SFERA-III

Solar Facilities for the European Research Area

"5G and IoT Platform for CSP"

Inga Miadowicz, DLR, Solar Research

NETWORKING

Summer School: "Smart CSP: How Smart Tools, Devices, and Software can help improve the Design and Operation of Concentrating Solar Power Technologies" - WP1 Capacity building and training activities - Cologne, Germany, September 14th-15th 2023

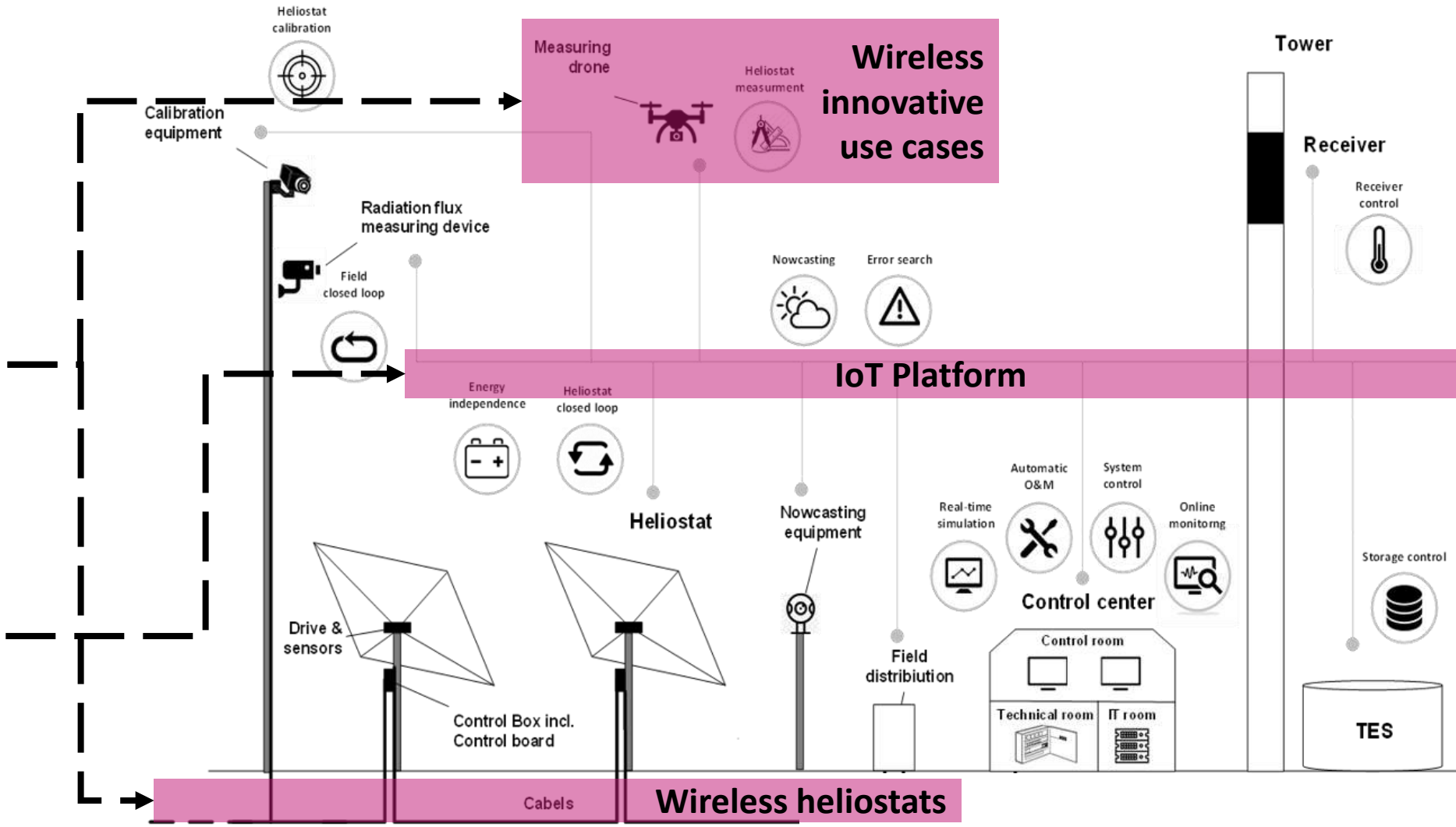
THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO **823802**

Content

Smart CSP Infrastructure

1. **5G Campus Network**
   Private 5G network for wireless use cases and heliostats

2. **IoT Platform**
   System infrastructure for data management and interconnection of subsystems



SFERA-III

Solar Facilities for the European Research Area

Part 1: 5hine - 5G Solutions for efficient solar-thermal power plants

Inga Miadowicz, DLR, Solar Research

5G and IoT Platform for CSP

Summer School: "Smart CSP: How Smart Tools, Devices, and Software can help improve the Design and Operation of Concentrating Solar Power Technologies" - WP1 Capacity building and training activities - Cologne, Germany, September 14th-15th 2023

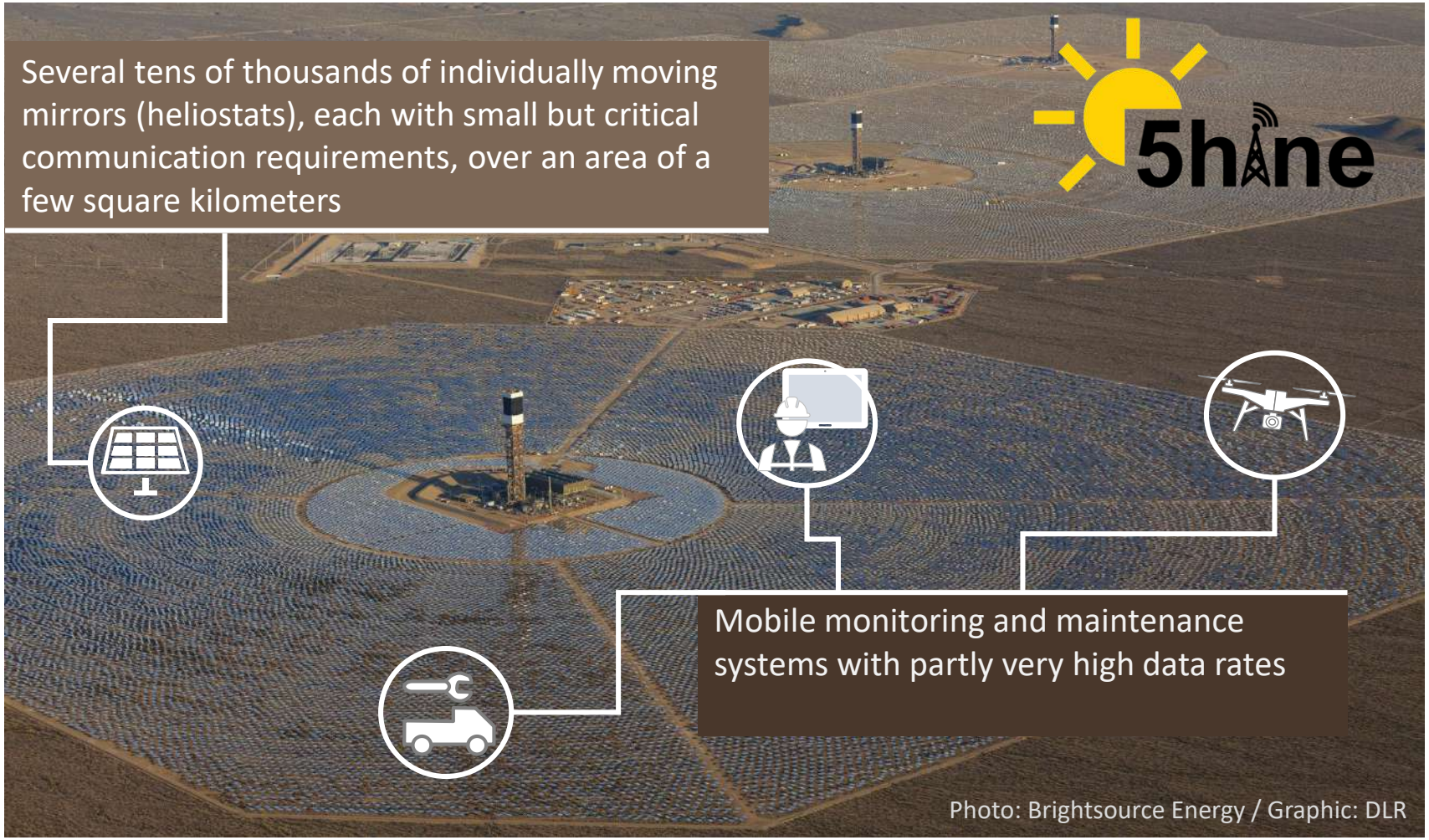
THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO **823802**

Motivation

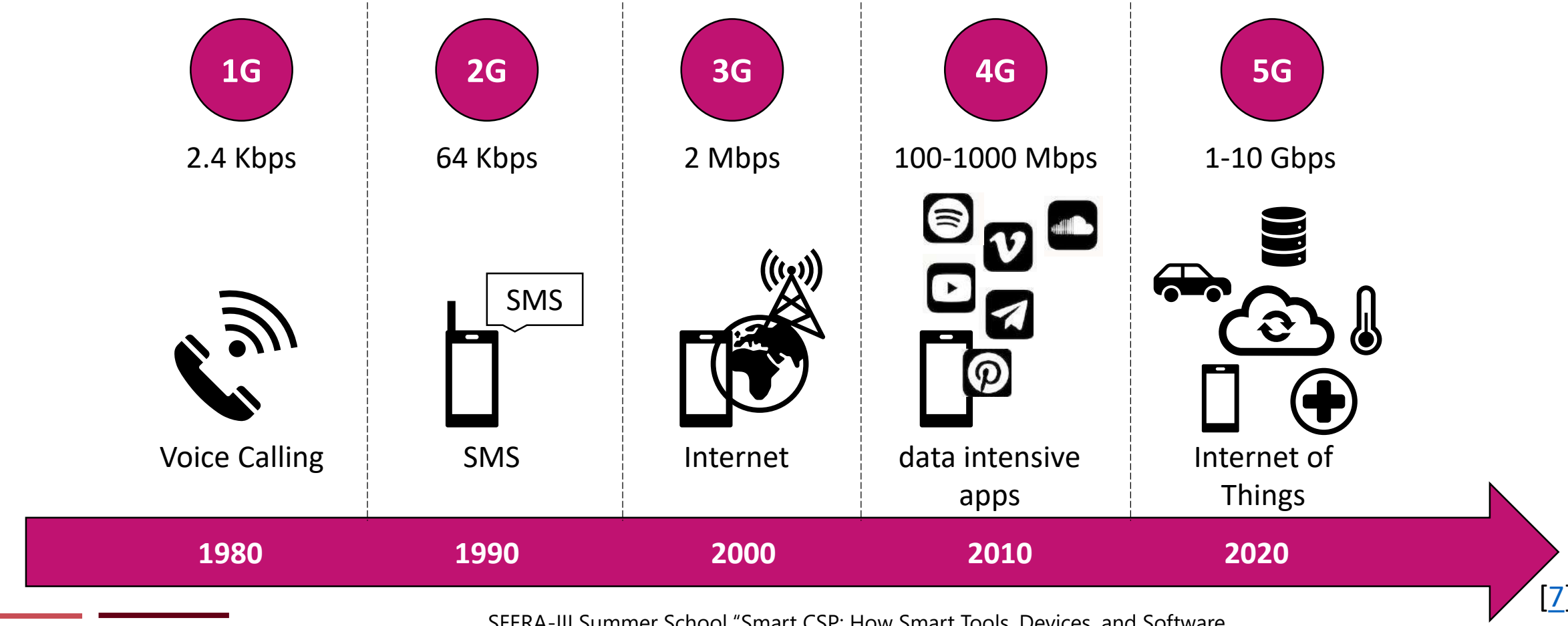
- Issue 1:
  Wiring of Heliostat field is expensive and elaborate
  → ~ 7% of total investment costs [6]

- Issue 2:
  Monitoring & Maintenance needs flexible wireless solutions
  → eg. Drones

- Issue 3:
  High communication requirements in designated areas



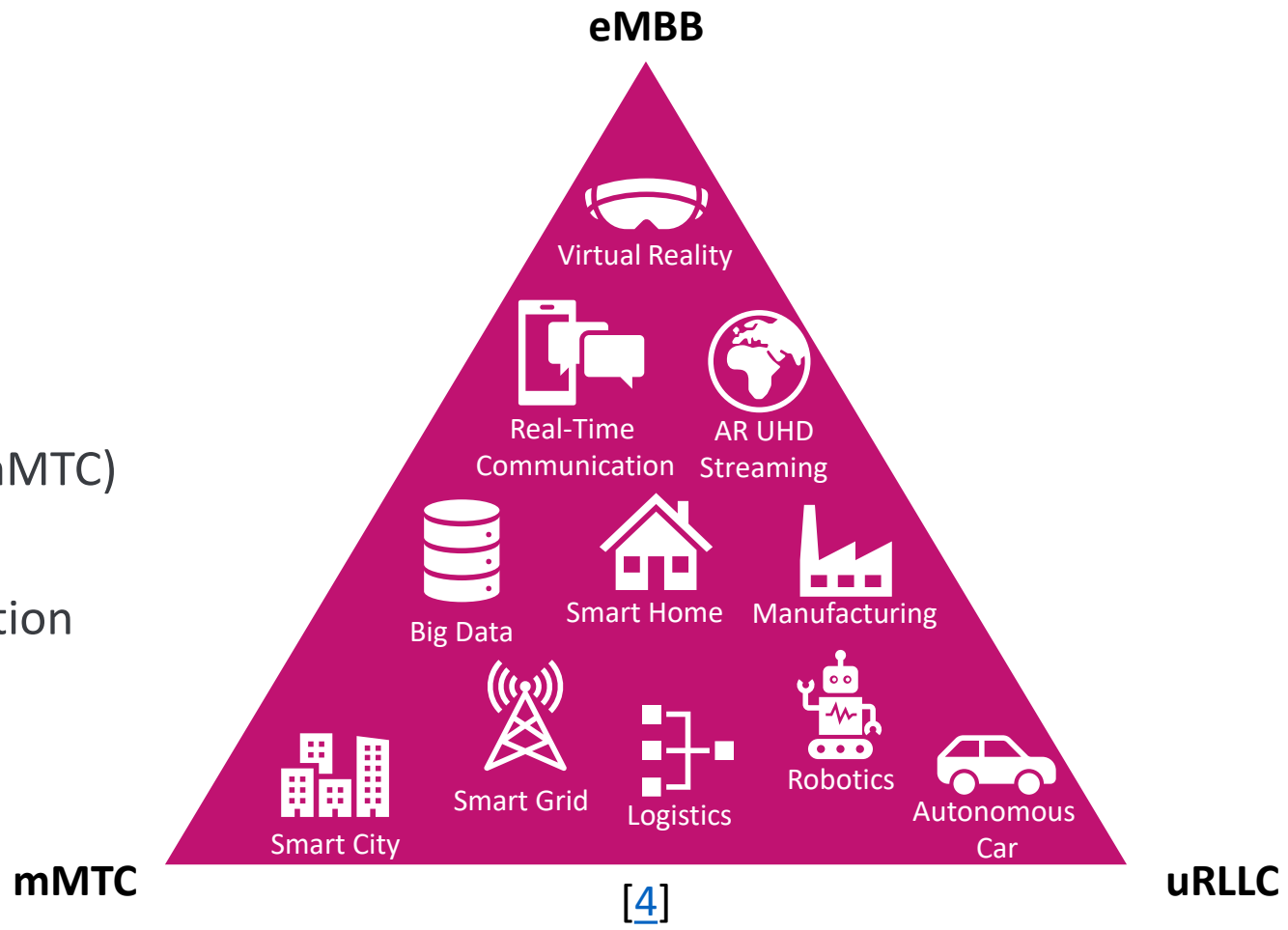
Background



[7]

Background

- 5G Requirements profiles
  - Enhanced Mobile Broadband (eMBB)
  - Massive Machine Type Communication (mMTC)
  - Ultra-reliable and low latency communication (uRLLC)
  - Mixed requirement profiles



[4]

Background

- 5G campus network and new network operation models
  - Geo-localized networks adapted for special requirements of the domain
  - Can be completely isolated or based on public infrastructure

Slice	Public 5G frequency 3.5 GHz
Hybrid – Shared RAN	Own core network
Hybrid – Small Cell	Own radio network
In-House operation	Local 5G frequency 3.7 GHz & 26 GHz

gNB (public)

gNB (private) [5]

Project goals

Initial situation

Solar power plants with up to 100,000 heliostats in geographical small area

- Expensive and elaborate wiring for energy and data
- Monitoring & Maintenance needs for flexible wireless solutions

Problem

Deployment of a 5G radio network for holistic solar power plant communication

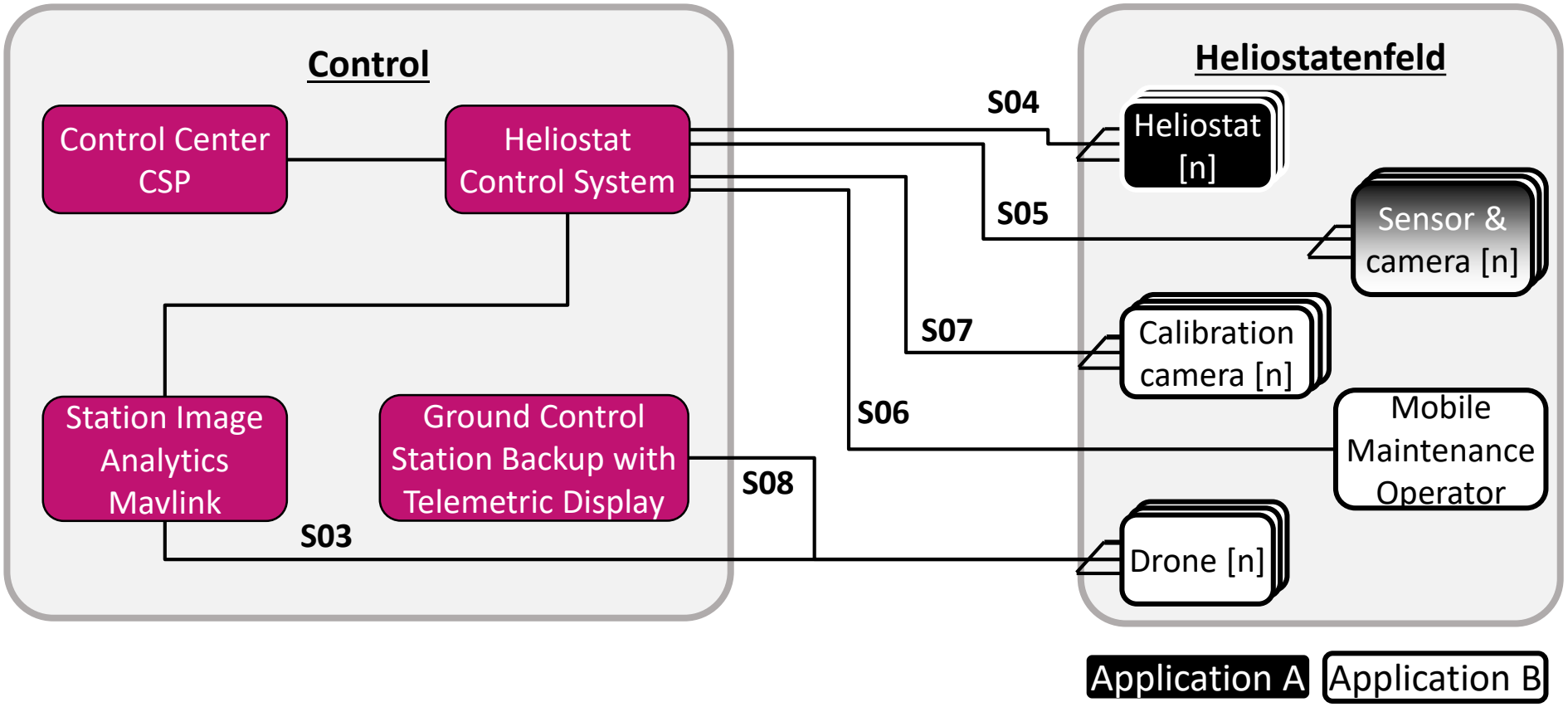
- Which 5G solutions can fullfill demands of solar power plants?
- Which frequency range can be technically realized and is available in all target areas?

Are reliable 5G Campus networks for energy efficient, wireless heliostats economically feasible?

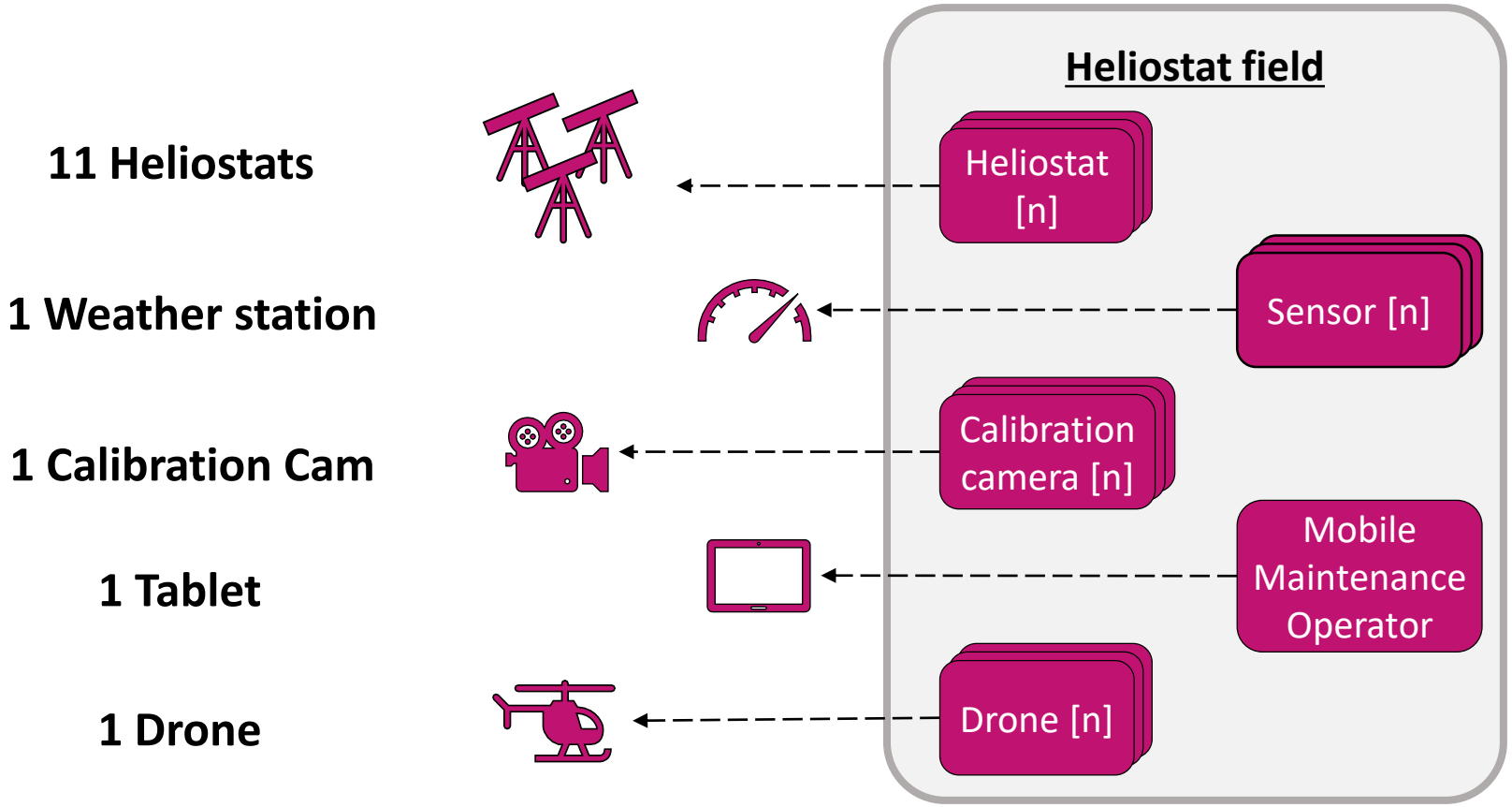
Requirements

Application A: Highly scaled number of participants with transmission of small amounts of data, cost effective, low power (heliostats, sensor)
→ **mMTC**

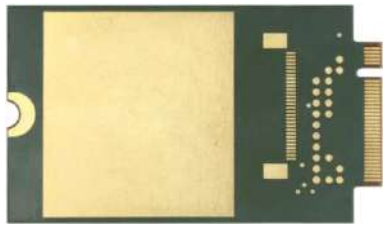
Application B: Small number of participants with high data volumes, low latency & reliability (e.g. drone)
→ **eMBB, uRLLC**



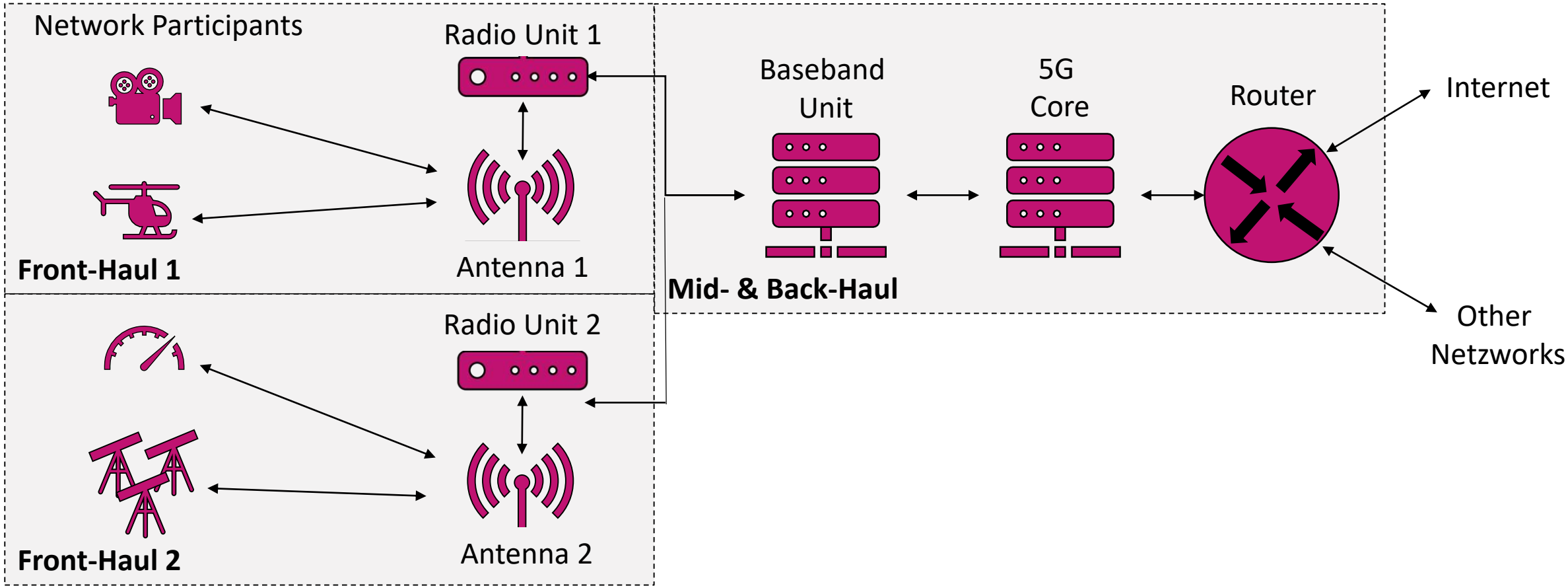
Concept


11 Heliostats
1 Weather station
1 Calibration Cam
1 Tablet
1 Drone
Heliostat field
Heliostat [n]
Sensor [n]
Calibration camera [n]
Mobile Maintenance Operator
Drone [n]

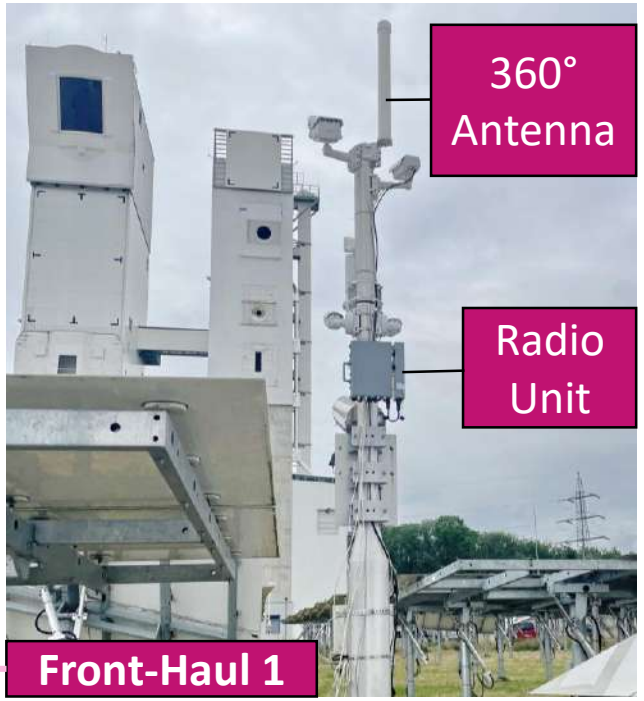
Concept

Device that directly supports 5G & campus network	5G Modem that can be integrated on board	5G Router that can be plugged into device in exchange for ethernet
Tablet	Drone, Heliostat (onboard)	Heliostat (plug-in), Calibration Cam, Weather Station
		
Support of campus networks currently limited!	*Most effort because of hardware re-design*	*Higher Hardware-Costs & Protection with outdoor case neccessary*

Concept


Network Participants
Radio Unit 1
Baseband Unit
5G Core
Router
Internet
Front-Haul 1
Antenna 1
Mid- & Back-Haul
Other Netzworks
Radio Unit 2
Front-Haul 2
Antenna 2

Realization



Summary

- **Wireless heliostats** allow to **safe costs and effort for cabling & allow more flexibility** for innovative use cases like drones
- 5G technology has a **higher data rate**, can support **different requirement profiles** and allows the use of **campus networks**
- Solar power plants are **typically location in designated areas** have a **heterogeneous requirement profile for data communication**
- A 5G campus network is currently **demonstrated & evaluated at solar tower Jülich** → technical and economical evaluation is still ongoing

SFERA-III

Solar Facilities for the European Research Area

Part 2: An IoT Platform as the basis for monitoring and automation in the solar thermal power plant

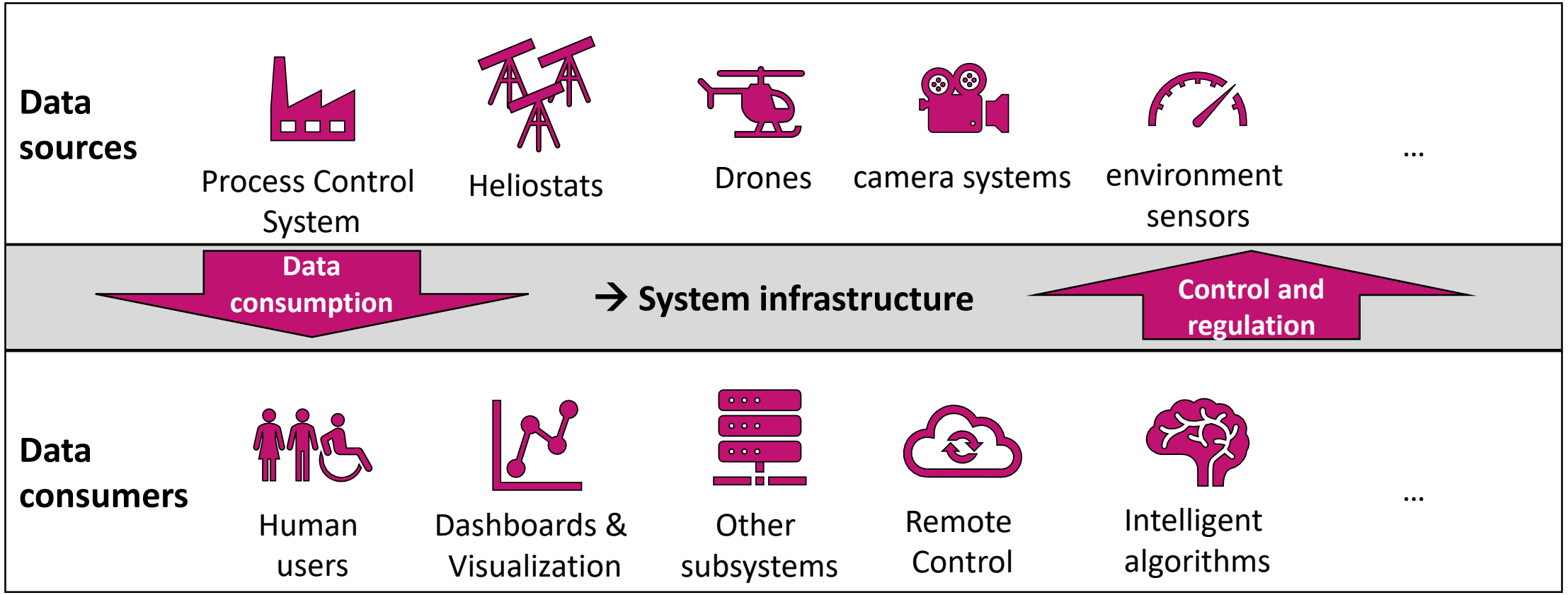
Inga Miadowicz, DLR, Solar Research

5G and IoT Platform for CSP

Summer School: "Smart CSP: How Smart Tools, Devices, and Software can help improve the Design and Operation of Concentrating Solar Power Technologies" - WP1 Capacity building and training activities - Cologne, Germany, September 14th-15th 2023

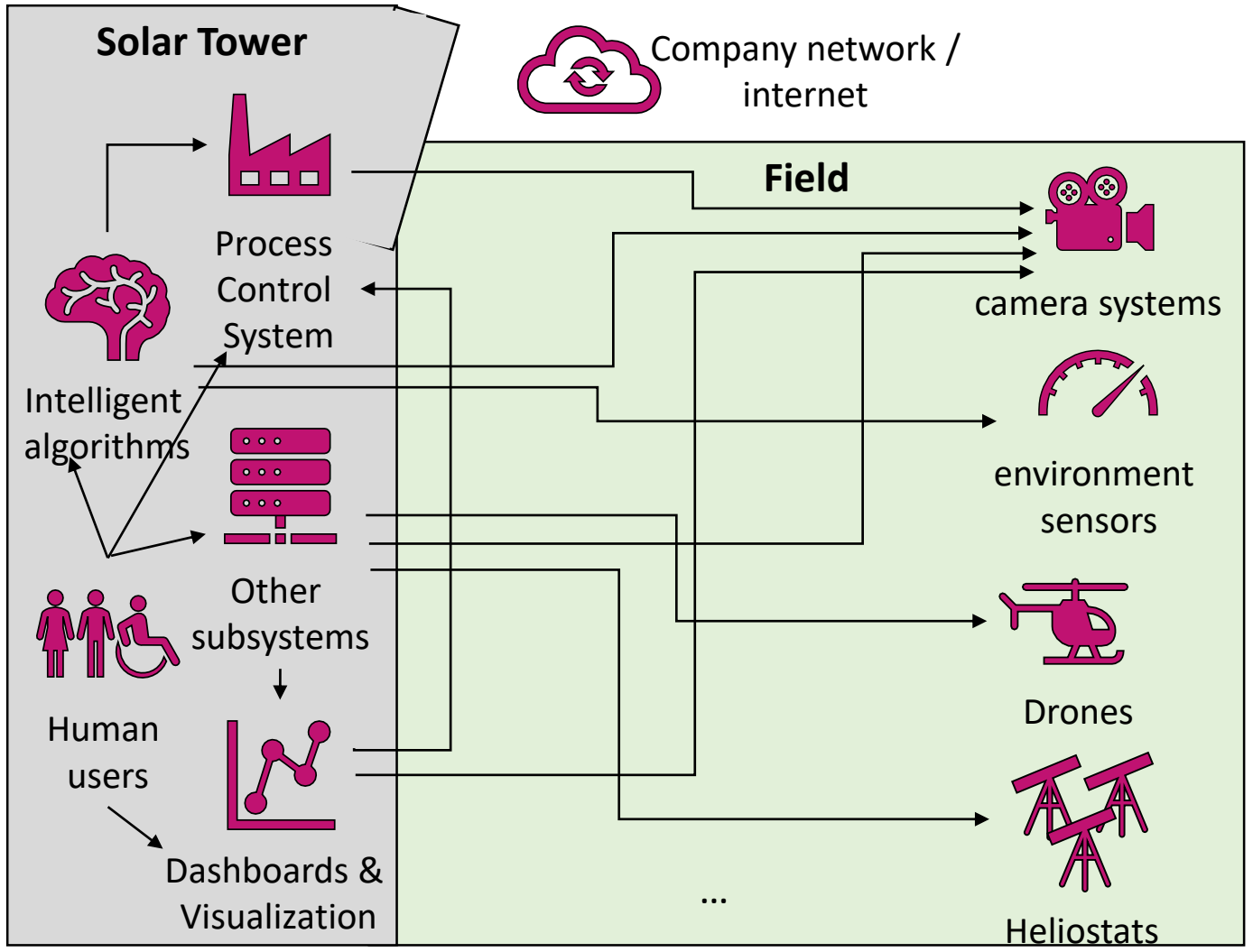
THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO **823802**

Motivation


Data sources
Process Control System
Heliostats
Drones
camera systems
environment sensors
...
Data consumption
→ System infrastructure
Control and regulation
Data consumers
Human users
Dashboards & Visualization
Other subsystems
Remote Control
Intelligent algorithms
...

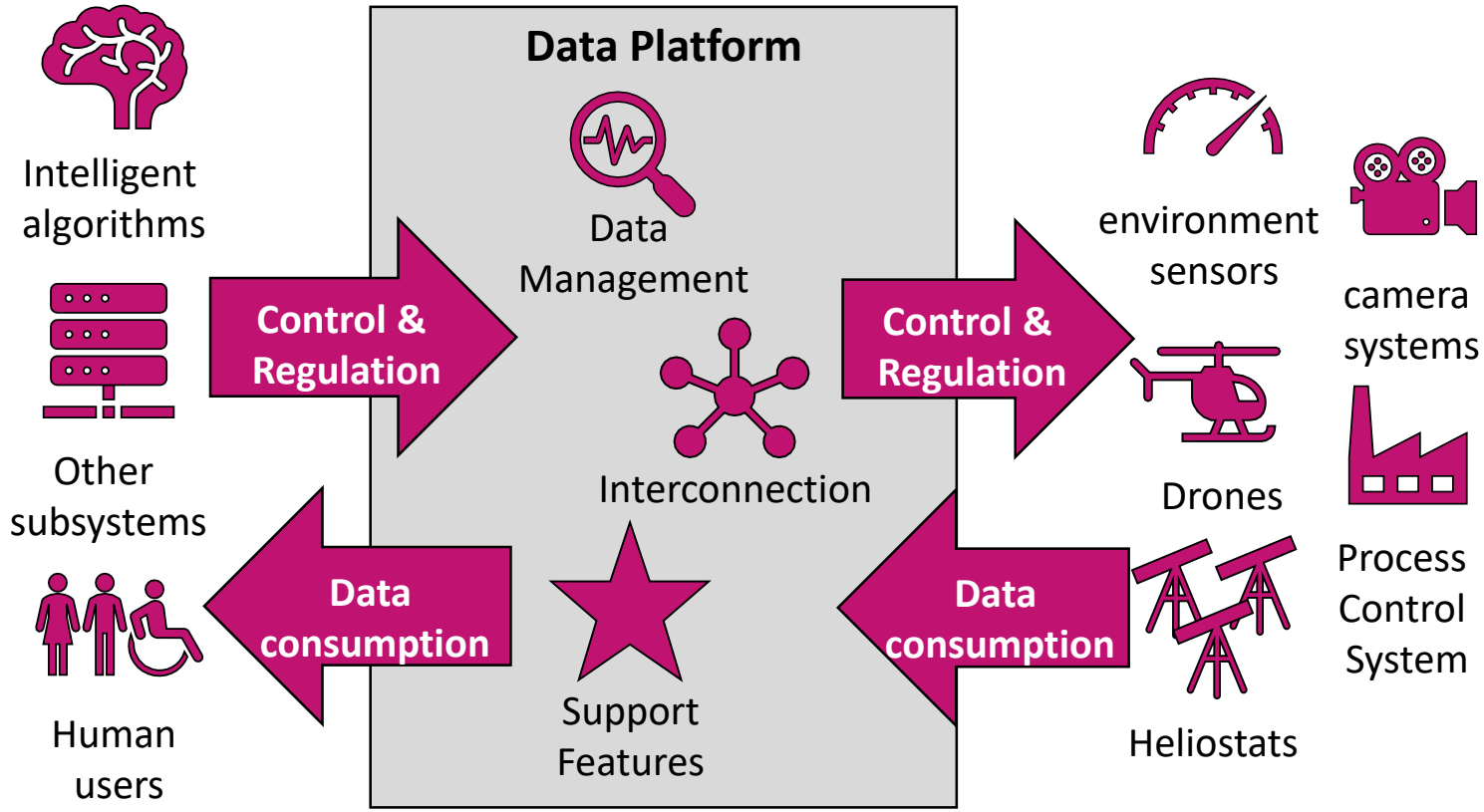
Motivation

- Actual situation
  - Series of distributed subsystems
  - Partly connected data silos
  - Airgapped high-security environment
- Challenges
  - Heterogeneous systems and interfaces
  - Performance, stability and security
  - Huge amount of data
    - ~ 5.5 TB to process per day
    - ~ 10 TB to store per year
  - Complexity of the overall system
  - …



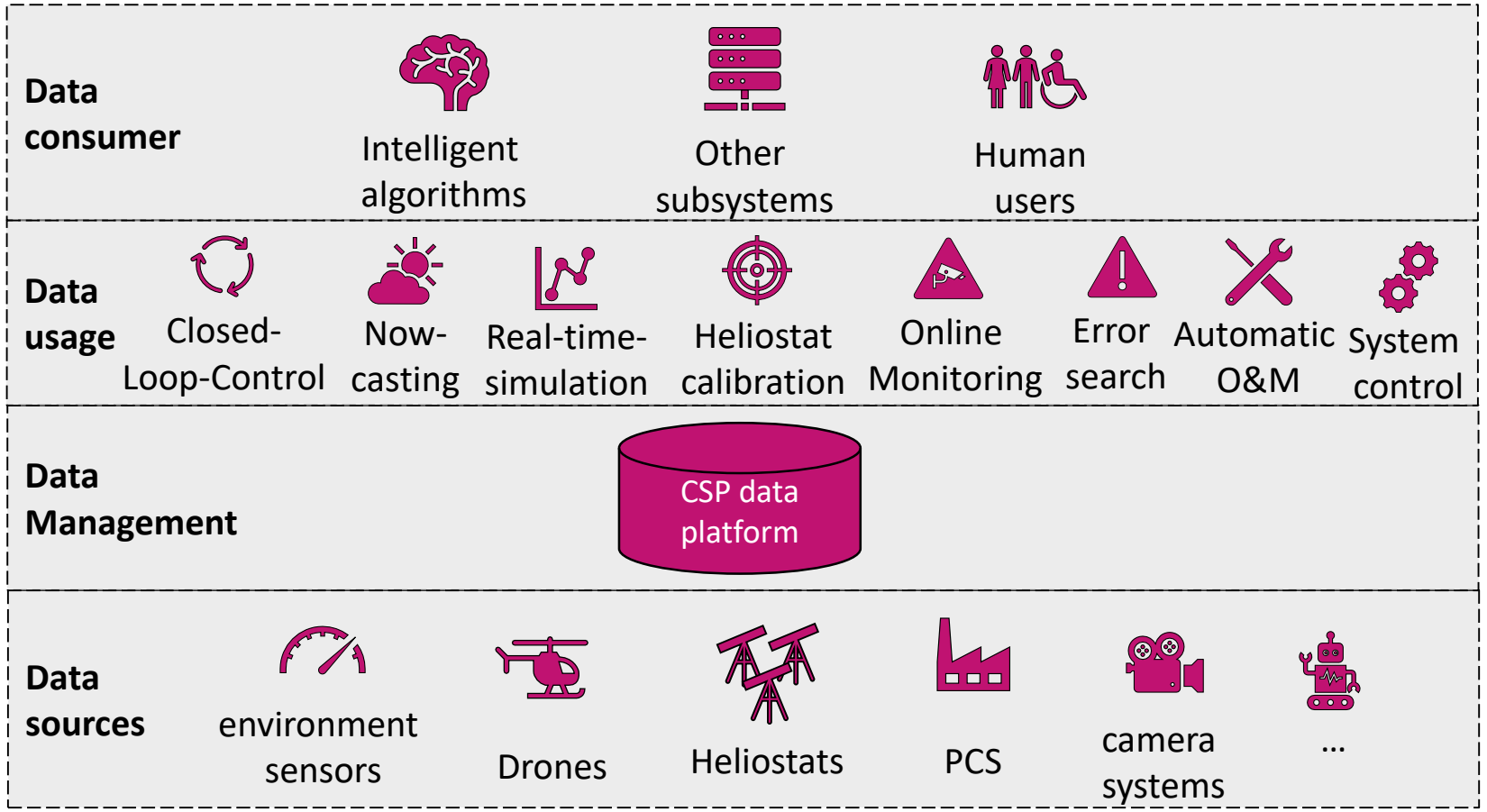
Project Goal

- Data Platform as a centralized infrastructure for interconnection & data management
  - Collect & provide data from all sources and allow their control and regulation of system components
  - Break data silos and provide features for data-based applications and human users
  - Provide robust, secure, performant, flexible and scalable system infrastructure



Requirements

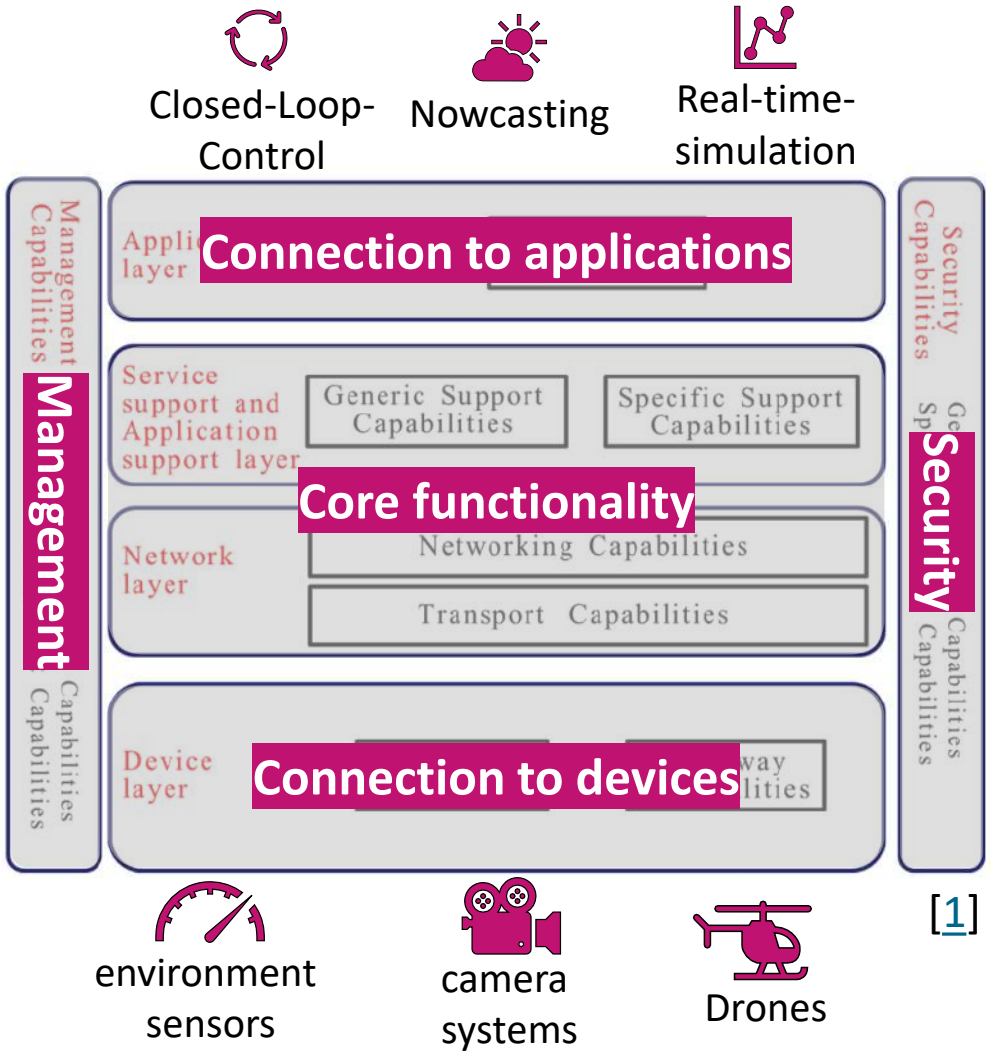
- Data consolidation
- Flexible interfaces to data sources
- Big Data Processing & Storage
- Scalable Deployment
- Different interfaces for data access



- Stream / batch processing
- Semantic interpretation of data
- Visualization, Alerts & Dashboards
- Monitoring of system health & Self-Healing
- Comprehensive IT security protection

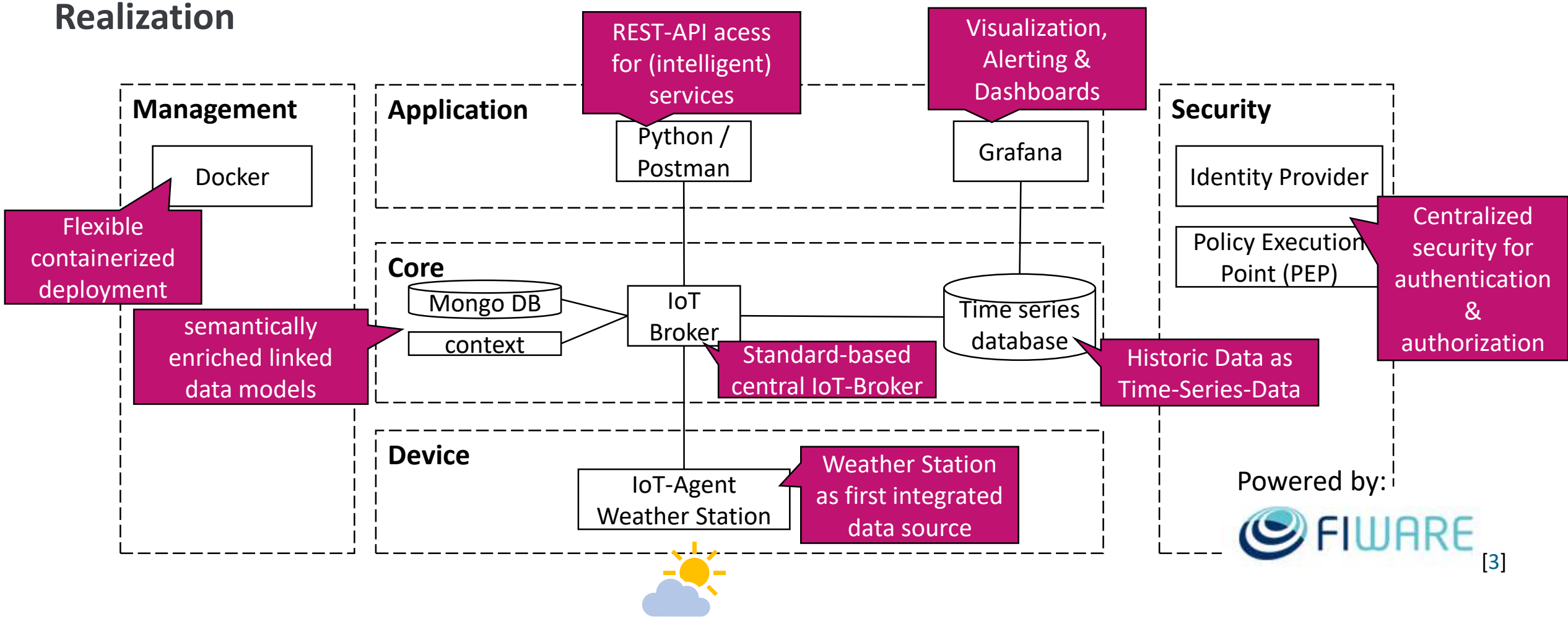
Concept

- Reference Architectures for (I)IoT-Platforms
  - Consumes data at device layers and provides it to application layer
  - Core functionality for data management
  - Management and security services that provide functions for all layers



[1]

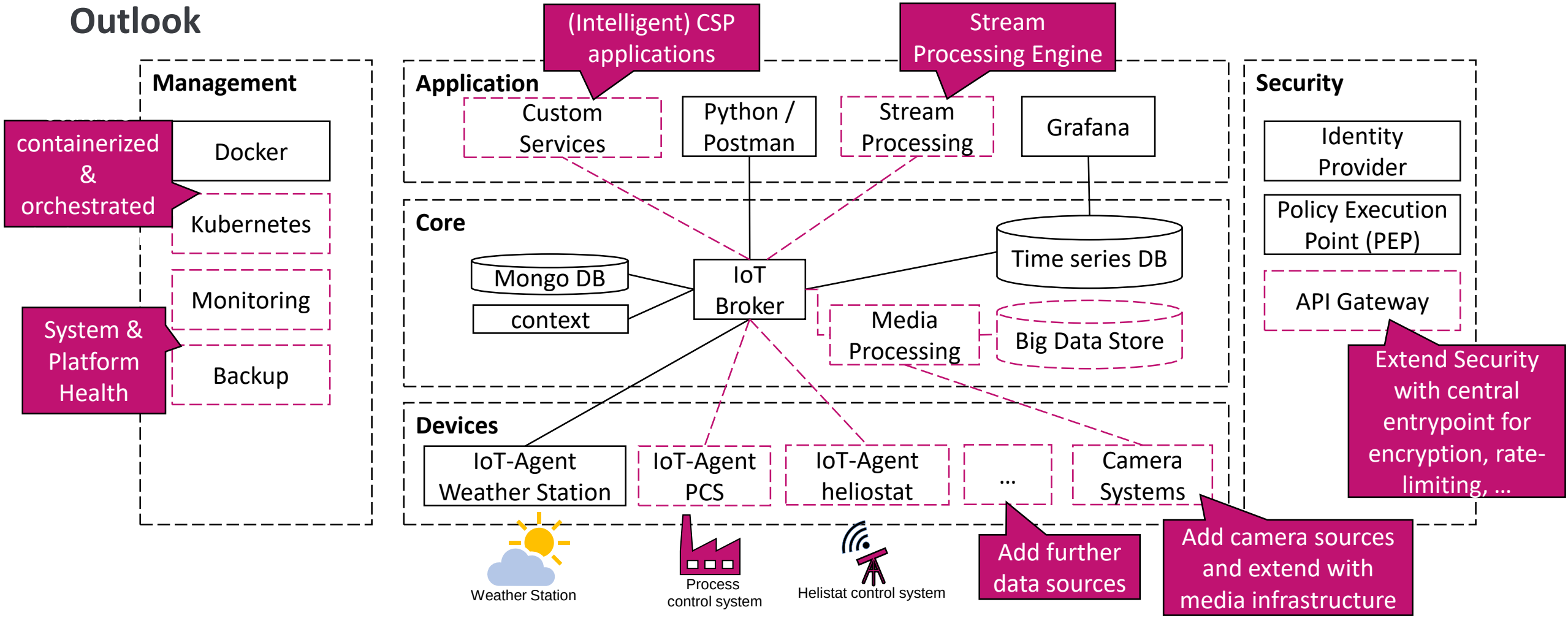
Realization



[3]

Realization

Outlook


(Intelligent) CSP applications
Stream Processing Engine
Management
containerized & orchestrated
Docker
Kubernetes
Monitoring
System & Platform Health
Backup
Application
Custom Services
Python / Postman
Stream Processing
Grafana
Core
Mongo DB
context
IoT Broker
Time series DB
Media Processing
Big Data Store
Devices
IoT-Agent Weather Station
IoT-Agent PCS
IoT-Agent heliostat
...
Camera Systems
Weather Station
Process control system
Helistat control system
Add further data sources
Add camera sources and extend with media infrastructure
Security
Identity Provider
Policy Execution Point (PEP)
API Gateway
Extend Security with central entrypoint for encryption, rate-limiting, ...

Summary

- The **amount of data** and the **need for processing methods** is growing
- **Solar power plants have high requirements on technical infrastructure** like huge amount of subsystems and data, high degree of heterogeneity, sensitive control processes, low latency requirements…
- **A qualitative system infrastructure for data management and interconnection** of system components is important as a **basis for condition monitoring and automatization**
- A **data platform** can be used as a **middleware for interconnection and data management** of the system and its components

SFERA-III

Solar Facilities for the European Research Area

Thank you.

Inga Miadowicz, DLR, Solar Research

NETWORKING

Summer School: "Smart CSP: How Smart Tools, Devices, and Software can help improve the Design and Operation of Concentrating Solar Power Technologies" - WP1 Capacity building and training activities - Cologne, Germany, September 14th-15th 2023

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO **823802**

Literature

- [1] International Electrotechnical Comission (IEC): *"IoT 2020: Smart and secure IoT platform"*, 2016, Geneva, Schweiz, https://www.iec.ch/basecamp/iot-2020-smart-and-secure-iot-platform (visited at 18.10.2022)
- [2] M. Ullah and A. Narayanan and A. Wolff and P. H. J. Nardelli: *„Unified Framework to Select an IoT Platform for Industrial Energy Management Systems"*, MIPRO 2021, Opatija, Kroatien
- [3] FIWARE Foundation e.V.: *„FIWARE, the Open Source Platform for Our Smart Digital Future"*, 2022, Online: https://www.fiware.org/ (visited at 02.05.2023)
- [4] International Telecommunication Union: "ICT infrastructure business planning toolkit – 5G networks", 2023, Online: https://www.itu.int/hub/publication/d-pref-ef-ict_struct_kit-2023/ (visited at 08.09.2023)
- [5] Bundesministerium für Wirtschaft und Energie (BMWi): *"Leitfaden 5G-Campusnetze – Orientierungshilfe für kleine und mittelständische Unternehmen"*, 2020, Berlin
- [6] SANDIA Report: *Power Tower Technology Roadmap and Cost Reduction Plan* (2011), SAND2011-2419
- [7] Rana, M. M., et al. (2016). Microgrid State Estimation Using the IoT with 5G Technology. Internet of Things (IoT) in 5G Mobile Technologies. C. X. Mavromoustakis, G. Mastorakis and J. M. Batalla. Cham, Springer International Publishing: 175-195.

Imprint

Topic:	**5G and IoT Platform for CSP** Presentation at the SFERA III Summer School in Cologne
Date:	15.09.2023
Author:	Inga Miadowicz
Institute:	Institute of Solar Research
Credits:	DLR: P. Schwarzbözl, D. Maldonado Quinto | Siticom: C. Falkenstern, Synhelion: S. Dieckmann | LeiKon: U. Ernste, N. Scholl | CONDOR: S. Warislohner | TU Dortmund: P. Jörke, J. Golembiewski, Prof. Dr.-Ing. T. Faulwasser, Univ.-Prof. Dr.-Ing. C. Wietfeld
Disclaimer:	This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement n°823802