate_offset_coarse
Label: Coarse offset
Default Value: 0
Minimum: -25k
Maximum: 25k
Converter: Integer
Variable
ID: baud_decim
Value: 1
Complex to Mag
FFT Sink
Title: Baud
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 50m
Notebook: main_notebook, 4
Variable Slider
ID: xlate_decim_index
Label: Xlate Decim
Default Value: 0
Minimum: 0
Maximum: 8
Converter: Integer
Virtual Source
Stream ID: bb
Power
Exponent: 2
Variable
ID: pow_decim
Value: 1
Multiply Const
Constant: 1
Variable Slider
ID: pow_div
Label: Div
Default Value: 0
Minimum: 0
Maximum: 100
Converter: Integer
Notebook: main_notebook, 3
Rational Resampler
Decimation: 1
Interpolation: 1
Taps:
Fractional BW: 0
FFT Sink
Title: Pow
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 66.7m
Notebook: main_notebook, 3
Variable Text Box
ID: decim
Label: Decimation
Default Value: 64
Converter: Integer
Variable Static Text
ID: xlate_decim
Label: Xlate Decim
Default Value: 2**x...m_index
Converter: Float
Virtual Source
Stream ID: bb
AGC
Rate: 100u
Reference: 1
Gain: 1
Max Gain: 0
Differential Phasor
Feed Forward AGC
Num Samples: 1.024k
Reference: 1
FFT Sink
Title: FFT Plot
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Notebook: main_notebook, 9
AGC2
Attack Rate: 100m
Decay Rate: 10m
Reference: 1
Gain: 1
Max Gain: 0
AM Demod
Channel Rate: 40k
Audio Decimation: 2
Audio Pass: 4.5k
Audio Stop: 5k
Rational Resampler
Decimation: 50
Interpolation: 48
Taps:
Fractional BW: 0
FFT Sink
Title:
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 66.7m
Notebook: main_notebook, 0
Waterfall Sink
Title:
Sample Rate: 40k
Baseband Freq: 0
Dynamic Range: 100
Reference Level: 50
Ref Scale (p2p): 2
FFT Size: 1.024k
FFT Rate: 25
Window Size: 640, 520
Notebook: main_notebook, 9
Scope Sink
Title: Scope Plot
Sample Rate: 40k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 1
Fast AutoCorrelation Sink
Title: Fast AutoCorrelation
Sample Rate: 40k
Baseband Freq: 0
Size: 32.768k
Rate: 15
Y per Div: 10 dB
Ref Level (dB): 50
Notebook: main_notebook, 5
Scope Sink
Title: Scope Plot
Sample Rate: 40k
XY Mode: On
Window Size: 500, 500
Notebook: main_notebook, 11
Virtual Source
Stream ID: bb
Complex To Float
Quadrature Demod
Gain: 1
Multiply Const
Constant: 100
Complex to Mag
Virtual Sink
Stream ID: quad
Variable Slider
ID: quad_demod_gain
Label: Quadrature Demod Gain
Default Value: 100
Minimum: 1
Maximum: 1k
Converter: Integer
Notebook: main_notebook, 1
Wav File Sink
File: /mnt/Dagron/sat-am.wav
Sample Rate: 48k
Bits per Sample: 16
Audio Sink
Sample Rate: 48KHz
Scope Sink
Title: Scope Plot
Sample Rate: 48k
Notebook: main_notebook, 9
FFT Sink
Title: FFT Plot
Sample Rate: 48k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Notebook: main_notebook, 9
Probe MPSK SNR
Type: SNR
Alpha: 1
Probe Rate: 10
Scope Sink
Title: Scope Plot
Sample Rate: 4k
Notebook: main_notebook, 6
Number Sink
Title: Number Plot
Units: Units
Sample Rate: 1M
Min Value: -100
Max Value: 100
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 15
Show Gauge: Show
Notebook: main_notebook, 6
Variable Slider
ID: eye_samp_per_sym
Label: Samples per symbol
Default Value: 20
Minimum: 1
Maximum: 100
Converter: Integer
Notebook: main_notebook, 2
Variable Slider
ID: eye_num_plots
Label: Num plots
Default Value: 100
Minimum: 1
Maximum: 100
Converter: Integer
Notebook: main_notebook, 2
PLL Carrier Tracking
Alpha: 100m
Beta: 100m
Max Freq: 500m
Min Freq: 100m
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 40k
Symbol Rate: 64k
Alpha: 350m
Num Taps: 2
Eye Diagram
Title: Eye Diagram
Sample Rate: 40k
Samples per symbol: e...r_sym
Num plots: eye_num_plots
Symbol decimation: 20
Notebook: main_notebook, 2
Virtual Source
Stream ID: bb
Complex to Arg
File Sink
File: ...ump/beacon-arg.cfile
Scope Sink
Title: Arg
Sample Rate: 40k
V Scale: 1
T Scale: 1m
Notebook: main_notebook, 7
Virtual Sink
Stream ID: cyclo_input
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 40k
Symbol Rate: 19.2k
Alpha: 350m
Num Taps: 486
Virtual Source
Stream ID: re_bb
Complex to Arg
Sample Rate: 40k
Notebook: main_notebook, 7
Variable
ID: test_decim
Value: 20
Quadrature Demod
Gain: 2
Rational Resampler
Decimation: 20
Interpolation: 1
Taps:
Fractional BW: 0
FFT Sink
Title: FFT Plot
Sample Rate: 2k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 2.048k
Refresh Rate: 30
Average Alpha: 66.7m
Notebook: main_notebook, 7
Differential Phasor
Hilbert
Num Taps: 64
Scope Sink
Title: Arg
Sample Rate: 40k
Notebook: main_notebook, 7
Virtual Sink
Stream ID: cyclo_input
Waterfall Sink
Title:
Sample Rate: 2k
Baseband Freq: 0
Dynamic Range: 100
Reference Level: 50
Ref Scale (p2p): 2
FFT Size: 256
FFT Rate: 25
Notebook: main_notebook, 7
Phase Mod
Sensitivity: 1
Frequency Mod
Sensitivity: 1
FFT Sink
Title: FFT Plot
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 66.7m
Notebook: main_notebook, 7
FFT Sink
Title:
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 66.7m
Notebook: main_notebook, 6
Fast AutoCorrelation Sink
Title: Fast AutoCorrelation
Sample Rate: 40k
Baseband Freq: 0
Size: 65.536k
Rate: 15
Y per Div: 10 dB
Ref Level (dB): 50
Notebook: main_notebook, 8
Scope Sink
Title: Scope Plot
Sample Rate: 40k
V Scale: 200
T Scale: 200u
Notebook: main_notebook, 1
Waterfall Sink
Title:
Sample Rate: 40k
Baseband Freq: 0
Dynamic Range: 100
Reference Level: 50
Ref Scale (p2p): 2
FFT Size: 512
FFT Rate: 15
Notebook: main_notebook, 7
Variable Slider
ID: sym_rate_fine
Label: Symbol rate (fine)
Default Value: 0
Minimum: -500
Maximum: 500
Converter: Integer
Notebook: main_notebook, 2
Variable Slider
ID: sym_rate
Label: Symbol rate
Default Value: 30.8k
Minimum: 1k
Maximum: 91.5k
Converter: Integer
Notebook: main_notebook, 2
Virtual Source
Stream ID: bb
Virtual Source
Stream ID: re_bb
Constellation Sink
Title: Constellation (M=4)
Sample Rate: 40k
Frame Rate: 15
Constellation Size: 2.048k
M: 4
Theta: 0
Alpha: 10m
Max Freq: 60m
Mu: 500m
Gain Mu: 20m
Symbol Rate: 64k
Omega Limit: 5m
Notebook: main_notebook, 2
Variable Slider
ID: sym_rate_coarse
Label: Symbol rate (coarse)
Default Value: 0
Minimum: -5k
Maximum: 5k
Converter: Integer
Notebook: main_notebook, 2
Parameter
ID: sym_rate
Label: Symbol rate
Value: sym_rate_slider
Type: Int
Variable
ID: samp_per_sym
Value: 2
Variable Static Text
ID: sym_rate
Label: Symbol rate
Default Value: 64k
Converter: Integer
Variable Text Box
ID: sym_rate_base
Label: Symbol rate
Default Value: 64k
Converter: Integer
Notebook: main_notebook, 2
Variable
ID: sym_rate
Value: 64k
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 40k
Symbol Rate: 64k
Alpha: 350m
Num Taps: 2
Virtual Source
Stream ID: quad
Variable Delay
Delay: 1
Multiply
FFT Sink
Title: Baud
Sample Rate: 40k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 50m
Notebook: main_notebook, 8
Variable Slider
ID: Dquad
Label: Delay
Default Value: 1
Minimum: 1
Maximum: 256
Converter: Integer
Notebook: main_notebook, 8
Variable
ID: quad_decim
Value: 1
Rational Resampler
Decimation: 1
Interpolation: 1
Taps:
Fractional BW: 0



Options
ID: sat
UDP Source
IP Address: 0.0.0.0
Port: 1.234k
Payload Size: 16.384k
BorIP: On
Vec Length: 2
Vector to Stream
Num Items: 2
IShort To Complex
Variable
ID: decim
Value: 64
Variable
ID: xlate_decim
Value: 5
Variable
ID: baseband_rate
Value: 24k
Variable
ID: over_samp
Value: 10
FFT Sink
Title: FFT Plot
Sample Rate: 200k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 25
Average Alpha: 250m
Notebook: main_notebook, 0
Fast AutoCorrelation Sink
Title: Fast AutoCorrelation
Sample Rate: 24k
Baseband Freq: 0
Size: 131.072k
Rate: 10
Y per Div: 10 dB
Ref Level (dB): 50
Average Alpha: 200m
Notebook: main_notebook, 7
Keep 1 in N
N: 4
Import
Import: baz
Variable Slider
ID: sym_rate
Label: Symbol Rate
Default Value: 10k
Minimum: 300
Maximum: 20k
Converter: Integer
Variable
ID: adc_rate
Value: 64M
Variable
ID: samp_rate
Value: 1M
XMLRPC Server
Address: 0.0.0.0
Port: 8.08k
Wav File Source
File: ...726Z_16653kHz_RF.wav
Repeat: Yes
Float To Complex
Variable
ID: sym_rate
Value: 2.4k
Threshold
Low: 11
High: 10
Initial State: 0
Variable
ID: accept_bytes
Value: 0
Multiply Const
Constant: 1k
Throttle
Sample Rate: 1M
Feed Forward AGC
Num Samples: 16
Reference: 1
Variable Sink
Variable: accept_bytes
Decimation: 1
Simple Squelch
Threshold (dB): sq
Alpha: alpha
Notebook
ID: main_notebook
Tab Orientation: Top
Labels: BB, Dem...C, PSK, FAC
File Source
File: ...beacon-hilbert.cfile
Repeat: No
File Sink
File: /mnt/Krump/mpsk_bb.dat
AGC
Rate: 100u
Reference: 1
Gain: 1
Max Gain: 0
Waterfall Sink
Title: Waterfall Plot
Sample Rate: 24k
Baseband Freq: 0
Dynamic Range: 100
Reference Level: 50
Ref Scale (p2p): 2
FFT Size: 512
FFT Rate: 25
Notebook: main_notebook, 0
Constellation Sink
Title: Constellation Plot
Sample Rate: 24k
Frame Rate: 15
Constellation Size: 2.048k
M: 2
Theta: 0
Alpha: 5m
Max Freq: 60m
Mu: 500m
Gain Mu: 5m
Symbol Rate: 2.4k
Omega Limit: 5m
Notebook: main_notebook, 1
Scope Sink
Title: Scope Plot
Sample Rate: 24k
Frequency Xlating FIR Filter
Decimation: 5
Taps: firdes.low_pass(1, s...
Center Frequency: 0
Sample Rate: 1M
MPSK Sync
Alpha: 10m
Beta: 25u
Max Freq: 60m
Min Freq: 10m
Reference Phase
Omega: 10
Gain Omega: 2.5
Mu: 500m
Gain Mu
DD MPSK Sync
Alpha: 10m
Beta: 25u
Max Freq: 10m
Min Freq: 60m
Reference Phase: 0
Omega: 10
Gain Omega: 2.5m
Mu: 500m
Variable Slider
ID: sq
Default Value: 3
Minimum: 0
Maximum: 24
Converter: Float
Variable Slider
ID: alpha
Default Value
Minimum: 0
Maximum: 1
Converter: Float
Variable Slider
ID: xlate_offset_fine
Label: Fine Offset
Default Value: 0
Minimum: -10k
Maximum: 10k
Converter: Float
Virtual Sink
Stream ID: re_bb
AGC2
Attack Rate: 60m
Decay Rate: 1m
Reference: 1
Gain: 1
Max Gain: 100
Rational Resampler
Decimation: 200k
Interpolation: 24k
Taps:
Fractional BW: 0
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 24k
Symbol Rate: 2.4k
Alpha: 350m
Num Taps: 112
Valve
Open: accept_bytes
Scope Sink
Title: Scope Plot
Sample Rate: 24k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 2
Note
Note: These don't work
Virtual Sink
Stream ID: filt_bb
Scope Sink
Title: Scope Plot
Sample Rate: 24k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 1
UChar To Float
Variable Config
ID: config_xlate_offset
Default Value: 0
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_offset
WriteBack: 0
Virtual Source
Stream ID: filt_bb
Scope Sink
Title: MPSK (M=8)
Sample Rate: 2.4k
V Scale: 500m
T Scale: 5
XY Mode: On
Notebook: main_notebook, 1
Histo Sink
Title: Histogram Plot
Num Bins: 8
Frame Size: 16
Notebook: main_notebook, 2
MPSK Receiver
M: 2
Theta: 0
Alpha: 50m
Beta: 625u
Min Freq: -10m
Max Freq: 10m
Mu: 500m
Gain Mu: 20m
Omega: 10
Gain Omega: 100u
Omega Relative Limit: 5m
Variable Slider
ID: mpsk_alpha
Variable Slider
ID: mpsk_gain_mu
Label: Gain Mu
Default Value: 20m
Minimum: 1m
Maximum: 500m
Converter: Float
Notebook: main_notebook, 1
Complex To Float
Eye Diagram
Title: Eye Diagram
Sample Rate: 24k
Samples per symbol: 3
Num plots: 500
Symbol decimation: 50
V Scale: 1
Notebook: main_notebook, 3
Variable Slider
ID: eye_samp_per_sym
Label: Samples per symbol
Default Value: 3
Minimum: 1
Maximum: 100
Converter: Integer
Notebook: main_notebook, 3
Variable Config
ID: config_xlate_bandwidth
Default Value: 24k
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_bandwidth
WriteBack: 24k
Quadrature Demod
Gain: 100
Costas Loop
Alpha: 10m
Beta: 25u
Max Freq: 10m
Min Freq: 60m
Order: 2
Complex to Arg
Complex to Mag
Variable Check Box
ID: swap_viterbi
Label: Swap Viterbi
Default Value: False
True: True
False: False
Notebook: main_notebook, 5
Variable Slider
ID: xlate_bandwidth
Label: Xlate BW
Default Value: 24k
Minimum: 5k
Maximum: 500k
Converter: Float
MPSK Receiver (Debug)
M: 8
Theta: 0
Alpha: 50m
Beta: 625u
Min Freq: -10m
Max Freq: 10m
Mu: 500m
Gain Mu: 20m
Omega: 10
Gain Omega: 100u
Omega Relative Limit: 10m
out
freq
phase
phase_error
mu
omega
mm_error
File Sink
File: .../Krump/mpsk_freq.dat
File Sink
File: ...Krump/mpsk_phase.dat
File Sink
File: ...mpsk_phase_error.dat
File Sink
File: /mnt/Krump/mpsk_mu.dat
File Sink
File: ...Krump/mpsk_omega.dat
File Sink
File: ...mp/mpsk_mm_error.dat
Clock Recovery MM
Omega: 10
Gain Omega: 2.5m
Mu: 500m
Gain Mu: 500m
Omega Relative Limit: 5m
Complex to Real
Quadrature Demod
Gain: 1
Variable Check Box
ID: delay_viterbi
Label: D
Default
True: 1
False: 0
Notebo
Variable Slider
ID: delay_puncture
Label: Puncture Delay
Default Value: 0
Minimum: 0
Maximum: 14
Converter: Integer
Notebook: main_notebook, 5
Variable Check Box
ID: invert
Label: Invert
Default Value: 1
True: -1
False: 1
Notebook: main_notebook, 5
Variable Chooser
ID: puncture_matrix
Label: Matrix
Default Value: 1, 1
Choices: [[1,1], [1,1,0,1]...
Labels: ['1/2','2/3','3/4'...
Type: Radio Buttons
Notebook: main_notebook, 5
File Sink
File: .../Krump/mpsk_real.dat
Scope Sink
Title: Scope Plot
Sample Rate: 24k
Notebook: main_notebook, 3
Scope Sink
Title: Scope Plot
Sample Rate: 2.4k
Notebook: main_notebook, 4
Variable Static Text
ID: pre_baseband_rate
Label: BB Rate
Default Value: 200k
Converter: Float
Notebook: main_notebook, 0
Scope Sink
Title: Scope Plot
Sample Rate: 24k
Notebook: main_notebook, 3
Decode CCSDS 27
out
metric
Null Sink
Packed to Unpacked
Bits per Chunk: 1
Endianness: MSB
Null Sink
Variable Text Box
ID: xlate_offset
Label: Xlate Offset
Default Value: 0
Converter: Float
Freq Alpha: 10m
Phase Alpha: 100m
Timing Alpha: 100m
sync
Null Sink
Complex to Real
Skip Head
Num Items: 4.8k
Add Const
Constant: -4.096k
Float To UChar
Differential Phasor
Multiply Const
Constant: 1
Differential Decoder
Modulus: 2
Scope Sink
Title: MPSK Freq
Sample Rate: 2.4k
V Scale: 2m
T Scale: 50m
Notebook: main_notebook, 6
Virtual Source
Stream ID: re_bb
Threshold
Low: 0
High: 0
Initial State: 0
Variable Delay
Delay: 0
Multiply Const
Constant: -1
Head
Num Items: 72k
Scope Sink
Title: Error Rate
Sample Rate: 150
V Scale: 4.096k
V Offset: 15.872k
Notebook: main_notebook, 5
Differential Phasor
DPSK Demod
Type: DBPSK
Samples/Symbol: 10
Excess BW: 350m
Costas Alpha: 50m
Gain Mu: 20m
Mu: 500m
Omega Relative Limit: 5m
Gray Code: Yes
Verbose: On
Any Block Sink
Desc:
Maker: <gr_bloc...t_char (2)>
Scope Sink
Title: Scope Plot
Sample Rate: 100k
V Scale: 500m
T Scale: 10m
Notebook: main_notebook, 2
Depuncture
Matrix: 1, 1
Variable Delay
Delay: 0
Swap
Swap: False
Complex to Imag
Single Pole IIR Filter
Alpha: 1
File Sink
File: ...96637kHz_RF-sync.dat
Any Block
Desc:
Maker: <gr_bloc...ked_bb (1)>
UChar To Float
Histo Sink
Title: Histogram Plot
Num Bins: 256
Frame Size: 256
Notebook: main_notebook, 4
Differential Encoder
Modulus: 2



Options
ID: top_block
UDP Source
IP Address: 0.0.0.0
Port: 1.234k
MTU: 16.384k
Vec Length: 2
Vector to Stream
Num Items: 2
IShort To Complex
Frequency Xlating FIR Filter
Decimation: 10
Taps: firdes.low_pass(1, s...
Center Frequency: 0
Sample Rate: 1M
XMLRPC Server
Address: 0.0.0.0
Port: 8.08k
Variable
ID: adc_rate
Value: 64M
Variable
ID: samp_rate
Value: 1M
Variable
ID: decim
Value: 64
Variable
ID: xlate_decim
Value: 10
Variable
ID: baseband_rate
Value: 96k
Variable
ID: sym_rate
Value: 9.6k
Variable
ID: bits_per_sym
Value: 2
FFT Sink
Title: FFT Plot
Sample Rate: 100k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 250m
Notebook: main_notebook, 0
Waterfall Sink
Title: Waterfall Plot
Sample Rate: 96k
Baseband Freq: 0
Dynamic Range: 100
Reference Level: 50
Ref Scale (p2p): 2
FFT Size: 512
FFT Rate: 25
Notebook: main_notebook, 0
Constellation Sink
Title: Constellation Plot
Sample Rate: 96k
Frame Rate: 15
Constellation Size: 2.048k
M: 4
Theta: 0
Alpha: 5m
Max Freq: 60m
Mu: 500m
Gain Mu: 5m
Symbol Rate: 9.6k
Omega Limit: 5m
Notebook: main_notebook, 1
Notebook
ID: main_notebook
Tab Orientation: Top
Labels: BB, Dem...Xtra, Scope
Rational Resampler
Decimation: 100k
Interpolation: 96k
Taps:
Fractional BW: 0
AGC2
Attack Rate: 60m
Decay Rate: 10m
Reference: 1
Gain: 1
Max Gain: 100
Complex To Float
Quadrature Demod
Gain: 100
Variable Slider
ID: xlate_offset_fine
Label: Fine Offset
Default Value: 0
Minimum: -10k
Maximum: 10k
Converter: Float
MPSK Receiver
M: 2
Theta: 0
Alpha: 10m
Beta: 100u
Min Freq: 10m
Max Freq: 60m
Mu: 500m
Gain Mu: 50m
Omega: 10
Gain Omega: 2.5m
Omega Relative Limit: 5m
Complex Conjugate
Multiply Const
Constant: 707m+707mj
Selector
Input Index: 0
Output Index: 0
Multiply Const
Constant: 1
Variable Check Box
ID: capture
Label: Capture
Default Value: 1
True: 0
False: 1
Scope Sink
Title: Scope Plot
Sample Rate: 96k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 1
Scope Sink
Title: Scope Plot
Sample Rate: 96k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 1
Variable Config
ID: config_xlate_offset
Default Value: 0
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_offset
WriteBack: 0
Complex To Float
Interleave
Valve
Open: 1
Import
Import: baz
Any Block
Desc:
Maker: <gr_bloc...ked_bb (3)>
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 96k
Symbol Rate: 9.6k
Alpha: 350m
Num Taps: 112
Complex to Real
Multiply Const
Constant: 1
Packed to Unpacked
Bits per Chunk: 1
Endianness: MSB
Skip Head
Num Items: 19.2k
Differential Decoder
Modulus: 2
Head
Num Items: 288k
Variable Config
ID: config_xlate_bandwidth
Default Value: 96k
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_bandwidth
WriteBack: 96k
Variable Delay
Delay: 0
Depuncture
Matrix: 1, 1
MPSK Receiver
M: 4
Theta: 0
Alpha: 50m
Beta: 625u
Min Freq: 10m
Max Freq: 600m
Mu: 500m
Gain Mu: 50m
Omega: 10
Gain Omega: 62.5m
Omega Relative Limit: 5m
Variable Delay
Delay: 0
Decode CCSDS 27
Null Sink
Any Block Sink
Desc:
Maker: <gr_bloc...t_char (4)>
Swap
Swap: False
Add Const
Constant: -4.096k
Multiply Const
Constant: -1
Scope Sink
Title: Error Rate
Sample Rate: 600
V Scale: 4.096k
V Offset: 15.872k
Notebook: main_notebook, 3
DPSK Demod
Type: DBPSK
Samples/Symbol: 10
Excess BW: 350m
Costas Alpha: 20m
Gain Mu: 100m
Variable Slider
ID: xlate_bandwidth
Label: Xlate BW
Default Value: 96k
Minimum: 12.5k
Maximum: 500k
Converter: Float
Notebook: main_notebook, 0
Repeat
Interpolation: 3
Scope Sink
Title: MPSK
Sample Rate: 9.6k
V Scale: 1
T Scale: 1m
XY Mode: On
Notebook: main_notebook, 1
Variable Check Box
ID: select_conj
Label: Conjugate
Default Value: 0
True: 1
False: 0
Variable Slider
ID: delay_puncture
Label: Puncture Delay
Default Value: 0
Minimum: 0
Maximum: 14
Converter: Integer
Notebook: main_notebo...
...able Slider
...elay_viterbi
...: Viterbi Delay
...lt Value: 0
...num: 0
...mum: 1
...erter: Integer
Variable Check Box
ID: swap_viterbi
Label: Swap Viterbi
Default Value: False
True: True
False: False
Notebook: main_notebook, 3
Omega Relative Limit: 5m
Variable Static Text
ID: pre_baseband_rate
Label: BB Rate
Default Value: 100k
Converter: Float
Notebook: main_notebook, 0
DPSK2 Demod
Type: DQPSK
Samples/Symbol: 10
Excess BW: 350m
Freq Alpha: 10m
Phase Alpha: 100m
Timing Alpha: 100m
Timing Max Dev: 1.5
Omega Relative Limit: 5m
Gray Code: Yes
Sync Out: On
Null Sink
Differential Phasor
Complex to Imag
Scope Sink
Title: Scope Plot
Sample Rate: 100k
V Scale: 1
Notebook: main_notebook, 2
Variable Chooser
ID: phase_mult
Label: Phase shift
Default Value: 1
Choices: 1, 1j, -1, -1j
Labels: 0, 90, 180, 270
Type: Radio Buttons
ID: delay_viterbi
Label: Delay Viterbi
Default Value: 0
True: 1
False: 0
Notebook: main_notebo...
Variable Check Box
ID: invert
Label: Invert
Default Value: 1
True: -1
False: 1
ID: puncture_matrix
Label: Matrix
Default Value: 1, 1
Choices: [[1,1], [1,1,0,1]...
Labels: ['1/2','2/3','3/4'...
Type: Radio Buttons
Notebook: main_notebook
Variable Text Box
ID: xlate_offset
Label: Xlate Offset
Default Value: 0
Converter: Float
Notebook: main_notebook, 0

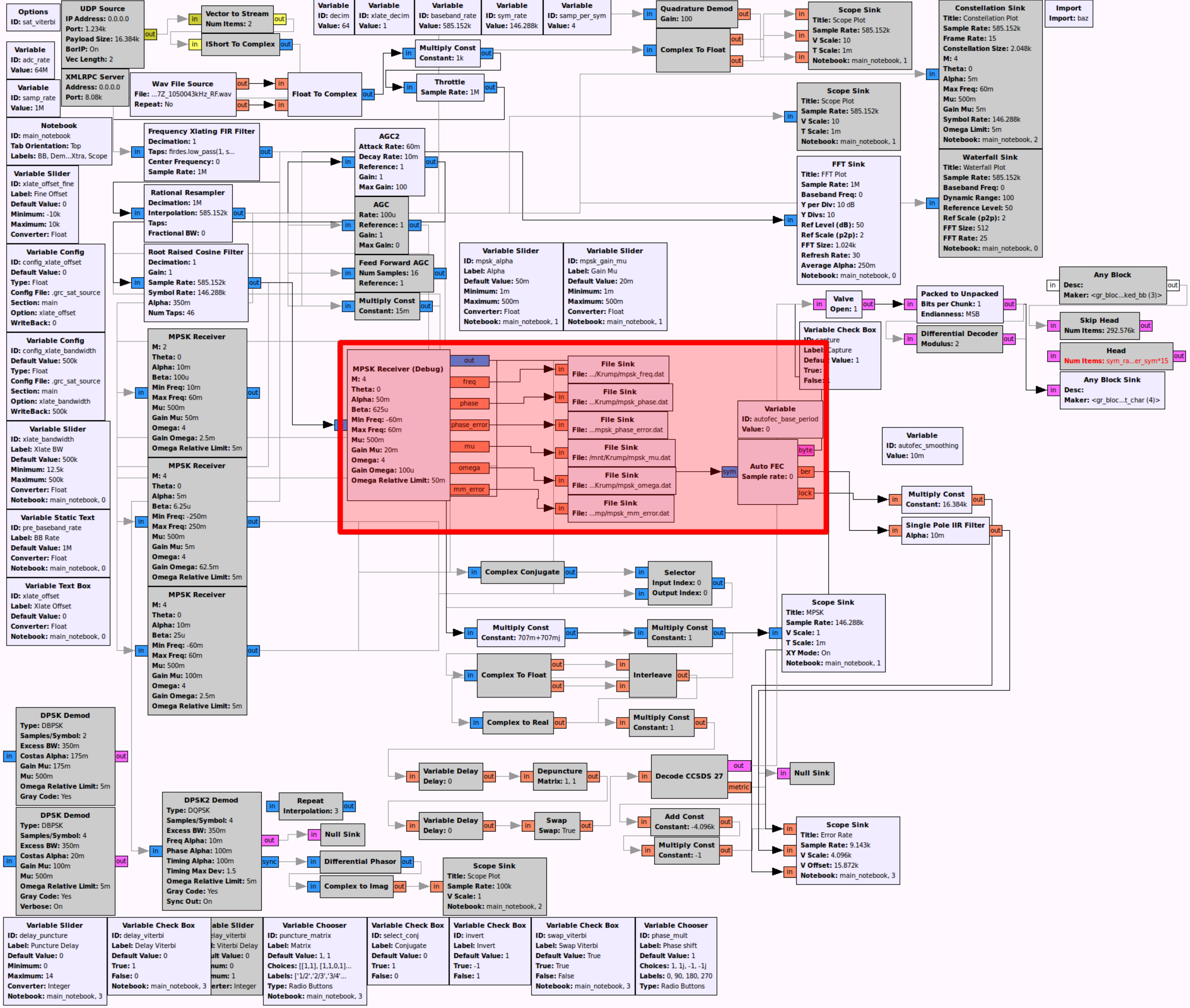

Auto FEC
Sample rate: 0
sym
byte
ber
lock

Auto FEC

```
Creating Auto-FEC:
    sample_rate:                800000
    ber_threshold:              2048
    ber_smoothing:              0.01
    ber_duration:               8192
    ber_sample_decimation:      1
    settling_period:  4096
    pre_lock_duration:          8192

De-puncturer relative rate: 1.000000
==> Using throttle at sample rate: 800000
==> Using lock throttle rate: 50000
Auto-FEC thread started: Thread-1
Skipping initial samples while MPSK receiver locks: 4096

Reached excess BER limit: 11437.1352901 , locked: False , current puncture matrix: 0 , total samples
    received: 12289
    Applying lock value: 0
Beginning search...
    Applying rotation: 1j

Reached excess BER limit: 11870.4144919 , locked: False , current puncture matrix: 0 , total samples
    received: 24586
    Applying rotation: 1
    Applying conjugation: 0

Locking current XForm
==============================================================
```

FEC locked: 1/2

```
==============================================================
    Applying lock value: 1
```



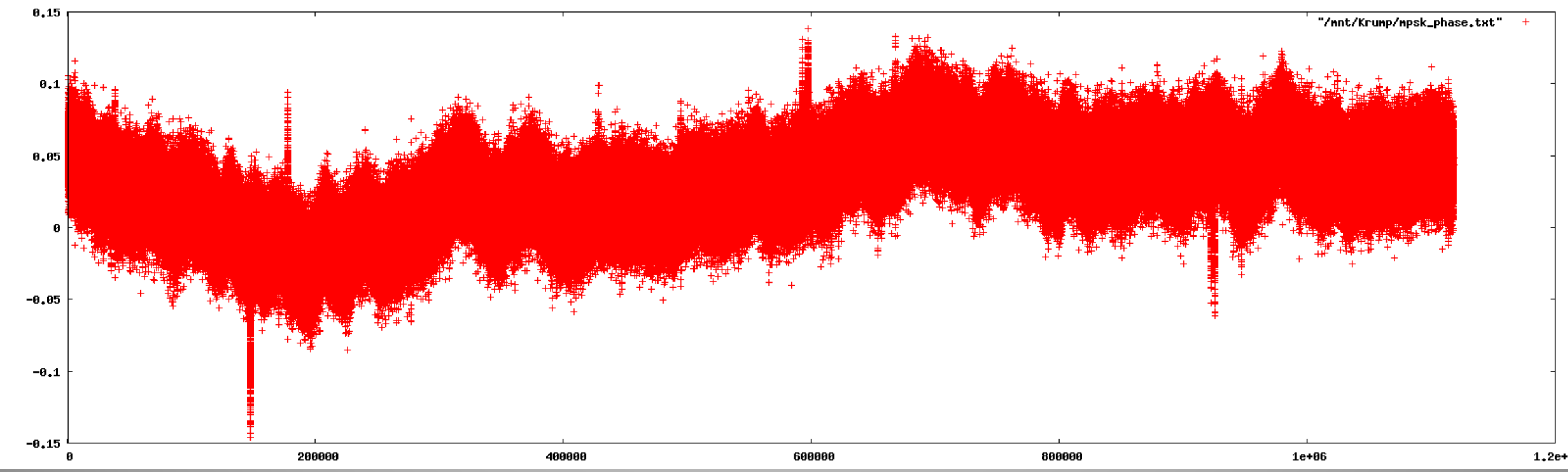
Options
ID: sat_viterbi
UDP Source
IP Address: 0.0.0.0
Port: 1.234k
Payload Size: 16.384k
BorIP: On
Vec Length: 2
Vector to Stream
Num Items: 2
IShort To Complex
Variable
ID: decim
Value: 64
Variable
ID: xlate_decim
Value: 1
Variable
ID: baseband_rate
Value: 585.152k
Variable
ID: sym_rate
Value: 146.288k
Variable
ID: samp_per_sym
Value: 4
Quadrature Demod
Gain: 100
Complex To Float
Scope Sink
Title: Scope Plot
Sample Rate: 585.152k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 1
Constellation Sink
Title: Constellation Plot
Sample Rate: 585.152k
Frame Rate: 15
Constellation Size: 2.048k
M: 4
Theta: 0
Alpha: 5m
Max Freq: 60m
Mu: 500m
Gain Mu: 5m
Symbol Rate: 146.288k
Omega Limit: 5m
Notebook: main_notebook, 2
Import
Import: baz
Variable
ID: adc_rate
Value: 64M
Variable
ID: samp_rate
Value: 1M
XMLRPC Server
Address: 0.0.0.0
Port: 8.08k
Wav File Source
File: ...7Z_1050043kHz_RF.wav
Repeat: No
Float To Complex
Multiply Const
Constant: 1k
Throttle
Sample Rate: 1M
Scope Sink
Title: Scope Plot
Sample Rate: 585.152k
V Scale: 10
T Scale: 1m
Notebook: main_notebook, 1
Notebook
ID: main_notebook
Tab Orientation: Top
Labels: BB, Dem...Xtra, Scope
Frequency Xlating FIR Filter
Decimation: 1
Taps: firdes.low_pass(1, s...
Center Frequency: 0
Sample Rate: 1M
AGC2
Attack Rate: 60m
Decay Rate: 10m
Reference: 1
Gain: 1
Max Gain: 100
FFT Sink
Title: FFT Plot
Sample Rate: 1M
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 250m
Notebook: main_notebook, 0
Waterfall Sink
Title: Waterfall Plot
Sample Rate: 585.152k
Baseband Freq: 0
Dynamic Range: 100
Reference Level: 50
Ref Scale (p2p): 2
FFT Size: 512
FFT Rate: 25
Notebook: main_notebook, 0
Variable Slider
ID: xlate_offset_fine
Label: Fine Offset
Default Value: 0
Minimum: -10k
Maximum: 10k
Converter: Float
Rational Resampler
Decimation: 1M
Interpolation: 585.152k
Taps:
Fractional BW: 0
AGC
Rate: 100u
Reference: 1
Gain: 1
Max Gain: 0
Variable Config
ID: config_xlate_offset
Default Value: 0
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_offset
WriteBack: 0
Root Raised Cosine Filter
Decimation: 1
Gain: 1
Sample Rate: 585.152k
Symbol Rate: 146.288k
Alpha: 350m
Num Taps: 46
Feed Forward AGC
Num Samples: 16
Reference: 1
Multiply Const
Constant: 15m
Variable Slider
ID: mpsk_alpha
Label: Alpha
Default Value: 50m
Minimum: 1m
Maximum: 500m
Converter: Float
Notebook: main_notebook, 1
Variable Slider
ID: mpsk_gain_mu
Label: Gain Mu
Default Value: 20m
Minimum: 1m
Maximum: 500m
Converter: Float
Notebook: main_notebook, 1
Any Block
Desc:
Maker: <gr_bloc...ked_bb (3)>
Valve
Open: 1
Packed to Unpacked
Bits per Chunk: 1
Endianness: MSB
Skip Head
Num Items: 292.576k
Variable Check Box
ID: capture
Label: Capture
Default Value: 1
True: 1
False: 0
Differential Decoder
Modulus: 2
Head
Num Items: sym_ra...er_sym*15
Any Block Sink
Desc:
Maker: <gr_bloc...t_char (4)>
Variable Config
ID: config_xlate_bandwidth
Default Value: 500k
Type: Float
Config File: .grc_sat_source
Section: main
Option: xlate_bandwidth
WriteBack: 500k
MPSK Receiver
M: 2
Theta: 0
Alpha: 10m
Beta: 100u
Min Freq: 10m
Max Freq: 60m
Mu: 500m
Gain Mu: 50m
Omega: 4
Gain Omega: 2.5m
Omega Relative Limit: 5m
MPSK Receiver (Debug)
M: 4
Theta: 0
Alpha: 50m
Beta: 625u
Min Freq: -60m
Max Freq: 60m
Mu: 500m
Gain Mu: 20m
Omega: 4
Gain Omega: 100u
Omega Relative Limit: 50m
out
freq
phase
phase_error
mu
omega
mm_error
File Sink
File: .../Krump/mpsk_freq.dat
File Sink
File: ...Krump/mpsk_phase.dat
File Sink
File: ...mpsk_phase_error.dat
File Sink
File: /mnt/Krump/mpsk_mu.dat
File Sink
File: ...Krump/mpsk_omega.dat
File Sink
File: ...mp/mpsk_mm_error.dat
Variable
ID: autofec_base_period
Value: 0
Auto FEC
Sample rate: 0
sym
byte
ber
lock
Variable
ID: autofec_smoothing
Value: 10m
Variable Slider
ID: xlate_bandwidth
Label: Xlate BW
Default Value: 500k
Minimum: 12.5k
Maximum: 500k
Converter: Float
Notebook: main_notebook, 0
Multiply Const
Constant: 16.384k
Single Pole IIR Filter
Alpha: 10m
Variable Static Text
ID: pre_baseband_rate
Label: BB Rate
Default Value: 1M
Converter: Float
Notebook: main_notebook, 0
MPSK Receiver
M: 4
Theta: 0
Alpha: 5m
Beta: 6.25u
Min Freq: -250m
Max Freq: 250m
Mu: 500m
Gain Mu: 5m
Omega: 4
Gain Omega: 62.5m
Omega Relative Limit: 5m
Complex Conjugate
Selector
Input Index: 0
Output Index: 0
Variable Text Box
ID: xlate_offset
Label: Xlate Offset
Default Value: 0
Converter: Float
Notebook: main_notebook, 0
MPSK Receiver
M: 4
Theta: 0
Alpha: 10m
Beta: 25u
Min Freq: -60m
Max Freq: 60m
Mu: 500m
Gain Mu: 100m
Omega: 4
Gain Omega: 2.5m
Omega Relative Limit: 5m
Multiply Const
Constant: 707m+707mj
Multiply Const
Constant: 1
Scope Sink
Title: MPSK
Sample Rate: 146.288k
V Scale: 1
T Scale: 1m
XY Mode: On
Notebook: main_notebook, 1
Complex To Float
Interleave
Complex to Real
Multiply Const
Constant: 1
DPSK Demod
Type: DBPSK
Samples/Symbol: 2
Excess BW: 350m
Costas Alpha: 175m
Gain Mu: 175m
Mu: 500m
Omega Relative Limit: 5m
Gray Code: Yes
Variable Delay
Delay: 0
Depuncture
Matrix: 1, 1
Decode CCSDS 27
out
metric
Null Sink
DPSK2 Demod
Type: DQPSK
Samples/Symbol: 4
Excess BW: 350m
Freq Alpha: 10m
Phase Alpha: 100m
Timing Alpha: 100m
Timing Max Dev: 1.5
Omega Relative Limit: 5m
Gray Code: Yes
Sync Out: On
Repeat
Interpolation: 3
Variable Delay
Delay: 0
Swap
Swap: True
Add Const
Constant: -4.096k
Multiply Const
Constant: -1
DPSK Demod
Type: DBPSK
Samples/Symbol: 4
Excess BW: 350m
Costas Alpha: 20m
Gain Mu: 100m
Mu: 500m
Omega Relative Limit: 5m
Gray Code: Yes
Verbose: On
Null Sink
Differential Phasor
Complex to Imag
Scope Sink
Title: Scope Plot
Sample Rate: 100k
V Scale: 1
Notebook: main_notebook, 2
Scope Sink
Title: Error Rate
Sample Rate: 9.143k
V Scale: 4.096k
V Offset: 15.872k
Notebook: main_notebook, 3
Variable Slider
ID: delay_puncture
Label: Puncture Delay
Default Value: 0
Minimum: 0
Maximum: 14
Converter: Integer
Notebook: main_notebook, 3
Variable Check Box
ID: delay_viterbi
Label: Delay Viterbi
Default Value: 0
True: 1
False: 0
Notebook: main_notebook, 3
Variable Chooser
ID: puncture_matrix
Label: Matrix
Default Value: 1, 1
Choices: [[1,1], [1,1,0,1]...
Labels: ['1/2','2/3','3/4'...
Type: Radio Buttons
Notebook: main_notebook, 3
Variable Check Box
ID: select_conj
Label: Conjugate
Default Value: 0
True: 1
False: 0
Variable Check Box
ID: invert
Label: Invert
Default Value: 1
True: -1
False: 1
Variable Check Box
ID: swap_viterbi
Label: Swap Viterbi
Default Value: True
True: True
False: False
Notebook: main_notebook, 3
Variable Chooser
ID: phase_mult
Label: Phase shift
Default Value: 1
Choices: 1, 1j, -1, -1j
Labels: 0, 90, 180, 270
Type: Radio Buttons

Demodulated & error-corrected

- Symbol rate = 9600 symbols/sec
- Pre-FEC raw bit rate = 19200 bits/sec
- Post-FEC raw bit rate = 9600 bits/sec (½ rate)

- Visualise data: look for additional clues
  - Differential encoding
  - Scrambling
  - Structure

QPSK Phase Debug

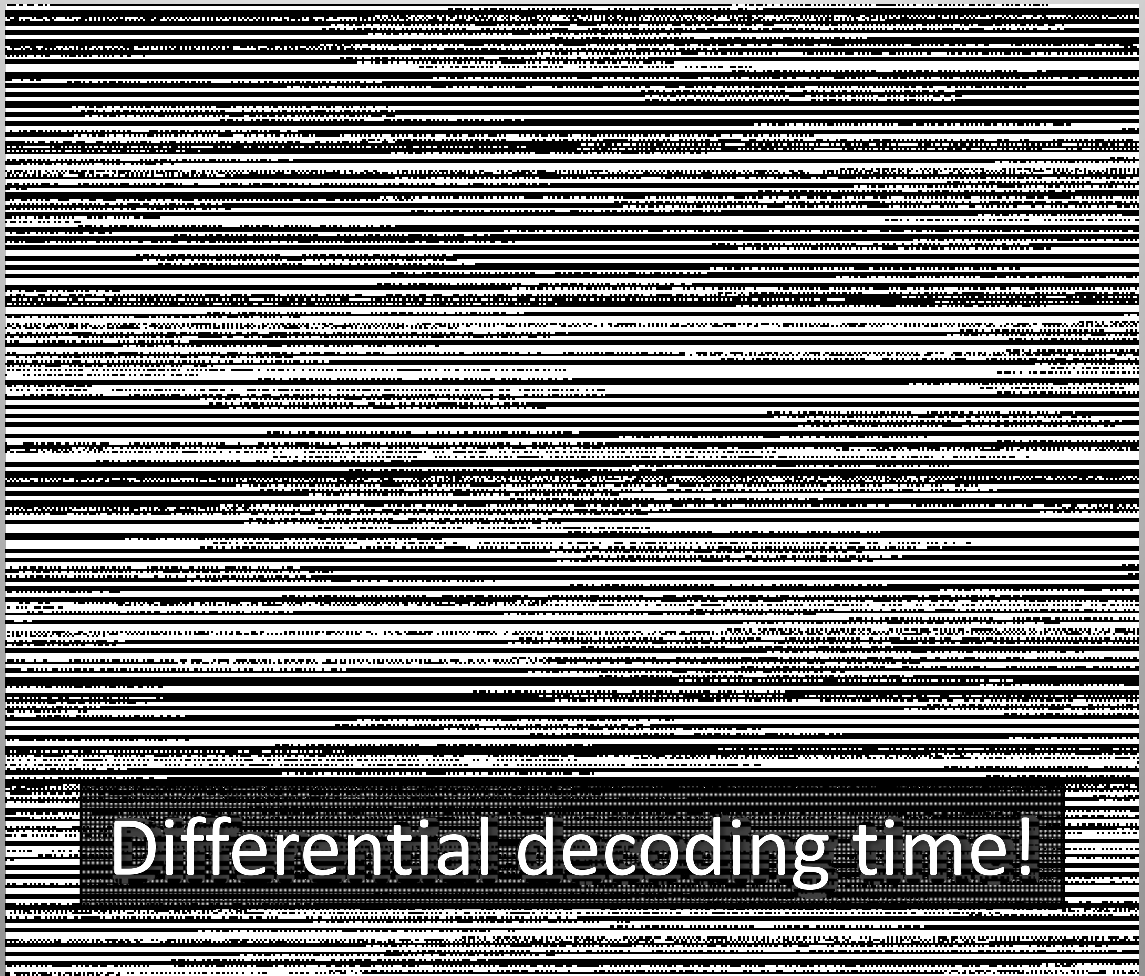


Visualisation

- Raw data (0: black, 1: white)

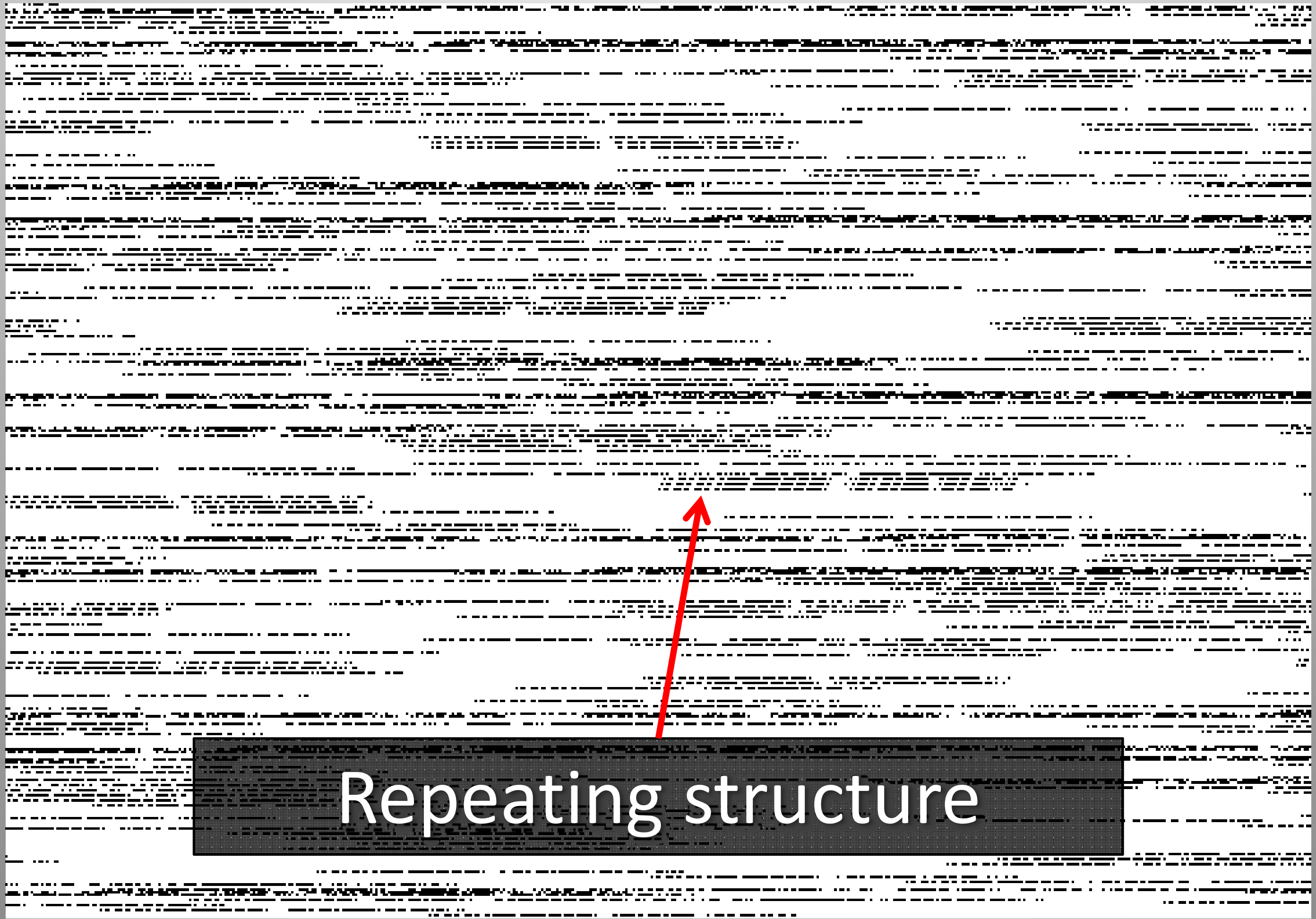
De-scrambled

- Better, but long runs of 0s and 1s (not ideal)



Diff. decoded & de-scrambled

- Structured, asynchronous packets of data!



Pattern Search

```
44 bits #0002-0002[+0000, /0000]: 00000001000011101000000010001011101111111011 (dfdd1017080)
44 bits #0002-0002[+0000, /0000]: 00000001100000011111000010111101010101111111 (feabd0f8180)
44 bits #0002-0002[+0000, /0000]: 00000001100001011111000010111101010101111111 (feabd0fa180)
44 bits #0004-0004[+0000, /0000]: 00000001100000110000100010111101010101111111 (feabd10c180)

43 bits #0000-0005[+0001, /0000]: 0110111100110000001001100110001000011000000 (1846640cf6)

42 bits #0002-0002[+0000, /0000]: 000000011001000111010011000011000010000000 (430cb8980)
42 bits #0002-0002[+0000, /0000]: 000000010000010000100000011001101100000010 (10366042080)
42 bits #0002-0002[+0000, /0000]: 000000011001000100011011000000111110000000 (7c0d88980)
42 bits #0001-0003[+0000, /0000]: 000000010000111010000000100010111011111110 (1fdd1017080)
42 bits #0003-0003[+0000, /0000]: 000000011000100111010011000011000010000000 (430cb9180)
42 bits #0000-0004[+0002, /0000]: 000000110000011000010001011110101010111111 (3f55e8860c0)

41 bits #0002-0002[+0000, /0000]: 00000001000011001001110000100111110000000 (3e4393080)
41 bits #0003-0003[+0000, /0000]: 00000001000101001001110000001111110000000 (3f0392880)
41 bits #0001-0003[+0000, /0000]: 00000001000011101000000011110110110000001 (1036f017080)
41 bits #0000-0003[+0001, /0000]: 00000010000111010000000100010111011111110 (fee880b840)
41 bits #0000-0004[+0002, /0000]: 00000001000011101000000010100000101011111 (1f505017080)
41 bits #0006-0006[+0000, /0000]: 00000001000001000010000000101111110000000 (3fa042080)

40 bits #0002-0002[+0000, /0000]: 1100001000101111100101000000100011000000 (18829f443)
40 bits #0002-0002[+0000, /0000]: 0110000101111111010100001000110000000111 (e0310afe86)
40 bits #0002-0002[+0000, /0000]: 0000000100001110100000001000101100111111 (fcd1017080)
40 bits #0002-0002[+0000, /0000]: 0001110100101110011010000000100011000001 (81881674b8)
40 bits #0000-0003[+0001, /0000]: 0000001000011101000000011110110110000001 (81b780b840)
40 bits #0000-0003[+0001, /0000]: 0000001100010011101001100001100001000000 (21865c8c0)
40 bits #0001-0004[+0000, /0000]: 0000000100001110100000001000101110111111 (fdd1017080)
40 bits #0001-0004[+0000, /0000]: 0000000100001110100000001111011011000000 (36f017080)
40 bits #0001-0005[+0000, /0000]: 0000000100001110100000001010000010101111 (f505017080)
40 bits #0006-0006[+0000, /0000]: 0000000100000100001000000010111111000000 (1fa042080)

39 bits #0002-0002[+0000, /0000]: 111110100101110011110100001000110000000 (c42f3a5f)
39 bits #0002-0002[+0000, /0000]: 001000000011111110100101110000101111111 (7f43a5fc04)
39 bits #0002-0002[+0000, /0000]: 000000010101010100100011010001111000001 (41e2c4aa80)
39 bits #0002-0002[+0000, /0000]: 011101001011100110100000001000110000010 (2062059d2e)
39 bits #0002-0002[+0000, /0000]: 011111010010111001111010000100011000000 (1885e74be)
39 bits #0002-0002[+0000, /0000]: 010110100101110001100000001000110000000 (c4063a5a)
39 bits #0000-0003[+0001, /0000]: 000000100010100100111000000111111000000 (1f81c9440)
39 bits #0000-0004[+0001, /0000]: 000000100001110100000001000101110111111 (7ee880b
39 bits #0000-0004[+0001, /0000]: 000000100001110100000001111011011000000 (1b780b8
39 bits #0000-0005[+0002, /0000]: 000000100001110100000001010000010101111 (7a8280b
39 bits #0000-0006[+0004, /0000]: 000000100000100001000000101111111000000 (1fd0210
39 bits #0166-0172[+0000, /0000]: 111111101001100010011000100110010000000 (9919197

38 bits #0002-0002[+0000, /0000]: 01001000101110100001100001000110000000 (62185d12
38 bits #0002-0002[+0000, /0000]: 11110100101111011110100001000110000001 (206217bd
38 bits #0002-0002[+0000, /0000]: 00011000010111001011010000100011000000 (c42d3a18)
38 bits #0002-0002[+0000, /0000]: 00110000101111110011010000100011000000 (62167d0c)
38 bits #0001-0003[+0000, /0000]: 00000001010101010010001101000111100000 (1e2c4aa80)
38 bits #0000-0003[+0001, /0000]: 11111010010111001111010000100011000000 (c42f3a5f)
38 bits #0000-0003[+0001, /0000]: 01110100101110011010000000100011000001 (2062059d2e)
38 bits #0000-0006[+0004, /0000]: 00000010000010000100000010111111000000 (fd021040)
38 bits #0000-0172[+0166, /0000]: 11111101001100010011000100110010000000 (4c8c8cbf)

37 bits #0002-0002[+0000, /0000]: 1110110000000111010110110000001000000 (40dae037)
37 bits #0002-0002[+0000, /0000]: 1011010010111101101000000010001100000 (6205bd2d)
37 bits #0002-0002[+0000, /0000]: 0000000111101100001011100110101111111 (1fd6743780)
37 bits #0000-0003[+0001, /0000]: 0000001010101010010001101000111100000 (f1625540)
37 bits #0000-0010[+0008, /0000]: 0000000100000100001000000010111111010 (bfa042080)
37 bits #0000-0010[+0008, /0000]: 0000000100000100001000000010111110110 (dfa042080)
37 bits #0000-0010[+0008, /0000]: 0000000100000100001000000010111110001 (11fa042080)
```

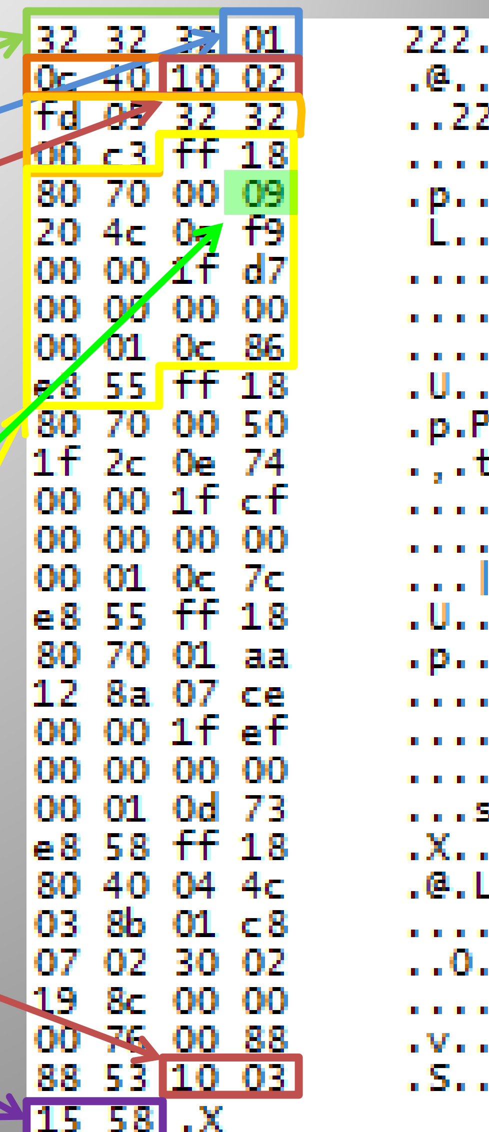
- Search for repeating strings of bits
- Try to find frame header
- Clue: sudden increase in # of occurrences

```
38 bits #0000-0006[+0004, /0000]: 00000010000010000100000010111111000000 (fd021040)
38 bits #0000-0172[+0166, /0000]: 11111101001100010011000100110010000000 (4c8c8cbf)

37 bits #0002-0002[+0000, /0000]: 1110110000000111010110110000001000000 (40dae037)
37 bits #0002-0002[+0000, /0000]: 1011010010111101101000000010001100000 (6205bd2d)
```

Preceding 1s are just part of 'idle' stream when no data is being sent

Frame analysis

- Header
  - SYN SYN SYN (EBCDIC)
- Character-oriented encoding:
  - SOH
  - STX
  - ETX
  - CRC (CCITT-16)
- Numbers of fixed-length messages
  - Each contains an ID



Un-pack & find patterns

#

Message header

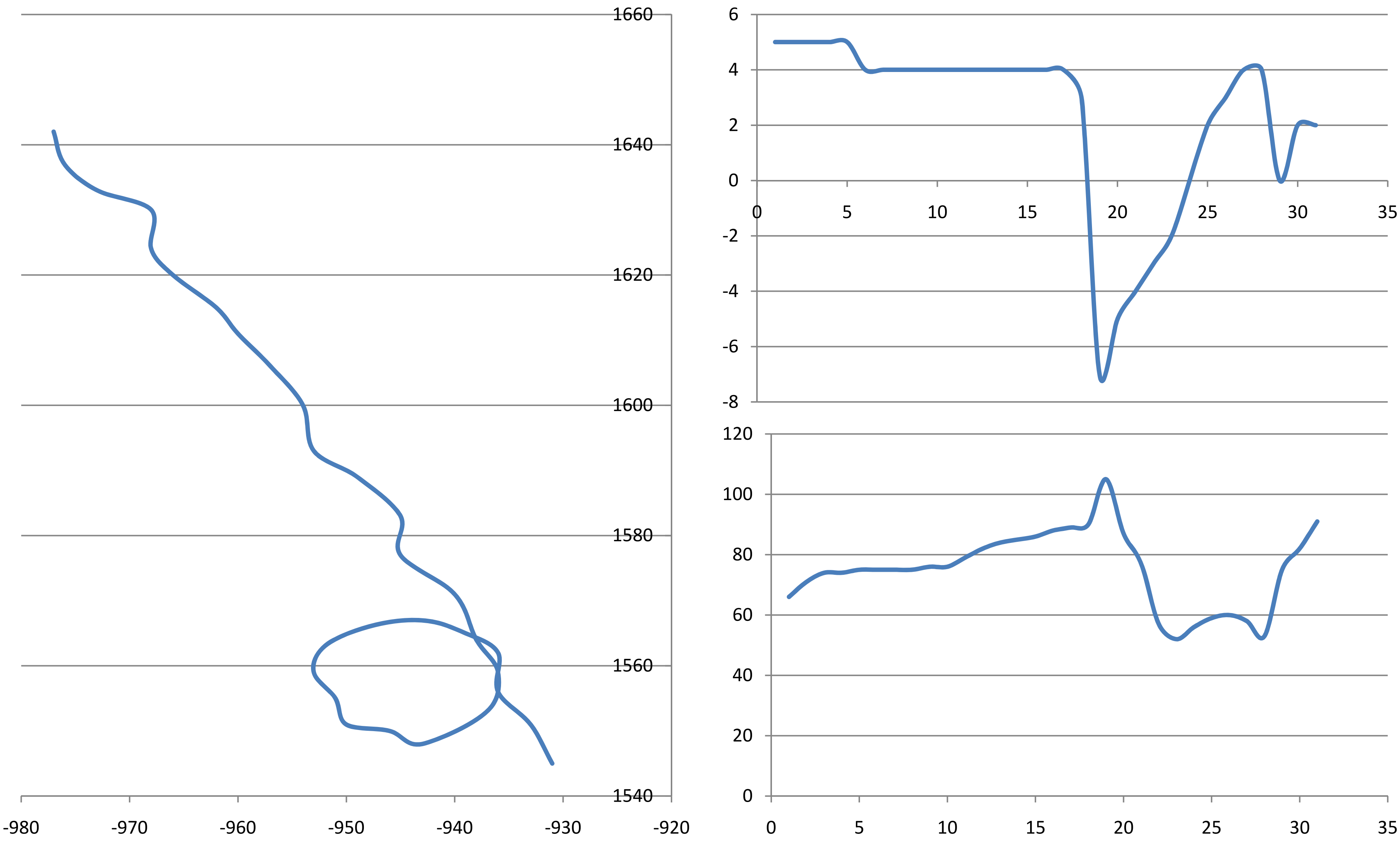
16-bit signed

8-bit signed

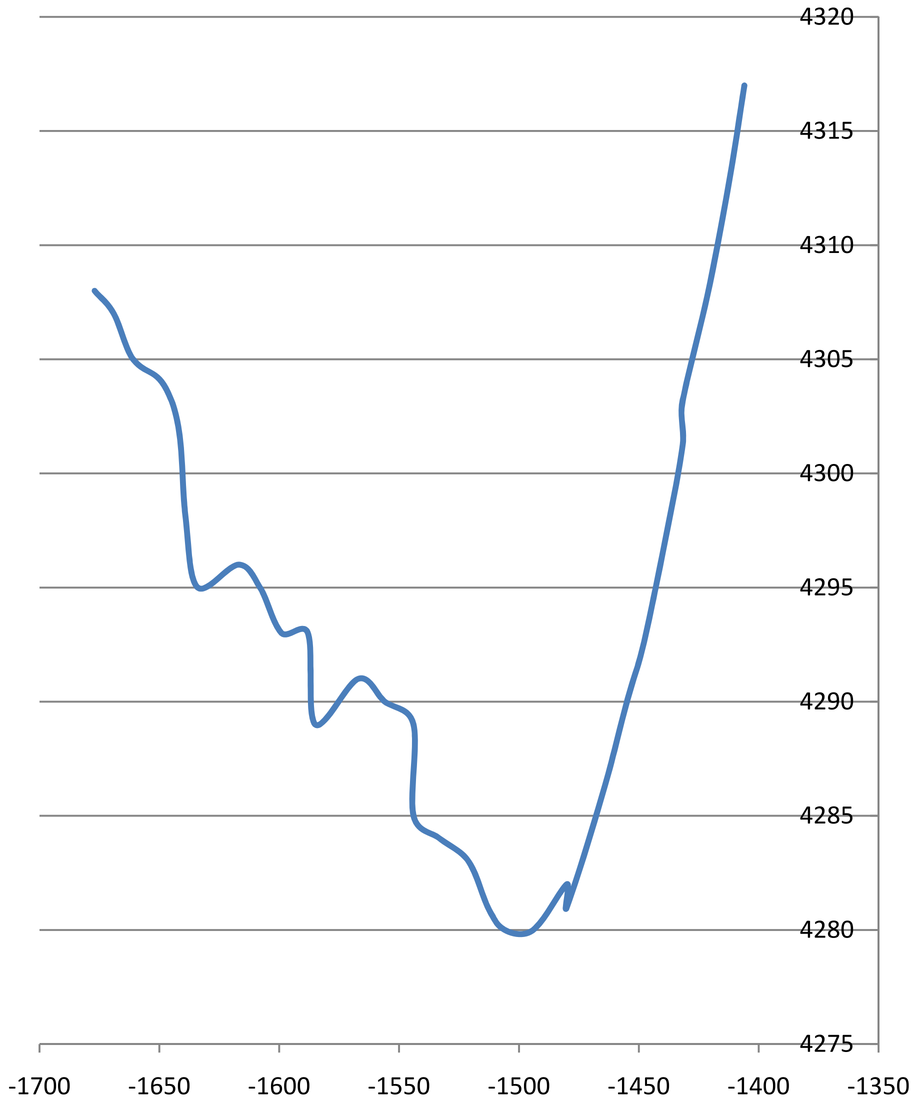
BCD

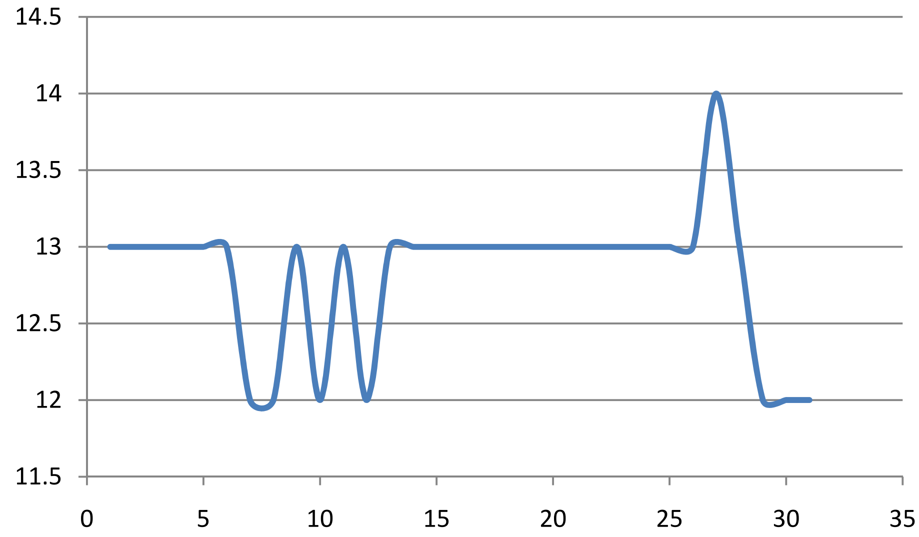
```
0001 [20 049 200] (1/1) ff 18 80 70 01 24 e9 ae ed 26 1a 07 31 90 19 fa 00 00 03 02 00 72 e9 2e
0034 [20 051 161] (1/1) ff 18 80 70 01 24 e9 c7 ed 24 1a 07 31 90 19 fa 00 00 03 02 00 72 e9 2d
0067 [20 053 121] (1/1) ff 18 80 70 01 24 e9 d9 ed 2c 1a 07 31 90 19 fa 00 00 03 02 00 71 e9 2d
0101 [20 055 082] (1/1) ff 18 80 70 01 24 e9 ee ed 2f 1a 07 31 90 19 fa 00 00 03 02 00 71 e9 2d
0134 [20 057 043] (1/1) ff 18 80 70 01 24 e9 ff ed 36 1a 07 31 90 19 fa 00 00 03 03 00 72 e9 2e
0167 [20 059 004] (1/1) ff 18 80 70 01 [illegible] 1a 07 31 90 19 fa 00 00 03 02 00 72 e9 2d
0200 [20 060 221] (1/1) ff 18 80 70 [illegible] 07 31 90 19 fa 00 00 03 02 00 73 e9 2d
0233 [20 062 182] (1/1) ff 18 80 70 [illegible] 24 ea 3b ed [illegible] 31 90 19 fa 00 00 03 02 00 72 e9 2d
0266 [20 064 142] (1/1) ff 18 80 70 01 24 ea 4d ed 4c [illegible] 31 90 19 fa 00 00 03 03 00 74 e9 2c
0299 [20 066 103] (1/1) ff 18 80 70 01 24 ea 62 ed 4f [illegible] 90 19 fa 00 00 03 03 00 71 e9 2c
0332 [20 068 064] (1/1) ff 18 80 70 01 24 ea 75 ed 54 [illegible] 90 19 fa 00 00 03 04 00 70 e9 2c
0365 [20 070 025] (1/1) ff 18 80 70 01 24 ea 80 ed 62 [illegible] 90 19 fa 00 00 03 03 00 6d e9 2d
0398 [20 071 242] (1/1) ff 18 80 70 01 24 ea 98 ed 64 [illegible] 90 19 fa 00 00 03 02 00 6b e9 2d
0431 [20 073 203] (1/1) ff 18 80 70 01 24 ea a7 ed 6e [illegible] 31 90 19 fa 00 00 03 00 00 6c e9 2d
0464 [20 075 164] (1/1) ff 18 80 70 01 24 ea bc ed [illegible] 31 90 19 fa 00 00 03 00 00 6c e9 2d
0497 [20 077 125] (1/1) ff 18 80 70 01 24 [illegible] 08 31 90 19 fa 00 00 02 99 00 6d e9 2d
0530 [20 079 086] (1/1) ff 18 80 70 01 24 [illegible] 1a 08 31 90 19 fa 00 00 03 00 00 6b e9 2b
0563 [20 081 047] (1/1) ff 18 80 70 01 24 [illegible] 80 1a 08 31 90 19 fa 00 00 03 01 00 69 e9 2b
0596 [20 083 008] (1/1) ff 18 80 70 01 24 [illegible] 8a 1a 08 31 90 19 fa 00 00 03 01 00 66 e9 2b
0630 [20 084 225] (1/1) ff 18 80 70 01 24 [illegible] 8e 1a 08 31 90 19 fa 00 00 03 01 00 67 e9 2b
0663 [20 086 187] (1/1) ff 18 80 70 01 24 [illegible] 92 1a 08 31 90 19 fa 00 00 03 01 00 6a e9 2c
0696 [20 088 148] (1/1) ff 18 80 70 01 24 eb 45 ed 95 1a 08 31 90 19 fa 00 00 03 01 00 70 e9 2c
0729 [20 090 109] (1/1) ff 18 80 70 01 24 eb 59 ed 99 1a 08 31 90 19 fa 00 00 03 03 00 73 e9 2c
0762 [20 092 069] (1/1) ff 18 80 70 01 24 eb [illegible] ed a1 1a 08 31 90 19 fa 00 00 03 03 00 75 e9 2b
0795 [20 094 030] (1/1) ff 18 80 70 01 24 [illegible] a9 1a 08 31 90 19 fa 00 00 03 03 00 76 e9 2b
0828 [20 095 247] (1/1) ff 18 80 70 01 24 [illegible] af 1a 08 31 90 19 fa 00 00 03 03 00 75 e9 2b
0861 [20 097 208] (1/1) ff 18 80 70 01 24 [illegible] b3 1a 08 31 90 19 fa 00 00 03 02 00 74 e9 2b
0894 [20 099 169] (1/1) ff 18 80 70 01 24 eb b7 ed b6 1a 08 31 90 19 fa 00 00 03 03 00 72 e9 2b
0927 [20 101 130] (1/1) ff 18 80 70 01 24 eb ca ed bd 1a 08 31 90 19 fa 00 00 03 03 00 71 e9 2b
0960 [20 103 091] (1/1) ff 18 80 70 01 24 eb da ed c4 1a 08 31 90 19 fa 00 00 03 03 00 70 e9 2b
0993 [20 105 052] (1/1) ff 18 80 70 01 24 eb ef ed c9 1a 08 31 90 19 fa 00 00 03 03 00 70 e9 2b
1026 [20 107 013] (1/1) ff 18 80 70 01 24 ec 03 ed cd 1a 08 31 90 19 fa 00 00 03 03 00 71 e9 2b
```

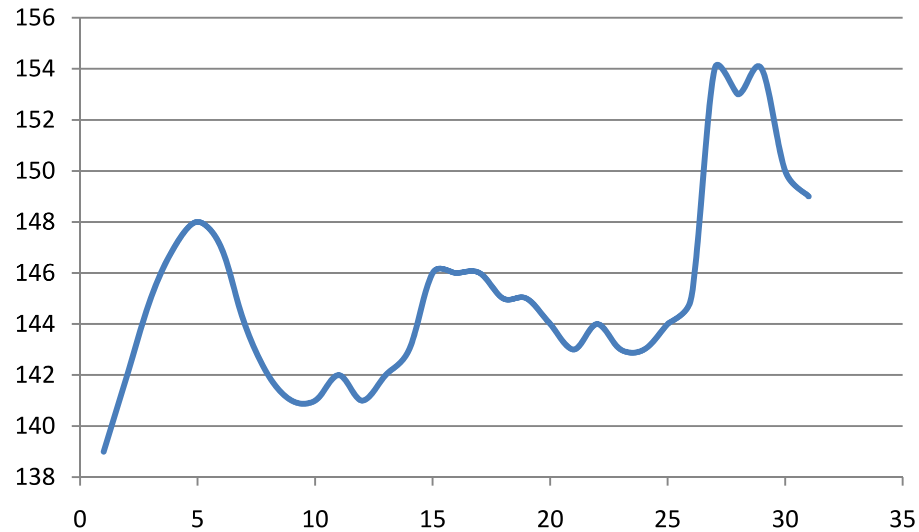
Graphing the Data

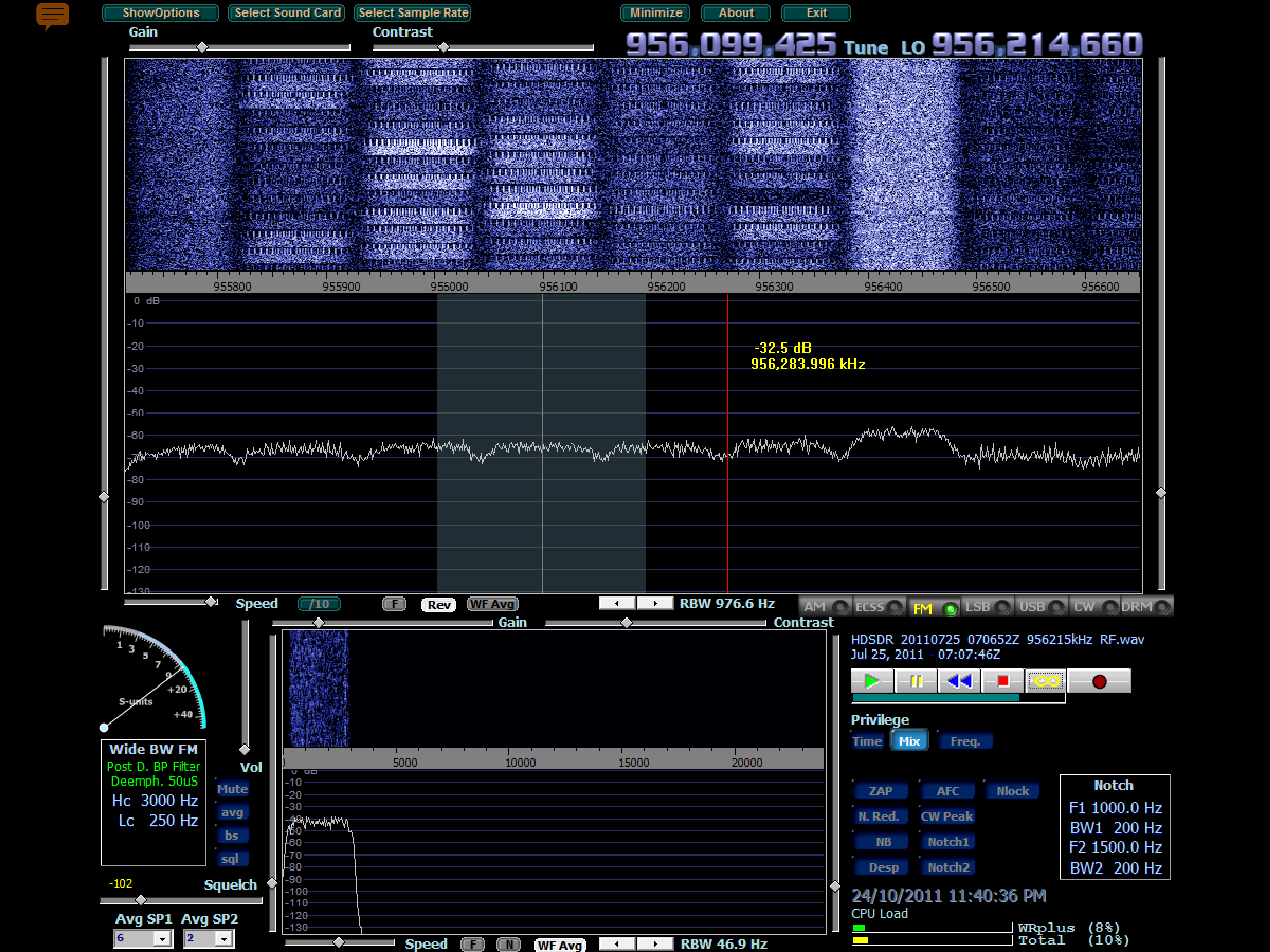


Graphing the Data

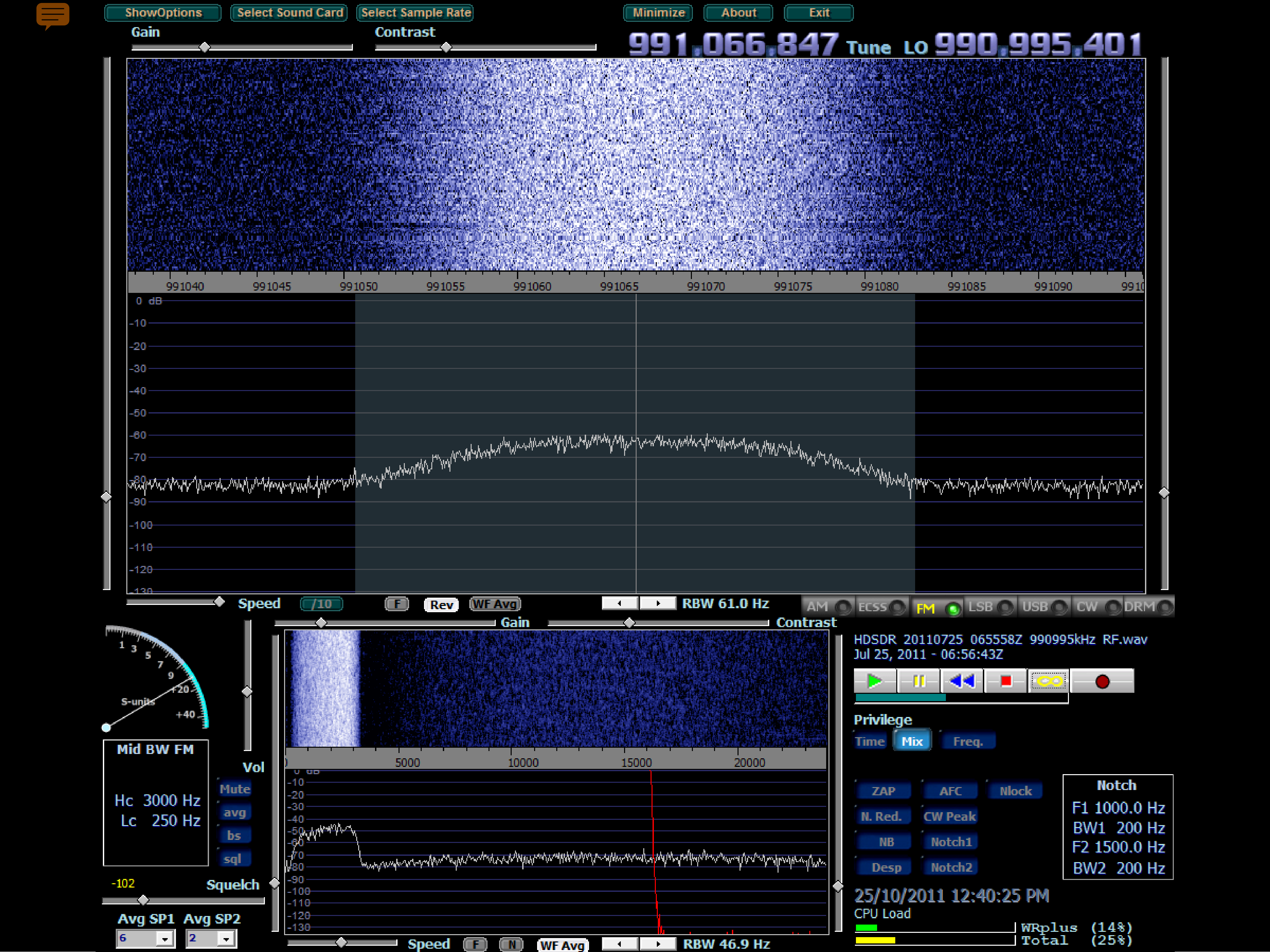






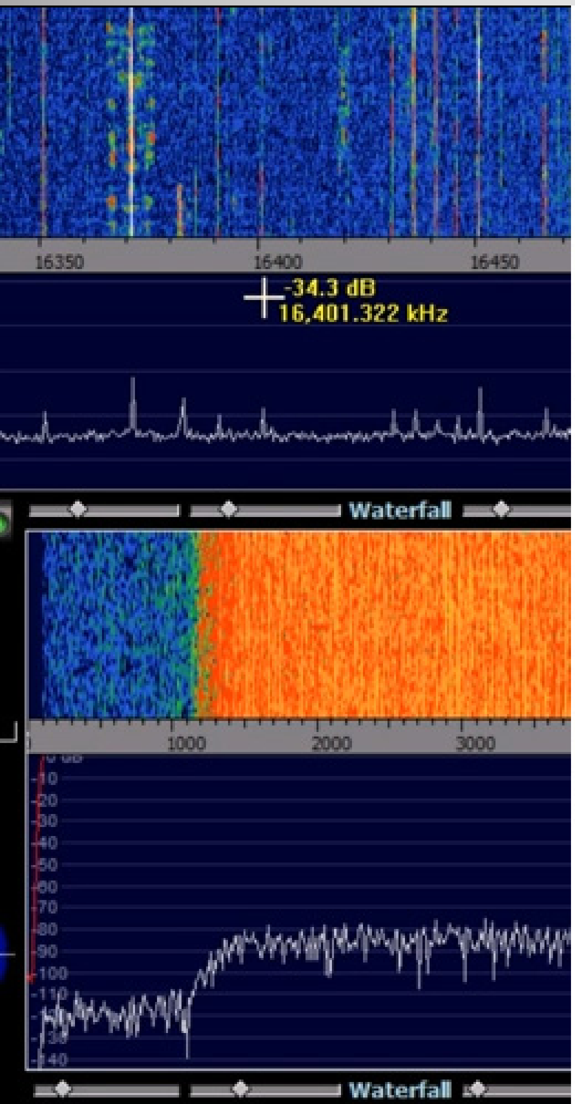


ShowOptions
Select Sound Card
Select Sample Rate
Minimize
About
Exit
Gain
Contrast
956.099.425 Tune LO 956.214.660
955800
955900
956000
956100
956200
956300
956400
956500
956600
-32.5 dB
956,283.996 kHz
Speed
/10
F
Rev
WF Avg
RBW 976.6 Hz
AM
ECSS
FM
LSB
USB
CW
DRM
Gain
Contrast
S-units
Wide BW FM
Post D. BP Filter
Deemph. 50uS
Hc 3000 Hz
Lc 250 Hz
Vol
Mute
avg
bs
sql
-102
Squelch
Avg SP1
Avg SP2
5000
10000
15000
20000
Speed
F
N
WF Avg
RBW 46.9 Hz
HDSDR 20110725 070652Z 956215kHz RF.wav
Jul 25, 2011 - 07:07:46Z
Privilege
Time
Mix
Freq.
ZAP
AFC
Nlock
N. Red.
CW Peak
NB
Notch1
Desp
Notch2
Notch
F1 1000.0 Hz
BW1 200 Hz
F2 1500.0 Hz
BW2 200 Hz
24/10/2011 11:40:36 PM
CPU Load
WRplus (8%)
Total (10%)



ShowOptions
Select Sound Card
Select Sample Rate
Minimize
About
Exit
Gain
Contrast
991.066.847 Tune LO 990.995.401
991040
991045
991050
991055
991060
991065
991070
991075
991080
991085
991090
0 dB
Speed
/10
F
Rev
WF Avg
RBW 61.0 Hz
AM
ECSS
FM
LSB
USB
CW
DRM
Gain
Contrast
S-units
Mid BW FM
Hc 3000 Hz
Lc 250 Hz
Vol
Mute
avg
bs
sql
-102
Squelch
Avg SP1
Avg SP2
5000
10000
15000
20000
Speed
F
N
WF Avg
RBW 46.9 Hz
HDSDR 20110725 065558Z 990995kHz RF.wav
Jul 25, 2011 - 06:56:43Z
Privilege
Time
Mix
Freq.
ZAP
AFC
Nlock
N. Red.
CW Peak
NB
Notch1
Desp
Notch2
Notch
F1 1000.0 Hz
BW1 200 Hz
F2 1500.0 Hz
BW2 200 Hz
25/10/2011 12:40:25 PM
CPU Load
WRplus (14%)
Total (25%)

STANAG 4285



STANAG-4285

STANAG-4285 is specified by the NATO (North Atlantic Treaty Organization) Military Agency for Standardization in "Characteristics of 1200 / 2400 / 3600 Bits per Second Single Tone Modulators / Demodulators for HF Radio Links" (16. February 1989).

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	8-PSK
Center frequency	1800 Hz
Symbol rate	2400 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

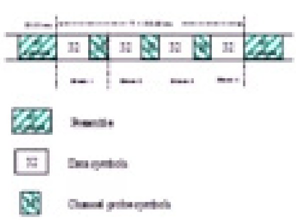
The modulation technique used in this mode consists of phase shift keying (8-PSK) of a single tone sub-carrier of 1800 Hz. The modulation speed (symbol rate) is always 2400 Bd.

Using different M-PSK modulations and FEC (Forward Error Correction) coding rates, serial binary user information (raw data) accepted at the line side input can be transmitted at different user data rates.

STANAG 4285 single tone waveform has the following characteristics which may be selected from **Options |Frame Format...**:

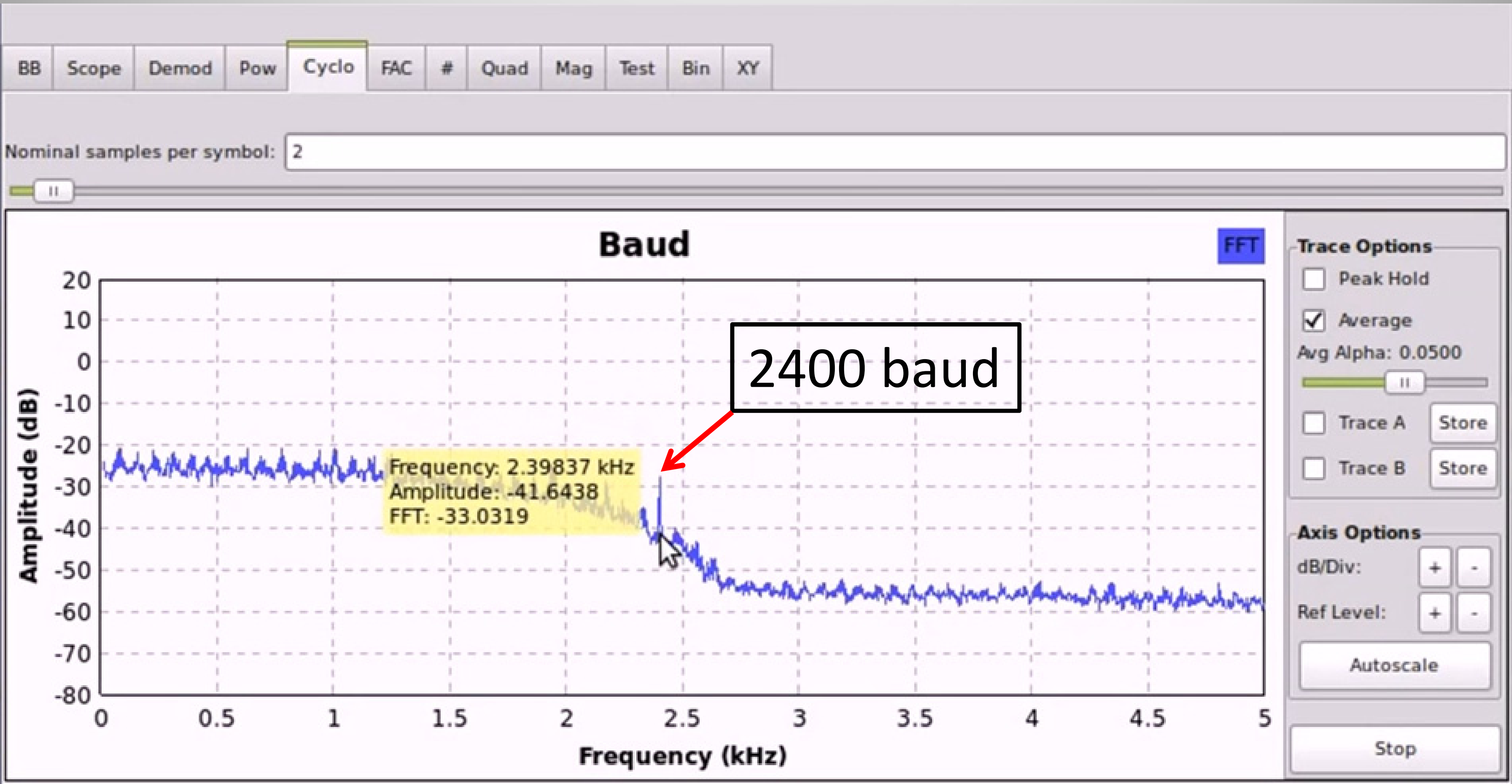
Baud Rate	User data rate (bps)	User data rate (bps)	FEC coding rate	Interleaver	No. of unknown 8-phase symbols (User Data)	No. of known 8-phase symbols (Channel Probe)
2400	2400	3 (8-PSK)	2 / 3	SHORT or LONG	32	16
2400	1200	2 (QPSK)	1 / 2	SHORT or LONG	32	16
2400	600	1 (BPSK)	1 / 2	SHORT or LONG	32	16
2400	300	1 (BPSK)	1 / 4	SHORT or LONG	32	16
2400	150	1 (BPSK)	1 / 8	SHORT or LONG	32	16
2400	75	1 (BPSK)	1 / 16	SHORT or LONG	32	16
2400	3600	3 (8-PSK)	No coding	ZERO	32	16
2400	2400	2 (QPSK)	No coding	ZERO	32	16
2400	1200	1 (BPSK)	No coding	ZERO	32	16

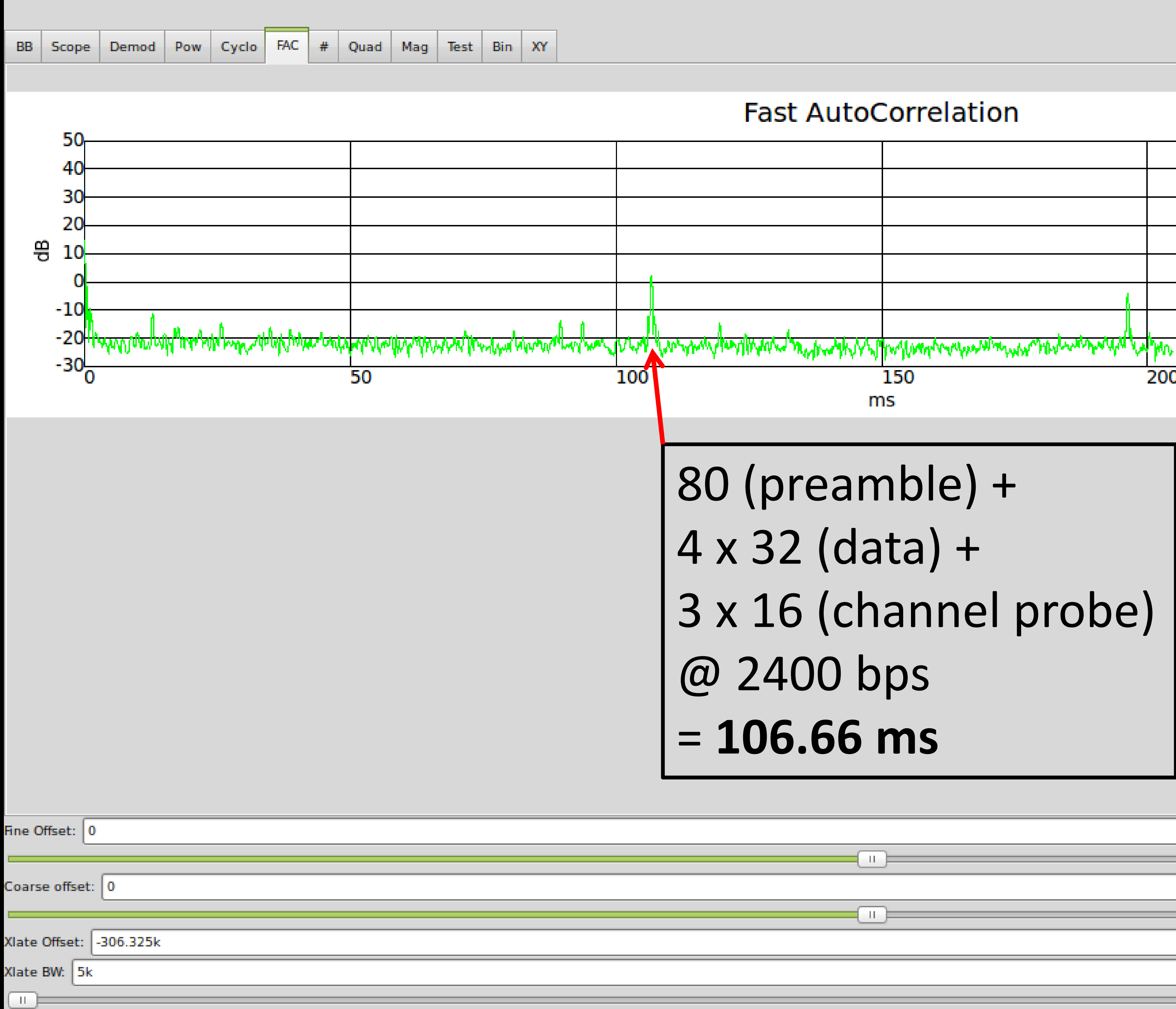
The user data is transmitted using a continuous frame structure. Each frame begins with a 33.33 ms preamble containing 80 symbols, the next 176 symbols are divided into four 32-symbol data segments and three 16-symbol channel probe segments.

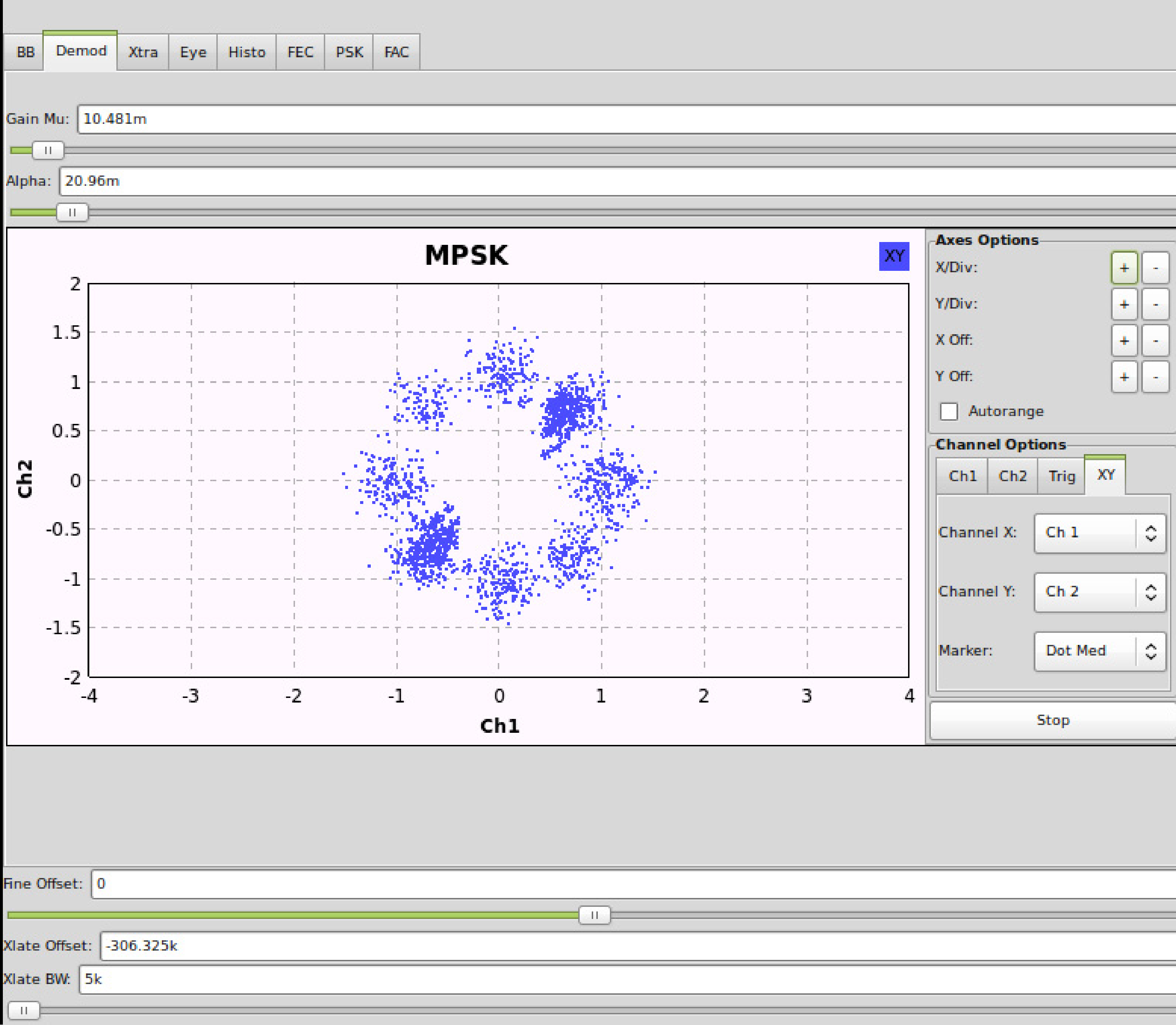


At the end of transmission, a certain bit-pattern (in hexadecimal notation, 4B65A5B2, MSB first) is sent to mark the end of message (EOM). The

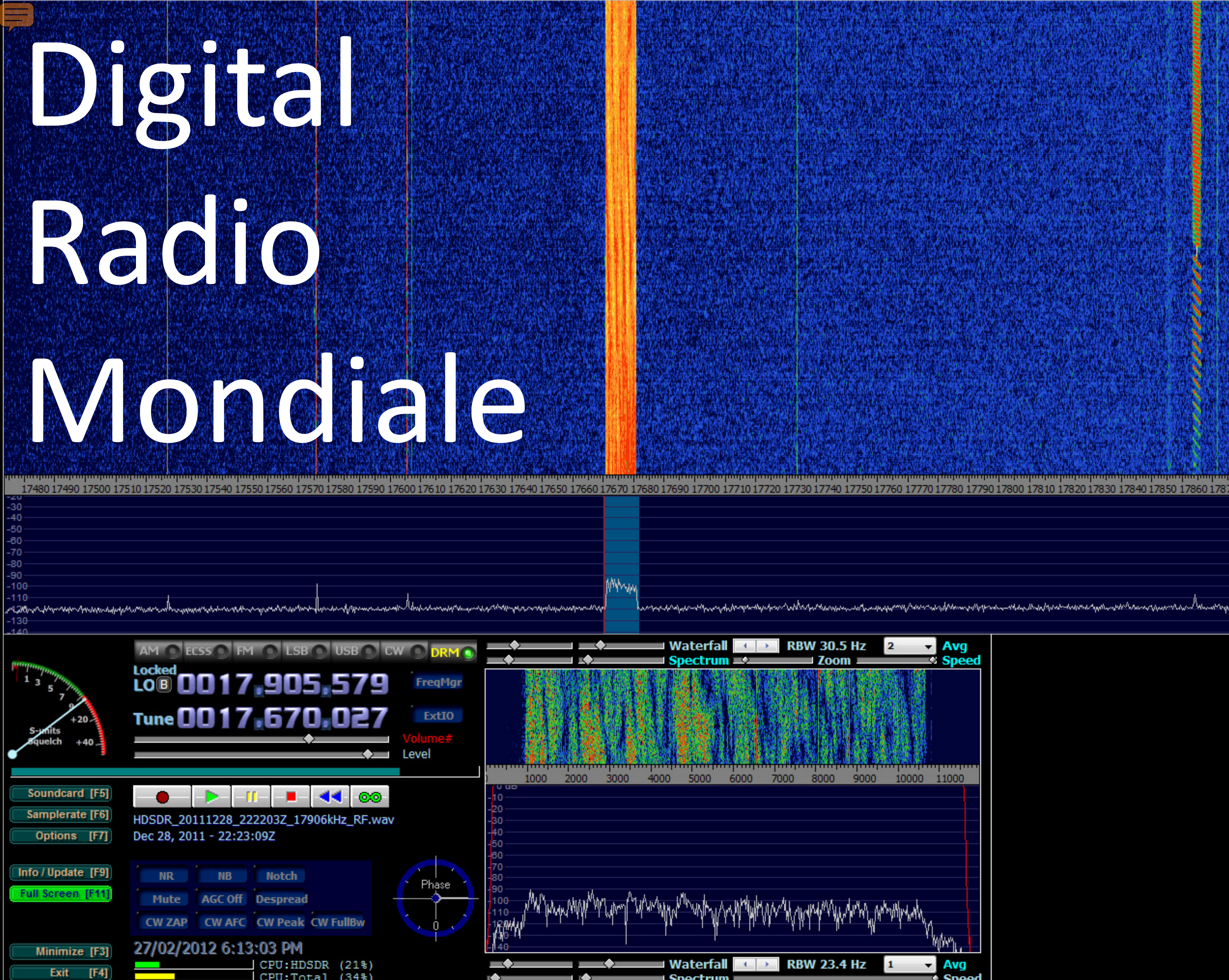
STANAG 4285


BB
Scope
Demod
Pow
Cyclo
FAC
#
Quad
Mag
Test
Bin
XY
Nominal samples per symbol:
2
Baud
FFT
2400 baud
Frequency: 2.39837 kHz
Amplitude: -41.6438
FFT: -33.0319
Amplitude (dB)
Frequency (kHz)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Trace Options
Peak Hold
Average
Avg Alpha: 0.0500
Trace A
Store
Trace B
Store
Axis Options
dB/Div:
Ref Level:
Autoscale
Stop


BB
Scope
Demod
Pow
Cyclo
FAC
#
Quad
Mag
Test
Bin
XY
Fast AutoCorrelation
dB
50
40
30
20
10
0
-10
-20
-30
0
50
100
150
200
ms
80 (preamble) +
4 x 32 (data) +
3 x 16 (channel probe)
@ 2400 bps
= 106.66 ms
Fine Offset:
0
Coarse offset:
0
Xlate Offset:
-306.325k
Xlate BW:
5k

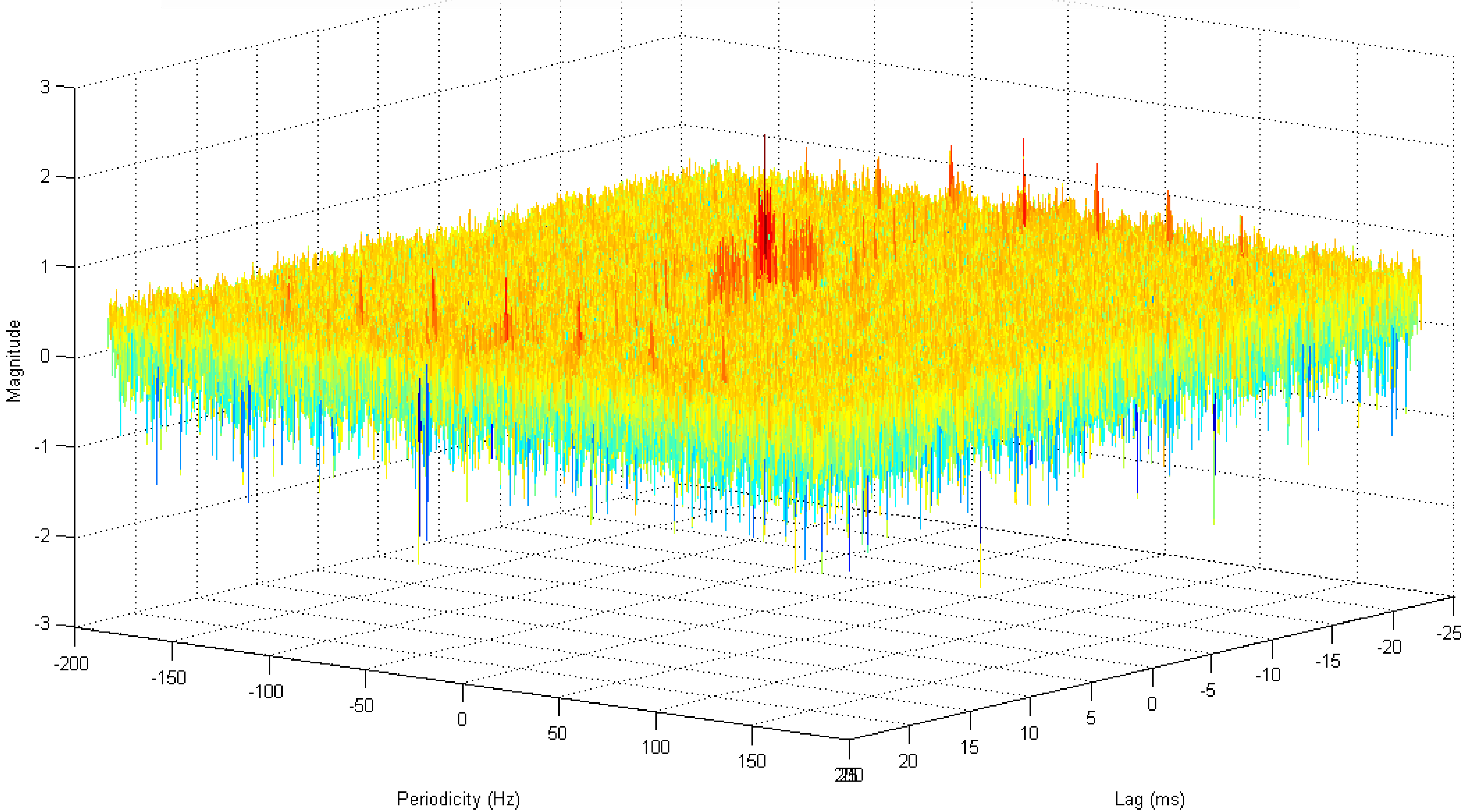

BB
Demod
Xtra
Eye
Histo
FEC
PSK
FAC
Gain Mu: 10.481m
Alpha: 20.96m
MPSK
XY
Ch2
Ch1
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-4
-3
-2
-1
0
1
2
3
4
Axes Options
X/Div:
Y/Div:
X Off:
Y Off:
Autorange
Channel Options
Ch1
Ch2
Trig
XY
Channel X: Ch 1
Channel Y: Ch 2
Marker: Dot Med
Stop
Fine Offset: 0
Xlate Offset: -306.325k
Xlate BW: 5k

Digital Radio Mondiale

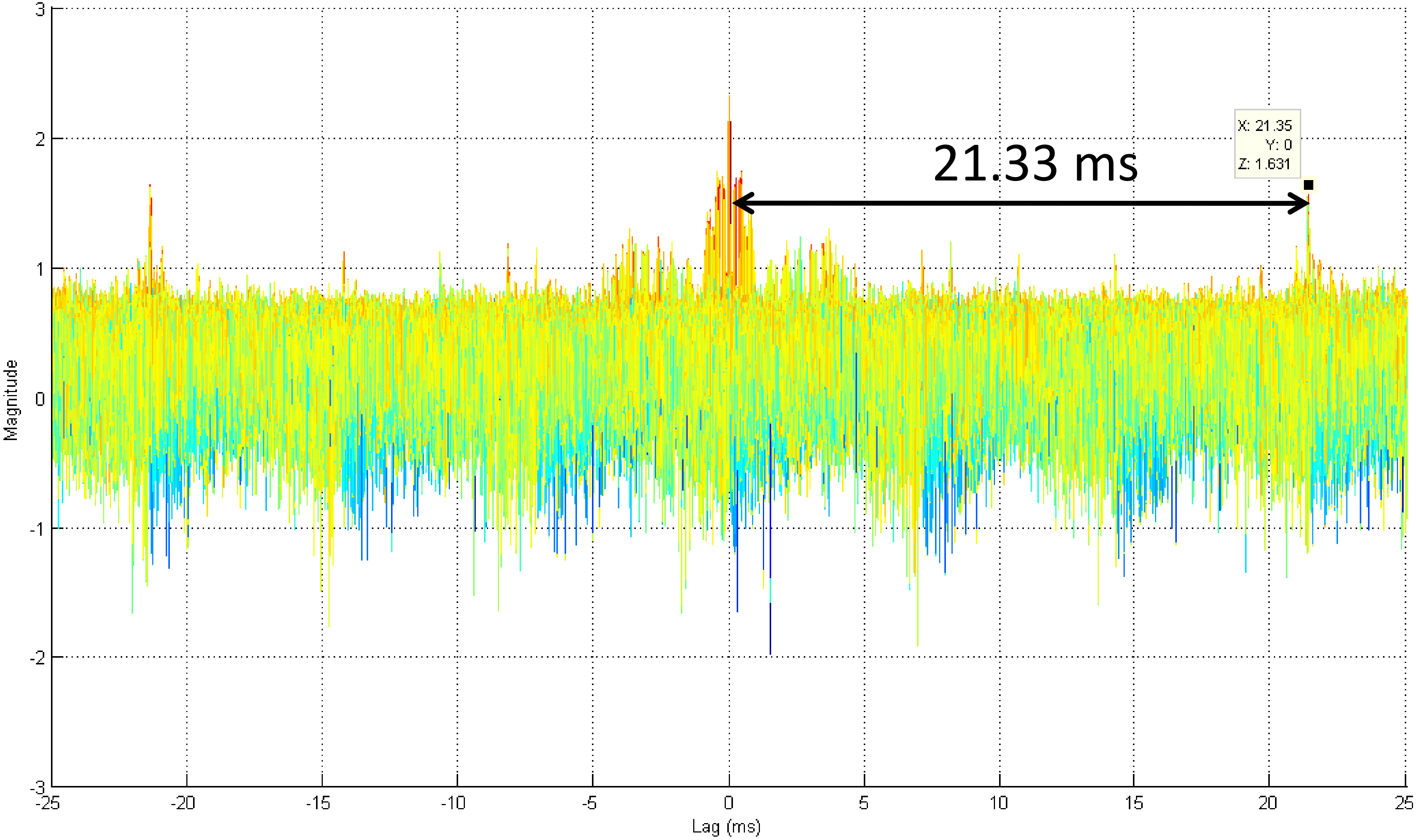


Cyclic Autocorrelation Function

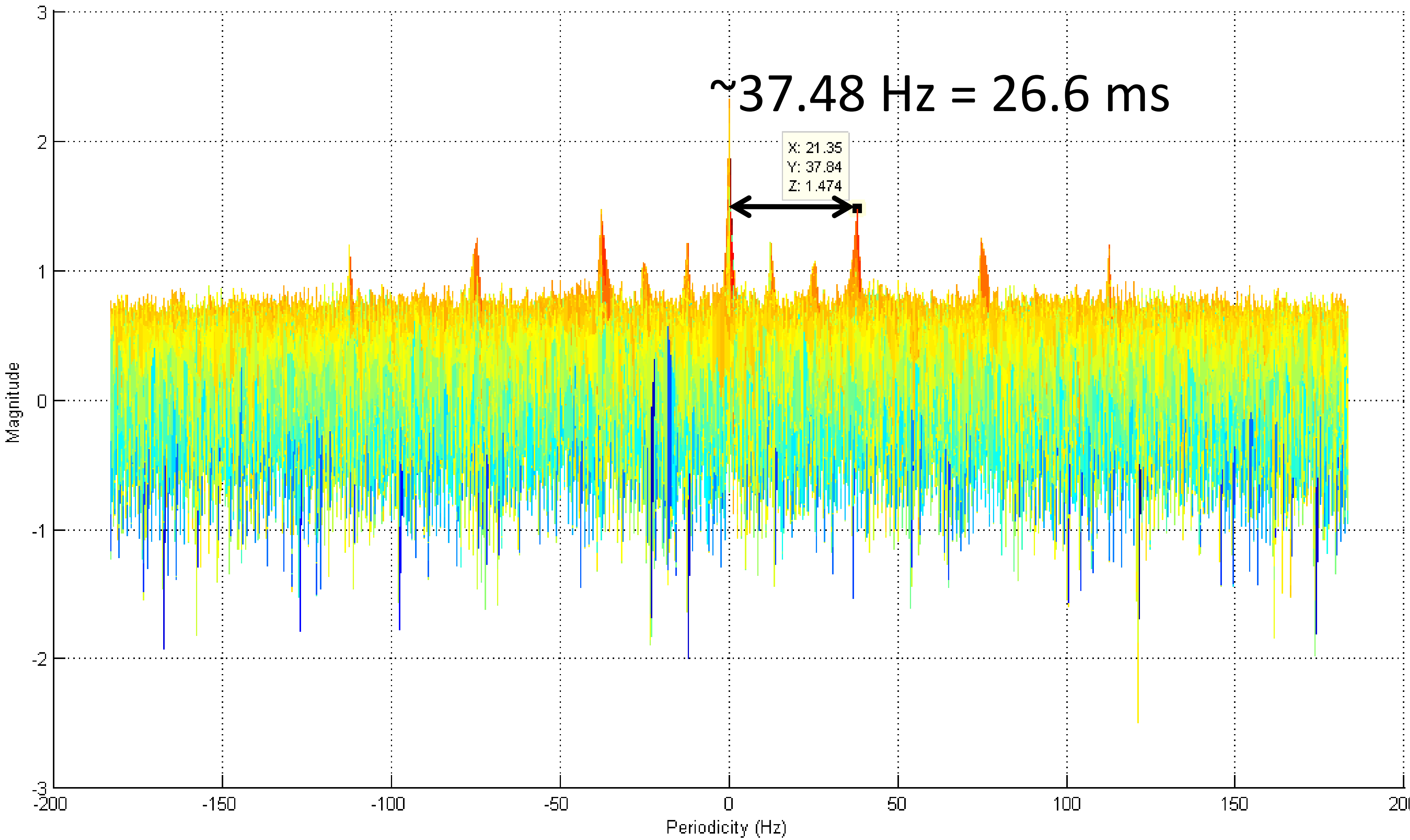
Han, Sohn & Moung,"A Blind OFDM Detection and Identification Method Based on Cyclostationarity for Cognitive Radio Application"



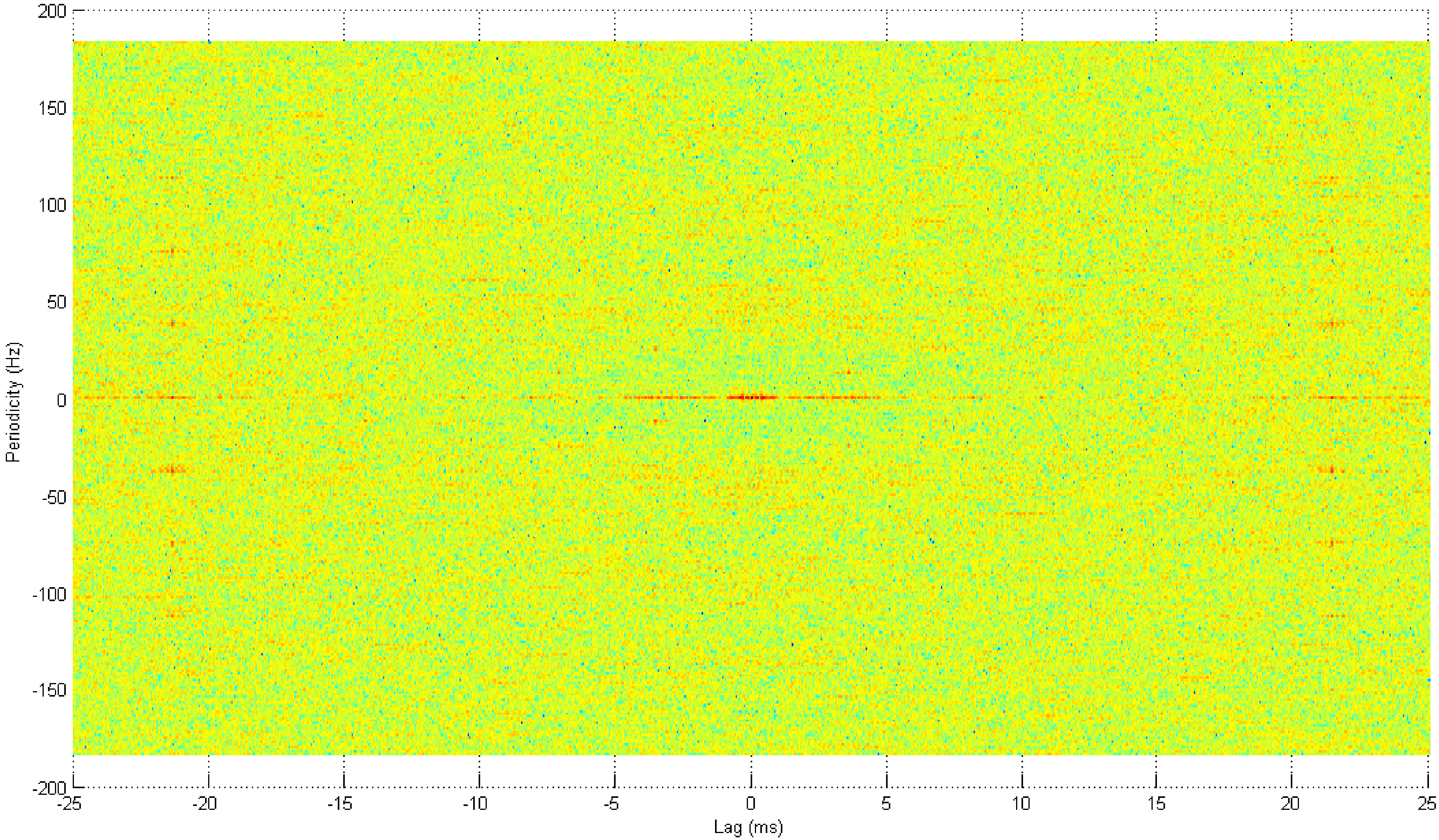
Un-guarded Symbol Time



Total Symbol Duration



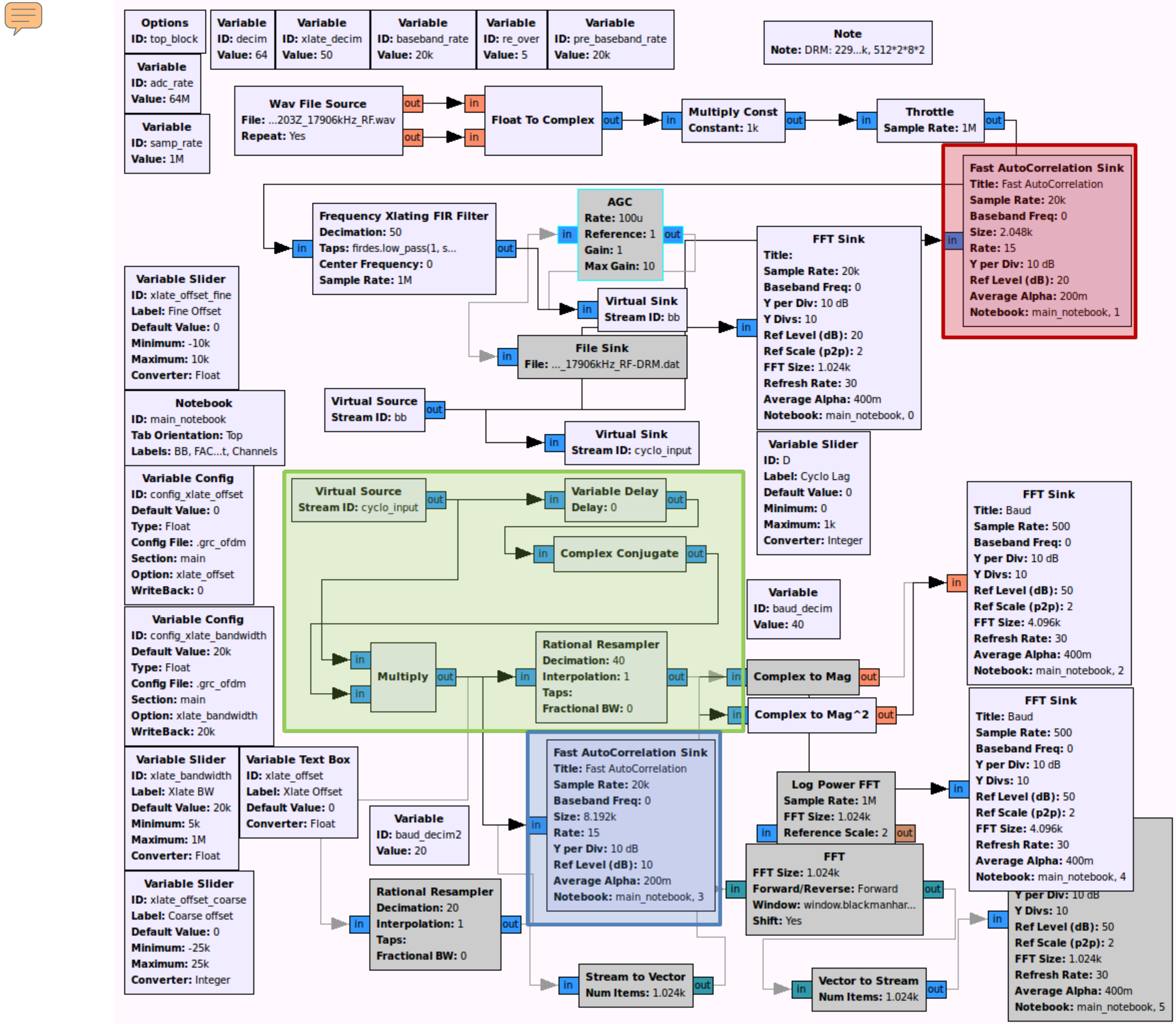
Top-down DRM Symmetry



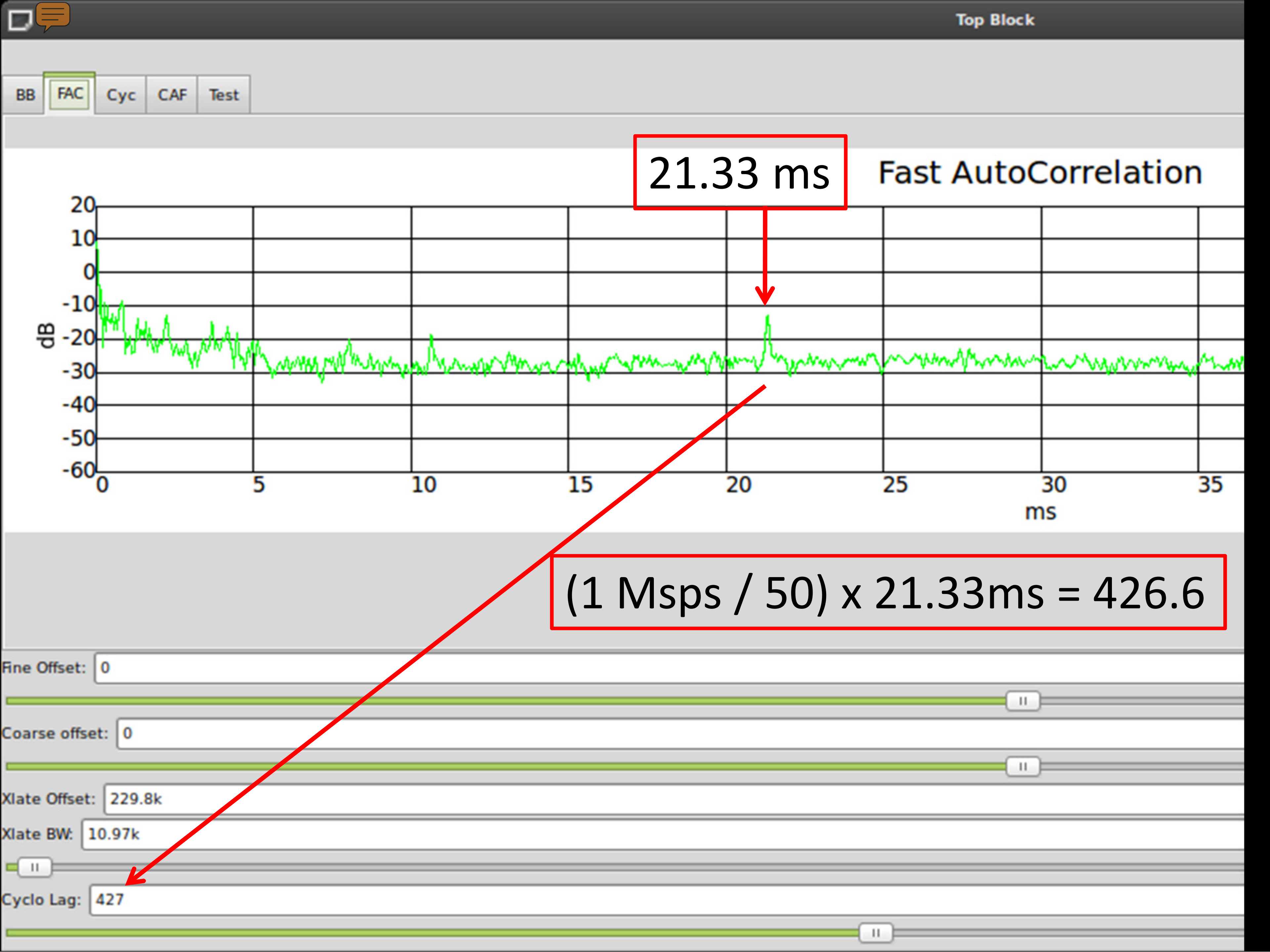
DRM Class B

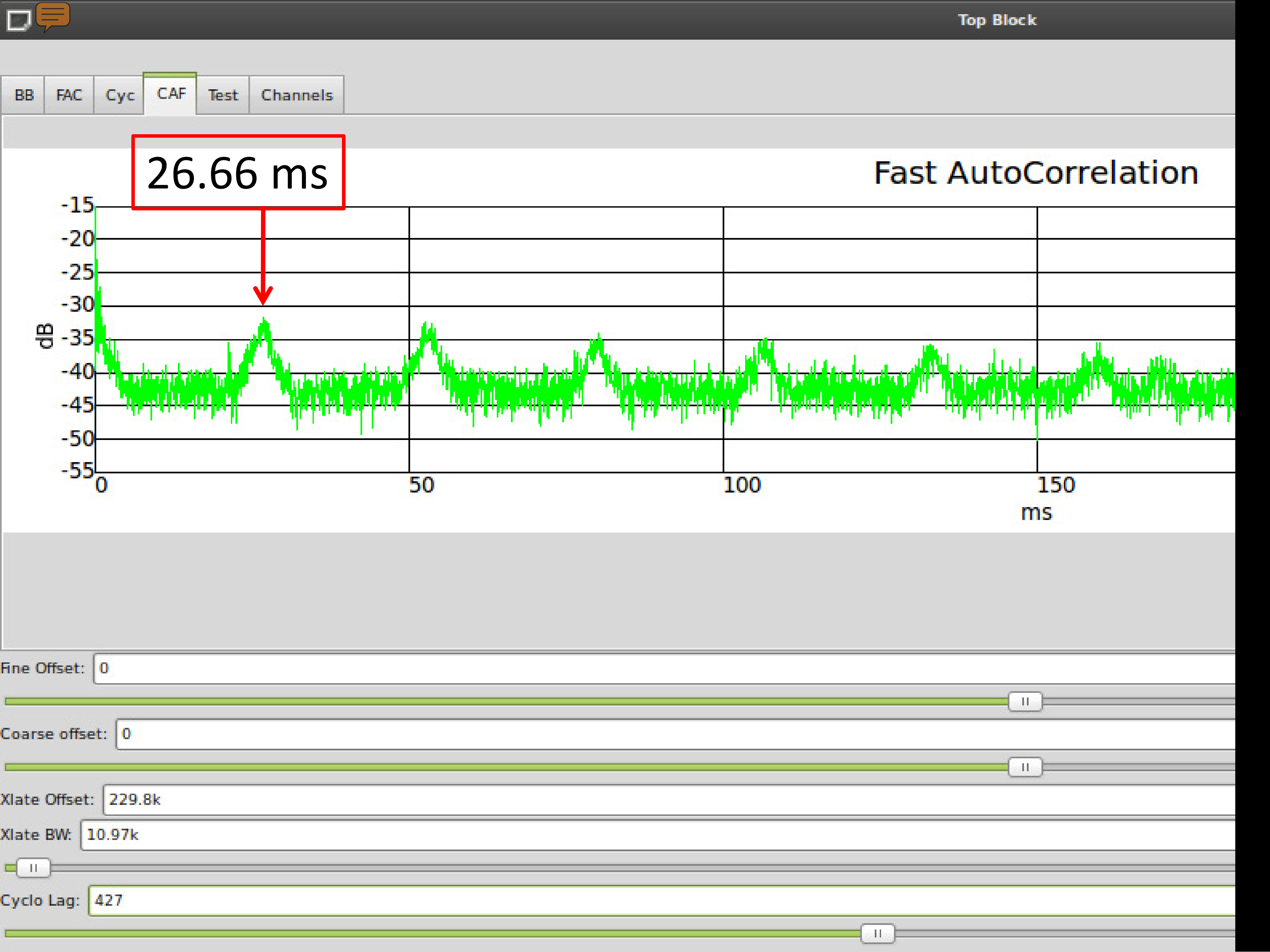
Modulation property	Value
Un-guarded symbol time	**21.33 ms**
Sub-carrier spacing	46 7/8 Hz
Guard interval	5.33 ms
Total symbol duration	**26.66 ms**
Guard interval ratio	1/4
Symbols per frame	15

1 / (21.33 ms)



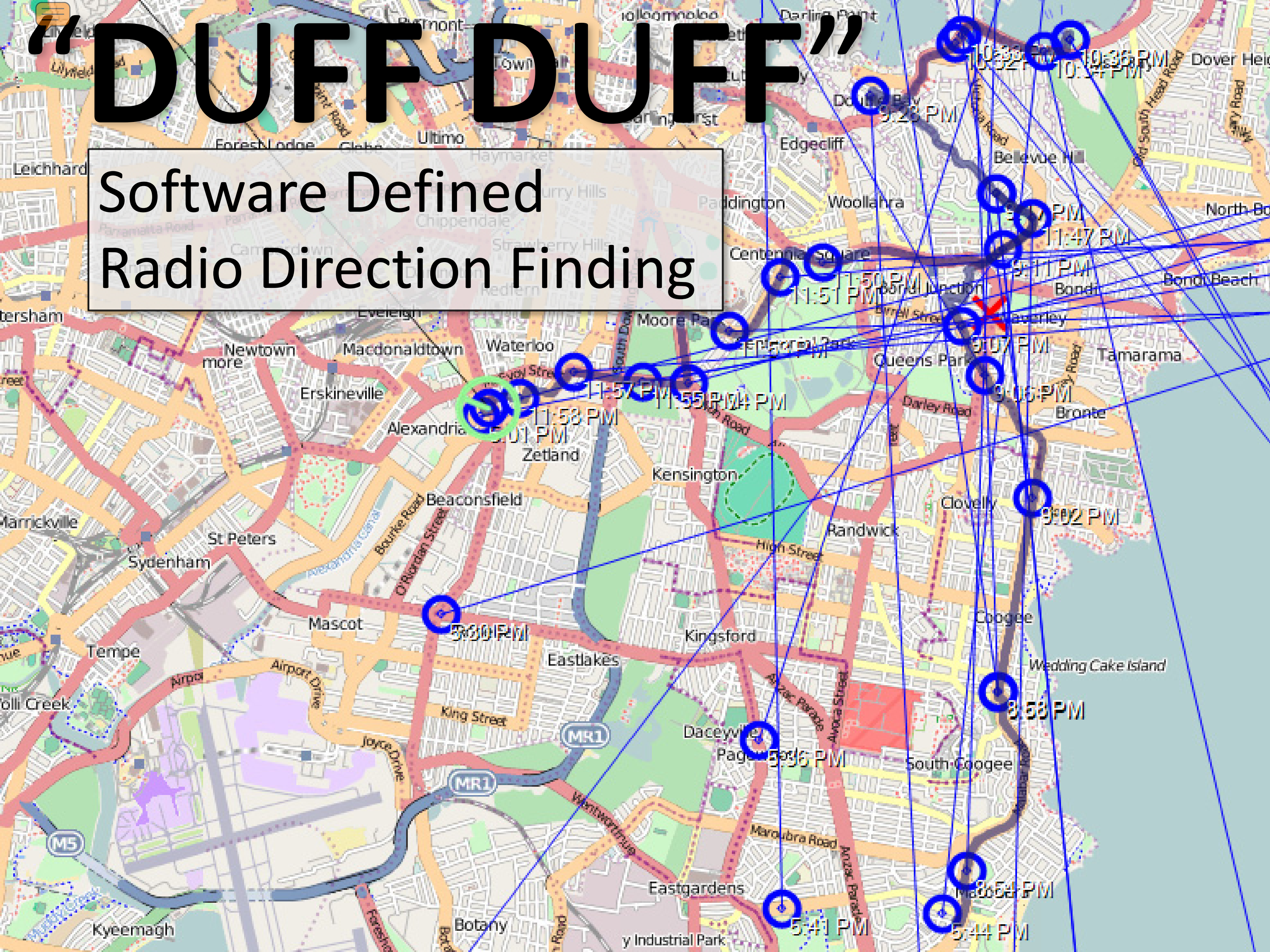
Options
ID: top_block
Variable
ID: decim
Value: 64
Variable
ID: xlate_decim
Value: 50
Variable
ID: baseband_rate
Value: 20k
Variable
ID: re_over
Value: 5
Variable
ID: pre_baseband_rate
Value: 20k
Note
Note: DRM: 229...k, 512*2*8*2
Variable
ID: adc_rate
Value: 64M
Variable
ID: samp_rate
Value: 1M
Wav File Source
File: ...203Z_17906kHz_RF.wav
Repeat: Yes
out
out
in
in
Float To Complex
out
in
Multiply Const
Constant: 1k
out
in
Throttle
Sample Rate: 1M
out
Fast AutoCorrelation Sink
Title: Fast AutoCorrelation
Sample Rate: 20k
Baseband Freq: 0
Size: 2.048k
Rate: 15
Y per Div: 10 dB
Ref Level (dB): 20
Average Alpha: 200m
Notebook: main_notebook, 1
in
Frequency Xlating FIR Filter
Decimation: 50
Taps: firdes.low_pass(1, s...
Center Frequency: 0
Sample Rate: 1M
in
out
AGC
Rate: 100u
Reference: 1
Gain: 1
Max Gain: 10
in
out
FFT Sink
Title:
Sample Rate: 20k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 20
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 400m
Notebook: main_notebook, 0
in
Virtual Sink
Stream ID: bb
in
File Sink
File: ..._17906kHz_RF-DRM.dat
in
Variable Slider
ID: xlate_offset_fine
Label: Fine Offset
Default Value: 0
Minimum: -10k
Maximum: 10k
Converter: Float
Notebook
ID: main_notebook
Tab Orientation: Top
Labels: BB, FAC...t, Channels
Virtual Source
Stream ID: bb
out
Virtual Sink
Stream ID: cyclo_input
in
Variable Slider
ID: D
Label: Cyclo Lag
Default Value: 0
Minimum: 0
Maximum: 1k
Converter: Integer
Variable Config
ID: config_xlate_offset
Default Value: 0
Type: Float
Config File: .grc_ofdm
Section: main
Option: xlate_offset
WriteBack: 0
Virtual Source
Stream ID: cyclo_input
out
Variable Delay
Delay: 0
in
out
Complex Conjugate
in
out
FFT Sink
Title: Baud
Sample Rate: 500
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 400m
Notebook: main_notebook, 2
in
Variable
ID: baud_decim
Value: 40
Variable Config
ID: config_xlate_bandwidth
Default Value: 20k
Type: Float
Config File: .grc_ofdm
Section: main
Option: xlate_bandwidth
WriteBack: 20k
Multiply
in
in
out
Rational Resampler
Decimation: 40
Interpolation: 1
Taps:
Fractional BW: 0
in
out
Complex to Mag
in
out
Complex to Mag^2
in
out
Variable Slider
ID: xlate_bandwidth
Label: Xlate BW
Default Value: 20k
Minimum: 5k
Maximum: 1M
Converter: Float
Variable Text Box
ID: xlate_offset
Label: Xlate Offset
Default Value: 0
Converter: Float
Fast AutoCorrelation Sink
Title: Fast AutoCorrelation
Sample Rate: 20k
Baseband Freq: 0
Size: 8.192k
Rate: 15
Y per Div: 10 dB
Ref Level (dB): 10
Average Alpha: 200m
Notebook: main_notebook, 3
in
Variable
ID: baud_decim2
Value: 20
Log Power FFT
Sample Rate: 1M
FFT Size: 1.024k
Reference Scale: 2
in
out
FFT Sink
Title: Baud
Sample Rate: 500
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 400m
Notebook: main_notebook, 4
in
FFT
FFT Size: 1.024k
Forward/Reverse: Forward
Window: window.blackmanhar...
Shift: Yes
in
out
Variable Slider
ID: xlate_offset_coarse
Label: Coarse offset
Default Value: 0
Minimum: -25k
Maximum: 25k
Converter: Integer
Rational Resampler
Decimation: 20
Interpolation: 1
Taps:
Fractional BW: 0
in
out
Stream to Vector
Num Items: 1.024k
in
out
Vector to Stream
Num Items: 1.024k
in
out
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 400m
Notebook: main_notebook, 5
in


Top Block
BB
FAC
Cyc
CAF
Test
21.33 ms
Fast AutoCorrelation
dB
20
10
0
-10
-20
-30
-40
-50
-60
0
5
10
15
20
25
30
35
ms
(1 Msps / 50) x 21.33ms = 426.6
Fine Offset: 0
Coarse offset: 0
Xlate Offset: 229.8k
Xlate BW: 10.97k
Cyclo Lag: 427


Top Block
BB
FAC
Cyc
CAF
Test
Channels
26.66 ms
Fast AutoCorrelation
-15
-20
-25
-30
-35
-40
-45
-50
-55
dB
0
50
100
150
ms
Fine Offset:
0
Coarse offset:
0
Xlate Offset:
229.8k
Xlate BW:
10.97k
Cyclo Lag:
427

“DUFF DUFF”

Software Defined
Radio Direction Finding



DF Usage

- Radio navigation
  - Predecessor to RADAR
- SIGINT
- Emergency aid
  - Avalanche rescue
- Wildlife tracking
- Reconnaissance
  - Trajectory tracking
- Sport?!

Rotatable loop antenna

History

- WW I & II
  - Y-stations along the British coastline
  - Find bearing to U-boats in Atlantic
  - 'U-Adcock' system
    - Four 10m high vertical aerials around hut →
    - DF goniometer (angle measurement) & radio

DF for HF

- HF: 3-30 MHz
  - long wavelengths → large distances
- HF/DF = "HUFF DUFF!"
- Used for SIGINT
- Large installations: AN/FLR-9 array near Augsburg, Germany →

Amateur RDF

- ‘Fox hunts’
- Competitor on ‘2-meter band’ ARDF course

Highly-directional Yagi antenna

Crazy-serious German HAM

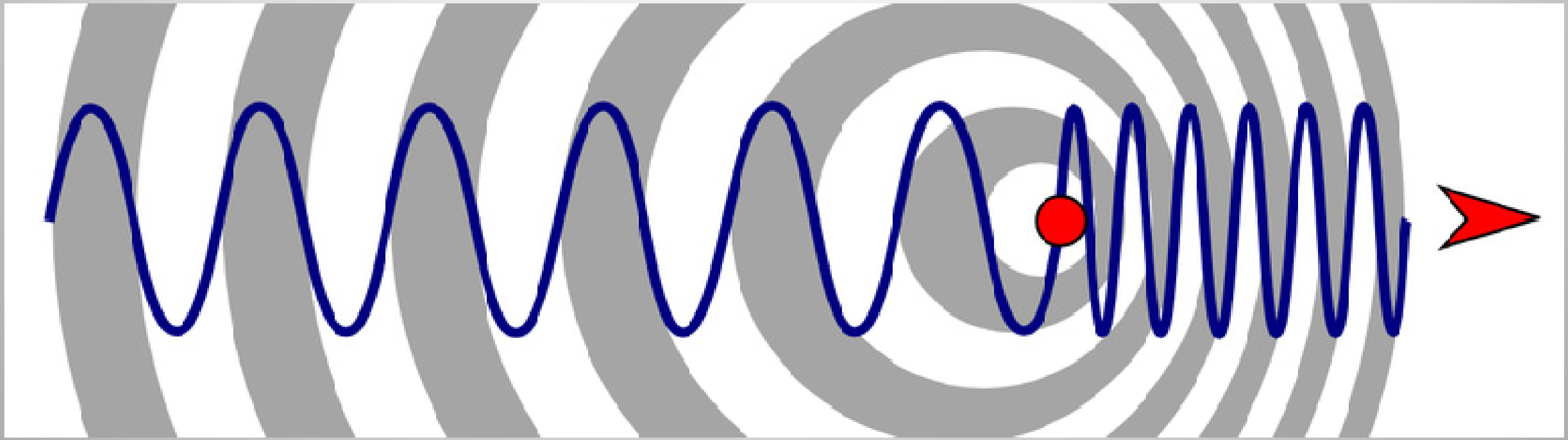
(Pseudo-) Doppler DF

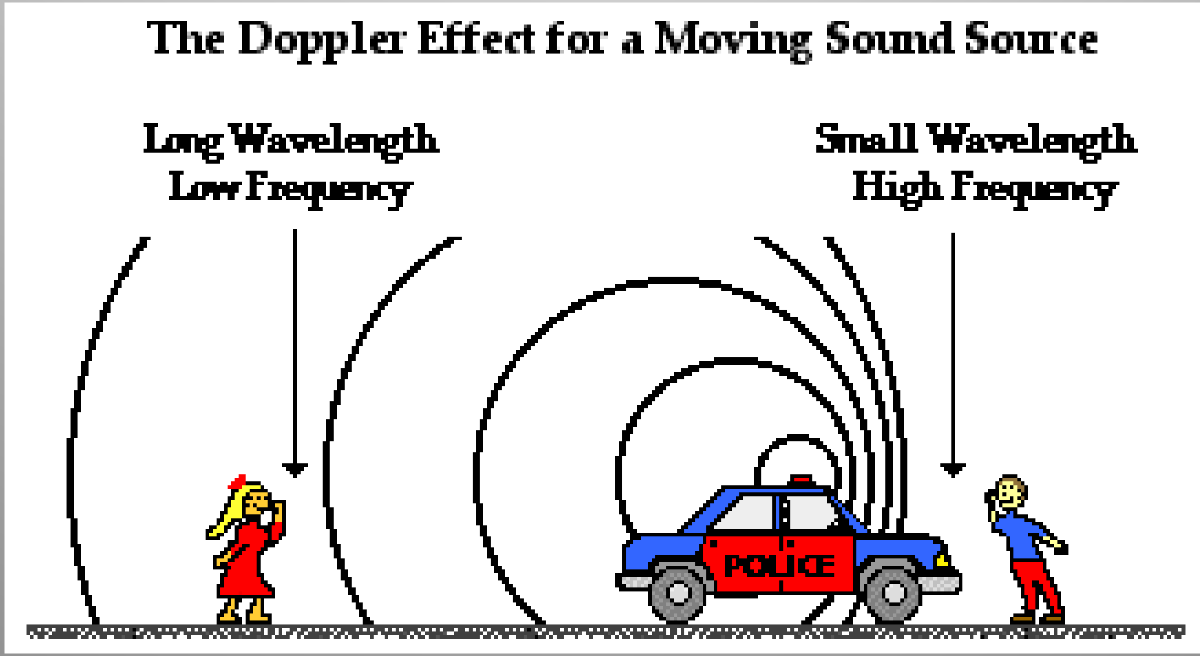
- Exploit Doppler shifting of radio waves caused by motion of an antenna

- Measure the shift in detected signal

  → Determine direction of transmission

Recap: Doppler Effect



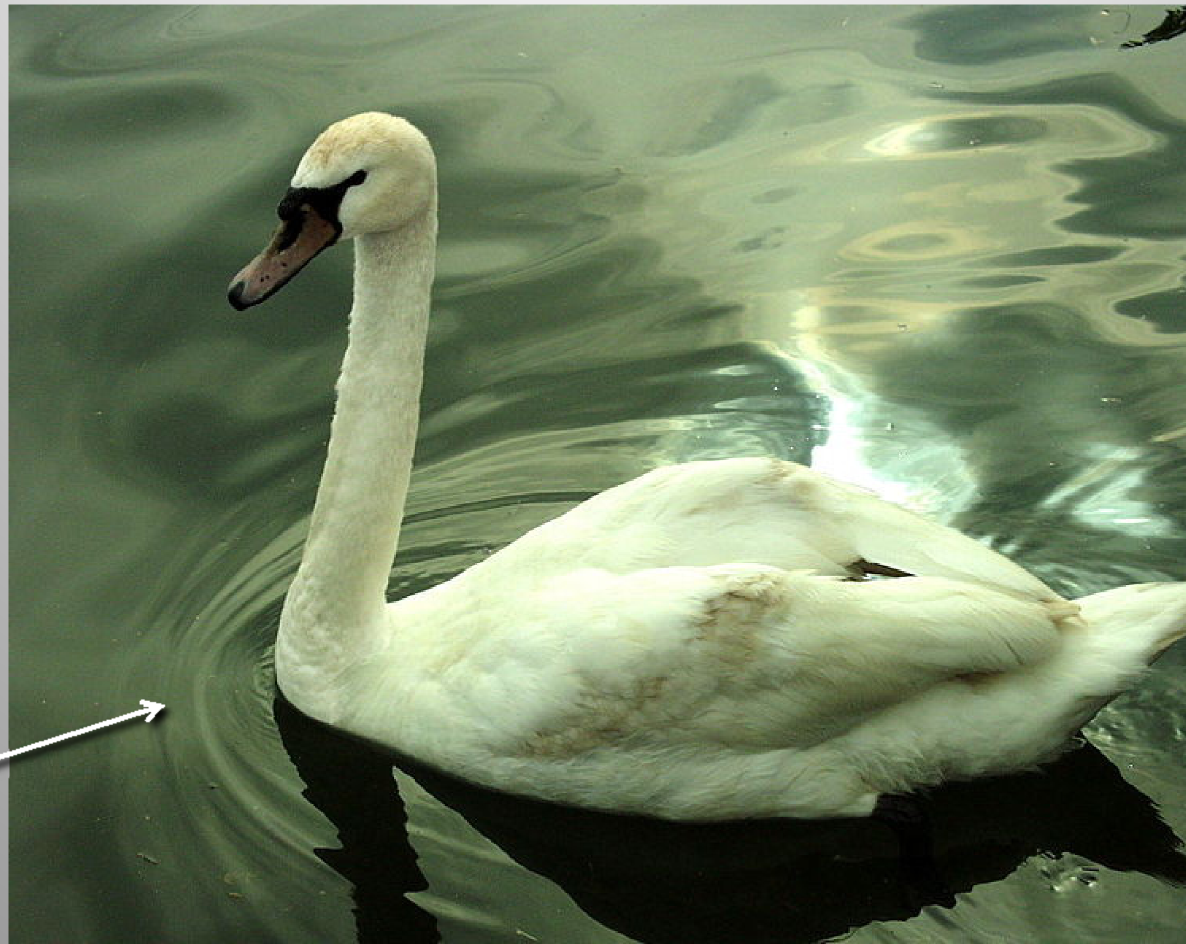


Aside: Siren Misconception

"…the **observed** frequency **increases** as the object approaches an observer and then **decreases** only as the object passes the observer."

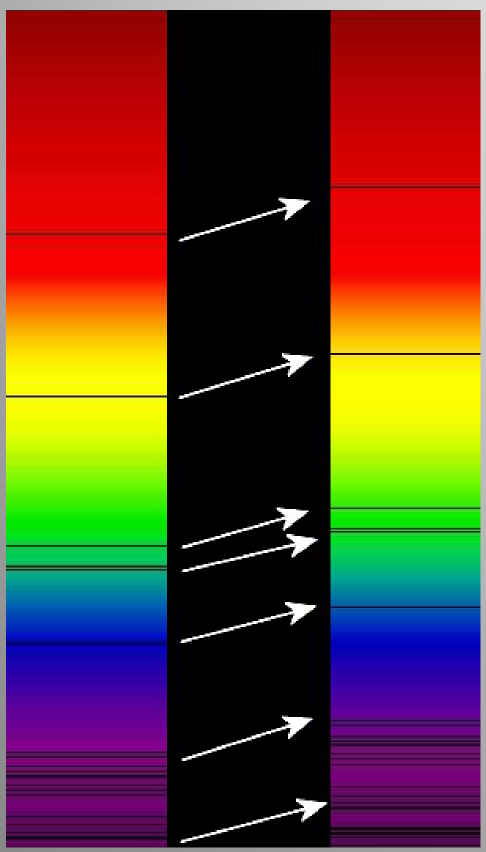
"…**Higher sound pressure levels** make for a small decrease in **perceived pitch** in low frequency sounds, and for a small increase in perceived pitch for high frequency sounds."

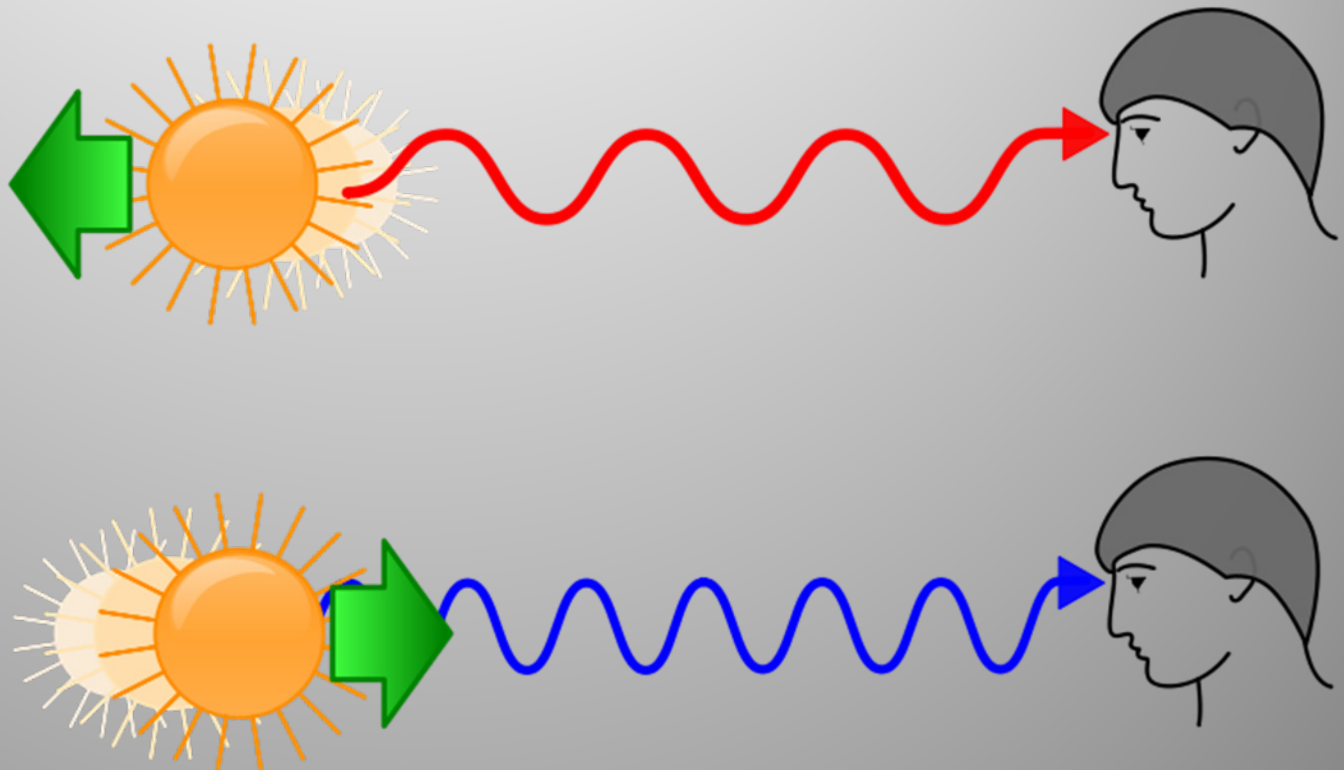
A Swan



Doppler
Effect

Cosmological Redshift

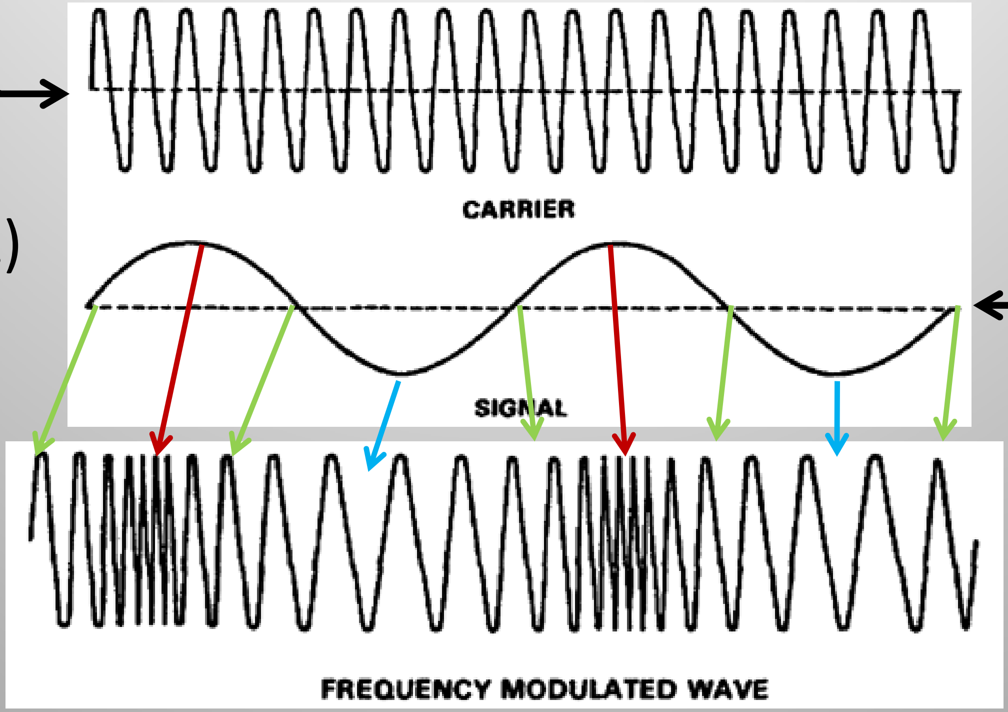




Expansion of space, not motion of radiating object!

Frequency Modulation 101

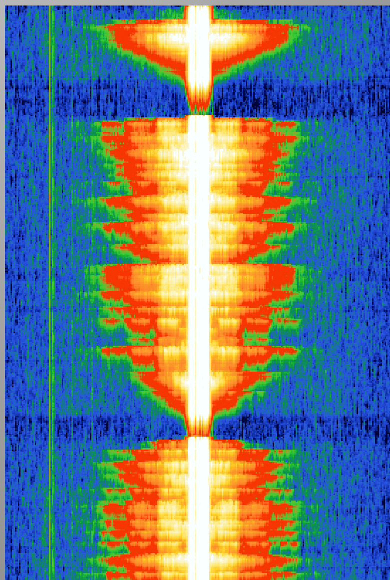
‘Main’ transmission frequency (e.g. 105.7 MHz)



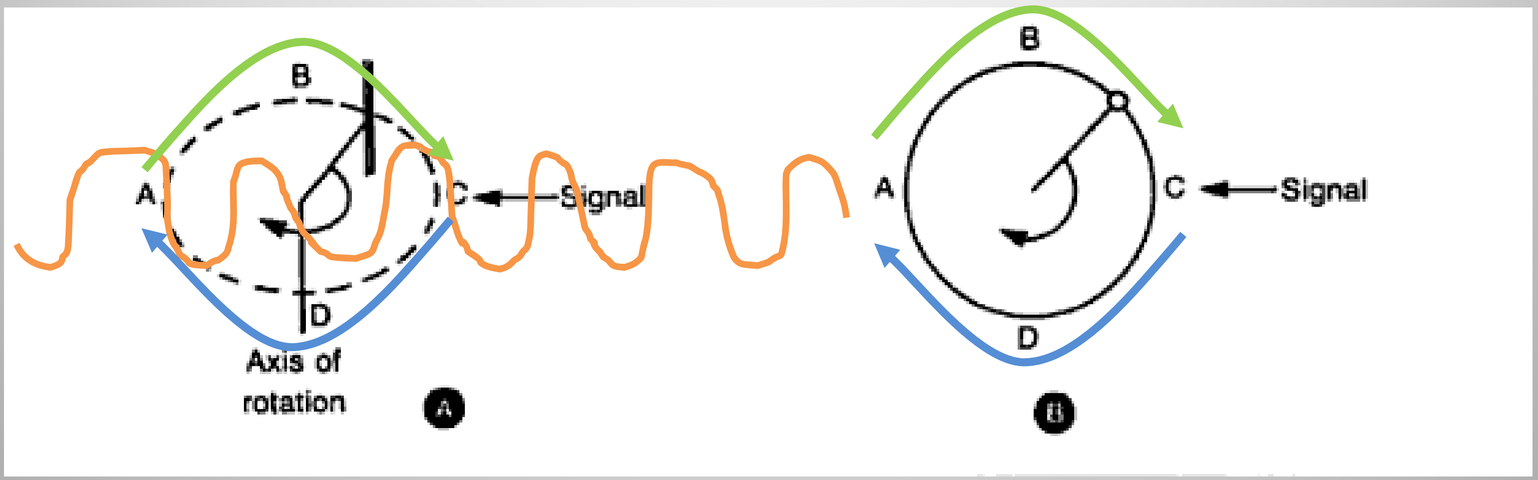
Analog or digital Information to be transmitted

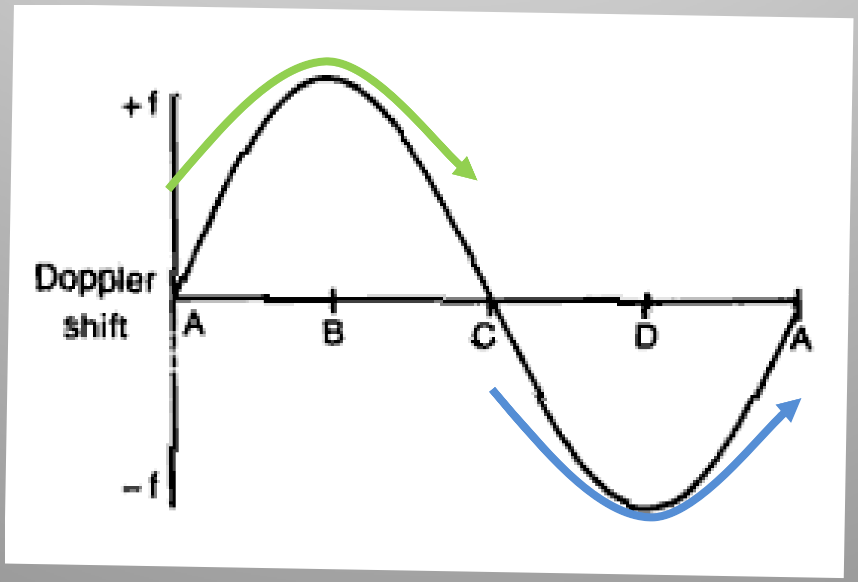
Frequency modulation changes the carrier’s frequency

→ Moves the carrier slightly left/right of its original position on frequency plot



Physically Rotated Antenna





Joseph Moell,
"Transmitter Hunting:
Radio Direction
Finding Simplified",
1987 (McGraw-Hill)

Doppler Shift

- Doppler shift of received signal used to calculate angle of transmitter
- Easy with an FM radio!
- Frequency Modulation:
  - Shifts the centre (carrier) frequency about based on the original modulating signal
  - Doppler shift just moves it around some more
- FM receiver detects Doppler as an extra tone!

Extra tone: sine wave

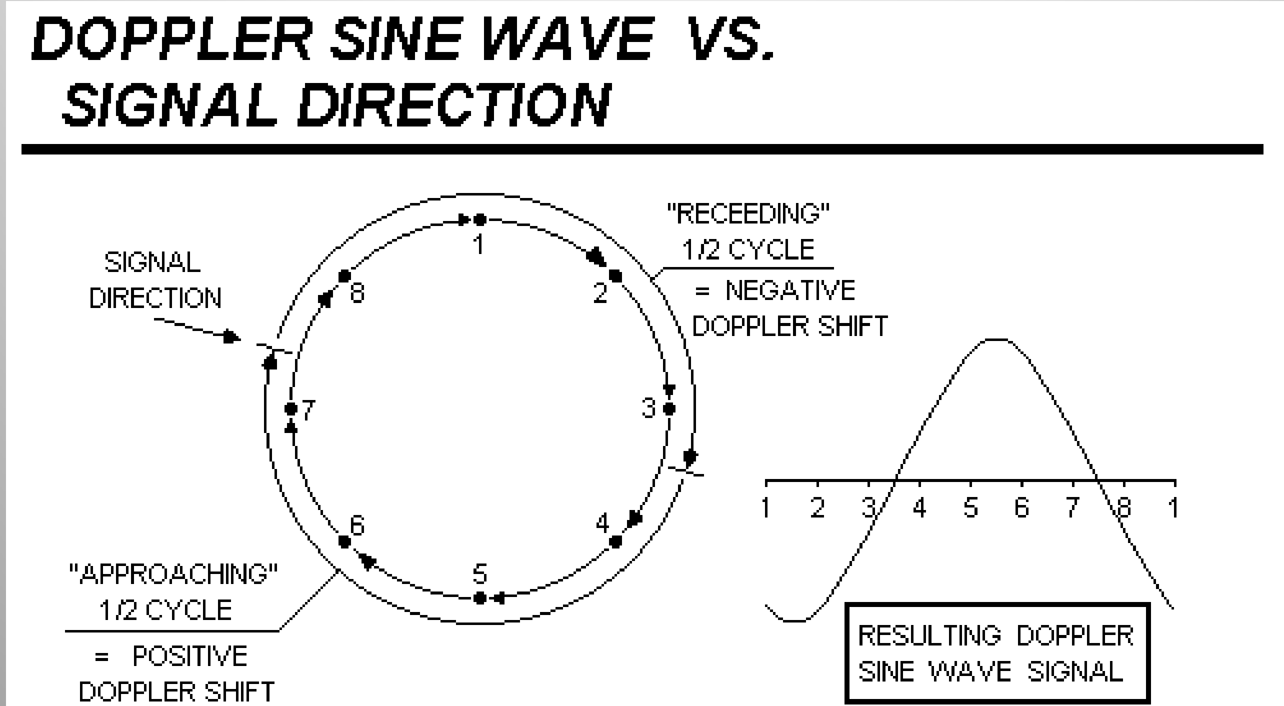


FIGURE 2

The sine wave zero - crossing at the end of the positive half - cycle signals the exact instant when the hypothetical antenna is nearest the signal source

http://silcom.com/~pelican2/PicoDopp/ABOUT_DOPP.html

Mechanical Rotation Rate

- Doppler equation relates:
  - Doppler shift
  - Radius of antenna
  - Angular velocity (rotation rate)
  - Frequency of signal
- For a small antenna setup tuned to 2m wavelength (~150 MHz), requires:

38600 RPM

~643 rot/sec

Pseudo-Doppler

- Array of **fixed** antennas
- Switch **electronically** between them
  - ‘Simulate’ physical rotation

PRODUCING DOPPLER SHIFT ON A RECIEVED SIGNAL USING STATIONARY ANTENNAS

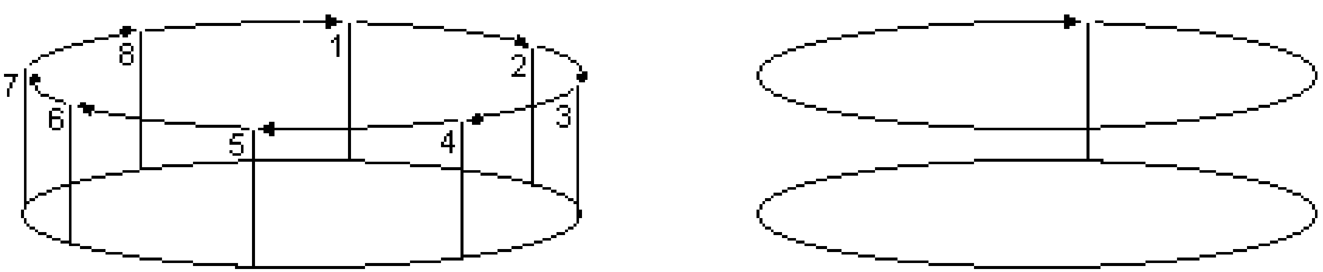
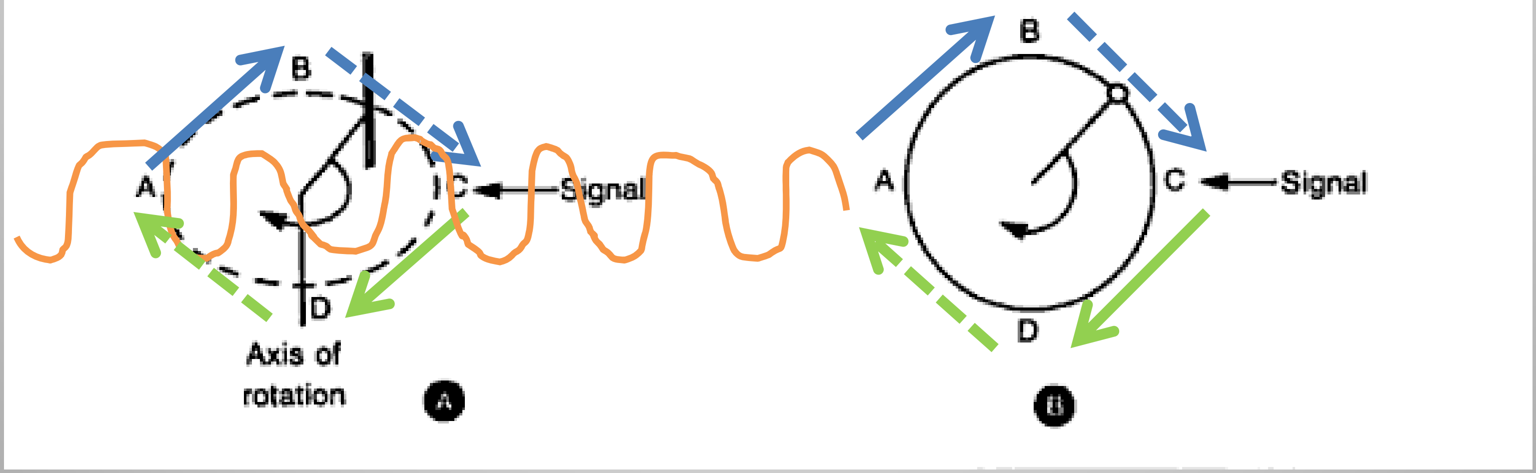
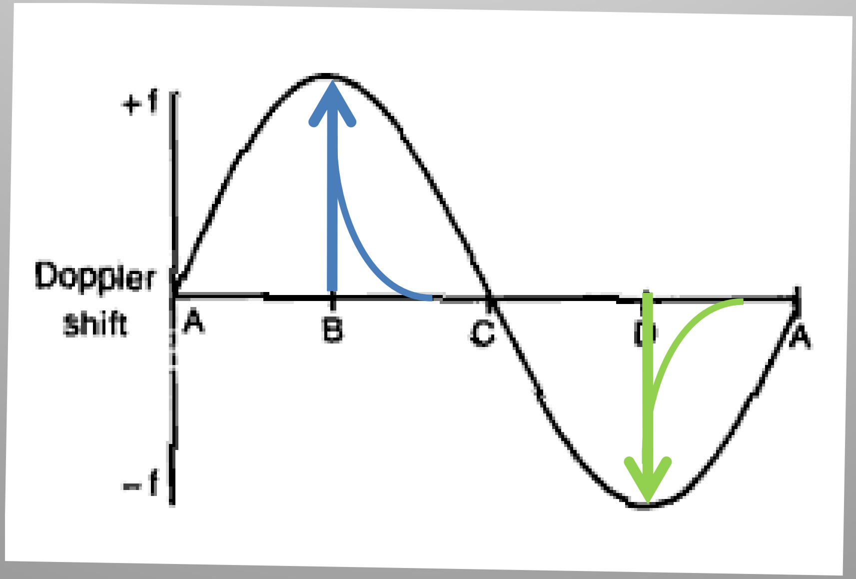


FIGURE 1

Switching a receiver between 8 stationary antennas (arranged in a circle) simulates the action of a single, *hypothetical* antenna, moving in a circle.

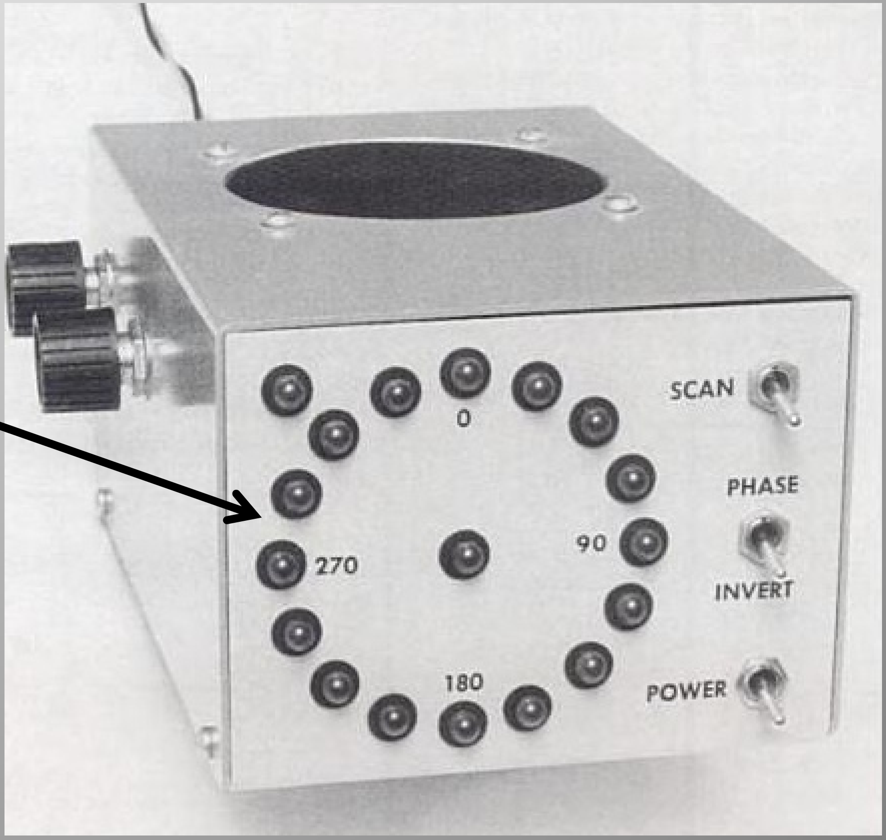
Electronically Rotated Antenna





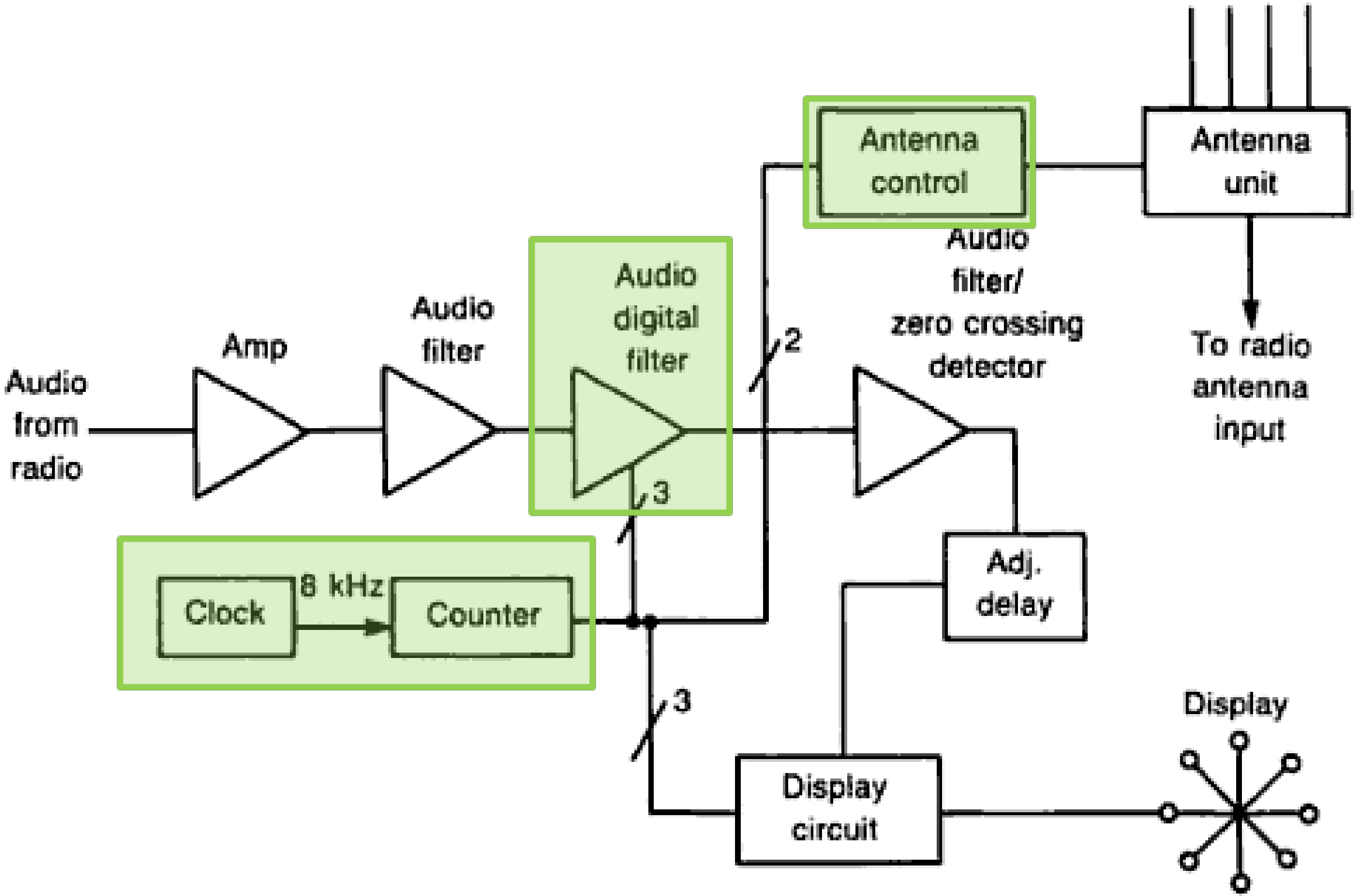
Home-made RDF

- 'Roanoke Doppler'
- Four antennas
- Control box
- Plug in **any standard FM radio**
- LEDs indicate direction

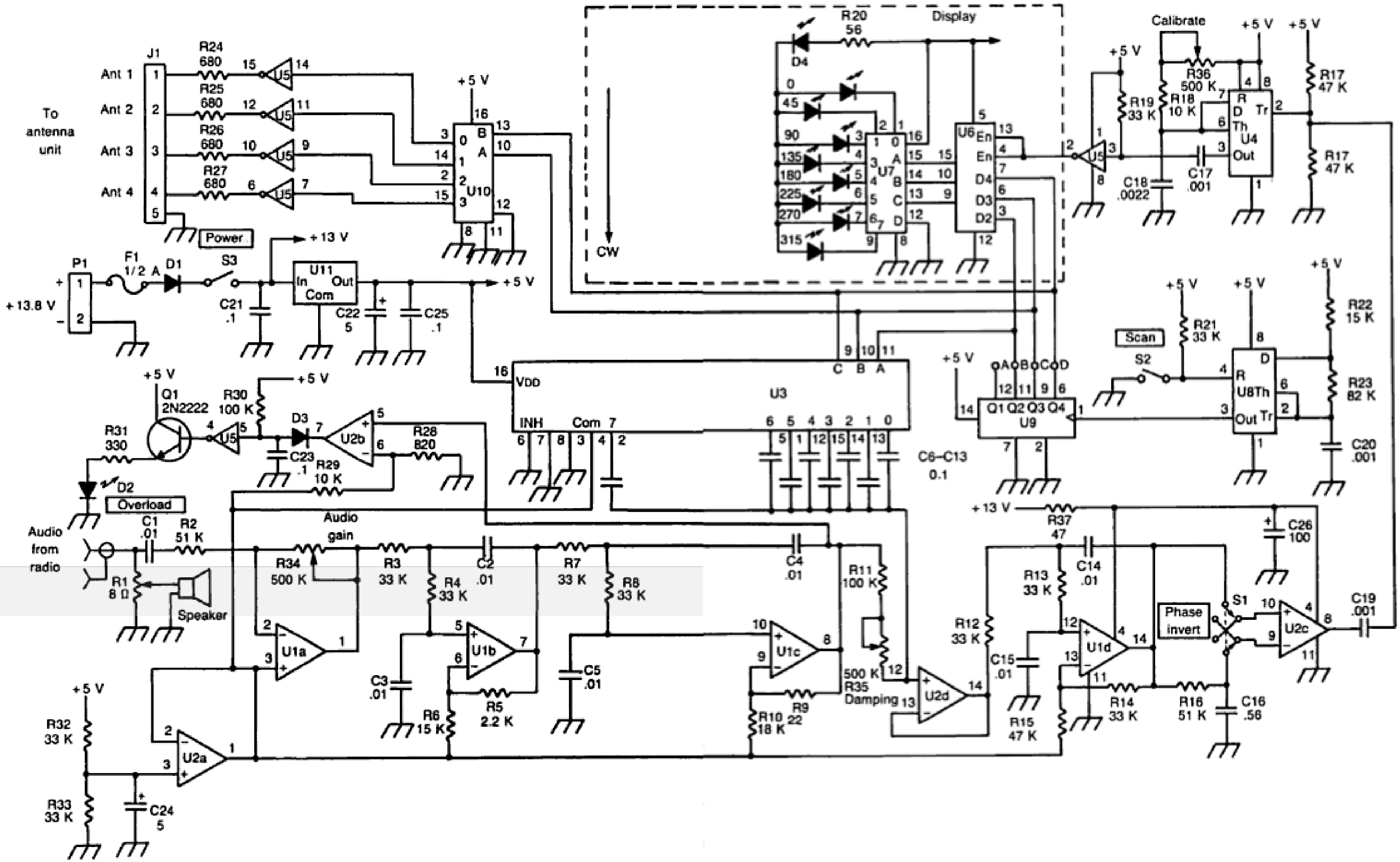


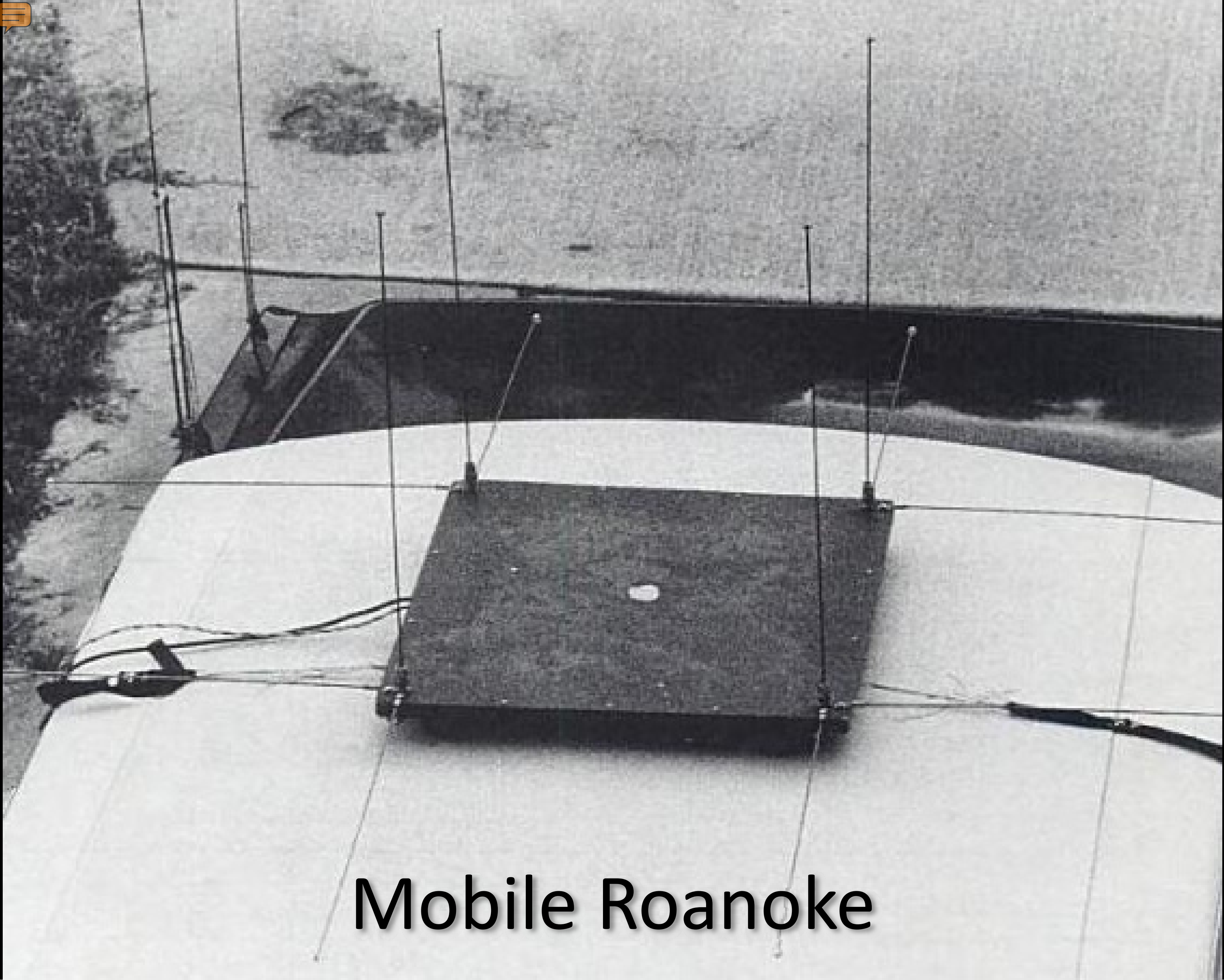
Joseph Moell,
"Transmitter Hunting:
Radio Direction Finding Simplified",
1987 (McGraw-Hill)

Block Diagram



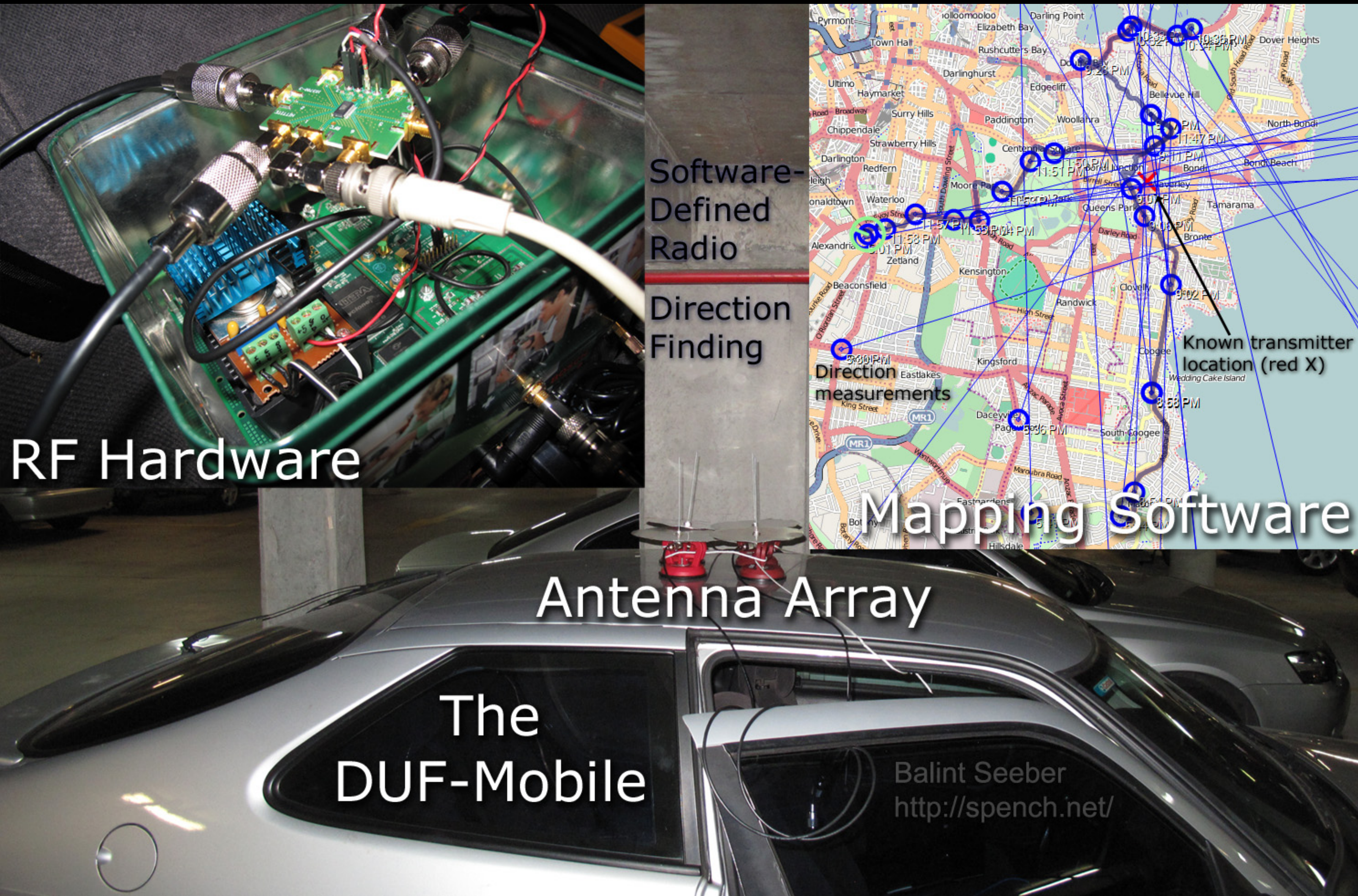
Circuit Diagram





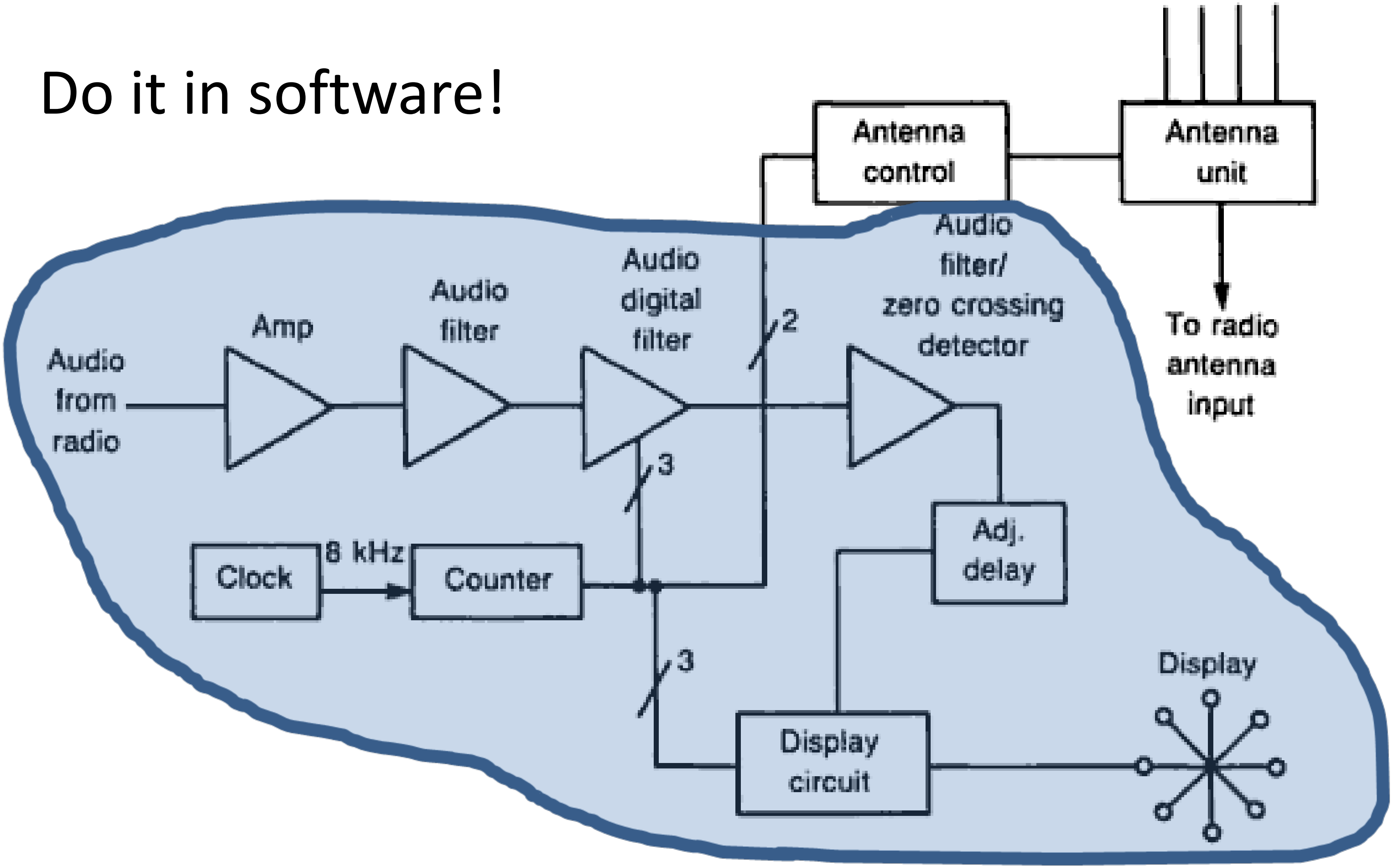
Mobile Roanoke

Time to go colour…

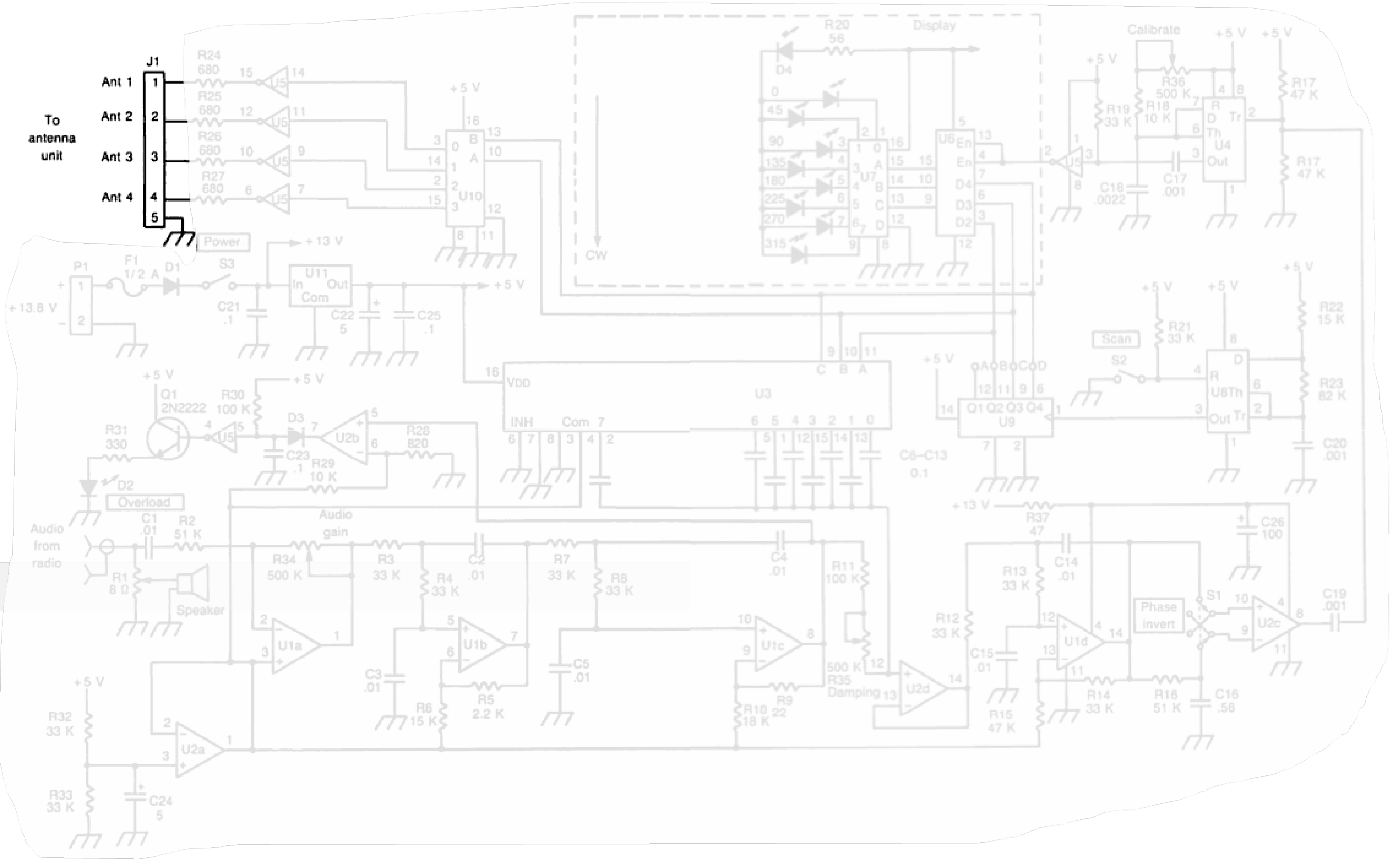


Software Defined RDF

Do it in software!

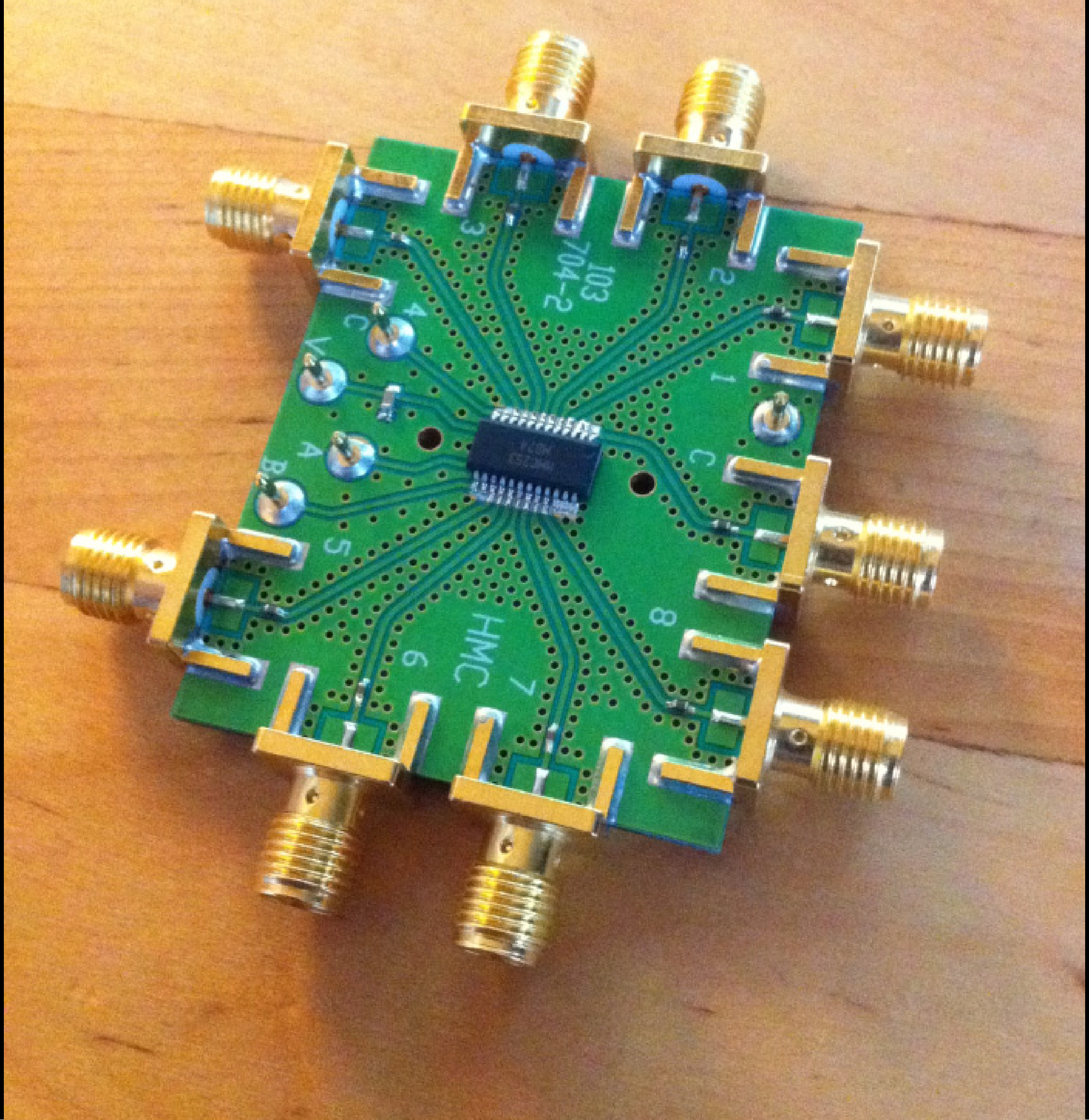


Software Defined RDF




Antenna
Array

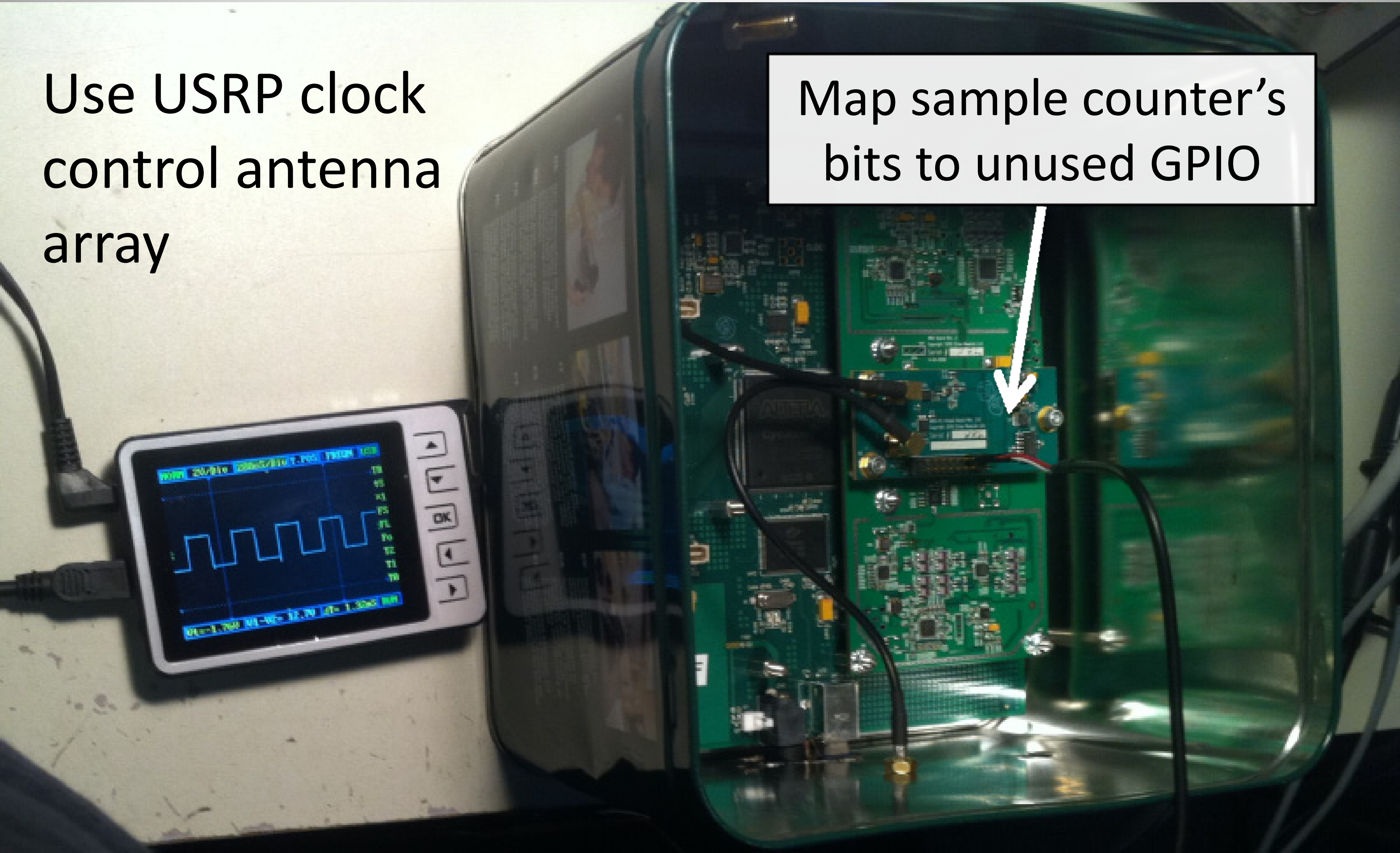
Antenna Switch



FPGA Modification

Use USRP clock control antenna array

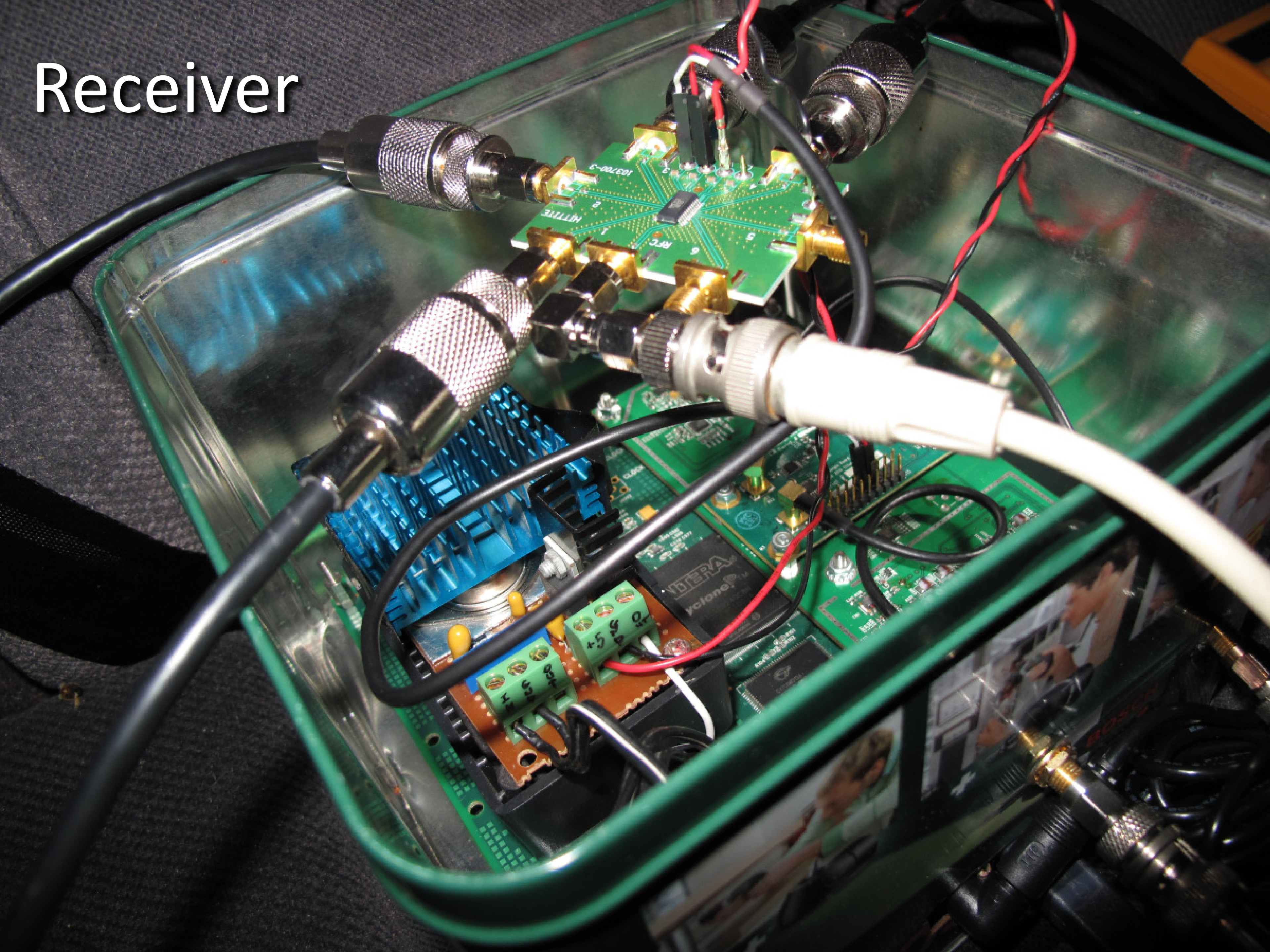
Map sample counter's bits to unused GPIO



Modification Bonuses

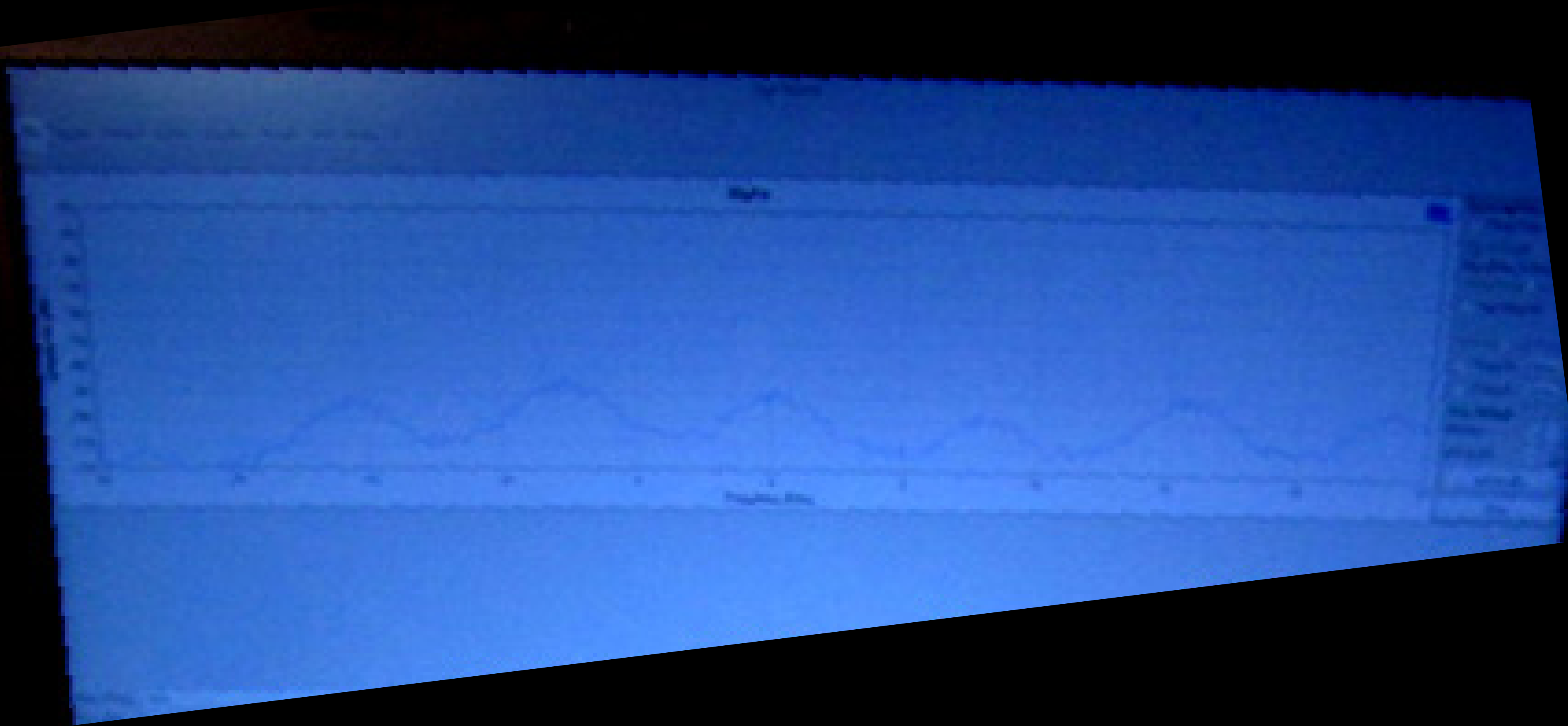
- Using FPGA clock ensures antenna switching is in lockstep with samples arriving at host
  - Same clock domain → host-side ‘just works’
  - Use host-generated sine wave as reference
- FPGA’s sample counter begins at zero for each stream start
  - Calibrate array orientation just once

Receiver

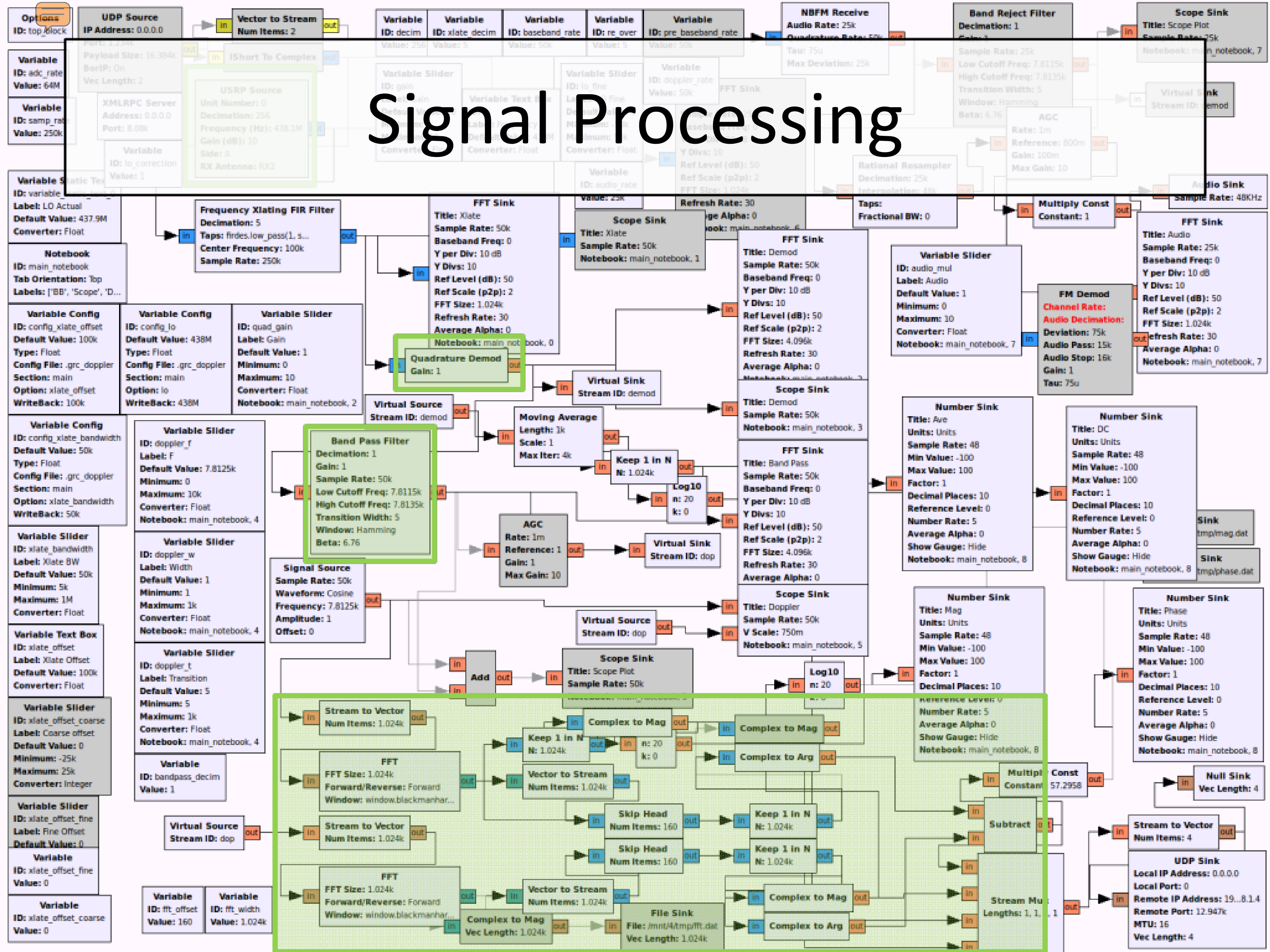


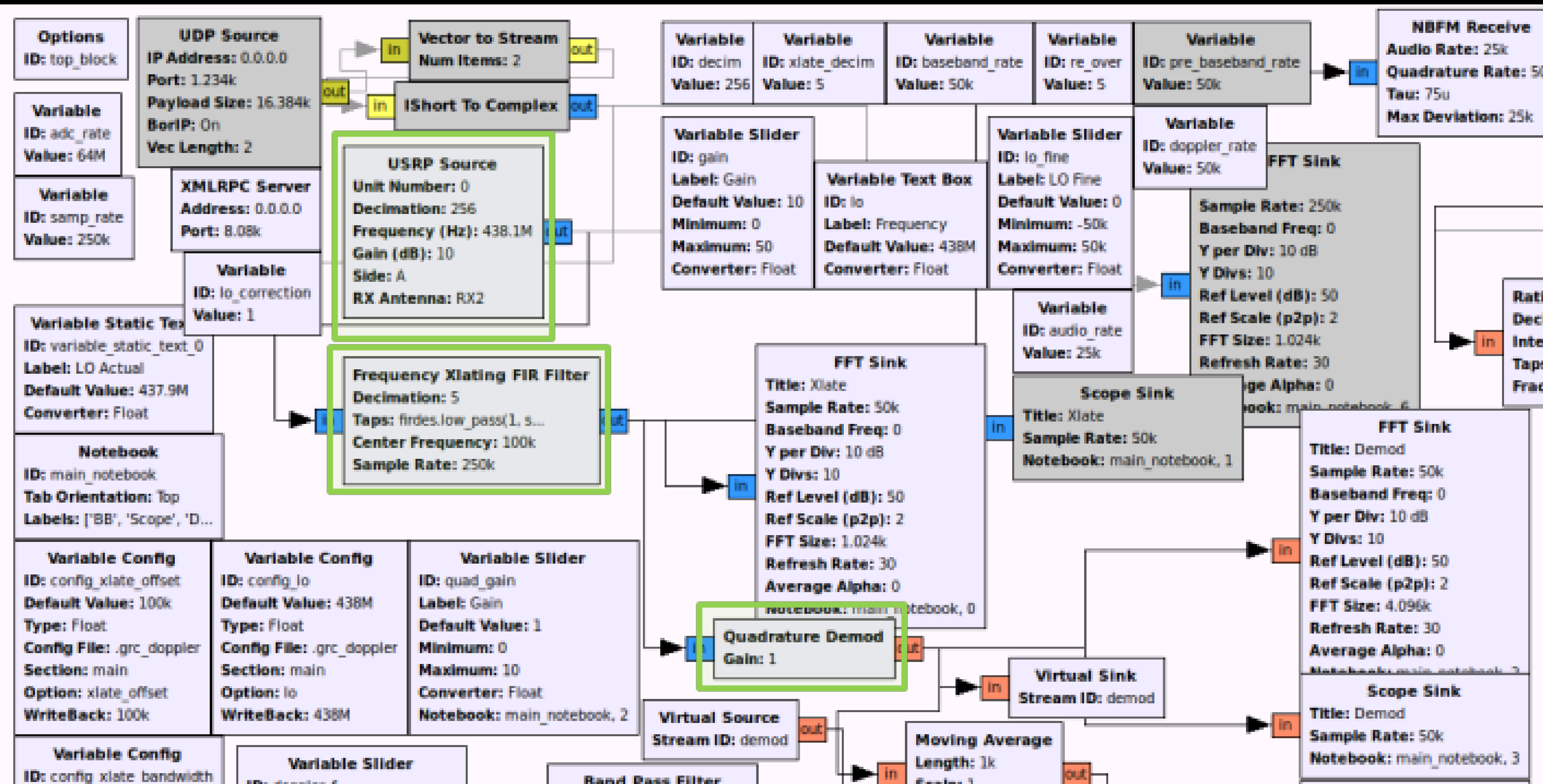
Processing & Display

Switching affecting spectrum



Signal Processing





Options
ID: top_block
UDP Source
IP Address: 0.0.0.0
Port: 1.234k
Payload Size: 16.384k
BorIP: On
Vec Length: 2
Vector to Stream
Num Items: 2
IShort To Complex
Variable
ID: adc_rate
Value: 64M
Variable
ID: samp_rate
Value: 250k
XMLRPC Server
Address: 0.0.0.0
Port: 8.08k
USRP Source
Unit Number: 0
Decimation: 256
Frequency (Hz): 438.1M
Gain (dB): 10
Side: A
RX Antenna: RX2
Variable
ID: lo_correction
Value: 1
Variable Static Tex
ID: variable_static_text_0
Label: LO Actual
Default Value: 437.9M
Converter: Float
Notebook
ID: main_notebook
Tab Orientation: Top
Labels: ['BB', 'Scope', 'D...
Frequency Xlating FIR Filter
Decimation: 5
Taps: firdes.low_pass(1, s...
Center Frequency: 100k
Sample Rate: 250k
Variable
ID: decim
Value: 256
Variable
ID: xlate_decim
Value: 5
Variable
ID: baseband_rate
Value: 50k
Variable
ID: re_over
Value: 5
Variable
ID: pre_baseband_rate
Value: 50k
NBFM Receive
Audio Rate: 25k
Quadrature Rate: 50
Tau: 75u
Max Deviation: 25k
Variable Slider
ID: gain
Label: Gain
Default Value: 10
Minimum: 0
Maximum: 50
Converter: Float
Variable Text Box
ID: lo
Label: Frequency
Default Value: 438M
Converter: Float
Variable Slider
ID: lo_fine
Label: LO Fine
Default Value: 0
Minimum: -50k
Maximum: 50k
Converter: Float
Variable
ID: doppler_rate
Value: 50k
FFT Sink
Sample Rate: 250k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Variable
ID: audio_rate
Value: 25k
FFT Sink
Title: Xlate
Sample Rate: 50k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 30
Average Alpha: 0
Scope Sink
Title: Xlate
Sample Rate: 50k
Notebook: main_notebook, 1
FFT Sink
Title: Demod
Sample Rate: 50k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 0
Quadrature Demod
Gain: 1
Virtual Sink
Stream ID: demod
Scope Sink
Title: Demod
Sample Rate: 50k
Notebook: main_notebook, 3
Variable Config
ID: config_xlate_offset
Default Value: 100k
Type: Float
Config File: .grc_doppler
Section: main
Option: xlate_offset
WriteBack: 100k
Variable Config
ID: config_lo
Default Value: 438M
Type: Float
Config File: .grc_doppler
Section: main
Option: lo
WriteBack: 438M
Variable Slider
ID: quad_gain
Label: Gain
Default Value: 1
Minimum: 0
Maximum: 10
Converter: Float
Notebook: main_notebook, 2
Virtual Source
Stream ID: demod
Moving Average
Length: 1k
Scale: 1
Variable Config
ID: config_xlate_bandwidth
Variable Slider
Band Pass Filter

Tricks

- Only need to know:
  1. Sample rate (FPGA clock / decimation)
  2. Which bit of sample counter is MSB of switch

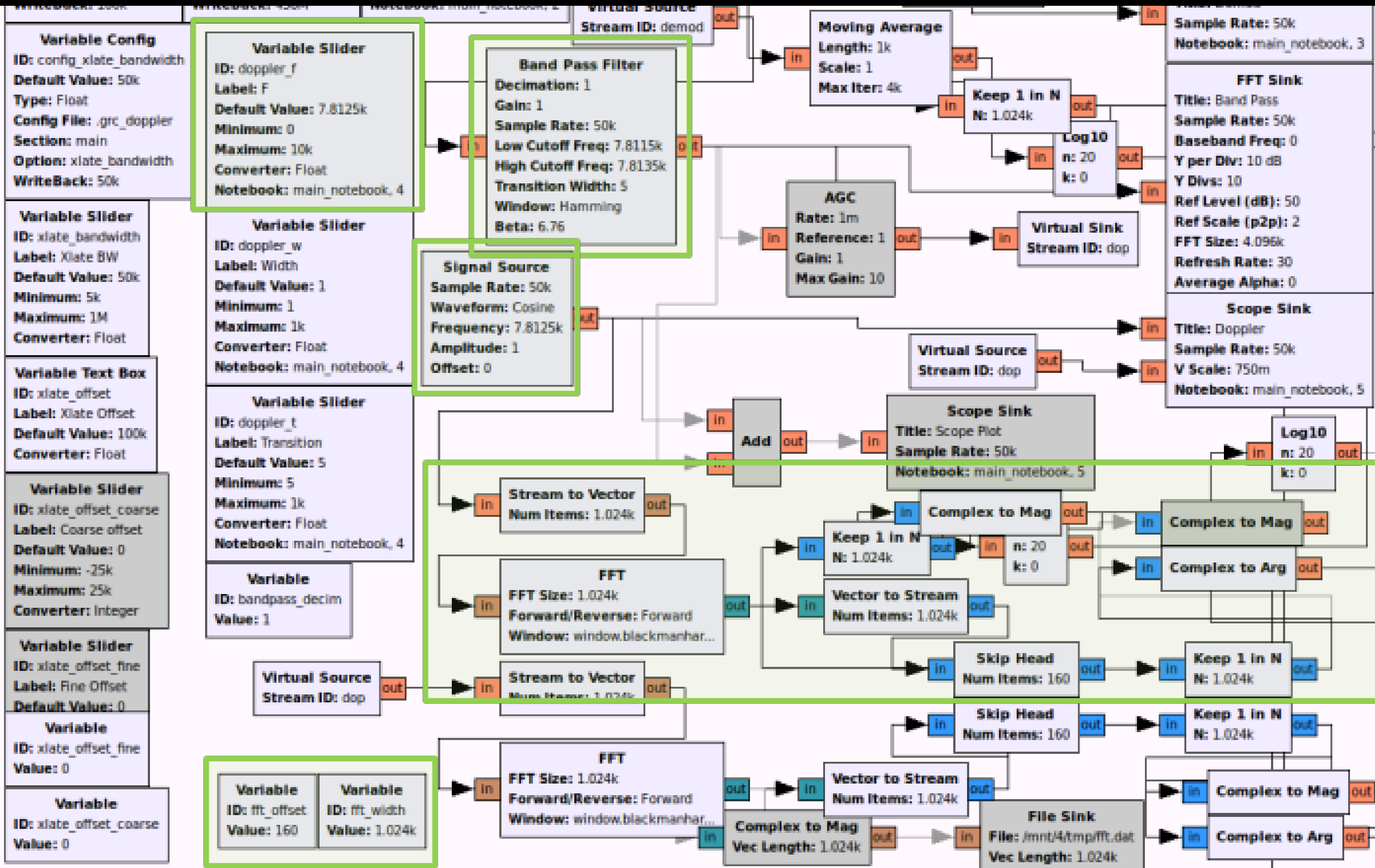
(64 MHz / 256) = **250 ksps**

31st and **32nd** bits used

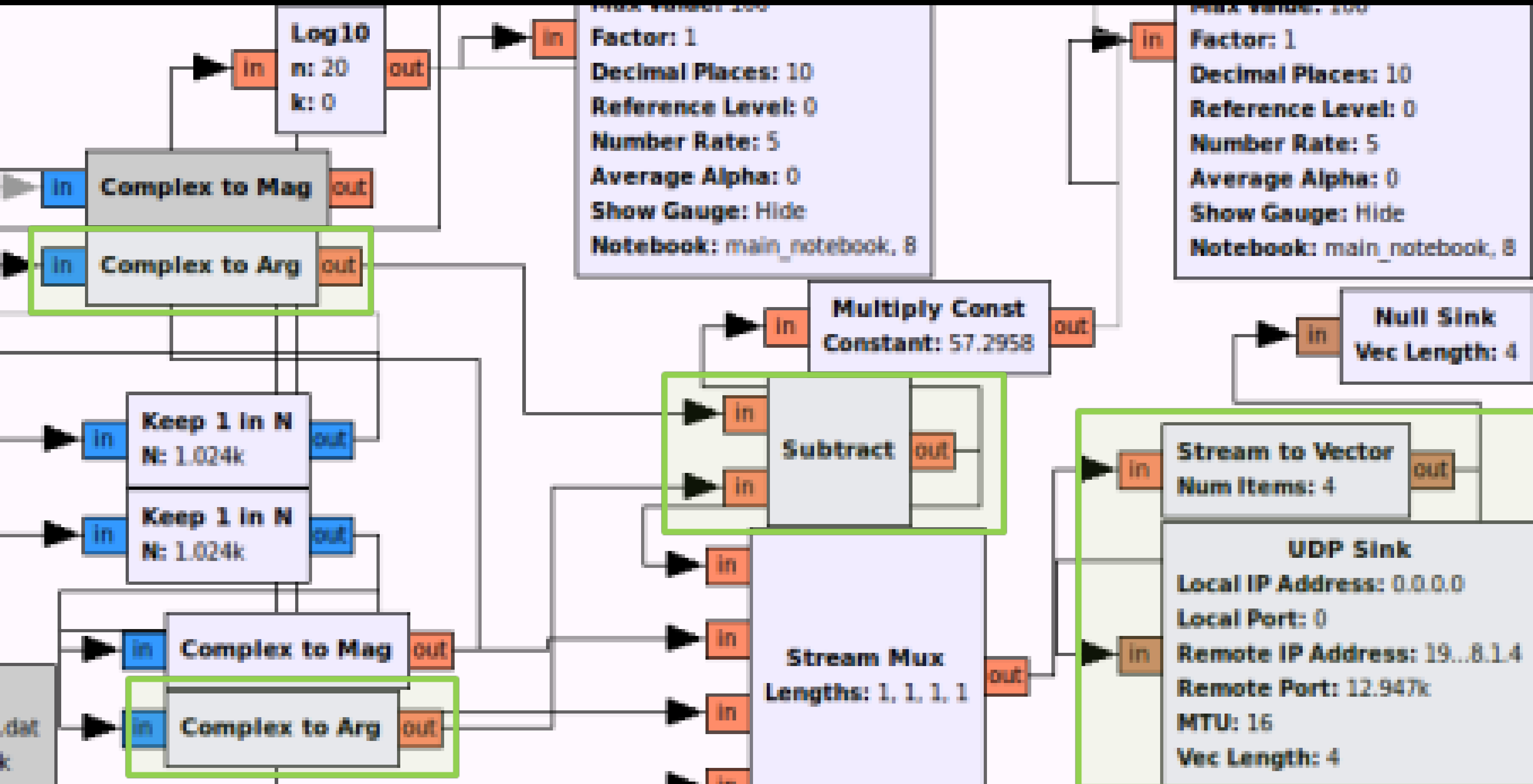
→ 250k / 32 = 7.8125 kHz tone

For Xlate **decim 5** & **1024 FFT bins**, tone sits in:

((250 ksps / 5) / 1024) * 7812.5 = **160 exactly**



Variable Config
ID: config_xlate_bandwidth
Default Value: 50k
Type: Float
Config File: .grc_doppler
Section: main
Option: xlate_bandwidth
WriteBack: 50k
Variable Slider
ID: doppler_f
Label: F
Default Value: 7.8125k
Minimum: 0
Maximum: 10k
Converter: Float
Notebook: main_notebook, 4
Band Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 50k
Low Cutoff Freq: 7.8115k
High Cutoff Freq: 7.8135k
Transition Width: 5
Window: Hamming
Beta: 6.76
Stream ID: demod
Moving Average
Length: 1k
Scale: 1
Max Iter: 4k
Keep 1 in N
N: 1.024k
Log10
n: 20
k: 0
Sample Rate: 50k
Notebook: main_notebook, 3
FFT Sink
Title: Band Pass
Sample Rate: 50k
Baseband Freq: 0
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 4.096k
Refresh Rate: 30
Average Alpha: 0
AGC
Rate: 1m
Reference: 1
Gain: 1
Max Gain: 10
Virtual Sink
Stream ID: dop
Variable Slider
ID: xlate_bandwidth
Label: Xlate BW
Default Value: 50k
Minimum: 5k
Maximum: 1M
Converter: Float
Variable Slider
ID: doppler_w
Label: Width
Default Value: 1
Minimum: 1
Maximum: 1k
Converter: Float
Notebook: main_notebook, 4
Signal Source
Sample Rate: 50k
Waveform: Cosine
Frequency: 7.8125k
Amplitude: 1
Offset: 0
Scope Sink
Title: Doppler
Sample Rate: 50k
V Scale: 750m
Notebook: main_notebook, 5
Virtual Source
Stream ID: dop
Variable Text Box
ID: xlate_offset
Label: Xlate Offset
Default Value: 100k
Converter: Float
Variable Slider
ID: doppler_t
Label: Transition
Default Value: 5
Minimum: 5
Maximum: 1k
Converter: Float
Notebook: main_notebook, 4
Add
Scope Sink
Title: Scope Plot
Sample Rate: 50k
Notebook: main_notebook, 5
Log10
n: 20
k: 0
Variable Slider
ID: xlate_offset_coarse
Label: Coarse offset
Default Value: 0
Minimum: -25k
Maximum: 25k
Converter: Integer
Stream to Vector
Num Items: 1.024k
Complex to Mag
Keep 1 in N
N: 1.024k
n: 20
k: 0
Complex to Arg
FFT
FFT Size: 1.024k
Forward/Reverse: Forward
Window: window.blackmanhar...
Variable
ID: bandpass_decim
Value: 1
Vector to Stream
Num Items: 1.024k
Skip Head
Num Items: 160
Variable Slider
ID: xlate_offset_fine
Label: Fine Offset
Default Value: 0
Virtual Source
Stream ID: dop
Stream to Vector
Variable
ID: xlate_offset_fine
Value: 0
Variable
ID: fft_offset
Value: 160
Variable
ID: fft_width
Value: 1.024k
Variable
ID: xlate_offset_coarse
Value: 0
File Sink
File: /mnt/4/tmp/fft.dat
Vec Length: 1.024k
Complex to Mag
Vec Length: 1.024k
in
out


Log10
n: 20
k: 0
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 5
Average Alpha: 0
Show Gauge: Hide
Notebook: main_notebook, 8
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 5
Average Alpha: 0
Show Gauge: Hide
Notebook: main_notebook, 8
Complex to Mag
Complex to Arg
Multiply Const
Constant: 57.2958
Null Sink
Vec Length: 4
Keep 1 in N
N: 1.024k
Keep 1 in N
N: 1.024k
Subtract
Stream to Vector
Num Items: 4
UDP Sink
Local IP Address: 0.0.0.0
Local Port: 0
Remote IP Address: 19...8.1.4
Remote Port: 12.947k
MTU: 16
Vec Length: 4
Stream Mux
Lengths: 1, 1, 1, 1
Complex to Mag
Complex to Arg

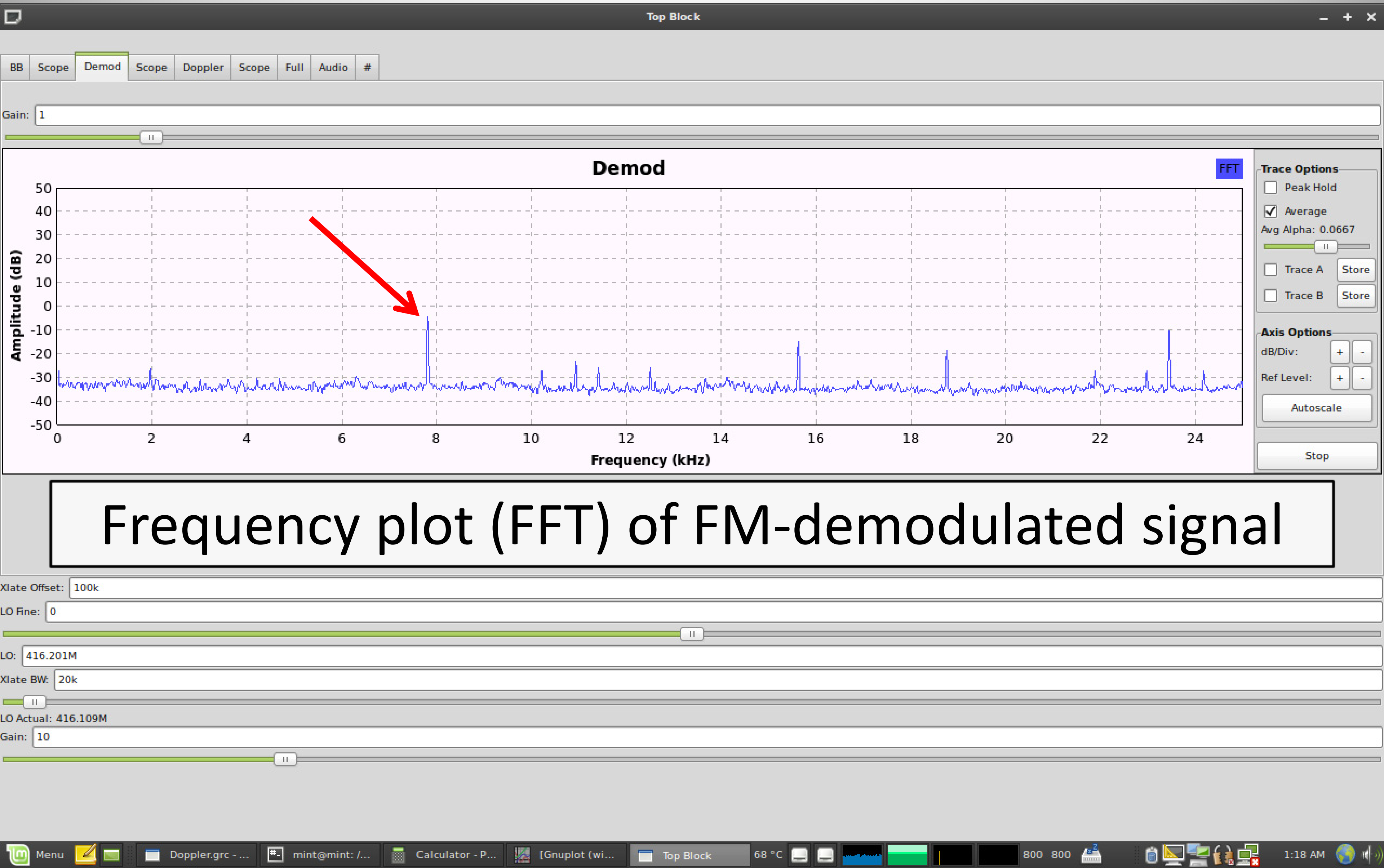
Magic of SDR

FM (quadrature) demodulation:

→ Multiply current signal sample by complex conjugate of previous one and find the argument (angle)

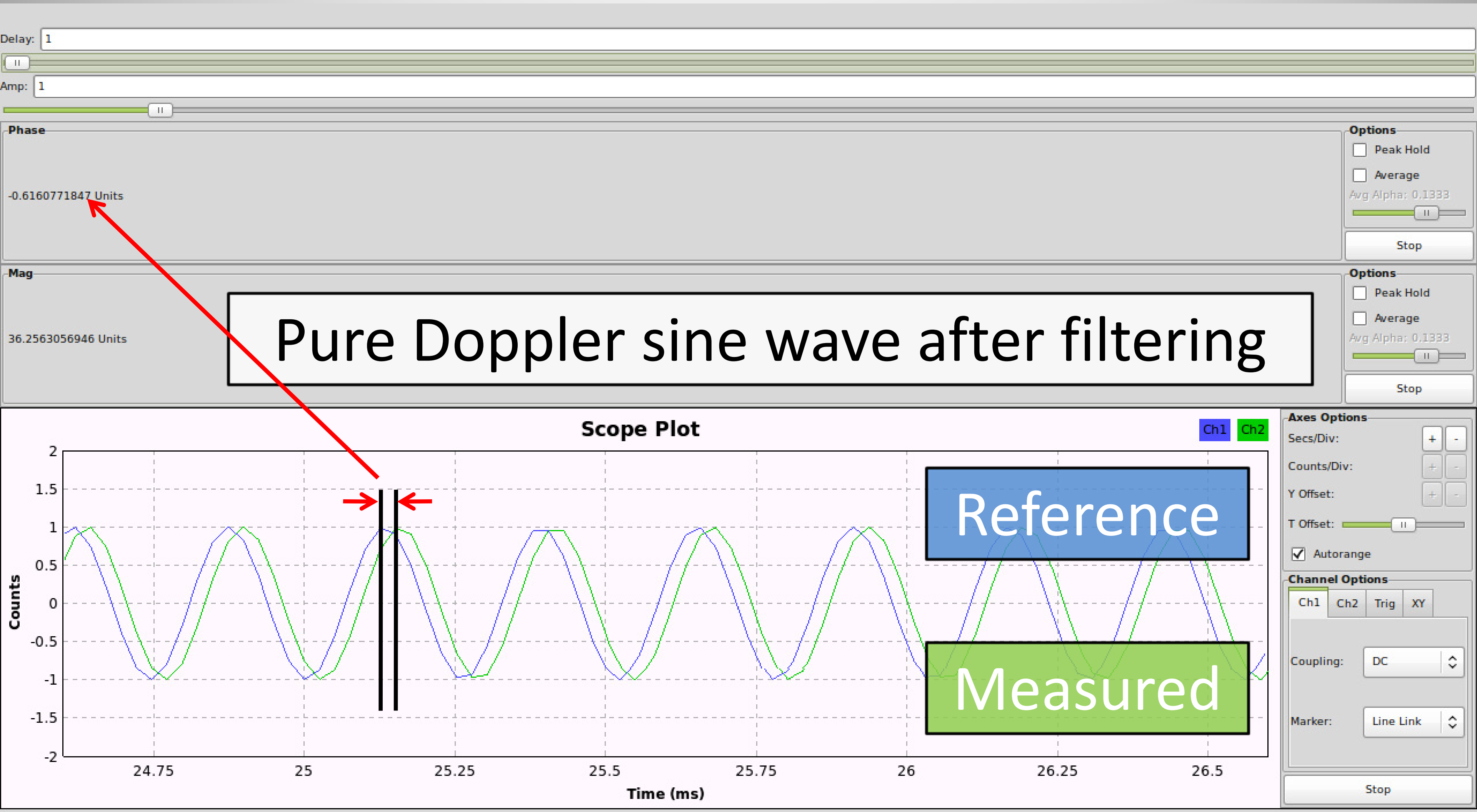
```
 for (int i = 0; i < noutput_items; i++) {
    gr_complex product = in[i] * conj(in[i-1]);
    out[i] = d_gain * arg (product);
}
```

Doppler sine wave



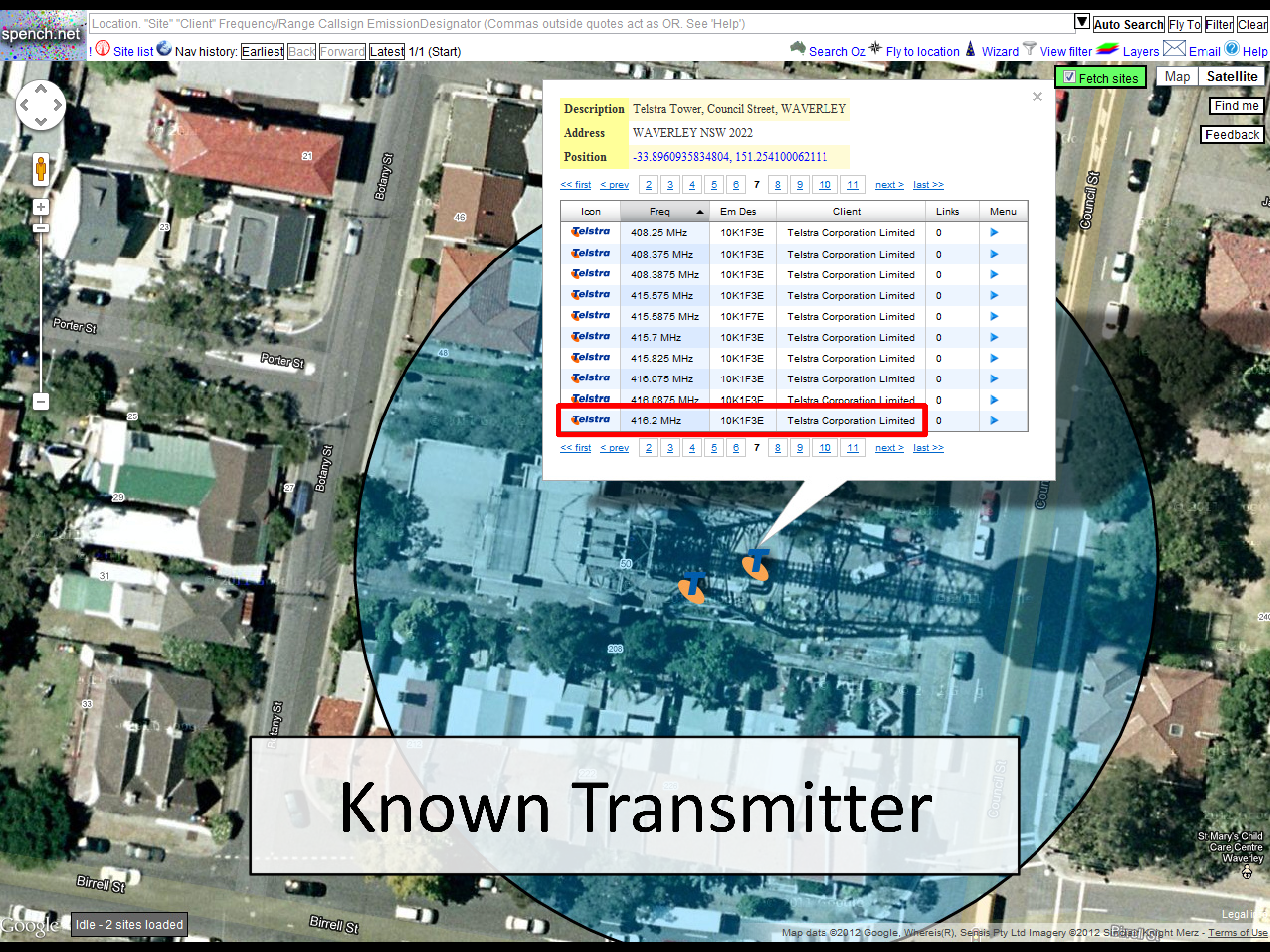
Frequency plot (FFT) of FM-demodulated signal

Doppler sine wave

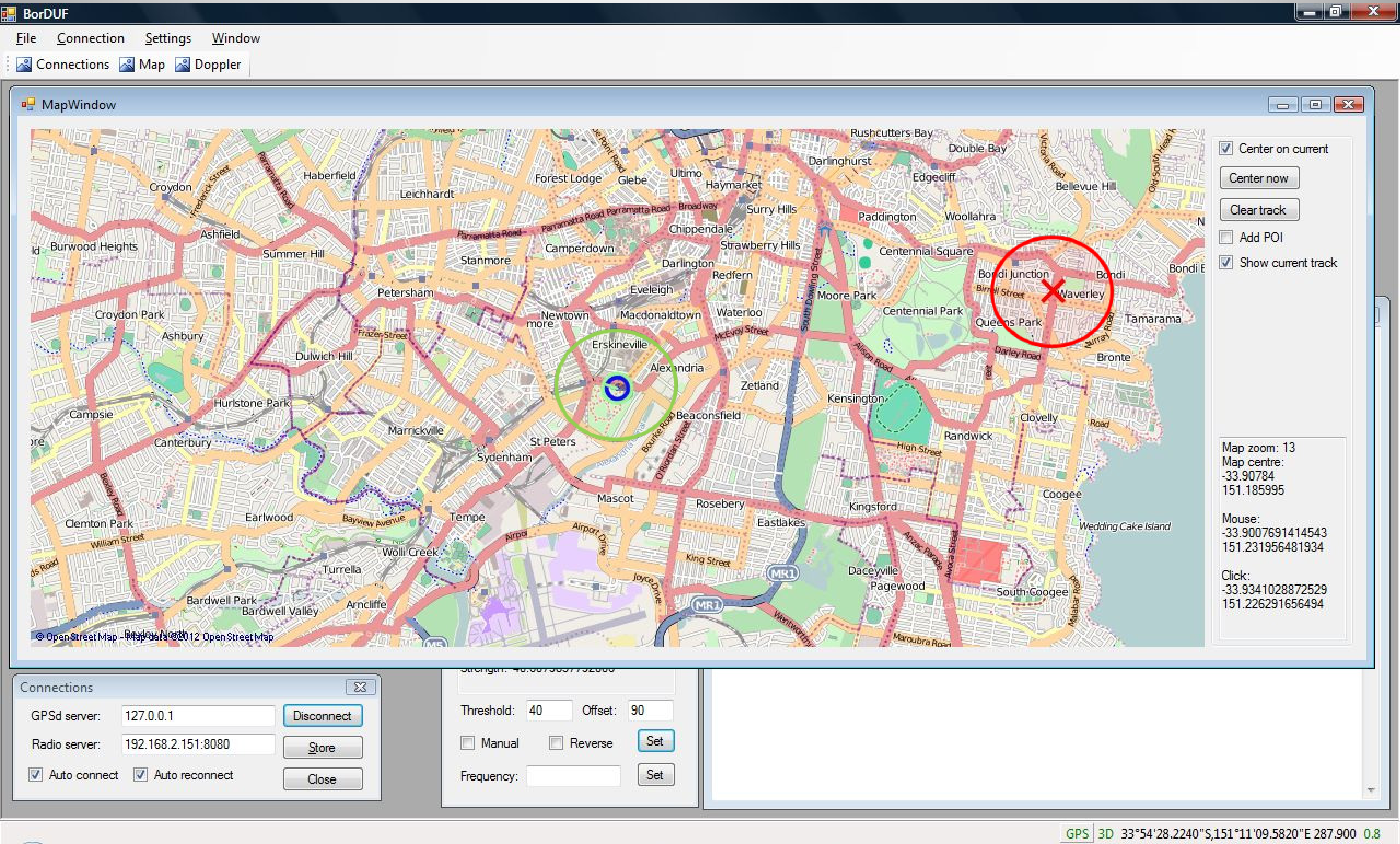



Find a target

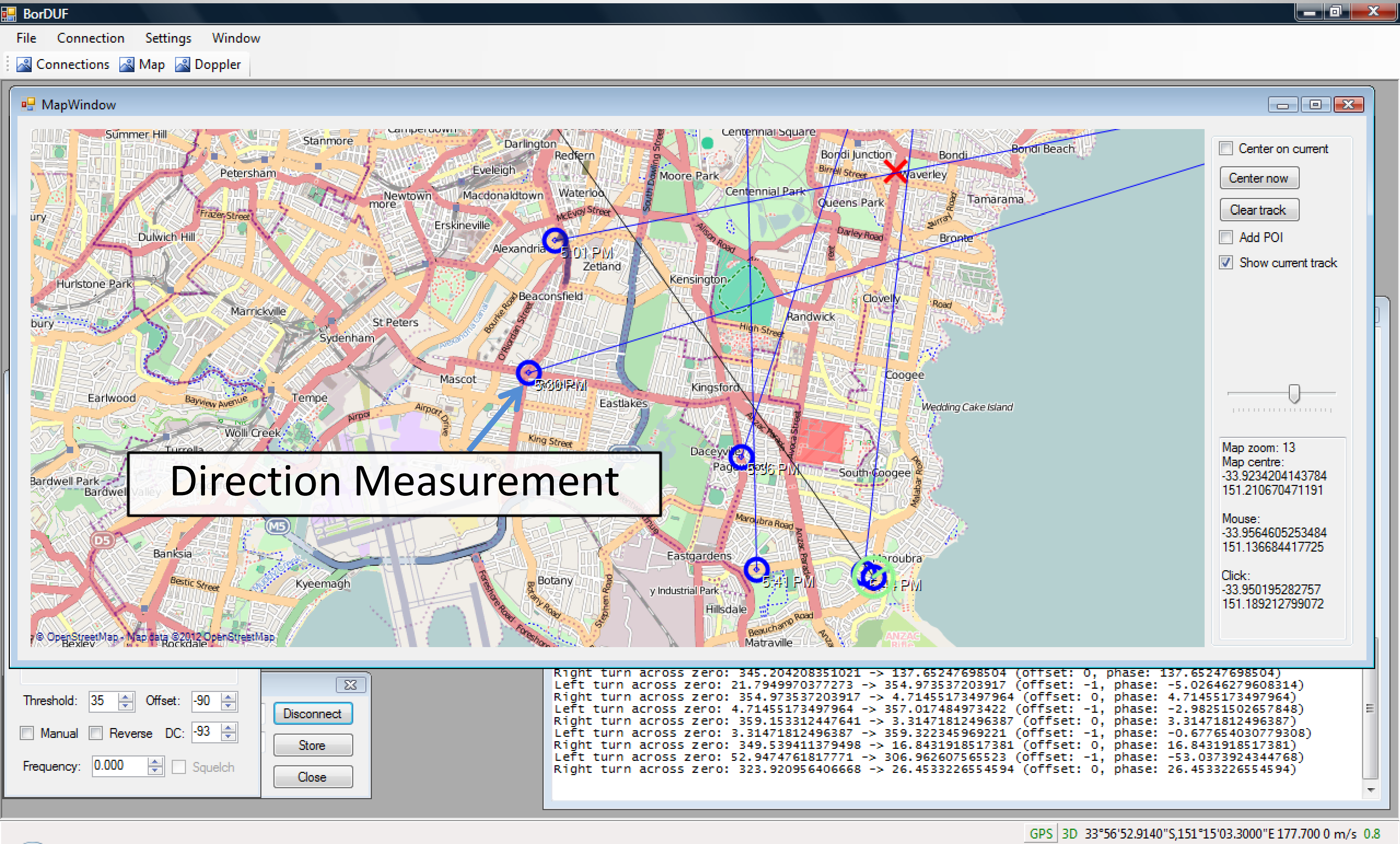

Telstra Tower on Council St


spench.net
Location. "Site" "Client" Frequency/Range Callsign EmissionDesignator (Commas outside quotes act as OR. See 'Help')
Auto Search
Fly To
Filter
Clear
Site list
Nav history:
Earliest
Back
Forward
Latest
1/1 (Start)
Search Oz
Fly to location
Wizard
View filter
Layers
Email
Help
Fetch sites
Map
Satellite
Find me
Feedback
Description Telstra Tower, Council Street, WAVERLEY
Address WAVERLEY NSW 2022
Position -33.8960935834804, 151.254100062111
<< first < prev 2 3 4 5 6 7 8 9 10 11 next > last >>
Icon | Freq | Em Des | Client | Links | Menu
Telstra | 408.25 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 408.375 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 408.3875 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 415.575 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 415.5875 MHz | 10K1F7E | Telstra Corporation Limited | 0
Telstra | 415.7 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 415.825 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 416.075 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 416.0875 MHz | 10K1F3E | Telstra Corporation Limited | 0
Telstra | 416.2 MHz | 10K1F3E | Telstra Corporation Limited | 0
<< first < prev 2 3 4 5 6 7 8 9 10 11 next > last >>
Botany St
Porter St
Council St
Birrell St
St Mary's Child Care Centre Waverley
Idle - 2 sites loaded
Map data ©2012 Google, Whereis(R), Sensis Pty Ltd Imagery ©2012 Sinclair Knight Merz - Terms of Use
Known Transmitter

Start


BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 13
Map centre:
-33.90784
151.185995
Mouse:
-33.9007691414543
151.23195648193
Click:
-33.9341028872529
151.226291656494
© OpenStreetMap - Map data ©2012 OpenStreetMap
Connections
GPSd server:
127.0.0.1
Disconnect
Radio server:
192.168.2.151:8080
Store
Auto connect
Auto reconnect
Close
Threshold:
40
Offset:
90
Manual
Reverse
Set
Frequency:
Set
GPS
3D
33°54'28.2240"S,151°11'09.5820"E 287.900
0.8

Drive

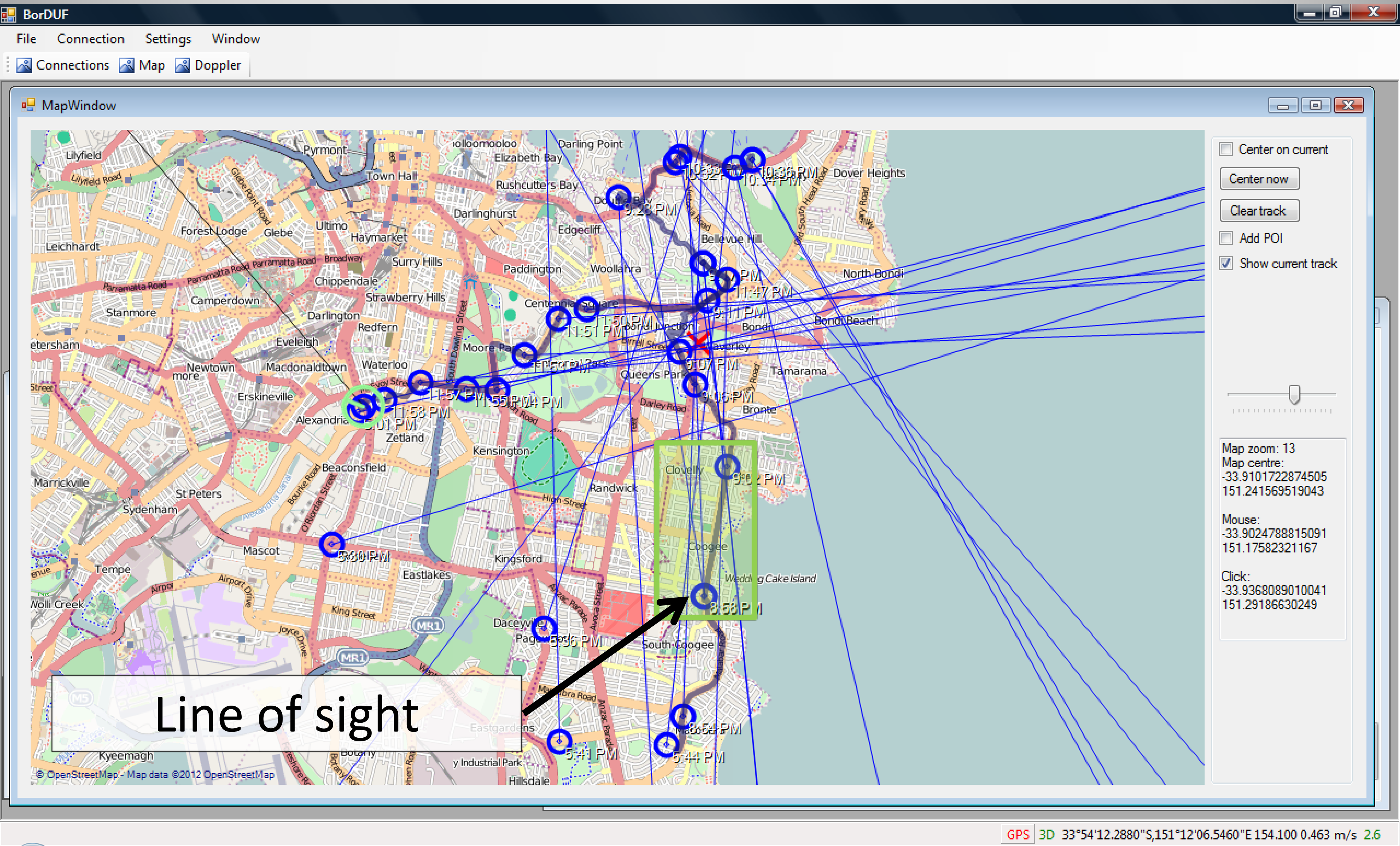


BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
Direction Measurement
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 13
Map centre:
-33.9234204143784
151.210670471191
Mouse:
-33.9564605253484
151.136684417725
Click:
-33.950195282757
151.189212799072
© OpenStreetMap - Map data ©2012 OpenStreetMap
Threshold: 35
Offset: -90
Manual
Reverse
DC: -93
Frequency: 0.000
Squelch
Disconnect
Store
Close
Right turn across zero: 345.204208351021 -> 137.65247698504 (offset: 0, phase: 137.65247698504)
Left turn across zero: 21.7949970377273 -> 354.973537203917 (offset: -1, phase: -5.02646279608314)
Right turn across zero: 354.973537203917 -> 4.71455173497964 (offset: 0, phase: 4.71455173497964)
Left turn across zero: 4.71455173497964 -> 357.017484973422 (offset: -1, phase: -2.98251502657848)
Right turn across zero: 359.153312447641 -> 3.31471812496387 (offset: 0, phase: 3.31471812496387)
Left turn across zero: 3.31471812496387 -> 359.322345969221 (offset: -1, phase: -0.677654030779308)
Right turn across zero: 349.539411379498 -> 16.8431918517381 (offset: 0, phase: 16.8431918517381)
Left turn across zero: 52.9474761817771 -> 306.962607565523 (offset: -1, phase: -53.0373924344768)
Right turn across zero: 323.920956406668 -> 26.4533226554594 (offset: 0, phase: 26.4533226554594)
GPS 3D 33°56'52.9140"S,151°15'03.3000"E 177.700 0 m/s 0.8

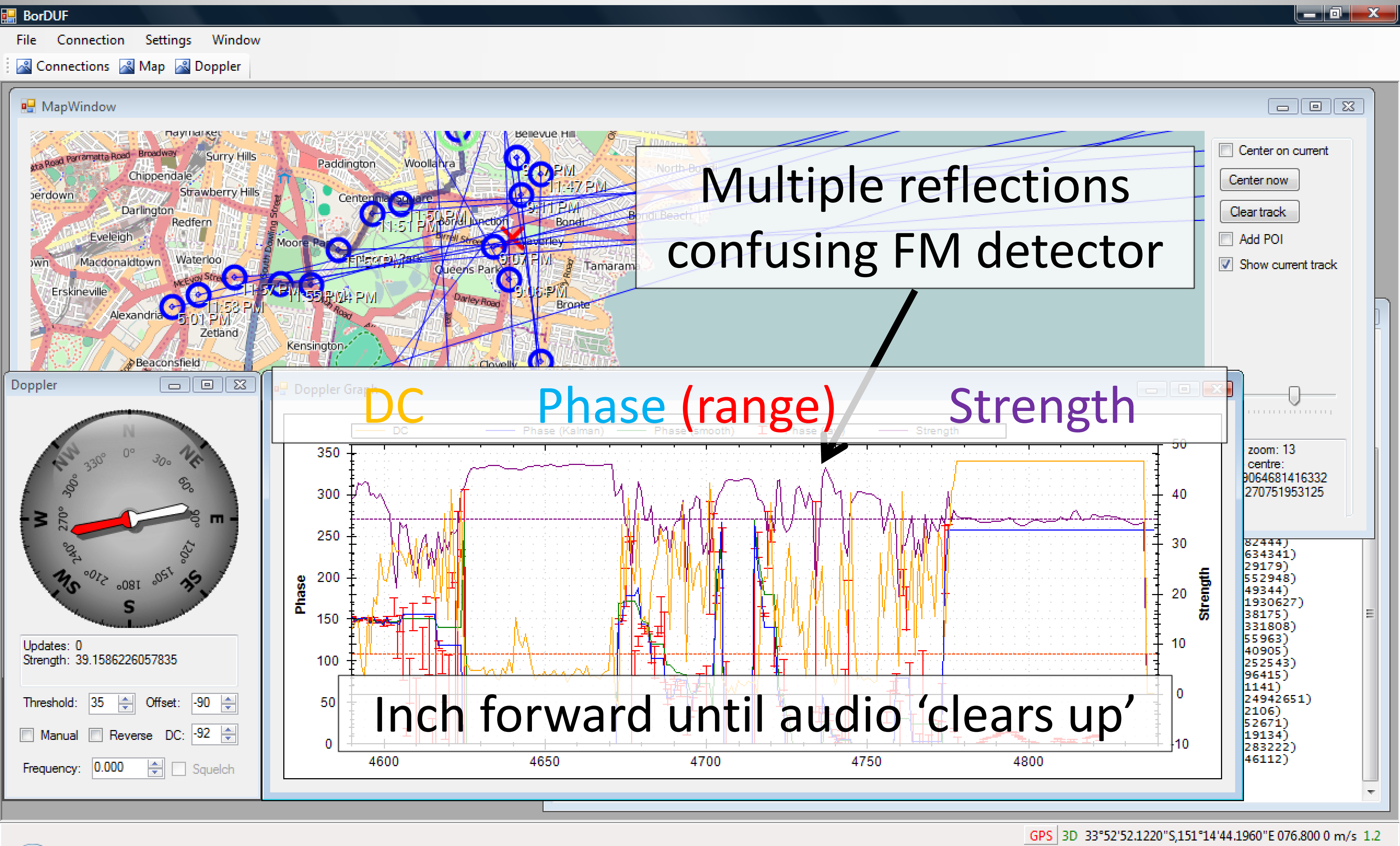
Complications

- Line-Of-Sight
  - Beware of reflections
    - Descending into ‘valley’…
  - Reflections in urban areas
  - Multiple wavefronts will ‘confuse’ FM detector
    - Doppler

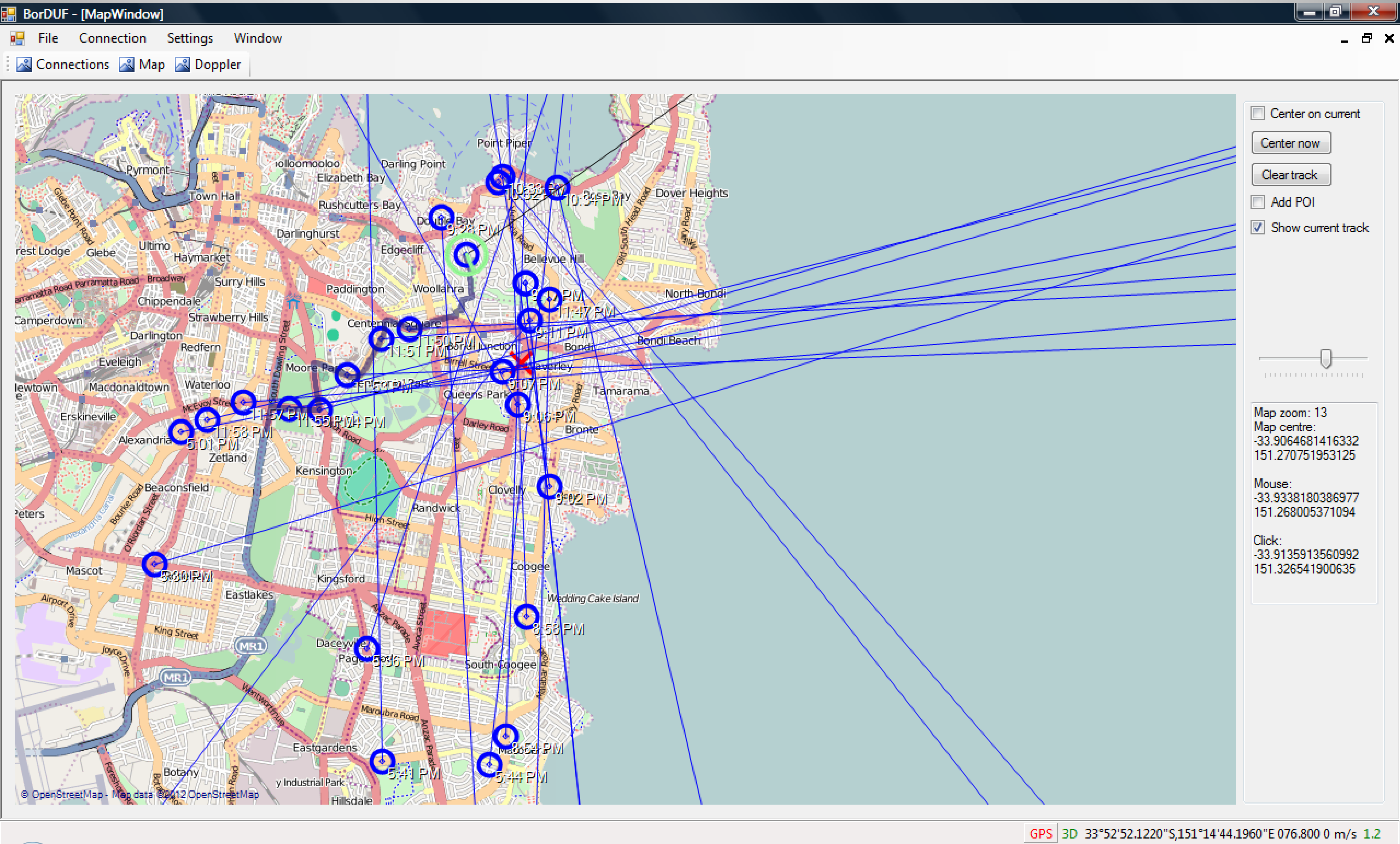
Complications: Coogee



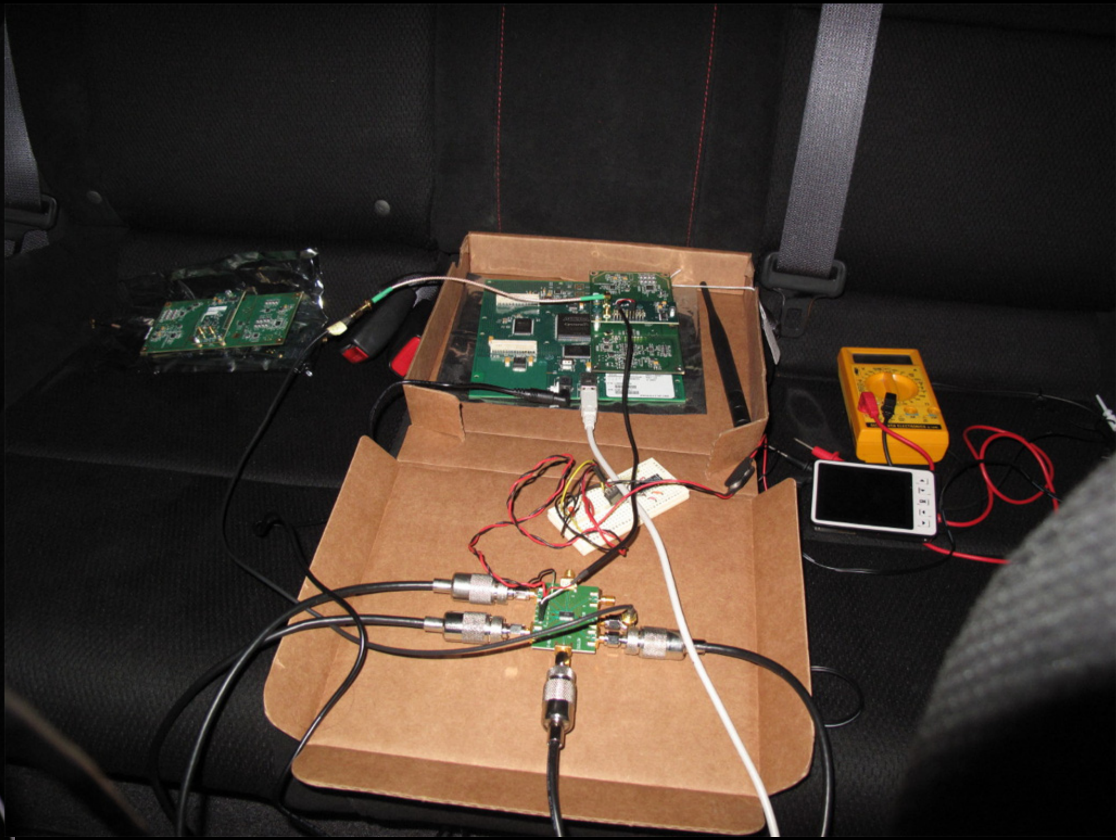
Listen: Multipath



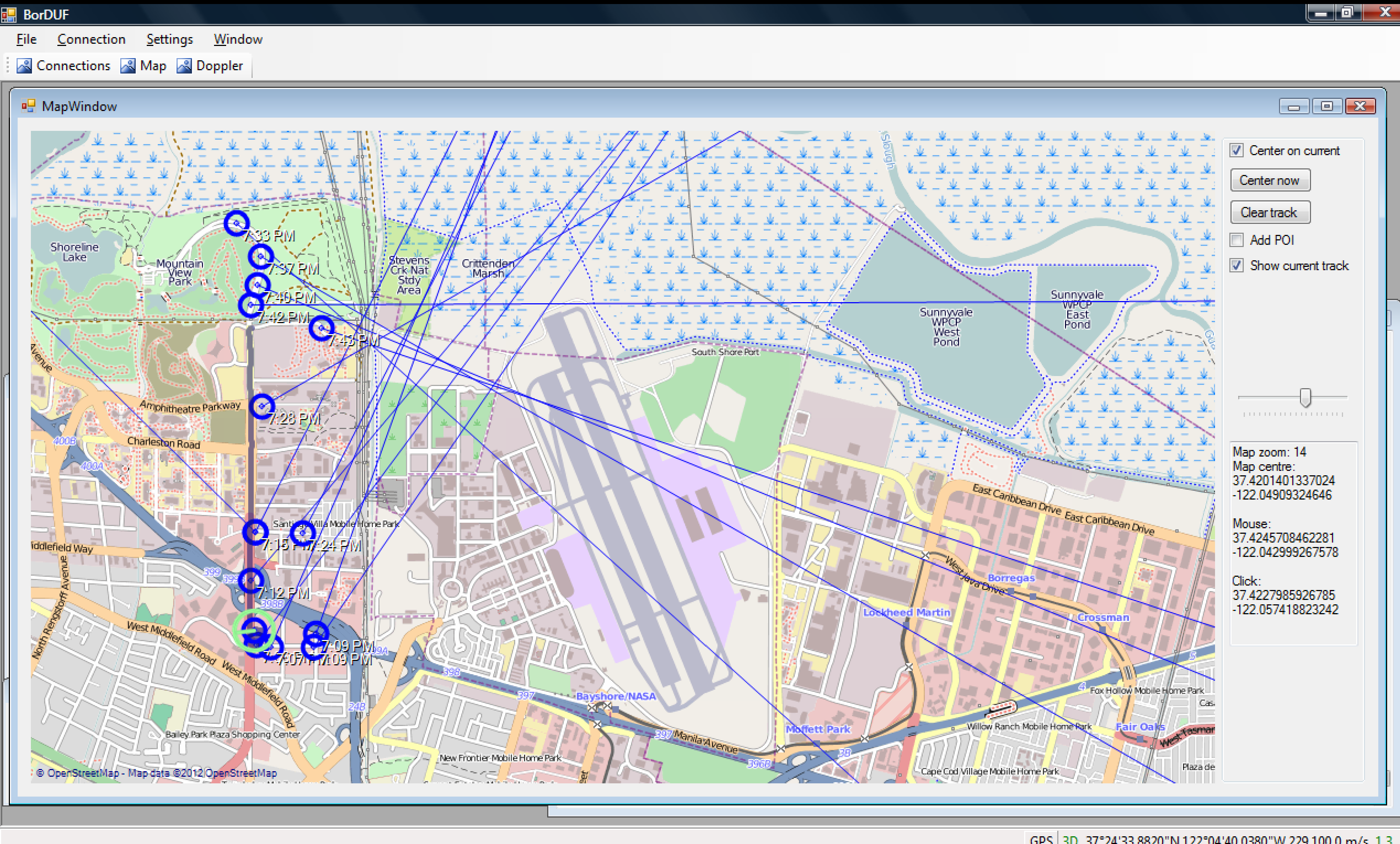
Done


BorDUF - [MapWindow]
File
Connection
Settings
Window
Connections
Map
Doppler
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 13
Map centre:
-33.9064681416332
151.270751953125
Mouse:
-33.9338180386977
151.268005371094
Click:
-33.9135913560992
151.326541900635
© OpenStreetMap - Map data ©2012 OpenStreetMap
GPS 3D 33°52'52.1220"S,151°14'44.1960"E 076.800 0 m/s 1.2

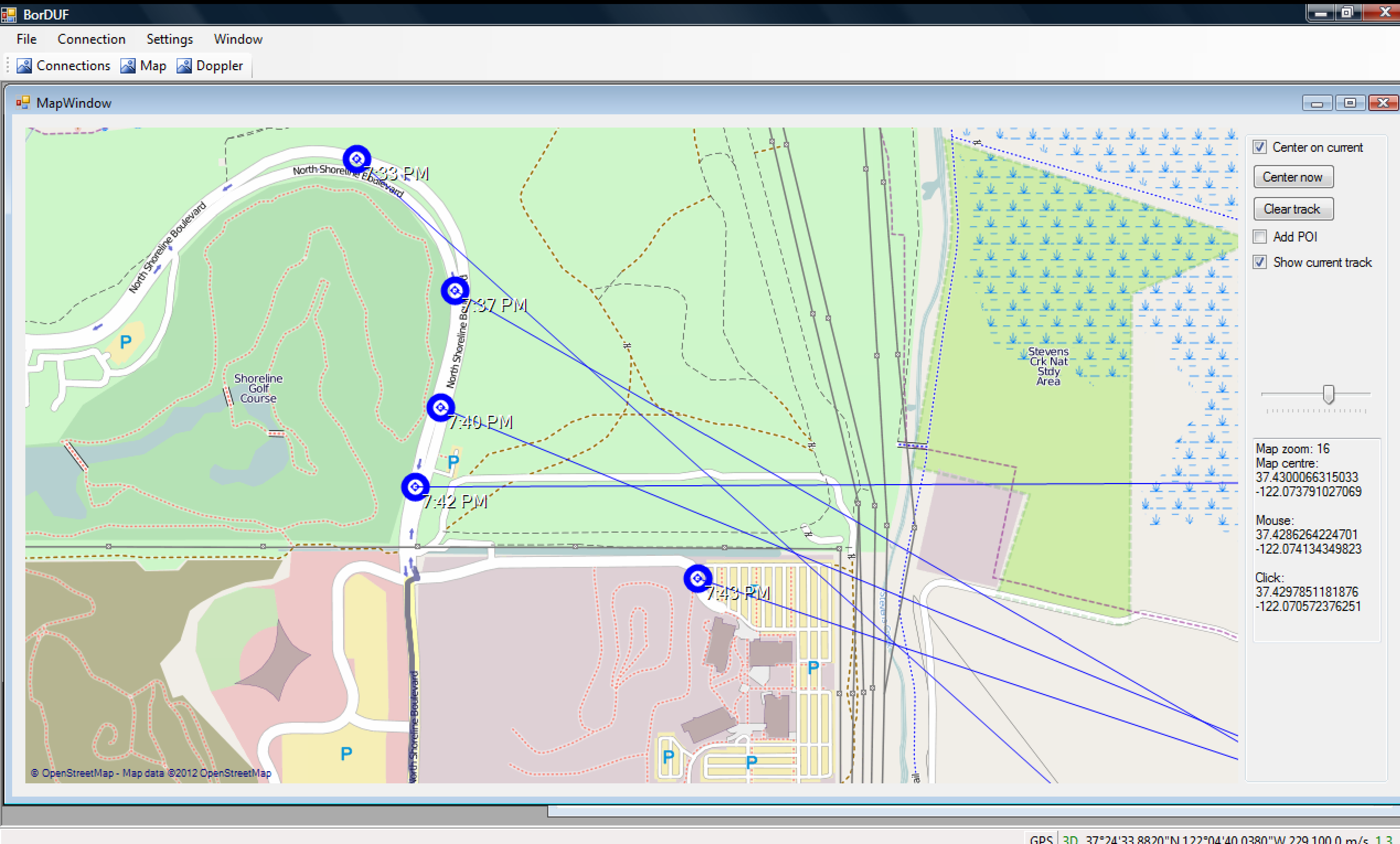
Closer to (my new) home

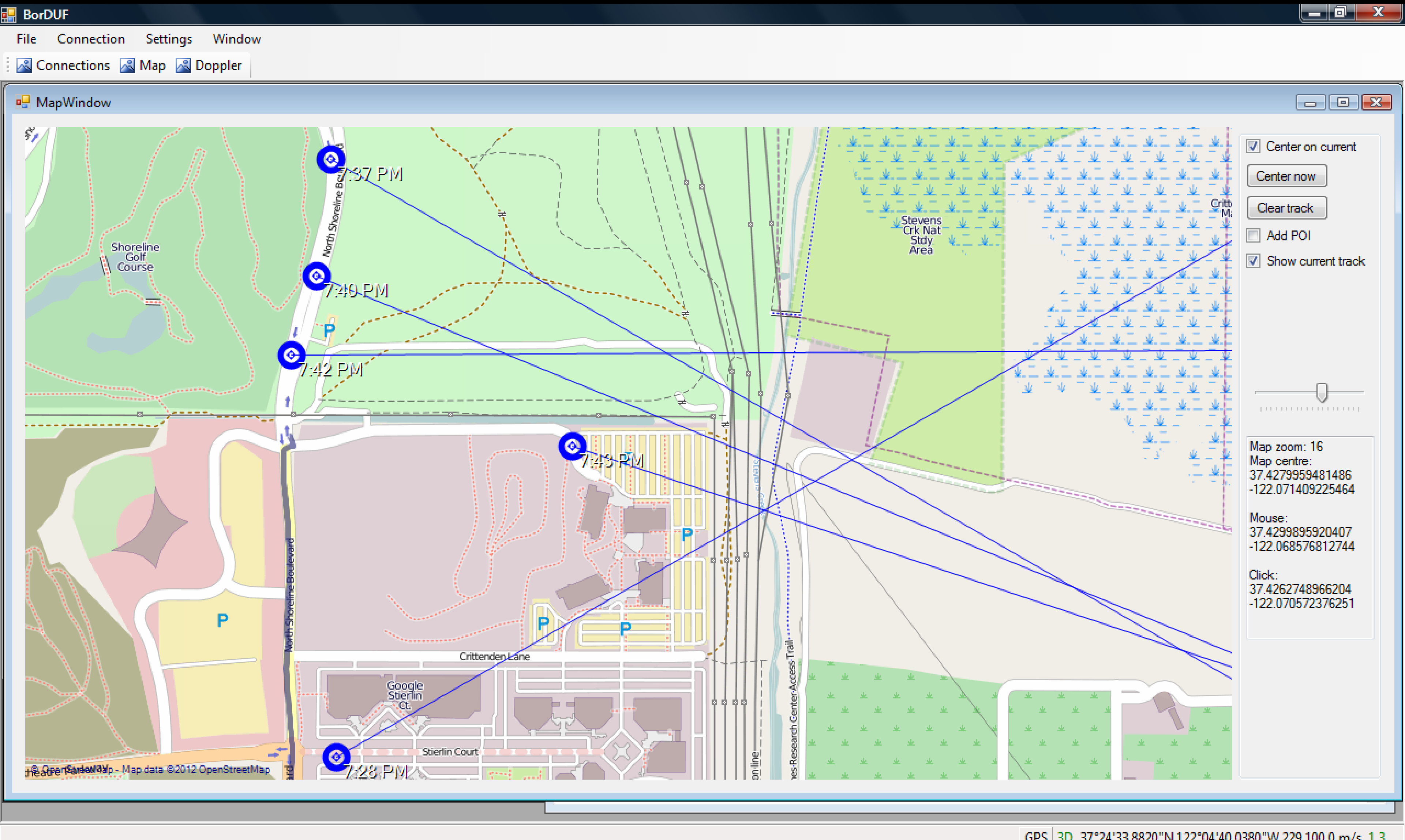



BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
Palo Alto
Embarcadero Road
Oregon Expressway
East Bayshore Road
Middlefield Road
El Camino Real
Alma Street
Palm Drive
CA 82
CR G3
CR G6
Fabian Way
Garcia Avenue
Charleston Road
Old Middlefield Way
Antonio Road
East Caribbean Drive
Guadalupe Slough
Guadalupe River
Center on current
Center now
Clear track
Add POI
Show current track
Doppler
N
NE
E
SE
S
SW
W
NW
Updates: 43
Strength: 40.4121494123098
Threshold: 35
Offset: -90
Manual
Reverse
DC: -80
Frequency: 0.000
Squelch
Phase
Strength
GPS
3D
37°25'50.7540"N,122°04'39.0180"W 197.400 0 m/s 1.1

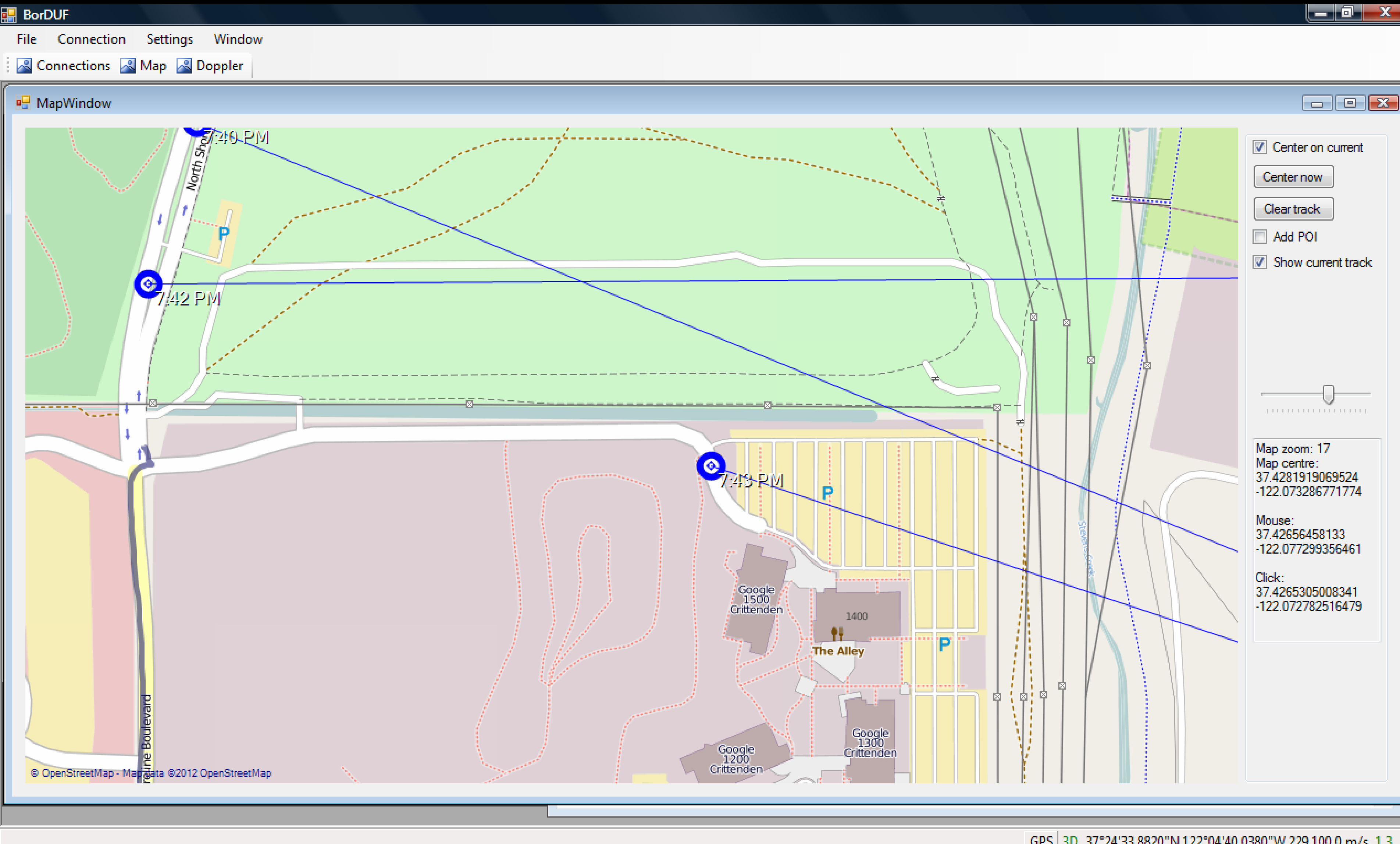


BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 14
Map centre:
37.4201401337024
-122.04909324646
Mouse:
37.4245708462281
-122.042999267578
Click:
37.4227985926785
-122.057418823242
Shoreline Lake
Mountain View Park
Stevens Crk Nat Stdy Area
Crittenden Marsh
Sunnyvale WPCP West Pond
Sunnyvale WPCP East Pond
South Shore Port
Amphitheatre Parkway
Charleston Road
Middlefield Way
West Middlefield Road
North Rengstorff Avenue
East Caribbean Drive
West Java Drive
Borregas
Lockheed Martin
Crossman
Bayshore/NASA
Manila Avenue
Moffett Park
Fair Oaks
West Tasman
Fox Hollow Mobile Home Park
Willow Ranch Mobile Home Park
Cape Cod Village Mobile Home Park
New Frontier Mobile Home Park
Bailey Park Plaza Shopping Center
7:33 PM
7:37 PM
7:40 PM
7:42 PM
7:28 PM
7:12 PM
7:09 PM
© OpenStreetMap - Map data ©2012 OpenStreetMap
GPS
3D
37°24'33.8820"N,122°04'40.0380"W 229.100 0 m/s 1.3


BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
North Shoreline Boulevard
7:33 PM
7:37 PM
7:40 PM
7:42 PM
7:45 PM
Shoreline Golf Course
Stevens Crk Nat Stdy Area
© OpenStreetMap - Map data ©2012 OpenStreetMap
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 16
Map centre:
37.4300066315033
-122.073791027069
Mouse:
37.4286264224701
-122.074134349823
Click:
37.4297851181876
-122.070572376251
GPS 3D 37°24'33.8820"N,122°04'40.0380"W 229.100 0 m/s 1.3



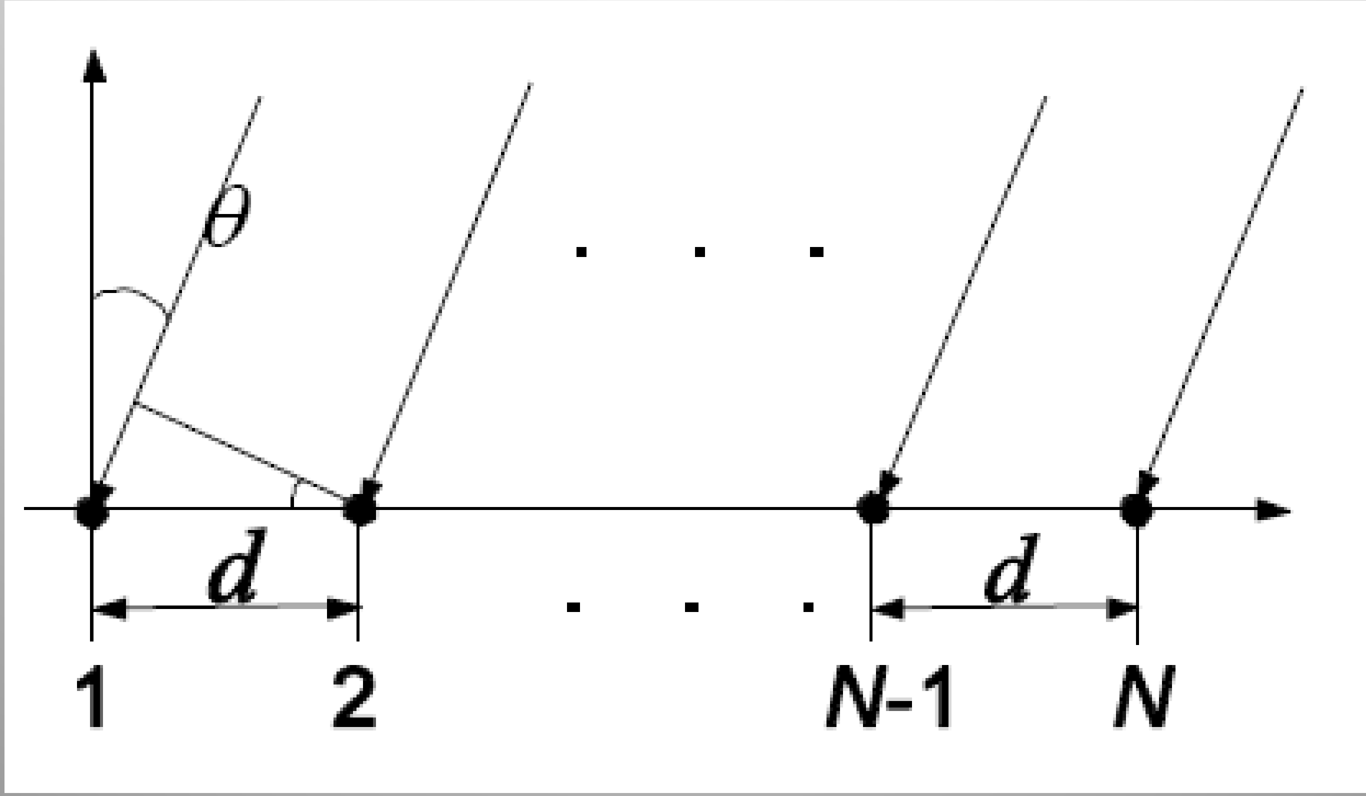
BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
7:37 PM
7:40 PM
7:42 PM
7:43 PM
7:28 PM
Shoreline Golf Course
North Shoreline Boulevard
Stevens Crk Nat Stdy Area
Crittenden Lane
Google Stierlin Ct.
Stierlin Court
© OpenStreetMap - Map data ©2012 OpenStreetMap
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 16
Map centre:
37.4279959481486
-122.071409225464
Mouse:
37.4299895920407
-122.068576812744
Click:
37.4262748966204
-122.070572376251
GPS 3D 37°24'33.8820"N,122°04'40.0380"W 229.100 0 m/s 1.3


BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
7:40 PM
7:42 PM
7:43 PM
North Shore
The Alley
Google 1500 Crittenden
1400
Google 1300 Crittenden
Google 1200 Crittenden
Charleston Boulevard
© OpenStreetMap - Mapdata ©2012 OpenStreetMap
Center on current
Center now
Clear track
Add POI
Show current track
Map zoom: 17
Map centre:
37.4281919069524
-122.073286771774
Mouse:
37.42656458133
-122.077299356461
Click:
37.4265305008341
-122.072782516479
GPS
3D
37°24'33.8820"N,122°04'40.0380"W 229.100 0 m/s
1.3

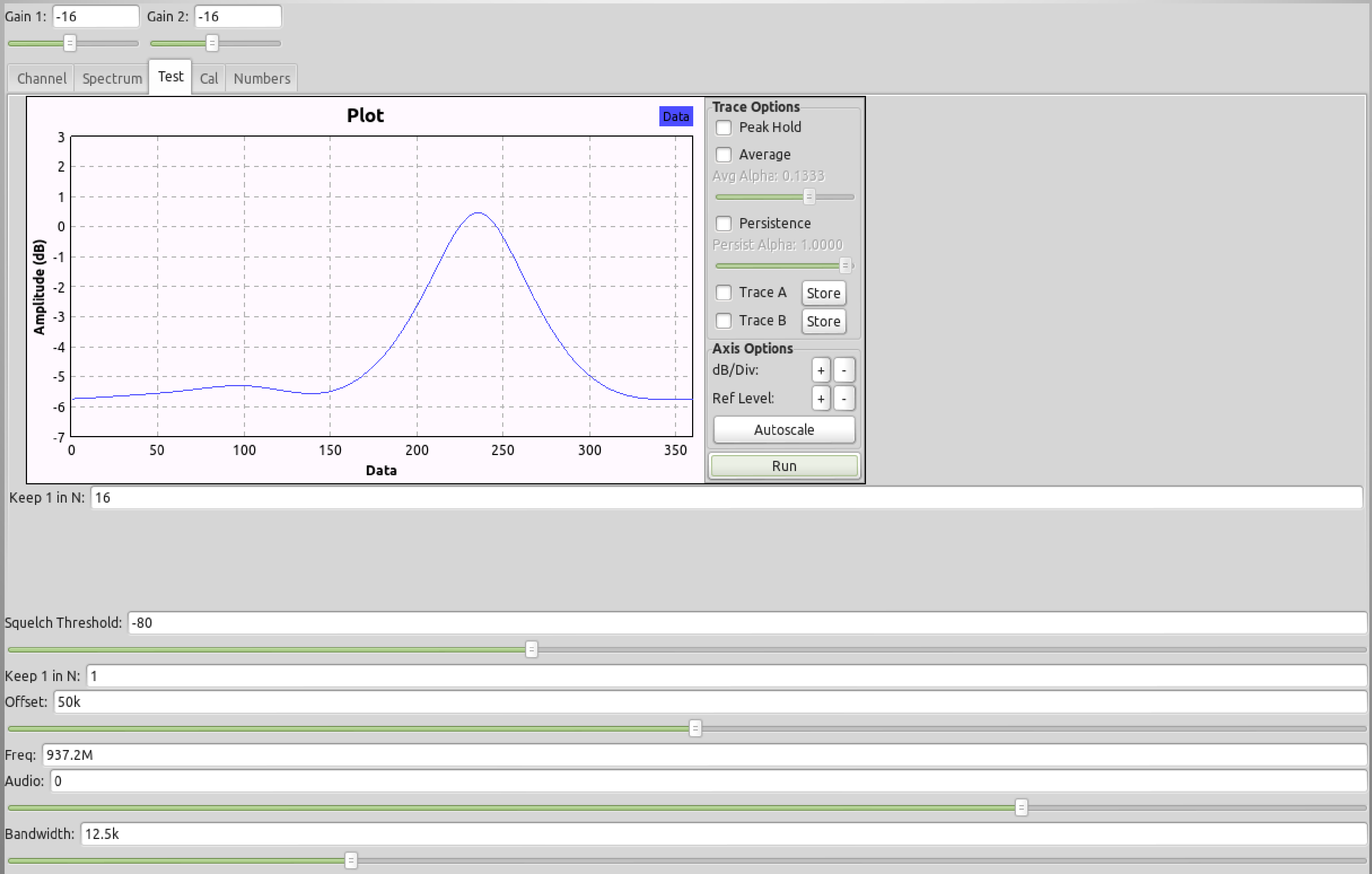
Method 2: Super-resolution algorithms

- Simultaneously receive multiple streams
  - One stream per antenna → antenna array
- Apply a mathematical model
  - Linear (far-field) wavefront approaching antenna array
  - Model/calibrate for antenna response
- MUSIC: **MU**ltiple **SI**gnal **C**lassification
  - Sample signal at each antenna (assuming sinusoids)
  - Maths (sample correlation matrix, eigenvector decomposition, orthogonal signal/noise subspaces)
  - Search through array response to find peak → DOA

Wavefront impinging on antenna array



Find maximal array response

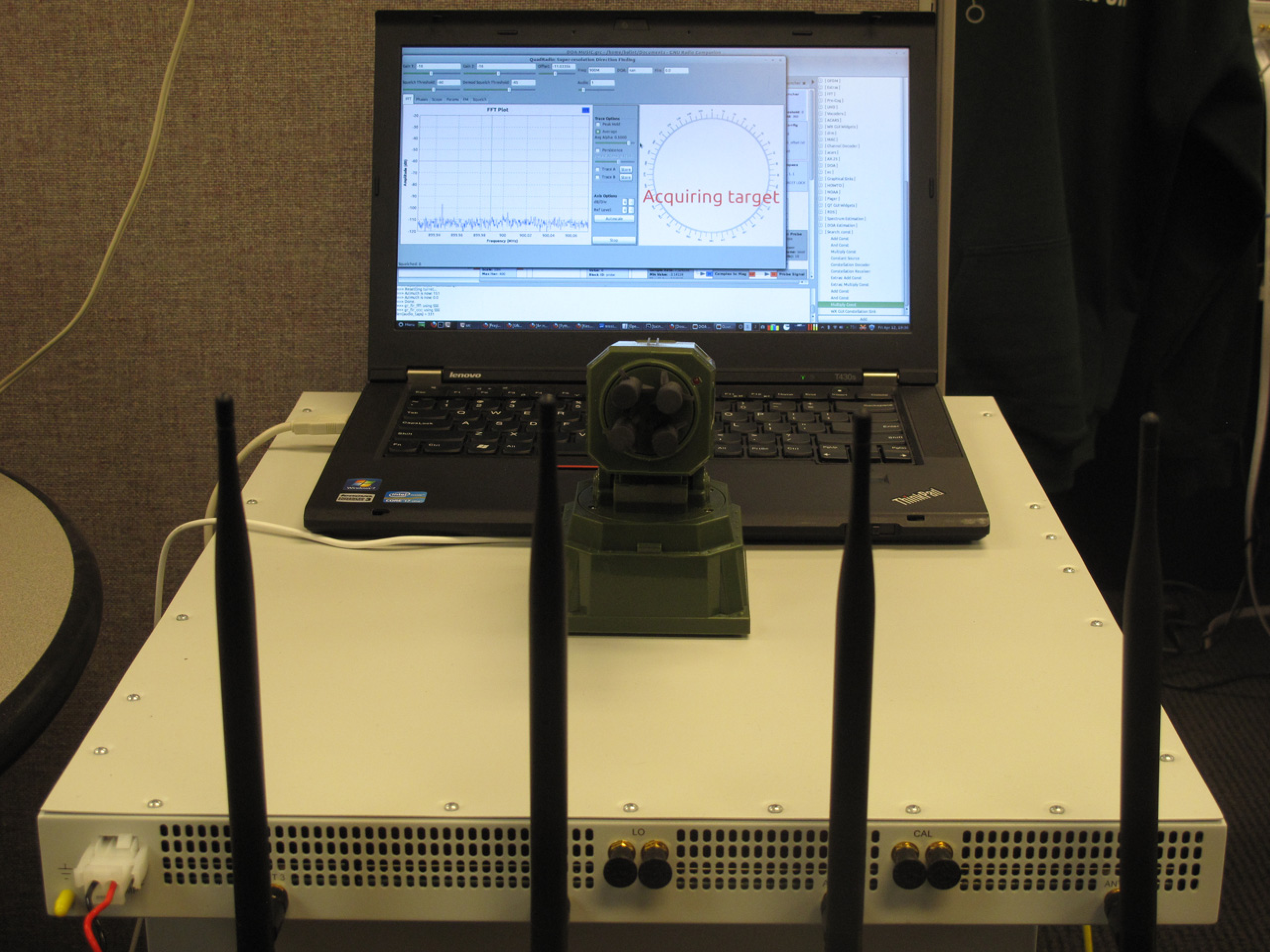


Advantages

- Much higher resolution
  - Assuming model is correct & system is calibrated
- Detect & process multiple signals of interest simultaneously!

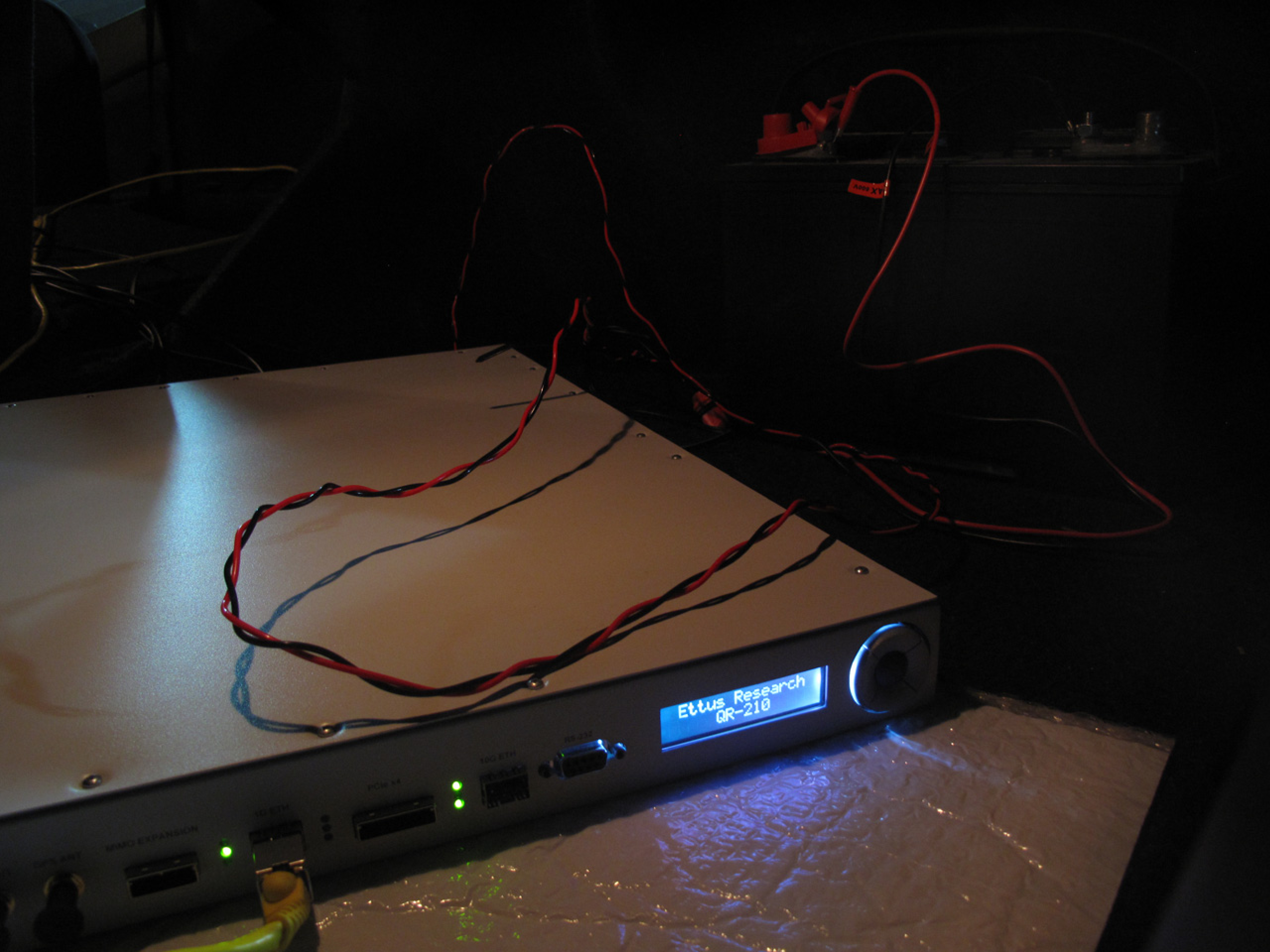
- However…

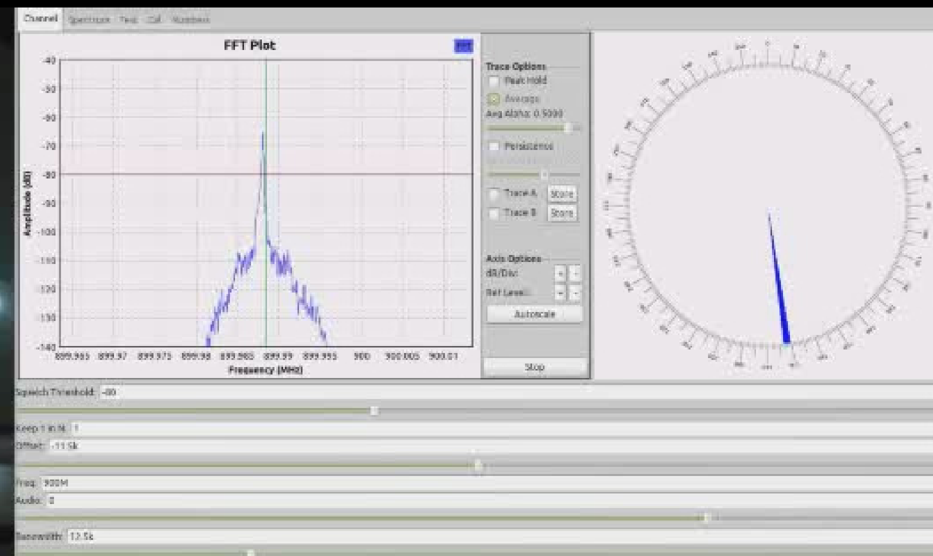
  you need more (coherent) radios.

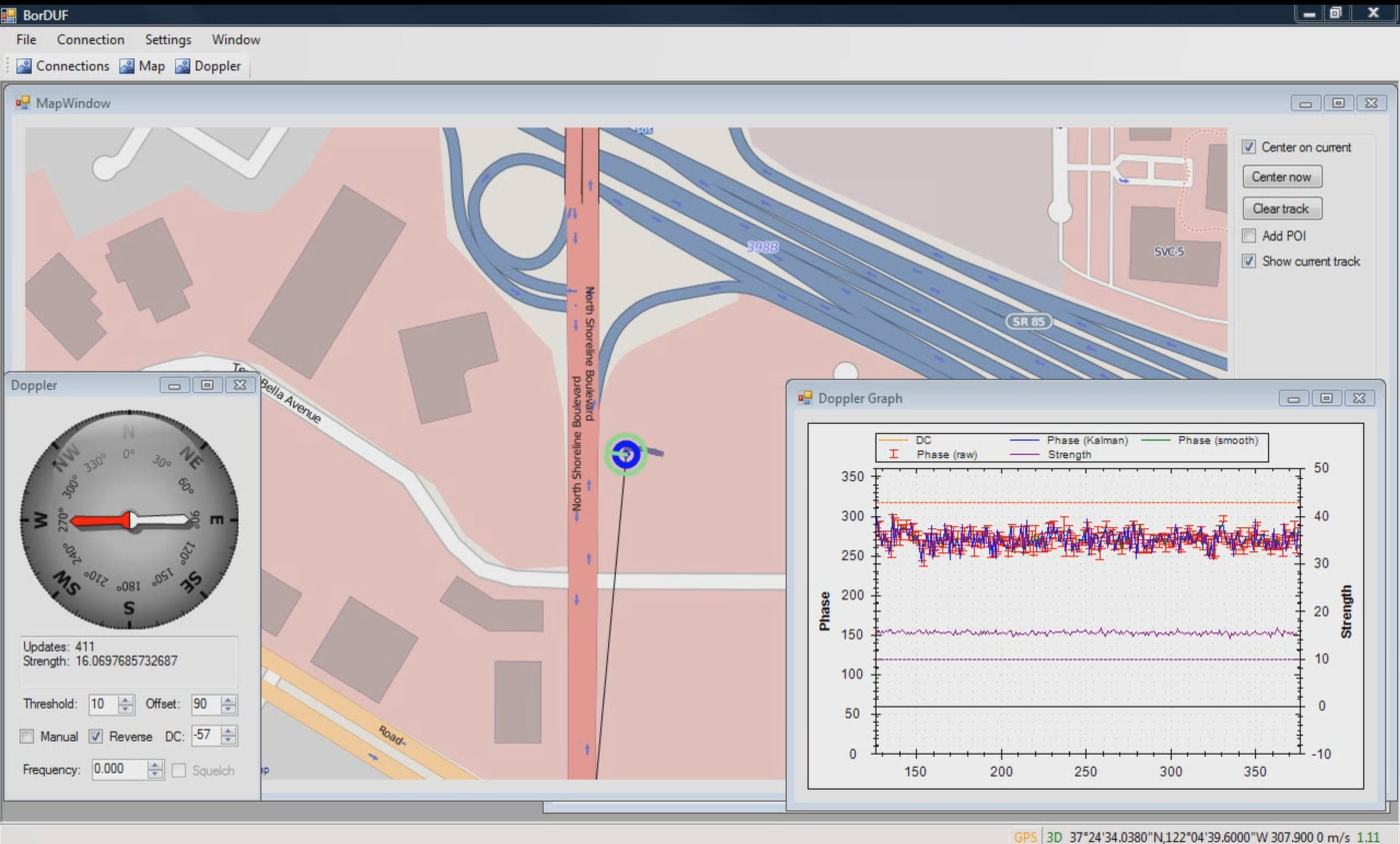

FFT Plot
Acquiring target
lenovo
T430s
ThinkPad
LO
CAL

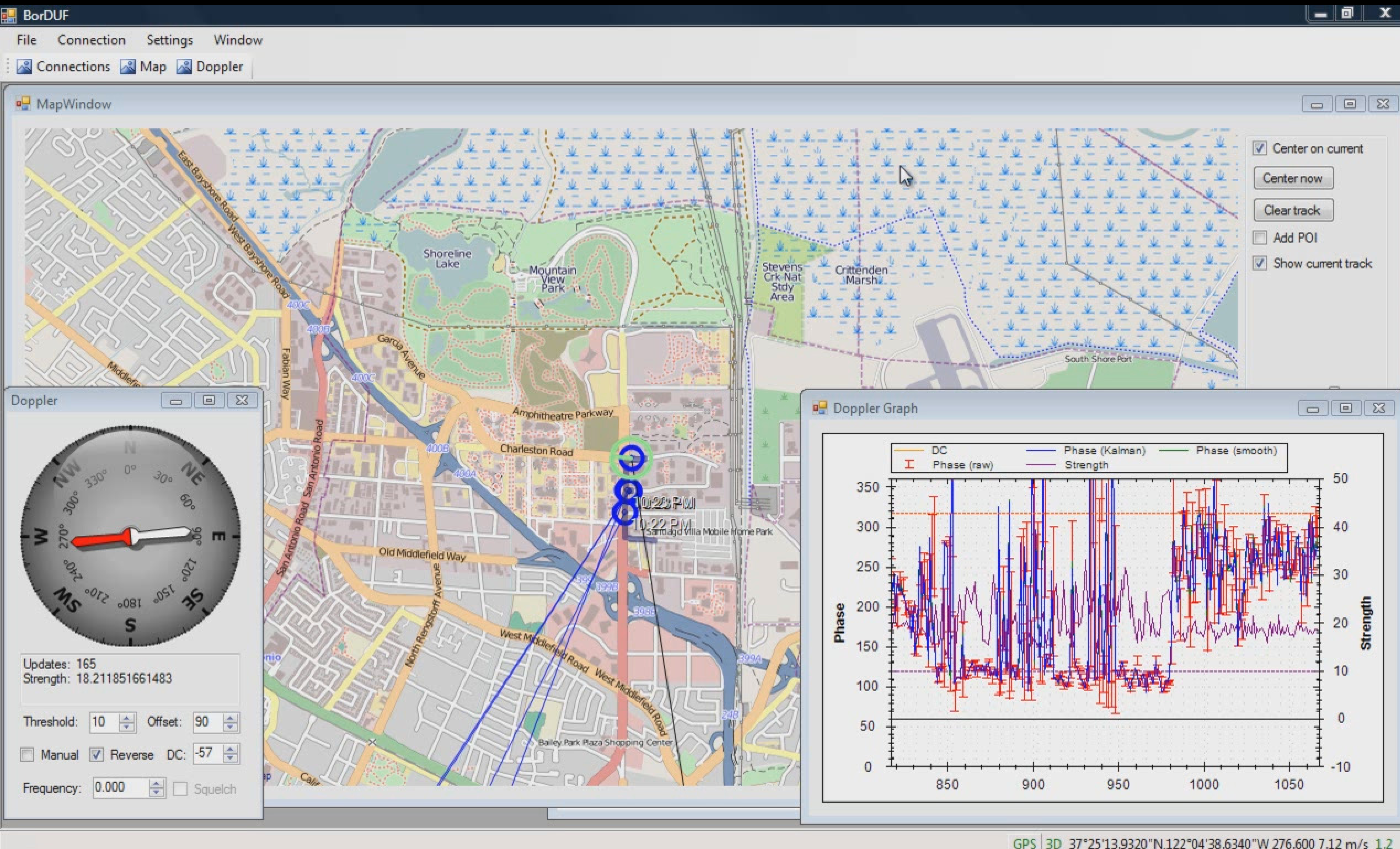

E LANE


Chess
moving


Ettus Research
QR-210

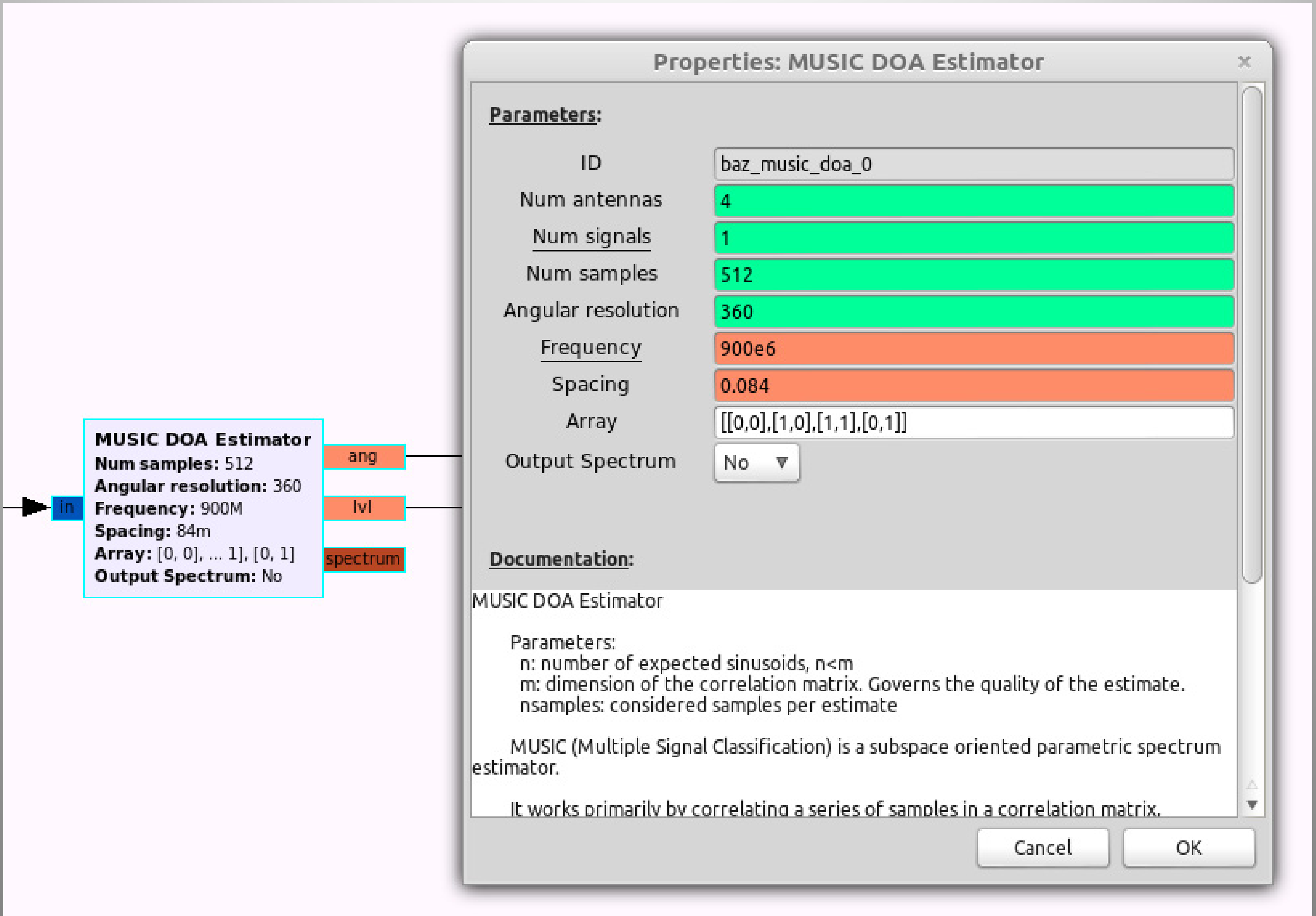

Channel
FFT Plot
Trace Options
Peak Hold
Average
Persistence
Trace A
Trace B
Store
Axis Options
dB/Div
Autoscale
Stop
Frequency (MHz)
Amplitude (dB)
Squelch Threshold:
Offset:
Freq:
Audio:
Bandwidth:


BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
Center on current
Center now
Clear track
Add POI
Show current track
North Shoreline Boulevard
Bella Avenue
398B
SVC-5
SR 85
Road
Doppler
N
NE
E
SE
S
SW
W
NW
Updates: 411
Strength: 16.0697685732687
Threshold: 10
Offset: 90
Manual
Reverse
DC: -57
Frequency: 0.000
Squelch
Doppler Graph
DC
Phase (Kalman)
Phase (smooth)
Phase (raw)
Strength
Phase
Strength
GPS 3D 37°24'34.0380"N,122°04'39.6000"W 307.900 0 m/s 1.11



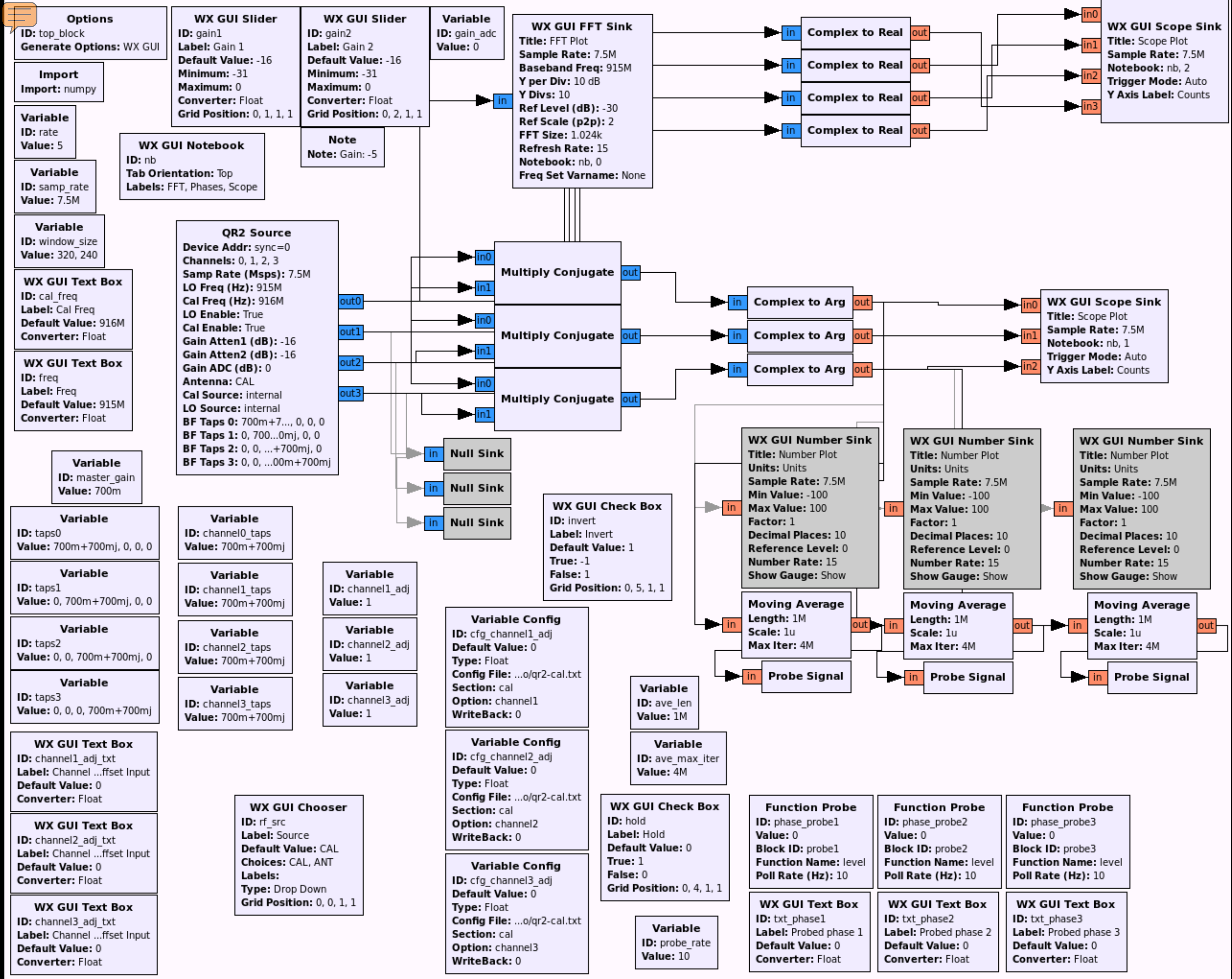
BorDUF
File
Connection
Settings
Window
Connections
Map
Doppler
MapWindow
Center on current
Center now
Clear track
Add POI
Show current track
Shoreline Lake
Mountain View Park
Stevens Crk Nat Stdy Area
Crittenden Marsh
South Shore Port
East Bayshore Road
West Bayshore Road
Garcia Avenue
Amphitheatre Parkway
Charleston Road
San Antonio Road
Fabian Way
Old Middlefield Way
North Rengstorff Avenue
West Middlefield Road
Santiago Villa Mobile Home Park
Bailey Park Plaza Shopping Center
Doppler
N
NE
E
SE
S
SW
W
NW
Updates: 165
Strength: 18.211851661483
Threshold:
10
Offset:
90
Manual
Reverse
DC:
-57
Frequency:
0.000
Squelch
Doppler Graph
DC
Phase (Kalman)
Phase (smooth)
Phase (raw)
Strength
Phase
Strength
GPS
3D
37°25'13.9320"N,122°04'38.6340"W 276.600 7.12 m/s 1.2

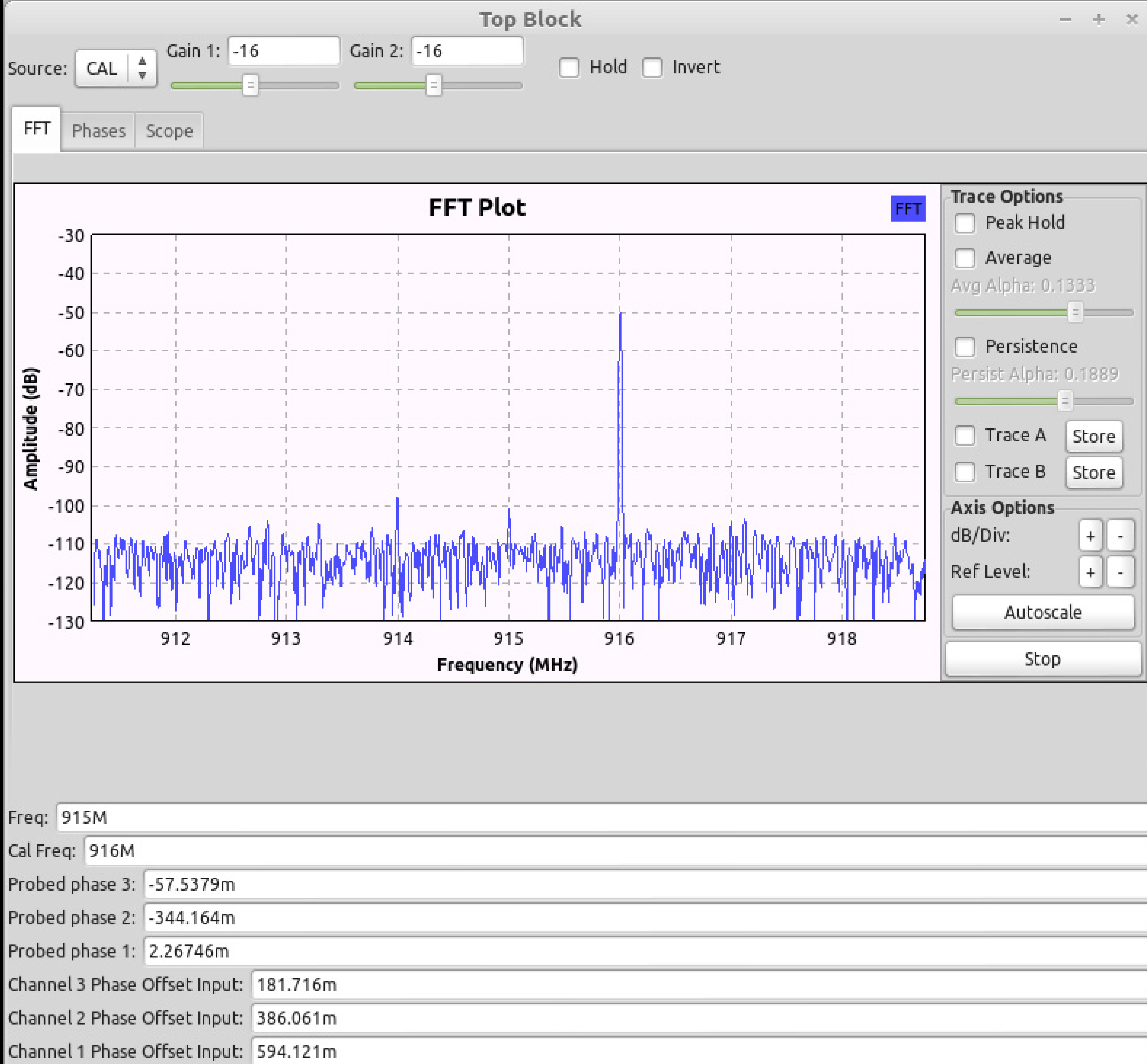
GNU Radio MUSIC DOA block

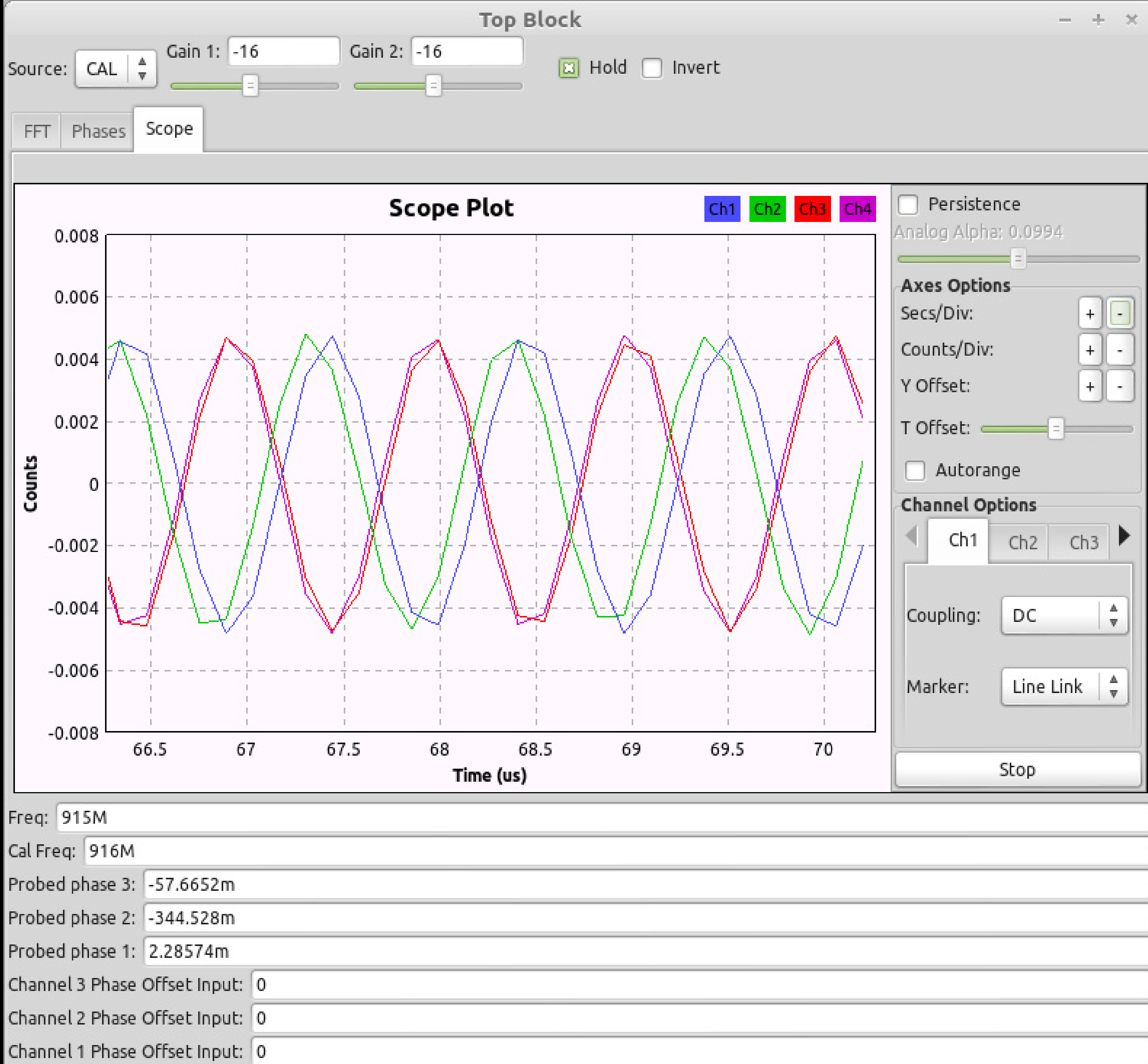


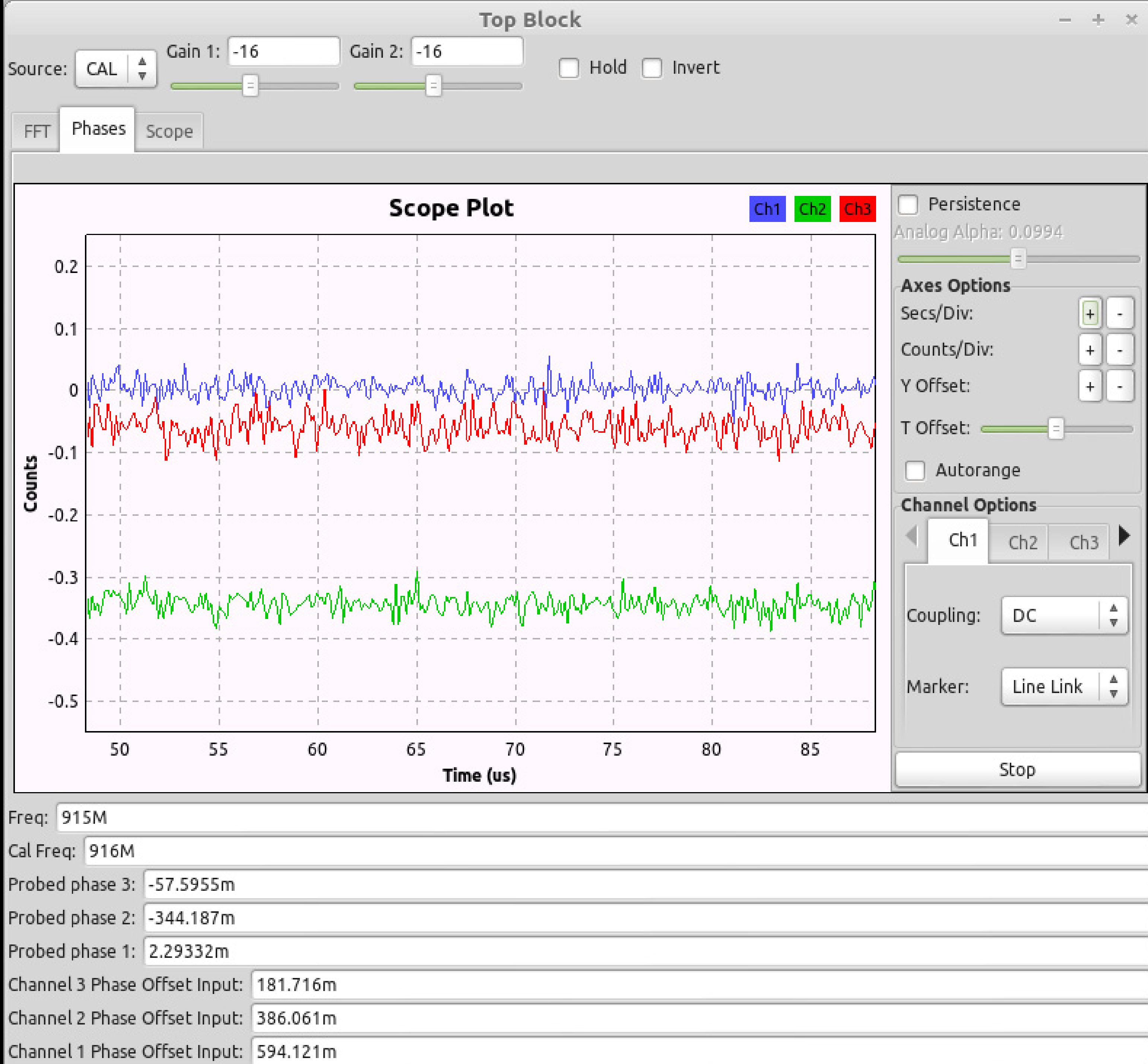
Calibration

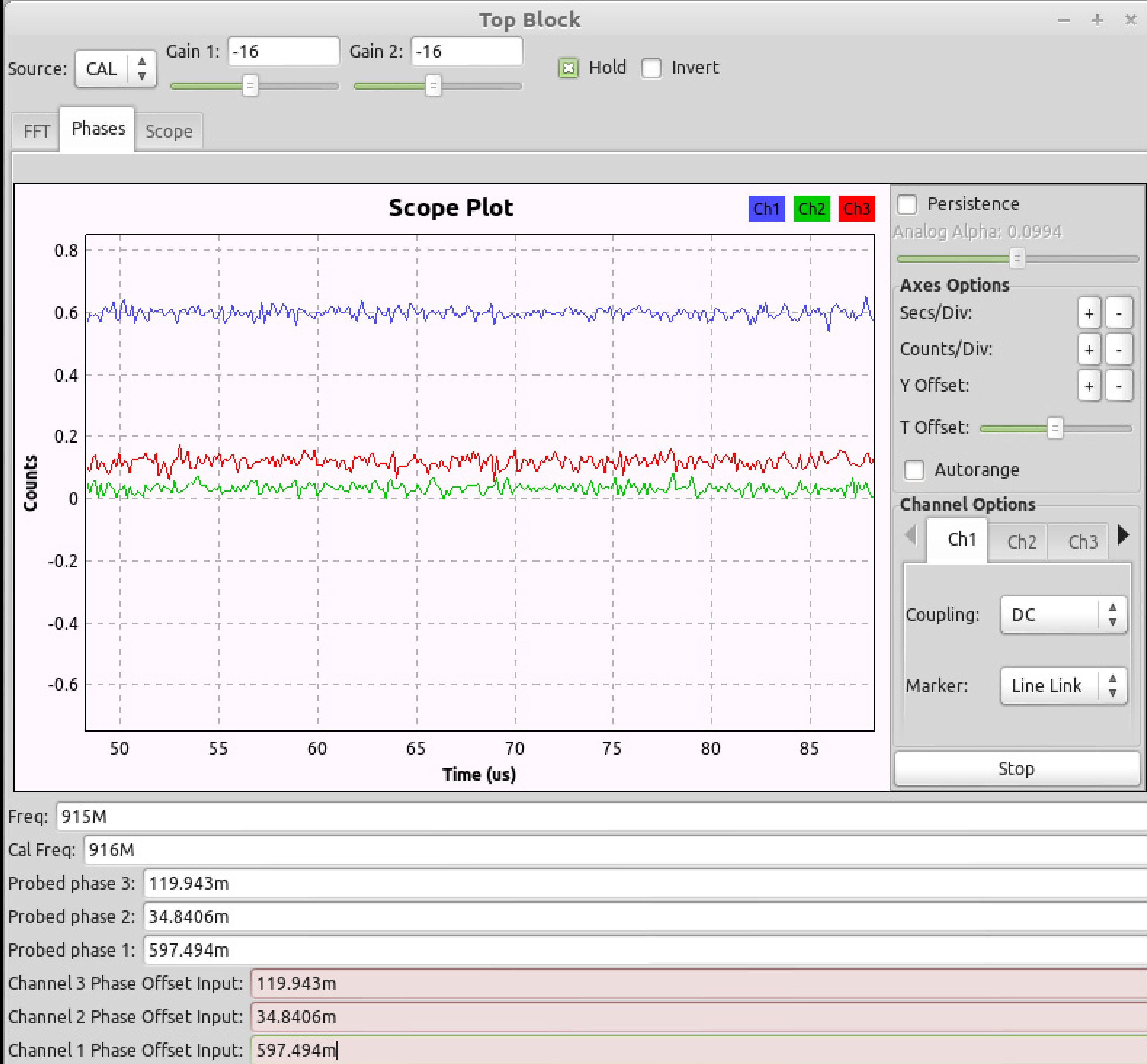
- Use shared Local Oscillator
- Inject shared tone in each channel
- Calculate per-channel phase differences
  - w. r. t. reference channel
- Apply corrections
- Periodically re-calibrate

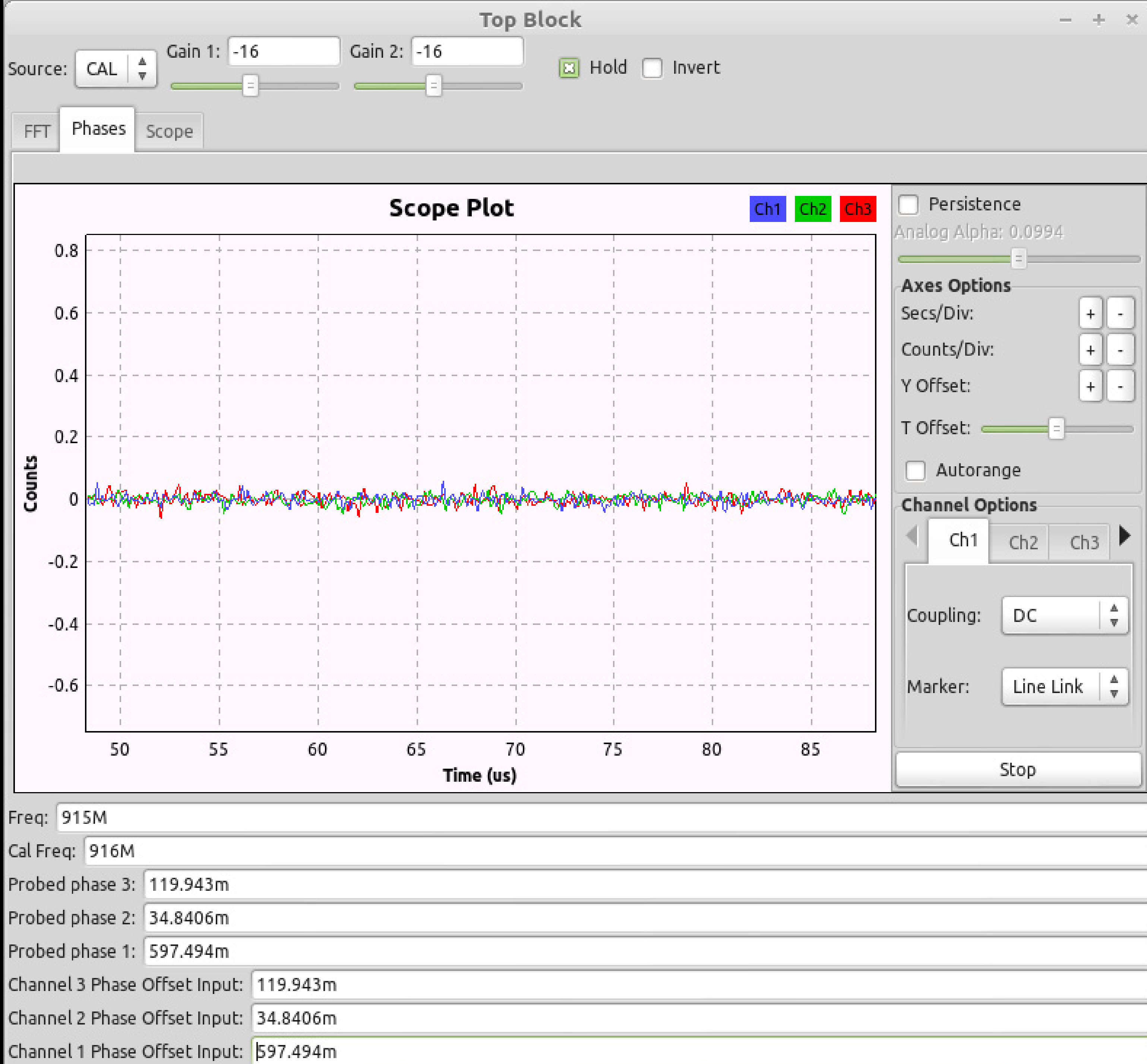

Options
ID: top_block
Generate Options: WX GUI
Import
Import: numpy
Variable
ID: rate
Value: 5
Variable
ID: samp_rate
Value: 7.5M
Variable
ID: window_size
Value: 320, 240
WX GUI Text Box
ID: cal_freq
Label: Cal Freq
Default Value: 916M
Converter: Float
WX GUI Text Box
ID: freq
Label: Freq
Default Value: 915M
Converter: Float
WX GUI Slider
ID: gain1
Label: Gain 1
Default Value: -16
Minimum: -31
Maximum: 0
Converter: Float
Grid Position: 0, 1, 1, 1
WX GUI Slider
ID: gain2
Label: Gain 2
Default Value: -16
Minimum: -31
Maximum: 0
Converter: Float
Grid Position: 0, 2, 1, 1
Variable
ID: gain_adc
Value: 0
Note
Note: Gain: -5
WX GUI Notebook
ID: nb
Tab Orientation: Top
Labels: FFT, Phases, Scope
WX GUI FFT Sink
Title: FFT Plot
Sample Rate: 7.5M
Baseband Freq: 915M
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): -30
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 15
Notebook: nb, 0
Freq Set Varname: None
in
Complex to Real
Complex to Real
Complex to Real
Complex to Real
in
out
WX GUI Scope Sink
Title: Scope Plot
Sample Rate: 7.5M
Notebook: nb, 2
Trigger Mode: Auto
Y Axis Label: Counts
in0
in1
in2
in3
QR2 Source
Device Addr: sync=0
Channels: 0, 1, 2, 3
Samp Rate (Msps): 7.5M
LO Freq (Hz): 915M
Cal Freq (Hz): 916M
LO Enable: True
Cal Enable: True
Gain Atten1 (dB): -16
Gain Atten2 (dB): -16
Gain ADC (dB): 0
Antenna: CAL
Cal Source: internal
LO Source: internal
BF Taps 0: 700m+7..., 0, 0, 0
BF Taps 1: 0, 700...0mj, 0, 0
BF Taps 2: 0, 0, ...+700mj, 0
BF Taps 3: 0, 0, ...00m+700mj
out0
out1
out2
out3
Multiply Conjugate
Multiply Conjugate
Multiply Conjugate
Complex to Arg
Complex to Arg
Complex to Arg
WX GUI Scope Sink
Title: Scope Plot
Sample Rate: 7.5M
Notebook: nb, 1
Trigger Mode: Auto
Y Axis Label: Counts
Null Sink
Null Sink
Null Sink
Variable
ID: master_gain
Value: 700m
Variable
ID: taps0
Value: 700m+700mj, 0, 0, 0
Variable
ID: taps1
Value: 0, 700m+700mj, 0, 0
Variable
ID: taps2
Value: 0, 0, 700m+700mj, 0
Variable
ID: taps3
Value: 0, 0, 0, 700m+700mj
Variable
ID: channel0_taps
Value: 700m+700mj
Variable
ID: channel1_taps
Value: 700m+700mj
Variable
ID: channel2_taps
Value: 700m+700mj
Variable
ID: channel3_taps
Value: 700m+700mj
Variable
ID: channel1_adj
Value: 1
Variable
ID: channel2_adj
Value: 1
Variable
ID: channel3_adj
Value: 1
WX GUI Check Box
ID: invert
Label: Invert
Default Value: 1
True: -1
False: 1
Grid Position: 0, 5, 1, 1
WX GUI Number Sink
Title: Number Plot
Units: Units
Sample Rate: 7.5M
Min Value: -100
Max Value: 100
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 15
Show Gauge: Show
Moving Average
Length: 1M
Scale: 1u
Max Iter: 4M
Probe Signal
Variable Config
ID: cfg_channel1_adj
Default Value: 0
Type: Float
Config File: ...o/qr2-cal.txt
Section: cal
Option: channel1
WriteBack: 0
Variable Config
ID: cfg_channel2_adj
Default Value: 0
Type: Float
Config File: ...o/qr2-cal.txt
Section: cal
Option: channel2
WriteBack: 0
Variable Config
ID: cfg_channel3_adj
Default Value: 0
Type: Float
Config File: ...o/qr2-cal.txt
Section: cal
Option: channel3
WriteBack: 0
Variable
ID: ave_len
Value: 1M
Variable
ID: ave_max_iter
Value: 4M
WX GUI Text Box
ID: channel1_adj_txt
Label: Channel ...ffset Input
Default Value: 0
Converter: Float
WX GUI Text Box
ID: channel2_adj_txt
Label: Channel ...ffset Input
Default Value: 0
Converter: Float
WX GUI Text Box
ID: channel3_adj_txt
Label: Channel ...ffset Input
Default Value: 0
Converter: Float
WX GUI Chooser
ID: rf_src
Label: Source
Default Value: CAL
Choices: CAL, ANT
Labels:
Type: Drop Down
Grid Position: 0, 0, 1, 1
WX GUI Check Box
ID: hold
Label: Hold
Default Value: 0
True: 1
False: 0
Grid Position: 0, 4, 1, 1
Variable
ID: probe_rate
Value: 10
Function Probe
ID: phase_probe1
Value: 0
Block ID: probe1
Function Name: level
Poll Rate (Hz): 10
Function Probe
ID: phase_probe2
Value: 0
Block ID: probe2
Function Name: level
Poll Rate (Hz): 10
Function Probe
ID: phase_probe3
Value: 0
Block ID: probe3
Function Name: level
Poll Rate (Hz): 10
WX GUI Text Box
ID: txt_phase1
Label: Probed phase 1
Default Value: 0
Converter: Float
WX GUI Text Box
ID: txt_phase2
Label: Probed phase 2
Default Value: 0
Converter: Float
WX GUI Text Box
ID: txt_phase3
Label: Probed phase 3
Default Value: 0
Converter: Float

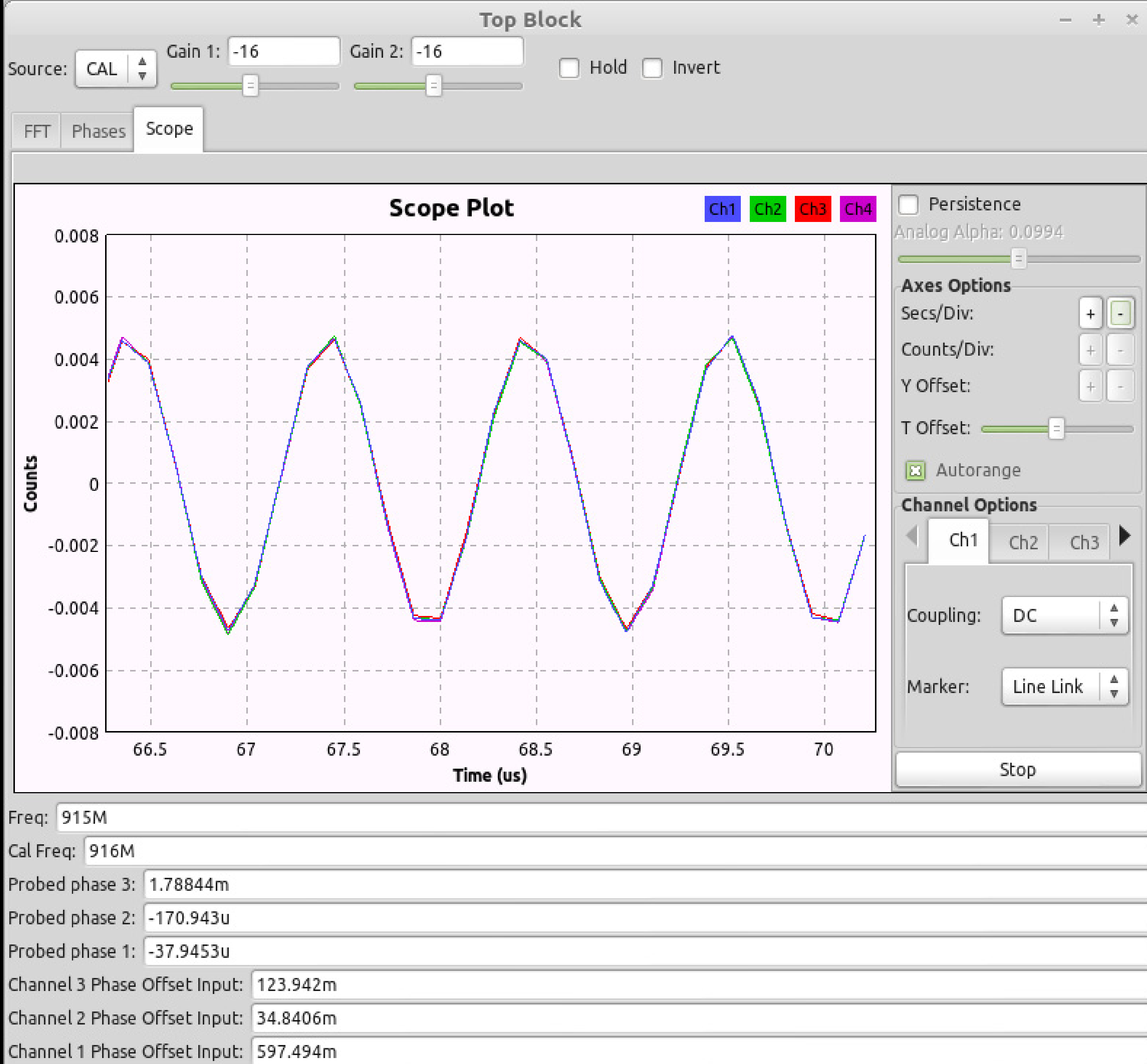

Top Block
Source: CAL
Gain 1: -16
Gain 2: -16
Hold
Invert
FFT
Phases
Scope
FFT Plot
FFT
Amplitude (dB)
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
912
913
914
915
916
917
918
Frequency (MHz)
Trace Options
Peak Hold
Average
Avg Alpha: 0.1333
Persistence
Persist Alpha: 0.1889
Trace A
Store
Trace B
Store
Axis Options
dB/Div:
Ref Level:
Autoscale
Stop
Freq: 915M
Cal Freq: 916M
Probed phase 3: -57.5379m
Probed phase 2: -344.164m
Probed phase 1: 2.26746m
Channel 3 Phase Offset Input: 181.716m
Channel 2 Phase Offset Input: 386.061m
Channel 1 Phase Offset Input: 594.121m

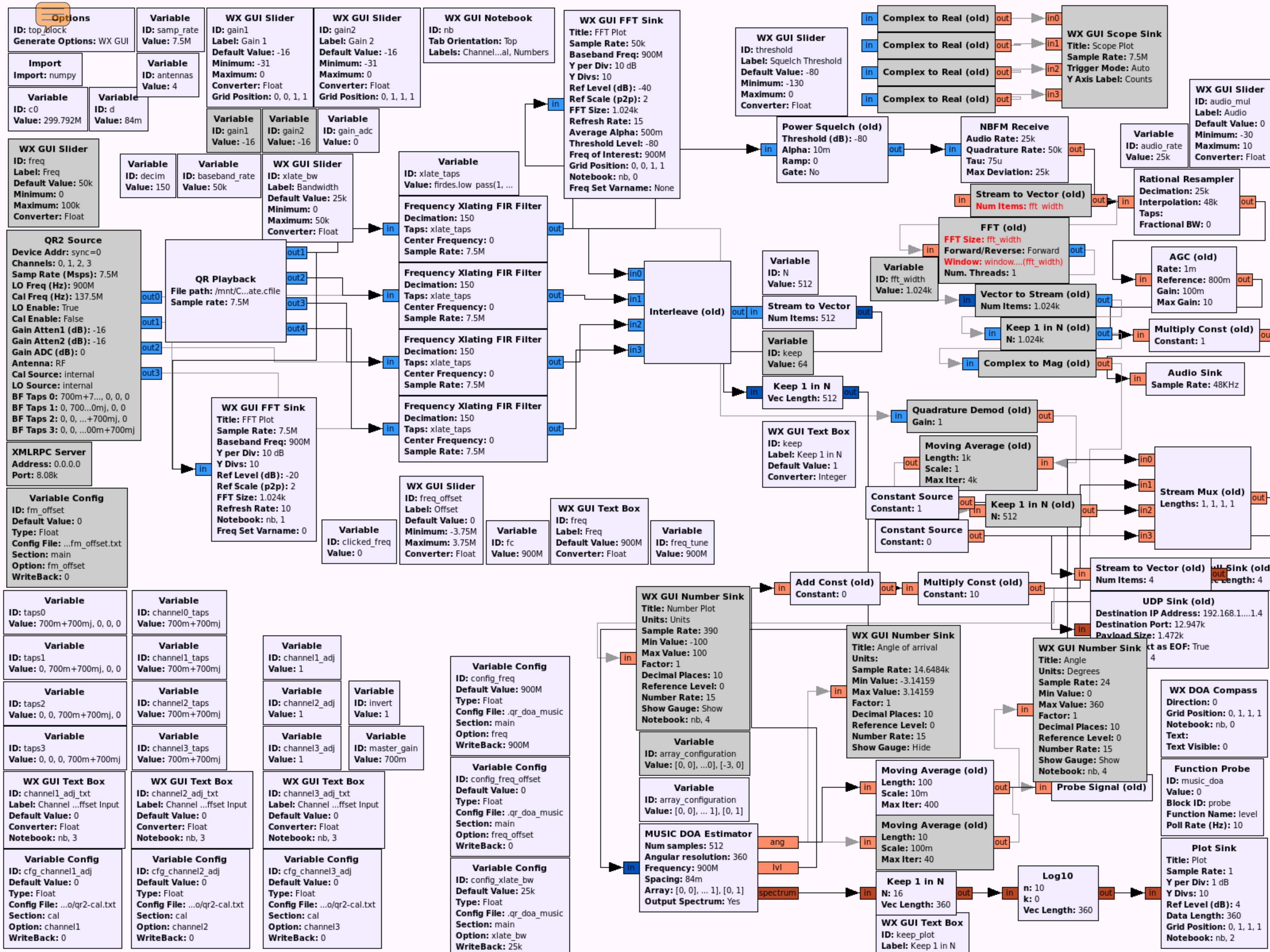

Top Block
Source: CAL
Gain 1: -16
Gain 2: -16
Hold
Invert
FFT
Phases
Scope
Scope Plot
Ch1
Ch2
Ch3
Ch4
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
Counts
66.5
67
67.5
68
68.5
69
69.5
70
Time (us)
Persistence
Analog Alpha: 0.0994
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
Autorange
Channel Options
Ch1
Ch2
Ch3
Coupling:
DC
Marker:
Line Link
Stop
Freq: 915M
Cal Freq: 916M
Probed phase 3: -57.6652m
Probed phase 2: -344.528m
Probed phase 1: 2.28574m
Channel 3 Phase Offset Input: 0
Channel 2 Phase Offset Input: 0
Channel 1 Phase Offset Input: 0

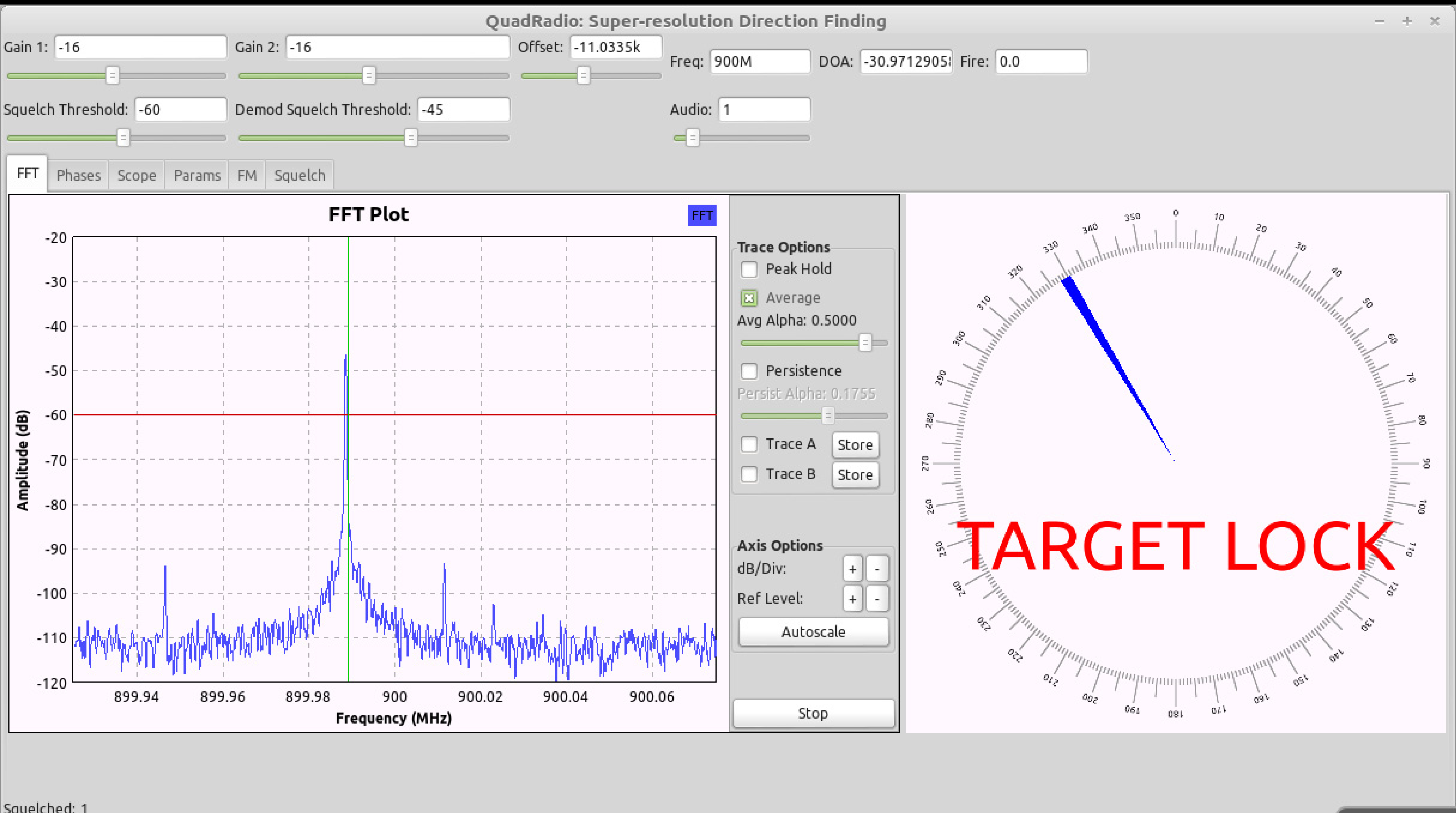

Top Block
Source: CAL
Gain 1: -16
Gain 2: -16
Hold
Invert
FFT
Phases
Scope
Scope Plot
Ch1
Ch2
Ch3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
Counts
50
55
60
65
70
75
80
85
Time (us)
Persistence
Analog Alpha: 0.0994
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
Autorange
Channel Options
Ch1
Ch2
Ch3
Coupling: DC
Marker: Line Link
Stop
Freq: 915M
Cal Freq: 916M
Probed phase 3: -57.5955m
Probed phase 2: -344.187m
Probed phase 1: 2.29332m
Channel 3 Phase Offset Input: 181.716m
Channel 2 Phase Offset Input: 386.061m
Channel 1 Phase Offset Input: 594.121m


Top Block
Source: CAL
Gain 1: -16
Gain 2: -16
Hold
Invert
FFT
Phases
Scope
Scope Plot
Ch1
Ch2
Ch3
Counts
Time (us)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
50
55
60
65
70
75
80
85
Persistence
Analog Alpha: 0.0994
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
Autorange
Channel Options
Coupling: DC
Marker: Line Link
Stop
Freq: 915M
Cal Freq: 916M
Probed phase 3: 119.943m
Probed phase 2: 34.8406m
Probed phase 1: 597.494m
Channel 3 Phase Offset Input: 119.943m
Channel 2 Phase Offset Input: 34.8406m
Channel 1 Phase Offset Input: 597.494m


Top Block
Source: CAL
Gain 1: -16
Gain 2: -16
Hold
Invert
FFT
Phases
Scope
Scope Plot
Ch1
Ch2
Ch3
Counts
Time (us)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
50
55
60
65
70
75
80
85
Persistence
Analog Alpha: 0.0994
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
Autorange
Channel Options
Ch1
Ch2
Ch3
Coupling: DC
Marker: Line Link
Stop
Freq: 915M
Cal Freq: 916M
Probed phase 3: 119.943m
Probed phase 2: 34.8406m
Probed phase 1: 597.494m
Channel 3 Phase Offset Input: 119.943m
Channel 2 Phase Offset Input: 34.8406m
Channel 1 Phase Offset Input: 597.494m


Top Block
Source:
CAL
Gain 1:
-16
Gain 2:
-16
Hold
Invert
FFT
Phases
Scope
Scope Plot
Ch1
Ch2
Ch3
Ch4
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
Counts
66.5
67
67.5
68
68.5
69
69.5
70
Time (us)
Persistence
Analog Alpha: 0.0994
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
Autorange
Channel Options
Ch1
Ch2
Ch3
Coupling:
DC
Marker:
Line Link
Stop
Freq:
915M
Cal Freq:
916M
Probed phase 3:
1.78844m
Probed phase 2:
-170.943u
Probed phase 1:
-37.9453u
Channel 3 Phase Offset Input:
123.942m
Channel 2 Phase Offset Input:
34.8406m
Channel 1 Phase Offset Input:
597.494m


Options
ID: top_block
Generate Options: WX GUI
Variable
ID: samp_rate
Value: 7.5M
WX GUI Slider
ID: gain1
Label: Gain 1
Default Value: -16
Minimum: -31
Maximum: 0
Converter: Float
Grid Position: 0, 0, 1, 1
WX GUI Slider
ID: gain2
Label: Gain 2
Default Value: -16
Minimum: -31
Maximum: 0
Converter: Float
Grid Position: 0, 1, 1, 1
WX GUI Notebook
ID: nb
Tab Orientation: Top
Labels: Channel...al, Numbers
WX GUI FFT Sink
Title: FFT Plot
Sample Rate: 50k
Baseband Freq: 900M
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): -40
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 15
Average Alpha: 500m
Threshold Level: -80
Freq of Interest: 900M
Grid Position: 0, 0, 1, 1
Notebook: nb, 0
Freq Set Varname: None
WX GUI Slider
ID: threshold
Label: Squelch Threshold
Default Value: -80
Minimum: -130
Maximum: 0
Converter: Float
Complex to Real (old)
Complex to Real (old)
Complex to Real (old)
Complex to Real (old)
WX GUI Scope Sink
Title: Scope Plot
Sample Rate: 7.5M
Trigger Mode: Auto
Y Axis Label: Counts
Import
Import: numpy
Variable
ID: antennas
Value: 4
Variable
ID: c0
Value: 299.792M
Variable
ID: d
Value: 84m
Variable
ID: gain1
Value: -16
Variable
ID: gain2
Value: -16
Variable
ID: gain_adc
Value: 0
WX GUI Slider
ID: audio_mul
Label: Audio
Default Value: 0
Minimum: -30
Maximum: 10
Converter: Float
Power Squelch (old)
Threshold (dB): -80
Alpha: 10m
Ramp: 0
Gate: No
NBFM Receive
Audio Rate: 25k
Quadrature Rate: 50k
Tau: 75u
Max Deviation: 25k
Variable
ID: audio_rate
Value: 25k
WX GUI Slider
ID: freq
Label: Freq
Default Value: 50k
Minimum: 0
Maximum: 100k
Converter: Float
Variable
ID: decim
Value: 150
Variable
ID: baseband_rate
Value: 50k
WX GUI Slider
ID: xlate_bw
Label: Bandwidth
Default Value: 25k
Minimum: 0
Maximum: 50k
Converter: Float
Variable
ID: xlate_taps
Value: firdes.low_pass(1, ...
Stream to Vector (old)
Num Items: fft_width
Rational Resampler
Decimation: 25k
Interpolation: 48k
Taps:
Fractional BW: 0
QR2 Source
Device Addr: sync=0
Channels: 0, 1, 2, 3
Samp Rate (Msps): 7.5M
LO Freq (Hz): 900M
Cal Freq (Hz): 137.5M
LO Enable: True
Cal Enable: False
Gain Atten1 (dB): -16
Gain Atten2 (dB): -16
Gain ADC (dB): 0
Antenna: RF
Cal Source: internal
LO Source: internal
BF Taps 0: 700m+7..., 0, 0, 0
BF Taps 1: 0, 700...0mj, 0, 0
BF Taps 2: 0, 0, ...+700mj, 0
BF Taps 3: 0, 0, ...00m+700mj
QR Playback
File path: /mnt/C...ate.cfile
Sample rate: 7.5M
Frequency Xlating FIR Filter
Decimation: 150
Taps: xlate_taps
Center Frequency: 0
Sample Rate: 7.5M
Frequency Xlating FIR Filter
Decimation: 150
Taps: xlate_taps
Center Frequency: 0
Sample Rate: 7.5M
Frequency Xlating FIR Filter
Decimation: 150
Taps: xlate_taps
Center Frequency: 0
Sample Rate: 7.5M
Frequency Xlating FIR Filter
Decimation: 150
Taps: xlate_taps
Center Frequency: 0
Sample Rate: 7.5M
FFT (old)
FFT Size: fft_width
Forward/Reverse: Forward
Window: window....(fft_width)
Num. Threads: 1
Variable
ID: fft_width
Value: 1.024k
AGC (old)
Rate: 1m
Reference: 800m
Gain: 100m
Max Gain: 10
Interleave (old)
Variable
ID: N
Value: 512
Stream to Vector
Num Items: 512
Vector to Stream (old)
Num Items: 1.024k
Keep 1 in N (old)
N: 1.024k
Multiply Const (old)
Constant: 1
Variable
ID: keep
Value: 64
Complex to Mag (old)
Audio Sink
Sample Rate: 48KHz
Keep 1 in N
Vec Length: 512
Quadrature Demod (old)
Gain: 1
WX GUI FFT Sink
Title: FFT Plot
Sample Rate: 7.5M
Baseband Freq: 900M
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): -20
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 10
Notebook: nb, 1
Freq Set Varname: 0
XMLRPC Server
Address: 0.0.0.0
Port: 8.08k
WX GUI Text Box
ID: keep
Label: Keep 1 in N
Default Value: 1
Converter: Integer
Moving Average (old)
Length: 1k
Scale: 1
Max Iter: 4k
Stream Mux (old)
Lengths: 1, 1, 1, 1
Variable Config
ID: fm_offset
Default Value: 0
Type: Float
Config File: ...fm_offset.txt
Section: main
Option: fm_offset
WriteBack: 0
WX GUI Slider
ID: freq_offset
Label: Offset
Default Value: 0
Minimum: -3.75M
Maximum: 3.75M
Converter: Float
Variable
ID: clicked_freq
Value: 0
Variable
ID: fc
Value: 900M
WX GUI Text Box
ID: freq
Label: Freq
Default Value: 900M
Converter: Float
Variable
ID: freq_tune
Value: 900M
Constant Source
Constant: 1
Keep 1 in N (old)
N: 512
Constant Source
Constant: 0
Stream to Vector (old)
Num Items: 4
Add Const (old)
Constant: 0
Multiply Const (old)
Constant: 10
UDP Sink (old)
Destination IP Address: 192.168.1....1.4
Destination Port: 12.947k
Payload Size: 1.472k
WX GUI Number Sink
Title: Number Plot
Units: Units
Sample Rate: 390
Min Value: -100
Max Value: 100
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 15
Show Gauge: Show
Notebook: nb, 4
Variable
ID: taps0
Value: 700m+700mj, 0, 0, 0
Variable
ID: channel0_taps
Value: 700m+700mj
Variable
ID: taps1
Value: 0, 700m+700mj, 0, 0
Variable
ID: channel1_taps
Value: 700m+700mj
Variable
ID: channel1_adj
Value: 1
Variable Config
ID: config_freq
Default Value: 900M
Type: Float
Config File: .qr_doa_music
Section: main
Option: freq
WriteBack: 900M
WX GUI Number Sink
Title: Angle of arrival
Units:
Sample Rate: 14.6484k
Min Value: -3.14159
Max Value: 3.14159
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 15
Show Gauge: Hide
WX GUI Number Sink
Title: Angle
Units: Degrees
Sample Rate: 24
Min Value: 0
Max Value: 360
Factor: 1
Decimal Places: 10
Reference Level: 0
Number Rate: 15
Show Gauge: Show
Notebook: nb, 4
WX DOA Compass
Direction: 0
Grid Position: 0, 1, 1, 1
Notebook: nb, 0
Text:
Text Visible: 0
Variable
ID: taps2
Value: 0, 0, 700m+700mj, 0
Variable
ID: channel2_taps
Value: 700m+700mj
Variable
ID: channel2_adj
Value: 1
Variable
ID: invert
Value: 1
Variable
ID: array_configuration
Value: [0, 0], ...0], [-3, 0]
Variable
ID: taps3
Value: 0, 0, 0, 700m+700mj
Variable
ID: channel3_taps
Value: 700m+700mj
Variable
ID: channel3_adj
Value: 1
Variable
ID: master_gain
Value: 700m
Variable Config
ID: config_freq_offset
Default Value: 0
Type: Float
Config File: .qr_doa_music
Section: main
Option: freq_offset
WriteBack: 0
Variable
ID: array_configuration
Value: [0, 0], ... 1], [0, 1]
Moving Average (old)
Length: 100
Scale: 10m
Max Iter: 400
Probe Signal (old)
Function Probe
ID: music_doa
Value: 0
Block ID: probe
Function Name: level
Poll Rate (Hz): 10
WX GUI Text Box
ID: channel1_adj_txt
Label: Channel ...ffset Input
Default Value: 0
Converter: Float
Notebook: nb, 3
WX GUI Text Box
ID: channel2_adj_txt
Label: Channel ...ffset Input
Default Value: 0
Converter: Float
Notebook: nb, 3
WX GUI Text Box
ID: channel3_adj_txt
Label: Channel ...ffset Input
Default Value: 0
Converter: Float
Notebook: nb, 3
MUSIC DOA Estimator
Num samples: 512
Angular resolution: 360
Frequency: 900M
Spacing: 84m
Array: [0, 0], ... 1], [0, 1]
Output Spectrum: Yes
Moving Average (old)
Length: 10
Scale: 100m
Max Iter: 40
Variable Config
ID: cfg_channel1_adj
Default Value: 0
Type: Float
Config File: ...o/qr2-cal.txt
Section: cal
Option: channel1
WriteBack: 0
Variable Config
ID: cfg_channel2_adj
Default Value: 0
Type: Float
Config File: ...o/qr2-cal.txt
Section: cal
Option: channel2
WriteBack: 0
Variable Config
ID: cfg_channel3_adj
Default Value: 0
Type: Float
Config File: ...o/qr2-cal.txt
Section: cal
Option: channel3
WriteBack: 0
Variable Config
ID: config_xlate_bw
Default Value: 25k
Type: Float
Config File: .qr_doa_music
Section: main
Option: xlate_bw
WriteBack: 25k
Keep 1 in N
N: 16
Vec Length: 360
Log10
n: 10
k: 0
Vec Length: 360
Plot Sink
Title: Plot
Sample Rate: 1
Y per Div: 1 dB
Y Divs: 10
Ref Level (dB): 4
Data Length: 360
Grid Position: 0, 1, 1, 1
Notebook: nb, 2
WX GUI Text Box
ID: keep_plot
Label: Keep 1 in N


QuadRadio: Super-resolution Direction Finding
Gain 1: -16
Gain 2: -16
Offset: -11.0335k
Freq: 900M
DOA: -30.9712905
Fire: 0.0
Squelch Threshold: -60
Demod Squelch Threshold: -45
Audio: 1
FFT
Phases
Scope
Params
FM
Squelch
FFT Plot
FFT
Amplitude (dB)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
899.94
899.96
899.98
900
900.02
900.04
900.06
Frequency (MHz)
Trace Options
Peak Hold
Average
Avg Alpha: 0.5000
Persistence
Persist Alpha: 0.1755
Trace A
Store
Trace B
Store
Axis Options
dB/Div:
+
-
Ref Level:
+
-
Autoscale
Stop
TARGET LOCK
Squelched: 1

Police Checklist

- Car’s rego paper
- Amateur Radio licence
- Antenna structural redundancy
- Dress code
- Clean-shaven
- Hide Motorola XTS radios
- Avoid turning around and trying to desperately disconnect antennas

Gedanken: TX

DO NOT TRY THIS AT…

WHEREVER!

Gedanken: Pagers

- Don’t like a doctor/nurse?
  - Send them on many a wild goose chase
- Is your arch-nemesis in hospital?
  - Tell them to remove the *other* *********
- Need to distract security?
  - Issue an ‘automated’ alert

Gedanken: Mode S

- Want to reach cruising altitude a little quicker?
  – Put a ‘plane’ heading towards you (at a slightly lower altitude)
- Think the pilot made the wrong choice in deciding to land?
  – Put a ‘plane’ on the runway
- Want to display a message on everyone’s radar screen?
  – Spell one using ‘aircraft marker’ art

Gedanken: ACARS

- Don't want to fly on a particular aircraft?
  - Send a severe fault report
- Was the flight a little bumpy?
  - Send an engine performance report to RR with large vibration values
- Need to message the cockpit privately?
  - Address the message to cockpit printer #1

Gedanken: Satellite

- Uplink power is generally kept at the minimum level to save money
- Depends on the weather:
  - Clear sky: a few W
  - Heavy rain: a few kW
- Turn yours up to (theirs + 1)

Customers may use uplink power control systems (UPC) to compensate for uplink rain attenuation. Since a malfunctioning UPC system can interfere with other services and even damage a satellite TWTA, UPC systems must be approved by Optus before use and are strictly limited in the amount of uplink compensation permitted. Details of the amount of UPC permitted under various operating conditions may be obtained from Optus.


Remember: be legal and be....
SAFE
TX
RX
BOSCH
BOSCH
IXO
powered by
Li-ion
technology

http://wiki.spench.net/wiki/RF

http://spench.net/

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