ETSI
The Standards People

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

Hexa-X-II NTN view

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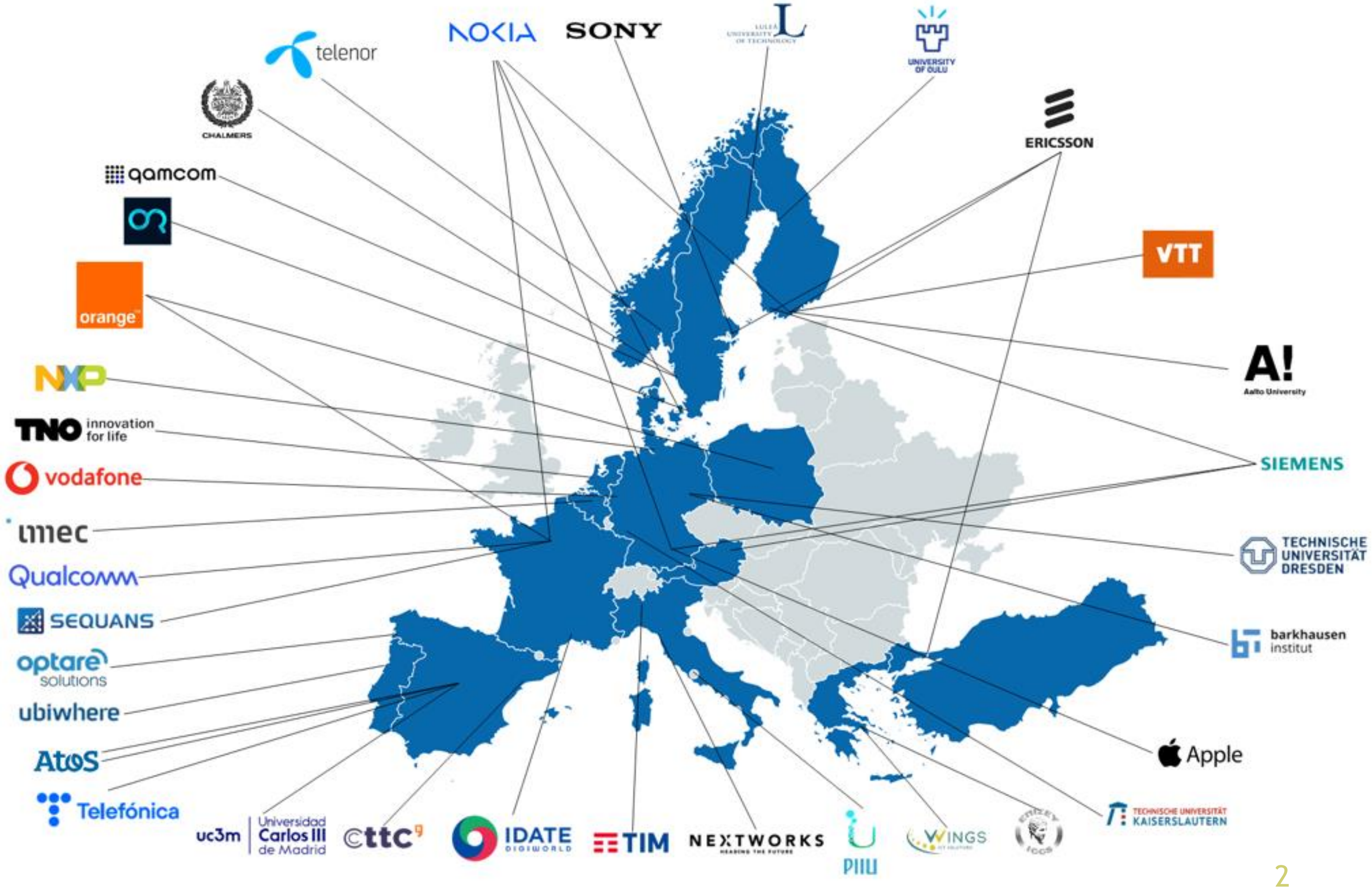
Hexa-X-II overview

- Hexa-X-II is the next European level 6G Flagship
- Focus will be continued development of technology and define the 6G platform and system
- Funded through Horizon Europe SNS-JU
- 44 partners
  - Cover the entire value-stack from hardware to system to platform to applications to service providers and a strong academic presence
- Nokia is overall leader
- Ericsson is technical manager



Overall objectives of Hexa-X-II

A holistic flagship towards the 6G platform and system

to inspire digital transformation for the world to act together in meeting needs in society and ecosystems with novel 6G services

Hexa-X

Hexa-X & Horizon-2020 candidate enablers →

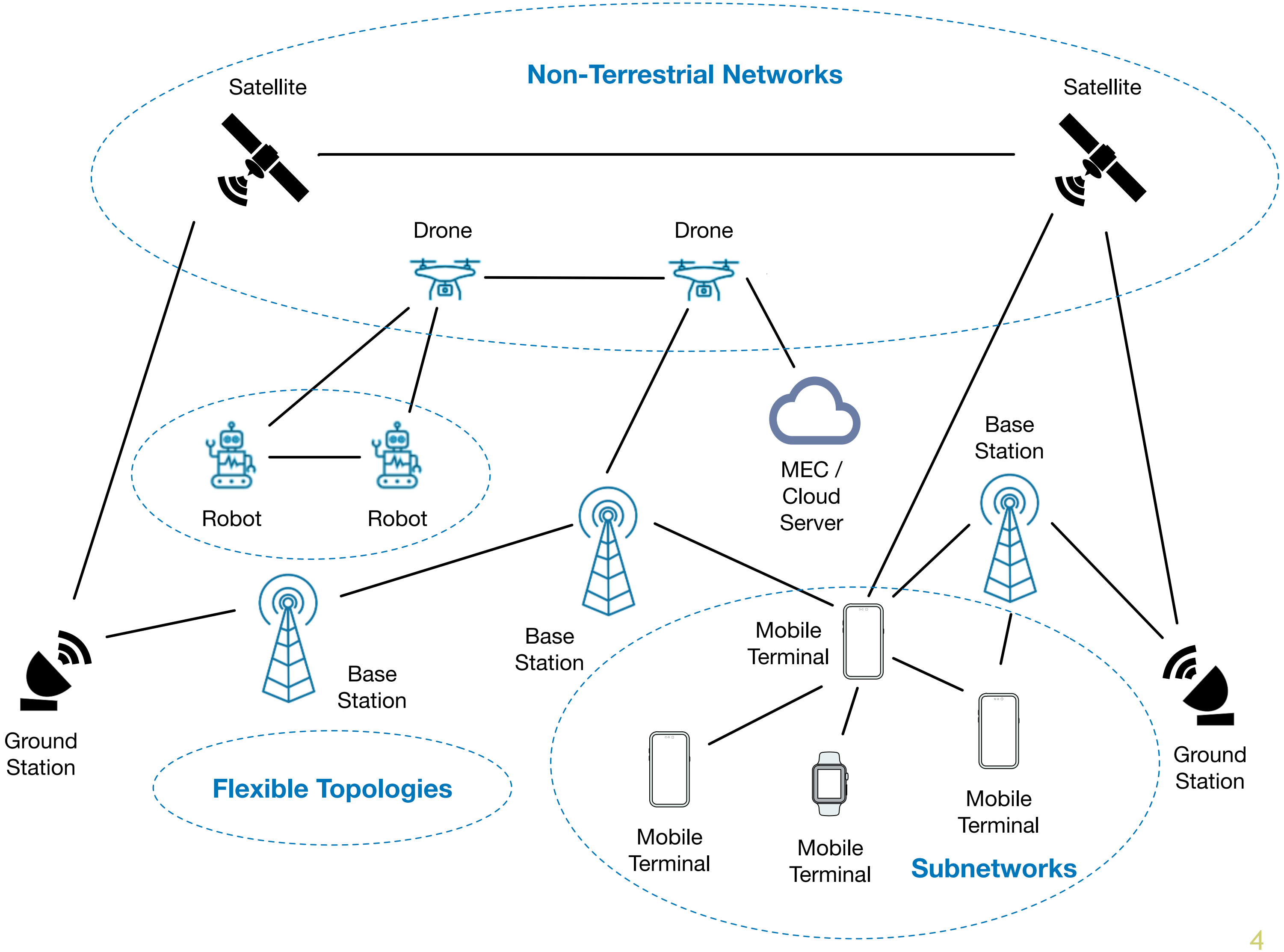
HEXA-X-II

6G use cases, services, and requirements	Value for society
6G system blueprint and platform	Global dissemination impact
6G technology readiness	Strategic autonomy

↑ SNS stream B projects

Introduction
Hexa-X-II Network of Networks paradigm

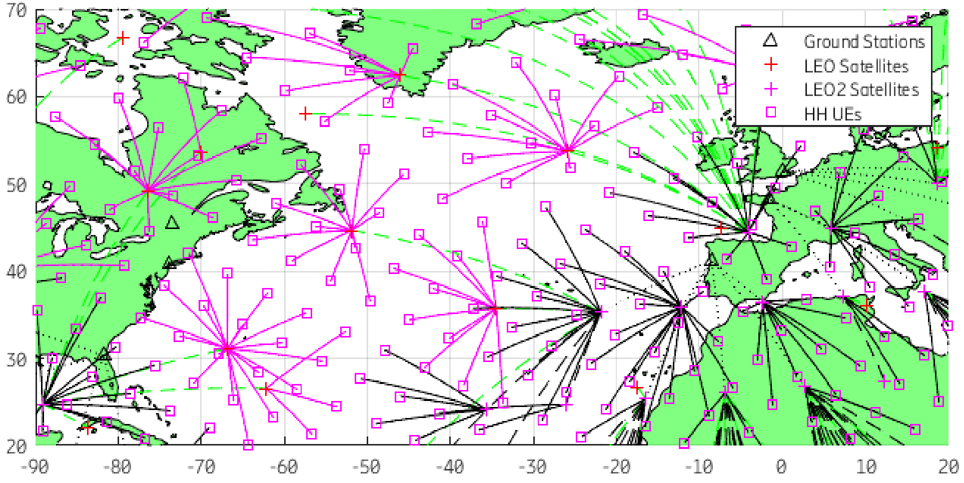
- Interconnected networks, each with its own unique characteristics and capabilities, that function as a unified, larger network
- Network of networks enables:
  - a seamless and ubiquitous communication system
  - integration of multiple subnetworks, including terrestrial, aerial and non-terrestrial nodes
- Work focuses on:
  - Subnetworks and NTN architecture
  - Management procedures and resource allocation frameworks
  - Prediction of future coverage developments

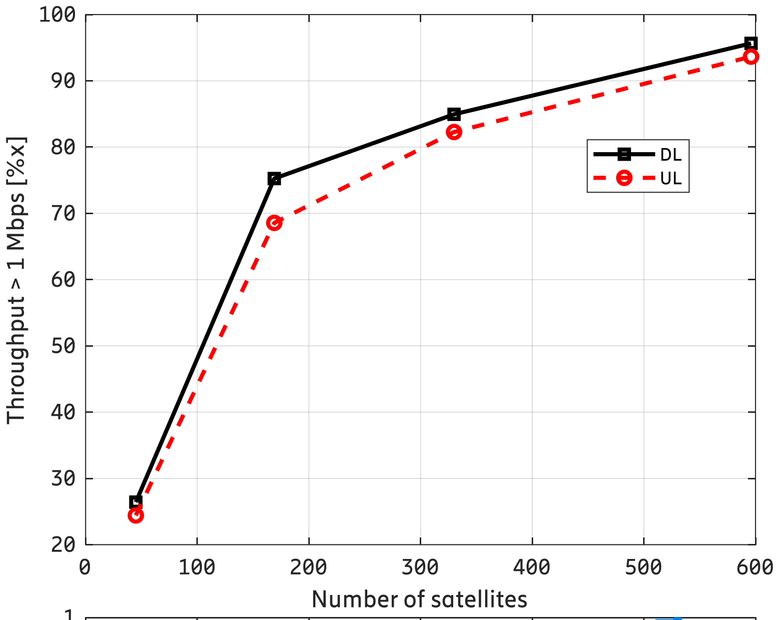


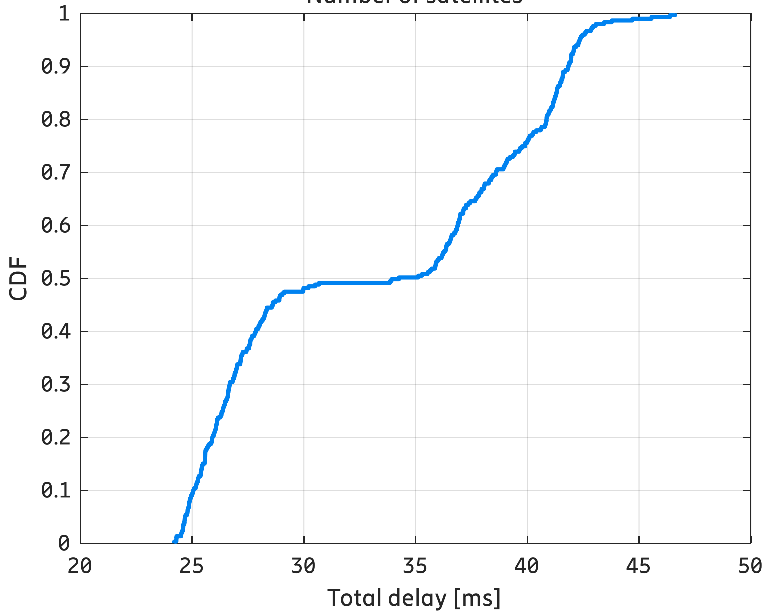
Introduction
NTN ocean coverage

- **Global service coverage evaluated in Hexa-X**
  - LEO deployment evaluated for Atlantic ocean coverage
    - Handheld (HH) device connected directly to the LEO Satellites
    - Inter-satellite-link (ISL) hops to provide coverage with adjacent path
    - Regenerative architecture assumed here
    - Very low traffic load per beam
    - Possible to achieve 1 Mbps for 99% of the users

Scenario 1; LEO Satellites and the handheld devices







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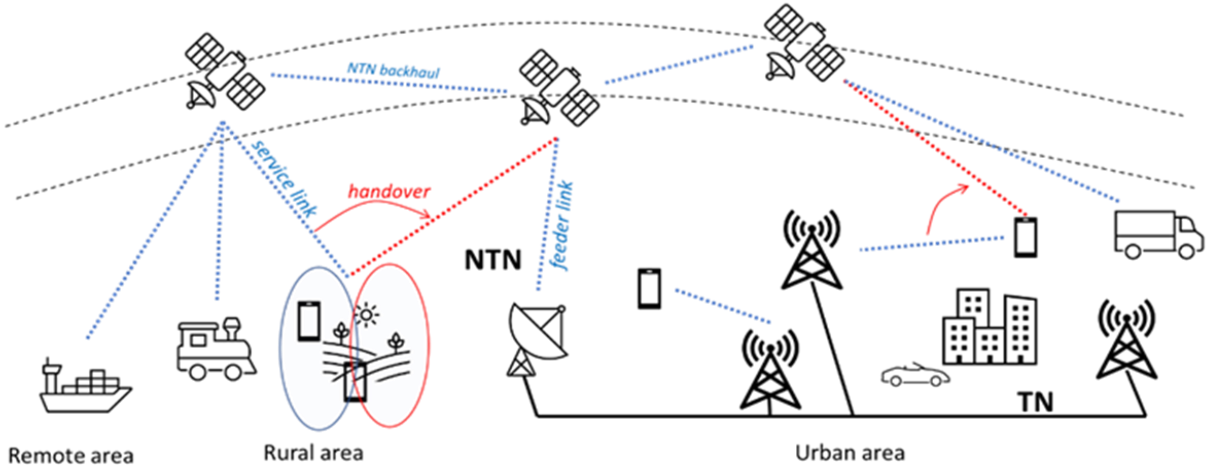
NTN mobility

NTN Mobility problems

- Interruption time due to frequent HO
- Large number of UEs may need to perform HO concurrently
- Handover signalling overhead

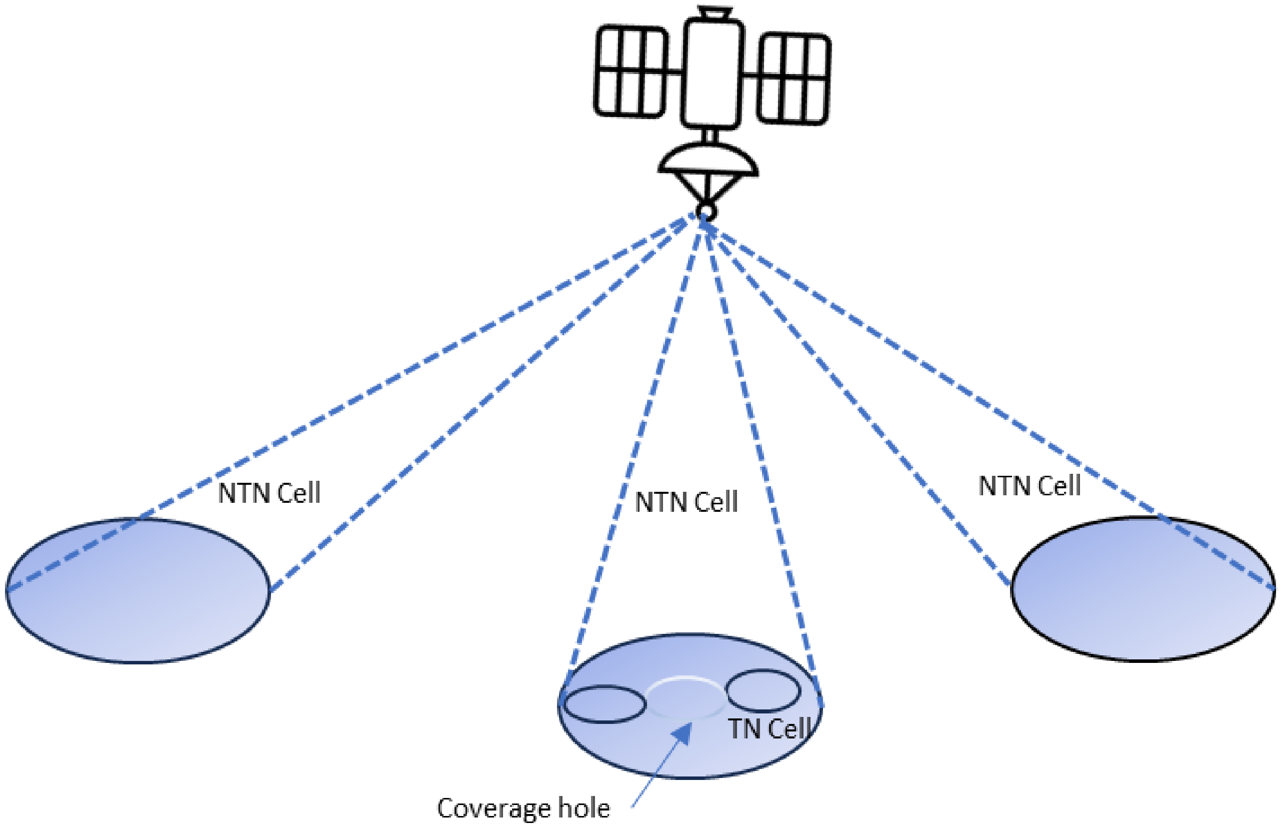


Possible solutions

- QoS-aware omission of HO common information
  - for sporadic data, delay tolerant traffic
  - + HO common info from SIB broadcasting during source/target cell overlapping time to ensure validity
- Random time-based handover
  - avoids overloading RACH
  - if not using RACH-less HO
- PCI change only (i.e., cell change without HO)
  - DAPS is complex for implementation at UE
  - PCI unchanged constraints soft switch

NTN mobility
NTN-TN global coverage and coverage holes

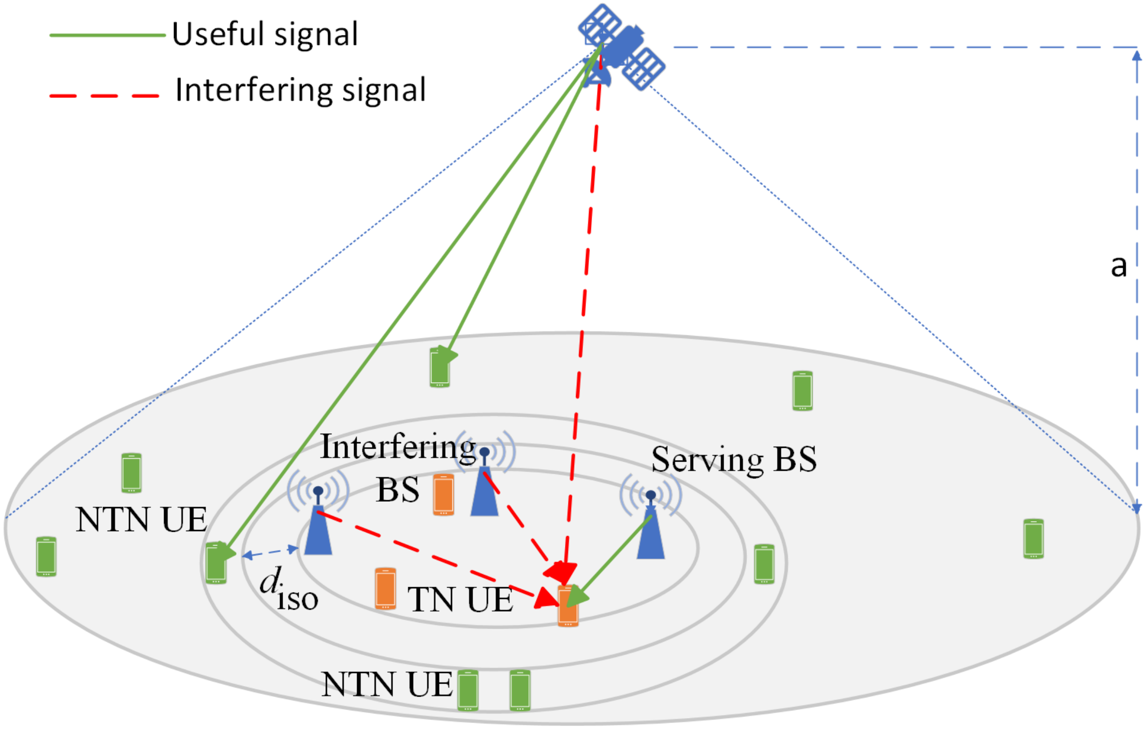
- As part of global coverage, user may stick to TN coverage as much as possible and NTN may be used to cover the TN coverage holes.
- Fast switch dual connectivity between NTN and TN can handle coverage holes and improve the (possible) interruption time
  - UE anchor/master could be TN or NTN cell
  - The TN and NTN links may have rather different latencies which may impact the connection negatively



NTN-TN Spectrum Sharing

- NTN is already a reality
  - Direct to Device
  - Starlink, Kuiper, ASTMobile, OneWeb, Lynk, …

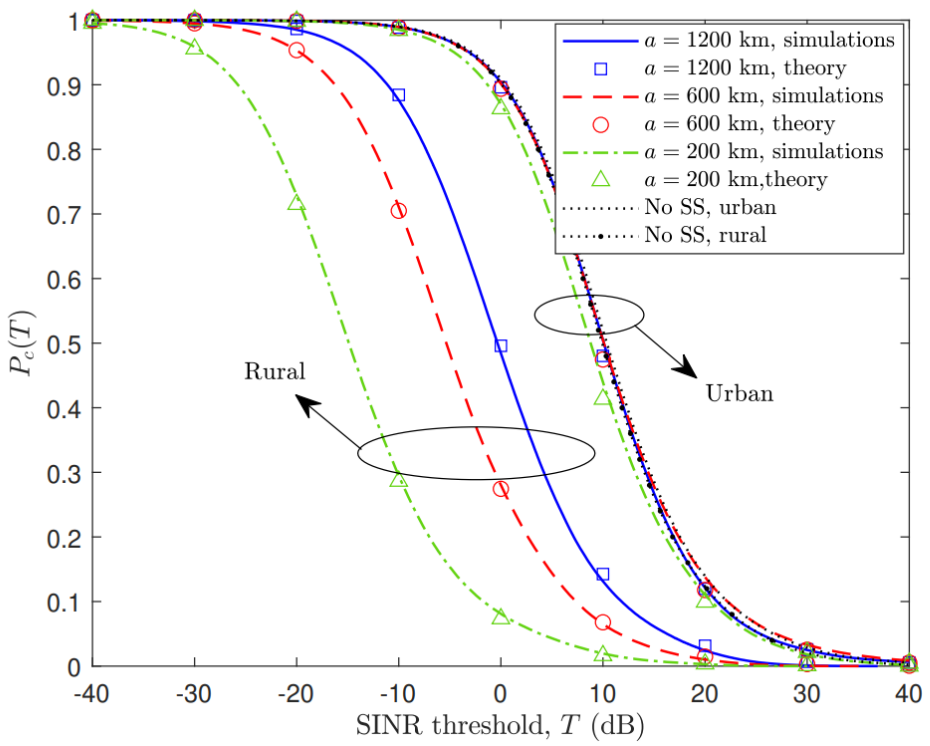
- Sharing and Coexistence studies are needed
  - Protection criteria, separation distance, maximum power



Performance study of TN-NTN integrated networks in S-band
NTN and TN share same spectrum (2 GHz band)

Downlink, NTN DL interferes with TN DL

Probability that SINR>Threshold

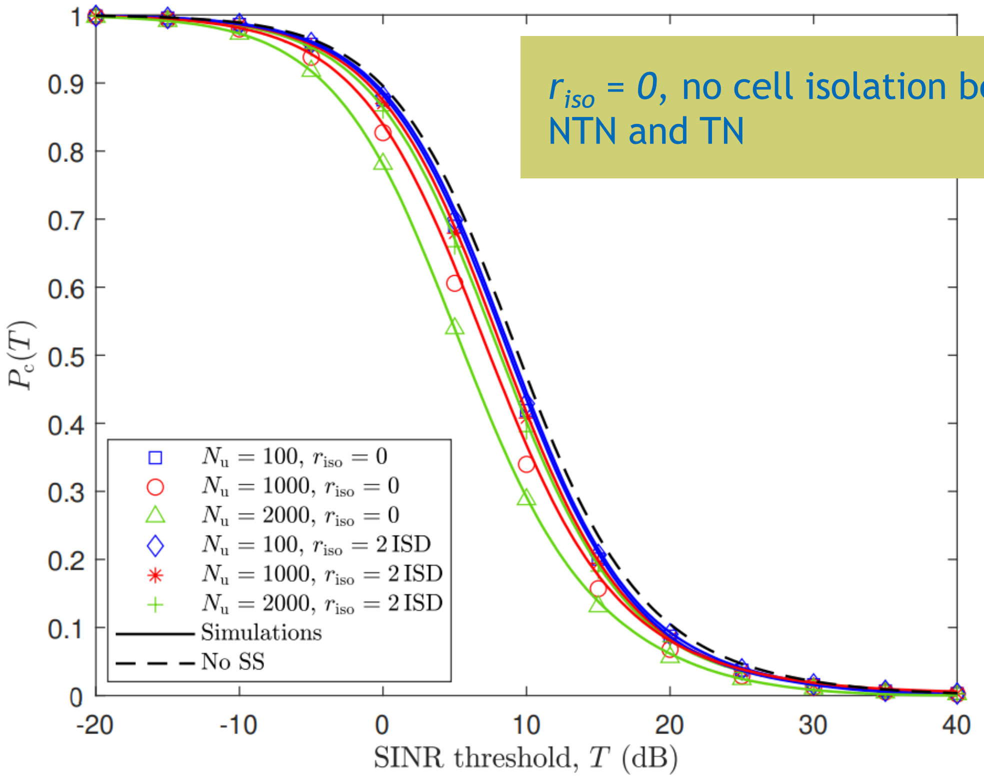


(a) 100% load.

The altitude of satellite an impact on TN rural area SINR

Uplink, NTN UL interferes with TN DL

r_{iso} = 0, no cell isolation between NTN and TN

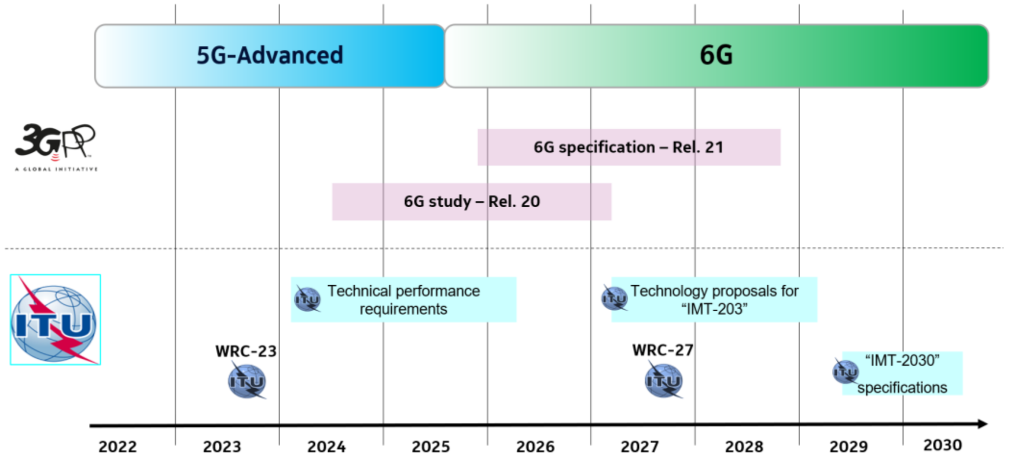


(a) 100% load.

[2401.08453] Co-existence of Terrestrial and Non-Terrestrial Networks in S-band (arxiv.org)

Hexa-X-II standardization impact on NTN study

3GPP Release 21 will contain the first 6G specifications which are based on 6G studies reported in Release 20



- Hexa-X-II partners are actively contributing to various standardization and industry groups.
- Standards and industry groups impacted
    - 3GPP RAN1, 2, 3, 4
    - 3GPP SA 2, 3, 5
    - ITU-R and ITU-T
    - ETSI ZSM, MEC, THz, etc.
    - NGMN, ORAN nGRG, GSMA, BEREC, TMFroum, IETF, IRTF

On NTN topic in particular:

- Non-Terrestrial Networks (NTN) solutions
    - NTN handover enhancement
    - Signalling overhead reduction
- Flexible spectrum use and access, Spectrum management

	Targeted by the end of the project	Achieved
Total number of standards contributions by participants based on work in Hexa-X	More than 120	103

Conclusions and takeaways

- NTN can provide coverage with descent in remote areas such as Atlantic ocean
- NTN mobility can be further improved with various solutions to minimize overhead, signaling and interruption time
- NTN complementing TN coverage via a fast switch connectivity may improve coverage holes but is not without challenges

- Spectrum sharing in 2 GHz band (interference from NTN to TN)
  - Interference from NTN may not always be harmful to TN.
  - Interference from NTN can be harmful particularly for
    - Rural areas (larger ISDs) and
    - TN cell edge users
  - Separation distance and power limits must be defined

- Hexa-X-II standardisation efforts towards 3GPP RAN and ITU

- More details can be found in coming deliverables D3.3 and D4.3 to be released on the https://hexa-x-ii.eu/ in May 2024

HEXA-X-II

HEXA-X-II.EU //

Co-funded by the European Union

6GSNS

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Performance study of TN-NTN integrated networks in S-band
Parameters

Spectrum sharing results in the S-band (2 GHz)

- Illustrates the coverage probability and data rate of the integrated network in terms of:
  - Inter-site distances
  - Satellite's altitude
  - Transmit power
  - TN network load
  - Number of NTN UEs
  - Isolation distance
  - Location of TN UE

Parameter	Value
Inter-Site Distance	0,75 km (urban); 7,5 km (rural)
Path Loss Exponent	2 (NTN), 3 (TN)
Fading	Rician, K = 20 (NTN), 0 (TN)
Tx Power	46 dBm (Satellite, BS), 23 dBm (NTN-UL)
Antenna Gain	30 dBi (Satellite), 1 dBi (NTN-UL), 17 dBi (BS)
Frequency	2 GHz
Bandwidth	20 MHz
Number of TN BSs	19

Performance study of TN-NTN integrated networks in S-band
Theory

- A theoretical approach based on stochastic geometry

$$\mathrm{SINR} = \frac{p_{\mathrm{TN}} G_{\mathrm{TN}} H_{\mathrm{TN}} R_0^{-\alpha_{\mathrm{TN}}}}{I_{\mathrm{TN}} + I_{\mathrm{NTN}} + \sigma^2} \qquad I_{\mathrm{UL}} = \sum_{n=1}^{N_{\mathrm{u}}} p_{\mathrm{NTN}} G_{\mathrm{NTN}} H_{\mathrm{NTN}} \mathcal{R}_n^{-\alpha_{\mathrm{NTN}}}$$

$$P_{\mathrm{c}}(T) = \int_0^{2(r_{\mathrm{TN}}+d_{\mathrm{ISD}})} f_{R_0}(r_0) \Bigg[e^{-s\sigma^2} \sum_{k=0}^{m-1} \frac{\sum_{l=0}^{k} \binom{k}{l} (s\sigma^2)^l (-s)^{k-l} \frac{\partial^{k-l}}{\partial s^{k-l}} \left(\mathcal{L}_{I_{\mathrm{TN}}}(s) \mathcal{L}_{I_{\mathrm{UL}}}(s) \right)}{k!} \Bigg]_{s=s_{\mathrm{c}}} dr_0. \quad (13)$$

$$s_{\mathrm{c}} = \frac{m T r_0^{\alpha_{\mathrm{TN}}}}{p_{\mathrm{TN}} G_{\mathrm{TN}}}$$

$$\mathcal{L}_{I_{\mathrm{TN}}}(s) \triangleq \mathbb{E}_{I_{\mathrm{TN}}}\left[e^{-sI_{\mathrm{TN}}}\right] \quad (9)$$
$$= \left(\int_{r_0}^{2(r_{\mathrm{TN}}+d_{\mathrm{ISD}})} \mathcal{L}_{H_{\mathrm{TN}}}\left(s p_{\mathrm{TN}} G_{\mathrm{TN}} r_n^{-\alpha_{\mathrm{TN}}}\right) f_{R_n|R_0}(r_n|r_0)\, dr_n \right)^{N_{\mathrm{c}}}.$$

$$\mathcal{L}_{I_{\mathrm{UL}}}(s) \triangleq \mathbb{E}_{I_{\mathrm{UL}}}\left[e^{-sI_{\mathrm{UL}}}\right] \quad (14)$$
$$= \left(\int_{w-x_0}^{r_{\mathrm{NTN}}+x_0} \mathcal{L}_{H_{\mathrm{NTN}}}\left(s p_{\mathrm{NTN}} G_{\mathrm{NTN}} z_n^{-\alpha_{\mathrm{TN}}}\right) f_{\mathcal{R}_n}(z_n)\, dz_n \right)^{N_{\mathrm{u}}}$$