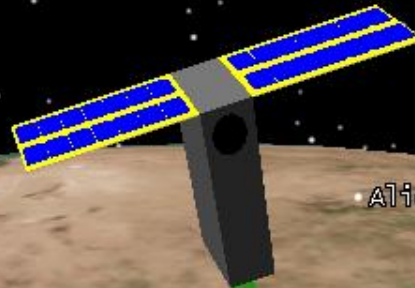


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Alice_Springs

Can a Constellation of CubeSats Create a Capability?

Satisfying Australia's Future Need for Multi-Spectral Imagery

Presenter
Iain Cartwright

Co authors
Leon Stepan
David Lingard



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A globe of the Earth is shown with several curved lines in red, green, yellow, and blue. These lines represent paths or connections between various points on the globe. Each point is marked with a small colored dot and a label consisting of a number followed by a subscript (e.g., 1_1, 2_1, 3_1, 4_1, 5_1, 1_2, 2_2, 3_2, 4_2, 5_2, 1_3, 2_3, 3_3, 4_3, 5_3, 1_4, 2_4, 3_4, 4_4, 5_4, 1_5, 2_5, 3_5, 4_5, 5_5). The globe is set against a dark background with small white stars, suggesting a space or global context. A large, semi-transparent grey rectangular box is centered over the globe, containing the text "Strength from Numbers?".

Strength from Numbers?

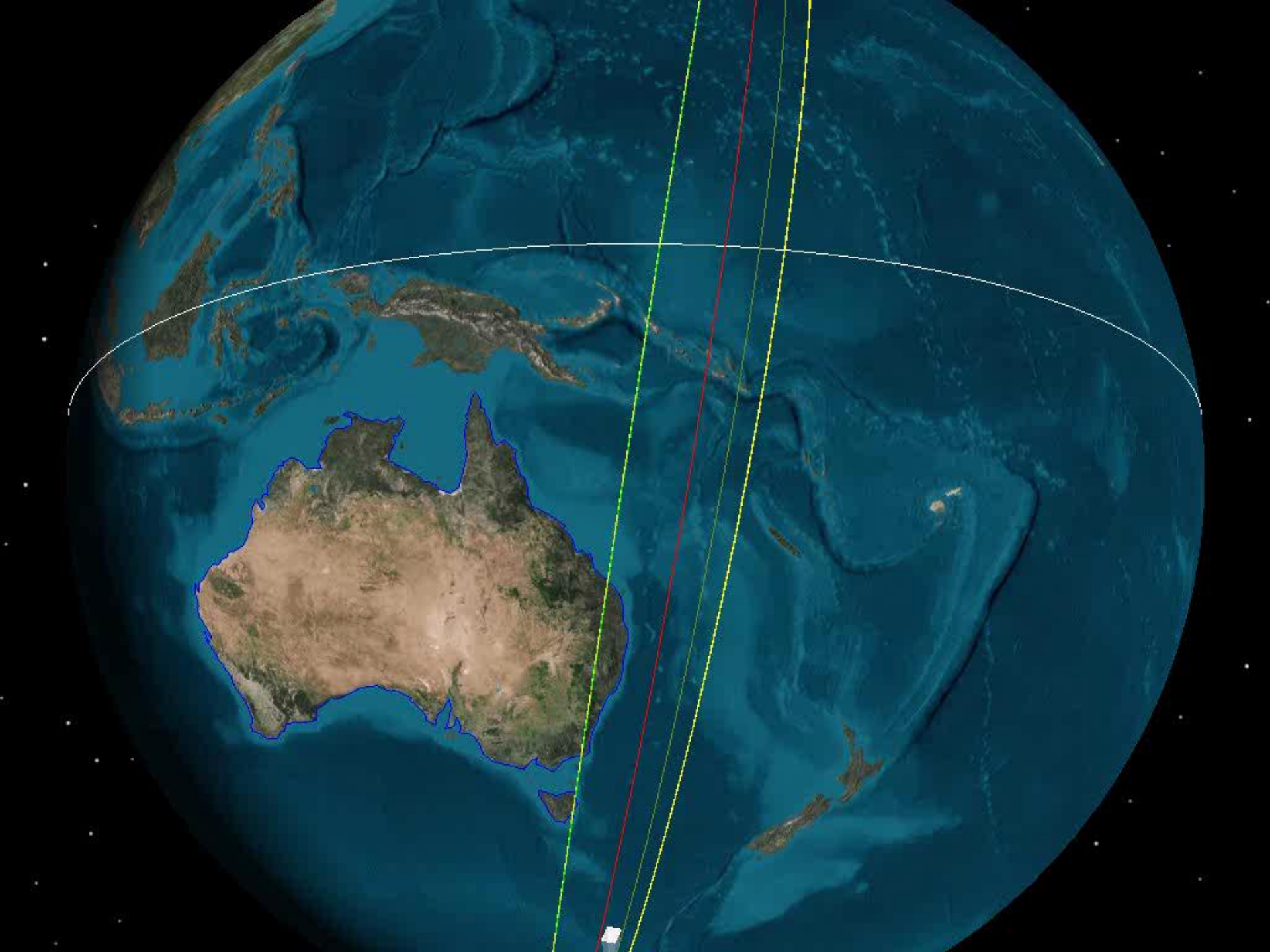
The Problem

10 - 80m GSD MSI

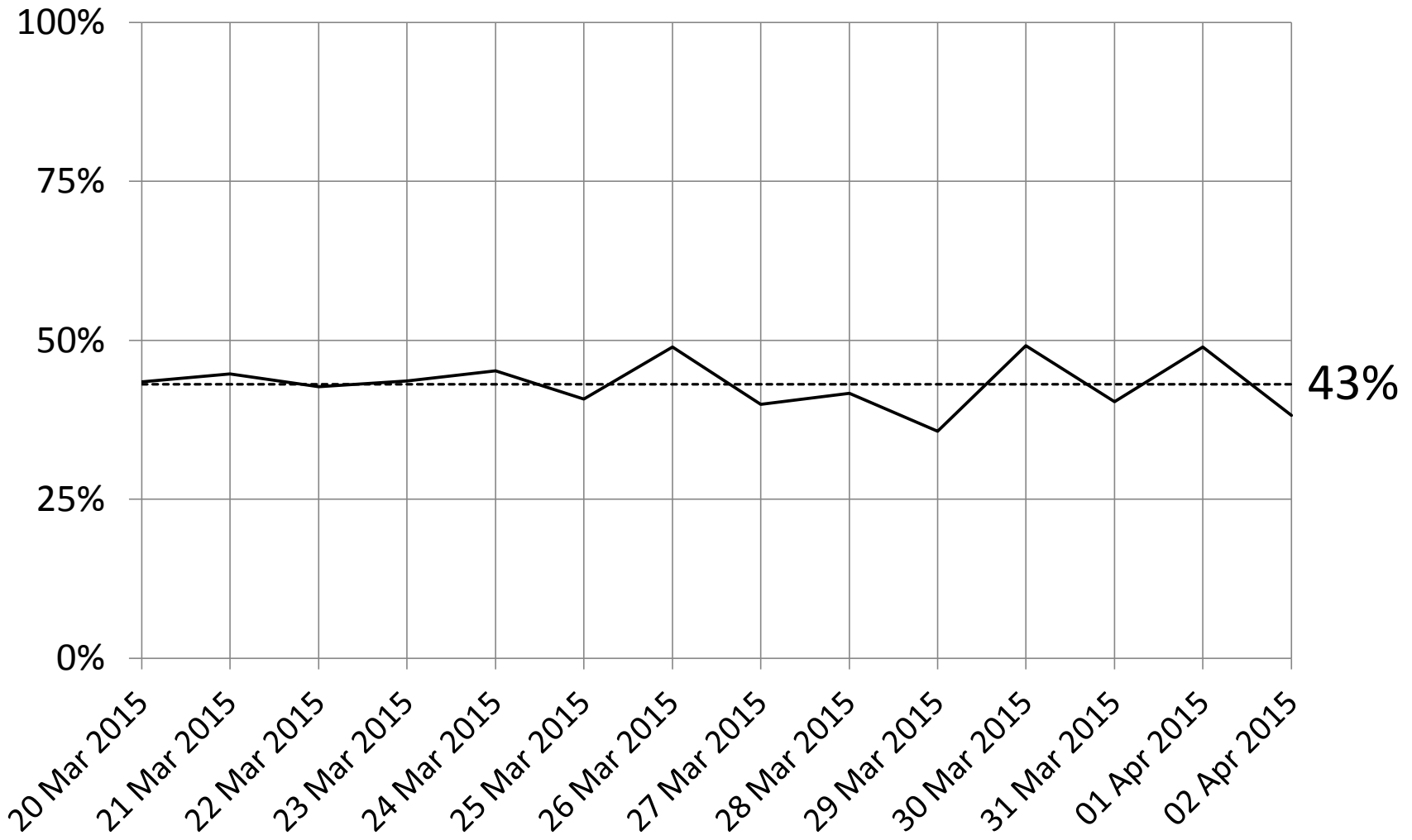


Area: 7.7M km² = 2.9M miles²





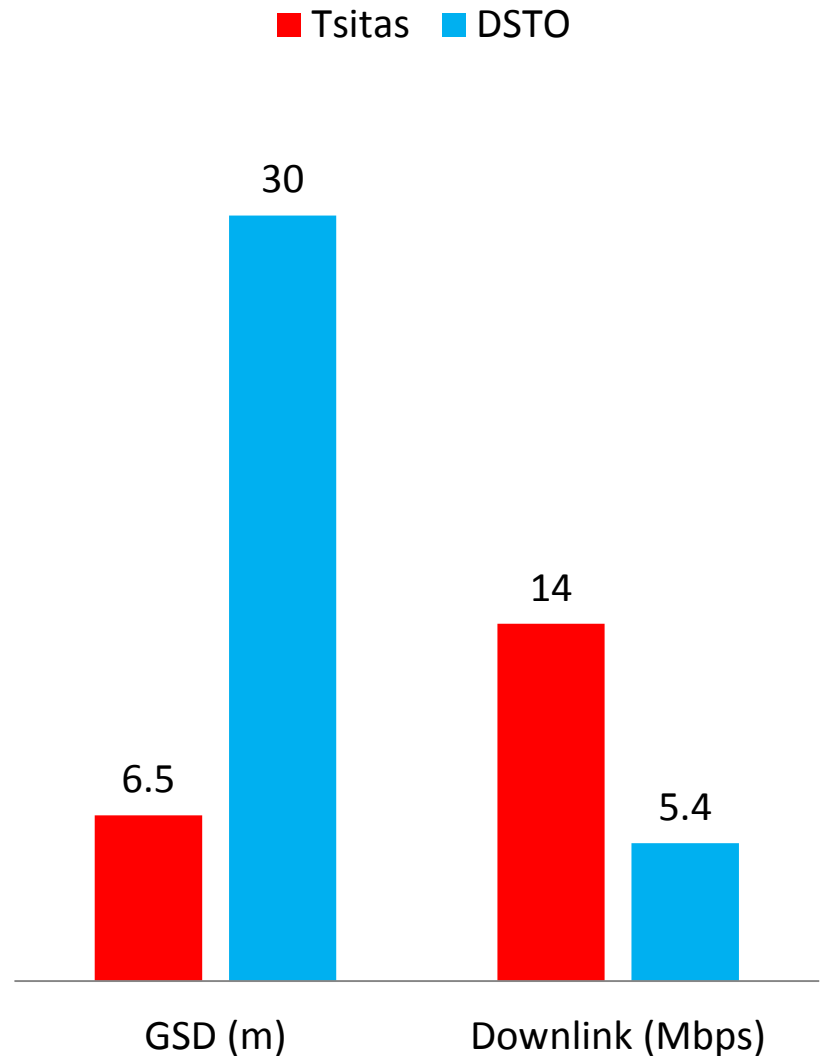
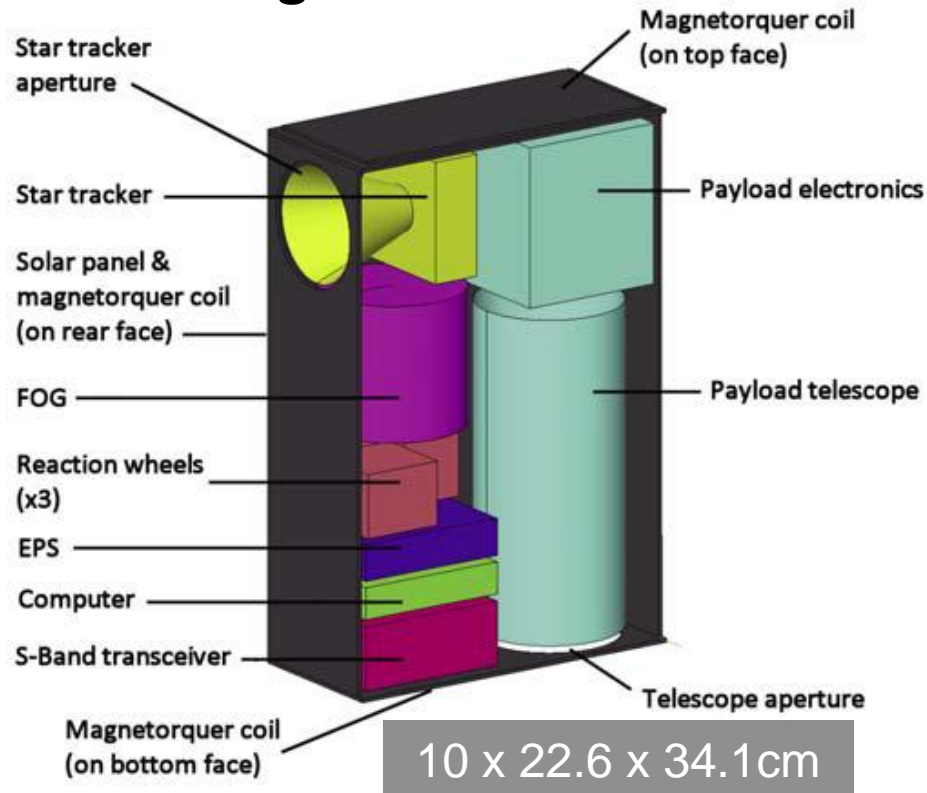
Public Good Collection Contribution



CubeSat Space Segment

S. Tsitas (Uni Cranfield/UNSW):

- 8kg 6U satellite Cubesat, with equivalent mission capability of 150kg satellite.





Alice_Springs

Hobart

Casey



Department of Defence
Defence Science and
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Collection Planning & Analysis Workstation (CPAW)

CPAW Workstation - default

File Orders Scales Manage Weather Help

Control/Status DEMOSAT1_2010050100000020100701000000

CP ID: 10440269, OB_ID: DEMOSAT1, Ephemeris: Complete, Weather: No weather applied, Spacecraft ID: DEMOSAT1, Scales Included: 24, Window Start: 2010-05-15T02:55:39.600Z, Orbit: Violation, Details, Window Stop: 2010-05-15T03:12:00.000Z

Planning Windows Scale CP Management

Map Request Auto Request Pathfinder Timeout (min) 1

Index	Task Order	Strip	Priority	Area Score	Status	CCF	Max CC	Strip Angle	Off Nadir	GSD	Steno	Imaging Start Time	Duration	Start	Start ONA	End ONA	Access	Access Start Time	Access End Time
1	Image10	Image10_1_120	839	426	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:03.200Z	7.6	N	12.266	11.262	2010-05-15T03:02:08.400Z	2010-05-15T03:04:05.800Z	2010-05-15T03:04:05.81
2	Image10	Image10_1_120	857	414	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:04.200Z	6.8	N	13.338	12.437	2010-05-15T03:02:10.000Z	2010-05-15T03:04:05.200Z	2010-05-15T03:04:05.21
3	Image10	Image10_1_120	760	401	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:05.200Z	6.2	N	14.38	13.593	2010-05-15T03:02:11.800Z	2010-05-15T03:04:04.400Z	2010-05-15T03:04:04.41
4	Image10	Image10_1_120	863	388	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:06.200Z	5.4	N	15.424	14.736	2010-05-15T03:02:13.600Z	2010-05-15T03:04:03.600Z	2010-05-15T03:04:03.61
5	Image10	Image10_1_120	568	375	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:07.200Z	4.6	N	16.45	15.987	2010-05-15T03:02:15.400Z	2010-05-15T03:04:02.800Z	2010-05-15T03:04:02.81
6	Image10	Image10_1_120	566	374	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:07.600Z	4.8	N	17.571	16.853	2010-05-15T03:02:16.200Z	2010-05-15T03:04:02.000Z	2010-05-15T03:04:02.01
7	Image11	Image11_1_120	1337	488	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:02:08.200Z	10.8	N	1.034	1.48	2010-05-15T03:01:10.200Z	2010-05-15T03:03:18.200Z	2010-05-15T03:03:18.21
8	Image11	Image11_1_120	1520	485	Included	-1	100	0.0	0.30	846	-	2010-05-15T03:02:08.600Z	10	N	27.568	25.25	2010-05-15T03:01:08.600Z	2010-05-15T03:03:17.400Z	2010-05-15T03:03:17.41
9	Image11	Image11_1_120	1700	515	Included	-1	100	0.0	0.30	793	-	2010-05-15T03:02:37.200Z	12.8	N	19.95	17.647	2010-05-15T03:01:05.600Z	2010-05-15T03:03:16.400Z	2010-05-15T03:03:16.41
10	Image11	Image11_1_120	1601	511	Included	-1	100	0.0	0.30	796	-	2010-05-15T03:02:16.400Z	13	N	15.509	8.261	2010-05-15T03:01:06.400Z	2010-05-15T03:03:15.200Z	2010-05-15T03:03:15.21
11	Image11	Image11_1_120	423	367	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:02:13.600Z	3.6	N	7.115	6.633	2010-05-15T03:01:16.800Z	2010-05-15T03:03:14.000Z	2010-05-15T03:03:14.01
12	Image12	Image12_1_120	880	436	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:04:31.400Z	8	N	8.39	7.288	2010-05-15T03:03:34.600Z	2010-05-15T03:05:36.400Z	2010-05-15T03:05:36.41
13	Image12	Image12_1_120	972	410	Included	-1	100	0.0	0.30	816	-	2010-05-15T03:04:14.200Z	6.8	N	26.035	23.69	2010-05-15T03:03:35.600Z	2010-05-15T03:05:36.600Z	2010-05-15T03:05:36.61
14	Image12	Image12_1_120	861	423	Included	-1	100	0.0	0.30	78	-	2010-05-15T03:04:04.200Z	7.2	N	19.344	17.603	2010-05-15T03:03:37.000Z	2010-05-15T03:05:36.800Z	2010-05-15T03:05:36.81
15	Image12	Image12_1_120	954	426	Included	-1	100	0.0	0.30	726	-	2010-05-15T03:04:47.600Z	7.6	N	14.43	13.062	2010-05-15T03:03:38.200Z	2010-05-15T03:05:36.000Z	2010-05-15T03:05:36.01
16	Image12	Image12_4_120	591	383	Included	-1	100	0.0	0.30	717	-	2010-05-15T03:04:36.200Z	0	N	12.468	11.815	2010-05-15T03:04:42.600Z	2010-05-15T03:05:36.400Z	2010-05-15T03:05:36.41
17	Image12	Image12_3_120	601	374	Included	-1	100	0.0	0.30	796	-	2010-05-15T03:04:59.000Z	2.4	N	23.136	22.186	2010-05-15T03:04:42.800Z	2010-05-15T03:05:37.000Z	2010-05-15T03:05:37.01
18	Image13	Image13_1_120	1159	442	Included	-1	100	0.0	0.30	241	-	2010-05-15T03:04:18.600Z	7.6	N	28.71	25.062	2010-05-15T03:02:56.400Z	2010-05-15T03:04:29.600Z	2010-05-15T03:04:29.61
19	Image13	Image13_1_120	1516	490	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:45.200Z	11.6	N	20.737	19.342	2010-05-15T03:02:58.200Z	2010-05-15T03:04:43.800Z	2010-05-15T03:04:43.81
20	Image13	Image13_1_120	1601	499	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:45.600Z	12.2	N	21.819	20.371	2010-05-15T03:02:58.200Z	2010-05-15T03:04:43.000Z	2010-05-15T03:04:43.01
21	Image13	Image13_4_120	1600	500	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:46.000Z	12.8	N	22.878	21.385	2010-05-15T03:02:44.200Z	2010-05-15T03:04:42.200Z	2010-05-15T03:04:42.21
22	Image13	Image13_1_120	1601	503	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:47.400Z	12.6	N	23.823	22.383	2010-05-15T03:02:59.800Z	2010-05-15T03:04:41.400Z	2010-05-15T03:04:41.41
23	Image13	Image13_1_120	165	417	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:53.200Z	7.4	N	24.185	23.364	2010-05-15T03:03:16.600Z	2010-05-15T03:04:40.200Z	2010-05-15T03:04:40.21
24	Image13	Image13_7_120	287	332	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:03:59.000Z	2.2	N	24.58	24.344	2010-05-15T03:03:21.400Z	2010-05-15T03:04:38.800Z	2010-05-15T03:04:38.81
25	Image14	Image14_1_120	2055	569	Included	-1	100	0.0	0.30	189	-	2010-05-15T03:05:20.200Z	1.8	N	22.068	20.343	2010-05-15T03:04:29.200Z	2010-05-15T03:06:30.800Z	2010-05-15T03:06:30.81
26	Image14	Image14_1_120	2005	568	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:05:22.000Z	15.6	N	23.889	22.038	2010-05-15T03:04:39.800Z	2010-05-15T03:06:19.800Z	2010-05-15T03:06:19.81
27	Image14	Image14_10_120	2005	555	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:05:28.400Z	15.6	N	26.433	24.712	2010-05-15T03:04:52.800Z	2010-05-15T03:06:19.800Z	2010-05-15T03:06:19.81
28	Image14	Image14_11_120	1003	429	Available	-1	100	0.0	0.30	-	-	2010-05-15T03:05:17.600Z	6.2	N	27.21	26.251	2010-05-15T03:04:46.600Z	2010-05-15T03:06:48.600Z	2010-05-15T03:06:48.61

Events

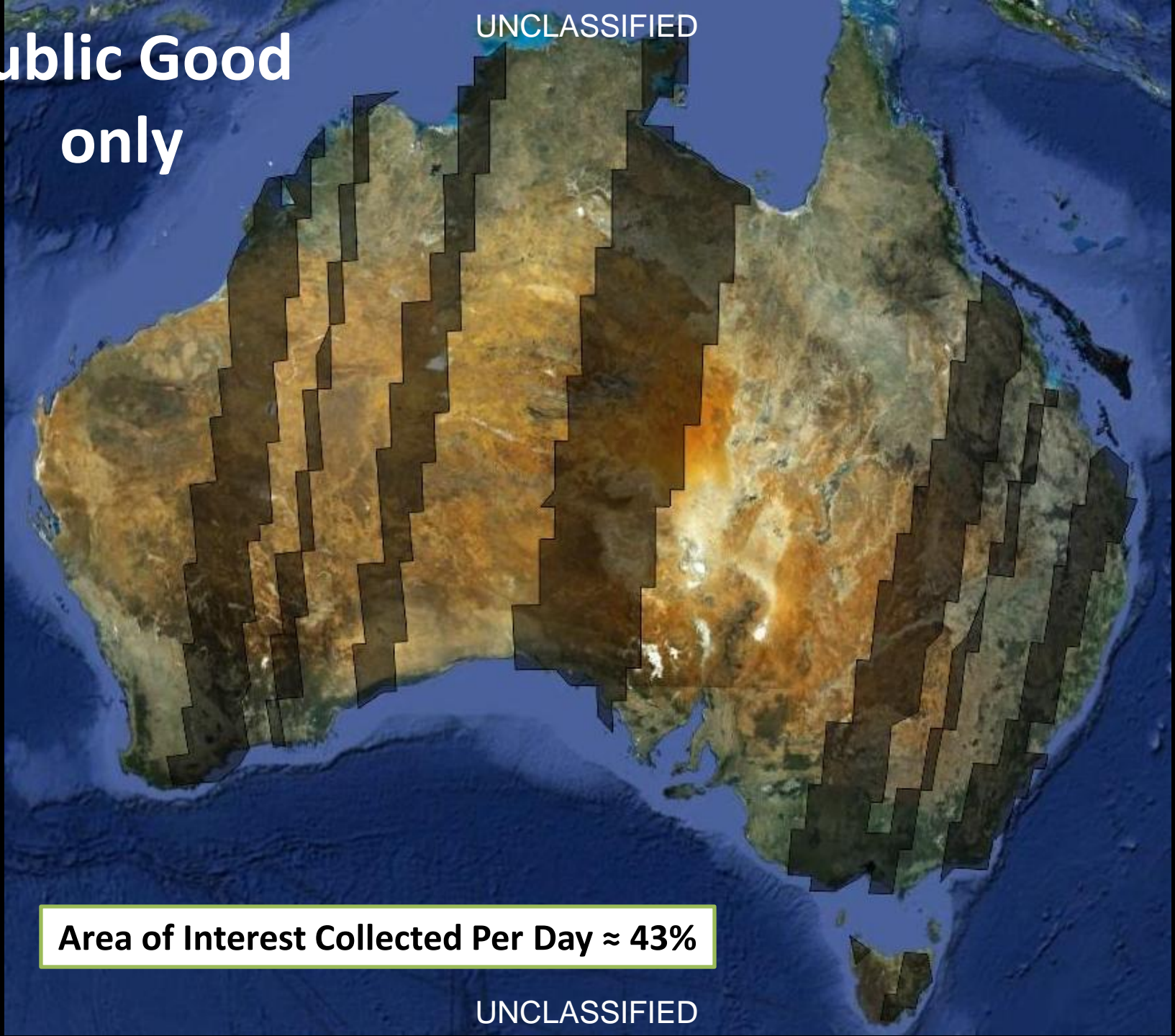
2010-05-15T03:59:49.800Z DROD Score from run 4 was 0 with 0 included scans, 0 requested.
 2010-05-15T03:59:49.800Z DROD Score from run 4 was 0 with 0 included scans, 0 requested.
 2010-05-15T03:59:49.800Z DROD Score from run 7 was 0 with 0 included scans, 0 requested.
 2010-05-15T03:59:49.800Z DROD Score from run 7 was 0 with 0 included scans, 0 requested.
 2010-05-15T03:59:50.000Z DROD Pathfinder interrupted after 81.175 seconds
 2010-05-15T03:59:50.000Z DROD Pathfinder interrupted after 80.175 seconds
 2010-05-15T03:59:51.500Z DROD CP build completed successfully.

Constraints & Resources:

- Data
- Downlink
- Battery
- Cloud

**Public Good
only**

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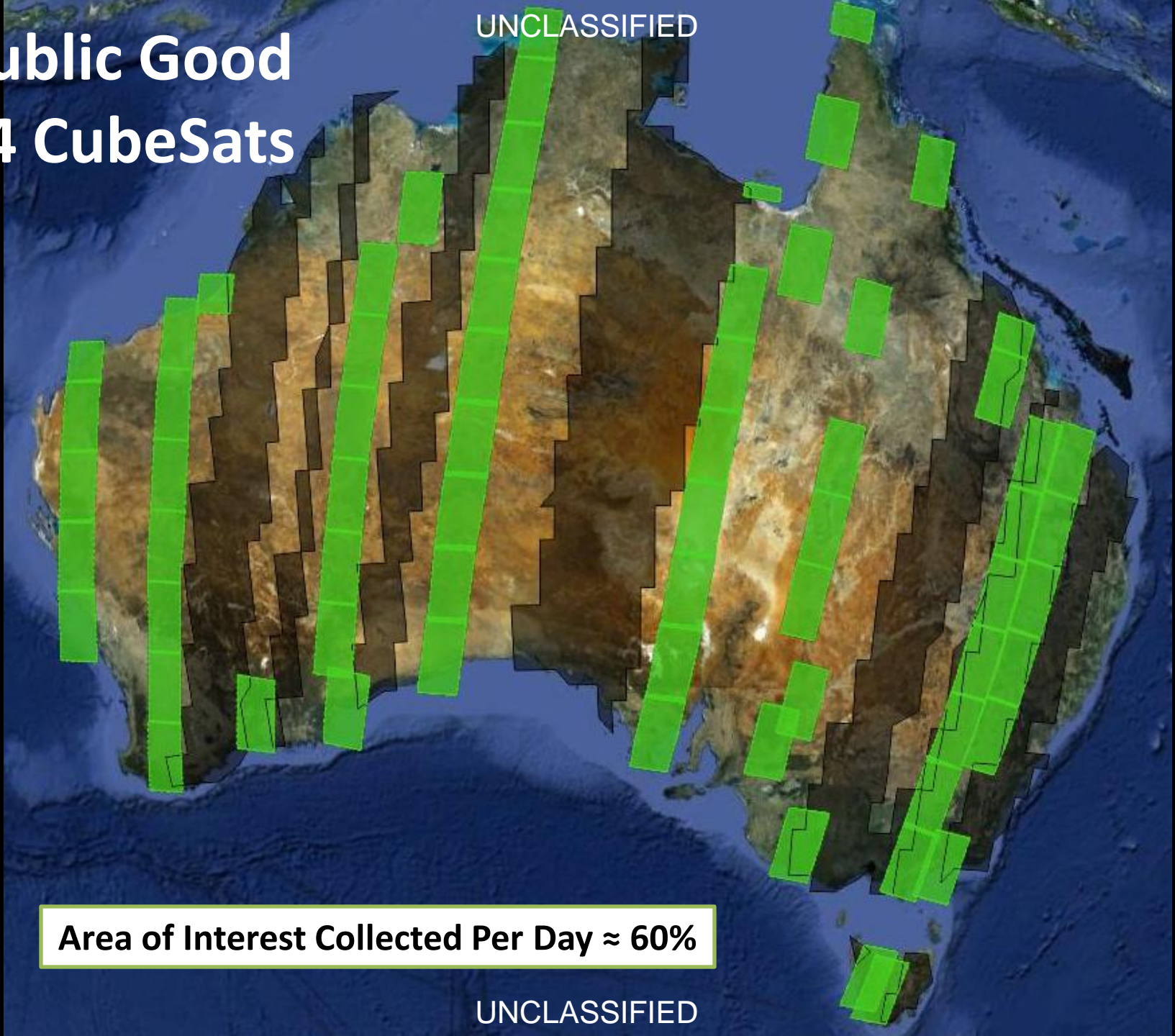


Area of Interest Collected Per Day \approx 43%

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Public Good +4 CubeSats

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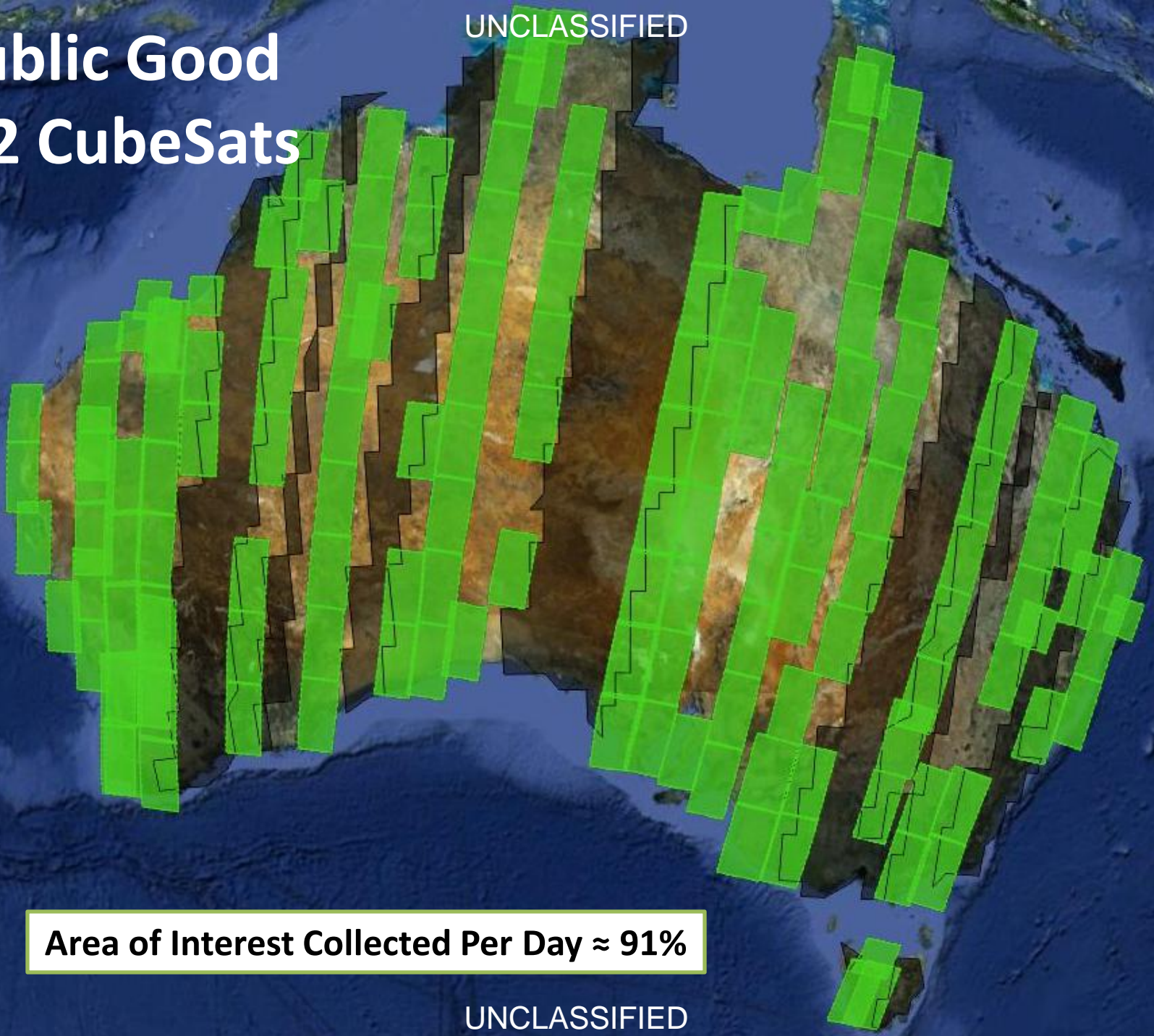


Area of Interest Collected Per Day \approx 60%

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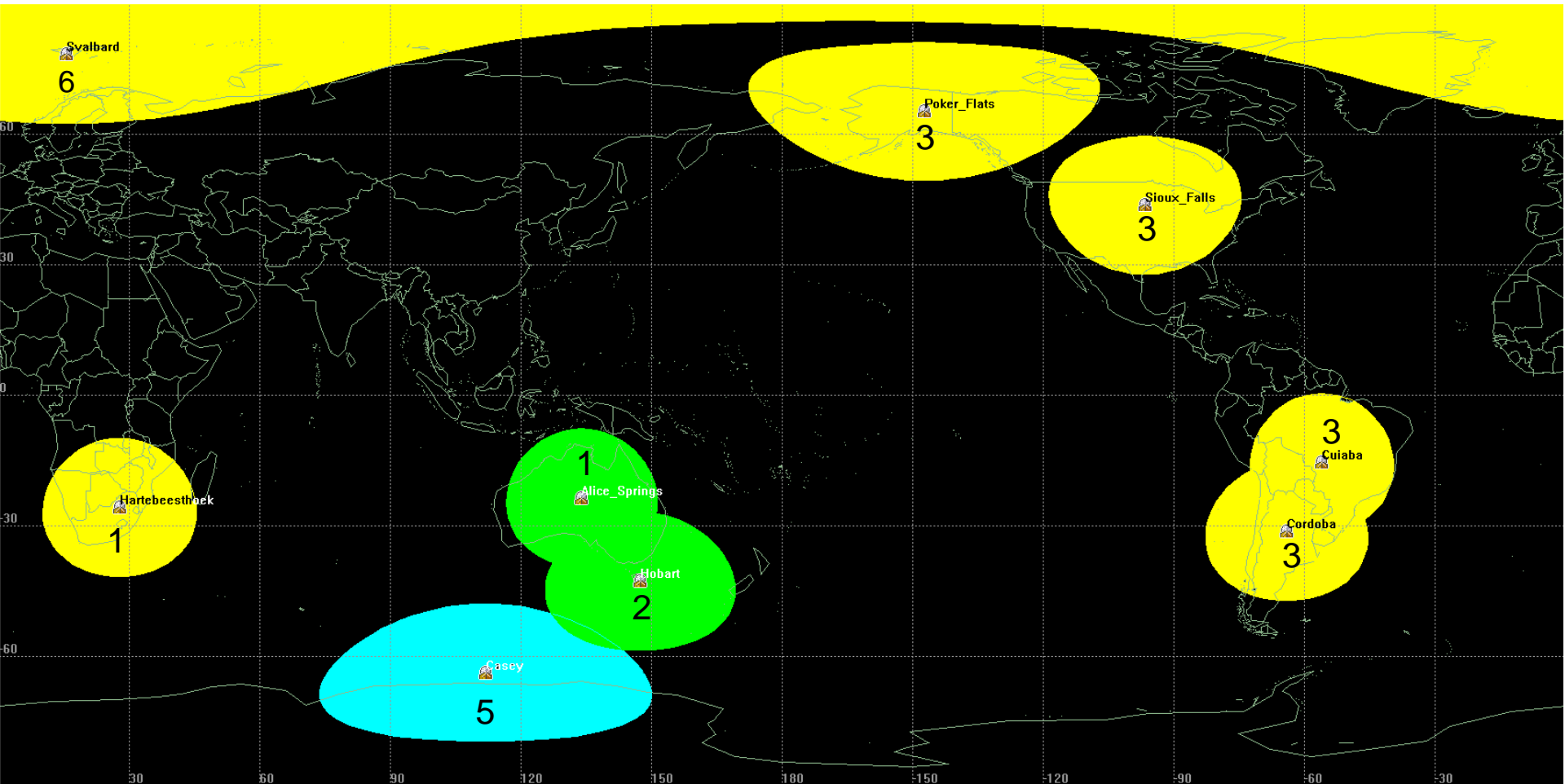
Public Good +12 CubeSats



Area of Interest Collected Per Day \approx 91%

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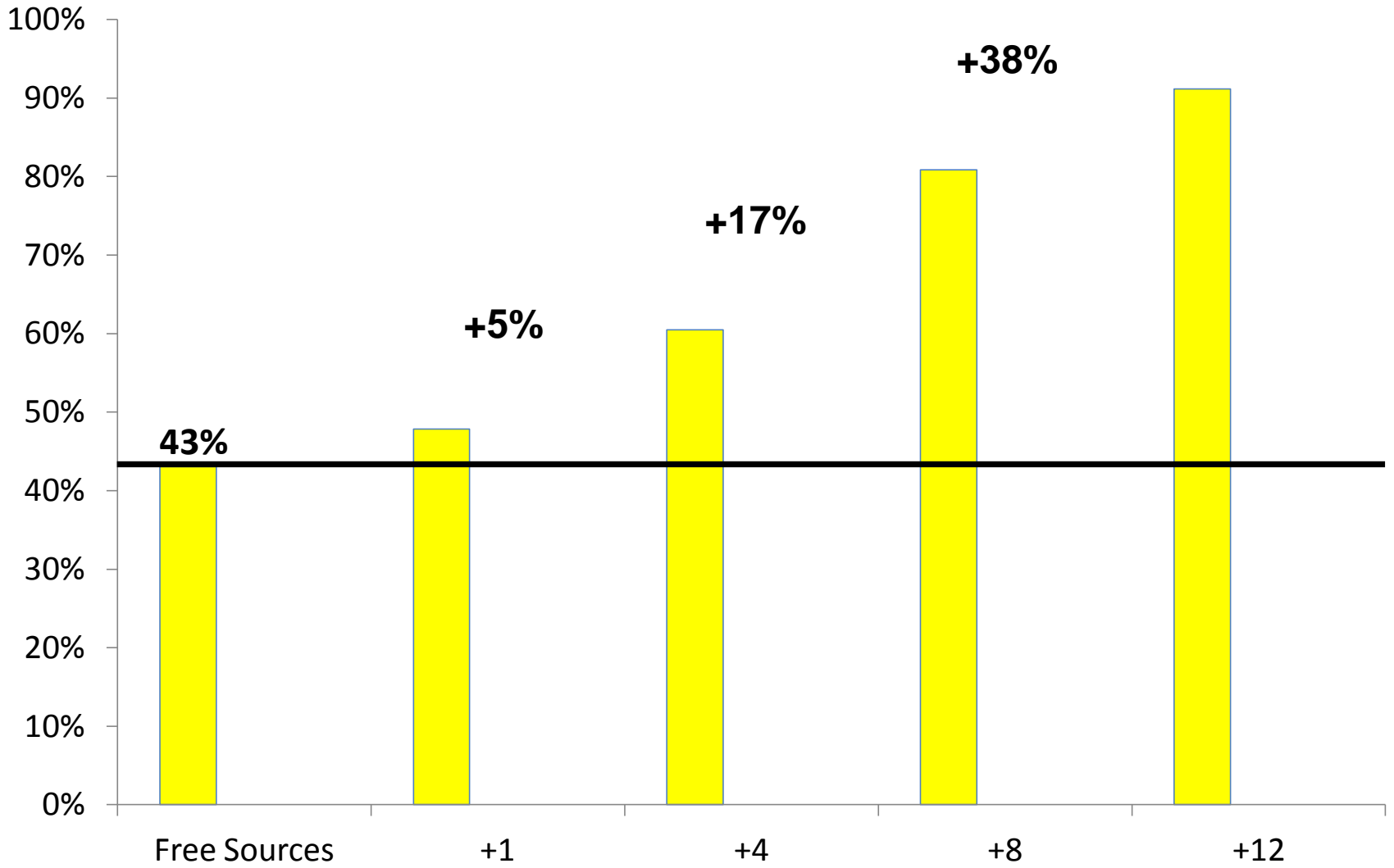
Ground Station Network Downlinks

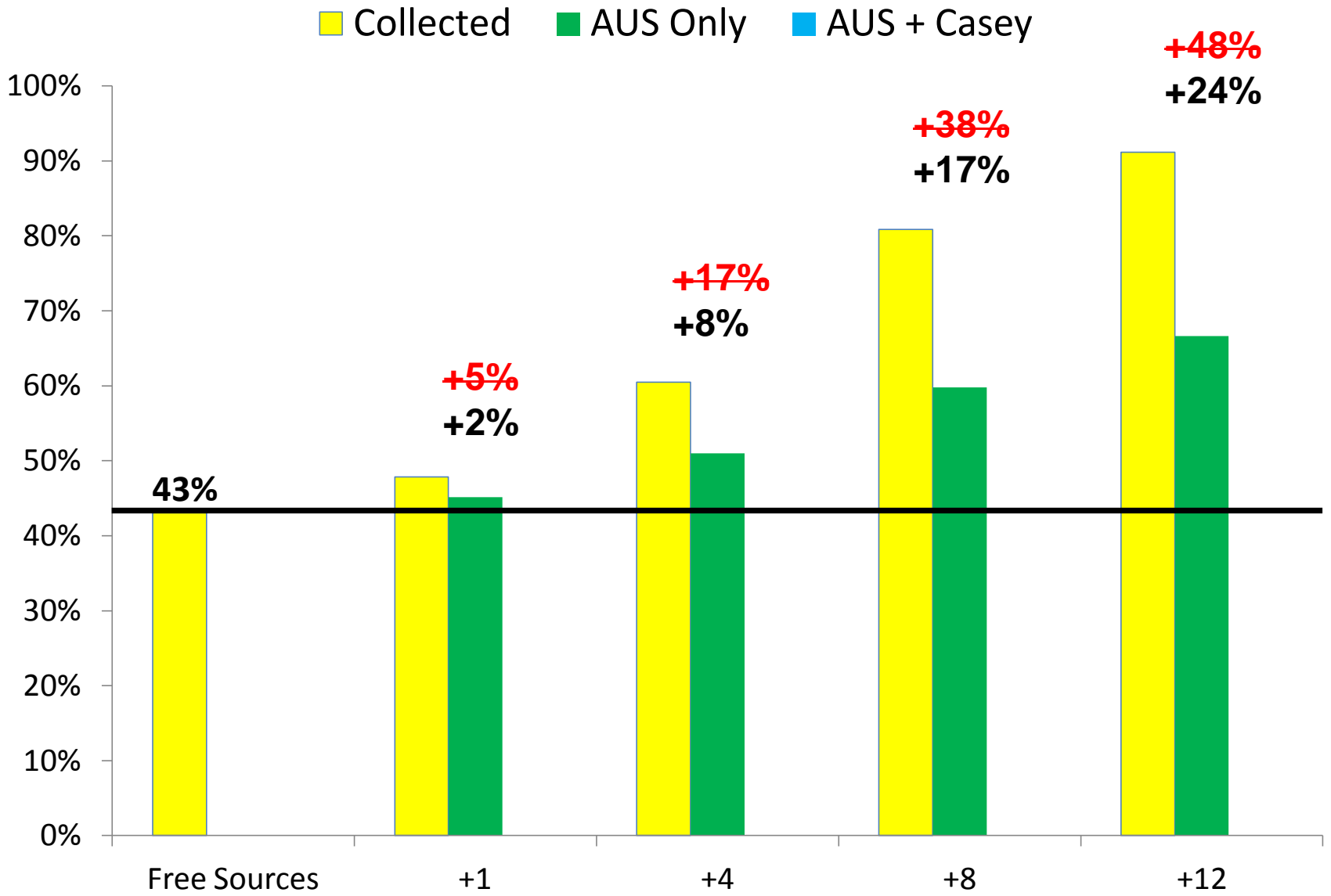


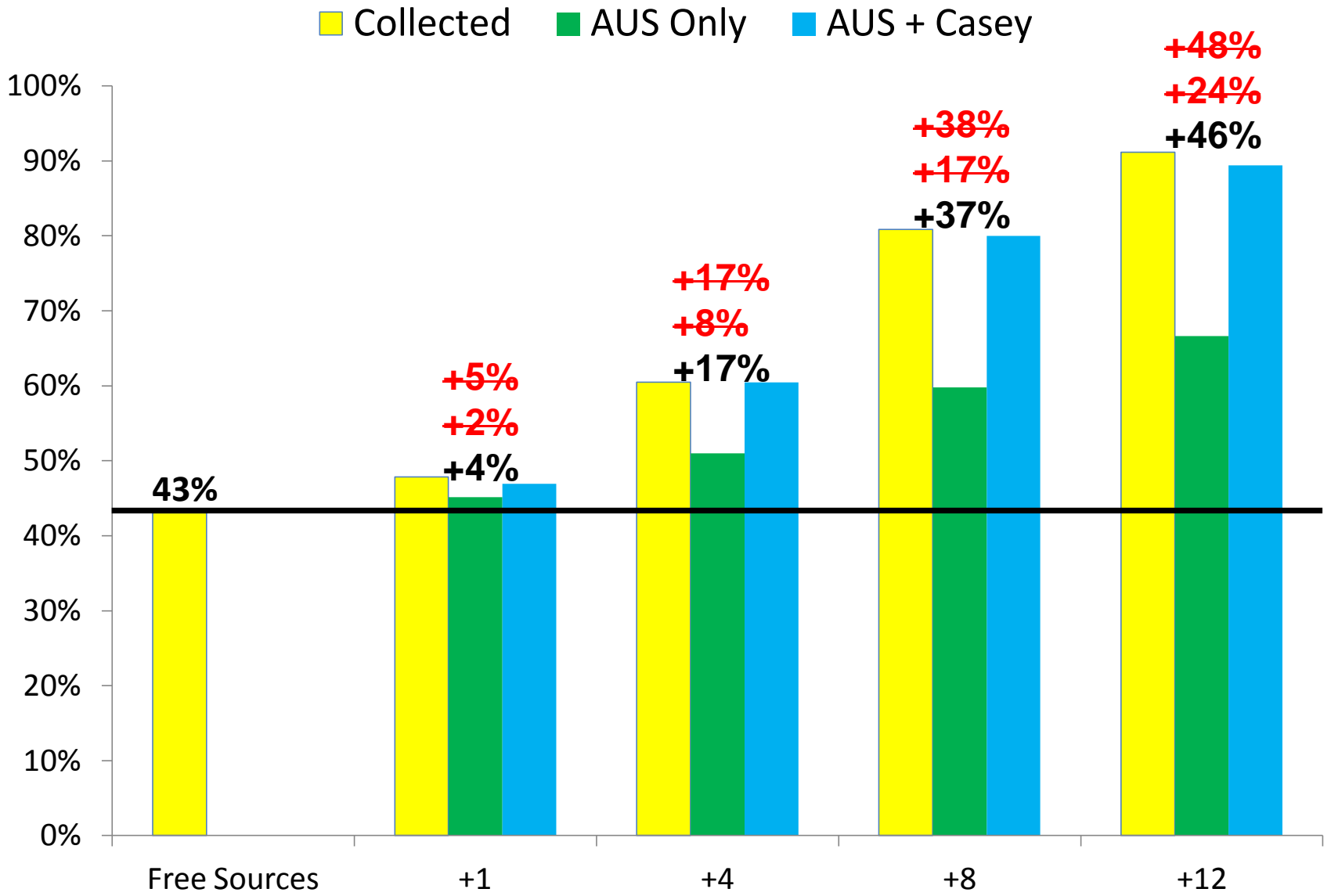
AUS Only	3
Casey Base	5
LS7 GSN	19

Example: single satellite 24 hours

■ Collected ■ AUS Only ■ AUS + Casey







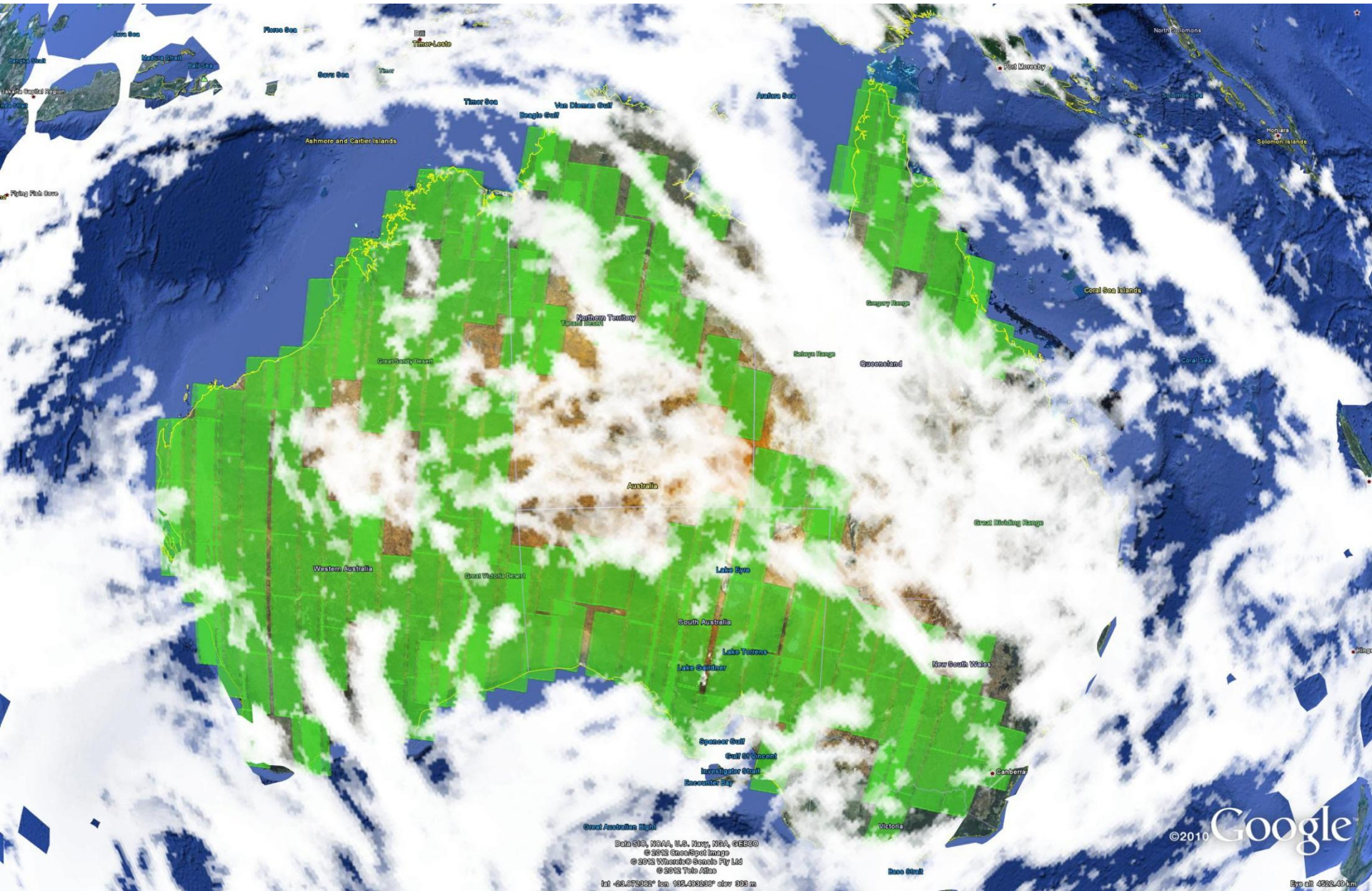
Area of Australia – 7.74M km²

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Area Collected – 4.18M km²

Percentage – 54% (down from 93%)

20 satellites & Cloud Constraint



Conclusions

- Medium Resolution/Whole of Australia/Daily Revisit
- System performance is dependent upon *both* the space **and** ground segments.
- **Suitable to CubeSats** vs. Large infrastructure.
- **12 x 6U CubeSats contributed 48% making 91% of requirement.**

Further Work

- Emergency Response Case
- Higher fidelity system model

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Thank you.

Presented by Iain Cartwright
iain.cartwright@dsto.defence.gov.au

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Happy Birthday!
Roger Franzen



Additional Slides

- Cloud Free 93%
- Constellation Design
- GSN temporal characteristics
- Resources

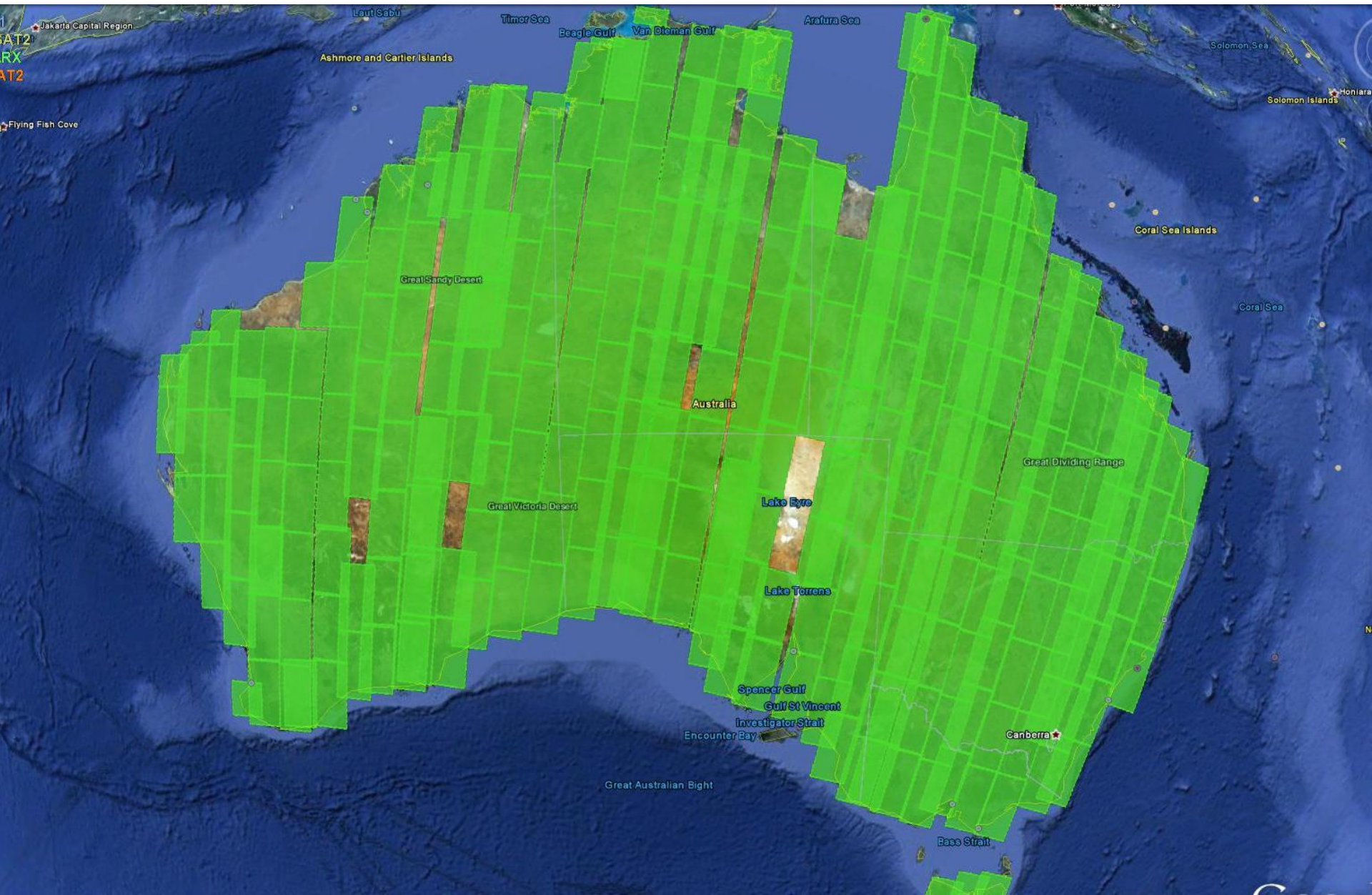
Area of Australia – 7.7M km²

Area Collected – 7.2M km²

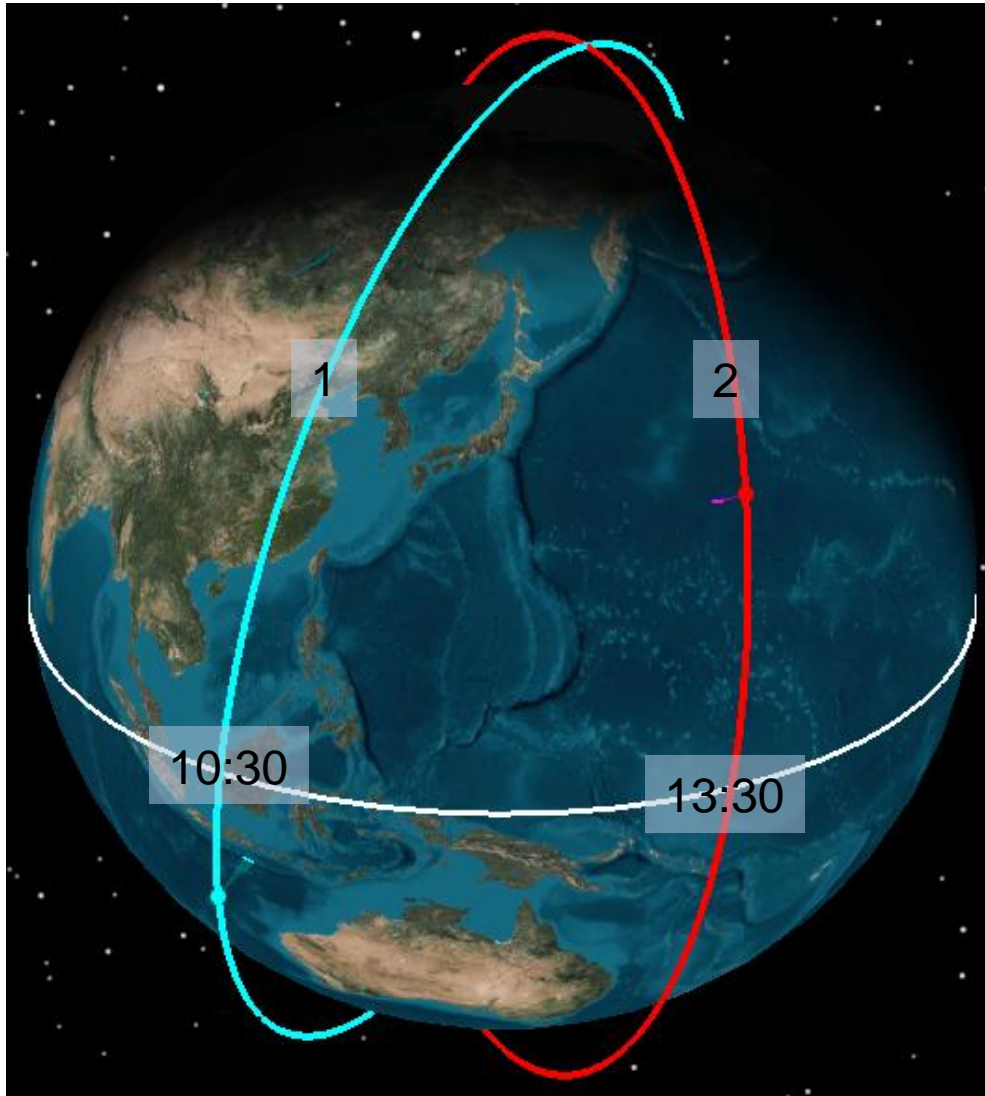
Percentage – 93%

20 satellites

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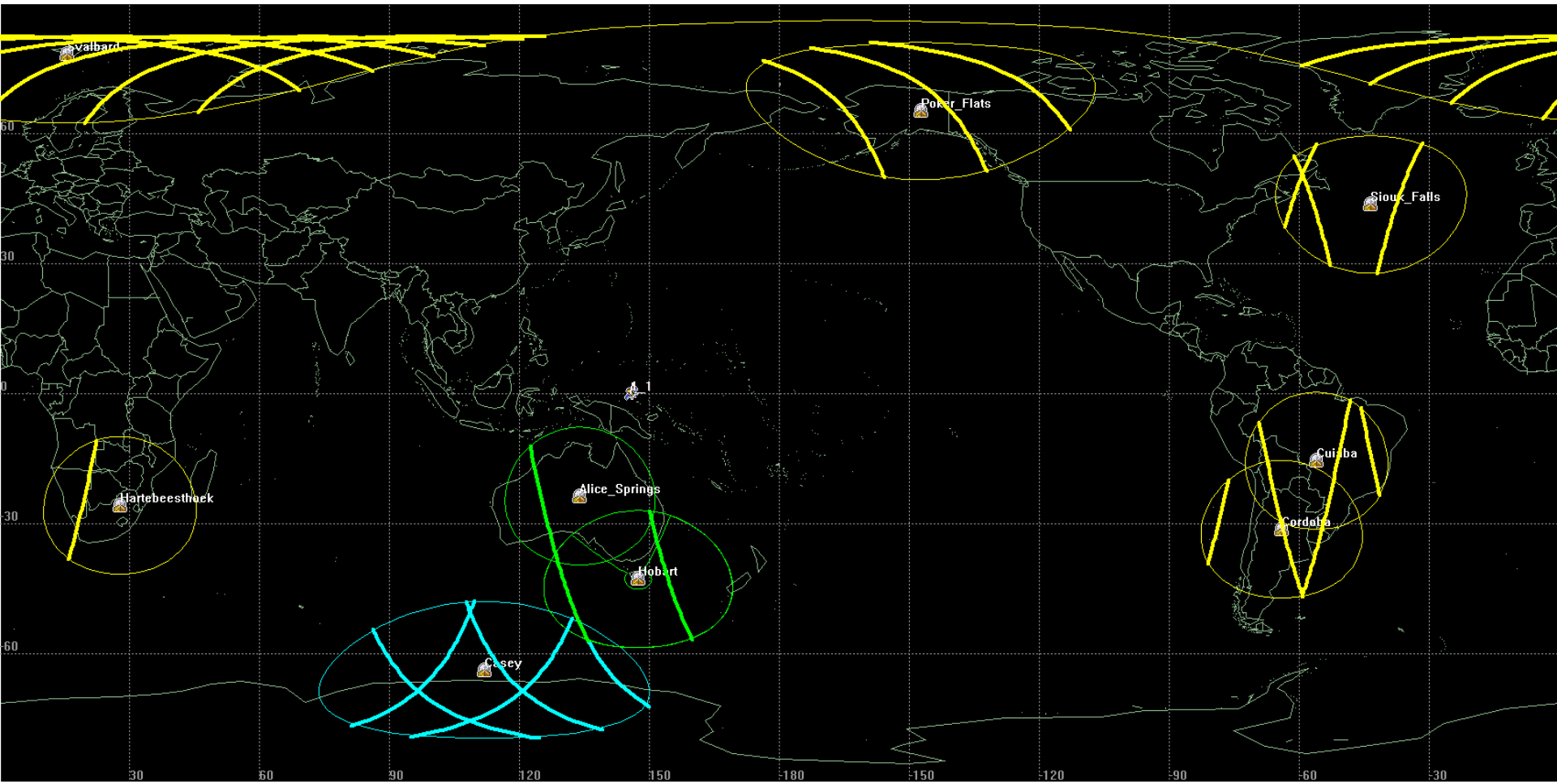


Constellation Design



Variant	Orbital Planes	Sats Per Plane	Total Sats
A	1	1	1
B	1	4	4
C	1	5	5
D	2	4	8
E	2	10	20

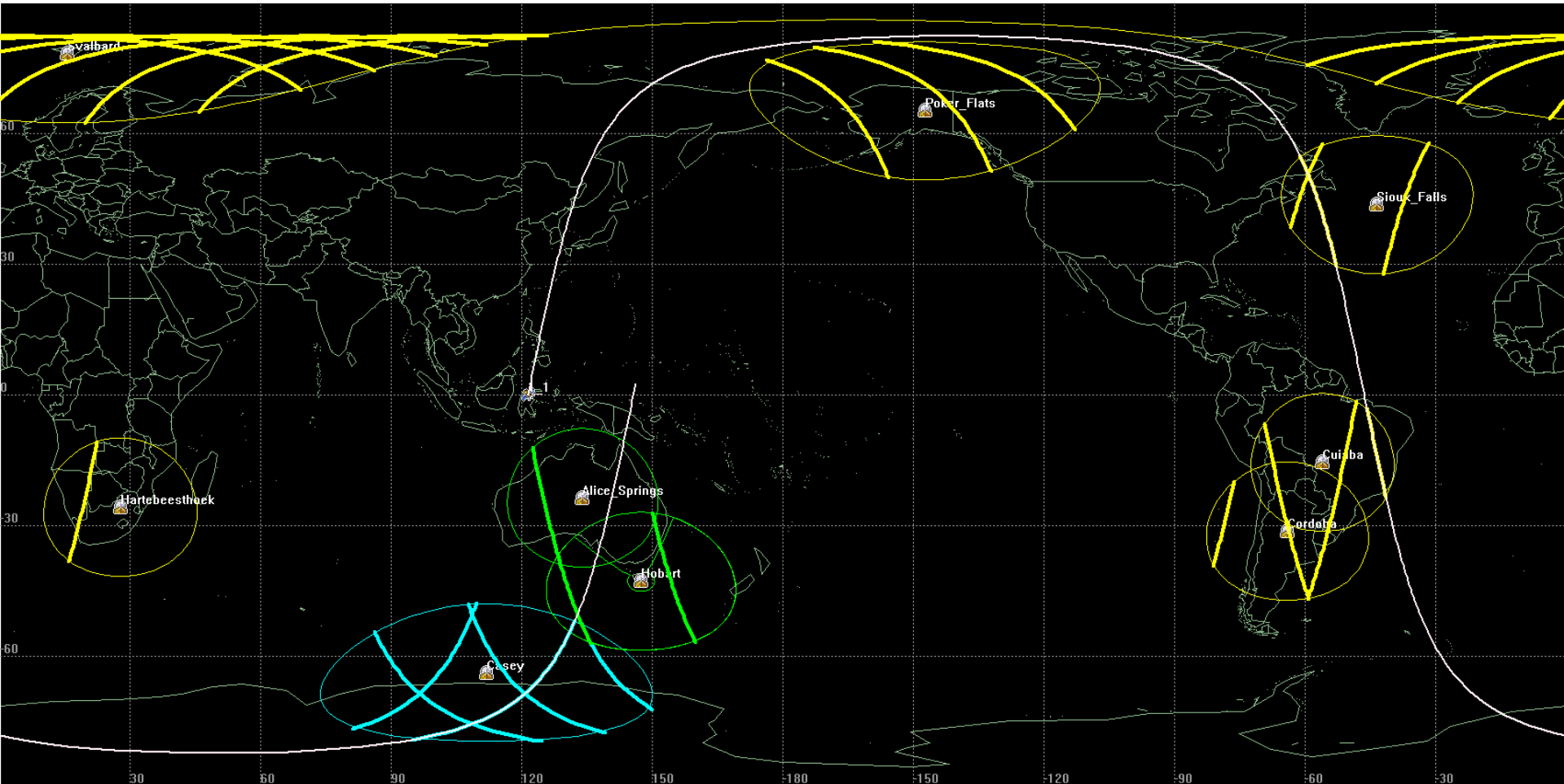
GSN Downlink Opportunities (1/3)



AUS Only
Casey Base
LS7 GSN

00:55 GMT

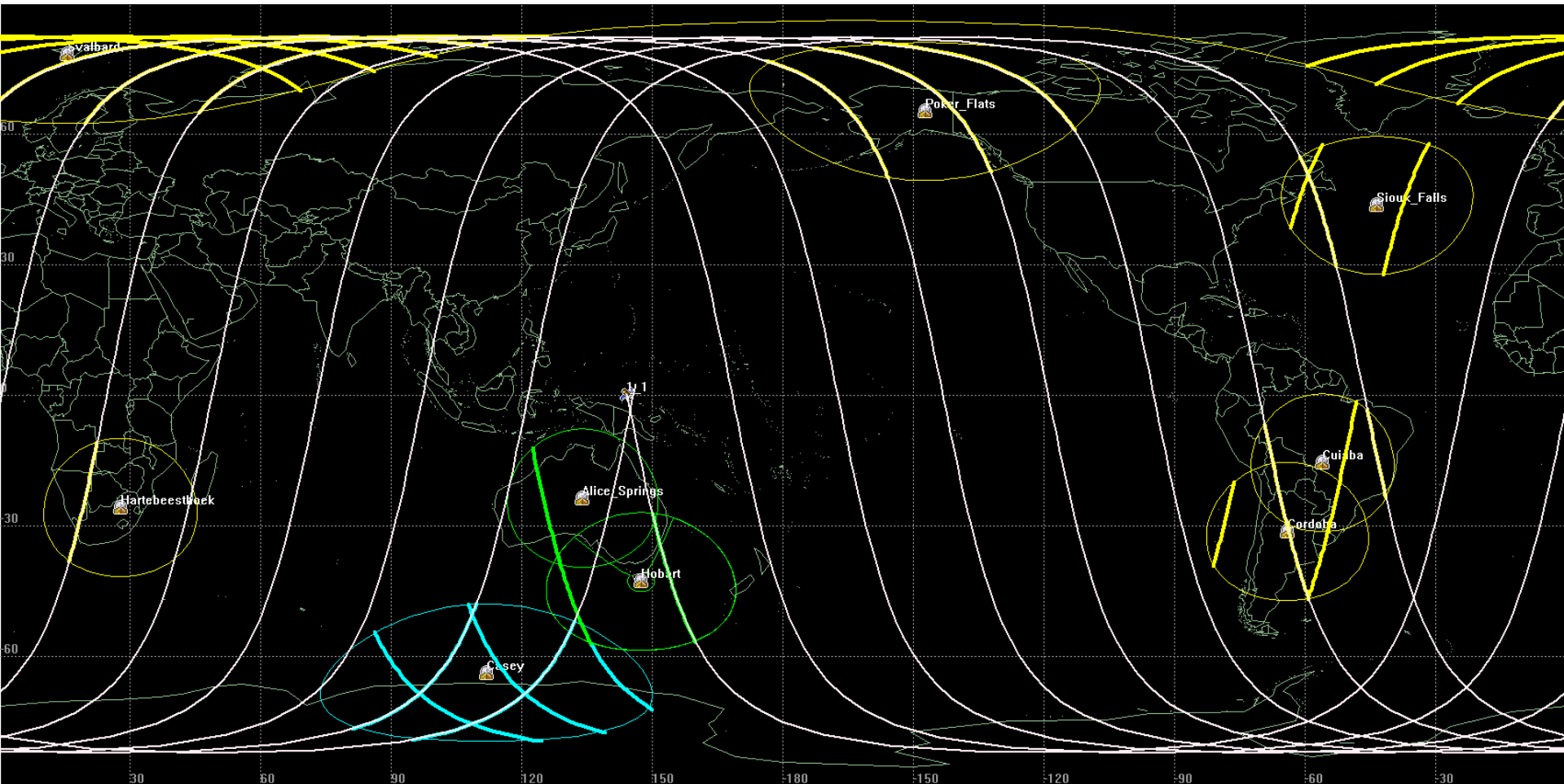
GSN Downlink Opportunities (2/3)



AUS Only
Casey Base
LS7 GSN

02:32 GMT

GSN Downlink Opportunities (3/3)



AUS Only
Casey Base
LS7 GSN

13:01 GMT

Resource: Power

