ODARIS

ON-BOARD DATA ANALYSIS AND REAL-TIME INFORMATION SYSTEM

Kurt Schwenk, Daniel Herschmann

DLR – Raumflugbetrieb und Astronautentraining

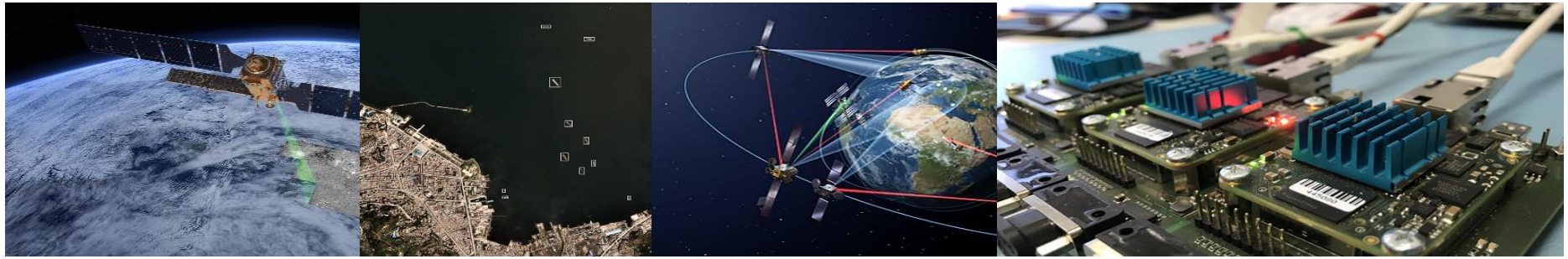
EDHCP 2022 – 06.10.2023

Session 29 – Software for On-Board Data Handling and Processing

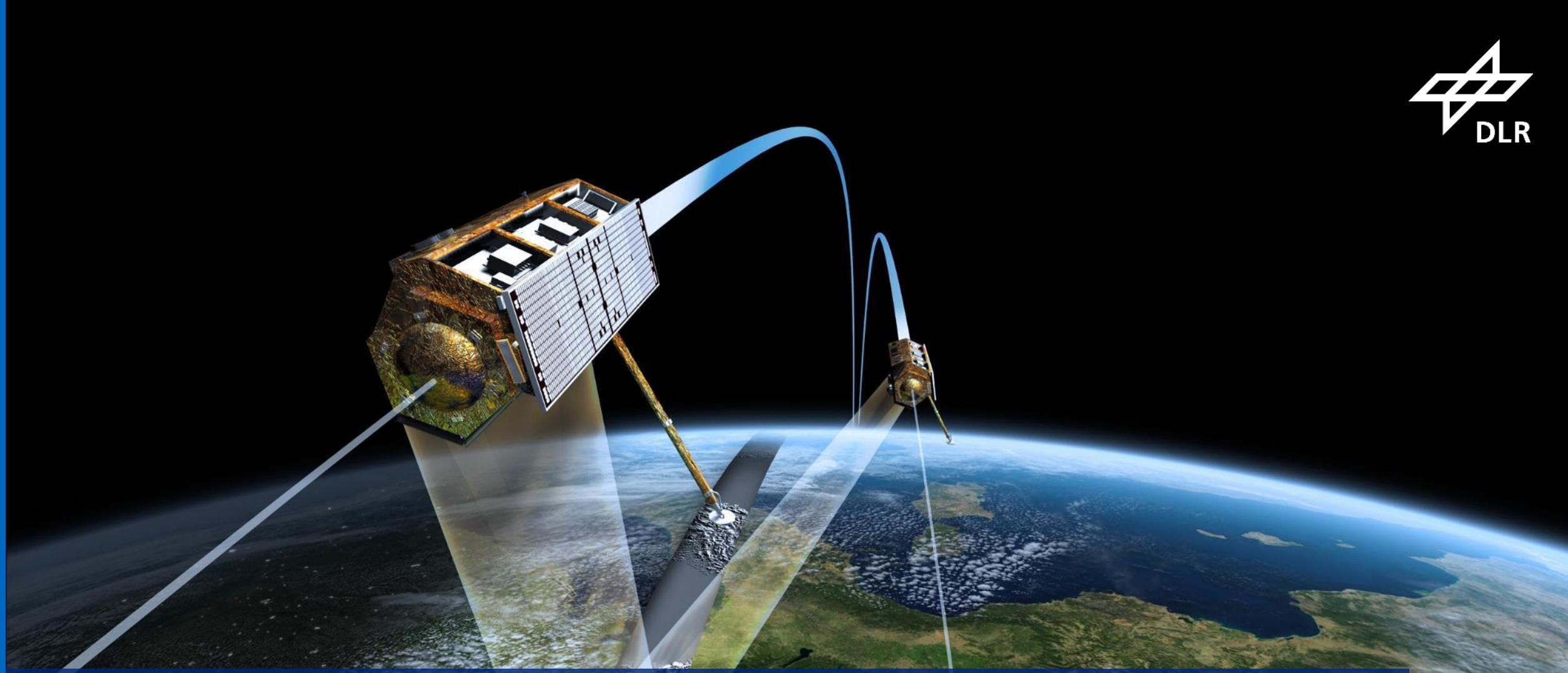
DLR

AGENDA

Adenda



1. Background & Motivation
2. The ODARIS Concept
3. System architecture
4. Data Handling and Processing
5. Implementation Details
6. Summary & Outlook



BACKGROUND & MOTIVATION

Background: Who are we ?

Who:

- Kurt Schwenk, Daniel Herschmann
- Management, Development, Operation

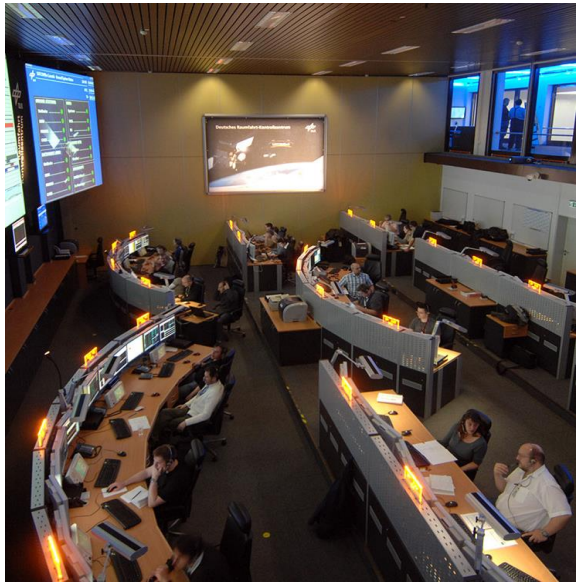
Where:

- DLR – Oberpfaffenhofen (Munich)
- Space Operations and Astronaut Training
- On Orbit Servicing and Autonomy Group (Space flight technology)

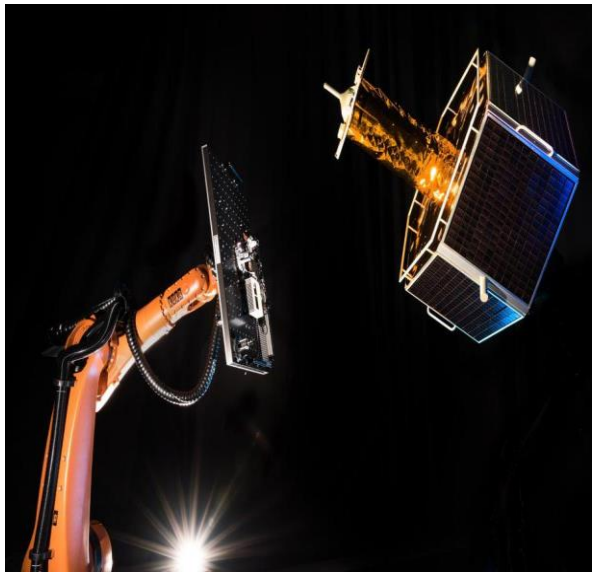
Topic:

- On-Board Data Analysis and real-time information system*
- Knowledge: C++, Linux, Embedded systems, rt com, on-board computing, AI infrastructure, SW build&deploy, project management

DLR sites in Germany, dlr.de



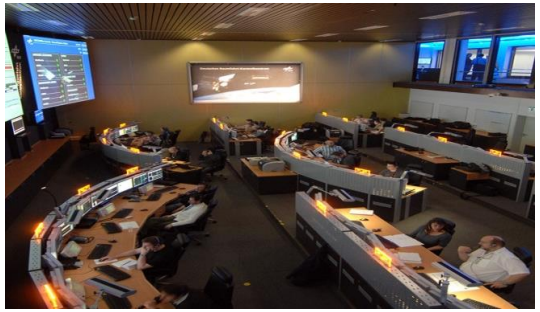
GSOC control room



EPOS Facility

* Schwenk, Kurt und Herschmann, Daniel, *On-Board Data Analysis and Real-Time Information System – Status&Outlook.* Deutscher Luft- und Raumfahrtkongress 2022, Sep. 2022, https://elib.dlr.de/192449/

Background: Motivation



Satellite operation

- Communication via ground stations
- Passive data store-forward operation

Bottlenecks

- Low responsiveness
- Limited download capacity
- Low operation flexibility
- Inefficient resource usage
- Good for classical remote sensing
- Bad for monitoring applications

Background: Motivation

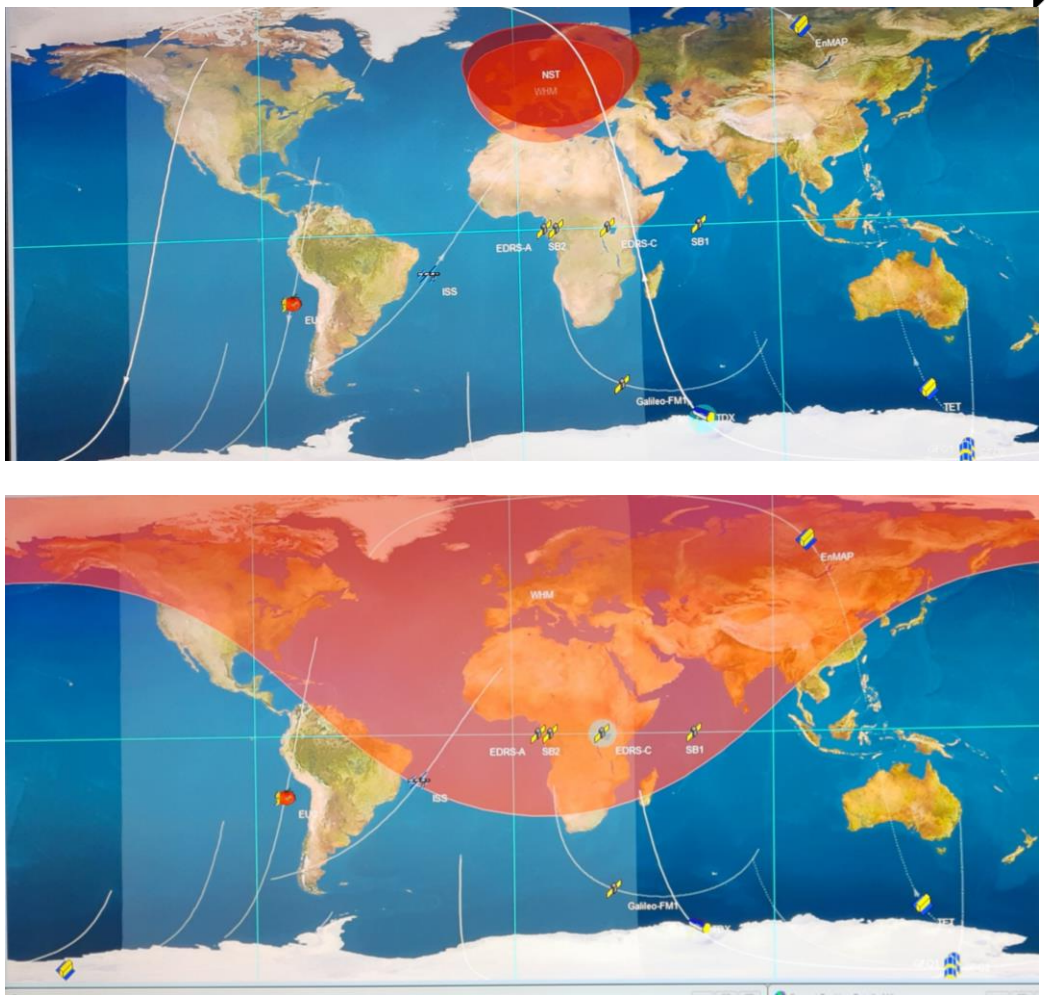
Technology development

- Data relay satellite networks
- Laser based communication
- Sat-Sat constellation communication
- Onboard data compression

Wanted

For small/medium sized satellite missions

- Low latency alarming services
- On demand data access



Ground station contact windows of satellite missions

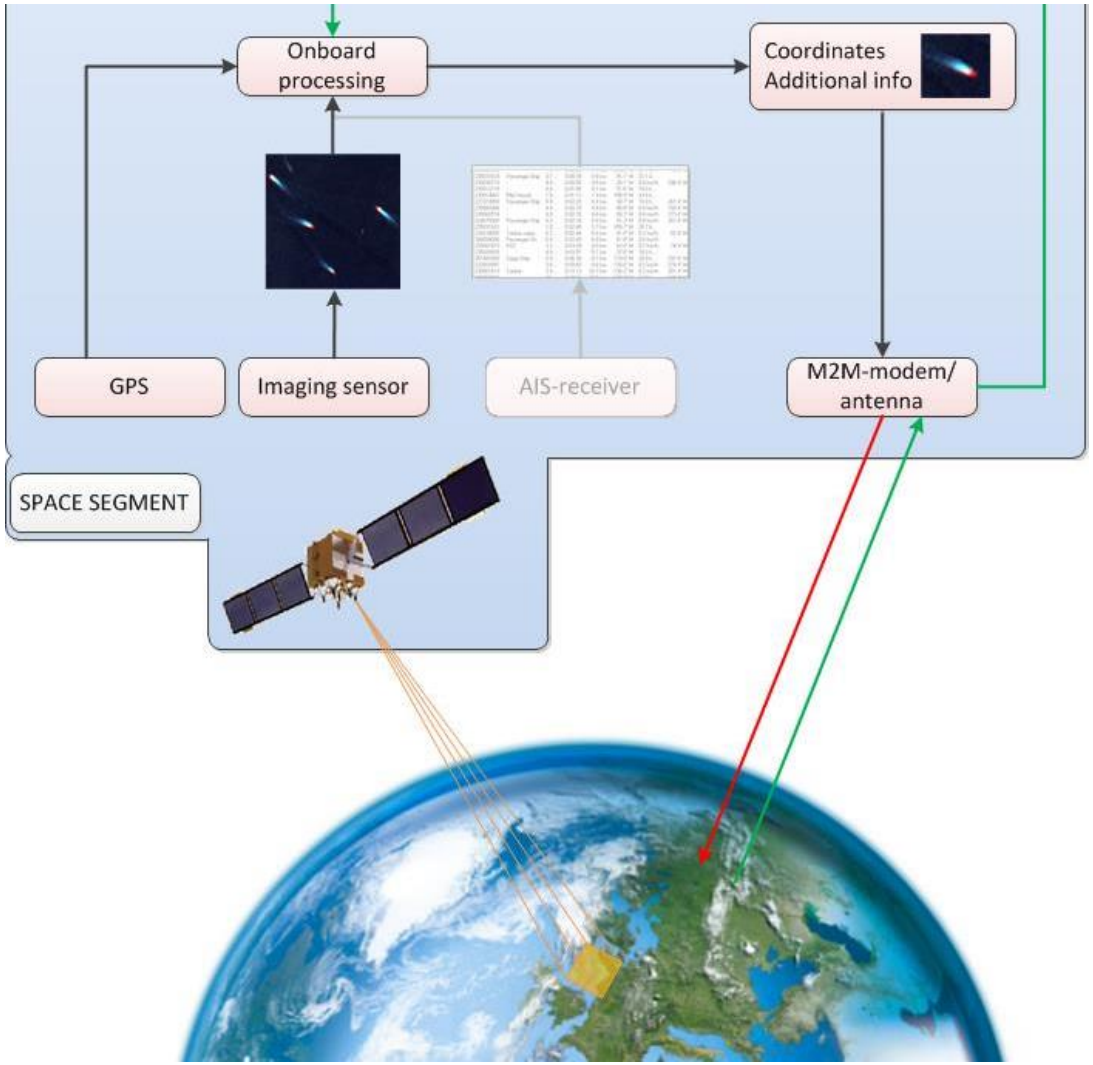
Background: Solution Approach on-board computing

Enabling technology

- Satellite networks meant for telecommunication (Iridium)
- Issue: Very low bandwidth
- Countermeasure: On-Board product data generation (edge computing)

Open issues

- Real-time communication link
- Information system
- On-board data processing
- Application service platform
- Space segment compatibility



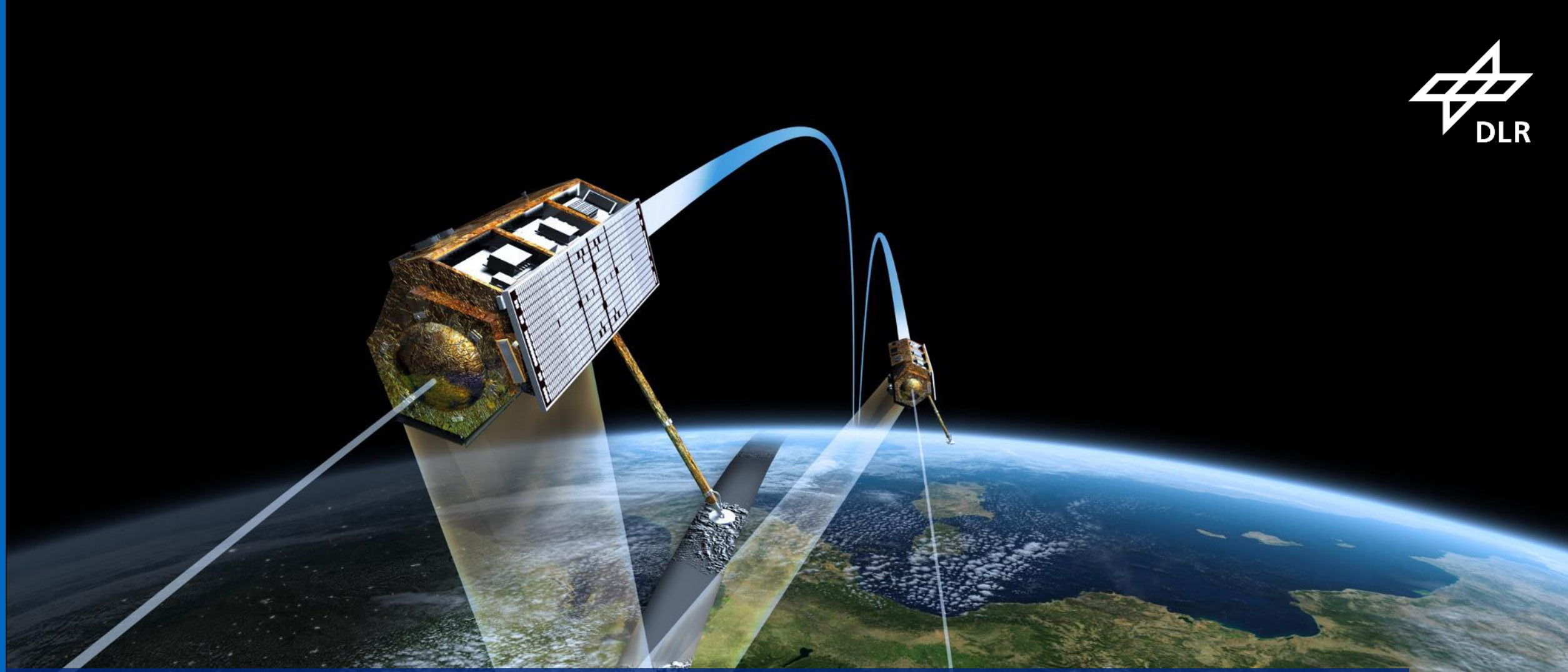
Concept of an on-board computing system

Background: History

Idea
(before 2016)

Amaro (2016-2018)
- Aircraft flight experiment
- On-Board Ship Detection System

ODARIS (Since 2019)
- Space experiment preparation
- AI application
- Participation ScOSA, Seranis (2022)

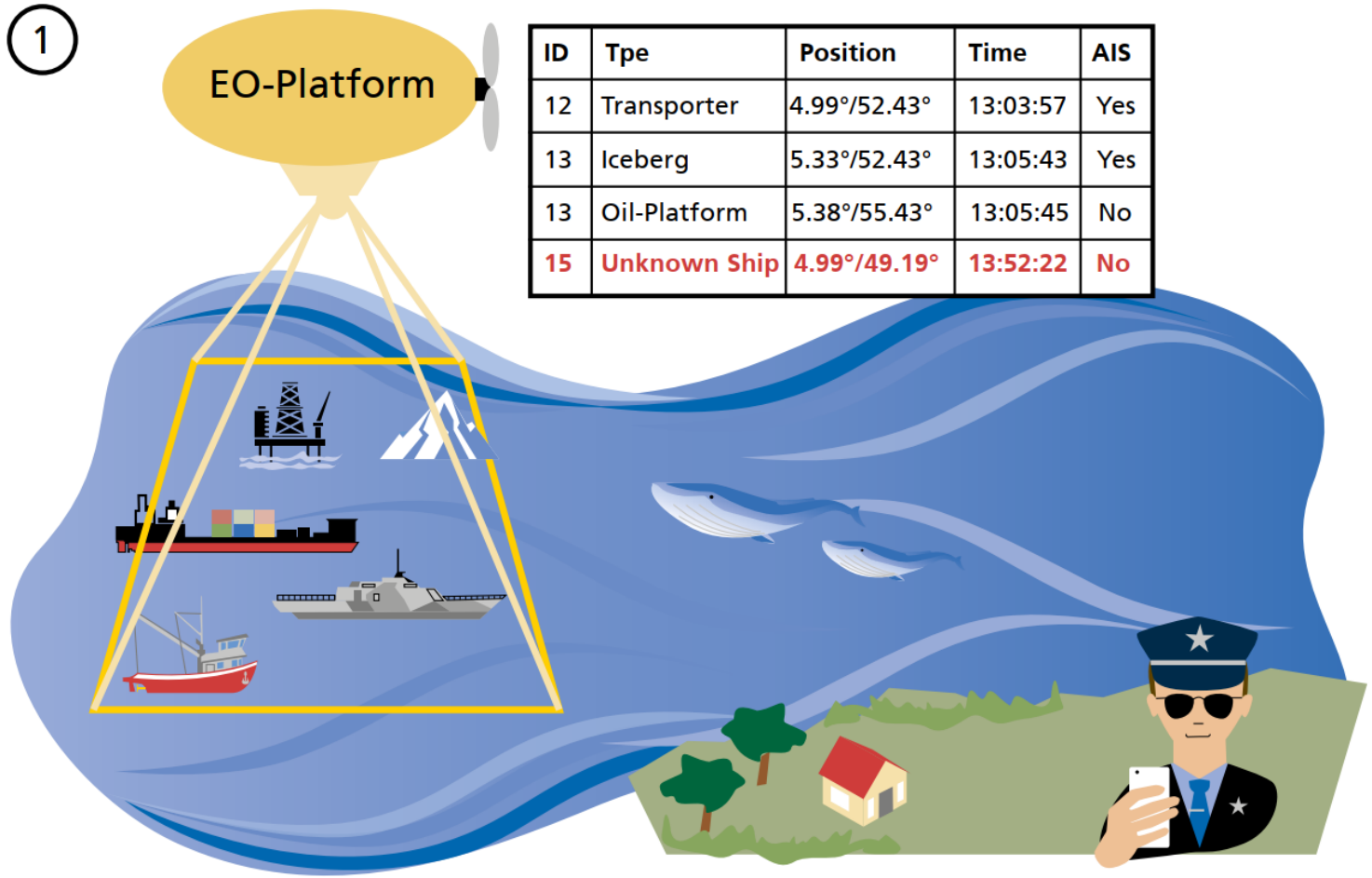


THE ODARIS CONCEPT

USE CASE SCENARIO

ODARIS – Use-case example scenario

Example scenario meant for illustration of the basic concept. Usecase does not necessarily reflect any current mission or configuration

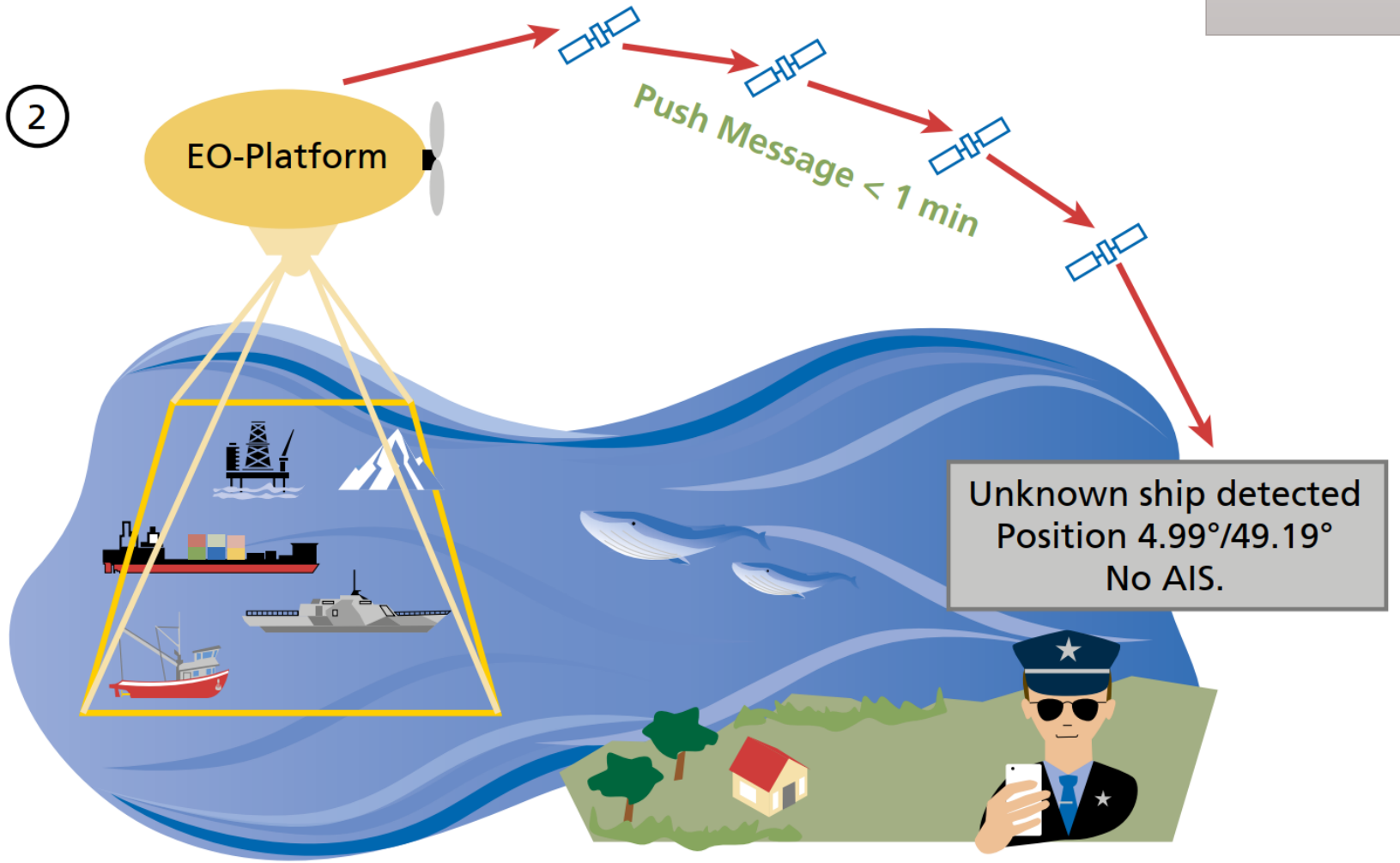


ID	Tpe	Position	Time	AIS
12	Transporter	4.99°/52.43°	13:03:57	Yes
13	Iceberg	5.33°/52.43°	13:05:43	Yes
13	Oil-Platform	5.38°/55.43°	13:05:45	No
15	Unknown Ship	4.99°/49.19°	13:52:22	No

Step 1: Images are captured, analysed and alarm event detection is performed

ODARIS – Use-case example scenario

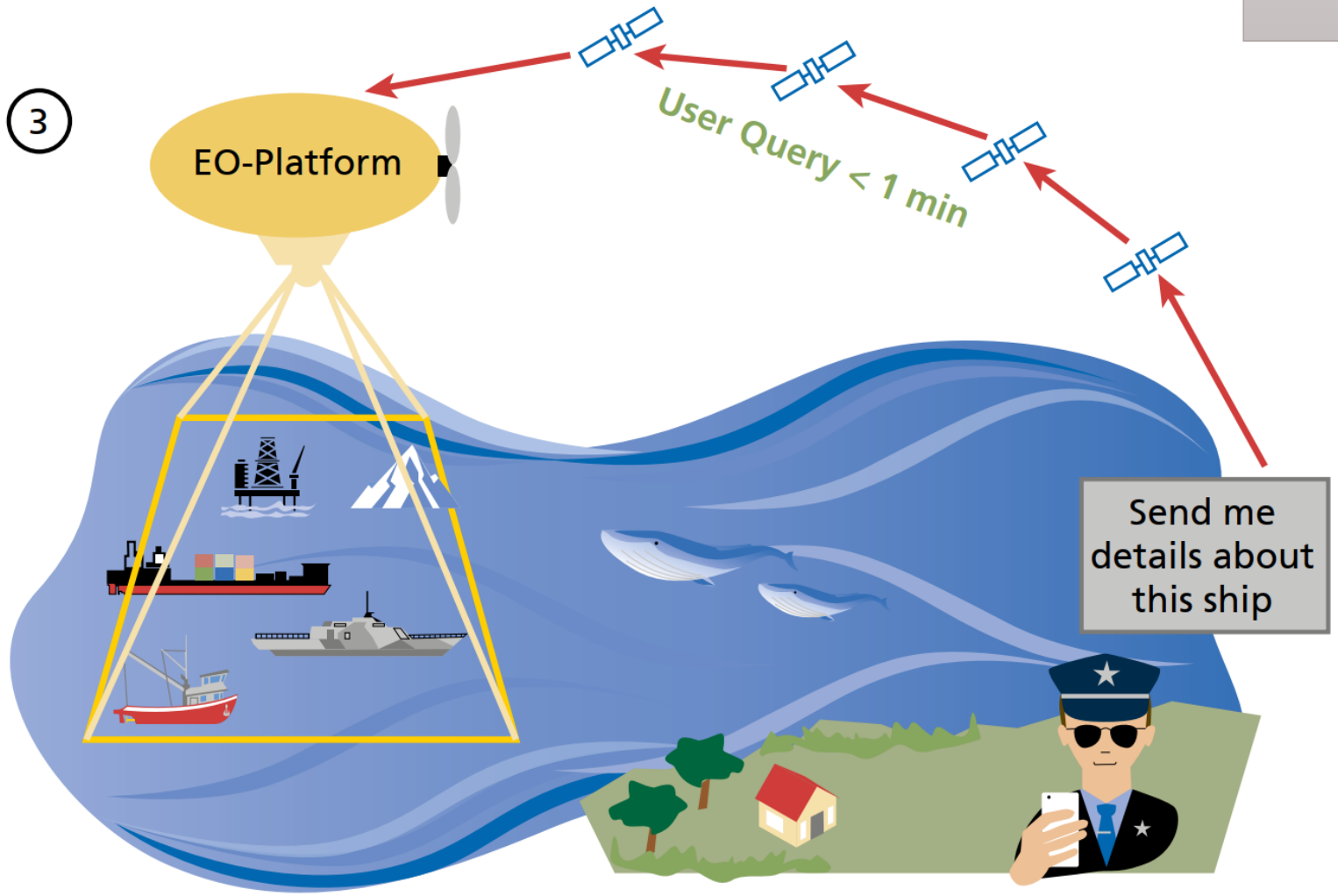
Example scenario meant for illustration of the basic concept. Usecase does not necessarily reflect any current mission or configuration



Step 2: Alarm event message is generated and sent to the user

ODARIS – Use-case example scenario

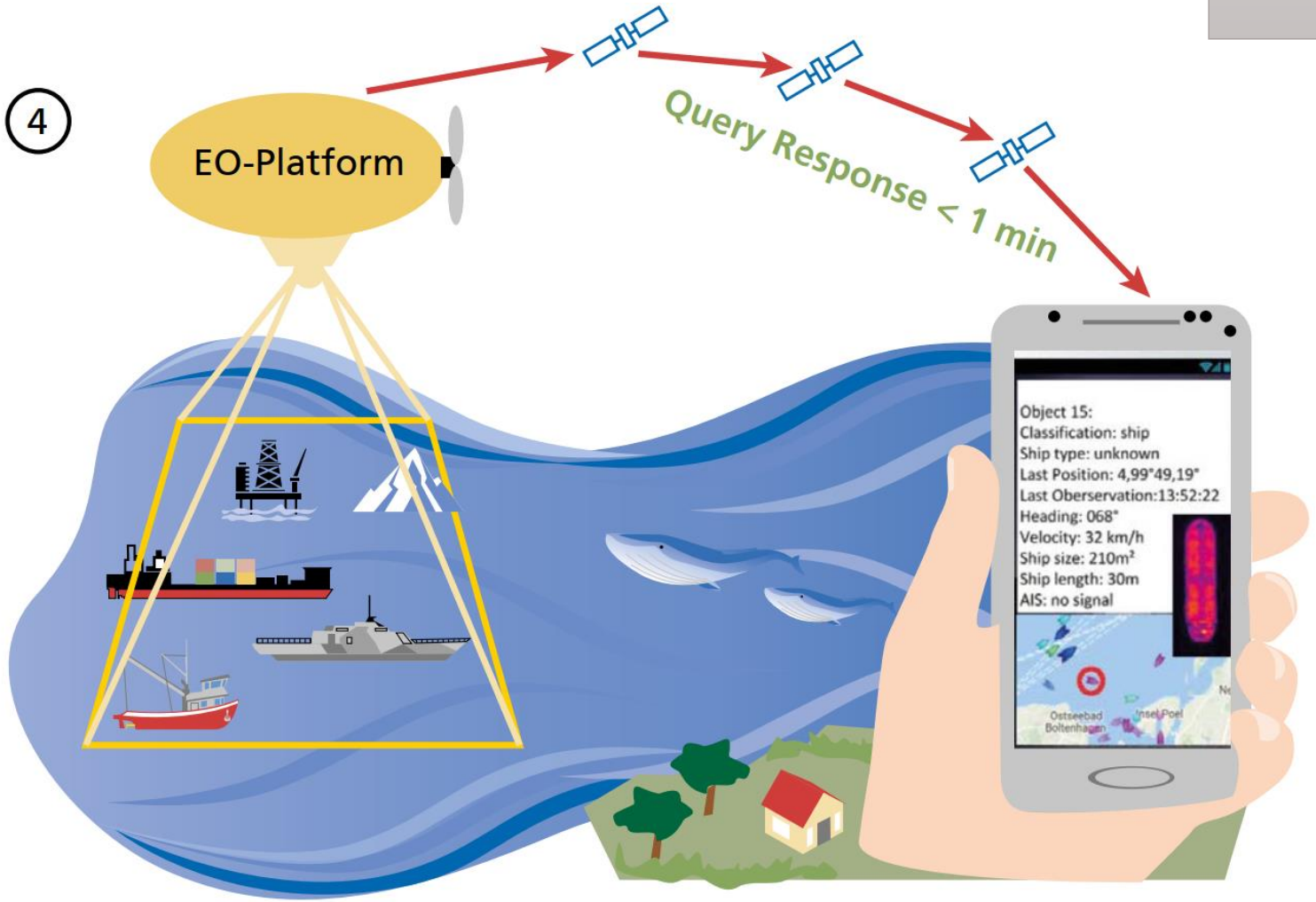
Example scenario meant for illustration of the basic concept. Usecase does not necessarily reflect any current mission or configuration



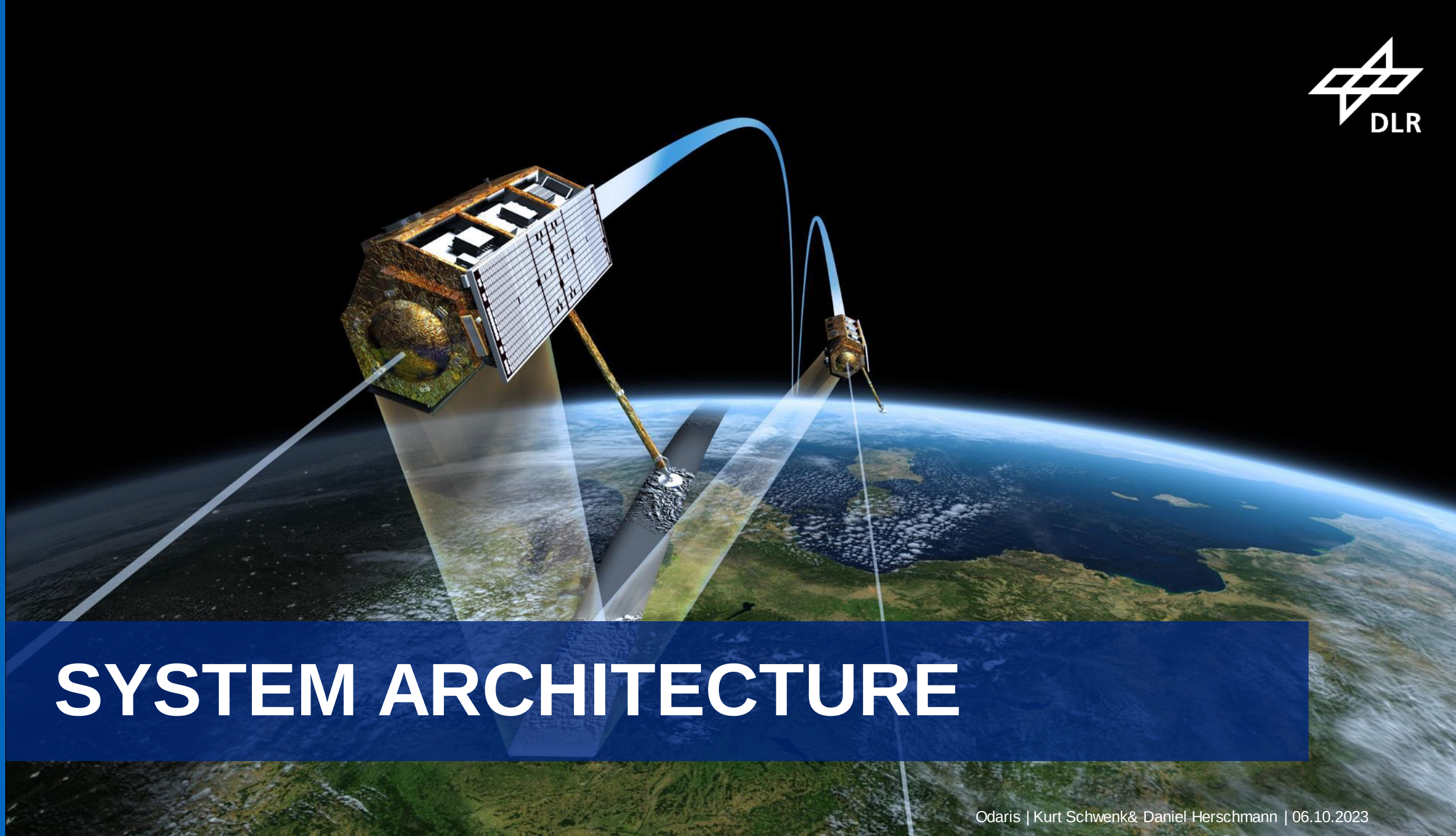
Step 3: User examines alarm message and requests additional information

ODARIS – Use-case example scenario

Example scenario meant for illustration of the basic concept. Usecase does not necessarily reflect any current mission or configuration

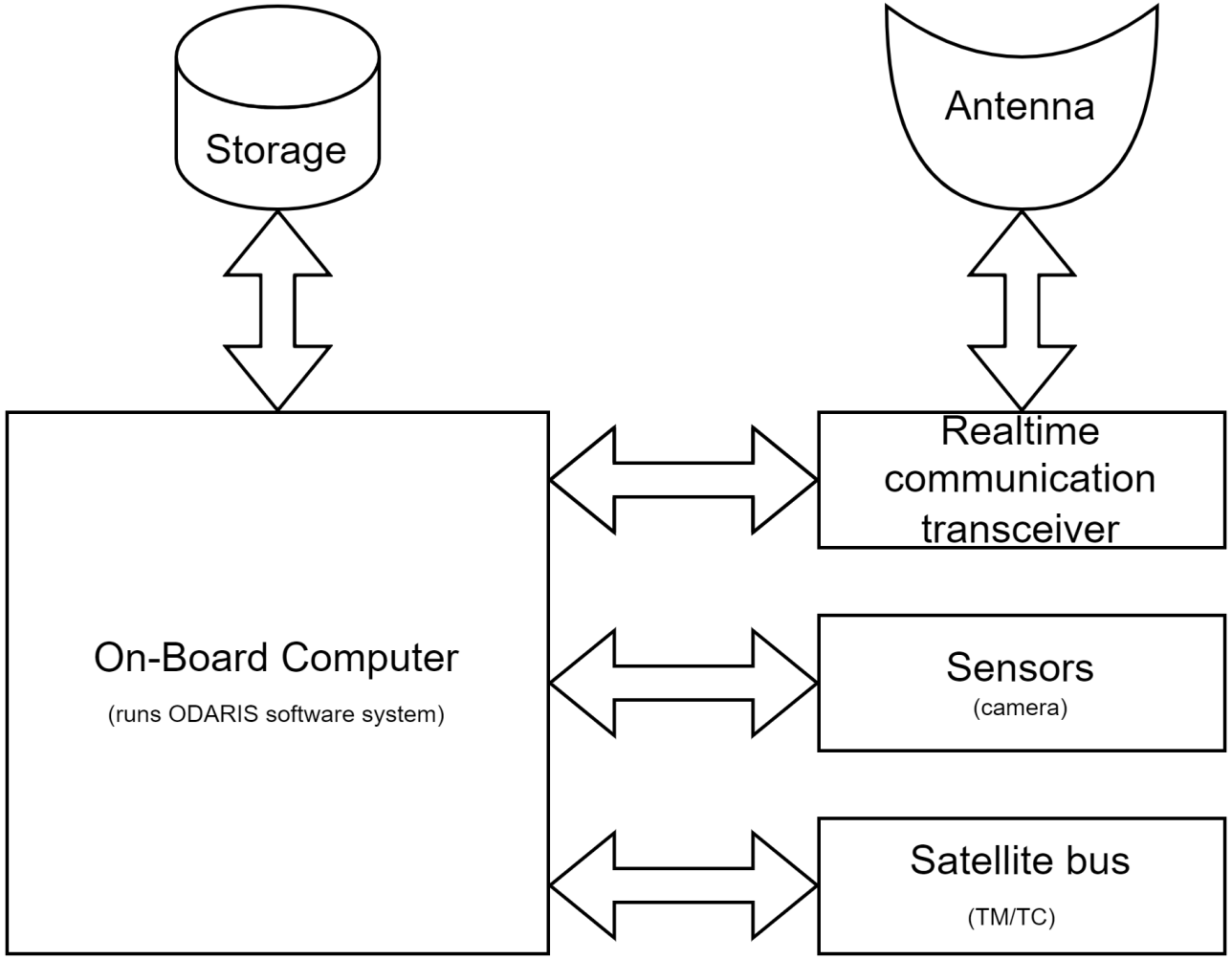


Step 4: Respond message is generated and sent back to the user



SYSTEM ARCHITECTURE

ODARIS - Hardware architecture



Hardware architecture of an typical ODARIS implementation

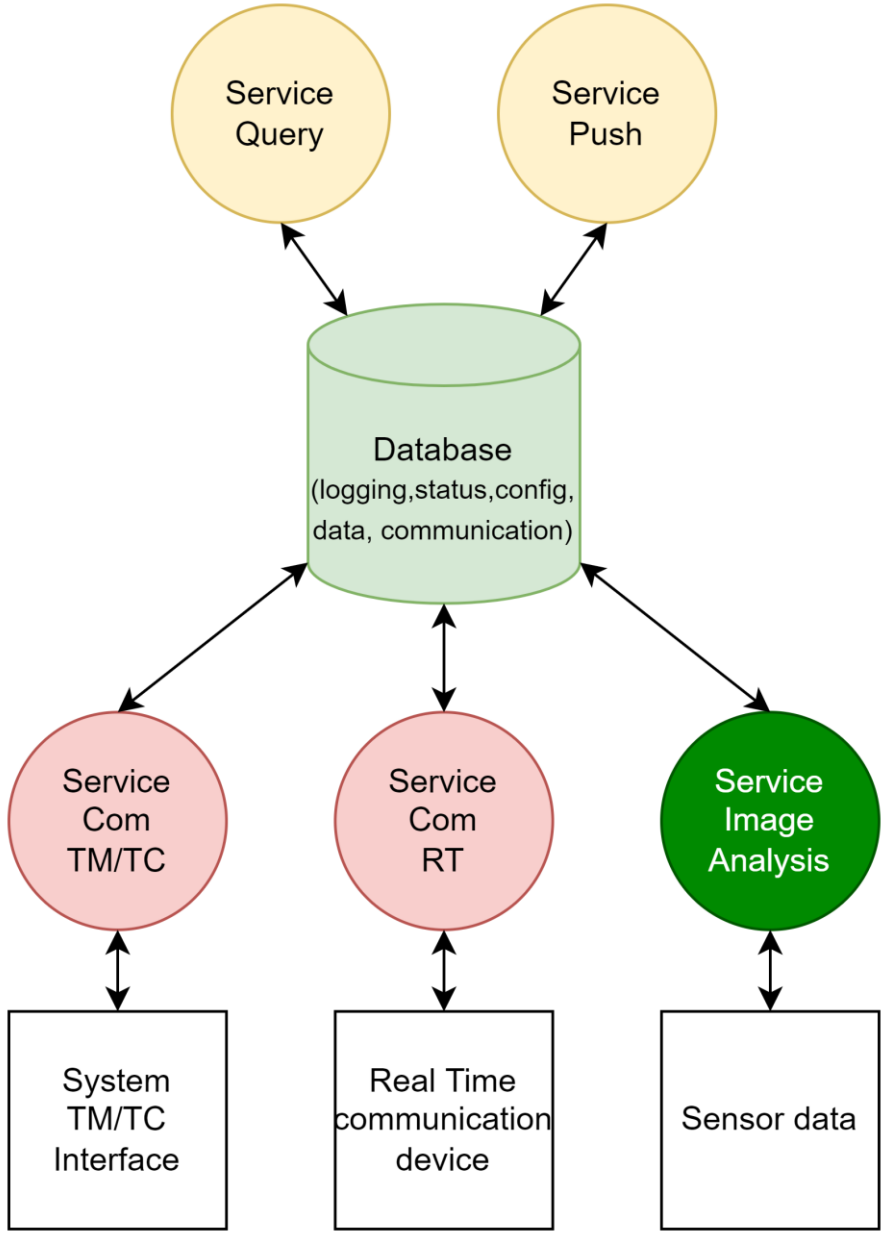
ODARIS Software architecture

Requirements

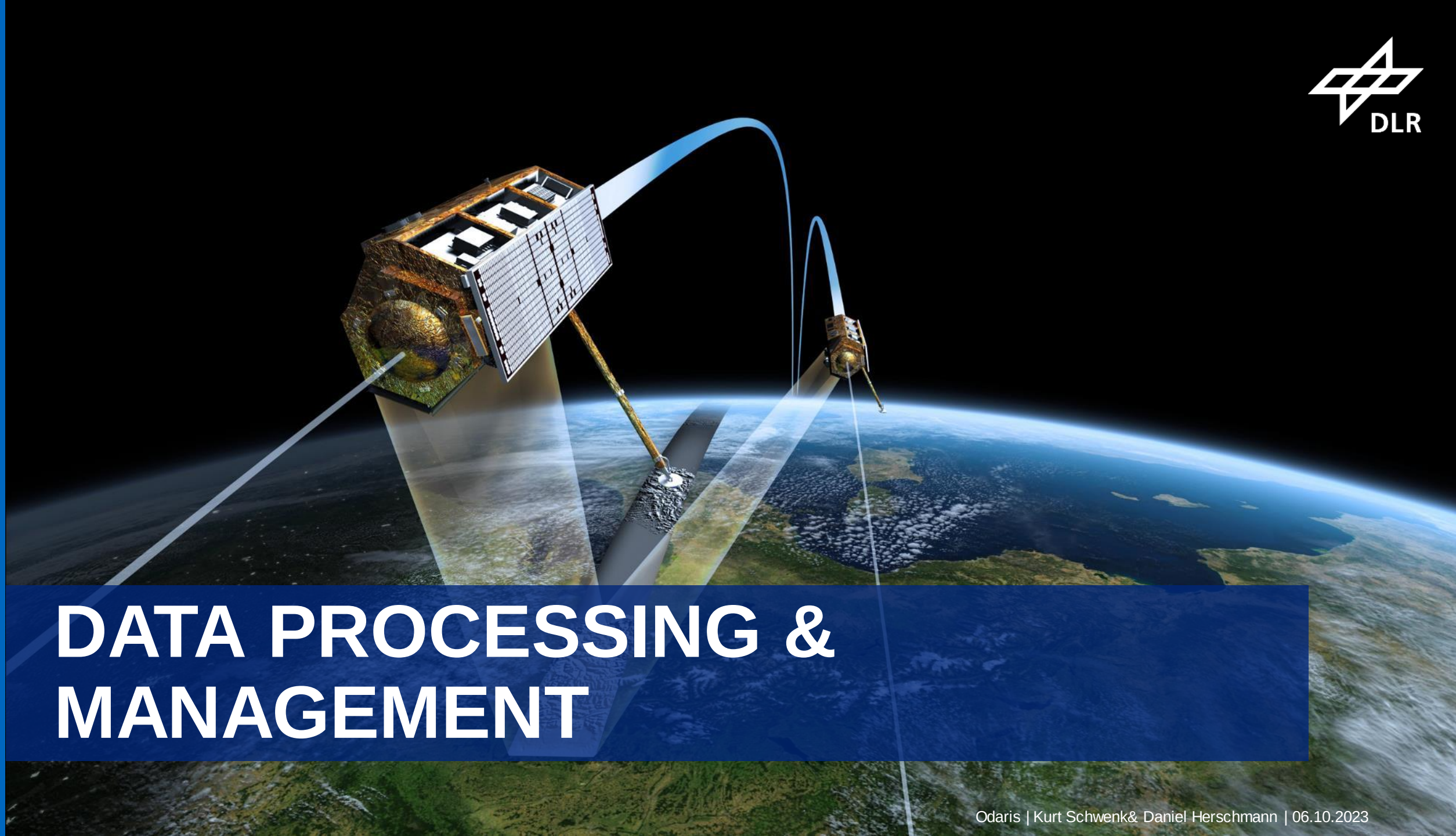
- Responsiveness
- Reliability
- Extensibility
- Flexibility
- Efficiency
- Performance

Design

- Service driven architecture
- Database centric architecture
- Message based communication



Software context of an typical ODARIS implementation

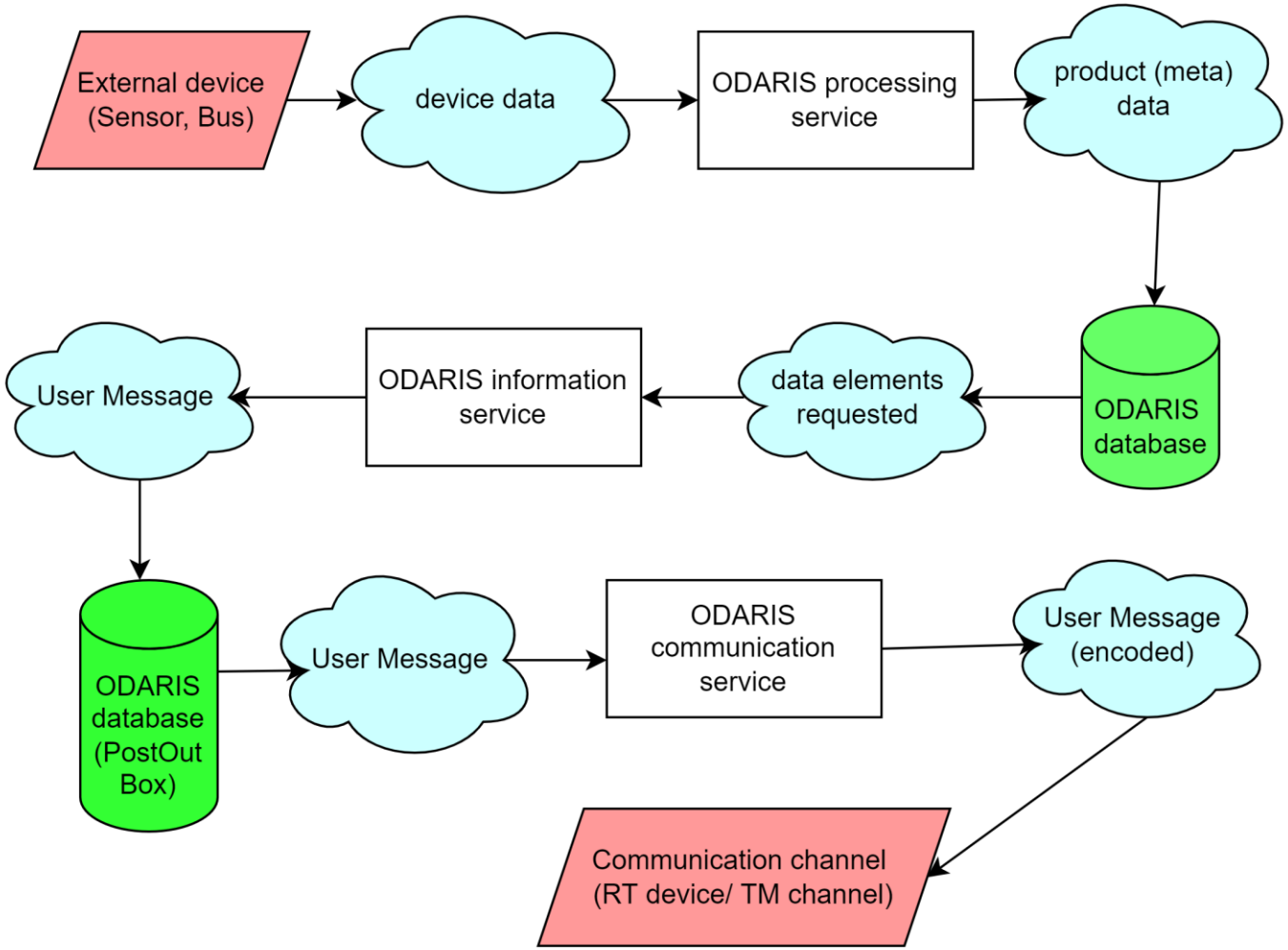


DATA PROCESSING & MANAGEMENT

DATA PROCESSING & MANAGEMENT OVERVIEW

- Database centric architecture
  - Product data storage
  - Log/Status data
  - System communication
  - Query language (SQL)
- Service based architecture:
  - Data generation/management/communication decoupled
  - Process separation per task/thread possible
- Features:
  - Low latency response time
  - Data delivery on demand
  - Fine granular data access
  - Failure hardening
  - Extensible

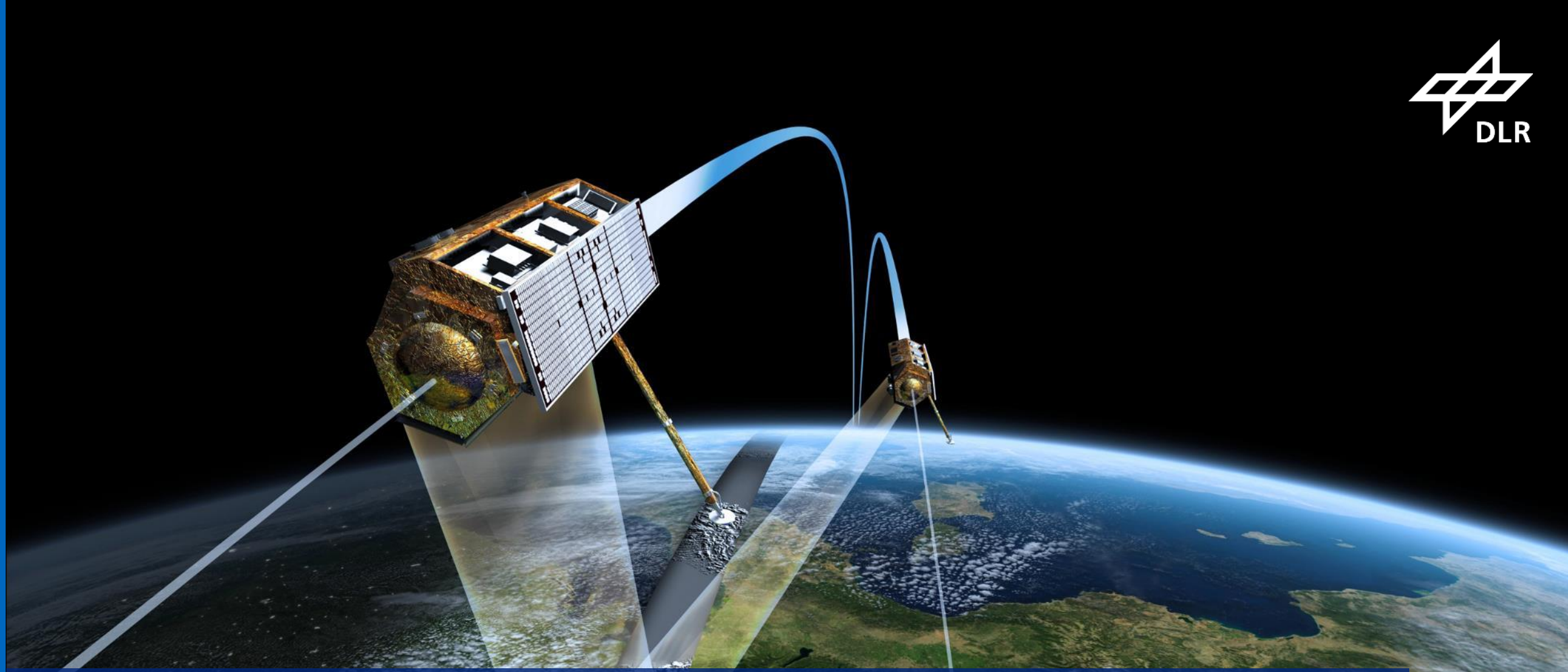
Typical dataflow within the ODARIS system



ODARIS Logging

	id	Module	Name	Value	LogTime
	Fi…	Filter	Filter	Filter	Filter
1	1	serviceQuery	QueryErrors	3	2023-07-05 17:05:18
2	2	serviceQuery	ReceivedQuerys	28	2023-07-05 17:06:58
3	3	serviceQuery	Initialized	yes	2023-07-05 17:05:18
4	4	serviceQuery	ExecutionCycles	203	2023-07-05 17:08:41

	id	Timestamp	Severity	Module	Message
	Fi…	Filter	Filter	Filter	Filter
29	29	2023-07-05 15:28:59	info	serviceQuery	Initialized service_query
30	30	2023-07-05 15:29:09	info	serviceQuery	Received SQL-Query: system.db SELECT *
31	31	2023-07-05 15:29:09	warning	serviceQuery	Error SQL-Query: SELECT *, (likely wrong sql …
32	32	2023-07-05 15:29:09	error	Exception_DbSQLite_c	SqlQuery:no tables specified [/home/kurt/…
33	33	2023-07-05 15:29:26	info	serviceQuery	Received SQL-Query: system.db SELECT *
34	34	2023-07-05 15:29:26	warning	serviceQuery	Error SQL-Query: SELECT *, (likely wrong sql …



IMPLEMENTATION DETAILS

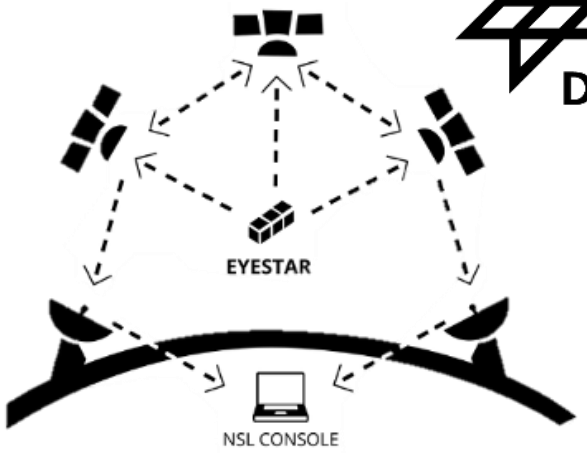
ODARIS – Real-time communication system

- Usage of satellite based telecommunication networks
- Reasonable communication performance on air-craft platforms
- Challenge on space platforms

- Using commercial solution from

  https://www.nearspacelaunch.com

  - EyeStar-S4 Radio
  - Based on Iridium network
  - < 13,5 Bytes/s downlink (~ 1MB/day)
  - Message size: ~ 200 Bytes
  - Anywhere-Anytime
  - Uplink available



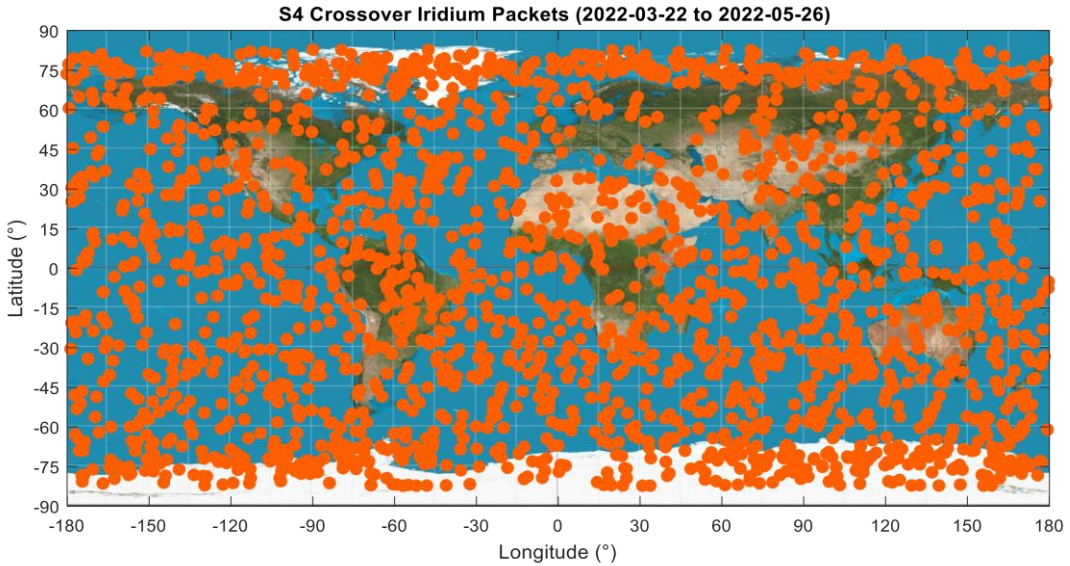


Figure 1 Global Iridium coverage data of transferred packets from the S4-Crosoover mission. Using the Iridium TX firmware within the EyeStar-S4. Note the full global coverage, with increased connectivity over the polar regions.

Product information, EyeStar-S4-Radio, Source: https://nearspacelaunch.com/eye-star/ (copyright provided by NSL)

ODARIS - Implementation

Typical hardware environment

- Zynq-7020 SoC (Xilinx/AMD)
- 512 Mbyte Ram
- ARM Cortex-A9MP dual core
- Frequency ~ 800 MHz

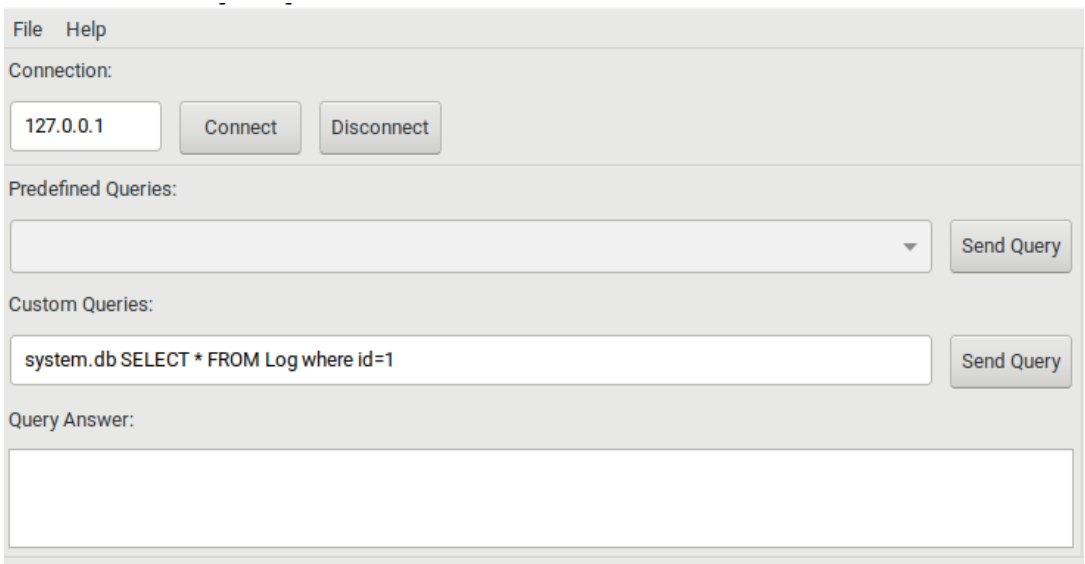
Typical software environment

- OS: YoctoPoky Embedded Linux
- Lib: TFLite/OpenCv/Boost/SQLite
- Dev: C++/CMake/Bash
- CI: Gitlab/CodeAnalysis/TargTest

Typcial testing environment

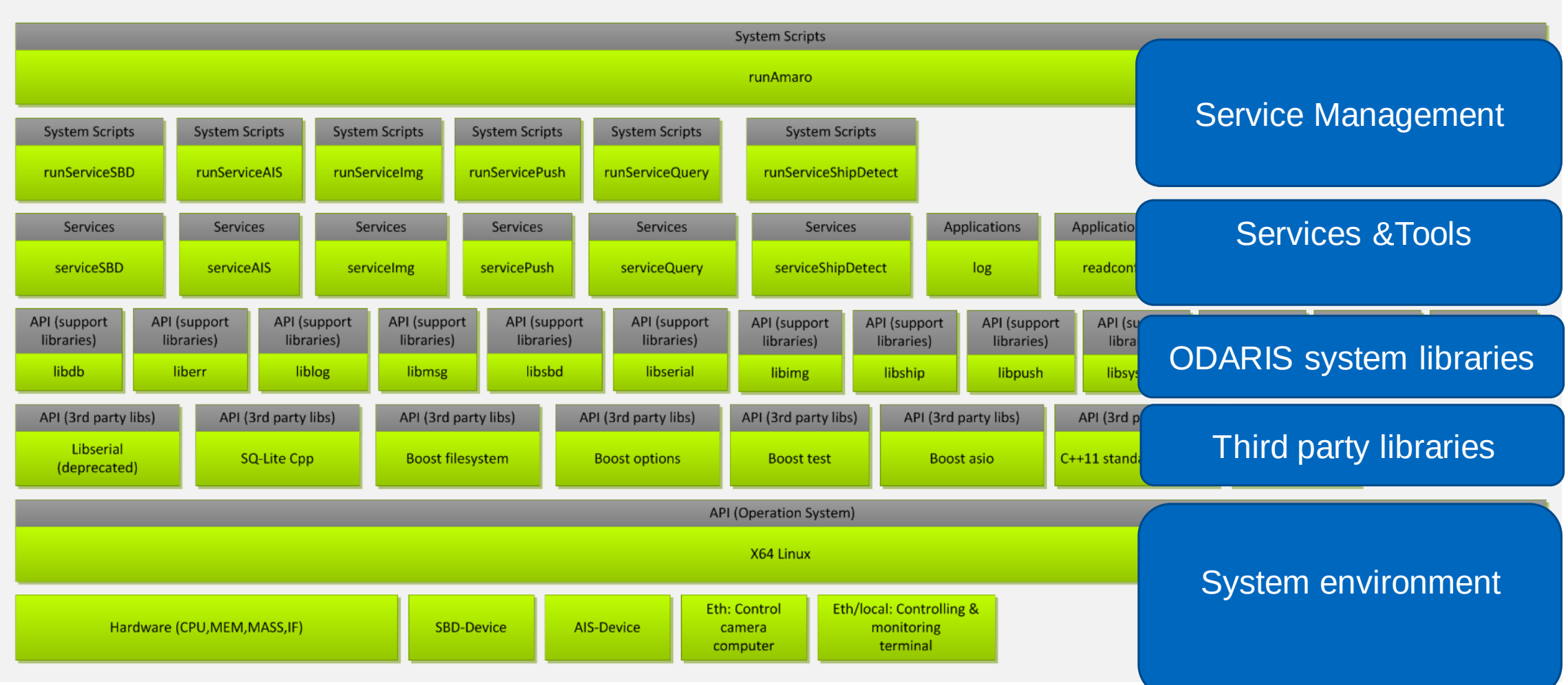
- Laboratory demonstration environment
- Command GUI

ODARIS laboratory demonstration environment



ODARIS command GUI

ODARIS SW Component Overview
Linux Standalone AMARO configuration



SUMMARY & OUTLOOK

Summary

Key message

- Demand for anytime/anywhere low latency satellite system access, especially for small/medium sized satellite missions
- ODARIS solution approach:
  - Utilizing satellite telecommunication networks
  - Onboard data analysis
- Questions
  - Real-time communication channel performance?
  - Reliable operation in space environment ?
  - Deploy ability on space systems ?

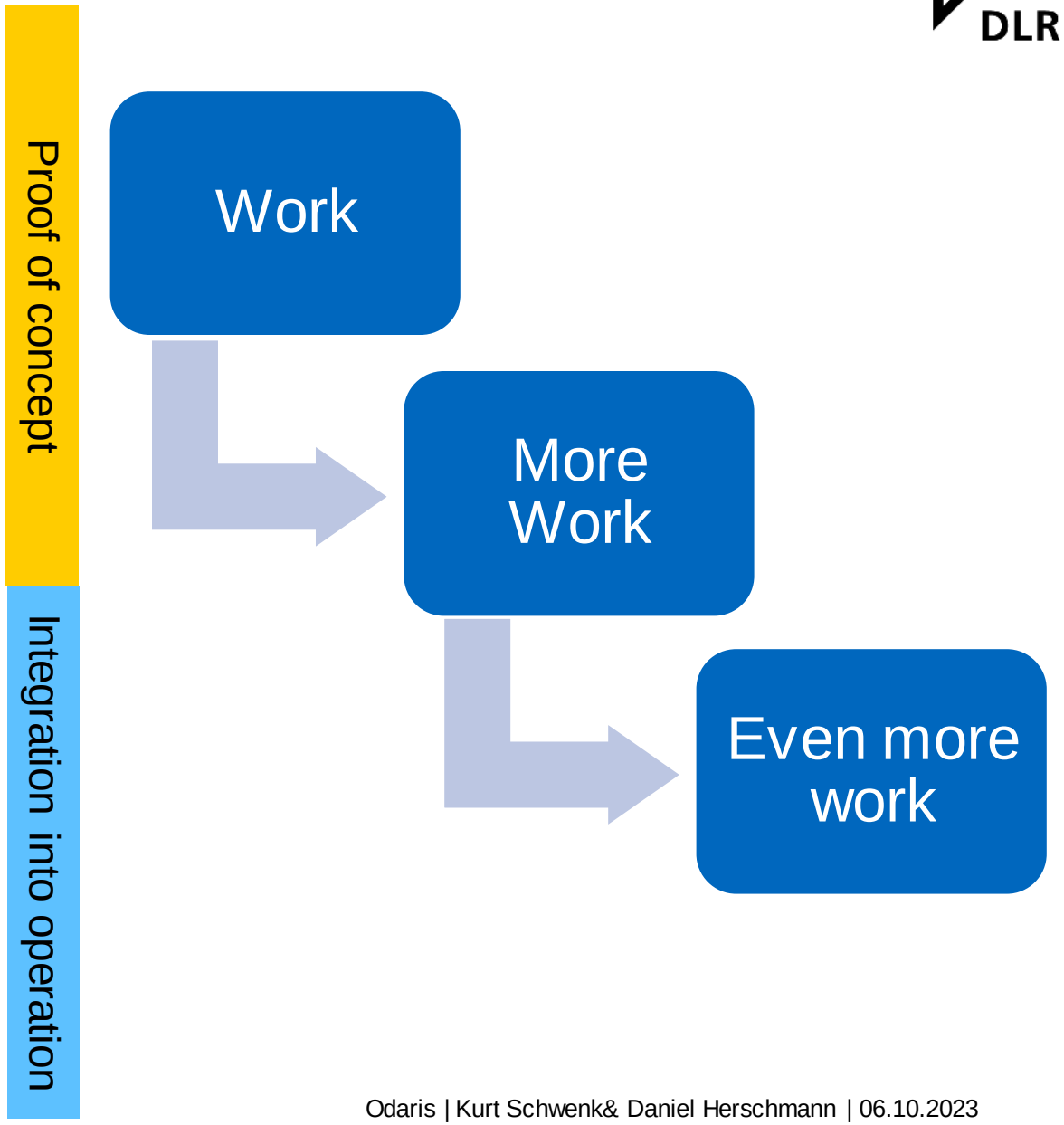
Challenges and next steps

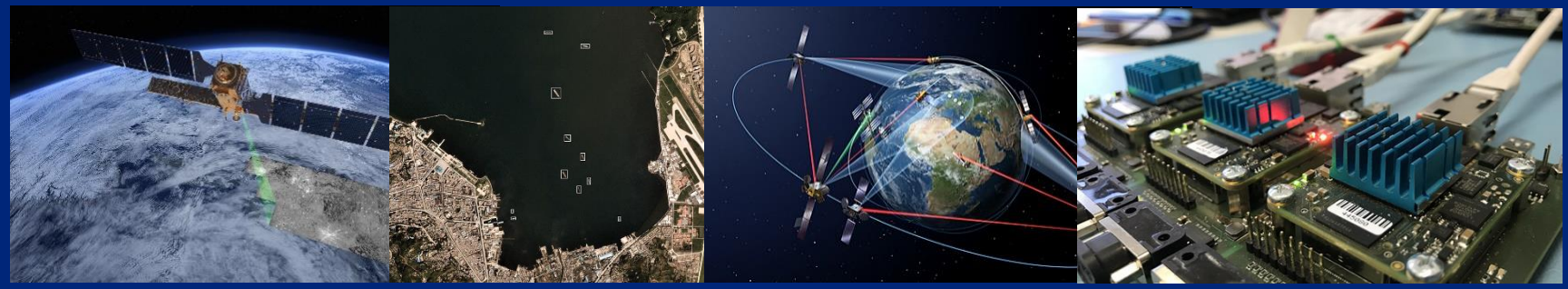
Near future

- Experiment flight platform integration
- AI-cloud detection integration
- FDIR concept & implementation
- Operational mission concept
- Quality management
- Documentation

Far future

- Space software deployment concepts
- Integration of 3rd party application
- Integration in satellite operation





Thank you for your attention

Questions?

Contact: kurt.schwenk@dlr.de

Imprint

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