

OPEN RAN – NETWORK PERFORMANCE IN THE LAB AND IN THE FIELD



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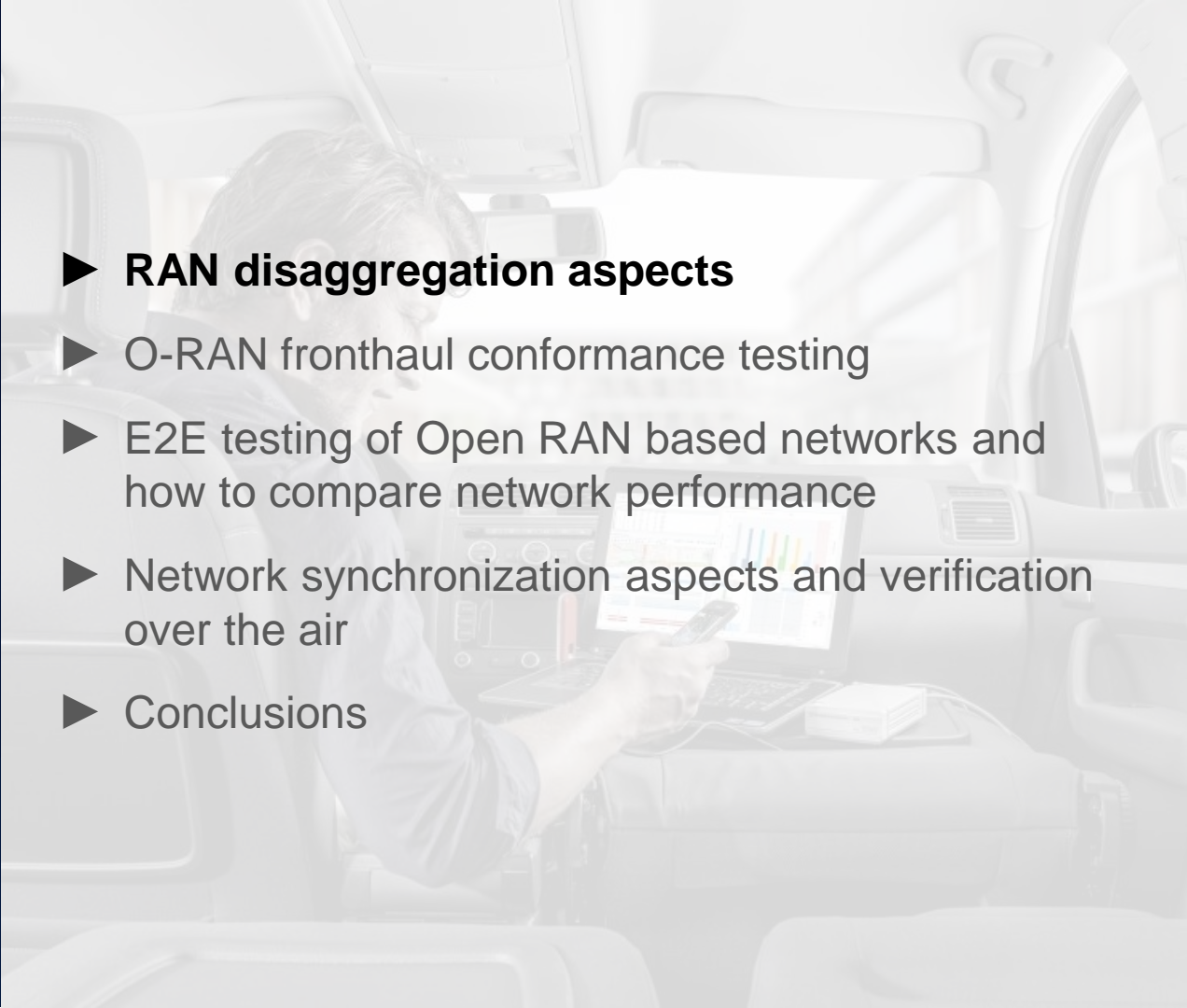
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Make ideas real

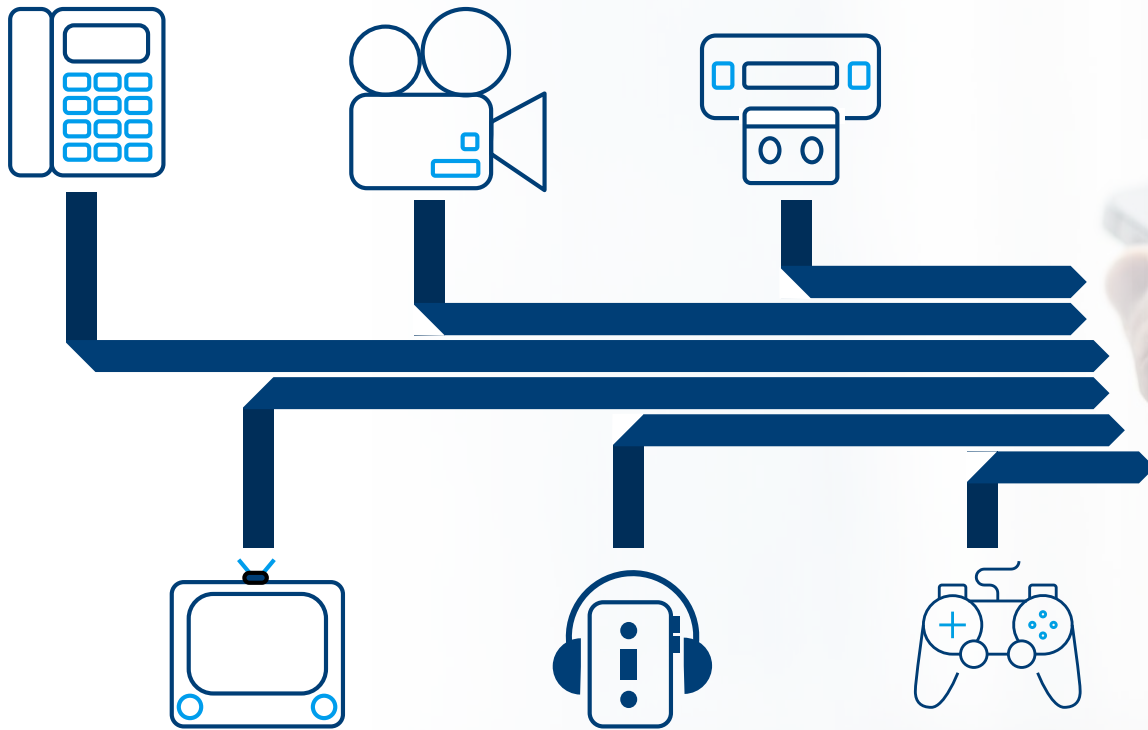


AGENDA

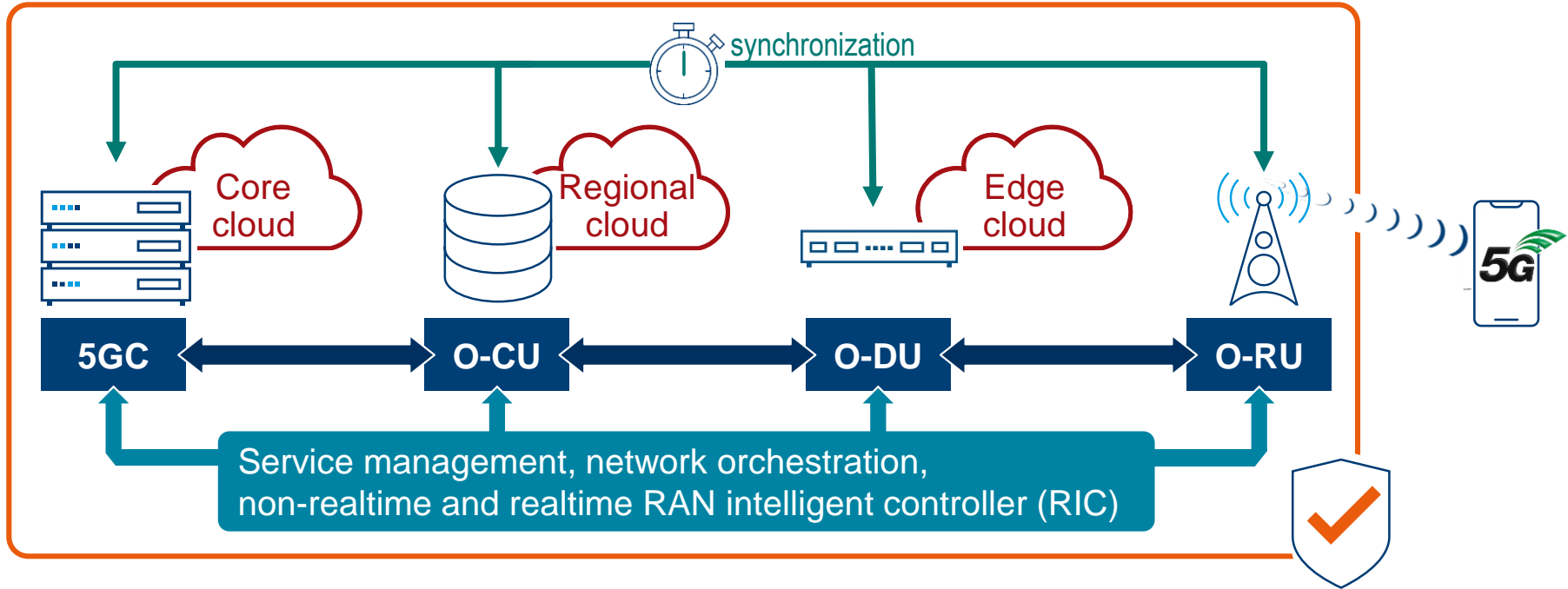
- ▶ **RAN disaggregation aspects**
 - ▶ O-RAN fronthaul conformance testing
 - ▶ E2E testing of Open RAN based networks and how to compare network performance
 - ▶ Network synchronization aspects and verification over the air
 - ▶ Conclusions
- 
- A person is seated in the driver's seat of a car, working on a laptop. The laptop screen displays a bar chart with multiple colored bars. The person is also holding a smartphone in their left hand. The car's interior, including the dashboard and seats, is visible in the background. The image is overlaid with a semi-transparent white layer to make the text legible.

OPEN RAN – MOTIVATION: PLATFORM EVOLUTION

From a single purpose device to a general purpose hardware



OPEN RAN: HIGH LEVEL ARCHITECTURE



Open RAN is a cooperation between **radio technologies**, transport network, **cloud data storage**, network management and RIC control, time synchronization and **security**

OPEN RAN TERMINOLOGY (SOURCE ERICSSON)

Open RAN

Industry term for open radio access network architecture.

This includes RAN with open interoperable interfaces, RAN virtualization, Big Data and AI-enabled RAN.

O-RAN

Refers to [the O-RAN Alliance](#), creates standards covering three different areas: RAN disaggregation, RAN automation and RAN virtualization. **The O-RAN specifications complement the 3GPP specifications** by defining interface profiles, additional new open interfaces and new nodes.

OpenRAN

Refers to initiatives driven by TIP's [OpenRAN Project Group](#).

vRAN

('v' stands for virtual) denotes the development of 5G RAN as it becomes software-defined and programmable. Operators deploying Open RAN can choose between 3GPP-based vRAN or O-RAN architectures.

Cloud RAN

Is a virtualized RAN that is designed to be [cloud native](#), built on a future-proof architecture and incorporating key elements such as microservices, [CI/CD](#) (continuous integration and deployment) and containerization.

MEC

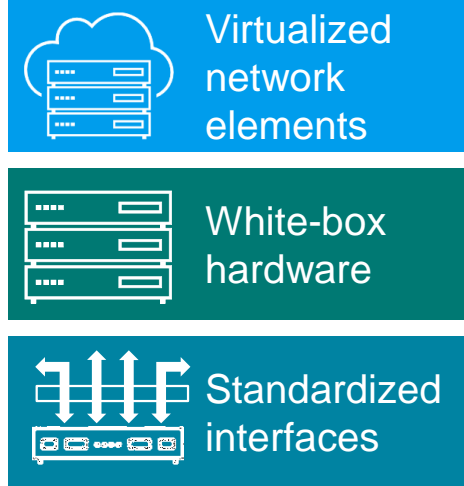
Mobile Edge Computing, MEC, or Multi-Access Edge Computing, can provide execution resources (compute and storage) for applications with networking closer to the end users

O-RAN ALLIANCE: Reshaping the industry to boost innovations and openness

Leading global mobile operators drive the O-RAN initiative in order to:

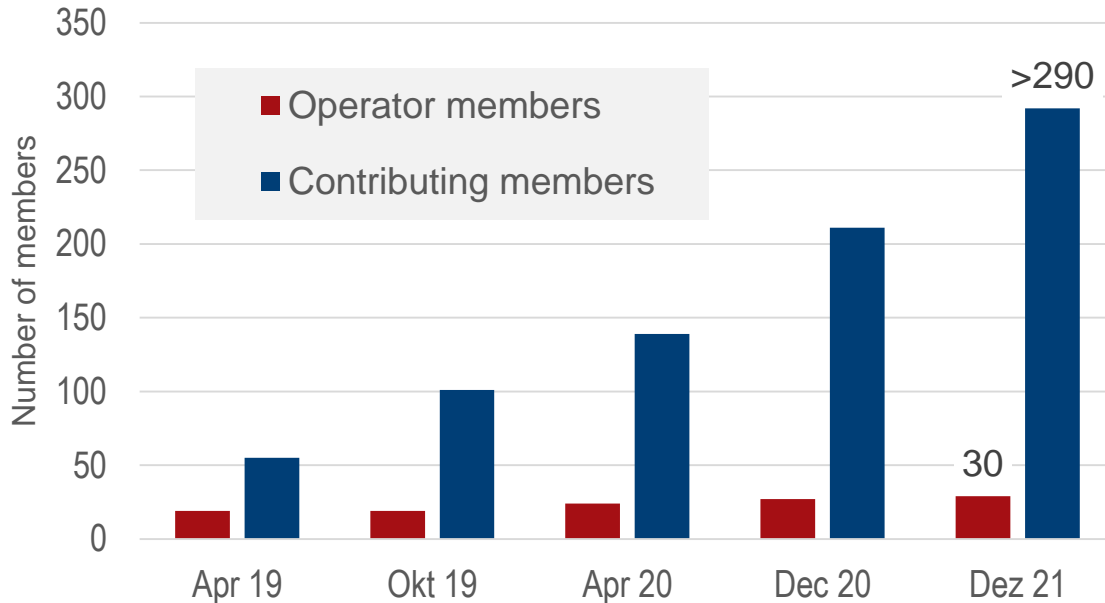
- Avoid vendor lock-in
- Reduce cost
- Boost innovation
- Enable new 5G business models

Open RAN Alliance mission is to re-shape the RAN industry towards more intelligent, open, virtualized and fully interoperable mobile networks.



O-RAN COMMUNITY EVOLUTION

Fast increasing O-RAN community, including 30 leading MNOs and > 290 contributing members from the industry ecosystem 3.5 years after foundation.



Founded in Feb. 2018 by by leading operators including AT&T, T-Mobile, Orange, China Mobile, NTT Docomo



Liaison agreement with TIP in Feb. 2020



Cooperation agreement with NGMN in Dec. 2020

[Sources:
<https://www.o-ran.org/membership>
<https://www.thefastmode.com/technology-solutions/16523-o-ran-alliance-tip-team-up-to-develop-interoperable-open-ran-solutions>
<https://www.ngmn.org/ngmn-news/press-release/ngmn-and-o-ran-alliance-sign-co-operation-agreement.html>

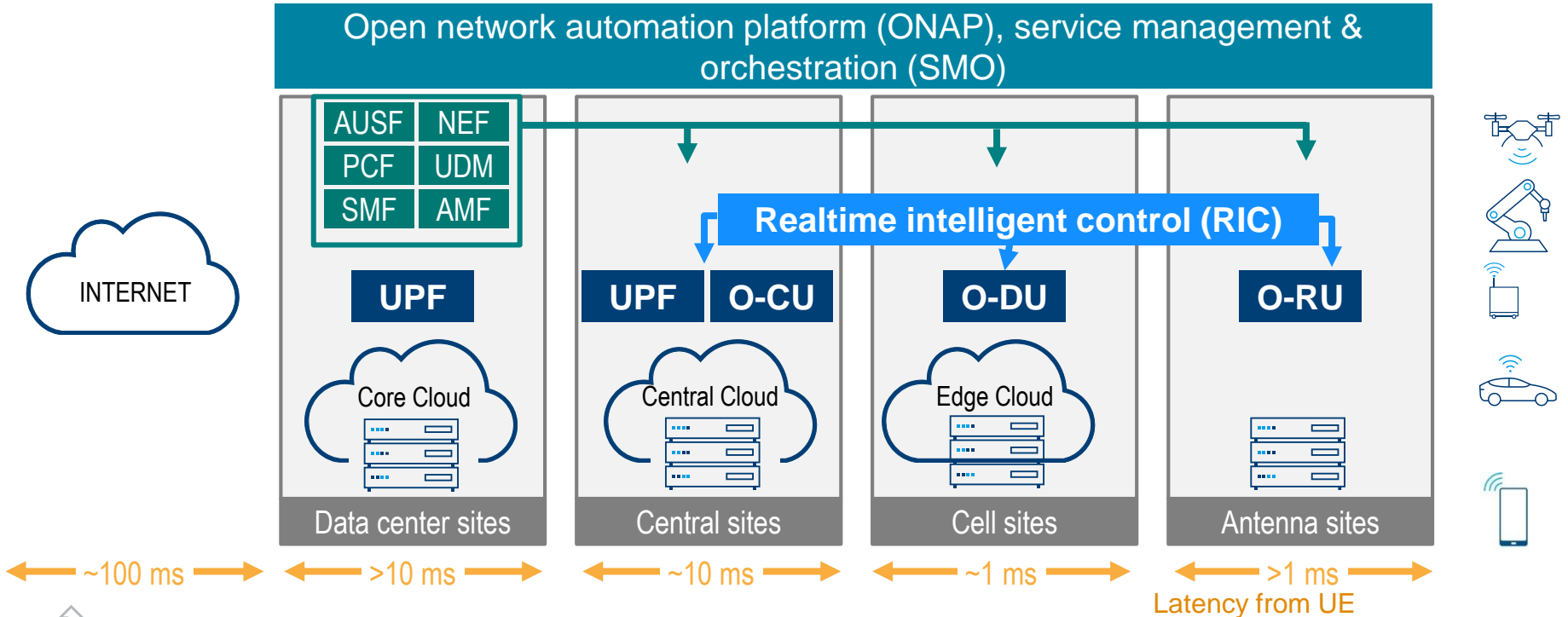


OPEN RAN – THE HOLISTIC PICTURE

Making the RAN flexible, smart and agile.

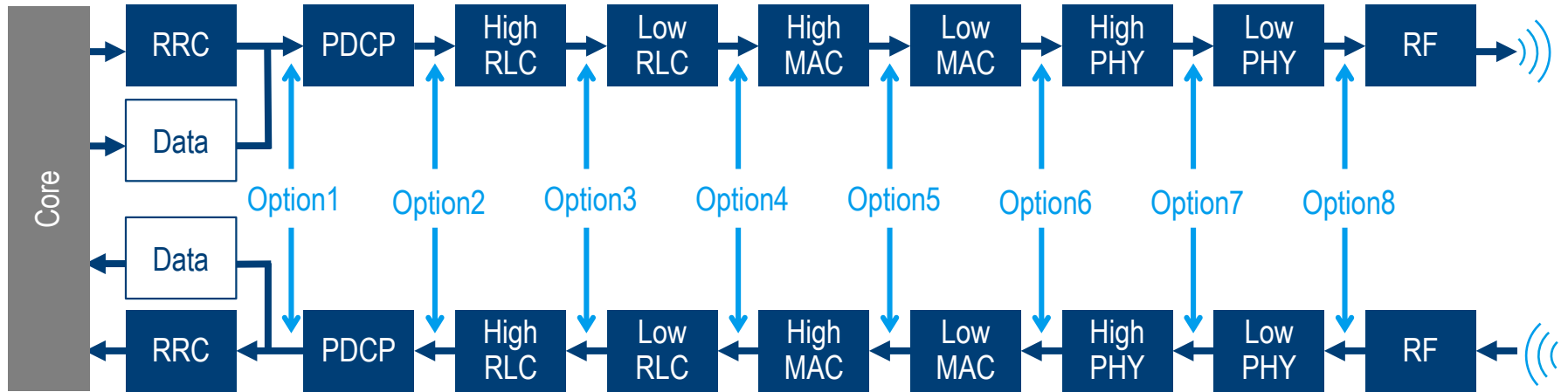
=> There is more than one interface

=> There is a dependency between interfaces and network functions



3GPP FUNCTIONAL SPLIT

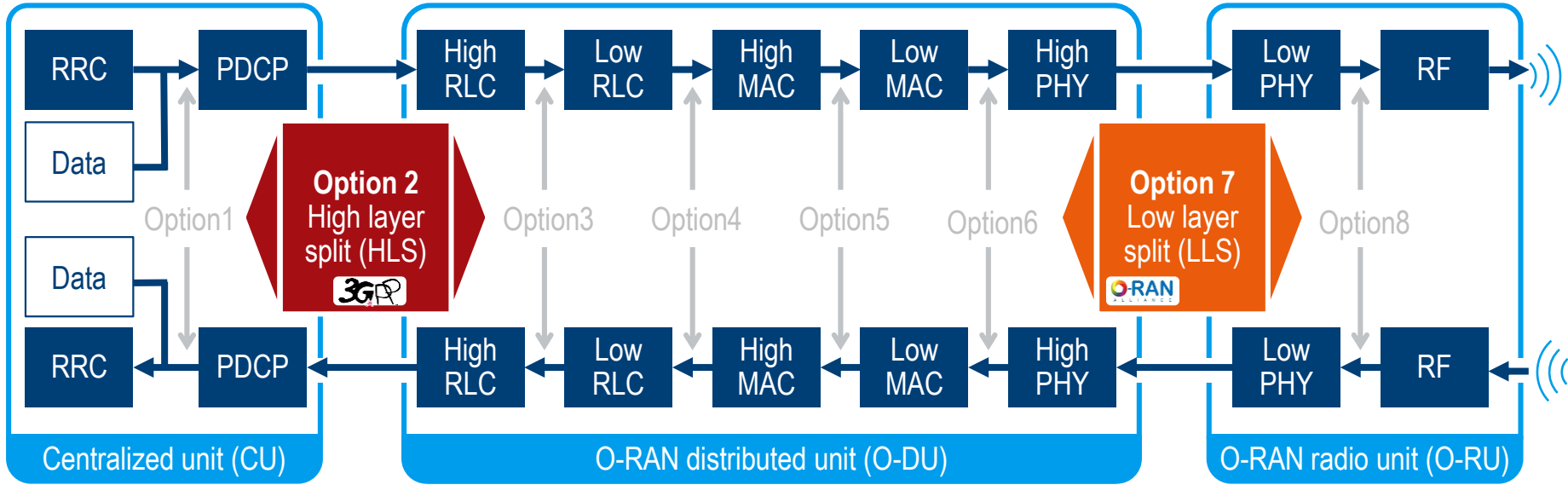
TR 38.801 describes several proposals of functional split between CU and DU



Real-time and latency requirements + higher data rates

Least demanding transport network data rates + relaxed timing

O-RAN INITIATIVE HLS AND LLS COMBINATION

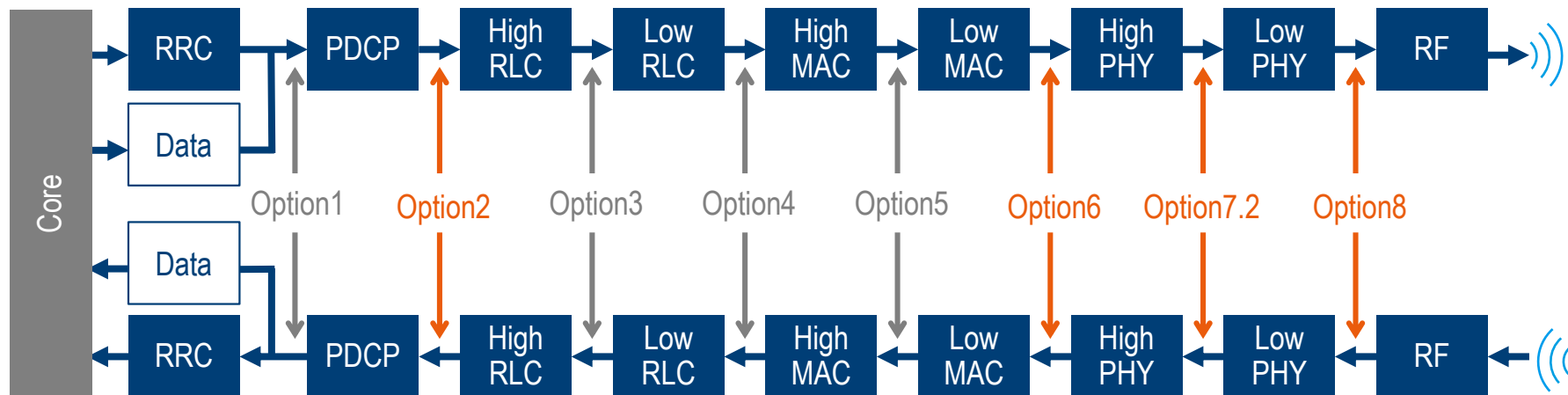


Double split option to bridge between centralization, data rate requirements and multi-radio coordination

☺ RU complexity low + disaggregation, open but standardized interfaces => multi-vendors

☹ Requires additional standardization as complement to 3GPP + interoperability

RAN DISAGGREGATION – VARIOUS SPLIT OPTIONS



S-CU

F1

S-DU

nFAP1

S-RU

CPRI

CU

F1

REC

CPRI

RE



O-CU

F1

O-DU

OFH

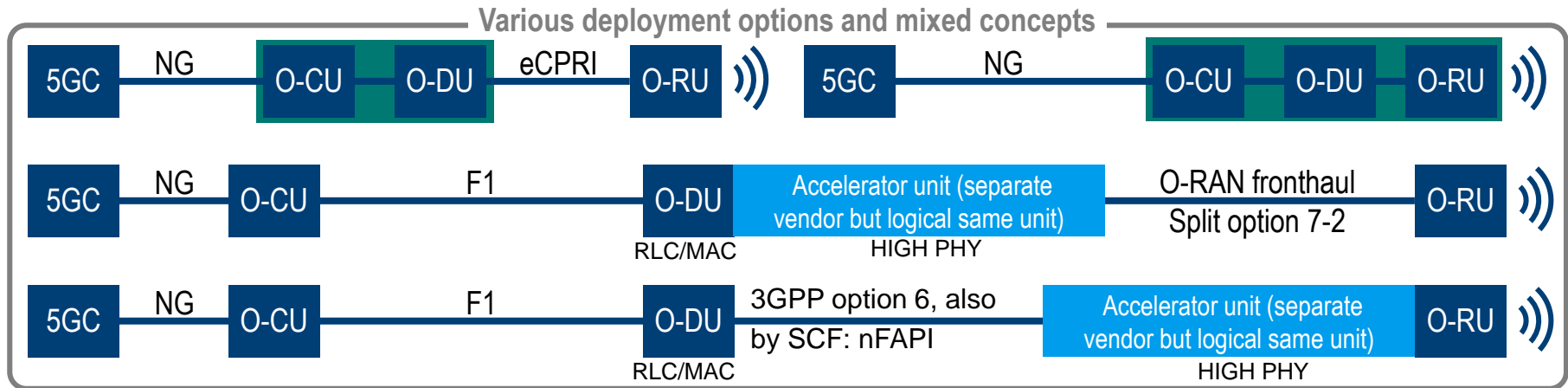
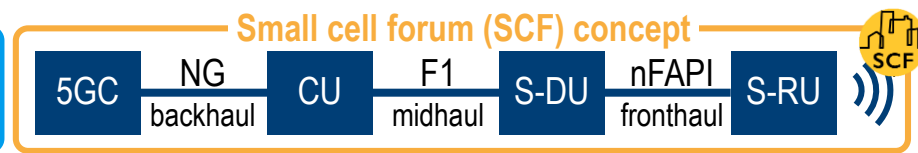
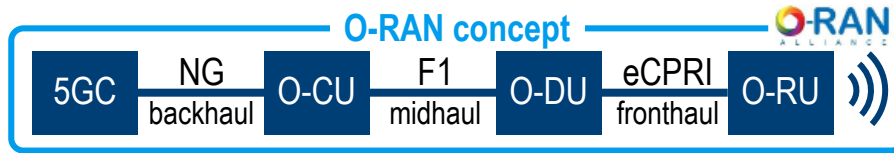
O-RU



CPRI



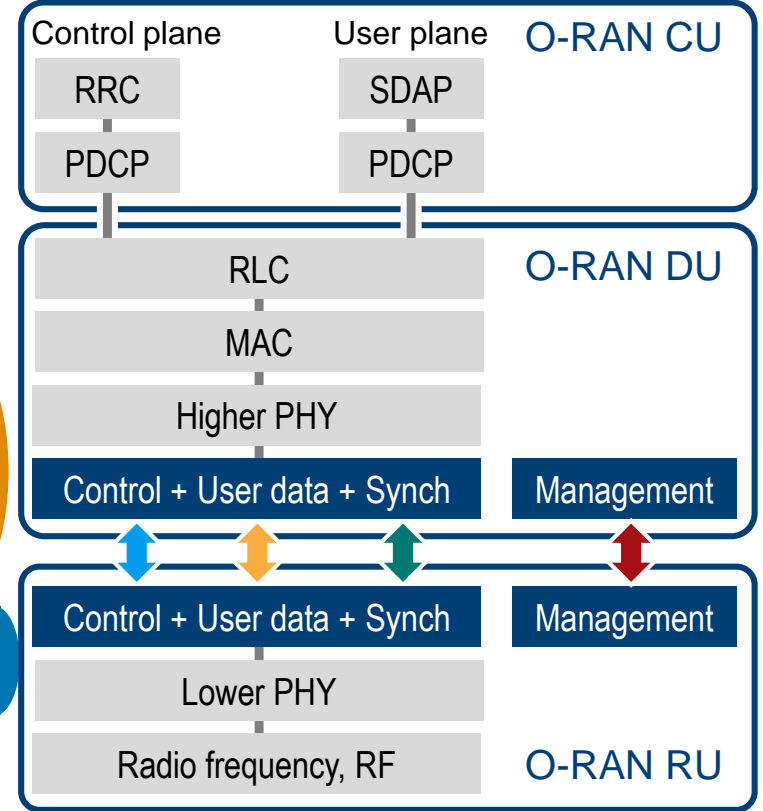
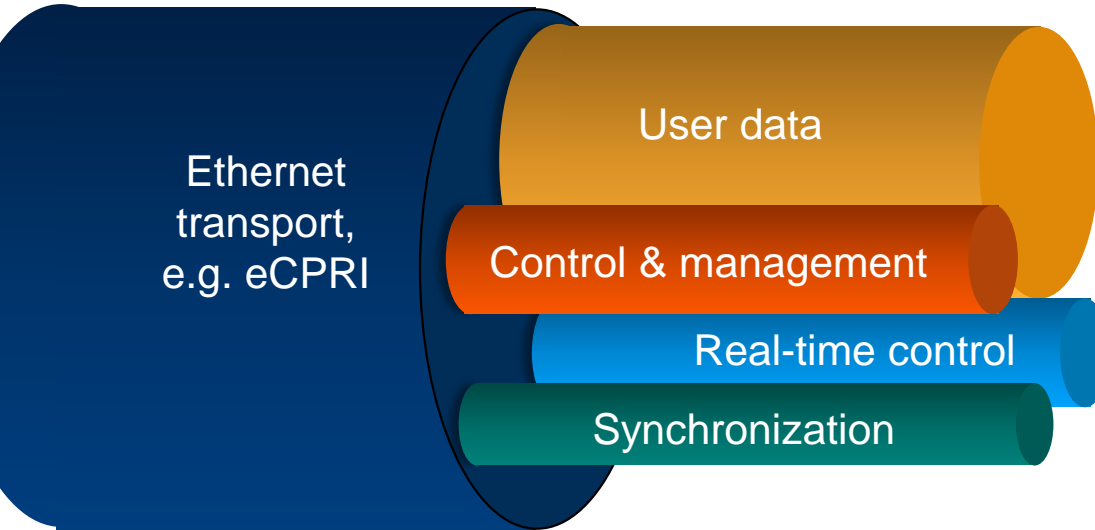
REAL WORLD: VARIOUS CU, DU AND RU COMBINATIONS



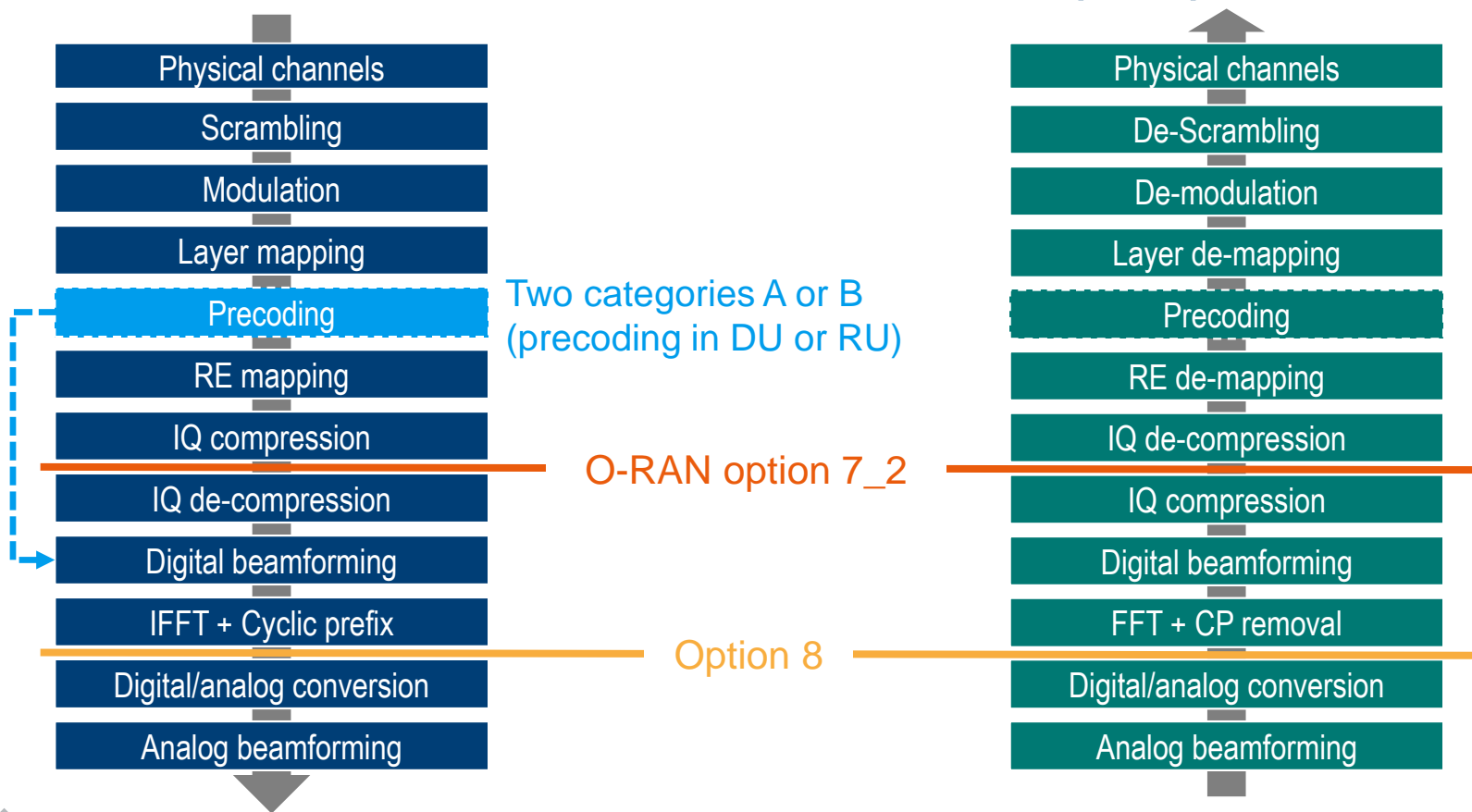
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- ▶ RAN disaggregation aspects
- ▶ **O-RAN fronthaul conformance testing**
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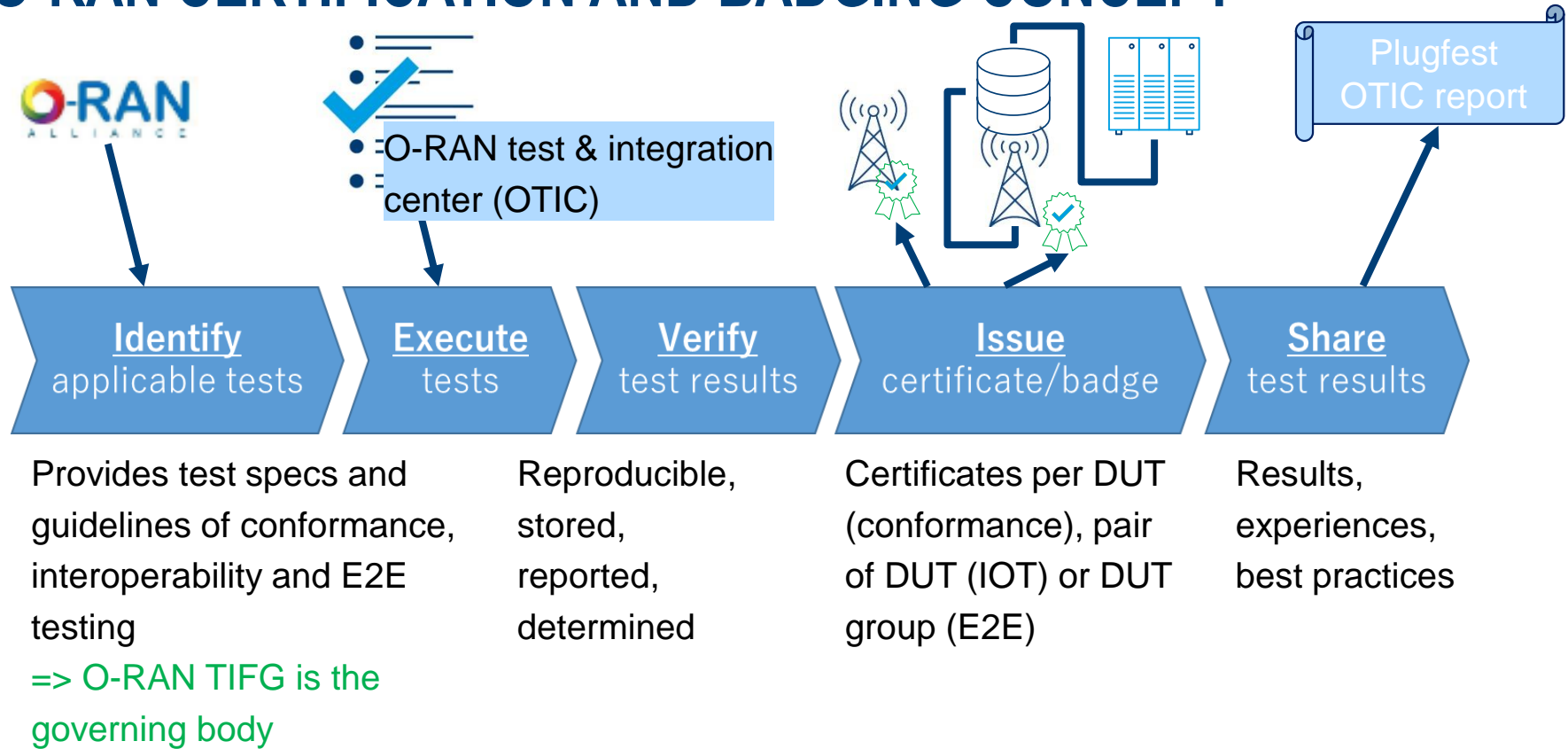
O-RAN FRONTHAUL INTERFACE



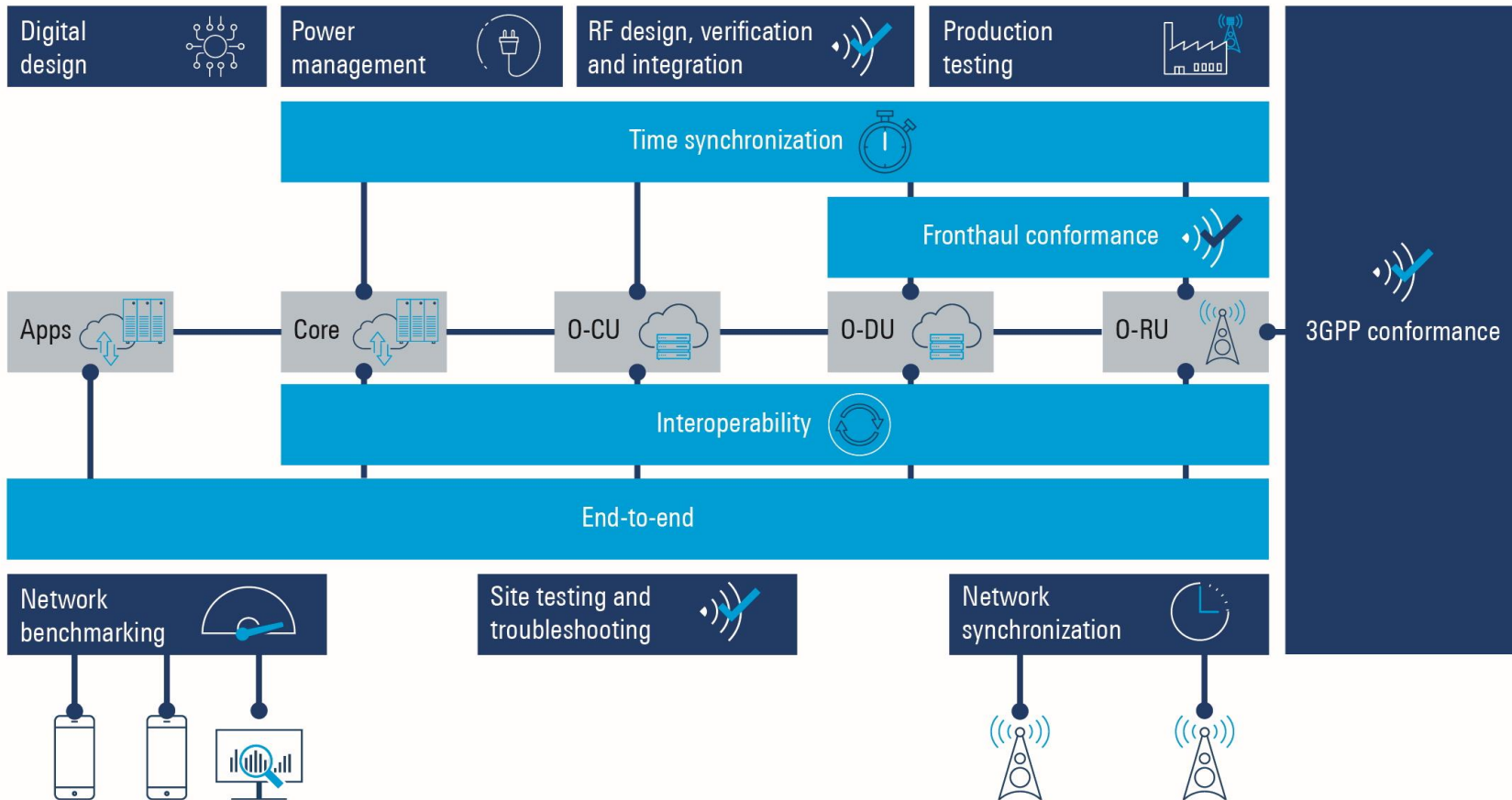
O-RAN INITIATIVE: LOWER LAYER SPLIT (LLS) DETAILS



O-RAN CERTIFICATION AND BADGING CONCEPT



PROFIT FROM R&S COMPETENCE FOR O-RAN TESTING



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Open RAN – network performance in the lab and in the field

O-RAN TESTING ASPECTS - OVERVIEW



NG interface



O-CU



F1 interface



O-DU



O-RAN fronthaul



O-RU



Uu interface

O-RAN FH conformance testing verifies proper behaviour of fronthaul interface

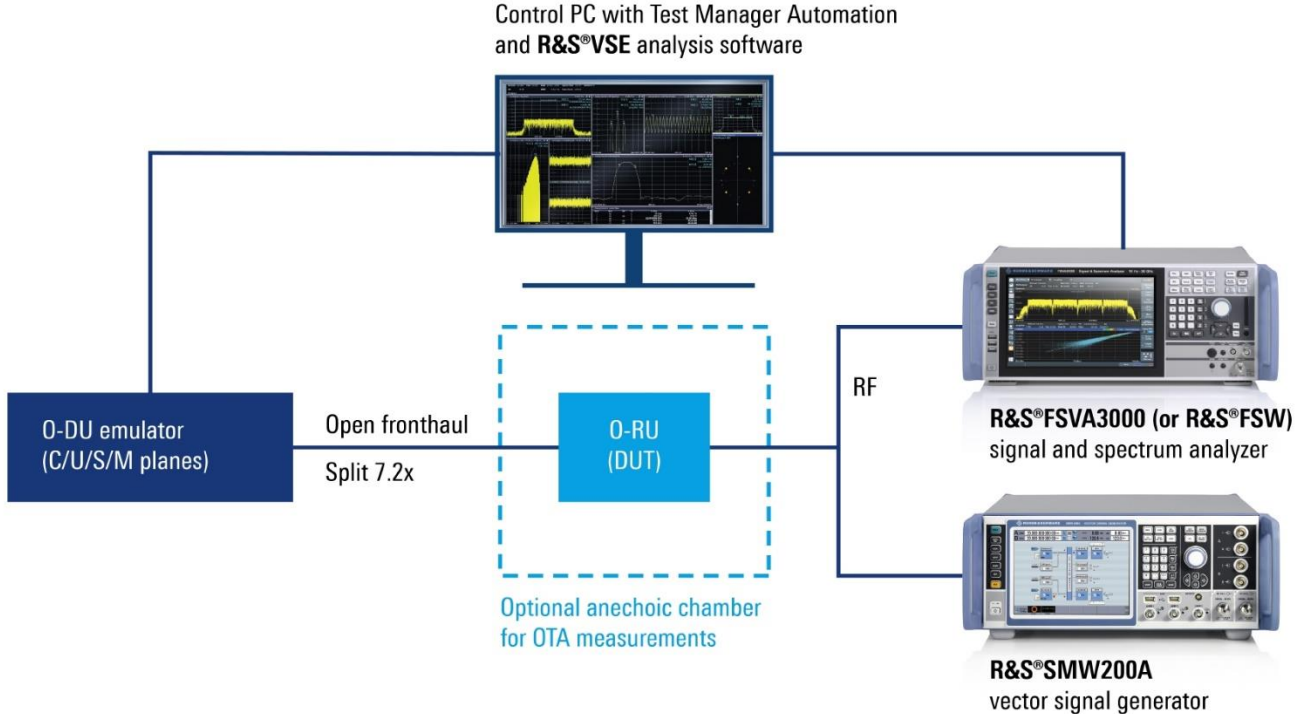
3GPP testing verifies RF aspects

O-RAN interoperability testing verifies proper interworking of two network entities, i.e. O-DU and O-RU

O-RAN E2E testing verifies KPIs of system or O-RAN subsystem



TEST AND VALIDATE YOUR O-RU



Integrated test set-up compliant to
3GPP & O-RAN Fronthaul Conformance Specifications



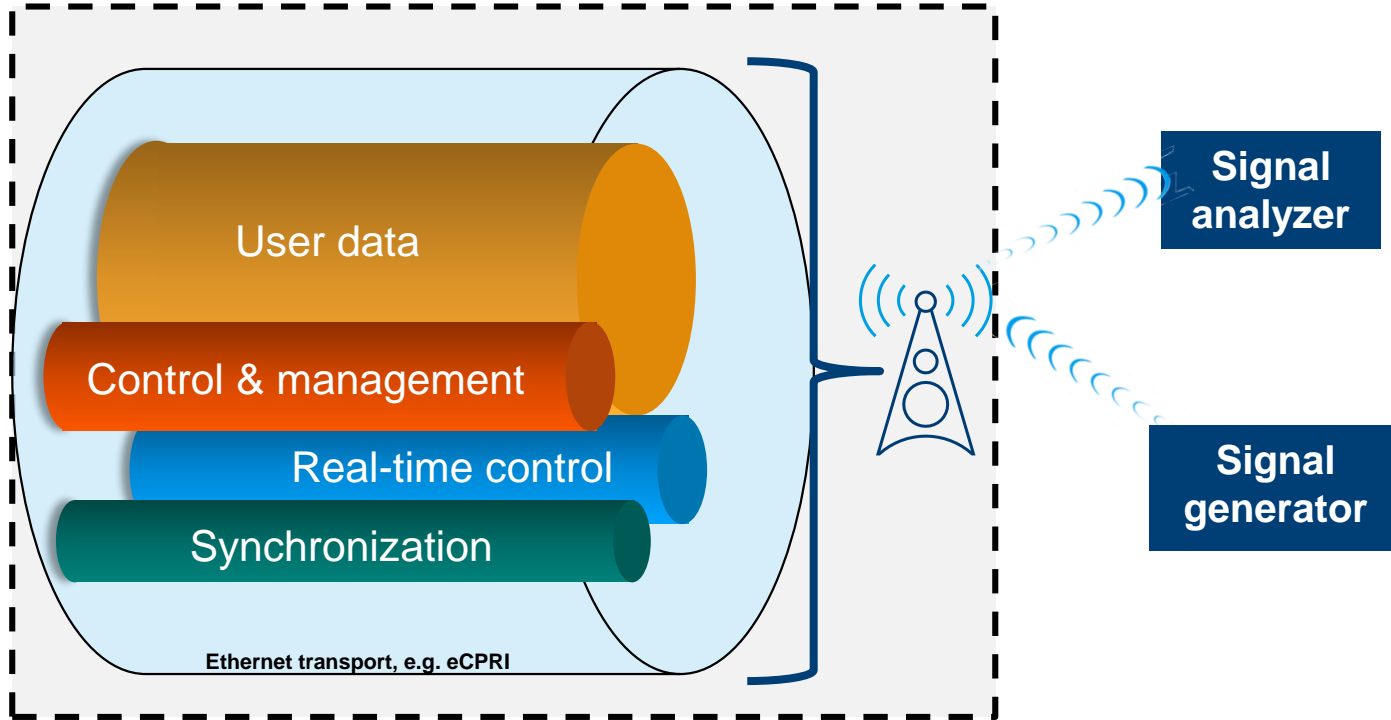
O-RAN FRONTHAUL CONFORMANCE TESTING OVERVIEW

Verify that user data on fronthaul interface is mapped properly onto RF (TX and RX)

Verify that scheduling or beamforming commands are properly executed on RF

Verify that DUT syncs properly to reference time

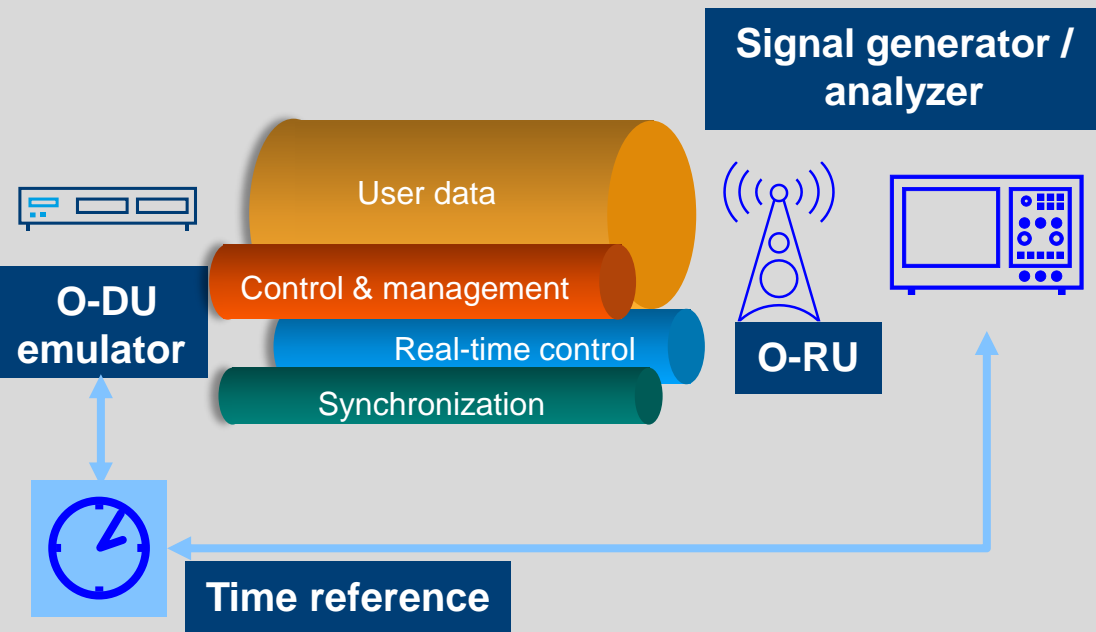
Verify that DUT connects properly to 5G system and can be managed properly



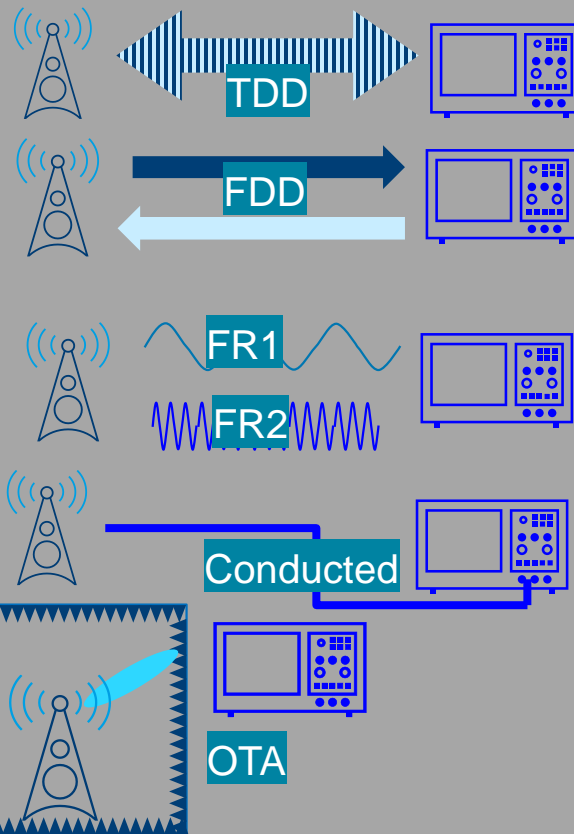
O-RU as DUT

O-RAN FRONTHAUL INTERFACE – TRANSPORT PROTOCOLS

O-RAN fronthaul conformance testing: We use the **air interface** to verify that the **user plane** data is mapped according to the **real-time control plane** scheduling commands



Testcases classified into:

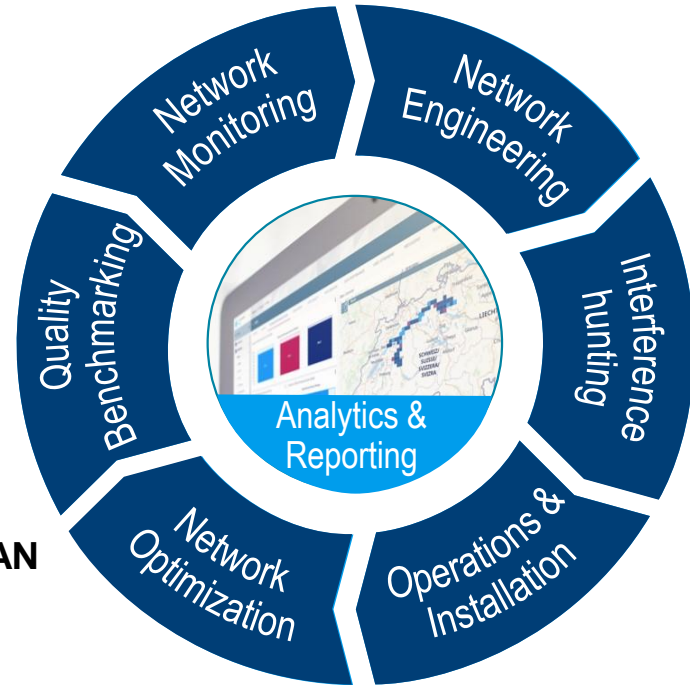


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OPEN RAN IN-FIELD TESTING STRATEGY

- ▶ **Open RAN E2E system testing for Engineering and Optimization**
 - **Engineering** in pre-commercial phase (before roll-out)
 - Lab testing and Field trials
 - **Site Testing and Performance Tuning** after deployment
 - **Optimization and troubleshooting** in operational networks
- ▶ **QoS/QoE testing**
 - **Established quality baseline verification applies to Open RAN**
 - **E2E Quality Benchmarking**
 - Compare different vendors and RAN architectures
 - **E2E Quality Monitoring**
 - 24/7 surveillance of the capacity, stability and integrity



O-RAN CHALLENGES AND IMPACT ON TESTING

Q14: For Open RAN multi-vendor deployments, what do you see as the biggest challenge?

Interoperability of different elements	42%
Achieving similar performance to single-vendor networks	20%
Implementing virtualized/cloud RAN	14%
Achieving substantial cost savings	15%
Harder to outsource network maintenance and testing so need to do more in-house	9%



- ▶ Fair evaluation of network performance in field (End-2-End) from end-user perspective
- ▶ Benchmarking the network quality of Open RAN vs. single vendor networks

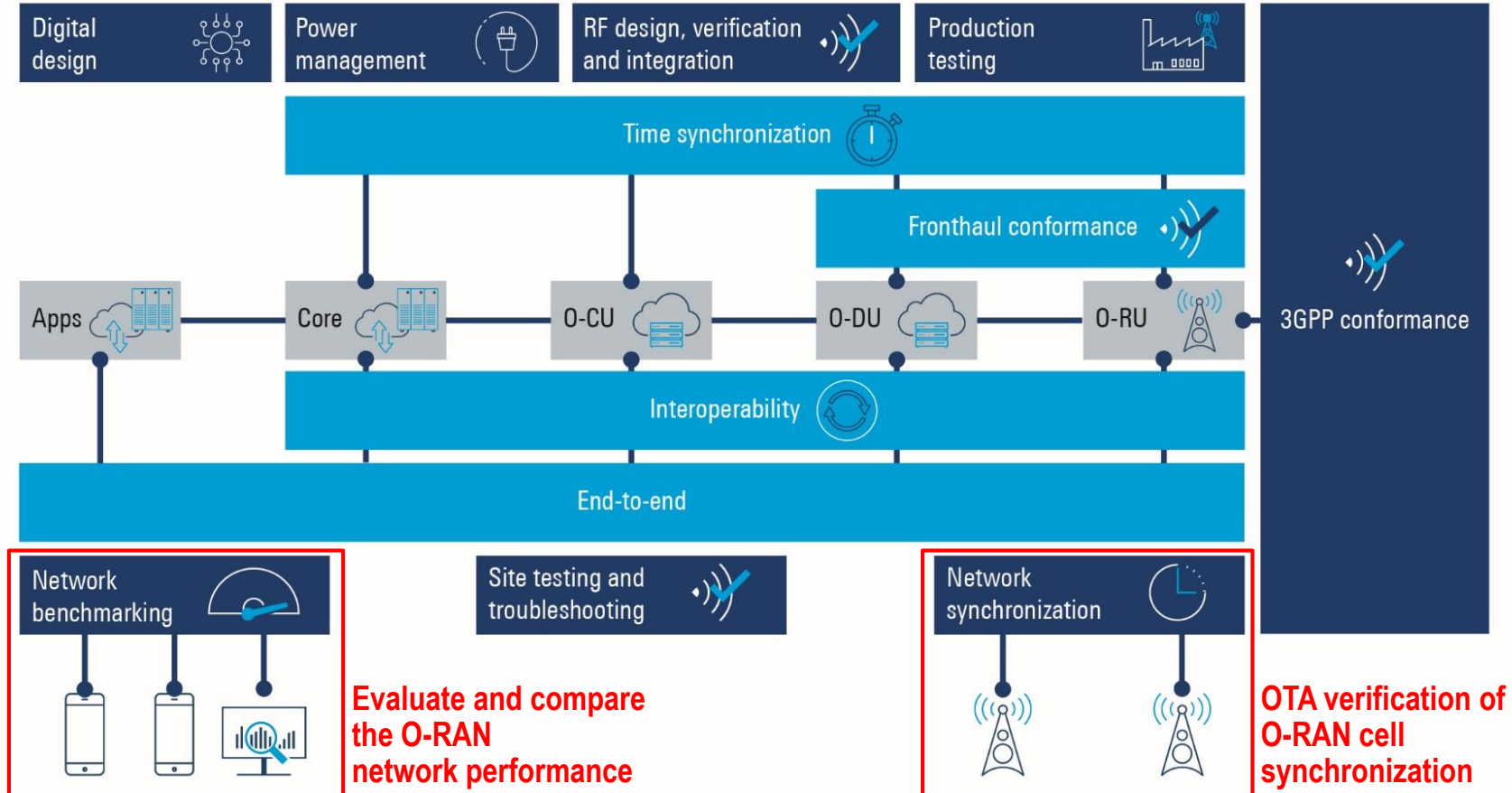
Source:



▶ Mobile Network Testing helps to overcome the Network Performance challenge



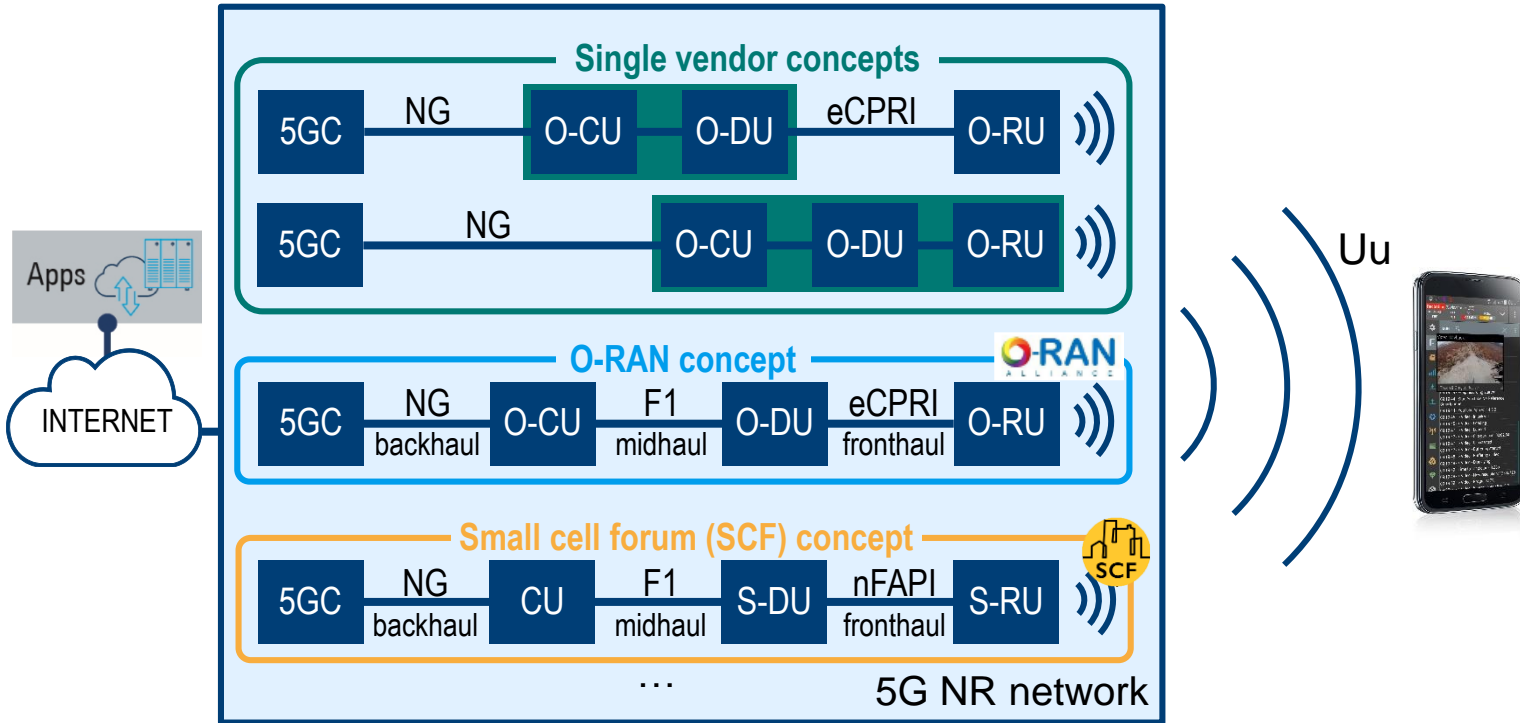
PROFIT FROM R&S COMPETENCE FOR O-RAN TESTING



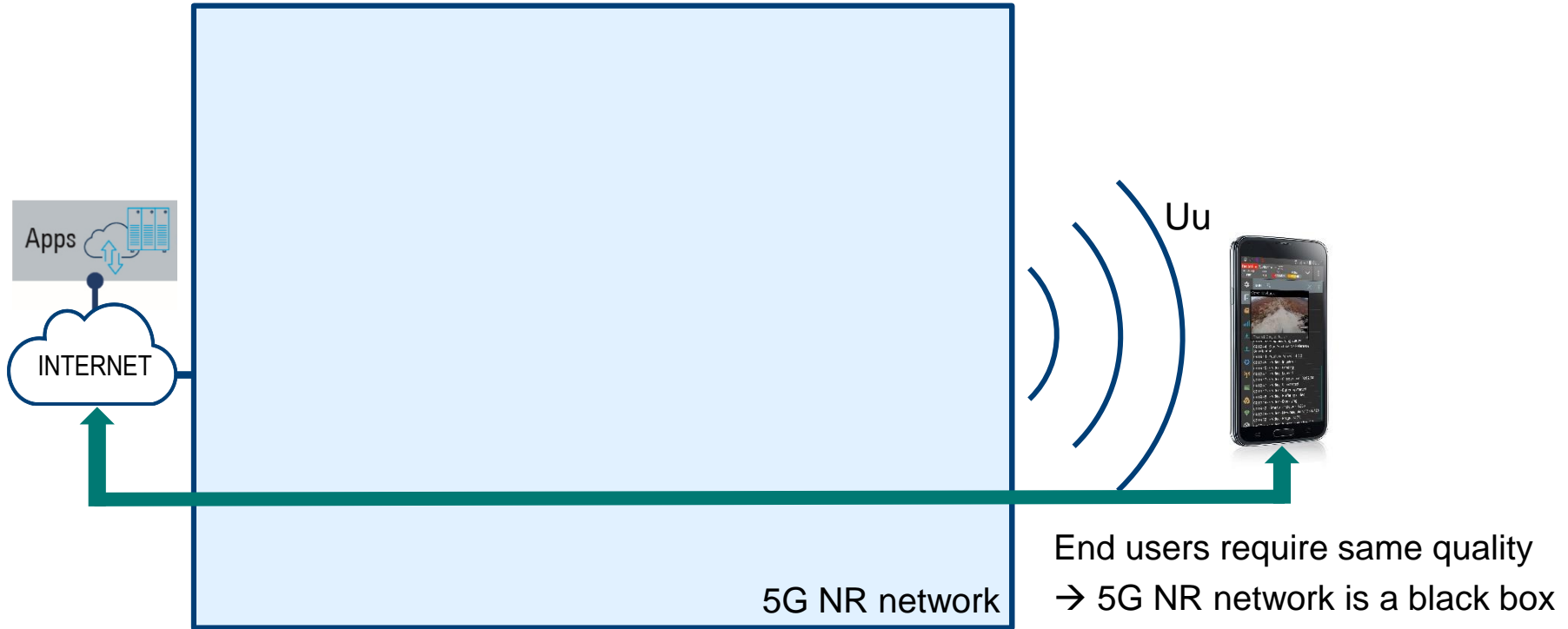
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Open RAN – network performance in the lab and in the field

EVALUATE OPEN RAN NETWORK PERFORMANCE

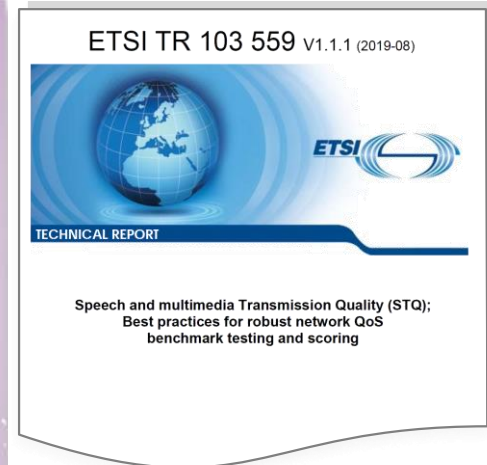
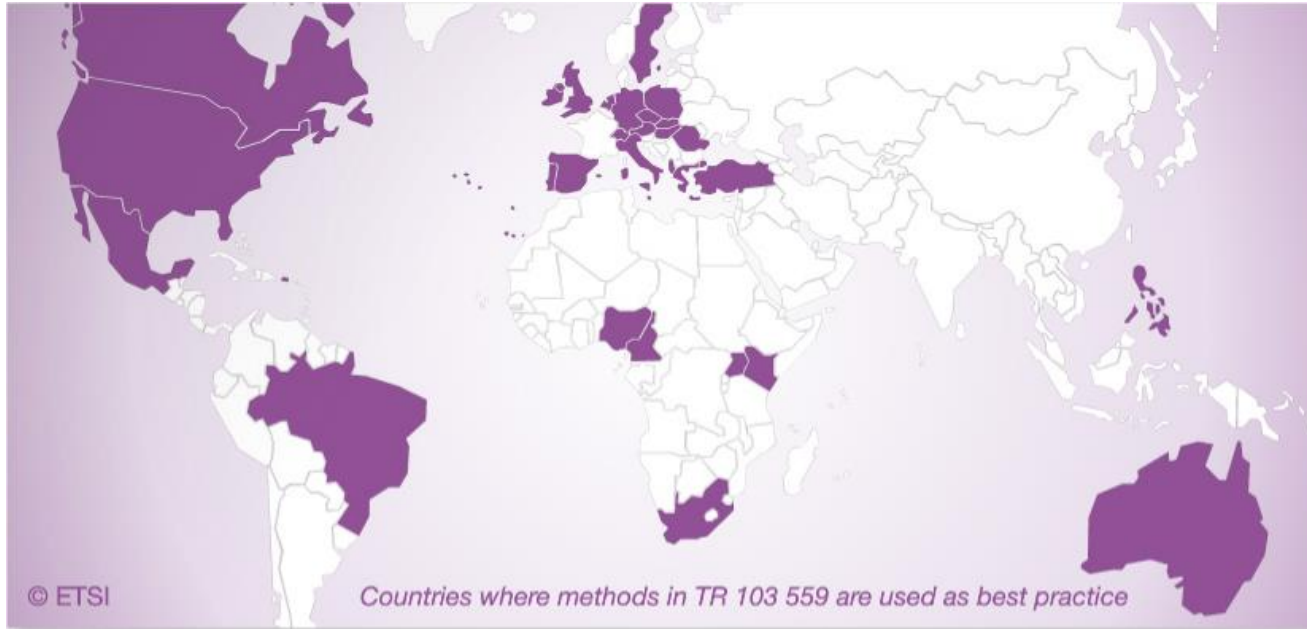


EVALUATE OPEN RAN NETWORK PERFORMANCE



► Fair and comparable end-to-end Quality of Experience testing needed (→ ETSI TR 103559)

ETSI METHODOLOGY USED ON GLOBAL SCALE

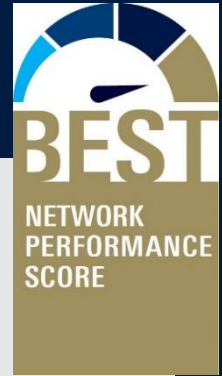


ETSI - TR in August 2019
► Harmonized method:
measure, weight, aggregate

“TR 103 559 describes its scoring method with full transparency for the benefit of implementers, network providers and regulatory authorities, and has been applied on a global scale”.

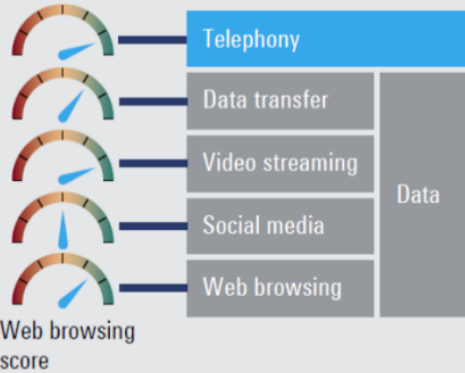
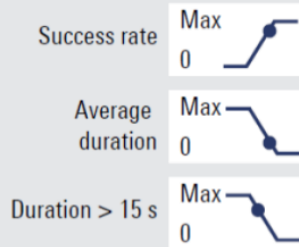
(Source: Enjoy! THE ETSI MAG, July 2021)

Network Performance Score (NPS)



Highway Test campaign

KPIs, e.g.
score for web browsing



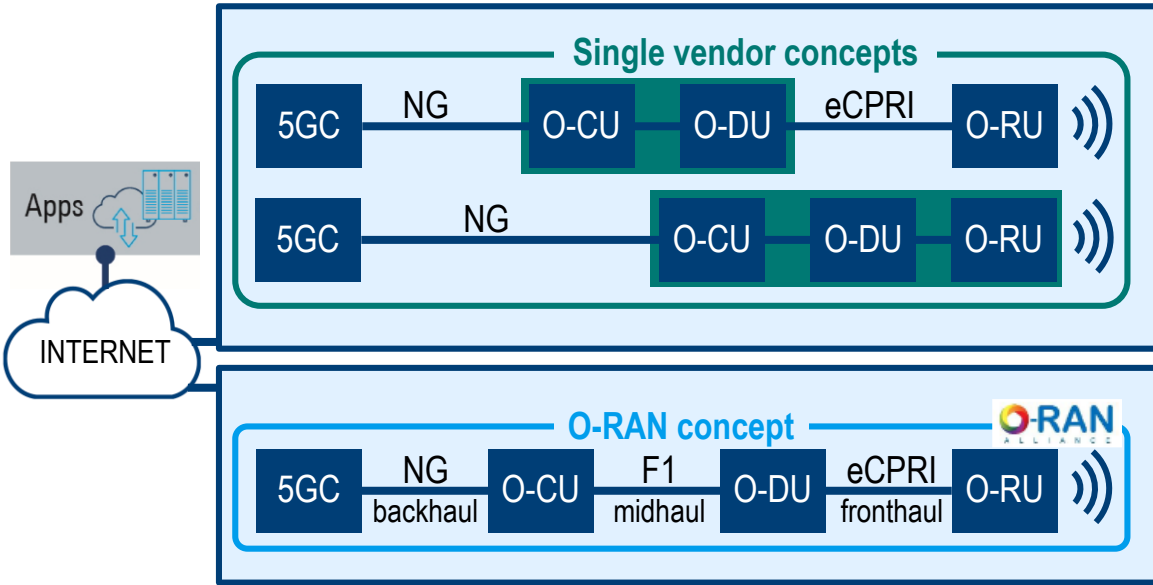
Highway score

City score

Overall network score

- ▶ Technology-agnostic and transparent
- ▶ Makes different networks/countries/regions and different RAN architectures comparable

COMPARING NETWORK PERFORMANCE OF OPEN RAN WITH SINGLE VENDOR REGIONS



NPS abc
with all available details



NPS xzy
with all available details

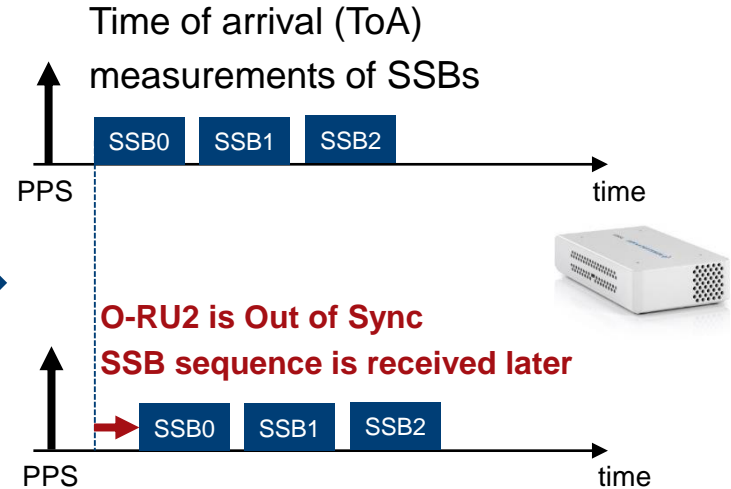
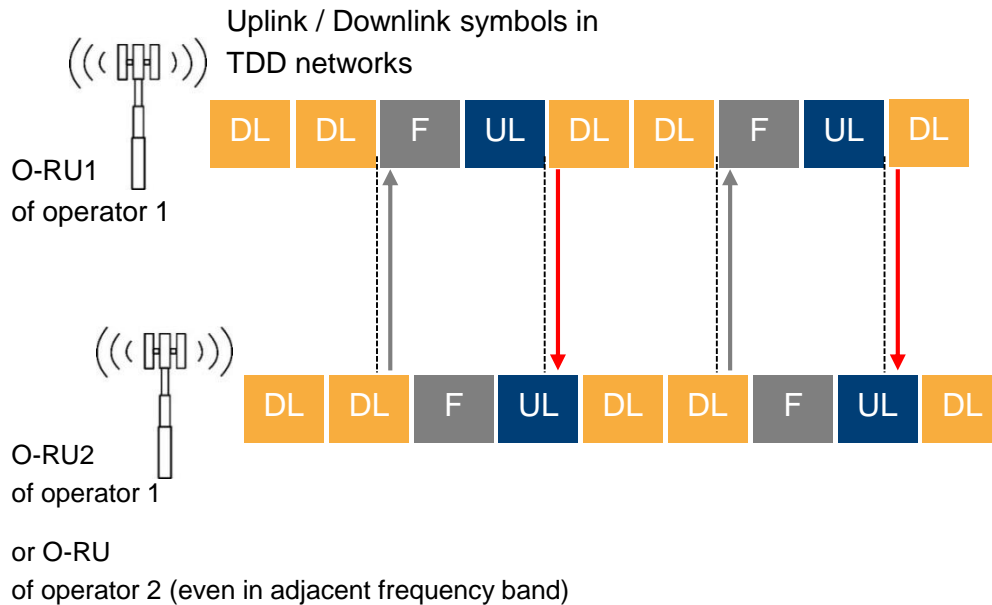
- ▶ ETSI TR 103 559 used as harmonized method
- ▶ Fair comparison of perceived quality end-to-end (end user perspective)



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NETWORK SYNCHRONIZATION: O-RAN cell synchronization measured over-the-air



- ▶ DL of O-RU1 interferes with UL of O-RU2
- ▶ Interference in time domain

Subcarrier Spacing	Symbol length
15 kHz	66.7 μ s
30kHz	33.3 μ s
60 kHz	16.7 μ s
120 kHz	8.3 μ s
...	...

NETWORK SYNCHRONIZATION: Measurement results (failure case)

#	PCI	SSB Idx	SS-RSRP	SS-SINR	NR-ARFCN	SS-Ref	ToA(PPS)
1	373	0	-75.61	22.58	637632	3564.48	3.07324139
2	372	0	-101.25	-25.65	637632	3564.48	3.07328682
3	716	0	-105.05	-29.46	637632	3564.48	3.07339537
4	85	0	-111.29	-4.41	637632	3564.48	0.07598861
5	603	0	-113.76	-7.67	637632	3564.48	0.07827527
8	96	0	-120.36	-13.59	637632	3564.48	0.07834053
10	629	0	-120.41	-14.85	637632	3564.48	0.08629245
7	692	0	-120.80	-15.27	637632	3564.48	0.08328950
6	29	0	-121.03	-15.93	637632	3564.48	0.07921318
11	652	0	-122.48	-16.80	637632	3564.48	0.08449997
9	304	0	-125.21	-19.91	637632	3564.48	0.07559080
12	325	0	-126.23	-21.02	637632	3564.48	0.07707206
13	574	0	-130.54	-25.21	637632	3564.48	0.07509223

ToA = the difference of
SSB reception to PPS (GPS)

$3.073 \text{ ms} - 0.076 \text{ ms} = 3 \text{ ms}$
time difference!

Completely out of sync!

▶ Typically, asynchronous cells have a difference of a few 100's μs



NETWORK SYNCHRONIZATION: Measurement results (successful)

#	PCI	SSB Idx	SS-RSRP	SS-SINR	NR-ARFCN	SS-Ref	ToA(PPS)
2	94	0	-108.40	-0.95	633984	3509.76	0.07673132
1	73	0	-109.90	-3.48	633984	3509.76	0.07468142
6	429	0	-116.34	-11.13	633984	3509.76	0.07755952
16	403	0	-122.98	-18.05	633984	3509.76	0.08401424
15	372	0	-124.59	-19.64	633984	3509.76	0.08148061
13	356	0	-125.10	-20.14	633984	3509.76	0.08099457
14	209	0	-126.16	-21.25	633984	3509.76	0.07641720
3	372	1	-113.52	-2.65	633984	3509.76	0.29555349
8	429	1	-116.48	-6.70	633984	3509.76	0.29134429
10	94	1	-116.79	-7.07	633984	3509.76	0.29077441
9	73	1	-122.38	-13.27	633984	3509.76	0.28874580
18	403	1	-123.88	-14.80	633984	3509.76	0.29809783
19	207	1	-129.96	-21.01	633984	3509.76	0.28878754
29	209	1	-130.13	-21.11	633984	3509.76	0.28957665

Difference between SSB 0 and SSB 1 is ~ 200 μ s

Difference is < 9 μ s

Difference is < 9 μ s

ToA measurements are done as drive tests (large area in short time) → target: detect outliers!

▶ Open RAN synchronization measurements suitable in field as quick feasibility check

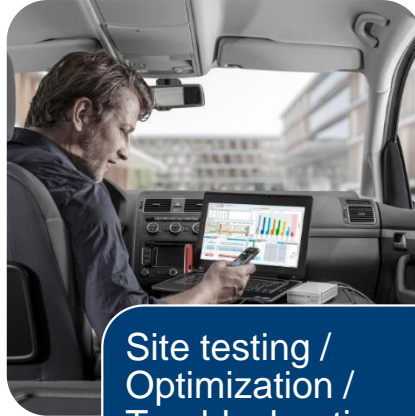


OPEN RAN TEST SOLUTIONS OF R&S MOBILE NETWORK TESTING



Engineering

- Function
 - Network Access
 - Mobility
 - Scheduling
- Performance
 - Throughput DL / UL
 - Latency
 - Interactivity



Site testing / Optimization / Troubleshooting

- Coverage
- Interference hunting
- Time synchronization
- EMF verification
- Performance
 - Throughput DL / UL
 - Latency
 - Interactivity



QoS / QoE

- Data services
 - Data transfer
 - Web content
- Voice
 - VoLTE / EPS Fallback
 - VoNR
- Video Streaming
- Video Call

OPEN RAN TEST SOLUTIONS OF R&S MOBILE NETWORK TESTING



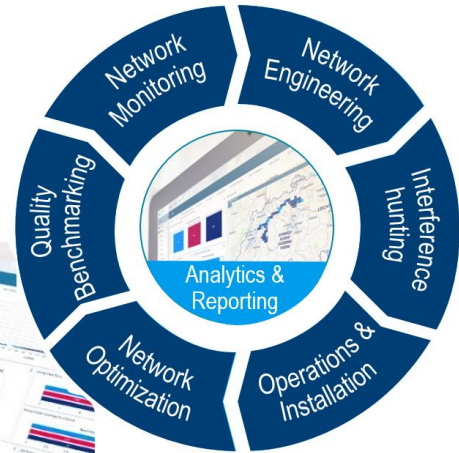
QualiPocAndroid
R&S ROMES4



R&S TSM A6
R&S 5G STS



SmartBenchmarker
SmartMonitor
SmartAnalytics



Conclusions

O-RAN Alliance specifications complement 3GPP baseline

Multiple RAN disaggregation options allow for multiple implementations from multiple players
→ Additional interoperability / conformance / time synchronization / security requirements

In-field evaluation and comparison of Open RAN network performance using the well-established ETSI TR method are essential for the success of O-RAN architecture

Network Synchronization needs to be verified – asynchronous cells are a potential and probable source of interference in Open RAN networks

▶ Rohde & Schwarz is your test solutions supplier for 3GPP and O-RAN conformance and network performance in the lab and in the field

www.rohde-schwarz.com/wireless/O-RAN

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q&a

Thank you for listening.

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Make ideas real

