

EXTENDING LONG-TERM VISUAL SATELLITE HEALTH MONITORING BEYOND TELEMETRY

D. Leidreiter and Mission Operations Technology (MBT) group, DLR GSOC

**ESAW workshop
2026-04-15**





ViDA & ATHMoS

Ground Stations / Voice

- Weilheim
- Kummen / Uralia
- Castle Rock / Alpha

Data Lines

- Weilheim
- Intelsat

Operations

- OPS-Team

Countdown In
Ground System completely GO.
Weather at launch

UTC 028/01:03:42
MET 000/00:00:00

AGI

DLR
Raumfahrt
Kontrollzentrum

DLR
Raumfahrt
Kontrollzentrum

DLR
Raumfahrt
Kontrollzentrum



GSOC

GSOC

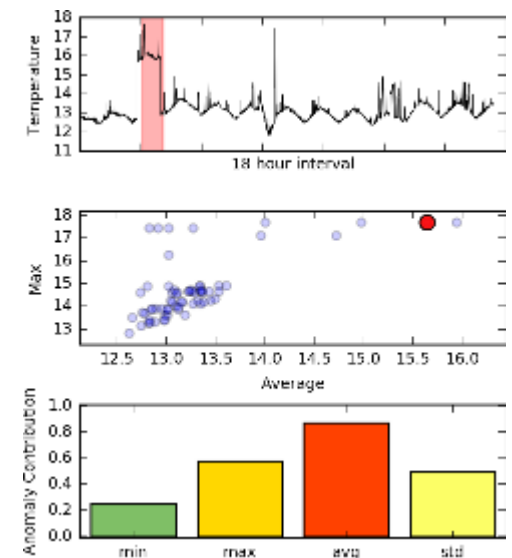
■ ViDA – Visualisation and Data Analysis

- Web-based visualisation platform using offline data, for...
 - ... long-term TM plotting
 - ... bulk routine inspection
 - ... displaying ai derived results, ...
- Orthogonal to existing tools

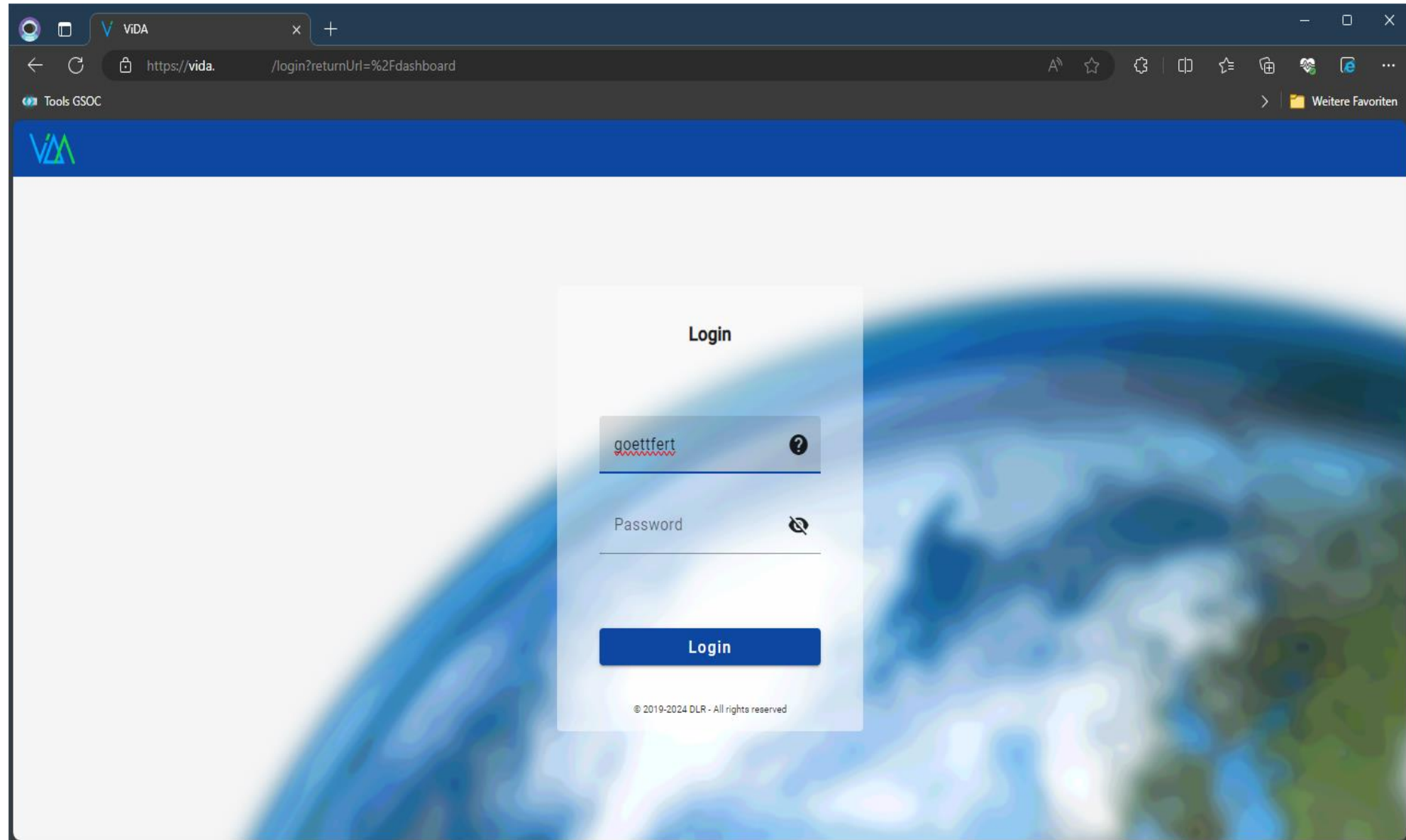


■ ATHMoS – Automated Telemetry Health Monitoring System

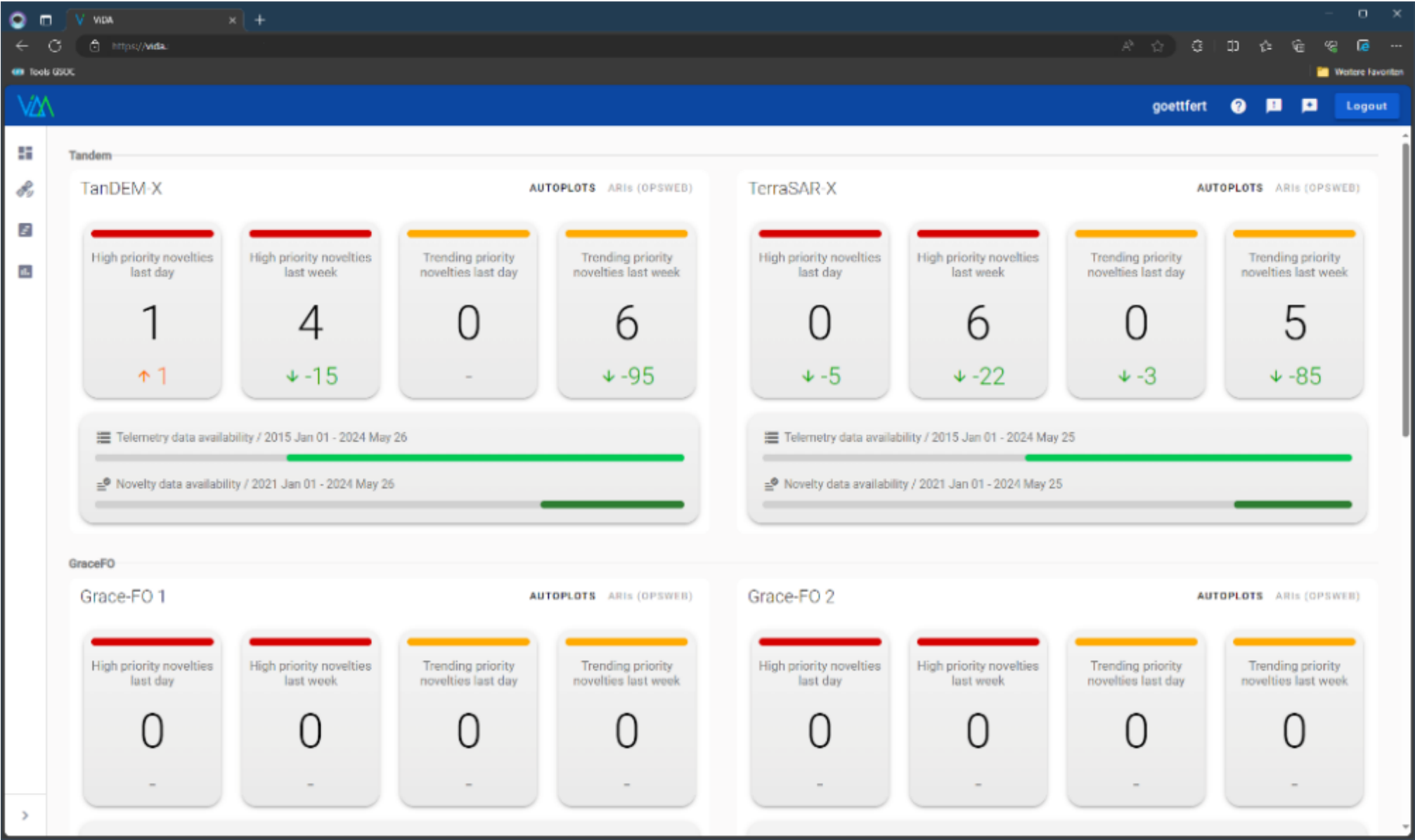
- Novelty detection system
- Semi-supervised „classical“ machine learning
- Monovariate clustering-based method (performant, explainable, little tuning needed)



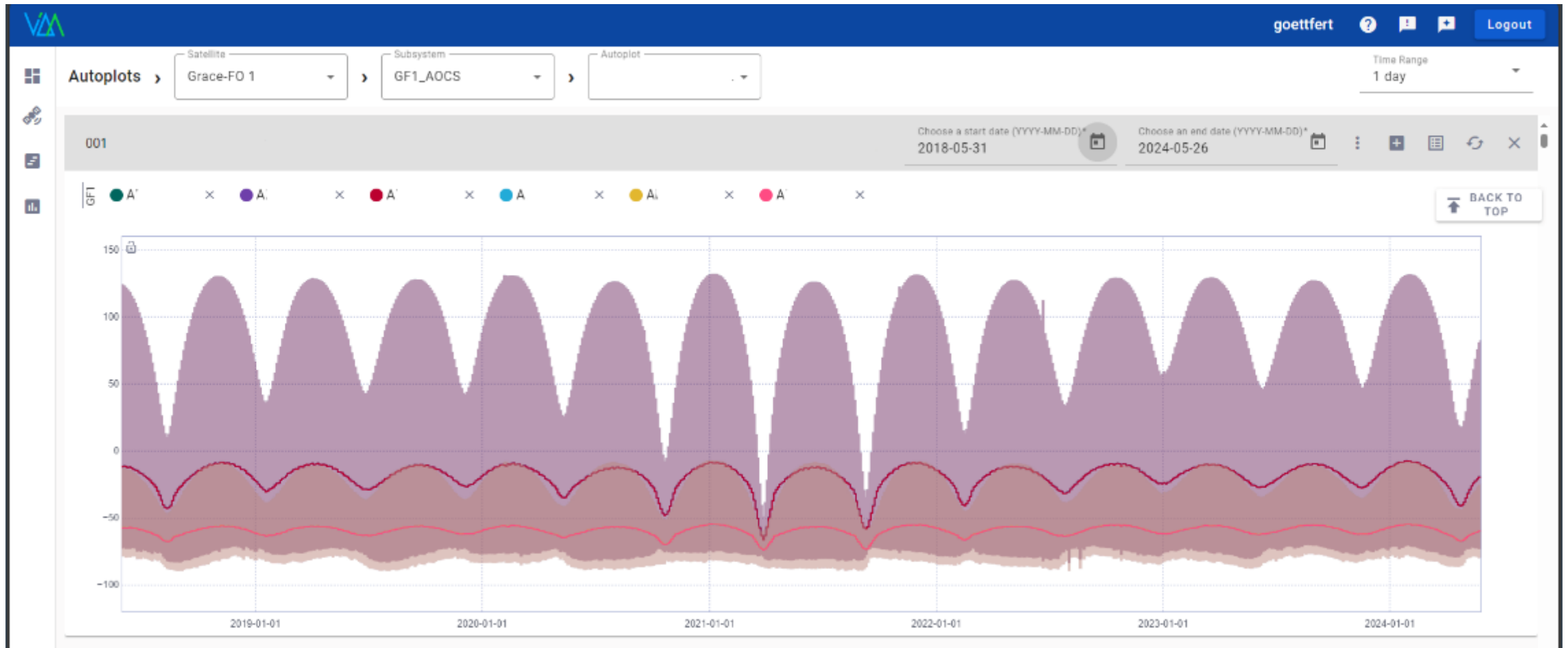
ViDA walk-through



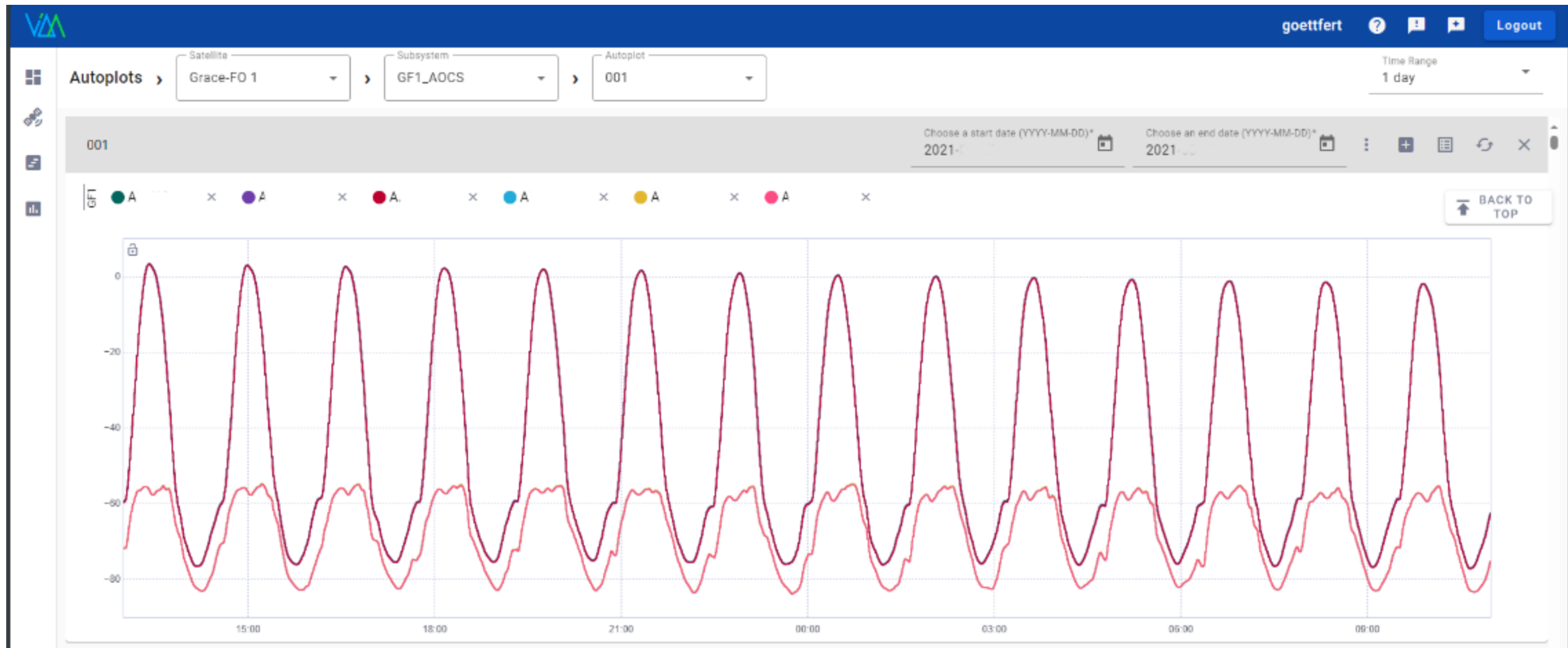
ViDA walk-through



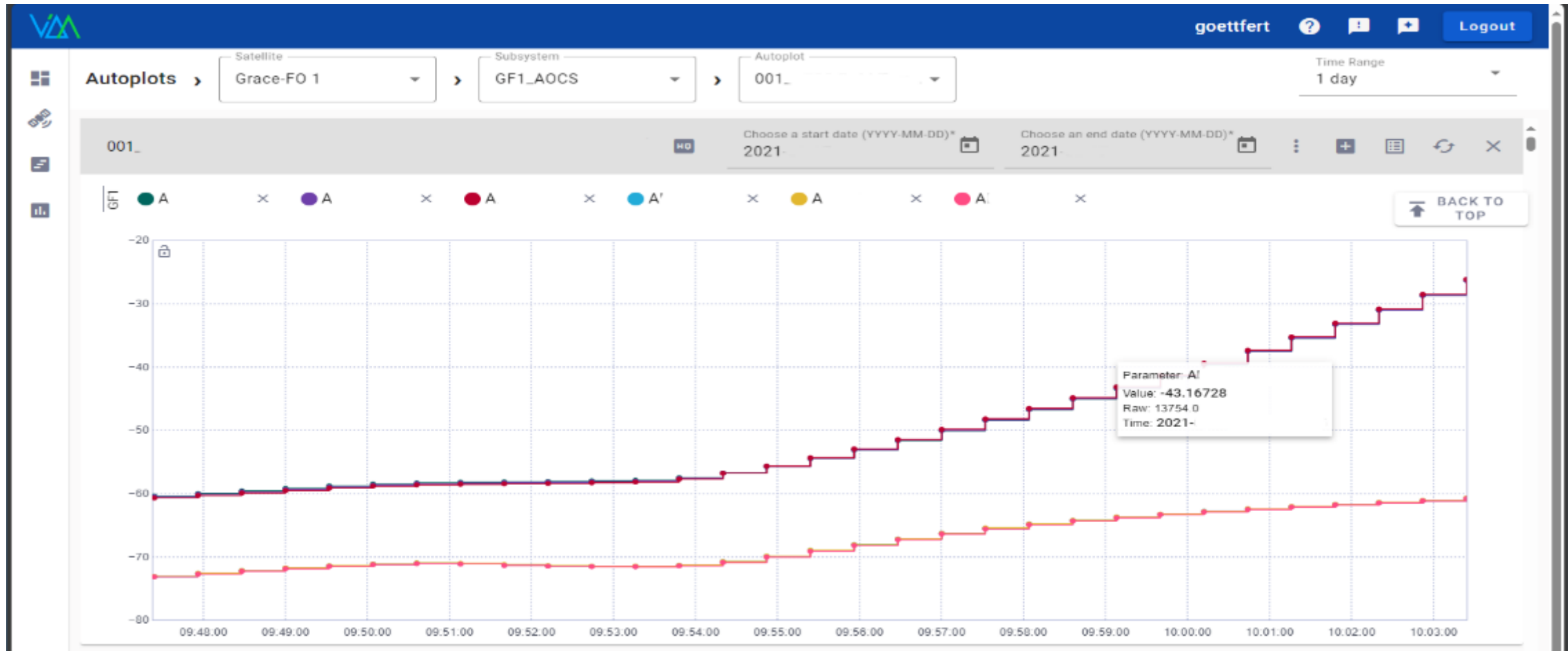
ViDA walk-through



ViDA walk-through



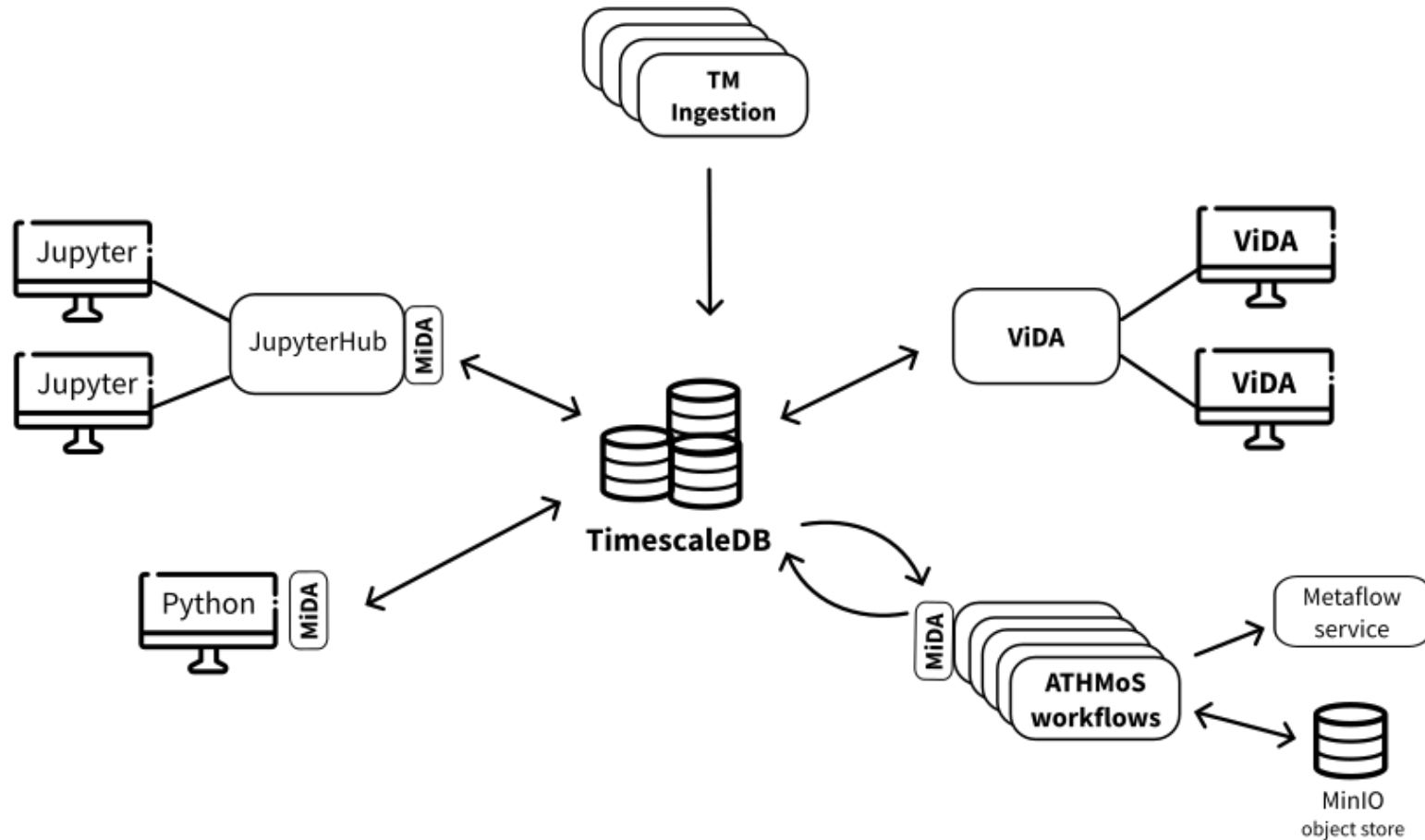
ViDA walk-through





ViDA - INFRASTRUCTURE

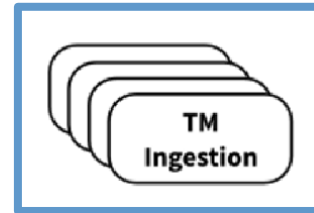
Components & Use Cases



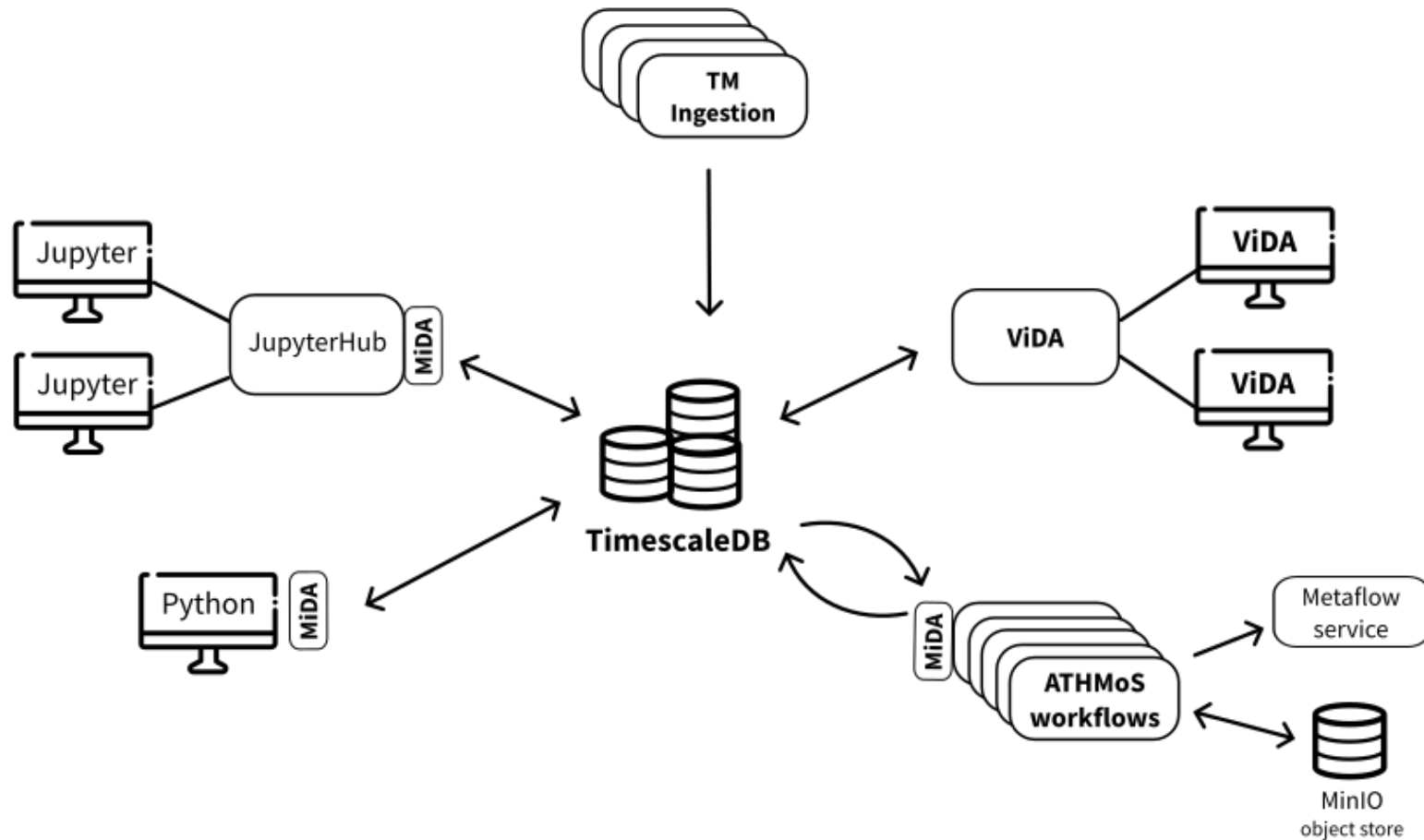
Components & Use Cases

TM Ingestion

- Receives offline TM archives from MCS
- Highly Parallelised



Components & Use Cases



Components & Use Cases

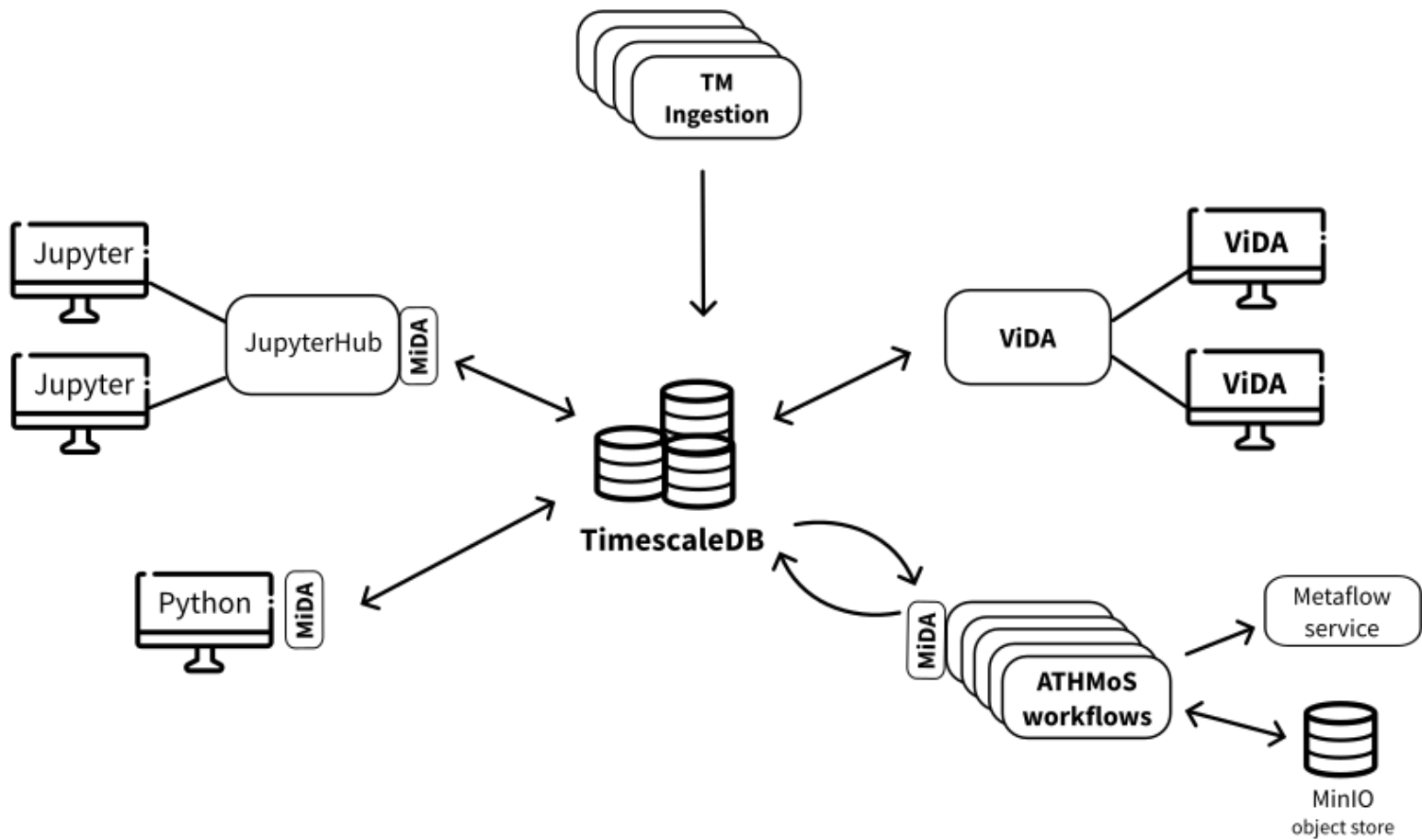


TimescaleDB

- efficient and performant timeseries data in PostgreSQL
- We use:
 - Hypertable storage for timeseries data
 - Compression
 - Hierarchical Aggregation
 - Hyperfunctions



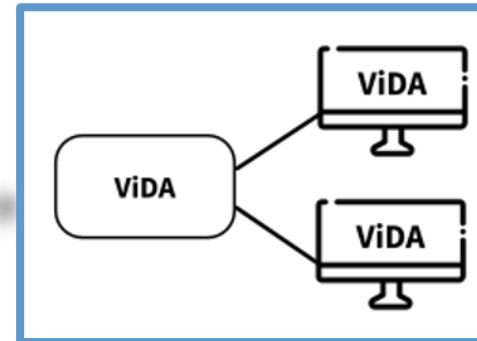
Components & Use Cases



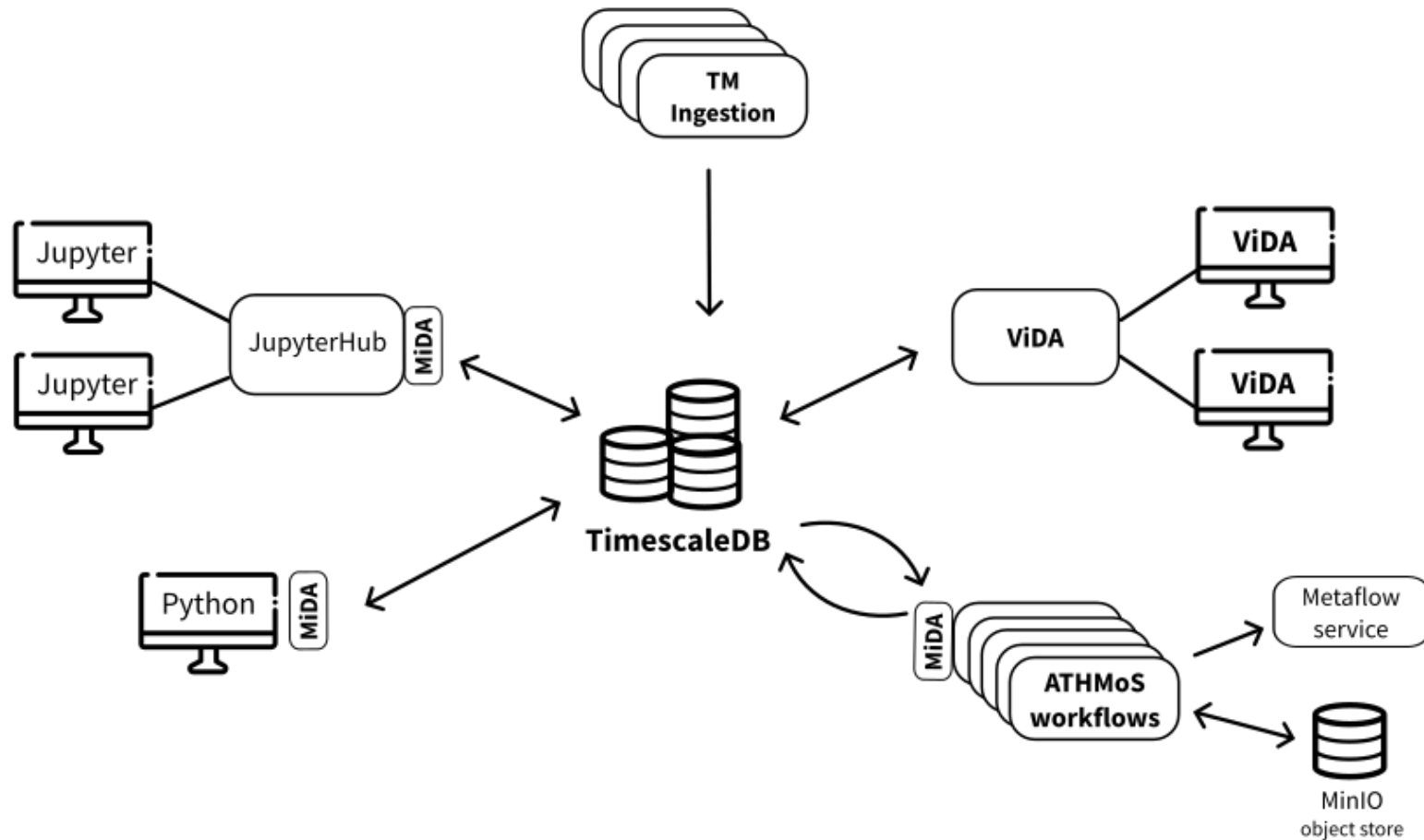
Components & Use Cases

ViDA Frontend & Backend

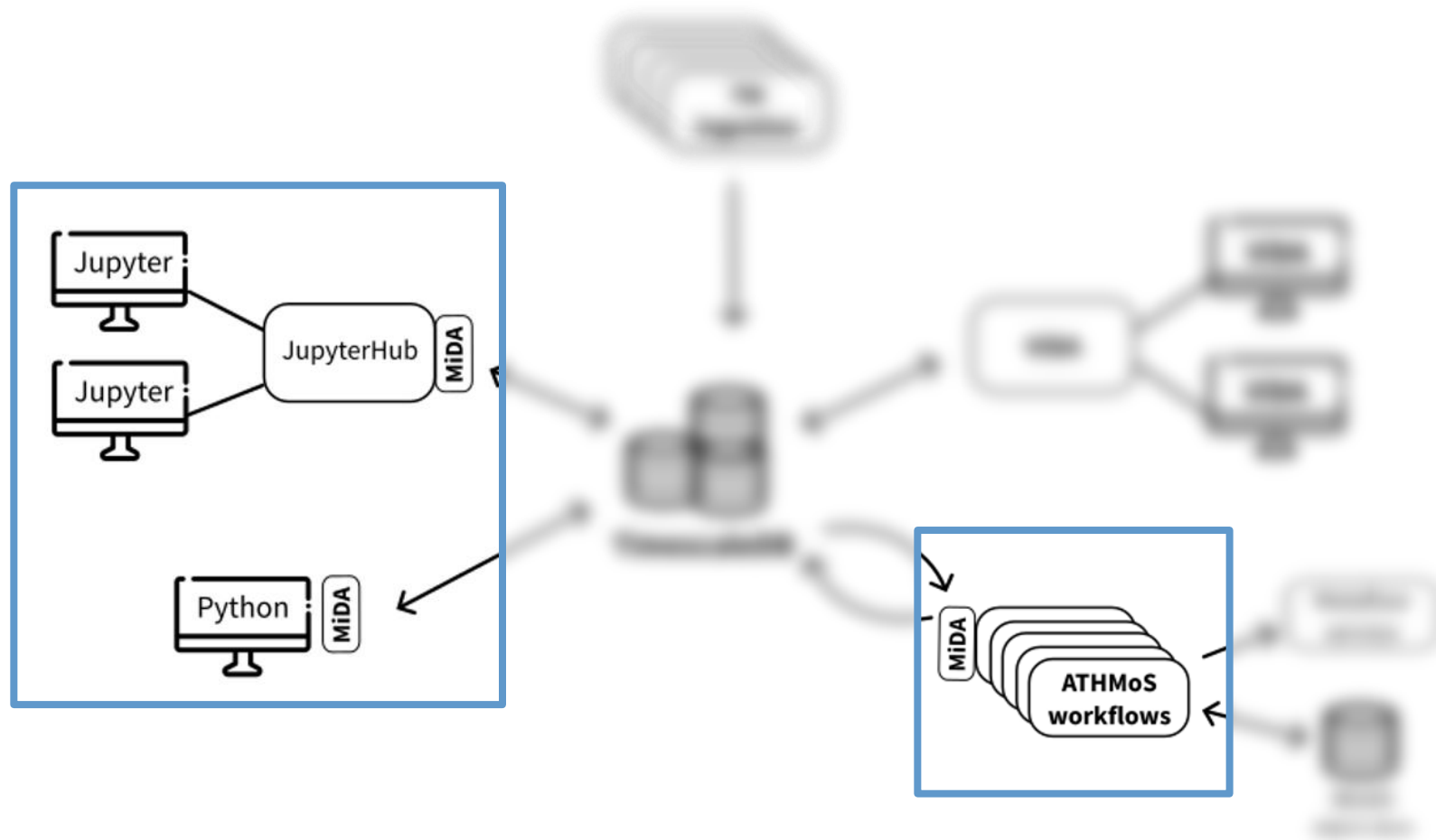
- Frontend
 - Requests data via GraphQL
 - Plots data
- Backend
 - Checks permissions
 - Requests data from database



Components & Use Cases



Components & Use Cases

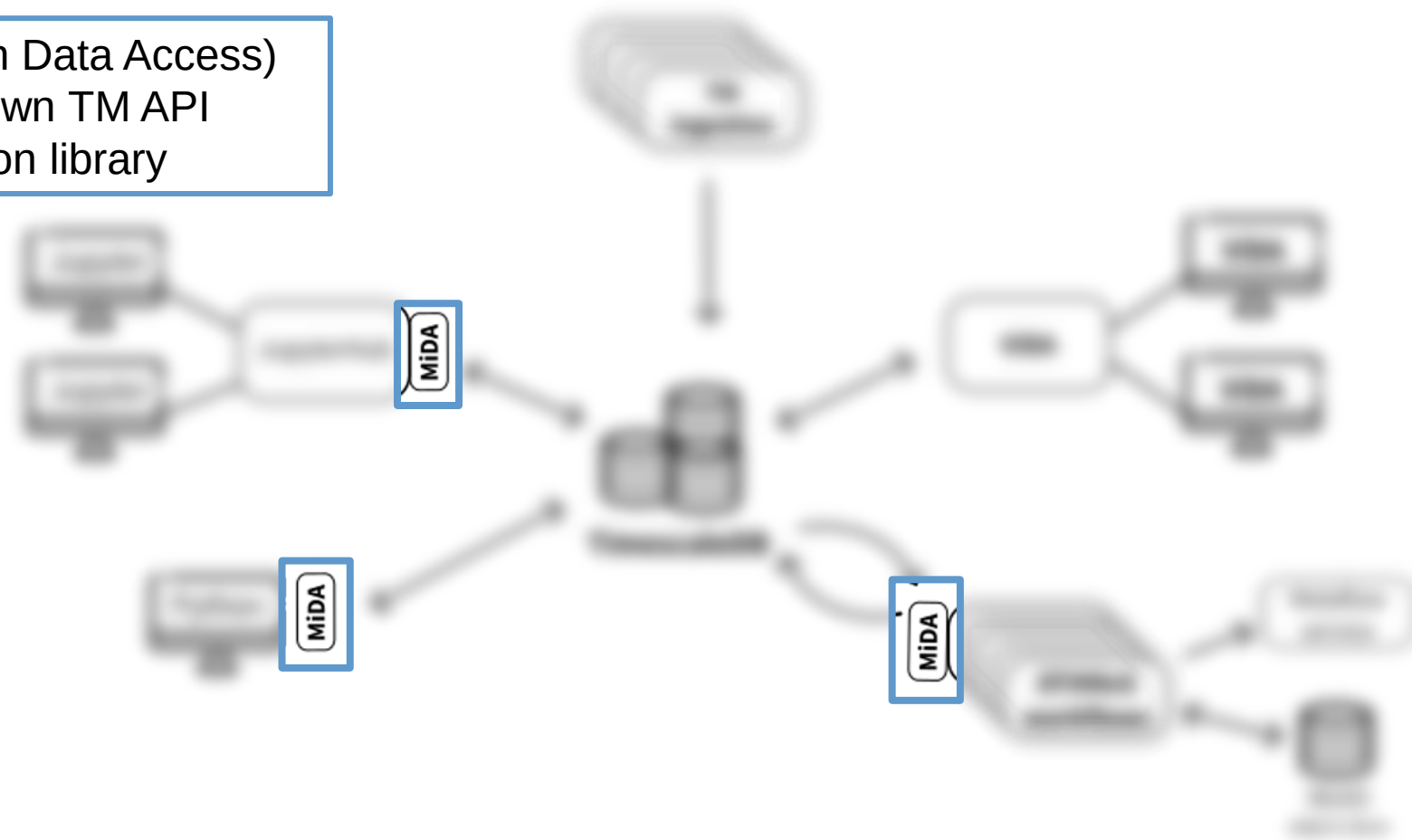


Components & Use Cases

MiDA

(Mission Data Access)

- our own TM API
- Python library



Components & Use Cases



MiDA

(Mission Data Access)

- our own TM API
- Python library

MiDA example

```
1 import mida.mission_data as md
2 from mida.mission_data import Db, Table, Column
3 db = md.mbt_database_connection(user="johndoe", pw="<here-or-interactively>")
4 data = db.read(Db.EXMPL, Table.TM, Column.PAR("=", "ANGSP_1"), ("2018-01-01", "2019-01-01"))
5 display(data) # is a pandas dataframe
```

The background of the slide is a photograph of a satellite in orbit. The satellite has a central body wrapped in crinkled gold thermal insulation and two large, rectangular solar panel arrays extended outwards. The panels are white with visible black circuitry. The satellite is positioned against the backdrop of the Earth's blue and white horizon and a deep black space filled with numerous stars.

CONTEXT VIA OPS PRODUCTS

Finding explanations for novelties

- Possible Causes:
 - Hardware malfunctions / degradation
 - Space weather
 - Manoeuvres / experiment operations
 - ...
- Avenues of Investigation:
 - Look at more TM + knowledge of S/C
 - Ask other engineers
 - Search Ops Products



- Telecommand Log (TCLog)
 - Log of all TCs released from control software
 - Includes TC Parameter values, Acknowledges, ...

Name	Description	PID	SSC	Release Time	Execution Time	R	GTO	A	C
TC000001	Test Command 1	1	0	2050.001.00.00.01	2050.001.00.00.01.800	S	SSS	S	S
TC000001	Test Command 1	1	1	2050.001.00.02.01	2050.001.00.02.01.800	S	SSS	S	S
TC000002	Test Command 2	2	0	2050.001.05.00.01	2050.002.00.06.01.800	S	SSS	S	I
TCPAR001	PAR VALUE 1	ENG		SOMEVALUE					
TCPAR002	PAR VALUE 2	ENG		10					
TCPAR003	PAR VALUE 3	ENG		OTHERVALUE					
TCPAR004	PAR VALUE 4	ENG		22					
TC000001	Test Command 1	1	2	2050.001.05.30.01	2050.001.05.30.01.800	S	SSS	S	S

- Telecommand Acknowledge History (TCAH)
 - Log of all TC acknowledges received from the S/C
 - Includes Error Codes

Generation Time	Reception Time	APID	PID	SSC	SType	FID	TC_SSC
2050.001.00.00.01.500	2050.003.00.01.01.300	10	1	101	ACC_OK	-	0
2050.001.00.00.01.850	2050.003.00.01.01.300	10	1	102	EXE_OK	-	0
2050.001.00.02.01.450	2050.003.00.01.01.300	10	1	103	ACC_OK	-	1
2050.001.00.02.01.900	2050.003.00.01.01.300	10	1	104	EXE_OK	-	1
2050.001.05.30.01.550	2050.003.00.01.01.300	10	1	105	ACC_OK	-	2
2050.001.05.30.01.800	2050.003.00.01.01.300	10	1	106	EXE_OK	-	2
2050.002.00.06.01.600	2050.003.00.01.01.300	22	2	10	ACC_OK	-	0
2050.002.00.06.01.950	2050.003.00.01.01.300	22	2	11	EXE_OK	-	0

- Log Messages generated by S/C
- ...

OPS Products: Current Situation



- Large tabular archive files
- Information spread between files
- Difficult to search

OPS Products: Goals



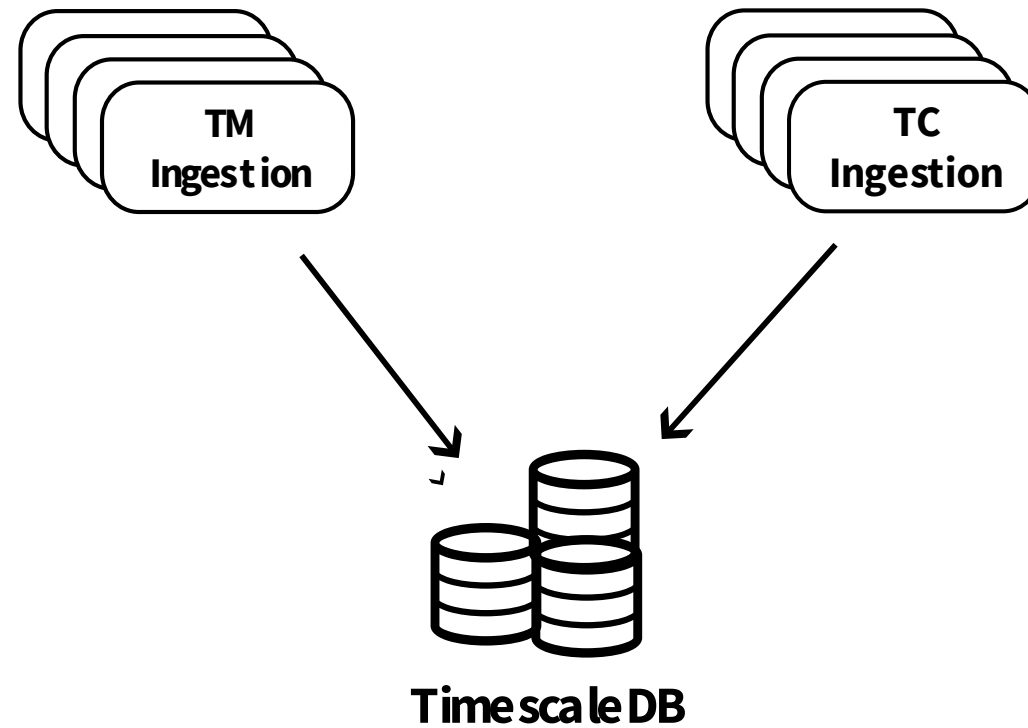
- Ops Products should be accessible
 - In ViDA
 - Via the MiDA API (to our AI tools)

➤ Easy to search / access

The background of the slide is a photograph of a satellite in orbit. The satellite has a central body covered in crinkled gold thermal insulation and two large, rectangular solar panel arrays extended outwards. The panels are white with visible black circuitry and wiring. The satellite is positioned against the backdrop of the Earth's blue and white horizon, with a field of stars visible in the deep black space above.

TELECOMMAND INGESTION

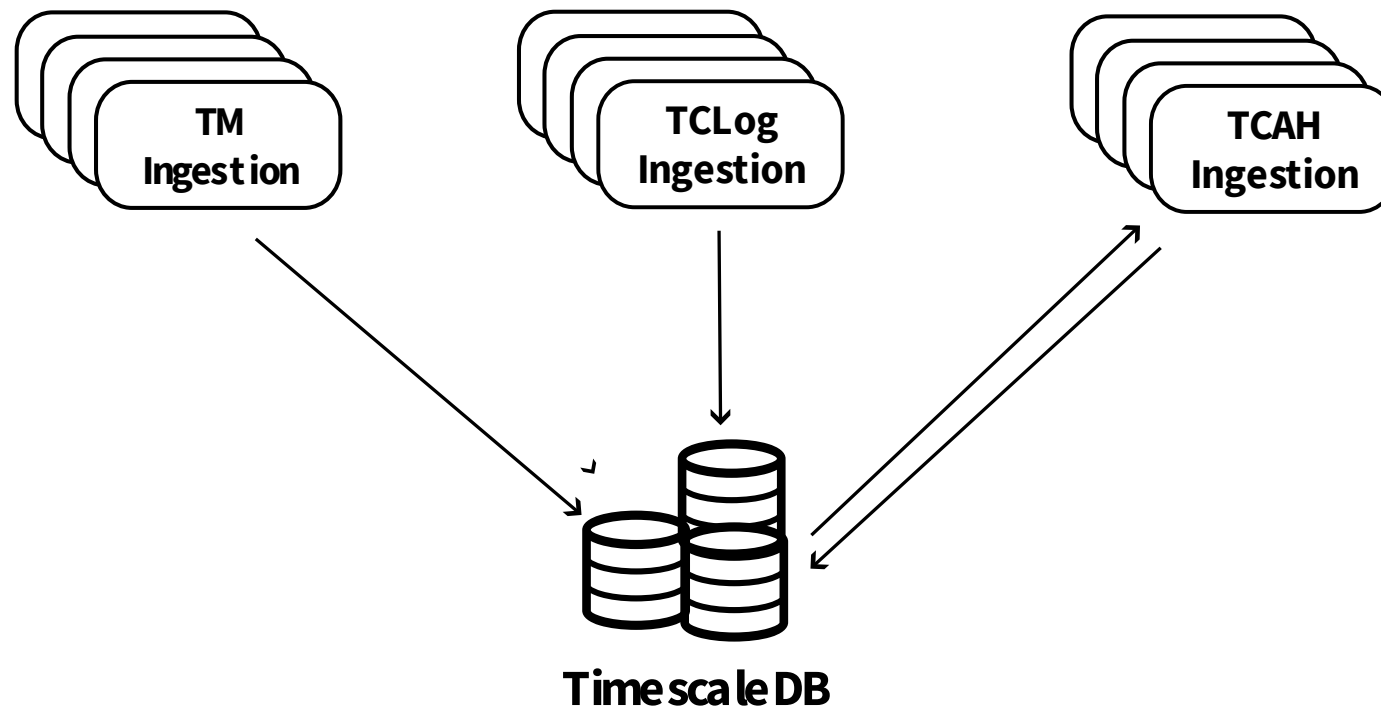
TC Ingestion Process



- Multiple sources of truth (TCLOG, TCAH)
 - Products can arrive independently
 - Delay between entries in TCLOG and TCAH

➤ Careful matching of data needed

TC Ingestion Process



Ingestion – Matching TC Information



Generation Time	PID	SType	TC_SSC
2050.001.00.00.01.500	1	ACC_OK	0
2050.001.00.00.01.850	1	EXE_OK	0
2050.001.00.02.01.450	1	ACC_OK	1
2050.001.00.02.01.900	1	EXE_OK	1
2050.001.05.30.01.550	1	ACC_OK	2
2050.001.05.30.01.800	1	EXE_OK	2
2050.002.00.06.01.600	2	ACC_OK	0
2050.002.00.06.01.950	2	EXE_OK	0

Ingestion – Matching TC Information



Generation Time	PID	SType	TC_SSC
2050.001.00.00.01.500	1	ACC_OK	0
2050.001.00.00.01.850	1	EXE_OK	0
2050.001.00.02.01.450	1	ACC_OK	1
2050.001.00.02.01.900	1	EXE_OK	1
2050.001.05.30.01.550	1	ACC_OK	2
2050.001.05.30.01.800	1	EXE_OK	2
2050.002.00.06.01.600	2	ACC_OK	0
2050.002.00.06.01.950	2	EXE_OK	0

Ingestion – Matching TC Information



Generation Time	PID	SType	TC_SSC
2050.001.00.00.01.500	1	ACC_OK	0
2050.001.00.00.01.850	1	EXE_OK	0
2050.001.00.02.01.450	1	ACC_OK	1
2050.001.00.02.01.900	1	EXE_OK	1
2050.001.05.30.01.550	1	ACC_OK	2
2050.001.05.30.01.800	1	EXE_OK	2
2050.002.00.06.01.600	2	ACC_OK	0
2050.002.00.06.01.950	2	EXE_OK	0

Ingestion – Matching TC Information



Name	PID	SSC	Execution Time	R	GTO	A	C

TC000001	1	0	2050.001.00.00.01.800	S	SSS	S	S
TC000001	1	1	2050.001.00.02.01.800	S	SSS	S	S
TC000002	2	0	2050.002.00.06.01.800	S	SSS	S	I
TC000001	1	2	2050.001.05.30.01.800	S	SSS	S	S

Ingestion – Matching TC Information



Name	PID	SSC	Execution Time	R	GTO	A	C

TC000001	1	0	2050.001.00.00.01.800	S	SSS	S	S
TC000001	1	1	2050.001.00.02.01.800	S	SSS	S	S
TC000002	2	0	2050.002.00.06.01.800	S	SSS	S	I
TC000001	1	2	2050.001.05.30.01.800	S	SSS	S	S

- PID-SSC combinations repeat (NOT unique)
- Not all acknowledges expected for all TCS
- ...

The background of the slide is a photograph of a satellite in orbit above Earth. The satellite has a central body wrapped in crinkled gold thermal insulation and two large, rectangular solar panel arrays extended outwards. The panels are white with visible black circuitry and wiring. The Earth's blue and white horizon is visible at the bottom, and the blackness of space with distant stars is at the top.

TELECOMMANDS IN VIDA

- Use Case 1:
 - TCs as context for telemetry
 - Vertical lines in telemetry plots

- Use Case 2:
 - TC information archive
 - Detailed Tabular View of TCs

TC Plots - TC Selection

Select ops products

Search

TDX TC

Mission/Satellite
TDX

Subsystem

Type
TC

TDX	A AACS TC	☐
TDX	B PTS TC	☐
TDX	Y TMTG TC	☐

Select Deselect Cancel Clear Plot

TC Plots - TC Selection

Select ops products

Search

TDX

TMTC

TC

Mission/Satellite

Subsystem

Type

TDX

TMTC

TC

Selected ops products

Y

TDX

Y

TMTC | TC |

☒

Select

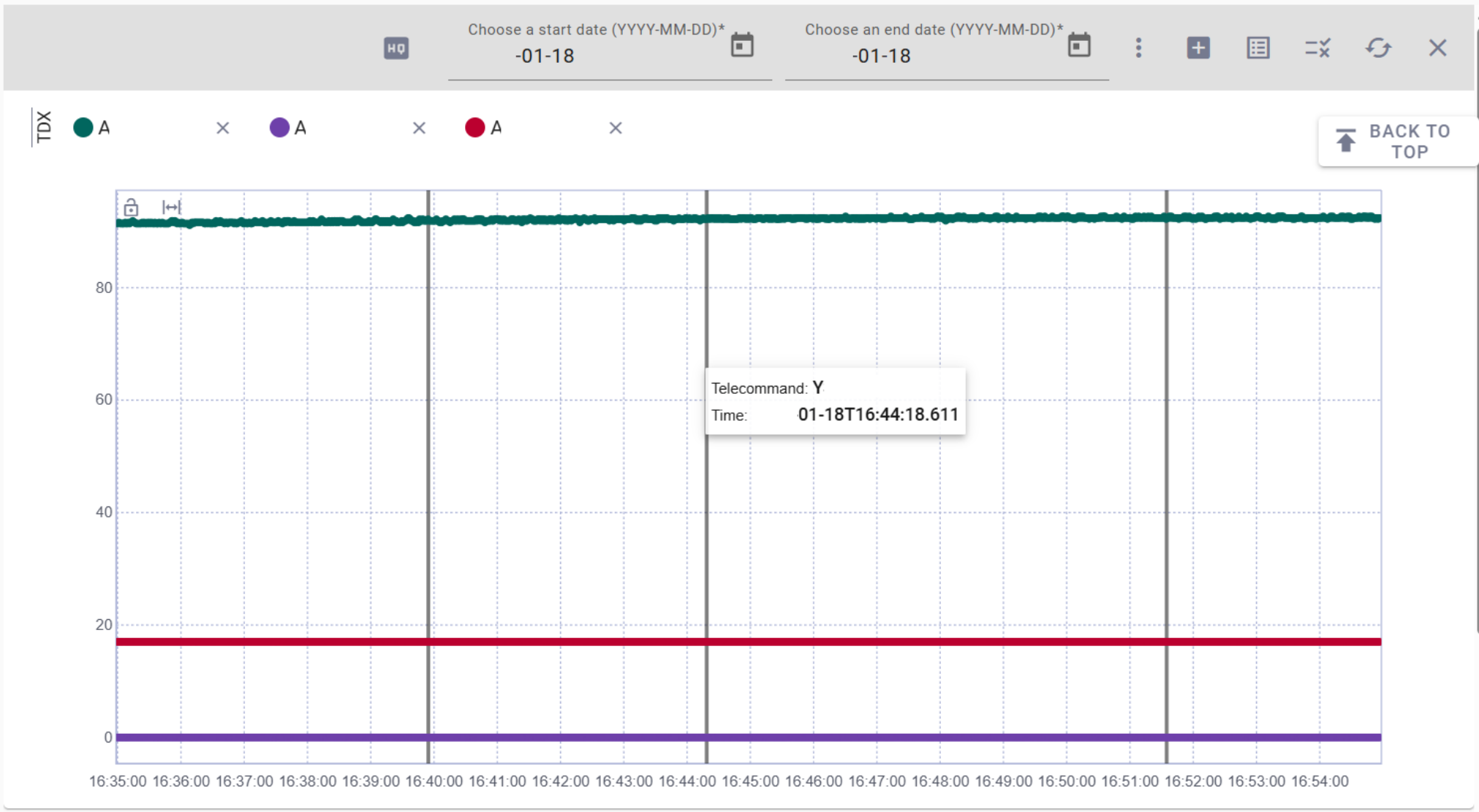
Deselect

Cancel

Clear

Plot

TC Plots



Conclusion & Outlook



■ Status

- TC ingestion fully implemented, but not yet live
 - Historic TCs ingested for 2 satellites
- ViDA TC plot implementation in progress
- MiDA TC API access implemented

■ Plans

- Enable TC ingestion & visualization for all missions in office
- ViDA TC table view

Topic: **Extending long-term visual satellite health monitoring beyond telemetry**

Date: 2026-04-15

Author: Daniel Leidreiter

Institute: DLR-RB
German Aerospace Center – Space Operations and Astronaut Training

Image credits: DLR, ESA

Icons:
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