Fraunhofer IIS

Fraunhofer Institute for Integrated Circuits IIS

NTN Days, Toulouse FRANCE
October 1st, 2025

6G Laboratory In Orbit (ESA 6G-LINO)

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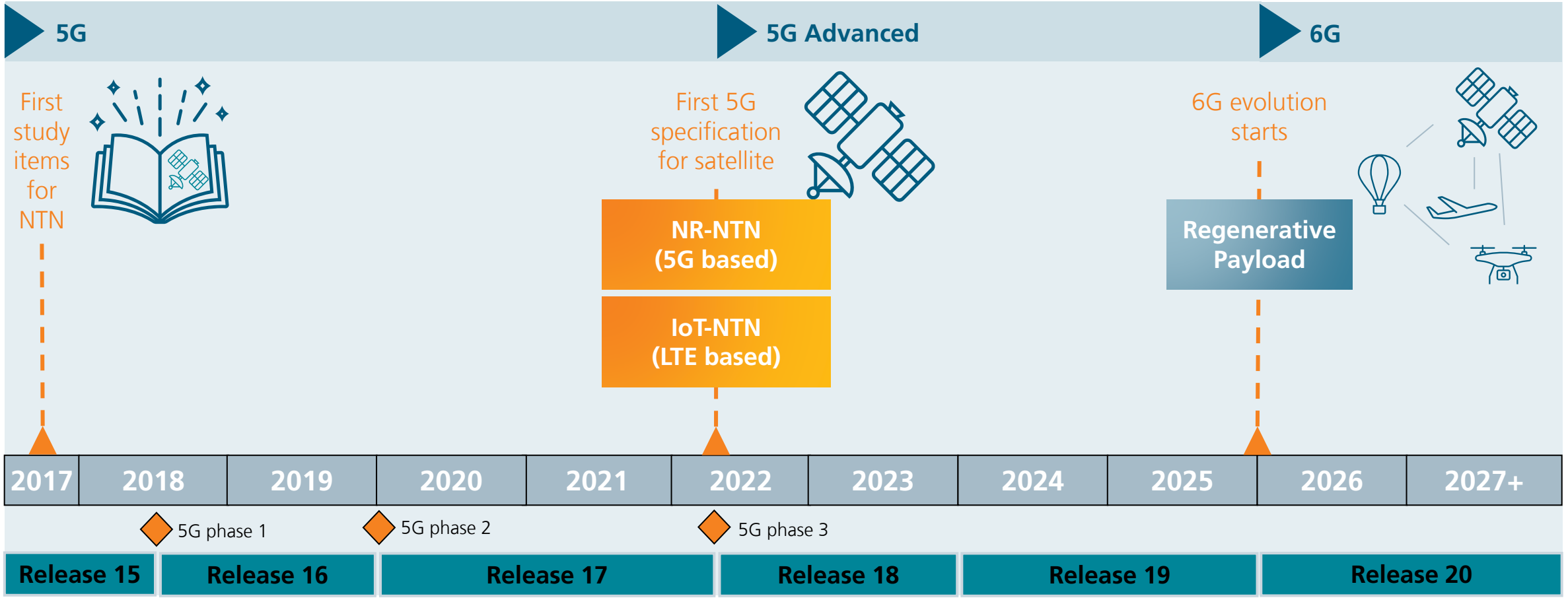
Non-Terrestrial Networks (NTN)

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



ESA 6G LINO (Laboratory IN Orbit)

Project Details

Mission

Scientific experimental demonstration satellite mission (previously called 6G SATELLITE PRECURSOR - STERLING IN-ORBIT LABORATORY)

Goals

- Enable Europe in the field of 5G/6G satellite communications, e.g. for Direct-2-Device communications
- Deliver an open in-orbit laboratory incl. space, ground & user segment
- 6G applications can boost the technological potential of the European digital and aerospace industry and broadband connectivity even further

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Project Details

Main Contractor

European Space Agency, ESA ESTEC for its ARTES 4.0 SPL 5G/6G program line

Consortium / Partners

Germany:

- Tesat, Airbus DS, Fraunhofer IIS

United Kingdom:

- OpenCosmos, University of Surrey

Source: https://www.tesat.de/news/press/943-esa-selecs-tesat-for-6g-precursor

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Satellite Mission

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: Q4/2026

Source: https://www.nanosats.eu/sat/mantis

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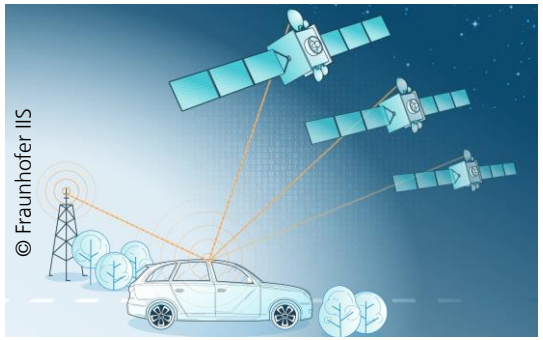
Our First Initial 4 Experiments

#1: End-to-End 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

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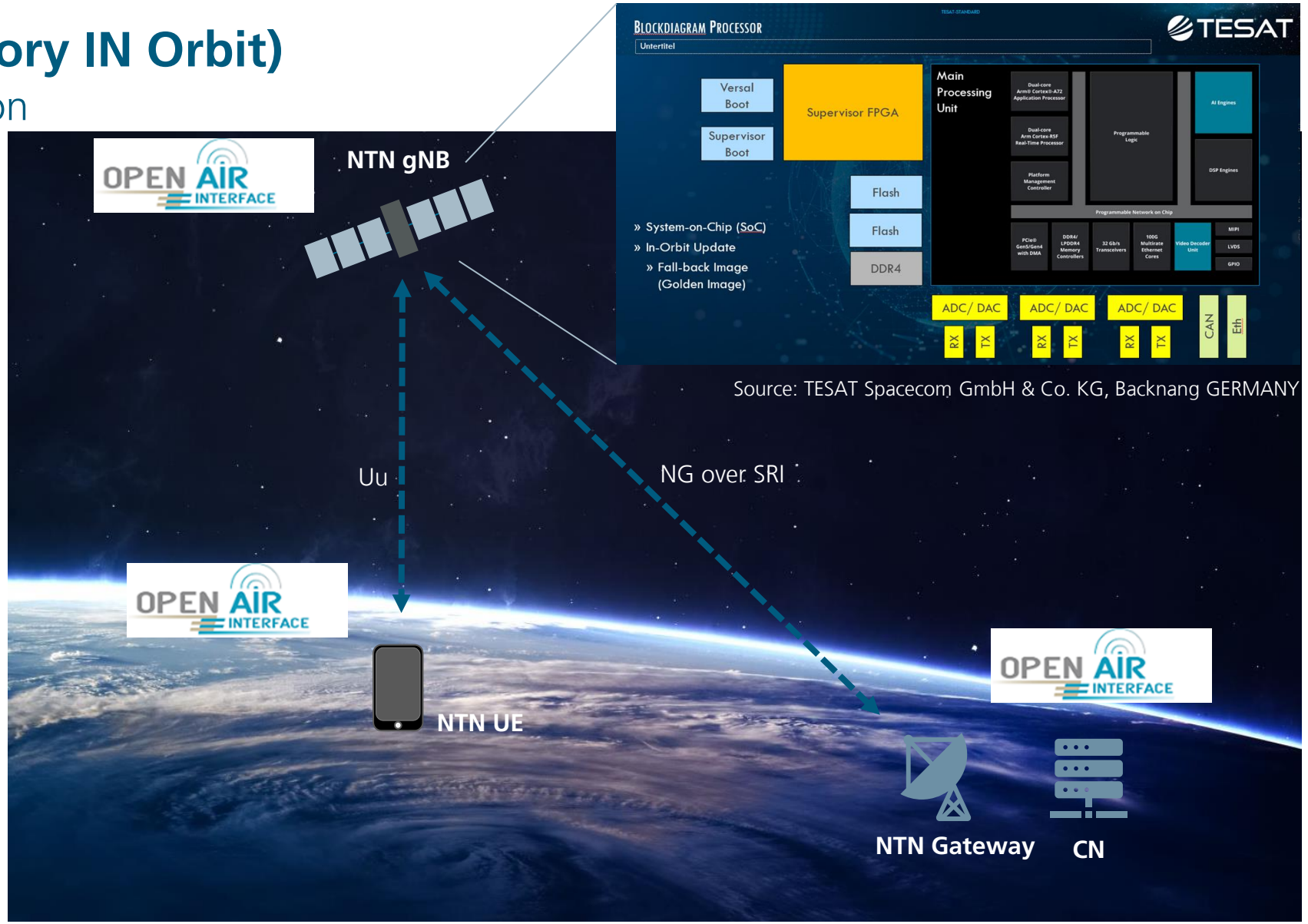
#1: End-to-End Demonstration

Space Segment

- NTN End-to-End demonstration with full gNB implementation in the reconfigurable payload

Ground & User Segment

- NTN Gateway: Feeder-Link (SRI) based on DVB-S2X
- NTN UE: Uu Interface based on NR-NTN
- Frequency: K/Ka band (Down/Up-Link)



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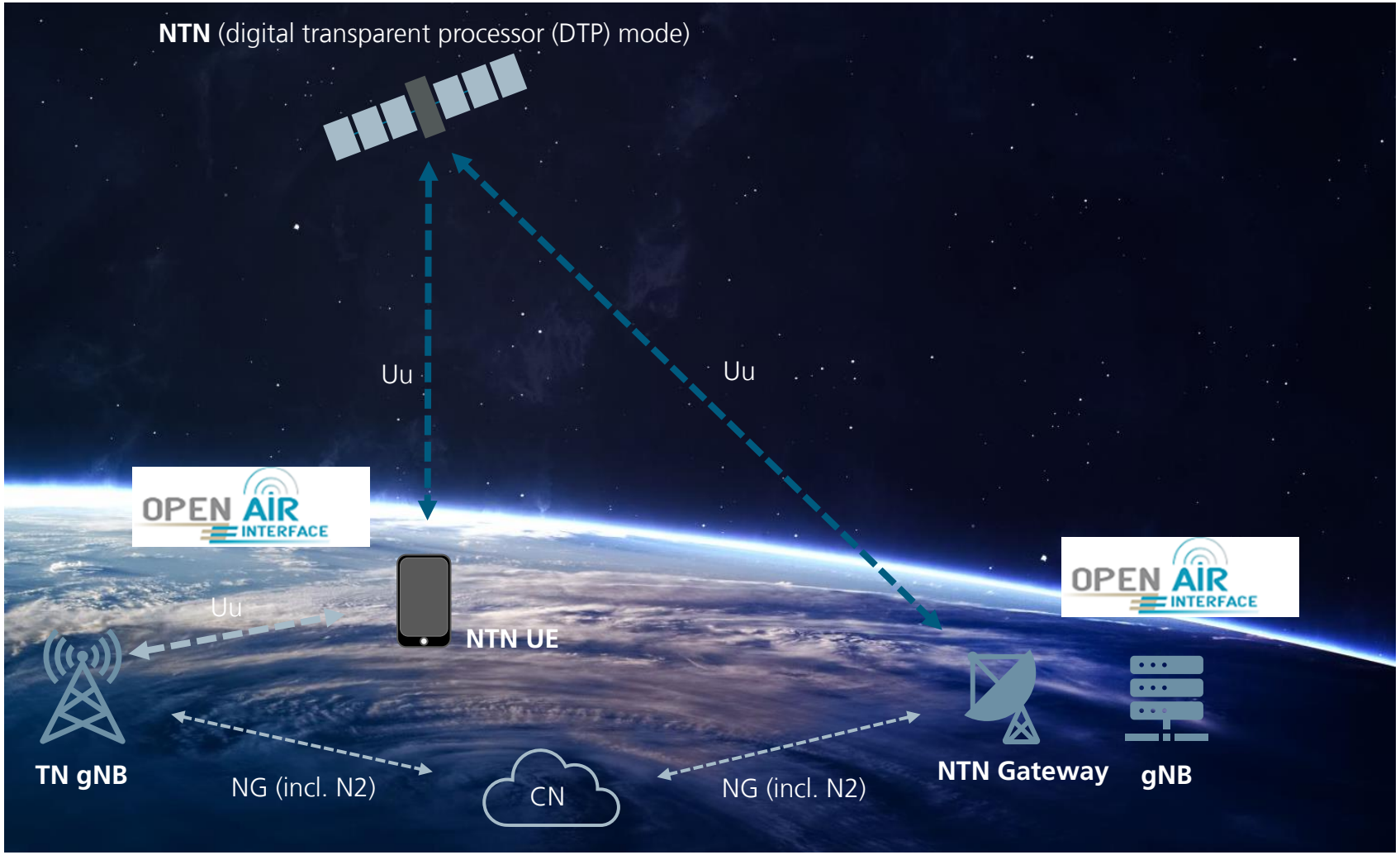
#2: Handover (TN/NTN)

Space Segment

- Digital payload in transparent mode

Ground & User Segment

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



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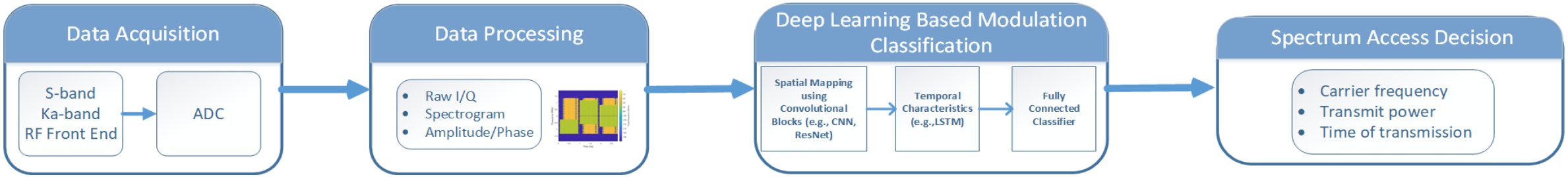
#3: Spectrum Management



Motivation

- Ground-based and space-based spectrum monitoring for license-shared and unlicensed access
- Resource constraints for implementation with joint communication or dedicated sensing platforms

State-of-the-Art

- Comprehensive selection of convolutional and hybrid architectures for benchmarking performance using the same labeled dataset
- Evaluation of complex-valued neural network implementation for selected CNNs

Model	Parameters(10^3)	MFLOPS(10^6)
Modified ResNet	240	153
MCNet	126	22.9
MBNet	65	18.4
SBCNN	88	85
Lmod	102	162
CLDNN	109	166
SRCNN	1378	237
MCLDNN	407	291
DUAL	1271	872
MLResNet	121	156
GrrNet	654	898
CvResNet	447	604
CvLmod	204	647

Raghunandan, Sahana; Begaj, Sara: "Analysis of deep neural networks for automatic modulation classification", IET Conference Proceedings, p. 117-122, January 2023, [Online] Available: https://digital-library.theiet.org/content/conferences/10.1049/icp.2024.0832

A. Vagollari, M. Hirschbeck and W. Gerstacker, "An End-to-End Deep Learning Framework for Wideband Signal Recognition," in IEEE Access, vol. 11, pp. 52899-52922, 2023.

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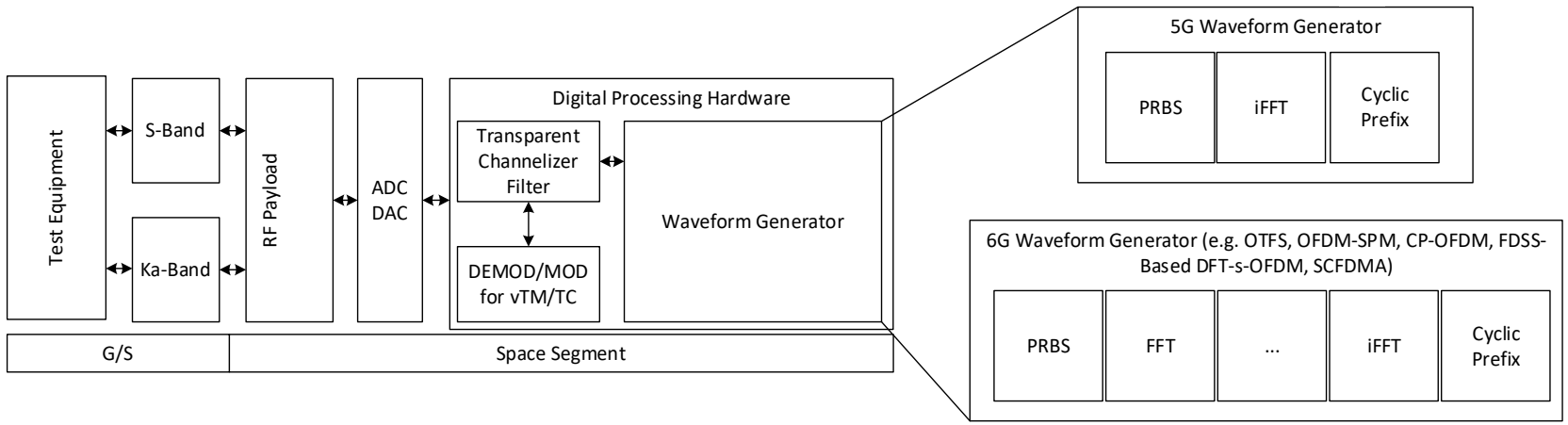
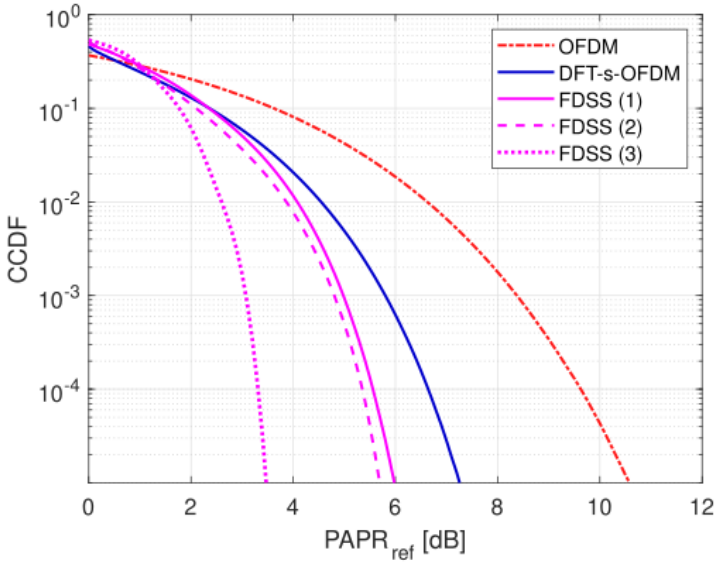
#4: 6G Waveform

Logo: 3GPP.org

- Goal: Improve efficiency, e.g. in terms of Peak-to-Average-Power-Ratio (PAPR) reduction
- Baseline waveform still based on DFT-s-OFDM, possible 6G enhancements candidates could be:
  - FDSS (Frequency-Domain Spectral Shaping)
  - DFT-s-OFDM
  - OFDM-SPM (OFDM with Subcarrier Power Modulation)
  - SC-FDMA (Single Carrier FDMA)
  - uNOW (unified Non-Orthogonal Waveform)





ESA 6G LINO (Laboratory IN Orbit)

Open Platform for Everyone

Open platform for future live experiments and demonstration via a flexible LEO satellite

Aims demonstration and test of future 6G techniques as proof-of-concept

Please contact us for your 6G experiment ideas

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