Project overview

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Industry day

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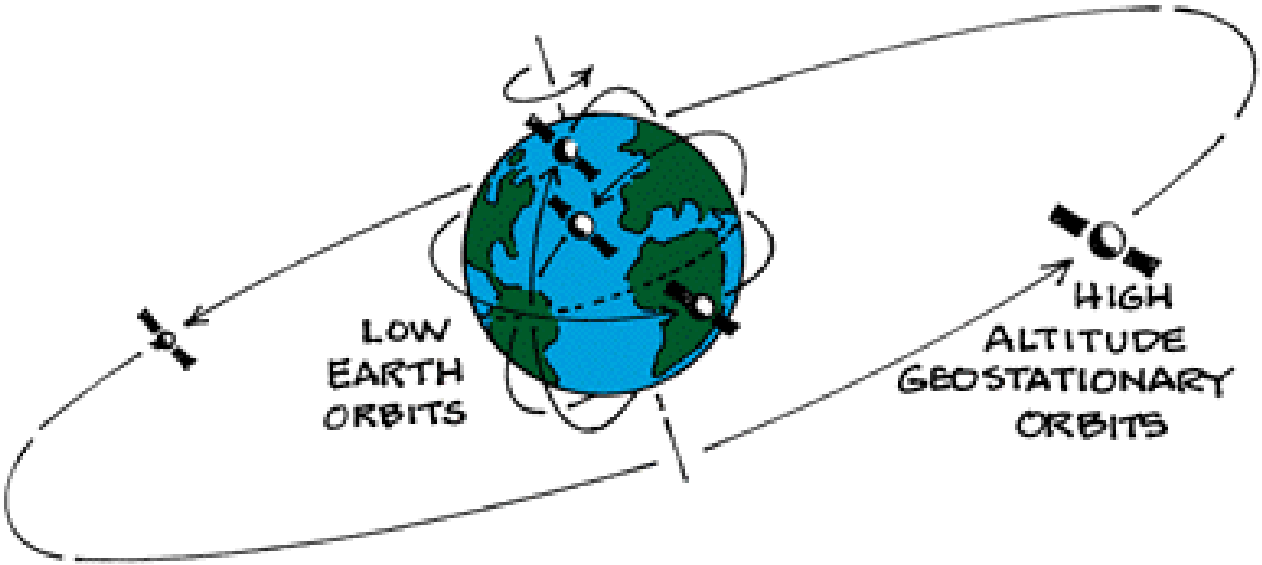
Roadmap of talk

- Why do this project (3 slides),
- Size, timing, partners (1 slide),
- What have we done (12 slides).

A pic of satellite orbits, just in case



Earth is 12,742km diameter
GEO orbit is 36,000km altitude (24 hour)
MEO orbit is 2,000 to 19,000km altitude (2- 10 hours)
LEO orbit is 600 – 1600km (about 90 minutes)

Why do this project

- We focus on eMBB. And we need a way of reaching every terminal wherever they are:
  - The USP of satellite is a high vantage point providing good coverage,
- Satellites links have a reputation for being expensive, not easy to use, having low throughput, and with high latency:
  - The cost of ownership reduces with future satellite systems and with virtualisation of network functions – **business aspects of integration**
  - Adoption of 3GPP into satellite, and integration of satellite into 5G networks makes them easy to use – **technical aspects of integration**
  - Throughput is greater with modern GEO satellites, and with new upcoming lower orbit systems (MEO, LEO), giving lower costs,
  - Latency is lower with upcoming MEO and LEO systems (10s of ms).
- Integration will become more important as new MEO and LEO systems come on line, given their lower costs, greater capacity, global coverage (and greater complexity).

Sat5G size, timing and partners

- Size is 8.3 million Euros,
- Timing is 1st July 2017 to 29th February 2020 (33 months),
- Partners are [16]:
  - Avanti (co-ordinator) (UK) – GEO Satellite network operator,
  - Thales Alenia Space (France) – Standards,
  - University of Surrey (UK) – Testbeds, software development
  - SES TechCom (Luxembourg) – MEO / GEO Satellite network operator,
  - Airbus Space and Defence (France) – Systems architecture,
  - Ekinops (France) – OTT services (multi-linking),
  - TNO (Netherlands) – Research institution (MEC, security),
  - BT (UK) – Mobile and fixed Network Operator, and service provider,
  - Zodiac (Germany) – Aircraft Infotainment systems,
  - Broadpeak (France) – OTT services (content distribution),
  - Gilat Satellite Networks (Israel) – Satellite terminal vendor,
  - ST Engineering (iDirect) (Ireland) – Satellite terminal vendor/ system provider,
  - IMEC (Belgium) – Research institution (business modelling),
  - i2CAT (Spain) – Research institution (MANO),
  - University of Oulu (Finland) – Analysis of NR over satellite,
  - Quortus (UK) – Core network supplier.

So what have we done ?

We have:

- Identified the most promising use-cases,
- Performed techno-economic modelling on those use-cases, including cost of ownership and revenues,
- Designed architectures with plug and play in mind,
- Taken steps towards integrating satellite with 5G networks,
- Proved integration concepts on testbeds,
- Contributed heavily to ETSI and 3GPP standards.

Business

Technical

Integration of satellite – bit more detail

- At multiple levels:
  - At the business level, modelling costs of use-cases
  - At the connectivity level
    - Support to control and user plane separation and network slicing
    - Virtualisation of satellite-specific network functions (VNFs)
    - KPIs derived from high level 5G KPIs
  - At the OSS level
    - Autonomy, so that the user doesn't have to do anything (plug and play)
    - Single core network
  - At the standards level
    - To enable industry take up
    - Through contributions to 3GPP, ETSI, ITU, IETF groups

At the business level

- We defined use-cases that give greatest potential for market impact and revenues:
  1. Edge delivery and offload of content and VNF software,
  2. 5G fixed backhaul, for connecting cellular base-stations
  3. 5G to premises, in parallel with fixed network to enhance broadband
  4. 5G moving platform backhaul, such as aeroplanes and trains
- We performed quantitative techno-economic analysis of these use-cases,
- We did economic modelling of computing and networking resource for VNFs and network slicing,
- We modelled each use-case and produced business-specific results
- And we introduced the ‘broker’ concept

More detail and results will be given in the next talk

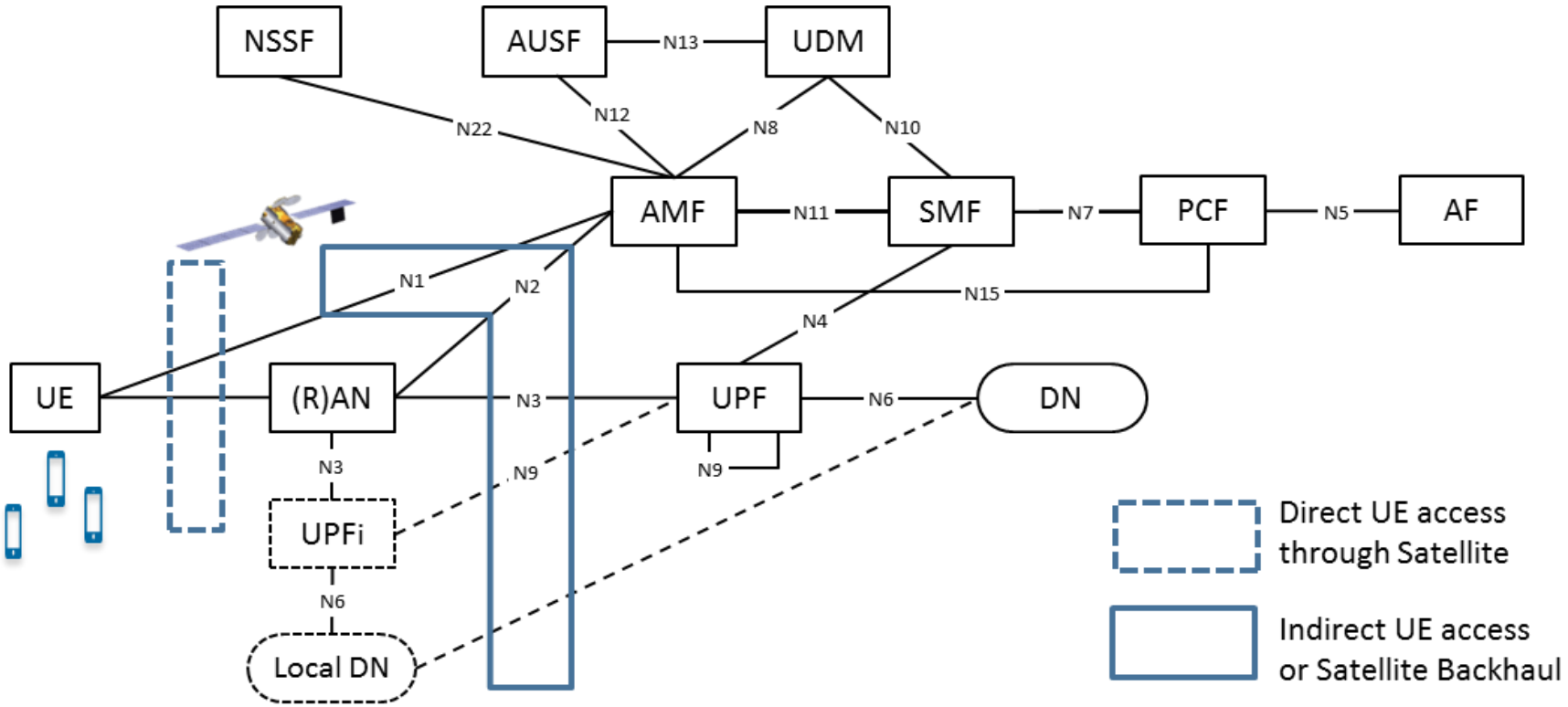
At the connectivity level

- Portable UEs cannot currently connect directly with satellites but:
  - We have allowed for direct connection in the architecture,
  - We have simulated NR over satellite,
- We developed these forms of connectivity:
  - Satellite terminals as ‘non-terrestrial’ UEs,
  - Satellite to connect core networks to the cellular network edge, including with MEC facilities,
  - Satellite to connect core networks to moving platforms such as aircraft,
  - Satellite to connect core networks to premises in parallel with terrestrial connections (xDSL).

Edge delivery and ‘backhaul’ with or without multicast

Multi-linking

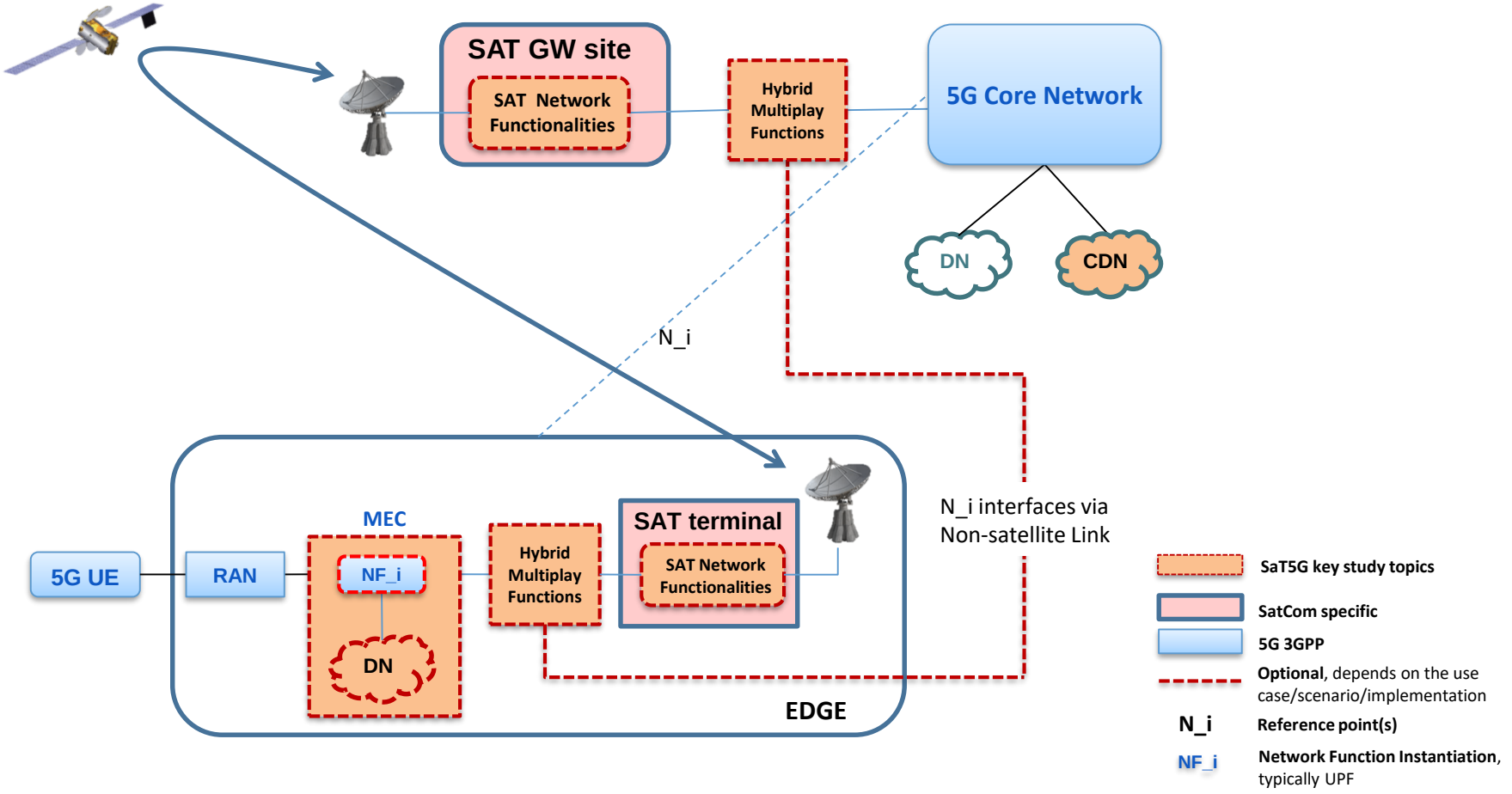
Connectivity of satellite in 5G



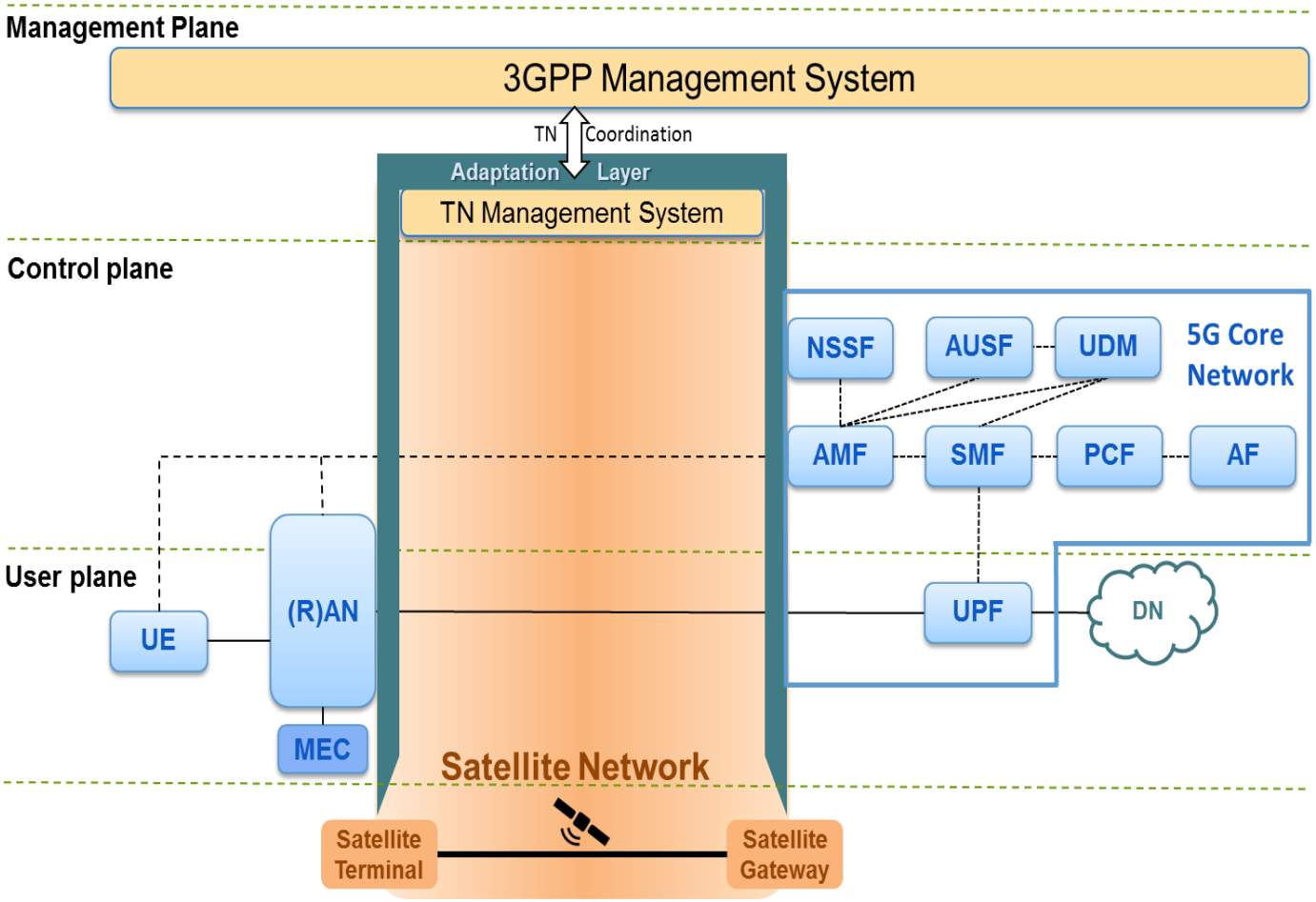
Key Performance Indicators

High level KPI 5GPPP	Satellite segment	Performance	Caching	Traffic
Service creation in minutes		*Service creation time, QoS support, Reliability, Satellite VNFs performance*		
1000x capacity			*Efficiency of caching algorithms, Multicast usage on satellite link*	*Traffic density increase*
Increased coverage		*Satellite backhaul performance*		
10x to 100x user data rate	*Peak data rate decrease*			*Multilink performance*

Reference architecture

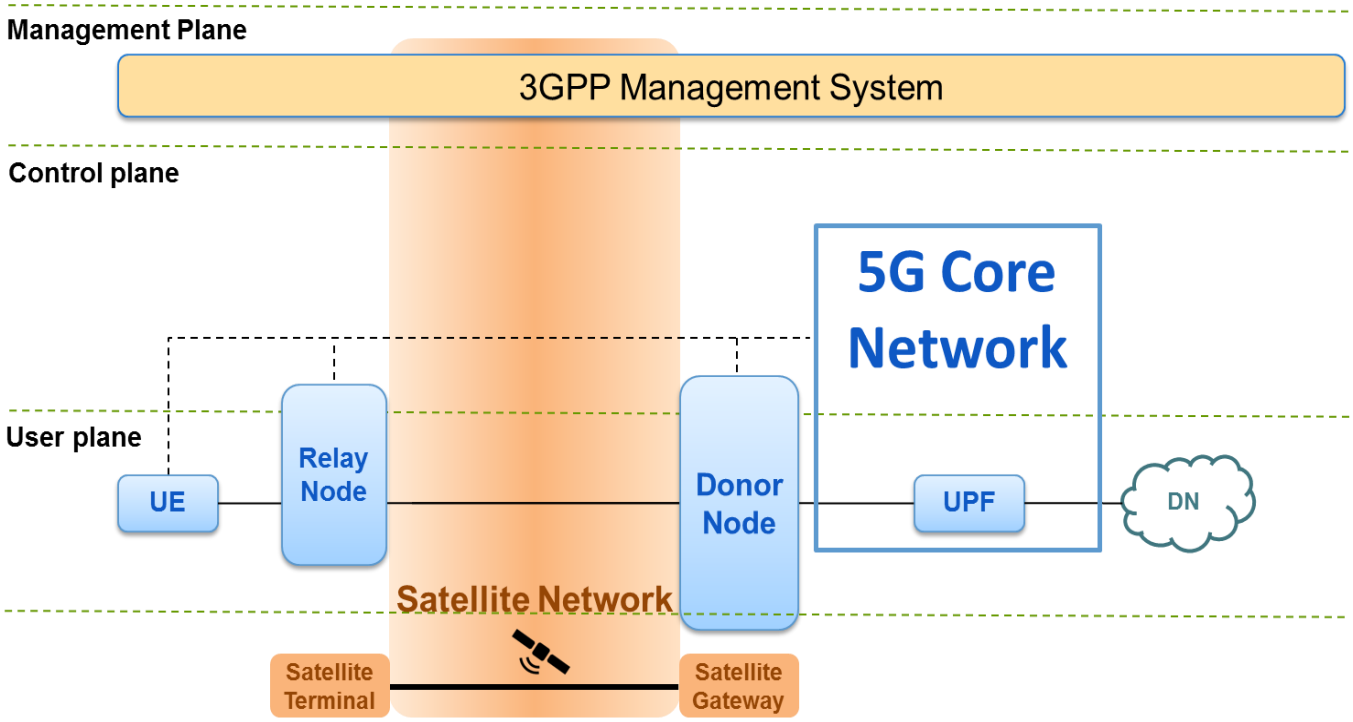


At the OSS level - interworking (transport mode)



Satellite and MNO OSS need to communicate but are not integrated
Can be 3GPP or not

At the OSS level – integration (relay mode)



Satellite and MNO OSS are integrated and satellite is aware of slices
Can be 3GPP or not, and if not 3GPP, 'trusted' or not

At the standards level - some of our contributions

- The project has made over 200 contributions to 3GPP and ETSI standards, here are some of the more significant ones:
  - 3GPP TR 22.822 “Study on using Satellite Access in 5G”
  - 3GPP TR 38.811 “Study on NR to support non-terrestrial networks”
  - 3GPP TS 22.261 on satellite access
  - 3GPP TR 23.737 “Study on architecture aspects for using satellite access in 5G; (Release 16)”
  - 3GPP TR 38.821 “Study on solutions for NR to support non-terrestrial networks (NTN) (Release 16)”

Some SaT5G firsts

- Business modelling for satellite integration into 5G
- Deployment of satellite specific VNFs on OpenStack and Kubernetes
- Adoption of 3GPP network architecture in satellite networks
- Integration of satellite into 5G networks
- Plug and play at MNO level
  - Integration of satellite OSS with service orchestrator (MANO)

Connectivity

- Protocols for latency reduction and viewing synchronisation for multi-casting over satellite
- Demonstration of Application layer multi-linking over satellite / terrestrial paths
  - DASH / DANE for video streaming
  - MP-QUIC over satellite

Services