Measurement-based Research, Sustainability and Research Data Management

Session: Large Scale Experimentation Facilities

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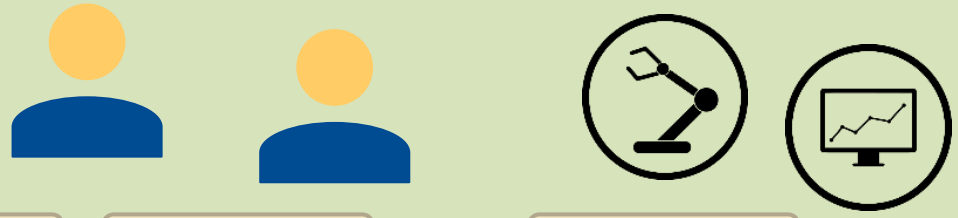
Measurement Research: Different Layers

Society, Industry,
Cities, Regions, World:
Sustainability

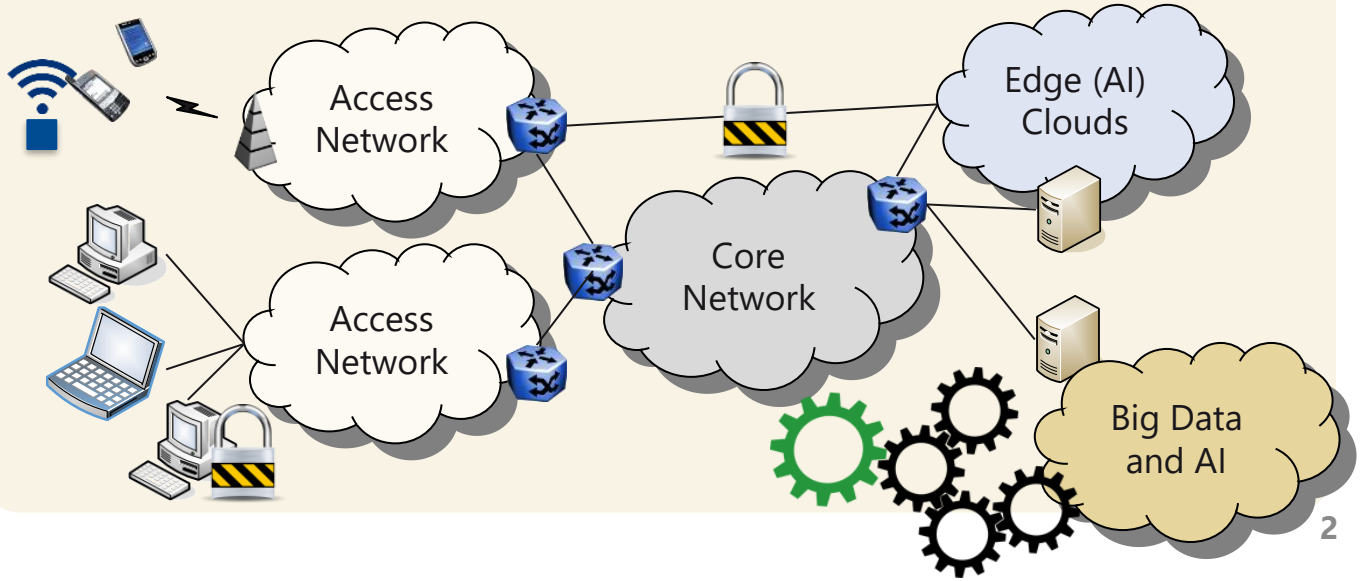
Applications and services for people and companies

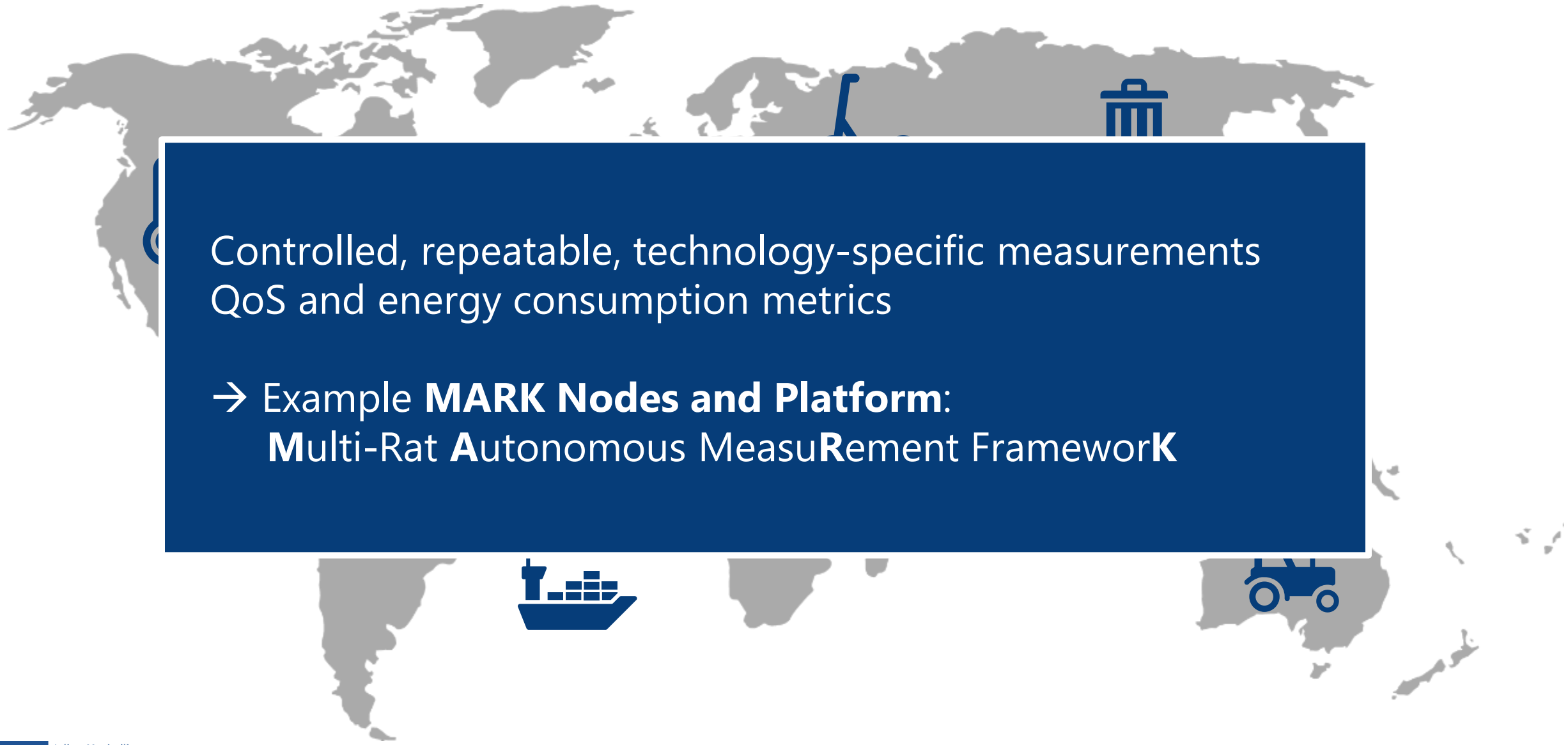


Application 1 | Application 2 | . . . | Application n

Networking, provision, operation of infrastructure, applications and services

Technical infrastructure: hardware (networks, servers, cloud) and software



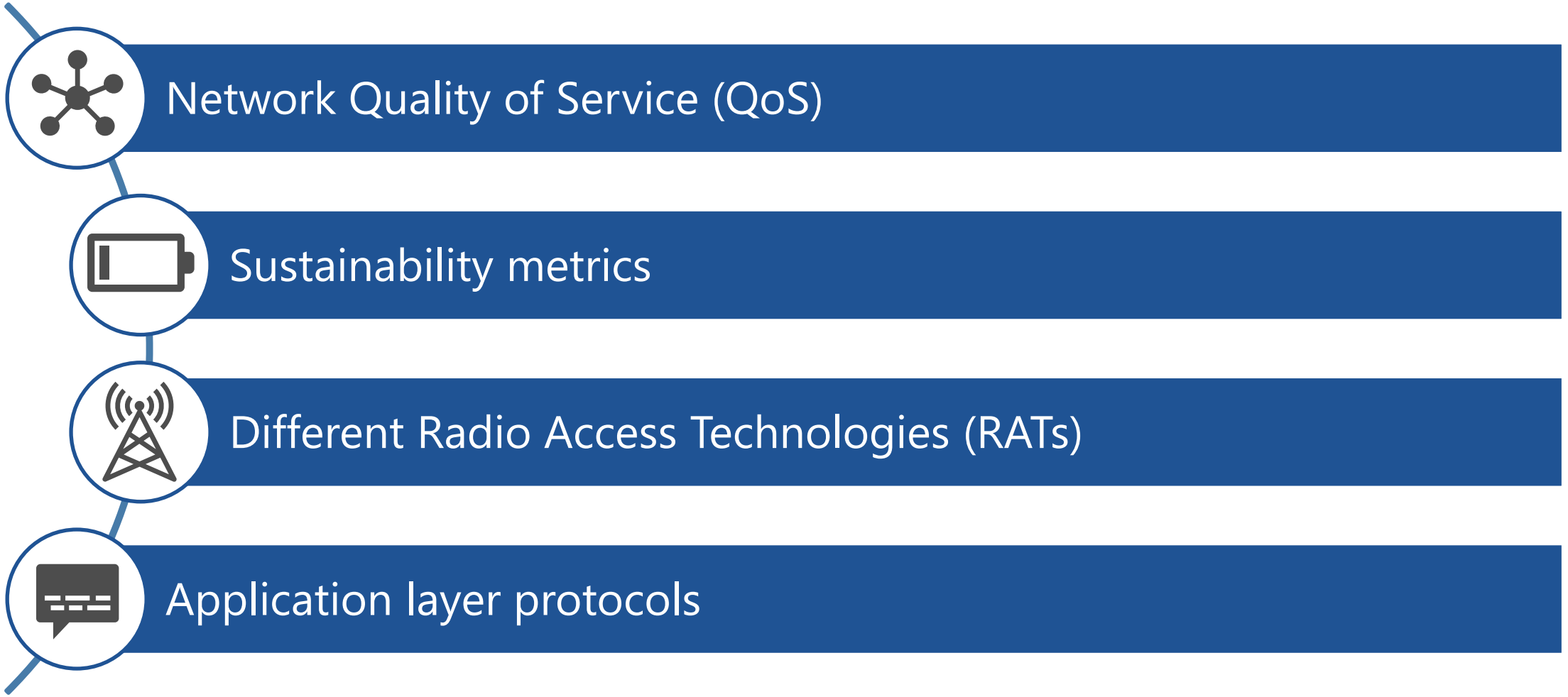


Controlled, repeatable, technology-specific measurements
QoS and energy consumption metrics

→ Example **MARK Nodes and Platform**:
Multi-Rat **A**utonomous Measu**R**ement Framewor**K**

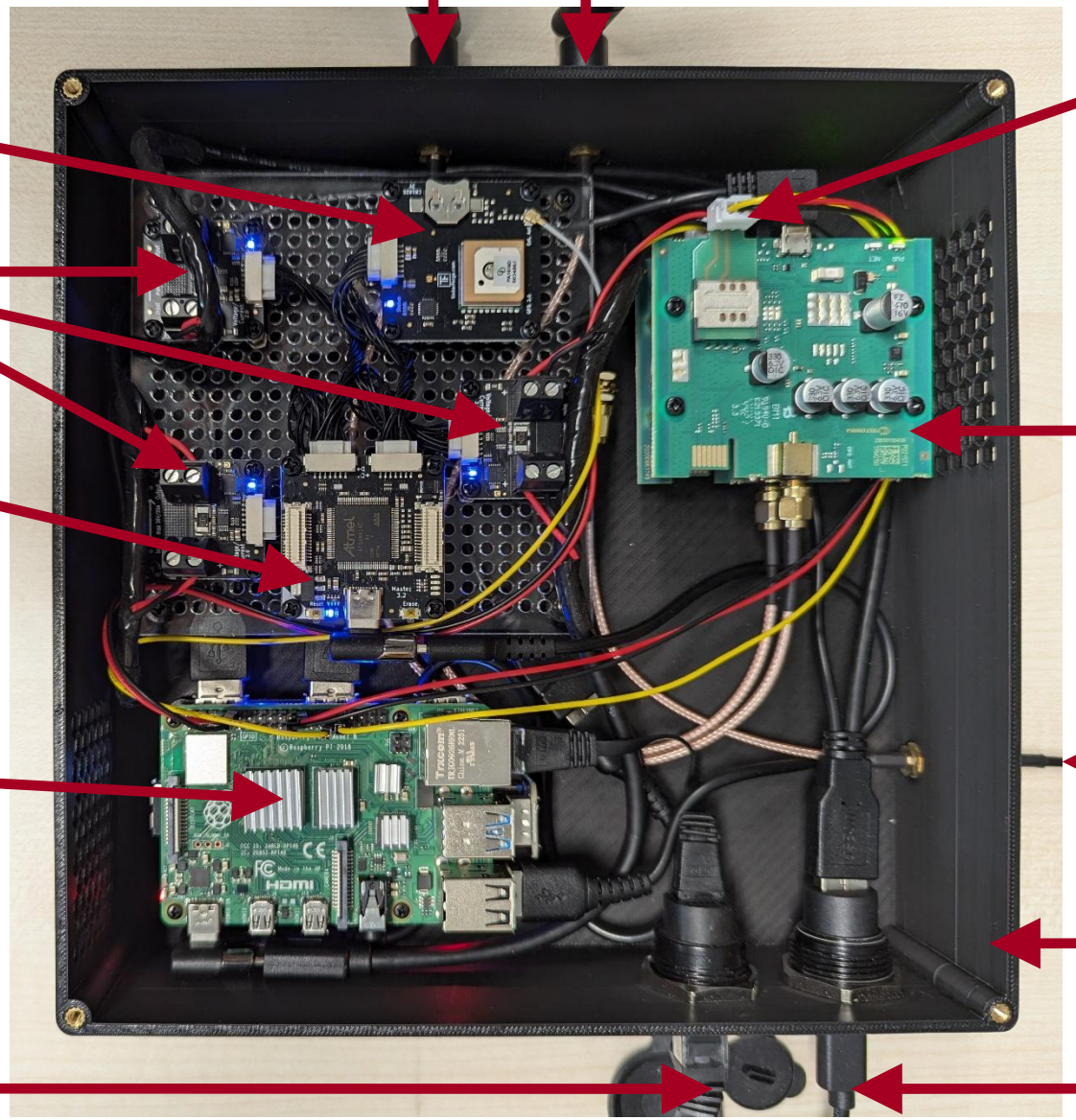
Purpose of Measurement Platform

- Development of a platform for distributed mobile measurements with a focus on



MARK Node

Antennas
TRM240 & TRM250



Tinkerforge

GPS Bricklet
- GPS, GLONASS, Galileo
- Positioning and time synchronization

Current/Voltage Bricklet
- Current monitoring
- Voltage monitoring

Masterbrick
- Module control
- Data collection

Pi & USB-Hub (stacked)

Raspberry Pi 4
- Experiment controller
- Application host
- Data storage

MEGA4 PPPS Hub
- Per-port power switching
- Remotely power-cycle modems

SIM PCB adapter

Modems (stacked)

Teltonika TRM240 (Quectel EC21)
- 2G
- 3G
- 4G (LTE Cat 1)

Teltonika TRM250 (Quectel BG96)
- 2G
- LTE-M
- NB-IoT

GPS antenna

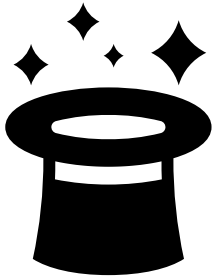
3D printed enclosure

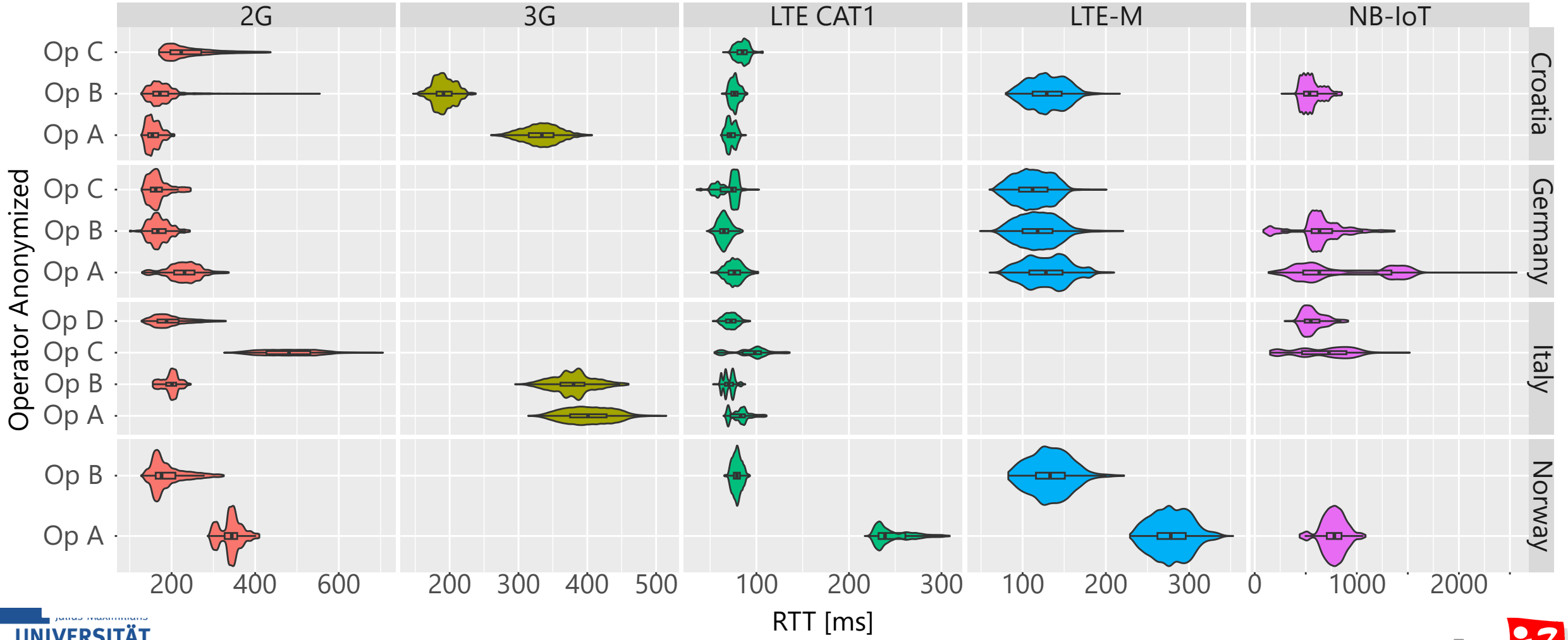
Ethernet

Power (USB-C)

Latency Distributions

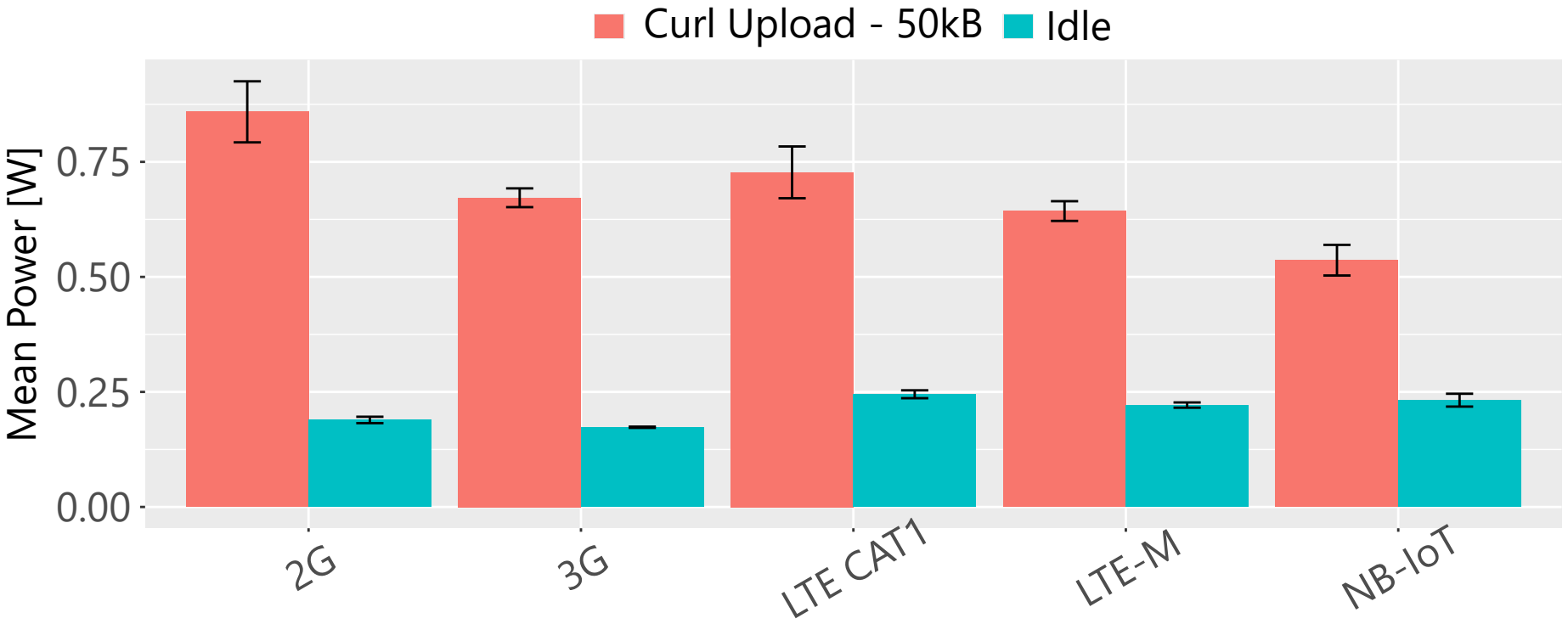
- Interesting insights across operators, countries, technologies !





Mean Power Draw

- Results in real-world not as expected !



- Limited set of hardware (modems) and SIM identities, e.g. regional restrictions
- More nodes → better statistical confidence → fewer random local effects

→ Extend number of nodes and expand presence in countries

Why Large-scale Experimental Facilities?

1. Realism at Scale
2. Stress Testing & Scalability
3. Diversity of Environments
4. Reproducibility Across Sites
5. Community and Shared Use

Asking people

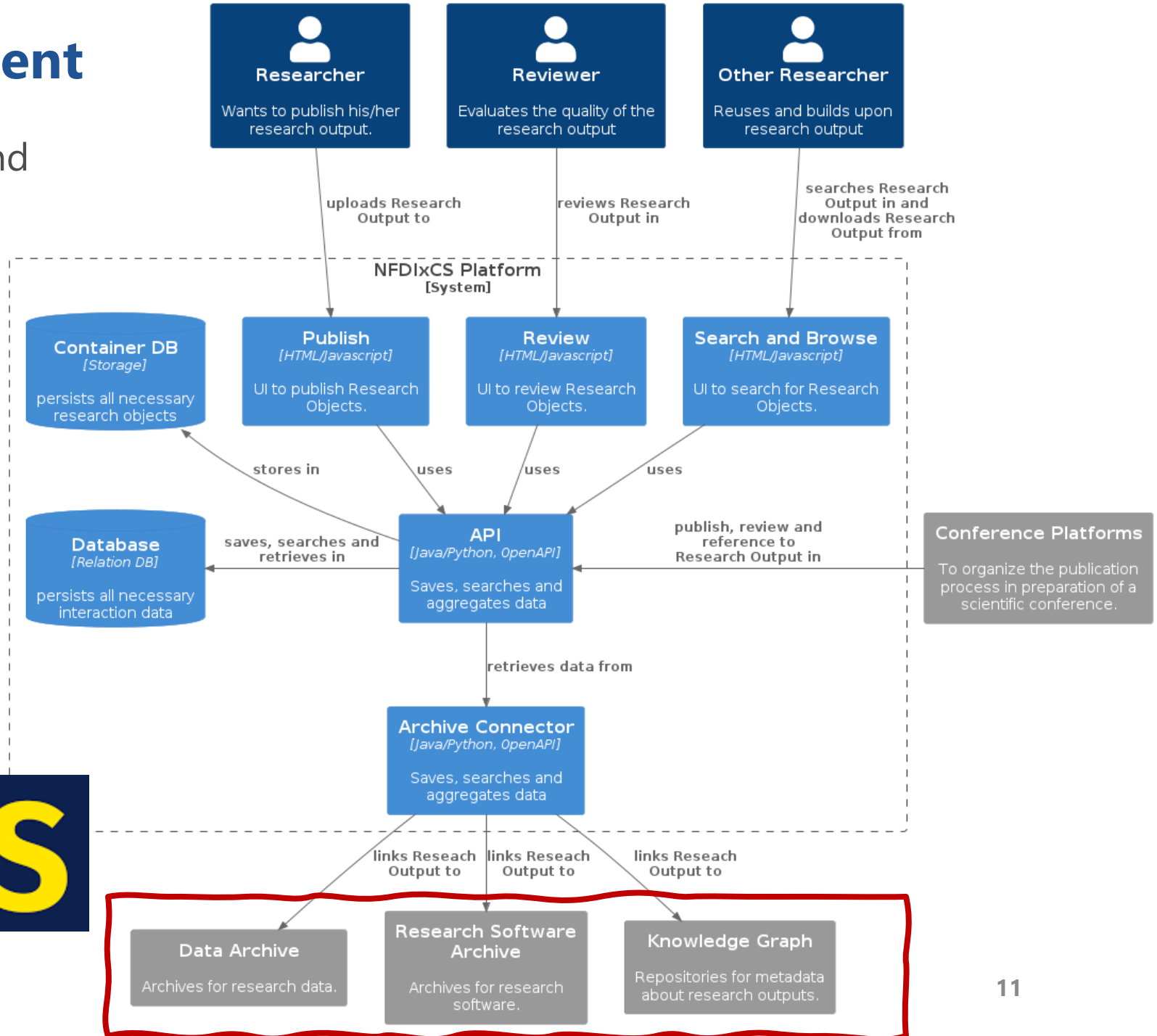
- *What do you need for your research? What are issues?*
  - Issue: only smaller scale possible, limitations of realism
  - *Get access to new **technology** / hardware*
  - *Access to specialized testbeds and methods, e.g. energy*
  - *Get a **shared testbed***
  - *Get access to (large-scale) realistic / **real-world data***

  - *Experiments archived somewhere so that it is easy to set them up again or extend follow-up studies → **Execution environment**: container system such as the **NFDIxCS prototype***

Research Data Management

- Organizing, storing, preserving, and sharing
  - research **data** &
  - research **software** in execution environments

- FAIR principle
  - Findable
  - Accessible
  - Interoperable
  - Reusable

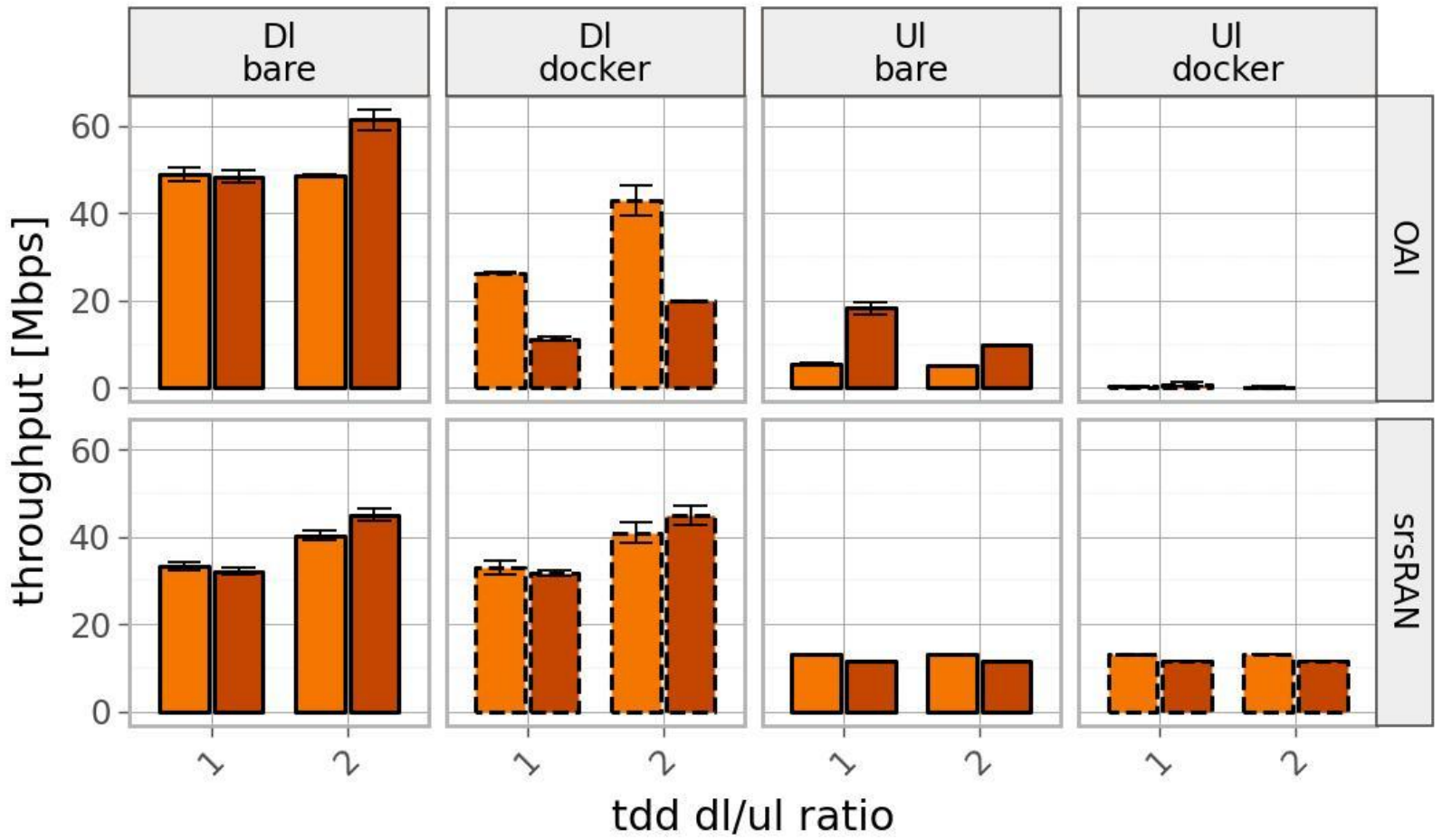


NFDI × CS

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

5G Campus Testbed: gNB Dockerization

- Throughput for dockerized gNB implementations
- srsRAN roughly stable for Docker and bare metal
- OAI exhibits significant loss of throughput with Docker



Issues for reproducible research to be addressed !

Conclusions: Large-Scale Shared Experimental Facility

Realistic Evaluation	Tests in environments resembling actual deployments
Shared Infrastructure	Cost-effective and avoids duplication of effort.
Community Collaboration	Enables multi-institutional, cross-border research.
Data Availability	Facilitates measurement-based research with high-quality, real-world data traces.
Reproducibility	controlled, repeatable experiments across researchers
Research Data Management	is essential for transparency, reproducibility, and long-term value of research.

Thanks to my team members !

Especially for the slides: Viktoria Vomhoff (MARK Plattform), Simon Raffeck (5G Testbed), Nikolas Wehner (Reproducibility and NFDIxCS)

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