Open 6Ge

Evolving Open 5G and 5G-Advanced Towards 6G

An open evolution platform for integrating, experimenting, accelerating, automating, and validating emerging 6G technologies on today's open 5G and 5G-Advanced foundation.

INTEGRATE · EVOLVE · ACCELERATE · AUTOMATE · VALIDATE

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From Open 5G to Open 6G

Over the past several years, the open telecom ecosystem has matured significantly.

Today, open-source projects are available across:

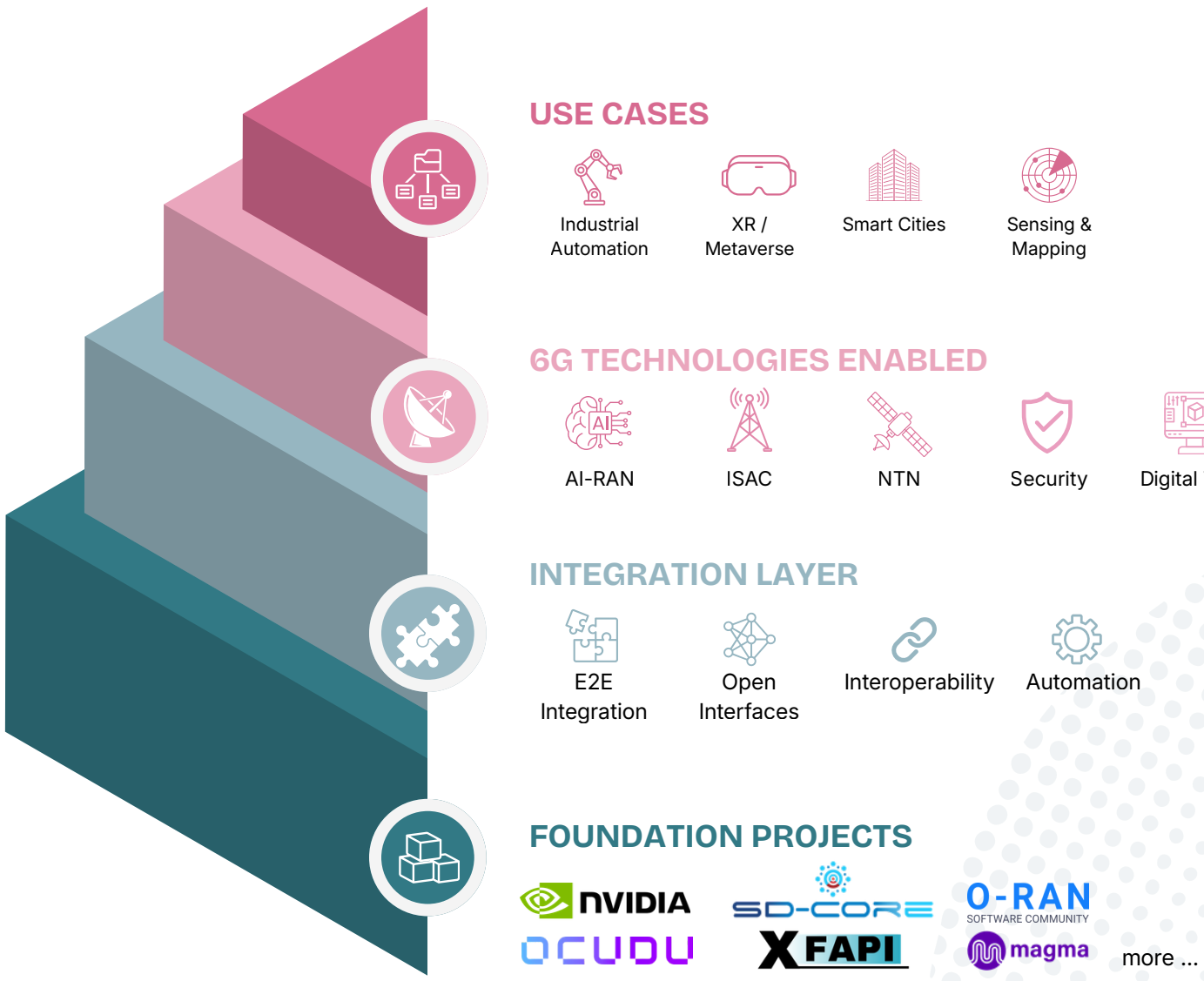
- RAN
- 5G Core
- RIC and SMO
- IMS
- Cloud infrastructure
- Network orchestration
- Simulation
- Observability
- Automation
- Testing

Individually, these technologies provide strong building blocks.
The bigger opportunity is to bring them together into a common end-to-end environment and progressively introduce technologies expected to play a much larger role in 6G.

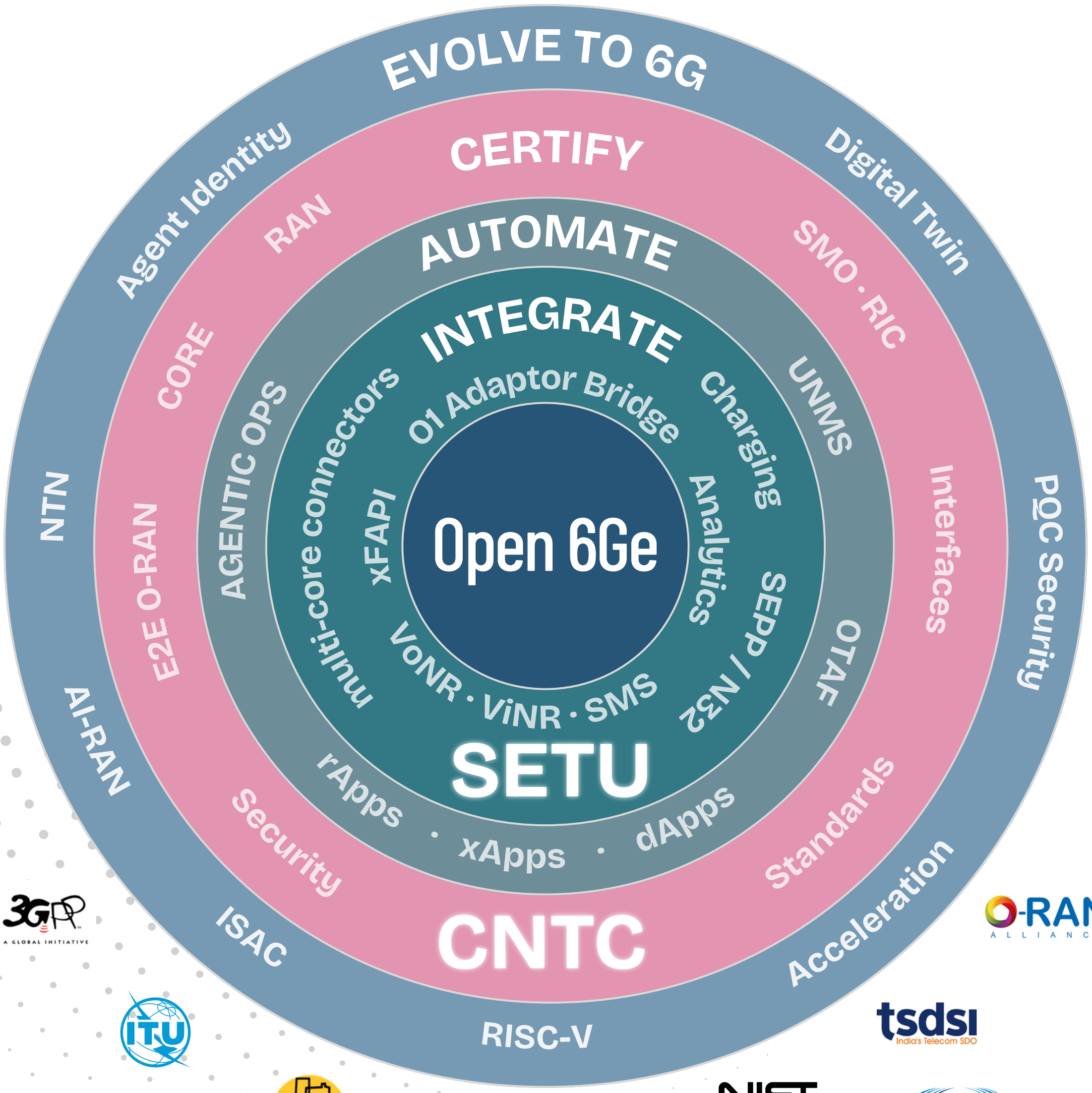
Open6Ge therefore follows a simple philosophy:

Open 5G → 5G-Advanced → Emerging 6G Technologies → Open 6G

The objective is not to replace existing open-source projects.
It is to **integrate them, extend them and create a common experimentation and validation environment around them.**



The Open6Ge Ecosystem



Building the Evolution Foundation

xFAPI
Open bridge across the L1 ↔ L2 boundary - FAPI, transport and runtime.

OAI | OCUDU | NVIDIA AERIAL | FLEXRAN | OSC DU-HIGH

01 adaptor bridge
Any SMO ↔ any RAN - a vendor config model mapped onto the 3GPP NRM.

O1 | NETCONF | YANG | CM · PM · FM

eBPF Bridge
Programmable control-plane ↔ user-plane bridge, cloud-native.

EBPF USER PLANE | XDP / TC | CP ↔ UP COMPOSITION

SETU
the interworking bridge

One bridge layer, two directions - so separately built components run as one network.

◄ RAN SIDE | CORE & IMS ►

VoNR · ViNR · SMS
Voice, video and messaging over 5G SA — IMS bridged onto the core.

KAMAILIO | OPENSIPS | IOS MCN | IMS ↔ SBI

Multi-core connectors
One bridge, many cores — session, policy and subscriber interworking.

SD-CORE | FREE5GC | MAGMA | SBI

Charging · Analytics · Roaming
Usage and CDR export, core-signalling insight, inter-PLMN interworking.

CHF · N40 | ANALYTICS | SEPP | N32-C / N32-F

RAN certification
A split gNB certified as TS 33.523 classes - a certificate per class.

O-DU | O-CU-CP | O-CU-UP | O-RU · ROADMAP

Core certification
5G user plane and core control plane, driven through real interfaces.

UPF | AMF | SMF | CORE CP

O-RAN & end-to-end
SMO, RIC and full O-RAN network certification on the roadmap.

NEAR-RT RIC | SMO | XAPPS / RAPPS | E2E O-RAN

CNTC
certification & validation

Requirements become automated tests, graded verdicts and auditable certificates.

◄ WHAT WE CERTIFY | HOW IT WORKS ►

ranbench engine
One adapter per RAN stack - one real UE attach, every interface decoded.

ADAPTER | BRING UP | DRIVE | CAPTURE | DECODE

Graded verdicts
Level 1 - 58 automated tests, 30 essential · Level 2 adversarial.

PASS | FAIL | INCOMPLETE | VERSIONED CATALOGUE

Auditable certificates
Evidence on the wire becomes the certificate - every class must pass.

N2 | F1-C | F1-U | E1 | N3 | RRC

2D → 3D BIM conversion
Automated BIM generation from construction drawings.

DWG / PDF | AI EXTRACTION | 3D BIM | REVIT / IFC

Sionna RT · ray tracing
Site-specific propagation from 3D scenes - per-path delay and Doppler.

SIONNA RT | 3D SCENES | PER-PATH CIR | GPU

NTN scenarios
LEO and GEO orbits - delay, Doppler, timing advance, beam mobility.

LEO | GEO | DELAY · DOPPLER | SIB19 · EPHEMERIS

DIGITAL TWIN
PLATFORM · simulate first

A unified digital twin of infrastructure, radio, networks and AI - connecting physical environments to intelligent, autonomous networks.

◄ SIMULATE | DATA & ML ►

BIM-powered digital twin
Real-world infrastructure reconstructed as a simulation-ready 3D environment.

3D BIM | SITE GEOMETRY | ASSETS | DIGITAL TWIN

Multi-UE RF simulation
Many nr-UEs on one gNB over a simulated radio - no RF hardware needed.

NR-UE × N | RFSIMULATOR | HANDOVER | MOBILITY

Data collection for AI-RAN
Labelled per-UE, per-slot datasets captured straight from the twin.

PER-UE DATASETS | PHY · MAC KPIS | CSV / PARQUET | REPLAY

OPEN 5G · 5G-ADVANCED
the upstream foundation we build on

OCUDU | O-RAN SC | SD-CORE | FREE5GC | CORAN LABS | MAGMA | KAMAILIO | ONAP | OPENAIRINTERFACE | NVIDIA AERIAL

Open 6Ge Architecture

VISION

- AI-Native Networks
- Programmable Everything
- Sensing & Communication (ISAC)
- Ubiquitous Connectivity (NTN)
- Sustainable & Green Networks
- Open Ecosystem & Multi-vendor Interoperability

TOSSI OPEN6Ge STACK ARCHITECTURE

Use Cases

eMBB | URLLC | mMTC | Industrial Automation | Connected Vehicles | Smart Cities & IoT | XR / Metaverse | Public Safety | Sensing & Mapping

Applications & Services

Network Applications | Exposure APIs | Northbound APIs | Service Enablement | Developer Portal

Intelligence & Automation

AI-Native Network Intelligence

- AI-RAN (L1/L2/L3 Intelligence)
- Hierarchical ML Scheduling
- xApps / rApps / dApps (Closed Loop Automation)
- Digital Twin & Simulation
- Analytics & Insights
- Intent Based Networking

Integration & Orchestration (SMO)

OTAF - Open Telecom Applications Framework

- **Application Lifecycle & Packaging**: Build | Package | Testing Kit
- **Applications sdk**: Non-RT RIC (rApps) | Near-RT RIC (xApps) | Radio access Network (dApps)
- **SMO platform services adaption**: Inventory | Topology | Fault | Config | Security | Performance | AI/ML Services
- **Interfaces**: A1 | O1 | O2 | E2 | Open APIs

Core Integration Layer

Core Network Integration

Canonical Charm - Cloud Native 5G Core | eBPF/XDP Acceleration | SETU Bridge | SBI / Open APIs | eUPF | Kamailio IMS

RAN Integration Layer

RAN Integration

xFAPI | O-DU / O-CU | AI-RAN | Intelligent Scheduling | RAN Acceleration | ISAC | Digital Twin

3GPP Interfaces: F1 | E1 | X2/Xn | NG | E2 | A1 **O-RAN Interfaces:** Open Fronthaul (xFAPI) | E2 | O1 | O2

Data, AI & Acceleration Layer

Data & AI Fabric

Data Lakehouse | Real-time Data Streaming | AI/ML Pipeline | Model Repository | Feature Store | GPU/FPGA Cluster

Connectivity Extensions

Extended Connectivity

NTN Integration | Multi-Access Edge Computing | Wi-Fi / Fixed / Private 5G | Satellite Backhaul | IAB & Backhaul

Testing & Certification Layer

CNTC - Cloud Native Telecom Certification

Automated Conformance Testing | 5G User Plane | RAN Certification | SCAS Security Testing | Auditable Certificates | 5G Core Control Plane

Infrastructure Layer

Cloud Native & Infrastructure

- Kubernetes Orchestration
- Multi-Cloud / Hybrid Cloud (AWS | Azure | GCP | On-prem)
- Edge Cloud (Distributed)
- Infrastructure as Code (Terraform | Ansible)
- Observability (Prometheus | Grafana | ELK)
- GitOps / CI-CD (DevSecOps)

Standards Alignment

3GPP, ITU, SCF, tsdsi, tmforum, ETSI, IEEE, O-RAN Alliance, IETF, NIST, GSMA

References

NVIDIA, SD-CORE, OPEN AIR interface, KAMAILIO, OCUDU, XFAPI, magma, OTAF, freeSGC, ONAP, O-RAN SOFTWARE COMMUNITY, coRAN LABS, Benetel

6G Innovation & Usecases

Open6Ge provides a foundation for exploring and integrating emerging 6G technologies. The stack brings together open-source network components with capabilities across AI, sensing, satellite connectivity, security, digital twins, and network automation.

ISAC

Integrated Sensing & Communication

Combining wireless communication and sensing to enable networks that can detect, locate, and understand their physical environment.

NTN

Non-Terrestrial Networks

Extending mobile connectivity beyond terrestrial networks through satellite and aerial platforms, with support for end-to-end NTN integration and testing.

AI-RAN

Intelligent & Adaptive RAN

Applying AI/ML across the RAN to improve scheduling, link adaptation, prediction, and network optimization.

PQC Security

Post-Quantum Security

Exploring post-quantum cryptography and crypto-agile architectures to prepare telecom networks for emerging security requirements.

Agentic AI & Automation

Intelligent Network Operations

Using AI agents and automation to interpret network data, make decisions, and execute actions across the network.

Digital Twins

Model, Simulate & Optimize

Creating digital representations of network and radio environments to evaluate configurations, algorithms, and new technologies before deployment.

Open RAN and Core Integration

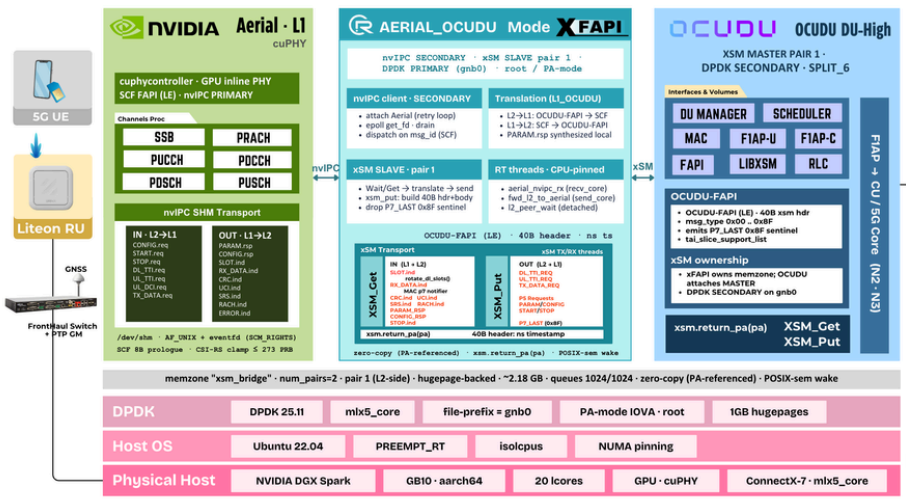
Connecting independently developed components through open interfaces

RAN, Core, IMS, transport, orchestration and cloud infrastructure must work together across open interfaces.

The Open6Ge architecture therefore includes integration capabilities across both the RAN and Core.

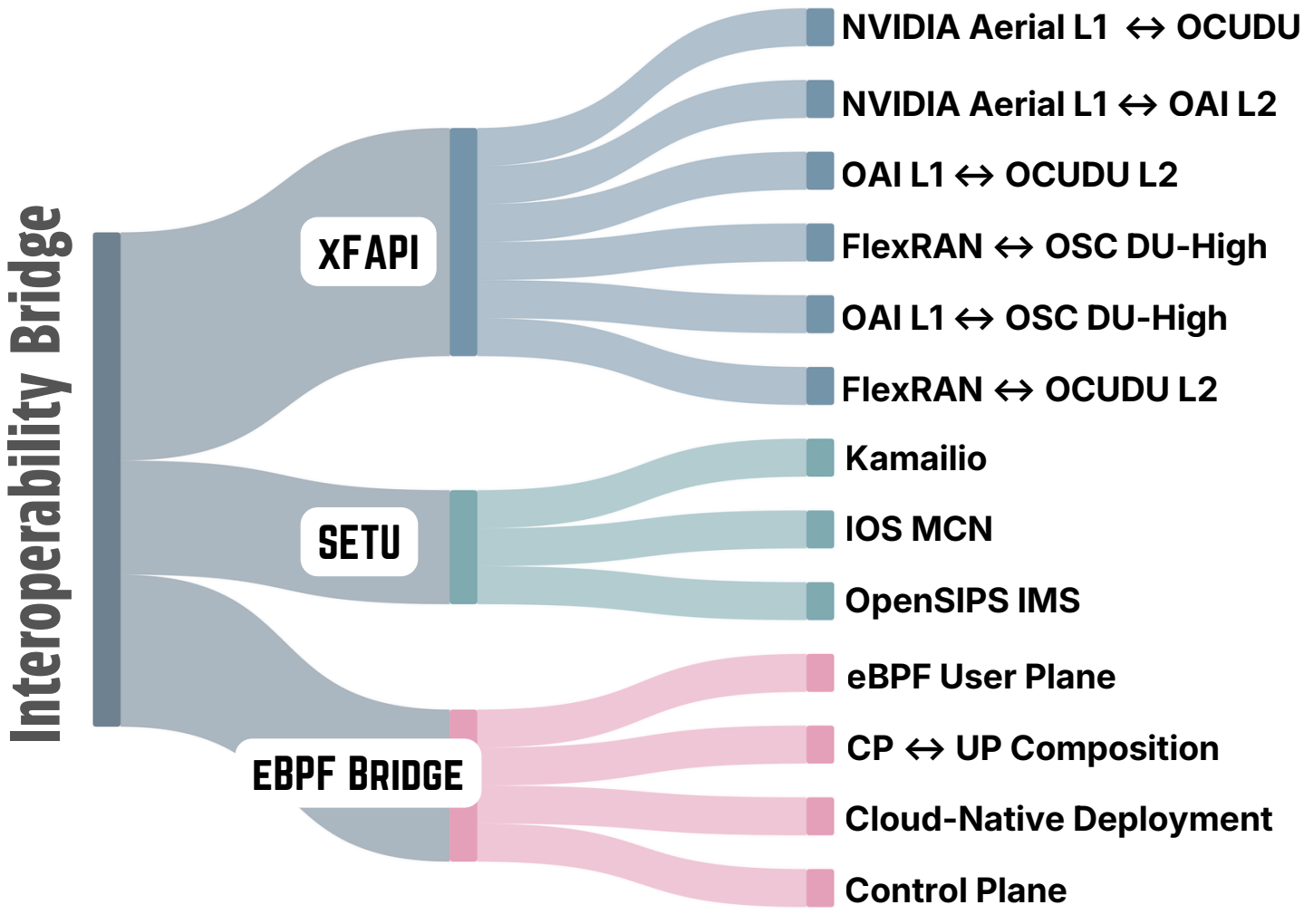
On the RAN side, technologies such as xFAPI can bridge differences between independently developed L1 and L2 implementations, enabling combinations across open and accelerated RAN platforms.

On the Core side, cloud-native network functions, programmable user planes and open APIs provide a foundation for rapid experimentation.
Additional interoperability components such as SETU and HEXAeBPF address integration across IMS, multi-core environments, control-plane/user-plane composition and programmable packet processing.



Key Capabilities

- L1–L2 Interoperability
- Multi-Vendor RAN Integration
- OAI ↔ OCUDU Integration
- NVIDIA Aerial ↔ OCUDU Integration
- Core–IMS Interworking
- User- & Control-Plane Integration
- Cloud-Native Network Integration
- End-to-End Validation



AI RAN

Intelligent, predictive and slice-aware RAN

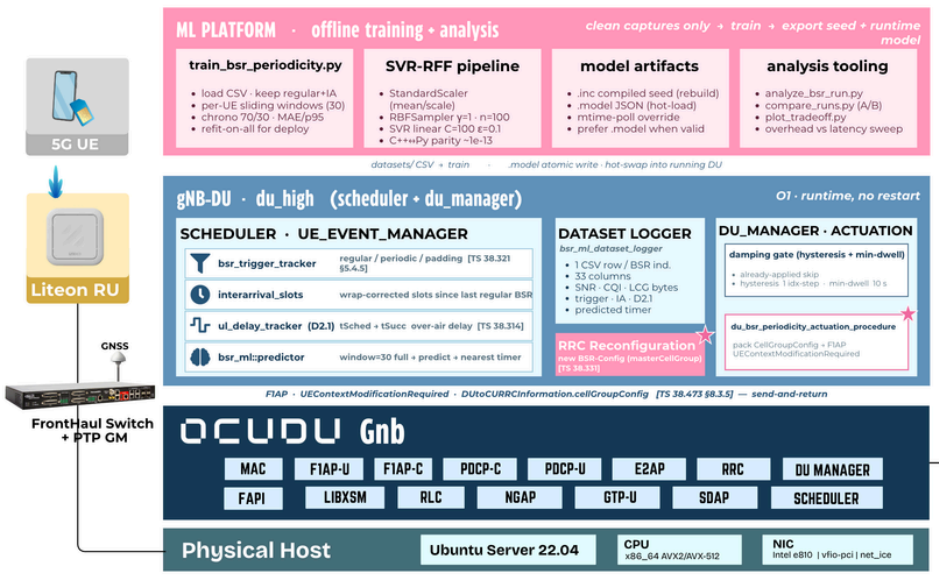
Open6Ge brings AI directly into the RAN scheduler, enabling per-UE intelligence, predictive link adaptation and dynamic scheduling based on real-time network conditions.

Building on TOSSI's OCUDU AI-RAN framework, the stack supports ML-based MCS selection, BSR prediction and CSI prediction, while extending intelligent scheduling towards different network slices with dynamically changing performance requirements and priorities. The approach combines offline training, lightweight in-RAN inference, live model updates and safe fallback to conventional scheduling.

Instead of relying entirely on static scheduling rules, future RAN systems can combine real-time network information with learned models while retaining safe fallback mechanisms to conventional schedulers.
This creates a practical evolution path from today's RAN toward increasingly **AI-native radio networks**.

Key Capabilities

- ML-Based Link Adaptation
- Predictive CSI
- Intelligent Scheduling
- Dynamic Slice-Aware Scheduling
- eMBB / URLLC / mMTC Optimization
- Real-Time RAN Inference
- Traffic-Aware Scheduling
- Closed-Loop Optimization
- Online Model Updates
- Quantum Machine Learning



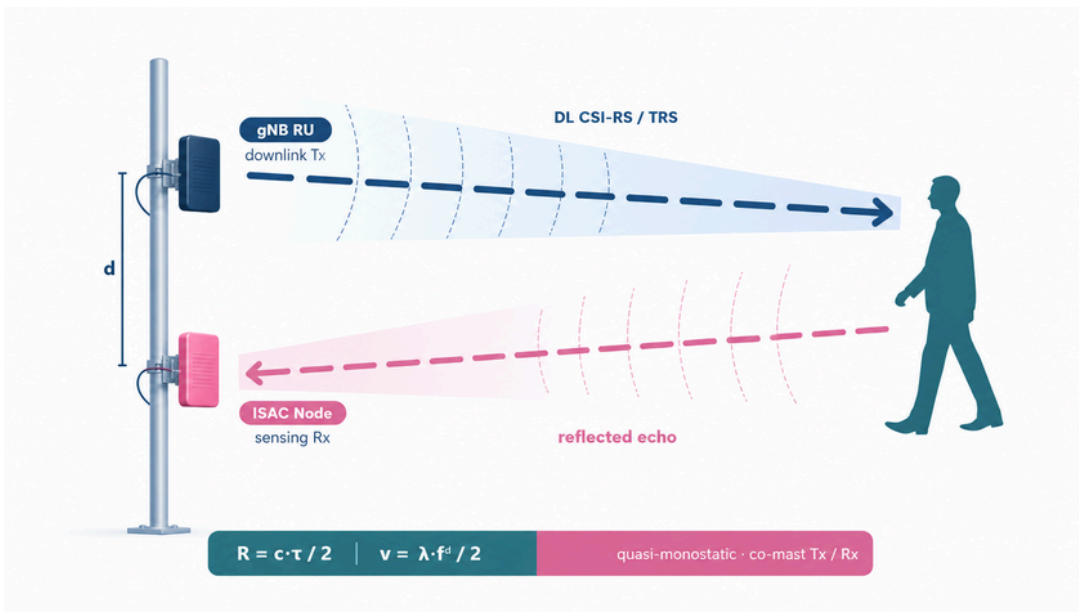
Open ISAC Testbed

Turning an open 5G network into a sensing system

6G is expected to extend wireless networks beyond communication.

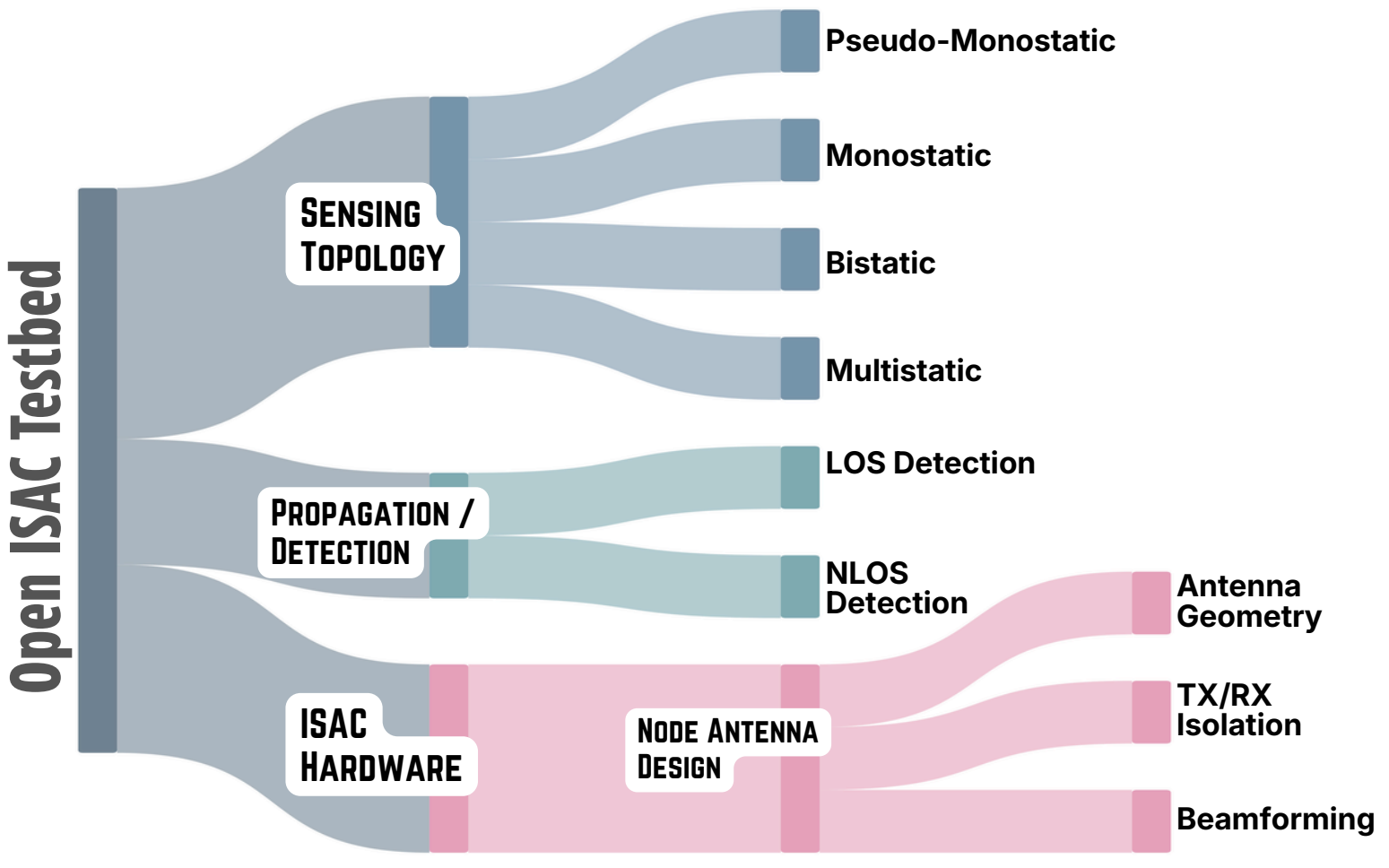
With Integrated Sensing and Communication - ISAC, the same radio infrastructure used to transmit information can also be used to understand the physical environment.
The Open6Ge ISAC environment explores this using 5G NR signals such as CSI-RS to extract sensing information.

This means the mobile network can gradually evolve from simply connecting devices to becoming a distributed sensing infrastructure.
Applications could eventually span industrial environments, mobility, robotics, smart cities, public safety and environmental awareness.



Key Capabilities

- 5G NR CSI-RS Sensing
- Pseudo-Monostatic Sensing
- Range & Doppler Estimation
- Live Range-Doppler Mapping
- LOS & NLOS Detection
- Monostatic, Bistatic & Multistatic Sensing
- O-RAN Radio Integration
- ISAC Node Antenna Design
- Open & Reproducible Testbed



Standards Alignment

- TS 22.137
- TR 22.837
- TR 38.765
- TR 38.901
- TS 38.211
- TS 38.213–38.215
- TS 38.300
- TS 38.331
- TS 38.401
- TS 38.473

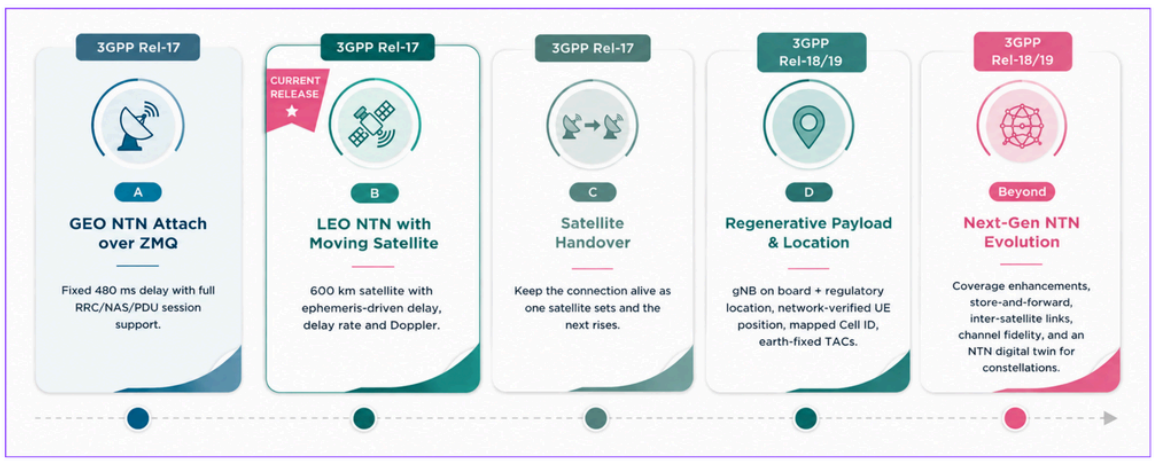
Open NTN Testbed

End-to-end open testbed for satellite-enabled connectivity

Another major part of the evolution toward 6G is the convergence of terrestrial and non-terrestrial networks.

Open6Ge includes an Open NTN Testbed that allows satellite-enabled connectivity to be explored using an end-to-end software environment.

The advantage of a software-based approach is that researchers can evaluate NTN behaviour without always requiring access to dedicated satellite infrastructure.
This allows terrestrial 5G systems to gradually evolve toward integrated **terrestrial + satellite connectivity**.

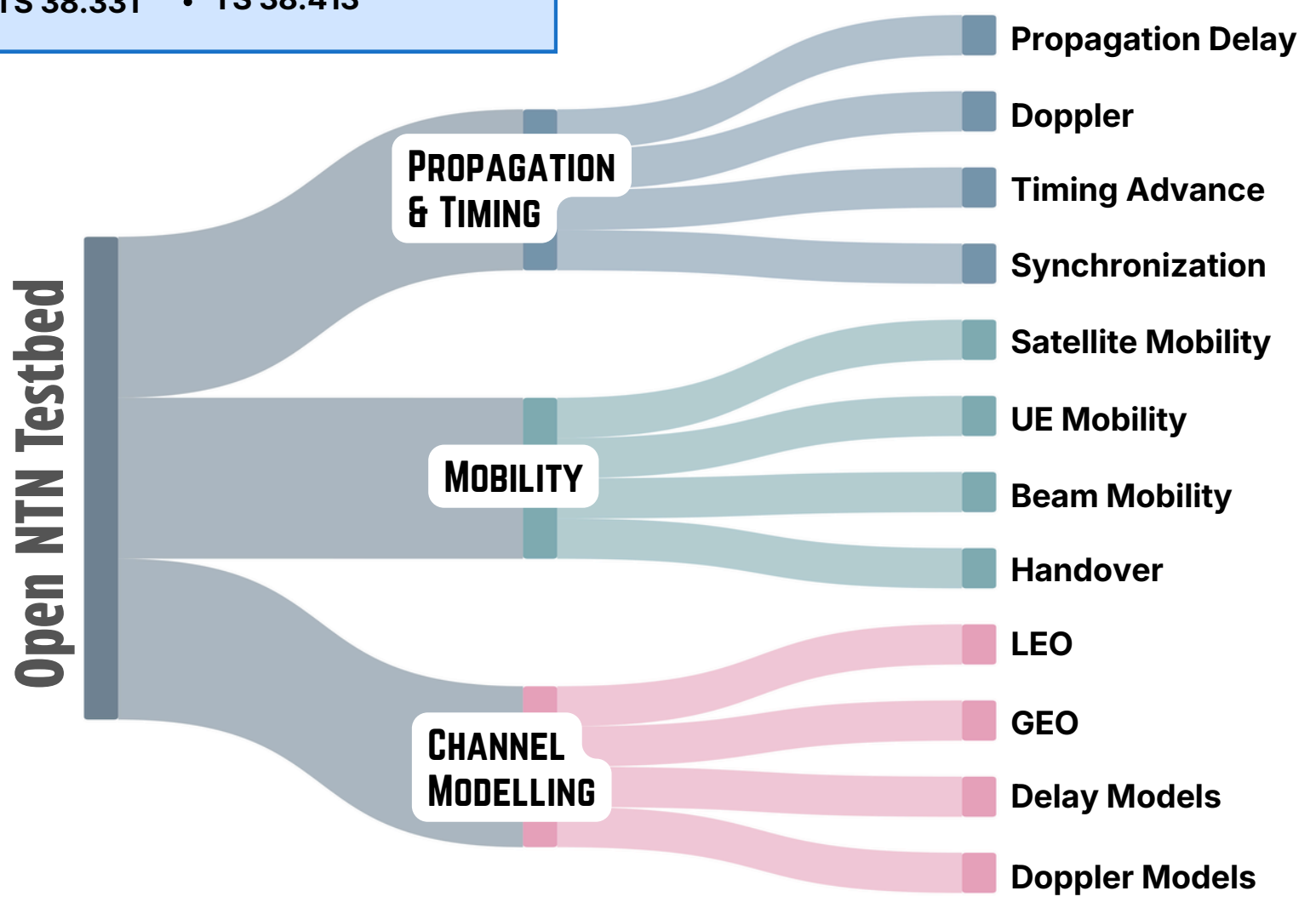


Key Capabilities

- 3GPP Release 17 NTN
- GEO & LEO Scenarios
- Satellite Channel Modelling
- Dynamic Propagation & Doppler
- NTN Timing & Synchronization
- Ephemeris & SIB19
- NTN Mobility & Handover
- End-to-End 5G SA Testing
- Software-Based & Reproducible
- Terrestrial–Satellite Integration

Standards Alignment

- **TR 38.811**
- **TR 38.821**
- **TR 38.863**
- **TS 38.300**
- **TS 38.331**
- **TS 38.101-5**
- **TS 38.108**
- **TS 23.501 / TS 23.502**
- **TR 23.737**
- **TS 38.413**



Post-Quantum Security

Preparing open telecom networks for long-term security

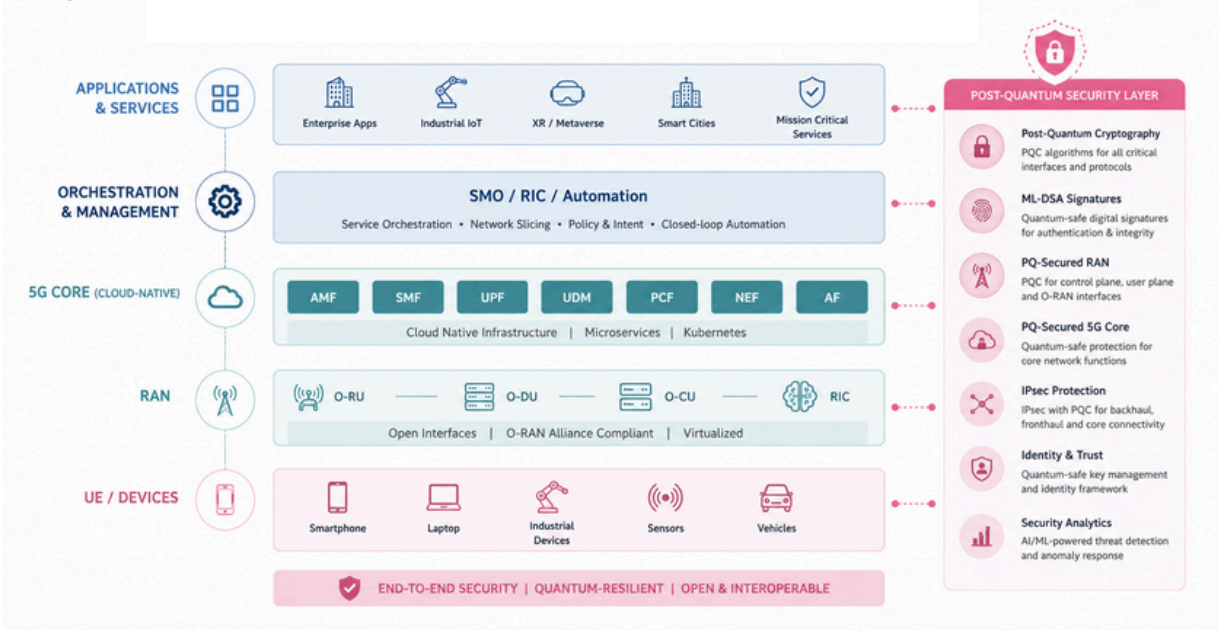
6G infrastructure being designed today may remain operational for decades. Security therefore needs to consider not only today's threats, but also the long-term impact of quantum computing.

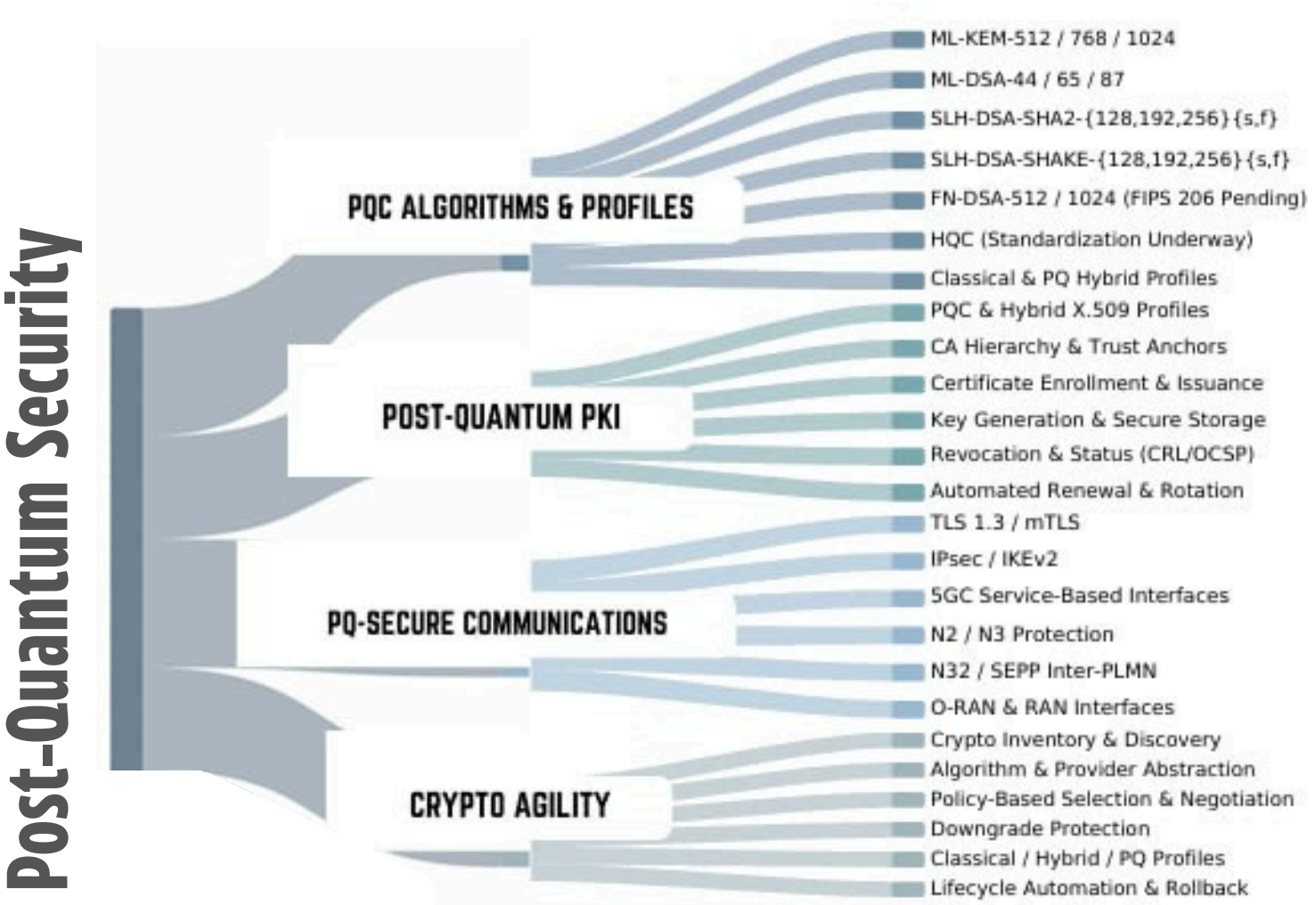
Open6Ge integrates post-quantum security across the telecom architecture.

An important principle here is **crypto agility**.
Networks should not be tied permanently to one algorithm.
They need the ability to discover deployed cryptography, select policies, migrate between classical, hybrid and post-quantum profiles, manage certificates and keys, and prevent cryptographic downgrade.
That capability will be critical for any long-lived 6G infrastructure.

Key Capabilities

- ML-KEM, ML-DSA, SLH-DSA
- classical/PQ hybrid profiles
- PQC and hybrid X.509 certificates
- PQC-enabled PKI
- TLS 1.3 / mTLS, IPsec / IKEv2
- 5GC SBI protection
- N2/N3 security
- N32/SEPP security
- crypto inventory and discovery
- policy-driven crypto agility





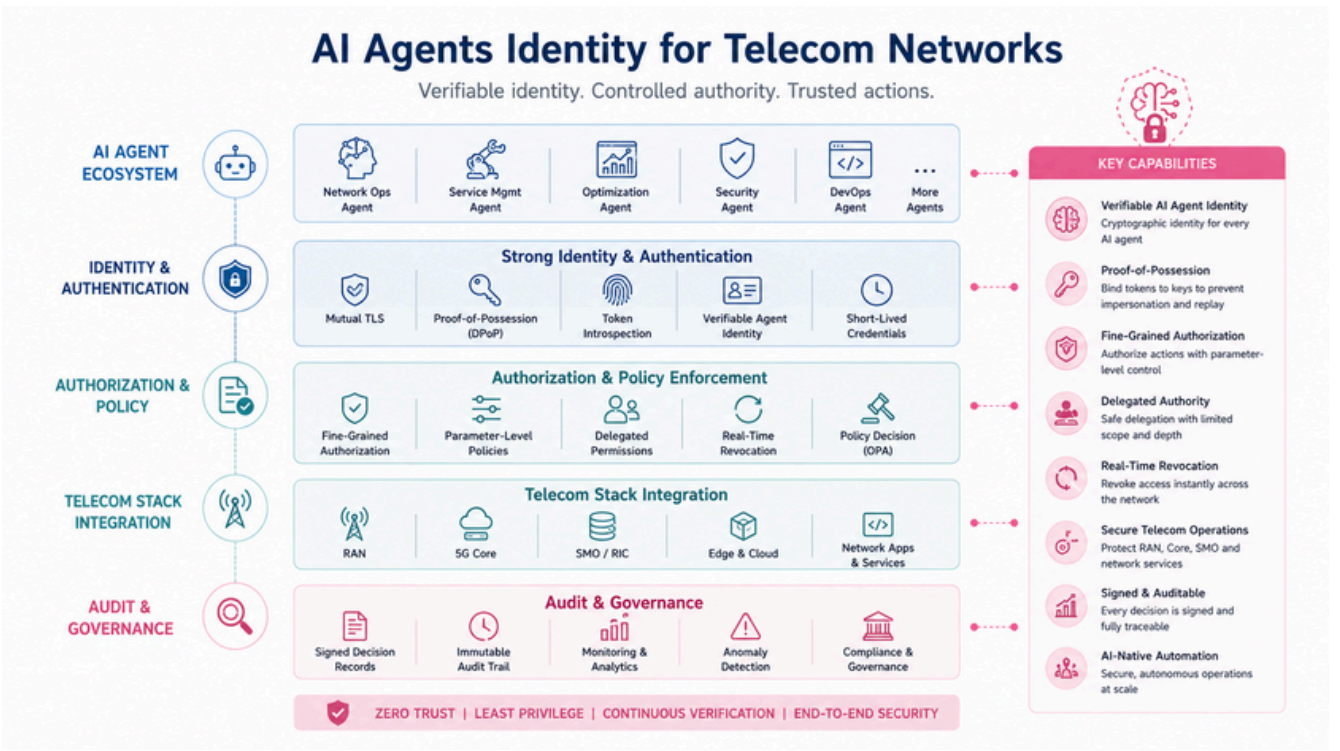
Standards Alignment

- **TS 33.501**
- **TR 33.703**
- **TS 33.210 / TS 33.310**
- **TS 33.511 / TS 33.523**
- **TS 33.512–33.519**
- **TS 33.526**
- **TS 33.117 / TS 33.916 / TS 33.926**
- **TS 33.527**
- **TS 33.120**
- **TS 33.122**

Identity for AI Agents

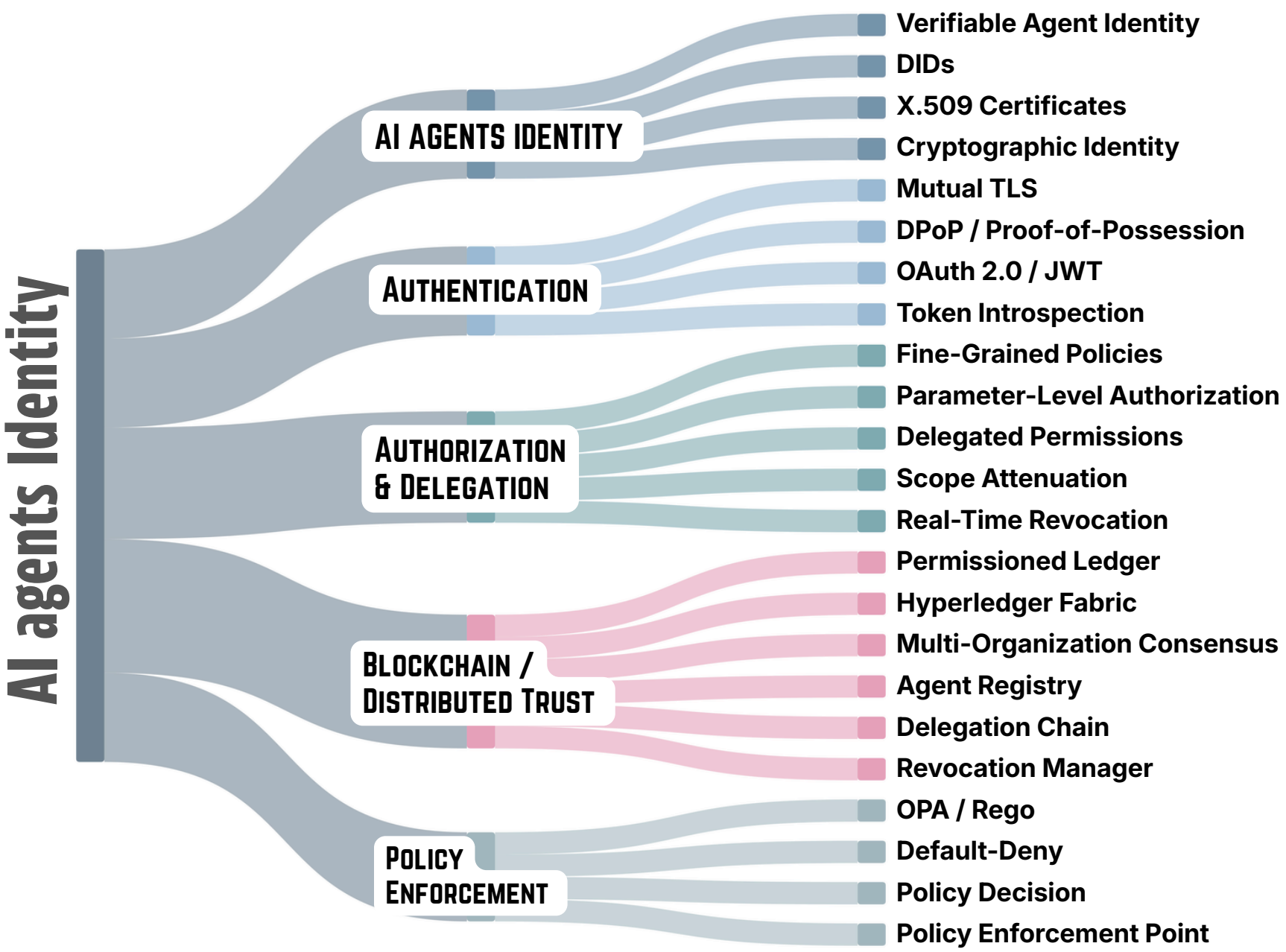
Identity and authorization for intelligent telecom networks

Open6Ge extends AI agents beyond server operations into the telecom network stack, giving agents a verifiable identity and controlled authority to interact with RAN, Core, SMO, applications and infrastructure. The approach uses cryptographic identity, proof-of-possession, policy-based authorization, delegated permissions and revocation so that every agent action can be authenticated and evaluated before it reaches a network function.



Key Capabilities

- Verifiable AI Agent Identity
- Cryptographic Authentication
- Proof-of-Possession
- Parameter-Level Policies
- Real-Time Revocation
- Policy-Based Access Control
- Secure RAN & Core Operations
- Agent-to-Agent Trust
- AI-Native Network Automation



Automation from RAN to Cloud

End-to-end orchestration for open, disaggregated networks

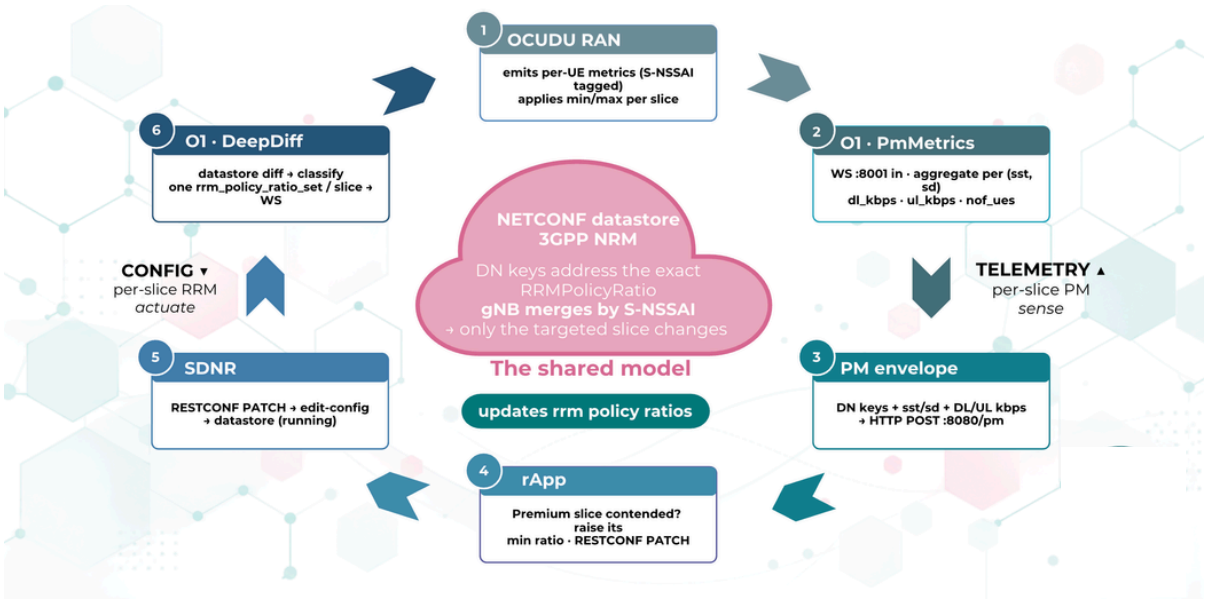
Open networks become difficult to operate if every component has to be configured independently.
Automation is therefore a core part of Open6Ge.
Through SMO, RIC and **OTAF - Open Telecom Automation Framework**, the architecture supports lifecycle and policy management across RAN, Core and cloud infrastructure.

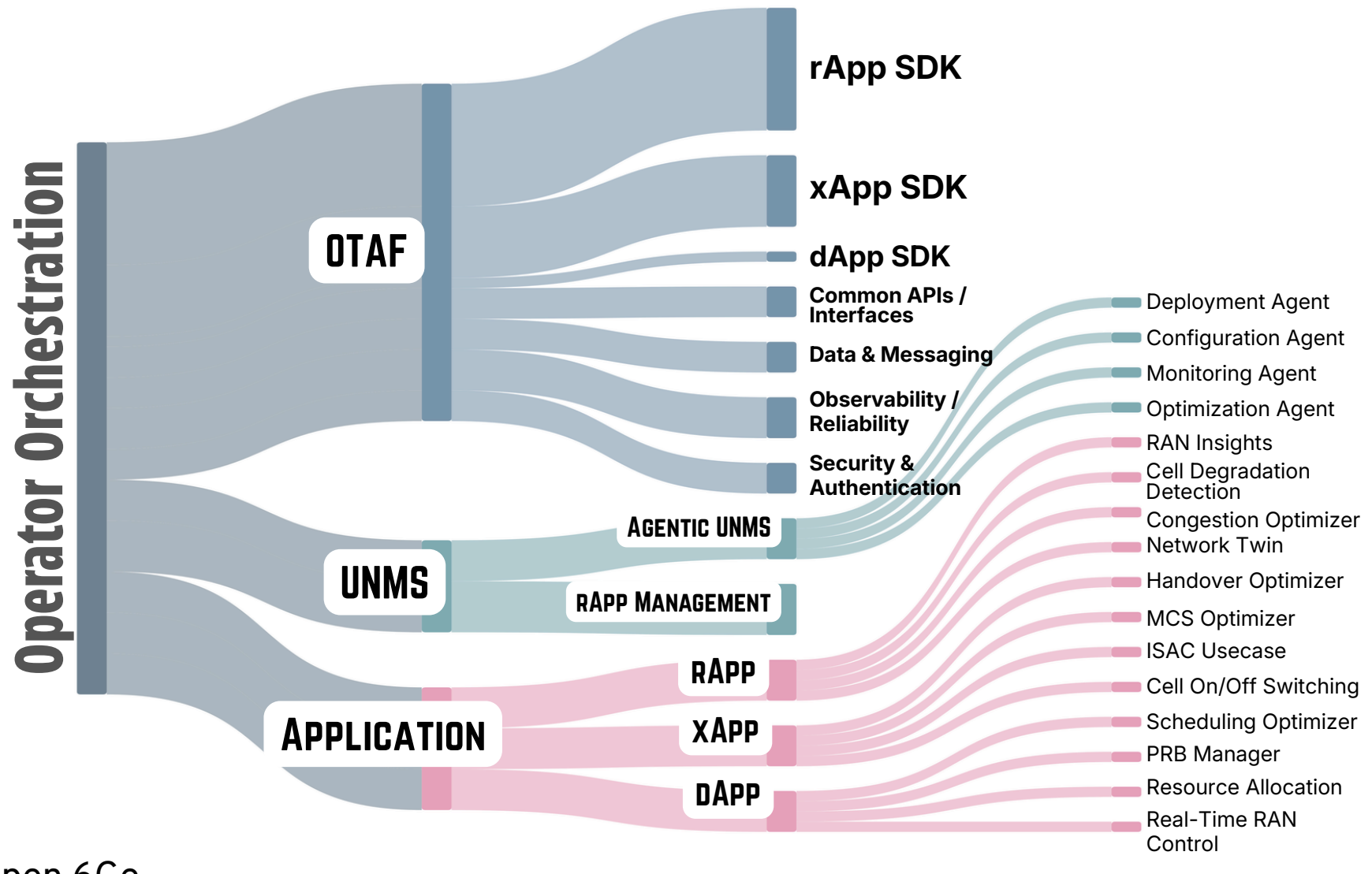
This allows network intelligence to operate across multiple timescales:
Non-Real-Time → rApps
Near-Real-Time → xApps
Real-Time / RAN-local → dApps

Together, they create a hierarchical automation model that can progressively move telecom networks toward autonomous operation.

Key Capabilities

- Network Slice Lifecycle
- SMO & RIC Integration
- AI agents
- O1 / A1 / E2 Interfaces
- Policy & Intent Management
- RAN & Core Configuration
- Closed-Loop Automation
- rApp & xApp Integration
- Network Lifecycle Management





Standards Alignment

- **TS 28.530**
- **TS 28.533**
- **TS 28.312**
- **TS 28.319**
- **TS 28.550**
- **TS 28.552**
- **TS 28.554**
- **TS 28.540–28.541**
- **TS 28.531–28.532**
- **TS 23.501 / TS 23.502**

Open RISC-V Telecom Ecosystem

Building an open hardware and software foundation for next-generation telecom

The evolution toward 6G is not only about software.
Future telecom infrastructure will also require increasingly specialized compute architectures.
Open6Ge therefore explores RISC-V as an open and customizable computing foundation for telecom.

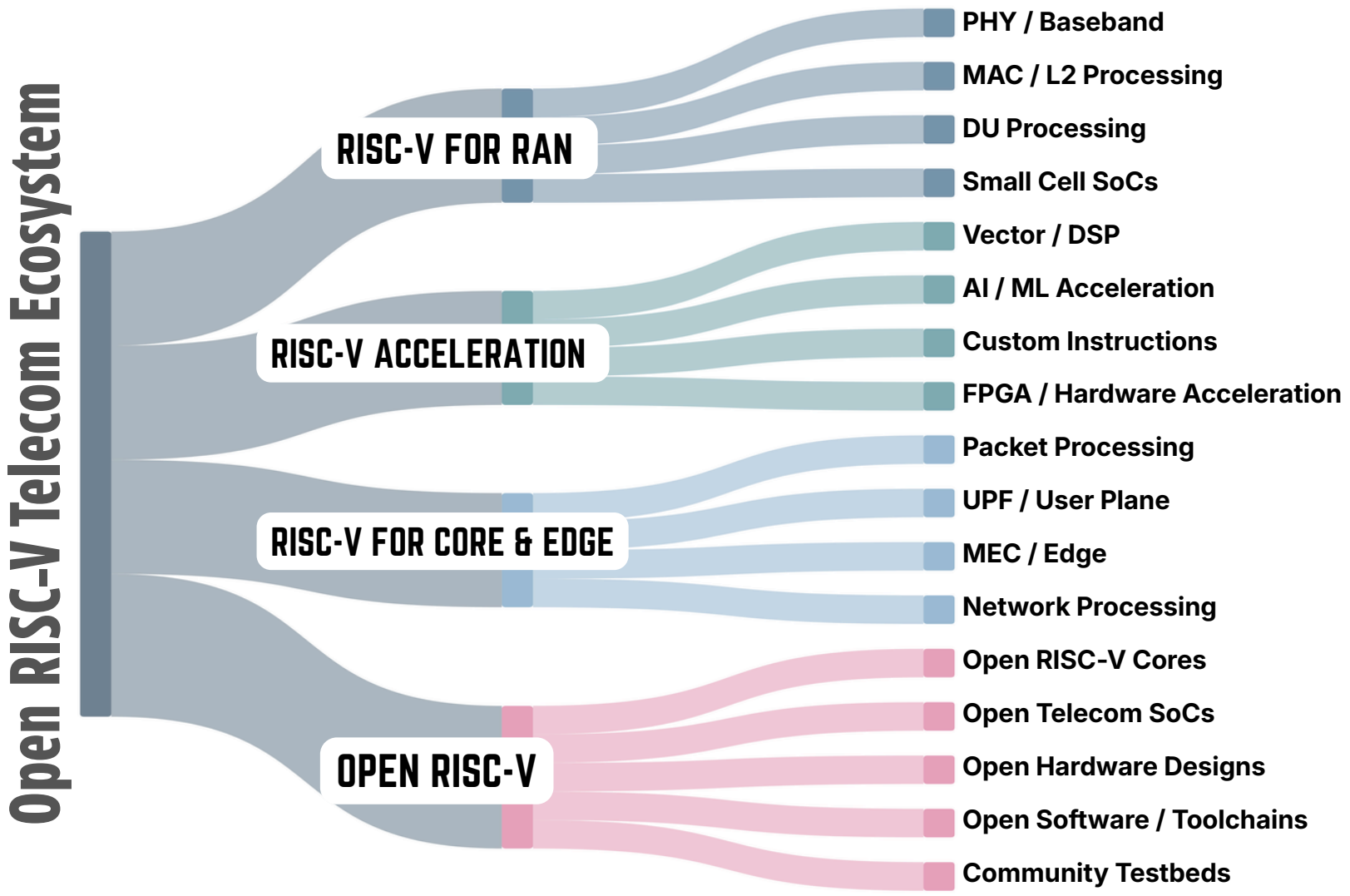
The combination of open software with open compute architectures could allow the telecom community to experiment with new accelerators without being permanently tied to proprietary processor architectures.

Key Capabilities

- PHY/baseband processing
- MAC/L2
- DU processing
- packet processing
- UPF acceleration
- edge computing
- AI/ML acceleration
- vector processing
- DSP functions
- custom instructions
- hardware/software co-design

Standards Alignment

- RISC-V Standards
- RISC-V Unprivileged ISA
- RISC-V Privileged ISA
- RISC-V Profiles / RVA22
- RISC-V Vector Extension (RVV)
- RISC-V Cryptography Extensions
- RISC-V Vector Cryptography
- RISC-V Hypervisor Extension
- RISC-V Bit-Manipulation Extension
- RISC-V SBI



CNTC - Cloud-Native Telecom Certification

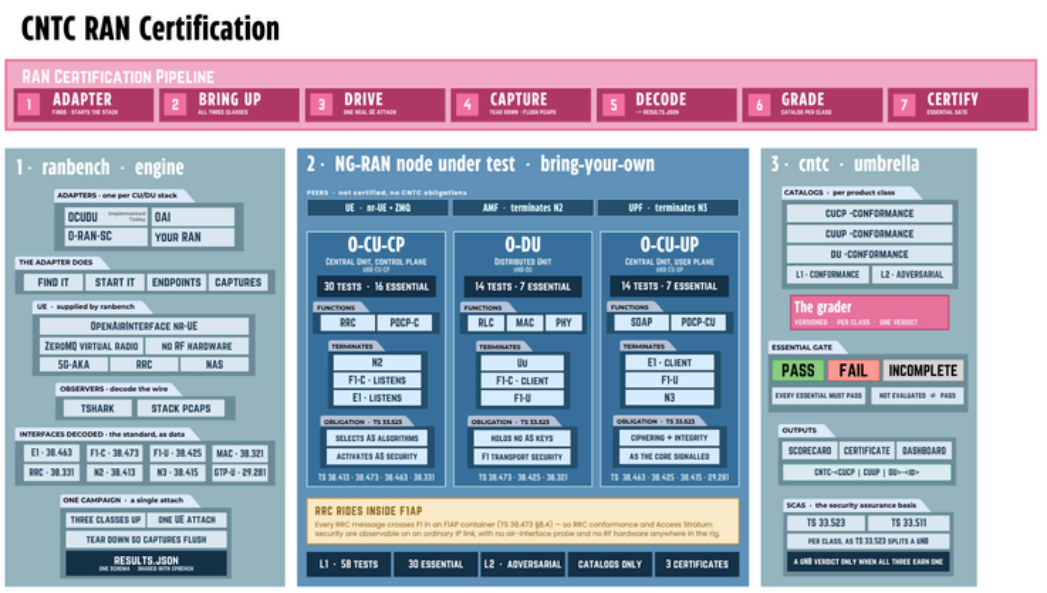
Open, reproducible certification for cloud-native telecom

As open systems become increasingly modular and multi-vendor, it becomes necessary to prove that components actually work together.

That is where CNTC - Cloud-Native Telecom Certification fits into Open6Ge.
CNTC converts telecom and cloud requirements into:

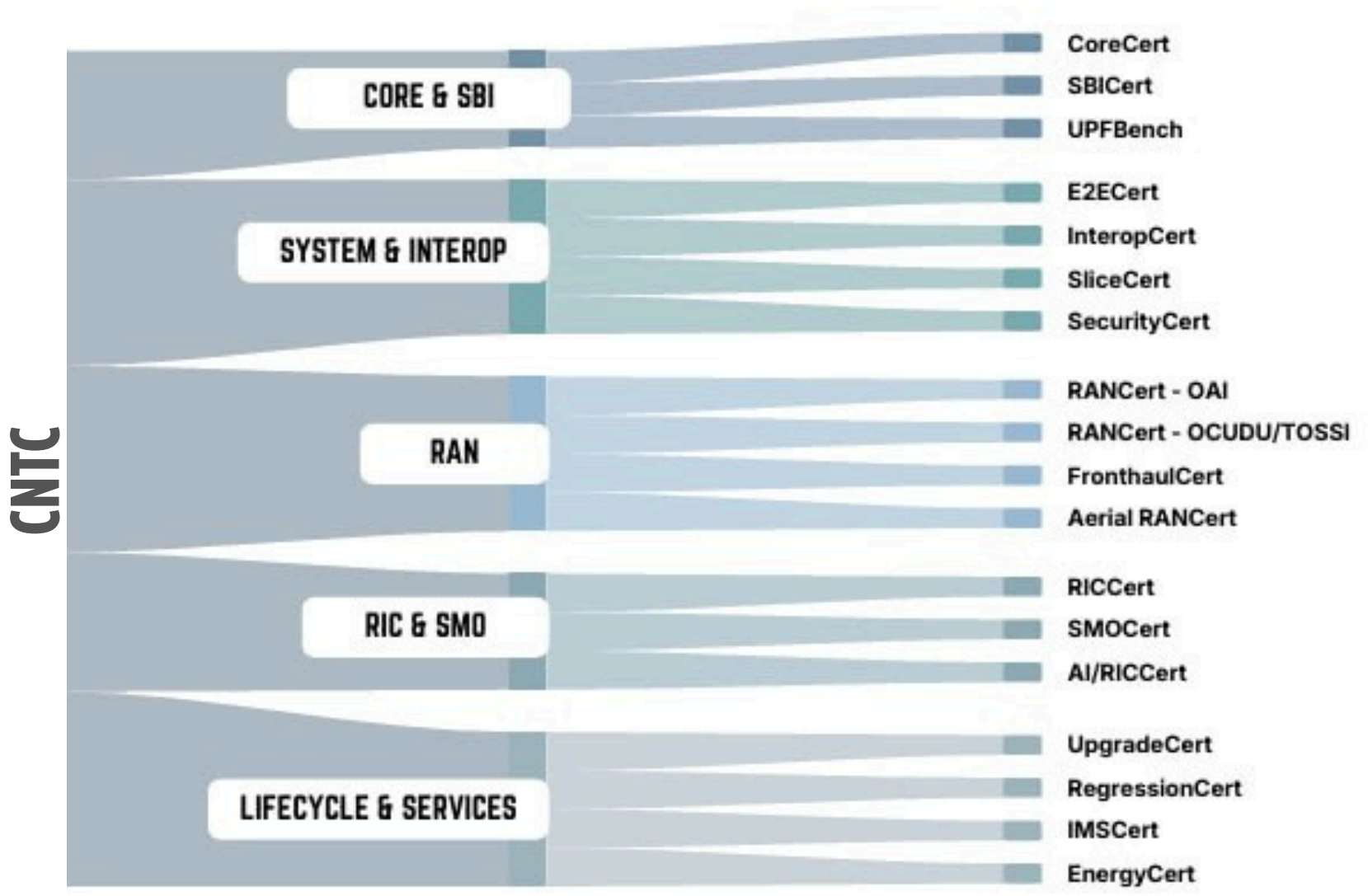
- automated tests
- repeatable execution
- measurable evidence
- graded verdicts
- auditable results

This creates an important progression: **Build → Integrate → Experiment → Validate → Certify**
Rather than simply demonstrating that a technology works once, the goal is to make results **repeatable and reproducible**.



Key Capabilities

- 3GPP Standards-Based Testing
- Automated Conformance Testing
- UPF / 5G User Plane
- 5G Core Control Plane
- RAN Certification
- SCAS Security Testing
- Automated Certificates
- Reproducible Testing
- End-to-End O-RAN Certification



Open, Validated & Community Driven

Built to Be Open

The most important principle behind Open6Ge is openness. It is not intended to become another closed telecom stack.

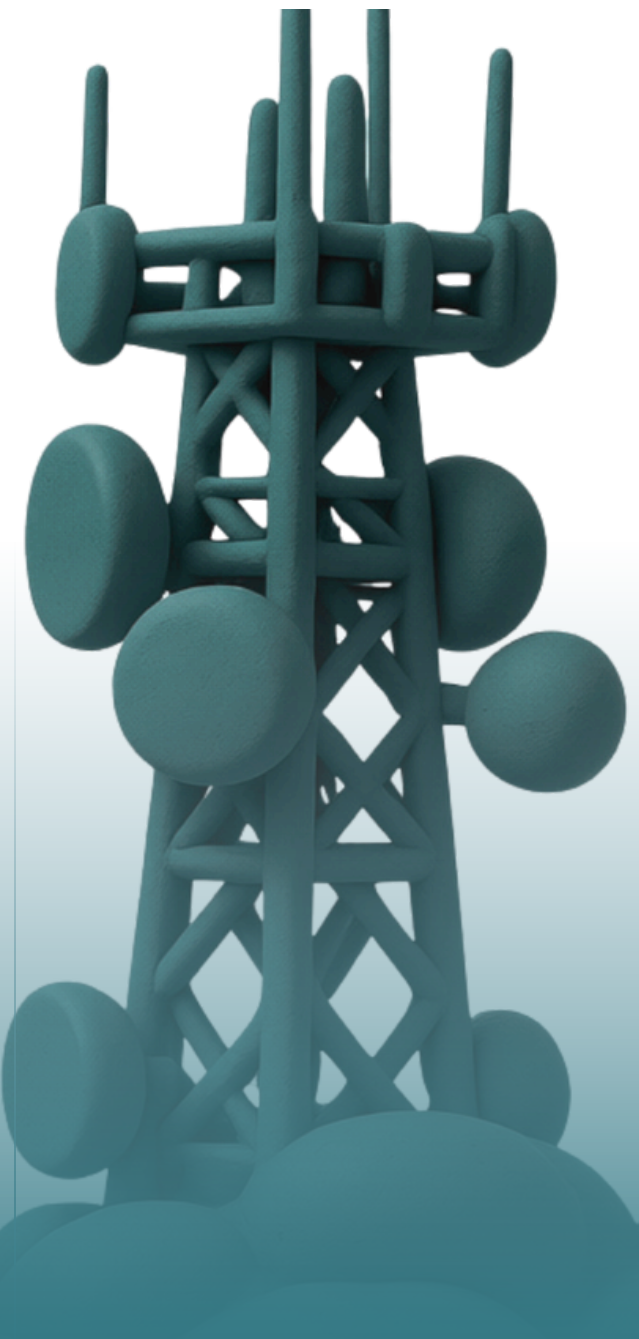
Open6G stack is built on open-source projects, open interfaces, and established industry standards. It provides a modular foundation that enables the community to integrate existing technologies, develop new capabilities, and contribute improvements back to the broader open-source ecosystem.

Objective is to create an environment where the community can:

- Reuse existing open-source projects
- Integrate technologies from different ecosystems
- Experiment with emerging 6G capabilities
- Build new components
- Validate interoperability
- Contribute improvements upstream
- Create reproducible test environments

Upstream Contribution

Encourages contributions and enhancements to be developed in alignment with upstream projects and the wider open-source community.



The Journey to 6G Has Already Started

There is still significant work ahead before 6G becomes a commercial reality.

- Standards will evolve.
- Radio technologies will evolve.
- AI architectures will evolve.
- Spectrum will evolve.
- Satellite integration will evolve.
- Security models will evolve.
- Compute platforms will evolve.

But we do not need to wait for a final 6G specification before building the environment needed to explore those technologies.

We can start with what already works today.

- Open 5G.
- 5G-Advanced.
- Open RAN.
- Cloud-native Core.
- RIC and SMO.

And progressively introduce:

- AI-RAN.
- ISAC.
- NTN.
- Post-Quantum Security.
- Digital Twins.
- Agentic AI.
- RISC-V.
- Accelerated Computing.
- Automated Certification.

That is the idea behind Open6Ge.

Open6Ge: Evolving Open 5G and 5G-Advanced Towards 6G

An open evolution platform for integrating, experimenting, accelerating, automating, and validating emerging 6G technologies on today’s open 5G and 5G-Advanced foundation.

INTEGRATE · EVOLVE · ACCELERATE · AUTOMATE · VALIDATE
The journey to 6G should be open, evolutionary and reproducible.

tossi.org/open6ge