Aircraft Scatter 2021

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North Texas Microwave Society

2021

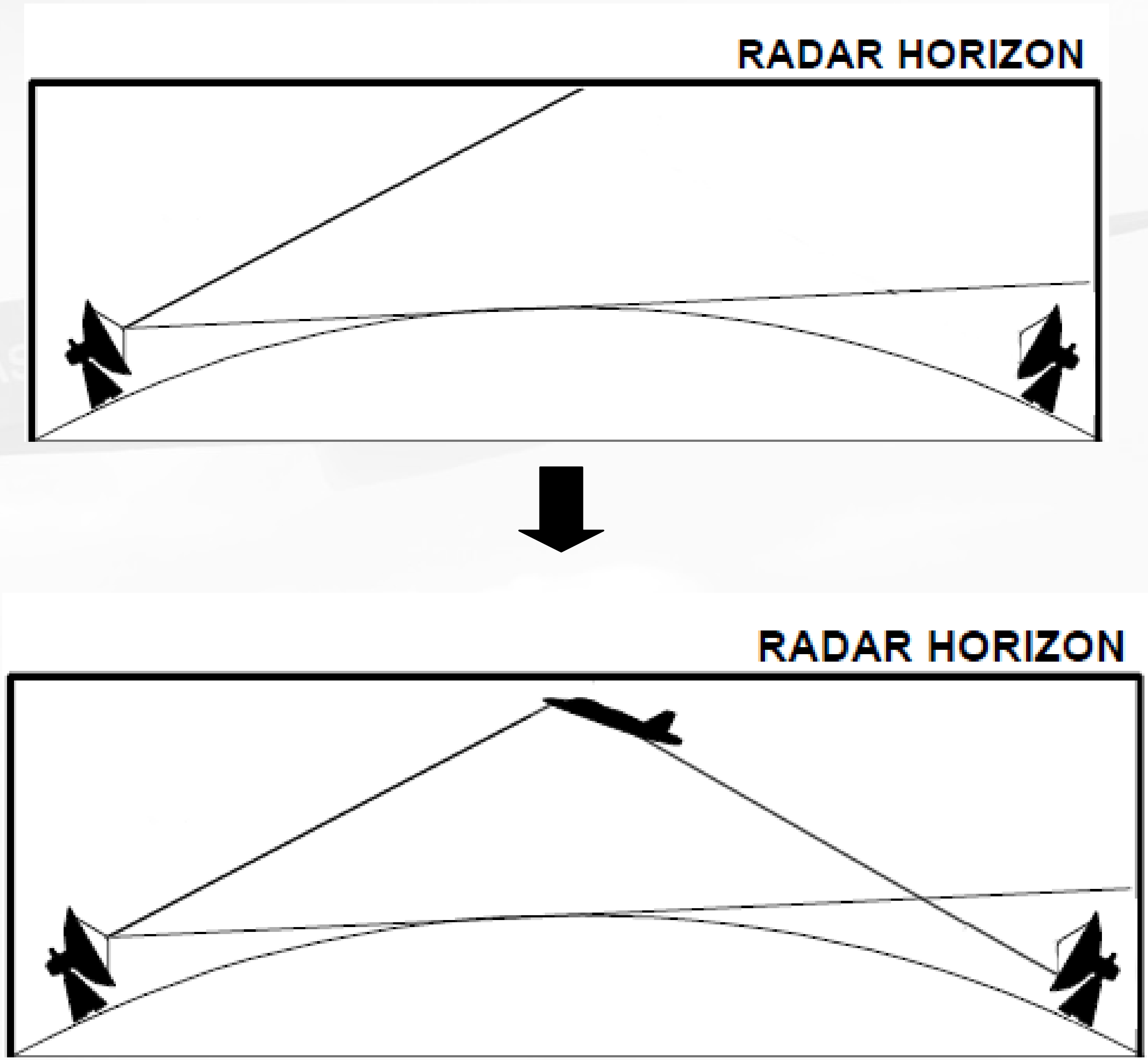
Aircraft Scatter

- Scattering of radio signals by airplanes
- First documented June 1930 at 33 MHz by L.A. Hyland of Naval Research Laboratory
- First mention in Amateur Radio Literature was by Henry Root W1QNG in Technical Correspondence section of QST in August, 1967

Aircraft Scatter

- Uses aircraft to redirect RF that would otherwise be lost in space
- Increases Communications Distance
- Has increasing advantage over troposcatter as frequency increases
- Has increasing advantage as distance increases, up to ~ 900 km (560 miles)
- Truly a weak-signal mode

Aircraft Scatter is Bistatic Radar



Physics

Bistatic Radar Equation for Path Loss:

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

L = total loss (dB)

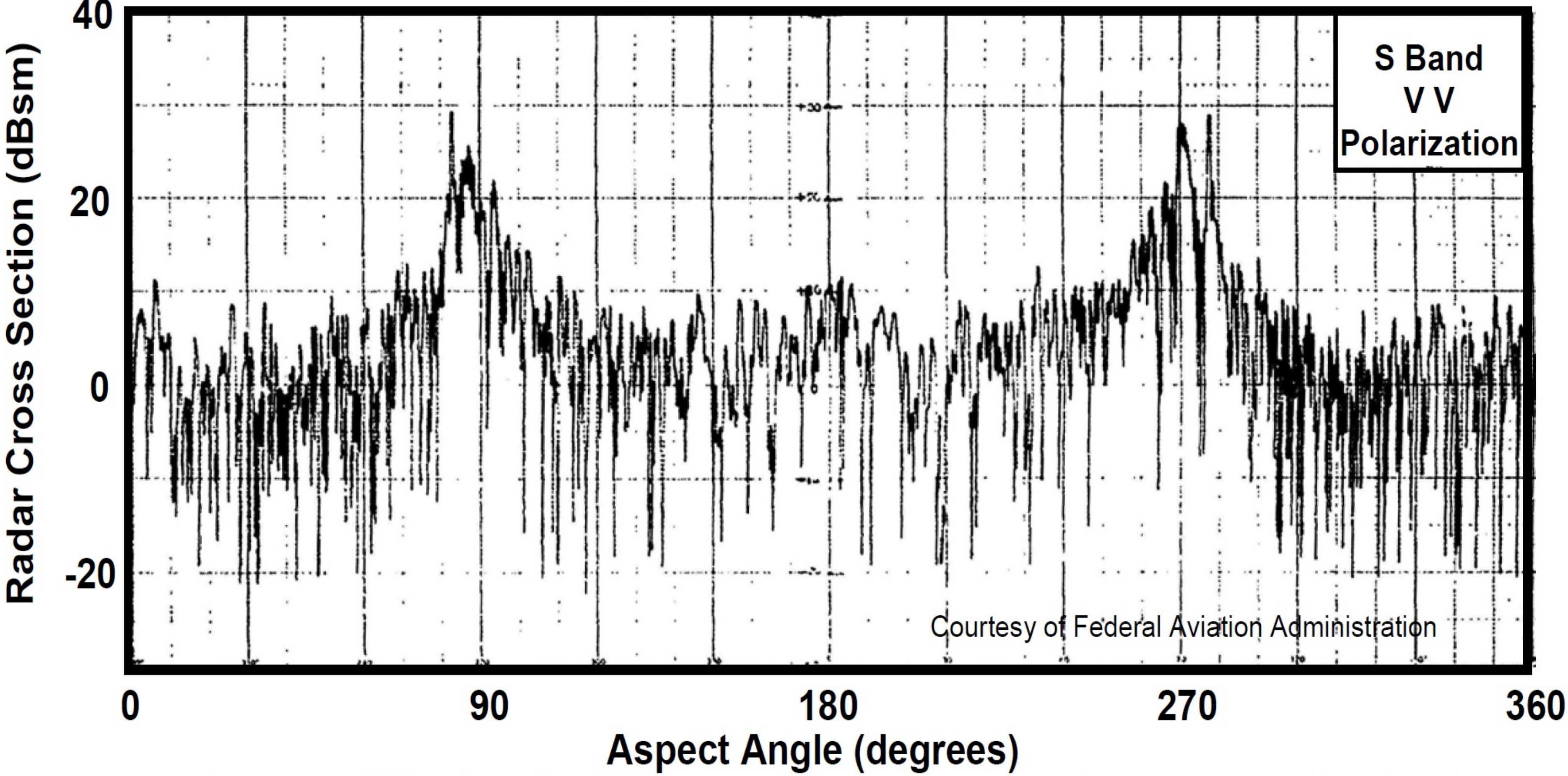
Rt = distance from transmitter to reflector (km)

Rr = distance from receiver to reflector (km)

lambda = wavelength (m)

S = radar cross section of aircraft (sq m)

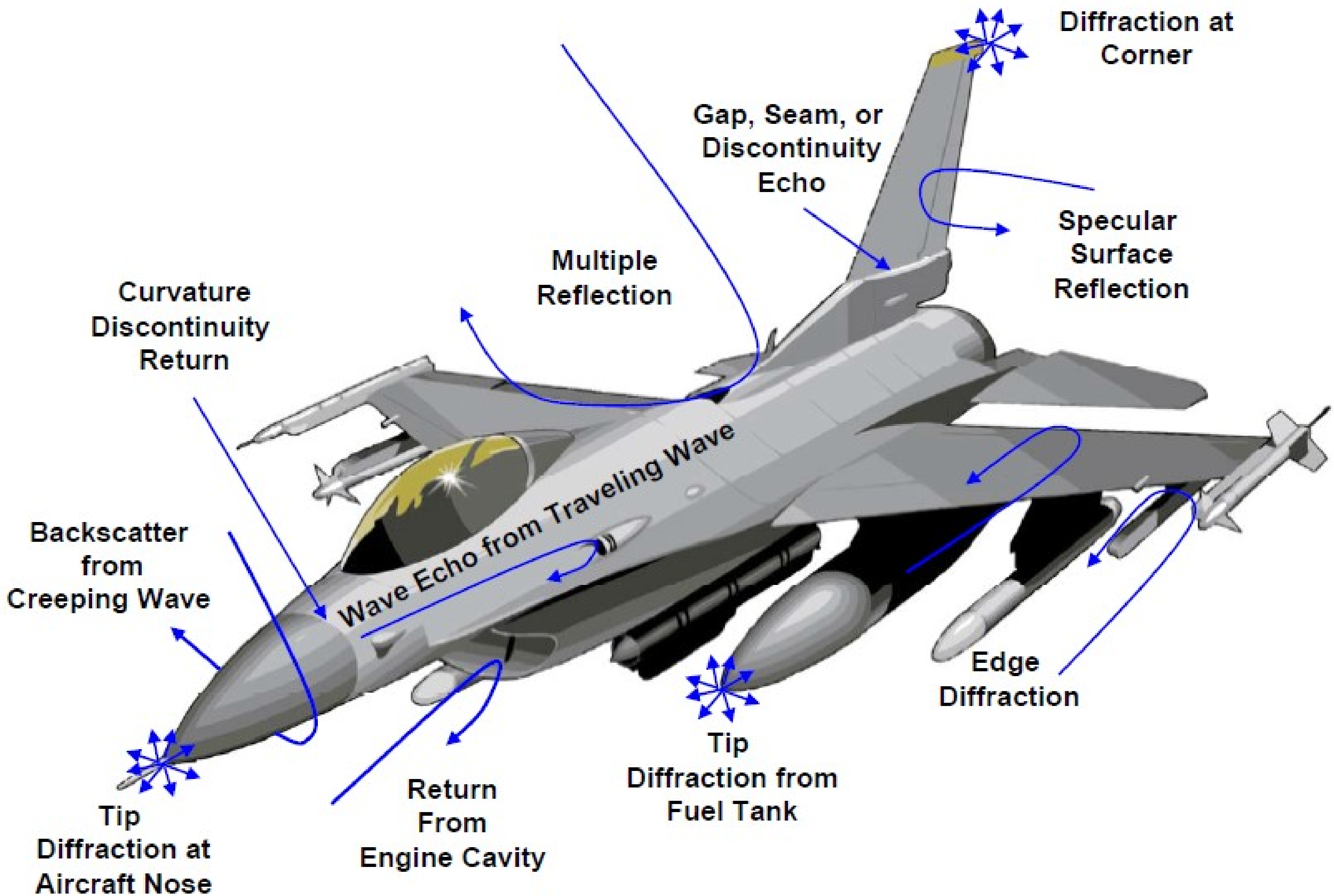
Measured at RATSCAT (6585th Test Group) Holloman AFB for FAA

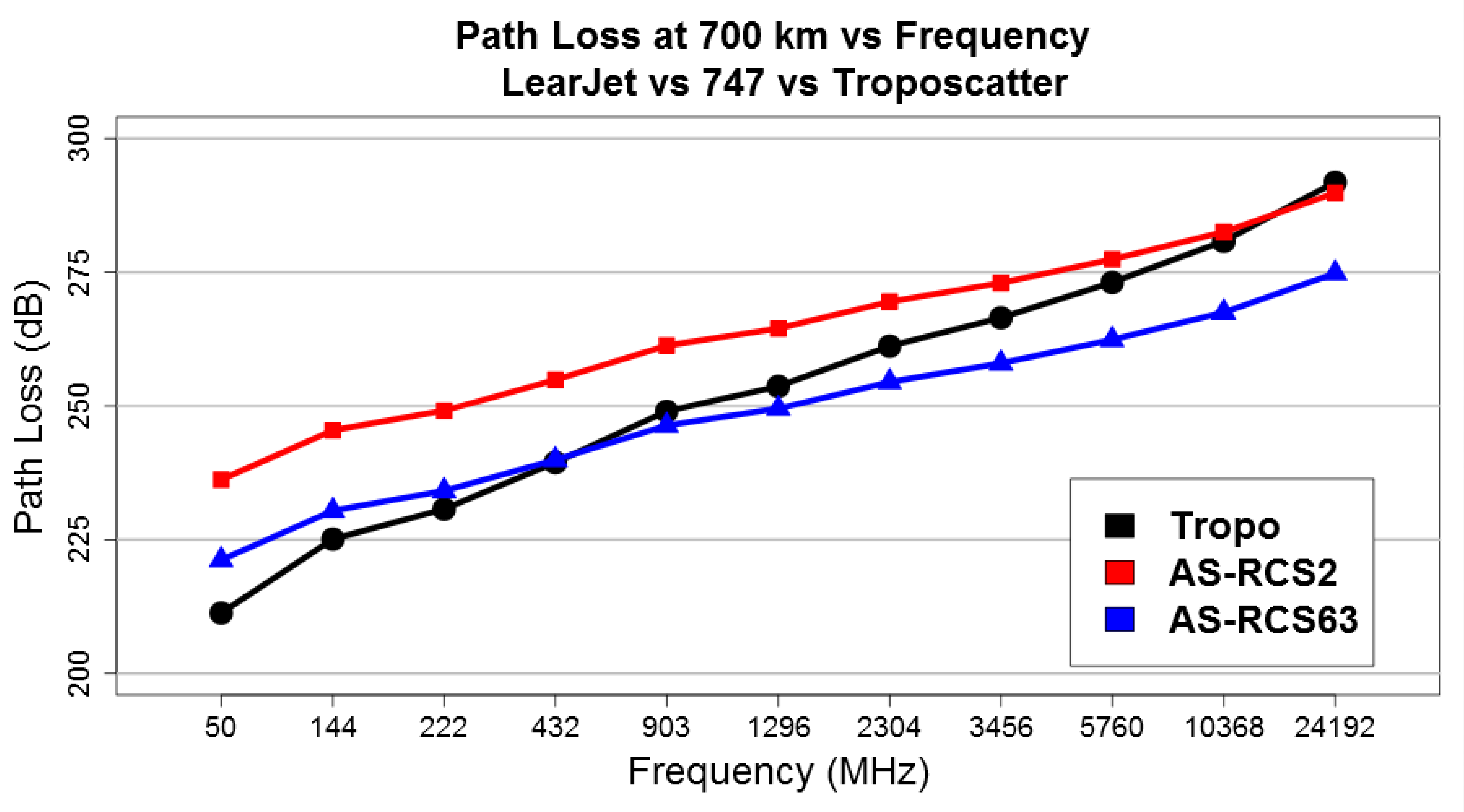


Cessna 150L (in takeoff)

Cessna 150L (in flight)

Scattering Mechanisms for an Arbitrary Target





LearJet RCS = 2
B747 RCS = 63

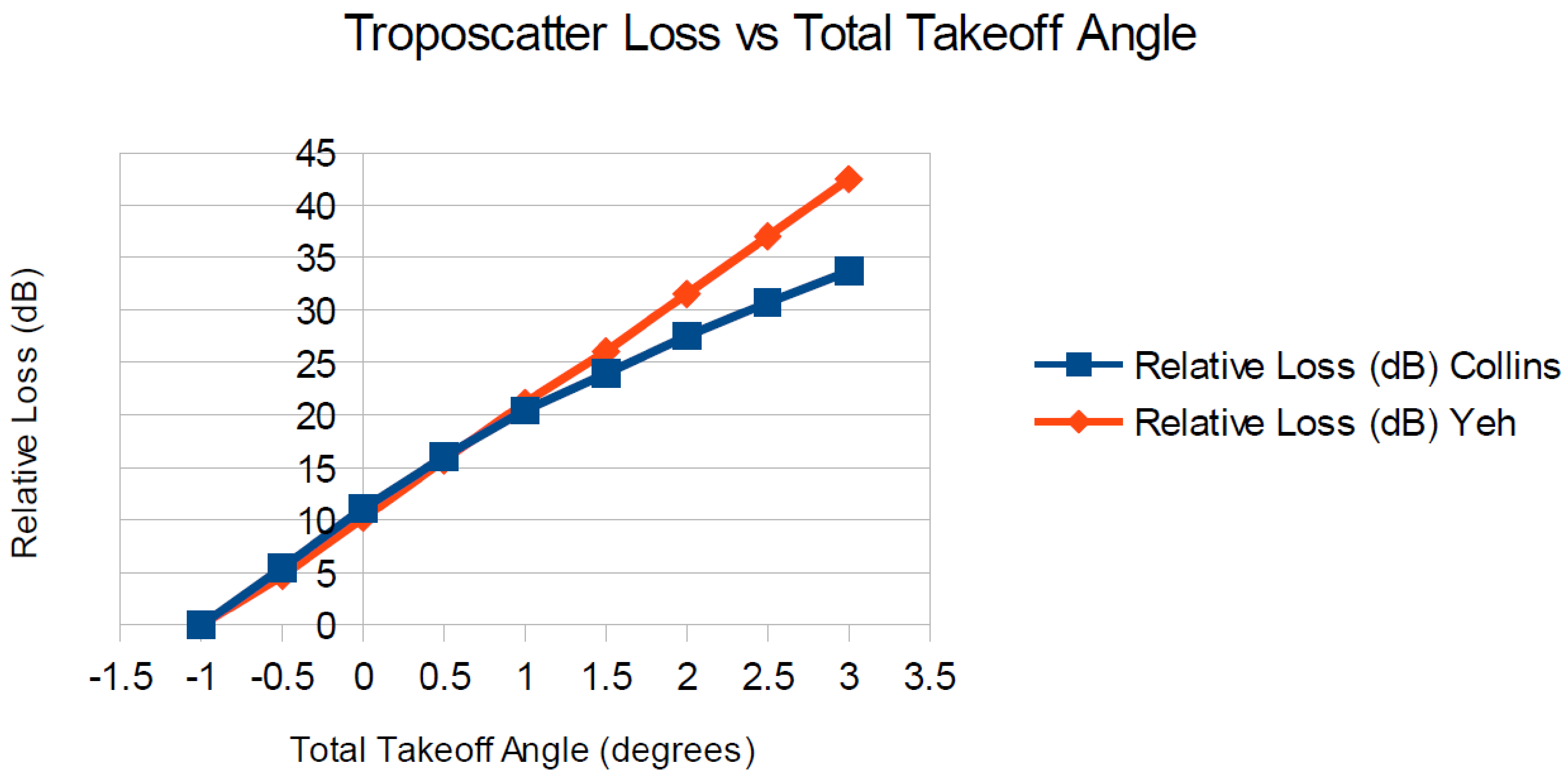
10 * Log(2/63) = -15 dB

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.

Troposcatter's Achilles' Heel



Forward Scatter Enhancement

Aircraft Scattering Angle

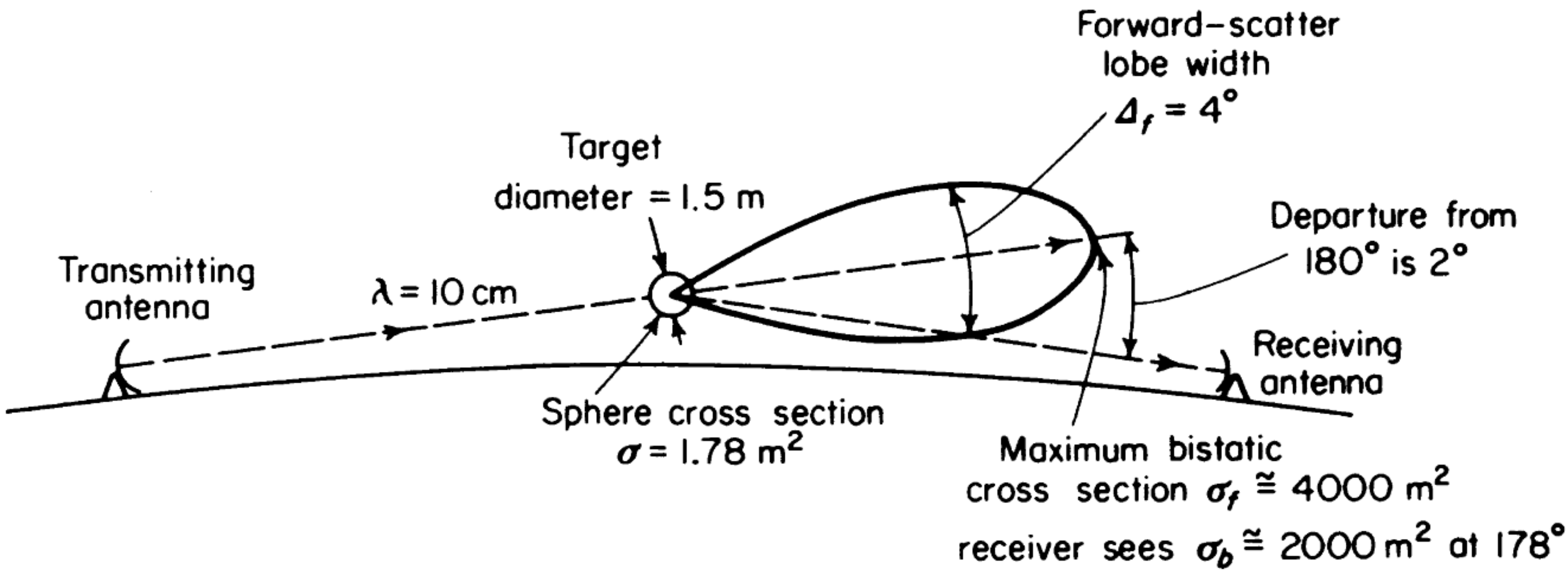


Figure 1: An example of bistatic radar where the transmitter and receiver are close to alignment, copied from Barton[9]

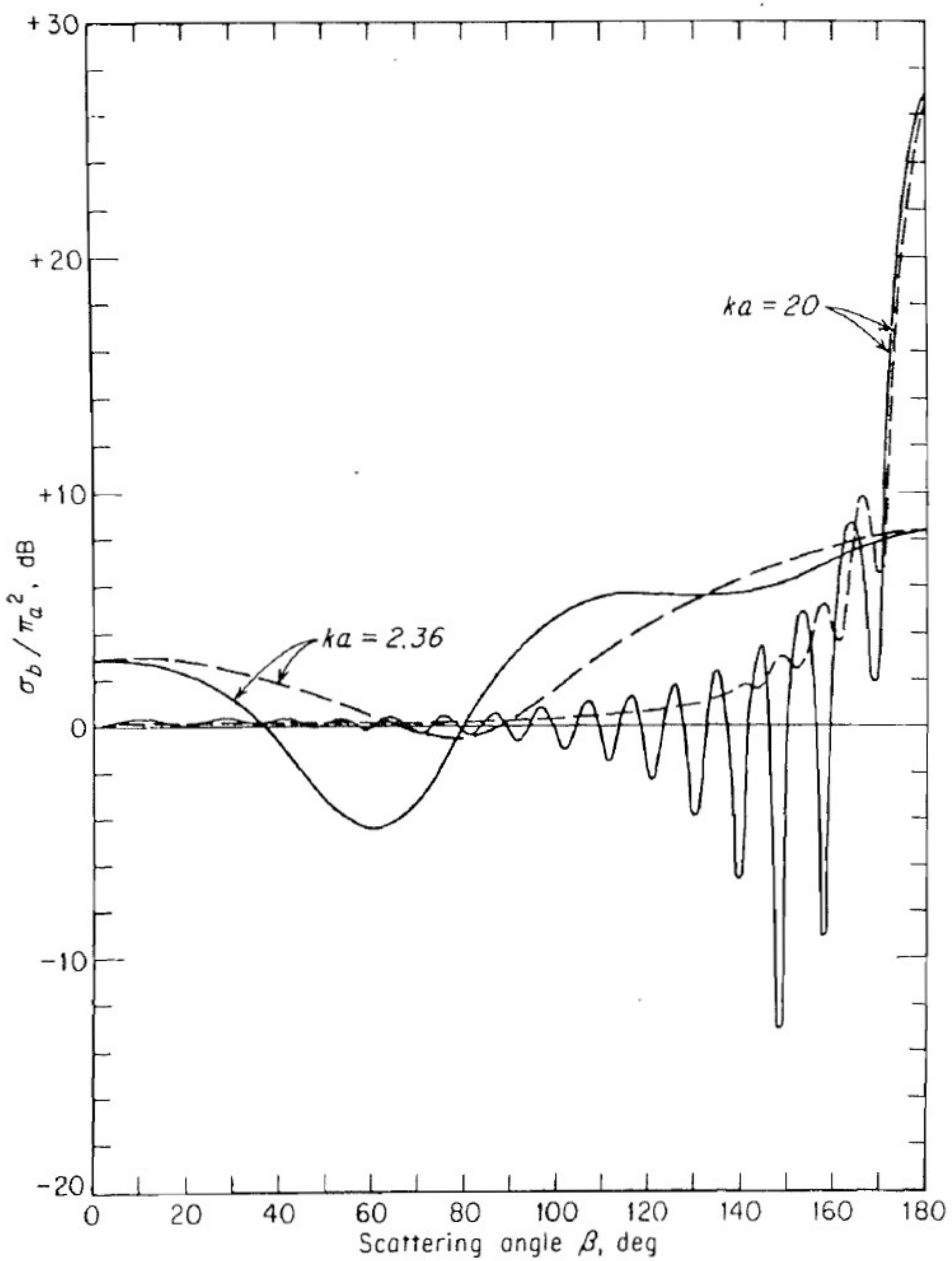
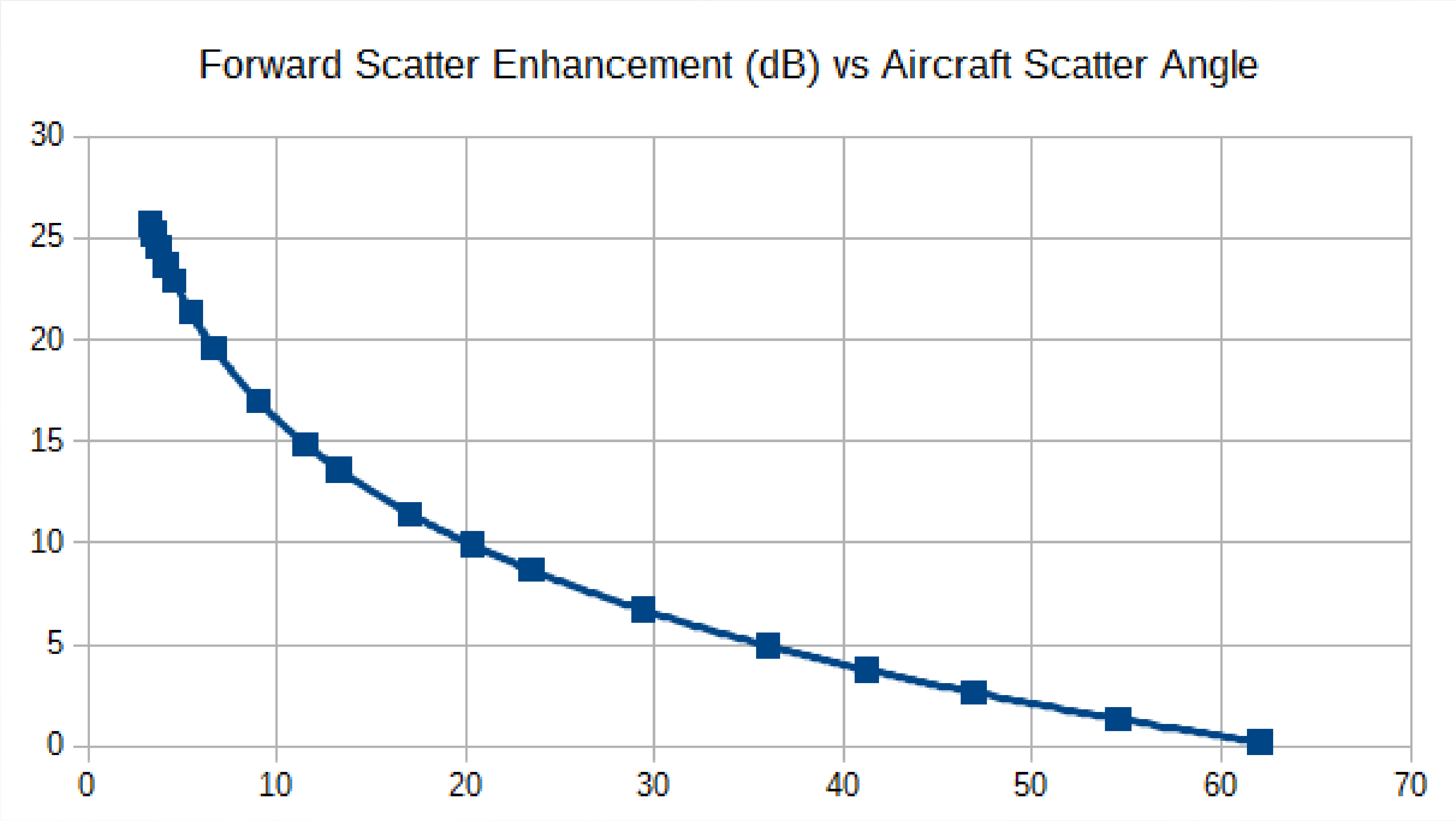


Figure 14.13 Bistatic cross section σ_b of a sphere as a function of the scattering angle β and two values of $ka = 2\pi a/\lambda$, where a is the sphere radius and λ is the wavelength. Solid curves are for the E plane (β measured in the plane of the E vector); dashed curves are for the H plane (β measured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

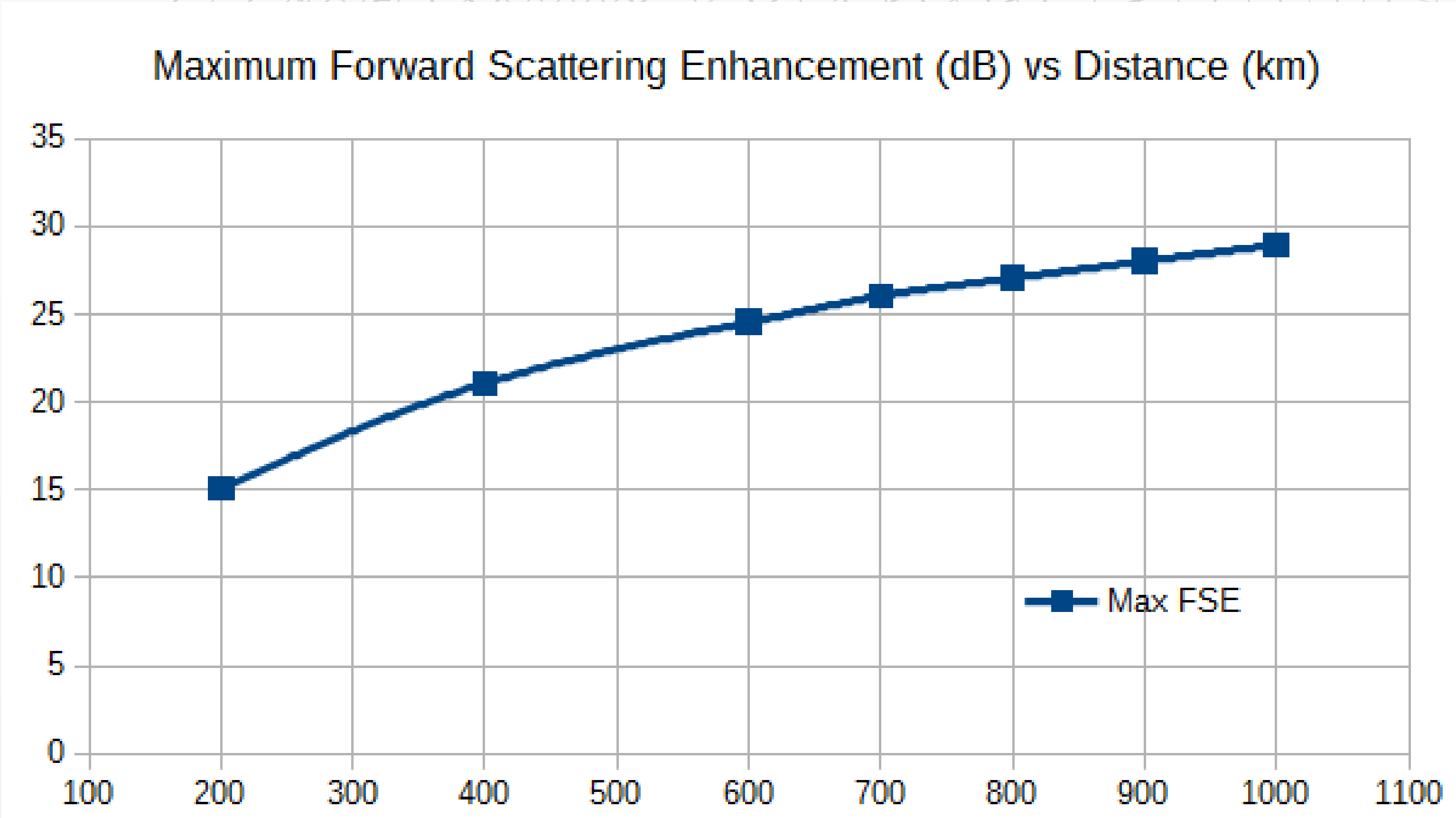
Not just any Magic, but Physics Magic

When the forward scattering angle is 180 degrees:
We get constructive interference of the scattered radiation 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



Remember:
Aircraft Scatter Angle depends on the SUM of your skew angle PLUS your partner's skew angle in 3D.



Take-home message:

Keep YOUR skew angle less than 3-5 degrees to keep FSE within 10 dB of maximum possible value

Trade-off with increased reflector size or higher frequency: FSE vs beamwidth

Forward Scatter Enhancement:
39.5 * (Pi*R/lambda)2**

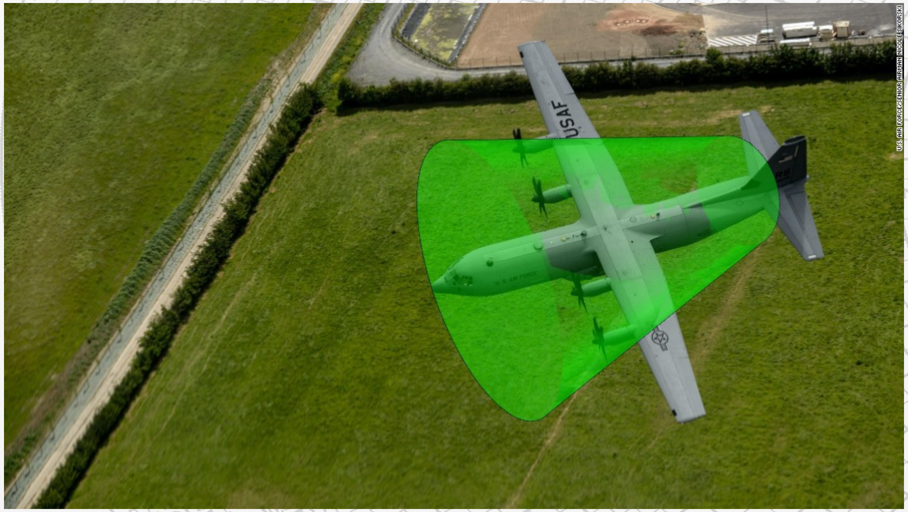
Beamwidth (in degrees):
14.32 * lambda / R

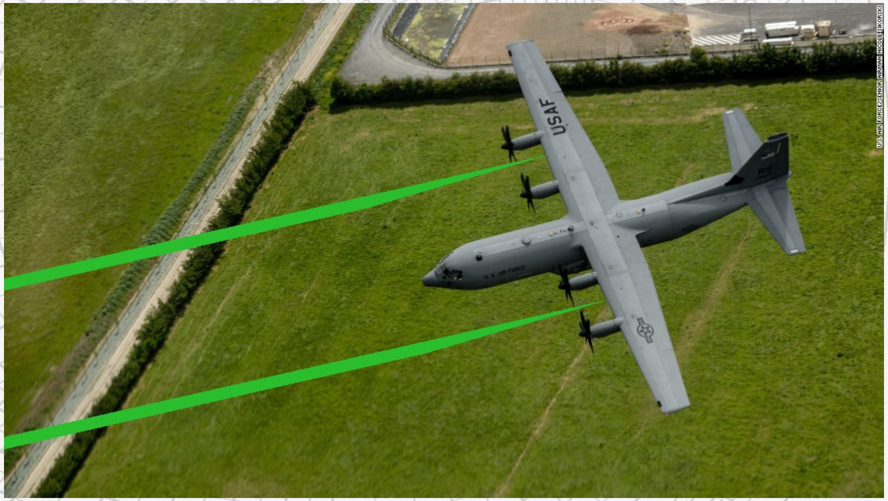
Can’t have both Maximum FSE and Maximum Beamwidth

Radius (m)		Frequency MHz	144	432	1296	2304	3G	5G	10G
1		3 dB beamwidth (degrees)	29.84	9.95	3.32	1.87	1.24	0.75	0.41
5		3 dB beamwidth (degrees)	5.97	1.99	0.66	0.37	0.25	0.15	0.08
10		3 dB beamwidth (degrees)	2.98	1.00	0.33	0.19	0.12	0.08	0.04

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





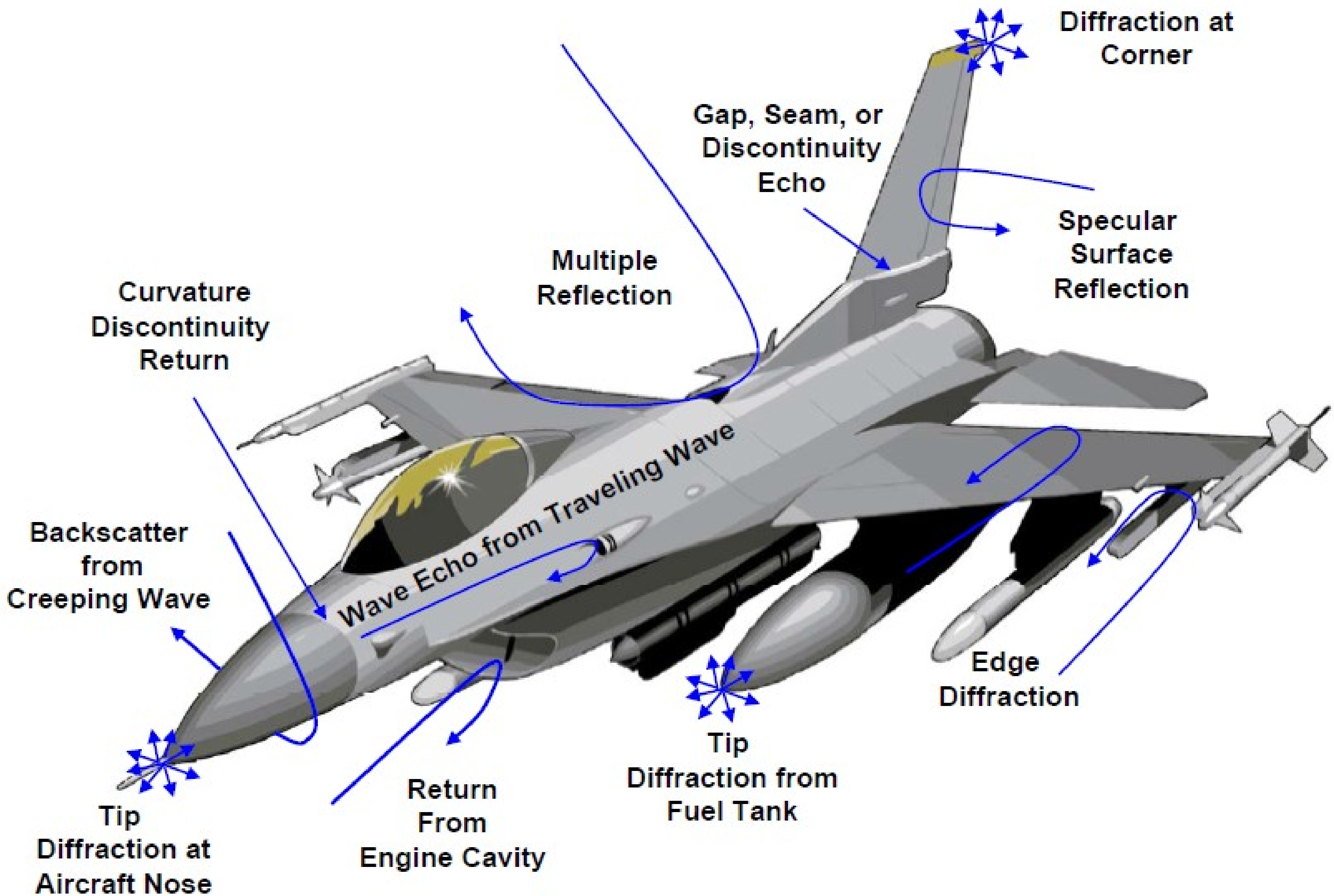
Small R / lambda occurs with:
- Lower frequency
- Smaller reflector

Results in: Less FSE
Wider beamwidth

Large R / lambda occurs with:
- Higher frequency
- Larger reflector

Results in: More FSE
Narrower beamwidth

Scattering Mechanisms for an Arbitrary Target



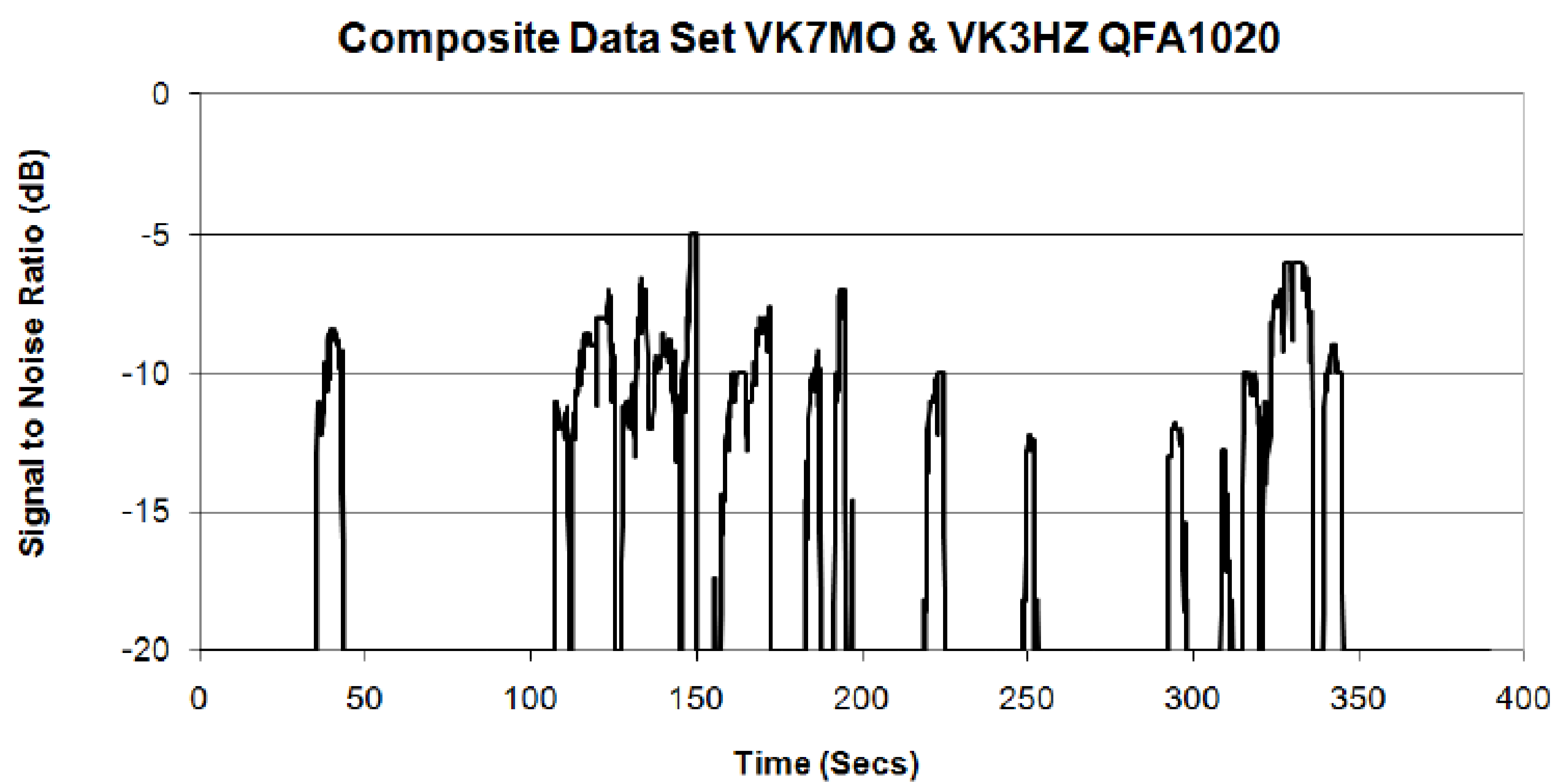
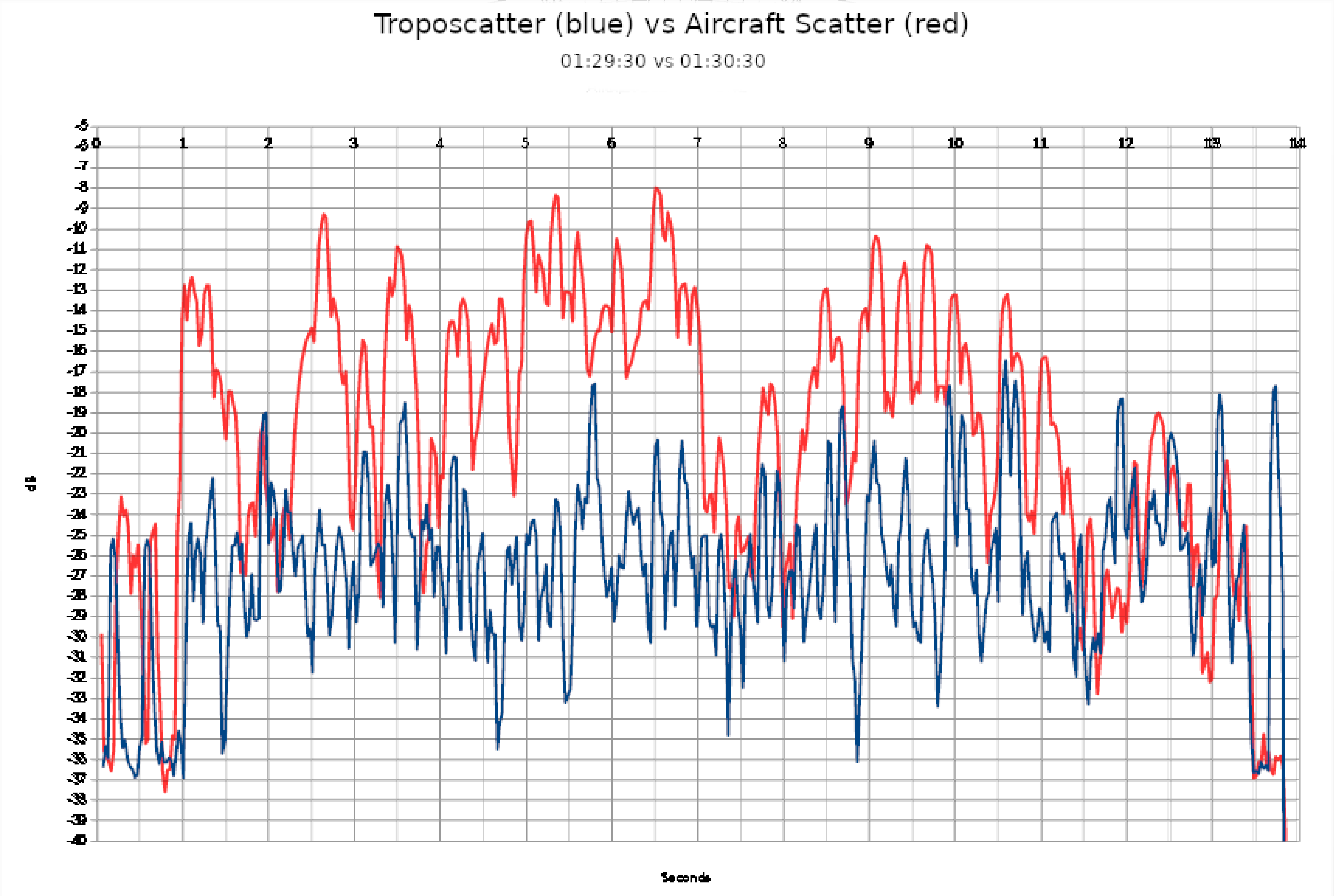
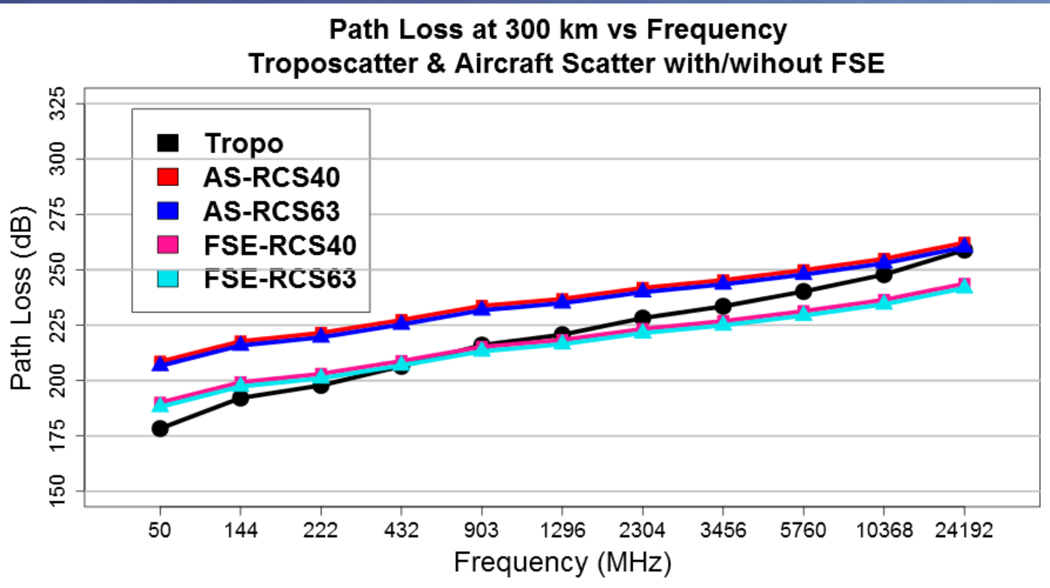
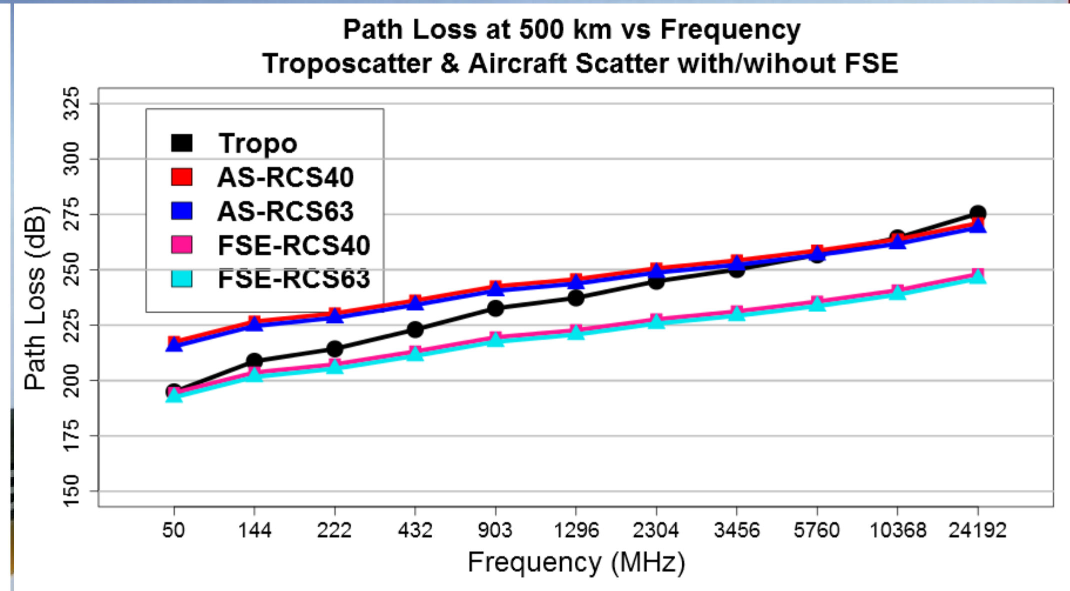


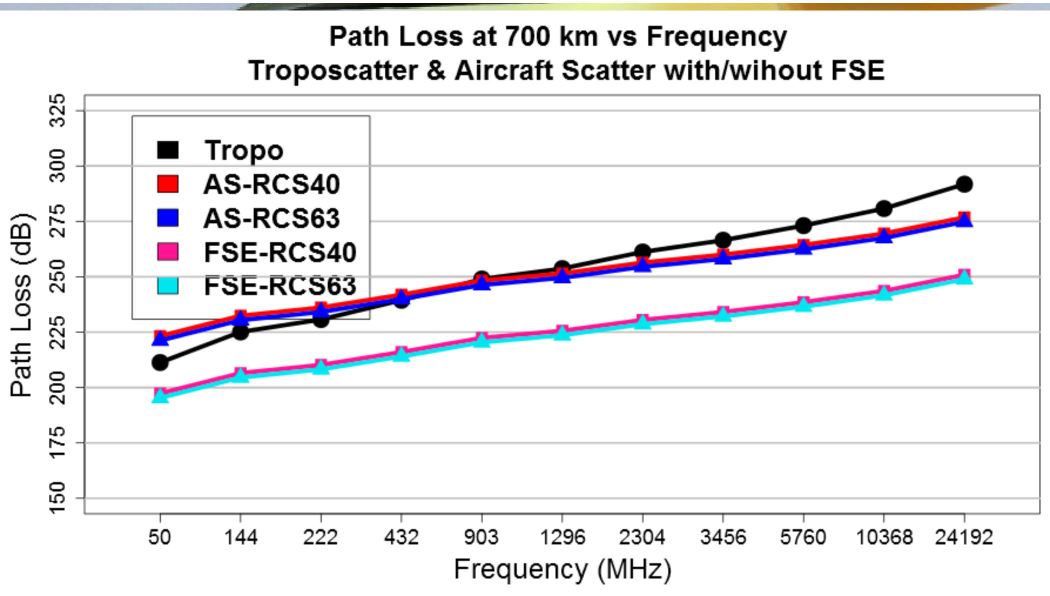
Fig 1: 10 GHz aircraft scatter signals from Werribee in Victoria to Swansea in Tasmania

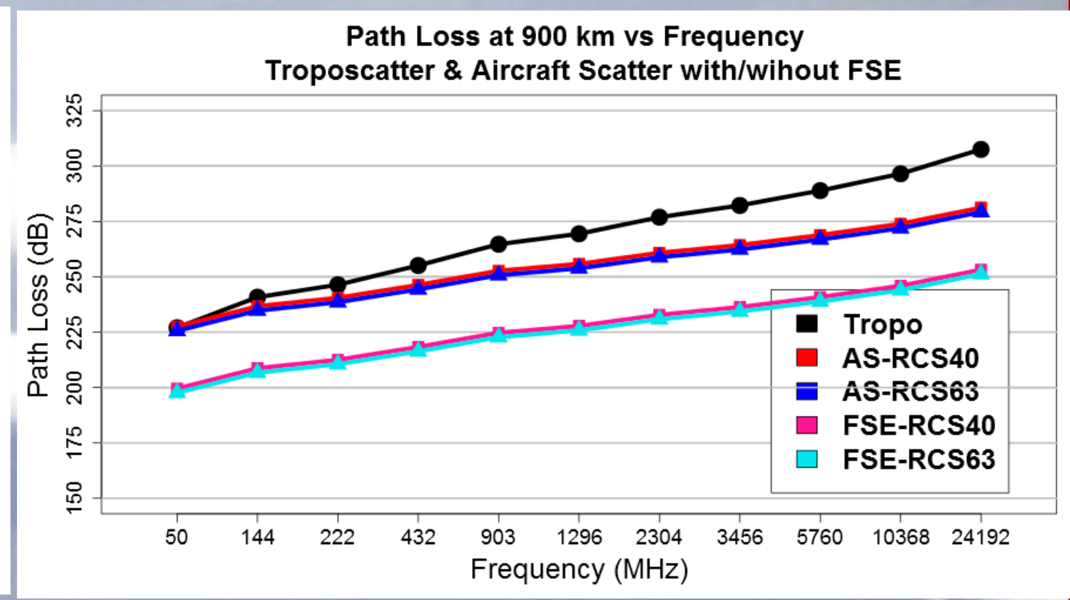


Troposcatter (blue) vs Aircraft Scatter (red)
01:29:30 vs 01:30:30
dB
Seconds


Path Loss at 300 km vs Frequency
Troposcatter & Aircraft Scatter with/wihout FSE
Tropo
AS-RCS40
AS-RCS63
FSE-RCS40
FSE-RCS63
Path Loss (dB)
150
175
200
225
250
275
300
325
50
144
222
432
903
1296
2304
3456
5760
10368
24192
Frequency (MHz)


Path Loss at 500 km vs Frequency
Troposcatter & Aircraft Scatter with/wihout FSE
Tropo
AS-RCS40
AS-RCS63
FSE-RCS40
FSE-RCS63
Path Loss (dB)
150
175
200
225
250
275
300
325
50
144
222
432
903
1296
2304
3456
5760
10368
24192
Frequency (MHz)


Path Loss at 700 km vs Frequency
Troposcatter & Aircraft Scatter with/wihout FSE
Tropo
AS-RCS40
AS-RCS63
FSE-RCS40
FSE-RCS63
Path Loss (dB)
150
175
200
225
250
275
300
325
50
144
222
432
903
1296
2304
3456
5760
10368
24192
Frequency (MHz)


Path Loss at 900 km vs Frequency
Troposcatter & Aircraft Scatter with/wihout FSE
Tropo
AS-RCS40
AS-RCS63
FSE-RCS40
FSE-RCS63
Path Loss (dB)
150
175
200
225
250
275
300
325
50
144
222
432
903
1296
2304
3456
5760
10368
24192
Frequency (MHz)

Doppler Shift

Commercial aircraft speeds generally 600-1100 km/h (370-680 mph)

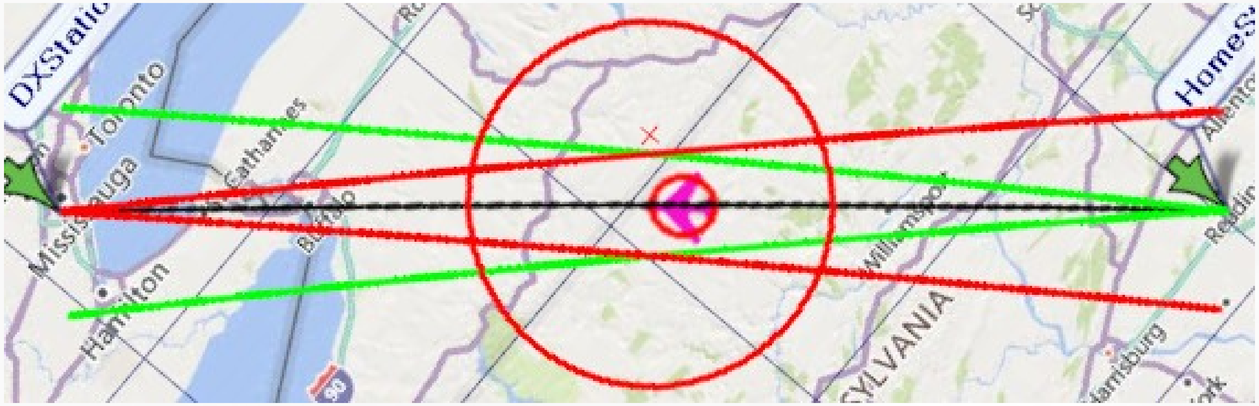
$\Delta f = (1/\lambda) * (V_{Tx} + V_{Rx})$

- λ = wavelength
- V_{Tx} = Plane's Velocity component along path from aircraft to Tx station
- V_{Rx} = Plane's Velocity component along path from aircraft to Rx station

When plane is moving along the direct path between Tx and Rx stations, the two Doppler Velocities cancel out

When plane is moving perpendicular to the direct path between the Tx and Rx stations, the two Doppler Velocities ADD

This is another HUGE reason why it is GREAT when you can make use of a plane traveling along the direct path between your station and your QSO partner's station

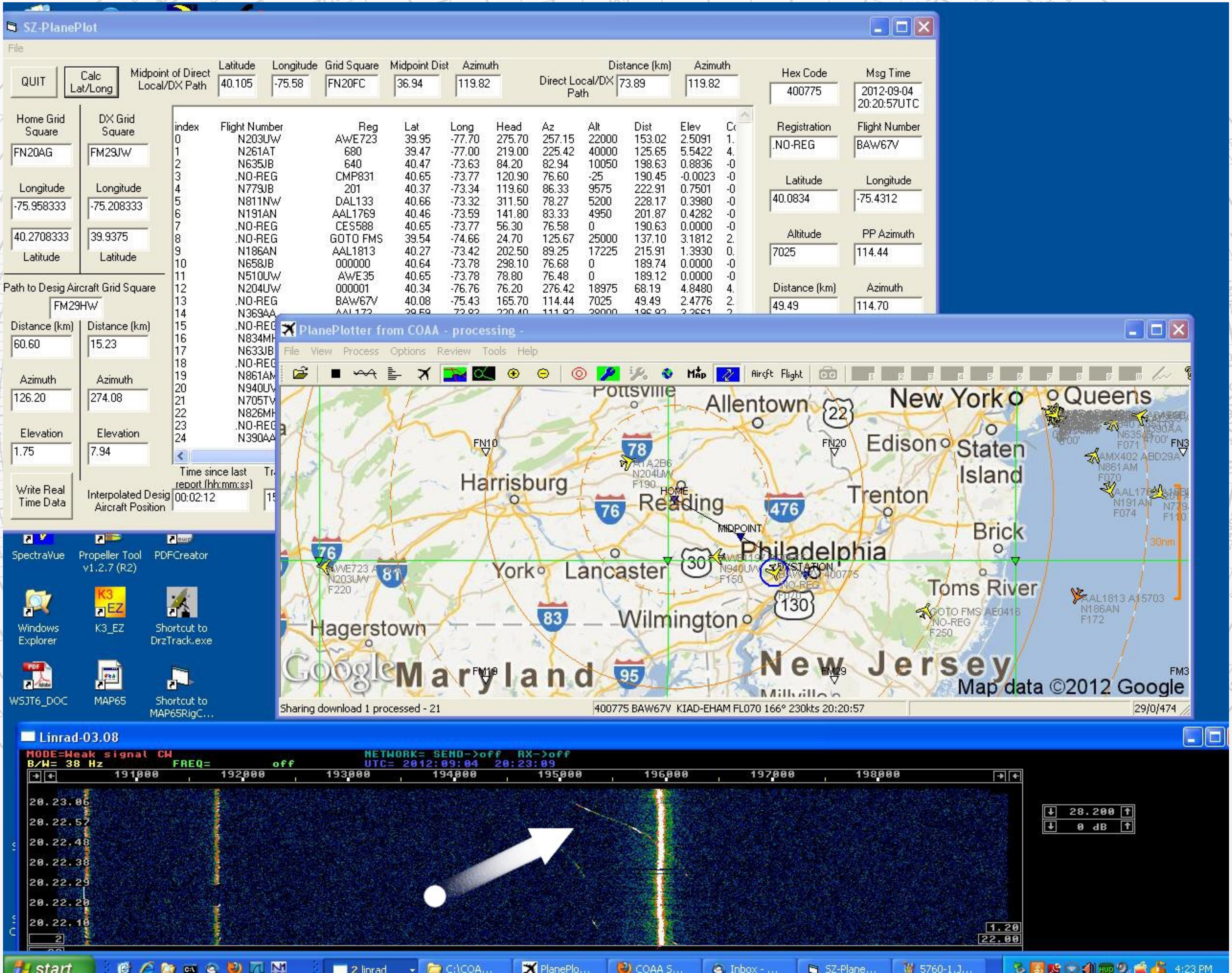


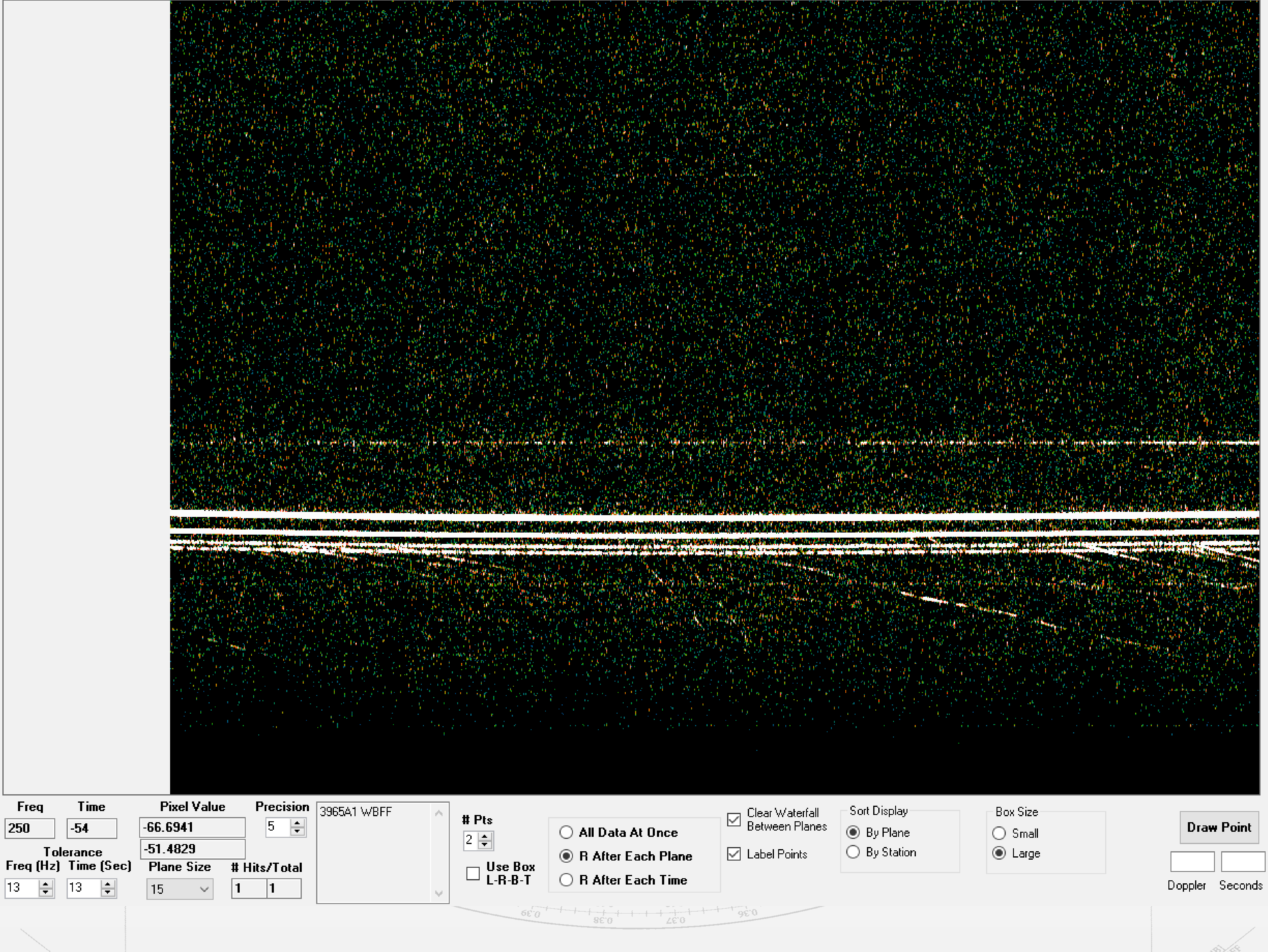
Doppler Shift (Hz)

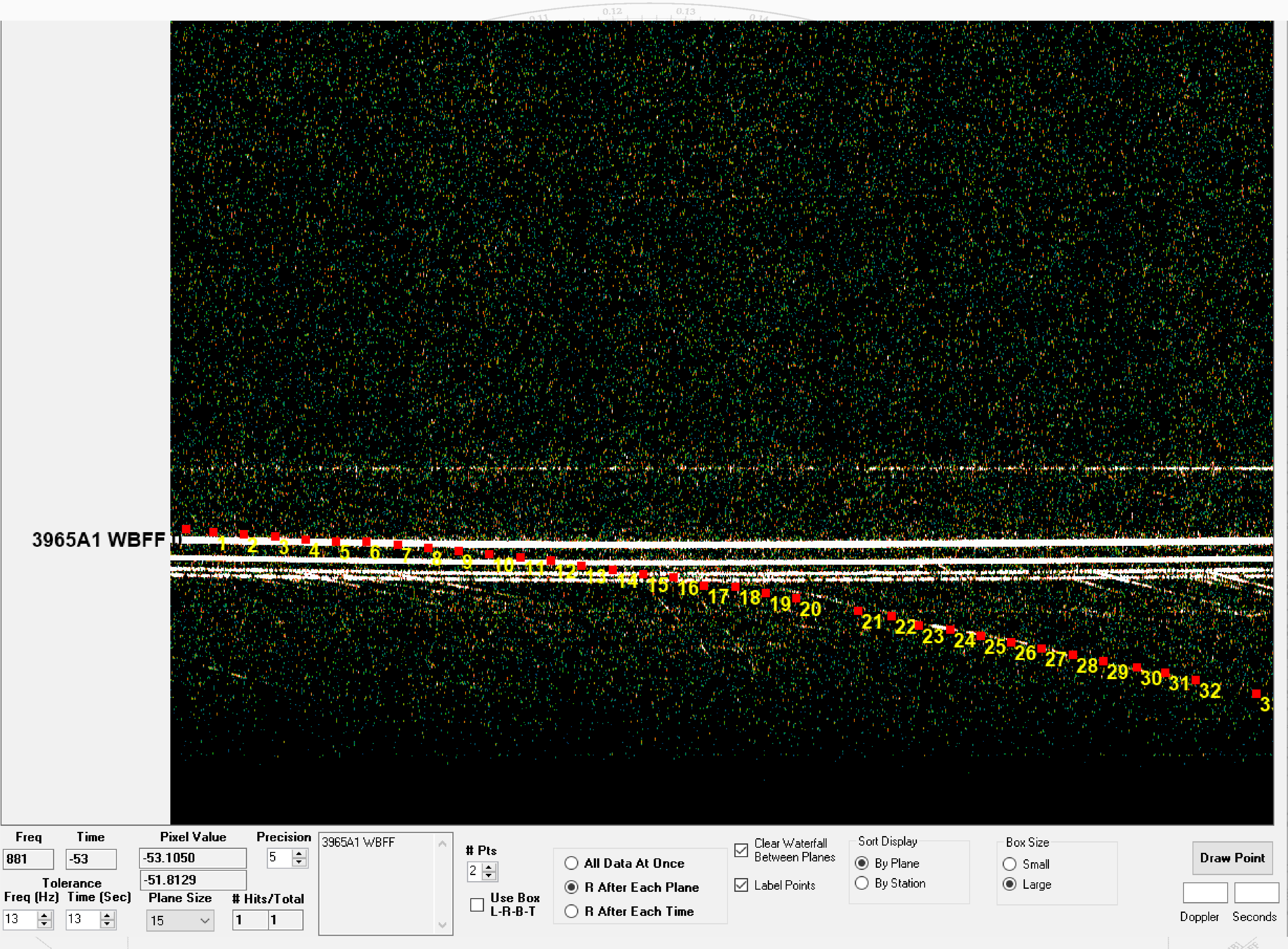
Flight Perpendicular to Inter-station Path
(Both Station Components)

MHz km/h	600	700	800	900	1000
50	56	65	74	83	93
144	160	187	213	240	267
222	247	288	329	370	411
432	480	560	640	720	800
903	1003	1171	1338	1505	1672
1296	1440	1680	1920	2160	2400
2304	2560	2987	3413	3840	4267
3456	3840	4480	5120	5760	6400
5760	6400	7467	8533	9600	10667
10368	11520	13440	15360	17280	19200
24192	26880	31360	35840	40320	44800

Example of AS Doppler Shift

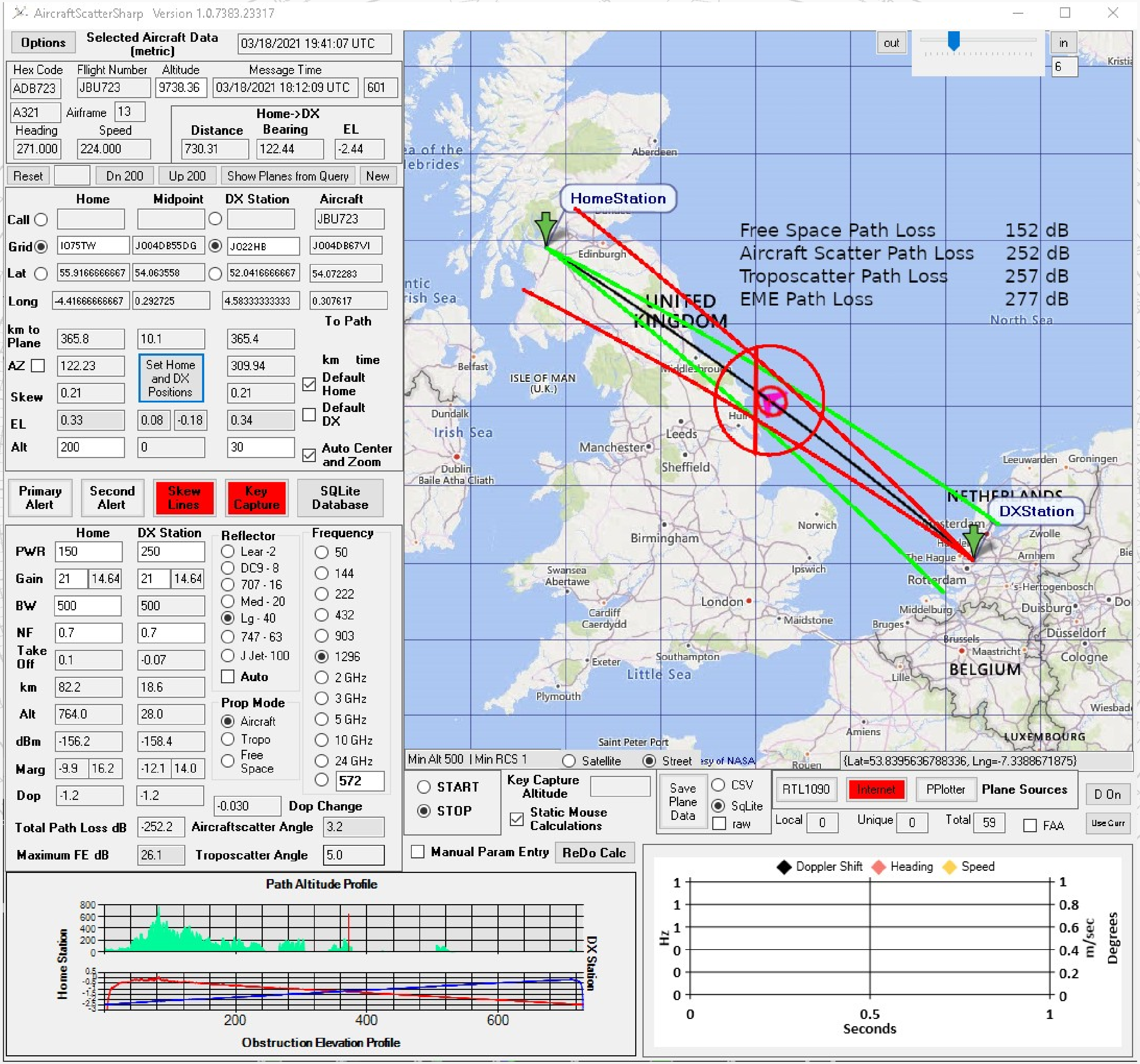



Freq
250
Time
-54
Pixel Value
-66.6941
-51.4829
Precision
5
Tolerance
Freq (Hz)
13
Time (Sec)
13
Plane Size
15
Hits/Total
1
1
3965A1 WBFF
Pts
2
Use Box
L-R-B-T
All Data At Once
R After Each Plane
R After Each Time
Clear Waterfall
Between Planes
Label Points
Sort Display
By Plane
By Station
Box Size
Small
Large
Draw Point
Doppler
Seconds

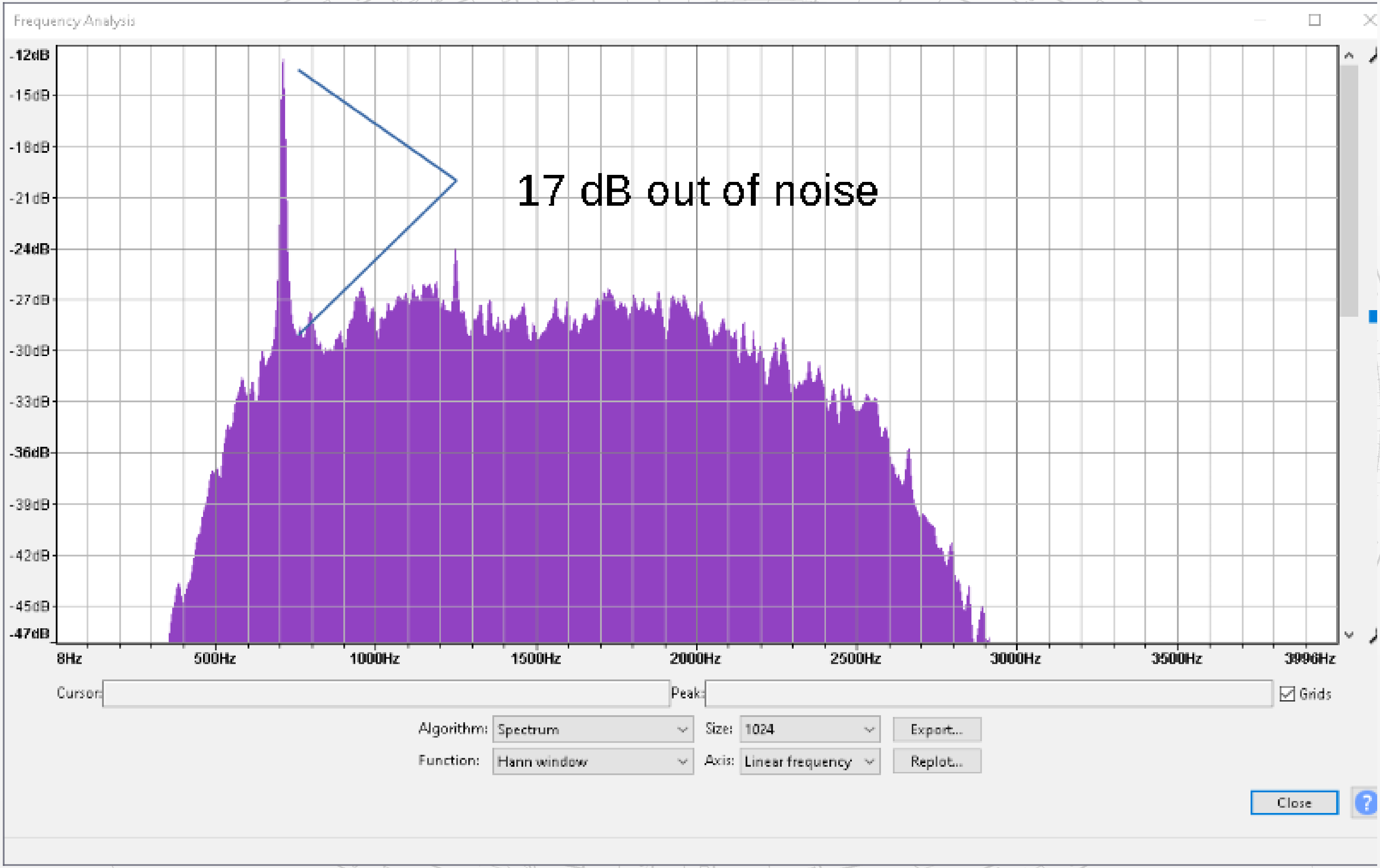


0.12
0.13
3965A1 WBFF
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 3
Freq
881
Time
-53
Pixel Value
-53.1050
-51.8129
Precision
5
3965A1 WBFF
Tolerance
Freq (Hz)
13
Time (Sec)
13
Plane Size
15
Hits/Total
1
1
Pts
2
Use Box L-R-B-T
All Data At Once
R After Each Plane
R After Each Time
Clear Waterfall Between Planes
Label Points
Sort Display
By Plane
By Station
Box Size
Small
Large
Draw Point
Doppler
Seconds

GM4CXM heard by aircraft scatter at PA0EHG on 1296 MHz



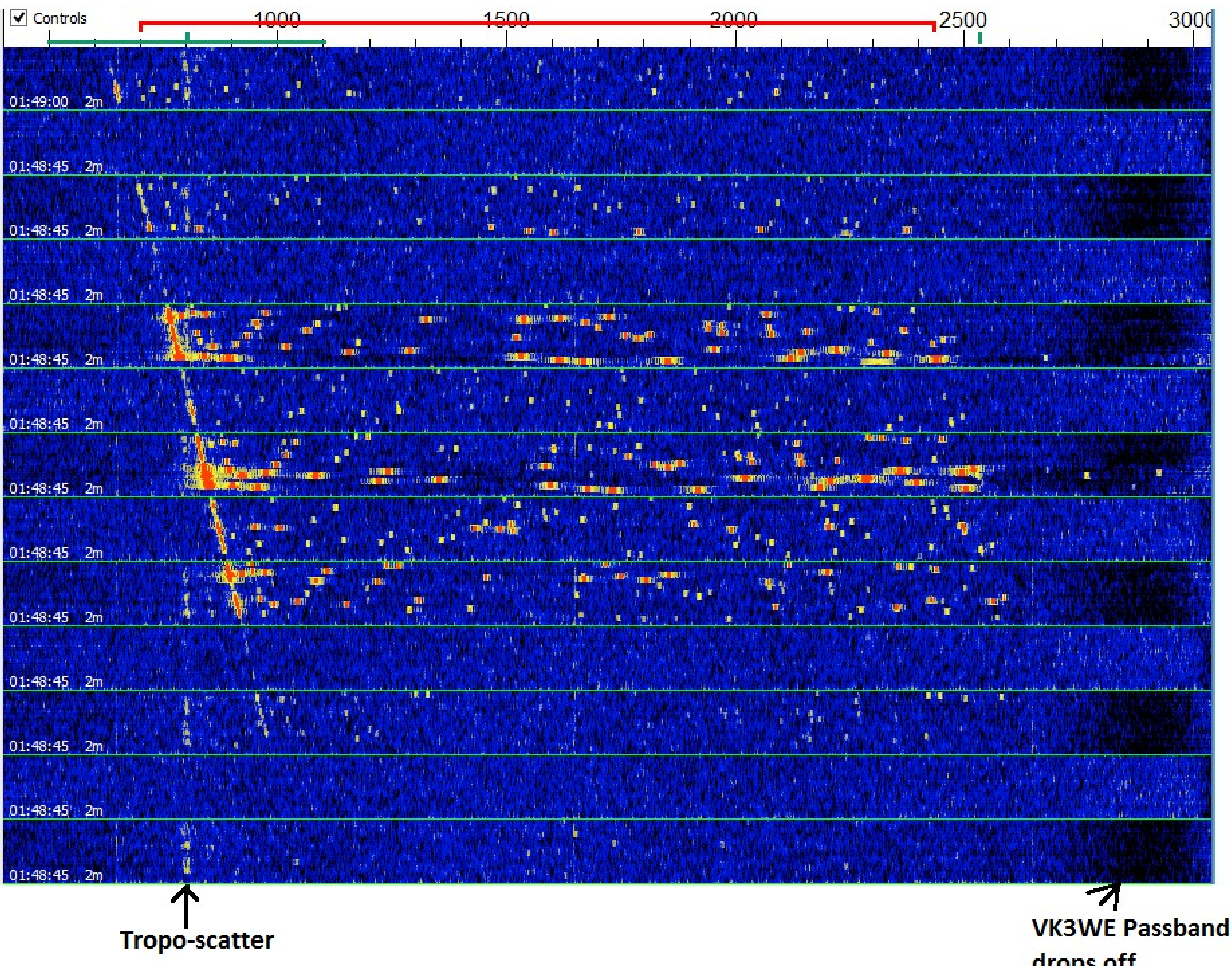
GM4CXM heard by aircraft scatter at PA0EHG on 1296 MHz



T

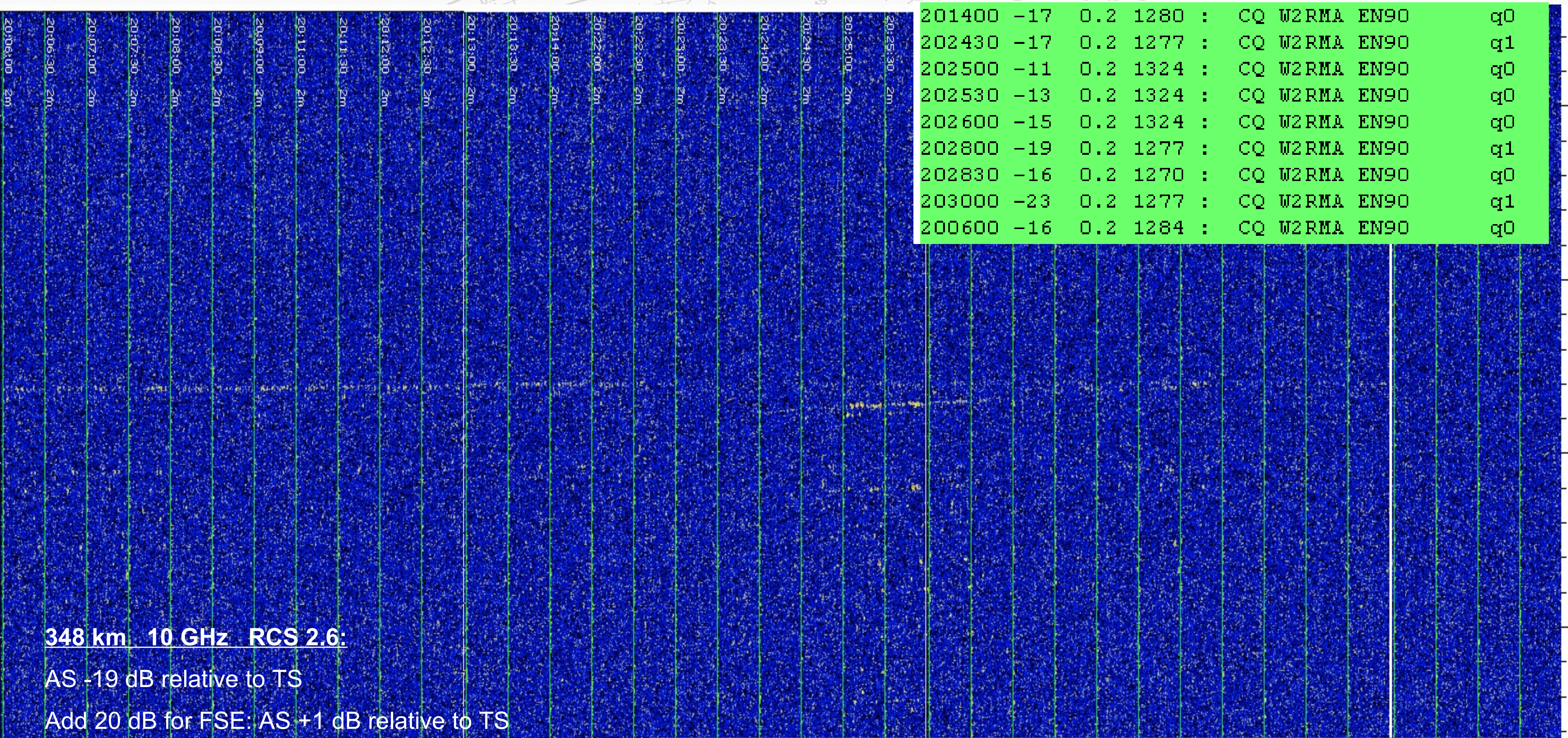
AS

VK3WE heard by aircraft scatter at VK7MO (and vice versa) on 10 GHz 568 km path with Q65-15C



	Decodes & S/N	Propagation
90 w	Nil	Mixed AS & TS
10 W	Nil	
90 W	-3	AS
10 W	-16	AS
90 W	+8	AS
10 W	-7	AS
90 W	+10	AS
10 W	-3	AS
90 W	+3	AS
10 W	-19	AS
90 W	-9	AS
10 W	Nil	
90 W	-11	TS

AS = Aircraft Scatter
TS = Tropo Scatter



201400	-17	0.2	1280	:	CQ W2RMA EN90	q0
202430	-17	0.2	1277	:	CQ W2RMA EN90	q1
202500	-11	0.2	1324	:	CQ W2RMA EN90	q0
202530	-13	0.2	1324	:	CQ W2RMA EN90	q0
202600	-15	0.2	1324	:	CQ W2RMA EN90	q0
202800	-19	0.2	1277	:	CQ W2RMA EN90	q1
202830	-16	0.2	1270	:	CQ W2RMA EN90	q0
203000	-23	0.2	1277	:	CQ W2RMA EN90	q1
200600	-16	0.2	1284	:	CQ W2RMA EN90	q0

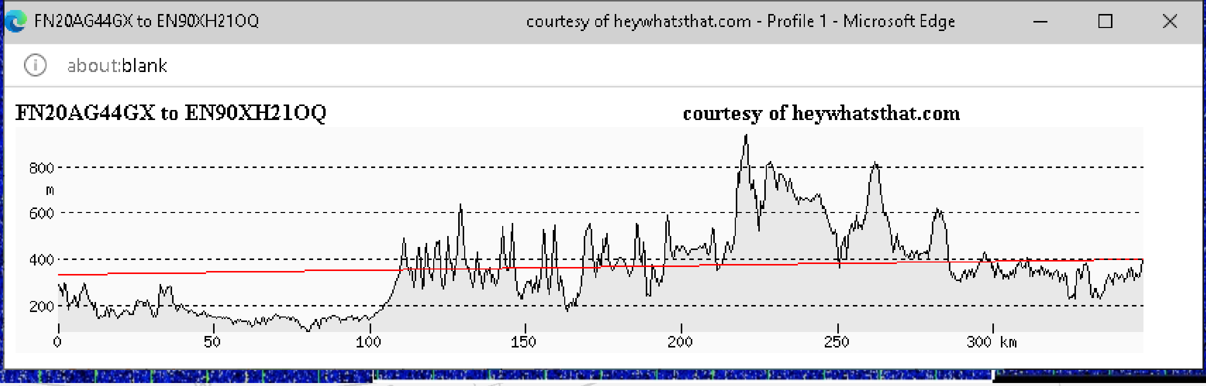
348 km 10 GHz RCS 2.6:

AS -19 dB relative to TS

Add 20 dB for FSE: AS +1 dB relative to TS

So we expect AS to be +1 dB relative to TS

but AS is about +5 dB better than TS.



What Do We Know So Far?

Relative benefit of AS increases with frequency and with distance

Plane must be along the inter-station path or within about 3 degrees to get 20-30 dB Forward Scattering Enhancement

Longer distances (600-900 km or 432-560 miles) will give greater FSE than shorter distances

Path loss is high, generally above 200 dB for 144 MHz and up, even with maximum Forward Scattering Enhancement

The RCS is never precisely known for any particular case, so exact prediction of signal strengths is not possible. The calculations should be considered to be “order of magnitude”, at best

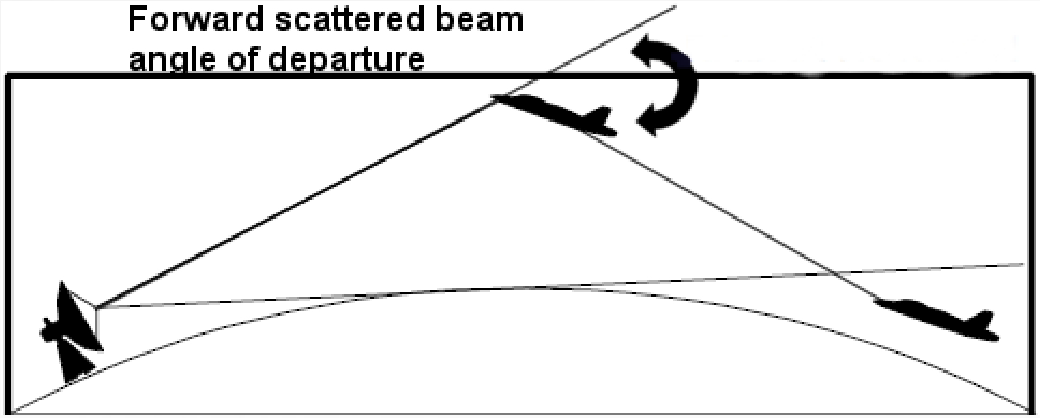
Other Considerations

Antenna Pointing

Doppler Shift/Digital Modes

Is Pointing at the Aircraft Necessary?

Consider <u>both Elevation and Horizontal Skew</u> compared with beamwidth of antenna array



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

On 10 GHz, 0.6 M dish with 65% efficiency has 3.3 degree 3 dB beam width (half beam width is 1.7 deg)

Complications when using Digital Modes with Aircraft Scatter

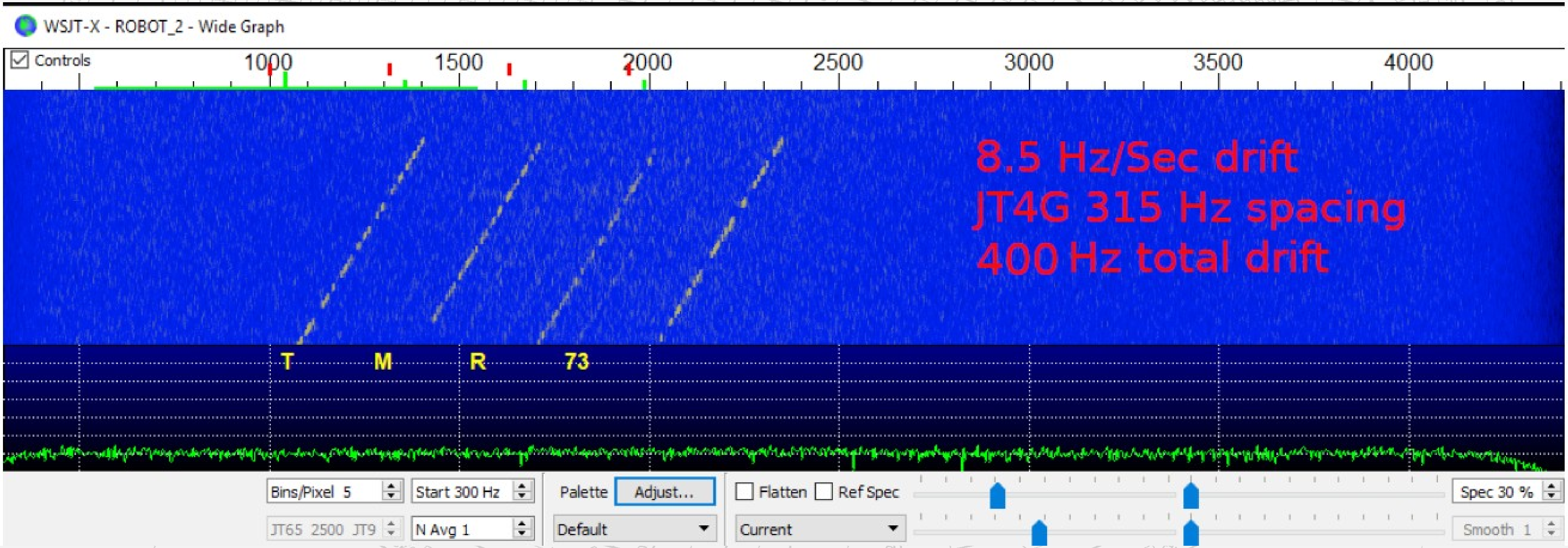
Doppler shift may adversely affect decoding

Short chopped up signal blocks

Short interval to complete QSO if plane flying perpendicular to inter-station path due to loss of Forward Scatter Enhancement as skew angle increases

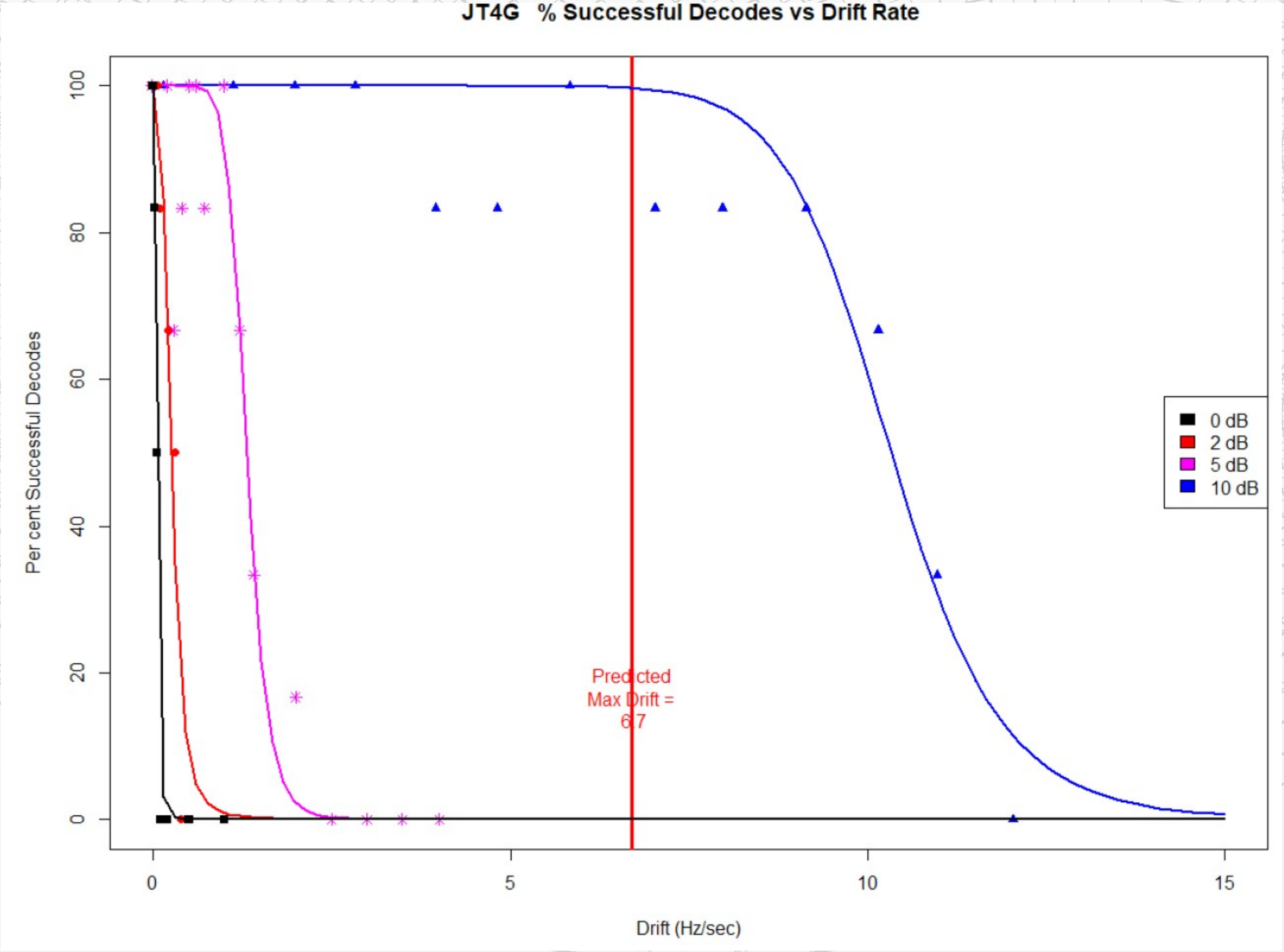
Doppler and Digital Modes

During the Tx cycle, each symbol migrates into bin of next higher symbol:



Doppler and Digital Modes

Ability to tolerate Doppler shift depends on signal strength:



Which Digital Mode to Use?

Mode	Spacing	BW (Hz)	Baud rate)	Duration (s)	S/N (dB)
JT4A	4.38	17.5	4.38	47.1	-23
JT9A	1.74	15.6	1.74	49	-27
JT65A	2.69	177.6	2.69	46.8	-25
QRA64A	1.74	111.1	1.74	48.4	-26
ISCAT-A	21.5	905	21.5	1.18	-17*
ISCAT-B	43.1	1809	43.1	0.59	-17*
JT9E	27.78	224	25	3.4	-23
JT9F	55.56	446.2	50	1.7	-22
JT9G	111.11	890.6	100	0.85	-21
JT9H	222.22	1779.5	200	0.43	-20
MSK144			2000	0.07	-2/-8#

For Microwaves, ISCAT was preferred due to its tolerance for Doppler shifts, its 15 second periods and ability to cope with short bursts. MSK144 requires signal to be within 200 Hz of 1500 Hz and JT65 is too slow and can't handle bursts. *with 30s average #for 70/500 ms burst <<ISCAT and QRA-64 ARE GONE & Q65 IS ARRIVING>>

Which Digital Mode to Use?

Mode	Spacing	BW (Hz)	Baud rate)	Duration (s)	S/N (dB)
ISCAT-A	21.5	905	21.5	1.18	-17*
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JT9F	55.56	446.2	50	1.7	-22
JT9G	111.11	890.6	100	0.85	-21
JT9H	222.22	1779.5	200	0.43	-20
Q65-15C	26.67	1733	6.7	12.8	-22.2#
				0.02	-23.7&

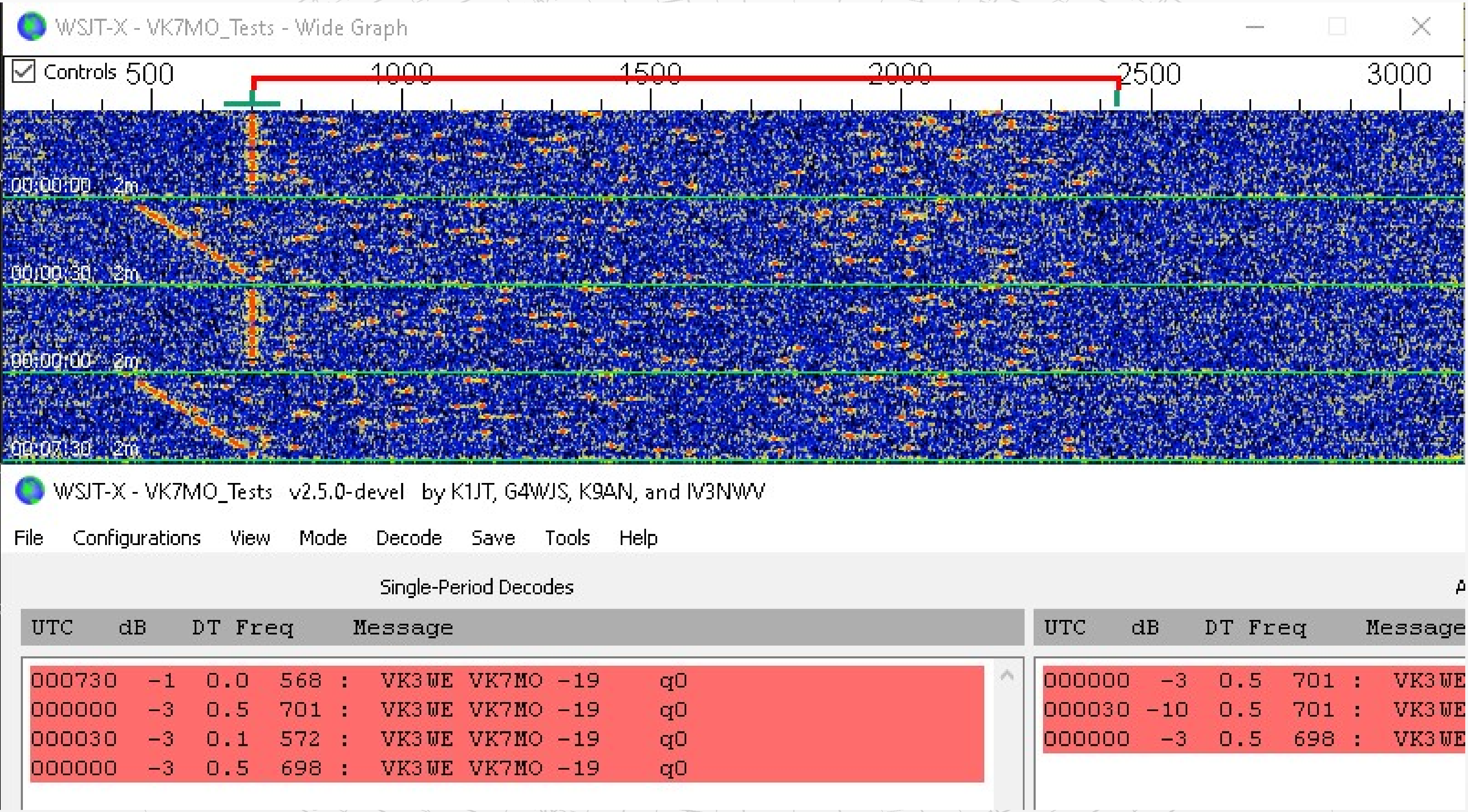
For Microwaves, ISCAT was preferred due to its tolerance for Doppler shifts, its 15 second periods and ability to cope with short bursts.

*** with 30s average**

 # No AP (est) & Max AP (est) **<<ISCAT is GOING AWAY & Q65 IS ARRIVING>>**

Just Use Q65-15C

- New WSJT-X version 2.5.0-rc1 has SUPERB Doppler Compensation built in for Q65
  - It handles Doppler shift rates up to and including 20 Hz/sec far better than ISCAT-A/B, MSK144, JT9-Fast modes (E-H)


WSJT-X - VK7MO_Tests - Wide Graph
Controls 500 1000 1500 2000 2500 3000
00:00:00 2m
00:00:30 2m
00:00:00 2m
00:07:30 2m
WSJT-X - VK7MO_Tests v2.5.0-devel by K1JT, G4WJS, K9AN, and IV3NWV
File Configurations View Mode Decode Save Tools Help
Single-Period Decodes
UTC dB DT Freq Message
000730 -1 0.0 568 : VK3WE VK7MO -19 q0
000000 -3 0.5 701 : VK3WE VK7MO -19 q0
000030 -3 0.1 572 : VK3WE VK7MO -19 q0
000000 -3 0.5 698 : VK3WE VK7MO -19 q0
UTC dB DT Freq Message
000000 -3 0.5 701 : VK3WE
000030 -10 0.5 701 : VK3WE
000000 -3 0.5 698 : VK3WE

What's Needed?

1. A willing partner
2. Good station with accurate antenna pointing
3. Knowledge of generally when aircraft will be in suitable positions (historical data may be helpful) so you know WHEN to get on the air
4. Real-time knowledge of where aircraft are at any given moment while you are attempting a contact so you know WHERE to point and EXACTLY WHEN THE MAXIMUM PROBABILITY OF SUCCESS will be

Getting real-time plane data

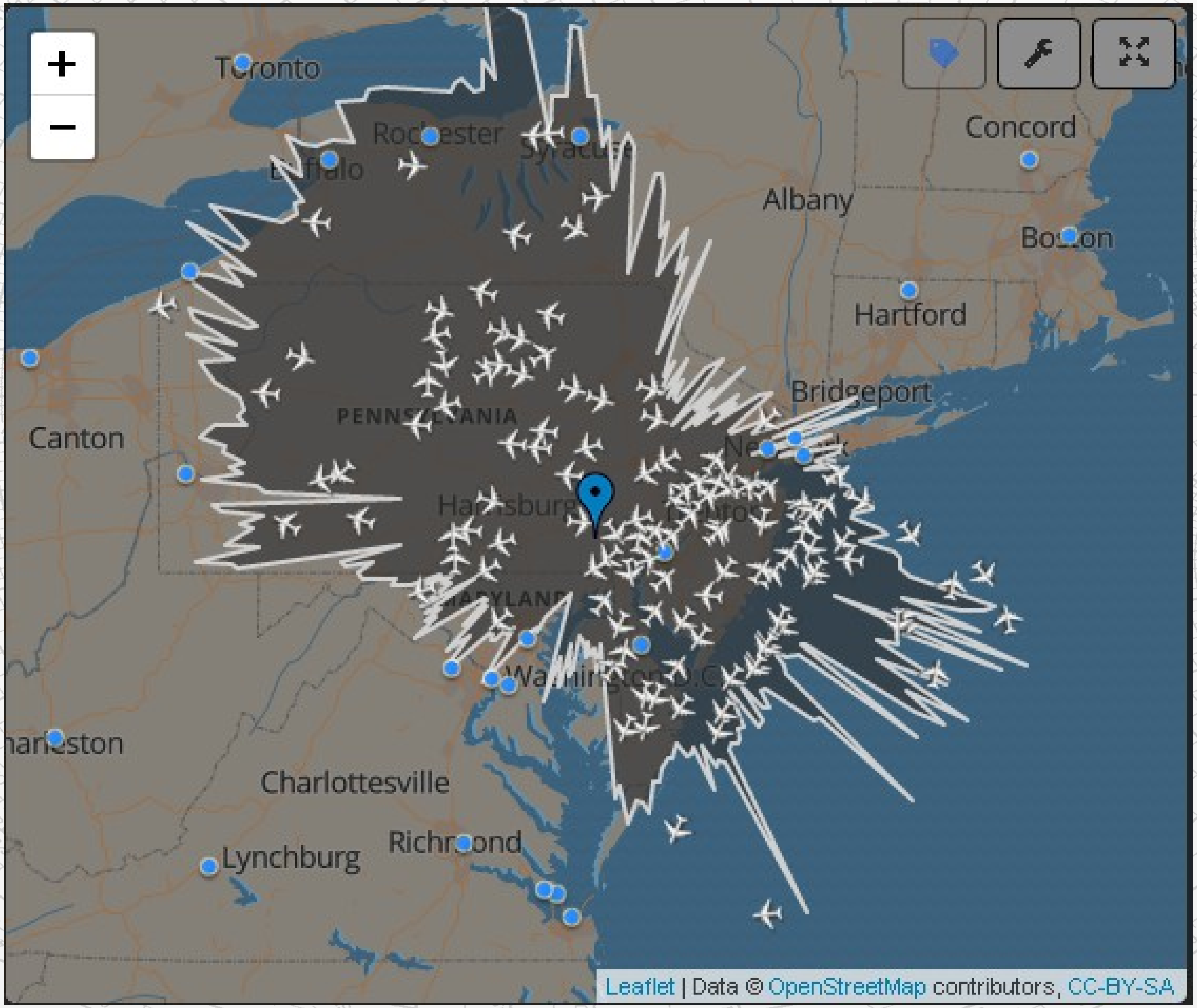
- Directly off the air --OR--
- Via internet servers
- Both make use of mode S and/or ADS-B transponder data
- Both provide accurate real-time data
- Getting data directly off the air is fun, but for our purposes internet data is necessary as some useful planes will be out of range of local ADS-B receiver.

Realtime data at W3SZ

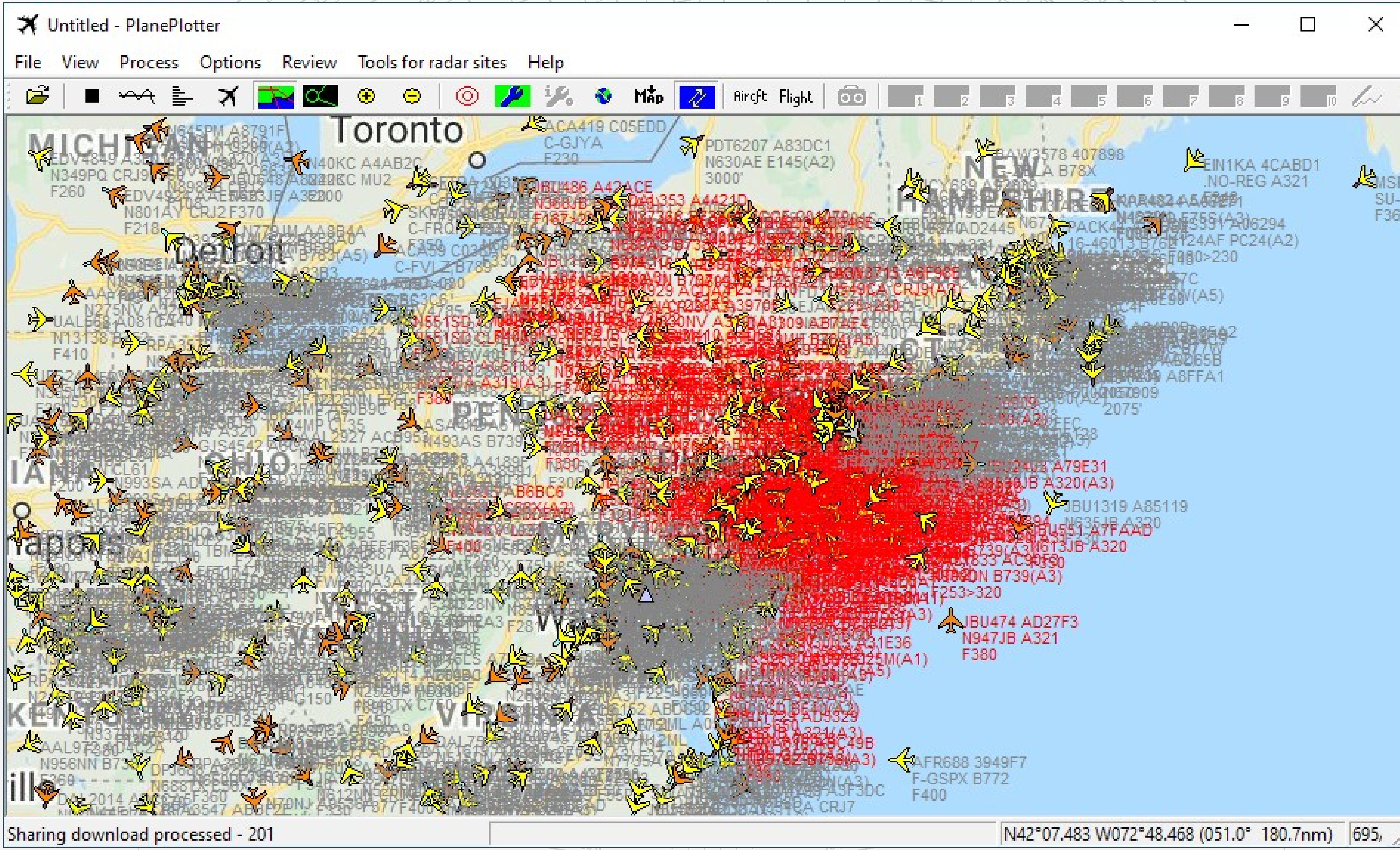
- **$20 RTL2378 Dongle from Amazon**
- **WIMO-GP1090 antenna**
- **Kuhne 1090 MHz preamplifier**
- **Dump1090 decoder/server software (free)**
- **AircraftScatter Sharp or PlanePlotter**
- **I generally see 100-150 planes at a time**
  - **Limited SW/NE exposure due to State Forest**

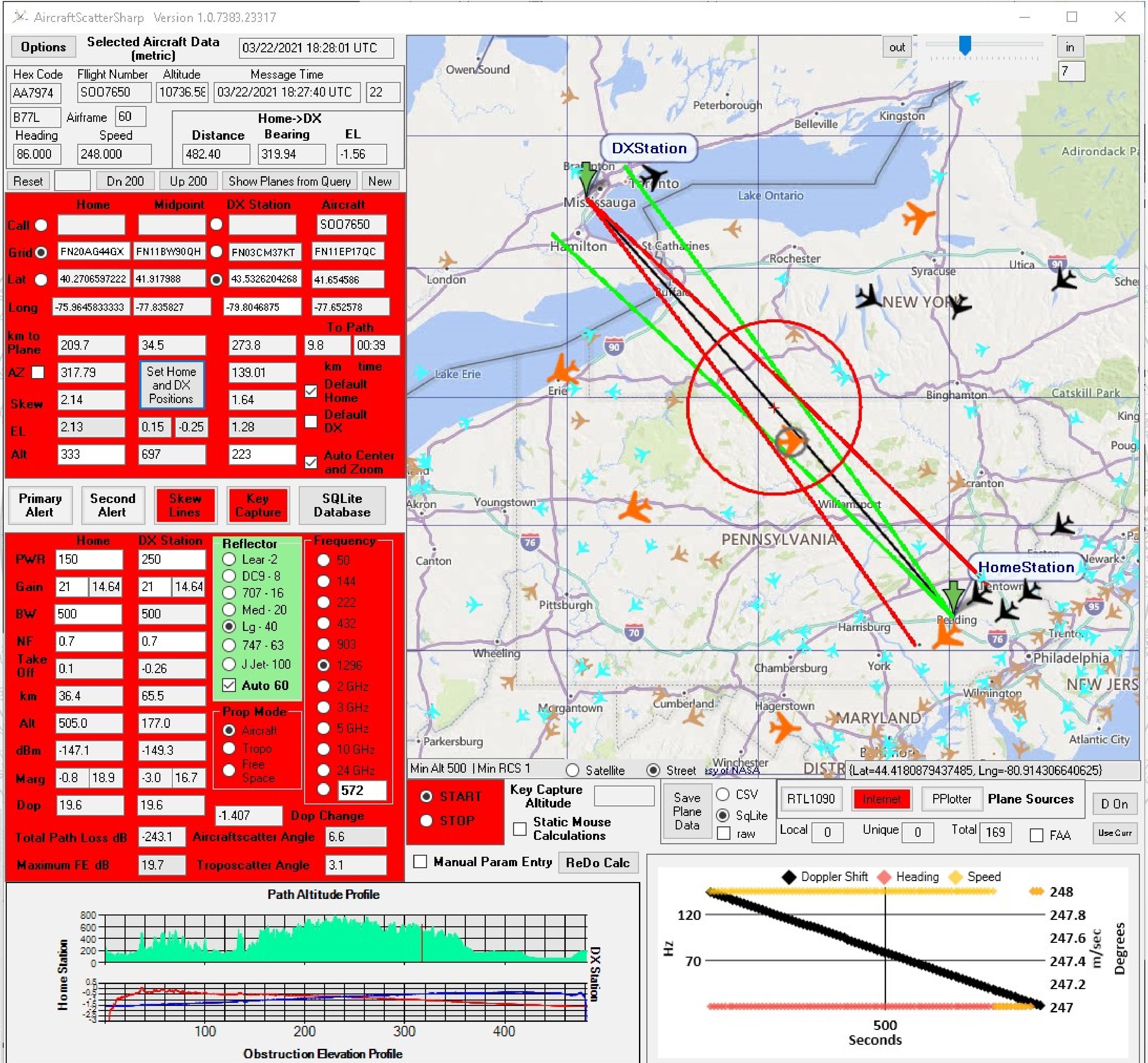
Real-time data at W3SZ

coverage pattern



W3SZ Realtime Data

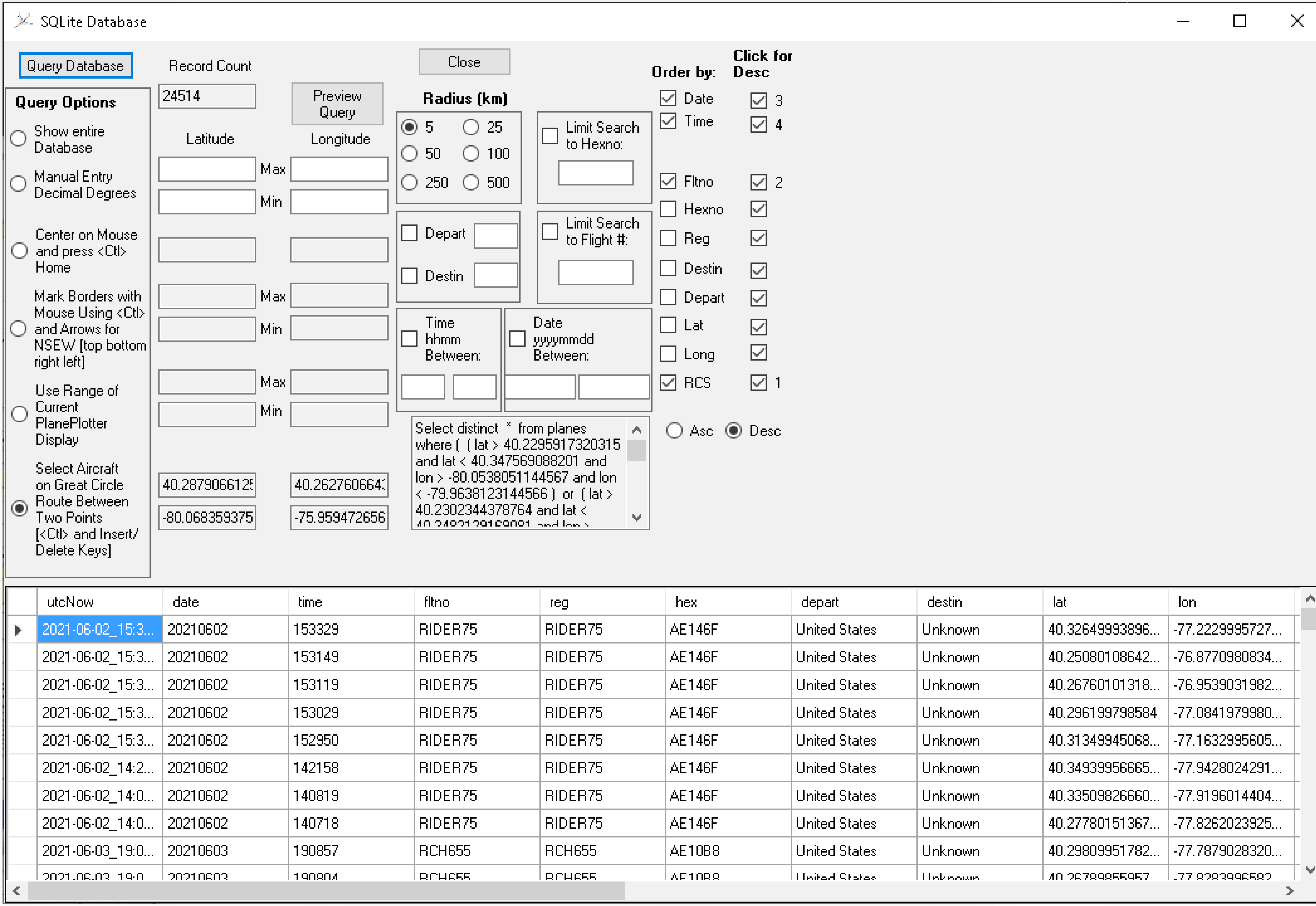




AircraftScatterSharp Version 1.0.7383.23317
Options
Selected Aircraft Data (metric)
03/22/2021 18:28:01 UTC
Hex Code
Flight Number
Altitude
Message Time
AA7974
SOO7650
10736.58
03/22/2021 18:27:40 UTC
22
B77L
Airframe
60
Heading
Speed
86.000
248.000
Home->DX
Distance
Bearing
EL
482.40
319.94
-1.56
Reset
Dn 200
Up 200
Show Planes from Query
New
Home
Midpoint
DX Station
Aircraft
Call
SOO7650
Grid
FN20AG44GX
FN11BY90QH
FN03CM37KT
FN11EP17QC
Lat
40.2706597222
41.917988
43.5326204268
41.654586
Long
-75.9645833333
-77.835827
-79.8046875
-77.652578
To Path
km to Plane
209.7
34.5
273.8
9.8
00:39
AZ
317.79
Set Home and DX Positions
139.01
km
time
Default Home
Skew
2.14
1.64
Default DX
EL
2.13
0.15
-0.25
1.28
Alt
333
697
223
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
Reflector
Frequency
PWR
150
250
Lear -2
50
DC9 - 8
144
Gain
21
14.64
21
14.64
707 - 16
222
BW
500
500
Med - 20
432
Lg - 40
NF
0.7
0.7
747 - 63
903
Take Off
0.1
-0.26
J Jet- 100
1296
Auto 60
km
36.4
65.5
2 GHz
Alt
505.0
177.0
Prop Mode
3 GHz
Aircraft
5 GHz
dBm
-147.1
-149.3
Tropo
10 GHz
Free Space
24 GHz
Marg
-0.8
18.9
-3.0
16.7
572
Dop
19.6
19.6
-1.407
Dop Change
Total Path Loss dB
-243.1
Aircraftscatter Angle
6.6
Maximum FE dB
19.7
Troposcatter Angle
3.1
out
in
7
Owen Sound
Peterborough
Belleville
Kingston
DXStation
Adirondack P
Brampton
Toronto
Lake Ontario
Mississauga
Hamilton
St Catharines
Rochester
London
Syracuse
Utica
Sche
NEW YORK
Buffalo
Lake Erie
Erie
Binghamton
Catskill Park
King
Poug
Scranton
Akron
Youngstown
Williamsport
PENNSYLVANIA
Canton
HomeStation
Newark
Allentown
Pittsburgh
Reading
Harrisburg
Trenton
Wheeling
Philadelphia
Chambersburg
York
NEW JERS
Wilmington
Morgantown
Cumberland
Hagerstown
MARYLAND
Parkersburg
Atlantic City
Winchester
Baltimore
Min Alt 500 | Min RCS 1
Satellite
Street
DISTR
(Lat=44.4180879437485, Lng=-80.914306640625)
START
STOP
Key Capture Altitude
Static Mouse Calculations
Save Plane Data
CSV
SqLite
raw
RTL1090
Internet
PPlotter
Plane Sources
D On
Local
0
Unique
0
Total
169
FAA
Use Curr
Manual Param Entry
ReDo Calc
Path Altitude Profile
800
600
400
200
0
Home Station
DX Station
100
200
300
400
Obstruction Elevation Profile
Doppler Shift
Heading
Speed
120
70
Hz
248
247.8
247.6
247.4
247.2
247
m/sec
Degrees
500
Seconds

AircraftScatterSharp Original Features

- Real-time capture and display of plane position data derived from an internet plane server, from a local RTL1090 server, or both
- Display of the direct path line between two stations, along with skew lines to allow a quick assessment of the angular deviation of an aircraft's position from the direct path between the stations, and a midpoint circle to show when an aircraft is within a specified distance from the midpoint of the path.
- Path altitude and elevation/obstruction profiles (SRTM)
- Real-time calculation of estimated path loss, received signal strength, and signal margin at both stations based on plane location and user-adjustable station parameters, using either bistatic aircraft scatter, troposcatter or free path formulas.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Query Database
Record Count
24514
Close
Preview Query
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
Max
Min
Max
Min
40.287906612
40.262760664
-80.068359375
-75.959472656
Radius (km)
5
25
50
100
250
500
Limit Search to Hexno:
Depart
Destin
Limit Search to Flight #:
Time hhmm Between:
Date yyyymmdd Between:
Select distinct * from planes where ((lat > 40.2295917320315 and lat < 40.347569088201 and lon > -80.0538051144567 and lon < -79.9638123144566) or (lat > 40.2302344378764 and lat <
Order by:
Click for Desc
Date 3
Time 4
Fltno 2
Hexno
Reg
Destin
Depart
Lat
Long
RCS 1
Asc
Desc
utcNow | date | time | fltno | reg | hex | depart | destin | lat | lon
2021-06-02_15:3... | 20210602 | 153329 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.32649993896... | -77.2229995727...
2021-06-02_15:3... | 20210602 | 153149 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.25080108642... | -76.8770980834...
2021-06-02_15:3... | 20210602 | 153119 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.26760101318... | -76.9539031982...
2021-06-02_15:3... | 20210602 | 153029 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.296199798584 | -77.0841979980...
2021-06-02_15:3... | 20210602 | 152950 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.31349945068... | -77.1632995605...
2021-06-02_14:2... | 20210602 | 142158 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.34939956665... | -77.9428024291...
2021-06-02_14:0... | 20210602 | 140819 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.33509826660... | -77.9196014404...
2021-06-02_14:0... | 20210602 | 140718 | RIDER75 | RIDER75 | AE146F | United States | Unknown | 40.27780151367... | -77.8262023925...
2021-06-03_19:0... | 20210603 | 190857 | RCH655 | RCH655 | AE10B8 | United States | Unknown | 40.29809951782... | -77.7879028320...

AircraftScatterSharp Original Features

Select distinct * from planes where ((lat > 40.2295917320315 and lat < 40.347569088201 and lon > -80.0538051144567 and lon < -79.9638123144566) or (lat > 40.2302344378764 and lat < 40.3482129169081 and lon > -79.9942533089094 and lon < -79.9042605089094) or (lat > 40.2308466387713 and lat < 40.3488261874041 and lon > -79.934700411653 and lon < -79.844707611653) or (lat > 40.2314283335315 and lat < 40.3494088984974 and lon > -79.8751464759904 and lon < -79.7851536759904) or (lat > 40.2319795210318 and lat < 40.3499610490562 and lon > -79.8155915552333 and lon < -79.7255987552333) or (lat > 40.2325002002064 and lat < 40.3504826380083 and lon > -79.7560357027008 and lon < -79.6660429027008) or (lat > 40.2329903700488 and lat < 40.3509736643413 and lon > -79.6964789717194 and lon < -79.6064861717194) or (lat > 40.2334500296121 and lat < 40.3514341271028 and lon > -79.6369214156228 and lon < -79.5469286156228) or (lat > 40.2338791780087 and lat < 40.3518640253998 and lon > -79.5773630877508 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and lon < -78.9513194108094) or (lat > 40.2364923950644 and lat < 40.3544818091798 and lon > -78.9817491000206 and lon < -78.8917563000206) or (lat > 40.2365858790568 and lat < 40.3545754565512 and lon > -78.922185804507 and lon < -78.8321930045069) or (lat > 40.2366488458707 and lat < 40.3546385334106 and lon > -78.8626223776538 and lon < -78.7726295776538) or (lat > 40.2366812953918 and lat < 40.354671039643 and lon > -78.8030588728476 and lon < -78.7130660728476) or (lat > 40.2366832275652 and lat < 40.3546729751933 and lon > -78.7434953434755 and lon < -78.6535025434755) or (lat > 40.2366546423957 and lat < 40.3546443400661 and lon > -78.6839318429247 and lon < -78.5939390429247) or (lat > 40.2365955399475 and lat < 40.354585134326 and lon > -78.6243684245823 and lon < -78.5343756245823) or (lat > 40.2365059203443 and lat < 40.3544953580974 and lon > -78.5648051418346 and lon < -78.4748123418346) or (lat > 40.2363857837693 and lat < 40.3543750115645 and lon > -78.505242048067 and 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AircraftScatterSharp New Features (2018-2019)

Doppler Calculations (value and rate of change)

Radar Cross Section modeling now with estimated RCS for more than 100 aircraft

Optionally, program will now automatically assign estimated RCS to selected aircraft using this model

Adjustable lower limits for altitude, elevation, and estimated RCS below which planes will not be displayed

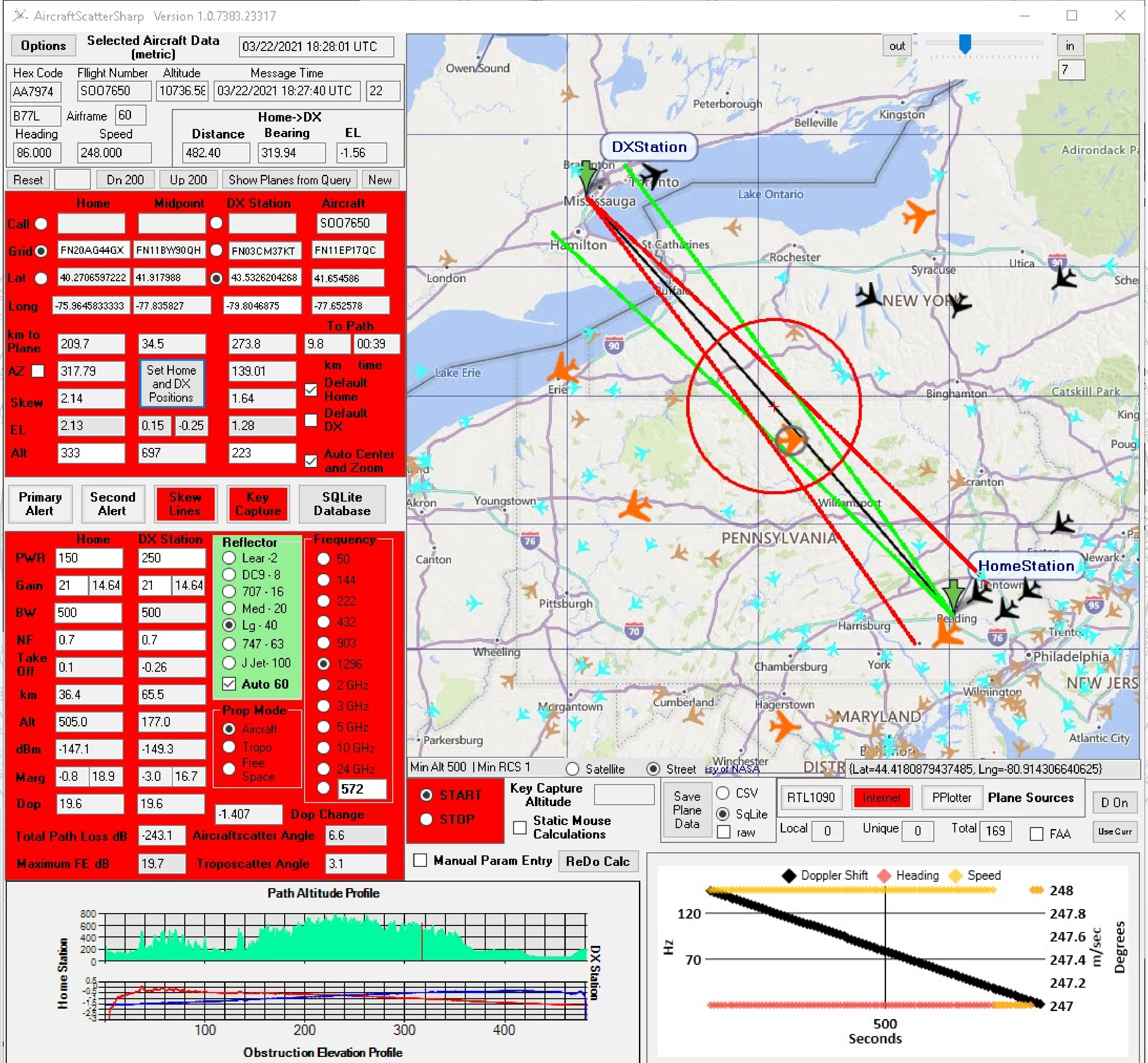
Planes not meeting these limits will be removed from display

Plane icon size and color are indexed to estimated RCS

More extensive Manual Parameter Entry options including both static and dynamic modeling

Rolling terrain elevation reporting

N1MM-based rotor control


AircraftScatterSharp Version 1.0.7383.23317
Options
Selected Aircraft Data (metric)
03/22/2021 18:28:01 UTC
Hex Code
Flight Number
Altitude
Message Time
AA7974
SOO7650
10736.58
03/22/2021 18:27:40 UTC
22
B77L
Airframe
60
Heading
Speed
86.000
248.000
Home->DX
Distance
Bearing
EL
482.40
319.94
-1.56
Reset
Dn 200
Up 200
Show Planes from Query
New
Home
Midpoint
DX Station
Aircraft
Call
SOO7650
Grid
FN20AG44GX
FN11BW90QH
FN03CM37KT
FN11EP17QC
Lat
40.2706597222
41.917988
43.5326204268
41.654586
Long
-75.9645833333
-77.835827
-79.8046875
-77.652578
To Path
km to Plane
209.7
34.5
273.8
9.8
00:39
AZ
317.79
Set Home and DX Positions
139.01
km
time
Default Home
Skew
2.14
1.64
Default DX
EL
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-0.25
1.28
Alt
333
697
223
Auto Center and Zoom
Primary Alert
Second Alert
Skew Lines
Key Capture
SQLite Database
Home
DX Station
Reflector
Frequency
PWR
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250
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Gain
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14.64
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707 - 16
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Med - 20
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NF
0.7
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Lg - 40
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747 - 63
1296
Take Off
0.1
-0.26
J Jet- 100
2 GHz
km
36.4
65.5
Auto 60
3 GHz
Alt
505.0
177.0
Prop Mode
5 GHz
Aircraft
10 GHz
dBm
-147.1
-149.3
Tropo
24 GHz
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-0.8
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-3.0
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Free Space
572
Dop
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19.6
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Dop Change
Total Path Loss dB
-243.1
Aircraftscatter Angle
6.6
Maximum FE dB
19.7
Troposcatter Angle
3.1
out
in
7
DXStation
HomeStation
Owen Sound
Peterborough
Belleville
Kingston
Adirondack Pa
Brampton
Toronto
Mississauga
Lake Ontario
Hamilton
St Catharines
Rochester
Syracuse
Utica
London
Buffalo
NEW YORK
Lake Erie
Erie
Binghamton
Catskill Park
Youngstown
Akron
Williamsport
Scranton
PENNSYLVANIA
Canton
Allentown
Newark
Pittsburgh
Reading
Harrisburg
Trenton
Wheeling
Chambersburg
York
Philadelphia
NEW JERS
Morgantown
Cumberland
Hagerstown
Wilmington
MARYLAND
Parkersburg
Atlantic City
Winchester
Min Alt 500 | Min RCS 1
Satellite
Street
(Lat=44.4180879437485, Lng=-80.914306640625)
START
STOP
Key Capture Altitude
Static Mouse Calculations
Save Plane Data
CSV
SqLite
raw
RTL1090
Internet
PPlotter
Plane Sources
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Local
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Unique
0
Total
169
FAA
Use Curr
Manual Param Entry
ReDo Calc
Path Altitude Profile
800
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Home Station
DX Station
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300
400
Obstruction Elevation Profile
Doppler Shift
Heading
Speed
120
70
Hz
248
247.8
247.6
247.4
247.2
247
m/sec
Degrees
500
Seconds

Summary / Suggestions

Try to use aircraft with minimal skew (< 3-5 degrees) to maximize FSE

Try to use aircraft flying along inter-station path to maximize QSO time, maximize FSE and signal strength, minimize Doppler shift and its rate of change

Use a program like Aircraft Scatter Sharp to track aircraft in real time

Aircraft Scatter Sharp will also allow you to estimate signal levels, compare expected AS vs tropo signal levels, see estimated Doppler shift

Digital modes increase your likelihood of completing very-weak-signal QSOs (path losses greater than 200 dB); Formerly complex advice on which mode to use now replaced by simple “Use Q65-15C”.

Whether or not you need to point at the aircraft rather than at the remote station depends on your beamwidth, horizontal skew angle, aircraft elevation

Links

https://w3sz.com/AircraftScatter.htm

https://w3sz.com/updates/AircraftScatterSharp.exe