ESEIAAT

Cubesat Constellation
Astrea

Technical Sheets

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0.1 Communication Protocols

In order to accomplish the requirements of the communications protocols, the standards of the Consultative Committee for Space Data Systems (CCSDS) have been followed, toguether with the ISO model. Regarding the protocols of the Ground Segment, security has been the most important requirement to decide the protocol. The chosen protocols are exposed in the following table.

Space segment: CCSDS Standards		
Transport Layer	Space communication protocol specification transmission protocol: SCSP-TP	
Network layer	Main protocol Routing protocol Complementary protocols	Internet Protocol version 6 (IPv6) Open Shortest Path First (OSPF) IP over CCSDS
Data Link Layer	Data Link Protocol Sublayer Sync and Channel Coding Sublayer	TC Space Data Link Protocol TC Sync and Channel Coding
Ground segment		
Presentation of the data to the client		Application
Protocol		Secure Shell (SSH)

Table 0.1.1: Communications protocol overview

The headers in the space segment are added by each layer considering that the entire message coming from the above layer is the whole message (including above layer's header). For this reason, the total number of bits ocuppied by the headers is important.

Layer	Header (octets)	Header (bits)
Transport Layer	33	264
Network Layer	44	352
Data Link Layer	5	40
Total lenght of headers	82	656

Table 0.1.2: Headers of Space Segment Protocols

0.2 Ground segment

The ground segment is composed by the Ground Stations (GS) and the Mission Control Center (MCC), that allow the receiving of the information from the constellation to the Earth.
The placement of the different nodes of the Ground Segment is shown in the following map, toguether with the amount of links that are available in a given instant (except for the MCC,

that no links with satellites are established.

Node	Country	Minimum available number of links	Maximum available number of links
GS1	Canada	2	12
GS2	Falkland Islands	2	12
GS3	United Kingdom	2	12
MCC	Spain	-	-

Table 0.2.1: Countries of location and available links

The MCC is composed by a set of offices with good connection to the GS. The systems that compose the GS are exposed in the following table.

System	Frequency range	Features	Purpose	Elements included
S-band	2-4GHz	Half-duplex system: downlink and uplink capability	Housekeepink data/TT&C Client data upload	Transciever LNA HPA RF Limiter RF Swith RF Fuse Rotors
X-band	8-12GHz	X-band downlink capacity	Client data download	X-band receiver LNA RF Limiter RF Fuse Rotor

Table 0.2.2: GS's systems

0.3 Satellite Configuration

System	Weight/unit (g)	Sizes (mm)	N. of units
STRUCTURE AND MECHANICS			
Structure	304.3	100 x 100 x 300	1
Thermal protection	38	Covers all	1
Total	342.3		
ELECTRIC POWER SYSTEM			
Solar arrays	175	98 x 83 x 8.50	4
Batteries	155	90 x 63 x 12.02	2
Power management	126	92.0 x 88.9 x 20.5	1
Total	1136		
PAYLOAD			
Patch antenna	30	90 x 90 x4.35	8
Transceiver inter-satellite	16.4	65 x 40 x 6.5	3
Transceiver space to ground	101.5	86 x 86 x 45	1
Data handling system	28.3	65 x 40 x 6.5	1
Antenna Deployable	83	100 x 83 x 6.5	1
Total	502		
AOCDS			
Thruster	1500	90 x 90 x 95	1
ADACS	506	90 x 90 x 58	1
Total	2006		
TOTAL ESTIMATION	**3986.3**		

STRUCTURE

Brand and model	Features
Structure	
ISIS 3U structure	Low mass (304.3g) Highly compatible High temperature range
Thermal protection	
Dunmore Aerospace Satkit	Lightweight Durability Made for small satellites

Table 0.3.2: Estructure characteristics

EPS

Brand and model	Features
Solar arrays	
EXA-Agencia Espacial Ecuatoriana	Total power of 67.2W (4units) Mass of 270g (p.unit) Included thermal protection At least 4 years lifetime
Power management	
Gomspace NanoPower P60	Mass of 176g 9x configurable outputs 6x inputs per module EMI shielding High temperature range
Batteries	
EXA-Agencia Espacial Ecuatoriana	Total capacity of 106.4Wh (2u) Automatic heat regulation Highly stackable Total mass of 155g

Table 0.3.3: Electric Power System

Propulsion System

Thruster BGT-X5	
PARAMETERS	**VALUE**
Total thruster power	20 W
Thrust	0.5 N
Specific impulse	225 s
Thruster Mass	1500 g
Input voltage	12 V
Delta V	146 m/s

Table 0.3.4: Main features of BGT-X5

ADOCS

ADACS	
Features	**CUBE ADCS**
Power	3.3/5 VDC Peak: 7.045W
Mass	506 g
Size	90 x 90 x 58 mm
Sensors	3-Axis Gyro Fine Sun & Earth sensor Magnetometer 10x Coarse Sun Sensors Star tracker(optional)
Actuators	3 reactions wheels 2 torque rods
Computer	4-48 MHz full ADCS + OBC
Control Board	Works as OBC included

Table 0.3.5: Main ADACS features

Payload

Patch antenna AntDevCo	
Features	**Value**
Bands	L,S,C,X
Frequency range	1-12 GHz
Bandwidth	20 MHz
Gain	6 dBi
Polarization	Circular
Maximum power consumption	10 W
Impedance	50 Ohms
Operational temperature range	-65°C to +100°C
Mass	<250 grams

Table 0.3.6: Main features of the patch antenna

Inter-satellite comm.(S band)	
Features	**NanoCom TR-600**
Band	70 - 6000 MHz
Bandwidth	0.2 - 56 MHz
Vcc	3.3V
Max. Power consumption	14W
Dimensions	65 x 40 x 6.5 mm
Operational temperature range	-40°C to +85°C
Mass	16,4 grams

Table 0.3.7: Main inter-satellite communication transceiver features

Space to Ground comm.(X band)	
Features	**SWIFT-XTS**
Band	7 - 9 GHz
Bandwidth	10 - >100 MHz
Vcc	3.3V
Max. Power consumption	12W
Dimensions	86 x 86 x 45mm
Operational temperature range	-40°C to +85°C
Mass	350 grams

Table 0.3.8: Main space to ground communication transceiver features

PDHS computers options	
Features	**NanoMind Z7000**
Operating System	Linux
Storage	4GB to 32 GB
Processor	MPCoreA9 667 MHz
Vcc	3.3V
Max. Power consumption	30W
Dimensions	65 x 40 x 6.5mm
Operational temperature range	-40°C to +85°C
Mass	28.3 grams

Table 0.3.9: Main PDHS computer features

LINK

Payload communication capabilities. Depending onthe Bandwidth selected a Sensitivity, S, is imposed by 0.3.1. Then with this fixed power is possible to obtain the range of communication from Figure0.3.2.

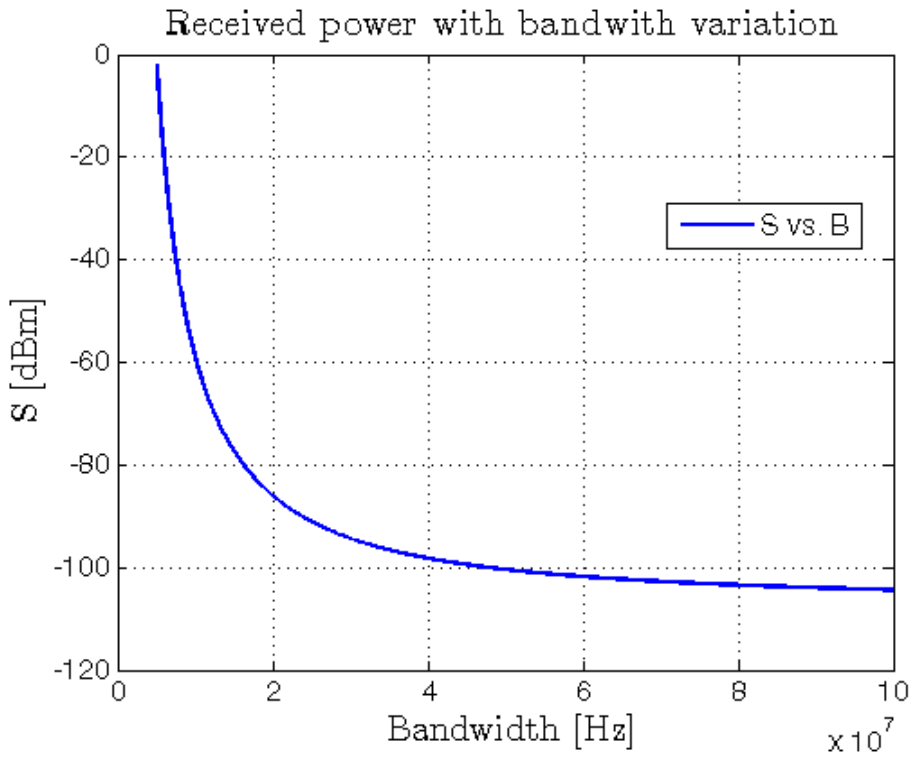

Figure 0.3.1: Sensibility change along Bandwidth variation

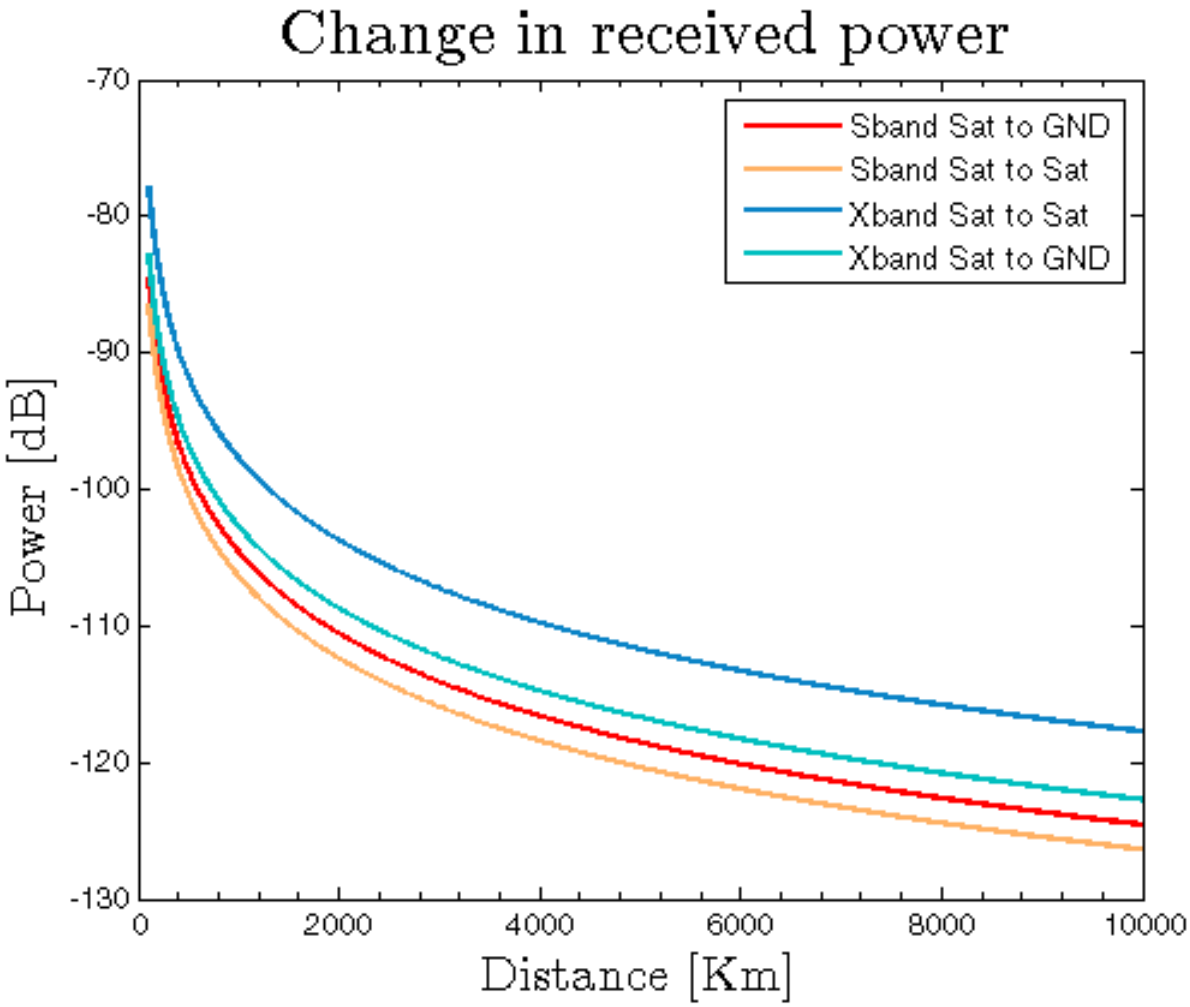

Figure 0.3.2: Received power with distance variation

0.3.0.1 Subsystems conceptual relations

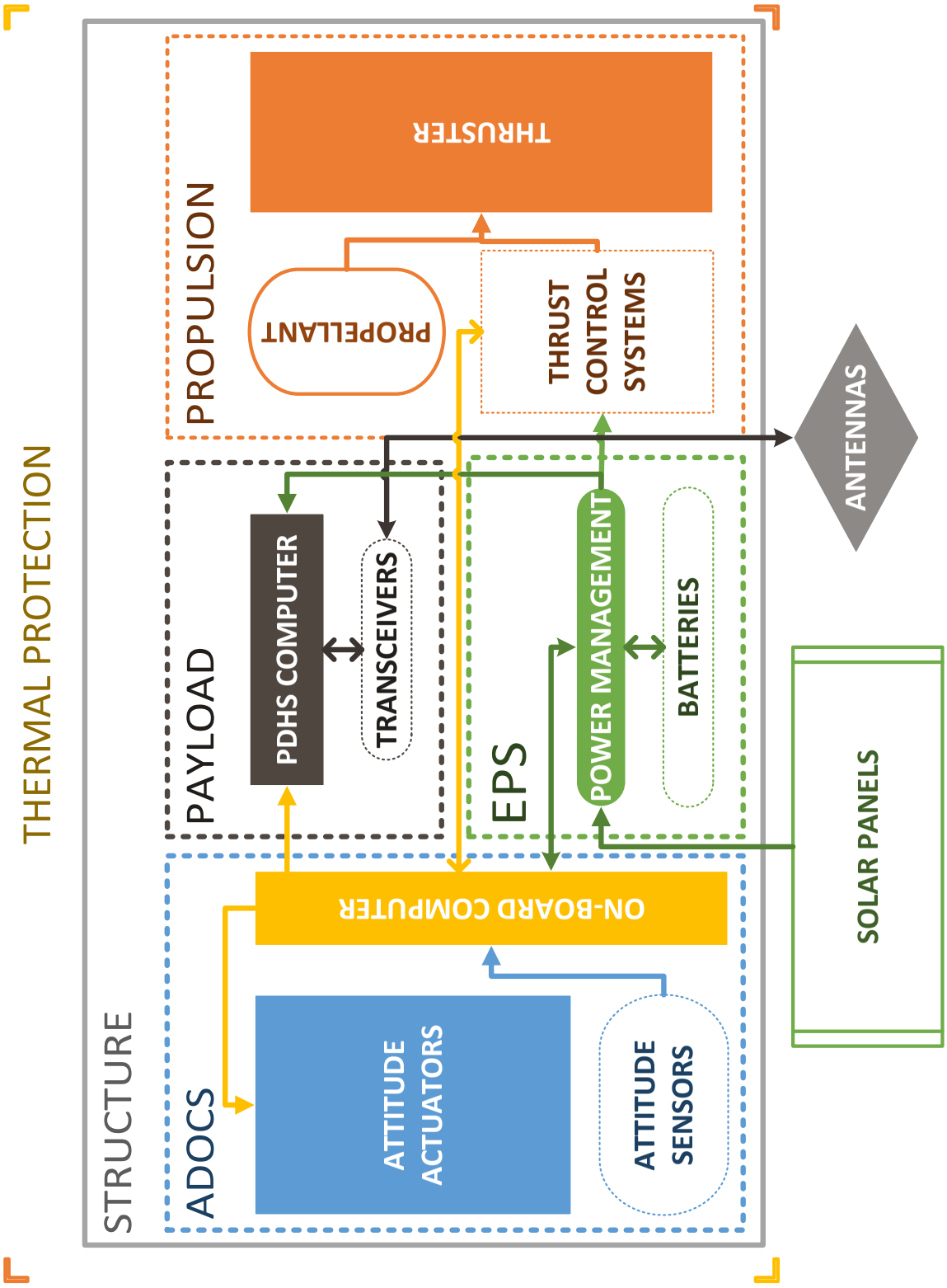

Figure 0.3.3: AstreaSAT main connections between systems

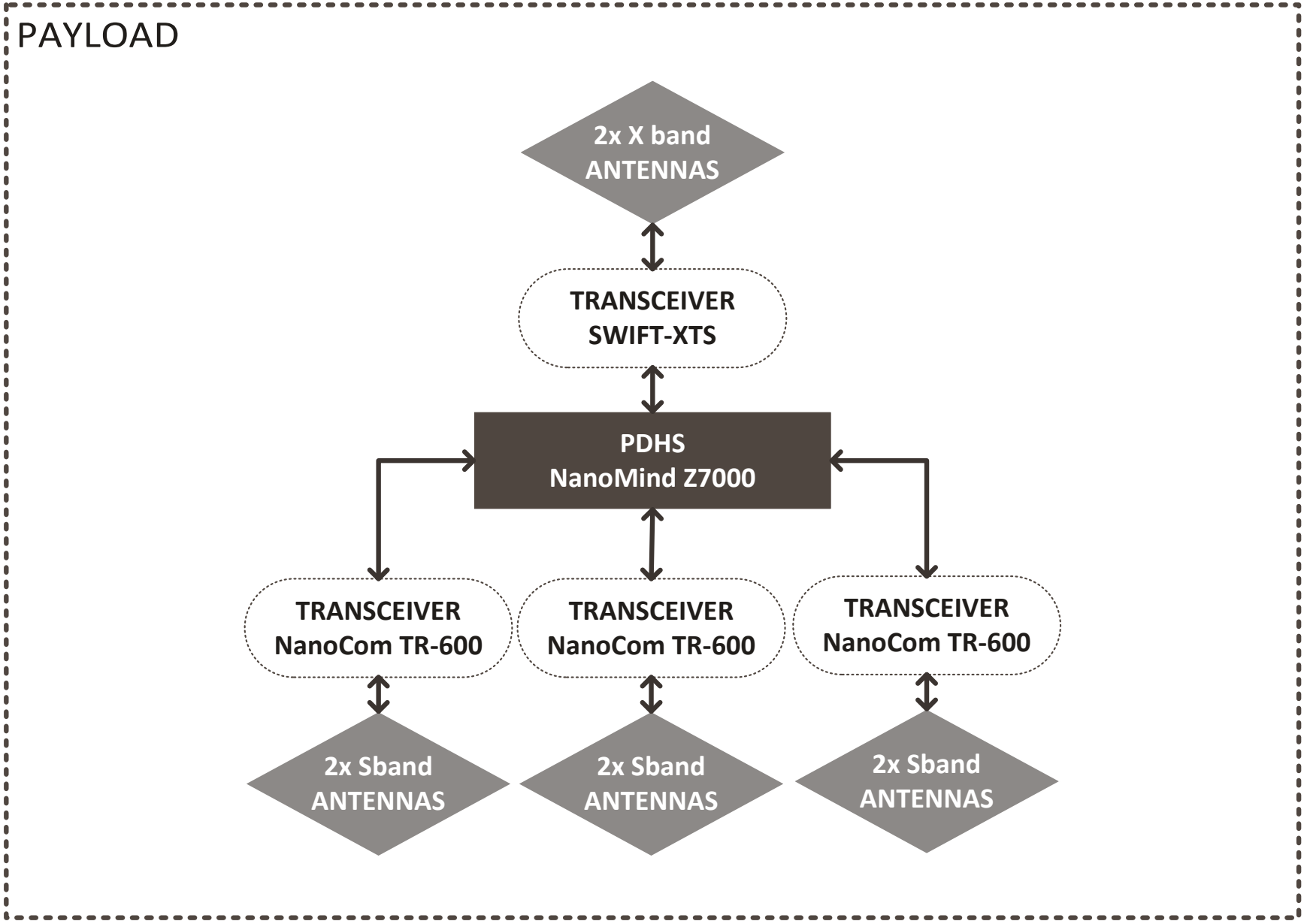

Figure 0.3.4: AstreaSAT Payload components connections

0.4 Constellation Orbital Parameters

Number of satellites	189
Number of Planes	9
Num. Satellites/Plane	21
Height of the orbits (km)	542
Constellation Type	Walker-Delta
Planes Inclination	72
Orbital Periods (min)	95.48
Minimum Elevation (deg)	20
Mean Pass time (min)	4.28

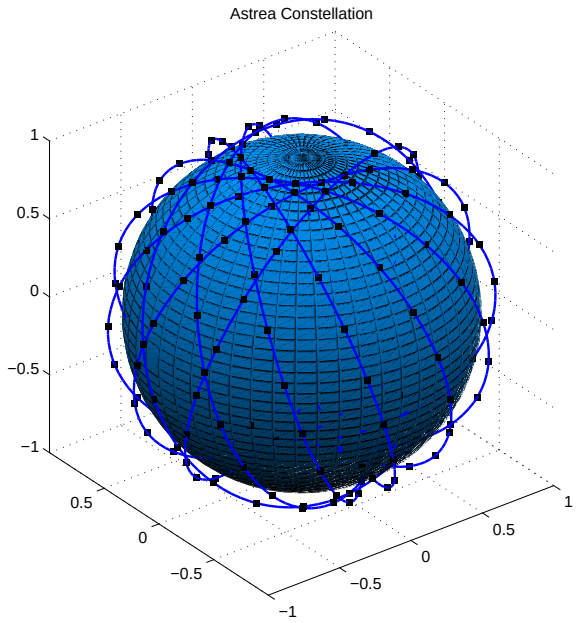

Figure 0.4.1: Spherical Distribution of the Constellation

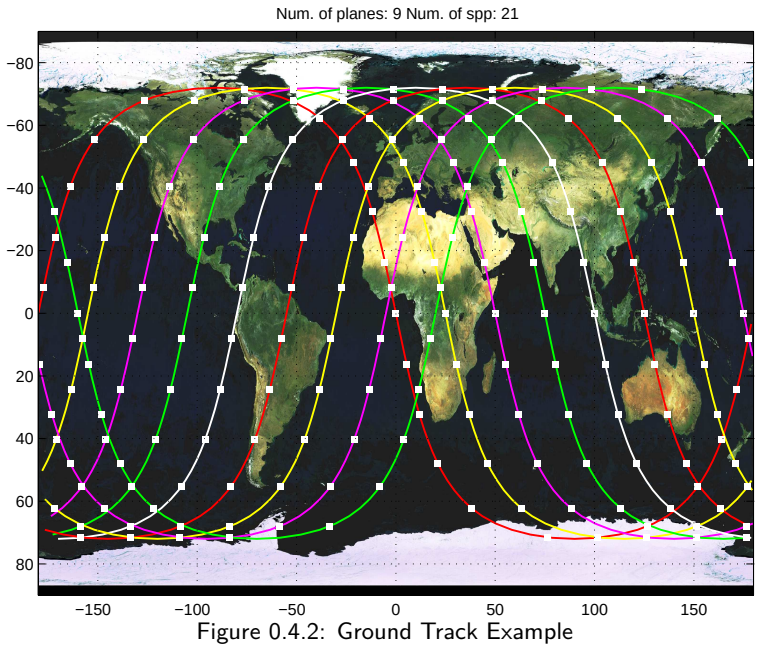

Figure 0.4.2: Ground Track Example

Planes distribution of the Astrea Constellation

The AstreaSATs are distributed in 9 plains. Even though there is symmetry inside each plane, the plains are not distributed equally in space. Their Right Arguments of the Ascendent Node are splitted regularly in a sector of 225 degrees, giving shape to the table and figures below:

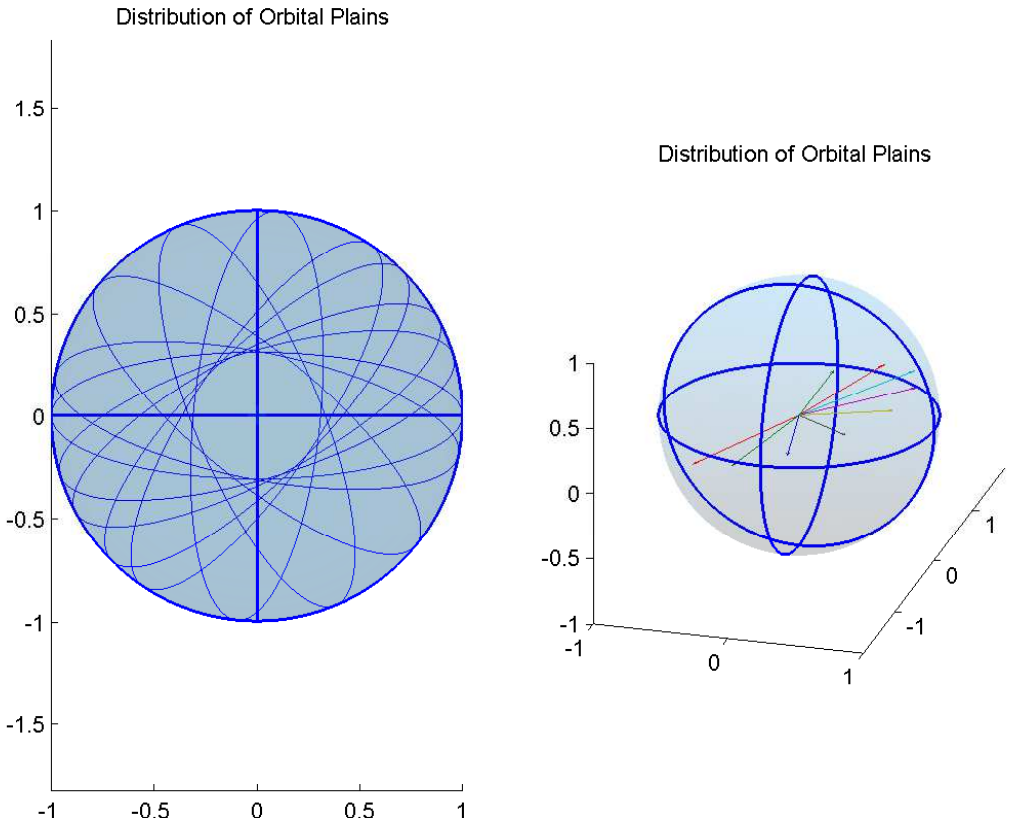

Figure 0.4.3: Planes distribution representation. Left: From a top view, the pattern that the orbital planes generate. Right: The planes normal vectors in the fan they create.

Plane	RAAN(º)
1	0
2	28.125
3	56.25
4	84.375
5	112.5
6	140.625
7	168.75
8	196.875
9	225

0.5 Satellites Orbits Table

The following table describes the orbit of each of the satellites at the time of full deployment of the constellation. It shows the following data:

- Name
- Number of the satellite
- Number of the plane at which the satellite belongs
- Height of the orbit (km)
- Orbital Period (minutes)
- Plain inclination (deg)
- Orbital Eccentricity
- Argument of the Ascendent Node or Ω (deg)
- Initial phase or Argument of perigee (deg)

Name	ID	P	H(km)	Per(min)	i(º)	e	AAN(º)	Phase(º)
AstreaSAT 1	1	1	542	95.4815	72	0	0	0
AstreaSAT 2	2	1	542	95.4815	72	0	0	17.1429
AstreaSAT 3	3	1	542	95.4815	72	0	0	34.2857
AstreaSAT 4	4	1	542	95.4815	72	0	0	51.4286
AstreaSAT 5	5	1	542	95.4815	72	0	0	68.5714
AstreaSAT 6	6	1	542	95.4815	72	0	0	85.7143
AstreaSAT 7	7	1	542	95.4815	72	0	0	102.8571
AstreaSAT 8	8	1	542	95.4815	72	0	0	120
AstreaSAT 9	9	1	542	95.4815	72	0	0	137.1429
AstreaSAT 10	10	1	542	95.4815	72	0	0	154.2857
AstreaSAT 11	11	1	542	95.4815	72	0	0	171.4286
AstreaSAT 12	12	1	542	95.4815	72	0	0	188.5714
AstreaSAT 13	13	1	542	95.4815	72	0	0	205.7143
AstreaSAT 14	14	1	542	95.4815	72	0	0	222.8571
AstreaSAT 15	15	1	542	95.4815	72	0	0	240
AstreaSAT 16	16	1	542	95.4815	72	0	0	257.1429
AstreaSAT 17	17	1	542	95.4815	72	0	0	274.2857
AstreaSAT 18	18	1	542	95.4815	72	0	0	291.4286
AstreaSAT 19	19	1	542	95.4815	72	0	0	308.5714

AstreaSAT 20	20	1	542	95.4815	72	0	0	325.7143
AstreaSAT 21	21	1	542	95.4815	72	0	0	342.8571
AstreaSAT 22	22	2	542	95.4815	72	0	28.125	0
AstreaSAT 23	23	2	542	95.4815	72	0	28.125	17.1429
AstreaSAT 24	24	2	542	95.4815	72	0	28.125	34.2857
AstreaSAT 25	25	2	542	95.4815	72	0	28.125	51.4286
AstreaSAT 26	26	2	542	95.4815	72	0	28.125	68.5714
AstreaSAT 27	27	2	542	95.4815	72	0	28.125	85.7143
AstreaSAT 28	28	2	542	95.4815	72	0	28.125	102.8571
AstreaSAT 29	29	2	542	95.4815	72	0	28.125	120
AstreaSAT 30	30	2	542	95.4815	72	0	28.125	137.1429
AstreaSAT 31	31	2	542	95.4815	72	0	28.125	154.2857
AstreaSAT 32	32	2	542	95.4815	72	0	28.125	171.4286
AstreaSAT 33	33	2	542	95.4815	72	0	28.125	188.5714
AstreaSAT 34	34	2	542	95.4815	72	0	28.125	205.7143
AstreaSAT 35	35	2	542	95.4815	72	0	28.125	222.8571
AstreaSAT 36	36	2	542	95.4815	72	0	28.125	240
AstreaSAT 37	37	2	542	95.4815	72	0	28.125	257.1429
AstreaSAT 38	38	2	542	95.4815	72	0	28.125	274.2857
AstreaSAT 39	39	2	542	95.4815	72	0	28.125	291.4286
AstreaSAT 40	40	2	542	95.4815	72	0	28.125	308.5714
AstreaSAT 41	41	2	542	95.4815	72	0	28.125	325.7143
AstreaSAT 42	42	2	542	95.4815	72	0	28.125	342.8571
AstreaSAT 43	43	3	542	95.4815	72	0	56.25	0
AstreaSAT 44	44	3	542	95.4815	72	0	56.25	17.1429
AstreaSAT 45	45	3	542	95.4815	72	0	56.25	34.2857
AstreaSAT 46	46	3	542	95.4815	72	0	56.25	51.4286
AstreaSAT 47	47	3	542	95.4815	72	0	56.25	68.5714
AstreaSAT 48	48	3	542	95.4815	72	0	56.25	85.7143
AstreaSAT 49	49	3	542	95.4815	72	0	56.25	102.8571
AstreaSAT 50	50	3	542	95.4815	72	0	56.25	120
AstreaSAT 51	51	3	542	95.4815	72	0	56.25	137.1429
AstreaSAT 52	52	3	542	95.4815	72	0	56.25	154.2857
AstreaSAT 53	53	3	542	95.4815	72	0	56.25	171.4286
AstreaSAT 54	54	3	542	95.4815	72	0	56.25	188.5714
AstreaSAT 55	55	3	542	95.4815	72	0	56.25	205.7143
AstreaSAT 56	56	3	542	95.4815	72	0	56.25	222.8571
AstreaSAT 57	57	3	542	95.4815	72	0	56.25	240
AstreaSAT 58	58	3	542	95.4815	72	0	56.25	257.1429
AstreaSAT 59	59	3	542	95.4815	72	0	56.25	274.2857
AstreaSAT 60	60	3	542	95.4815	72	0	56.25	291.4286

AstreaSAT 61	61	3	542	95.4815	72	0	56.25	308.5714
AstreaSAT 62	62	3	542	95.4815	72	0	56.25	325.7143
AstreaSAT 63	63	3	542	95.4815	72	0	56.25	342.8571
AstreaSAT 64	64	4	542	95.4815	72	0	84.375	0
AstreaSAT 65	65	4	542	95.4815	72	0	84.375	17.1429
AstreaSAT 66	66	4	542	95.4815	72	0	84.375	34.2857
AstreaSAT 67	67	4	542	95.4815	72	0	84.375	51.4286
AstreaSAT 68	68	4	542	95.4815	72	0	84.375	68.5714
AstreaSAT 69	69	4	542	95.4815	72	0	84.375	85.7143
AstreaSAT 70	70	4	542	95.4815	72	0	84.375	102.8571
AstreaSAT 71	71	4	542	95.4815	72	0	84.375	120
AstreaSAT 72	72	4	542	95.4815	72	0	84.375	137.1429
AstreaSAT 73	73	4	542	95.4815	72	0	84.375	154.2857
AstreaSAT 74	74	4	542	95.4815	72	0	84.375	171.4286
AstreaSAT 75	75	4	542	95.4815	72	0	84.375	188.5714
AstreaSAT 76	76	4	542	95.4815	72	0	84.375	205.7143
AstreaSAT 77	77	4	542	95.4815	72	0	84.375	222.8571
AstreaSAT 78	78	4	542	95.4815	72	0	84.375	240
AstreaSAT 79	79	4	542	95.4815	72	0	84.375	257.1429
AstreaSAT 80	80	4	542	95.4815	72	0	84.375	274.2857
AstreaSAT 81	81	4	542	95.4815	72	0	84.375	291.4286
AstreaSAT 82	82	4	542	95.4815	72	0	84.375	308.5714
AstreaSAT 83	83	4	542	95.4815	72	0	84.375	325.7143
AstreaSAT 84	84	4	542	95.4815	72	0	84.375	342.8571
AstreaSAT 85	85	5	542	95.4815	72	0	112.5	0
AstreaSAT 86	86	5	542	95.4815	72	0	112.5	17.1429
AstreaSAT 87	87	5	542	95.4815	72	0	112.5	34.2857
AstreaSAT 88	88	5	542	95.4815	72	0	112.5	51.4286
AstreaSAT 89	89	5	542	95.4815	72	0	112.5	68.5714
AstreaSAT 90	90	5	542	95.4815	72	0	112.5	85.7143
AstreaSAT 91	91	5	542	95.4815	72	0	112.5	102.8571
AstreaSAT 92	92	5	542	95.4815	72	0	112.5	120
AstreaSAT 93	93	5	542	95.4815	72	0	112.5	137.1429
AstreaSAT 94	94	5	542	95.4815	72	0	112.5	154.2857
AstreaSAT 95	95	5	542	95.4815	72	0	112.5	171.4286
AstreaSAT 96	96	5	542	95.4815	72	0	112.5	188.5714
AstreaSAT 97	97	5	542	95.4815	72	0	112.5	205.7143
AstreaSAT 98	98	5	542	95.4815	72	0	112.5	222.8571
AstreaSAT 99	99	5	542	95.4815	72	0	112.5	240
AstreaSAT 100	100	5	542	95.4815	72	0	112.5	257.1429
AstreaSAT 101	101	5	542	95.4815	72	0	112.5	274.2857

AstreaSAT 102	102	5	542	95.4815	72	0	112.5	291.4286
AstreaSAT 103	103	5	542	95.4815	72	0	112.5	308.5714
AstreaSAT 104	104	5	542	95.4815	72	0	112.5	325.7143
AstreaSAT 105	105	5	542	95.4815	72	0	112.5	342.8571
AstreaSAT 106	106	6	542	95.4815	72	0	140.625	0
AstreaSAT 107	107	6	542	95.4815	72	0	140.625	17.1429
AstreaSAT 108	108	6	542	95.4815	72	0	140.625	34.2857
AstreaSAT 109	109	6	542	95.4815	72	0	140.625	51.4286
AstreaSAT 110	110	6	542	95.4815	72	0	140.625	68.5714
AstreaSAT 111	111	6	542	95.4815	72	0	140.625	85.7143
AstreaSAT 112	112	6	542	95.4815	72	0	140.625	102.8571
AstreaSAT 113	113	6	542	95.4815	72	0	140.625	120
AstreaSAT 114	114	6	542	95.4815	72	0	140.625	137.1429
AstreaSAT 115	115	6	542	95.4815	72	0	140.625	154.2857
AstreaSAT 116	116	6	542	95.4815	72	0	140.625	171.4286
AstreaSAT 117	117	6	542	95.4815	72	0	140.625	188.5714
AstreaSAT 118	118	6	542	95.4815	72	0	140.625	205.7143
AstreaSAT 119	119	6	542	95.4815	72	0	140.625	222.8571
AstreaSAT 120	120	6	542	95.4815	72	0	140.625	240
AstreaSAT 121	121	6	542	95.4815	72	0	140.625	257.1429
AstreaSAT 122	122	6	542	95.4815	72	0	140.625	274.2857
AstreaSAT 123	123	6	542	95.4815	72	0	140.625	291.4286
AstreaSAT 124	124	6	542	95.4815	72	0	140.625	308.5714
AstreaSAT 125	125	6	542	95.4815	72	0	140.625	325.7143
AstreaSAT 126	126	6	542	95.4815	72	0	140.625	342.8571
AstreaSAT 127	127	7	542	95.4815	72	0	168.75	0
AstreaSAT 128	128	7	542	95.4815	72	0	168.75	17.1429
AstreaSAT 129	129	7	542	95.4815	72	0	168.75	34.2857
AstreaSAT 130	130	7	542	95.4815	72	0	168.75	51.4286
AstreaSAT 131	131	7	542	95.4815	72	0	168.75	68.5714
AstreaSAT 132	132	7	542	95.4815	72	0	168.75	85.7143
AstreaSAT 133	133	7	542	95.4815	72	0	168.75	102.8571
AstreaSAT 134	134	7	542	95.4815	72	0	168.75	120
AstreaSAT 135	135	7	542	95.4815	72	0	168.75	137.1429
AstreaSAT 136	136	7	542	95.4815	72	0	168.75	154.2857
AstreaSAT 137	137	7	542	95.4815	72	0	168.75	171.4286
AstreaSAT 138	138	7	542	95.4815	72	0	168.75	188.5714
AstreaSAT 139	139	7	542	95.4815	72	0	168.75	205.7143
AstreaSAT 140	140	7	542	95.4815	72	0	168.75	222.8571
AstreaSAT 141	141	7	542	95.4815	72	0	168.75	240
AstreaSAT 142	142	7	542	95.4815	72	0	168.75	257.1429

AstreaSAT 143	143	7	542	95.4815	72	0	168.75	274.2857
AstreaSAT 144	144	7	542	95.4815	72	0	168.75	291.4286
AstreaSAT 145	145	7	542	95.4815	72	0	168.75	308.5714
AstreaSAT 146	146	7	542	95.4815	72	0	168.75	325.7143
AstreaSAT 147	147	7	542	95.4815	72	0	168.75	342.8571
AstreaSAT 148	148	8	542	95.4815	72	0	196.875	0
AstreaSAT 149	149	8	542	95.4815	72	0	196.875	17.1429
AstreaSAT 150	150	8	542	95.4815	72	0	196.875	34.2857
AstreaSAT 151	151	8	542	95.4815	72	0	196.875	51.4286
AstreaSAT 152	152	8	542	95.4815	72	0	196.875	68.5714
AstreaSAT 153	153	8	542	95.4815	72	0	196.875	85.7143
AstreaSAT 154	154	8	542	95.4815	72	0	196.875	102.8571
AstreaSAT 155	155	8	542	95.4815	72	0	196.875	120
AstreaSAT 156	156	8	542	95.4815	72	0	196.875	137.1429
AstreaSAT 157	157	8	542	95.4815	72	0	196.875	154.2857
AstreaSAT 158	158	8	542	95.4815	72	0	196.875	171.4286
AstreaSAT 159	159	8	542	95.4815	72	0	196.875	188.5714
AstreaSAT 160	160	8	542	95.4815	72	0	196.875	205.7143
AstreaSAT 161	161	8	542	95.4815	72	0	196.875	222.8571
AstreaSAT 162	162	8	542	95.4815	72	0	196.875	240
AstreaSAT 163	163	8	542	95.4815	72	0	196.875	257.1429
AstreaSAT 164	164	8	542	95.4815	72	0	196.875	274.2857
AstreaSAT 165	165	8	542	95.4815	72	0	196.875	291.4286
AstreaSAT 166	166	8	542	95.4815	72	0	196.875	308.5714
AstreaSAT 167	167	8	542	95.4815	72	0	196.875	325.7143
AstreaSAT 168	168	8	542	95.4815	72	0	196.875	342.8571
AstreaSAT 169	169	9	542	95.4815	72	0	225	0
AstreaSAT 170	170	9	542	95.4815	72	0	225	17.1429
AstreaSAT 171	171	9	542	95.4815	72	0	225	34.2857
AstreaSAT 172	172	9	542	95.4815	72	0	225	51.4286
AstreaSAT 173	173	9	542	95.4815	72	0	225	68.5714
AstreaSAT 174	174	9	542	95.4815	72	0	225	85.7143
AstreaSAT 175	175	9	542	95.4815	72	0	225	102.8571
AstreaSAT 176	176	9	542	95.4815	72	0	225	120
AstreaSAT 177	177	9	542	95.4815	72	0	225	137.1429
AstreaSAT 178	178	9	542	95.4815	72	0	225	154.2857
AstreaSAT 179	179	9	542	95.4815	72	0	225	171.4286
AstreaSAT 180	180	9	542	95.4815	72	0	225	188.5714
AstreaSAT 181	181	9	542	95.4815	72	0	225	205.7143
AstreaSAT 182	182	9	542	95.4815	72	0	225	222.8571
AstreaSAT 183	183	9	542	95.4815	72	0	225	240

AstreaSAT 184	184	9	542	95.4815	72	0	225	257.1429
AstreaSAT 185	185	9	542	95.4815	72	0	225	274.2857
AstreaSAT 186	186	9	542	95.4815	72	0	225	291.4286
AstreaSAT 187	187	9	542	95.4815	72	0	225	308.5714
AstreaSAT 188	188	9	542	95.4815	72	0	225	325.7143
AstreaSAT 189	189	9	542	95.4815	72	0	225	342.8571

Table 0.5.1: Satellites Orbital Parameters

0.6 Launch and Deployment

The rocket selected to launch the constellation is Electron, from Rocket Lab enterprise. It is a two stage rocket capable of launching 24 3U CubeSats every week at a LEO orbit with a range of inclinations from 39.2 to 99. The cost per launch is 5.760.000 US dollars. The basic dimensions of the electron are 17 m long and 1.2 m diameter.

Figure 0.6.1: Electron Rocket

Figure 0.6.2: Electron Rocket

Event	Time(s)	Altitude(km)
Lift-off	0	0
Max Q	79	11
Stage 1 separation	152	69
Stage 2 ignition	159	69
Fairing separation	183	110
Stage 2 apogee kick	457	284
Engine cut off	3157	540
Payload separation	3200	542

Table 0.6.1: Injection manouver

The cycle of the constellation is shown in the next figure. As it can be seen, there will be a launch every week so it will take 9 weeks to put in orbit all the cubesats. After 5 years the constellation will be replaced. The replacement strategy is designed in a way that will not affect the performance of the constellation in any way. To acomplish this, when a new plane is placed the old plane will be shuted down and will decay.

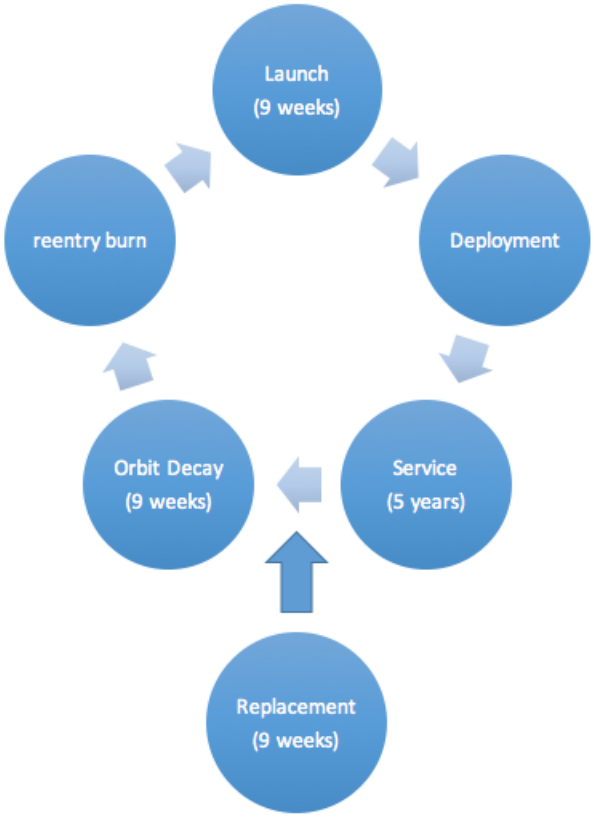

Figure 0.6.3: Cycle of the Astrea Constellation