



BRNO
UNIVERSITY
OF TECHNOLOGY



FACULTY OF ELECTRICAL
ENGINEERING AND COMMUNICATION
department
of telecommunications



Topic: Communication Systems for Internet of Things (mMTC; IIoT; 5G; 5G-IoT)

Presented by: Dr. Pavel Mašek

Brno, March 18, 2024

- **Dr. Pavel Mašek**
 - [LinkedIn](#), [ResearchGate](#), [BUT profile](#)
- Assistant professor
 - Faculty of Electrical Engineering and Communication (FEEC)
- Courses:
 - Communication Systems for IoT
 - Mobile Network Communication Systems
- Bio: Pavel is co-supervising the WISLAB research group and leading the **#VodafoneUniLab**, where his current research interests include various aspects in the area of heterogeneous wireless communication networks.





Anyone can talk about 5G and IoT.
Who is able to really explain?

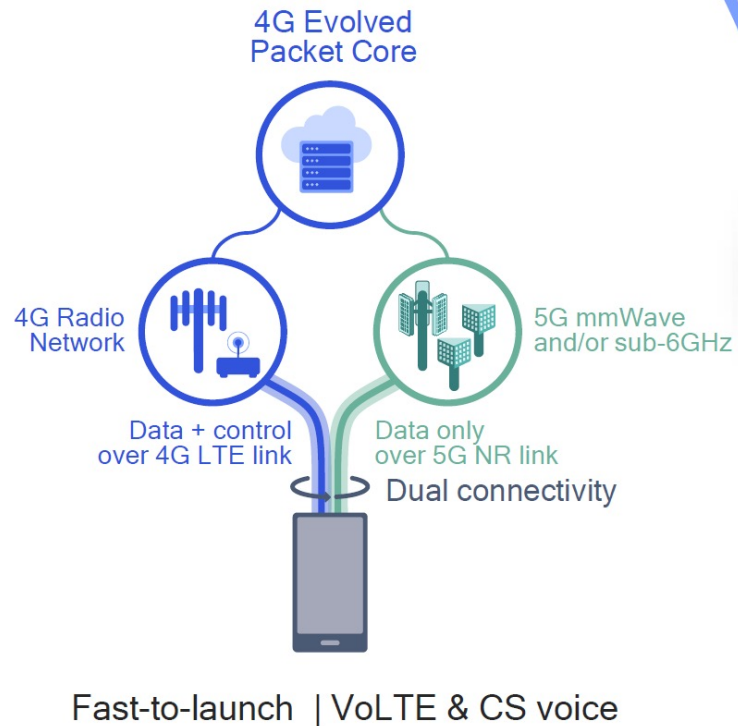


Sources: White-papers and materials by: Qualcomm, Cisco, Nokia, Ericsson, and IBM.

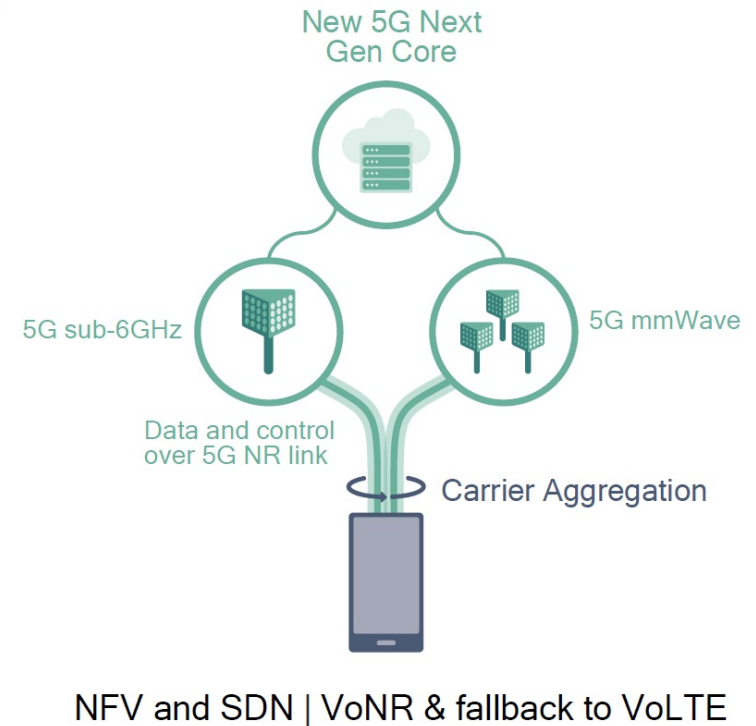


5G (N)SA – Launching With a Helping Hand of 4G

Non-Standalone (NSA) stepping stone to new core

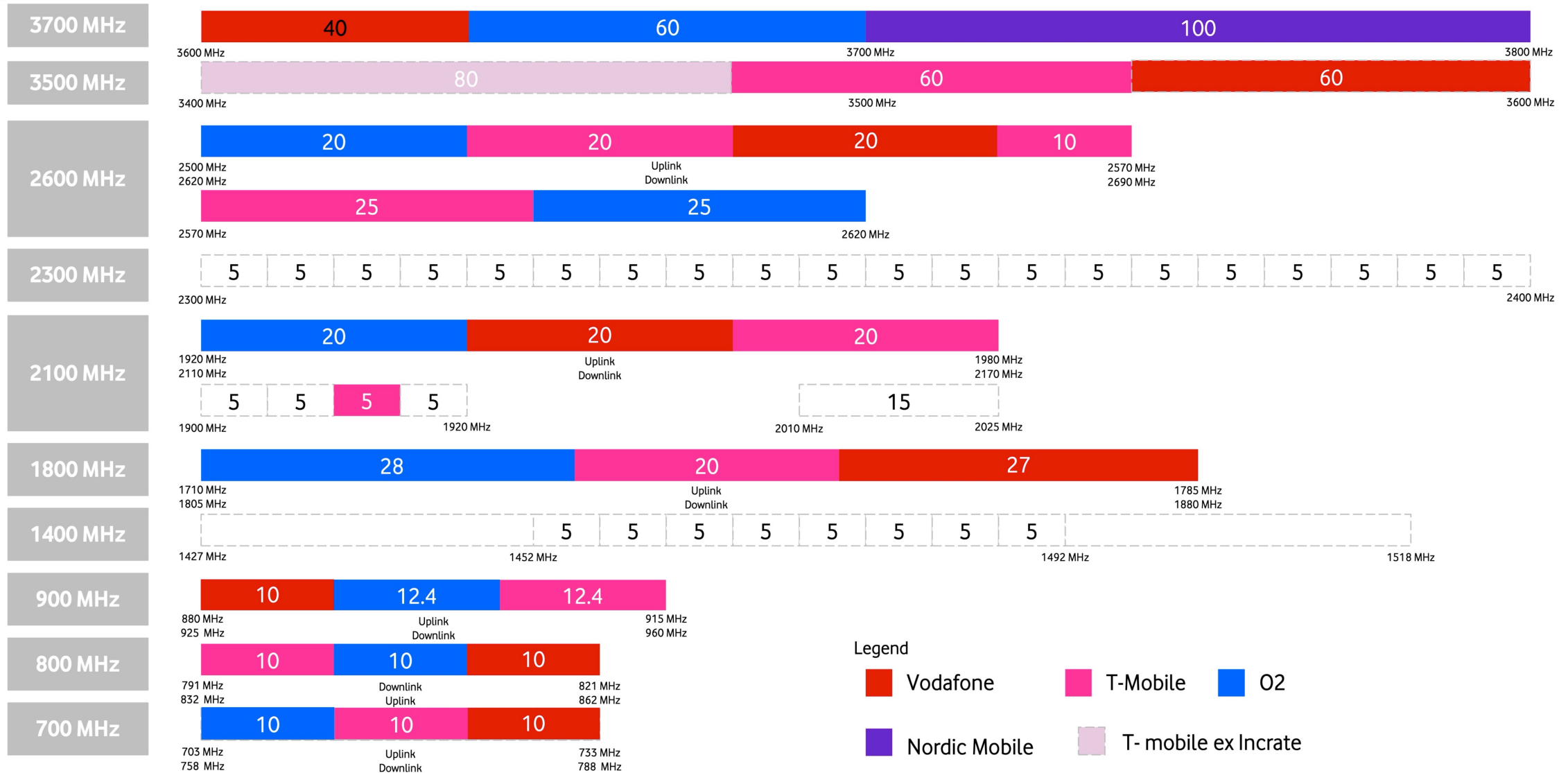


Standalone (SA) for new core benefits



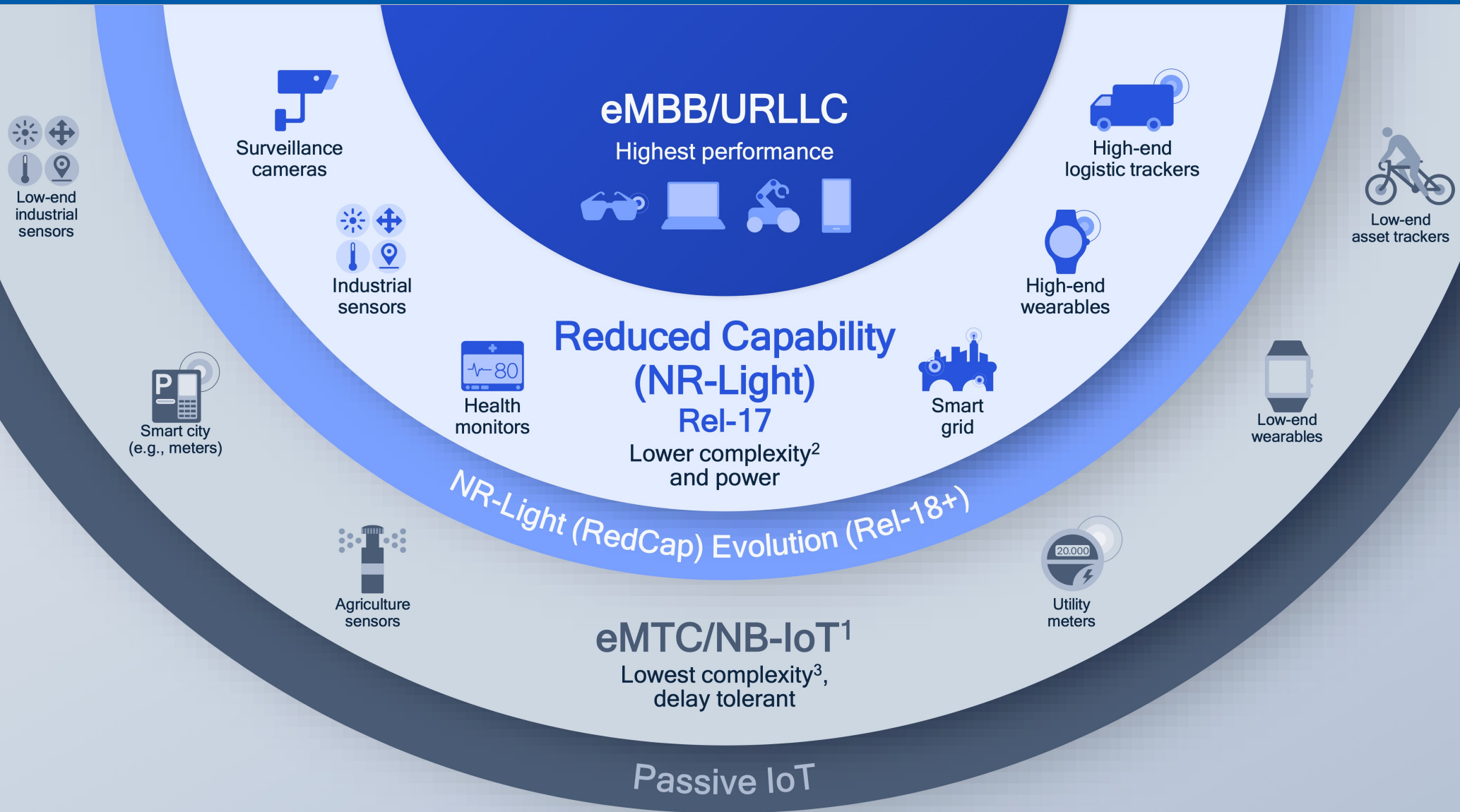


Czech Republic Spectrum Overview (2023)





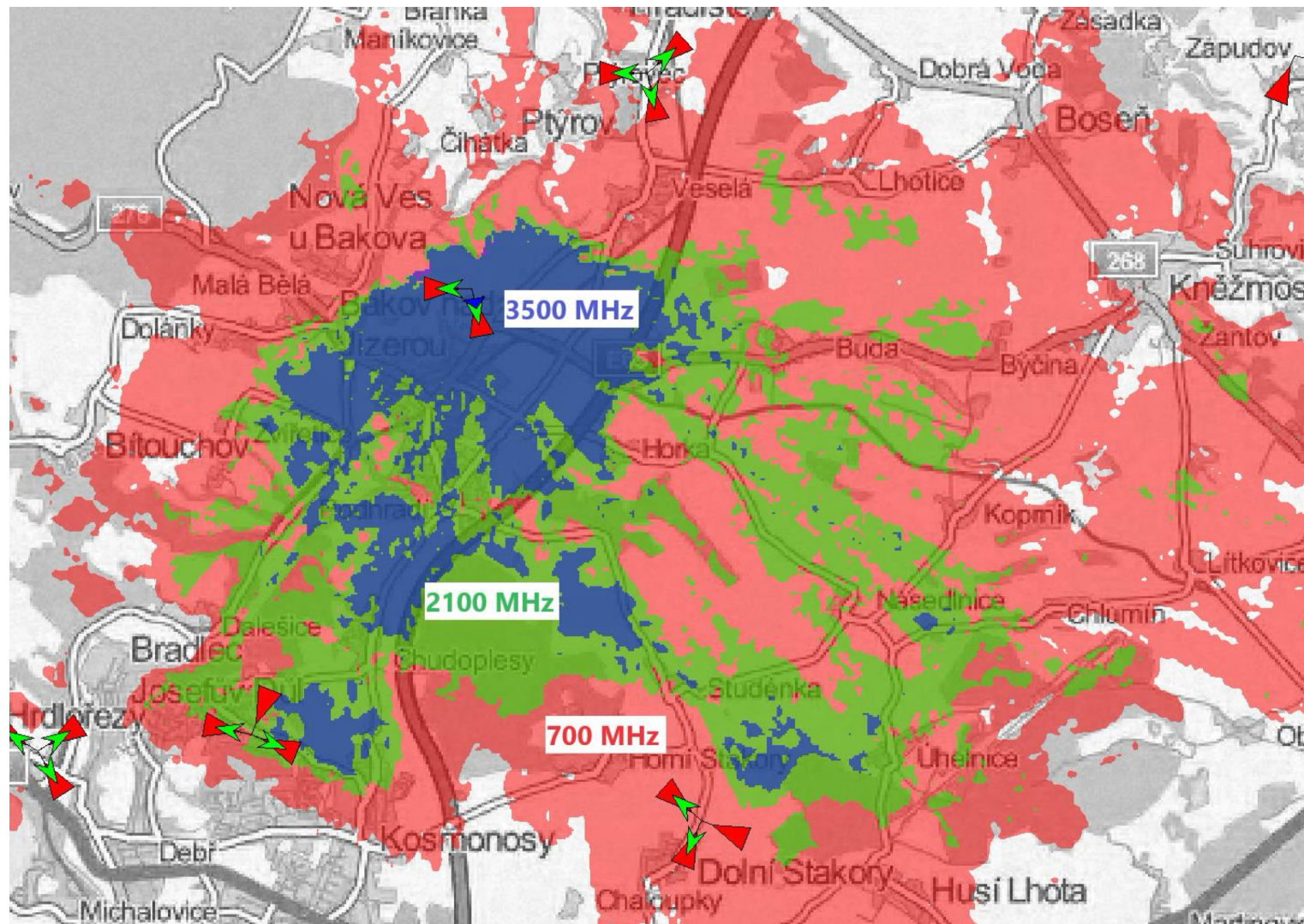
Scaling Down 5G NR for Lower Complexity IoT Devices





Designing a Unified, More Capable 5G-IoT Air Interface

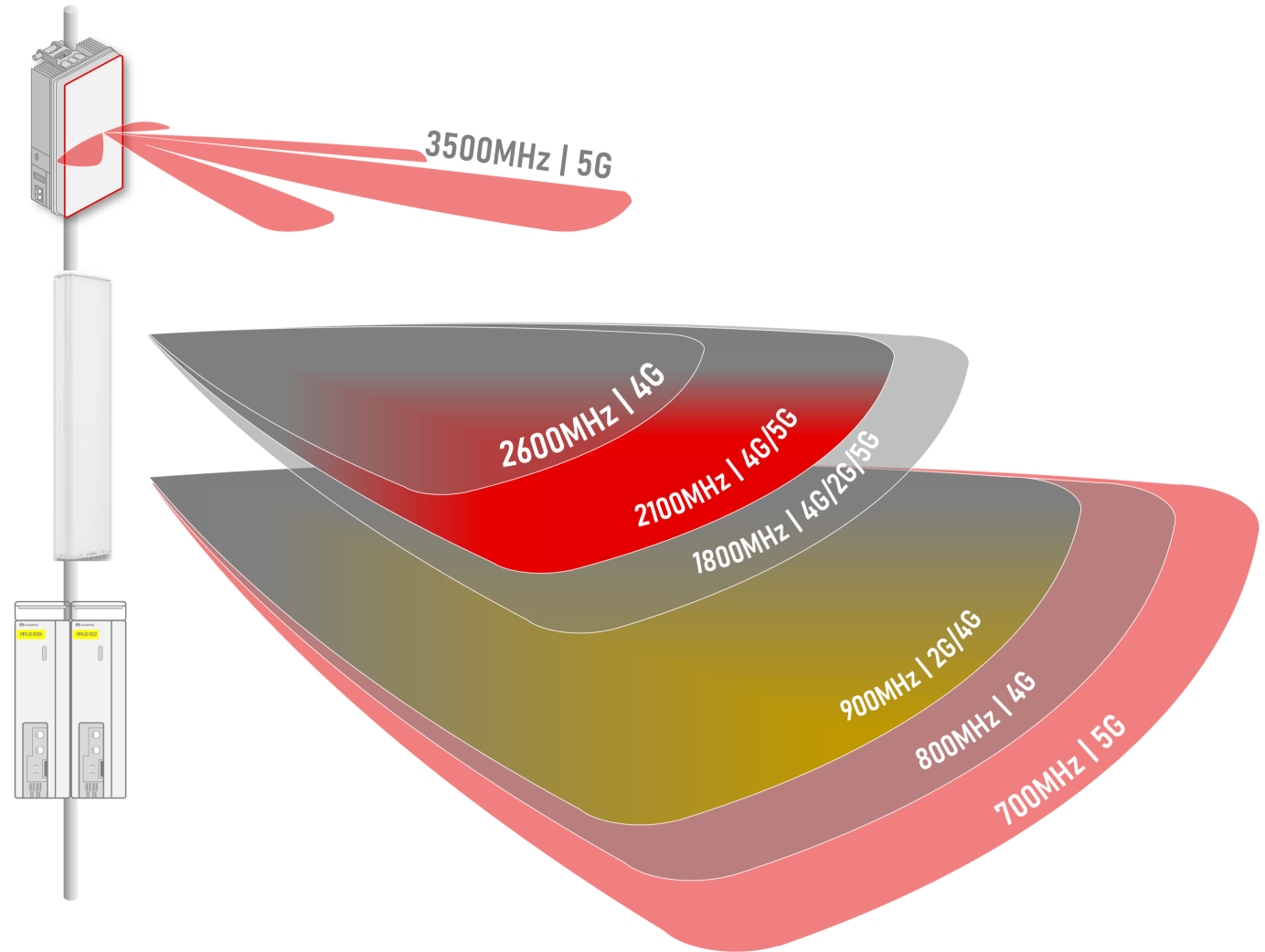
- Channel bandwidth:
 - 3500 (100 MHz).
 - 2600 (20 MHz).
 - 2100 (20 MHz).
 - 1800 (27 MHz).
 - 900 (10 MHz).
 - 800 (10 MHz).
 - 700 (10 MHz).
- Priorities of the cells.
- Capabilities of the terminals.
- Admission/congestion control.
- Load balancing.
- Power save features.





Designing a Unified, More Capable 5G-IoT Air Interface

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Low-Power Wide-Area Networks



Cellular IoT Technologies for mMTC

Up to 23dBm (200mW)

Low-Power Wide-Area Networks

10+ years on simple battery



Cellular IoT Technologies for mMTC

15-70km rural outdoor

Low-Power **Wide-Area** Networks

2-3km urban indoor



Cellular IoT Technologies for mMTC

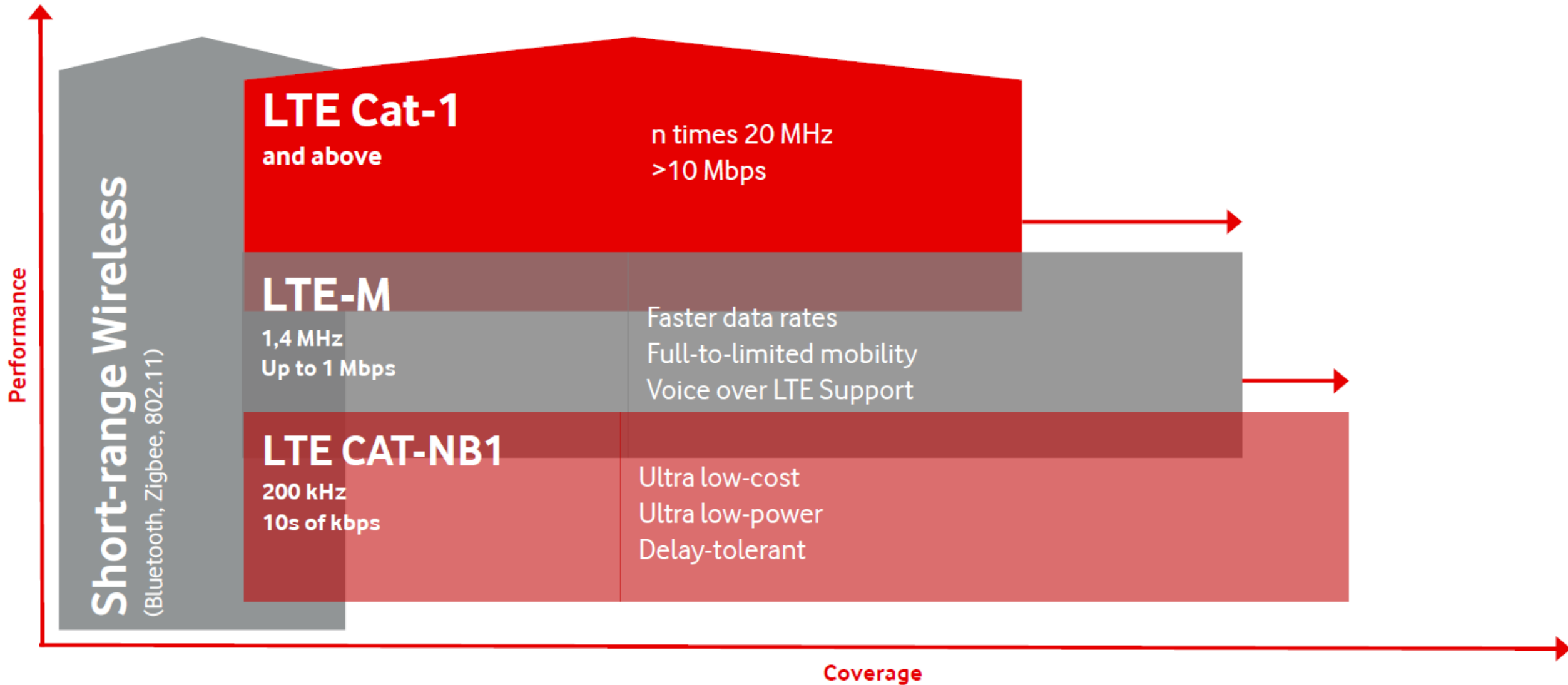
License-exempt

Low-Power Wide-Area **Networks**

Licensed spectrum

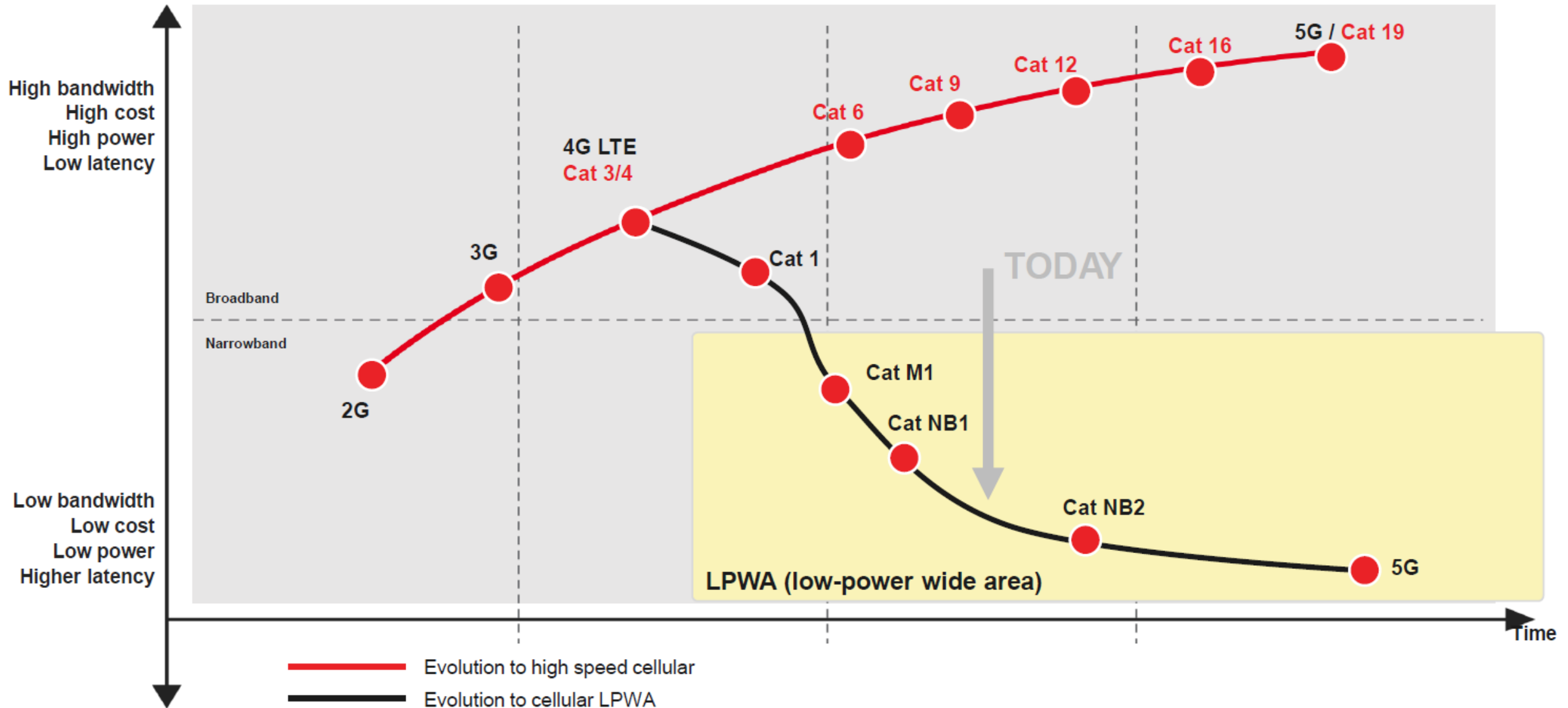


Cellular IoT – Two New LTE-Based Technologies



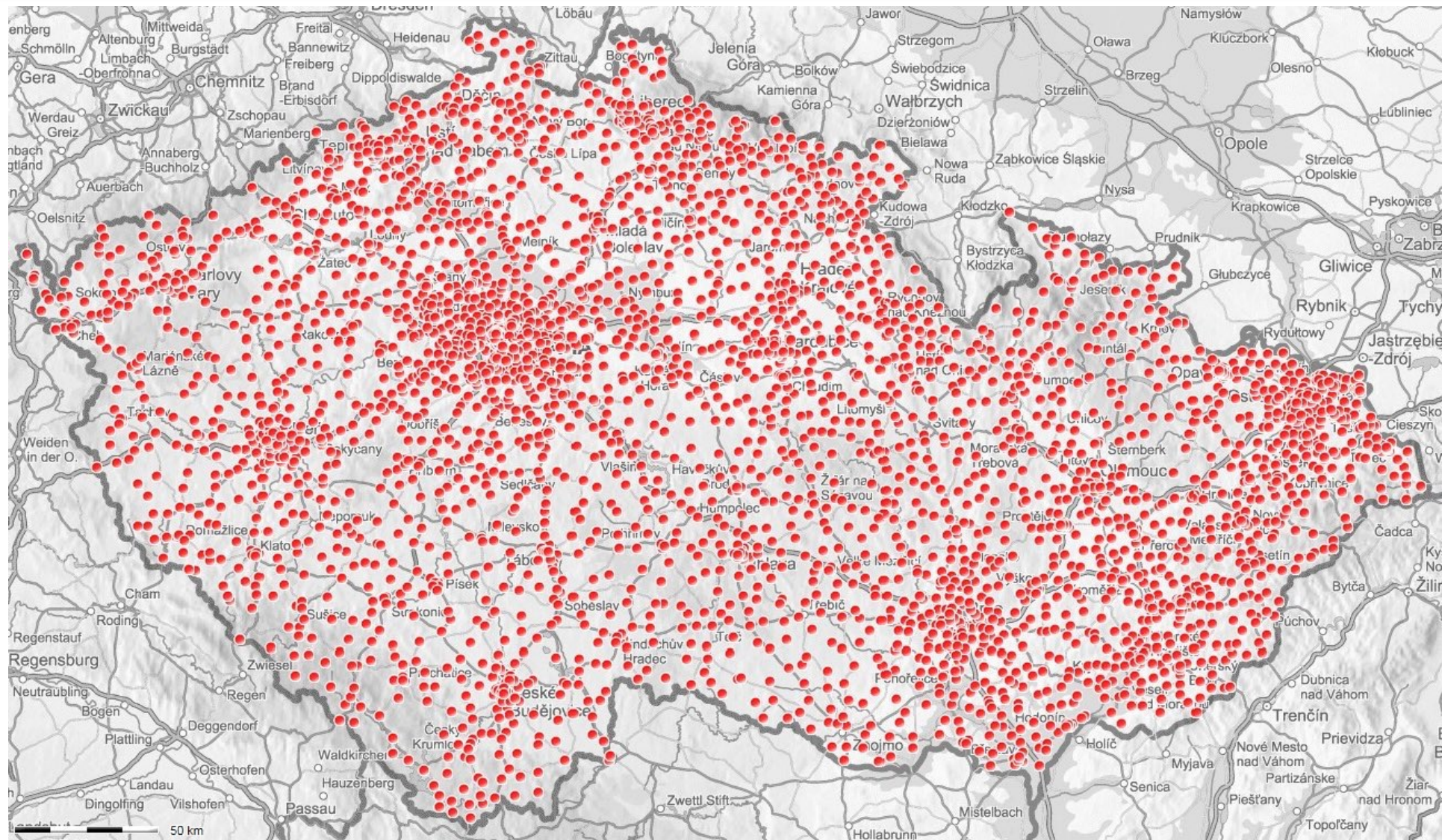


... with a Focus on LPWA (CIoT) Technologies for the IoT



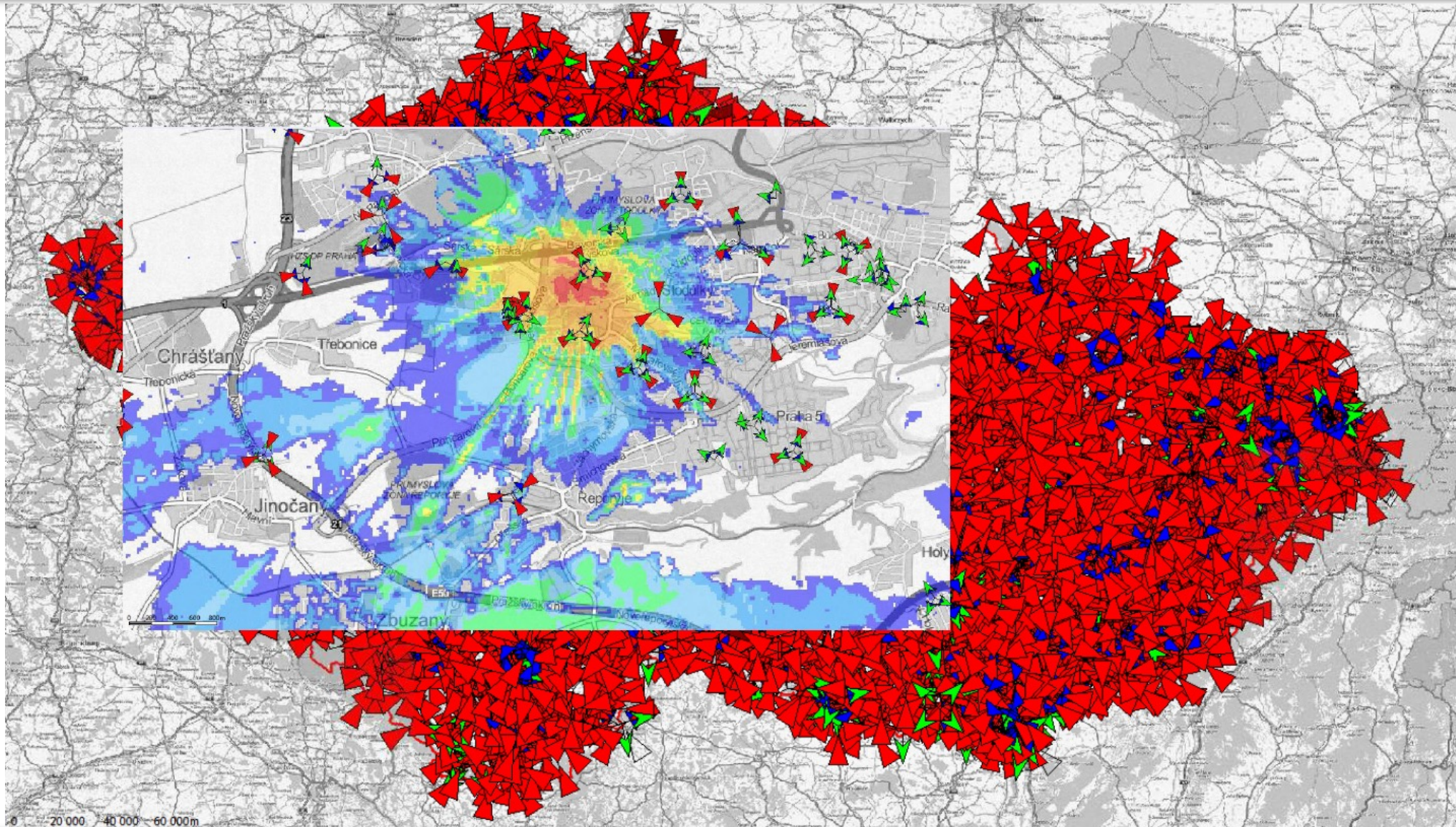


NB-IoT / LTE Cat-M Deployment In Czech Republic (VF)





NB-IoT / LTE Cat-M Deployment In Czech Republic (VF) – [Map](#)





NB-IoT / LTE Cat-M Deployment In Czech Republic (VF) – [Map](#)

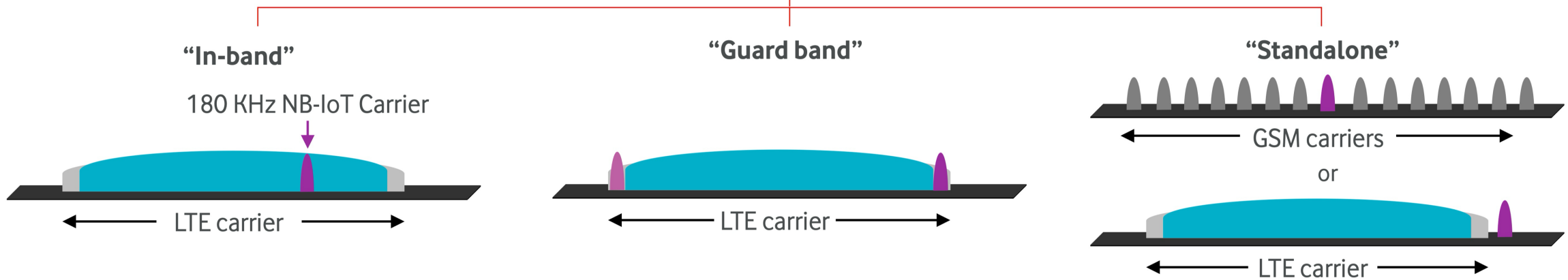
NB-IoT – 1RB 180kHz = 12subcarriers x 15kHz

LTE 10 MHz - 50RB -> 50x180kHz = 9MHz 2x 500kHz guard band

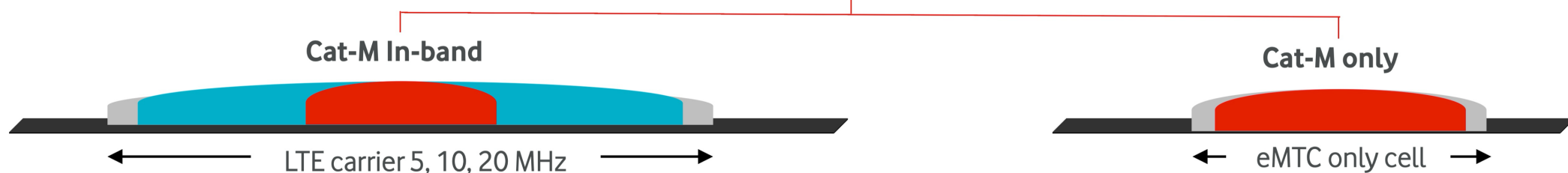
LTE Cat M1/ eMTC - 6RB – UE side

eNB side DSS eMTC and LTE

NB-IoT deployment options:



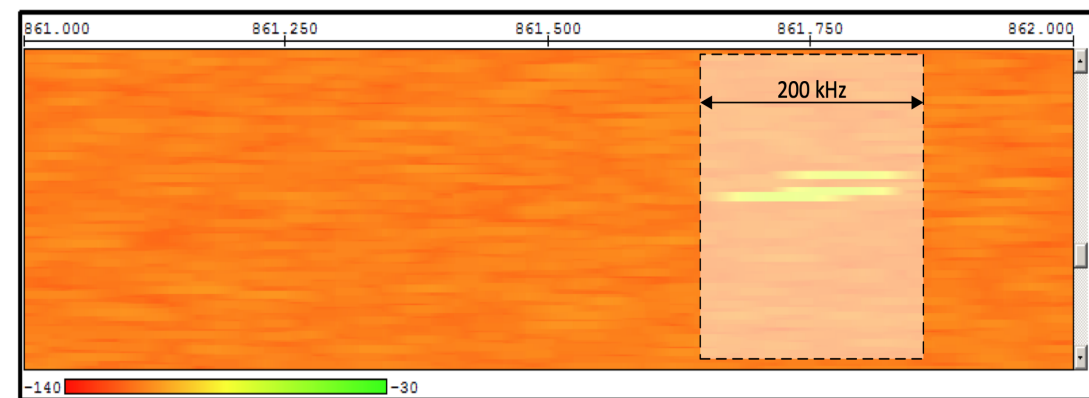
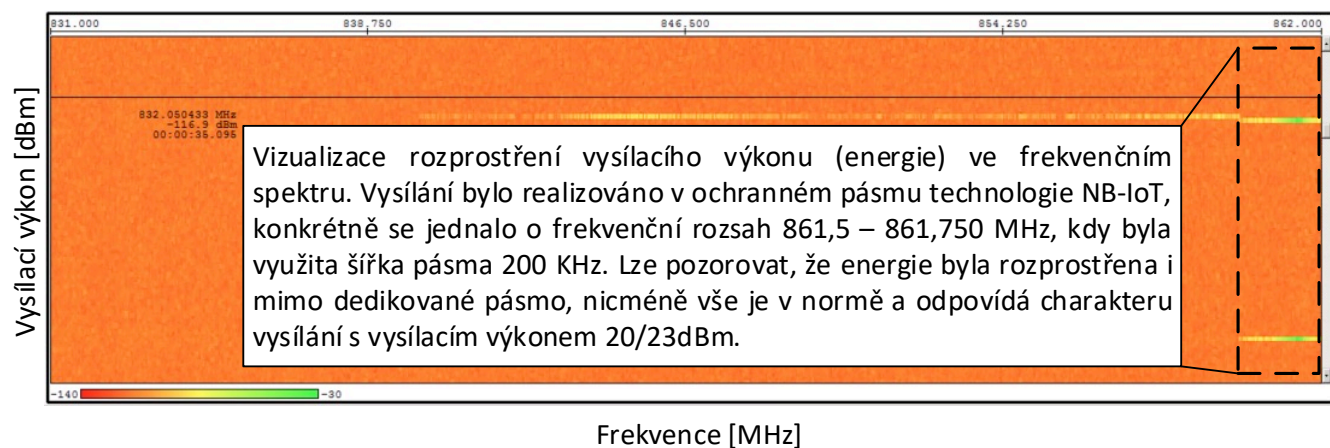
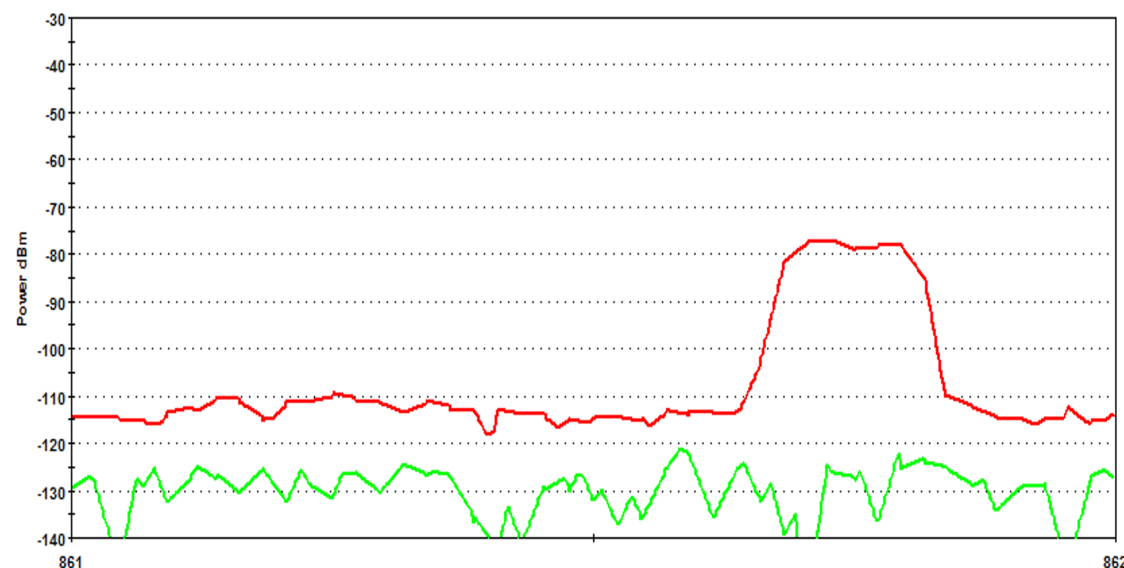
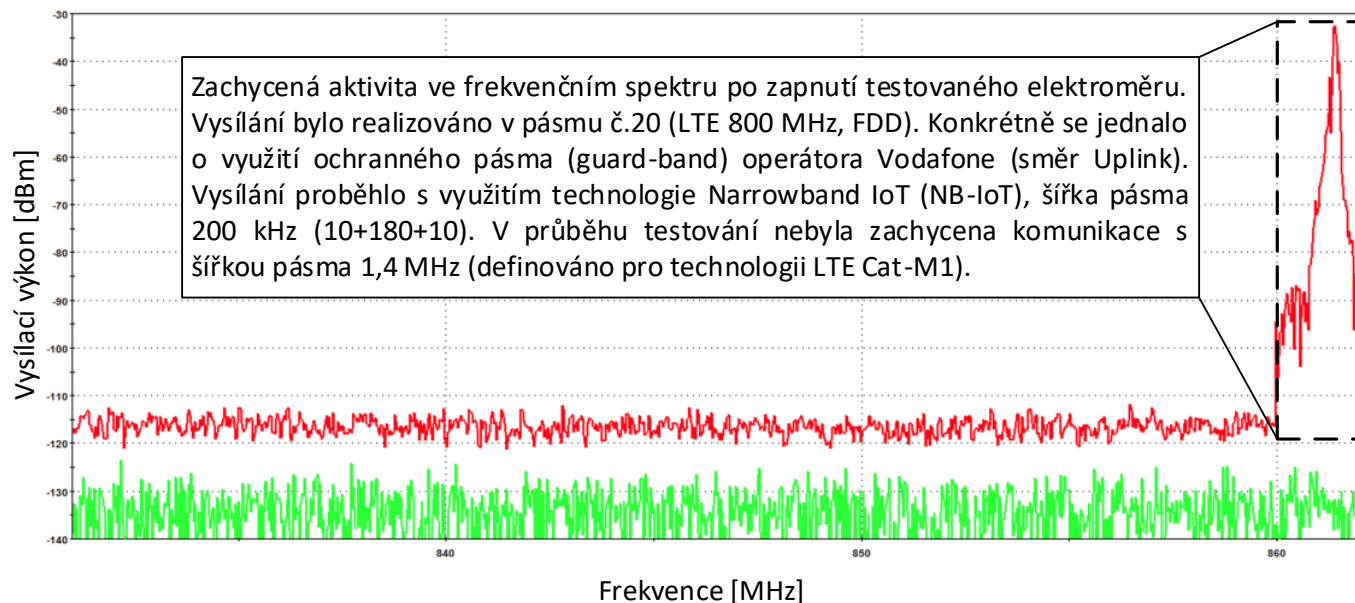
LTE cat-M deployment options:



Possible implementation in 5G NR – guardband or BWP – Bandwidth part

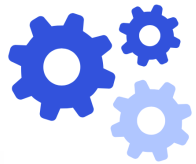
Subcarrier spacing 15kHz – influence on 5G performance

Czech Republic Frequency Spectrum – NB-IoT Example

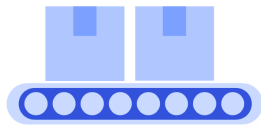




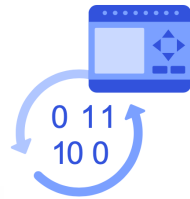
5G-IoT Takes Industry 4.0 to the Next Level



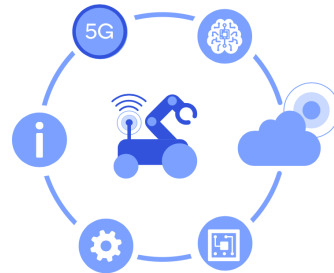
Industry
1.0
Mechanization



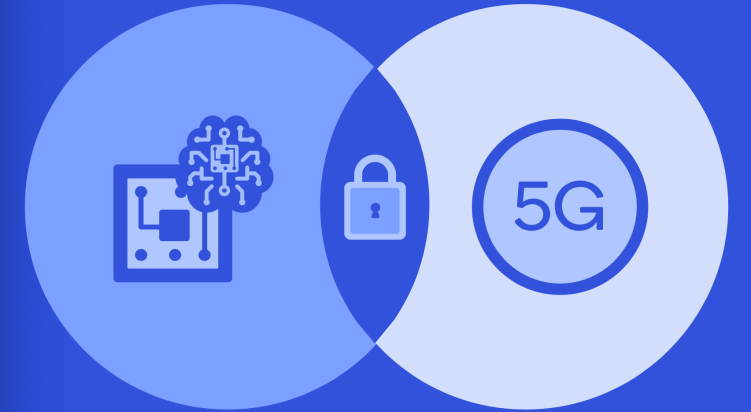
Industry
2.0
Electrification



Industry
3.0
Digitalization



Industry
4.0 + 5G
Wireless Connectivity



Compute • Security • Connectivity

On-device
processing and
sensing

CV and AI for
autonomous
robots

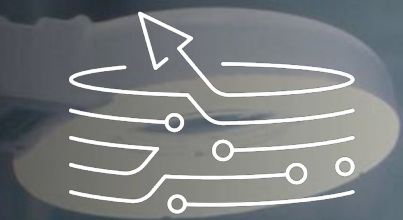
Edge services
and data privacy

Single
futureproof 5G
network

Scalable
capacity and
reliability

Flexibility with
wireless Ethernet

#VodafoneUniLab



T BUTCA

T FACULTY OF ELECTRICAL department
ENGINEERING of telecommunications
AND COMMUNICATION



T BRNO
UNIVERSITY
OF TECHNOLOGY

 **vodafone**
business



5G Rollout at BUT

#Vodafone
UniLab

LTE Cat-M (M1) RRH
900 MHz (band n.8)

5G NSA and NB-IoT (NB1, NB2)
RRH 800 MHz (band n.20)
RRH 900 MHz (band n.8)
RRH 1800 MHz (band n.3)
RRH 2100 MHz (band n.1)
RRH 2600 MHz (band n.7)

Shield box for the verification
of the different radio levels

Connection of the tested
devices with the antenna
system



5G Takes Industry 4.0 to the Next Level at BUT

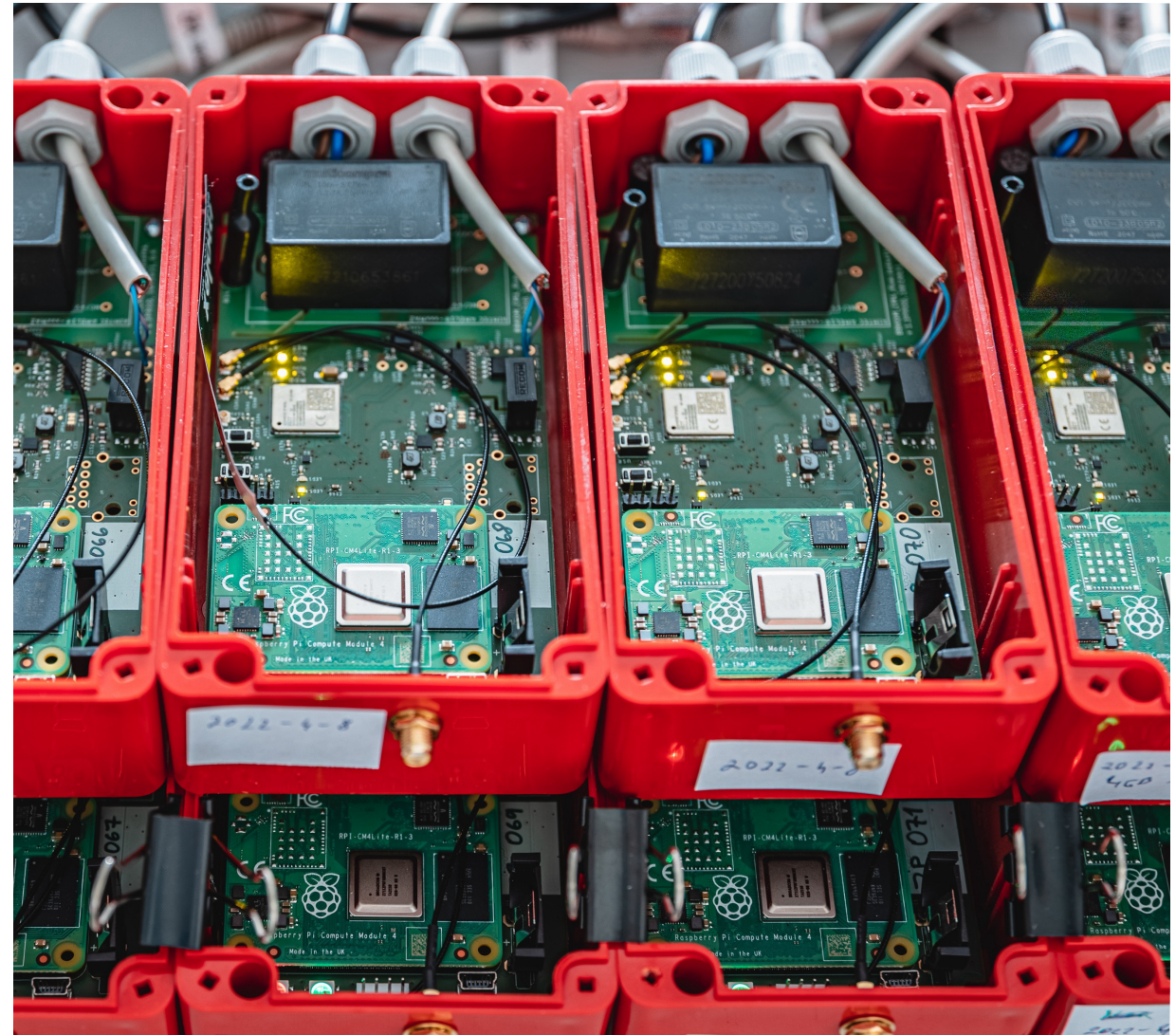


Smartbox



Smartbox – Smart Metering and Management Utilizing 5G-IoT

- Transformation of already deployed smart meters towards the intelligent device capable of secured communication utilizing the 5G-IoT technologies.
- Communication utilizing the Narrowband IoT (NB-IoT) and LTE Cat-M technologies, i.e., 5G-IoT.
- The cybersecurity implemented following Annex No. 4 to Decree No. 359/2020 Coll., compliance with FIPS 140-2, NIST and NÚKIB.





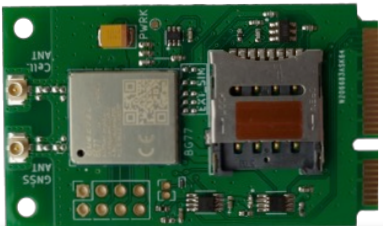
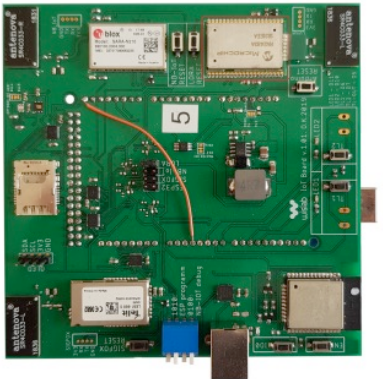
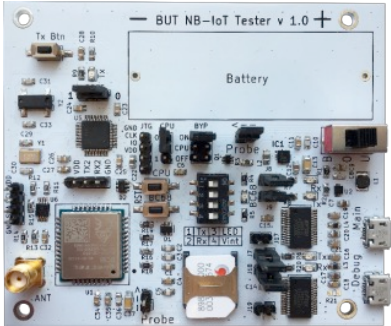
Smartbox – Smart Metering and Management Utilizing 5G-IoT

Research

Design

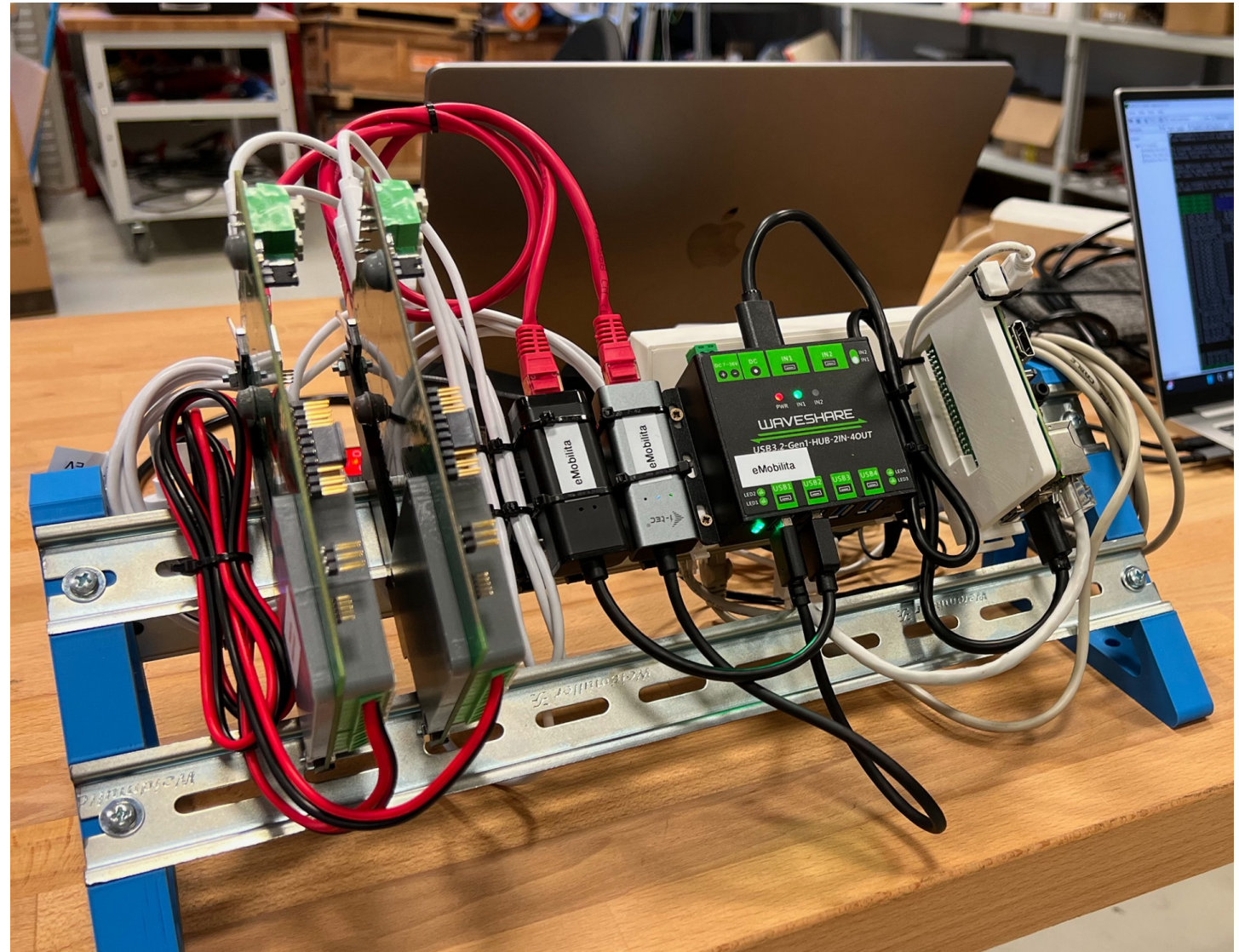
Verification

Production



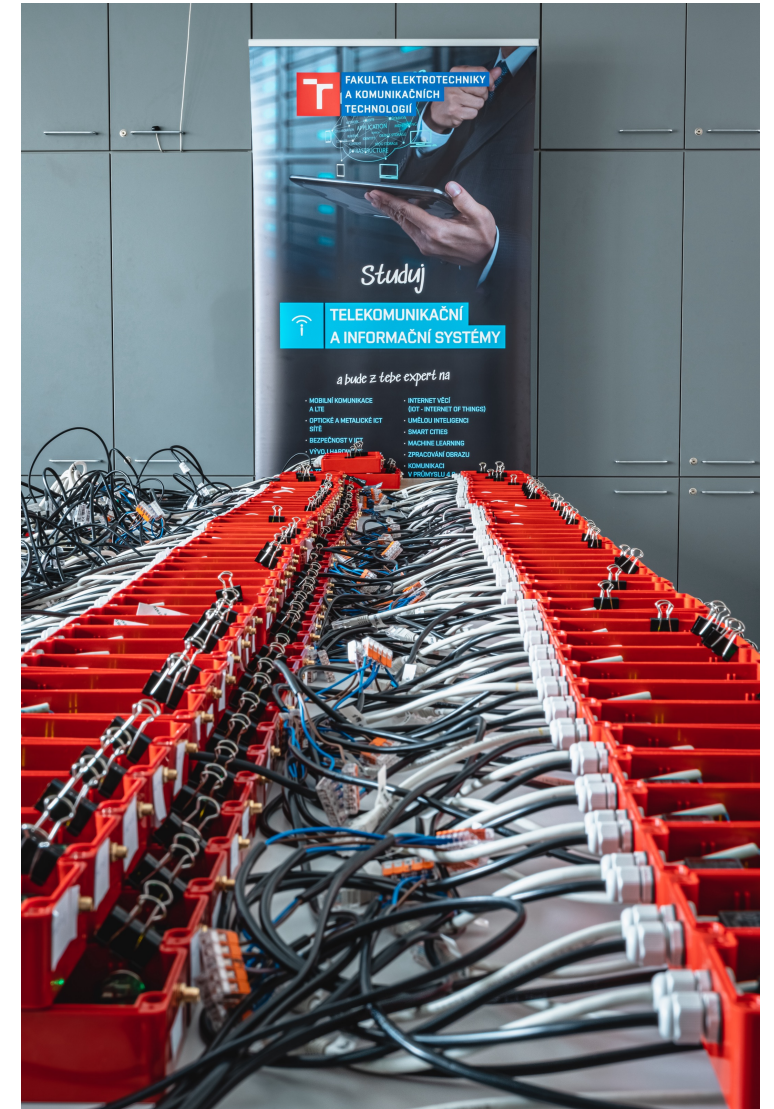
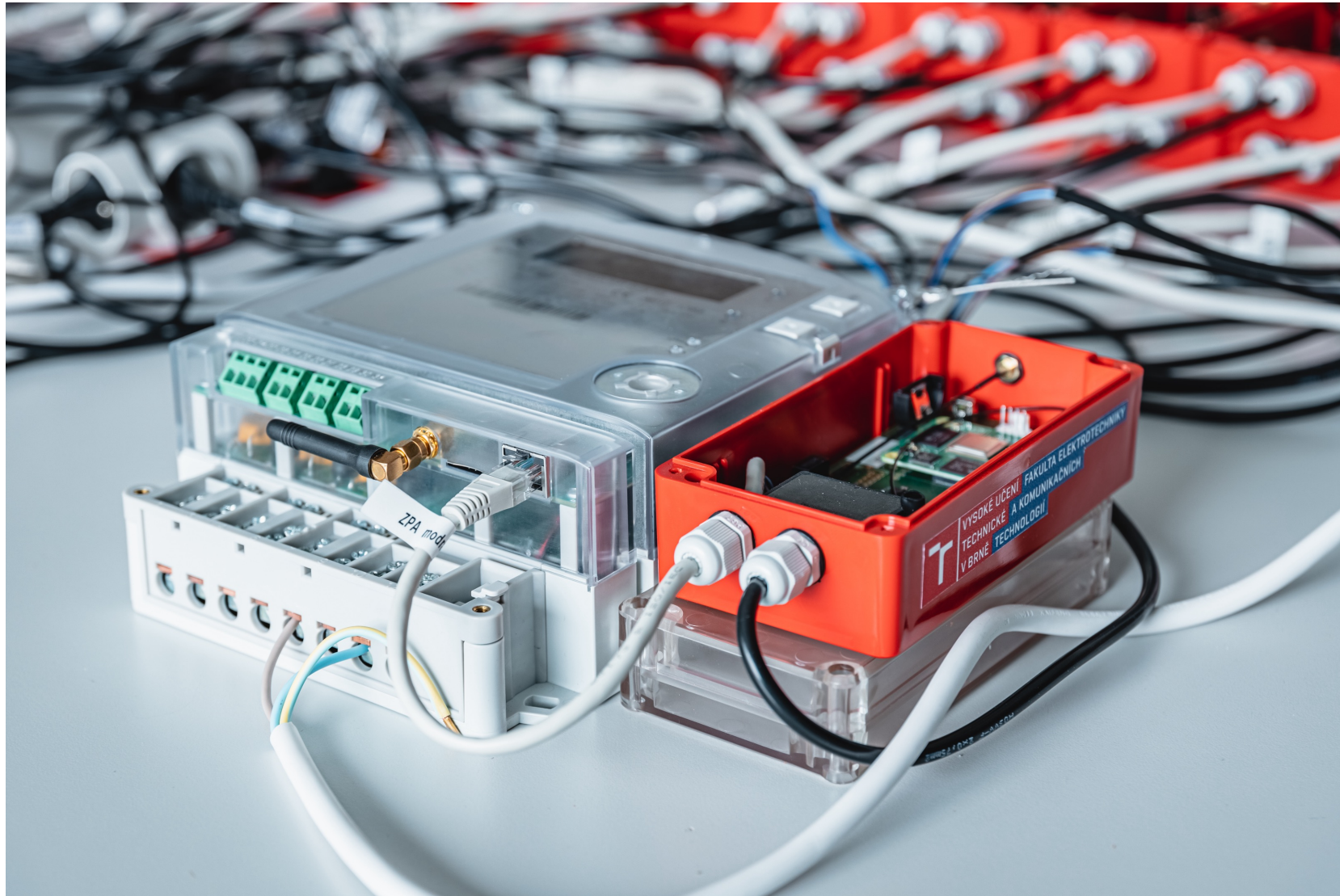


Smartbox – Smart Metering and Management Utilizing 5G-IoT



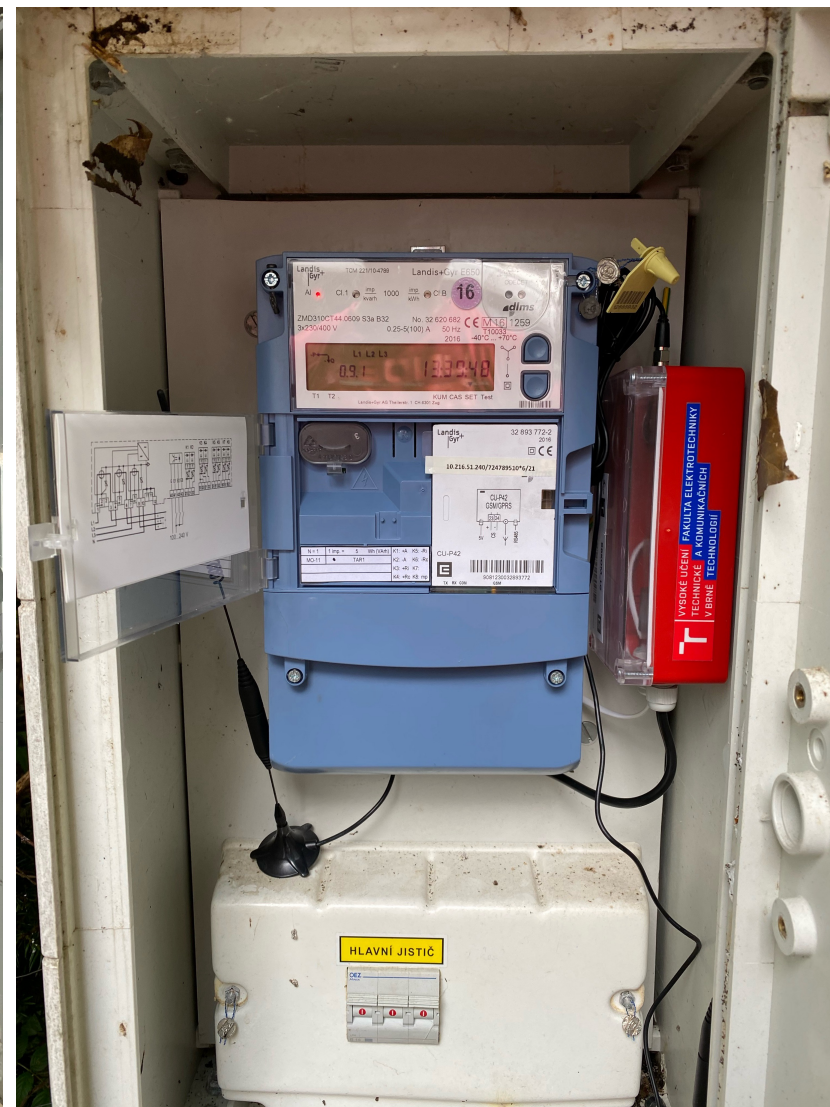


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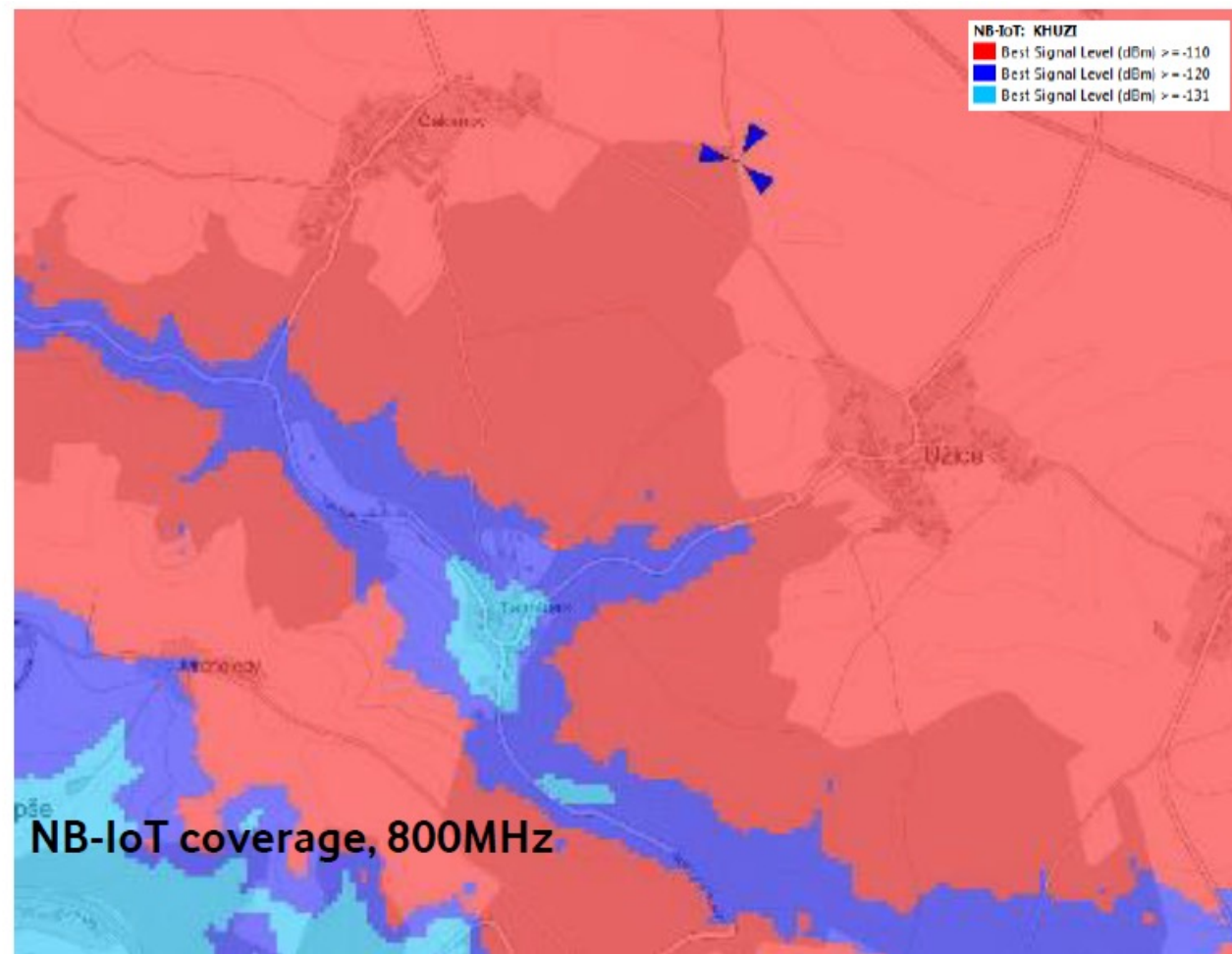
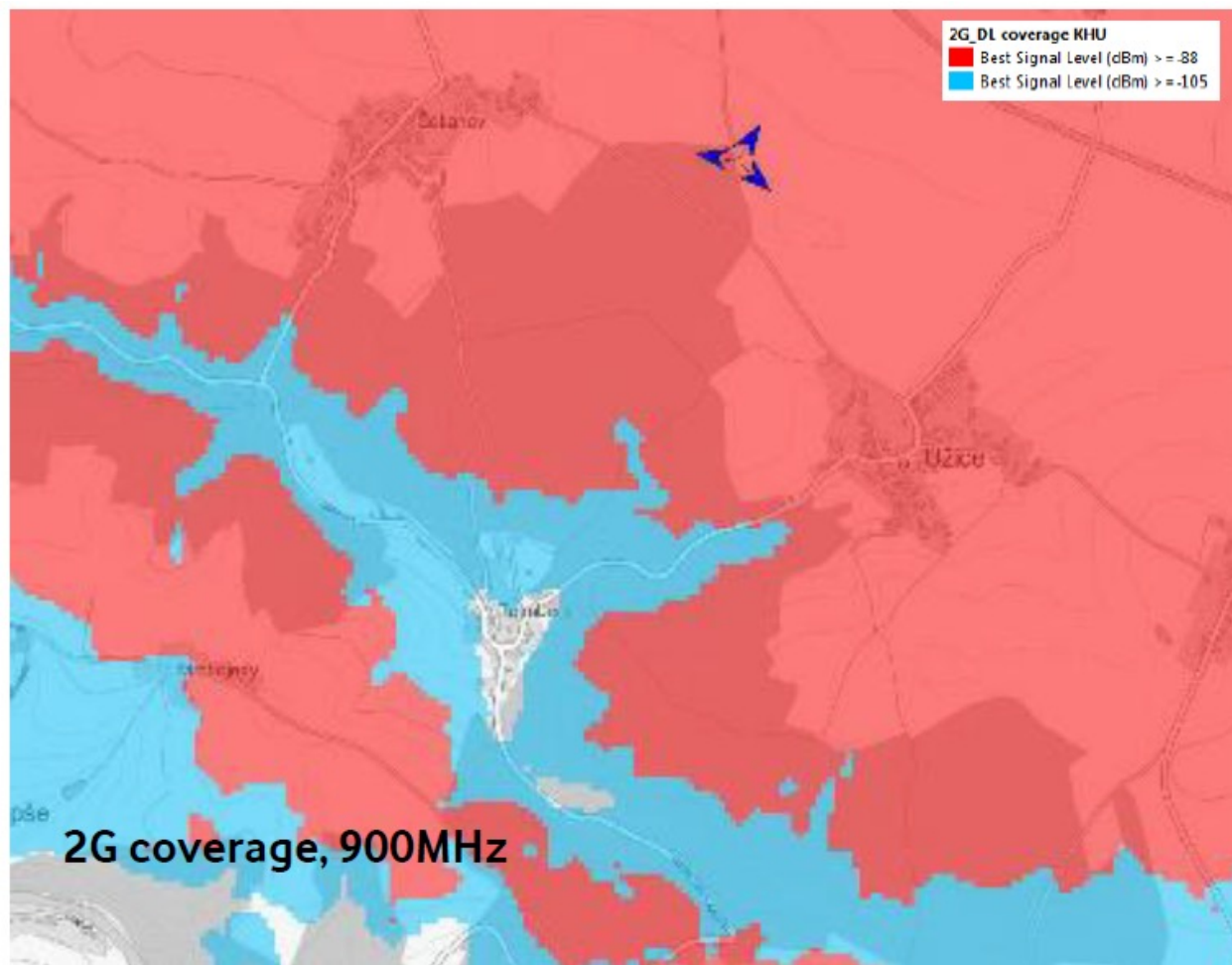


Smartbox – Smart Metering and Management Utilizing 5G-IoT



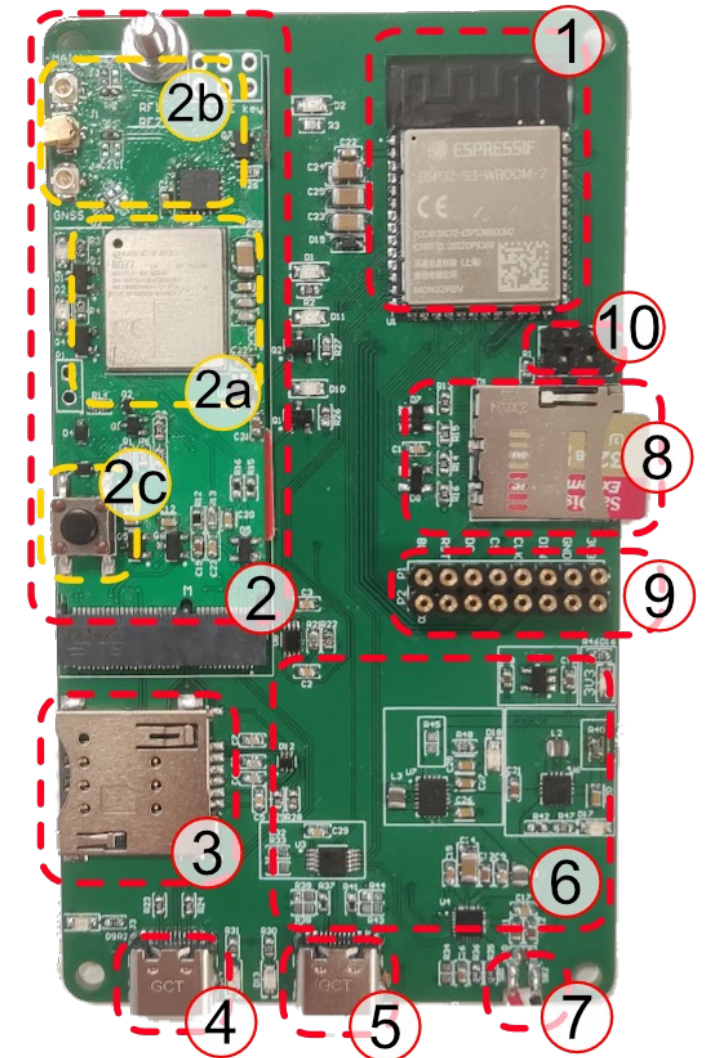
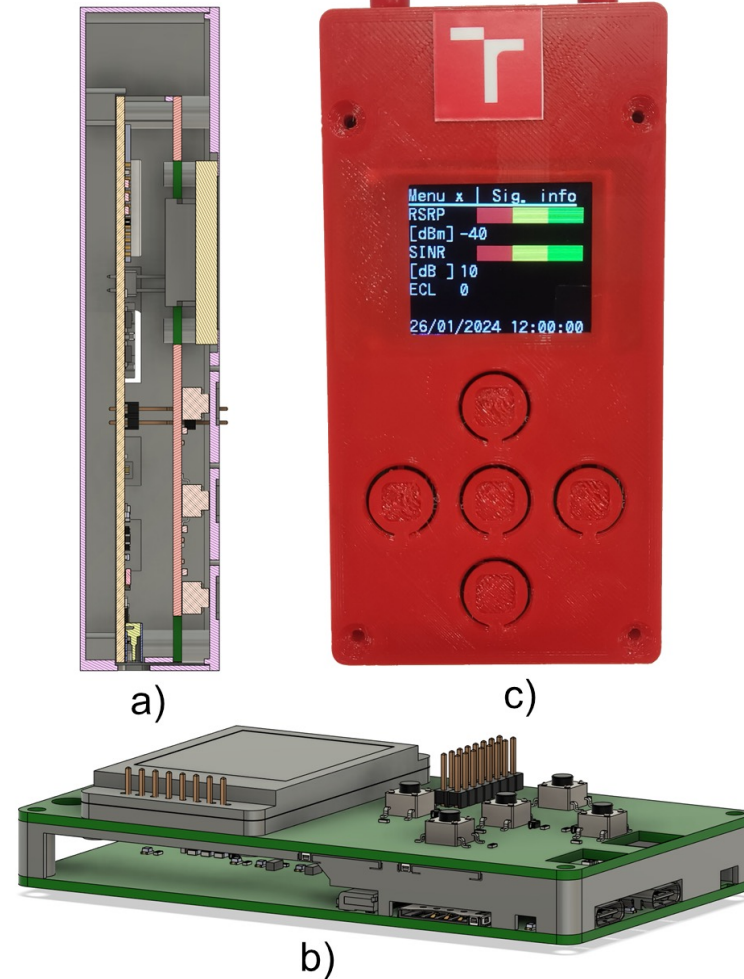
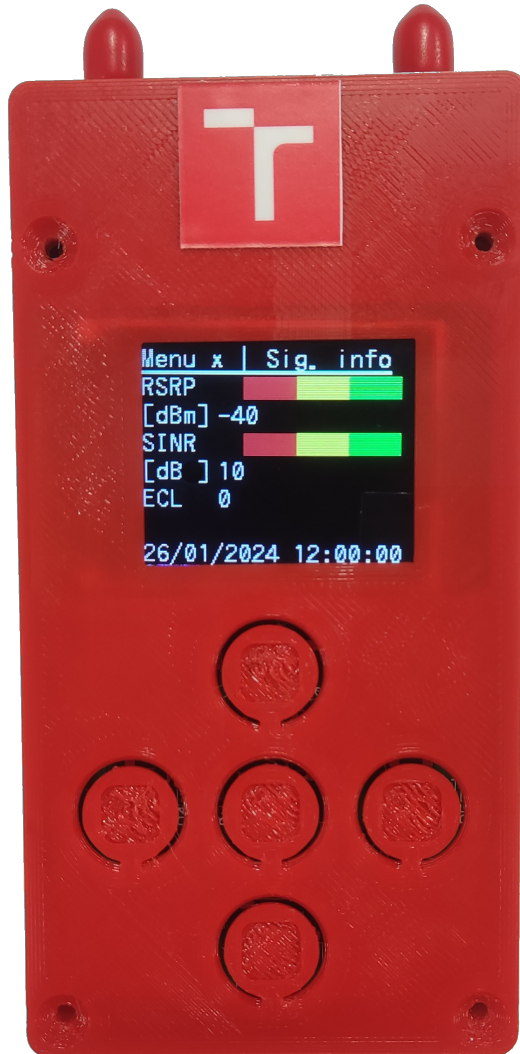


NB-IoT / LTE Cat-M1 Deployment In Czech Republic (VF)





Smartbox – Handheld Tester for Our Customers





Smartbox – Golden Amper 2024 Awarded





Smartbox – Golden Amper 2024 Awarded



Thank you for your attention.

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