COMSEARCH

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Analysis of Potential RADAR Interference Issues for BEGAN Operations at the Hawaii Pacific Teleport (HPT)

Background: HPT is considering the installation of a 13-meter C-Band earth station at the HPT to support BEGAN INMARSAT operations. The BEGAN operations will require the earth station to operate in the extended reception band of 3550 – 4200 MHz. In addition the HPT will have to install INMARSAT terminals to support L-Band INMARSAT operations. The issues that are addressed in this analysis are the potential interference conditions that may occur at the HPT to the operation of the C-Band earth station and the INMARSAT terminals and how these conditions can be dealt with.

Discussion: The electromagnetic environment at the HPT that may cause interference to the extended band operation of the C-Band earth station is the result of U. S. Military RADAR's operating in the vicinity of the HPT. These RADARs are mainly installed on ships that operate off the coast of Hawaii and as they enter the naval base at Pearl Harbor, and they may also be installed at land based sites. The following is a list of the RADAR's, that have been given fictitious names in this report for security reasons, that are potential interferers:

RADAR A
RADAR B
RADAR C
RADAR D
RADAR E
RADAR F
FAA RADAR

All of these RADAR's operate in the frequency band directly adjacent to and below the band of operation of the proposed 13-meter earth station. However, there are two ways they pose an interference threat. First, their high peak power can saturate the front end of the earth station receiver, and secondly, their spectrum roll-off side lobes fall into the pass band of the earth station receiver and are a worse case threat to the lower portion of the proposed earth station reception band.

Additionally, FAA RADAR operations from the Honolulu Airport may disrupt the operation of the INMARSAT terminals to be installed at the HPT. Figures 1 and 2 show the relative locations of the ship and land based RADAR locations with respect to the HPT selected for the analysis in this report.

Earth Station System Parameters: Two earth station systems at the HPT are considered in this analysis; the 13-meter C-Band earth station and the L-Band INMARSAT Terminal. Table 1 contains the operating parameters for the C-Band earth station and Table 2 contains the operating parameters for INMARSAT Terminal.

Table 1 C-Band Earth Station Operating Parameters and Coordination Data

SATELLITE EARTH STATION
FREQUENCY COORDINATION DATA
05/10/2006

Company	Hawaii Pacific Teleport, L.P.
Earth Station Name, State	KAPOLEI, HI
Latitude (DMS) (NAD83)	21 20 9.0 N
Longitude (DMS) (NAD83)	158 5 25.0 W
Ground Elevation AMSL (Ft/m)	120.02 / 36.58
Antenna Centerline AGL (Ft/m)	31.99 / 9.75
Receive Antenna Type:	Vertex RSI
4.0 GHz Gain (dBi) / Diameter (m)	53.5 / 13.0
3 dB / 15 dB Half Beamwidth	0.19 / 0.38
Transmit Antenna Type:	VERTEX RSI
6.0 GHz Gain (dBi) / Diameter (m)	56.8 / 13.0
3 dB / 15 dB Half Beamwidth	0.13 / 0.26
Operating Mode	TRANSMIT AND RECEIVE
Modulation	DIGITAL
Emission / Receive Band (MHz)	51K2G7W - 36M0G7W / 3550.00 - 4200.00
Emission / Transmit Band (MHz)	51K2G7W - 36M0G7W / 5850.00 - 6425.00
Max. Available RF Power (dBW)/4 kHz)	-2.70
(dBW)/MHz)	21.30
Max. EIRP (dBW)/4 kHz)	54.10
(dBW)/MHz)	78.10
Max permissible Interference Power	
4.0 GHz, 20% (dBW/1 MHz)	-156.0
4.0 GHz, 0.0100% (dBW/1 MHz)	-146.0
6.0 GHz, 20% (dBW/4 kHz)	-154.0
6.0 GHz, 0.0025% (dBW/4 kHz)	-131.0
Range of Satellite Arc (Geostationary)	
Degrees Longitude	98.0 W / 216.5 W
Azimuth Range (Min/Max)	101.8 / 257.1
Corresponding Elevation Angles	19.5 / 21.6
Radio Climate	C
Rain Zone	4
Max Great Circle Coordination Distance (Mi/Km)	
4.0 GHz	579.9 / 933.4
6.0 GHz	269.7 / 434.1

Precipitation Scatter Contour Radius (Mi/Km)

4.0 GHz	229.5 / 369.4
6.0 GHz	62.1 / 100.0

Table of Earth Station Coordination Values
05/10/2006

Earth Station Name KAPOLEI HI
Owner Hawaii Pacific Teleport, L.P.
Latitude (DMS) (NAD83) 21 20 9.0 N
Longitude (DMS) (NAD83) 158 5 25.0 W
Ground Elevation (Ft/m) 120.02 / 36.58 AMSL
Antenna Centerline (Ft/m) 31.99 / 9.75 AGL

Objectives: Receive -156.0 (dBW /1 MHz)
Transmit -154.0 (dBW /4 kHz) TX Power -2.7 (dBW/4 kHz)

Azimuth (Deg)	Horizon Elevation Angle (Deg)	Antenna Disc. Angle (Deg)	4.0 GHz Antenna Gain (dBi)	4.0 GHz Coordination Distance (Km)	6.0 GHz Antenna Gain (dBi)	6.0 GHz Coordination Distance (Km)
0	9.56	101.64	-10.00	100.0	-10.00	100.0
5	7.65	96.68	-10.00	119.9	-10.00	100.0
10	7.42	91.78	-10.00	122.3	-10.00	100.0
15	7.64	86.89	-10.00	120.0	-10.00	100.0
20	7.02	82.02	-10.00	126.6	-10.00	100.0
25	6.32	77.17	-10.00	134.1	-10.00	100.0
30	5.81	72.36	-10.00	142.0	-10.00	100.0
35	5.13	67.59	-10.00	157.8	-10.00	100.0
40	4.12	62.91	-10.00	171.6	-10.00	100.0
45	3.43	58.27	-10.00	195.3	-10.00	100.0
50	3.12	53.63	-10.00	208.3	-10.00	100.0
55	2.84	49.03	-10.00	223.5	-10.00	100.0
60	2.36	44.59	-9.23	262.0	-9.23	100.0
65	2.12	40.18	-8.10	289.0	-8.10	109.3
70	1.91	35.90	-6.88	318.2	-6.88	127.3
75	1.70	31.81	-5.56	351.6	-5.56	149.0
80	1.34	28.09	-4.21	411.2	-4.21	184.3
85	0.75	24.97	-2.94	556.9	-2.94	251.1
90	0.00	22.67	-1.88	892.6	-1.88	408.6
95	0.00	20.60	-0.84	918.9	-0.84	422.7
100	0.00	19.56	-0.28	933.4	-0.28	434.0
105	0.00	19.73	-0.38	931.0	-0.38	432.8
110	0.00	21.06	-1.09	912.7	-1.09	419.3
115	0.00	23.37	-2.22	884.3	-2.22	404.2
120	0.00	26.40	-3.54	852.1	-3.54	387.1
125	0.00	29.92	-4.90	820.0	-4.90	370.3
130	0.00	33.79	-6.22	793.1	-6.22	354.8
135	0.00	37.90	-7.47	765.5	-7.47	340.9
140	0.00	42.16	-8.62	740.3	-8.62	328.6
145	0.00	46.33	-9.65	718.4	-9.65	318.1
150	0.00	50.34	-10.00	710.9	-10.00	314.6

155	0.00	54.11	-10.00	710.9	-10.00	314.6
160	0.00	57.56	-10.00	710.9	-10.00	314.6
165	0.00	60.55	-10.00	710.9	-10.00	314.6
170	0.00	62.92	-10.00	710.9	-10.00	314.6
175	0.00	64.46	-10.00	710.9	-10.00	314.6
180	0.00	65.00	-10.00	710.9	-10.00	314.6

Table of Earth Station Coordination Values
05/10/2006

Earth Station Name KAPOLEI HI
Owner Hawaii Pacific Teleport, L.P.
Latitude (DMS) (NAD83) 21 20 9.0 N
Longitude (DMS) (NAD83) 158 5 25.0 W
Ground Elevation (Ft/m) 120.02 / 36.58 AMSL
Antenna Centerline (Ft/m) 31.99 / 9.75 AGL

Objectives: Receive -156.0 (dBW /1 MHz)
Transmit -154.0 (dBW /4 kHz) TX Power -2.7 (dBW/4 kHz)

Azimuth (Deg)	Horizon Elevation Angle (Deg)	Antenna Disc. Angle (Deg)	4.0 GHz Antenna Gain (dBi)	4.0 GHz Coordination Distance (Km)	6.0 GHz Antenna Gain (dBi)	6.0 GHz Coordination Distance (Km)
185	0.00	64.46	-10.00	710.9	-10.00	314.6
190	0.00	62.92	-10.00	710.9	-10.00	314.6
195	0.00	60.55	-10.00	710.9	-10.00	314.6
200	0.00	57.56	-10.00	710.9	-10.00	314.6
205	0.00	54.11	-10.00	710.9	-10.00	314.6
210	0.00	50.34	-10.00	710.9	-10.00	314.6
215	0.00	46.33	-9.65	718.4	-9.65	318.1
220	0.00	42.16	-8.62	740.3	-8.62	328.6
225	0.00	38.06	-7.51	764.5	-7.51	340.4
230	0.00	34.16	-6.34	790.5	-6.34	353.5
235	0.00	30.53	-5.12	815.0	-5.12	367.7
240	0.00	27.30	-3.90	843.4	-3.90	382.5
245	0.00	24.62	-2.78	870.5	-2.78	396.8
250	0.00	22.67	-1.89	892.5	-1.89	408.5
255	0.00	21.68	-1.40	904.8	-1.40	415.1
260	0.00	21.75	-1.44	903.8	-1.44	414.6
265	0.00	22.90	-1.99	889.9	-1.99	407.1
270	0.00	24.96	-2.93	866.9	-2.93	394.9
275	0.00	27.73	-4.07	839.4	-4.07	380.4
280	0.00	31.03	-5.29	811.0	-5.29	365.7
285	0.00	34.69	-6.51	786.7	-6.51	351.6
290	0.22	38.52	-7.64	747.7	-7.64	332.1
295	0.52	42.54	-8.72	537.0	-8.72	240.6
300	1.11	46.62	-9.71	377.3	-9.71	162.8
305	1.76	50.85	-10.00	305.7	-10.00	118.0
310	2.72	55.15	-10.00	231.8	-10.00	100.0
315	3.08	59.69	-10.00	209.7	-10.00	100.0

320	3.57	64.28	-10.00	189.7	-10.00	100.0
325	4.23	68.91	-10.00	170.2	-10.00	100.0
330	4.76	73.61	-10.00	163.9	-10.00	100.0
335	5.26	78.35	-10.00	154.8	-10.00	100.0
340	5.96	83.12	-10.00	138.6	-10.00	100.0
345	6.54	87.93	-10.00	131.7	-10.00	100.0
350	8.25	92.78	-10.00	112.4	-10.00	100.0
355	10.32	97.70	-10.00	100.0	-10.00	100.0

Table 2 INMARSAT Terminal Operating Parameters And Cordination Data

SATELLITE EARTH STATION
FREQUENCY COORDINATION DATA
05/10/2006

Company	Hawaii Pacific Teleport, L.P.
Earth Station Name, State	KAPOLEI, HI
Latitude (DMS) (NAD83)	21 20 9.0 N
Longitude (DMS) (NAD83)	158 5 25.0 W
Ground Elevation AMSL (Ft/m)	120.02 / 36.58
Antenna Centerline AGL (Ft/m)	31.99 / 9.75
Receive Antenna Type:	
1.5.0 GHz Gain (dBi) / Diameter (m)	45.0 / 13.0
3 dB / 15 dB Half Beamwidth	0.19 / 0.38
Operating Mode	RECEIVE ONLY
Modulation	DIGITAL
Emission / Receive Band (MHz)	36M0F8W / 1525.00 - 1559.00
Max permissible Interference Power	
1.5 GHz, 20% (dBW/1 MHz)	-156.0
1.5 GHz, 0.0100% (dBW/1 MHz)	-146.0
Range of Satellite Arc (Geostationary)	
Degrees Longitude	98.0 W / 216.5 W
Azimuth Range (Min/Max)	101.8 / 257.1
Corresponding Elevation Angles	19.5 / 21.6
Radio Climate	C
Rain Zone	4
Max Great Circle Coordination Distance (Mi/Km)	
1.5 GHz	934.1 / 1503.5
Precipitation Scatter Contour Radius (Mi/Km)	
1.5 GHz	230.3 / 370.6

Table of Earth Station Coordination Values
05/10/2006

Earth Station Name	KAPOLEI HI
Owner	Hawaii Pacific Teleport, L.P.

Latitude (DMS) (NAD83) 21 20 9.0 N
Longitude (DMS) (NAD83) 158 5 25.0 W
Ground Elevation (Ft/m) 120.02 / 36.58 AMSL
Antenna Centerline (Ft/m) 31.99 / 9.75 AGL
Objectives: Receive -156.0 (dBW /1 MHz)

Azimuth (Deg)	Horizon Elevation Angle (Deg)	Antenna Disc. Angle (Deg)	Antenna Gain (dBi)	1.5 GHz Coordination Distance (Km)
0	9.56	101.64	-10.00	161.9
5	7.65	96.68	-10.00	197.2
10	7.42	91.78	-10.00	200.4
15	7.64	86.89	-10.00	197.4
20	7.02	82.02	-10.00	206.2
25	6.32	77.17	-10.00	216.4
30	5.81	72.36	-10.00	227.0
35	5.13	67.59	-10.00	247.2
40	4.12	62.91	-10.00	266.5
45	3.43	58.27	-10.00	299.9
50	3.12	53.63	-10.00	318.4
55	2.84	49.03	-10.00	339.3
60	2.36	44.59	-9.23	397.4
65	2.12	40.18	-8.10	438.2
70	1.91	35.90	-6.88	478.6
75	1.70	31.81	-5.56	538.8
80	1.34	28.09	-4.21	649.1
85	0.75	24.97	-2.94	904.3
90	0.00	22.67	-1.88	1435.6
95	0.00	20.60	-0.84	1479.4
100	0.00	19.56	-0.28	1503.5
105	0.00	19.73	-0.38	1499.5
110	0.00	21.06	-1.09	1469.0
115	0.00	23.37	-2.22	1421.9
120	0.00	26.40	-3.54	1368.7
125	0.00	29.92	-4.90	1316.3
130	0.00	33.79	-6.22	1267.7
135	0.00	37.90	-7.47	1223.9
140	0.00	42.16	-8.62	1184.9
145	0.00	46.33	-9.65	1161.0
150	0.00	50.34	-10.00	1149.6
155	0.00	54.11	-10.00	1149.6
160	0.00	57.56	-10.00	1149.6
165	0.00	60.55	-10.00	1149.6
170	0.00	62.92	-10.00	1149.6
175	0.00	64.46	-10.00	1149.6
180	0.00	65.00	-10.00	1149.6

Table of Earth Station Coordination Values
05/10/2006

Earth Station Name KAPOLEI HI
Owner Hawaii Pacific Teleport, L.P.
Latitude (DMS) (NAD83) 21 20 9.0 N

Longitude (DMS) (NAD83) 158 5 25.0 W
Ground Elevation (Ft/m) 120.02 / 36.58 AMSL
Antenna Centerline (Ft/m) 31.99 / 9.75 AGL
Objectives: Receive -156.0 (dBW /1 MHz)

Azimuth (Deg)	Horizon Elevation Angle (Deg)	Antenna Disc. Angle (Deg)	Antenna Gain (dBi)	1.5 GHz Coordination Distance (Km)
185	0.00	64.46	-10.00	1149.6
190	0.00	62.92	-10.00	1149.6
195	0.00	60.55	-10.00	1149.6
200	0.00	57.56	-10.00	1149.6
205	0.00	54.11	-10.00	1149.6
210	0.00	50.34	-10.00	1149.6
215	0.00	46.33	-9.65	1161.0
220	0.00	42.16	-8.62	1184.9
225	0.00	38.06	-7.51	1222.3
230	0.00	34.16	-6.34	1263.5
235	0.00	30.53	-5.12	1308.1
240	0.00	27.30	-3.90	1354.5
245	0.00	24.62	-2.78	1399.0
250	0.00	22.67	-1.89	1435.4
255	0.00	21.68	-1.40	1455.8
260	0.00	21.75	-1.44	1454.2
265	0.00	22.90	-1.99	1431.1
270	0.00	24.96	-2.93	1393.0
275	0.00	27.73	-4.07	1347.9
280	0.00	31.03	-5.29	1301.7
285	0.00	34.69	-6.51	1257.5
290	0.22	38.52	-7.64	1195.6
295	0.52	42.54	-8.72	879.6
300	1.11	46.62	-9.71	590.2
305	1.76	50.85	-10.00	460.9
310	2.72	55.15	-10.00	351.5
315	3.08	59.69	-10.00	320.5
320	3.57	64.28	-10.00	291.9
325	4.23	68.91	-10.00	264.6
330	4.76	73.61	-10.00	255.5
335	5.26	78.35	-10.00	243.1
340	5.96	83.12	-10.00	222.5
345	6.54	87.93	-10.00	213.2
350	8.25	92.78	-10.00	187.0
355	10.32	97.70	-10.00	147.8

RADAR Systems Characteristics: The RADAR system characteristics were taken from NTIA publication and public documents. Table 3 contains the parameters for the RADAR A, Table 4 the RADAR B , Table 5 RADAR C , Table 6 the RADARs D, E and F and Table 7 contains the parameters for the FAA RADAR.

Table 3 Operational Parameters of the RADAR A

Frequency Range	3000 - 3400 MHz

Transmit Power	1 MW Peak Power 1000 Watts Average Power
Emission Level (3550-3700MHz)	-4 dBW/MHz
Emission Level (3700 – 4200MHz)	-13 dBW/MHz
Pulse Width	Variable, 1 -10 μseconds
Pulse Recurring Frequency (PRF)	Variable, 100 -1000 pulses per sec
Antenna Gain (main beam)	42 dBi, 15,848.9
Antenna (side lobe)	- 10 dB, 0.1
Antenna type	Phase Array
Antenna Motion	Electronic Scan
Antenna Height	70 ft. AMSL

Table 4 Operational Parameters of the RADAR B

Frequency Range	3350 - 3550 MHz
Transmit Power	750 kW Peak Power 500 Watts Average Power
Emission Level (3550-3700MHz)	23.7 dBW/MHz
Emission level (3700 – 4200MHz)	-11.3 dBW/MHz
Pulse Width	1 μseconds
Pulse Recurring Frequency (PRF)	1125 pulses per sec
Antenna Gain (main beam)	32 dBi, 1,584
(side lobe)	- 10 dB, 0.1
Antenna type	Reflector
Antenna Motion	Mechanical Scan
Antenna Height	120 ft. AMSL

Table 5 Operational Parameters of the RADAR C

Frequency Range	2900 - 3100 MHz
Transmit Power	1MW Peak Power 1000 Watts Average Power
Emission Level (3550-3700MHz)	-7 dBW/MHz
Emission level (3700 – 4200MHz)	-16 dBW/MHz
Pulse Width	27 μseconds
Pulse Recurring Frequency (PRF)	200 pulses per sec
Antenna Gain (main beam)	36 dBi, 3981
(side lobe)	- 10 dB, 0.1
Antenna type	Phase Scan Array
Antenna Motion	Mechanical Scan Azimuth Electronic Scan Elevation
Antenna Height	100 ft. AMSL

Table 6 Operational Parameters of RADARs D, E, and F

Frequency Range	2900 - 3100 MHz
Transmit Power	0.5MW Peak Power
	500 Watts Average Power
Emission Level (3550-3700MHz)	-10 dBW/MHz
Emission Level (3700 – 4200MHz)	-19 dBW/MHz
Pulse Width	10 μseconds
Pulse Recurring Frequency (PRF)	200 pulses per sec
Antenna Gain (main beam)	36 dBi, 1,584
(side lobe)	- 10 dB, 0.1
Antenna type	Phase Scan Array
Antenna Motion	Mechanical Scan Azimuth
	Electronic Scan Elevation
Antenna Height	100 ft. AMSL

Table 7 Operational Parameters of FAA RADAR L-Band

Frequency Range	1250 - 1350 MHz
Transmit Power	0.5 MW Peak Power
	500 Watts Average Power
Emission Level (1525-1559MHz)	2 dBW/MHz
Pulse Width	3 μseconds
Pulse Recurring Frequency (PRF)	500 pulses per sec
Antenna Gain (main beam)	30 dBi, 1,584
(side lobe)	- 10 dB, 0.1
Antenna type	Phase Scan Array
Antenna Motion	Mechanical Scan Azimuth
Antenna Height	75 ft. AGL

Interference Calculations: The interference was calculated into the earth station receive systems at C-Band and L-Band for both in-band and out-of-band interference. The interference power level was calculated using the formula below:

$$P_r = P_t + G_t - FSL - OHLOSS + G_{es} - LL_t - LL_{es}$$

Where:

P_r : Interference power level received at victim earth station, in dBW or dBW/MHz

P_t: Transmitter power of RADAR system, in dBW or dBW/MHz

G_t: Gain of RADAR transmit antenna, in dBi

FSL: Free Space Loss between RADAR and earth station, in dB

OHLOSS: Over-the-Horizon losses between radiolocation system and earth station, in dB
G_{es}: Horizon gain of the earth station toward RADAR antenna, in dBi
LL_t: Line losses of the RADAR system, in dB (assume 2 dB per NTIA report)
LL_{es}: Line losses of the earth station system, in dB (assume 0 dB unless known)

This interference power level was then compared to in-band and out-of-band interference criteria. The in-band criteria was developed using ITU and FCC recommendations[1]. The out-of-band interference criteria was developed using the following:

The earth station's low –noise amplifier front-end overload criteria of was determined using the following calculations:

$$T = C - G$$

Where:
T = input threshold at which front-end overload occurs, dBW
C = output 1 dB gain compression point of the LNB/LNA, typical -20 dBW
G = Gain of the LNB/LNA, dB

For the purposes of this report it was assumed that the low-noise amplifier would not provide any out-of-band frequency rejection, thus no Frequency Dependent Rejection values based upon any RF selectivity, such as pre-LNB/LNA filtering or inherent LNB/ LNA filtering, have been assumed. The maximum level of interference includes the input saturation threshold value minus a 10 dB output back-off value to consider in operation levels.

The maximum interference power receive, P_r, allowable then becomes:

$$\text{Max } P_r \geq T - \text{IPBO}$$

For a 65 dB gain LNA this value is -95 dBW. In the absence of manufacturer LNA/LNB specifications the following typical values have been used:

T = -95 dBW
C = -20 dBW
G = 65 dB

The propagation model to determine the over-the-horizon loss is the NSMA OH-Loss model[2]. When the propagation link is very lengthy, over 250 miles, an estimated OH-loss using a rounded earth modeling value has been used. The calculated FSL and OH is shown in Table 8 along with the ship and land base RADAR locations. The ship

[1] FCC Rules 47CFR25.251 by reference ITU Radio Regulations Appendix S7.
[2] National Spectrum Managers Association has developed an industry accepted version which incorporates NBS Tech Note 101.

locations are in the Pearl Harbor, Pacific Missile Range and Hawaii operational areas. The land based sites are at Fort Shafter and the Honolulu Airport.

Table 8 Location of Ship's and Land Based RADARS and FSL and OH Calculation

Site Name	Latitude	Longitude	Bearing(deg)	Distance(mi)	FSL (dB)	OH (dB)
Pearl Harbor South OPAREA						
PHS1	190800	1591500	206.6	169.2	153	58.1
PHS2	210000	1580800	186.9	23.3	135.8	0
PHS3	210000	1573600	126	39.2	140.3	57.2
PHS4	191800	1562000	140.5	180.6	153.6	60
PHS5	184900	1574500	172.8	174.8	153.3	59.1
FORACS Hawaii						
Hawaii1	212530	1581100	315.8	8.6	127.1	91.8
Hawaii2	212100	1581500	275.5	10.4	128.8	2.8
Hawaii3	211500	1580800	205.3	6.5	124.7	0
Hawaii4	211500	1580700	196.1	6.1	124.2	0
Pacific Missile Range Facilty (PMRF)						
PMRF1	220000	1594500	116.1	293.5	149.8	76
PMRF2	220800	1620000	257.3	283	156.8	62.2
PMRF3	224500	1614000	249.3	293.7	156.4	66.2
PMRF4	260000	1581500	321.2	358.2	158.7	111.6
Fort Shafter	211800	1574900	97.9	17.8	133.5	58.9
Honolulu Airport	211955	1575511	91.3	11.0	120.0	3.7

The results of the calculation of the RADAR A fundamental signal into the C-Band earth station are shown in Table 9. This calculation was performed to determine whether there was a potential for LNA/LNB saturation.

Table 9 RADAR A Fundamental Frequency Interference Signal into Earth Station

Site Name	Main Beam Signal Level (dBW)	Side Lobe Signal level (dBW)	Main Beam Saturation	Side Lobe Saturation
Pearl Harbor South OPAREA				
PHS1	-121.1	-173.1	no	no
PHS2	-45.8	-97.8	yes	no
PHS3	-107.5	-159.5	no	no
PHS4	-123.6	-175.6	no	no
PHS5	-122.4	-174.4	no	no
FORACS Hawaii				
Hawaii1	-128.9	-180.9	no	no
Hawaii2	-41.6	-93.6	yes	yes
Hawaii3	-34.7	-86.7	yes	yes
Hawaii4	-34.2	-86.2	yes	yes
Pacific Missile Range Facility (PMRF)				
PMRF1	-135.8	-187.8	no	no
PMRF2	-129	-181	no	no

PMRF3	-132.6	-184.6	no	no
PMRF4	-180.3	-232.3	no	no

The results of the calculation of the RADAR B fundamental signal into the C-Band earth station are shown in Table 10. This calculation was performed to determine whether there was a potential for LNA/LNB saturation.

Table 10 RADAR B Fundamental Frequency Interference Signal into Earth Station

Site Name	Main Beam Signal Level (dBW)	Side Lobe Signal level (dBW)	Main Beam Saturation	Side Lobe Saturation
Pearl Harbor South OPAREA				
PHS1	-132.4	-174.4	no	no
PHS2	-57.1	-99.1	yes	no
PHS3	-118.8	-160.8	no	no
PHS4	-134.9	-176.9	no	no
PHS5	-133.7	-175.7	no	no
FORACS Hawaii				
Hawaii1	-140.2	-182.2	no	no
Hawaii2	-52.9	-95	yes	no
Hawaii3	-46	-88	yes	yes
Hawaii4	-45.5	-87.5	yes	yes
Pacific Missile Range Facility (PMRF)				
PMRF1	-147.1	-189.1	no	no
PMRF2	-140.3	-182.3	no	no
PMRF3	-143.9	-185.9	no	no
PMRF4	-191.6	-233.6	no	no

The results of the calculation of the RADAR C fundamental signal into the C-Band earth station are shown in Table 11. This calculation was performed to determine whether there was a potential for LNA/LNB saturation.

Table 11 RADAR C Fundamental Frequency Interference Signal into Earth Station

Site Name	Main Beam Signal Level (dBW)	Side Lobe Signal level (dBW)	Main Beam Saturation	Side Lobe Saturation
Pearl Harbor South OPAREA				
PHS1	-127.1	-173.1	no	no
PHS2	-51.8	-97.8	yes	no
PHS3	-113.5	-159.5	no	no
PHS4	-129.6	-175.6	no	no
PHS5	-128.4	-174.4	no	no
FORACS Hawaii				
Hawaii1	-134.9	-180.9	no	no
Hawaii2	-47.6	-93.6	yes	yes
Hawaii3	-40.7	-86.7	yes	yes
Hawaii4	-40.2	-86.2	yes	yes
Pacific Missile Range Facility (PMRF)				
PMRF1	-141.8	-187.8	no	no
PMRF2	-135	-181	no	no
PMRF3	-138.6	-184.6	no	no
PMRF4	-186.3	-232.3	no	no

The results of the calculation of the RADARs D, E and F fundamental signal into the C-Band earth station are shown in Table 12. This calculation was performed to determine whether there was a potential for LNA/LNB saturation.

Table 12 RADAR D, E and F Fundamental Frequency Interference Signal into Earth Station

Site Name	Main Beam Signal Level (dBW)	Side Lobe Signal level (dBW)	Main Beam Saturation	Side Lobe Saturation
Pearl Harbor South OPAREA				
PHS1	-130.1	-173.1	no	no
PHS2	-54.8	-97.8	yes	no
PHS3	-116.5	-159.5	no	no
PHS4	-132.6	-175.6	no	no
PHS5	-131.4	-174.4	no	no
FORACS Hawaii				
Hawaii1	-137.9	-180.9	no	no
Hawaii2	-50.6	-93.6	yes	yes
Hawaii3	-43.7	-86.7	yes	yes
Hawaii4	-43.2	-86.2	yes	yes
Pacific Missile Range Facilty (PMRF)				
PMRF1	-144.8	-187.8	no	no
PMRF2	-138	-181	no	no
PMRF3	-141.6	-184.6	no	no
PMRF4	-189.3	-232.3	no	no

The results of the calculation of the Fort Shafter RADAR F fundamental signal into the C-Band earth station and the Honolulu Airport FAA RADAR fundamental into the INMARSAT earth station are shown in Table 13. This calculation was performed to determine whether there was a potential for LNA/LNB saturation.

Table 13 Land Based RADAR F Fundamental Frequency Interference Signal into Earth Station

Site Name	Main Beam Signal Level (dBW)	Side Lobe Signal level (dBW)	Main Beam Saturation	Side Lobe Saturation	
Fort Shafter	-108.4	-154.4	no	no	C-Band
Honolulu Airport	-48.7	-88.7	yes	yes	L-band

To determine in the in-band interference to the C- and L-Band earth stations calculations were made with the RADAR emissions within the 3550 – 3700 MHz Band and the 3700 – 4200 MHz Band at C-Band and in the 1525 – 155 MHz Band at L-Band.

The results of the calculation of the RADAR A emissions into the pass band of the C-Band earth station are shown in Table 14. This calculation was performed to determine whether there was a potential for interference from the RADAR A into the extended and normal band pass frequencies of the earth station.

Table 14 RADAR A Emission In-Band Interference Signal into Earth Station

Site Name	Main Beam 3550-3700 MHz Level (dBW/MHz)	Side Lobe 3550-3700MHz Level (dBW/MHz)	Main Beam 3700-4200MHz Level (dBW/MHz)	Side Lobe 3700-4200MHz Level (dBW/MHz)
Pearl Harbor South OPAREA				
PHS1	-185.1	-237.1	-194.1	-246.1
PHS2	**-109.8**	-161.8	**-118.8**	-170.8
PHS3	-171.5	-223.5	-180.5	-232.5
PHS4	-187.6	-239.6	-196.6	-248.6
PHS5	-186.4	-238.4	-195.4	-247.4
FORACS Hawaii				
Hawaii1	-192.9	-244.9	-201.9	-253.9
Hawaii2	**-105.6**	-157.6	**-114.6**	-166.6
Hawaii3	**-98.7**	**-150.7**	**-107.7**	-159.7
Hawaii4	**-98.2**	**-150.2**	**-107.2**	-159.2
Pacific Missile Range Facility (PMRF)				
PMRF1	-199.8	-251.8	-208.8	-260.8
PMRF2	-193	-245	-202	-254
PMRF3	-196.6	-248.6	-205.6	-257.6
PMRF4	-244.3	-296.3	-253.3	-305.3

Yellow- exceeds interference criteria

The results of the calculation of the RADAR B emissions into the pass band of the C-Band earth station are shown in Table 15. This calculation was performed to determine whether there was a potential for interference from the RADAR B into the extended and normal band pass frequencies of the earth station.

Table 15 RADAR B Emission In-Band Interference Signal into Earth Station

Site Name	Main Beam 3550-3700 MHz Level (dBW/MHz)	Side Lobe 3550-3700MHz Level (dBW/MHz)	Main Beam 3700-4200MHz Level (dBW/MHz)	Side Lobe 3700-4200MHz Level (dBW/MHz)
Pearl Harbor South OPAREA				
PHS1	-167.4	-209.4	-202.4	-244.4
PHS2	**-92.1**	**-134.1**	**-127.1**	-169.1
PHS3	**-153.8**	-195.8	-188.8	-230.8
PHS4	-169.9	-211.9	-204.9	-246.9
PHS5	-168.7	-210.7	-203.7	-245.7
FORACS Hawaii				
Hawaii1	-175.2	-217.2	-210.2	-252.2
Hawaii2	**-87.9**	**-129.9**	**-122.9**	-164.9
Hawaii3	**-81**	**-123**	**-116**	-158
Hawaii4	**-80.5**	**-122.5**	**-115.5**	-157.5
Pacific Missile Range Facility (PMRF)				

PMRF1	-182.1	-224.1	-217.1	-259.1
PMRF2	-175.3	-217.3	-210.3	-252.3
PMRF3	-178.9	-220.9	-213.9	-255.9
PMRF4	-226.6	-268.6	-261.6	-303.6

Yellow- exceeds interference criteria

The results of the calculation of the RADAR C emissions into the pass band of the C-Band earth station are shown in Table 16. This calculation was performed to determine whether there was a potential for interference from the RADAR C into the extended and normal band pass frequencies of the earth station.

Table 16 RADAR C Emission In-Band Interference Signal into Earth Station

Site Name	Main Beam 3550-3700 MHz Level (dBW/MHz)	Side Lobe 3550-3700MHz Level (dBW/MHz)	Main Beam 3700-4200MHz Level (dBW/MHz)	Side Lobe 3700-4200MHz Level (dBW/MHz)
Pearl Harbor South OPAREA				
PHS1	-194.1	-240.1	-203.1	-249.1
PHS2	**-118.8**	-164.8	**-127.8**	-173.8
PHS3	-180.5	-226.5	-189.5	-235.5
PHS4	-196.6	-242.6	-205.6	-251.6
PHS5	-195.4	-241.4	-204.4	-250.4
FORACS Hawaii				
Hawaii1	-201.9	-247.9	-210.9	-256.9
Hawaii2	**-114.6**	-160.6	**-123.6**	-169.6
Hawaii3	**-107.7**	**-153.7**	**-116.7**	-162.7
Hawaii4	**-107.2**	**-153.2**	**-116.2**	-162.2
Pacific Missile Range Facility (PMRF)				
PMRF1	-208.8	-254.8	-217.8	-263.8
PMRF2	-202	-248	-211	-257
PMRF3	-205.6	-251.6	-214.6	-260.6
PMRF4	-253.3	-299.3	-262.3	-308.3

Yellow- exceeds interference criteria

The results of the calculation of RADAR D, E, and F emissions into the pass band of the C-Band earth station are shown in Table 17. This calculation was performed to determine whether there was a potential for interference from these RADARs into the extended and normal band pass frequencies of the earth station.

Table 17 RADARs D, E an F Emissions In-Band Interference Signal into Earth Station

Site Name	Main Beam 3550-3700 MHz Level (dBW/MHz)	Side Lobe 3550-3700MHz Level (dBW/MHz)	Main Beam 3700-4200MHz Level (dBW/MHz)	Side Lobe 3700-4200MHz Level (dBW/MHz)
Pearl Harbor South OPAREA				
PHS1	-197.1	-243.1	-206.1	-252.1
PHS2	**-121.8**	-167.8	**-130.8**	-176.8
PHS3	-183.5	-229.5	-192.5	-238.5
PHS4	-199.6	-245.6	-208.6	-254.6

PHS5	-198.4	-244.4	-207.4	-253.4
FORACS Hawaii				
Hawaii1	-204.9	-250.9	-213.9	-259.9
Hawaii2	**-117.6**	-163.6	**-126.6**	-172.6
Hawaii3	**-110.7**	-156.7	**-119.7**	-165.7
Hawaii4	**-110.2**	-156.2	**-119.2**	-165.2
Pacific Missile Range Facility (PMRF)				
PMRF1	-211.8	-257.8	-220.8	-266.8
PMRF2	-205	-251	-214	-260
PMRF3	-208.6	-254.6	-217.6	-263.6
PMRF4	-256.3	-302.3	-265.3	-311.3

Yellow-exceeds interference criteria

The results of the calculation of the Fort Shafter RADAR emission in band to the C-Band earth station are shown in Table 18. Also shown in table 18 is the Honolulu Airport FAA RADAR emission into the pass band of the INMARSAT earth station.

Table 18 Land Based RADAR Emissions In-Band Interference Signal into Earth Station

Site Name	Main Beam 3550-3700 MHz Level (dBW/MHz)	Side Lobe 3550-3700MHz Level (dBW/MHz)	Main Beam 3700-4200MHz Level (dBW/MHz)	Side Lobe 3700-4200MHz Level (dBW/MHz)
Fort Shafter	-178.4	-224.4	-187.4	-233.4
FAA Honolulu Airport RADAR-INMARSAT	1525 - 1559 MHz **-103.7**	1525 -1559 MHz **-143.7**		

Yellow- exceeds interference criteria

Conclusions and Recommendations: The calculations indicate that there is potential interference from RADAR transmitters located on the island of Oahu and on ships at-sea to the operation of the planned 13-meter C-Band earth station and to the INMARSAT earth station terminal at the Hawaii Pacific Teleport. This condition is true for any teleport that is located on the coastal plains of Oahu because of the presence of military RADAR on ships operating at sea off the island. The interference can occur in two ways; from the fundamental frequency of the RADAR transmitters, which in every case is below the pass band frequency of the earth stations, and from the RADAR emissions that will exist in the pass band of the earth stations' receivers.

The RADAR fundamental frequency can be filtered in front of the earth station's LNA/LNB this will prevent front end saturation and receiver overload. The typical filters for C-Band earth stations are built to operate from 3700 – 4200 MHz. Since it is desired to extend the operation of C-Band earth station to the 3550 – 4200 MHz band, a custom built filter will have to be designed to pass this band and reject signals below the band by as much as 65 dB based on the calculated levels at the earth station receiver. A high pass filter to protect the INMARSAT earth station will also be necessary to reject emissions from L-Band RADAR. A filter that rejects signals by 50 dB in the INMARSAT band of operation will take care of this interference based on the calculations.

The calculations also predict that there will be in band interference signals from the RADARs that must be considered. The calculations show that most of the instances of in band interference occur when the RADAR main beam is directed at the earth station. As a point of interest, no in band interference condition was predicted by the calculations for a RADAR antenna side lobe to earth station antenna side lobe orientation in the 3700 – 4200 MHz frequency band. There are a few predictions of interference for this relative antenna condition for the 3550 – 3700 MHz frequency band. To deal with this interference in the extended band and the main beam interference from the various RADARs to all of the C-Band earth station and to the INMARSAT operation, shielding can be installed at the site to reduce the interference signal levels that are predicted by the calculations. The site shielding will have to be designed to block and attenuate the signals from the identified operational areas and land based RADAR sites.

Comsearch reviewed the use of the extended C-Band in the United States in the FCC and their database. The review revealed that there were a few operators in the 3600 – 3700 MHz frequency range. The review also revealed that there were no licensed operations in the 3550 – 3600 MHz frequency range.

Comsearch recommends that a measurement site survey be conducted at the Hawaii Pacific Teleport so that the signal levels predicted in this report can be confirmed by measurement. The measurements will not only determine signal levels but will also confirm the direction that they are coming from. Knowing the measured levels and their point of origin will help in locating the optimum position of the C- and L-Band earth stations and the relative position of the shielding structure. The measurement report will not only provide the electromagnetic environmental data but will also include sketches of the shield design that can be used by HPT in getting proposals from building contractors for the purpose of installing the shield.

Through the use of optimum site selection for the earth stations, filter design and site shielding the interference conditions identified in this report can be mitigated. Through the proper application of these mitigation techniques the earth stations can be installed and operated at the HPT in an interference-free manner.

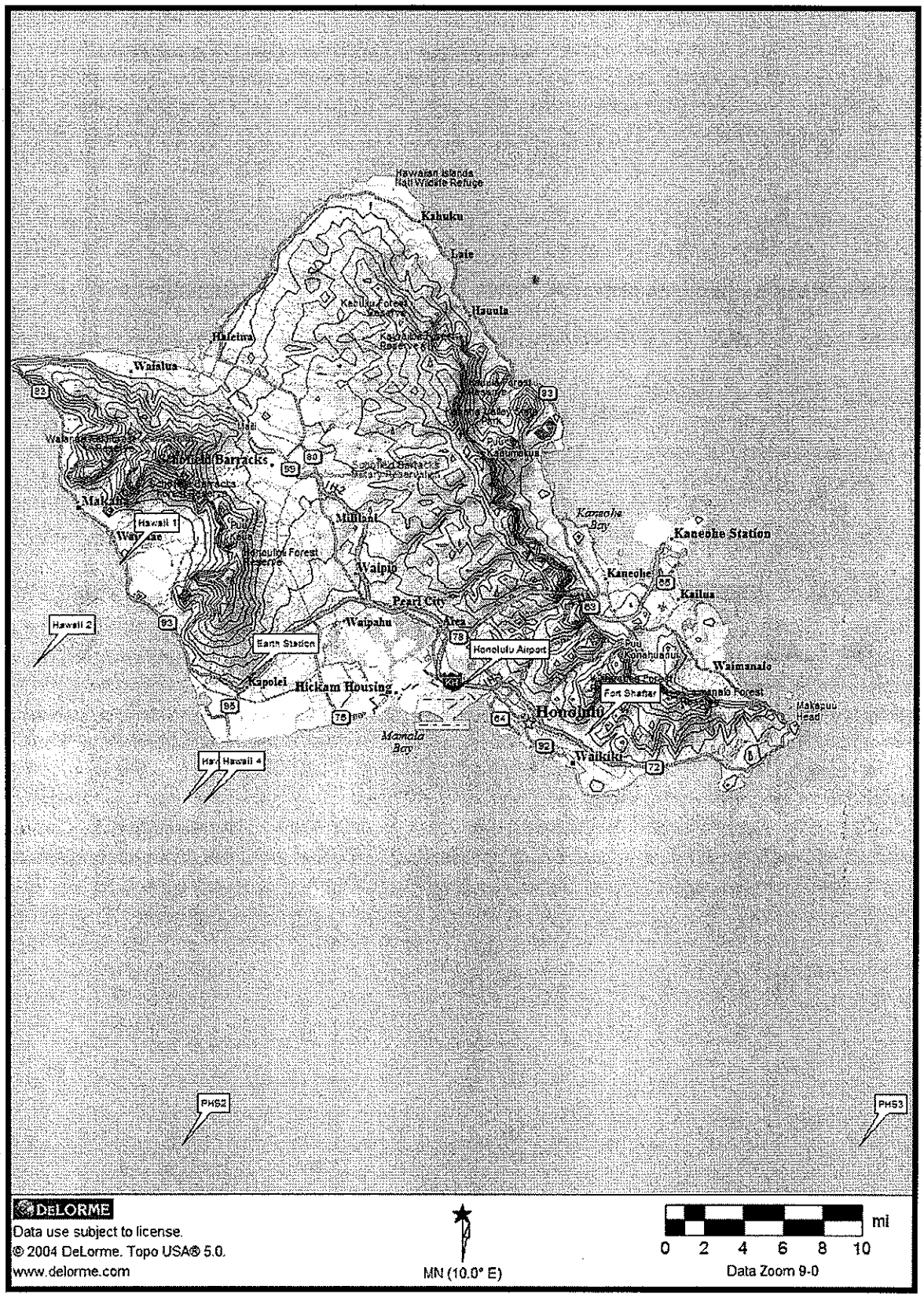

Figure 1 In-Close RADAR Sites to HPT

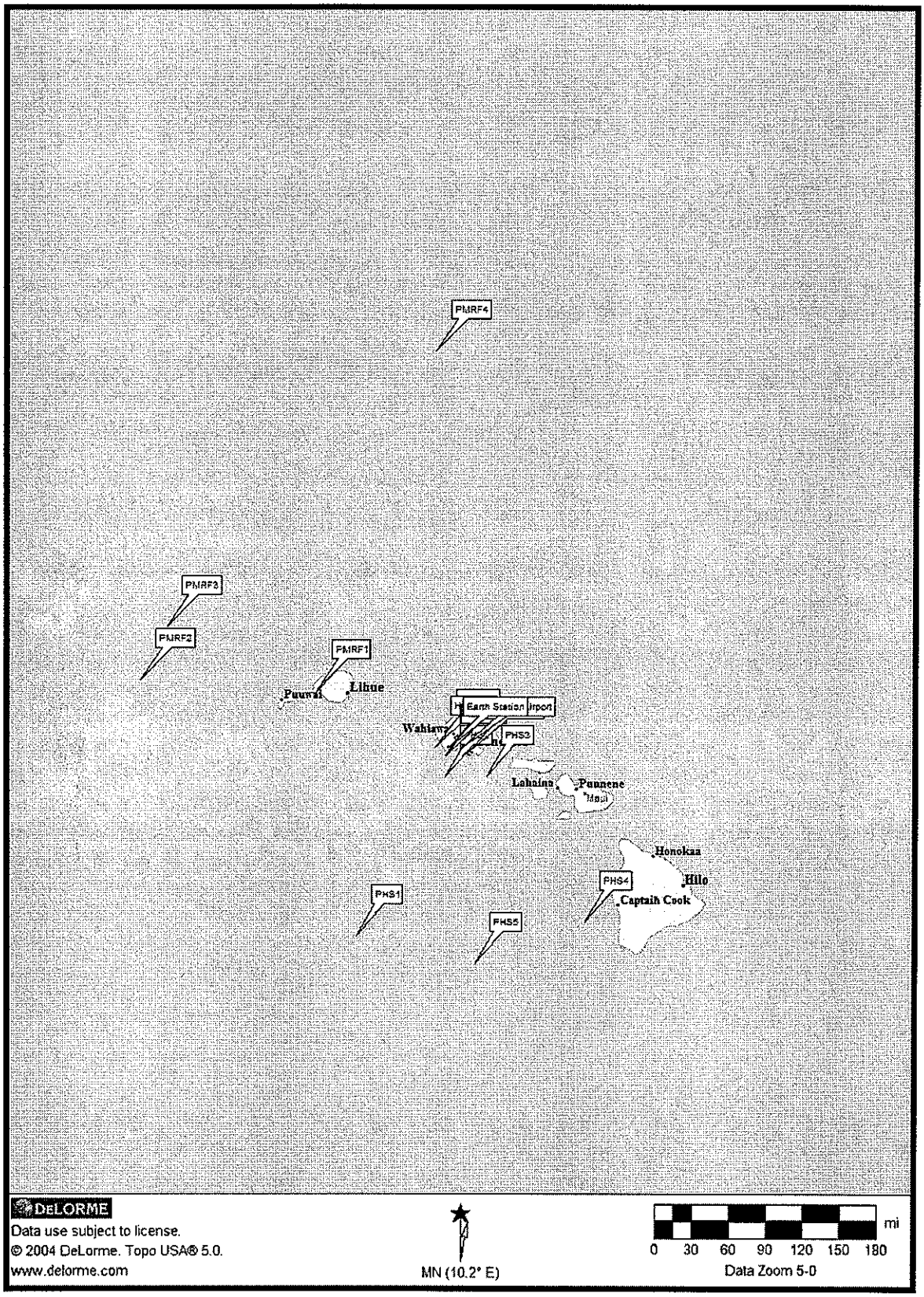

Figure 2 Other RADAR Sites Considered in Analysis