ATTACHMENT D
Astro Digital U.S., Inc.
Form 312, Exhibit 43

LANDMAPPER SATELLITE ANTENNA BEAM CONTOURS – PROGRAM PHASES 1,2 & 3

This Attachment provides a "paper version" of the beam antenna contours for each Landmapper satellite type and for each phase of the program.

Table D-1 summarizes the provided beam contour plots. There are three types of patterns: 1) Beam Gain Roll-Off/Beam Gain Contours; 2) Beam EIRP Contours; 3) Beam G/T Contours, as applicable to each situation and program phase.

Table D-1: LANDMAPPER Satellite Beam Antenna Contours

Contour No.:	*Program Phase:*	*Frequency Band:*	*U/L or D/L Location:*	*U/L or D/L:*	*Contour Type:*	*Satellite Type:*
D-UHF-D/L-01	Phase 1,2,3	UHF (400.175 MHz)	Moffett Field, CA	Downlink	Gain RO/Gain	CORVUS-BC
D-UHF-D/L-02	Phase 1,2,3	UHF (400.175 MHz)	Moffett Field, CA	Downlink	EIRP	CORVUS-BC
D-UHF-D/L-03	Phase 1,2,3	UHF (400.175 MHz)	Moffett Field, CA	Downlink	Gain RO/Gain	CORVUS-HD
D-UHF-D/L-04	Phase 1,2,3	UHF (400.175 MHz)	Moffett Field, CA	Downlink	EIRP	CORVUS-HD
D-UHF-U/L-05	Phase 1,2,3	UHF (402.600 MHz)	Moffett Field, CA	Uplink	Gain RO/Gain	CORVUS-BC
D-UHF-U/L-06	Phase 1,2,3	UHF (402.600 MHz)	Moffett Field, CA	Uplink	G/T	CORVUS-BC
D-UHF-U/L-07	Phase 1,2,3	UHF (402.600 MHz)	Moffett Field, CA	Uplink	Gain RO/Gain	CORVUS-HD
D-UHF-U/L-08	Phase 1,2,3	UHF (402.600 MHz)	Moffett Field, CA	Uplink	G/T	CORVUS-HD
D-Ka-D/L-09	Phase 1	Ka-band (26.8 GHz)	Svalbard, Norway	Downlink	Gain RO/Gain	CORVUS-BC & -HD
D-Ka-D/L-10	Phase 1	Ka-band (26.8 GHz)	Svalbard, Norway	Downlink	EIRP	CORVUS-BC & -HD
D-Ka-D/K-11	Phase 2	Ka-band (26.8 GHz)	Svalbard, Norway	Downlink	Gain RO/Gain	CORVUS-BC & -HD
D-Ka-D/L-12	Phase 2	Ka-band (26.8 GHz)	Svalbard, Norway	Downlink	EIRP	CORVUS-BC & -HD
D-Ka-D/L-13	Phase 3	Ka-band (26.8 GHz)	Svalbard, Norway	Downlink	Gain RO/Gain	CORVUS-BC & -HD
D-Ka-D/L-14	Phase 3	Ka-band (26.8 GHz)	Svalbard, Norway	Downlink	EIRP	CORVUS-BC & -HD
D-S-U/L-15	Phase 2, 3	S-band (2025.6 MHz)	Moffett Field, CA	Uplink	Gain RO/Gain	CORVUS-BC & -HD
D-S-U/L-16	Phase 2, 3	S-band (2025.6 MHz)	Moffett Field, CA	Uplink	G/T	CORVUS-BC & -HD
D-Ka-U/L-17	Phase 2, 3	Ka-band (29.95 GHz)	Svalbard, Norway	Uplink	Gain RO/Gain	CORVUS-BC & -HD
D-Ka-U/L-18	Phase 2, 3	Ka-band (29.95 GHz)	Svalbard, Norway	Uplink	G/T	CORVUS-BC & -HD

For the Exhibit 43 filing of the beam contours Astro Digital used a map system provided on-line by Google Earth®. These maps allow ground surface distances to be calculated directly. Off-boresight angles for each antenna roll-off value were converted to ground surface distances from the target location (the Earth station at either Moffett Field, CA or Svalbard, NO) and transferred using the surface arc distance measuring feature of Google Earth to each map. Roll-off contour rings were then constructed at suitable angles from boresight for each antenna case using surface distance graphics. Roll-off values were then converted to EIRP or G/T contours, as appropriate for TX or RX beams respectively. An orbit height of 500 km was used for each satellite in making the contours.

D.1: Method Used for Preparing Ka-band Transmit Beam Contour Plots

As this antenna has the highest gain of all Landmapper spacecraft antennas and the transmission system has an EIRP in excess of 20 dBW, special care was taken to make these plots. We consulted ITU Reference Publication APL-UM-001, Ver. 1.1.19 (2016-04-21) in an effort to identify a suitable ITU class spacecraft antenna that could be used to mathematically define our Ka-band transmit antenna system. This specific method was not successful. However, we were able to identify a ship Earth station antenna, which did resemble the pattern of our transmitting horn antenna on both spacecraft types. Although the original antenna was used at L-band as an Earth station antenna and our system is a Ka-band spacecraft antenna, the D/λ and roll-off behavior for the two antennas was found to be very similar.

First we "digitized" the data from our measured analog roll-off data from the supplying vendor. We then adjusted coefficients for the selected antenna, taken from ITU-R; APL-UM-001. The selected antenna has the name: APERC005V01. After adjusting the coefficients we developed the following relationships:

Equation Fit for Astro Digital Ka-band Antenna Pattern: See Table 2

$$G = G_{max} - 3.05E\text{-}3\left(\frac{D}{\lambda}\varphi\right)^2 \quad \text{[dBi]} \qquad \text{for } 0° \le \varphi < \varphi_m$$

$$G = G_1 = -14.4 + 15\log\left(\frac{D}{\lambda}\right) \quad \text{[dBi]} \qquad \text{tor } \varphi_m \le \varphi < \varphi_r$$

$$\varphi_m = 18.1\left(\frac{\lambda}{D}\right)\sqrt{(G_{max} - G_1)} \quad \text{[degrees]}$$

$$\varphi_r = 45°$$

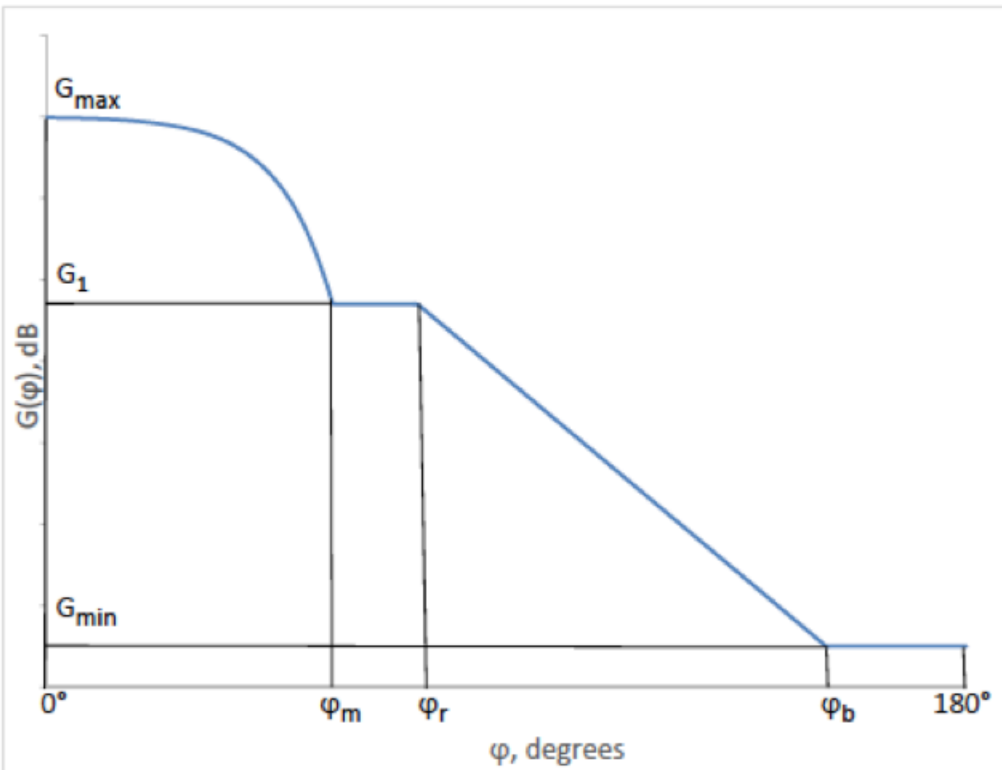
$$G = 51.5 - 10\log\left(\frac{D}{\lambda}\right) - 28\log\varphi \quad \text{[degrees]} \qquad \text{tor } \varphi_r \le \varphi < \varphi_b$$

Figure D-1: Equations Expressing Ka-Band Horn Antenna Pattern

Where gain and angle parameters are as defined in the following excerpt from ITU Reference Publication APL-UM-001:

Co-polar component: Mathematical description of the co-polar pattern component as defined in the referenced documents and implemented in the APL Standard Library. The following notations are used:

G	is the co-polar gain at the off-axis angle φ, dB.
G_x, Gx	is the cross-polar gain at the off-axis angle φ, dB.
G_{max}, Gmax	is the maximum co-polar gain, dB.
φ, Phi	is the off-axis angle referred to the main lobe, degrees.
φ_0, Phi0	is the half-power beamwidth, degrees.
D	is the antenna diameter, meters.
λ, lambda	is the wavelength, meters.
η	is the antenna efficiency.
B_{min}, Bmin	is the beamlet, degrees.
φ_m, Phi m	is the start angle of the first side lobe (plateau constant part), degrees.
φ_r, Phi r	is the start angle of the near side lobe (logarithmic part), degrees.
φ_b, Phi b	is the start angle of the back lobe (back constant part), degrees.
G_1, G1	is the gain of the first side lobe (plateau constant part), dB.
CoefA, CoefB	are parameters describing the near side lobe (logarithmic part), both in dB.
G_{min}, Gmin	is the gain of the back lobe (back constant part), dB.



log is a base 10 logarithmic function.

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Figure D-2: Mathematical Description of Co-polar Antenna Patterns

Table D-1 was then created to allow beam contours to be generated using a conversion from off-borsight angle to ground surface arc distance. From this table a plot of Gain Roll-Off vs. Surface Arc Distance was prepared; then the beam contours.

Table D1: Computed Beam Performance

Beam Performance Computed Using Formula Similar to APL-UM; APEREC005V01

	Gain (dBi):	Gain Roll-Off (dB):	η = φ (deg.): *	θ= 2φ(deg.):	H (km):	ρ (deg.):	Do (km):	D (km):	λ(deg.):	Surface Arc (km):	ε (deg.)
500 km Orbit	23.5	0.00	0.00	0.00	500.00	68.02	2574.52	500.00	0.00	0.00	90.00
	23.38	-0.11	1.00	2.00	500.00	68.02	2574.52	500.08	0.08	8.73	88.92
	23.03	-0.46	2.00	4.00	500.00	68.02	2574.52	500.33	0.16	17.46	87.84
	22.46	-1.04	3.00	6.00	500.00	68.02	2574.52	500.74	0.24	26.21	86.76
	21.64	-1.86	4.00	8.00	500.00	68.02	2574.52	501.32	0.31	34.97	85.69
	20.48	-3.01	5.10	10.20	500.00	68.02	2574.52	502.14	0.40	44.64	84.50
	17.82	-5.68	7.00	14.00	500.00	68.02	2574.52	504.05	0.55	61.43	82.45
	11.9	-13.95	11.00	22.00	500.00	68.02	2574.52	510.11	0.87	97.34	78.13
	6.8	-16.70	12.00	24.00	500.00	68.02	2574.52	512.08	0.96	106.47	77.04
	-0.88	-24.30	14.50	29.00	500.00	68.02	2574.52	517.81	1.16	129.66	74.34
G1; φm	-2.59	-26.10	15.00	30.00	500.00	68.02	2574.52	519.10	1.21	134.36	73.79
	-2.69	-26.19	45.00	90.00	500.00	68.02	2574.52	737.29	4.69	521.92	40.31
	-7.62	31.12	67.50	135.00	500.00	68.02	2574.52	2084.36	17.57	1956.22	4.93
	-11.12	-34.62	90.00	180.00	500.00	68.02	2574.52	N/A	N/A	N/A	Below Hor.
300 km Orbit	23.5	0.00	0.00	0.00	300.00	72.76	1979.11	300.00	0.00	0.00	90.00
	23.38	-0.11	1.00	2.00	300.00	72.76	1979.11	300.05	0.05	5.24	88.95
	23.03	-0.46	2.00	4.00	300.00	72.76	1979.11	300.19	0.09	10.48	87.91
	22.46	-1.04	3.00	6.00	300.00	72.76	1979.11	300.43	0.14	15.72	86.86
	21.64	-1.86	4.00	8.00	300.00	72.76	1979.11	300.77	0.19	20.98	85.81
	20.48	-3.01	5.10	10.20	300.00	72.76	1979.11	301.25	0.24	26.78	84.66
	17.82	-5.68	7.00	14.00	300.00	72.76	1979.11	302.36	0.33	36.85	82.67
	11.9	-13.95	10.97	21.94	300.00	72.76	1979.11	305.85	0.52	58.20	78.51
	6.8	-16.70	12.00	24.00	300.00	72.76	1979.11	307.03	0.57	63.84	77.43
	-0.88	-24.30	14.50	29.00	300.00	72.76	1979.11	310.36	0.70	77.71	74.80
	-2.59	-26.10	15.00	30.00	300.00	72.76	1979.11	311.11	0.72	80.52	74.28
	-2.69	-26.19	45.00	90.00	300.00	72.76	1979.11	434.75	2.76	307.53	42.24
	-7.62	31.12	67.50	135.00	300.00	72.76	1979.11	938.74	7.82	869.98	14.68
	-11.12	-34.62	90.00	180.00	300.00	72.76	1979.11	N/A	N/A	N/A	Below Hor.

* Calculated from Equations

* See Starting Cell O4

We believe this representation of our Ka-band satellite antenna pattern will be useful as a means of working within the ITU environment. Further, this approach minimizes measurement errors by smoothing out the vendor-supplied pattern information.

UHF Transmit and Receive Beam Contours

All three phases of the Landmapper program will use the UHF spectrum in the same manner. That is, the satellites will all use an omni-direction antenna system having a dipole-like pattern. While this system will nominally fly with one surface of the satellite directed to the NADIR direction, this system must be used at times when the spacecraft could be tumbling and not under attitude control. As such, the system must operate satisfactorily during times when there is motion about any axis of the CORVUS satellites (BC or HD). As there are certainly times when the system must operate with good performance during periods of uncontrolled attitude, it is inappropriate to produce beam contours that show specific levels or EIRP or G/T as would be the case for a GEO beam projection on the Earth. Rather, we have chosen to provide tables that show what the maximum and minimum EIRP and G/T values will be during periods when the satellite is operating within range of Mt. View, CA (that is, when in-range of the command/control Earth station). These levels are statistical in nature but, will vary only between a nominal minimum and nominal maximum EIRP and G/T.

We also present a table showing what the TX isotropic signal power level could be, which arrives from the spacecraft to an arbitrary Earth station location depending on the instantaneous elevation angle to that same spacecraft. Once again, the maximum and minimum possible isotropic signal power levels are computed and are based on:

- Path loss for a given slant range associated with a particular elevation angle to the Earth Station.

- Excess Path Loss, which includes primarily polarization losses as well as atmospheric and ionospheric losses. This value was fixed at -5.5 dB.

- The highest possible UHF antenna gain and the lowest possible UHF antenna gain measured for the UHF antenna system (different for both BC and HD satellite types). These were carefully measured during the satellite development program.

The G/T contour information for the system is based on a system noise temperature of 378 K, as has also been used for the link budgets in Attachment B.

The approach taken in this application seems to us to be the most appropriate way of presenting the signal performance of our T&C system in a simple manner, since:

1) During periods when the satellites could be tumbling, the signal level can only be bounded by the maximum and minimum EIRP value in any arbitrary direction.

2) At any instant in time, a victim station's location and direction from/to the satellite (where interference could occur) cannot be known.

3) At any location on the Earth, even if the satellite's motion were controlled, the amplitude of the signal would vary at a rate and by scalar amplitude determined by the effect known as Faraday rotation.

We note here also, that unlike all other RF systems in the CORVUS network, the satellite UHF transmitter and receiver are linearly polarized. This further increases the amplitude variations possible to a victim station.

Table D-UHF-D/L-01: CORVUS-BC UHF Transmit Beam – Gain Roll-Off/ Gain

Antenna Operating Frequency:	Maximum Gain in Tumble Mode:	Minimum Gain in Tumble Mode:
399.5 MHz	+2.14 dBi	-15.06 dBi
402.0 MHz	+1.83 dBi	-15.31 dBi

Table D-UHF-D/L-02A: CORVUS-BC UHF Transmit Beam – EIRP

Antenna Operating Frequency:	Maximum EIRP in Tumble Mode:	Minimum EIRP in Tumble Mode:
399.5 MHz	+3.6 dBW	-13.6 dBW
402.0 MHz	+3.3 dBW	-13.8 dBW

Table D-UHF-D/L-02B: CORVUS-BC UHF Transmit Isotropic Power Level

UHF Pattern	Range to G.S.:	Range to G.S.:	Beam Contour, Off NADIR Angle:	Elev. Angle from G.S.:	Antenna Gain @ φ Contour:		Isotropic Signal Level @ G.S.:	
TUMBLE MODE	D (km):	Path Loss (dB):	η = φ (deg.): *	ε (deg.)	Max.	Min.	Max.	Min.
625 km Orbit	648.00	140.8	0.0	90.0	1.83 dBi	-15.31 dBi	-143.0 dBW	-160.1 dBW
ε=0.0033	650.73	140.8	5.0	84.5	1.83 dBi	-15.31 dBi	-143.0 dBW	-160.1 dBW
	659.04	140.9	10.0	79.0	1.83 dBi	-15.31 dBi	-143.1 dBW	-160.2 dBW
	673.32	141.1	15.0	73.4	1.83 dBi	-15.31 dBi	-143.3 dBW	-160.4 dBW
	694.29	141.4	20.0	67.9	1.83 dBi	-15.31 dBi	-143.6 dBW	-160.7 dBW
	761.38	142.2	30.0	56.6	1.83 dBi	-15.31 dBi	-144.4 dBW	-161.5 dBW
	878.61	143.4	40.0	44.9	1.83 dBi	-15.31 dBi	-145.6 dBW	-162.7 dBW
	1094.16	145.3	50.0	32.4	1.83 dBi	-15.31 dBi	-147.5 dBW	-164.6 dBW
	1281.36	146.7	55.0	25.5	1.83 dBi	-15.31 dBi	-148.9 dBW	-166.0 dBW
	1601.09	148.6	60.0	17.4	1.83 dBi	-15.31 dBi	-150.8 dBW	-167.9 dBW
	2942.82	153.9	65.2	0.0	1.83 dBi	-15.31 dBi	-156.1 dBW	-173.2 dBW
300 km Orbit	300.00	134.1	0.0	90.0	1.83 dBi	-15.31 dBi	-136.3 dBW	-153.4 dBW
ε=0.0033	304.85	134.2	10.0	79.5	1.83 dBi	-15.31 dBi	-136.4 dBW	-153.5 dBW
	320.25	134.7	20.0	69.0	1.83 dBi	-15.31 dBi	-136.8 dBW	-154.0 dBW
	332.72	135.0	25.0	63.7	1.83 dBi	-15.31 dBi	-137.2 dBW	-154.3 dBW
	370.56	135.9	35.0	53.1	1.83 dBi	-15.31 dBi	-138.1 dBW	-155.2 dBW
	398.33	136.6	40.0	47.7	1.83 dBi	-15.31 dBi	-138.7 dBW	-155.9 dBW
	452.48	137.7	47.0	40.0	1.83 dBi	-15.31 dBi	-139.8 dBW	-157.0 dBW
	514.26	138.8	52.5	33.8	1.83 dBi	-15.31 dBi	-140.9 dBW	-158.1 dBW
	550.90	139.4	55.0	30.9	1.83 dBi	-15.31 dBi	-141.5 dBW	-158.7 dBW
	735.08	141.9	63.0	21.1	1.83 dBi	-15.31 dBi	-144.0 dBW	-161.2 dBW
				*	Measured Data			

* NOTE: Isotropic signal level measured in a 40 kHz bandwidth.

Table D-UHF-D/L-03: CORVUS-HD UHF Transmit Beam – Gain Roll-Off/ Gain

Antenna Operating Frequency:	Maximum Gain in Tumble Mode:	Minimum Gain in Tumble Mode:
399.5 MHz	-0.55 dBi	-12.24 dBi
402.0 MHz	+0.19 dBi	-12.71 dBi

Table D-UHF-D/L-04A: CORVUS-HD UHF Transmit Beam – EIRP

Antenna Operating Frequency:	Maximum EIRP in Tumble Mode:	Minimum EIRP in Tumble Mode:
399.5 MHz	+1.0 dBW	-12.23 dBW
402.0 MHz	+1.7 dBW	-12.7 dBW

Table D-UHF-D/L-04B: CORVUS-HD UHF Transmit Isotropic Power Level

UHF Pattern	Range to G.S.:	Range to G.S.:	Beam Contour, Off NADIR Angle:	Elev. Angle from G.S. :	Antenna Gain @ φ Contour:		Isotropic Signal Level @ G.S.:	
TUMBLE MODE	D (km):	Path Loss (dB):	η = φ (deg.): *	ε (deg.)	Max.	Min.	Max.	Min.
625 km Orbit	648.00	140.8	0.0	90.0	0.19 dBi	-12.71 dBi	-144.6 dBW	-157.5 dBW
ε=0.0033	650.73	140.8	5.0	84.5	0.19 dBi	-12.71 dBi	-144.6 dBW	-157.5 dBW
	659.04	140.9	10.0	79.0	0.19 dBi	-12.71 dBi	-144.7 dBW	-157.6 dBW
	673.32	141.1	15.0	73.4	0.19 dBi	-12.71 dBi	-144.9 dBW	-157.8 dBW
	694.29	141.4	20.0	67.9	0.19 dBi	-12.71 dBi	-145.2 dBW	-158.1 dBW
	761.38	142.2	30.0	56.6	0.19 dBi	-12.71 dBi	-146.0 dBW	-158.9 dBW
	878.61	143.4	40.0	44.9	0.19 dBi	-12.71 dBi	-147.2 dBW	-160.1 dBW
	1094.16	145.3	50.0	32.4	0.19 dBi	-12.71 dBi	-149.1 dBW	-162.0 dBW
	1281.36	146.7	55.0	25.5	0.19 dBi	-12.71 dBi	-150.5 dBW	-163.4 dBW
	1601.09	148.6	60.0	17.4	0.19 dBi	-12.71 dBi	-152.4 dBW	-165.3 dBW
	2942.82	153.9	65.2	0.0	0.19 dBi	-12.71 dBi	-157.7 dBW	-170.6 dBW
300 km Orbit	300.00	134.1	0.0	90.0	0.19 dBi	-12.71 dBi	-137.9 dBW	-150.8 dBW
ε=0.0033	304.85	134.2	10.0	79.5	0.19 dBi	-12.71 dBi	-138.0 dBW	-150.9 dBW
	320.25	134.7	20.0	69.0	0.19 dBi	-12.71 dBi	-138.5 dBW	-151.4 dBW
	332.72	135.0	25.0	63.7	0.19 dBi	-12.71 dBi	-138.8 dBW	-151.7 dBW
	370.56	135.9	35.0	53.1	0.19 dBi	-12.71 dBi	-139.7 dBW	-152.6 dBW
	398.33	136.6	40.0	47.7	0.19 dBi	-12.71 dBi	-140.4 dBW	-153.3 dBW
	452.48	137.7	47.0	40.0	0.19 dBi	-12.71 dBi	-141.5 dBW	-154.4 dBW
	514.26	138.8	52.5	33.8	0.19 dBi	-12.71 dBi	-142.6 dBW	-155.5 dBW
	550.90	139.4	55.0	30.9	0.19 dBi	-12.71 dBi	-143.2 dBW	-156.1 dBW
	735.08	141.9	63.0	21.1	0.19 dBi	-12.71 dBi	-145.7 dBW	-158.6 dBW
				*	Measured Data			

* NOTE: Isotropic signal level measured in a 40 kHz bandwidth.

Table D-UHF-U/L-05: Corvus-BC UHF Receive Beam – Gain Roll-Off/ Gain

Antenna Operating Frequency:	Maximum Gain in Tumble Mode:	Minimum Gain in Tumble Mode:
399.5 MHz	+2.14 dBi	-15.06 dBi
402.0 MHz	+1.83 dBi	-15.31 dBi

Table D-UHF-U/L-06: Corvus-BC UHF Receive Beam – G/T

Antenna Operating Frequency:	Maximum G/T in Tumble Mode:	Minimum G/T in Tumble Mode:
399.5 MHz	-24.1 dB/K	-41.4dB/K
402.0 MHz	-24.4 dB/K	-41.6 dBW

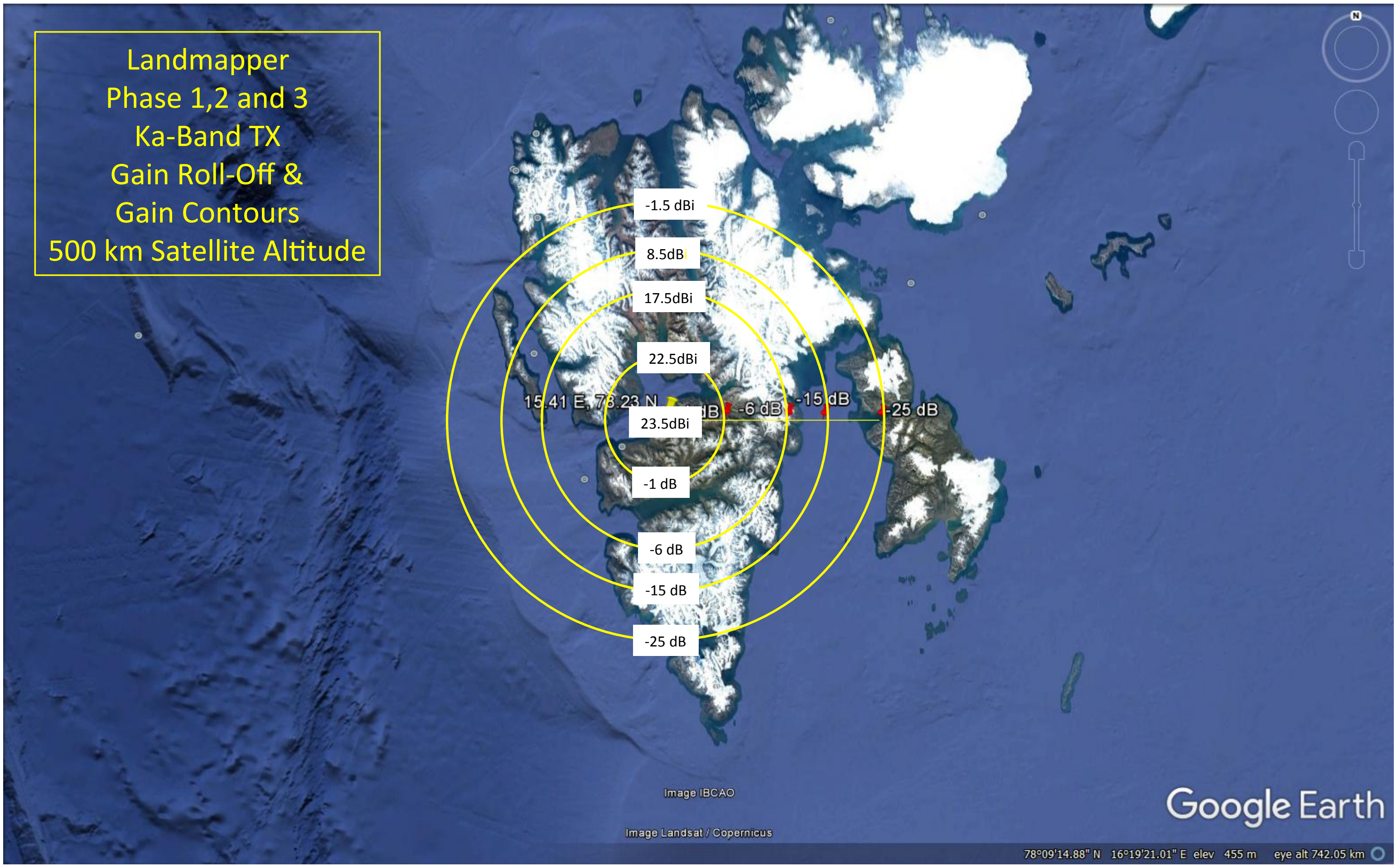
Table D-UHF-U/L-07: Corvus-HD UHF Receive Beam – Gain Roll-Off/Gain

Antenna Operating Frequency:	Maximum Gain in Tumble Mode:	Minimum Gain in Tumble Mode:
399.5 MHz	-0.55 dBi	-12.24 dBi
402.0 MHz	+0.19 dBi	-12.71 dBi

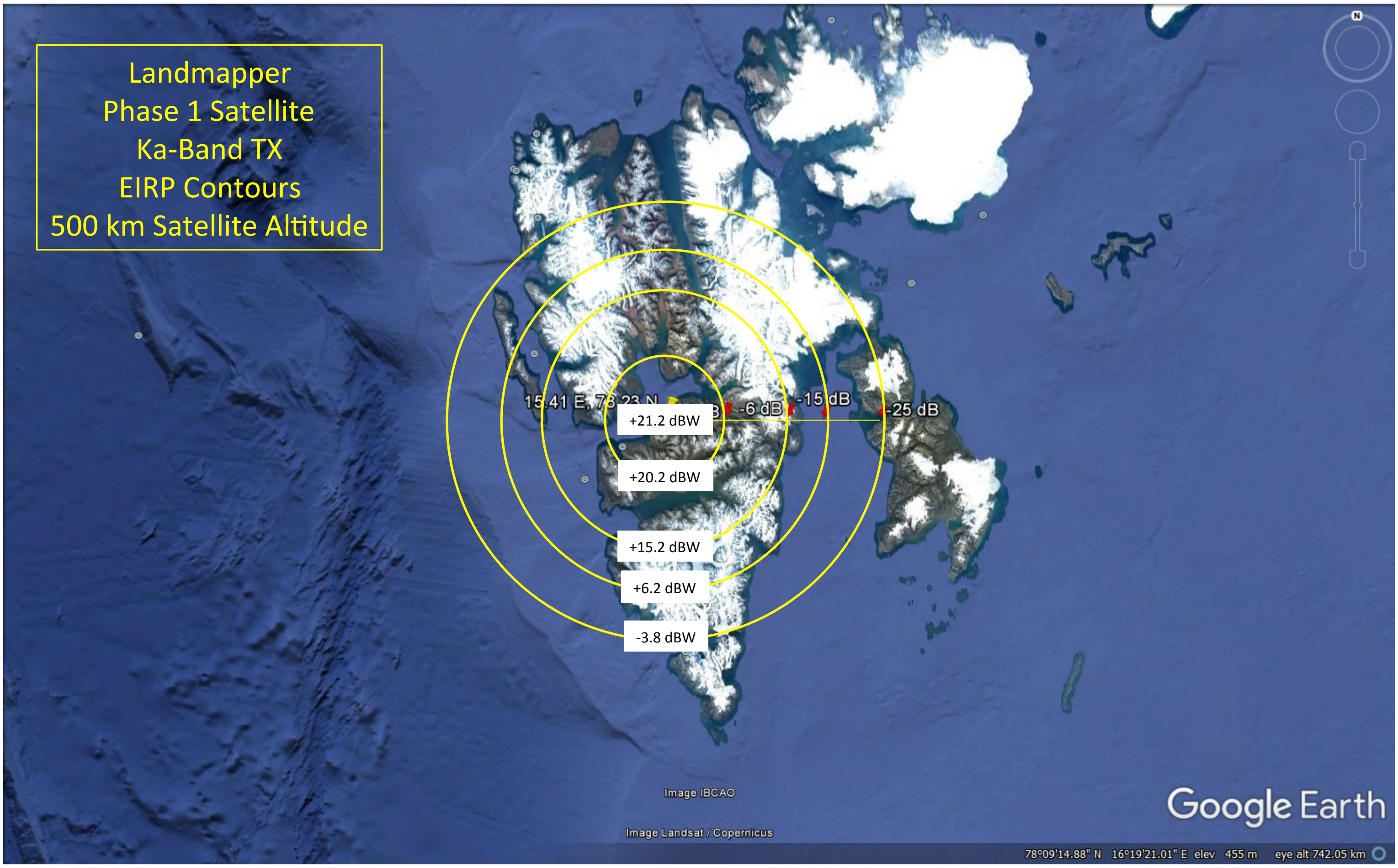
Table D-UHF-U/L-08: Corvus-HD UHF Receive Beam – G/T

Antenna Operating Frequency:	Maximum G/T in Tumble Mode:	Minimum G/T in Tumble Mode:
399.5 MHz	-26.8 dB/K	-38.5 dB/K
402.0 MHz	-26.1 dB/K	-39.0 dBW

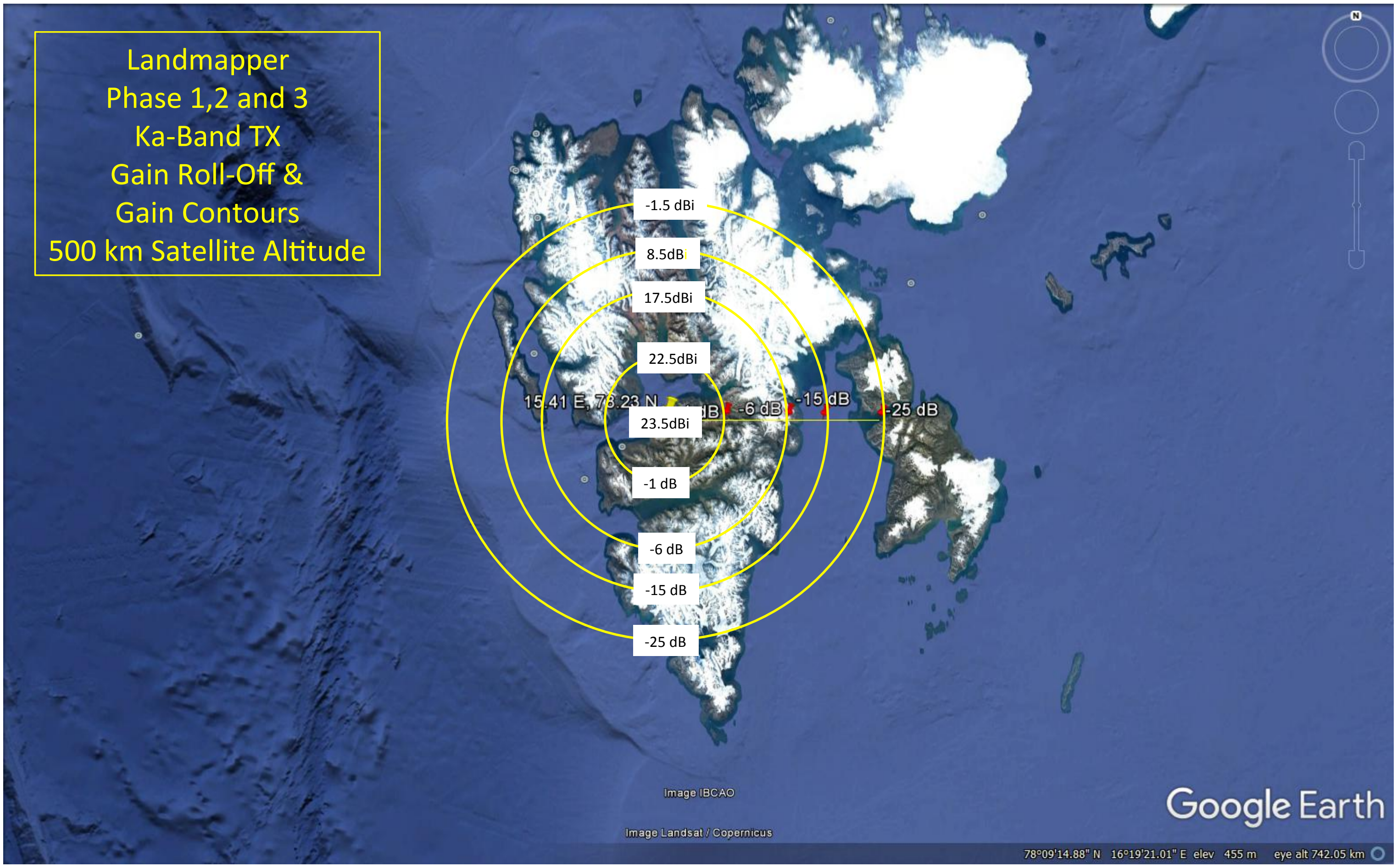
Beam Contour D-Ka-D/L-09: Corvus-BC and HD, Ka-band Transmit Beam – Gain Roll-Off/Gain for Program Phase 1



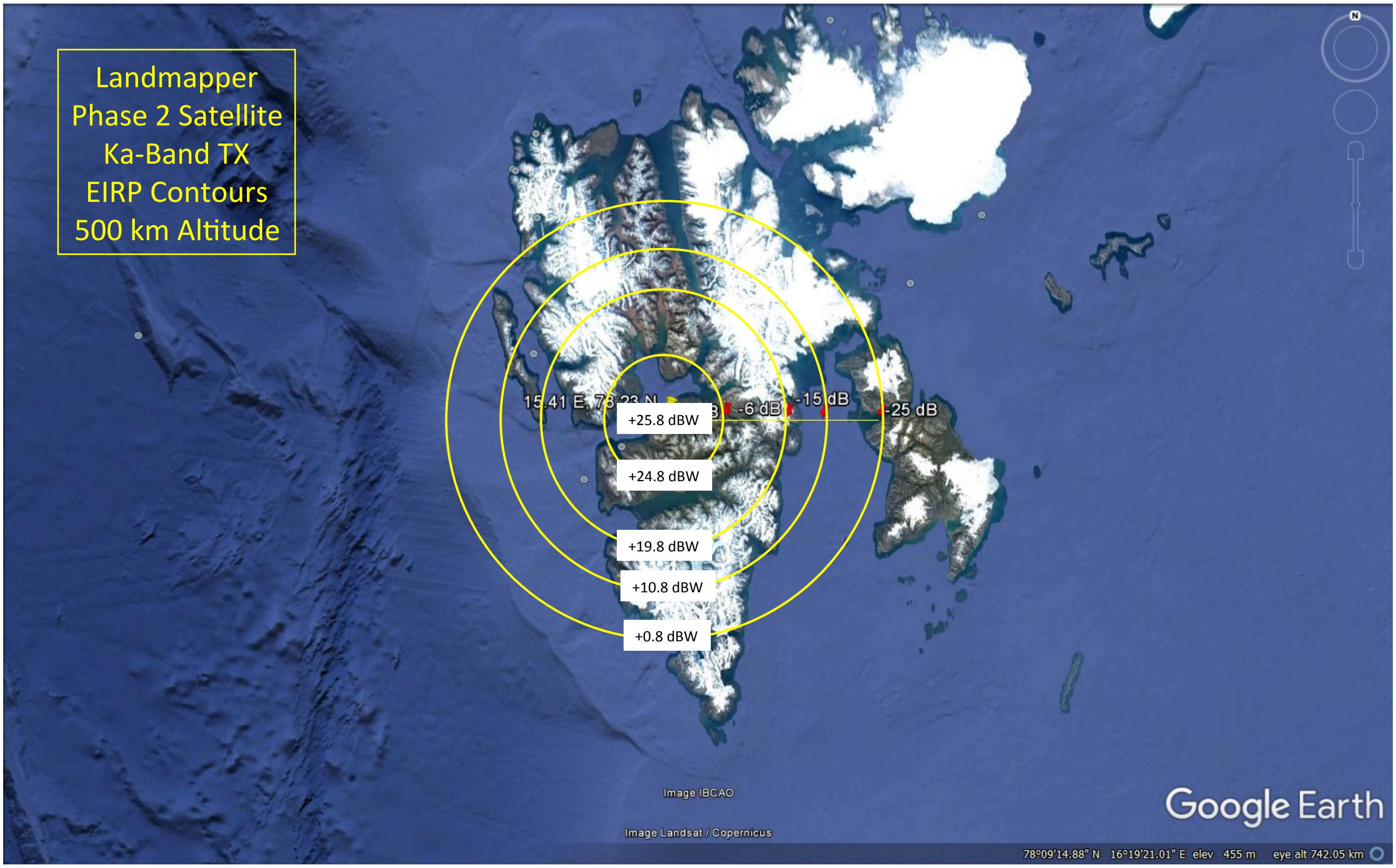
Beam Contour D-Ka-D/L-10: Corvus-BC and HD Ka-band Transmit Beam – EIRP for Program Phase 1



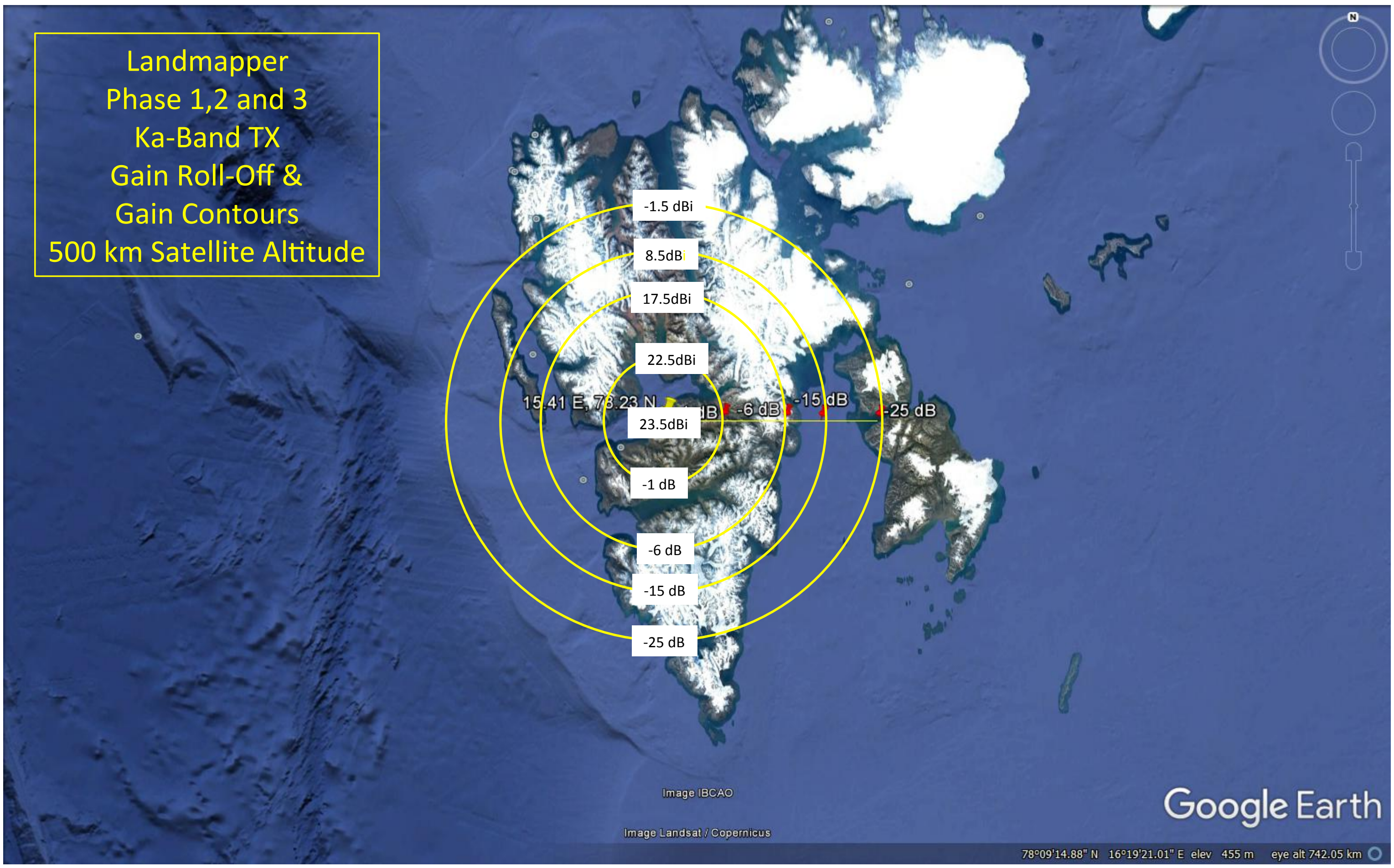
Beam Contour D-Ka-D/L-11: Corvus-BC and HD, Ka-band Transmit Beam – Gain Roll-Off/Gain for Program Phase 2



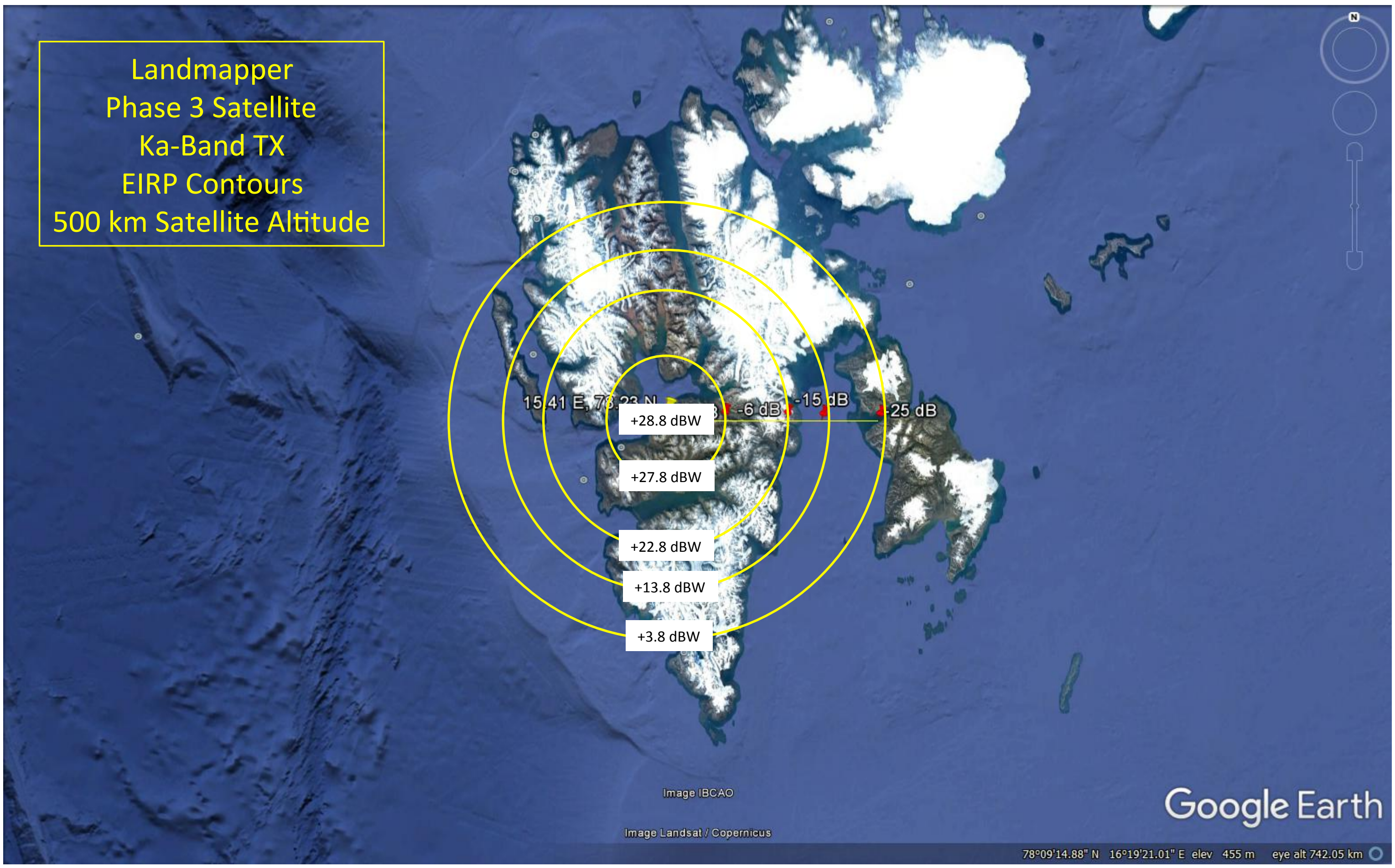
Beam Contour D-Ka-D/L-12: Corvus-BC and HD Ka-band Transmit Beam –
EIRP for Program Phase 2



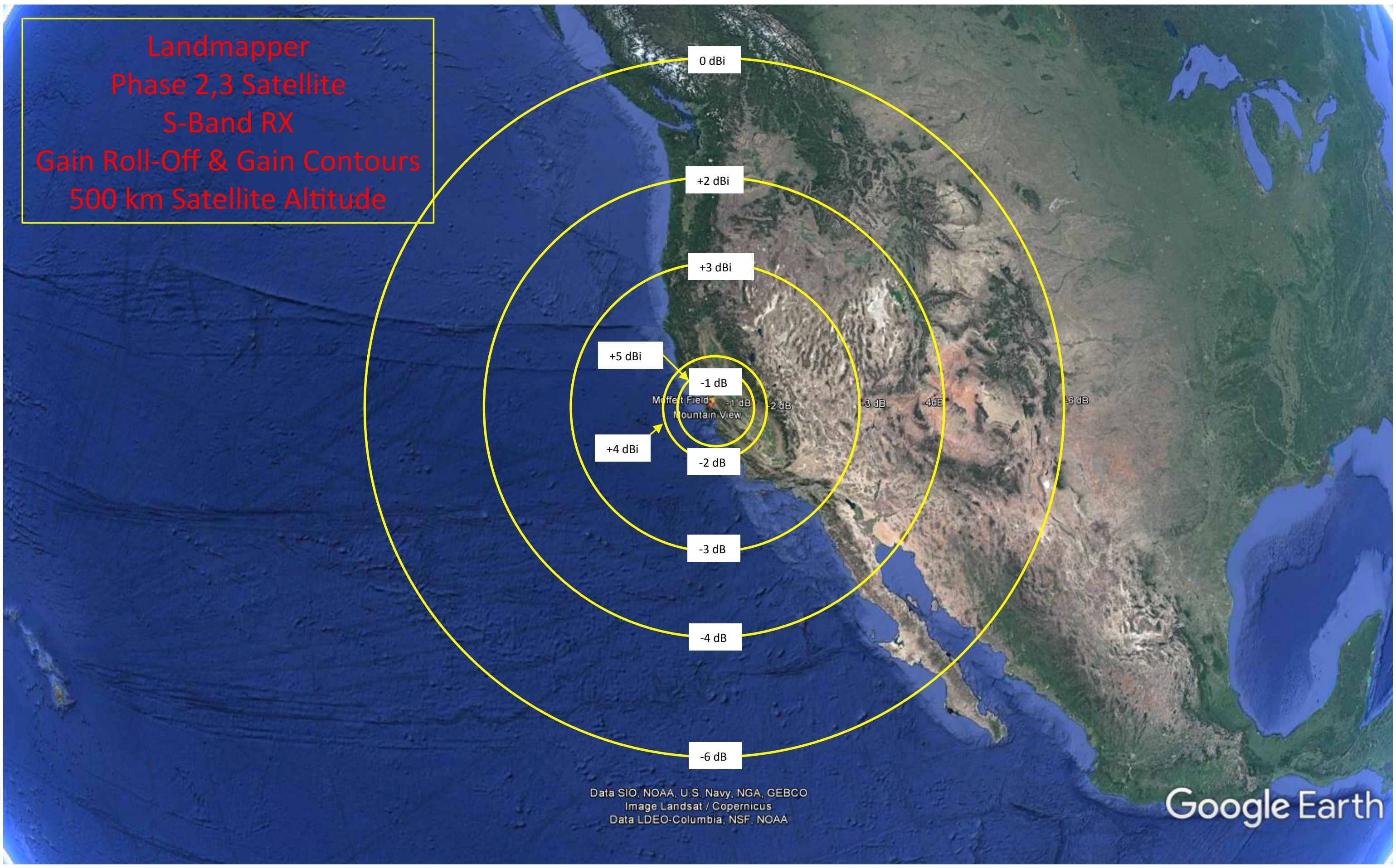
Beam Contour D-Ka-D/L-13: Corvus-BC and HD, Ka-band Transmit Beam – Gain Roll-Off/Gain for Program Phase 3



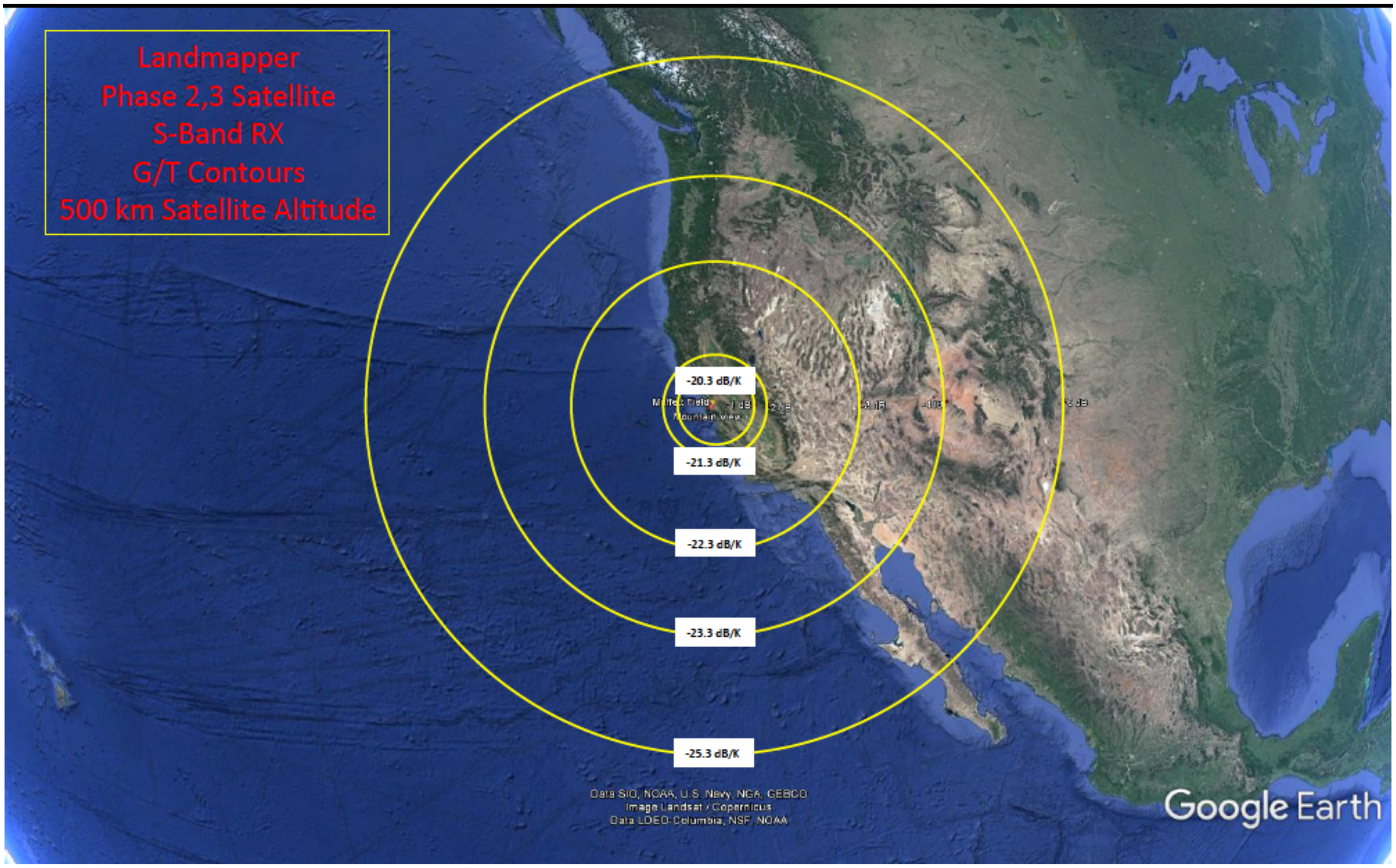
Beam Contour D-Ka-D/L-14: Corvus-BC and HD Ka-band Transmit Beam – EIRP for Program Phase 3



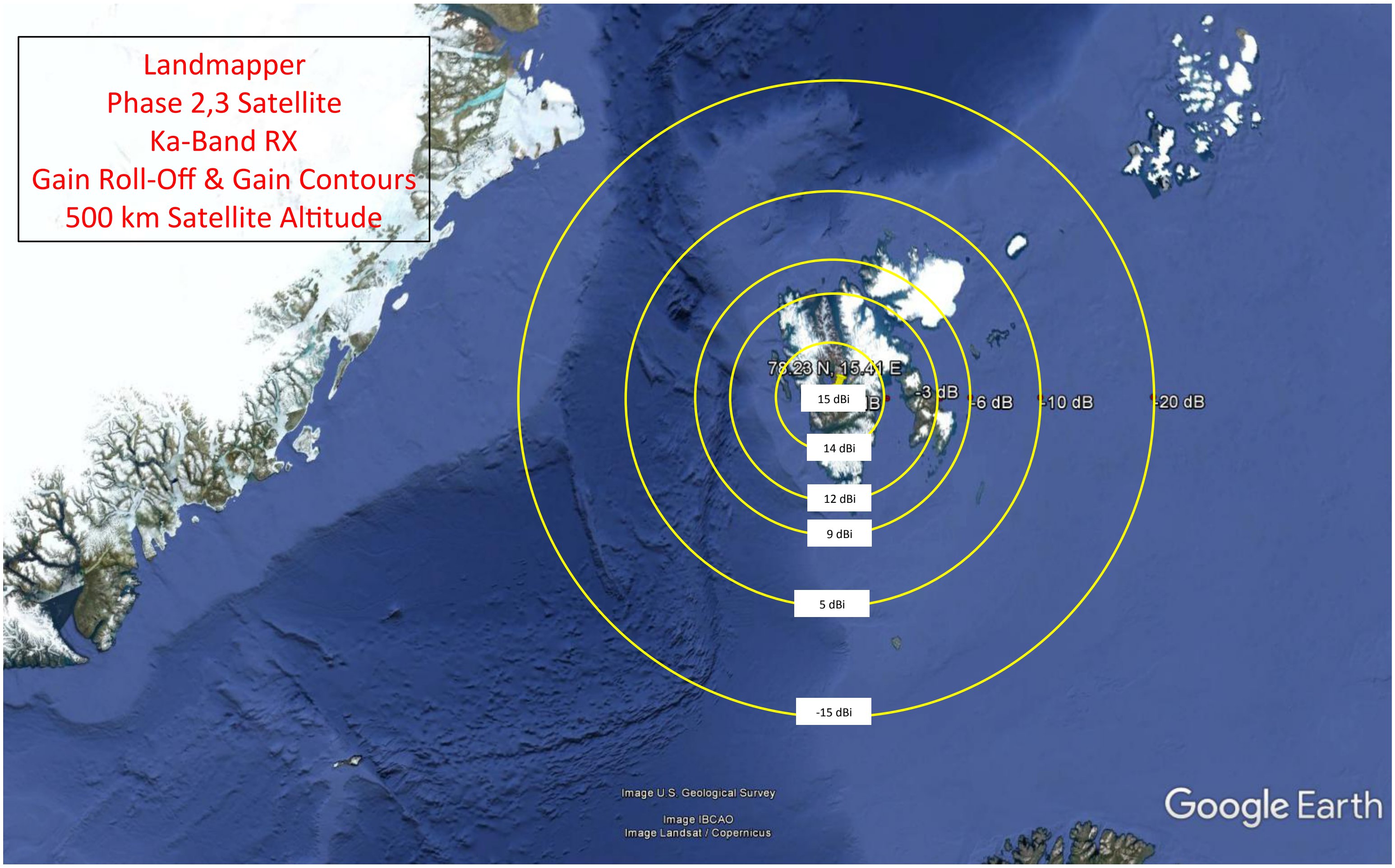
Beam Contour D-S-U/L-15: Corvus-BC and HD S-band Receive Beam – Gain Roll-Off/ Gain for Program Phases 2 and 3



Beam Contour D-S-U/L-16: Corvus-BC and HD S-band Receive Beam – G/T for Program Phases 2 and 3



Beam Contour D-Ka-U/L-17: Corvus-BC and HD Ka-band Receive Beam – Gain Roll-Off/ Gain for Program Phases 2 and 3



Beam Contour D-Ka-U/L-18: Corvus-BC and HD Ka-band Receive Beam – G/T for Program Phases 2 and 3