From 5G Advanced to 6G: the 5G-STARDUST Journey

ASMS/SPSC 2025

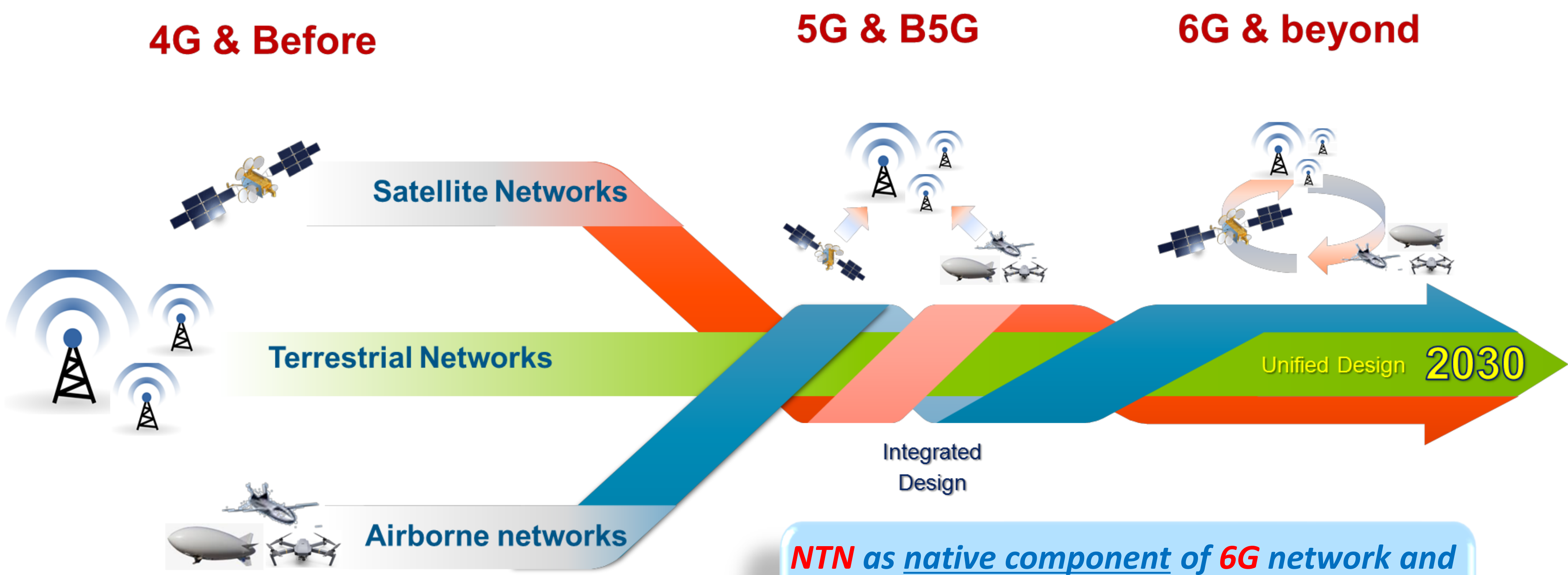
Sitges, 26-28.02.2025

Tomaso de Cola

German Aerospace Center (DLR)

Co-funded by the European Union

The outlook of NTN into 6G



NTN as native component of 6G network and protocols

From 5G to 6G: 5G-STARDUST

Satellite and Terrestrial Access for Distributed, Ubiquitous and Smart Telecommunications

Project Overview (1/2)

Project name: 5G-STARDUST (www.5g-stardust.eu)

Satellite and Terrestrial Access for Distributed, Ubiquitous and Smart Telecommunications

- Co-funded by EU: Smart Networks and Services Joint Undertaking (**SNS JU**) - under the European Union's Horizon Europe research and innovation programme
- **Stream:** *A-01-02 Ubiquitous Radio Access*

Objective:

To design, develop and demonstrate a deeper integration of TN and NTN: Deliver a fully integrated 5G-NTN autonomous system with novel self-adapting end-to-end connectivity models for enabling ubiquitous radio access

Project Overview (2/2)

5G stardust

Consortium:

10 partners

6 countries

cnit · SRS Software Radio Systems · orange · hispasat · AW2S Advanced Wireless Solutions & Services · Martel innovate · Thales Alenia Space · cttc Centre Tecnològic de Telecomunicacions de Catalunya · DLR Deutsches Zentrum für Luft- und Raumfahrt · Fraunhofer

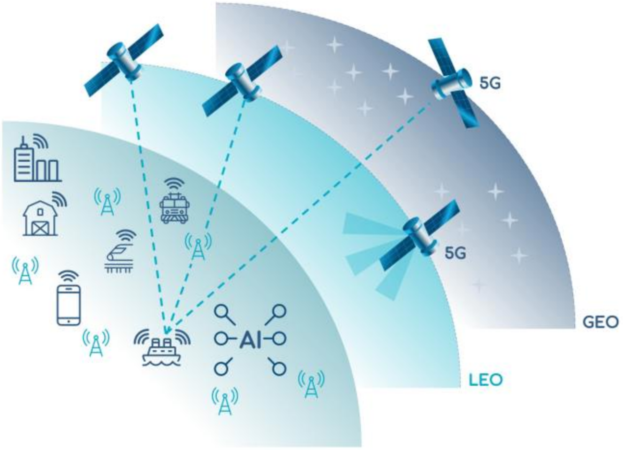
Project Coordinator: *Tomaso De Cola, DLR*

Technical Manager: *Albekaye Traore, Thales Alenia Space France*

PROJECT AMBITION

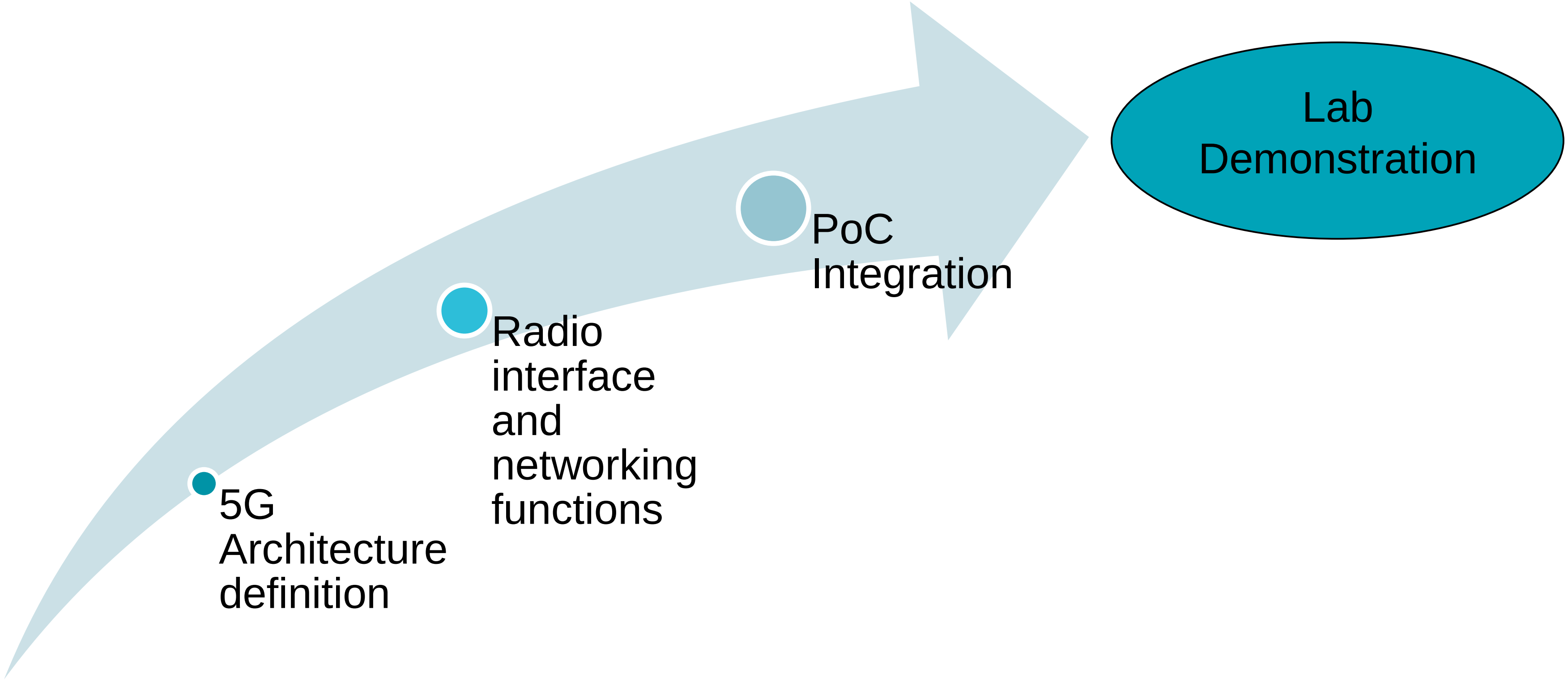
Design, develop and demonstrate a deeper integration of TN and NTN:
Deliver a fully integrated 5G-NTN autonomous system with novel self-adapting end-to-end connectivity models for enabling ubiquitous radio access.

KEY TECHNOLOGIES



- *Regenerative payloads for GEO and NGSO systems*
- *Unified radio interface for cost-effective converged TN/NTN multi-tenant networks*
- *Softwarised self-organised network architecture*
- *E2E AI-Driven Network Design*

Project Methodology



Use-Cases and Scenarios

Focus on airway: DC solutions on-ground and IAB connectivity in flight

1: QoS-driven LEO/GEO connectivity
2: IAB for residential broadband
3: TN-to-NTN backup for energy saving

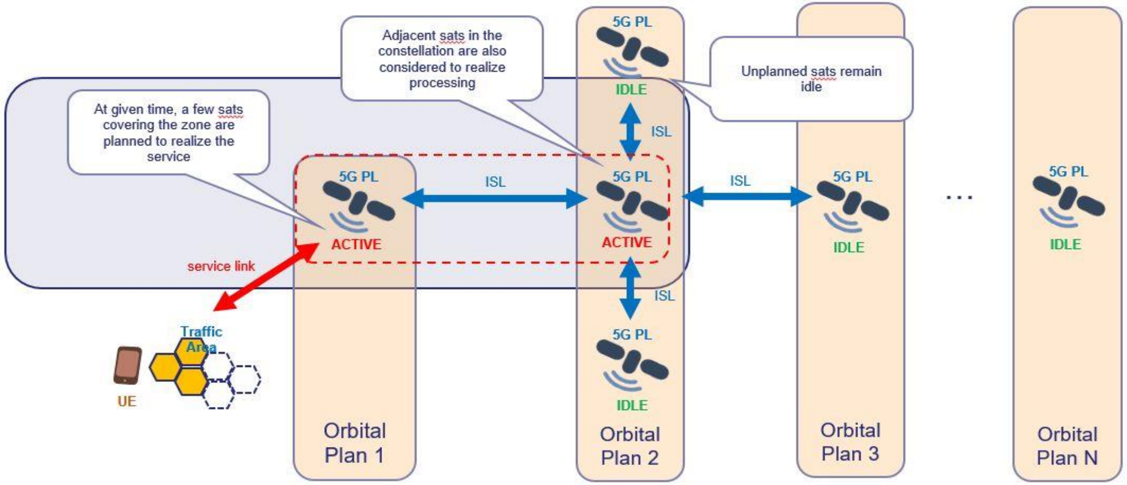
Integration of connectivity islands in a company-wide, spanning worldwide network

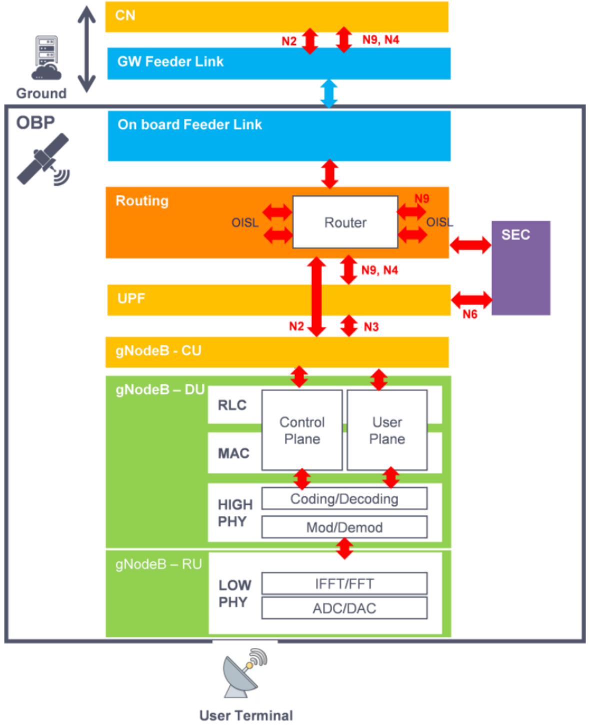
Focus on V2N solutions

Reference Satellite Architecture

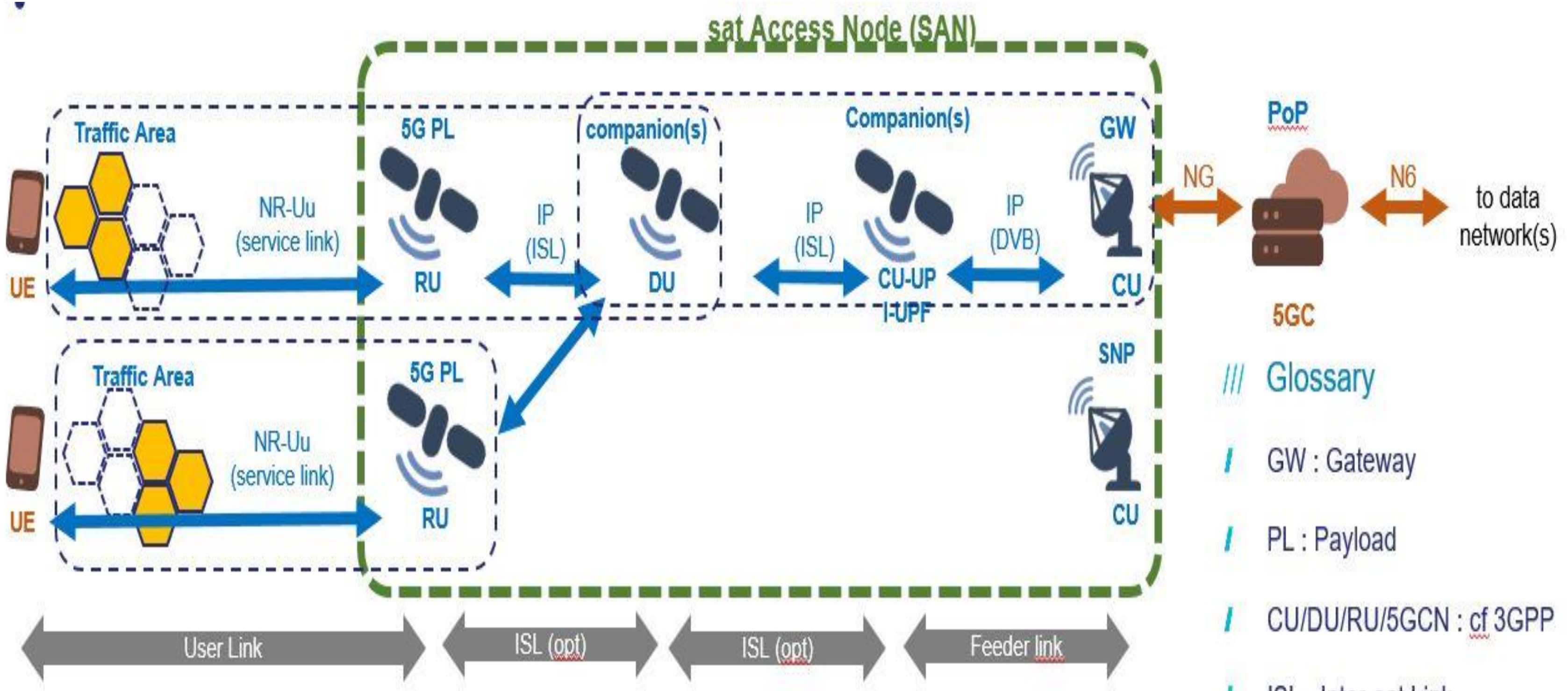
Composite LEO satellite constellation:

- OBP satellite payload
- gNB onboard satellite (different functionalsplitting options)
- 5G capabilities dynamically switched on and off





Functional Splits *(example)*



/// Glossary

- GW : Gateway
- PL : Payload
- CU/DU/RU/5GCN : cf 3GPP
- ISL : Inter-sat Link

AI/ML application

Reference O-RAN architecture

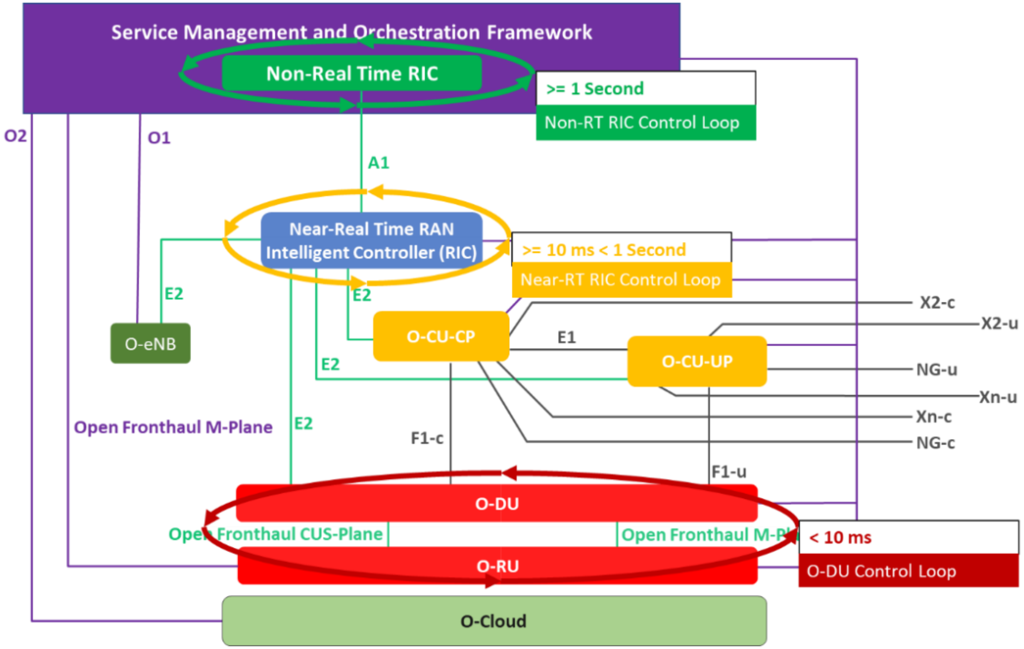
- RIC decomposition
- Differerent control loops

AI exploitation for:

- RRM (O-DU control loop)
- Network slicing/orchestration (non-RT RIC control loop)

Dual steer/multi-link optimisation

- Link selection, steering, switching (ATSSS-inspired)

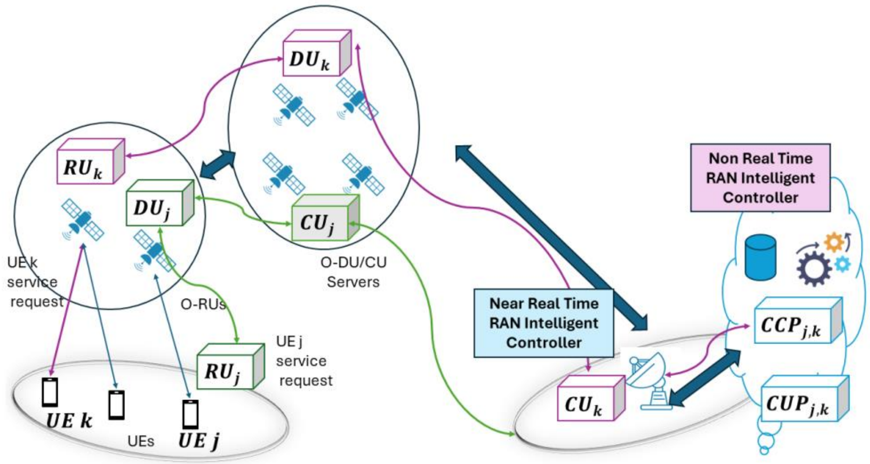


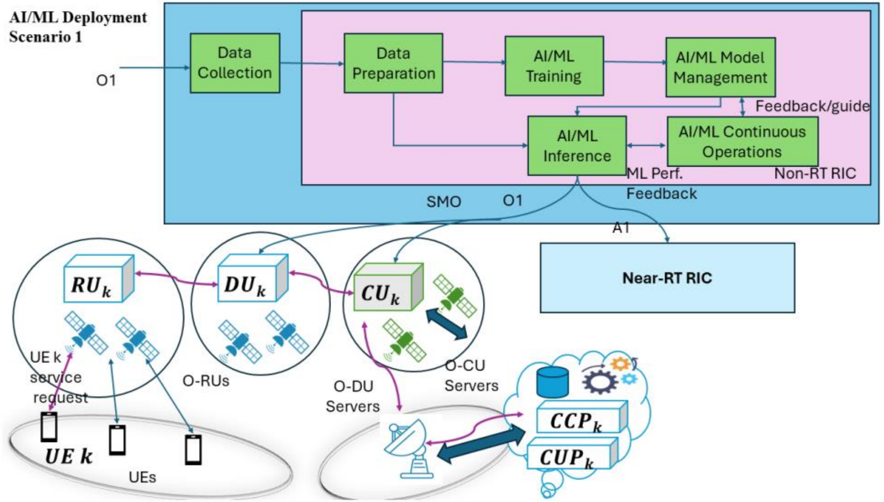
Network slicing optimisation

Dedicated vs. sharing slices

Multiple functional splits affecting the establishment and optimisation of network slices

Different control framework possible depending on system requirements and HW/SW capabilities



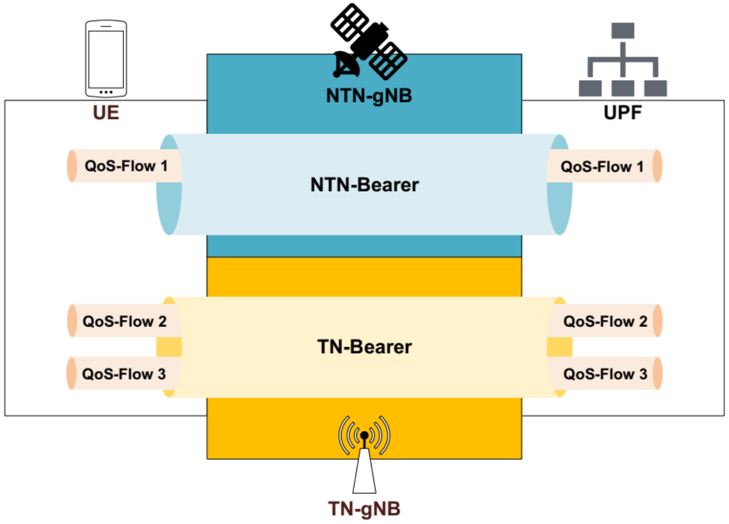


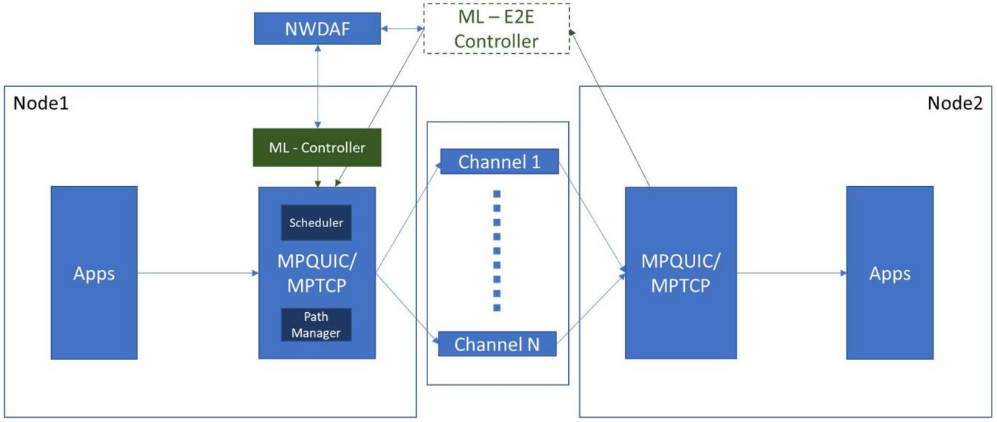
Multi-Connectivity optimisation

ATSSS-support

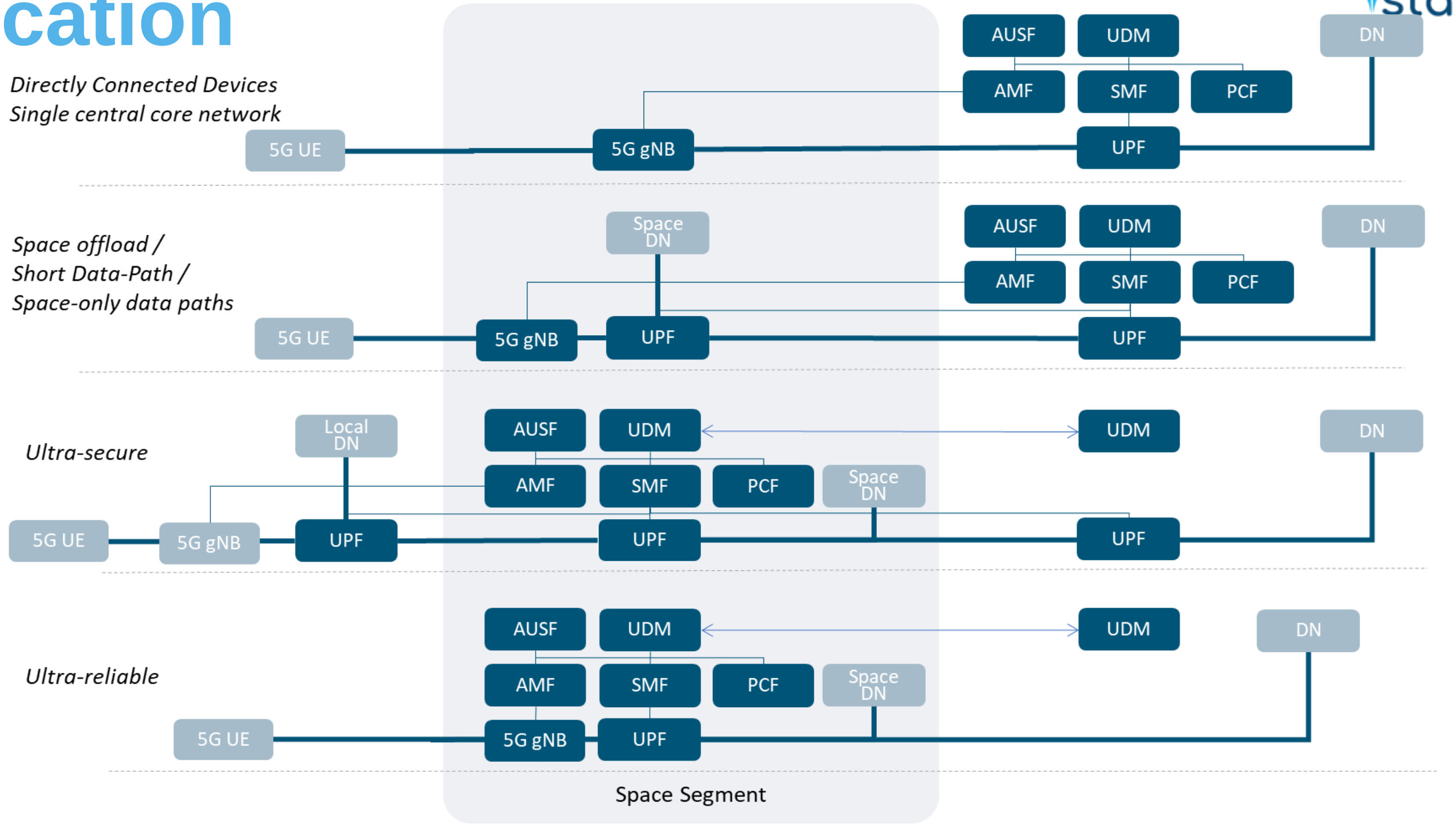
NWDAF for data analytic functions

E2E ML/AI controller for dynamic optimisation of multi-link management





Dynamic slice-oriented NFV allocation



PROJECT OUTCOME

To design, implement, and demonstrate (TRL 5) E2E services over a fully integrated TN-NTN
advanced network architecture with regenerative space nodes

High-level objectives of the PoCs

Build an E2E laboratory demonstrator functionally representative of the 5G NTN from the 5GC to the UE able to support the assessment of internal/external I/F and SW/HW performance

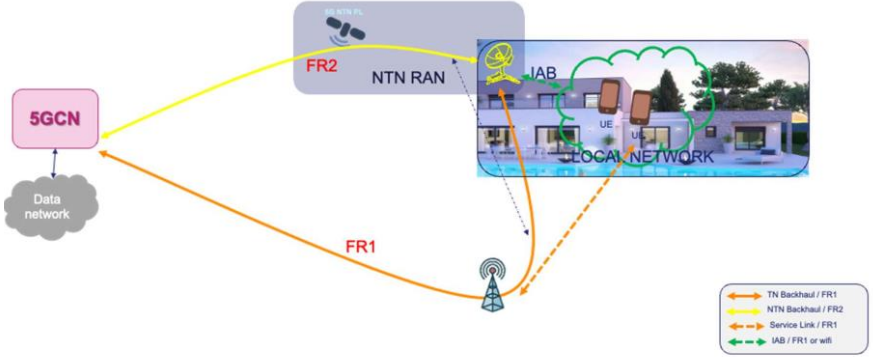
high-level requirements

- support NR waveforms on the service link with SCS=60 kHz and 100 MHz bandwidth
- implement the following gNB functional split options
  - full gNB on-board: RU+CU+DU co-located on a single payload
  - gNB split and functionally allocated to 3 separate parts: RU on-board, DU on-ground/on-board a secondary payload, CU on-ground
- demonstrate TN/NTN switching
- implement or emulate the IAB behaviour

PoC Use Cases

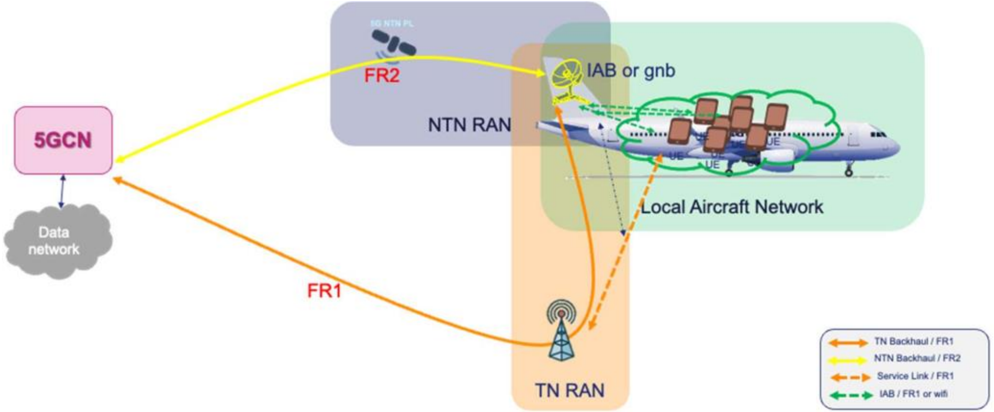
PoC #1 Residential Broadband

- PoC#1.1: Residential broadband for energy saving
- PoC#1.2: Residential broadband for large sparsely populated areas

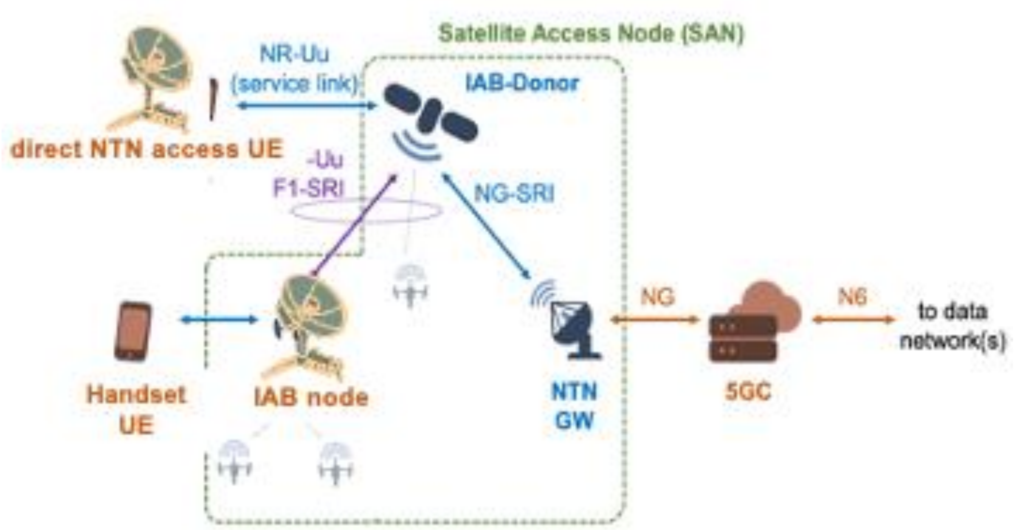


PoC #2 Air traffic

- PoC#2.1: TN/NTN switch at boarding
- PoC#2.2: in-flight entertainment



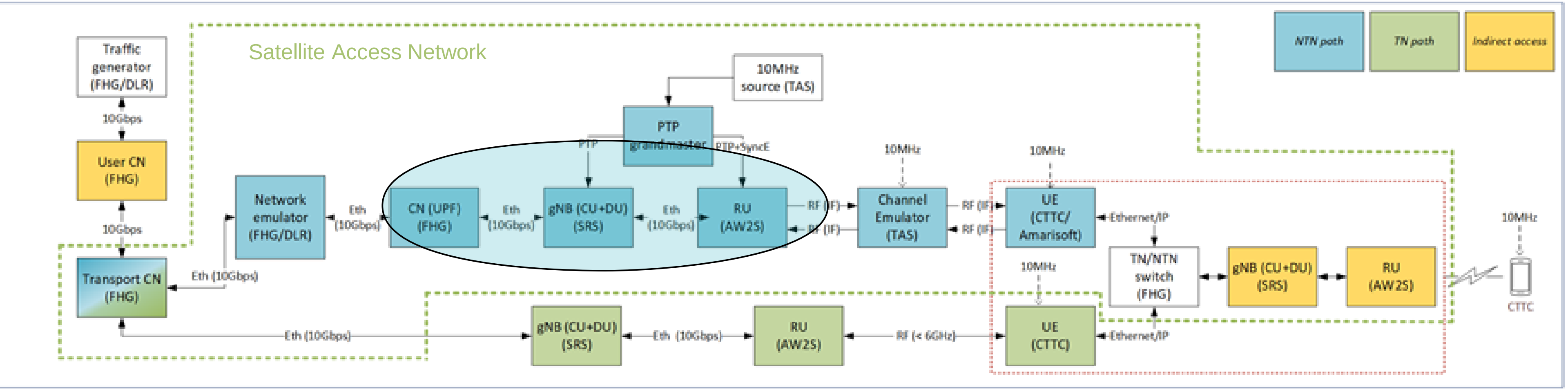
PoC macro-architecture



Two setups considered

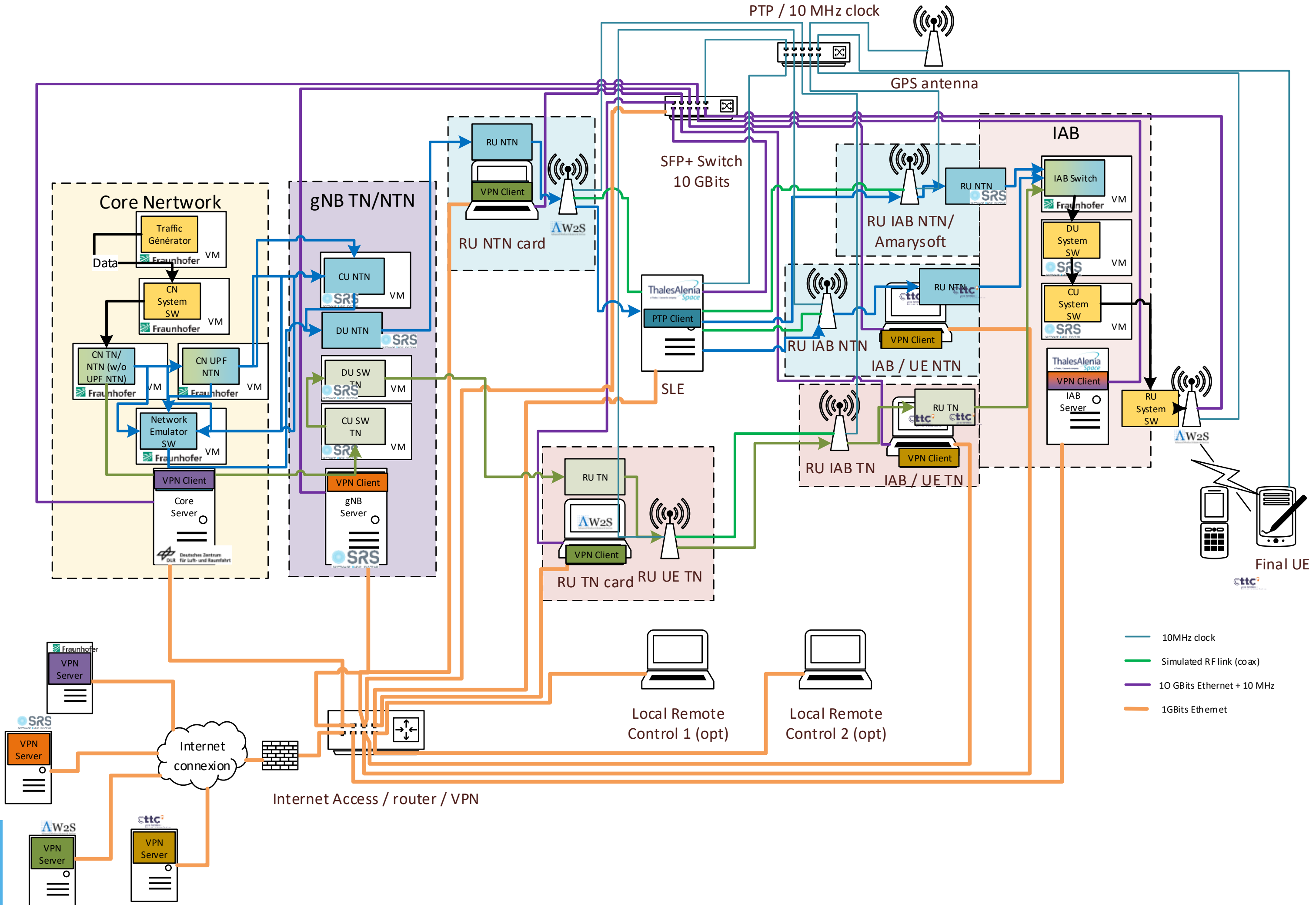
- Direct Access
- Indirect Access

PoC functional architecture:
full gNB onboard with 5G functions



Full gNB and Core Network User Plane Functions on-board

Stardust PoC proposed architeture



Summary

- Lessons Learnt
  - 5G is a complex ecosystem → integration of NTN components is a hard task!
  - Additional deeper investigations needed about:
    - Selection of the most appropriate functional splitting options
    - Overall architecture approaches
  - Achieving end-to-end integration encompasses many system elements:
    - RAN, CN, etc.
    - Unified approach towards QoS support, seamless connectivity, and service continuity
  - Some key questions:
    - Can existing standards be applied with minimum adaptation to a unified 6G-NTN system
    - Can existing standards from the terrestrial domain be extended to a TN/NTN framework (e.g., security, routing, QoS, etc.)
- Next Steps
  - Final demo, Q3-Q4 2025

THANKS FOR YOUR ATTENTION

GET IN TOUCH

Website
5g-stardust.eu

Email
info@5g-stardust.eu

Twitter
@5G_Stardust

Co-funded by the European Union

5G-STARDUST project has received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101096573.