3GPP TSG RAN Release 19 Workshop
June 15 – 16, 2023
Agenda Item: 5

RWS-230051

R19 NTN Enhancements

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Rel-19 NTN Enhancements Proposal Overview

Objectives: Enhance Rel-19 NTN to support additional use cases for NTN using high bandwidth LEO satellite communication links and to enhance the reliability of such links

Proposal	Benefits
Use NTN in ESIM scenarios for NGSO in Ka band	High data-rate communication services to a growing class of on-the-move satellite terminals
Enhance NTN to support spectrum sharing of NTN with TN in overlapping bands above 10 GHz	Efficient use of spectrum by dynamically accessing the spectrum in overlapping bands
Enhance resiliency of NTN links	Enhanced reliability and assured connectivity

Use NTN in ESIM Scenarios for NGSO in Ka Band

- **Scenario description**
  - WID[1] on NR NTN enhancements

> 4.1.2 NR-NTN deployment in above 10 GHz bands
>
> The following assumptions are taken a baseline for this work:
> - GSO and NGSO (e.g. LEO, MEO, HEO) based satellite access to be considered
> - ESIM scenarios for NGSO in Ka band are not considered in this WI.

  - ESIM operations on NGSO satellites (Ka band) are authorized by some spectrum regulators[2,3]
  - Agenda Item 1.16 of WRC-23[4] is on developing regulations to support the operations of ESIM in this scenario
  - An increase in recent deployments of NGSO satellites has resulted in the rapid growth of ESIM uses
  - Market need to support the increased user demand for high-bandwidth applications

Proposal	Benefits
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- **Proposed enhancement**
  - Adapt NTN to provide communication links to aeronautical-, maritime- and land-ESIM for NGSO in Ka band
    - Consider unique mobility features including handoffs, blocked channels, and varying antenna sizes
- **Benefits**
  - Access to high data-rate-communication services for travelers on planes, ships, and in vehicles that are in remote areas

[1] Thales, "NR NTN (Non-Terrestrial Networks) enhancements," 3GPP TSG RAN Meeting #99, RP-230728.
[2] FCC. *Second Report and Order in IB Docket No. 17-95 and Report and Order in IB Docket No. 18-315.*
[3] ECC. The harmonized use, free circulation and exemption from individual licensing of Land, Maritime and Aeronautical Earth Stations On Mobile Platforms (ESOMPs) operation with NGSO FSS satellite systems in the frequency ranges 17.3 – 20.2 GHz, 27.5 – 29.1 GHz and 29.5 – 30.0 GHz. ECC Decision (15)04.
[4] ITU Resolution 1399 (C20). *Agenda of the World Radiocommunication Conference (WRC-23).*

Enhance NTN to Support Spectrum Sharing of NTN with TN in Overlapping Bands Above 10 GHz

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- **Scenario description**
  - WID[1] on NR NTN enhancements

> 4.1.2 NR-NTN deployment in above 10 GHz bands
>
> The following assumptions are taken a baseline for this work:
>
> - ...
> - Co-existence between overlapping NTN and TN band portions is out of scope of this work item. This aspect will be captured in the specification.

  - Satellite-based NTN applications operate in the Fixed- and Mobile-Satellite Service (FSS/MSS) and applications of TN belong to the Mobile and Fixed Service (MS/FS)
  - As per ITU Radio Regulations[2], significant parts of the Ku, Ka, and V bands are commonly allocated to all these services
  - NTN and TN applications should ideally share the spectrum in a spectrally efficient manner
    - Spectrum sharing of NTN/ESIM with TN is challenging because of the mobility of the ESIM
- **Proposed enhancement**
  - Use a Network Control and Monitoring Center (NCMC) to estimate the location-dependent EIRP levels of ESIM network
    - Use AI/ML techniques to process inputs to NCMC
    - Input to NCMC: spectrum measurements and estimates, location information, MS network spectrum usage, etc.
- **Benefits**
  - Dynamic access to large parts of the shared spectrum results in more efficient overall spectrum use
    - In non-sharing, spectrum-splitting scenarios, per-service spectrum utilization is less efficient
  - Availability of NTN service for coverage gaps in TN service; seamless connectivity from TN to NTN

[1] Thales, "NR NTN (Non-Terrestrial Networks) enhancements," 3GPP TSG RAN Meeting #99, RP-230728.
[2] ITU Radio Regulations. Article 5. Edition of 2020.

Example: An Approach to Spectrum Sharing of NTN with TN in Overlapping Bands Above 10 GHz

L-ESIM network coexists with stations in the MS and FS systems by dynamically adapting power and transmission resources of the L-ESIM network

- The L-ESIM network is under the control and supervision of a Network Control and Monitoring Center (NCMC)
- L-ESIM send estimates of their location and surrounding spectrum sensing measurements to NCMC
- NCMC estimates the power and resources at each L-ESIM to comply with interference requirements
  - These estimates are based on statistical analysis of the composite interference signal from the L-ESIM network at the MS and FS stations

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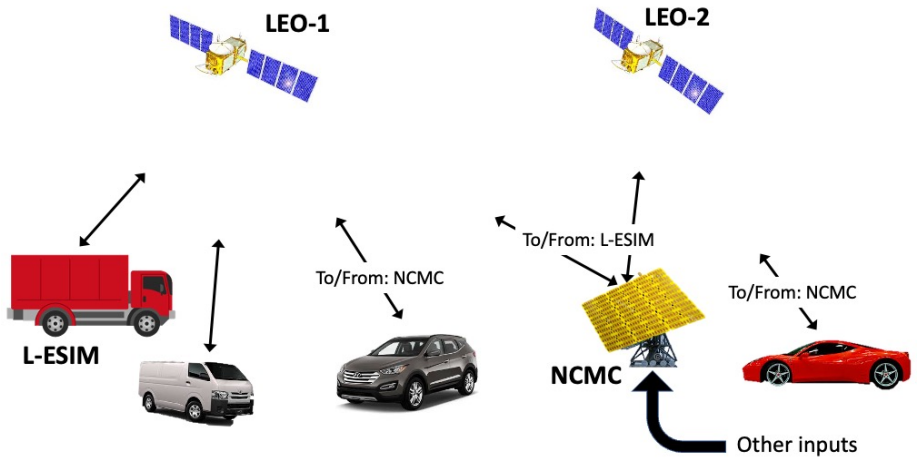
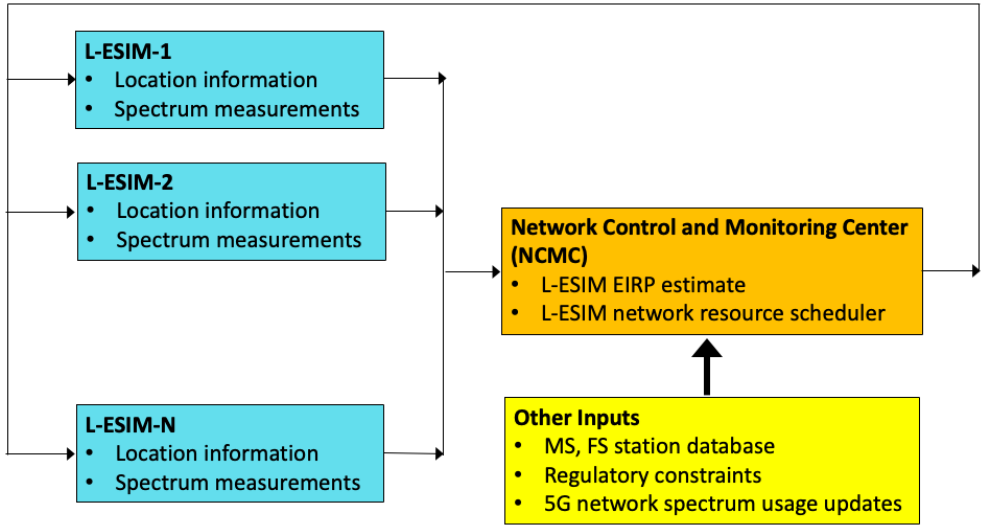
L-ESIM Network and NCMC communicating via LEO satellites



NCMC controling EIRP and resources of L-ESIM



Enhance Resiliency of NTN

- **Scenario description**
  - Satellites, unlike base stations, are susceptible to cyberattacks from distant locations[1,2]
  - The NR NTN waveform is vulnerable to jamming, spoofing and sniffing attacks[3]
    - Smart jammers can easily attack vulnerable channels
      - Signalling and control channels are especially vulnerable
      - SSB, PBCH, PRACH, and other channels are all susceptible to attacks
      - PSS (Primary Synchronization Signal): Downlink signal critical for network synchronization and timing
        - Jammer: low complexity and very low power
      - PRACH (Physical Random Access CHannel): Uplink channel necessary for link establishment
        - Jammer: medium complexity and medium power
- **Proposed enhancement**
  - Enhance resiliency of NTN PHY-layer channels (examples on the following slide)
- **Benefits**
  - Increased reliablity, lower outages, assured connectivity

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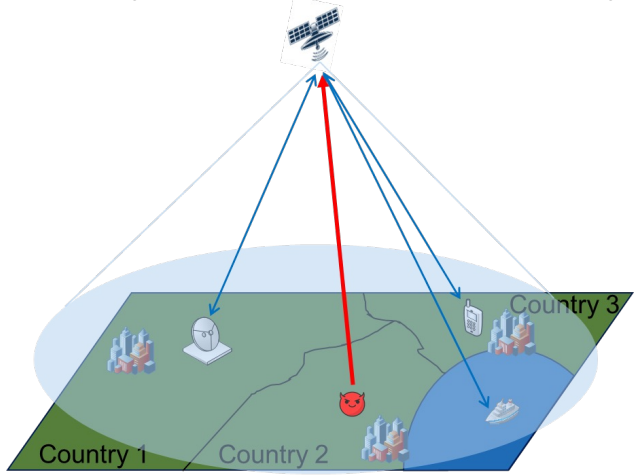
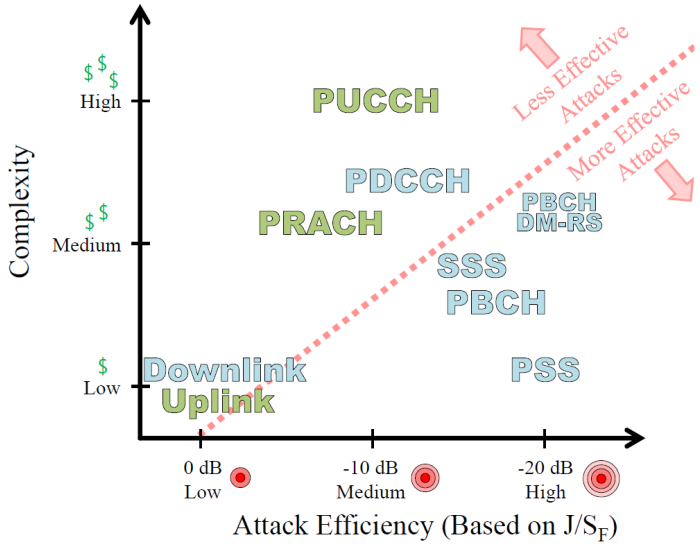
Satellite cyber attack from a different country



Complexity of attacking various NR (TN) channels vs. power efficiency[3]



[1]L. Laursen, "Satellite Signal Jamming Reaches New Lows. Startlink and other LEO constellations face a new set of security risks," IEEE Spectrum. 18 May 2023.
[2]R. Harmanci, "How Do You Hack a Satellite?" *Bw Daily*, March 1, 2023, https://www.bloomberg.com/news/newsletters/2023-03-01/satellite-hacking-is-a-big-and-little-understood-cyberwar-threat.
[3]M. Lichtman, R. Rao, V. Marojevic, J. Reed and R. P. Jover, "5G NR Jamming, Spoofing, and Sniffing: Threat Assessment and Mitigation," *2018 IEEE International Conference on Communications Workshops (ICC Workshops)*, Kansas City, MO, USA, 2018, pp. 1-6, doi: 10.1109/ICCW.2018.8403769.

Example: Potential Resiliency Enhancements to NTN

- Resiliency enhancements to NTN waveforms
  - Multiple, UE-specific, time/frequency resources to transmit SSBs1, PRACH, PDCCH, etc.
  - Encryption
- Multi-Satellite Diversity: availability of a large number of LEO satellites makes this feasible
  - TR 38.821 discusses architectural aspects
  - Network coding across satellites[2, 3, 4, 5]
- Connectivity via multi-band satellite links
  - Some satellite constellations support multiple band links
- Satellite-Terrestrial Diversity: terrestrial network support for satellite links

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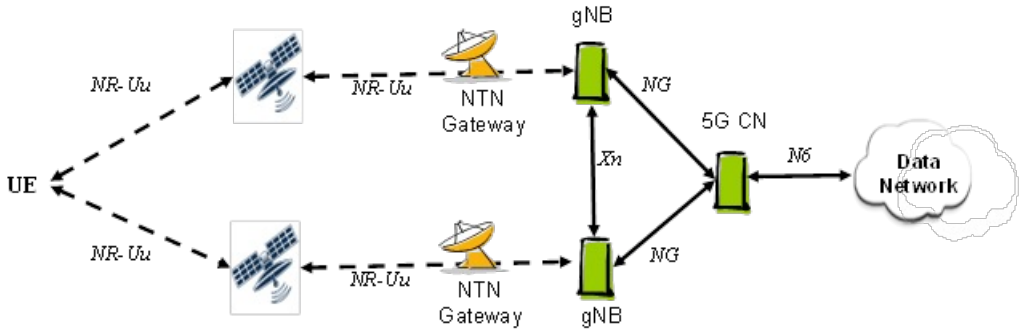
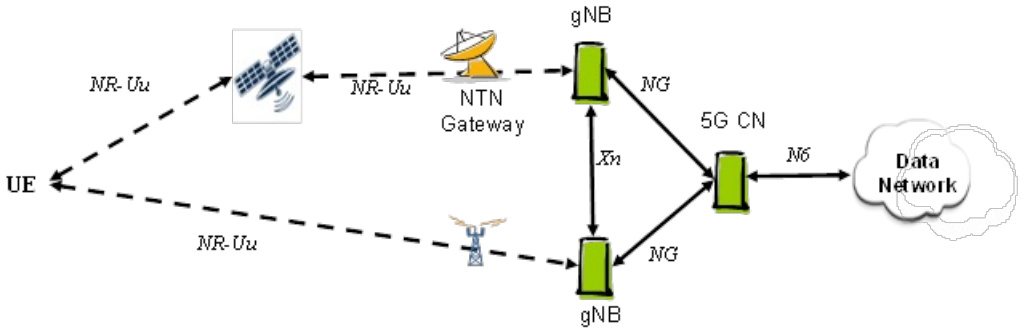


Multi-Satellite Diversity[6]



Satellite-Terrestrial Diversity[6]

[1]X. Lin, Z. Lin, S. E. Löwenmark, J. Rune, R. Karlsson and Ericsson, "Doppler Shift Estimation in 5G New Radio Non-Terrestrial Networks," 2021 IEEE Global Communications Conference (GLOBECOM), Madrid, Spain, 2021, pp. 1-6, doi: 10.1109/GLOBECOM46510.2021.9685184.
[2]Qualcomm, "On Coding Evolution for Rel-18 & Beyond," RWS-210028. 3GPP TSG RAN Rel-18 Workshop, June 28 – July 2, 2021.
[3]ZTE, Sanchips, "Discussion on Network Coding for 5G Advanced," RWS-210484. 3GPP TSG RAN Rel-18 Workshop, June 28 – July 2, 2021.
[4]Intel Corporation, "Linear Packet Coding in L2 for RAN Performance Improvement," RWS-210368. 3GPP TSG RAN Rel-18 Workshop, June 28 – July 2, 2021.
[5]AT&T, "Views on Non-eMBB-driven Functional Evolution for Rel-18," RWS-210213. 3GPP TSG RAN Rel-18 Workshop, June 28 – July 2, 2021.
[6]3GPP TR 38.821

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