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

TRANTOR: paving the path to 6G NTN through multi-connectivity

Xavier Artiga

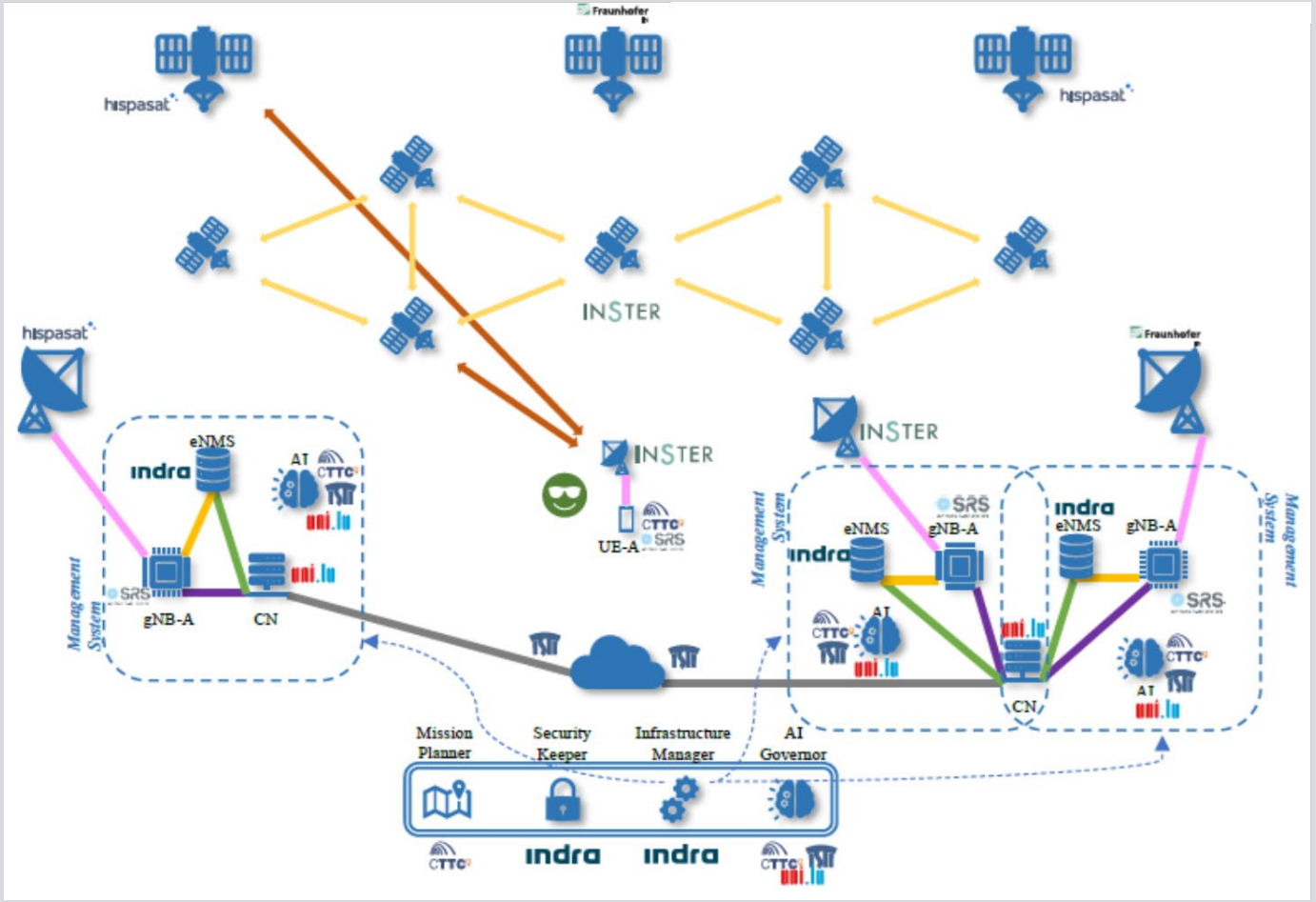
04/04/2024

5G+ EVOLUTION TO MUTIORBITAL MULTIBAND NETWORKS

Call: HORIZON-CL4-2021-SPACE-01
Type of Action: HORIZON-RIA
Acronym: TRANTOR
Current Phase: Grant Management
Number: 101081983
Duration: 36 months
GA based on the: HE MGA — Multi & Mono - 1.null
Start Date: 01 Jan 2023
Estimated Project Cost: €5,994,545.00
Requested EU Contribution: €5,994,544.75
Contact: Konstantinos PLIAKOSTATHIS

6G VISION

- 6G basic pillars:
  - User-centric communication systems
  - overcrowded NTN layered network
  - Automated and data driven network management system
- Current state:
  - Satellite systems are monolithically and independently operated
  - Users assigned to a single satellite resource
- TRANTOR will develop and demonstrate the enablers for a dynamic and automated operation of multi-link satellite networks
  - Multi-band
  - Multi-satellite
  - Multi-orbit

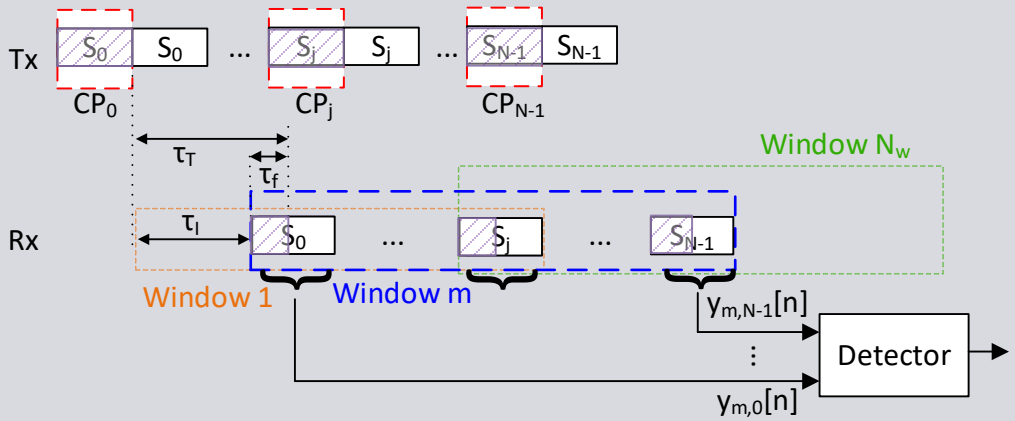


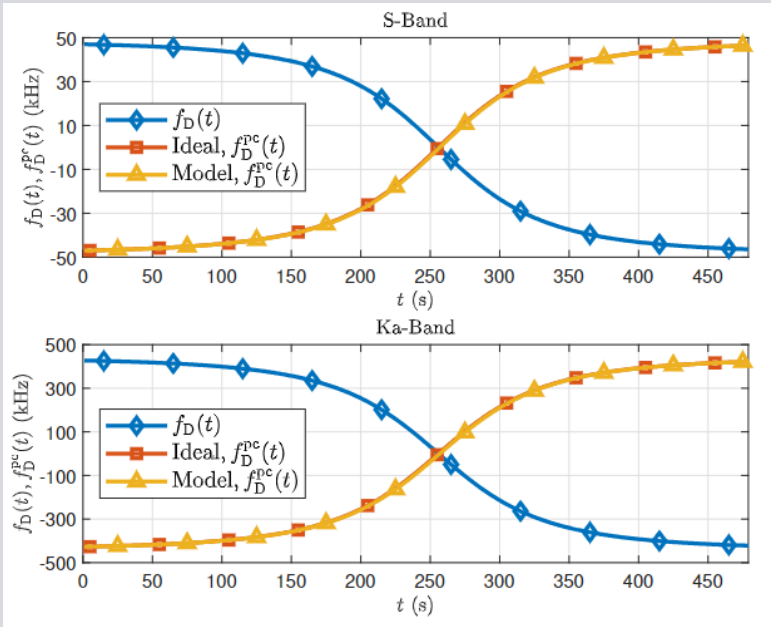
WORK FLOW & RELATION WITH STANDARDIZATION

- Release 17 as starting point:
  - Development of compliant SDR gNB and UE
  - Experimental demonstration through real GEO (Jun24) and a drone emulated LEO (DEC24)
- RAN improvements for initial access in FR2 (RAN1)
- Evaluation of CU-DU splitting options (RAN3)
  - Experimental demonstration of low PHY (7-2) split with real GEO satellite (DEC24)
- Evaluation of L1-2-3 multi-connectivity options (RAN2)
- Architectures for integrated & automated management (SA2, IETF)
  - Telemetry, QoS and multipath management
- AI/ Non AI-based resource management
- PHY- Network security aspects
- Mission Planner: software tool to design & evaluate complex multi-orbit scenarios
- Multi-connectivity experimental demonstrations (DEC25)
  - Single GEO multi-band (Ka/Ku)
  - Dual-connectivity with 2 GEOs
  - Dual connectivity with 1 GEO and a drone –emulated LEO
  - Dual-band multiorbit UE antenna

RAN IMPROVEMENTS FOR INITIAL ACCESS

- Novel PRACH signal design to increase the robustness to time and carrier frequency offsets in FR2.
  - **Advantages:** Guarantee the initial access of LEO satellite systems in presence of UE positioning errors.
  - **Trade-offs**: Increased complexity of the preamble detection scheme.
  - **System Impact**: gNB, UE, PHY layer, PRACH signal design and detection.
- Per beam adaptive frequency pre-compensation onboard LEO satellites
  - **Advantages:** Reduces the carrier frequency offset search space due to the satellite-induced Doppler effect.
  - **Trade-offs**: Increased control logic onboard the satellite.
  - **System Impact**: gNB, PHY layer, SSB generation.
- Downlink synchronization rasters for Ku and Ka band
- Doppler post-compensation at UE





MULTI-CONNECTIVITY

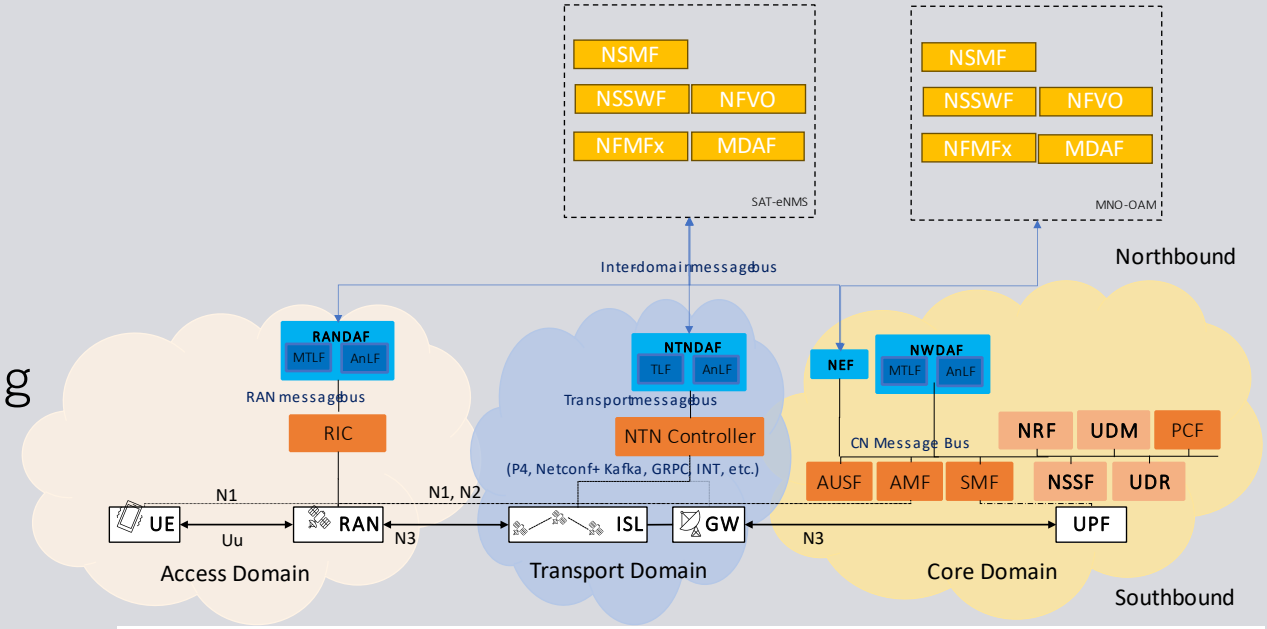
- Evaluation of MC scenarios and architectures:
  - Layer 1: mTRP
  - Layer 2: Dual connectivity (DC) & carrier aggregation (CA)
  - Layer 3: Network (MA-PDU)
- Current standardization supports NTN as far as MRTD is manageable
- MC Open Issues for NTN
  - Packet re-ordering, interface management, etc.
- Updated HO and SN procedures during NTN NR-DC connectivity
  - **Advantages**: Uninterrupted data plane connection, minimized data forwarding and buffering in the space segment
  - **Trade-offs**: Increased backhaul signaling.
  - **System Impact**: HO and SN procedures.

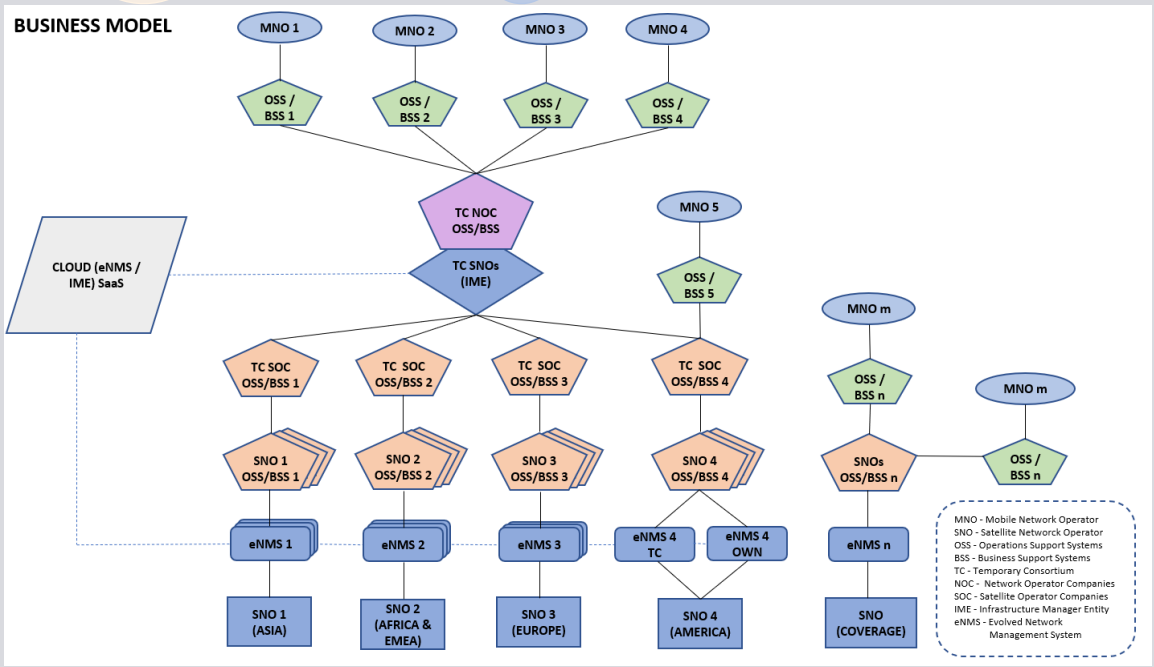
SN.	MC Scenario	Use Case	KPI
A	Multi-band, Single-GEO	Wide-area public safety	High reliability
B	Multi-band, Single-LEO	Hybrid TN-NTN for remote healthcare and telemedicine	Low latency and high reliability
C	Single-band, Multi-GEO	Remote environmental monitoring and disaster management	Ubiquitous coverage
D	Single-band, Multi-LEO	Disaster response and emergency communication	Low latency and wide coverage area.
E	Multi-band, Multi-GEO	NTN-TN Service continuity for mobile UE	High data rate & seamless handover
F	Multi-Band, Multi-LEO	Hybrid TN-NTN for rural connectivity	High reliability and wide coverage
G	Single-band, Multi-Orbital (LEO+GEO)	Maritime connectivity	High data rate and ubiquitous coverage
H	Multi-band, Multi-Orbital (LEO+GEO)	NTN-TN service continuity for mobile UE	High data rate and seamless handover
		Aerospace and aviation communication	High data rate, Low-latency, and ubiquitous coverage

		MC Scenario							
MC Technique	**Architecture**	A	B	C	D	E	F	G	H
CN	MA-PDU	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split
DC	1	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	SC4	Any fun. split
DC	2	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split	Any fun. split
DC	3	Any fun. split	Any fun. split	Any fun. split	SC2	Any fun. split	Any fun. split	Any fun. split	Any fun. split
CA	---	SC1	Any fun. split	Fun. split 5-8	Fun. split 5-8	Fun. split 5-8	Fun. split 5-8	Exces. MRTD	Exces. MRTD
mTRP	NC-JT	Any fun. split	Any fun. split	SC3	Fun. split 7.2x, 7.1, 8	Fun. split 7.2x, 7.1, 8	Fun. split 7.2x, 7.1, 8	Exces. MRTD	Exces. MRTD
mTRP	C-JT	Not with MB	Not with MB	Exces. MRTD	Exces. MRTD	Not with MB	Not with MB	Exces. MRTD	Not with MB

ARCHITECTURES FOR INTEGRATED & AUTOMATED MANAGEMENT

- eNMS: evolution of satellite NMS to cloud based orchestrator
- IME (Integrated Management Entity): overarching element above multiple evolved eNMS
- Distributed analytics extraction to support QoS and Traffic Monitoring in Mid/Back-haul
  - In-band Network Telemetry (INT)





STANDARDIZATION APPROACH

- Limited consortium resources: Leverage on current involvement of TRANTOR participants in standardization groups/activities
  - Hispasat: GSOA, 3GPP (RAN1-4)
  - FHG IIS: 3GPP (RAN1-4), SSIG
- Identification of technological outcomes
- Advertisement to relevant standardization groups/activities

WHERE TO FIND US

Xavier Artiga (CTTC)

xavier.artiga@cttc.es

Centre Tecnològic de Telecomunicacions de Catalunya (CTTC/CERCA)

Castelldefels (Barcelona), Spain

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101081983.