



NORWEGIAN DEFENCE
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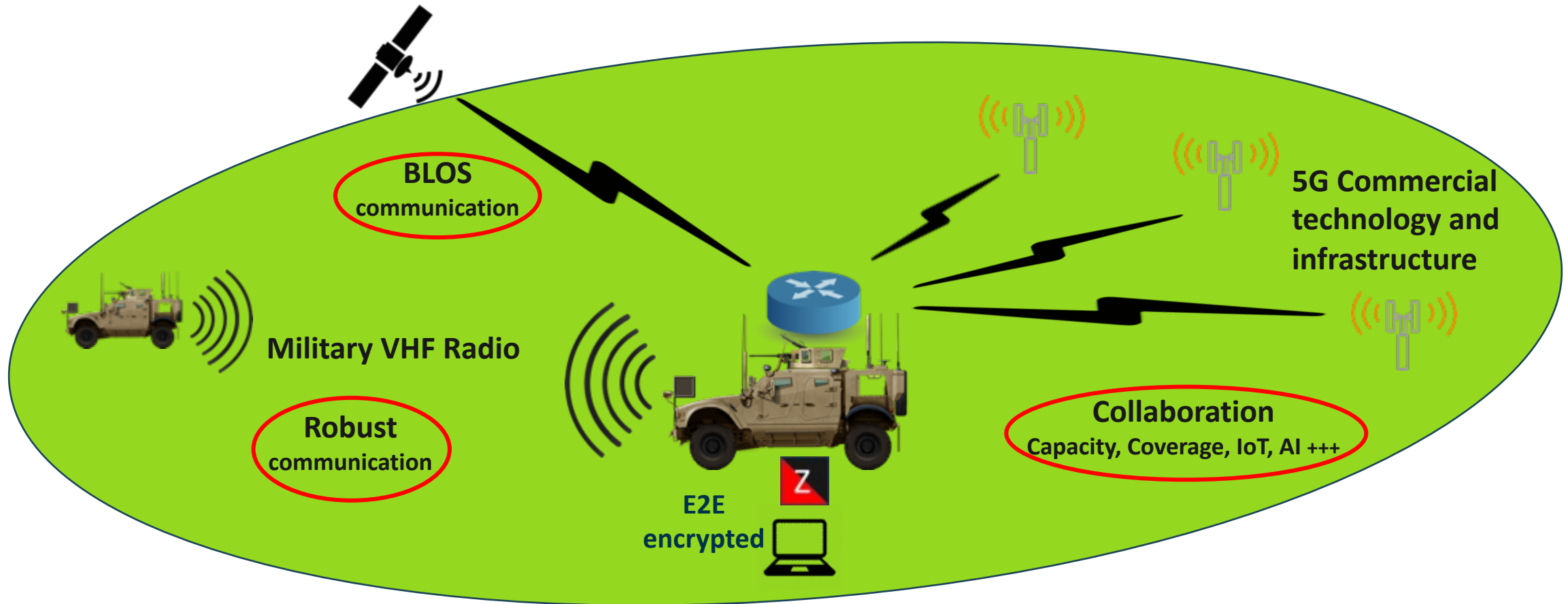
Military use of 5G

Kennet Nomeland

Radio Systems Architect

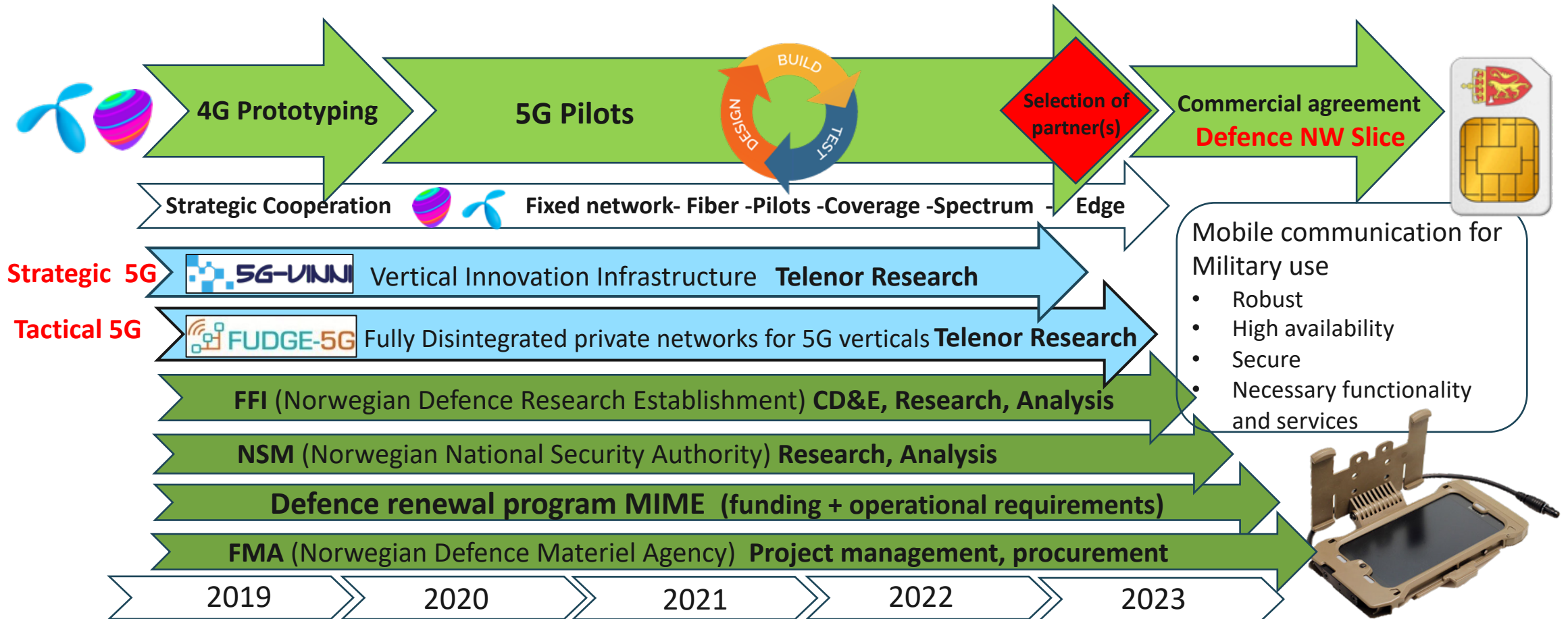


Communication for different scenarios



3GPP ecosystem gives many new possibilities

Broad collaboration & Iterative Development



Adapting 5G to military use

Rygge military airbase

Strategic 5G



890 MHz frequency spectrum
64x64 MIMO antennas – mmWave + C-band



Enterprise Edge
Defence Network Slice



Fiber + SATCOM
Backhaul





5G New Radio testing at Rygge military airbase

Range, Capacity and Robustness in different frequency bands





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FUDGE 5G pilot

5G Private Network



Cell on Wheels

Tactical 5G

Fully Disintegrated private networks for 5G verticals (FUDGE)

- EU funded 5G pilot - Running until March 2023
- Fully autonomous 5G SA Private Network
- Equipped with Edge for PPDR / Defence Use Cases

Goal:

- Utilize both **Public** and **Private** 5G network
- Utilize centralized Clouds, 5G and Edge to create **Better** and more **Robust** services
- Leverage 5G SUCI security concept (Subscription Concealed Identifier) to **mitigate IMSI catcher problems**



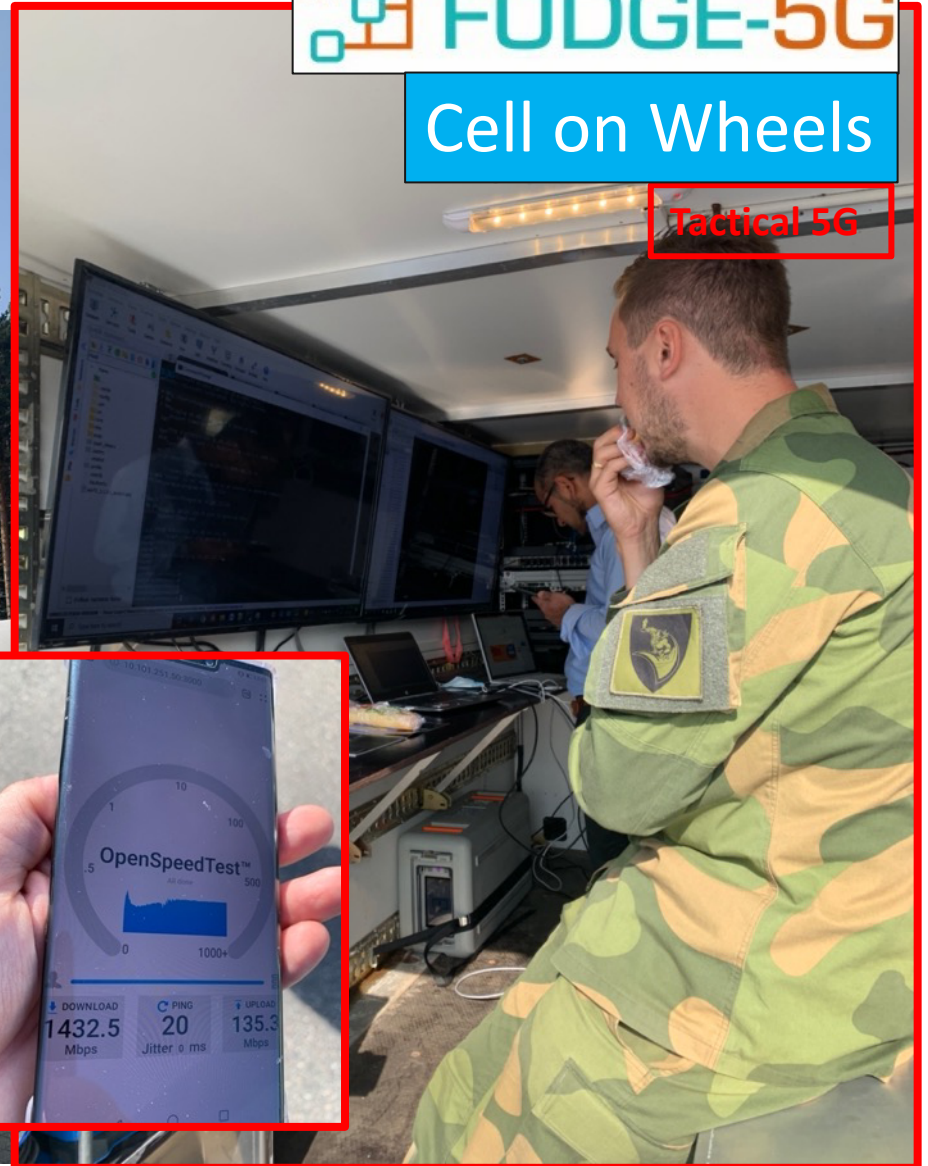


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 **FUDGE-5G**

Cell on Wheels

Tactical 5G





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 **FUDGE-5G**

Cell on Wheels

Tactical 5G

5G pilots - Rygge airbase

Technical testing – Studies – Use Cases

- Range, Capacity and Robustness (Electronic Warfare), LPD, LPI
- IMSI catching mitigation (5G SA + SUCI)
- Edge Autonomy
- Multiple Use Cases including use of AI/ML, Drone control etc.

C-band (NR)

Tactical 5G



5G Private Network / Cell on Wheels

Strategic 5G

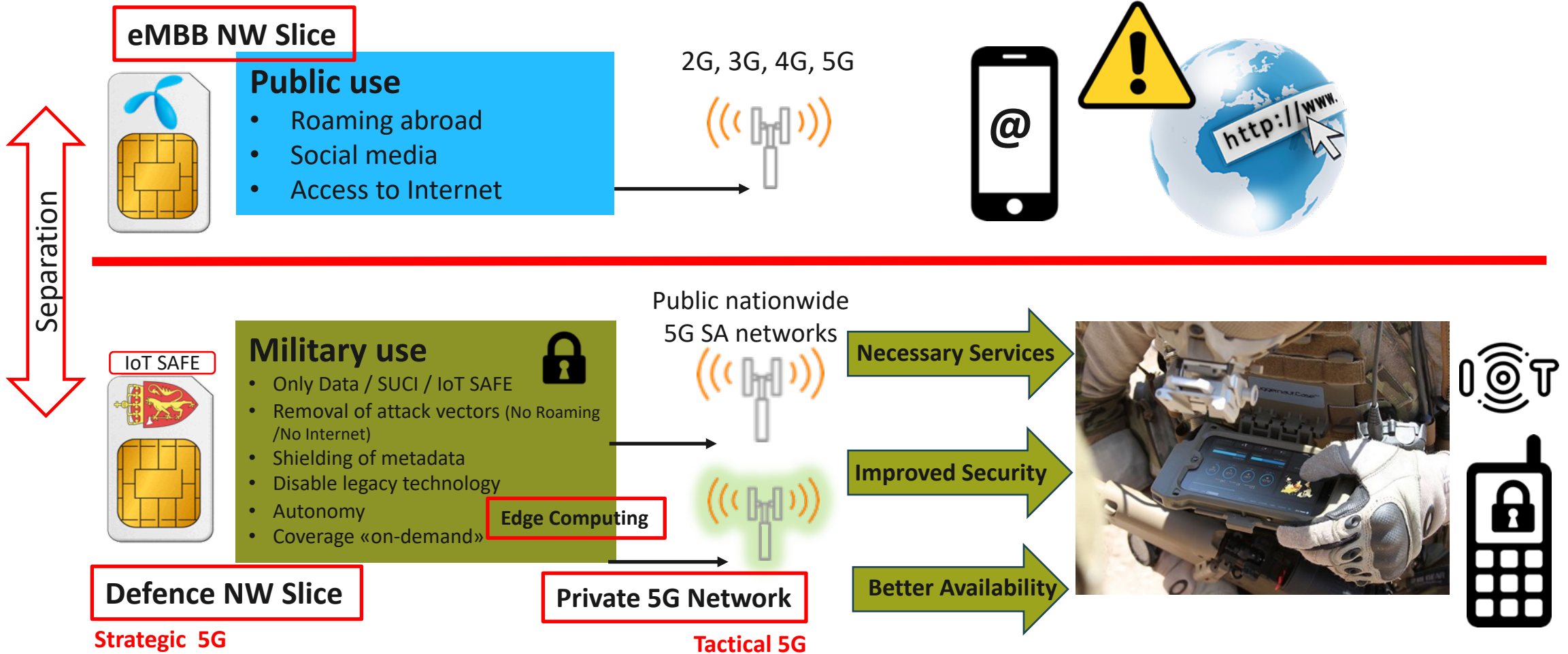


Fixed 5G Network
gNodeB+ Enterprise Edge

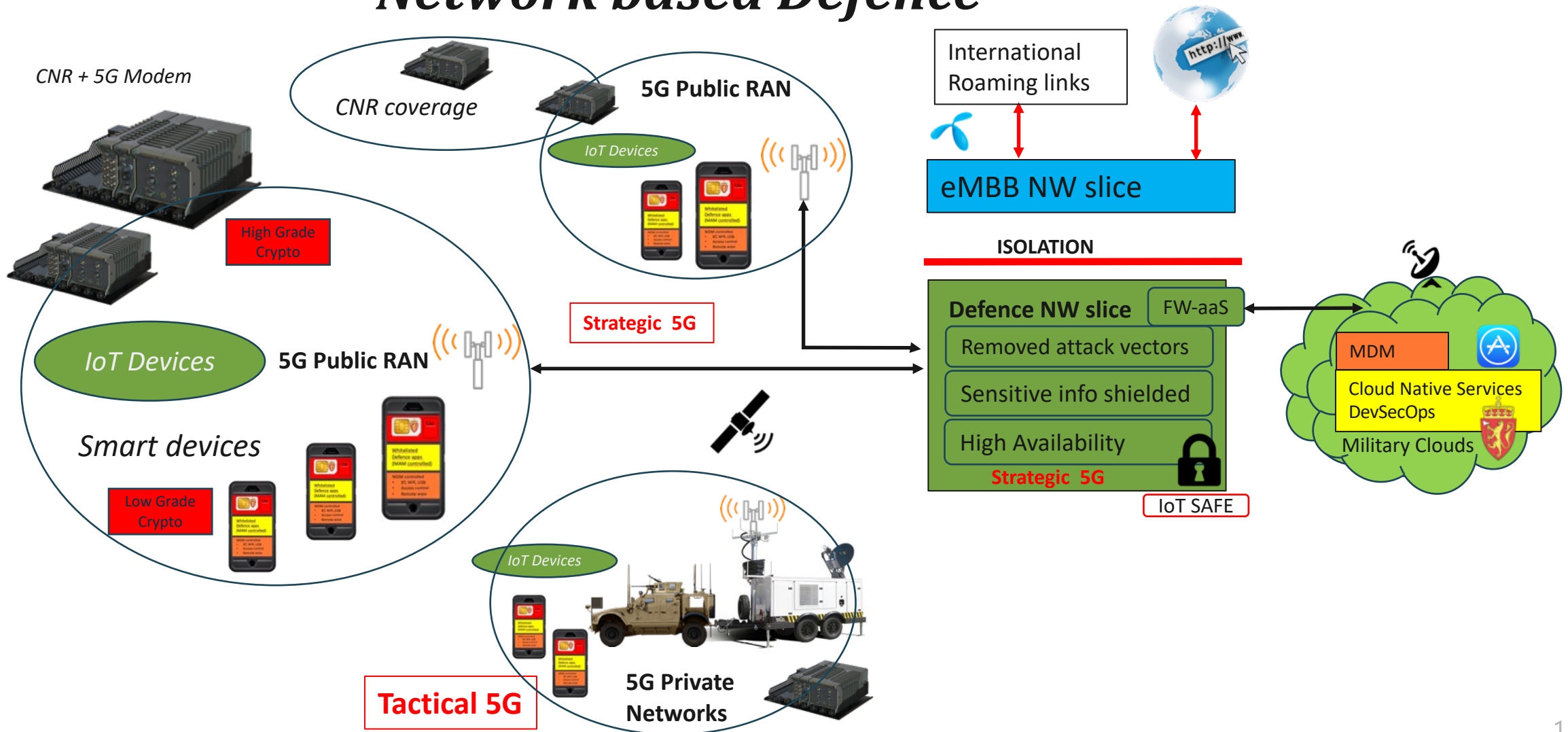
C-band (NR)
MmWave (NR)
Anchor-band (LTE)

C-band (NR)
MmWave (NR)
Anchor-band (LTE)

Network Slicing to separate Public and Military traffic



Network based Defence





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Autonomy

Enabled by **Edge Computing and 5G Private Networks**

5G Core
Central Data Center
Oslo

Autonomous Edge in strategic important areas
Defence Slice with full 5GC functionality + Services running in the Edge is providing services in important areas (airport, hospital, naval base) even when the central 5GC DC is not available

Fiber Cut

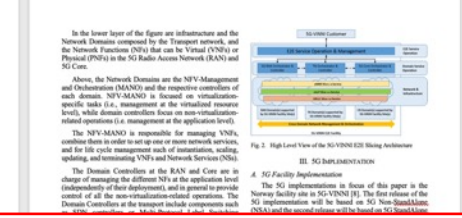
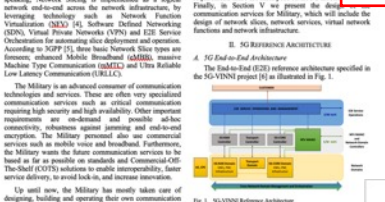
Defence Slice has dedicated 5G Core also in Edge
Important Services available in our Defence NW Slice e.g. PTT (Application Function)

Autonomous Edge (MEC) connected to gNB (basestations) Rygge Airbase

5G Service and Slice Implementation for a Military Use Case

By Gunnar, Anders Gundersen, Kari Malmberg, Kjetil Nordmark, Jan Pinar, Armin Dittmann, Tom Kristian Berg, Steffen Gjørdal
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The main contribution of this paper is the design and implementation of a 5G network slice for the military use case. This slice is designed to provide high availability and security for critical military services. The slice is implemented as a dedicated 5G Core in the Edge, connected to gNB (basestations) at Rygge Airbase. This ensures that critical services remain available even in the event of a fiber cut or central DC outage.

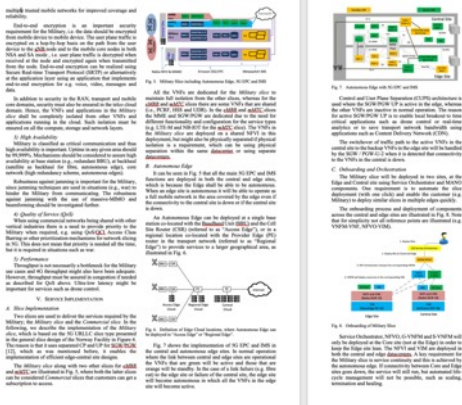


5G Service and Slice Implementation for a Military Use Case, IEEE International Conference on Communications Workshops (ICC Workshops), 2020
<https://ieeexplore.ieee.org/abstract/document/9145236>

The first approach to isolation of the resource level. Each network domain (RAN, Transport and Core) has particular characteristics and requirements. The RAN, different sub-networks or separated radio resource blocks can be used. In the transport domain, the IP address space can be used. In the core domain, the MPLS paths can be used. In the core domain, different domains, availability rules, compartmental blocks, VSM or domains provide different kind of isolation.

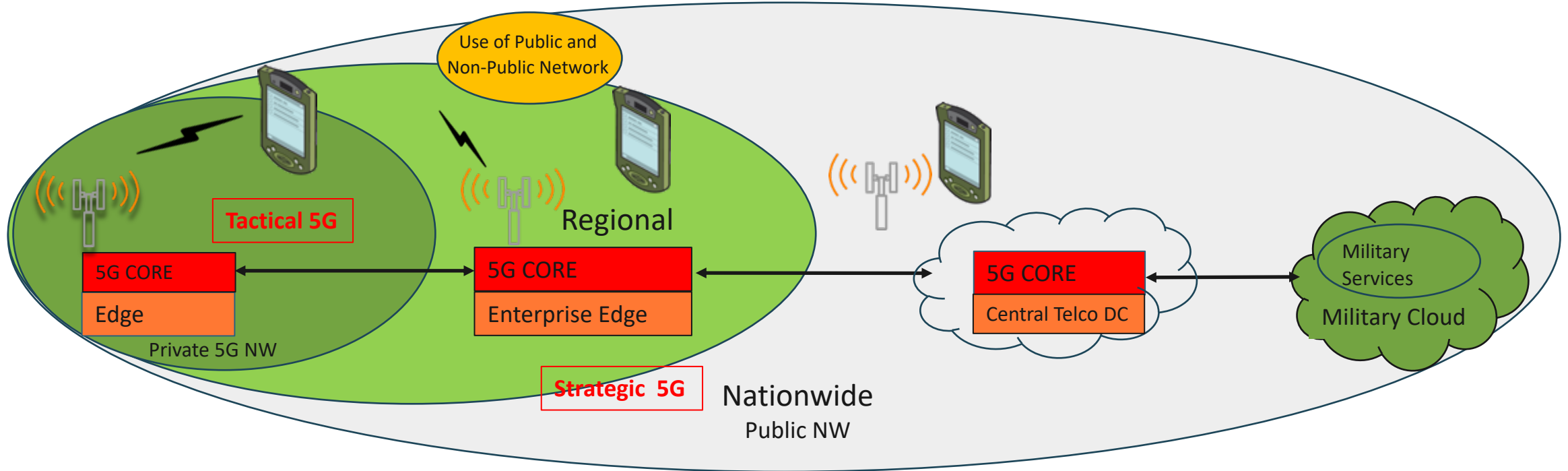
The second approach is in the management level, which is to support the isolation in two ways. First, the management tools allow the coordination of the isolated resources at the different network domains in order to enable unified and harmonized service across them. Second, the multiplicity concept that allows that only the resources that are separated to a given slice are managed without interfering with the others.

As Military transfer classified information over the network security of high importance. For this, some attack



The 5G Core in the Edge is implemented as a dedicated 5G Core, connected to gNB (basestations) at Rygge Airbase. This ensures that critical services remain available even in the event of a fiber cut or central DC outage. The Edge Core is implemented as a dedicated 5G Core, connected to gNB (basestations) at Rygge Airbase. This ensures that critical services remain available even in the event of a fiber cut or central DC outage.

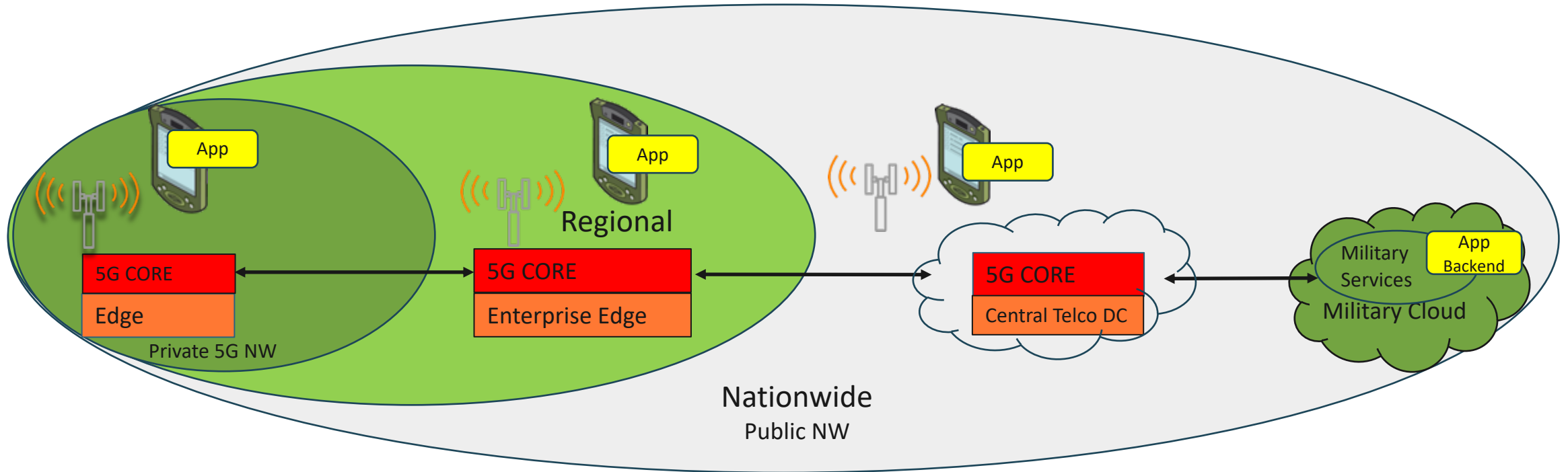
5G Private Networks (S-NPN)



From a **Telco** perspective

How to utilize both **Private** and **Public** 5G networks

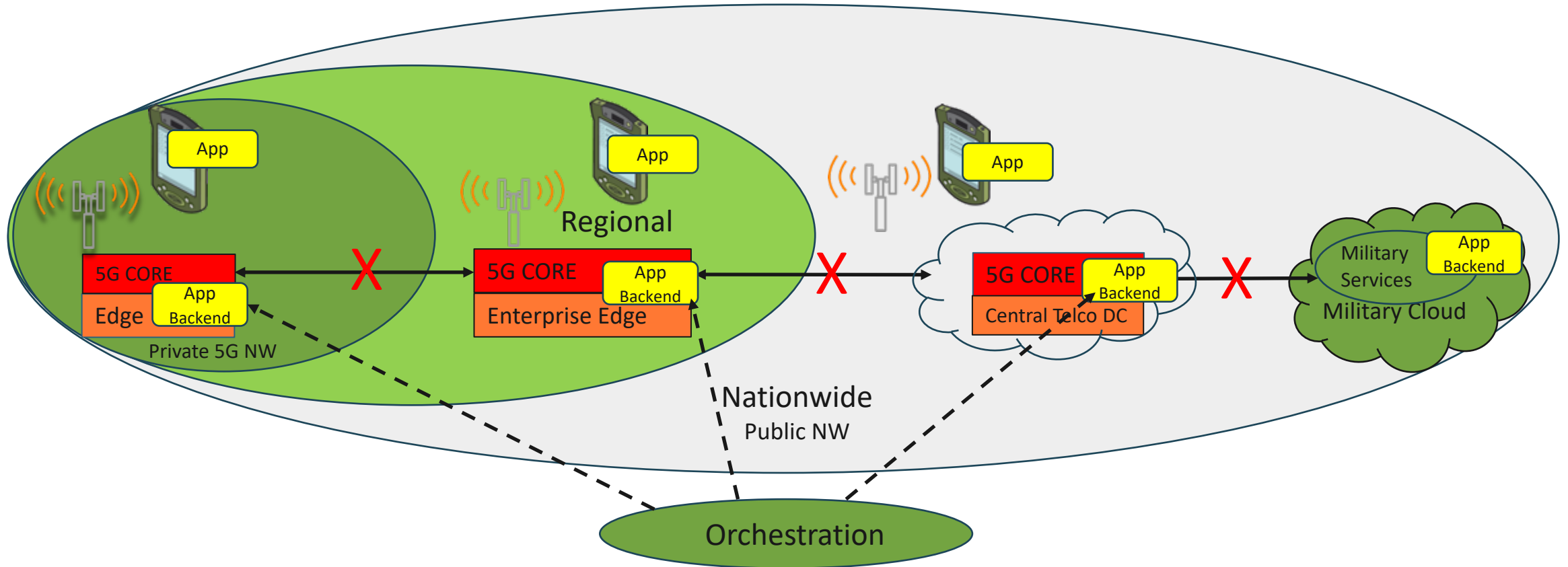
Edge Computing – The extended cloud



From a **Service** perspective

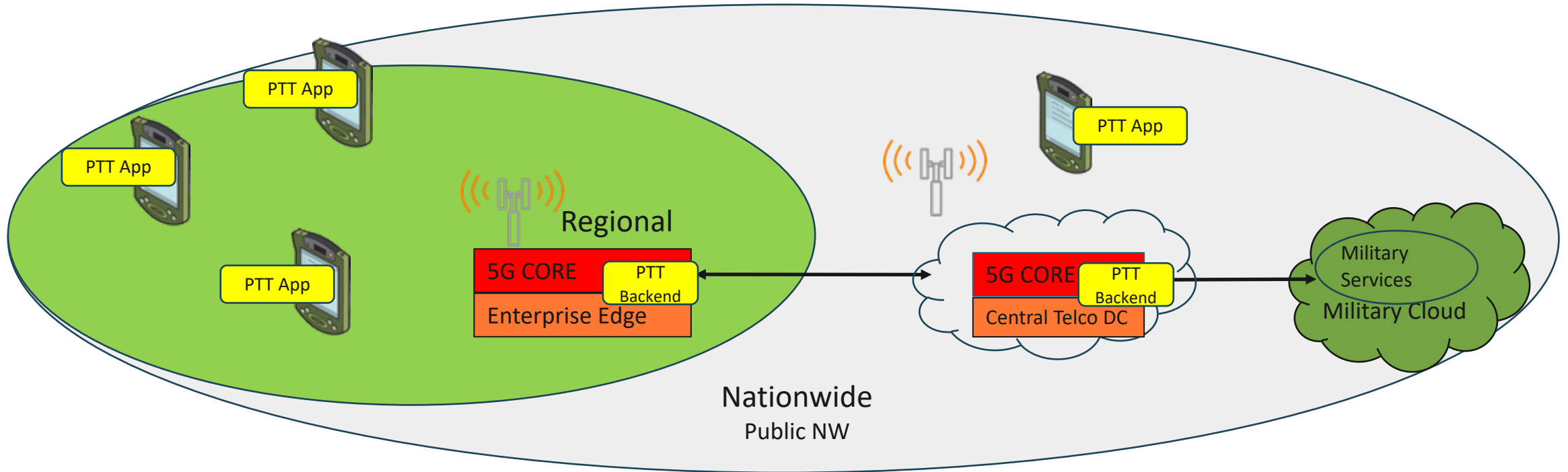
How to utilize centralized clouds, 5G and Edge to create **Better** and more **Robust** services

Edge Computing – The extended cloud



How to utilize centralized clouds, 5G and Edge to create **Better** and more **Robust** services
(Cloud Native principles)

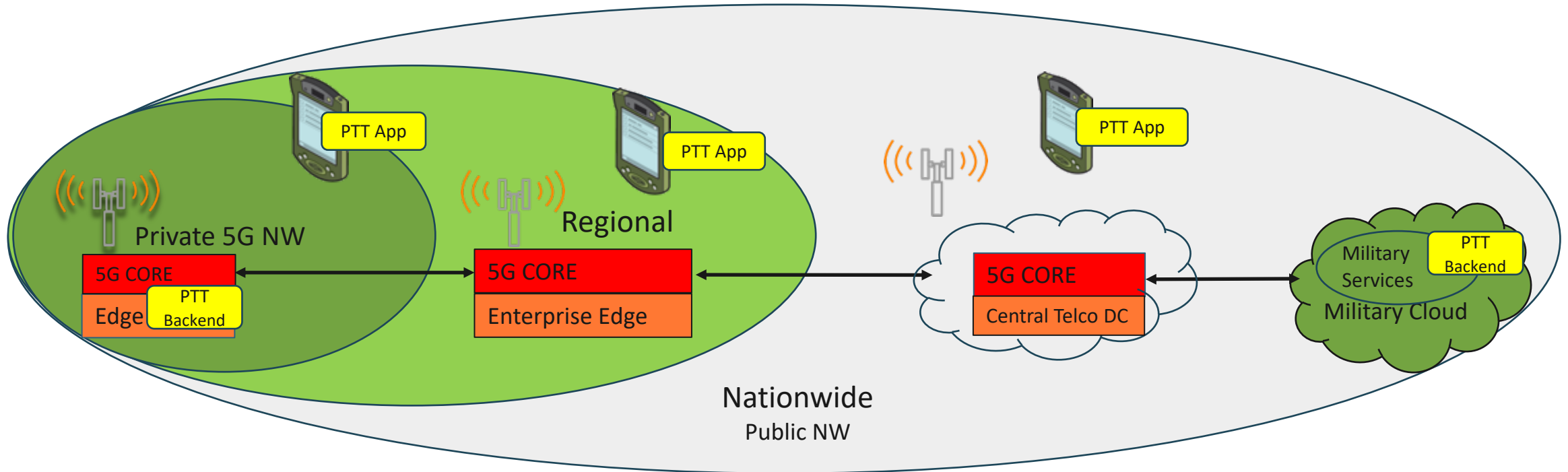
Edge Computing – The extended cloud



Services offered in close cooperation with a strategic MNO partner

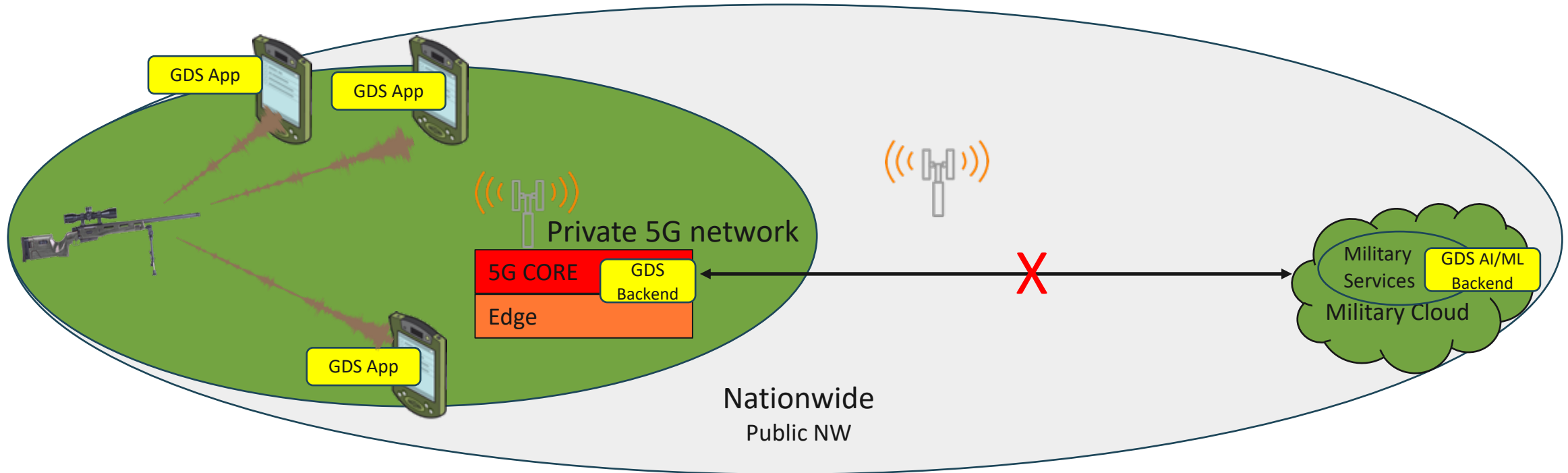
Application Function in Defence Network Slice + Enterprise Edge

Edge Computing – The extended cloud



Services offered from 5G Private Networks (NPN) and Military Clouds

Edge Computing – The extended cloud



From a **Service** perspective

How to utilize centralized clouds, 5G and Edge to create **Better** and more **Robust** services

- BLOS Drone control via 5G network
- Distribution of live video from the drone to relevant personnel
- GNSS independent
- AI to improve Situational Awareness



5G Drone control

Render Control Panel

- Full Screen Mode
- Show Render Workload Status
- Show Record
- Show Render System Control Panel
- Show Framerate
- Show Render Info
- Shown Light Controls
- Shown Camera Controls
- Render Wireframe

Thermal Sensor Control Panel

MIN/MAX Video Mode

- 20.000 Minimum Temp
- 80.000 Maximum Temp
- 0.250 Histogram S

Video Feed Control Panel

Model Selection

- Rygge Select Area
- Surface Model Type
- Clear
- 0.000 Altitude off
- 0.000 Heading offs
- Do render in map

Communication System

Number of Connections: 1

Agent: 1 grp: 0

Battery left percent 0.79

- ID 1 : 51.53 Altitude
- ID 1 : 23.32 (3.89) Voltage
- ID 1 : 0.06 speed m/s
- ID 1 : -0.12 climb m/s

Video (Gstreamer) : (Thermal) 1

Close Stream

- Invert Colors:
- Render Cross:
- Flip V:
- Flip H:

Video (Gstreamer) : (Visual) 1

Close Stream

- Invert Colors:
- Render Cross:
- Flip V:
- Flip H:



- BLOS Drone control via 5G network
- Distribution of live video from the drone to relevant personnel
- GNSS independent
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Simulation Control

Camera Settings

Telemetry Plot

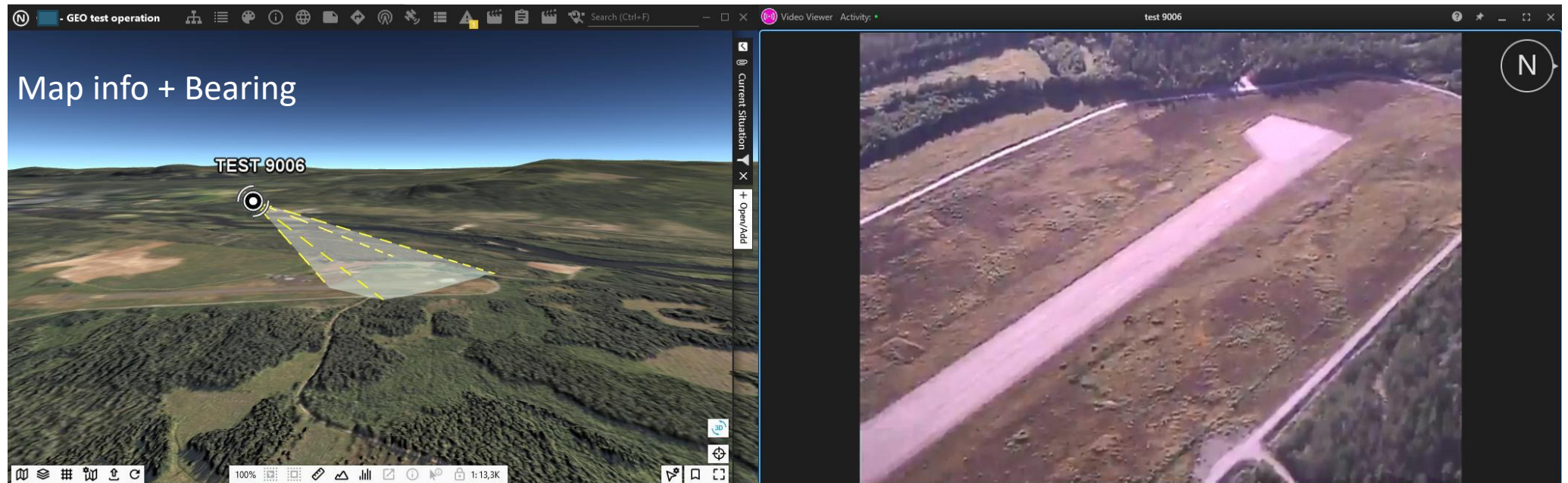
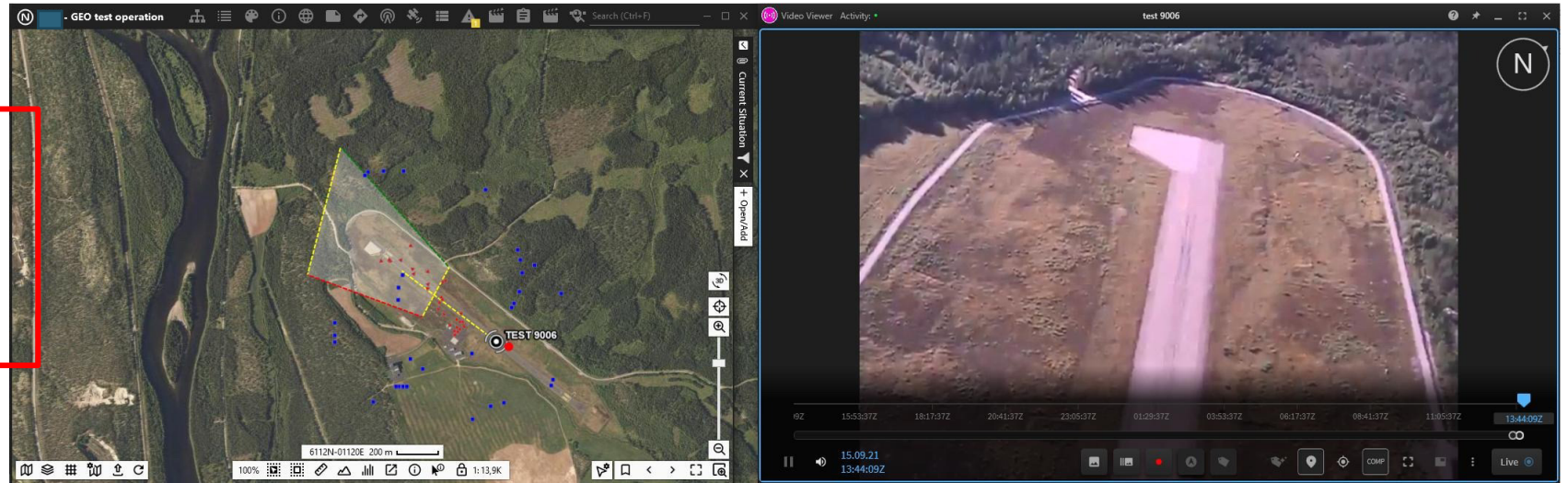
Sensor Plot

5G Drone control



Goal:

GNSS independent by use of
LMF (5G) + Onboard
camera/maps navigation.

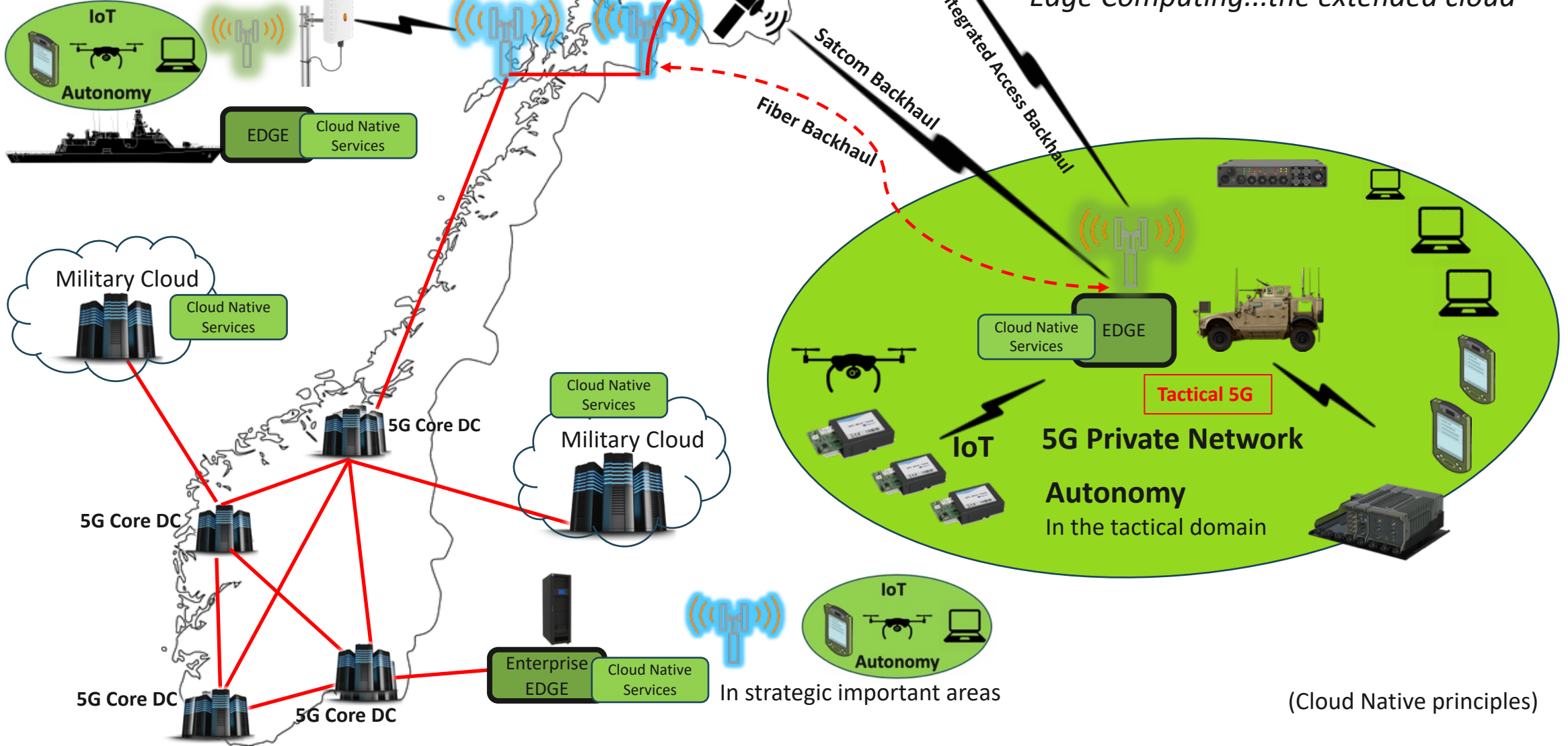


5G Private Network

5G CPE

Network-based Defence

Edge Computing...the extended cloud



(Cloud Native principles)



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5th Generation Changes Everything



Kennet Nomeland
Radio System Architect
Norwegian Defence Materiel Agency