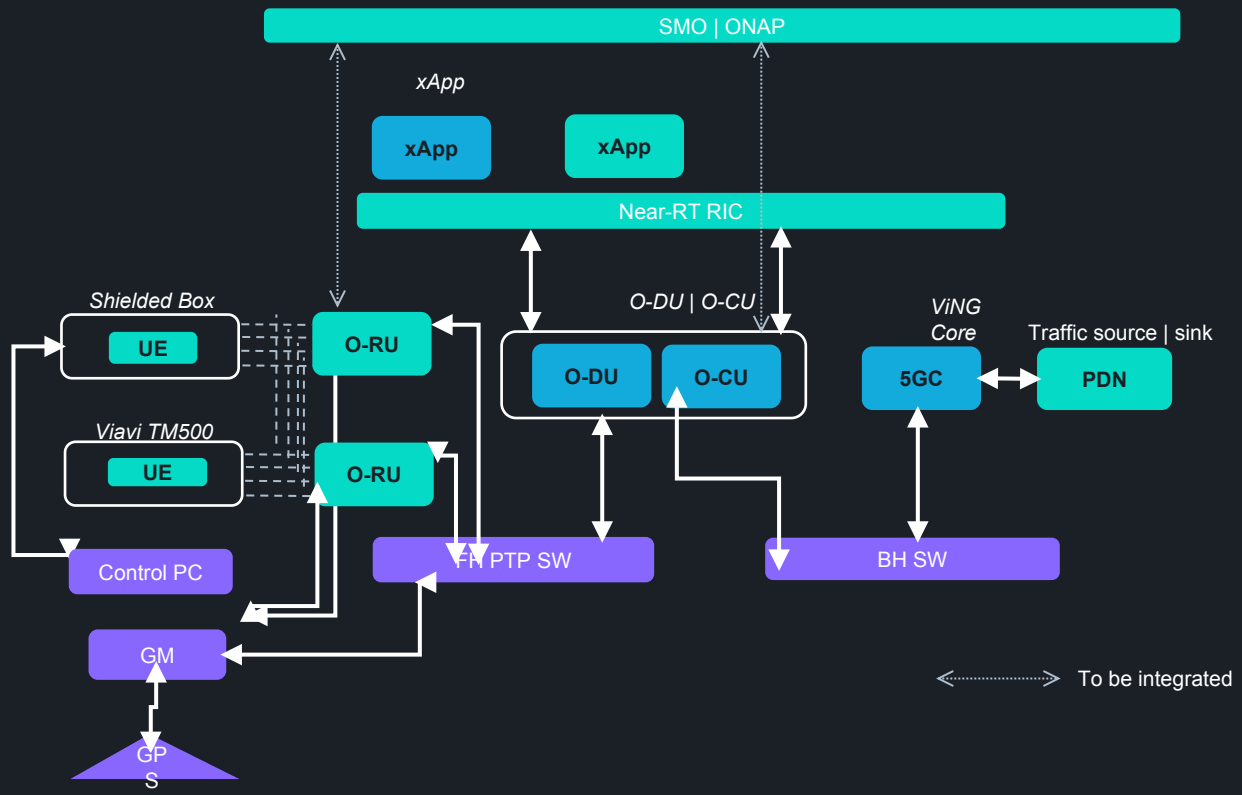

Capgemini engineering
UNLEASHING
THE POTENTIAL OF
RESEARCH & INNOVATION

CAPGEMINI'S SERVICES IN OPEN RAN

1	**System Engineering**	Work with i14YLab to come-up with Reference architecture based on O-RAN requirements. Identify the key components and infra options to realize the solution.
2	**System Integration**	E2E system Integration in multi vendor environment.
3	**Testing & Support**	Testing and Validation of deployed Setups. Dedicated support team to handle specific requirements.
4	**Lab Management**	Project Management. Lab Infra Design and Maintenance.
5	**O-RAN 5G Framework**	Compliant to O-RAN architecture (O-CU, O-DU, xApp, Near-RT RIC, Non-RT RIC, 5GCore) Support for E2/O1/Open-F1/Xn interfaces and FH 7.x support.

Testimonies @i14yLab

- ✓ Design & system integration of the lab E2E reference test setups
- ✓ E2E advanced test coverage: performance, functional, security
- ✓ Certification & Badging: based on the O-RAN Alliance and TIP
- ✓ Valuable contributions towards automation, LaaS and TaaS
- ✓ Support on the lab research topics around RIC uses cases and conflict resolution



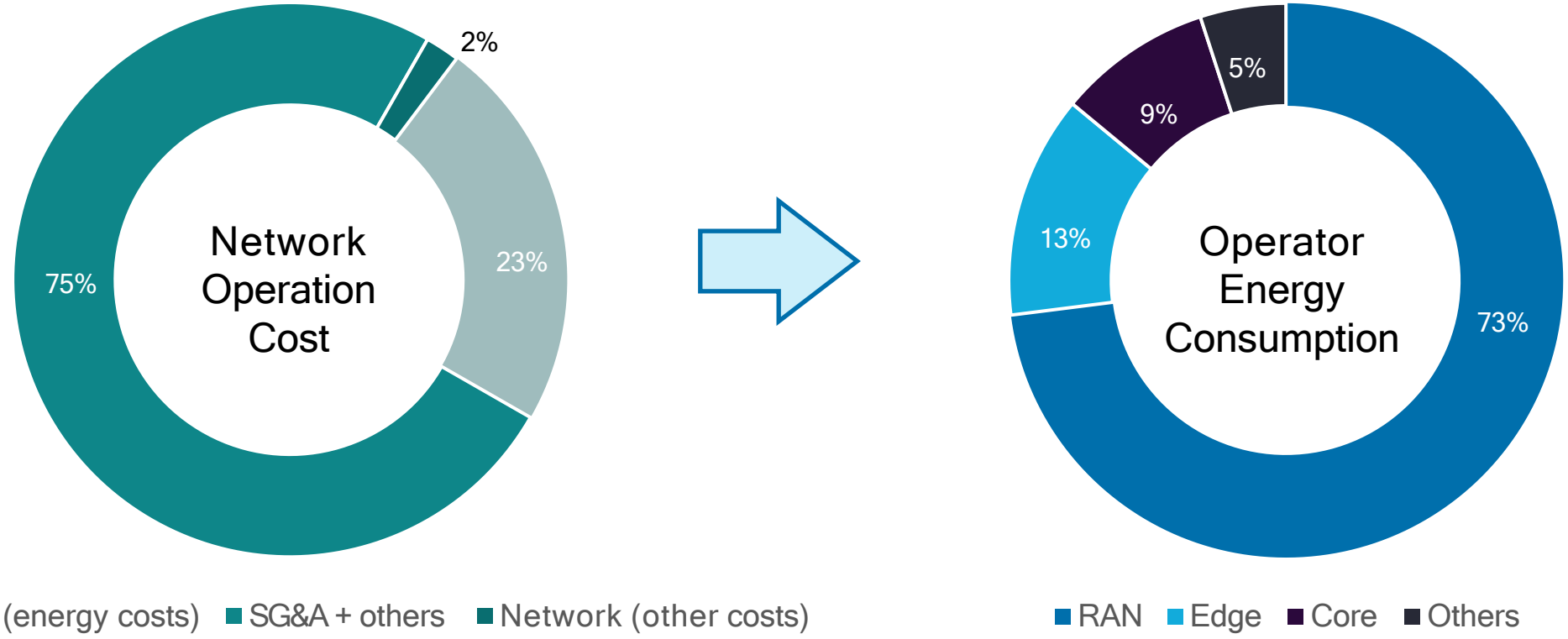
Capgemini engineering

Capgemini RAN Intelligent Controller (RIC)

Admission Control xApp Demo

SUSTAINABILITY IN ACTION WITH OPEN RAN

Energy cost is typically 23% of the network OPEX.
Out of this RAN takes approximately 73% of mobile network energy.

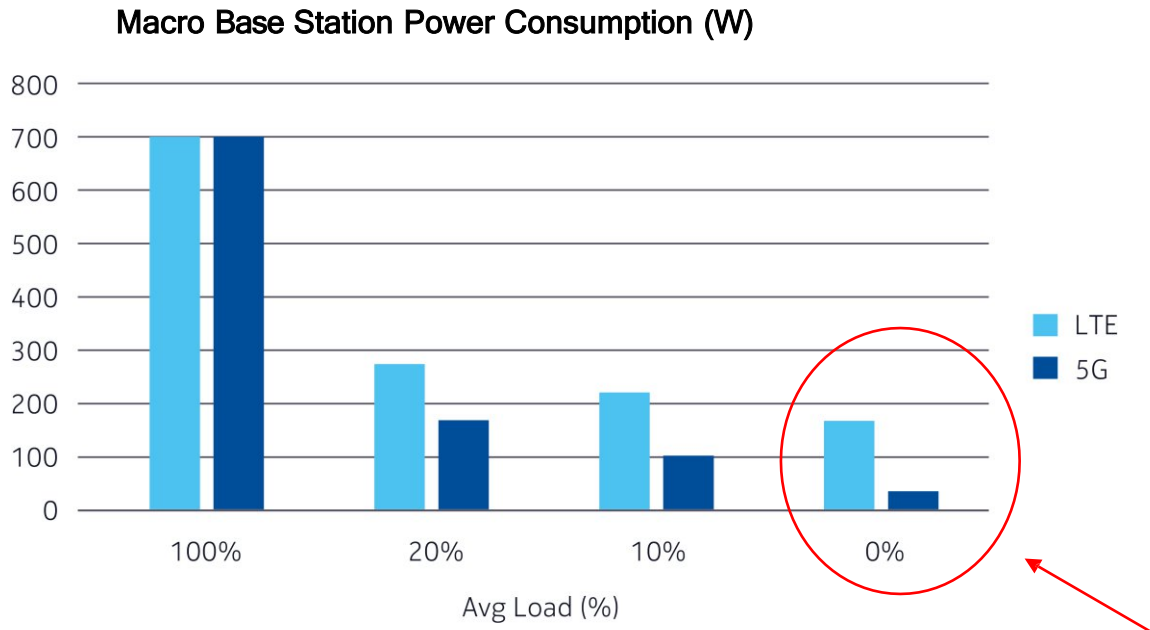


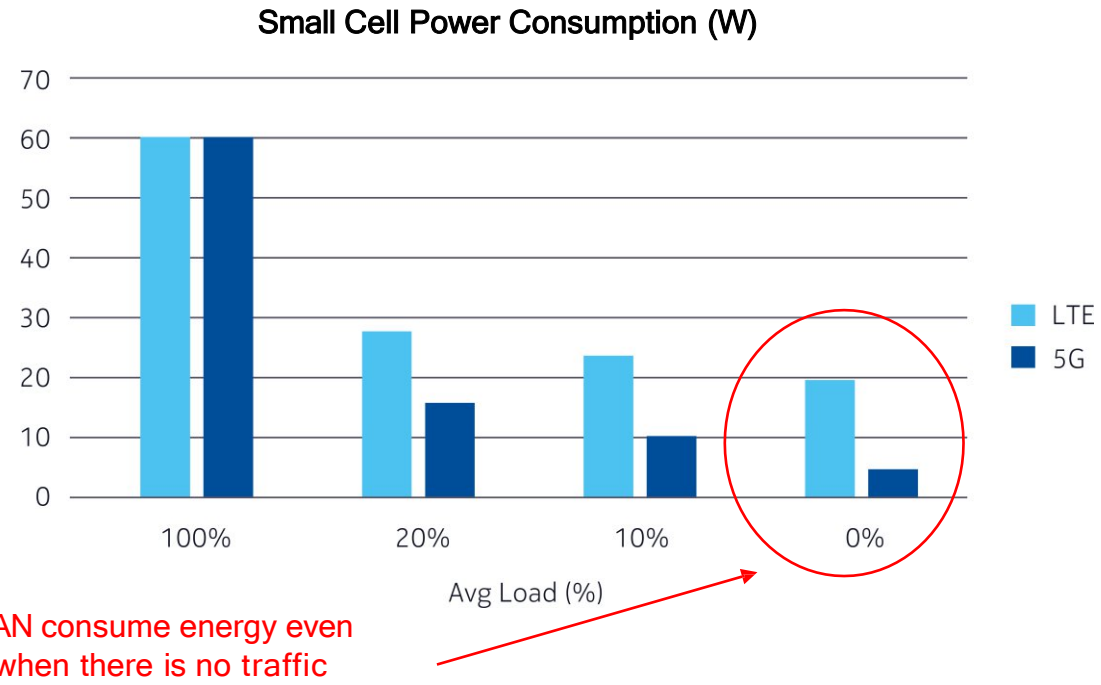
Source GSMA Intelligence

ENERGY USE BY MOBILE OPERATORS

SIGNIFICANT ENERGY SAVING BY GOING INTO SLEEP MODE DURING LOW/NO USER ACTIVITY

During periods of no activity, the base station can minimize its energy consumption by going into sleep mode.





RAN consume energy even when there is no traffic

Source - Whitepaper- 5G network energy efficiency

The potential reduction in the power consumption with 5G radio compared to LTE is expected to be 30-70 percent, at typical load levels of between 5 percent and 20 percent.

CAPGEMINI ENERGY SAVING RAPP

Overview

The **radio access network (RAN)** is responsible for a major part of the **energy consumption (EC)** in **mobile network**, and the **O-RU accounts** for the largest part of the consumption. **Capgemini** and **Intel** have implemented the “AI Enabled Energy Savings” use case as an ORAN rApp to reduce the **EC of the RAN**, by introducing **intelligent energy saving** mechanisms in O-RU.

The rApp uses **real-time monitoring** to provide current **energy consumption** and the corresponding **carbon emission** of the RAN nodes. It uses **advanced AI/ML prediction** to also forecast the future energy consumption and carbon emission, based on various types of data such as **wireless resource usage**, **service loads**, number of **mobile users** and **weather data** at different periods .

The rApp takes **intelligent decisions** on when to apply energy saving measures like **cell switch off/on** and **carrier switch off/on**, by predicting the future load on RAN nodes. The rApp not only uses the data of a single RAN, but also the neighbouring RAN nodes to **predict the load**. It uses closed **loop automation** to learn and **improve the energy saving decision over time**.

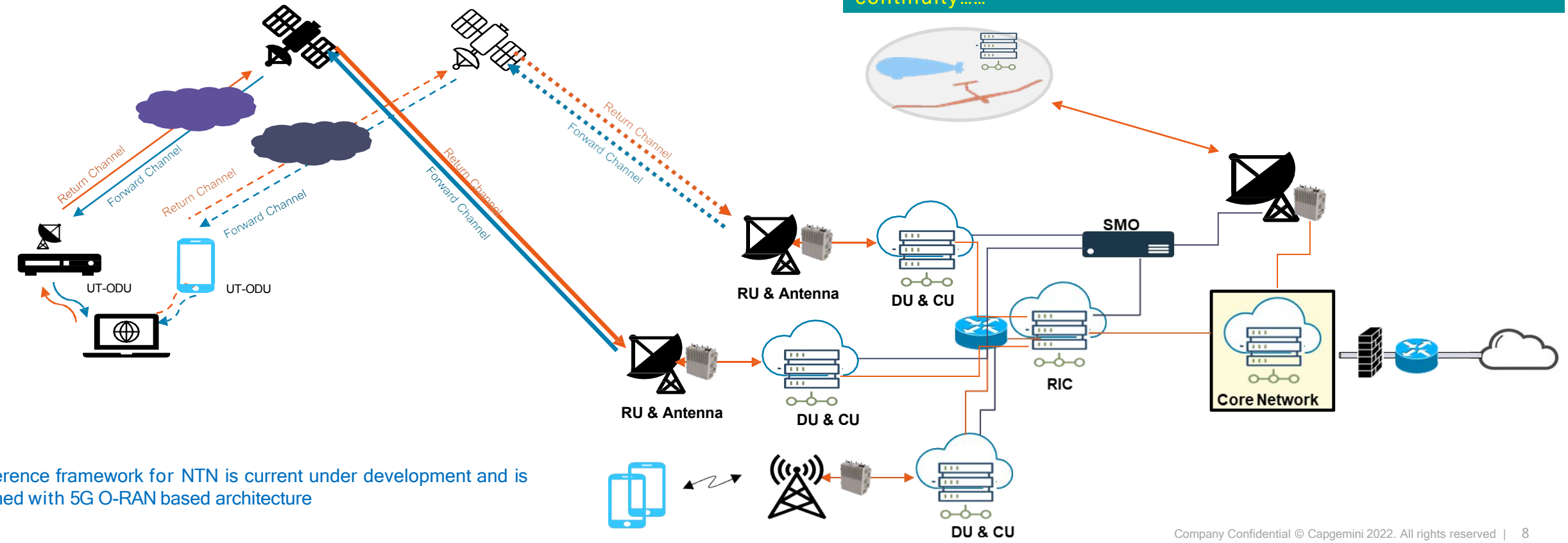
Open Skies, Open Networks: O-RAN's Journey to the Sky!!!

OPEN RAN BASED NETWORK ARCHITECTURE (EVOLUTION)

Evolution of Open RAN based network to support wireless , Satellite and HAPS Networks

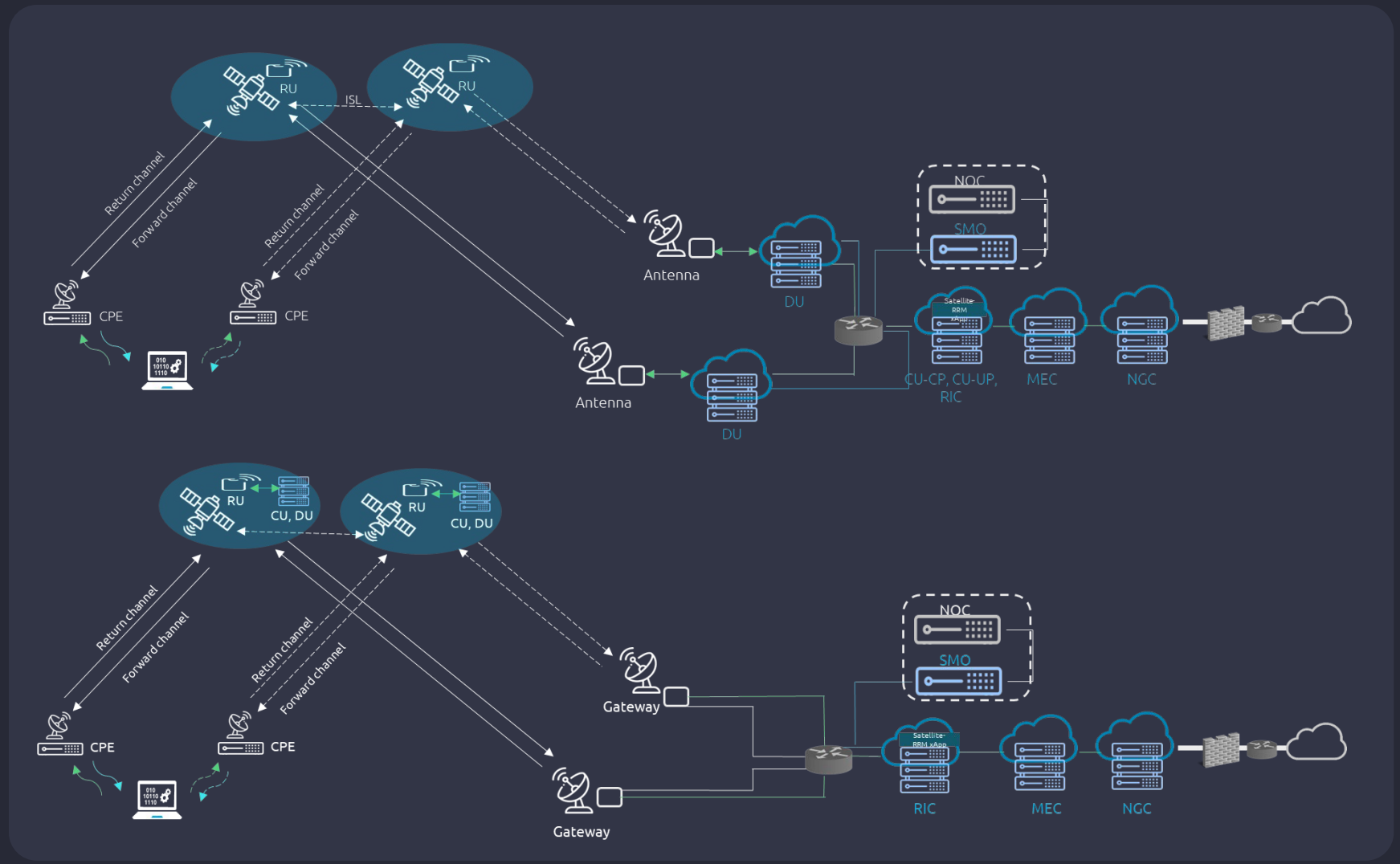
- Wireless networks – disaggregated or integrated CU/DU
- Satellite (transparent) – common SMO, RIC, CU/DU and NGC
- HAPS (regenerative) – common SMO and NGC

Key challenges to address in solution realization
Large doppler shifts, Long and time-varying propagation delays, large cells, moving cells (signalling load, frequent handovers), satellite tracking and resource management, beam/cell management, network session continuity……



Reference framework for NTN is current under development and is aligned with 5G O-RAN based architecture

Open Skies, Open Networks: O-RAN's Journey to the Sky!!!



Capgemini Solution Approach: e.g. TRANSPARENT

High-level architecture of NTN solution for transparent mode with **DU, CU-CP, CU-UP running on COTS Servers**

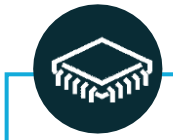
Capgemini Solution Approach: e.g. REGENERATIVE

High-level architecture of NTN solution for generative mode with **CU & DU running as part of Payload**

SUPPORT FOR NTN IN O-RAN ARCHITECTURE

System Architecture and Design for NTN Solution

(realization based on 5G deployment options)



Software Solution based on **deployment models**

(transparent or regenerative and HW/SW solutioning)

5G Network SW support based on 3GPP NTN enhancements

(L1, L2, L3, RRM, NGC)

Realize using **cloud-native architecture**

(COTS HW for ground-based systems)

Realization of NTN towards O-RAN architecture

SMO support for satellite Network

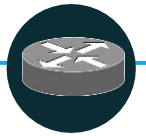
(FCAPS, provisioning of satellite specific data, monitoring)

Resource Management for Satellite using RIC

(spectrum and carrier allocation/management, interference, mobility)

System Engineering for NTN Solution

(link-level budget analysis based on satellite architecture, use-cases and deployment)



Custom Antenna, Fronthaul to RF Gateway

(FH for NTN aligned with eCPRI based O-RAN FH, custom Antenna)

Note – other aspects to be considered include Regulation, Materials, SWaP, Emission requirements, antenna design, beam-forming and coverage etc)

SMALL STEPS, BIG PROGRESS: A LOOK AT TODAY'S SUCCESS STORY

RESEARCH & DEVELOPMENT PROJECTS

TARGETING CURRENT AND FUTURE MARKET NEEDS

Federal Ministry for Economic Affairs and Energy · HORIZON 2020 · Federal Ministry of Education and Research · Seventh Framework Programme · Federal Ministry of Transport and Digital Infrastructure · eit European Institute of Innovation & Technology · Clean Sky 2 · ECSEL Joint Undertaking

FUTURE OF MOBILITY

TRINIDAT — Tilt Rotor Innovative Design And Wind Tunnel testing

gretel — Ecofriendly & cost-efficient Green Turboprop Experimental Laminar Flow Wind Tunnel testing

Inter Op — Interoperable Solutions for Mobility, Logistics – Company Network

AORTA — Trajectory-based collective traffic management

VERTIPORT — UAM - Design & development of a modular Vertiport

IntWertL — Smart supply chain platform for small series vehicle

BERTHA — Collaborative cross-stakeholder V&V-HUB in the Cloud

MultiLOAD — Architectural change for future EV-platforms – The "AC-Battery"

FUTURE NETWORKS & COMPUTE

i14y LAB — Open Lab to automate interoperability testing for 5G OpenRAN (O-RAN)

EQUALITY — Efficient Quantum Algorithms for Industry

safeURchain — Security & traceability in production and value net-works through Blockchain.

DIBIchain — Digital portrayal of Circulatory Systems via Blockchain Technology

SmartGridsBW Energien intelligent vernetzen. — Demand side management platform and Smart Grid business models

Energy Saving by Blockchain — Energy services and trading process based on blockchain

FUTURE OF INDUSTRY GREEN ENERGY

TopWind — Active flow control for an optimized wind harvest on wind turbines

H2 Innovation HSU ALTRAN StBZuEL — PEM fuel cell optimization, market, technologies and LCA assessment

HyReflexS — Sector coupling: emergency energy supply LCA assessment

FLEX4FACT — Cluster Flexibility Platform For Sustainable Factories To Reduce Co2 Emissions and Enable Energy Transition

HZwo DigiTwin — Scalable digital twin for flexible H2 operational management

ExElPro — Data-driven product and process optimization in high-variant electrode production

AEROSPACE-X — Ecosystem for an efficient and sustainable aerospace supply chain

FUTURE OF INDUSTRY INNOVATIVE MATERIALS

ecoTECH — Innovative and ecofriendly airframe technologies to improve aircraft life cycle environmental footprint

UMA3 — Unique Materials for Advanced Aerospace Applications

AutoMat — Sustainable vehicle production through a transformable manufacturing cell

Func2Ad — Functionalised, multiphysically optimised adhesive systems

Holistep — Sub-Wavelength Holographic Litography Stepper for integrated Circuit Production

Galley Efficient Catering Operations

FUTURE OF ENGINEERING

cAT 4HEAVY — Retrofit emission reduction technology for HEAVY Duty Engines

SARISTU — Smart Intelligent Aircraft Structures

PT Luftfahrt AUTOKAB — Designed for automated Manufacturing and installation

iFUNK — Functionalization, design and test of additively manufactured components

APPLIED AI

CARAMEL — Artificial Intelligence for cybersecurity in connected and automated vehicles

KI Wissen — AI Methods for Autonomous Driving: ADAS and auto pilots

GAIA-X4AI — European Compute & Data Infrastructure for Automotive & Mobility

GAIA-X4AMS — Infrastructure and cooperative-driven automated driving

NXT GEN AI METHODS — Generative AI methods for perception, prediction and planning

PRESENCE — Utilization of technology & methodology in other areas

DIDYMOS XR δίδυμος — To create large-scale digital twins, synchronized in real-time with the real world.

XReco — data-driven ecosystem for the media industry creation and (re-)use of location-related 2D and 3D assets + creation of XR experiences

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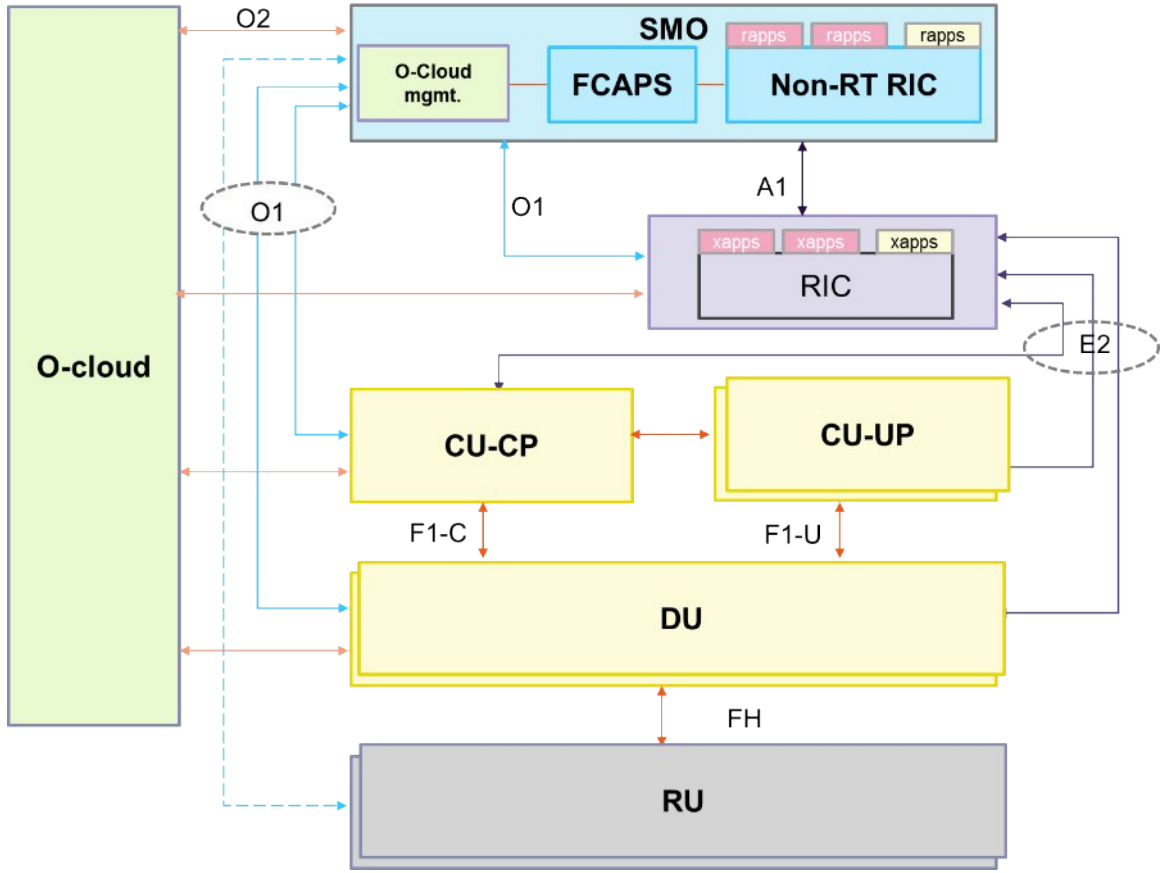
SUPPORT FOR O-RAN BASED ARCHITECTURE

Salient aspects of 5G CU/DU framework



- CU/DU supporting **3GPP Rel-16 with Rel-17 roadmap**, and based on **O-RAN based architecture and interfaces**
- Support for **3GPP defined interfaces,** distributed CU/DU or integrated CU/DU Options , and RAN split-options - 2,6,7.x,8
- Support for **O-RAN defined E2SM and proprietary E2SM**, and onboarding of **xApps integrated with RIC and CU/DU**;
- **Programmable and scalable CU/DU** with HW/SW decoupling (based on Intel based servers and accelerators) and efficient usage of cores;
- Support for HW accelerators (FPGA) and **data-path acceleration** (using DPDK);
  - Real-time kernel patch for real-time processing, CPU/memory usage, core-isolation / core-pinning, bind cores with same NUMA awareness, network interfaces (**SR-IOV, MACVLAN**), PTP support;
- Deployment using CSAR files, helm charts and integration with Cloud Infra.

