Fraunhofer
IIS

Fraunhofer Institute for Integrated Circuits IIS

Summer 2026 OAI Workshop

OAI 5G NR NTN – Current State and Roadmap

Porto, June 22th, 2026

Thomas Schlichter, Raghavendra Dinavahi, Thomas Heyn
Wireless Systems & Standardization Department
Communication Systems Division

Fraunhofer IIS

Fraunhofer Institute for Integrated Circuits IIS

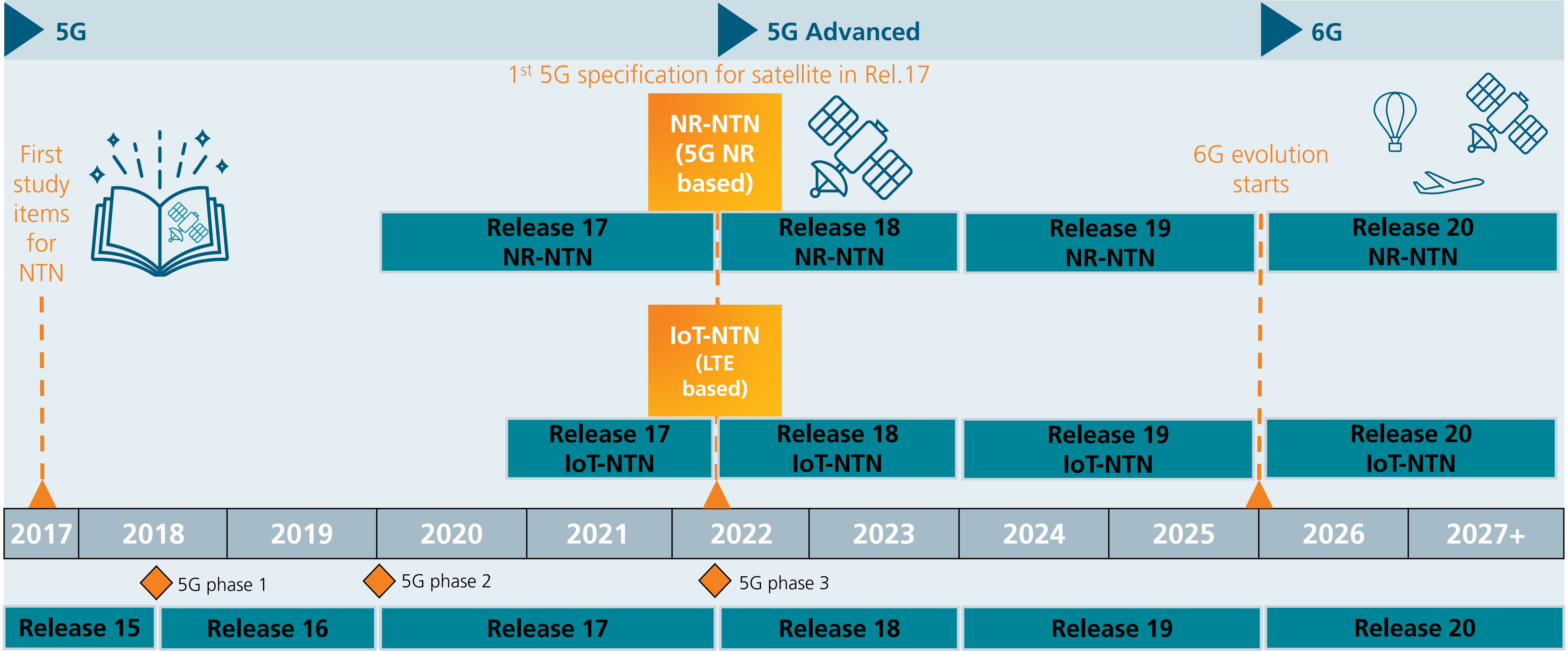
Summer 2026 OAI Workshop

5G ADVANCED

3GPP NTN Functionality Releases 17-19

3GPP 5G/6G NTN Roadmap

3GPP: Satellite Support fully integrated in 5G Standard since Release 17!

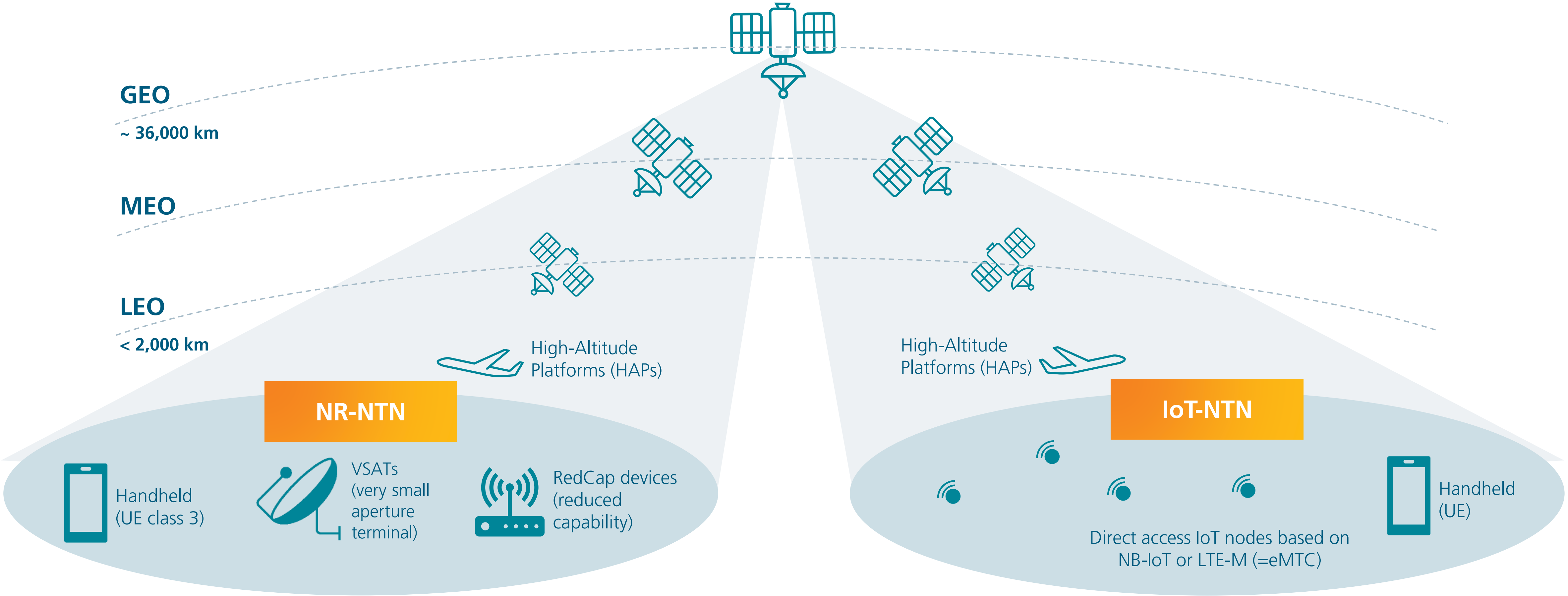


Fraunhofer IIS

3GPP 5G/6G NTN Architecture

NR-NTN and IoT-NTN

NTN =
LEO, MEO, GEO satellites and HAPs



Based on 5G New Radio (RAN specification series 38.xyz), **bandwidth 3 to 400 MHz**

Based on 4G LTE (RAN specification series 36.xyz), **bandwidth 180 kHz** / 1.4 MHz

3GPP 5G/6G NTN Features

Feature overview **NR-NTN**

Aspect	Basic spec in Rel-17	Additionally, in Rel-18	Additionally, in Rel-19	Additionally, in Rel-20
Completion date (core part for RAN)	June 22	March 2024	June 2025	2027
System architecture	**Transparent satellites (GEO, non-GEO);** Earth fixed/moving beams		**Regenerative payload (gNB on board; ISL)**, mesh connectivity (UE-Sat-UE)	
Aspects in RAN	Adaptations for long latency / Doppler	Network verified UE location, UL coverage enhancements	DL coverage enhancements, broadcast, UL capacity enhancements, channel bandwidth 3 MHz (in SAN spec, not in UE spec)	**HD-FDD in >10 GHz bands Study on GNSS robust operation**
RAN – Mobility (See dedicated slide)	Basic mobility based on terrestrial methods	**NR-NTN to NR-NTN conditional handover** in RRC_CONNECTED mode. NR-TN to NR-NTN handover in RRC_IDLE mode.	**LTE TN (incl. 5G NSA deployments!) to NR NTN** in RRC_IDLE mode (still with few seconds break during connections)	**Connected mode mobility LTE TN to NR-NTN**
Terminals	Smartphones (Power 23 dBm) with GNSS	5 UE typed with GNSS: Fixed **VSAT** for GSO/NGSO, mobile VSAT only for GSO (both with **mechanical and electronic steering** antennas)	**High power UE (26 dBm, 31 dBm)** for handheld and non-handheld; RedCap UE; (big) mobile VSAT for NGSO in Ku-band	**HPUE 29 dBm Small mobile VSAT for NGSO with HD-FDD**; GNSS robust operations
Frequency bands (all FDD)	**FR1: S-band (n256), L-band (n255)**	Combined L-/S-Band (n254), **Ka-band FDD** (n510, 511, 512)	**Ku-Band in FDD mode (FR1** & FR2 numerology), additional S- and L-bands	Discussion about IMT spectrum for NTN

Fraunhofer IIS

Fraunhofer IIS

Fraunhofer Institute for Integrated Circuits IIS

Summer 2026 OAI Workshop

OAI NTN Implementation

OAI NTN Implementation

Current State (1/2)

Currently supported High-Level NTN features

- Satellite Orbits: GEO and LEO
- gNB on board (regenerative SAT) or on ground (transparent SAT)
- Frequency Range 1
- Subcarrier Spacing: 15 kHz and 30 kHz
- Bands n254-n256
- Limited support for F1-based NTN/NTN Handover

Currently implemented features esp. for GEO satellites

- Extended rf-simulator for large delay
- Consider CellSpecificKoffset esp. for UL scheduling at gNB
- Disabling HARQ at gNB and UE esp. for GEO satellites
- Channel State Information (CSI) Reporting of SSB-SINR
- Adaptive Modulation and Coding (AMC) based on SSB-SINR (DL) and UL SNR

OAI NTN Implementation

Current State (2/2)

Currently implemented features esp. for LEO satellites

- Extended rf-simulator for time variant delay and Doppler
- Continuously updated SIB19 with current satellite orbit information
- Support for 32 (instead of 16) HARQ processes
- Improved DL time sync at UE to compensate continuous time drift
- Extended UL timing advance procedures at UE
  - Either autonomous TA adjustment based on DL time drift,
  - Or standard-compliant SIB19 based TA computation
- Continuous frequency offset compensation at UE
  - DL frequency offset (Doppler) compensation based on PBCH DMRS
  - UL frequency offset (Doppler) pre-compensation based on DL Doppler

OAI NTN Implementation

Roadmap (1/3)

High-Level NTN features in our pipeline

- Additional Satellite Orbits: GEO, LEO **+ MEO**
- Frequency Range 1 **+ 2**
- Subcarrier Spacing: 15 kHz, 30 kHz **and 120 kHz**
- Bands **n247-n256, n508-n512**
- ~~Limited~~ Support for F1- **and N2-**based NTN/NTN **and TN/NTN Conditional-**Handover
- **Support for SIB19 based SAT switching**
- **Support for TA-reporting and half-duplex FDD**

NTN feature contribution roadmap

- rf-simulator:
  - support transparent and regenerative MEO satellite orbit
- NR UE:
  - More accurate TA computation by considering DL and UL delay separately
  - Improved DL time sync by computing time drift based on SIB19
  - Improved FO (pre-)compensation by computing DL and UL Doppler based on SIB19
  - Improved inter-satellite HO by DL Doppler computation of target satellite

OAI NTN Implementation

Roadmap (2/3)

NTN feature contribution roadmap (continued)

- gNB and NR UE:
  - Add Rel-19 bands n247-n253, n508, n509
  - Time event (T1) triggered CHO, F1- and N2-based
  - Location event (D1) triggered CHO, F1- and N2-based
  - SIB19 based SAT switching
  - TA-reporting
- gNB:
  - Modify scheduling to support half-duplex FDD, considering UE-specific TA from TAR

Not NTN specific feature roadmap

- Optimized cont-fo-comp at NR UE by rotating used OFDM symbols only
- Improved write reorder handling at NR UE
- Improved application of initial TA from RAR at NR UE
- Support specifying IF frequencies per cell in NR UE configuration file
- Support for multiple cells at different IF frequencies at same RF port at NR UE

OAI NTN Implementation

Roadmap (3/3)

When?

- All but NTN half-duplex FDD by End of 2026!
- NTN half-duplex FDD planned for 2027
  - NTN half-duplex FDD is not standardized, yet
  - Planned for Rel-20

Fraunhofer IIS

Fraunhofer Institute for Integrated Circuits IIS

Summer 2026 OAI Workshop

NTN Testing Aspects – H2SAT, SEVECODE, LINO, IRIS²-Testbed

Testing Aspects

Heinrich-Hertz GEO Satellite fc

Space Segment

- Digital payload in transparent

Ground & User Segment

- NTN Gateway incl. Base Static
- NTN UE: Uu by 5G NR-NTN

https://www.iis.fraunhofer.de/en/ff/kom/satk

Beitrag von Fraunhofer IIS

Fraunhofer IIS
36.498 Follower:innen
5 Tage

5G via Satellit: Hohe Bandbreiten über Heinrich-Hertz-Satellit getestet

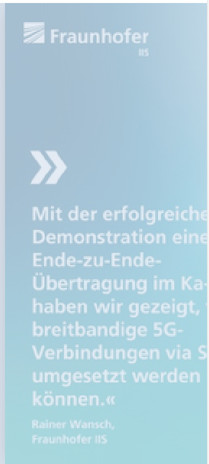
In hohen Frequenzen wie dem Ka-Band steht viel Bandbreite zur Verfügung. Wenn wir sie für nicht-terrestrische Netze (#NTN) nutzen, werden Satellitenmobilfunknetze deutlich leistungsfähiger. Wie die Umsetzung gelingt, haben wir jetzt über den deutschen Kommunikationssatelliten Heinrich Hertz im geostationären Orbit getestet.

Die Tests erfolgten im Rahmen der Heinrich-Hertz-Mission, die von der Deutsche Raumfahrtagentur im DLR geführt wird.

Unsere Ergebnisse im Überblick:
- 5G-NTN-Übertragung im Ka-Band mit speziell angepasstem Sender und Empfänger
- Kanalbandbreiten von 50 bis 100 MHz
- Datenraten bis zu 137 Mbit/s
- Nahtloser Handover zwischen Nord- und Südbeam des Satelliten

Damit zeigen wir: 5G via Satellit im Ka-Band ist ein zentraler Baustein, um leistungsfähige Mobilfunknetze auch in schwer zugänglichen Regionen verfügbar zu machen.

Mehr Details zum Kommunikationsexperiment in unserer Pressemitteilung: https://lnkd.in/d4ev_qNd



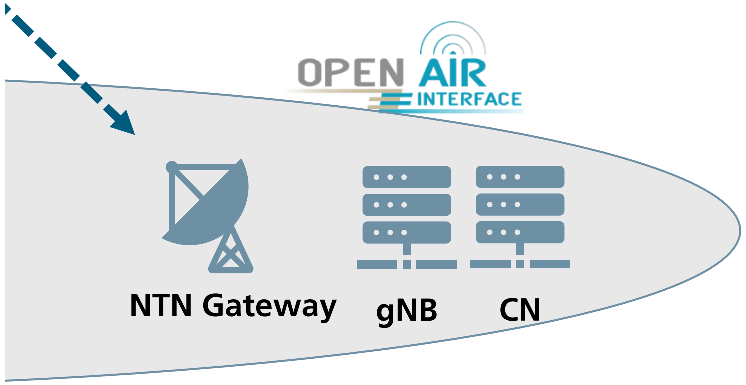
64

Heinrich Hertz GEO Satellite

© Fraunhofer IIS/Roger Riedel

Fraunhofer OBP (FOBP)

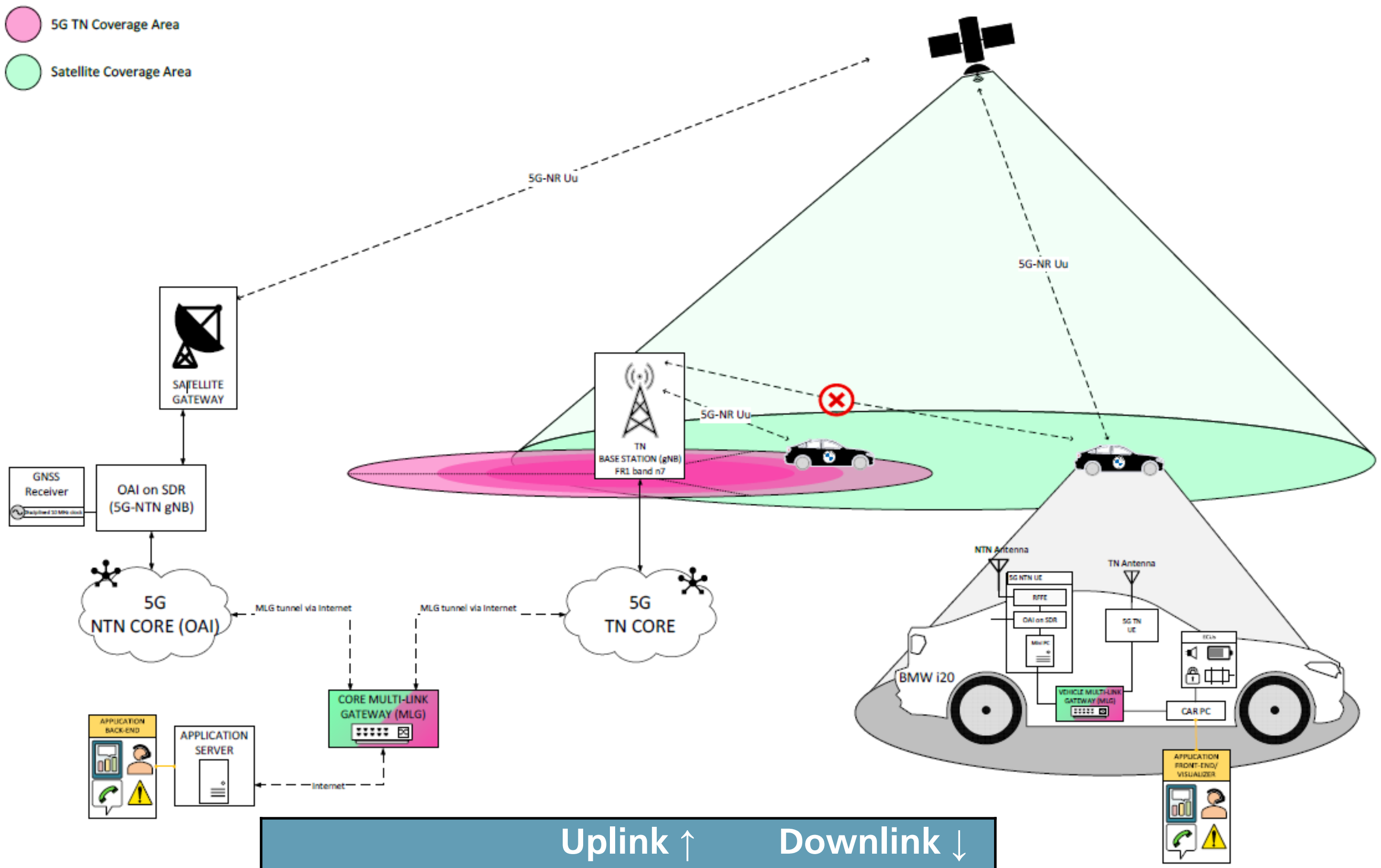
© Fraunhofer IIS/Paul Pulkert



Fraunhofer IIS

ESA SEVECODE

V2X - SERVICES DEMONSTRATION OVER SATELLITE



5G NR Dual System

- **NTN Network** at Griesheim, HUGHES
  - GEO Transparent Satellite operating in FR1
  - Core & gNB NTN OAI based
- **TN Network** at Erlangen, FIIS
  - Mobile gNB & Core by Deutsche Telekom
- Core MLG by MediaMobil as an interface between both networks' edges

Application Server at Munich, JEMBER

Demo location - Erlangen, FIIS

	Uplink ↑	Downlink ↓
NTN Feeder Link	Ka band	Ka band
NTN Service Link	FR1 (n256) 1980–2010 MHz	FR1 (n256) 2170–2200 MHz
TN Service Link	FR1 (n7) 2500 – 2570 MHz	FR1 (n7) 2620 – 2690 MHz

ESA 6G LINO (Laboratory IN Orbit)

Satellite Mission

https://connectivity.esa.int/projects/6g-lino

Satellite

- Size: 16U Cubesat satellite by OpenCosmos, UK
- Mass: 26 kg
- Power: < 200 Watts
- Payload: Reconfigurable Regenerative based on SoC by TESAT
- Orbit: LEO at 500-600 km altitude, 97.4° inclination (Polar Orbit)
- Launch: begin 2027

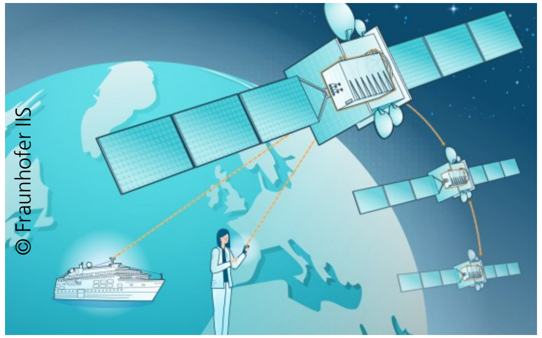
Air Interfaces

- User Link: 5G NR-NTN (OpenAirInterface gNB, UE)
- Feeder Link: DVB-S2X

ESA 6G LINO (Laboratory IN Orbit)

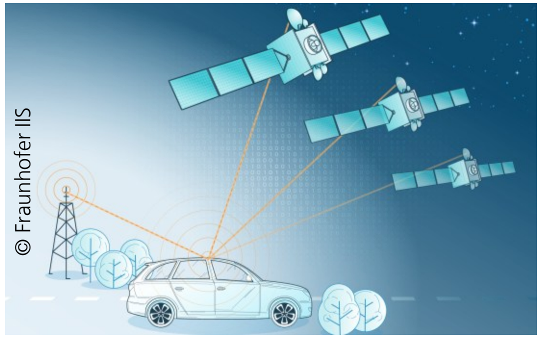
Our First Initial 4 Experiments

#1: E2E Demonstration



End-to-End transmission via satellite with NR-NTN base station (gNB) onboard the satellite

#2: Handover (TN/NTN)



Live demonstration and evaluation of 3GPP based conditional handover (CHO) between non-terrestrial and terrestrial base stations (gNBs)

#3: Spectrum Management

Spectrum monitoring in space as preparation for future spectrum allocation techniques assessments

#4: 6G Waveform

Logo: 3GPP.org

Test and evaluation of possible 6G waveform enhancements

NTN Testing Aspects

IRIS² Testbed

Fraunhofer IIS develops a testbed for IRIS²

- ESA funded
- partners are WORK Microwave and JoanneumResearch

Testbed comprises

- Multiple base-stations (gNB)
- Multiple UE
- Background traffic emulation for cell loading
- Channel emulation

- Multiple features: **FR1 & FR2 numerology, CHO, Multi-orbit, CU/DU split…**

Fraunhofer IIS
32.216 Follower:innen
3 Monate

Gemeinsam mit #WORKMicrowave und #JoanneumResearch entwickeln wir im Rahmen des von der #ESA finanzierten »Programme Related to EU Secure Connectivity« ein Testbed, das die ESA in ihrer Rolle als Qualifizierungs- und Validierungsstelle für #IRIS2 unterstützen wird.

Es kann beispielsweise erprobt werden, wie die Übertragung unter bestimmten Wetterbedingungen beeinflusst wird, wie der Datenaustauch über Basisstationen auf Satelliten läuft oder wie ein Handover über mehrere Satelliten hinweg gelingt. Dafür bauen wir eine komplette, 5G-basierte Übertragungskette auf – vom Endgerät über die per Kanalemulator nachgebildete Satellitenverbindung bis zur Basisstation.

Da es derzeit noch keine 5G User Terminals und Basisstationen für die Satellitenkommunikation gibt, entwickeln wir am Fraunhofer IIS Prototypen dieser beiden Komponenten. So bringen wir Mobilfunk und Satellitenkommunikation zusammen!

* Official ESA Disclaimer: The view expressed herein can in no way be taken to reflect the official opinion of the European Space Agency.

Fraunhofer IIS

Fraunhofer IIS

Fraunhofer Institute for Integrated Circuits IIS

Contact

Thomas Schlichter
Senior Engineer
Testbeds & Prototyping Group
Wireless Systems & Standardization Department
Communication Systems Division
Phone +49 9131 776-4055
Thomas.schlichter@iis.fraunhofer.de