Towards Sustainability - Evolving from Manufacturing Hardware to Providing Analytics Ready Data

National Space Conference 2024

Introduction | Facility

South African Facility

- 140 m^2 of ISO 6 clean room for optical payload assembly
- 520 m^2 of ISO 8 clean rooms for satellite assembly
- 155 m^2 of electronics laboratory and stores
- 750 x 1200mm Thermal Vacuum Chamber for cameras and unit testing
- 1780 x 2800mm Thermal Vacuum Chamber for satellite testing
- 80kN Shaker for vibration testing up to 800kg
- Mechanical workshop and paint booth
- Mission operations control centre

Introduction | CAMERAS

CubeSat Cameras

Microsatellite Cameras








	Gecko	Mantis	Chameleon	Chameleon SWIR	Caiman	Komodo	DragonEye	Raptor
GSD at 500 km	39 m	16 m	10 m	8.7 m	3.25 m	1.5 m	1.25 m	0.5 m (Native) / 0.36m (Super-Resolution)
Swath	80 km / 160 km	32 km	39 km	11.2 km	13 km	6 km / 15 km	19.7 km	8 km
Size (mm)	65 × 90 × 105	65 × 90 × 107	100 × 100 × 215	100 × 100 × 215	100 x 100 x 250	200 x 200 x 340	320 x 930	635 x 1450
Mass	0.5 kg	0.5 kg	1.6 kg	1.6 kg	1.4 kg	12 kg	18 kg	55 kg
Bands	RGB	RGB / 6x MS / 150x HS	RGB / 11x MS / 150x HS	4x SWIR	RGB / 11x MS	RGB / 11x MS	11x MS	7x MS
TRL	9	9	9	6	9	5	9	5

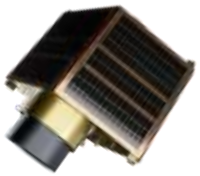
Introduction | SATELLITES

Satellite buses

Optical Satellites

	ηDragonfly	μDragonfly	Dragonfly	KomodoSat	AgriSat	RaptorSat
GSD at 500 km	-	-	-	1.5m	1.4m	0.5m (Native) / 0.36m (Super-Resolution)
Swath	-	-	-	15km	44km	8km
Power	70 W (OAP) / 1.2 kW (Peak)	140 W (OAP) / 1.2 kW (Peak)	800 W (OAP) / 4.2 kW (Peak)	25 W (Payload)	90 W (Payload)	45 W (Payload)
Mass	50 kg	100 kg	150 kg	60 kg	180 kg	180 kg
Bands	-	-	-	RGB / 11x MS	11x MS	7x MS
TRL	6	9	6	5	9	5

Customer Applications

	Data Products	Specifications	Precision Agriculture	Mining	Security	Maritime Domain Awareness	Infrastructure	ESG Monitoring
								
 **EOS SAT-1**	MS HR	3m, 11 bands, 46km swath	✓			✓		
 **RaptorSat**	MS VHR	0.3m, 7 bands, 8km swath		✓	✓		✓	
	HS MR	10m, 150 bands, 20km swath	✓	✓				
	SWIR MR	9m, 5 bands, 11km swath	✓	✓				
	Stereo VHR	0.3m DEM			✓		✓	
 **KomodoSat**	HS HR	4.5m, 150 bands, 30km swath	✓	✓	✓			✓
	SWIR HR	4m, 4 bands, 30km swath	✓	✓	✓			✓

The start of the journey

Earth Observation

- Denel Houwteq: Greensat (not launched)
- Dragonfly: EOS-SAT 1

Signal Monitoring / Traffic Monitoring

- CPUT: MDASat 1a, 1b, 1c
- CPUT: ZACUBE 2 (ZA 004)

Science Technology and Education

- nSIGHT 1 (QB50 AZ02)
- Sumbandila (ZA 002)
- Sunsat (ZA 001)
- ZA-AeroSat (QB50 AZ01)
- ZACUBE 1 (TshepisoSat, ZA 003)
- ZACUBE 2 (ZA 004)

https://space.skyrocket.de/directories/sat_c_southafrica.htm

The known path | Hardware Design & Manufacturing

Innovation Projects & FM Build (2020-2022)

- 22 Innovation Projects
- Electronic, Power, Mechanical, AOCS, Optical GSE Projects
- Facility Upgrade and Test Equipment
- 1 x Flatsat and Flight Software
- 2 x Structural Test Models and QM Models
- 1 x Flight Model Satellite
- ERP, Quality Management Systems,
- Company Infrastructure
- Overcame various challenges
- Majority of subsystems manufacture / procured in ZA

The lesser known path | Launch Campaign Preparation

EOS-SAT1 Launch Campaign Preparation

- Compliance
- Export Licence from National Conventional Arms Control Committee (NCACC)
- Launch License from The South African Council For Space Affairs (SACSA)
- International Telecommunication Union (ITU)
- Independent Communication Authority of South Africa (ICASA)
- SpaceX Launch – Requirements and Validation Timelines leading up to launch
- Staging and Integration Test & Support
- Satellite & Battery Shipment
- Insurance

The lesser known path | Launch Campaign

EOS-SAT1 Launch Campaign

- Shipping - 31 October
- Staging Area – 13 November
  Xenon Loading
- Activities at Cape Canaveral Space Force Station, Florida - 1 December

The lesser known path | EOS-SAT1 Commissioning

Launch 3 January 2023, Transporter 6

Satellite Orbit

- Velocity: 7.6 km/s (Ground speed: 7.0km/s)
- Revs per day: 15.2
- Orbit period: 1h 35m (94.75 min)
- Inclination: 97.425

Why 540km?

- Further and you can't see detail on the ground
- Closer and atmospheric drag becomes significant

Why Sun-Synchronous 9:30 LTDN?

- Illumination is always the same (at a given latitude)
- Angle of the lighting is good

LEOP

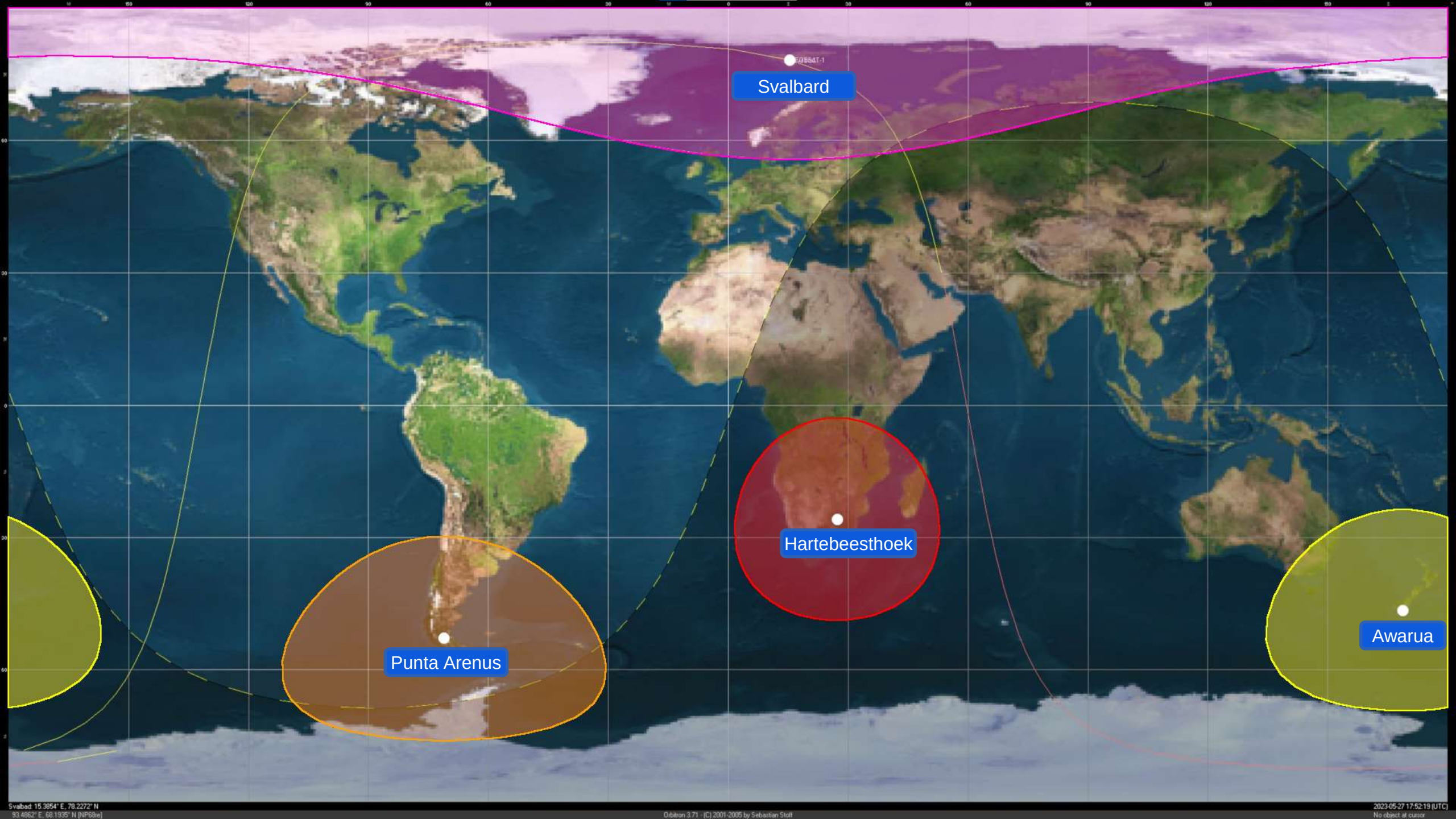
– Health Checks, Add systems one by one

Commissioning

- Test functionality and performance. All systems nominal.

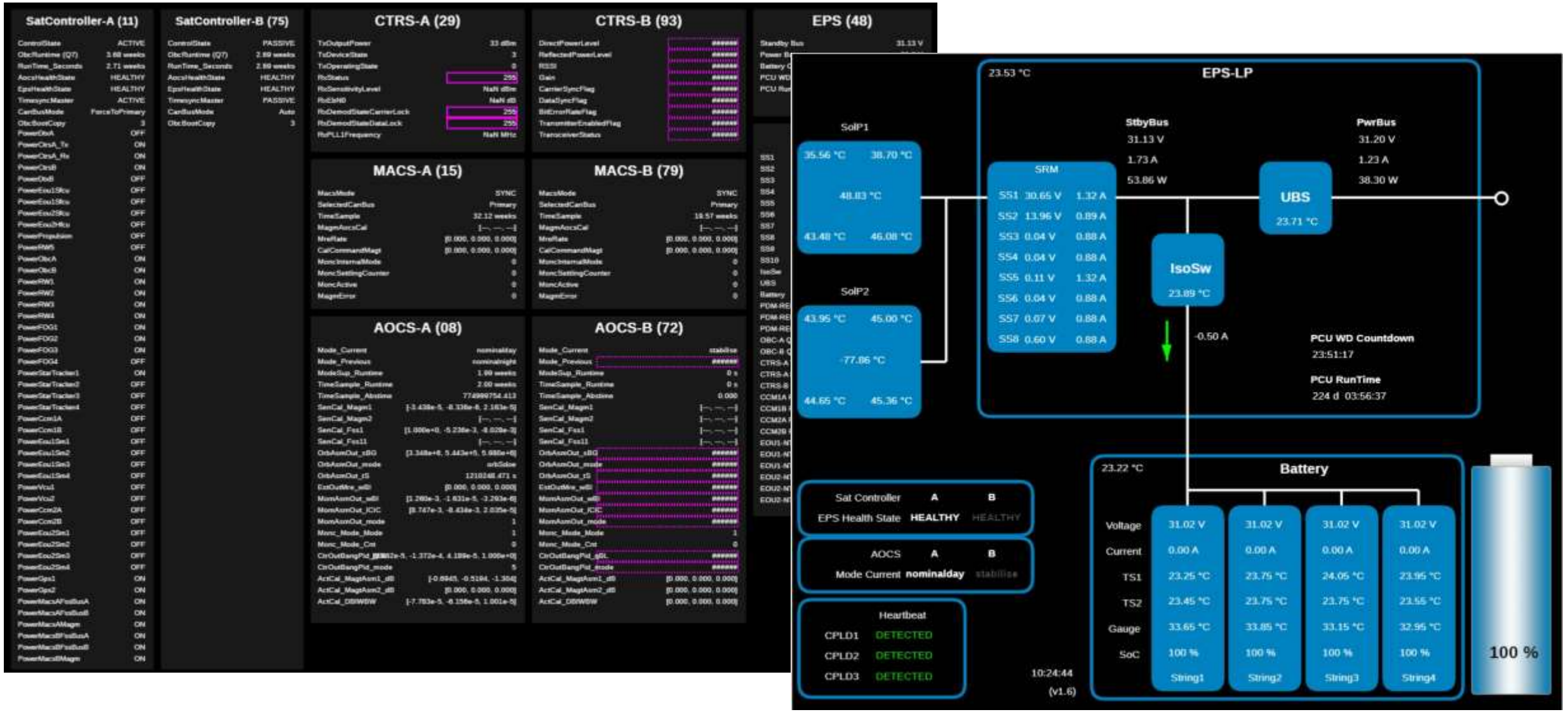
EOS SAT-1 Operations

Date	Start-End	Duration	Spacecraft	System	Station	Mission Profile
2024-07-23	02:31:46 - 02:41:43	00:09:57	AGRISAT-1	PA51	PUNTA_ARENAS	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	04:06:17 - 04:14:06	00:07:49	AGRISAT-1	PA51	PUNTA_ARENAS	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	06:23:21 - 06:30:21	00:07:00	AGRISAT-1	SG220	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	07:57:36 - 08:06:24	00:08:48	AGRISAT-1	SG220	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	08:07:40 - 08:17:23	00:09:43	AGRISAT-1	AT2	ATHENS	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	09:31:49 - 09:41:27	00:09:38	AGRISAT-1	SG220	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	10:27:37 - 10:37:30	00:09:53	AGRISAT-1	NZ3	AWARUA	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	11:05:54 - 11:15:40	00:09:46	AGRISAT-1	SG184	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	12:39:48 - 12:49:23	00:09:35	AGRISAT-1	SG220	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	13:16:11 - 13:26:13	00:10:02	AGRISAT-1	PA51	PUNTA_ARENAS	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	14:13:28 - 14:22:55	00:09:27	AGRISAT-1	SG184	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	14:51:54 - 14:59:15	00:07:21	AGRISAT-1	PA51	PUNTA_ARENAS	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	15:47:01 - 15:56:34	00:09:33	AGRISAT-1	SG220	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	17:20:42 - 17:30:26	00:09:44	AGRISAT-1	SG184	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	18:54:51 - 19:04:30	00:09:39	AGRISAT-1	SG184	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	20:29:48 - 20:38:43	00:08:55	AGRISAT-1	SG220	SVALSAT	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	21:08:57 - 21:18:40	00:09:43	AGRISAT-1	NZ3	AWARUA	EOSDA_SA_HS_XA_D_100MSPS
2024-07-23	22:44:18 - 22:51:53	00:07:35	AGRISAT-1	NZ3	AWARUA	EOSDA_SA_HS_XA_D_100MSPS

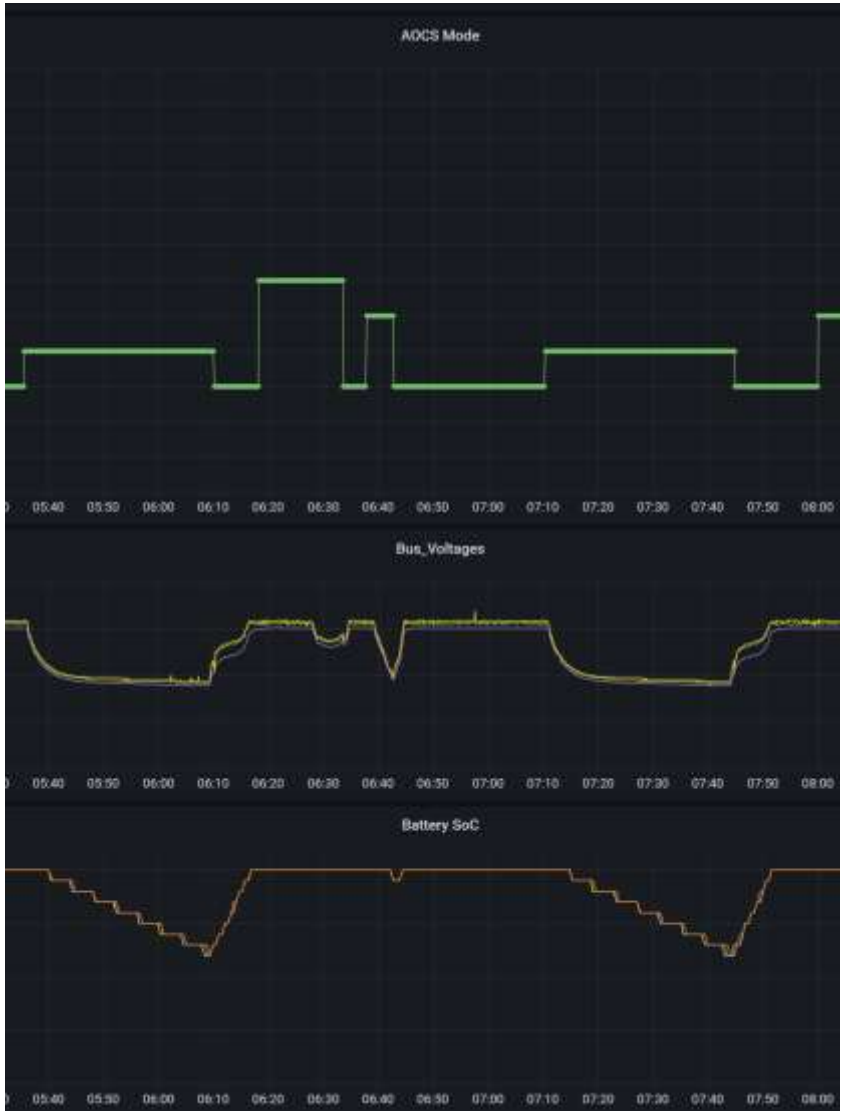

Svalbard
Hartebeesthoek
Punta Arenus
Awarua

EOS SAT-1 Operations

Yamcs Dashboards: Real-time display during an overpass



Grafana Dashboards: Telemetry Automatically Ingested for Analysis



EOS SAT-1 Operations – Current Status

- Days in orbit: 601
- # of orbits: 9 118
- # comms sessions: 8 770+
- # ground station locations: 4
- Distance travelled: 395 931 768km
- # successful images taken: 4 805, equating to 30 645 087km2 @ 19MB/km2
- Peak downlink speed achieved: 890 Mbps
- # scripts executed: 43400+
- Multiple Software and Firmware Updates

Did we arrive? The journey continues…

- Operate the satellite
- Further automation of cloud storage and processing
- Business Goal to deliver L1C data to customers and work closely with processing partner to achieve
- MCS and AOI Tasking - tasking API to 3rd party Image Resellers
- Data Delivery & Archiving: STAC and GEOTIFF on AWS

Automation of EOS SAT-1 Operations

- Images planning is done by an operator using a web-based tool.
- Everything else is automated.
- Remotely operated global network of ground stations
- Approximately 15 Overpasses per day: booked automatically via an API
- Overpasses automation includes,
  - Connection with the satellite
  - Downloading telemetry data and OBC logs
  - Uploading imaging tasks
  - Scheduling payload data downlinks.
- An instant messenger notifies operators of any critical satellite telemetry that is out of range.

EOS SAT-1 Operations | Tasking

- **Simulation for AOI Coverage**: The Mission Control System (MCS) includes an Image Tasking function that simulates coverage of specific Areas of Interest (AOIs), ensuring optimal imaging schedules.
- **Constraints Management**: Imaging requests can be constrained by off-nadir pointing (the angle between the satellite's nadir and the target) and required sun angle.
- **Preloaded Schedules:** The system allows for imaging schedules to be preloaded up to three days in advance, enabling precise planning and execution of satellite tasking.
- Exposing Tasking to **3rd Party** via STAPI
- **Sensor Tasking API (STAPI)** - defines a JSON-based web API to query for potential future data (image acquisitions) and place orders ("tasking") for this data from remote sensing data providers

Automation of EOS SAT-1 Processing Chain

KSAT KONGSBERG SATELLITE SERVICES

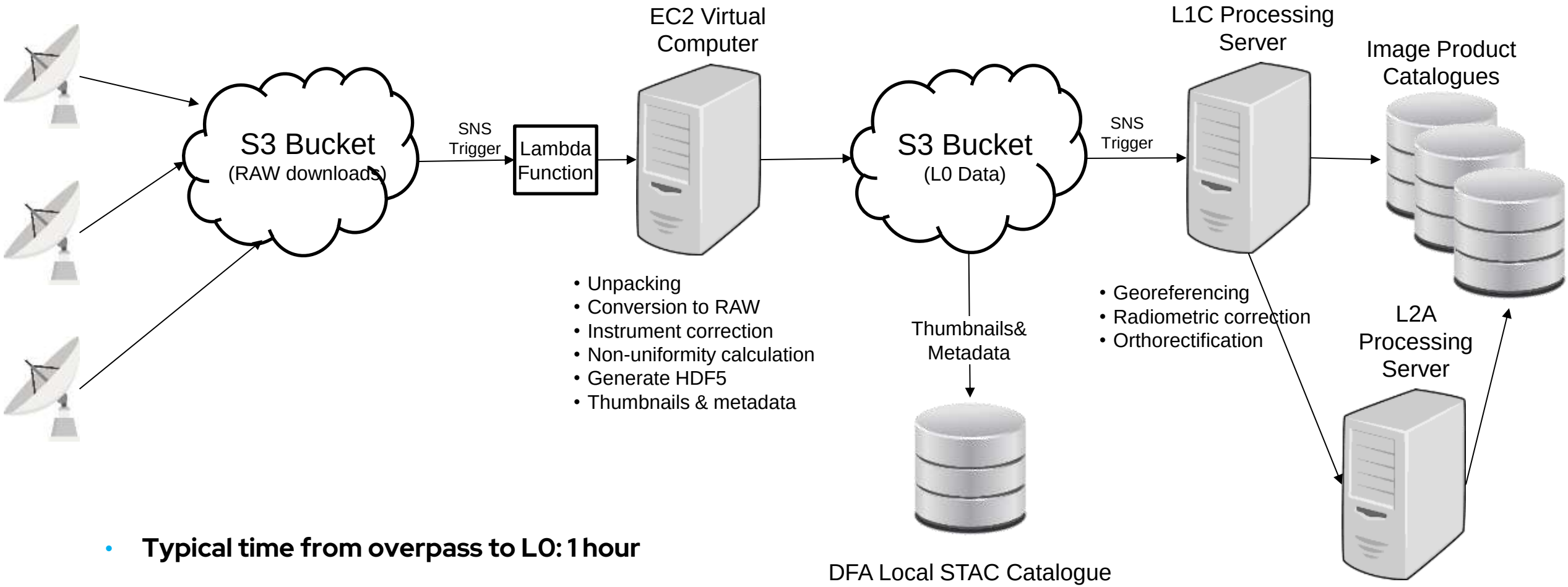
aws

pinkmatter

Global Ground Station Network

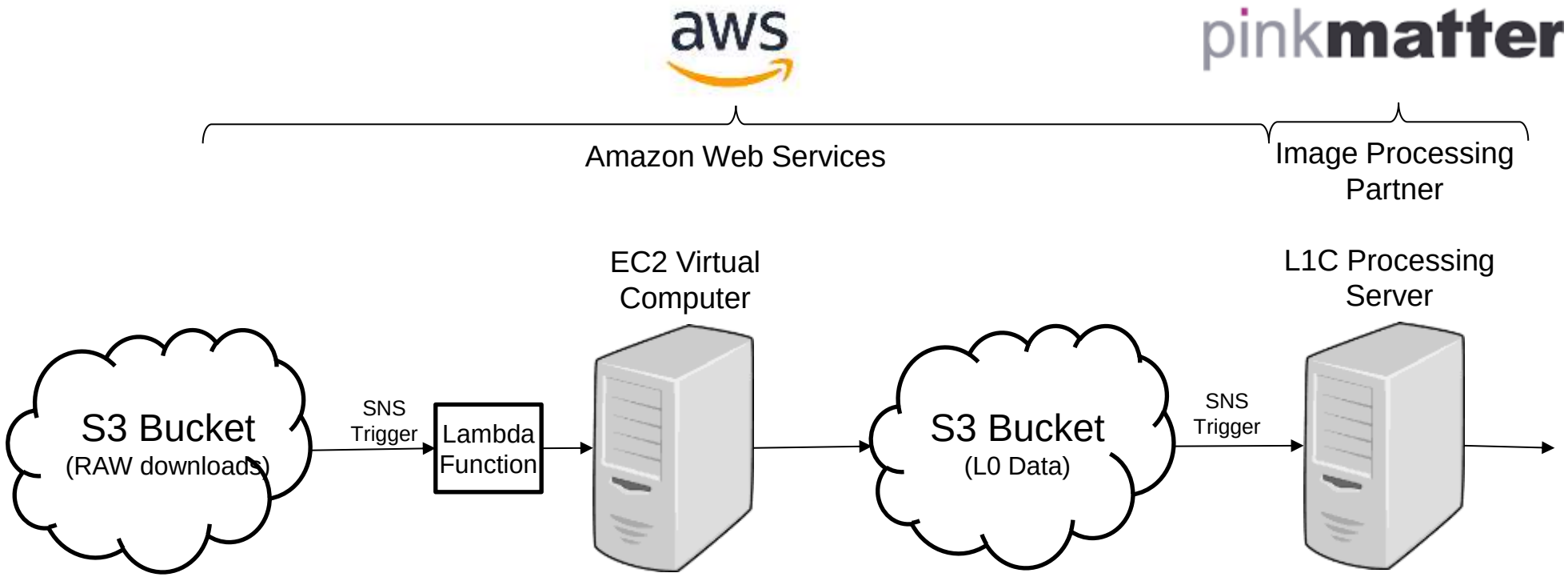
Cloud Storage & Processing

Image Processing Partner



- **Typical time from overpass to L0: 1 hour**

Automation of EOS SAT-1 Processing Chain



- Unpacking
- Conversion to RAW
- Engineering correction
- Non-uniformity calculation
- Generate HDF5
- Thumbnails & metadata

- Georeferencing
- Radiometric correction
- Orthorectification

Data Product Level Definitions

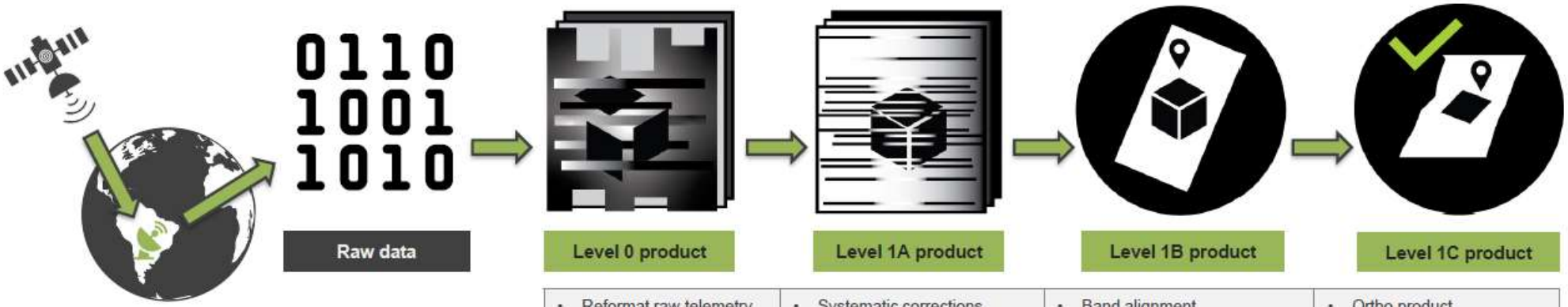
FarEarth for SmallSats
Product level definitions

Product levels brochure

farearth FOR SMALLSATS

Small satellite image data received from a ground segment undergoes multiple processing stages to produce usable image data products. Each stage provides products with varying amounts of data manipulation and advancement toward a usable image.

Note: Pinkmatter uses the following definition for the product levels.
The processing level and output data formats can be tailored to operational requirements.

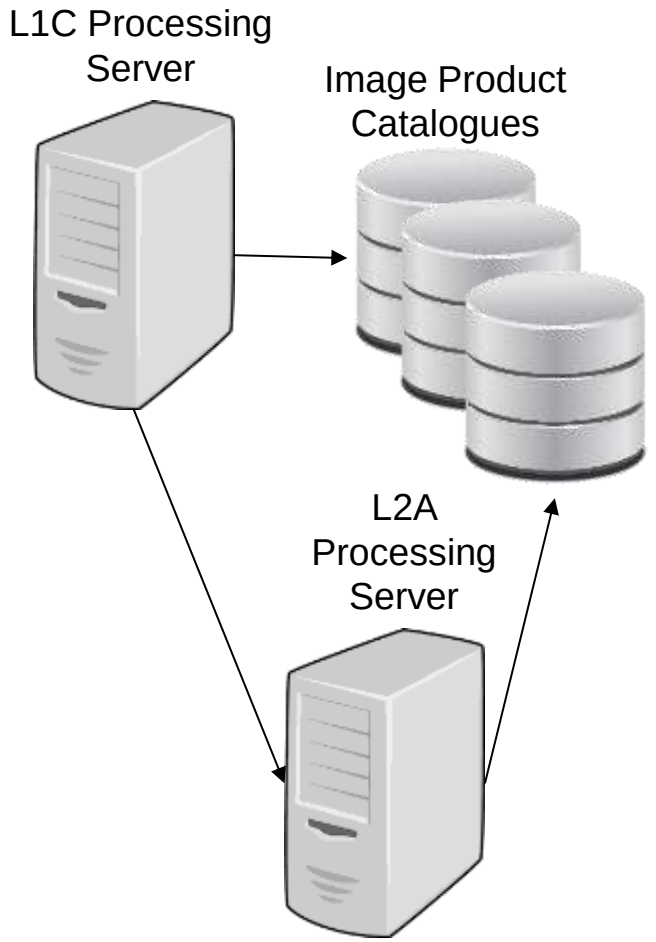


Level 0 product	Level 1A product	Level 1B product	Level 1C product
• Reformat raw telemetry data • Preserve data integrity	• Systematic corrections • Sensor geometry • Radiometric calibration • Georeferencing (RPC)	• Band alignment • RPC refinement • Terrain correction (Orthorectification) • Digital numbers to TOA radiance or reflectance	• Ortho product • Map projected *FarEarth* standard deliverable product

Automation of EOS SAT-1 Processing Chain

L2A for application such as agriculture / land classification

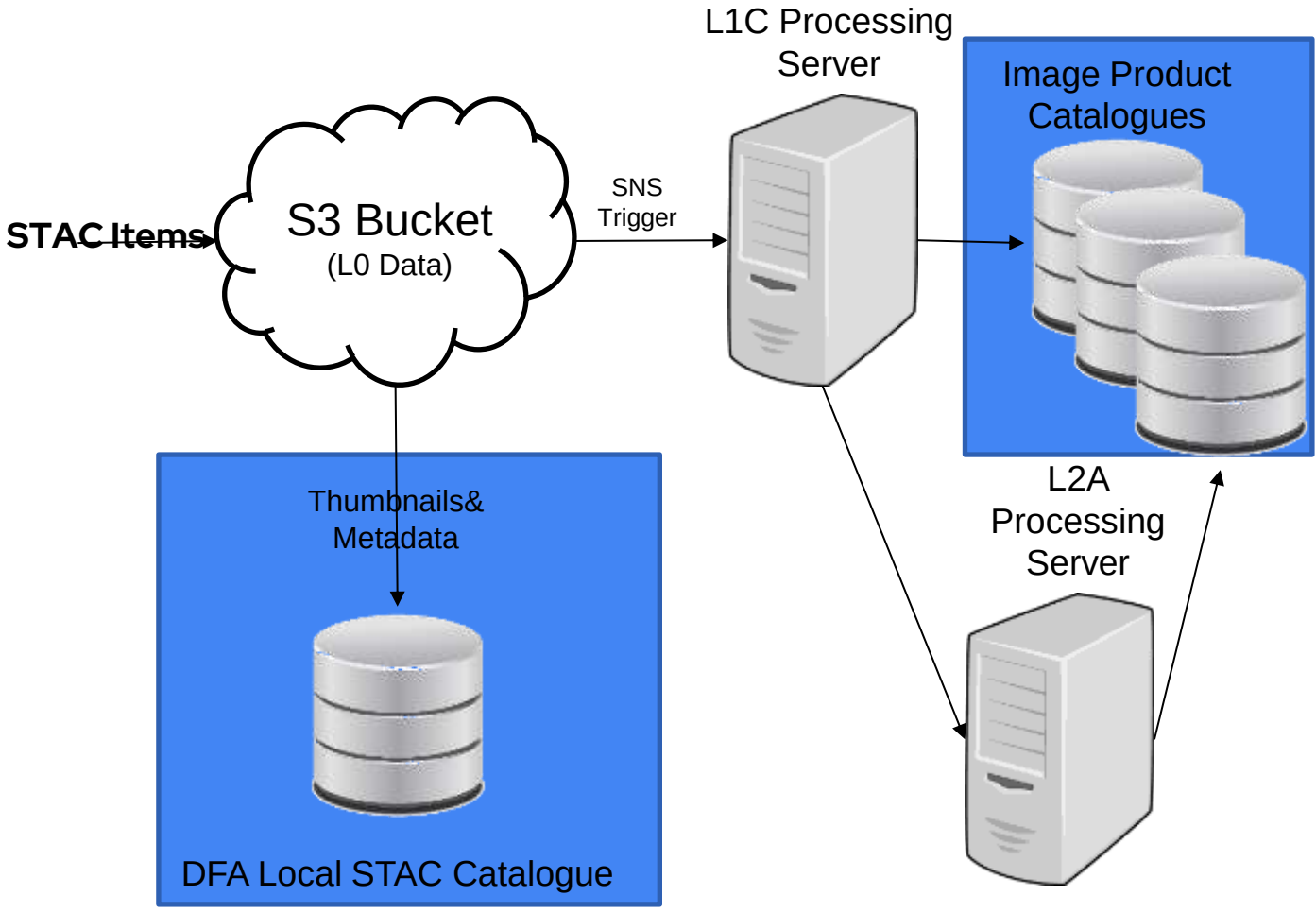
L2A products provide atmospherically corrected surface reflectance



Data Catalogues & Tasking

SpatioTemporal Asset Catalogs (STAC)

- STAC Items
- STAC Catalog
- STAC Collection
- STAC API



Data Catalogues & Tasking

Time Series Analysis

- STAC API Integration: Temporal data series of AOIs are supported through the STAC API, allowing for detailed time series queries and analysis.
- Advanced Search Features: Users can perform time series searches to monitor changes and trends over specific periods, enhancing the ability to track and analyse dynamic environments.
- Change Detection on Temporal Data Series

  Future Research with AI - AI-Driven Early Detection: Leverage artificial intelligence (AI) for feature detection, enabling early change detection already at the L1A stage. This approach will utilise catalogued imagery to identify and analyse changes more rapidly.

This Catalog is protected! You can browse parts of the catalog, but some parts may not load up. Please follow these instructions to gain full access:

> Access to the datasets are protected, but can be shared on request. Please Email Us for more information or to request access to the datasets.

EOSSAT-1_HR-250_20240523T162045_20240523T162049_L1C (EOSSAT-1_HR-250_20240523T162045_20240523T162049_L1C)

https://dragonfly-open-data.s3.eu-west-2.amazonaws.com/data/20240523/EOSSAT-1_HR-250_20240523T162045_20240523T162049_L1C/EOSSAT-1_HR-250_20240523T162045_20240523T

Preview | Thumbnail | Assets

Image: Preview image (Blue: 439 - 535 nm, Green: 537 - 582 nm, Red: 646 - 685 nm, NIR1: 767 - 908 nm)

METADATA	
Collection	20240523
GSD	3.14 m
Platform	eossat-1
Constellation	eossat
Instruments	dragoneye
Mission	EOSSAT-1 Sample Data
Title	EOSSAT-1_HR-250_20240523T162045_20240523T162049_L1C
Description	EOSSAT Item: EOSSAT-1_HR-250_20240523T162045_20240523T162049_L1C
Created	5/23/2024, 4:20:45 PM UTC
Updated	5/23/2024, 4:20:45 PM UTC
Acquired	5/23/2024, 4:20:45 PM UTC
PROJECTION	
EPSG Code	32614
Shape	1. 8,956 2. 9,287
VIEW GEOMETRY	
Sun Azimuth	91.941 °

Satellite Effect on Performance

Multispectral Calibration to L1C

Satellite effect on Instrument performance

- Stability

Required stability: 0.005 °/s
Achieved stability: 0.0015 °/s

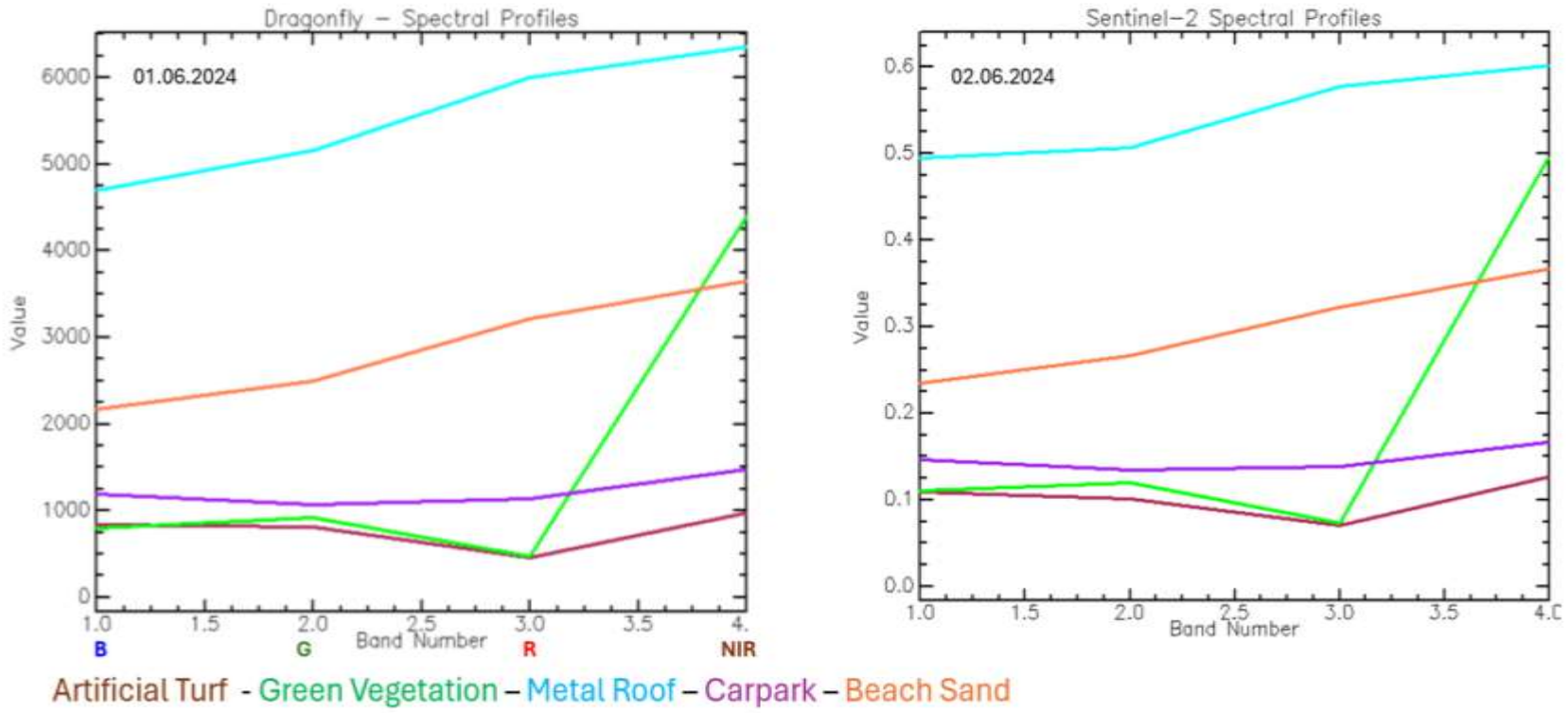
- Pointing Accuracy

Measured geolocation accuracy is better than 100m (3-sigma)

Influence Ground Control Points Search algorithms and processing time.

Multispectral Calibration to L1C: Radiometric Accuracy

- Radiometric accuracy of all bands measured to be less than 5% from Sentinel-2. Below example shows a relative accuracy of 1.73% from Sentinel-2. Absolute radiometric accuracy using in-situ measurements are ongoing.



Sustainability Goal

- Owned by Customer – operated by DFA
- Our part in the full Earth Observation value chain is up to application ready data delivery
- Working closely with processing partner
- Standard Data format for ingesting to the platforms of various End-Users, Resellers, Stakeholders
- Continue to grow in understanding each step in the value chain


Thank you