INMARSAT Wide Spot Beam Footprints from Aero Message Types 18 and 19

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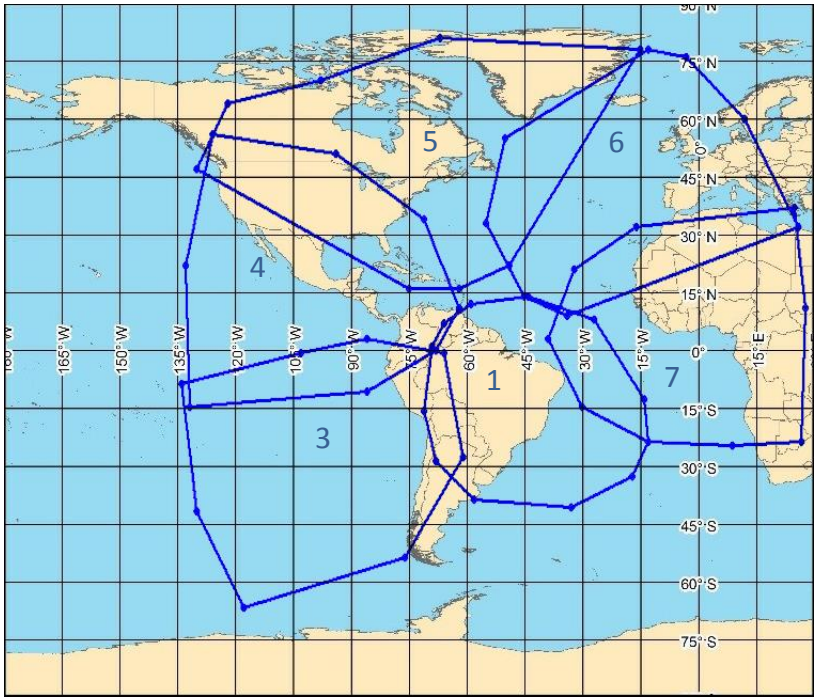
AORE (Atlantic Ocean Region East)

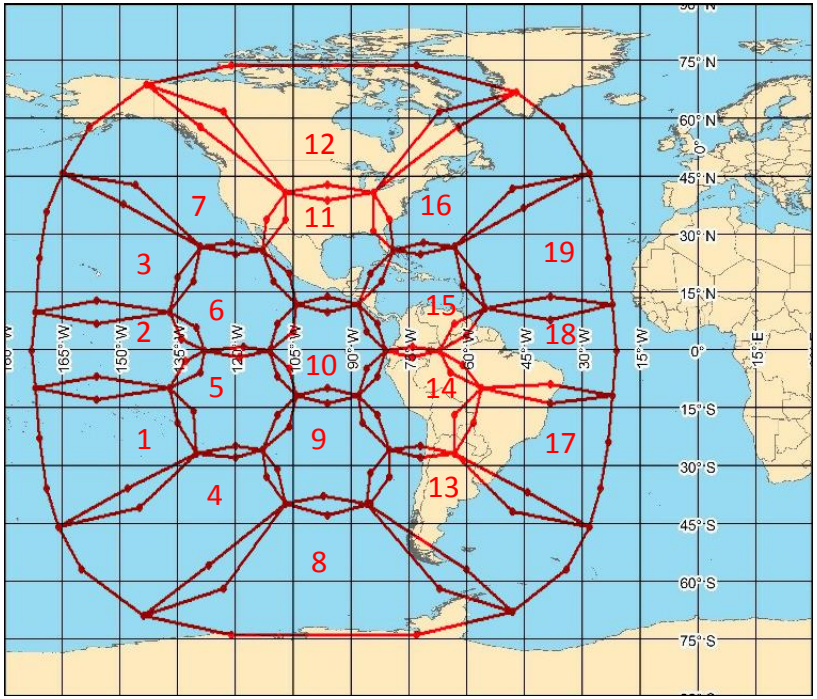


The INMARSAT wide beam footprints shown here were obtained from the Message Type 18 & 19 broadcasts INMARSAT satellite Aero transmissions. These have been overlaid onto an public NGA earth map. available on the web.

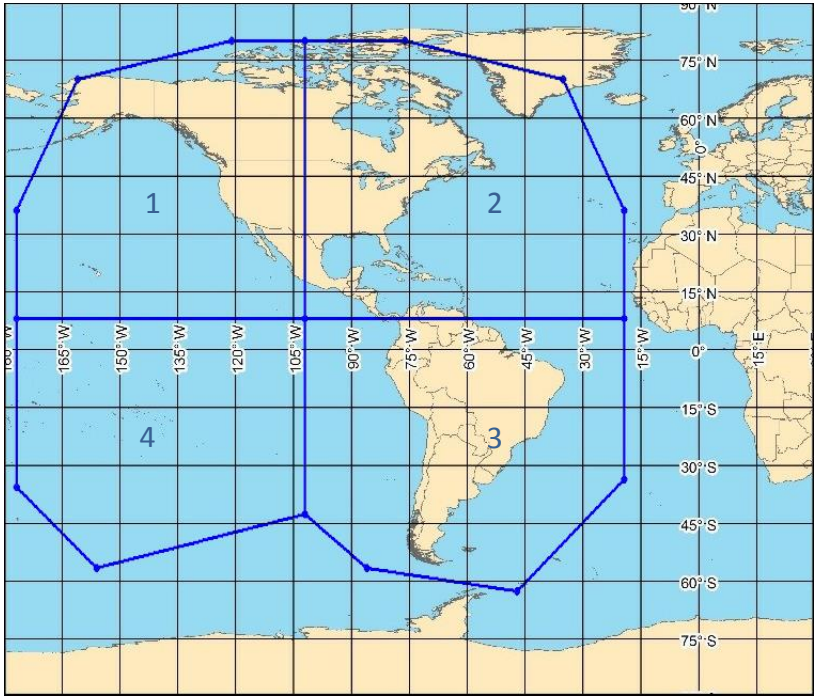
At the end of these is a INMARSAT map of global beam coverage that is found on INTERNET in various documents.

AORE (Atlantic Ocean Region East) Satellite ID number 1 INMARSAT 3-F5 (NORAD: 25153, Cospar number: 1998-006B) 54^{o} W
Beams: 1 global, 7 wide spot beams. Aero Message Type 7 indicates global beam and wide beams 1 and 3-7 can be used.
Burum, Netherlands is NCS and normally uplinks for all LESO.

AMER (Americas Region)



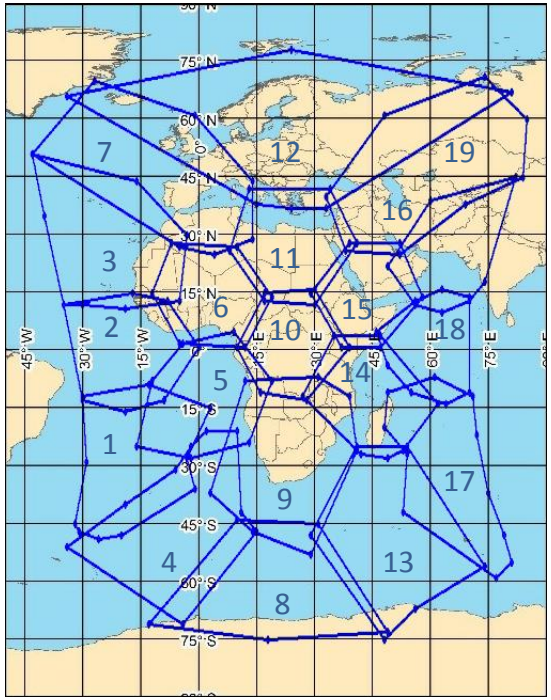
AORW (Atlantic Ocean Region West)



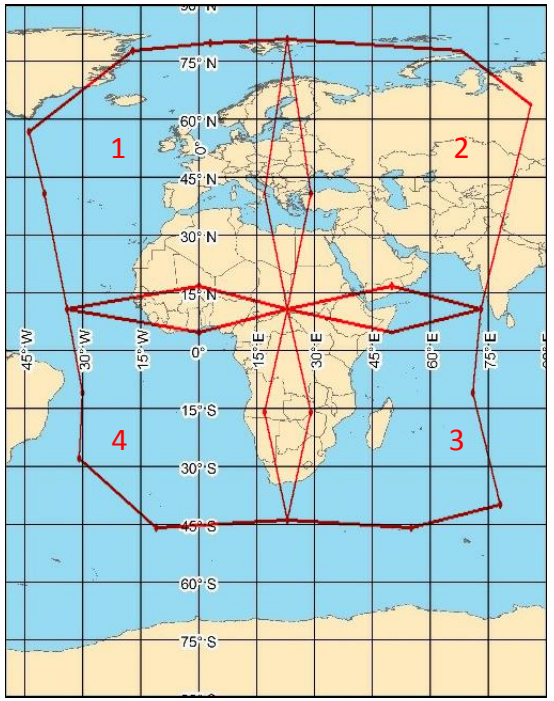
AMER (Americas Region) Satellite ID number 7 INMARSAT 4-F3 (NORAD: 33278, Cospar number: 2008-0039A) 97.5^{o} W Beams: 1 global, 19 wide spot beams, 228 narrow spot beams. Aero Message Type 7 indicates global beam and all 19 wide spot beams can be used. Paumalu, HI is NCS and normally uplinks for all LESO.

AORW (Atlantic Ocean Region West) Satellite ID number 0 (99^{o} W) This is a virtual satellite on the AMER satellite (using the global and synthesized spot beams on that satellite). (In system broadcast tables, virtual satellites are often listed as offset by 1.5 degrees from the host satellite.) Laurentides, Canada is NCS and normally uplinks for all LESO.

EMEA (Europe/Middle East/Africa Region)



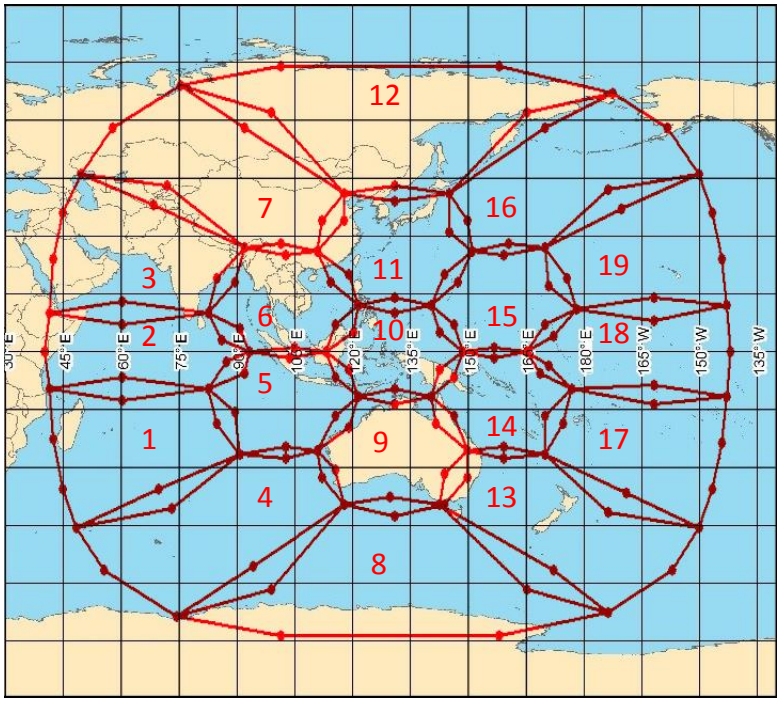
IOR Indian Ocean Region)



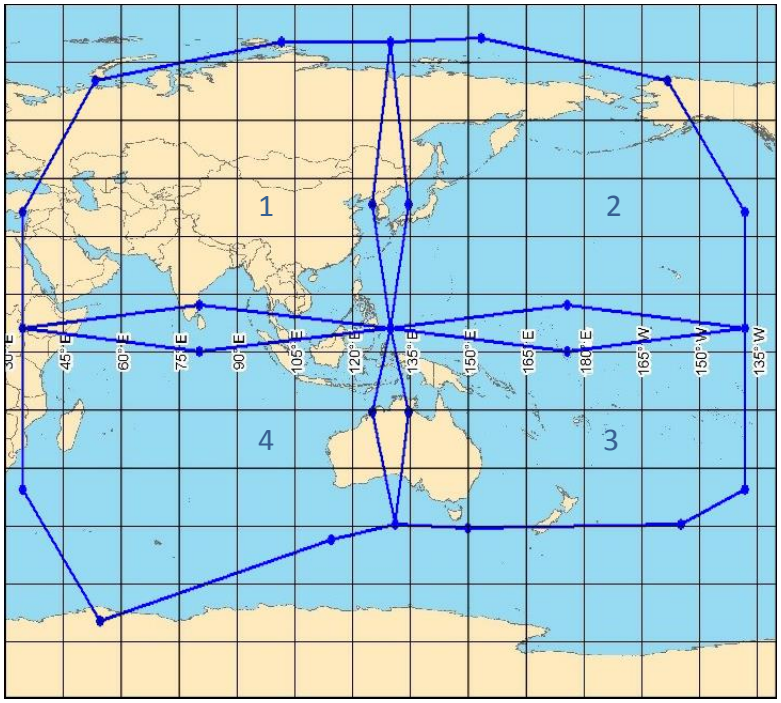
EMEA (Europe/Middle East/Africa Region) Satellite ID number 6 INMARSAT 4-AF4 NORAD: 39215, Cospar number: 2013-038A) 25.5^{o} E (Also known as Alphasat I-XL) Aero Message Type 7 indicates global beam and all 19 wide spot beams can be used.
Fucino, Italy is NCS and normally uplinks for all LESO.

IOR (Indian Ocean Region) Satellite ID number 3 (24^{o} W) This is a virtual satellite on the EMEA satellite (using the global and synthesized spot beams on that satellite). (In system broadcast tables, virtual satellites are often listed as offset by 1.5 degrees from the host satellite.)
Burum, Netherlands is NCS and normally uplinks for all LESO.

APAC (Asia-Pacific Region)



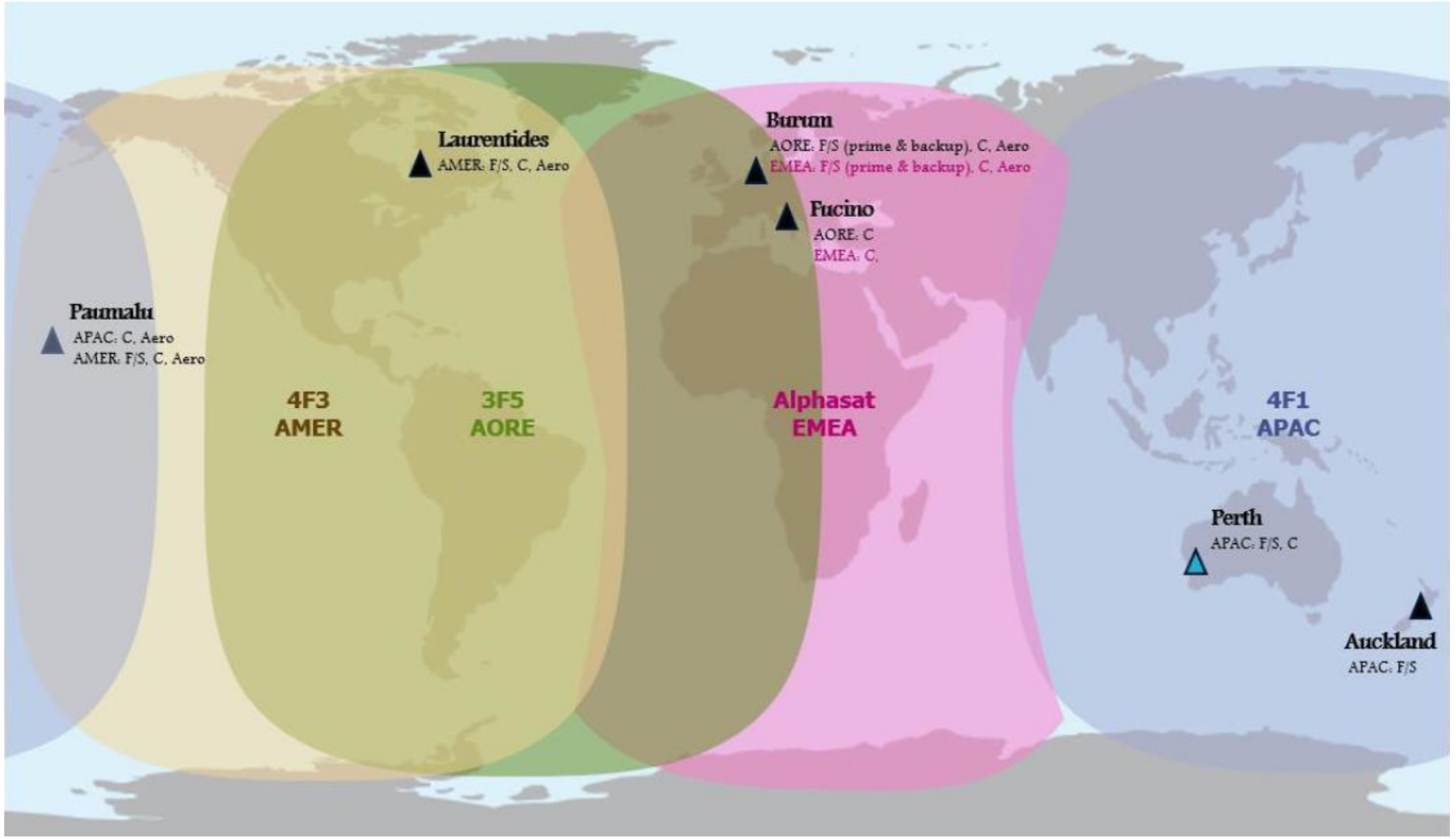
POR (Pacific Ocean Region)



APAC (Asia-Pacific Region) Satellite ID number 5 INMARSAT 4-F1 (NORAD: 28628, Cospar number: 2005-009A) 144^{o} E Beams: 1 global, 19 wide spot beams, 228 narrow spot beams. Aero Message Type 7 indicates global beam and all 19 wide spot beams can be used. Paumalu, Hawaii is NCS and normally uplinks for all LESO.

POR (Pacific Ocean Region) Satellite ID number 2 (142.5^{o} E) This is a virtual satellite on the APAC satellite (using the global and synthesized spot beams on that satellite). (In system broadcast tables, virtual satellites are often listed as offset by 1.5 degrees from the host satellite.)
Perth, Australia is NCS and normally uplinks for all LESO.

INMARSAT from on web showing global beam coverage



(From: https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/mission_support/ato_intl/documents/IPACG/IPACG45/8.0_IPACG45_PPT04_Inmarsat_Update_IPACG45_2019_F_INMARSAT.pdf)

Appendix I

This Appendix is only for the more curious.

The following shows how the spot beam regions presented in Messages Types 18 and 19 were obtained. In the slides presented here, Excel, PowerPoint, Paintshop Pro, and PSI-Plot were used.

The Message Types 18 and 19 were “harvested” form JAERO’s SU window by highlighting with the mouse large amounts of that window’s content, using Control-C to copy to the clipboard, and then using Control-V to paste into a Wordpad .txt document and then the Message Types 18 and 19 were saved. That document was then opened in Excel with a space separator and each column designated as text.

Appendix I

Here are the Message Types 18 and 19 from the AMER (Americas) INMARSAT. Note the Message Type 18 and 19 go together with Message Type 18 leading a series of Message Type 19 (interspersed with other message types). The set of these Message Types 18 and 19 ends when another Message Type 18 starts the repeat of these.

GES 320 (HEX D0)

```
18 01 3E 13 41 09 74 D0 70 AB Reserved_18
19 01 3D 68 41 58 CA 45 0B 3D Reserved_19
19 01 3C EE 4B FB 5E 41 70 88 Reserved_19
19 01 3B 42 0A 90 F0 8C CB 87 Reserved_19
19 01 3A 32 7E C4 76 53 70 AB Reserved_19
19 01 39 6C 60 70 88 7E 97 8C Reserved_19
19 01 38 A8 43 09 BB 2A A4 BB Reserved_19
19 01 37 98 11 8C CB 88 80 8C Reserved_19
19 01 36 A8 A0 59 B1 3B BF 4F Reserved_19
19 01 35 44 0A 4C 10 58 CA 5B Reserved_19
19 01 34 A4 5A 43 53 3F 46 99 Reserved_19
19 01 33 27 99 1D AC 2E 7C 3D Reserved_19
19 01 32 EE 45 0C 80 36 7E D5 Reserved_19
19 01 31 77 D2 6D FC 62 BA 5A Reserved_19
19 01 30 43 57 6C 58 CA 64 05 Reserved_19
19 01 2F 70 AB 7A 87 7E C4 46 Reserved_19
19 01 2E 0C A6 2B A3 63 9A FA Reserved_19
19 01 2D 8F BC 85 E3 7E D5 7B Reserved_19
19 01 2C FD 7E C4 82 F6 8C CB Reserved_19
19 01 2B 99 75 A4 BB 47 0A D5 Reserved_19
19 01 2A F9 B8 81 AE A9 A3 63 Reserved_19
19 01 29 A1 F4 A4 BB B4 1F BF Reserved_19
19 01 28 4F D0 36 DF BD 48 09 Reserved_19
19 01 27 49 73 46 AE 2E E0 1F Reserved_19
19 01 26 74 16 EB 16 BB 1D AC Reserved_19
19 01 25 30 05 46 99 49 0C 70 Reserved_19
19 01 24 D4 6E 0C 67 09 5A 64 Reserved_19
19 01 23 50 8C 46 AF 42 6C 46 Reserved_19
19 01 22 99 50 6C 5A 43 66 EF Reserved_19
19 01 21 6D FC 4A 0C 92 94 8F Reserved_19
19 01 20 CC 88 C9 7E F3 75 19 Reserved_19
19 01 1F 6E 0C 6B 34 6D FC 74 Reserved_19
```

GES 320 (HEX D0) ***(continued)***

```
19 01 1E FF 7E D5 88 AF 8F BC Reserved_19
19 01 1D 4B 0C BB 5C B8 98 AE Reserved_19
19 01 1C C4 A3 85 98 42 8F CC Reserved_19
19 01 1B 8C F4 8F BC 98 26 A3 Reserved_19
19 01 1A 63 AE A4 B8 81 4C 09 Reserved_19
19 01 19 E7 0B DD 4D D0 96 B8 Reserved_19
19 01 18 98 B5 BC B8 81 D0 53 Reserved_19
19 01 17 DF BD E6 DB 4D 0A 5B Reserved_19
19 01 16 D4 59 0D 4B 10 3E 78 Reserved_19
19 01 15 2E FA 1F 74 27 D1 46 Reserved_19
19 01 14 AE 51 EF 5A 64 4E 0C Reserved_19
19 01 13 80 62 7F 01 79 67 70 Reserved_19
19 01 12 FC 64 52 59 0D 57 9C Reserved_19
19 01 11 5A 64 64 35 6E 0C 77 Reserved_19
19 01 10 E6 7E F3 4F 0C A6 5D Reserved_19
19 01 0F A4 FD 99 C3 8E 85 84 Reserved_19
19 01 0E A8 7F 01 7C 2A 7E F3 Reserved_19
19 01 0D 85 F6 8F CC 9B 0F A3 Reserved_19
19 01 0C 85 50 0A D0 B1 BF D8 Reserved_19
19 01 0B B3 1F A4 FD A2 24 A3 Reserved_19
19 01 0A 85 AA 88 B8 98 D6 31 Reserved_19
19 01 09 DD 4D 51 09 72 76 6E Reserved_19
19 01 08 4E 5D 6D 4C 8B 3E 78 Reserved_19
19 01 07 44 04 59 0D 67 1D 70 Reserved_19
19 01 06 FC 52 0A 92 CE 90 0E Reserved_19
19 01 05 7F 2F 6E 4E 6B 6E 70 Reserved_19
19 01 04 FC 76 94 7F 01 88 DD Reserved_19
19 01 03 8E 85 53 09 B1 CB A0 Reserved_19
19 01 02 ED 90 0E 8A 5E 8E 85 Reserved_19
19 01 01 96 EF A4 FD BA 24 BF Reserved_19
19 01 00 D8 00 00 00 00 00 00 Reserved_19
```

The first column (with 18 or 19) indicates the message type. The second column is the revision number of that Message type. The third column is a Countdown of these. In this case, starting with 3E (HEX) indicating 3•16+14=62 rows of Message Type 19 will follow.

The fourth column of Message Type 18, a 13 (HEX) in this example, indicates that 1•16+3=19 spot beam footprints are going to be described.

(In the case of Message Type 19, the fourth column is just part of the data as described below.)

The 41 in the fifth column of Message Type 18 indicates that Spot Beam 1 will be described. (The spot beams are numbered in HEX as 41, 42, 43,…, 49, 4A, 4B,…, 4F, 50, 51, 52, and finally 53 being 19th spot beam. The 09 in the next column indicate there will be 09 (in HEX, which is also 9 in decimal) data values (groups of four HEX or 16 bits) describing the first spot beam. One needs to know how many octants for each beam to know when the data for the next spot beam starts.

This leads to the following breakout for the description of the 19 spot beams.

```
41 09 74D0 70AB 6841 58CA 450B 3DEE 4BFB 5E41 7088
42 0A 90F0 8CCB 8732 7EC4 7653 70AB 6C60 7088 7E97 8CA8
43 09 BB2A A4BB 9811 8CCB 8880 8CA8 A059 B13B BF4F
44 0A 4C10 58CA 5BA4 5A43 533F 4699 2799 1DAC 2E7C 3DEE
45 0C 8036 7ED5 77D2 6DFC 62BA 5A43 576C 58CA 6405 70AB 7A87 7EC4
46 0C A62B A363 9AFA 8FBC 85E3 7ED5 7BFD 7EC4 82F6 8CCB 9975 A4BB
47 0A D5F9 B881 AEA9 A363 A1F4 A4BB B41F BF4F D036 DFBD
48 09 4973 46AE 2EE0 1F74 16EB 16BB 1DAC 3005 4699
49 0C 70D4 6E0C 6709 5A64 508C 46AF 426C 4699 506C 5A43 66EF 6DFC
4A 0C 9294 8FCC 88C9 7EF3 7519 6E0C 6B34 6DFC 74FF 7ED5 88AF 8FBC
4B 0C BB5C B898 AEC4 A385 9842 8FCC 8CF4 8FBC 9826 A363 AEA4 B881
4C 09 E70B DD4D D096 B898 B5BC B881 D053 DFBD E6DB
4D 0A 5BD4 590D 4B10 3E78 2EFA 1F74 27D1 46AE 51EF 5A64
4E 0C 8062 7F01 7967 70FC 6452 590D 579C 5A64 6435 6E0C 77E6 7EF3
4F 0C A65D A4FD 99C3 8E85 84A8 7F01 7C2A 7EF3 85F6 8FCC 9B0F A385
50 0A D0B1 BFD8 B31F A4FD A224 A385 AA88 B898 D631 DD4D
51 09 7276 6E4E 5D6D 4C8B 3E78 4404 590D 671D 70FC
52 0A 92CE 900E 7F2F 6E4E 6B6E 70FC 7694 7F01 88DD 8E85
53 09 B1CB A0ED 900E 8A5E 8E85 96EF A4FD BA24 BFD8
```

Each four HEX is the location of a vertex for the boundary of the footprint of that rows spot beam. The location is actually at a 1^o x 1^o pixel number (after converting from HEX to DEC) that is converted into an integer longitude and integer latitude by the following formulas. (Note that "Floor()" function means the greatest integer which is less than the quantity in the parenthesis.)

$$LON = 360 \bullet [N / 360 - Floor(N / 360)] - 180$$
$$LAT = Floor(N / 360) - 90$$

As an example, 6841 (HEX) is 26689 (DEC). The above formula will reveal this to be Longitude -131 and Latitude -16 or W 131^o S 16^o.

Appendix I

The table below shows, in column, the values for each of the 19 spot beams in this example. The column showing The decimal value of the 1 º x 1 º pixel number is followed by the longitude and latitude of that pixel. Note that the first location for each beam has been repeated as a last location for that beam in each column, so that the spot beam (if one connects the points) encloses a region on the earth's surface.

1	29904	-156	-7	2	37104	-156	13	3	47914	-146	43	4	19472	-148	-36	5	32822	-118	1	6	42539	-121	28	7	54777	-123	62	8	18803	-97	-38	9	28884	-96	-10	10	37524	-96	14
	28843	-137	-10		36043	-137	10		42171	-129	27		22730	-130	-27		32469	-111	0		41827	-113	26		47233	-107	41		18094	-86	-40		28172	-88	-12		36812	-88	12
	26689	-131	-16		34610	-130	6		38929	-131	18		23460	-120	-25		30674	-106	-5		39674	-106	20		44713	-107	34		12000	-60	-57		26377	-83	-17		35017	-83	7
	22730	-130	-27		32452	-128	0		36043	-137	10		23107	-113	-26		28156	-104	-12		36796	-104	12		41827	-113	26		8052	-48	-68		23140	-80	-26		32499	-81	0
	17675	-145	-41		30291	-129	-6		34944	-156	7		21311	-109	-31		25274	-106	-20		34275	-105	5		41460	-120	25		5867	-73	-74		20620	-80	-33		29977	-83	-7
	15854	-166	-46		28843	-137	-10		36008	-172	10		18073	-107	-40		23107	-113	-26		32469	-111	0		42171	-129	27		5819	-121	-74		18095	-85	-40		28172	-88	-12
	19451	-169	-36		27744	-156	-13		41049	-171	24		10137	-123	-62		22380	-120	-28		31741	-119	-2		46111	-149	38		7596	-144	-69		17004	-96	-43		27444	-96	-14
	24129	-171	-23		28808	-172	-10		45371	-169	36		7596	-144	-69		22730	-130	-27		32452	-128	0		48975	-165	46		12293	-127	-56		18073	-107	-40		28156	-104	-12
	28808	-172	-10		32407	-173	0		48975	-165	46		11900	-160	-57		25605	-135	-19		33526	-134	3		53302	-158	58		18073	-107	-40		20588	-112	-33		29951	-109	-7
	29904	-156	-7		36008	-172	10		47914	-146	43		15854	-166	-46		28843	-137	-10		36043	-137	10		57277	-143	69		18803	-97	-38		23107	-113	-26		32469	-111	0
					37104	-156	13						19472	-148	-36		31367	-133	-3		39285	-135	19		54777	-123	62						26351	-109	-17		34991	-109	7
																	32452	-128	0		42171	-129	27										28156	-104	-12		36796	-104	12
																	32822	-118	1		42539	-121	28										28884	-96	-10		37524	-96	14

11	47964	-96	43	12	59147	-73	74	13	23508	-72	-25	14	32866	-74	1	15	42589	-71	28	16	53425	-35	58	17	29302	-38	-9	18	37582	-38	14	19	45515	-25
	47256	-84	41		56653	-47	67		22797	-63	-27		32513	-67	0		42237	-63	27		49112	-28	46		28238	-22	-12		36878	-22	12		41197	-23
	44740	-80	34		53398	-62	58		19216	-44	-37		31079	-61	-4		39363	-57	19		45855	-45	37		23917	-23	-24		32559	-21	0		36878	-22
	41861	-79	26		47256	-84	41		15992	-28	-46		28924	-56	-10		36485	-55	11		42237	-63	27		19595	-25	-36		28238	-22	-12		35422	-38
	38978	-82	18		46524	-96	39		12026	-34	-57		25682	-58	-19		33960	-60	4		41508	-72	25		15992	-28	-46		27502	-38	-14		36485	-55
	36812	-88	12		47233	-107	41		8052	-48	-68		22797	-63	-27		32513	-67	0		41861	-79	26		17412	-48	-42		28924	-56	-10		38639	-61
	36084	-96	10		53331	-129	58		10193	-67	-62		22428	-72	-28		31786	-74	-2		43656	-84	31		22797	-63	-27		30356	-64	-6		42237	-63
	36796	-104	12		57277	-143	69		18094	-86	-40		23140	-80	-26		32499	-81	0		47256	-84	41		26397	-63	-17		32513	-67	0		47652	-48
	38950	-110	18		59099	-121	74		20975	-85	-32		25653	-87	-19		34294	-86	5		54833	-67	62		28924	-56	-10		35037	-63	7		49112	-28
	41827	-113	26		59147	-73	74		23140	-80	-26		28172	-88	-12		36812	-88	12		56653	-47	67		29302	-38	-9		36485	-55	11		45515	-25
	44708	-112	34						23508	-72	-25		30694	-86	-5		39695	-85	20		53425	-35	58						37582	-38	14			
	47233	-107	41										32499	-81	0		41861	-79	26															
	47964	-96	43										32866	-74	1		42589	-71	28															

The points can now be plotted with connecting the dots in order to enclose each spot beam region. If overlaying on a map, one will need to do some adjustments when the regions goes beyond a map edge and needs to "wrap around" to the other end; and, of course, one has to deal with E/W, N/S, and signed longitude and latitude.

Appendix II

This appendix is only for the even more curious. It shows some of the key steps that led to figuring out what the Message Type 18 and 19 were and how the necessary equations were realized.

Initially, it was not known what these message types conveyed as they are only labelled as “reserved” in the available documentation. It took a couple months of spare time to determine what was being described and in what way.

Appendix II

The table below is the same table as in Appendix I except the octants that appear more than once (two or three times) are in red—bold red if they appear three times. Note that there are a lot of these and they most often appear as every other octant.

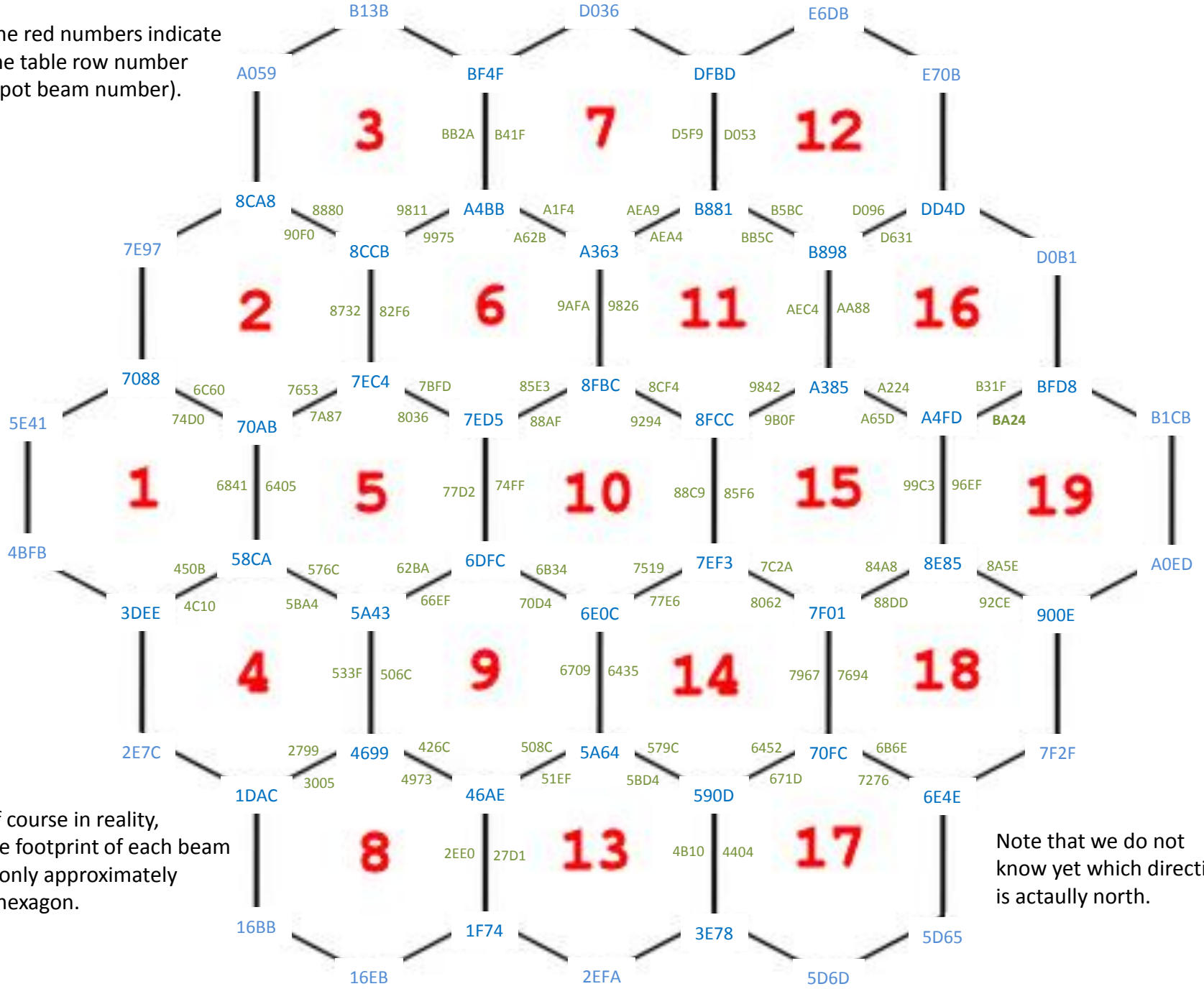
GES 320 (D0)

41	09	74D0	**70AB**	6841	**58CA**	450B	3DEE	4BFB	5E41	7088	
42	0A	90F0	**8CCB**	8732	**7EC4**	7653	**70AB**	6C60	7088	7E97	8CA8
43	09	BB2A	**A4BB**	9811	**8CCB**	8880	8CA8	A059	B13B	BF4F	
44	0A	4C10	**58CA**	5BA4	**5A43**	533F	**4699**	2799	1DAC	2E7C	3DEE
45	0C	8036	**7ED5**	77D2	**6DFC**	62BA	**5A43**	576C	**58CA**	6405	**70AB**	7A87	**7EC4**
46	0C	A62B	**A363**	9AFA	**8FBC**	85E3	**7ED5**	7BFD	**7EC4**	82F6	**8CCB**	9975	**A4BB**
47	0A	D5F9	**B881**	AEA9	**A363**	A1F4	**A4BB**	B41F	BF4F	D036	DFBD		
48	09	4973	46AE	2EE0	1F74	16EB	16BB	1DAC	3005	**4699**			
49	0C	70D4	**6E0C**	6709	**5A64**	508C	46AF	426C	**4699**	506C	**5A43**	66EF	**6DFC**
4A	0C	9294	**8FCC**	88C9	**7EF3**	7519	**6E0C**	6B34	**6DFC**	74FF	**7ED5**	88AF	**8FBC**
4B	0C	BB5C	**B898**	AEC4	**A385**	9842	**8FCC**	8CF4	**8FBC**	9826	**A363**	AEA4	**B881**
4C	09	E70B	DD4D	D096	**B898**	B5BC	**B881**	D053	DFBD	E6DB			
4D	0A	5BD4	**590D**	4B10	3E78	2EFA	1F74	27D1	46AE	51EF	**5A64**		
4E	0C	8062	**7F01**	7967	**70FC**	6452	**590D**	579C	**5A64**	6435	**6E0C**	77E6	**7EF3**
4F	0C	A65D	**A4FD**	99C3	**8E85**	84A8	**7F01**	7C2A	**7EF3**	85F6	**8FCC**	9B0F	**A385**
50	0A	D0B1	BFD8	B31F	**A4FD**	A224	**A385**	AA88	**B898**	D631	DD4D		
51	09	7276	6E4E	5D6D	4C8B	3E78	4404	**590D**	671D	**70FC**			
52	0A	92CE	900E	7F2F	6E4E	6B6E	**70FC**	7694	**7F01**	88DD	**8E85**		
53	09	B1CB	A0ED	900E	8A5E	**8E85**	96EF	**A4FD**	BA24	BFD8			

Two things occurred at this point. The first was that there are 19 things being described and this corresponds to the fact that this satellite has 19 wide spot beams. The second thing is that this might be a description of the beam foot prints with the same numbers appearing where the point corresponds to being measured on adjacent beams. Treating each rows data as a hexagonal puzzle piece and putting the puzzle together by matching edge octant like objects in a puzzle, the following assembled puzzle is obtained.

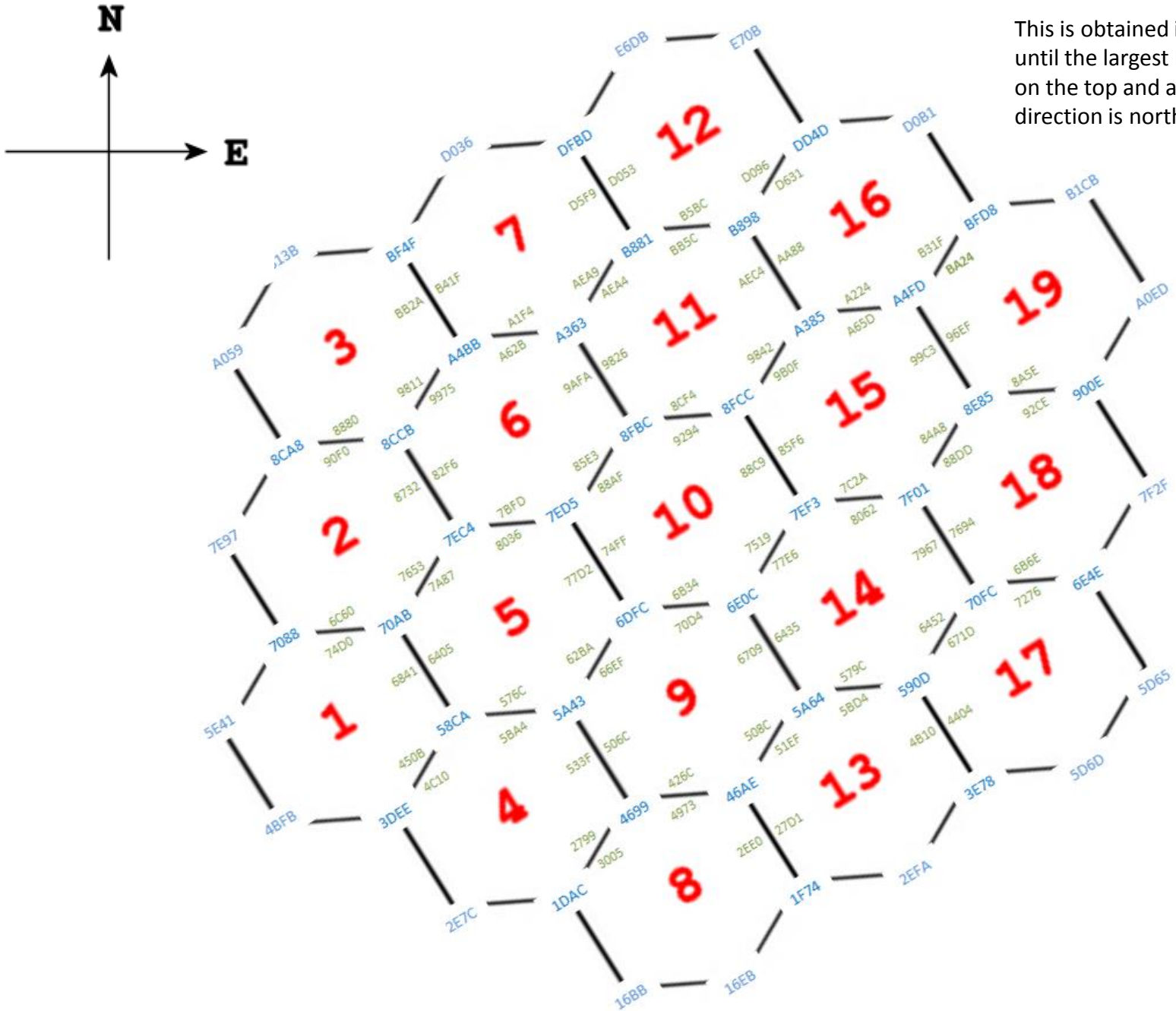
Appendix II

The red numbers indicate the table row number (spot beam number).



Of course in reality, the footprint of each beam is only approximately a hexagon.

Note that we do not know yet which direction is actaully north.



This is obtained if we rotate until the largest HEX values are on the top and assume that direction is north.

One is tempted to suspect that the first octant (two HEX characters) gives a scaled version of the latitude and the second octant gives the longitude. However, trying that will show that is not the case. In fact, it turns out that the first octant is, as an artifact of the actual scheme, only approximately a scaled version of the latitude. Eventually, one realizes that 1^o x 1^o pixels have been numbered starting in the lower left going horizontally them up and back to the left go vertically.

A little experimentation reveals the latitude as being: LAT = Floor(N / 360) – 90, where a negative result indicates "degrees south" rather than "degrees north", and, as in Appendix I, the "Floor()" function means the greatest integer which is less than the quantity in the parenthesis.

The remaining part of N / 360, that is, N / 360-Floor(N / 360) must encode the longitude. It is easily realized that scaling this to 360 • [N / 360-Floor(N / 360)] will give the needed 360 ^{o} range.

Finally for display purposes, an offset gives more usable longitude values: LON = 360 • [N / 360-Floor(N / 360)] – 180. (Note a different offset for some values is sometimes needed for the map being used.) This gives an accurate drawing of the beam foot prints.