ETSI Conference on
Non-Terrestrial Networks,
A Native Component of 6G

Initial views on Non-Terrestrial Networks (NTN) in the 6G era

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3rd–4th April 2024

We live in a world where connectivity is no longer a luxury, but a primary need.

In 5G we went Non-Terrestrial

NR (New Radio)

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In 6G will be supporting it for the long run

1. Sustainable, equitable and safe access to space

2. Efficiency of energy, spectrum and economics

3. Focus on the things that provide real value

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But first…a word on the spec

1. True TN-NTN spec convergence

- NTN came later to 3GPP
- Currently still separate NTN track
- Things are getting better from Rel-19 (slowly)
- But we are not yet at feature parity
- We are still “different”
- Do we need to? How much?

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2. Evolving the process towards 6G

- Word documents and ZIP files?

- Manual, human review?

- Specification as code
- The power of plain text

- Machine-aided review and management

5G → B5G → 6G
What's coming?

What's coming: safety and mission-critical

- Public Warning
- Emergency SOS and Safety (land, air and sea)
- Disaster roaming
- Mission Critical, Resilient communication

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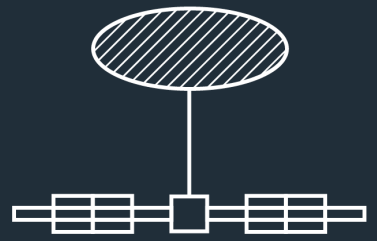




What's coming: Truly massive sensor networks

- Mass, low cost and simple environmental sensors
- Extremely low data rates
- Massive, asynchronous transmissions
- Non-IP

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What's coming: Planet scale mobility

- Advanced Air Mobiliy (AAM)
- Uncrewed, autonomous and remotely controlled systems
- Future land mobility and automotive
- Connectivity always, everywhere, seamlessly

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The Air interface

The Satellite Air Interface Engineer Mantra™

Smaller.
Faster.
Lighter.
Cheaper

(repeat)
(forever)

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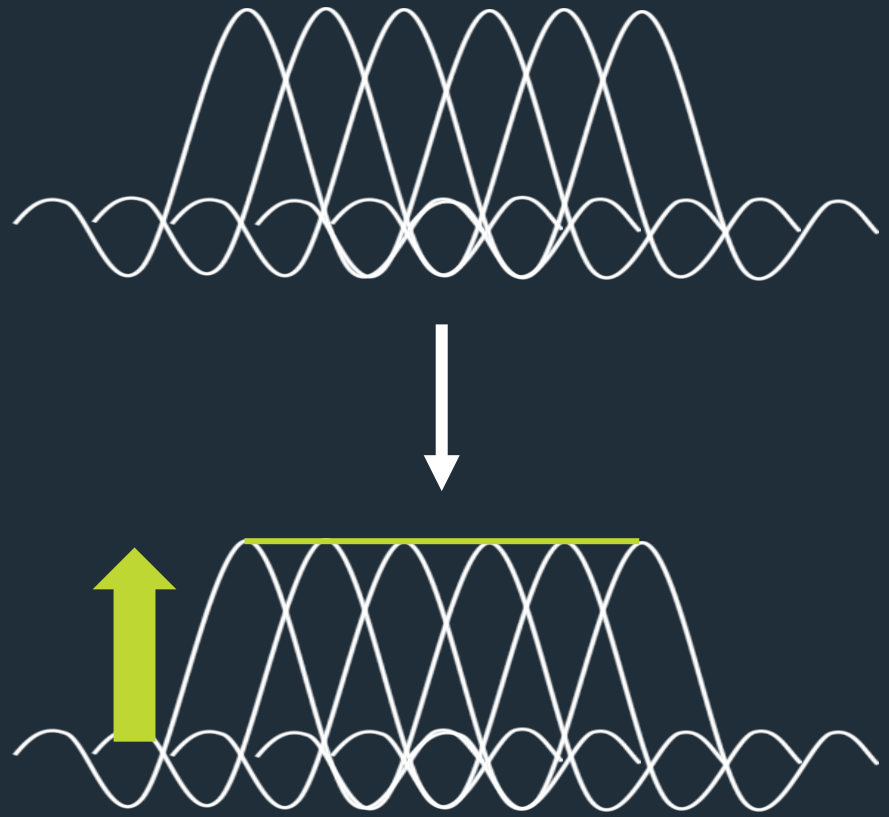
#1: More Power and Energy efficient

- Lower PAPR Waveforms to improve PA energy efficiency
- Maybe we don’t need to ditch OFDM(A), introduce precoding transforms (e.g. DFT-S-OFDM) and clever coding
- Cell discontinuous transmission (based on true demand)
- Lean, flexible and sporadic signalling based on scenarios
- Better support for NTN beamforming and MIMO



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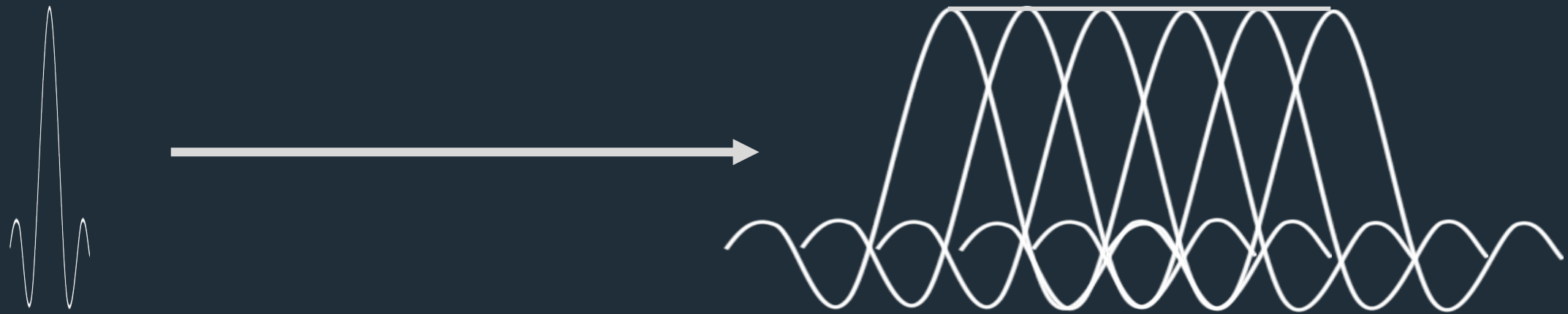
#2: More scalable and granular



From Ultra Narrow-Band…

…to Ultra Wide-Band

#2: Truly scalable, lean and flexible

- Improved bandwidth granularity
- Improved guard-band scalability
- Dynamically-scalable bandwidth
- Reduced, scalable Cyclic Prefixes
- Better spectrum utilization even with fragmented spectrum allocations
- Lean dynamic, configurable and scalable signalling
- Look again at CDMA, spread spectrum for mass scale asynchronous transmissions

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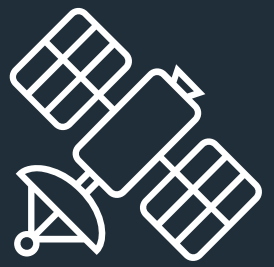
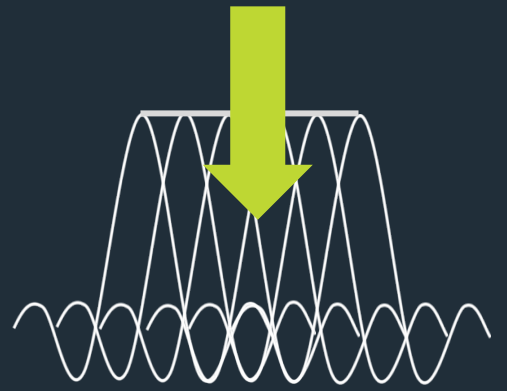
#3: More secure and resilient

PHY and MAC security
SSB/SIB Encryption
Quantum-secure encryption
Zero-Trust interfaces



GNSS-denied operation
Integrated PNT
Improved Network location determination and validation



Resilience to interference, Doppler and jamming
Low profile and noise-like operation
Privacy and Obfuscation

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#4: Better forward and backwards compatibility

- LTE and 5G introduced interesting concepts (in-band, DSS, BWPs, etc)
- Can we go beyond?
- Vertical support introduces very long lifetime terminals 10+ years (IoT, industrial, automotive, energy, maritime, aeronautical)
- What have we learned?
- learned that legacy remains there for a long time
- refarming is hard (and slow)

We need to design for Evolution,
not Revolution

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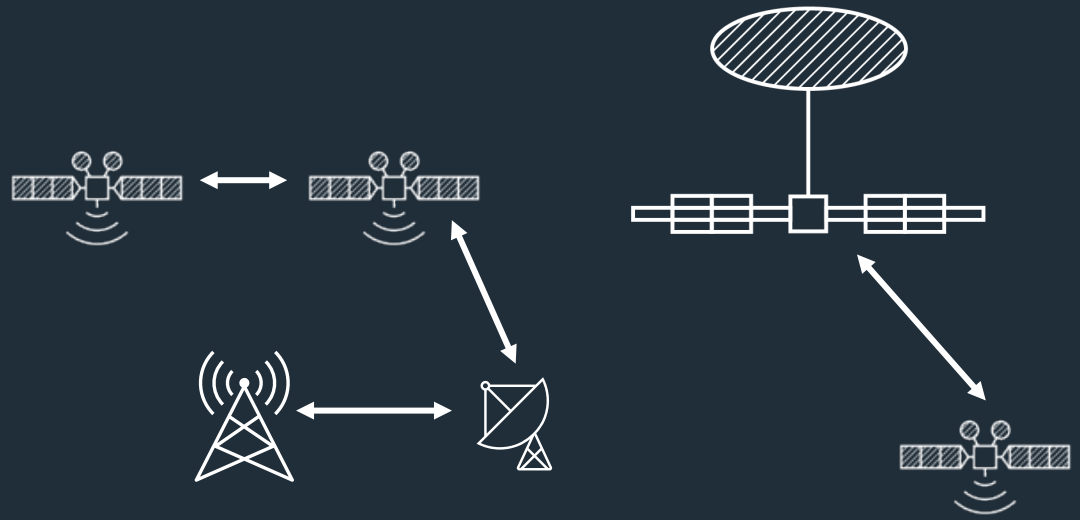
Ok, a broader look now:
The Network

Novel and Improved NTN topologies

- Space-to-space communication (not just ISLs)
- True LEO-GEO cooperation
- True multi-layer communication and cooperation
- Think NTN as a blanket coverage overlay
- UE-UE cooperation
- Intelligent surfaces, relays and materials e.g. to provide signal boosting, cleaning and conversion and indoor/in-vehicle communication



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Deeper TN-NTN network level integration

- TN and NTN will likely keep being operated by different entities
- But we still need truly seamless mobility
- **“Classic” Roaming will not be sufficient**

- We need Network level APIs to share coverage, demand, load, capabilities, interference information between TN and NTN networks in real-time

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Compression is a form of intelligence

Leveraging AI and Latent Space for NTN

Channel and Overhead Compression

- Channel State Compression via digital twin modelling of our systems
- AI offloading of channel estimation, demodulation, error correction and recovery
- Knowledge-based and inference-based interference, load and energy management

Data Compression

- Satellite links will always be more nimble, we need to be smarter
- Consider the difference between raw information and useful effective information
- Can AI-based generative compression/inference break the **perceived** Shannon bound?

+ Predictive Mobility, AI-based network instrumentation, etc,
I know, I know…

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What about the Apps, the OS, the Stack?

Some food for thought:

- Android Connectivity API now includes Non-Terrestrial Network access
- Many applications rely heavily on IP… and TCP, UDP…
- But do we actually need these in point-to-point radio link?
- TCP/IP is an interesting case, it used to handle a lot of stuff for us, now it's all QUIC-er!
- Deeper and increasing proliferation of Non-IP Data for IoT and Messaging (at least in competing technologies)

What about the Apps, the OS, the Stack?

We need:

- Leaner, less chatty protocol stacks
- Better handling of satellite latencies and jitter, also for very high-throughput links
- Application layer protocols to be aware and cooperative
  - SMS over NIDD, RCS NG, HTTP/3, VoNIDD?

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6G may be far away,
as we have just started with 5G,
but it doesn't hurt thinking ;)

Thank you!