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Technical Challenges for 5G satellites

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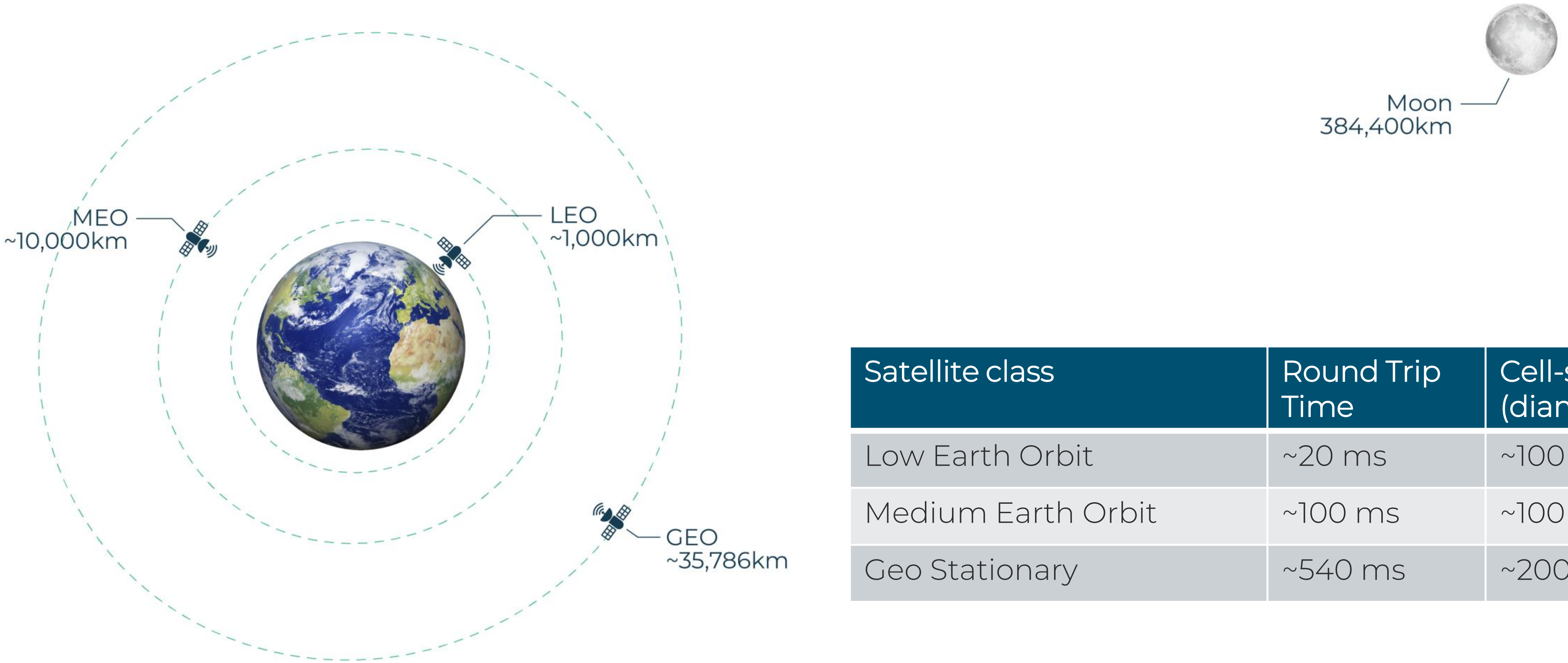
Sept 2022

SATELLITE CLASSIFICATION: LATENCY AND CELL SIZE



Satellite class	Round Trip Time	Cell-size (diameter)
Low Earth Orbit	~20 ms	~100km
Medium Earth Orbit	~100 ms	~100km
Geo Stationary	~540 ms	~200km

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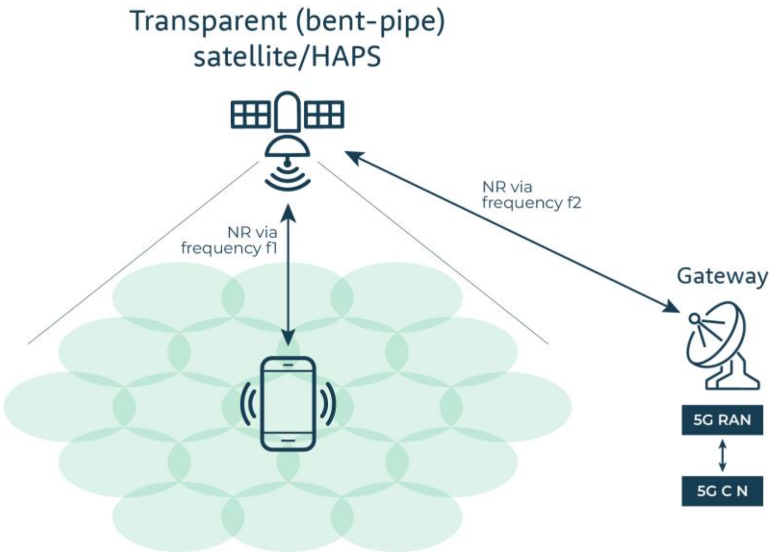
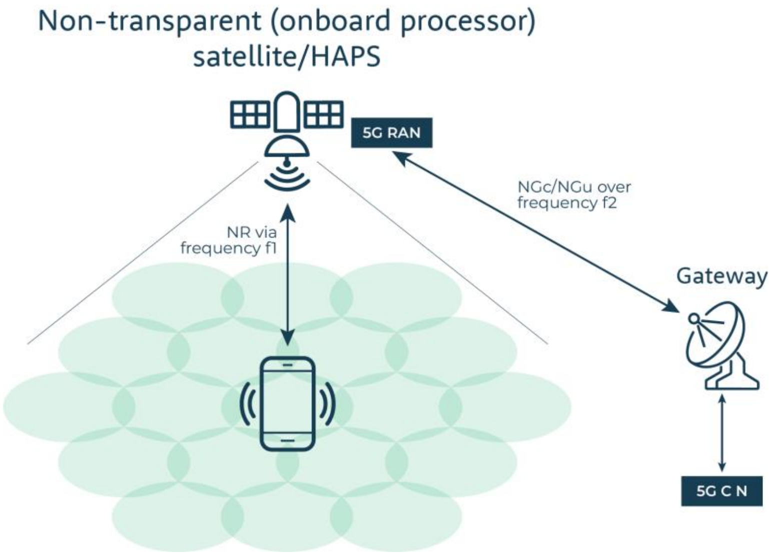
TRANSPARENT vs NON-TRANSPARENT SATELLITE ARCHITECTURE



3GPP TR 38.811



Transparent (bent-pipe):

- RF filtering, frequency conversion and amplification only on satellite
- Simple
- Longer round-trip delay from 5G Radio Access Network (RAN) to terminal and back again (e.g. 28 ms for LEO at 600km and low elevation angle)

Non-transparent (regenerative):

- RF filtering, frequency conversion, amplification, demodulation/decoding, switch and/or routing and coding/modulation.
- Equivalent to having gNodeB on board satellite
- Shorter round-trip delay from 5G Radio Access Network (RAN) to terminal and back again (e.g. 13 ms for LEO at 600km and low elevation angle)

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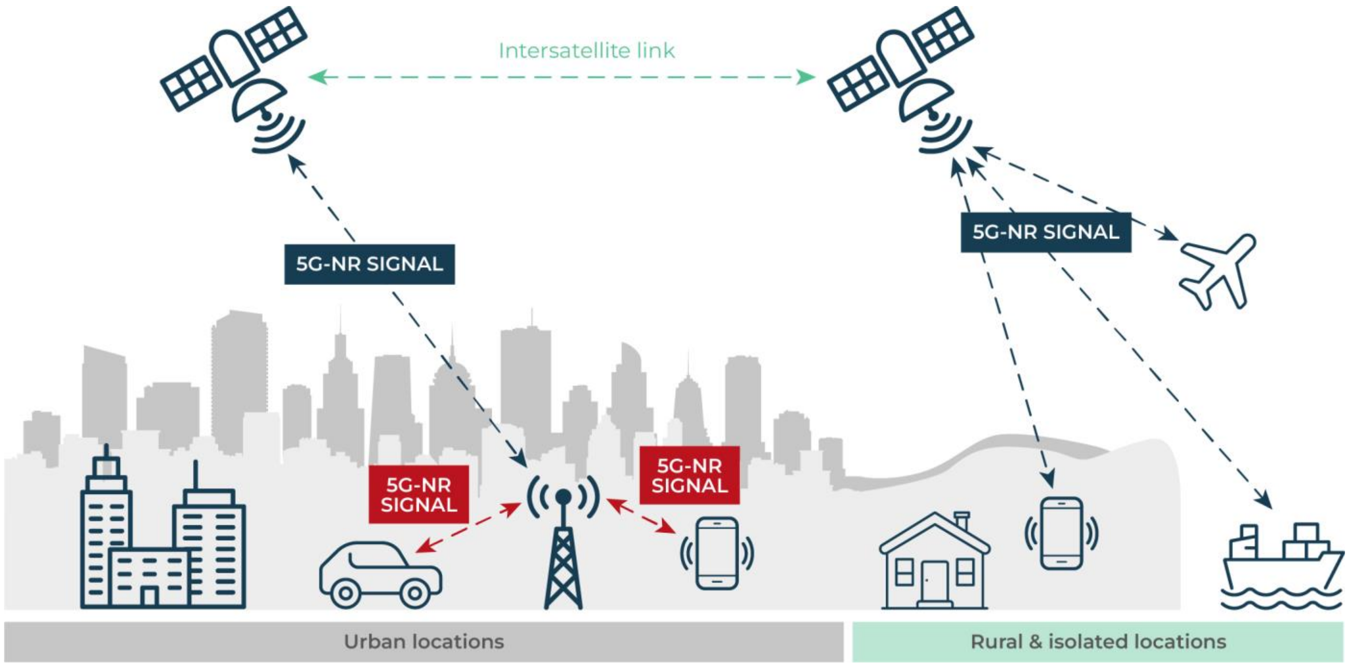
WIDE RANGE OF 3GPP NTN USE CASES

- Narrowband FR1 (1 or 2 Mbps) direct to handset and IoT
- Broadband FR2 (50 Mbps+) connectivity for aircraft, ships and fixed access
- Coverage for un-served remote areas
- Roaming between terrestrial and satellite networks in under-served areas
- Global 5G satellite overlay for safety-critical applications
- Broadcast and multi-cast services
- Indirect connection through a 5G satellite access network



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PERFORMANCE OF THE COMMUNICATION CHANNEL UNLOCKS 5G BUSINESS CASE

- Service continuity and ubiquity is central to business case
- Access to consumer market and minimizing UE costs is vital
- Latency and throughput are critical to user experience
- Retransmissions need to be avoided

Optimize performance of the antenna and L1

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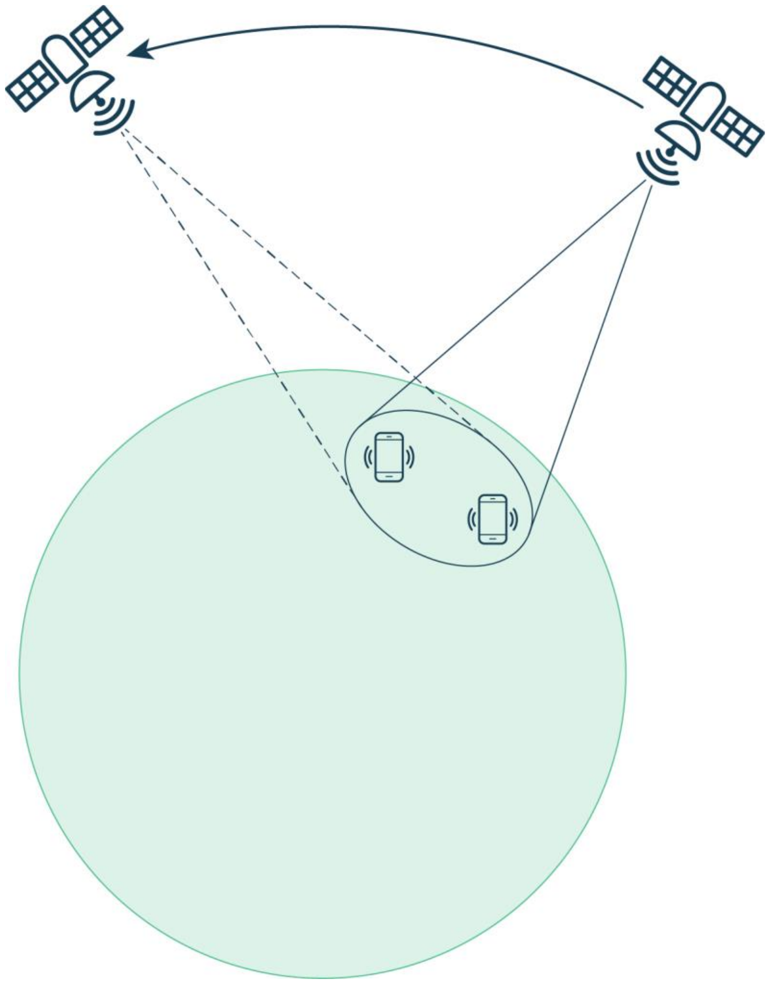
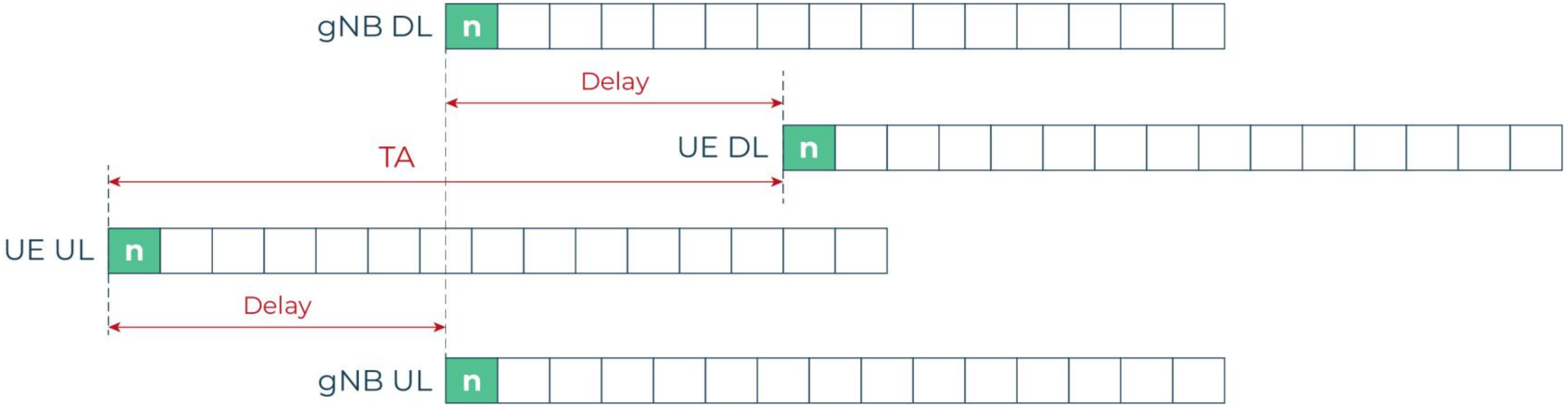
CHALLENGES OF 5G NTN PROPAGATION RELATIVE TO TERRESTRIAL



- Large beam footprint gives large cells that move
- Long propagation delays (~20 ms)
- Differential delays (e.g. 4 ms of variation)
- High Doppler shift (e.g. ±48 kHz for LEO at 600 km and 2 GHz carrier)
- High Doppler variation rate (e.g. varying from +48 kHz to -48 kHz over the course of 5 minutes)
- Line of sight probability is low when satellite is just above the horizon
- High path loss, owing to long propagation distance
- Rapid fluctuations in signal amplitude and phase caused by atmospheric and weather effects – particularly for FR2, vehicular terminals and broadband access

5G DIFFERENTIAL DELAYS: TIMING ADVANCE

- 5G UEs must adjust the timing of their transmission and reception, to accommodate the large propagation delays and so that signals are synchronised at the gNB.
- Common part of the timing advance can be calculated by the gNB and broadcast to the terminals.
- But different terminals at different locations within a beam can experience different delays – the terminal-specific part of the required timing advance can be calculated by terminal based on knowledge of its own location and of satellite trajectory.
- FDD is preferred in 5G NTN, because long guard periods are required to avoid a UE transmitting and receiving at the same time in TDD.



3GPP TR 38.821

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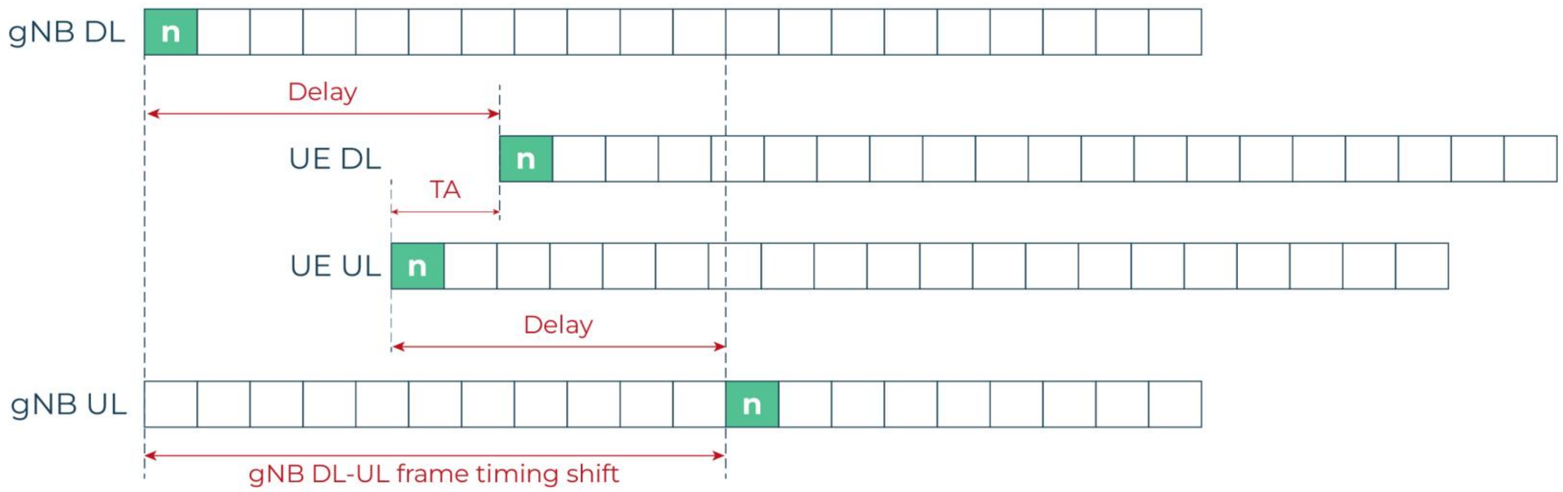
5G DIFFERENTIAL DELAYS: TIMING ADVANCE

- Timing advance can be reduced by shifting frame processing in the gNB.
- 3GPP standards updated to accommodate these big timing advances and support NTN frame timing shifting.
- Large delays lead to outdated channel knowledge, which can be mitigated using learning and prediction techniques.
- Large delays lead to very high latencies when relying on HARQ, which can be mitigated by disabling HARQ and using low MCS schemes or aggregation techniques, as well as relying on higher layer ARQ.



3GPP TR 38.821

DOPPLER: FREQUENCY PRE-COMPENSATION

- In the downlink, a gNodeB can apply knowledge of its velocity and beam geometry to predict the Doppler shift that will be imposed on the signals received by the connected terminals.
- The gNB can apply pre-compensation, to adjust the transmitted frequency, such that it is received at the expected frequency by the UE.
- Likewise, the gNB can apply post-compensation to the signals received in the uplink, to correct for the common part of the Doppler shift.
- However, in the uplink, different terminals at different locations within a beam can experience different Doppler shift and their signals can interfere when they are received at the gNB.
- To address this, some pre-compensation can be applied by the terminal, if it has knowledge of its own location and of the satellite trajectory,
- With these approaches, 3GPP terrestrial waveforms can be reused in NTN applications.

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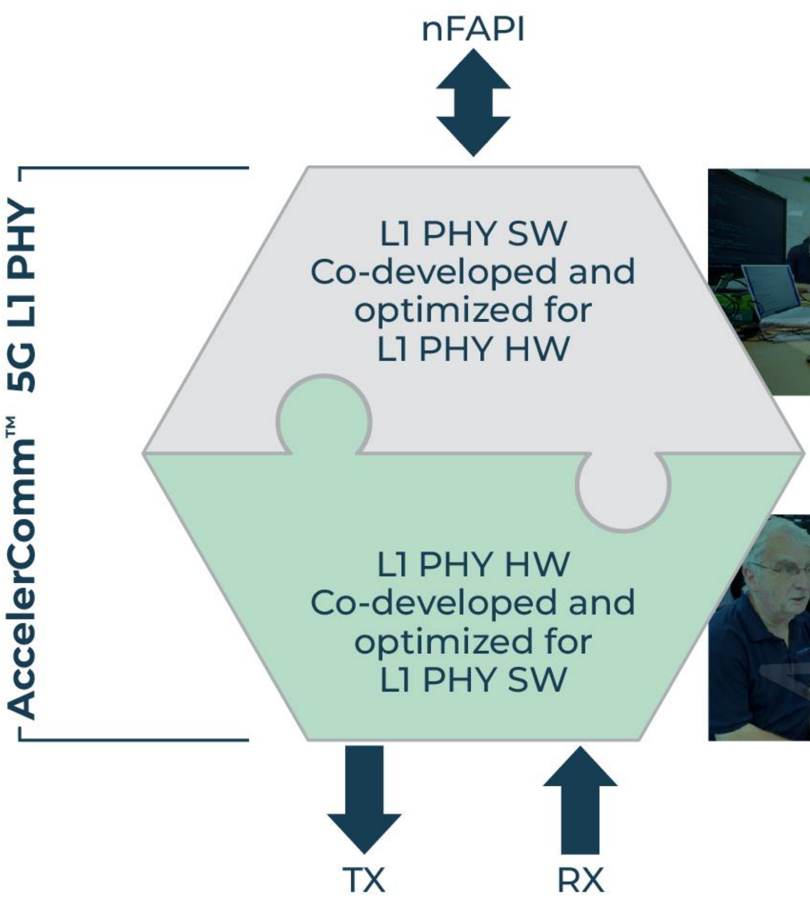
ACCELERCOMM INTEGRATED 5G HARDWARE AND SOFTWARE SOLUTION



- **Performant** – Optimized channel design for high throughput, low BLER, and low power consumption
- **Openly licensable IP** – Complete 5G Layer 1 solution for OEMs, Operators, and Semiconductor Companies
- **Complete** – Integrated hardware and software delivers heterogeneous solution
- **Compliant** – 3GPP, O-RAN and SCF
- **Flexible** – 5G-specific architecture addresses applications from IoT through to mMIMO
- **Portable** – FPGA reference design and ASIC-ready IP

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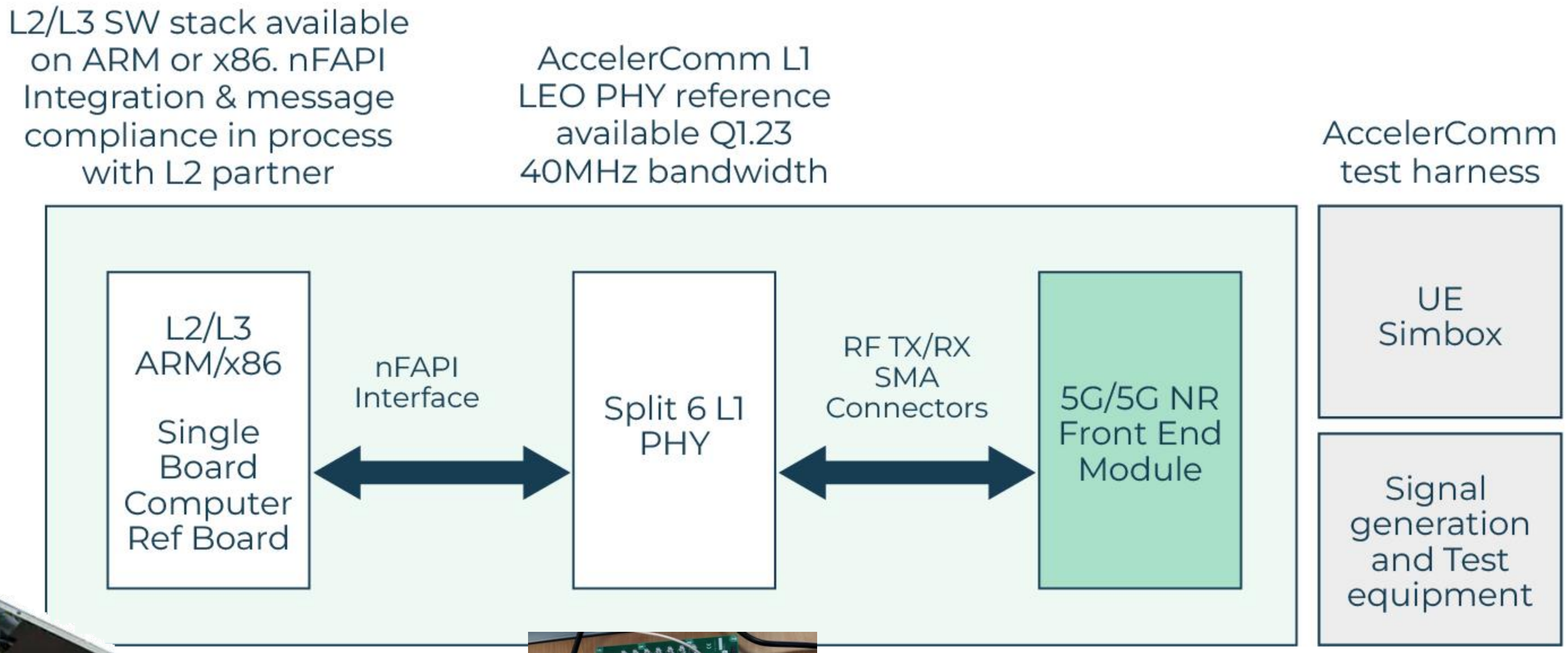
ACCELERCOMM L1 TO L3 DEVELOPMENT STATUS



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SUMMARY

- There remain several significant hurdles in technology and regulatory areas that need to be addressed for a standard 5G service.
- It is difficult: AccelerComm has experience of real design integration in a 5G satellite solution
- To succeed in launching a competitive LEO 5G service you will need the best technology possible that gets the most out of your investment in spectrum and hardware.
- The AccelerComm LEOphy layer 1 solution has been tailored to deliver maximum performance and reliability to enable more efficient 5G satellite communication.

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Thank you.
Any questions?

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www.accelercomm.com