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Dynamic spectrum sharing and bandwidth-efficient techniques for high-throughput MIMO Satellite systems

D2.4: Enabling Technologies and Roadmap – Version 1

Revision 1.1

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Abstract

This document aims at characterising the key technologies useful for DYNASAT. Candidate technologies, for spectrum sharing, are discussed and few of them are recommended for a short-term implementation, as required for a roadmap 2025-2030, as well as methodology to follow.

Keywords: Spectrum Sharing, Direct Access, Satellite, Mobile, Beamforming

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| Nature of the deliverable: | R | |
| Dissemination Level | | |
| PU | Public, fully open, e.g., web | √ |
| CI | Classified, information as referred to in Commission Decision 2001/844/EC | |
| CO | Confidential to DYNASAT project and Commission Services | |

* *R: Document, report (excluding the periodic and final reports)*
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc...

EXECUTIVE SUMMARY

This document adds information related to the type of missions and focused on 2 of them, one with on-board gNB-RU and Digital Beam Forming Network (DBFN) and the other ones, with full on-board gNB (RU+DU+CU: Radio, Distributed, Central Units), User Plane Function (UPF) and DBFN (section 2.1).

Main operational constraints and user services to support by the system (payloads, Ground segment) are recalled, for contextual information, even if it is not in the scope of D2.4.

Then, the components of the functional architectures, for each mission are discussed in regards of payload configurability and flexibility requirements.

In Section 4, key technologies are described, compared when possible, discussing the mapping of the satellites beams over the earth 5G cells, preferred antenna types and components of the system, split between the satellite payload and the on-ground equipment: feeder link terminal, Inter-Satellite Link (ISL) terminal, gNB-RU/DU/CU, on-board DBFN, on-ground GW and on-board switch & router

Section 4 also provides several trade-offs: at system level, at NR (New Radio) level, helpful to select the most promising techniques.

In section, 5, guide lines for on-board components implementations are provided, discussing Commercial Off-the-Shelf (COTS) vs. Field Programmable Gate Array (FPGA) vs. Application Specific Integrated Component (ASIC) based way forwards.

A Multiple Input Multiple Output (MIMO) technique is recommended: Beamforming with precoding for short term, as evaluated as the most feasible technology, at short term, able to leverage the user link's capacity and mitigate the interferences between beam foot prints.

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ABBREVIATIONS

| | |
|--------|---|
| 3GPP | Third Generation Partnership Project |
| ASIC | Application Specific Integrated Component |
| BFN | Beam Forming Network |
| BER | Bit Error Rate |
| CA | Carrier Aggregation |
| CN | Core Network (5G Context) |
| CoMP | Coordinated Multi-Point |
| COTS | Commercial Off the Shelf |
| CP | Cyclic Prefix |
| CU | Central Unit |
| DBFN | Digital Beam Forming Network |
| DRA | Direct Radiating Array |
| DSP | Digital Signal Processing |
| DTP | Digital Transparent Processor |
| DU | Distributed Unit |
| E2E | End-to-end |
| eFPGA | embed FPGA |
| EIRP | Effective Isotropic Radiated Power |
| eMBB | Enhanced Mobile Broadband |
| EPC | Encapsulated Power Converter |
| FDD | Frequency Division Duplexing |
| FD-SOI | Fully Depleted Silicon On Insulator |
| FinFET | Fin Field-Effect Transistor |
| FL | Feeder Link |
| FOV | Field of View |
| FPGA | Field Programmable Gate Array |
| gNB | gNodeB (5G base station) |
| gNB-CU | gNB Central Unit |
| gNB-DU | gNB Distributed Unit |
| gNB-RU | gNB Resource Unit |
| GPP | Generic Purpose Processor |

| | |
|--------|---|
| GW | Gateway. In this document it is a synonymous of NTN-GW. |
| HARQ | Hybrid automatic repeat request |
| HPA | High Power Amplifier |
| HW | Hardware |
| IMT | International Mobile Telecommunications |
| IoT | Internet of Things |
| IP | Intellectual Property |
| ISL | Inter-Satellite Link |
| ITU | International Telecommunications Union |
| JT | Joint Transmission |
| LAN | Local Area Network |
| LBO | Local Break Out |
| LDPC | Low Density Parity Check (Codes) |
| LEO | Low Earth Orbit |
| LNA | Low Noise Amplifier |
| LoS | Line of Sight |
| MC | Multi-Connectivity |
| M&C | Monitoring and Control |
| MIMO | Multiple Input Multiple Output |
| mMTC | Massive Machine Type Communications |
| MNO | Mobile Network Operator |
| MS | Mobile Service |
| MSS | Mobile Satellite Service |
| NC | Non-Coordinated |
| NG | Next Generation |
| NG-RAN | Next Generation Radio Access Network (5G context) |
| NOC | Network Operation Center |
| NP | Network Processor |
| NR | New Radio (5G Context) |
| NTN | Non-Terrestrial Network (5G context) |
| NTN-GW | Non-Terrestrial Network Gateway |
| NVF | Network Function Virtualization |



| | |
|--------|--|
| OBP | On-Board Processing |
| OFDM | Orthogonal Frequency Division Multiplexing |
| OSS | Operating and Support System |
| PAE | Park Air Electronics |
| PCI | Physical Cell Identity |
| PDCP | Packet Data Convergence Protocol |
| PDU | Protocol Data Unit |
| PFD | Power Flow Density |
| P/F | Platform |
| P/L | Payload |
| PRB | Physical Resource Block |
| PTRS | Phase Tracking Reference Symbol |
| QAM | Quadrature Amplitude Modulation |
| RAN | Radio Access Network |
| RE | Radiating element |
| RF | Radio-frequency |
| RRM | Radio Resource Management |
| RU | Radio Unit |
| SatCom | Satellite Communication |
| SDAP | Service Data Adaptation Protocol |
| SD-FEC | Soft-Decision Forward Error Correction. |
| SDL | Supplemental Downlink |
| SIP | System in Package |
| SNR | Signal to Noise Ratio |
| SOC | Satellite Operation Center |
| SRI | Satellite Radio Interface |
| SSPA | Solid State Power Amplifier |
| SUL | Supplemental Uplink |
| SW | Software |
| TDD | Time Division Duplexing |
| TN | Terrestrial Network |
| TR | Technical Report |

| | |
|------|----------------------------------|
| TRL | Technology Readiness Level |
| TRP | Transmission Reference Point |
| TS | Technical Specification |
| TT&C | Telemetry, Tracking & Command |
| UE | User Equipment (4G/5G contexts) |
| UPF | User Plane Function (5G context) |

1 INTRODUCTION

[REDACTED according to the Security Advisory Board indications]



2 TYPES OF MISSIONS AND OPERATIONAL CONSTRAINTS

[REDACTED according to the Security Advisory Board indications]

3 COMPONENTS OF THE ARCHITECTURE REQUIRED FOR THE MISSIONS

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4 TECHNOLOGIES DESCRIPTION, TRADE-OFFS AND REQUIREMENTS

[REDACTED according to the Security Advisory Board indications]

5 ROADMAP RECOMMENDATIONS

[REDACTED according to the Security Advisory Board indications]

6 CONCLUSION

[REDACTED according to the Security Advisory Board indications]

APPENDIX A – DYNASAT CONSTELLATIONS

[REDACTED according to the Security Advisory Board indications]

APPENDIX B – DYNASAT ANTENNA FOR SIMULATION

[REDACTED according to the Security Advisory Board indications]

APPENDIX C – HARDWARE SELECTION MATRIX FOR DIFFERENT EQUIPMENT

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