Aircraft Scatter 2014

Roger Rehr, W3SZ

NEWS Group Conference 2014

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Technical Correspondence

EMERGENCY COAX CONNECTOR

Technical Editor, *QST*:

I would like to comment on the brief article in the "Hints & Kinks" section of April *QST* entitled "Emergency Coax Connector."

According to my calculations the adapter described has a characteristic impedance close to 100 ohms. Generally speaking, the discontinuity presented to a 50-ohm transmission line by the adapter will be small at h.f. and v.h.f. frequencies and one should obtain good v.s.w.r. characteristics. However, for use in the u.h.f. region the mismatch will be more significant.

An improved match can be attained by soldering a sleeve over the two inner conductors such that the ratio of outer to inner coaxial conductor diameters will be approximately 2.3. This will result in an adapter with a 50-ohm characteristic impedance. — *Dennis J. Kozakoff, W3AYW, 3708 Balfour Drive, Orlando, Florida 32808.*

USING AIRCRAFT REFLECTIONS IN V.H.F. COMMUNICATIONS

Technical Editor, *QST*:

Most v.h.f. enthusiasts are familiar with "aircraft flutter." Combination of direct and reflected rays produces a fluttering that begins fairly weak, with a rapid rate, then grows stronger, with the rate reducing to nearly zero. Then the rate builds up again, and the fluttering grows weaker and finally disappears. This all occurs in a time span of from 10 seconds to as much as several minutes.

That a reflected signal of such strength is observed at random suggests that, with optimum techniques, it could be used for v.h.f. communication over paths where direct-ray signals are weak, or nonexistent. This has probably happened on occasion, perhaps without the amateurs involved realizing it. Our intent here will be to give some indication of signal levels to be expected when aircraft reflections are used intentionally, and to describe methods for this.

Aircraft flutter is observed normally on short paths, where communication is relatively good, but it should be usable over distances of 100 miles or more, on circuits where terrain obstructions make normal communication difficult. Vapor trails we often see are at an altitude that allows the pilot to see some 300 miles in any direction. Horizon distances for aircraft altitudes are given in Fig. 1. These great horizon distances do not necessarily imply use of aircraft reflections over similar paths. The beamwidth of amateur antennas is such that the percentage of the total radiated power is too small to produce a significant reflection over distances much greater than can be covered readily over open terrain.

I have conducted simple tests with TV signals to gain an insight into what may be reasonably expected. Stations 45 to 65 miles away were used. At these distances signals are normally weak on

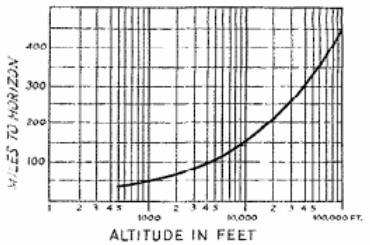


Fig. 1—Distance to the horizon, as seen from aircraft at elevations up to 100,000 feet.

receiving antennas close to the ground, the optimum situation for high-angle pickup. TV signals were tuned in, and the antenna was rotated for weakest direct pickup. This makes aircraft reflections much more obvious, and the first time I tried it there were enough aircraft present to make it difficult to tell when I had really minimized the direct signal. Here in the Northeast I have found these reflectors to be present for sustained periods, day in and day out. Based on depth of fluttering I estimated the reflected signals to range from 30 db. below the direct signal to equal to it.

I computed what the worst-case area of reflection might be, then applied this to voice and c.w. bandwidths for amateur use. The information of Fig. 2 implies 100 watts transmitter power, 3-kc. bandwidth for voice, 10-db. receiver noise figure, and antenna gain no greater than 10 db. over isotropic. This for a reflecting area of only 2 square meters. It can be seen that under these conservative estimates, stations A and B, 5 and 39 miles, respectively, from an aircraft would have a 10-db. signal-to-noise ratio in 50-Mc. communication on voice. With c.w. about 10 db. more margin would prevail.

Special circumstances are encountered with TV signals, as most TV stations concentrate their radiation along the horizon. Beam patterns may be only about 3 degrees above the horizon at Channel

(*Continued on page 146*)

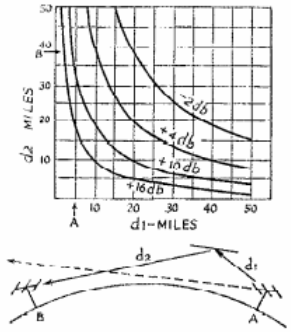
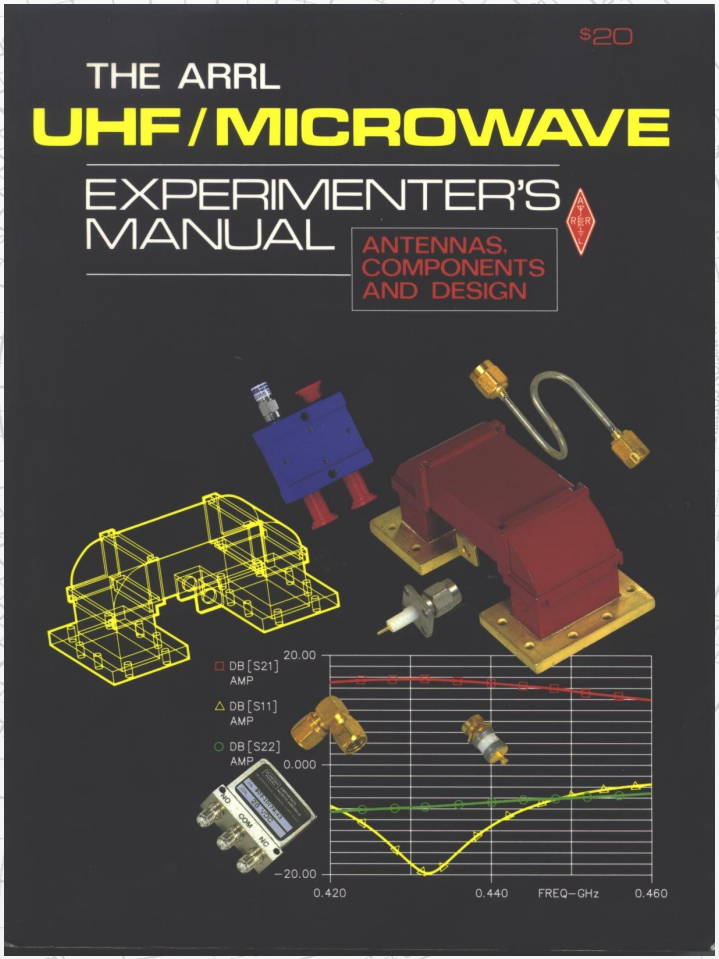


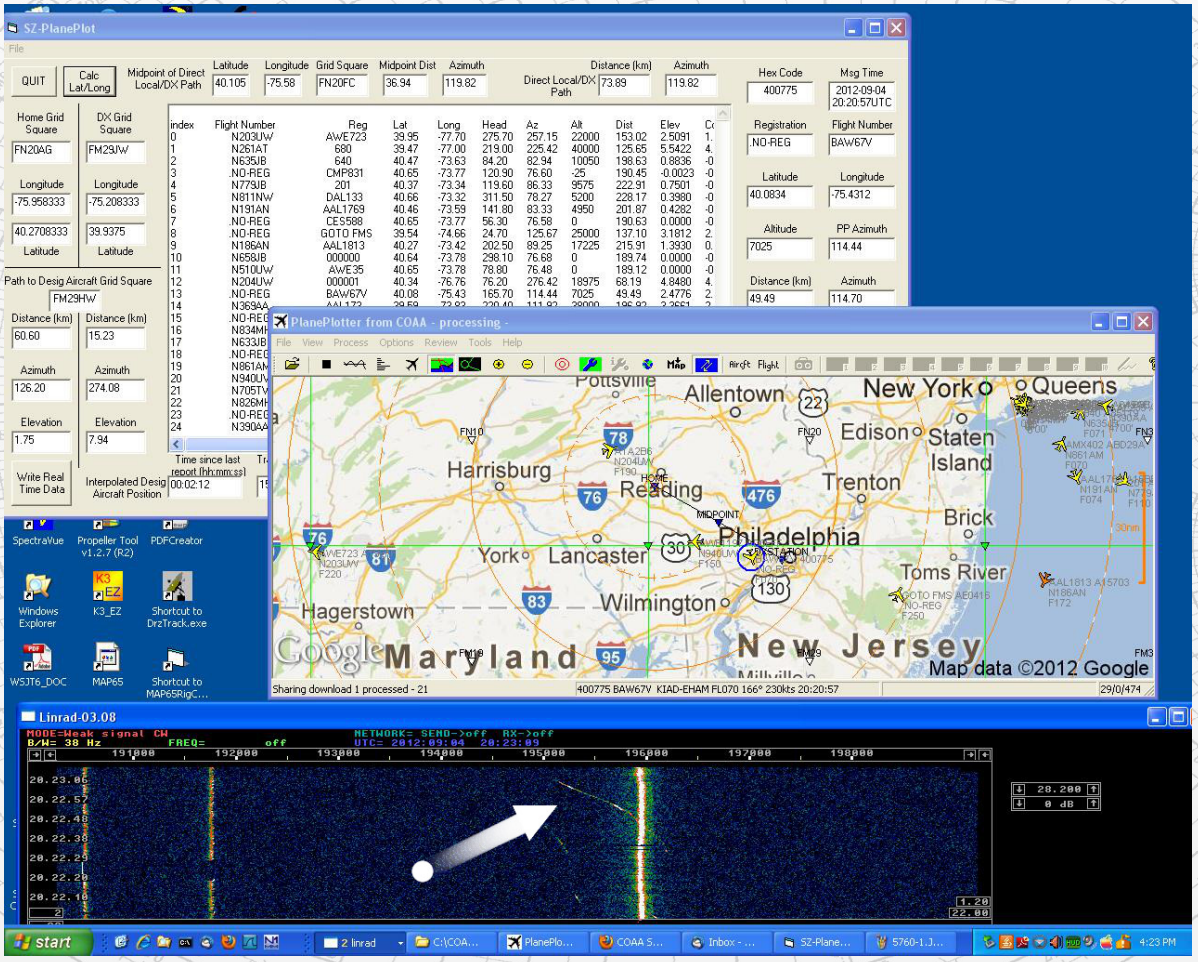
Fig. 2—Signal-to-noise ratios to be expected from aircraft reflections at 50 Mc. Information is for voice. Use of c.w. would produce about 10 db. greater margin over noise. In the example indicated, Station A at 5 miles from an aircraft and Station B, 39 miles, would have a 10-db. signal-to-noise ratio, with average 50-Mc. setups.

Aircraft Scatter

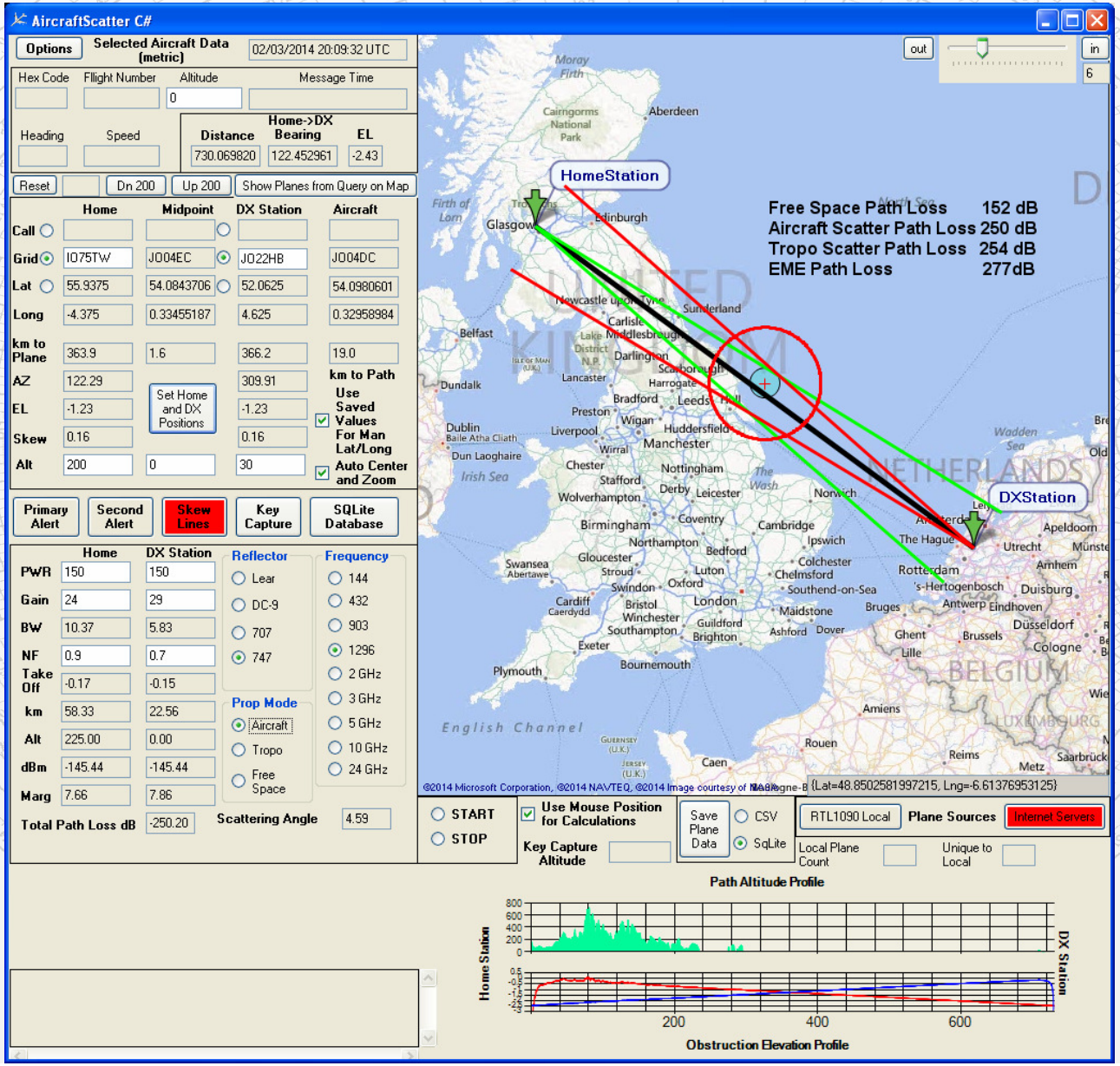
- Emil Polock, W3EP, devoted 2 pages to AS in the ARRL UHF/Microwave Experimenter's Manual, published in 1990



Aircraft Scatter



GM4CXM heard by aircraft scatter at PA0EHG on 1296 MHz



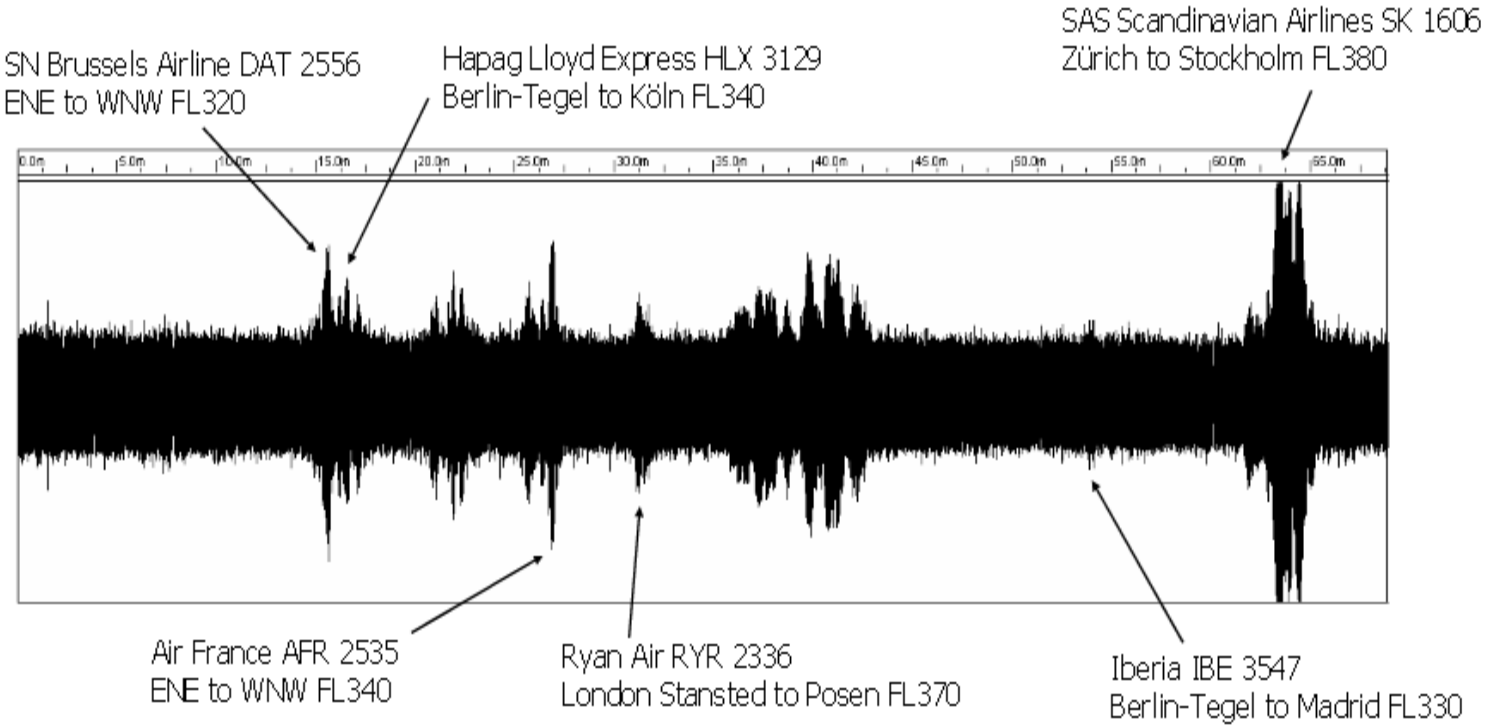
Experience from QSOs

- Example: 23 cm NAC May 2006 DF9IC in JN48iw

17:41	DL1SUZ	559	579	JO53UN	555 km	Airplane
17:51	PA5DD	55	56	JO22IC	452 km	
17:54	PA3CEG	53	54	JO33FB	485 km	
18:00	OZ1FF	529	519	JO45BO	743 km	Airplane
18:05	SK7MW	53	55	JO65MJ	777 km	Airplane (?)
18:15	OZ9KY	519	519	JO45VX	787 km	Airplane
18:20	OZ2LD	529	559	JO54TU	688 km	Airplane
18:29	SM7ECM	519	519	JO65NQ	809 km	Airplane
18:32	DJ8MS	52	52	JO64AD	624 km	Airplane
18:39	DK3WG	549	569	JO72GI	560 km	Airplane
18:45	DK9TF	56	57	JO31NF	279 km	
18:46	DJ6JJ/p	549	539	JO31LG	288 km	
18:48	DL3YEE	54	57	JO42GE	362 km	
18:49	DL5YEE	54	57	JO42GF	366 km	
18:56	DB6NT	59	59	JO50TI	263 km	
19:07	G4EAT	529	529	JO01HR	653 km	Airplane
19:16	ON4IY	519	559	JO20IV	360 km	Airplane
20:18	G4HUP	55	55	JP02PC	632 km	Airplane
20:19	DG1KJG	57	57	JO30NT	237 km	
20:23	DB5KN	54	59	JO31NB	262 km	
20:30	G4BEL	54	54	JO02BI	715 km	Airplane (?)
20:59	DL7VTX	519	539	JO62TM	528 km	Airplane

A propagation test on 1296 MHz

- Some reflections could be correlated with airplanes passing the „midway" area

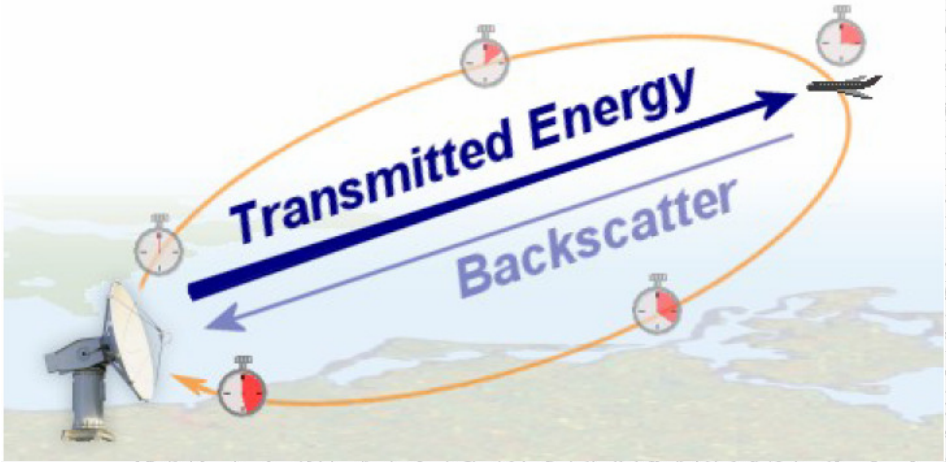


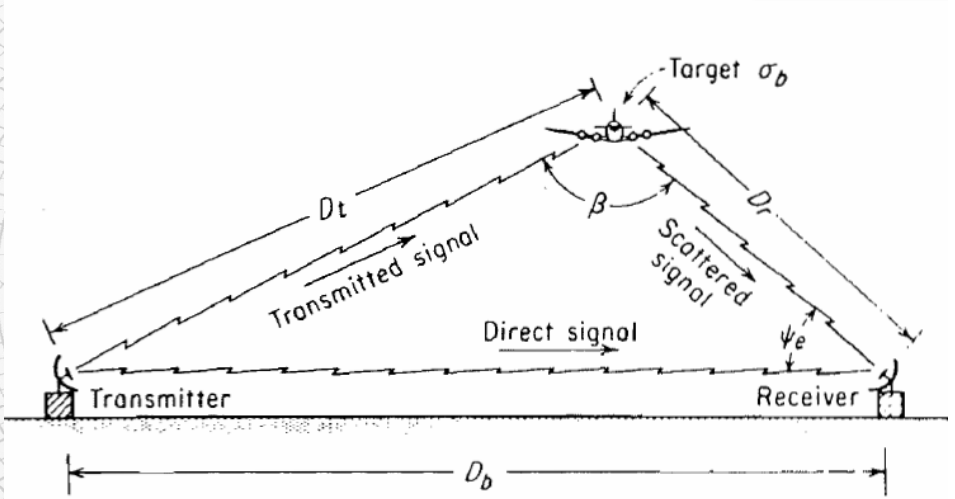
Signal Strength Calculations: AS vs TS

Distance	144 MHz	1296 MHz	10 GHz
300 km	AS -30 dB	AS -21 dB	AS -12 dB
600 km	AS -13 dB	AS -3 dB	AS +6 dB
800 km	AS -2 dB	AS +8 dB	AS +17 dB
950 km	AS +7 dB	AS +17 dB	AS +26 dB

These numbers do not include the effects of Forward Scatter Enhancement.

Physics


Transmitted Energy
Backscatter


Target σ_b
D_t
D_r
β
Transmitted signal
Scattered signal
Direct signal
ψ_e
Transmitter
Receiver
D_b

More Physics

Bistatic Radar Equation for Path Loss:

L = 10 log((lambda**2)*S/(((Rt**2)*(Rr)**2))) – 153

L = total loss (dB)

Rt = distance from transmitter to reflector (km)

Rr = distance from receiver to reflector (km)

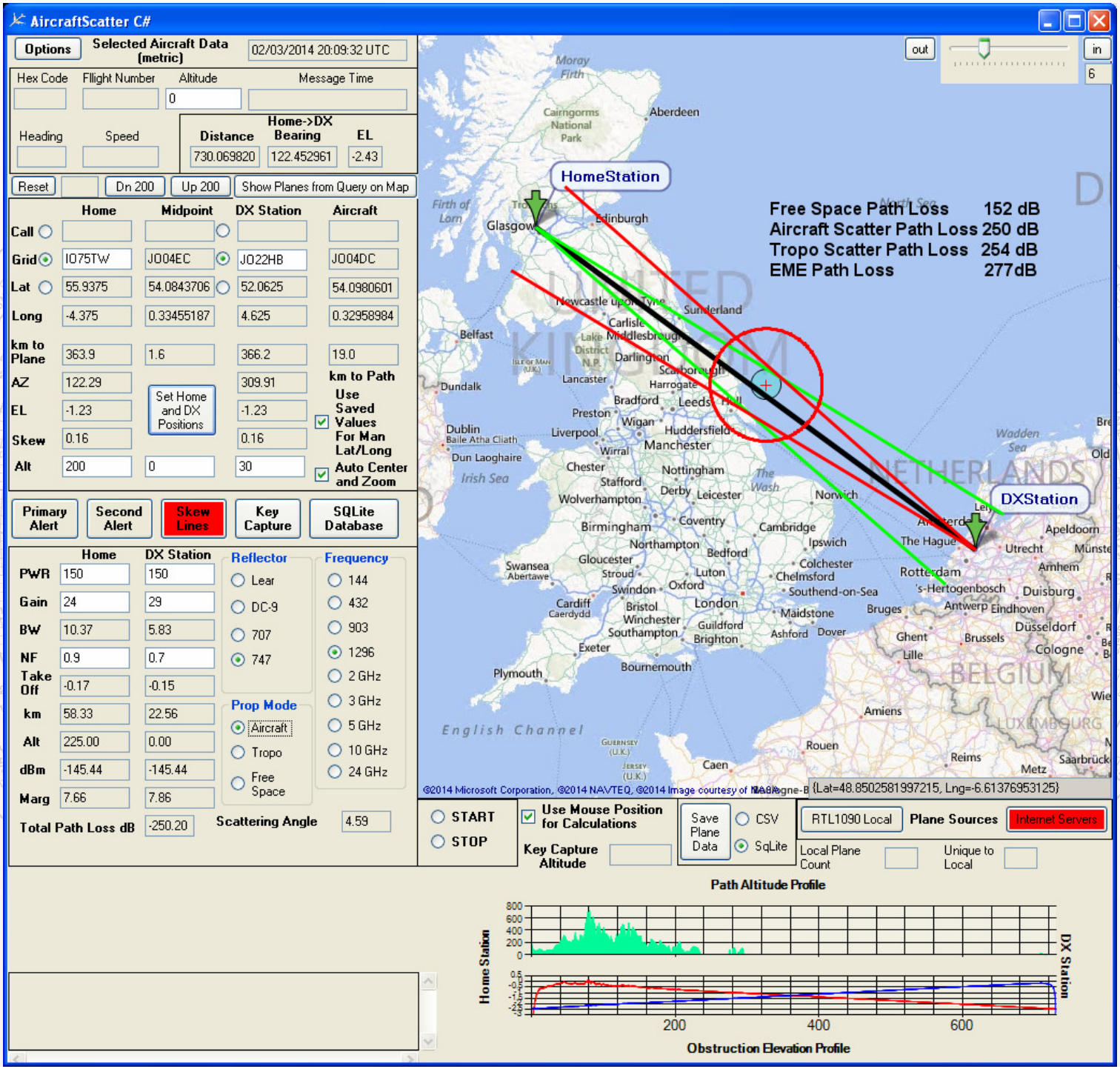
Lambda = wavelength (m)

S = radar cross section of aircraft (sq m)

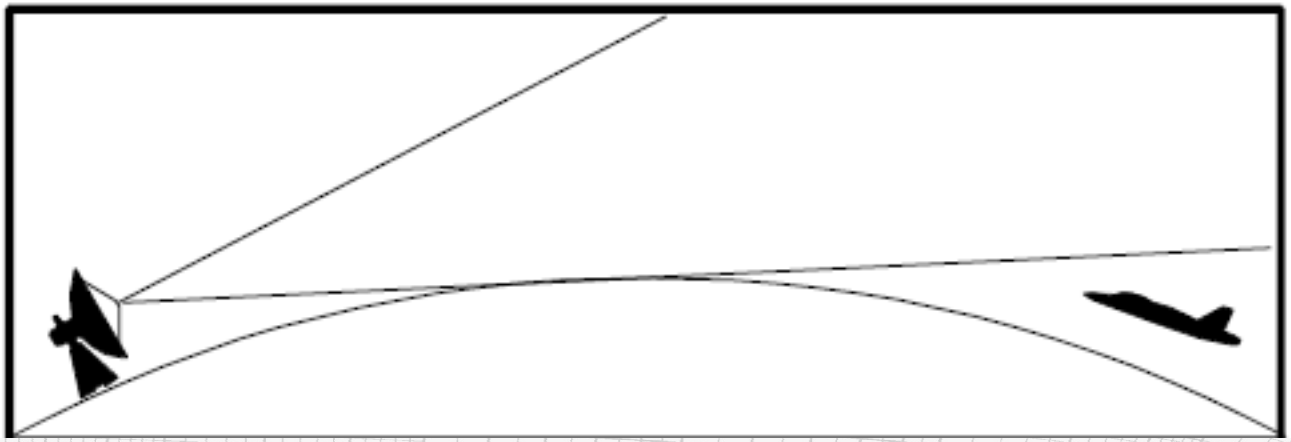
Table 2.2 Example radar cross sections at microwave frequencies

	Square meters
Conventional, unmanned winged missile	0.5
Small, single engine aircraft	1
Small fighter, or 4-passenger jet	2
Large fighter	6
Medium bomber or medium jet airliner	20
Large bomber or large jet airliner	40
Jumbo jet	100
Small open boat	0.02
Small pleasure boat	2
Cabin cruiser	10
Ship at zero grazing angle	See Eq. (2.38)
Ship at higher grazing angles	Displacement tonnage expressed in m^2
Pickup truck	200
Automobile	100
Bicycle	2
Man	1
Bird	0.01
Insect	10^{-5}

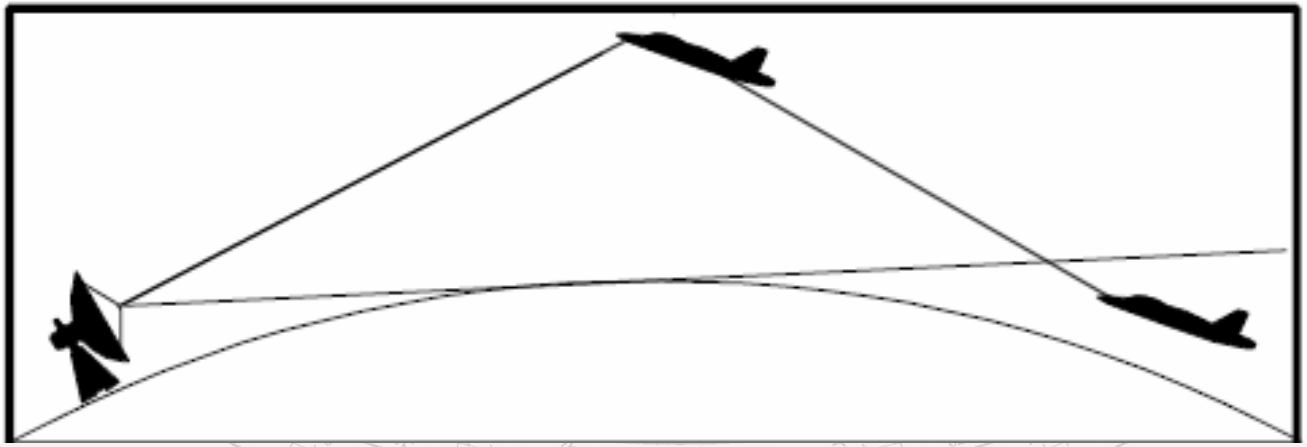
- F-117 fighter 0.1
- B-2 bomber 0.01


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/03/2014 20:09:32 UTC
Hex Code
Flight Number
Altitude
Message Time
Heading
Speed
Home->DX
Distance
Bearing
EL
730.069820
122.452961
-2.43
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
IO75TW
JO04EC
JO22HB
JO04DC
Lat
55.9375
54.0843706
52.0625
54.0980601
Long
-4.375
0.33455187
4.625
0.32958984
km to Plane
363.9
1.6
366.2
19.0
AZ
122.29
309.91
km to Path
EL
-1.23
-1.23
Set Home and DX Positions
Use Saved Values For Man Lat/Long
Skew
0.16
0.16
Alt
200
0
30
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
150
150
Gain
24
29
BW
10.37
5.83
NF
0.9
0.7
Take Off
-0.17
-0.15
km
58.33
22.56
Alt
225.00
0.00
dBm
-145.44
-145.44
Marg
7.66
7.86
Total Path Loss dB
-250.20
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
4.59
HomeStation
DXStation
Free Space Path Loss 152 dB
Aircraft Scatter Path Loss 250 dB
Tropo Scatter Path Loss 254 dB
EME Path Loss 277dB
out
in
6
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of
{Lat=48.8502581997215, Lng=-6.61376953125}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
Unique to Local
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile

RADAR HORIZON

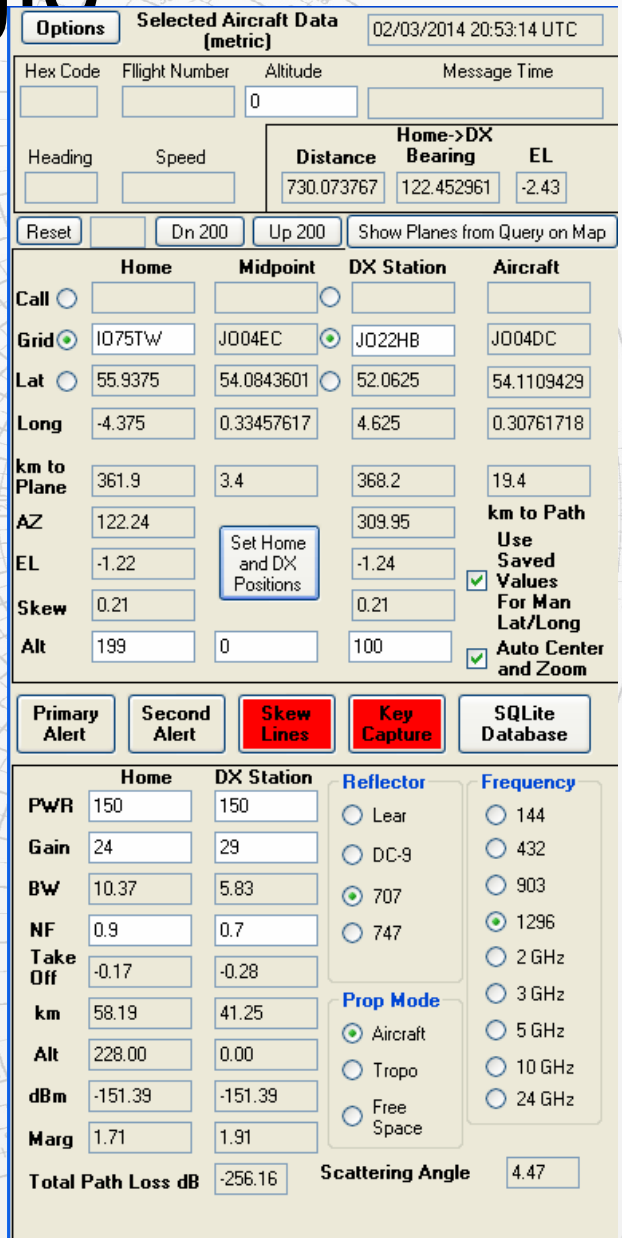


RADAR HORIZON



Magic

- S factors were derived, measured with monostatic radar
- S factor for a 747-sized plane at 144 MHz is 100
- For the special case of forward scatter where the scattering angle is 180 degrees the effective S is much larger: **Sef = 30,000**
  - Adds 25 dB signal (25 dB less loss)
- At 432 MHz, **Sef = 240,000**
  - Adds 34 dB signal (34 dB less loss)
- At 1296 MHz may add up to 40-50 dB

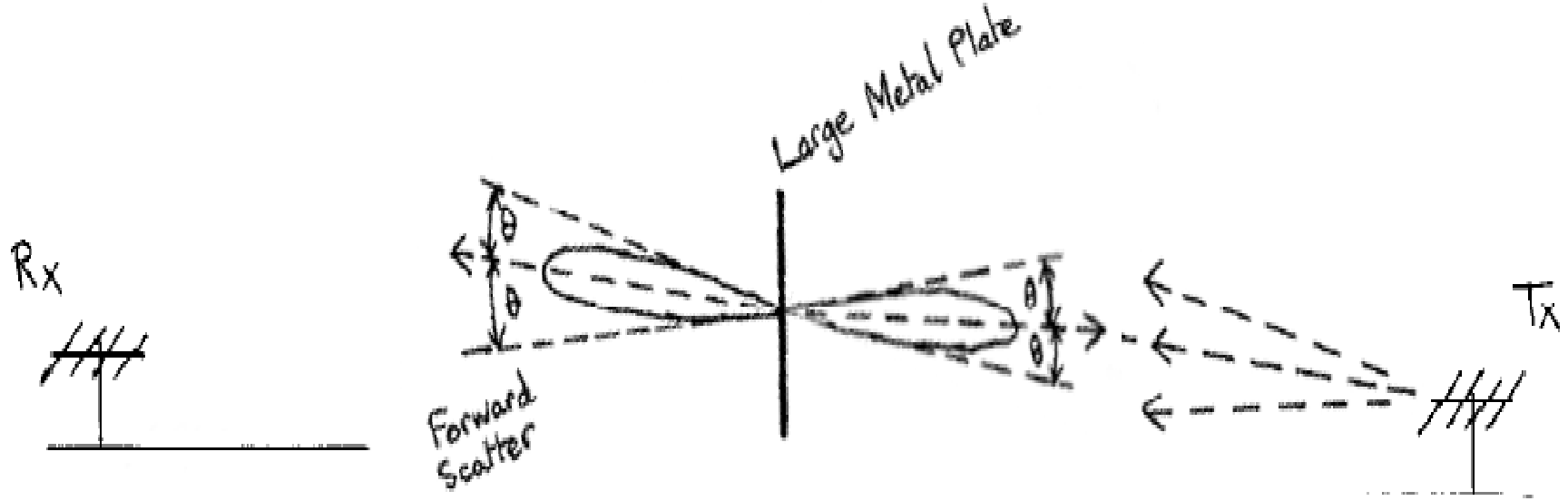


Physics Magic

When the forward scattering angle is 180 degrees:
We get constructive interference of the scattered radiation, called **"Diffractive Scattering"** which gives us
Forward scatter enhancement = 4*Pi* A/(lambda2)**

Radius in meters	Area in meters	Frequency Lambda (meters)	144 MHz 2	432 MHz 0.7	1296 0.23	2304 0.13	3G 0.1	5G 0.06	10G 0.03
1	3	dB Enhancement:	10	19	29	34	36	40	46
5	79	dB Enhancement:	24	33	43	48	50	54	60
10	314	dB Enhancement:	30	39	49	54	56	60	66

- For 1296 could expect 43 dB enhancement
  - So 1.7 dB signal margin becomes ~45 dB margin


Large Metal Plate
Rx
Tx
θ
θ
θ
θ
Forward
Scatter

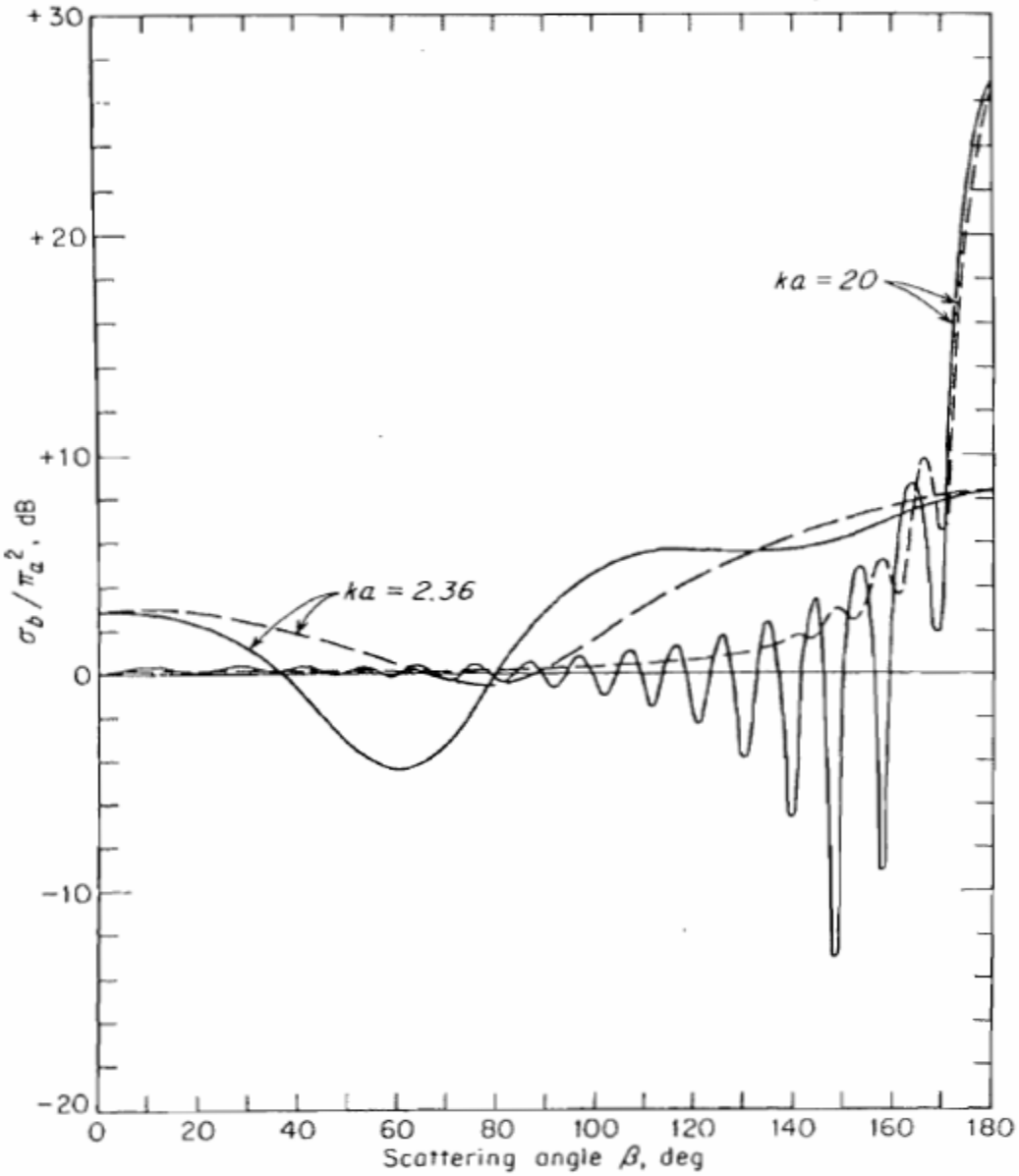
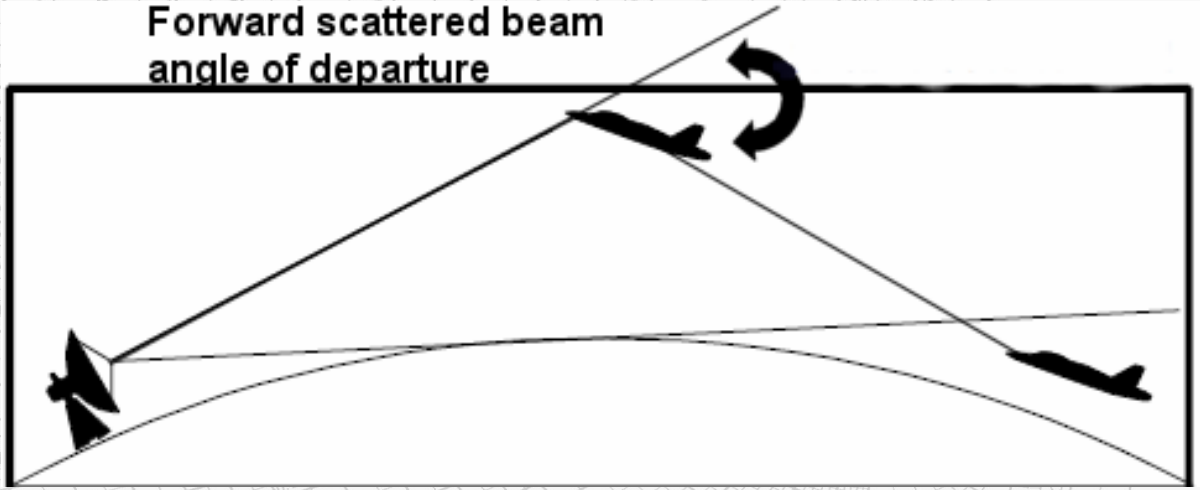


Figure 14.13 Bistatic cross section σ_b of a sphere as a function of the scattering angle β and two values of $ka = 2\pi a/\lambda$, where a is the sphere radius and λ is the wavelength. Solid curves are for the E plane (β measured in the plane of the E vector); dashed curves are for the H plane (β measured in the plane of the H vector, perpendicular to the E vector).[65,69]

Something for Nothing?

- Beamwidth = (lambda * 45) / (radius * Pi)



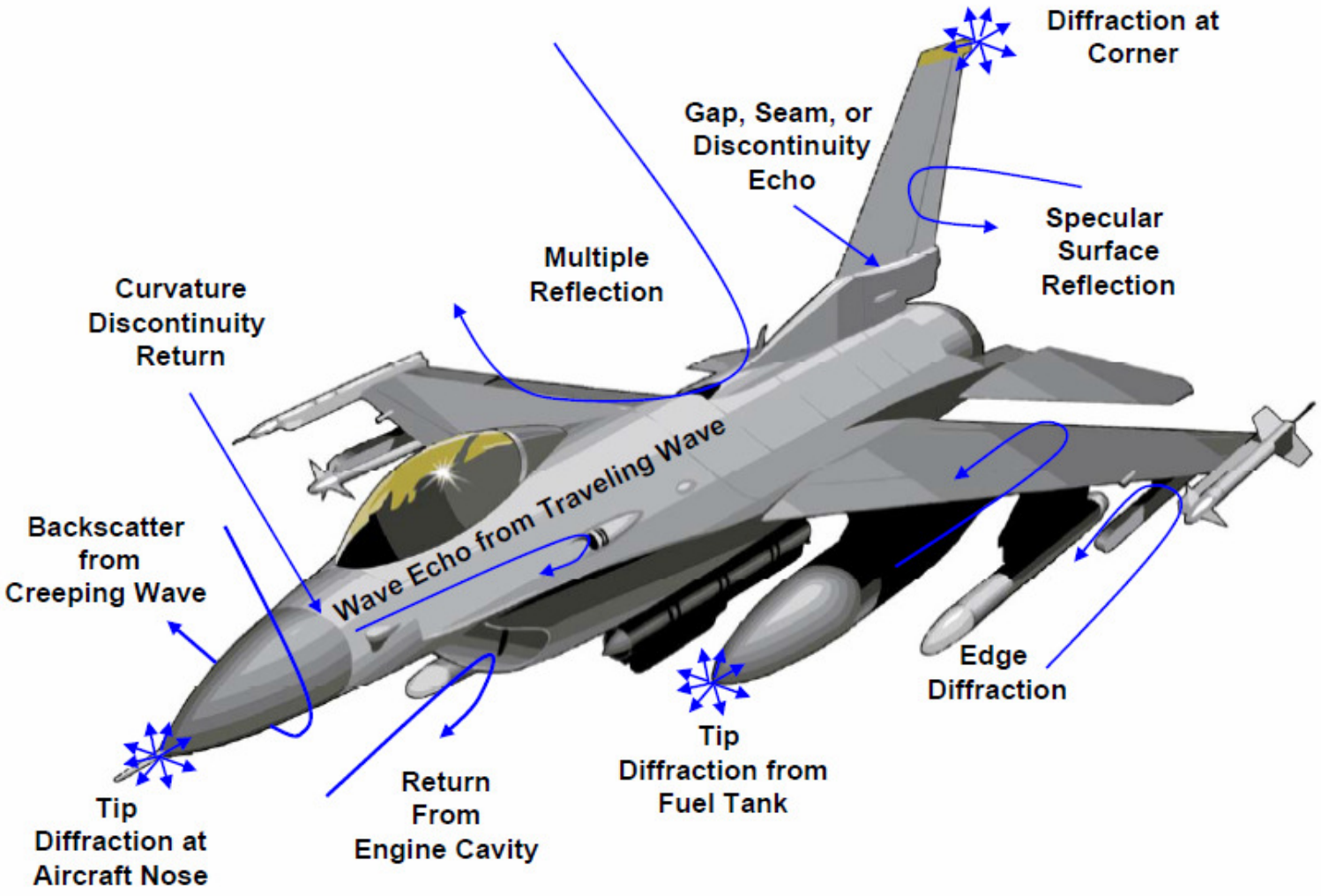
Frequency MHz		144	432	1296	2304	3G	5G	10G
Radius								
1 meter	3 dB beamwidth deg	28.647	10.02	3.294	1.862	1.432	0.859	0.429
5 meters	3 dB beamwidth deg	5.7296	2.005	0.658	0.372	0.286	0.171	0.085
10 meters	3 dB beamwidth deg	2.8648	1.002	0.329	0.186	0.143	0.085	0.043

Maximum size of scattering object to provide 3 dB beamwidth of at least 3 degrees

Freq (MHz)	144	432	1296	2304	3G	5G	10G
Radius (m)	9.54	3.34	1.10	0.620	0.477	0.286	0.143

Elevation in degrees vs Distance for Aircraft Altitude 10,000 meters					
Distance to Aircraft	100 km	200 km	300 km	400 km	500 km
QSO Distance	200 km	400 km	600 km	800 km	1000 km
Elevation	5.4	2.2	0.9	0.08	-0.54

Scattering Mechanisms for an Arbitrary Target



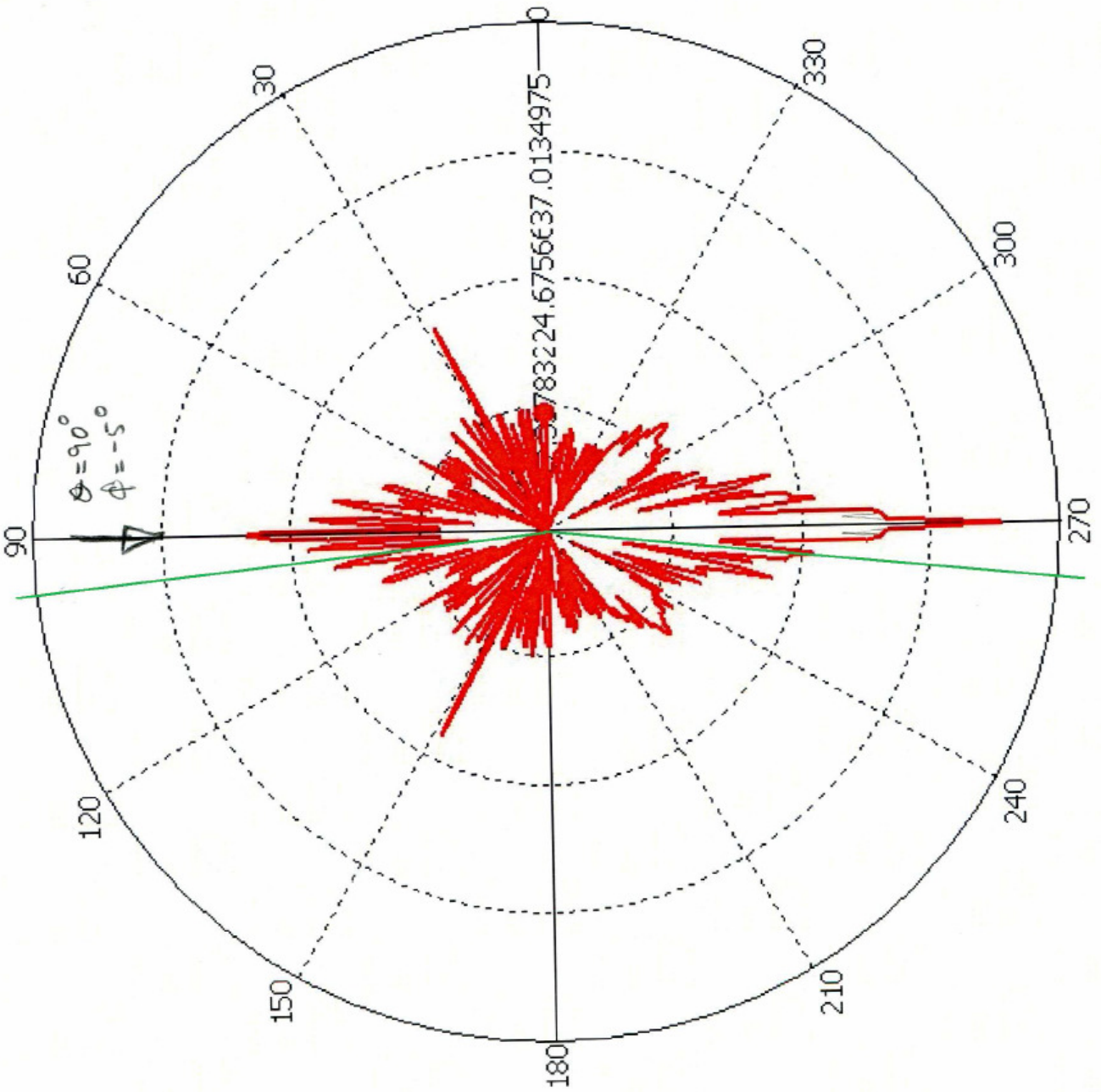


Figure 1 Scatter Pattern of an Aircraft at 1296 MHz

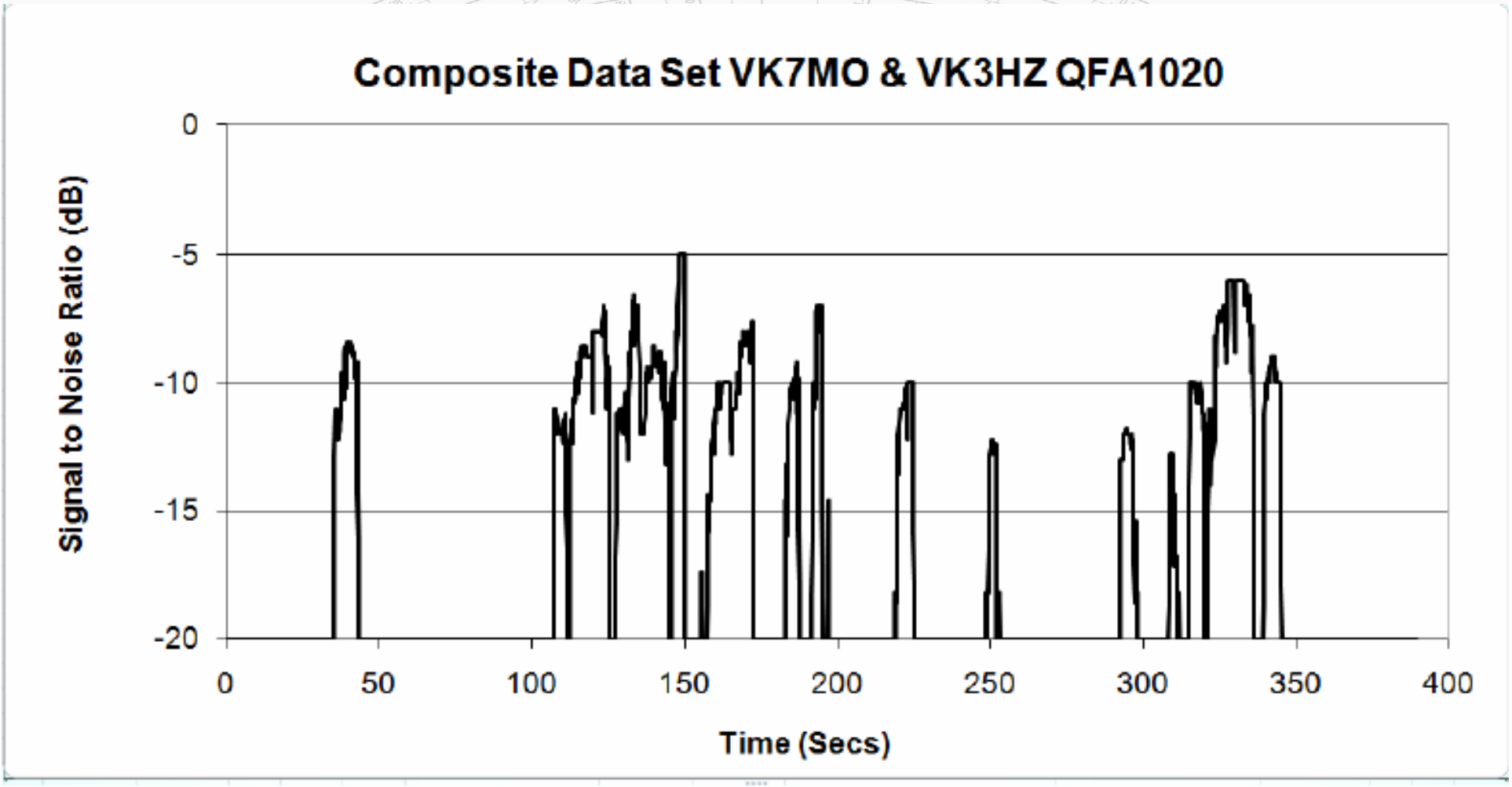


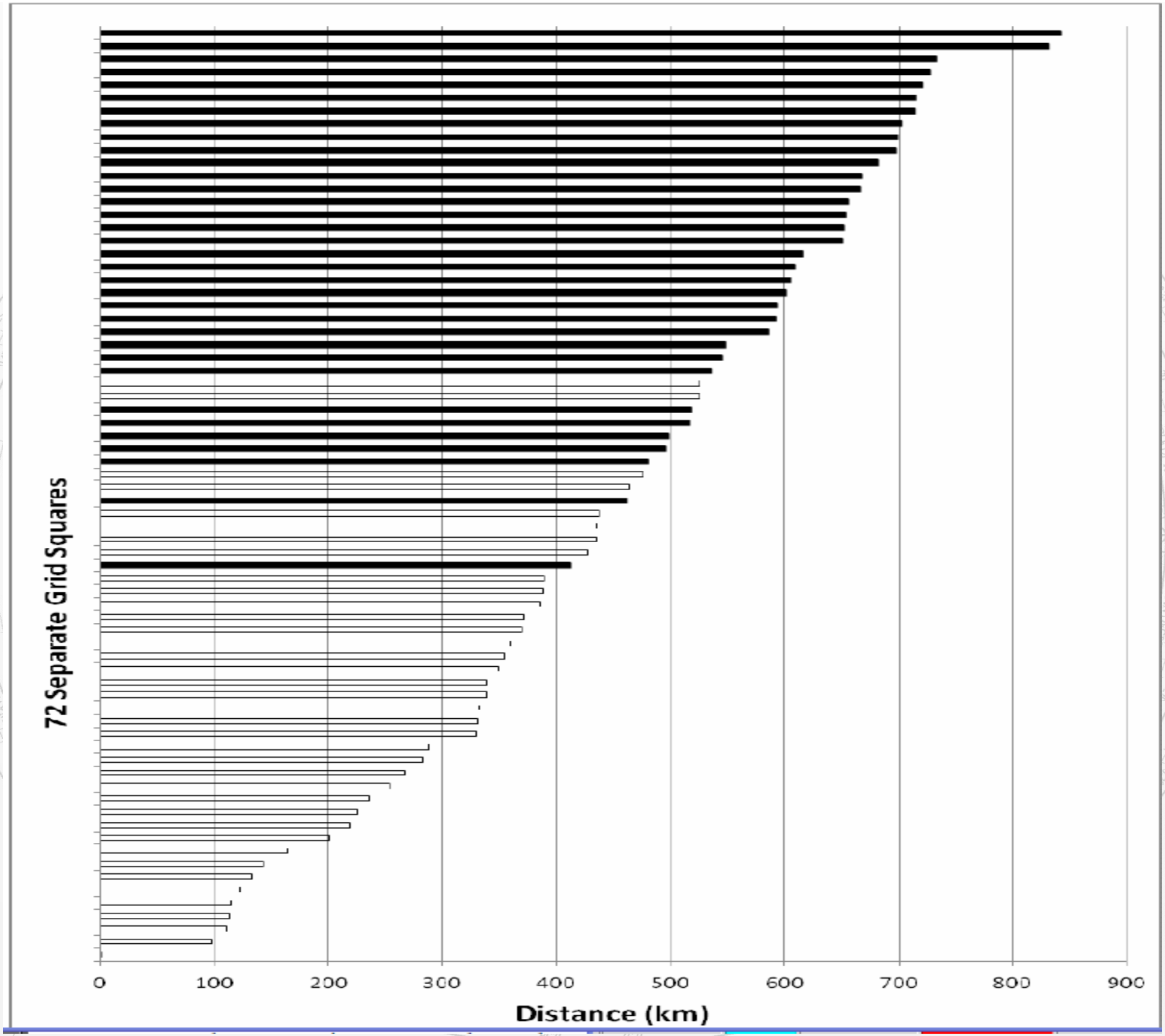
Fig 1: 10 GHz aircraft scatter signals from Werribee in Victoria to Swansea in Tasmania

Interesting Stuff from Down Under

- 1985 Doug McArthur, VK3UM, noted periods of ~ 24 dB enhancement due to aircraft scatter on 144 MHz
- Active discussion of aircraft scatter theory and activity in Australian / New Zealand amateur radio publications since that time
- VK7MO, VK3HZ have done excellent long range aircraft scatter work on 10 GHz and 24 GHz

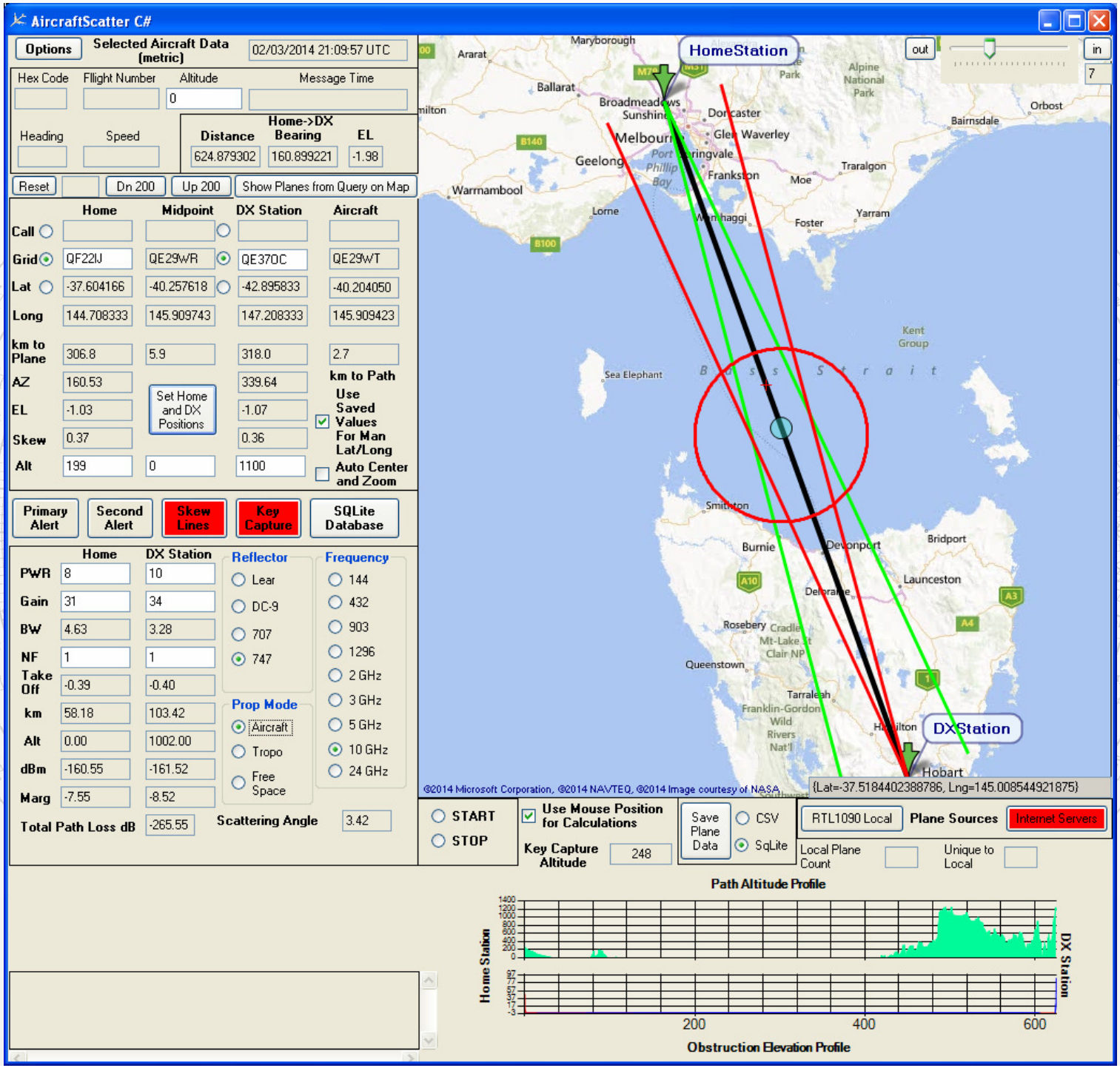
10 GHz –VK7MO, VK3HZ

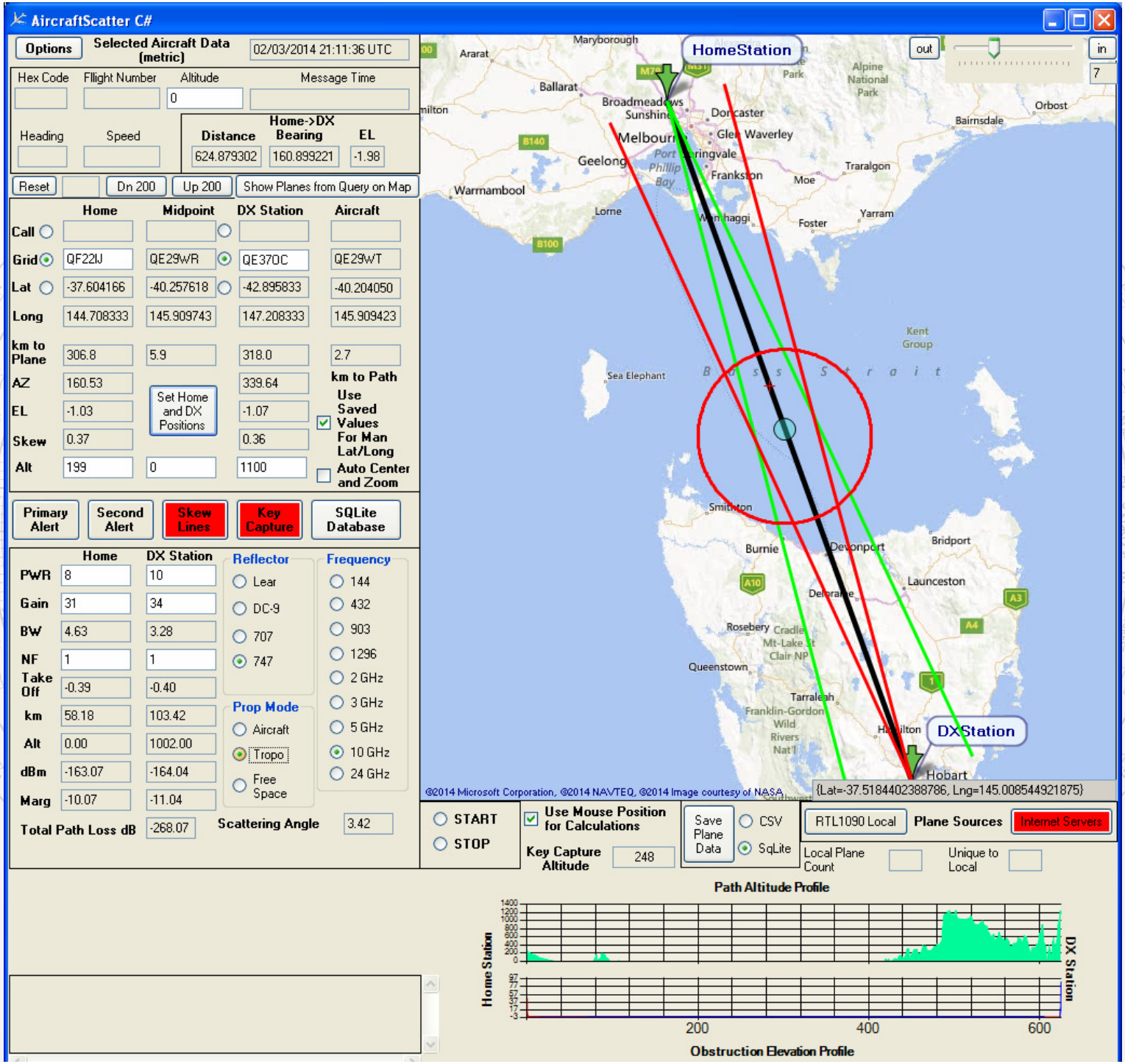
- 8-10 watts, 60 cm dishes
- JT65C for skew angles < 15 degrees
- ISCAT-A for greater skew angles
  - ISCAT-A less affected by Doppler
  - ISCAT-A better suited to short signal bursts
  - ISCAT modes 5-6 dB less sensitive than JT65C
  - There is now a 30 second JT65C mode
- Longest contact 842 km

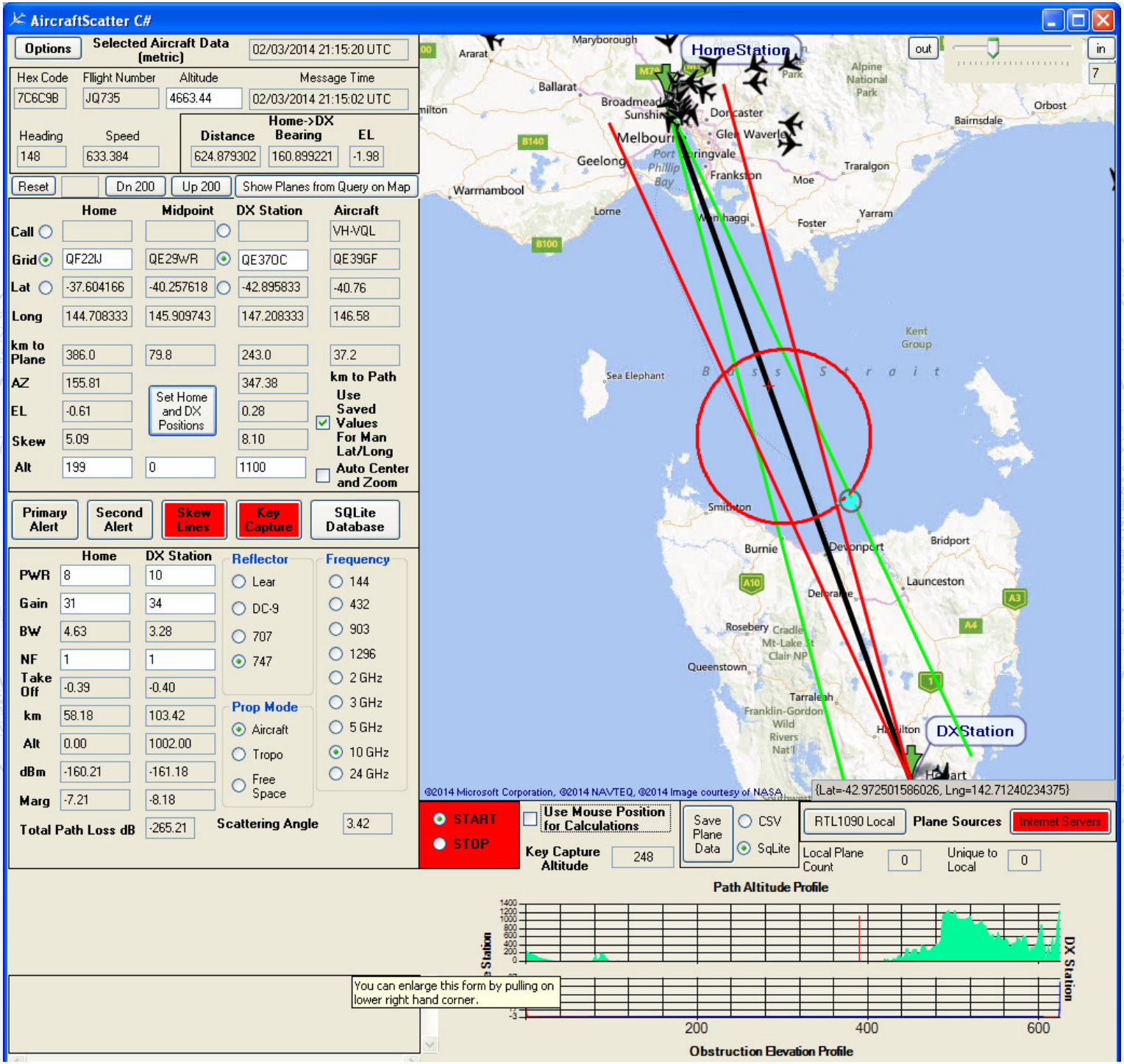

72 Separate Grid Squares
0
100
200
300
400
500
600
700
800
900
Distance (km)

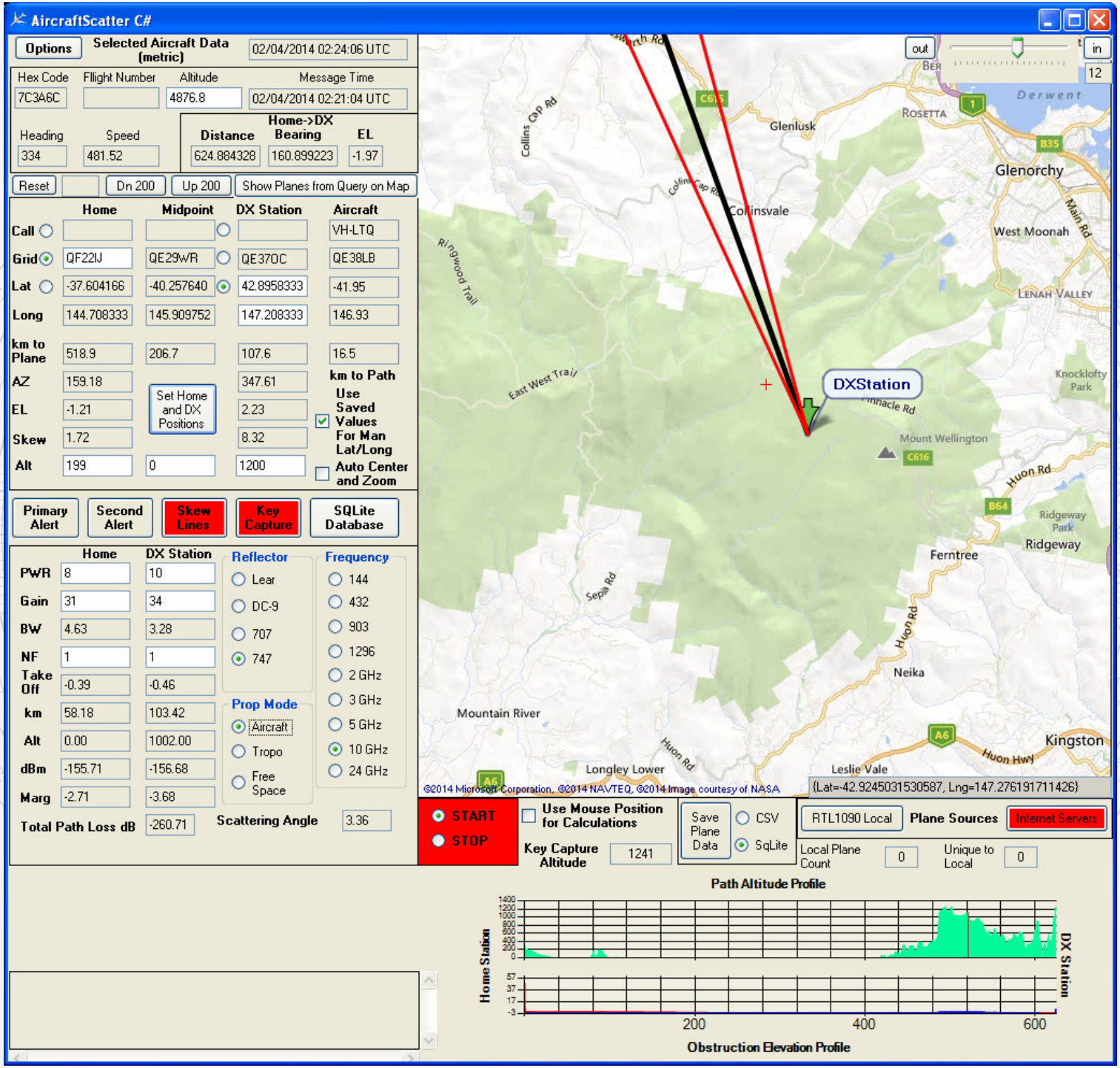
24 GHz-VK7MO, VK3HZ

- 1.5 – 3 watts
- 38 - 47 cm dishes
- JT65C only
  - ISCAT-A not sufficiently sensitive
- Longest contact 427 km


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/03/2014 21:09:57 UTC
Hex Code
Fllight Number
Altitude
Message Time
Heading
Speed
Home->DX
Distance
Bearing
EL
624.879302
160.899221
-1.98
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
QF22IJ
QE29WR
QE37OC
QE29WT
-37.604166
-40.257618
-42.895833
-40.204050
144.708333
145.909743
147.208333
145.909423
306.8
5.9
318.0
2.7
160.53
339.64
-1.03
-1.07
0.37
0.36
199
0
1100
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.39
-0.40
58.18
103.42
0.00
1002.00
-160.55
-161.52
-7.55
-8.52
Total Path Loss dB
-265.55
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.42
HomeStation
DXStation
Hobart
Melbourne
Geelong
Ballarat
Maryborough
Warrnambool
Lorne
Sea Elephant
Kent Group
Burnie
Devonport
Launceston
Queenstown
Smithton
Bridport
Frankston
Moe
Traralgon
Yarram
Foster
Orbost
Bairnsdale
Alpine National Park
Rosebery
Tarraleah
Franklin-Gordon Wild Rivers Nat'l
Cradle Mt-Lake St Clair NP
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=-37.5184402388786, Lng=145.008544921875}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
Unique to Local
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
200
400
600


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/03/2014 21:11:36 UTC
Hex Code
Fllight Number
Altitude
Message Time
Heading
Speed
Home->DX
Distance
Bearing
EL
624.879302
160.899221
-1.98
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
QF22IJ
QE29WR
QE37OC
QE29WT
Lat
-37.604166
-40.257618
-42.895833
-40.204050
Long
144.708333
145.909743
147.208333
145.909423
km to Plane
306.8
5.9
318.0
2.7
AZ
160.53
339.64
km to Path
EL
-1.03
-1.07
Skew
0.37
0.36
Alt
199
0
1100
Set Home and DX Positions
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
8
10
Gain
31
34
BW
4.63
3.28
NF
1
1
Take Off
-0.39
-0.40
km
58.18
103.42
Alt
0.00
1002.00
dBm
-163.07
-164.04
Marg
-10.07
-11.04
Total Path Loss dB
-268.07
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.42
HomeStation
DXStation
Hobart
Melbourne
Geelong
Ballarat
Warrnambool
Lorne
Frankston
Traralgon
Moe
Yarram
Foster
Orbost
Bairnsdale
Alpine National Park
Kent Group
Sea Elephant
Bass Strait
Smithton
Burnie
Devonport
Launceston
Bridport
Queenstown
Rosebery
Tarraleah
Franklin-Gordon Wild Rivers Nat'l
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=-37.5184402388786, Lng=145.008544921875}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
Unique to Local
Path Altitude Profile
Home Station
DX Station
200
400
600
Obstruction Elevation Profile


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/03/2014 21:15:20 UTC
Hex Code
Fllight Number
Altitude
Message Time
7C6C9B
JQ735
4663.44
02/03/2014 21:15:02 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
148
633.384
624.879302
160.899221
-1.98
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
QF22IJ
QE29WR
QE37OC
QE39GF
-37.604166
-40.257618
-42.895833
-40.76
144.708333
145.909743
147.208333
146.58
386.0
79.8
243.0
37.2
155.81
347.38
-0.61
0.28
5.09
8.10
199
0
1100
VH-VQL
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.39
-0.40
58.18
103.42
0.00
1002.00
-160.21
-161.18
-7.21
-8.18
Total Path Loss dB
-265.21
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.42
HomeStation
DXStation
out
in
7
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=-42.972501586026, Lng=142.71240234375}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
0
Unique to Local
0
Path Altitude Profile
DX Station
You can enlarge this form by pulling on lower right hand corner.
200
400
600
Obstruction Elevation Profile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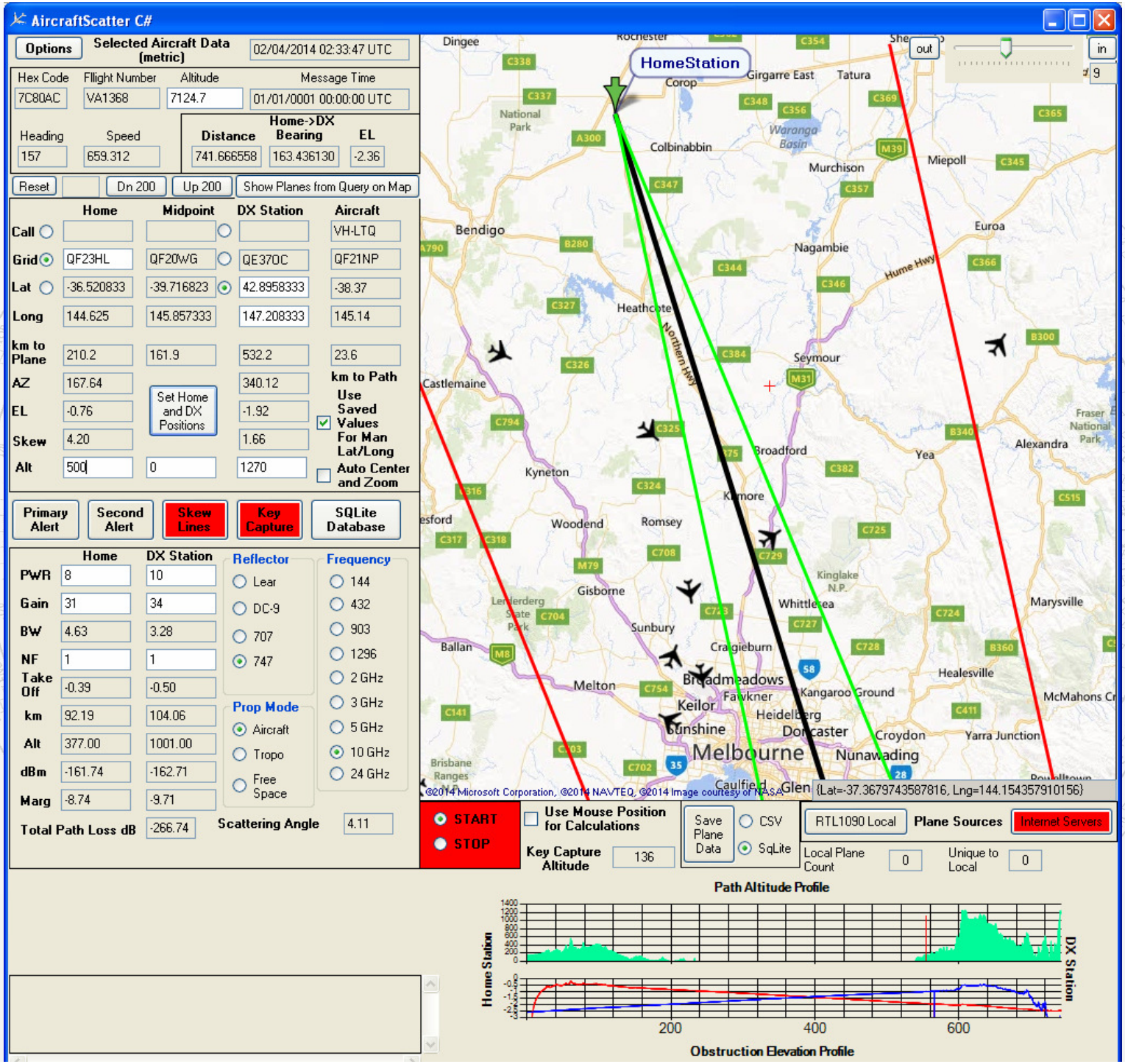
Options
Selected Aircraft Data (metric)
02/04/2014 02:24:06 UTC
Hex Code
Fllight Number
Altitude
Message Time
7C3A6C
4876.8
02/04/2014 02:21:04 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
334
481.52
624.884328
160.899223
-1.97
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
QF22IJ
QE29WR
QE37OC
QE38LB
-37.604166
-40.257640
42.8958333
-41.95
144.708333
145.909752
147.208333
146.93
518.9
206.7
107.6
16.5
159.18
347.61
-1.21
2.23
1.72
8.32
199
0
1200
VH-LTQ
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.39
-0.46
58.18
103.42
0.00
1002.00
-155.71
-156.68
-2.71
-3.68
Total Path Loss dB
-260.71
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.36
DXStation
Glenlusk
Collinsvale
Glenorchy
West Moonah
Lenah Valley
Knocklofty Park
Mount Wellington
Ridgeway Park
Ridgeway
Ferntree
Neika
Mountain River
Longley Lower
Leslie Vale
Kingston
Huon Rd
Huon Hwy
Derwent
Rosetta
Collins Cap Rd
Ringwood Trail
East West Trail
Sepia Rd
Main Rd
Pinnacle Rd
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=-42.9245031530587, Lng=147.276191711426}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
1241
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
0
Unique to Local
0
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
200
400
600


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/04/2014 02:33:47 UTC
Hex Code
Flight Number
Altitude
Message Time
7C80AC
VA1368
7124.7
01/01/0001 00:00:00 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
157
659.312
741.666558
163.436130
-2.36
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
QF23HL
QF20WG
QE37OC
QF21NP
-36.520833
-39.716823
42.8958333
-38.37
144.625
145.857333
147.208333
145.14
210.2
161.9
532.2
23.6
167.64
340.12
-0.76
-1.92
4.20
1.66
500
0
1270
VH-LTQ
-37.38
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.39
-0.50
92.19
104.06
377.00
1001.00
-161.74
-162.71
-8.74
-9.71
Total Path Loss dB
-266.74
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
4.11
HomeStation
Dingee
Corop
Girgarre East
Tatura
Colbinabbin
Murchison
Miepoll
Bendigo
Nagambie
Euroa
Heathcote
Seymour
Castlemaine
Kyneton
Broadford
Yea
Alexandra
Woodend
Romsey
Gisborne
Sunbury
Craigieburn
Whittlesea
Kinglake N.P.
Marysville
Melton
Broadmeadows
Kangaroo Ground
Healesville
Keilor
Heidelberg
Sunshine
Doncaster
Croydon
Yarra Junction
Melbourne
Nunawading
Caulfield
Glen
Ballan
Lerderderg State Park
Fraser National Park
Northern Hwy
Hume Hwy
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=-37.3679743587816, Lng=144.154357910156}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
136
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
0
Unique to Local
0
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
200
400
600

What's Needed?

1. A willing partner
2. Good station with accurate antenna pointing
3. SDR with waterfall
4. GPS locking for higher bands
5. Knowledge of when aircraft will be in suitable position (requires historical data)
6. Real-time knowledge of where aircraft are at any given moment while attempting a contact

Getting real-time data

- Directly off the air
- Via internet servers
- Both make use of mode S and/or ADS-B transponder data
- Both provide accurate real-time data
- Getting data directly off the air is fun, but for our purposes internet data is necessary

Realtime data at W3SZ

- $19.95 RTL2378 Dongle from Amazon
- WIMO-GP1090 antenna
- Kuhne 1090 MHz preamplifier
- Free RTL1090 decoder/server software
- AircraftScatter Sharp or PlanePlotter
- I generally see 20-60 planes at a time
  - Limited southern exposure due to State Forest

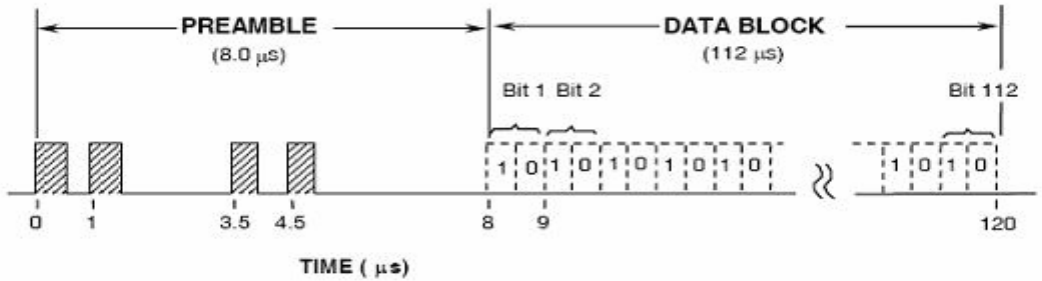
3.1.2.3 MODE S DATA STRUCTURE

3.1.2.3.1 *DATA ENCODING*

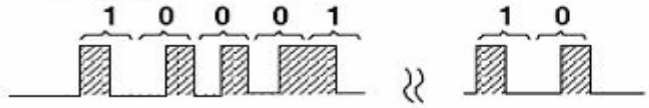
3.1.2.3.1.1 *Interrogation data.* The interrogation data block shall consist of the sequence of 56 or 112 data chips positioned after the data phase reversals within P_6 (3.1.2.1.5.2.3). A 180-degree carrier phase reversal preceding a chip shall characterize that chip as a binary ONE. The absence of a preceding phase reversal shall denote a binary ZERO.

3.1.2.3.1.2 *Reply data.* The reply data block shall consist of 56 or 112 data bits formed by binary pulse position modulation encoding of the reply data as described in 3.1.2.2.5.1.2. A pulse transmitted in the first half of the interval shall represent a binary ONE whereas a pulse transmitted in the second half shall represent a binary ZERO.

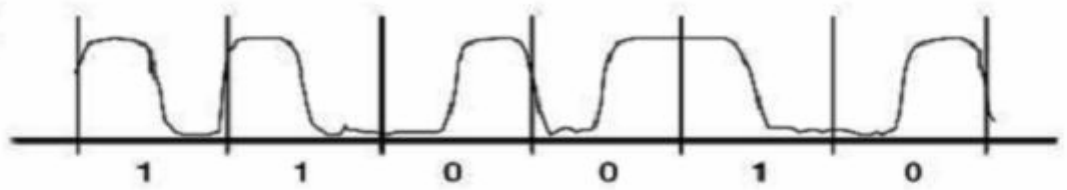
+ A chip early in the sample period is considered a logic "1"
+ A chip late in the sample period is considered a logic "0"



EXAMPLE:



• PULSE POSITION MODULATION (PPM)
• DATA RATE = 1 Mb/s



Decoding Example

We received the following frame of binary data after demodulation:

10001101101011001101001110110101011000110000000001001110001101010001011110001100101101001000010 0

The first 5 bits contain the DownLink format, and DF = 17 identifies it as an ADS-B Extended Squitter broadcast, which consists of a 112 bits total.

Bits 8-32 contain the aircrafts registration information under the International Civil Aviation Organization (ICAO). This aircraft's ICAO address is ACD3B5, which identifies it as a Mooney M20 owned by Wagner Enterprises.

The first 8 bits of the message field give TypeCode = 12, subtype code = 3, which is one of the identifiers for an airborne position message, and the remaining bits encode the location itself, giving the coordinates 38.4049 N, 89.6434 W. The straight line distance from our receiving station on the Washington University campus to the airplane's location is approximately 60 km, which is well within the unambiguous range of CPR encoded location, so we can be sure that this was in fact the location of the airplane when the message was received.

The final 24 bits of the ADS-B message are a parity check and contain no additional information.

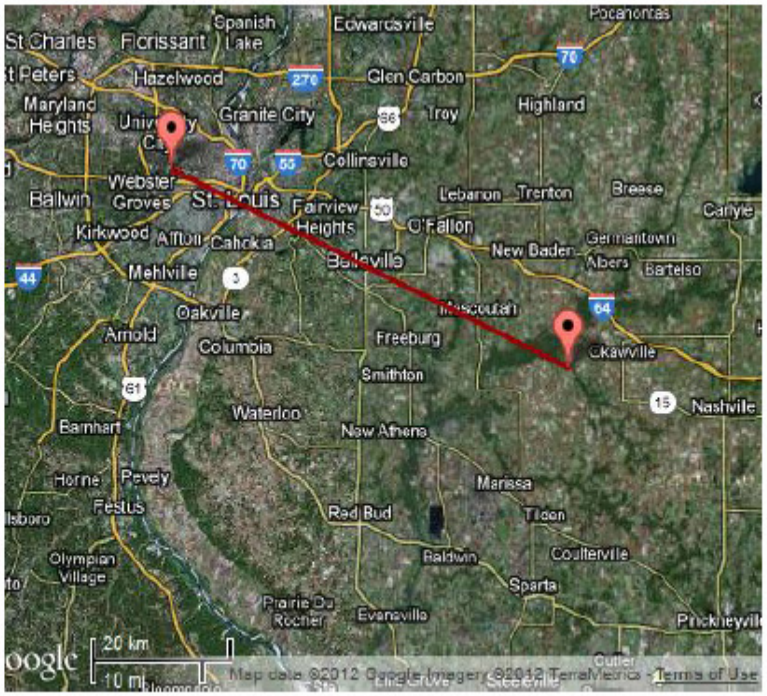


Figure 4: Receiving station (left) and Aircraft location (right).

CPR Decoding Algorithm

Given a zoneXCoord and zoneYCoord extracted from the ADS-B message, and the latitude and longitude of the receiver latS and lonS, the latitude and longitude of the aircraft can be decoded as follows:

dLat = 360 / (60 – cprFormat) where cprFormat = 1 for "odd" frames and 0 for "even" frames.

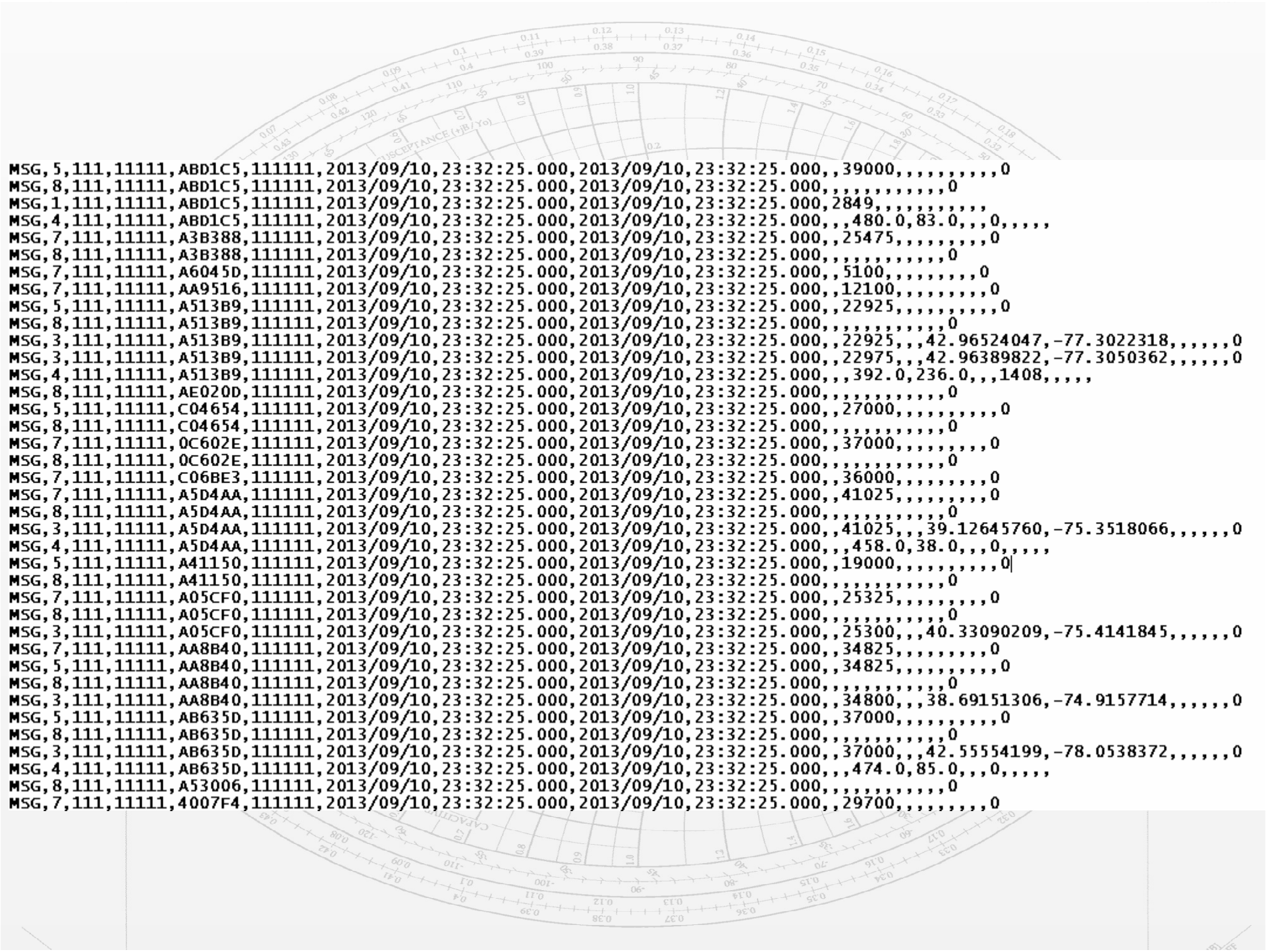
j = floor(latS / dLat) + floor(1/2+ latS mod dLat / dLat – zoneYCoord / 2^17

Latitude = dLat * (j + zoneYCoord / 2^17)

dLon = 360 / (NL(rLat) – cprFormat)

m = floor(lonS / dLon) + floor(1/2+ lonS mod dLon / dLon – zoneXCoord / 2^17

Longitude = dLon * (m + zoneXCoord / 2^17)



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MSG,8,111,11111,A5D4AA,111111,2013/09/10,23:32:25.000,2013/09/10,23:32:25.000,,,,,,,,,,,,0
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MSG,5,111,11111,AB635D,111111,2013/09/10,23:32:25.000,2013/09/10,23:32:25.000,,37000,,,,,,,,,0
MSG,8,111,11111,AB635D,111111,2013/09/10,23:32:25.000,2013/09/10,23:32:25.000,,,,,,,,,,,,0
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MSG,8,111,11111,A53006,111111,2013/09/10,23:32:25.000,2013/09/10,23:32:25.000,,,,,,,,,,,,0
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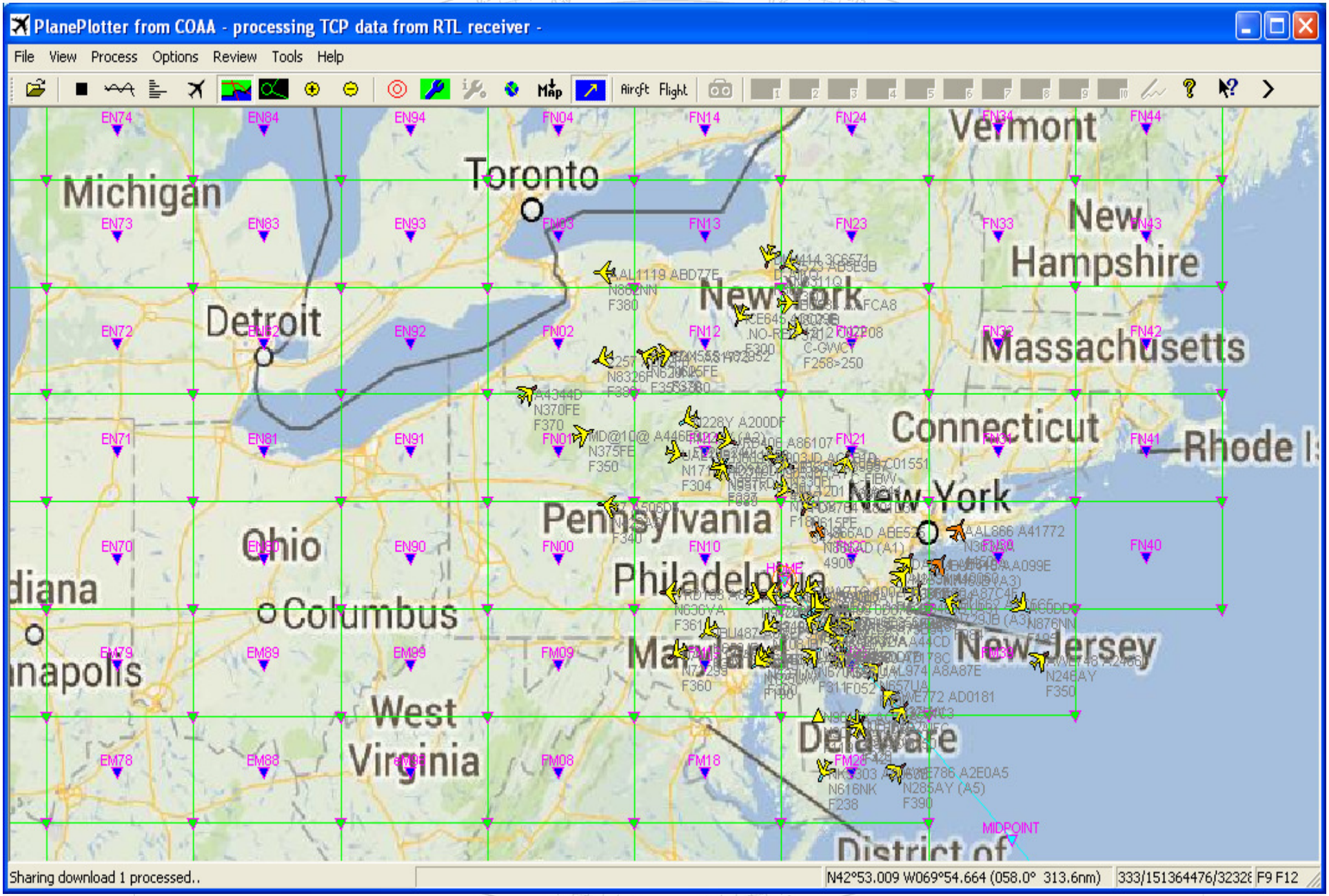
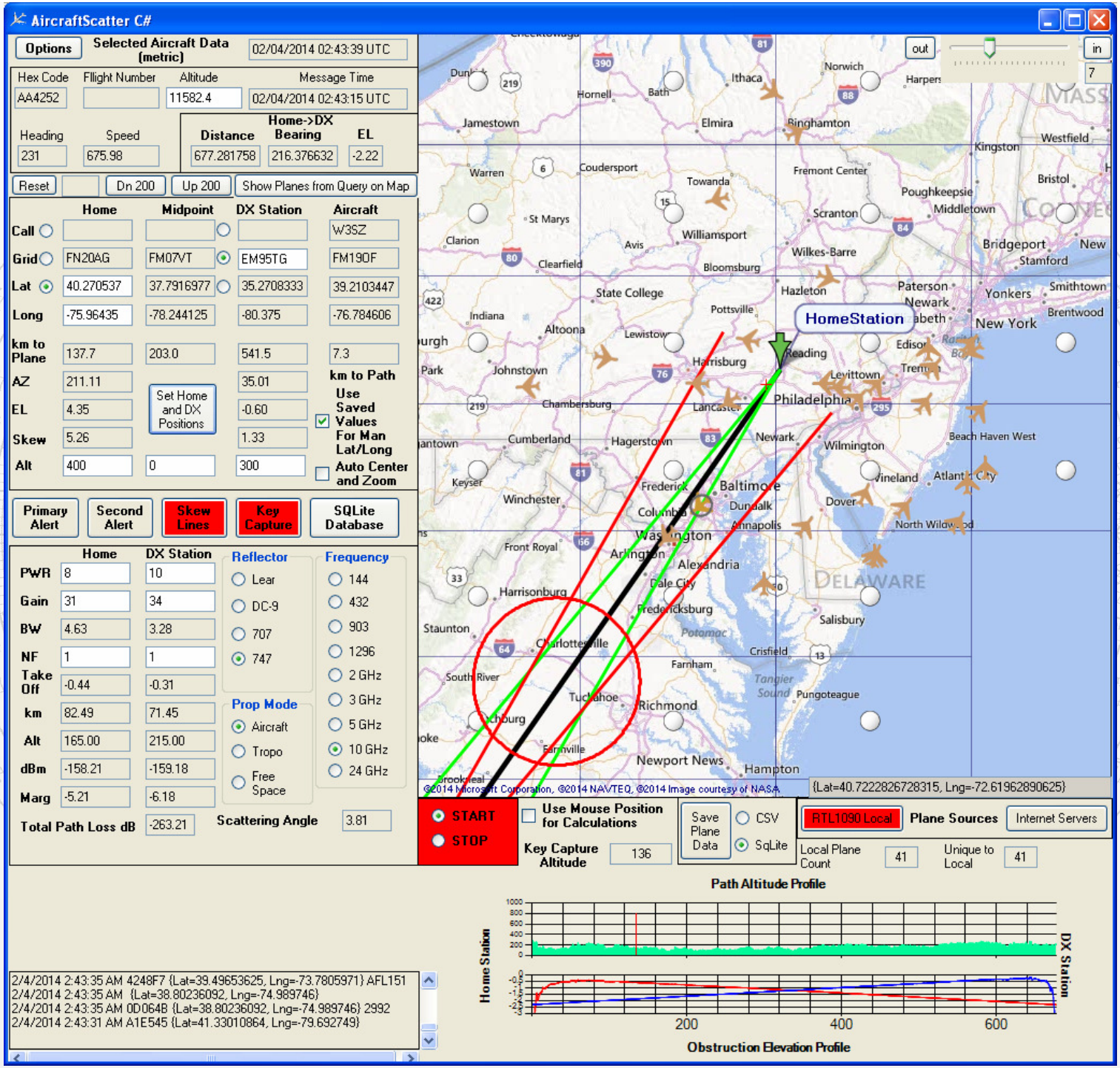

PlanePlotter from COAA - processing TCP data from RTL receiver -
File View Process Options Review Tools Help
Aircft Flight
Vermont
Michigan
Toronto
New Hampshire
New York
Detroit
Massachusetts
Connecticut
Rhode I
Pennsylvania
New York
Ohio
Philadelphia
Columbus
New Jersey
West Virginia
Delaware
MIDPOINT
Sharing download 1 processed..
N42°53.009 W069°54.664 (058.0° 313.6nm)
333/151364476/32328
F9 F12


AircraftScatter C#
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02/04/2014 02:43:39 UTC
Hex Code
Fllight Number
Altitude
Message Time
AA4252
11582.4
02/04/2014 02:43:15 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
231
675.98
677.281758
216.376632
-2.22
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
W3SZ
FN20AG
FM07VT
EM95TG
FM19OF
40.270537
37.7916977
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39.2103447
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-78.244125
-80.375
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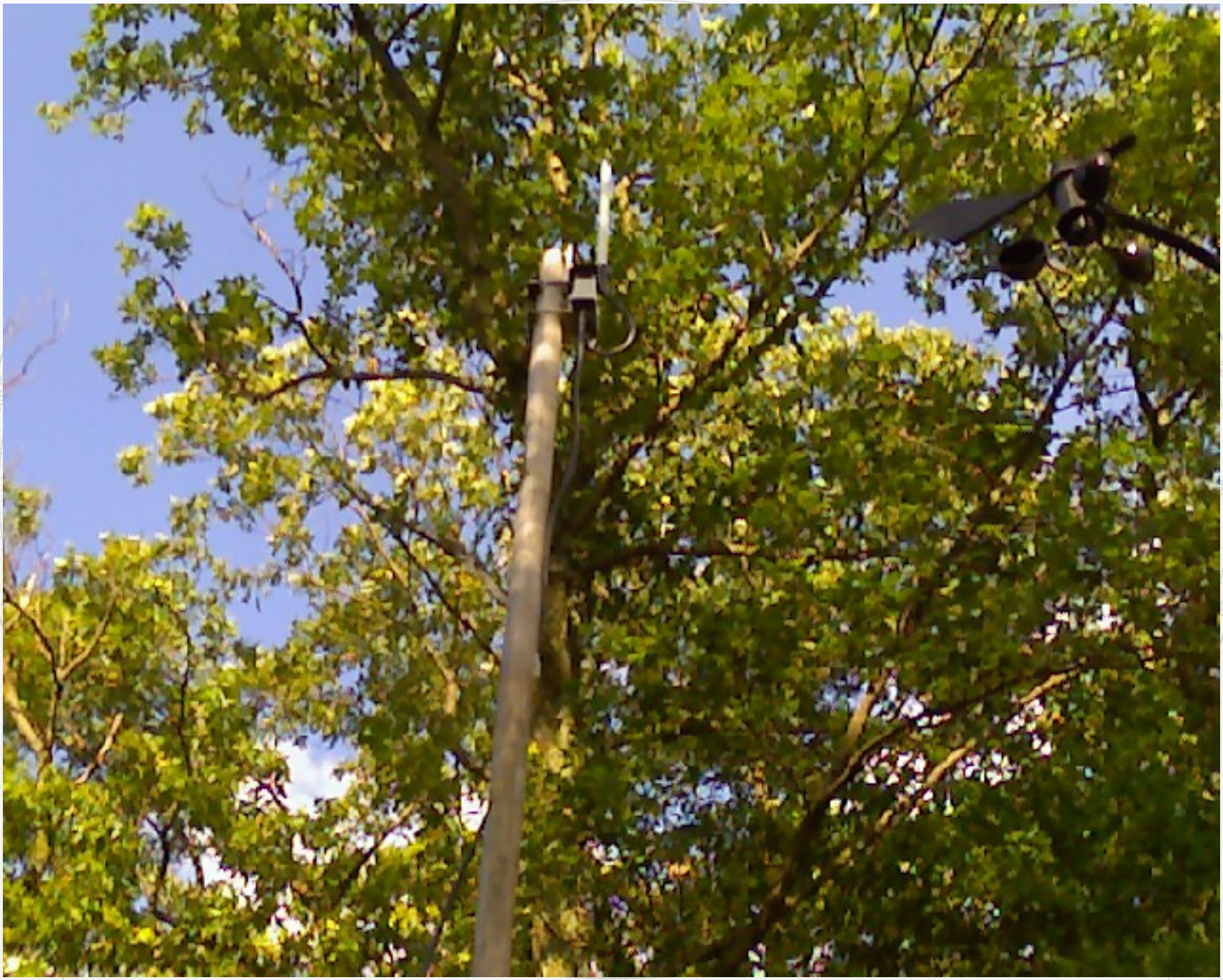
137.7
203.0
541.5
7.3
211.11
35.01
4.35
-0.60
5.26
1.33
400
0
300
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.44
-0.31
82.49
71.45
165.00
215.00
-158.21
-159.18
-5.21
-6.18
Total Path Loss dB
-263.21
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.81
HomeStation
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=40.7222826728315, Lng=-72.61962890625}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
136
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
41
Unique to Local
41
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
2/4/2014 2:43:35 AM 4248F7 {Lat=39.49653625, Lng=-73.7805971} AFL151
2/4/2014 2:43:35 AM {Lat=38.80236092, Lng=-74.989746}
2/4/2014 2:43:35 AM 0D064B {Lat=38.80236092, Lng=-74.989746} 2992
2/4/2014 2:43:31 AM A1E545 {Lat=41.33010864, Lng=-79.692749}



Internet Servers

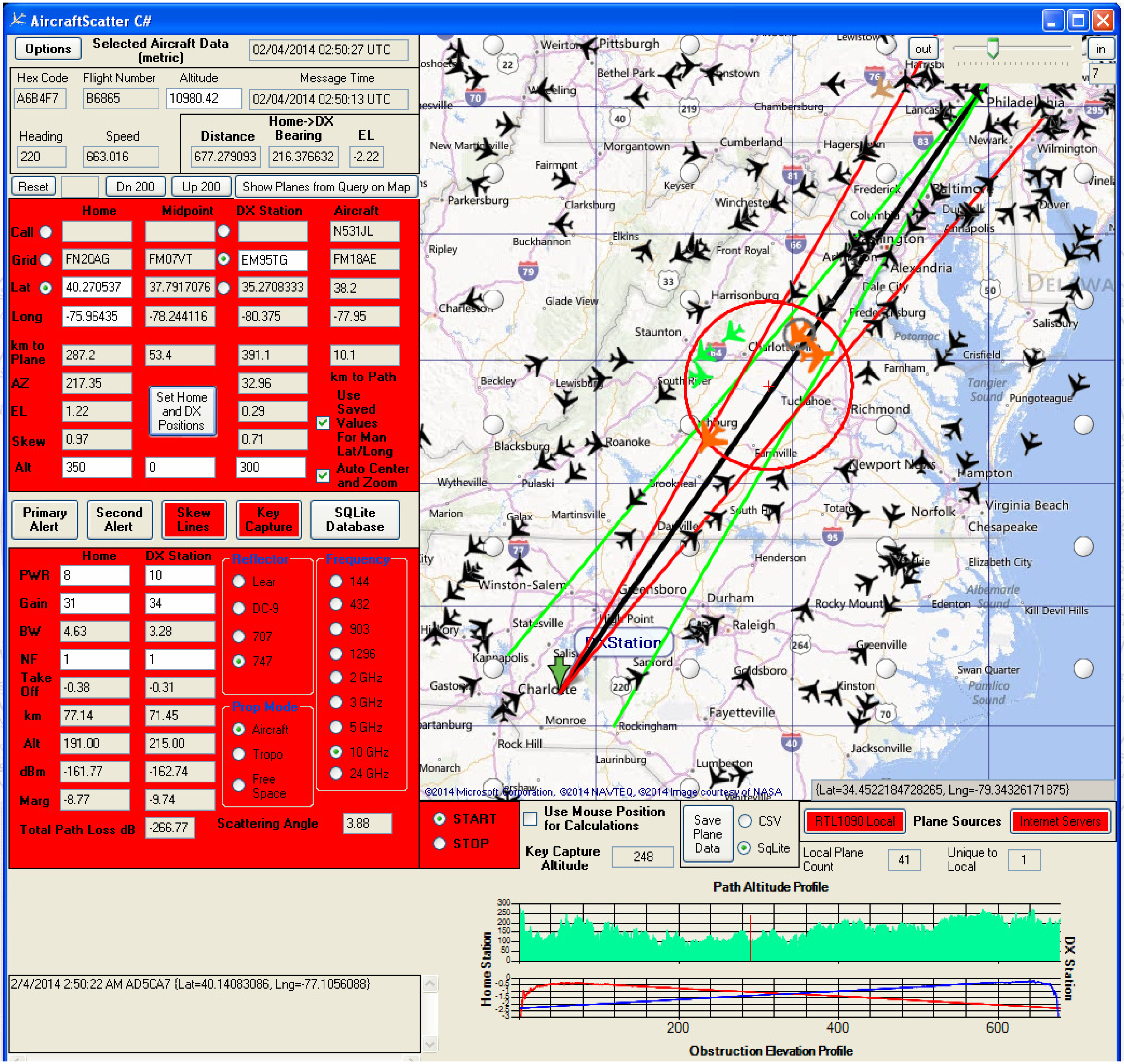
- Use with a display/analysis program
- Initial approach was with PlanePlotter and add-on software that I wrote
- Subsequently wrote C# program that obtains data directly from internet servers, has map and analysis functions integrated into one package
- This program also provides database capabilities which are very important for planning aircraft scatter sessions

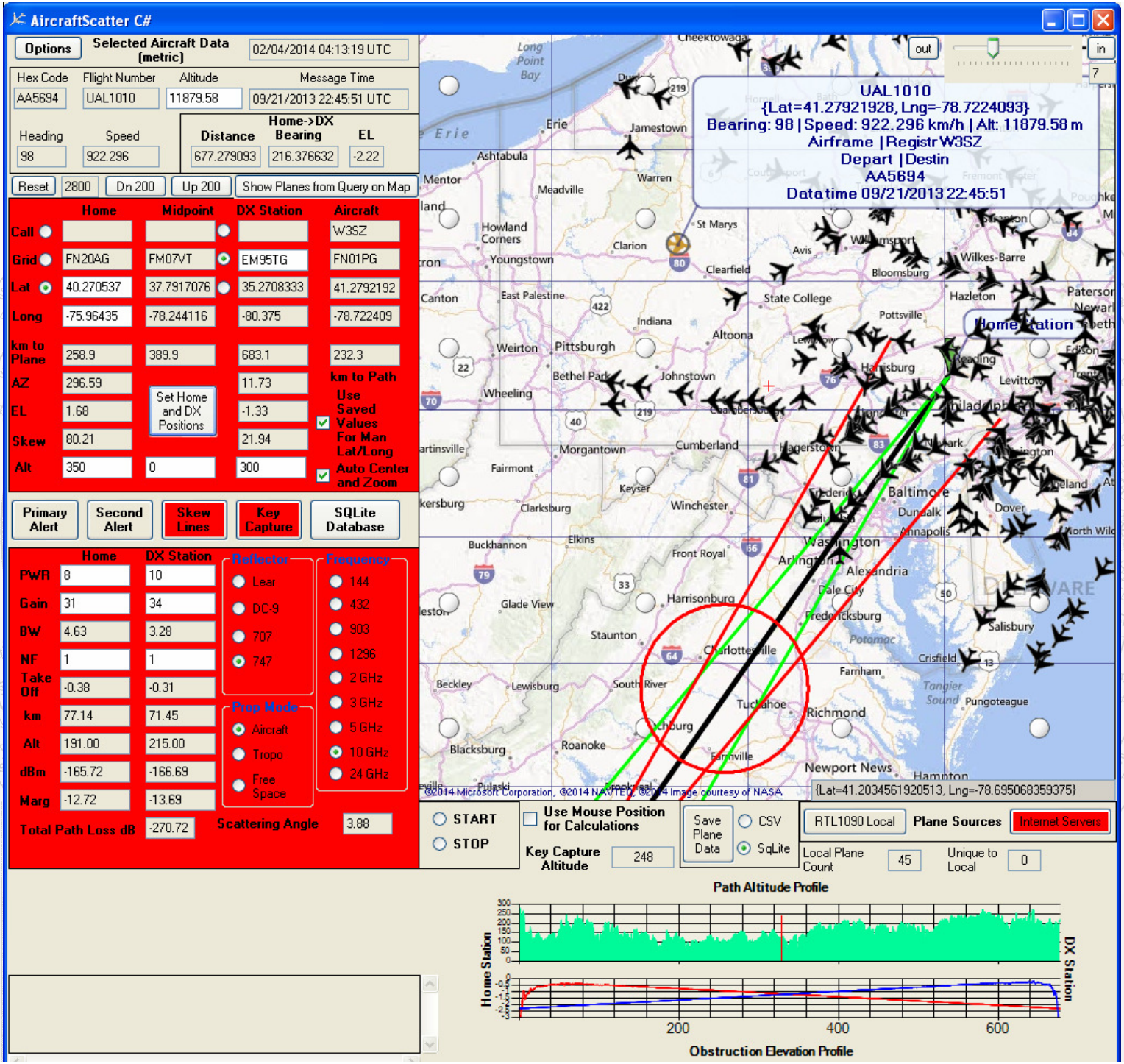
AircraftScatter Sharp

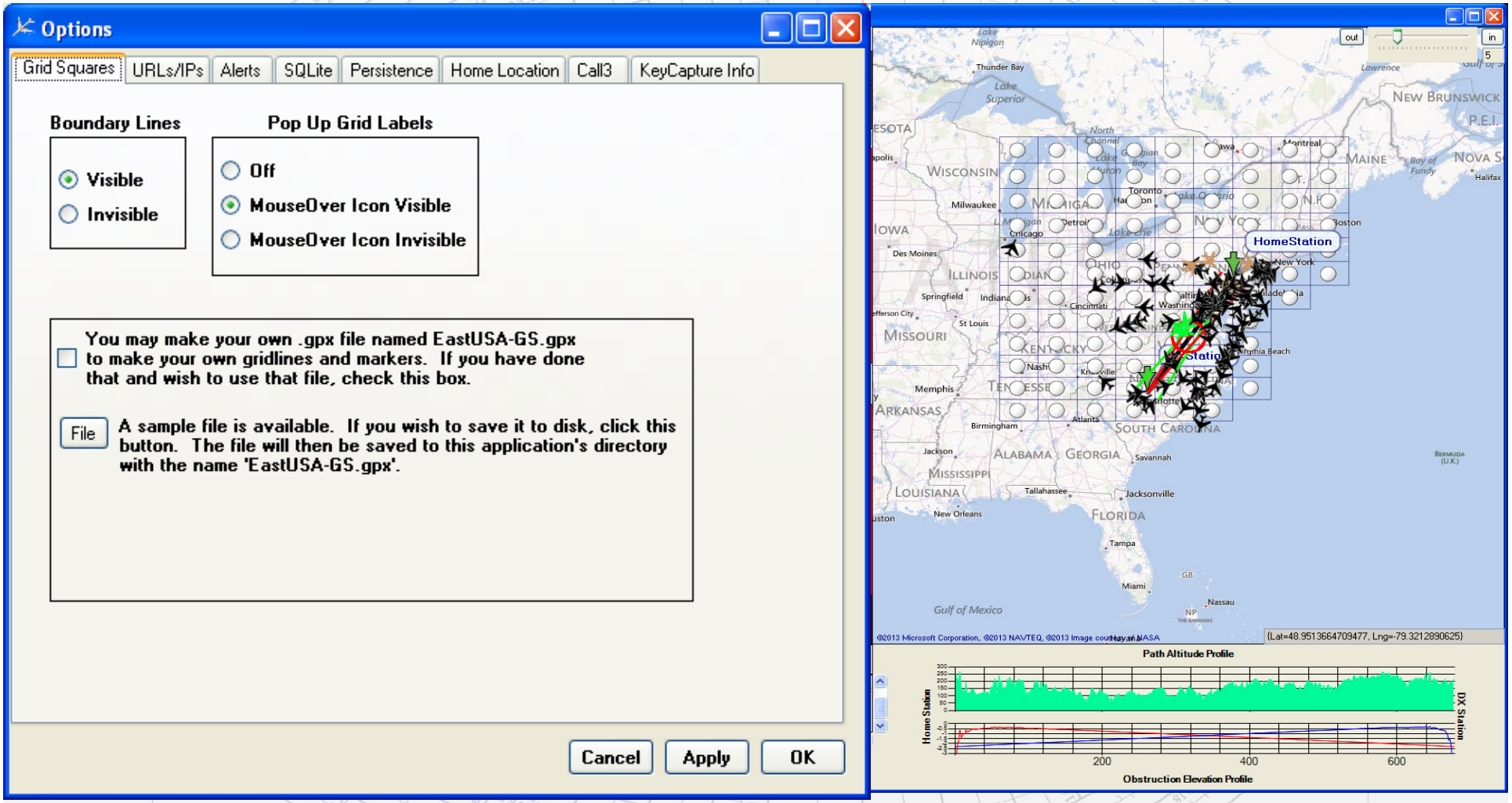
- Displays real-time plane position information
- Displays direct path line between two stations, along with skew lines and a midpoint circle (both user adjustable)
- Visually highlights aircraft which are near the position of optimal forward scatter enhancement, with optional audible alarms as well

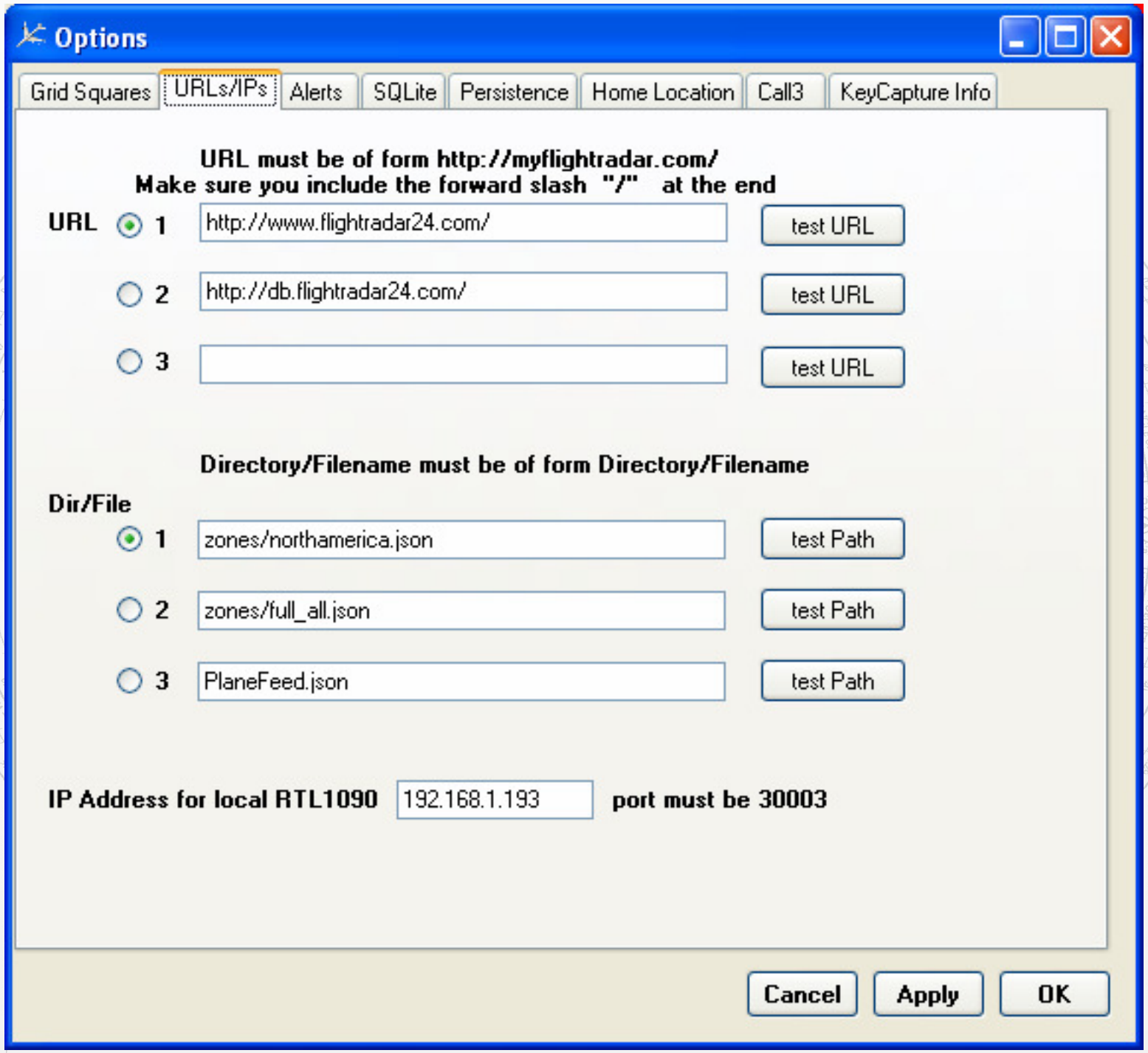
AircraftScatter Sharp

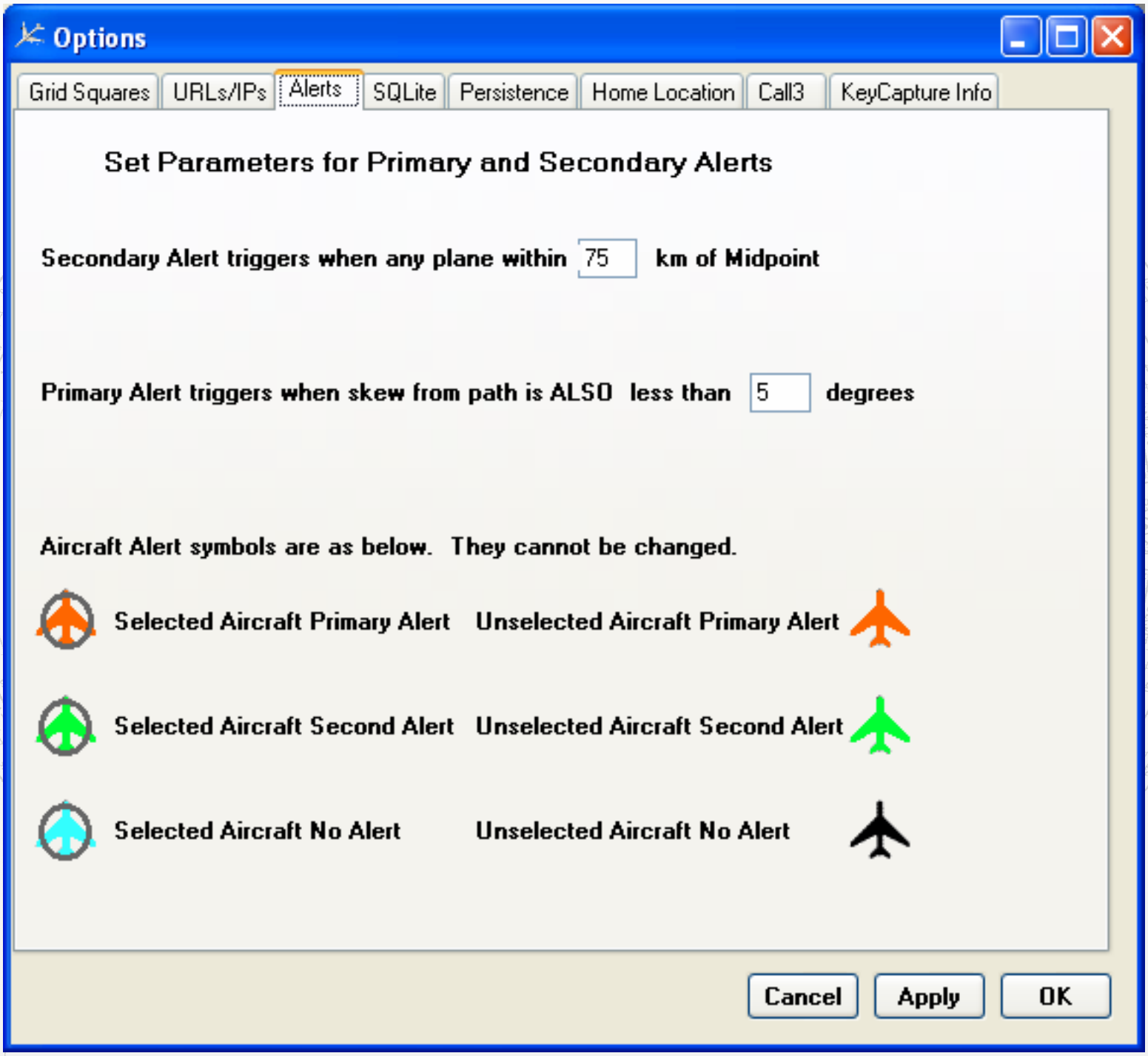
- Does real-time calculation of path loss, received signal strength at both locations based on plane position and station characteristics
- Allows storage of ALL received plane data in an integrated SqLite database, with automated query functions to permit tailored data analysis, useful for session planning and scheduling
- Map display and RF calculations can be done using the data of planes stored in SqLite database, just as with real-time plane data

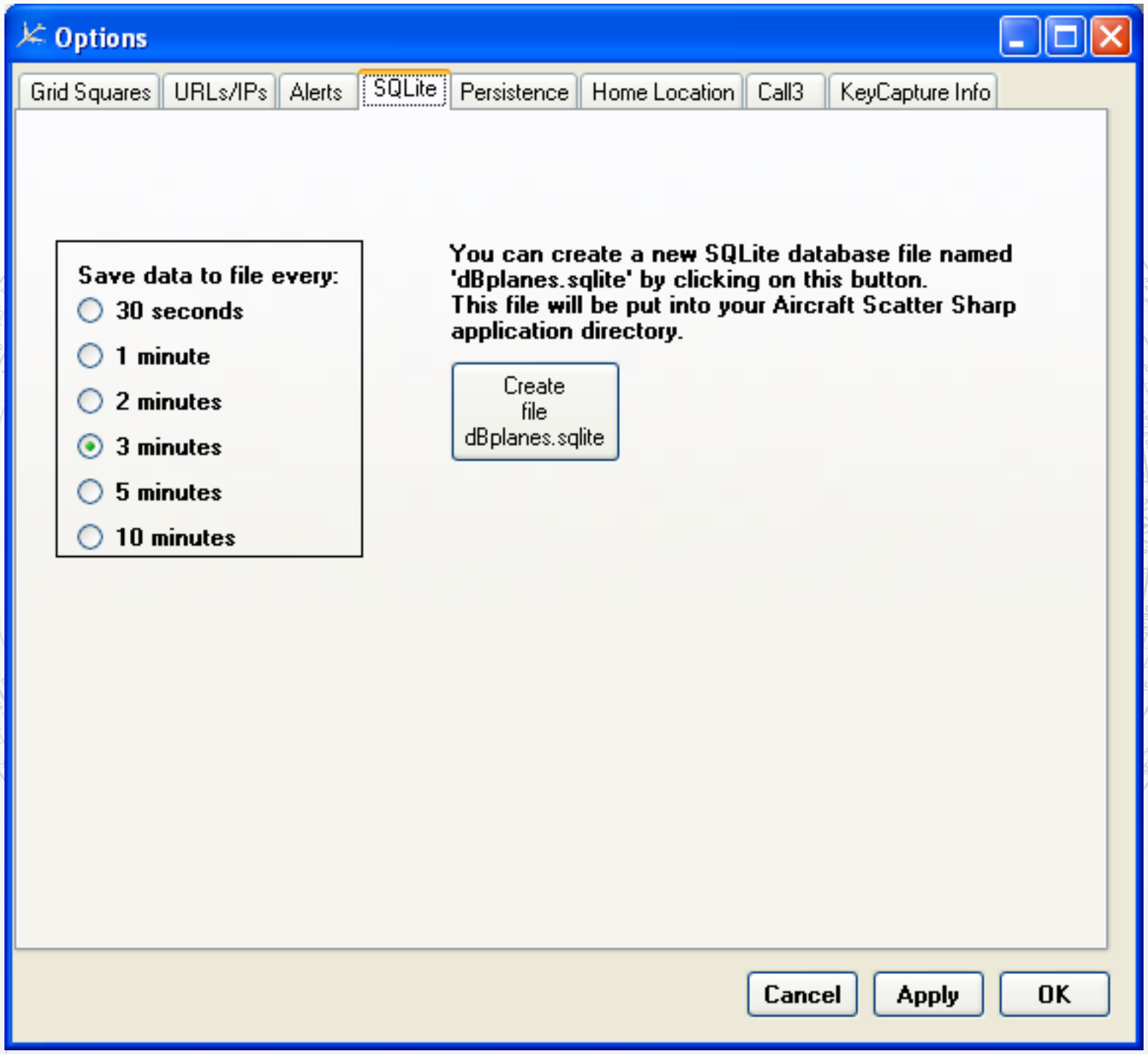

AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/04/2014 02:50:27 UTC
Hex Code
Flight Number
Altitude
Message Time
A6B4F7
B6865
10980.42
02/04/2014 02:50:13 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
220
663.016
677.279093
216.376632
-2.22
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
N531JL
Grid
FN20AG
FM07VT
EM95TG
FM18AE
Lat
40.270537
37.7917076
35.2708333
38.2
Long
-75.96435
-78.244116
-80.375
-77.95
km to Plane
287.2
53.4
391.1
10.1
km to Path
AZ
217.35
32.96
EL
1.22
0.29
Skew
0.97
0.71
Alt
350
0
300
Set Home and DX Positions
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
8
10
Gain
31
34
BW
4.63
3.28
NF
1
1
Take Off
-0.38
-0.31
km
77.14
71.45
Alt
191.00
215.00
dBm
-161.77
-162.74
Marg
-8.77
-9.74
Total Path Loss dB
-266.77
Scattering Angle
3.88
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
41
Unique to Local
1
out
in
7
DX Station
{Lat=34.4522184728265, Lng=-79.34326171875}
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
2/4/2014 2:50:22 AM AD5CA7 {Lat=40.14083086, Lng=-77.1056088}
Path Altitude Profile
Home Station
DX Station
200
400
600
Obstruction Elevation Profile

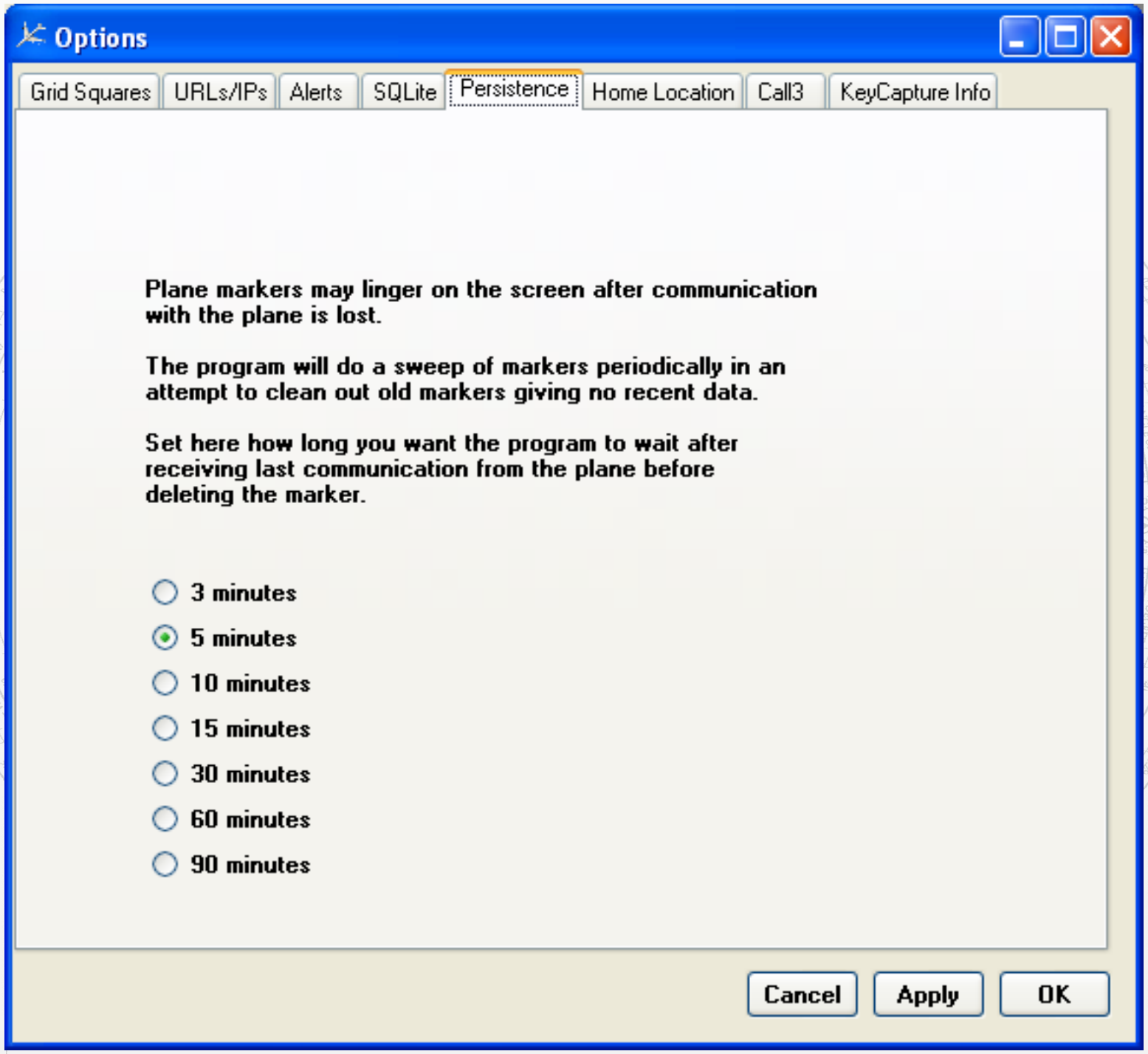

AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/04/2014 04:13:19 UTC
Hex Code
Fllight Number
Altitude
Message Time
AA5694
UAL1010
11879.58
09/21/2013 22:45:51 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
98
922.296
677.279093
216.376632
-2.22
Reset
2800
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
W3SZ
FN20AG
FM07VT
EM95TG
FN01PG
40.270537
37.7917076
35.2708333
41.2792192
-75.96435
-78.244116
-80.375
-78.722409
258.9
389.9
683.1
232.3
296.59
11.73
1.68
-1.33
80.21
21.94
350
0
300
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.38
-0.31
77.14
71.45
191.00
215.00
-165.72
-166.69
-12.72
-13.69
Total Path Loss dB
-270.72
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.88
UAL1010
{Lat=41.27921928, Lng=-78.7224093}
Bearing: 98 | Speed: 922.296 km/h | Alt: 11879.58 m
Airframe | Registr W3SZ
Depart | Destin
AA5694
Datatime 09/21/2013 22:45:51
Home Station
{Lat=41.2034561920513, Lng=-78.695068359375}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
45
Unique to Local
0
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
200
400
600

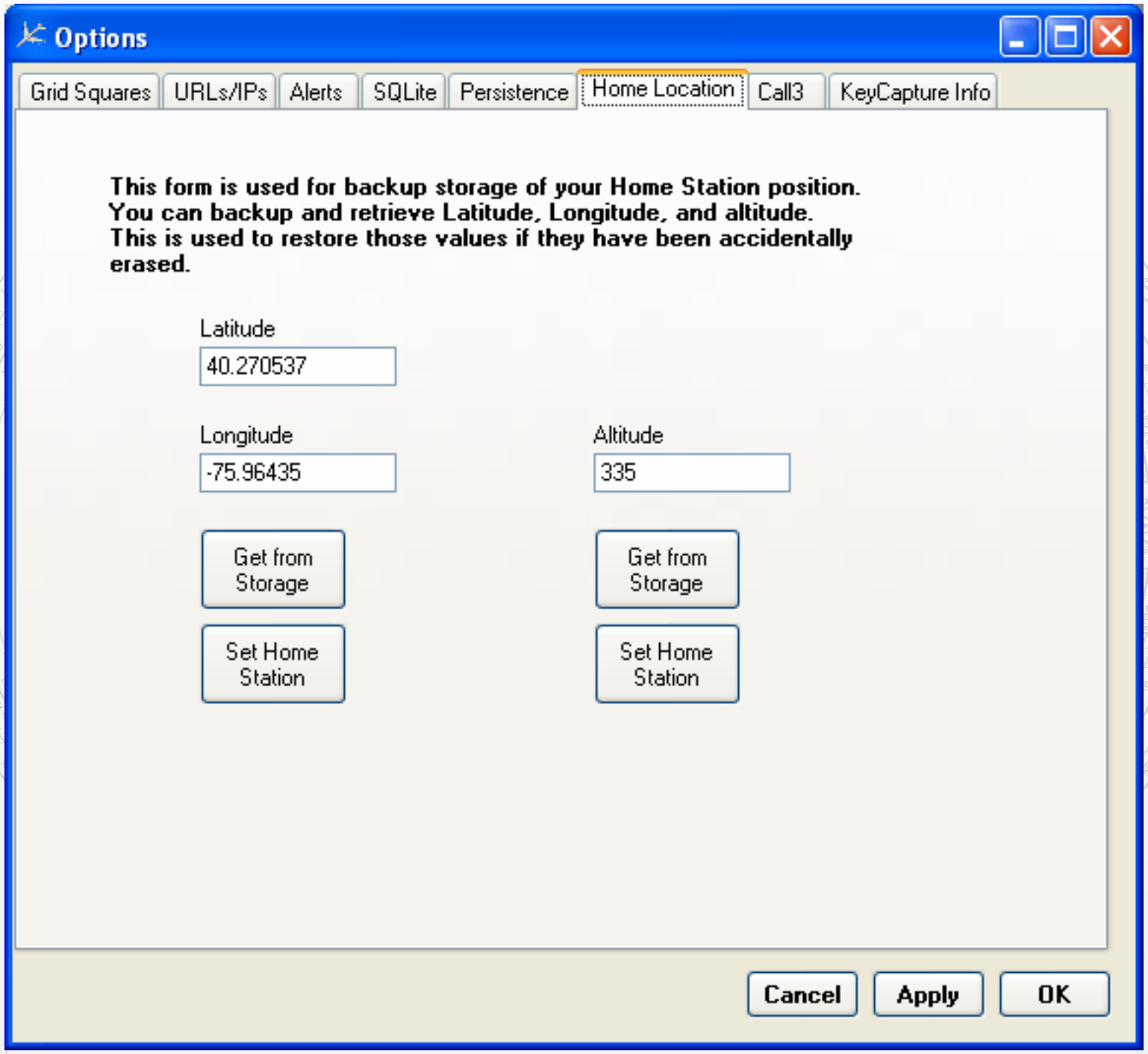

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
Boundary Lines
Visible
Invisible
Pop Up Grid Labels
Off
MouseOver Icon Visible
MouseOver Icon Invisible
You may make your own .gpx file named EastUSA-GS.gpx to make your own gridlines and markers. If you have done that and wish to use that file, check this box.
File
A sample file is available. If you wish to save it to disk, click this button. The file will then be saved to this application's directory with the name 'EastUSA-GS.gpx'.
Cancel
Apply
OK
HomeStation
Path Altitude Profile
Home Station
DX Station
200
400
600
Obstruction Elevation Profile

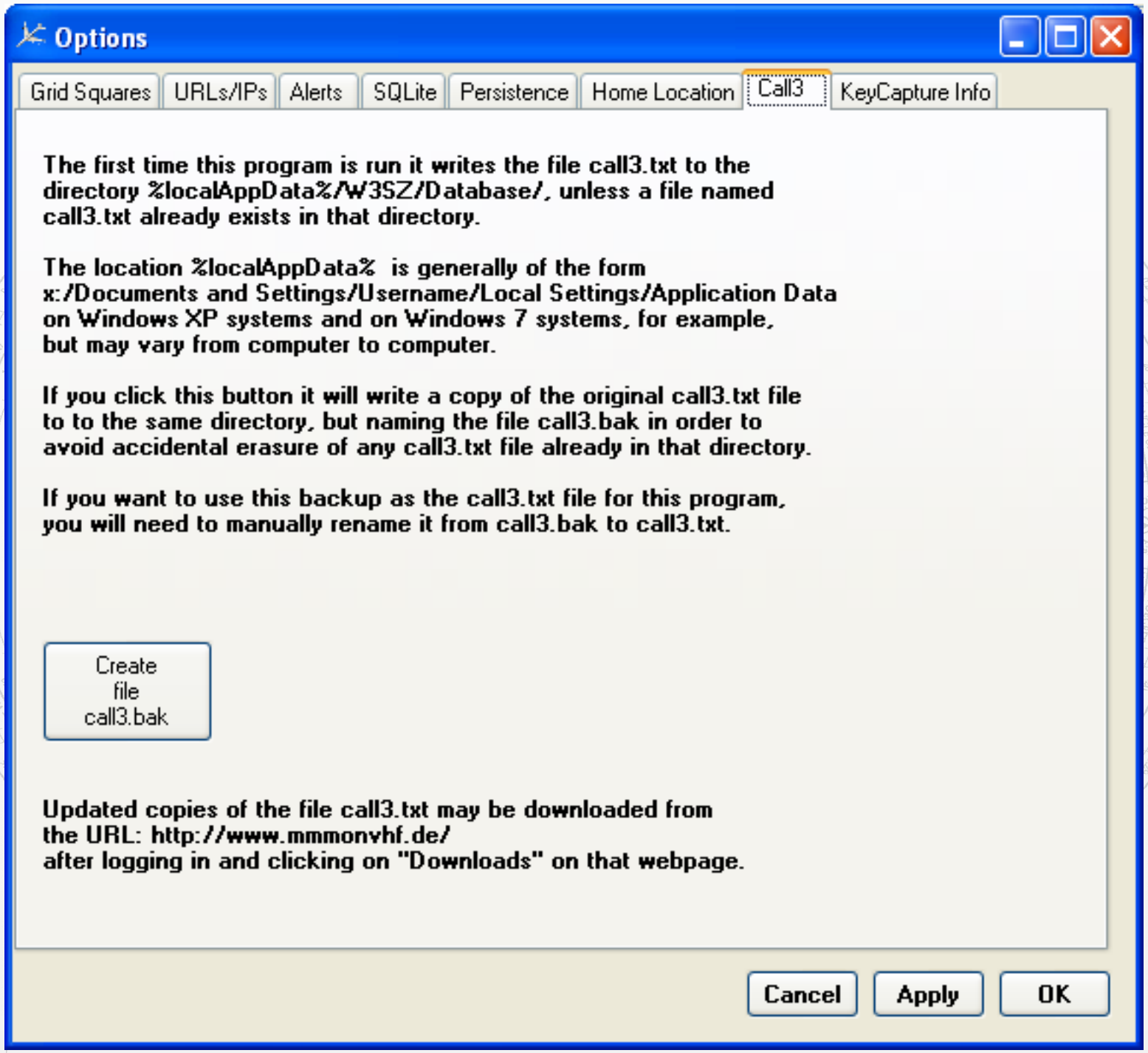

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
URL must be of form http://myflightradar.com/
Make sure you include the forward slash "/" at the end
URL
1
http://www.flightradar24.com/
test URL
2
http://db.flightradar24.com/
test URL
3
test URL
Directory/Filename must be of form Directory/Filename
Dir/File
1
zones/northamerica.json
test Path
2
zones/full_all.json
test Path
3
PlaneFeed.json
test Path
IP Address for local RTL1090
192.168.1.193
port must be 30003
Cancel
Apply
OK

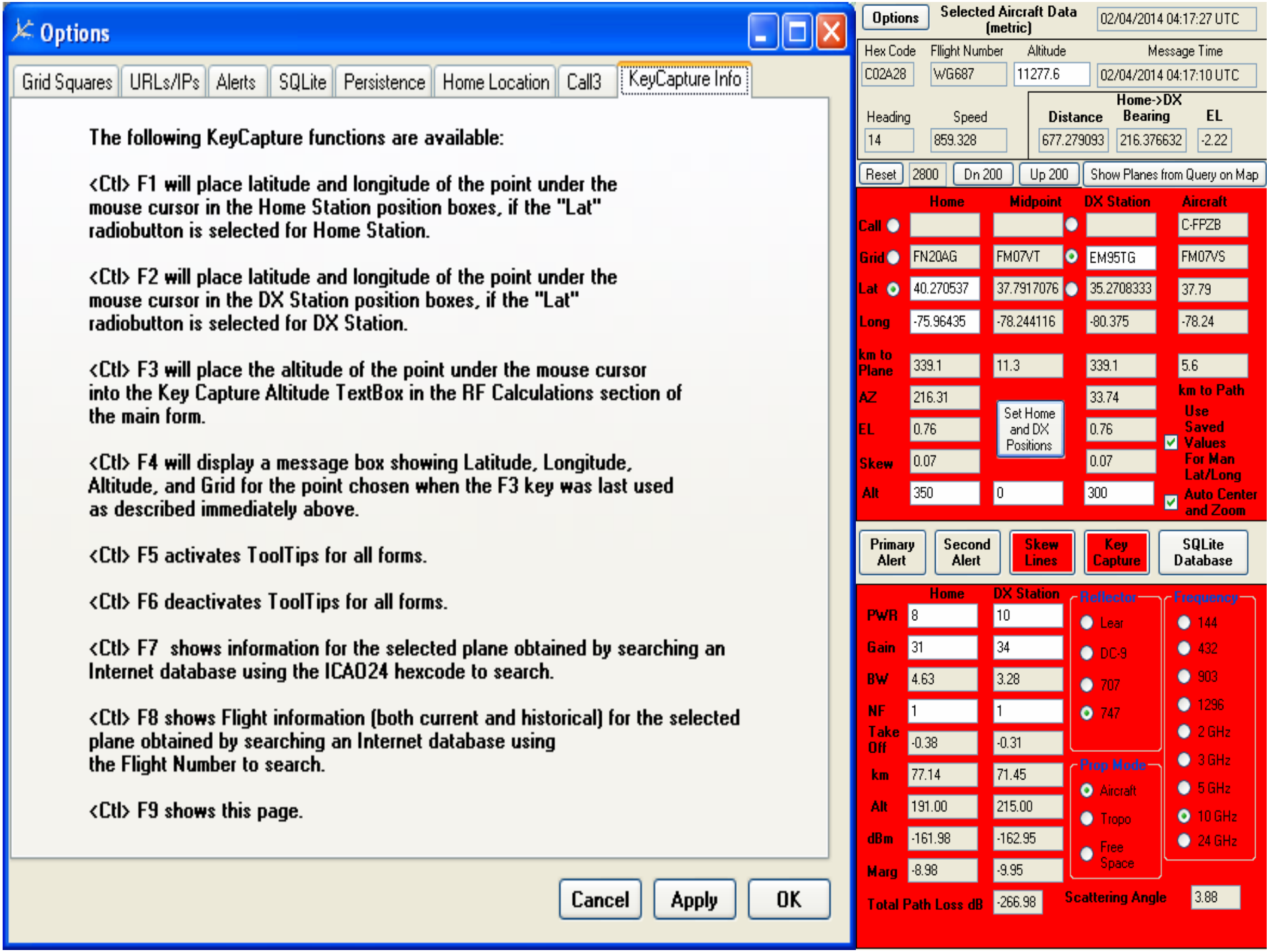

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
Set Parameters for Primary and Secondary Alerts
Secondary Alert triggers when any plane within 75 km of Midpoint
Primary Alert triggers when skew from path is ALSO less than 5 degrees
Aircraft Alert symbols are as below. They cannot be changed.
Selected Aircraft Primary Alert
Unselected Aircraft Primary Alert
Selected Aircraft Second Alert
Unselected Aircraft Second Alert
Selected Aircraft No Alert
Unselected Aircraft No Alert
Cancel
Apply
OK

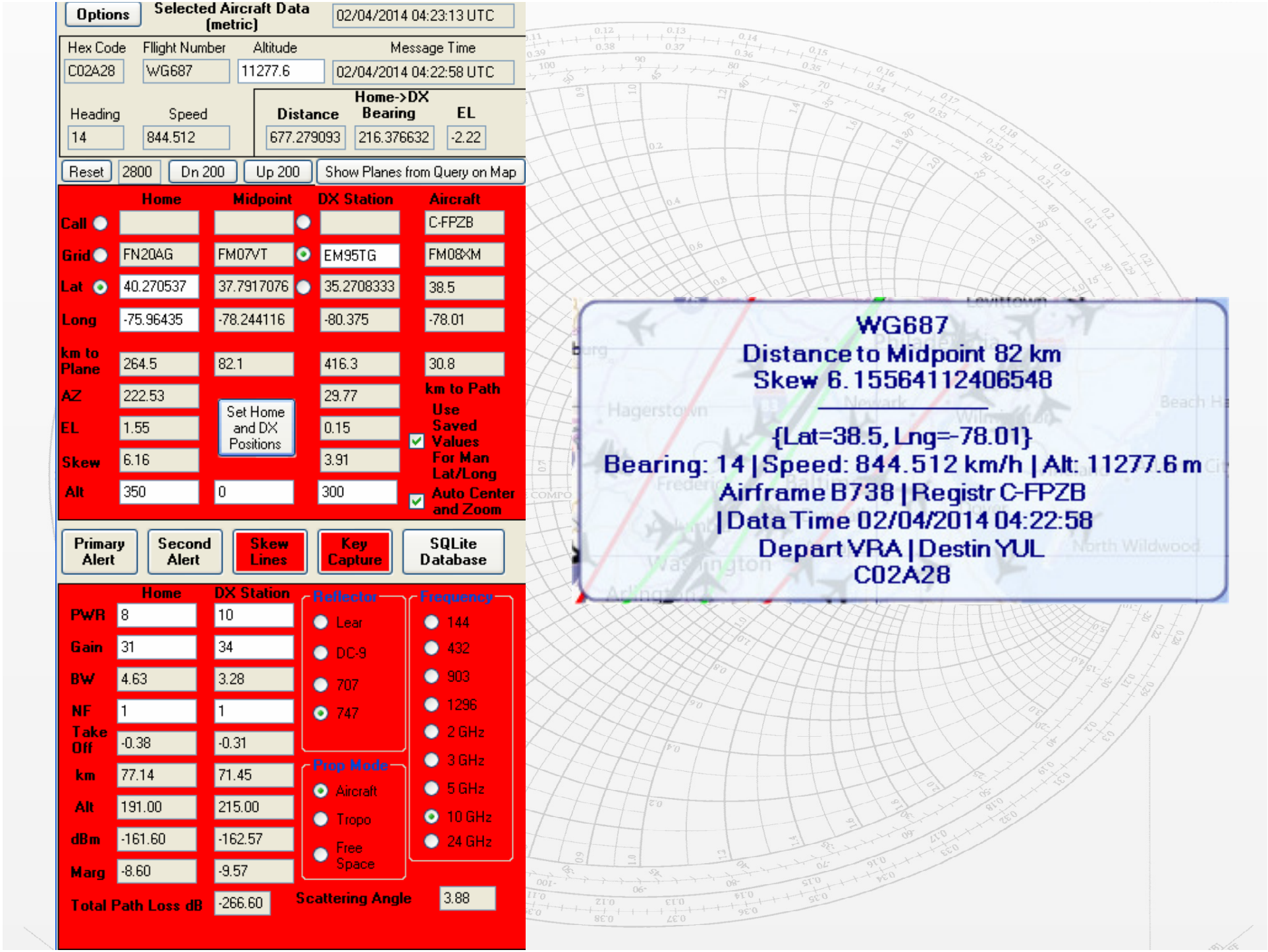

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
Save data to file every:
30 seconds
1 minute
2 minutes
3 minutes
5 minutes
10 minutes
You can create a new SQLite database file named 'dBplanes.sqlite' by clicking on this button.
This file will be put into your Aircraft Scatter Sharp application directory.
Create file dBplanes.sqlite
Cancel
Apply
OK

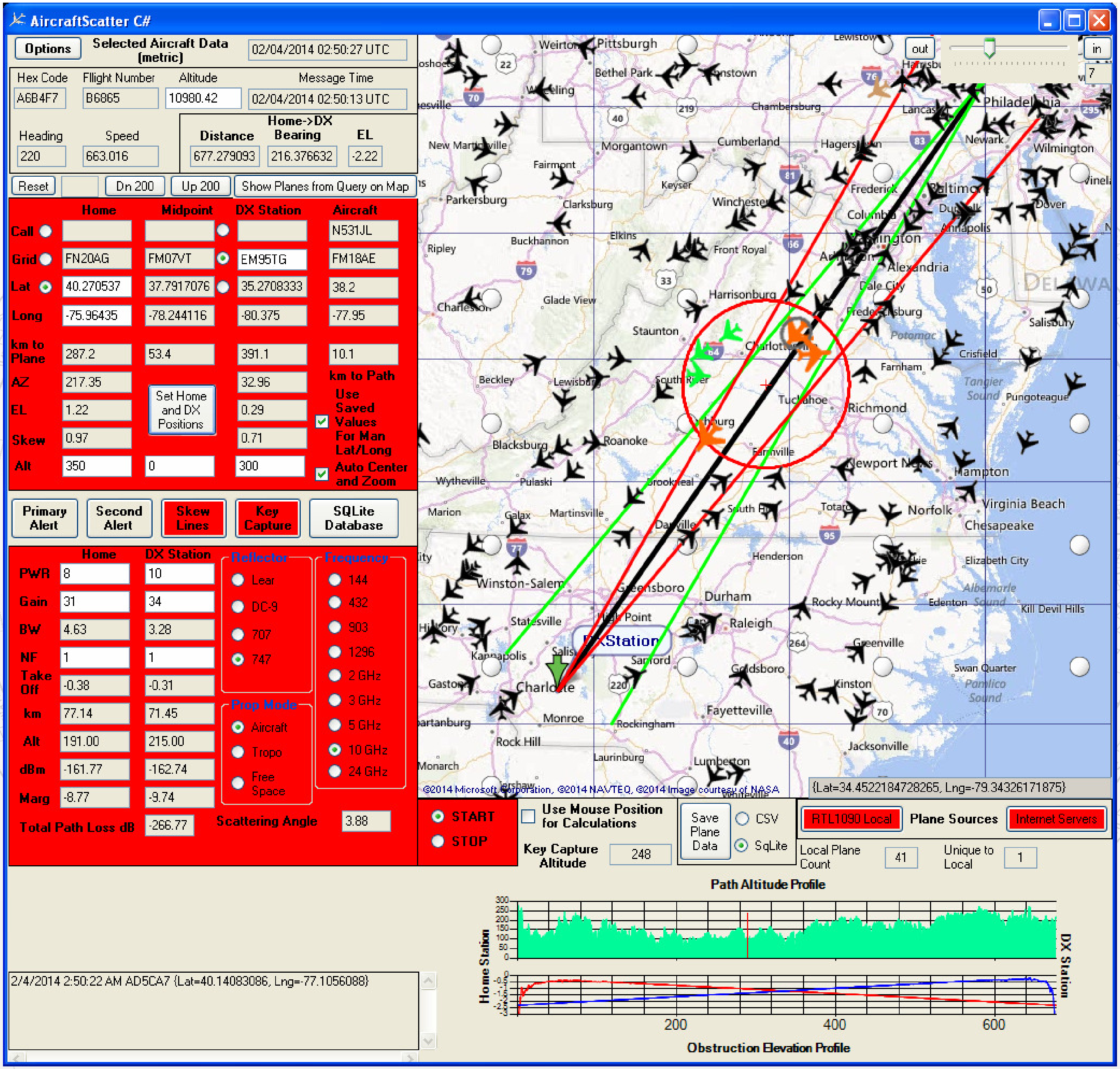

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
Plane markers may linger on the screen after communication with the plane is lost.
The program will do a sweep of markers periodically in an attempt to clean out old markers giving no recent data.
Set here how long you want the program to wait after receiving last communication from the plane before deleting the marker.
3 minutes
5 minutes
10 minutes
15 minutes
30 minutes
60 minutes
90 minutes
Cancel
Apply
OK

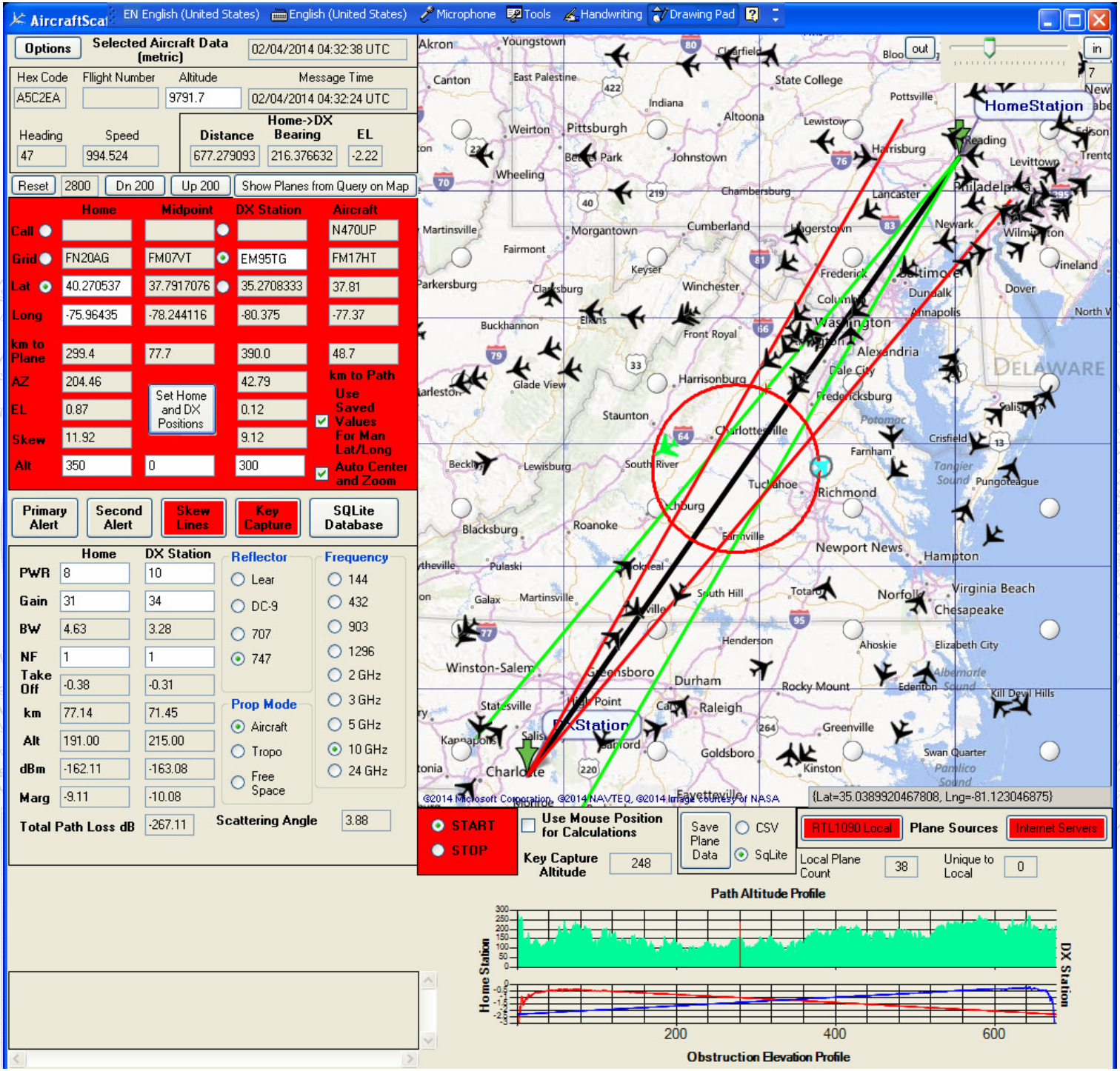

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
This form is used for backup storage of your Home Station position.
You can backup and retrieve Latitude, Longitude, and altitude.
This is used to restore those values if they have been accidentally erased.
Latitude
40.270537
Longitude
-75.96435
Altitude
335
Get from Storage
Set Home Station
Get from Storage
Set Home Station
Cancel
Apply
OK

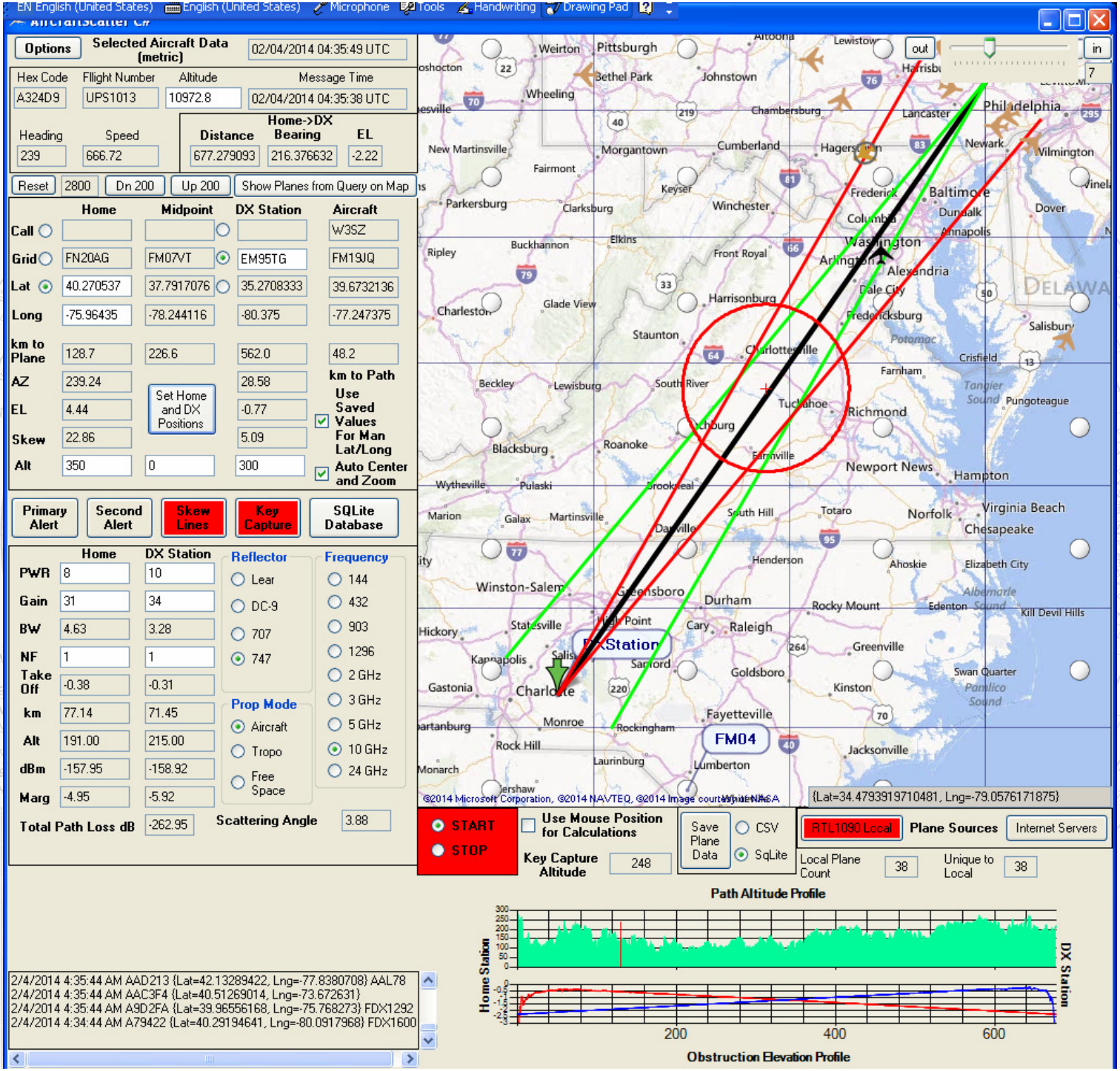

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
The first time this program is run it writes the file call3.txt to the directory %localAppData%/W3SZ/Database/, unless a file named call3.txt already exists in that directory.
The location %localAppData% is generally of the form x:/Documents and Settings/Username/Local Settings/Application Data on Windows XP systems and on Windows 7 systems, for example, but may vary from computer to computer.
If you click this button it will write a copy of the original call3.txt file to to the same directory, but naming the file call3.bak in order to avoid accidental erasure of any call3.txt file already in that directory.
If you want to use this backup as the call3.txt file for this program, you will need to manually rename it from call3.bak to call3.txt.
Create file call3.bak
Updated copies of the file call3.txt may be downloaded from the URL: http://www.mmmonvhf.de/ after logging in and clicking on "Downloads" on that webpage.
Cancel
Apply
OK

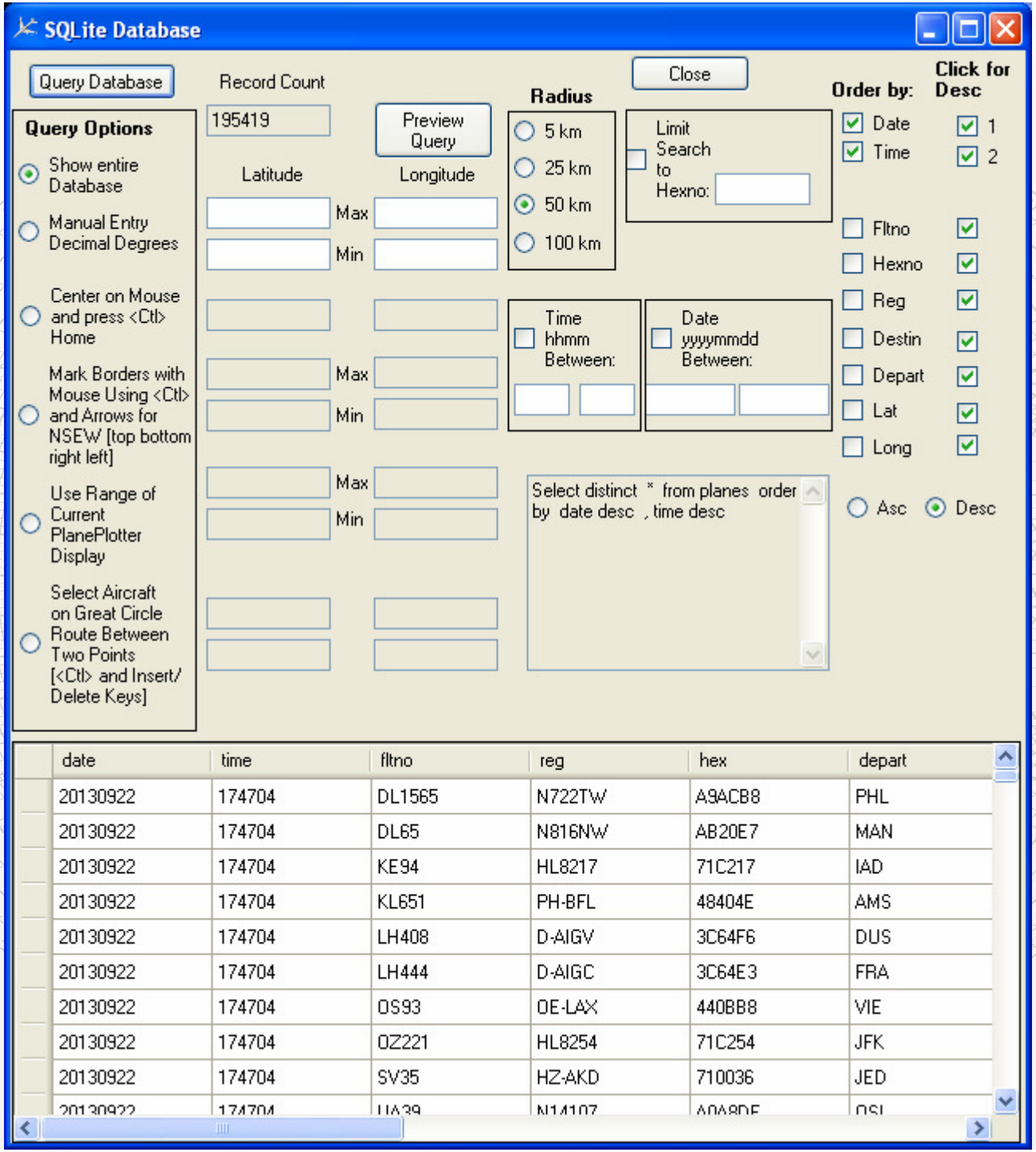

Options
Grid Squares
URLs/IPs
Alerts
SQLite
Persistence
Home Location
Call3
KeyCapture Info
The following KeyCapture functions are available:
<Ctl> F1 will place latitude and longitude of the point under the mouse cursor in the Home Station position boxes, if the "Lat" radiobutton is selected for Home Station.
<Ctl> F2 will place latitude and longitude of the point under the mouse cursor in the DX Station position boxes, if the "Lat" radiobutton is selected for DX Station.
<Ctl> F3 will place the altitude of the point under the mouse cursor into the Key Capture Altitude TextBox in the RF Calculations section of the main form.
<Ctl> F4 will display a message box showing Latitude, Longitude, Altitude, and Grid for the point chosen when the F3 key was last used as described immediately above.
<Ctl> F5 activates ToolTips for all forms.
<Ctl> F6 deactivates ToolTips for all forms.
<Ctl> F7 shows information for the selected plane obtained by searching an Internet database using the ICAO24 hexcode to search.
<Ctl> F8 shows Flight information (both current and historical) for the selected plane obtained by searching an Internet database using the Flight Number to search.
<Ctl> F9 shows this page.
Cancel
Apply
OK
Options
Selected Aircraft Data (metric)
02/04/2014 04:17:27 UTC
Hex Code
Fllight Number
Altitude
Message Time
C02A28
WG687
11277.6
02/04/2014 04:17:10 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
14
859.328
677.279093
216.376632
-2.22
Reset
2800
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
C-FPZB
Grid
FN20AG
FM07VT
EM95TG
FM07VS
Lat
40.270537
37.7917076
35.2708333
37.79
Long
-75.96435
-78.244116
-80.375
-78.24
km to Plane
339.1
11.3
339.1
5.6
AZ
216.31
33.74
km to Path
EL
0.76
Set Home and DX Positions
0.76
Use Saved Values For Man Lat/Long
Skew
0.07
0.07
Alt
350
0
300
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
Reflector
Frequency
PWR
8
10
Lear
144
Gain
31
34
DC-9
432
BW
4.63
3.28
707
903
NF
1
1
747
1296
Take Off
-0.38
-0.31
2 GHz
km
77.14
71.45
Prop Mode
3 GHz
Alt
191.00
215.00
Aircraft
5 GHz
dBm
-161.98
-162.95
Tropo
10 GHz
Marg
-8.98
-9.95
Free Space
24 GHz
Total Path Loss dB
-266.98
Scattering Angle
3.88

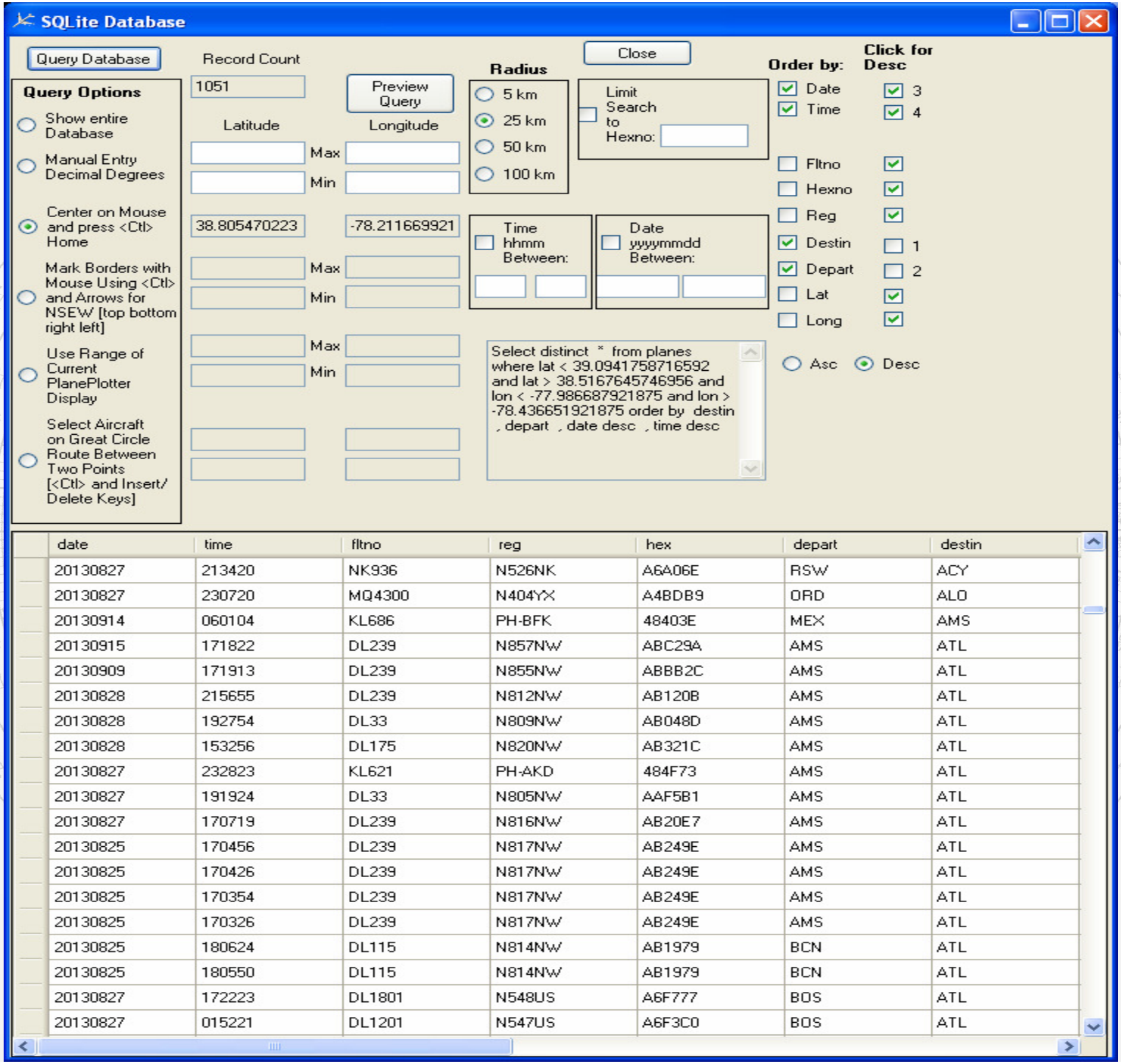

Options
Selected Aircraft Data (metric)
02/04/2014 04:23:13 UTC
Hex Code
Fllight Number
Altitude
Message Time
C02A28
WG687
11277.6
02/04/2014 04:22:58 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
14
844.512
677.279093
216.376632
-2.22
Reset
2800
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
C-FPZB
Grid
FN20AG
FM07VT
EM95TG
FM08XM
Lat
40.270537
37.7917076
35.2708333
38.5
Long
-75.96435
-78.244116
-80.375
-78.01
km to Plane
264.5
82.1
416.3
30.8
AZ
222.53
29.77
km to Path
EL
1.55
0.15
Skew
6.16
3.91
Alt
350
0
300
Set Home and DX Positions
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
8
10
Gain
31
34
BW
4.63
3.28
NF
1
1
Take Off
-0.38
-0.31
km
77.14
71.45
Alt
191.00
215.00
dBm
-161.60
-162.57
Marg
-8.60
-9.57
Total Path Loss dB
-266.60
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.88
WG687
Distance to Midpoint 82 km
Skew 6.15564112406548
{Lat=38.5, Lng=-78.01}
Bearing: 14 | Speed: 844.512 km/h | Alt: 11277.6 m
Airframe B738 | Registr C-FPZB
| Data Time 02/04/2014 04:22:58
Depart VRA | Destin YUL
C02A28


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/04/2014 02:50:27 UTC
Hex Code
Fllight Number
Altitude
Message Time
A6B4F7
B6865
10980.42
02/04/2014 02:50:13 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
220
663.016
677.279093
216.376632
-2.22
Reset
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
N531JL
Grid
FN20AG
FM07VT
EM95TG
FM18AE
Lat
40.270537
37.7917076
35.2708333
38.2
Long
-75.96435
-78.244116
-80.375
-77.95
km to Plane
287.2
53.4
391.1
10.1
km to Path
AZ
217.35
32.96
Set Home and DX Positions
EL
1.22
0.29
Use Saved Values For Man Lat/Long
Skew
0.97
0.71
Alt
350
0
300
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
Reflector
Frequency
PWR
8
10
Lear
144
Gain
31
34
DC-9
432
BW
4.63
3.28
707
903
NF
1
1
747
1296
Take Off
-0.38
-0.31
2 GHz
km
77.14
71.45
Prop Mode
3 GHz
Alt
191.00
215.00
Aircraft
5 GHz
dBm
-161.77
-162.74
Tropo
10 GHz
Marg
-8.77
-9.74
Free Space
24 GHz
Total Path Loss dB
-266.77
Scattering Angle
3.88
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
41
Unique to Local
1
out
in
7
DX Station
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=34.4522184728265, Lng=-79.34326171875}
2/4/2014 2:50:22 AM AD5CA7 {Lat=40.14083086, Lng=-77.1056088}
Path Altitude Profile
Home Station
DX Station
200
400
600
Obstruction Elevation Profile

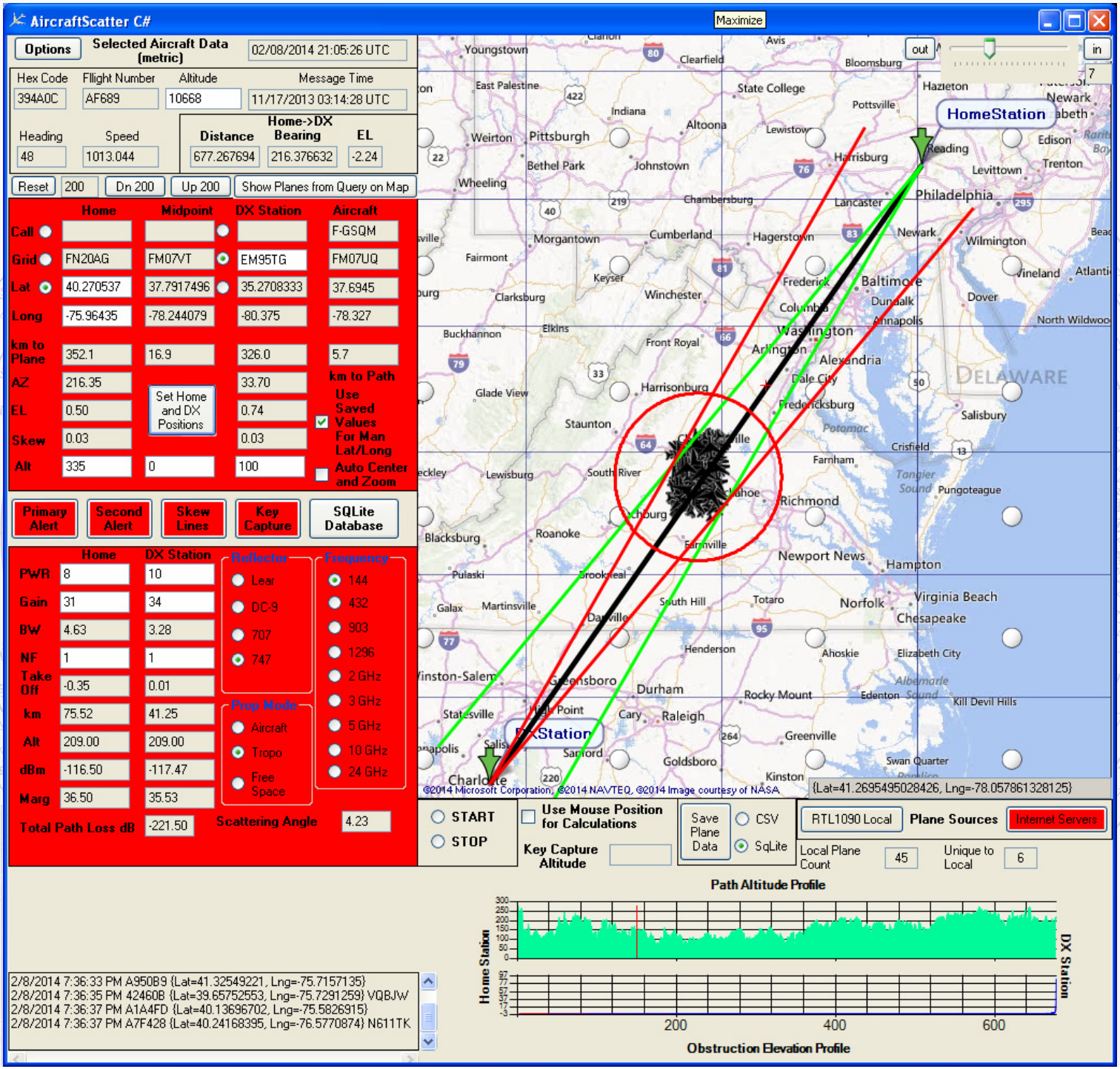

AircraftScat
EN English (United States)
English (United States)
Microphone
Tools
Handwriting
Drawing Pad
Options
Selected Aircraft Data (metric)
02/04/2014 04:32:38 UTC
Hex Code
Fllight Number
Altitude
Message Time
A5C2EA
9791.7
02/04/2014 04:32:24 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
47
994.524
677.279093
216.376632
-2.22
Reset
2800
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
N470UP
Grid
FN20AG
FM07VT
EM95TG
FM17HT
Lat
40.270537
37.7917076
35.2708333
37.81
Long
-75.96435
-78.244116
-80.375
-77.37
km to Plane
299.4
77.7
390.0
48.7
AZ
204.46
42.79
km to Path
EL
0.87
0.12
Set Home and DX Positions
Use Saved Values For Man Lat/Long
Skew
11.92
9.12
Alt
350
0
300
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
8
10
Gain
31
34
BW
4.63
3.28
NF
1
1
Take Off
-0.38
-0.31
km
77.14
71.45
Alt
191.00
215.00
dBm
-162.11
-163.08
Marg
-9.11
-10.08
Total Path Loss dB
-267.11
Scattering Angle
3.88
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
HomeStation
DXStation
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=35.0389920467808, Lng=-81.123046875}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
38
Unique to Local
0
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile

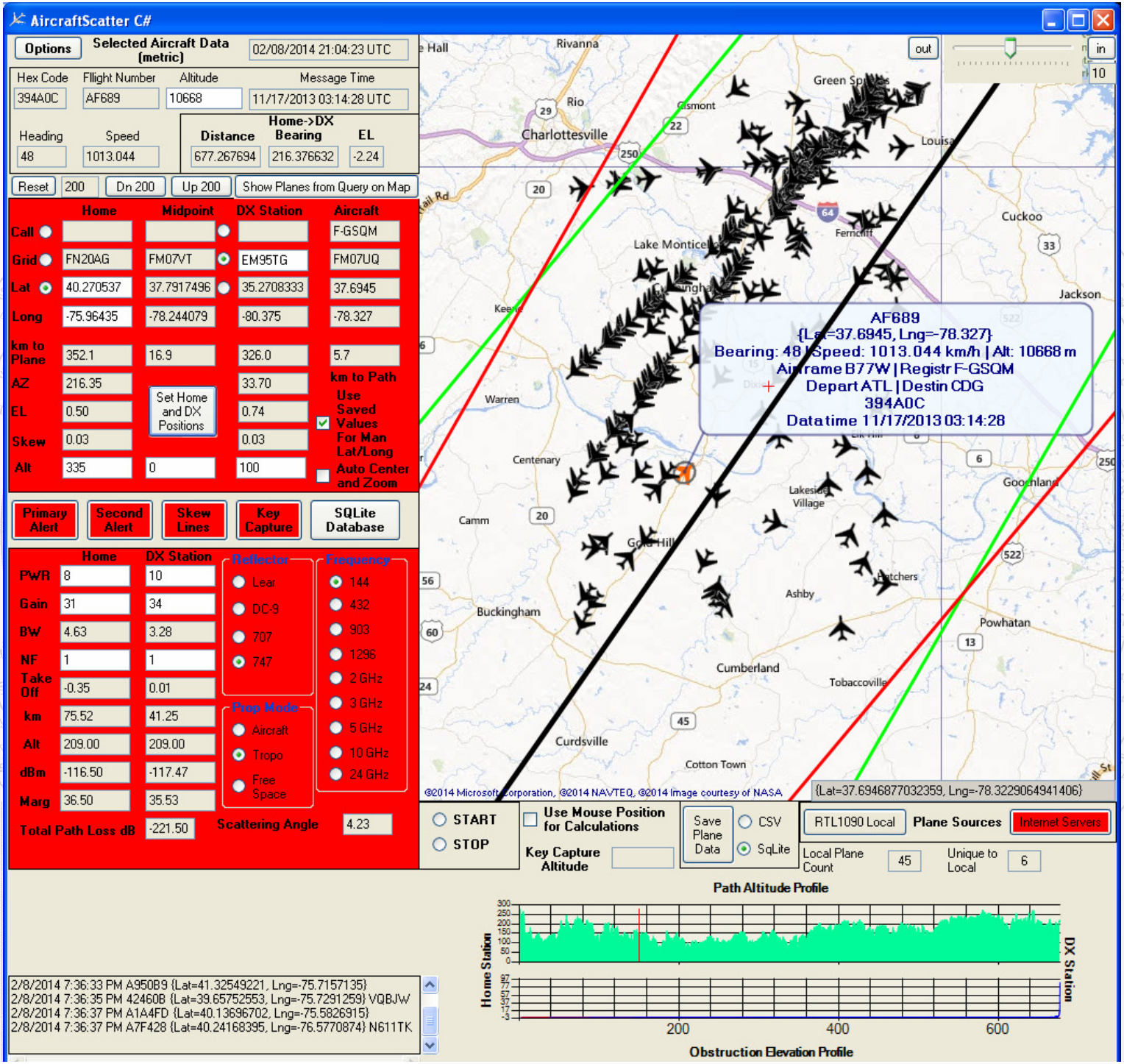

Options
Selected Aircraft Data (metric)
02/04/2014 04:35:49 UTC
Hex Code
Fllight Number
Altitude
Message Time
A324D9
UPS1013
10972.8
02/04/2014 04:35:38 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
239
666.72
677.279093
216.376632
-2.22
Reset
2800
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
W3SZ
FN20AG
FM07VT
EM95TG
FM19JQ
40.270537
37.7917076
35.2708333
39.6732136
-75.96435
-78.244116
-80.375
-77.247375
128.7
226.6
562.0
48.2
239.24
28.58
4.44
-0.77
22.86
5.09
350
0
300
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
31
4.63
1
-0.38
77.14
191.00
-157.95
-4.95
10
34
3.28
1
-0.31
71.45
215.00
-158.92
-5.92
Total Path Loss dB
-262.95
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Scattering Angle
3.88
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
248
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
38
Unique to Local
38
DX Station
FM04
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=34.4793919710481, Lng=-79.0576171875}
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
2/4/2014 4:35:44 AM AAD213 {Lat=42.13289422, Lng=-77.8380708} AAL78
2/4/2014 4:35:44 AM AAC3F4 {Lat=40.51269014, Lng=-73.672631}
2/4/2014 4:35:44 AM A9D2FA {Lat=39.96556168, Lng=-75.768273} FDX1292
2/4/2014 4:34:44 AM A79422 {Lat=40.29194641, Lng=-80.0917968} FDX1600


SQLite Database
Query Database
Record Count
195419
Preview Query
Close
Radius
5 km
25 km
50 km
100 km
Limit Search to Hexno:
Order by:
Click for Desc
Date
Time
Fltno
Hexno
Reg
Destin
Depart
Lat
Long
Query Options
Show entire Database
Manual Entry Decimal Degrees
Center on Mouse and press <Ctl> Home
Mark Borders with Mouse Using <Ctl> and Arrows for NSEW [top bottom right left]
Use Range of Current PlanePlotter Display
Select Aircraft on Great Circle Route Between Two Points [<Ctl> and Insert/ Delete Keys]
Latitude
Longitude
Max
Min
Time hhmm Between:
Date yyyymmdd Between:
Select distinct * from planes order by date desc , time desc
Asc
Desc
date
time
fltno
reg
hex
depart
20130922 174704 DL1565 N722TW A9ACB8 PHL
20130922 174704 DL65 N816NW AB20E7 MAN
20130922 174704 KE94 HL8217 71C217 IAD
20130922 174704 KL651 PH-BFL 48404E AMS
20130922 174704 LH408 D-AIGV 3C64F6 DUS
20130922 174704 LH444 D-AIGC 3C64E3 FRA
20130922 174704 OS93 OE-LAX 440BB8 VIE
20130922 174704 OZ221 HL8254 71C254 JFK
20130922 174704 SV35 HZ-AKD 710036 JED



date	time	fltno	reg	hex	depart	destin
20130827	213420	NK936	N526NK	A6A06E	RSW	ACY
20130827	230720	MQ4300	N404YX	A4BDB9	ORD	ALO
20130914	060104	KL686	PH-BFK	48403E	MEX	AMS
20130915	171822	DL239	N857NW	ABC29A	AMS	ATL
20130909	171913	DL239	N855NW	ABBB2C	AMS	ATL
20130828	215655	DL239	N812NW	AB120B	AMS	ATL
20130828	192754	DL33	N809NW	AB048D	AMS	ATL
20130828	153256	DL175	N820NW	AB321C	AMS	ATL
20130827	232823	KL621	PH-AKD	484F73	AMS	ATL
20130827	191924	DL33	N805NW	AAF5B1	AMS	ATL
20130827	170719	DL239	N816NW	AB20E7	AMS	ATL
20130825	170456	DL239	N817NW	AB249E	AMS	ATL
20130825	170426	DL239	N817NW	AB249E	AMS	ATL
20130825	170354	DL239	N817NW	AB249E	AMS	ATL
20130825	170326	DL239	N817NW	AB249E	AMS	ATL
20130825	180624	DL115	N814NW	AB1979	BCN	ATL
20130825	180550	DL115	N814NW	AB1979	BCN	ATL
20130827	172223	DL1801	N548US	A6F777	BOS	ATL
20130827	015221	DL1201	N547US	A6F3C0	BOS	ATL


AircraftScatter C#
Maximize
Options
Selected Aircraft Data (metric)
02/08/2014 21:05:26 UTC
Hex Code
Fllight Number
Altitude
Message Time
394A0C
AF689
10668
11/17/2013 03:14:28 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
48
1013.044
677.267694
216.376632
-2.24
Reset
200
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
F-GSQM
FN20AG
FM07VT
EM95TG
FM07UQ
40.270537
37.7917496
35.2708333
37.6945
-75.96435
-78.244079
-80.375
-78.327
km to Plane
352.1
16.9
326.0
5.7
AZ
216.35
33.70
km to Path
EL
0.50
0.74
Skew
0.03
0.03
Alt
335
0
100
Set Home and DX Positions
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
8
10
Gain
31
34
BW
4.63
3.28
NF
1
1
Take Off
-0.35
0.01
km
75.52
41.25
Alt
209.00
209.00
dBm
-116.50
-117.47
Marg
36.50
35.53
Total Path Loss dB
-221.50
Scattering Angle
4.23
Reflector
Lear
DC-9
707
747
Prop Mode
Aircraft
Tropo
Free Space
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
HomeStation
DX Station
out
in
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=41.2695495028426, Lng=-78.057861328125}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
45
Unique to Local
6
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
2/8/2014 7:36:33 PM A950B9 {Lat=41.32549221, Lng=-75.7157135}
2/8/2014 7:36:35 PM 42460B {Lat=39.65752553, Lng=-75.7291259} VQBJW
2/8/2014 7:36:37 PM A1A4FD {Lat=40.13696702, Lng=-75.5826915}
2/8/2014 7:36:37 PM A7F428 {Lat=40.24168395, Lng=-76.5770874} N611TK


AircraftScatter C#
Options
Selected Aircraft Data (metric)
02/08/2014 21:04:23 UTC
Hex Code
Fllight Number
Altitude
Message Time
394A0C
AF689
10668
11/17/2013 03:14:28 UTC
Heading
Speed
Home->DX
Distance
Bearing
EL
48
1013.044
677.267694
216.376632
-2.24
Reset
200
Dn 200
Up 200
Show Planes from Query on Map
Home
Midpoint
DX Station
Aircraft
Call
Grid
Lat
Long
km to Plane
AZ
EL
Skew
Alt
F-GSQM
FN20AG
FM07VT
EM95TG
FM07UQ
40.270537
37.7917496
35.2708333
37.6945
-75.96435
-78.244079
-80.375
-78.327
352.1
16.9
326.0
5.7
216.35
33.70
0.50
0.74
0.03
0.03
335
0
100
Set Home and DX Positions
km to Path
Use Saved Values For Man Lat/Long
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
PWR
Gain
BW
NF
Take Off
km
Alt
dBm
Marg
8
10
31
34
4.63
3.28
1
1
-0.35
0.01
75.52
41.25
209.00
209.00
-116.50
-117.47
36.50
35.53
Reflector
Lear
DC-9
707
747
Frequency
144
432
903
1296
2 GHz
3 GHz
5 GHz
10 GHz
24 GHz
Prop Mode
Aircraft
Tropo
Free Space
Total Path Loss dB
-221.50
Scattering Angle
4.23
AF689
{Lat=37.6945, Lng=-78.327}
Bearing: 48 | Speed: 1013.044 km/h | Alt: 10668 m
Airframe B77W | Registr F-GSQM
Depart ATL | Destin CDG
394A0C
Datatime 11/17/2013 03:14:28
©2014 Microsoft Corporation, ©2014 NAVTEQ, ©2014 Image courtesy of NASA
{Lat=37.6946877032359, Lng=-78.3229064941406}
START
STOP
Use Mouse Position for Calculations
Key Capture Altitude
Save Plane Data
CSV
SqLite
RTL1090 Local
Plane Sources
Internet Servers
Local Plane Count
45
Unique to Local
6
Path Altitude Profile
Home Station
DX Station
Obstruction Elevation Profile
2/8/2014 7:36:33 PM A950B9 {Lat=41.32549221, Lng=-75.7157135}
2/8/2014 7:36:35 PM 42460B {Lat=39.65752553, Lng=-75.7291259} VQBJW
2/8/2014 7:36:37 PM A1A4FD {Lat=40.13696702, Lng=-75.5826915}
2/8/2014 7:36:37 PM A7F428 {Lat=40.24168395, Lng=-76.5770874} N611TK

ICAO24 Hexcode Information

Aircraft Registration Database Lookup

Passenger airliners, cargo airplanes, business jets, helicopters, private aircraft, civil and military, showing common registry data as well as mode-S radar transponder addresses. The database is still **under development and construction.**

Aircraft database

Registration: [e.g. D-AIHA or daiha]

Selcal: [e.g. AE-KQ or aekq]

ICAO24 address: [Mode-S address, default hex, or ○ dec ○ oct ○ bin]

submit reset ... no bots ...

Your query for aircraft ICAO24-address 394A0C. Result: 1 row.

ICAO24-address 394A0C is from France [FR] : 380000...3BFFFF (262144 allocations, 001110-- -------- --------)
394A0C hex = 3754508 decimal = 16245014 octal = 00111001 01001010 00001100 binary.

Registration	Manuf.	Model	Type	c/n	l/n	i/t	Selcal	ICAO24	Reg / Opr	built	test reg	delivery	prev.reg	until	next reg	status	
F-GSQM	Boeing	777-328ER	B77W	32848	558	L2J	EKBC	394A0C	AFR [AF] Air France	2006		2006-03-31				active	edit
	Remarks:	[MODE-S] [ADS-B] [ACARS]															

Airline Flight Information

FlightAware LIVE FLIGHT TRACKING

Join FlightAware (Why Join?) Login English (USA) 02:45PM EST

- Live Flight Tracking
- Pilot Resources
- Aviation Photos
- Squawks & Headlines
- Discussions
- Commercial Services
- About FlightAware
- Contact

LIVE FLIGHT TRACKER

PRIVATE FLIGHT TRACKER:
Flight/Tail# e.g. N123AB
TRACK FLIGHT

AIRLINE FLIGHT TRACKER:
Airline Air France - AFR
Flight # 689
TRACK FLIGHT

FORGOT THE FLIGHT NUMBER?

AIRPORT TRACKER/INFO
Airport Code LFPG
-or-
Airport City e.g. New York
VIEW ACTIVITY
VIEW INFO

The page cannot l

There is a problem with th
cannot be displayed.

Please try the following:

- Open the home pag
information you wa
- Click the Refresh bu

HTTP 414 - Request - URI
Internet Information Servi

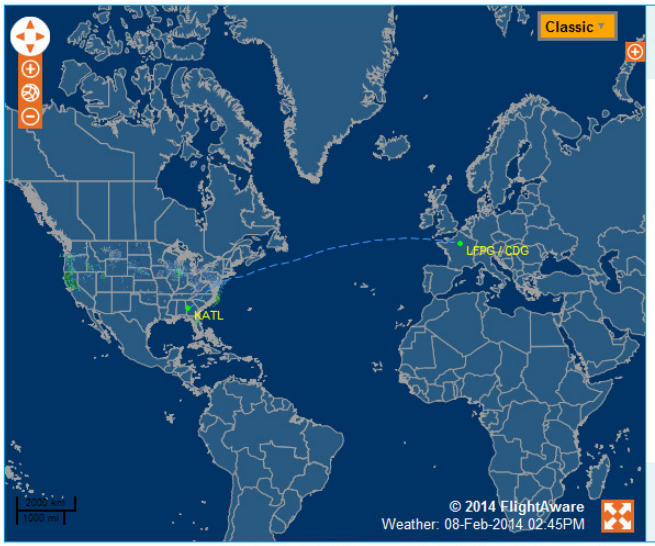
Technical Information (for

- Background

The server is refusi
Request-URI is too
in the following situ

A client has improp
request with long q

Live Flight Tracker ✈ Air France (AF) #689



Air France 689
AFR689 · "Airfrance" (all flights) airfrance.fr

Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)
Terminal I	Terminal 2E
09:10PM EST	*11:05AM CET*
Scheduled: 09:00PM EST	Scheduled: 10:55AM CET
7-day average: 10:12PM EST	7-day average: 11:25AM CET

Other flights between these airports

Duration: 7 hours 55 minutes
Saturday, February 8, 2014

Status	Scheduled (in 6 hours 13 minutes)
Aircraft	*Boeing 777-200 (twin-jet) (B772 – photos)*
Speed	Filed: 482 kts (graph)
Distance	Direct: 4,389 sm Planned: 4,448 sm
Route	DAWGS6 SPA J37 GVE J42 RBV J62 RIFLE SHHAR VITOL N27A NANSO N27A RAFIN NATW 4900N 03000W NATW SOMAX NATW ATSUR GAPLI UM25 LUKIP

Share this alert with a friend Advanced alerts
friend@example.com Submit →

At least part of this flight occurs outside of FlightAware's primary service area. Learn more about FlightAware's coverage

The page cannot be displayed

There is a problem with the page you are trying to reach and it cannot be displayed.

ACTIVITY LOG — Want a full history search for AFR689 dating back to 1998? Buy now. Get it within one hour.

Date	Aircraft	Origin	Destination	Departed	Arrival	Duration
09-Feb-2014	*B772*	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	*09:10PM EST*	*11:05AM CET (+1)*	Scheduled
08-Feb-2014	*B772*	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	*09:10PM EST*	*11:05AM CET (+1)*	Scheduled
07-Feb-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:17PM EST	10:21AM CET (+1)	7:04
06-Feb-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:20PM EST	10:37AM CET (+1)	7:17
05-Feb-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:22PM EST	10:22AM CET (+1)	7:00
04-Feb-2014	B772	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:27PM EST	10:51AM CET (+1)	7:24
03-Feb-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:20PM EST	10:33AM CET (+1)	7:13
02-Feb-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:21PM EST	10:33AM CET (+1)	7:12
01-Feb-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:19PM EST	10:35AM CET (+1)	7:16
31-Jan-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:30PM EST	10:45AM CET (+1)	7:15
30-Jan-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:17PM EST	10:40AM CET (+1)	7:23
29-Jan-2014	*B772*	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	*09:10PM EST*	*11:05AM CET (+1)*	Cancelled
28-Jan-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	11:03AM EST	*12:56AM CET (+1) (?)*	7:53
28-Jan-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	10:53AM EST	01:07AM CET (+1)	8:13
26-Jan-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:19PM EST	10:33AM CET (+1)	7:14
25-Jan-2014	B772/L	Hartsfield-Jackson Intl (KATL)	Charles de Gaulle/Roissy (LFPG / CDG)	09:14PM EST	10:20AM CET (+1)	7:06

More Past Flights →

Registered users (registering is free and easy!) view 4 months history. Join

Conclusions

- Aircraft Scatter works!
  - > 800 km on 10 GHz, > 400 km on 24 GHz
- Substantial enhancement can be achieved by using aircraft located near the midpoint of the direct path
- Best results can be obtained by using software to predict when the most profitable times for operation will occur and to guide real-time aiming of antennas while operating
- www.nitehawk.com/w3sz/AircraftScatter.htm