HERIOT WATT UNIVERSITY

Enabling Technologies for Satellite Systems in 6G

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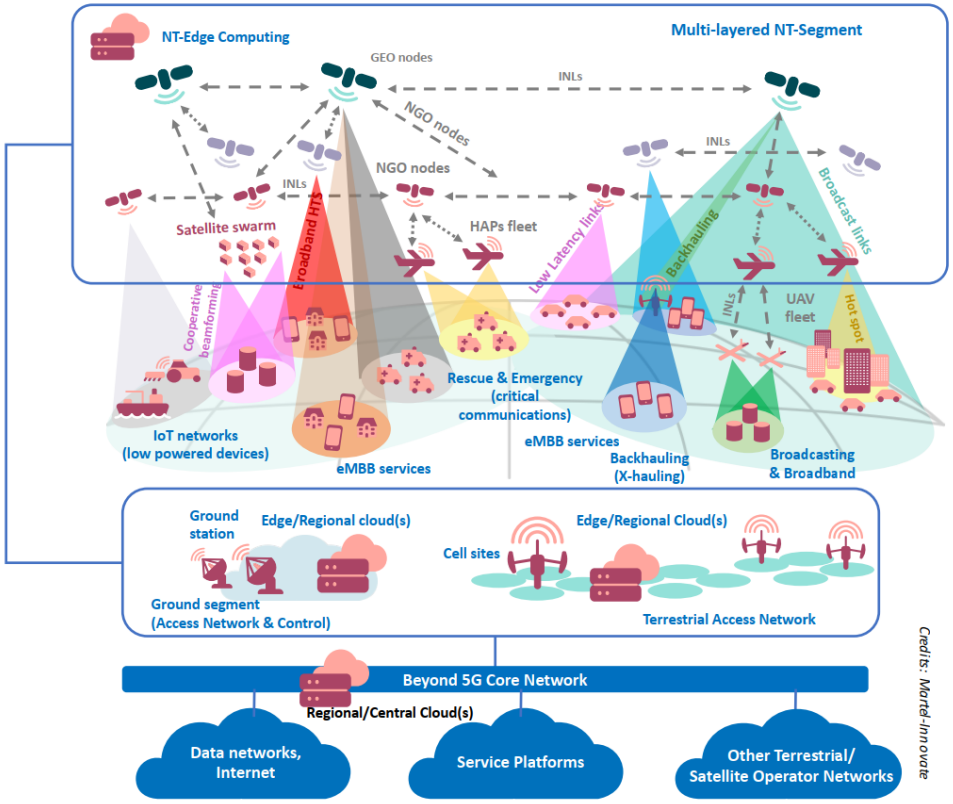
Head of Institute of Sensors Signals and Systems

School of Engineering and Physical Sciences

Heriot-Watt University

LEADERS IN IDEAS AND SOLUTIONS

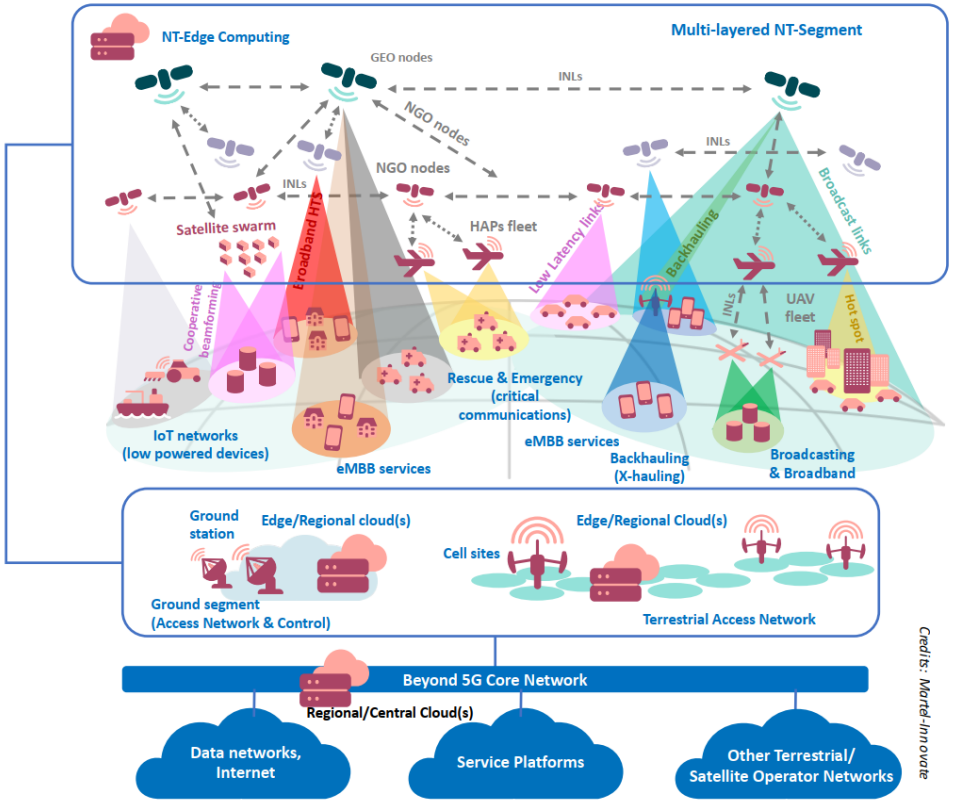
Satcom in 6G



Agenda

- Feeder link
  - Q/V- & W-bands
  - Site diversity
- User link
  - Passive technologies
  - Active technologies
  - System context
- Nano-satellites
- User terminals
- Concluding remarks

Satcom in 6G



Credits: Marte-Innovate

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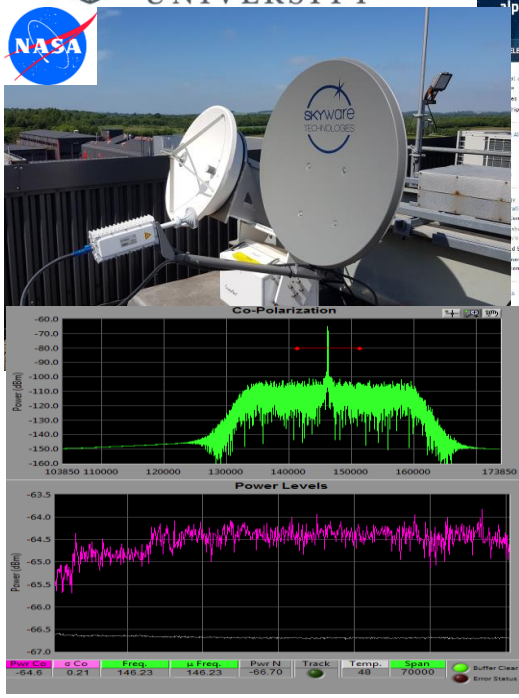
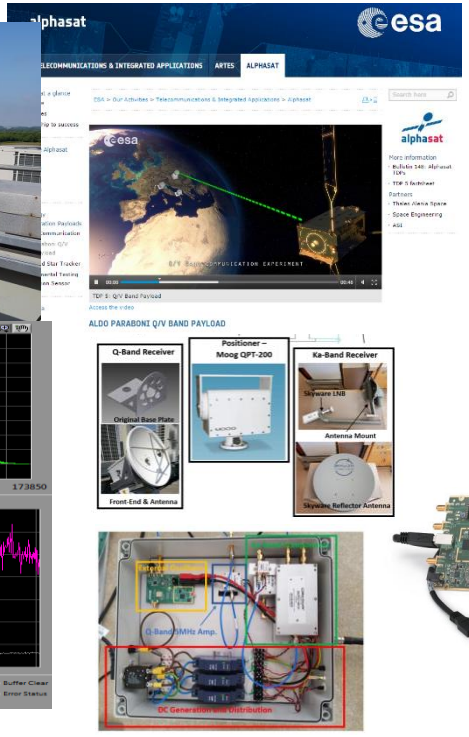
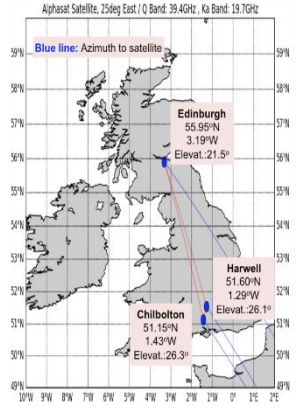
Beyond Ka-band

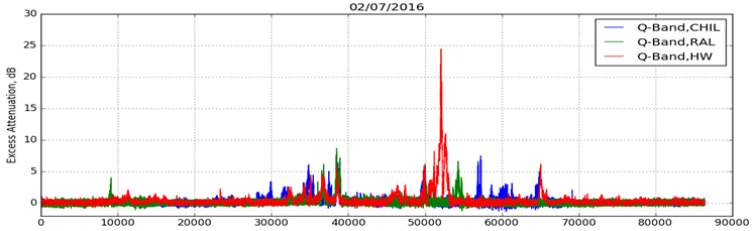


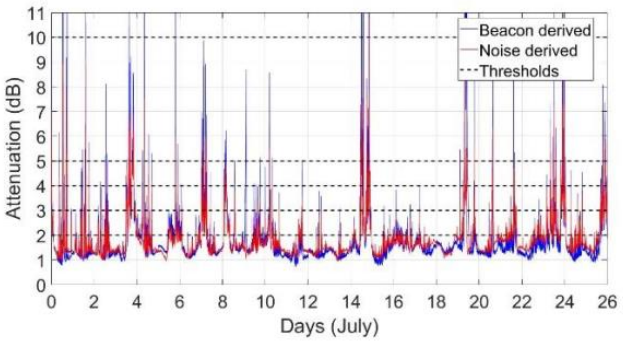


Data collection from ESA Q/V-band beacon in in-house SDR-based terminal

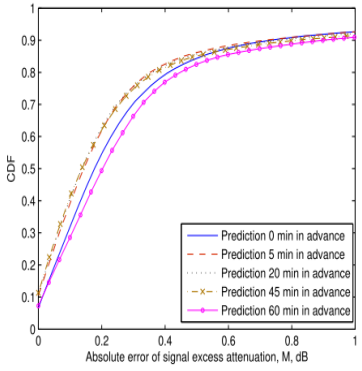
Multi-site data collection to understand availability within the UK

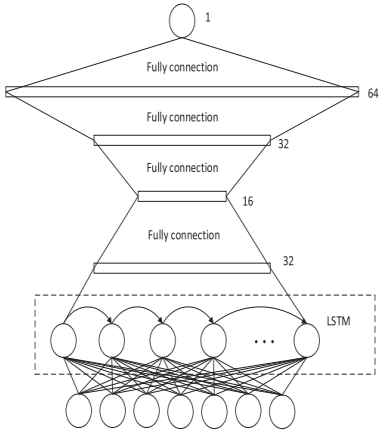






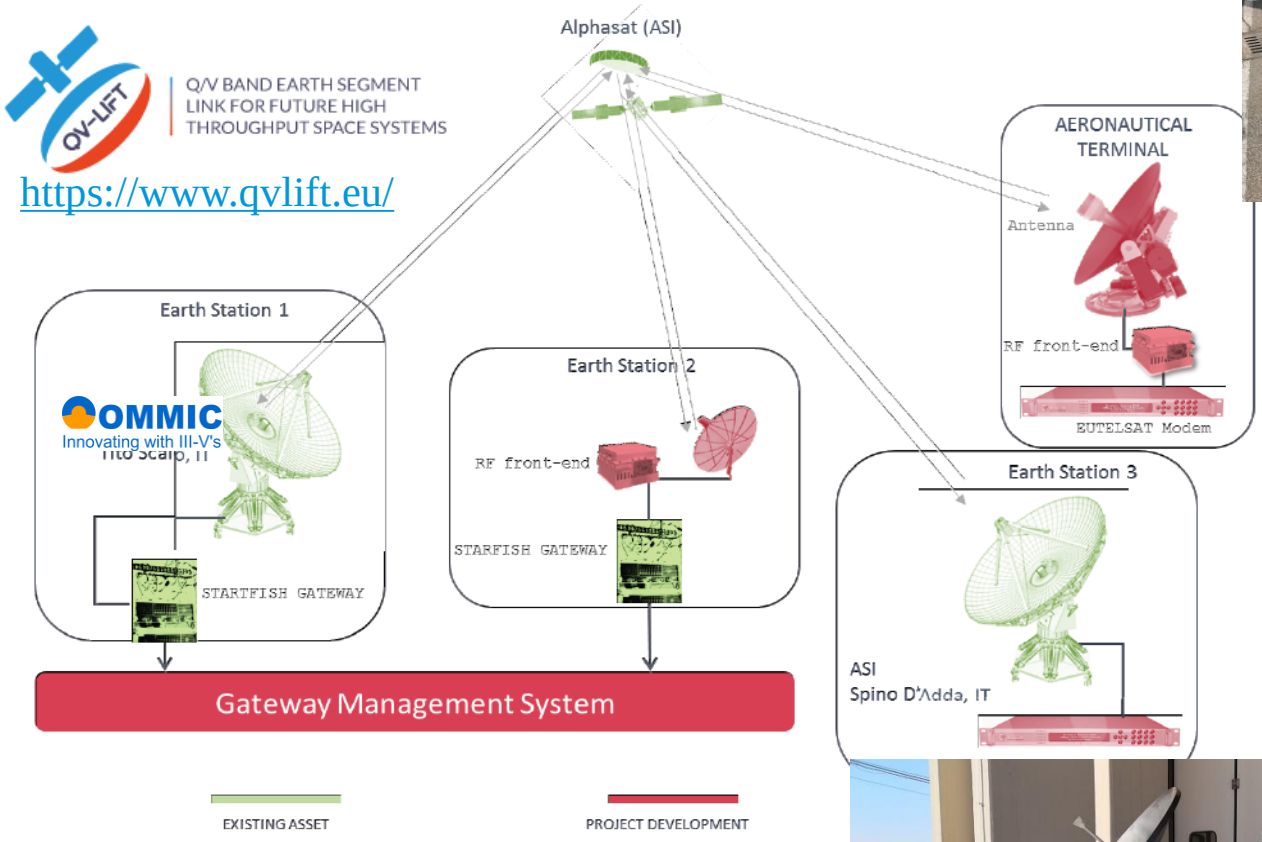
Passive radiometric data collection





Machine learning approaches for channel state prediction

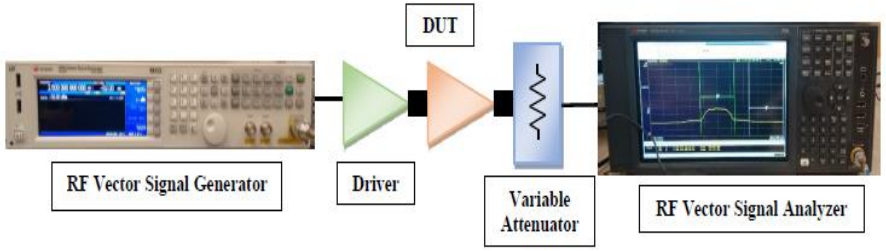
Site diversity

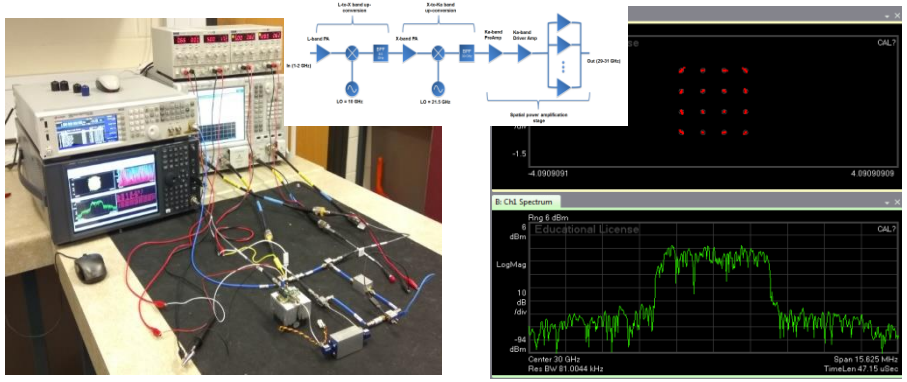


Mobility terminal

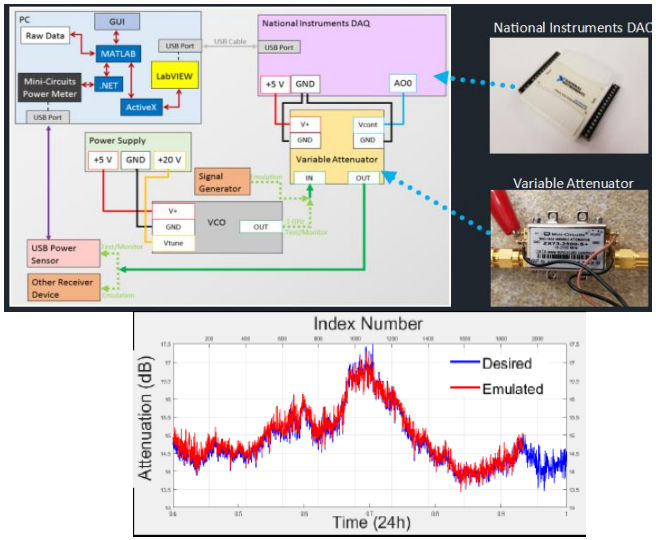
Mobile Gateway

Link level

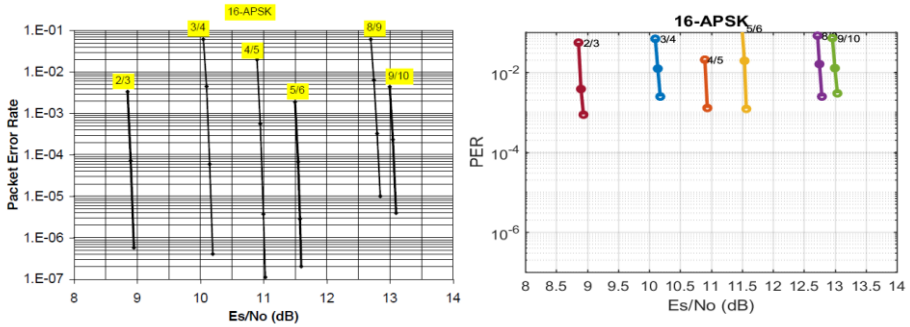




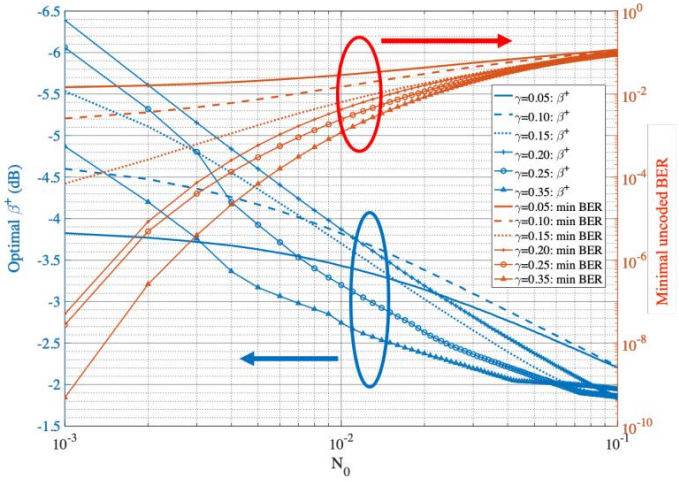
IF-to-IF testbed



Channel emulation

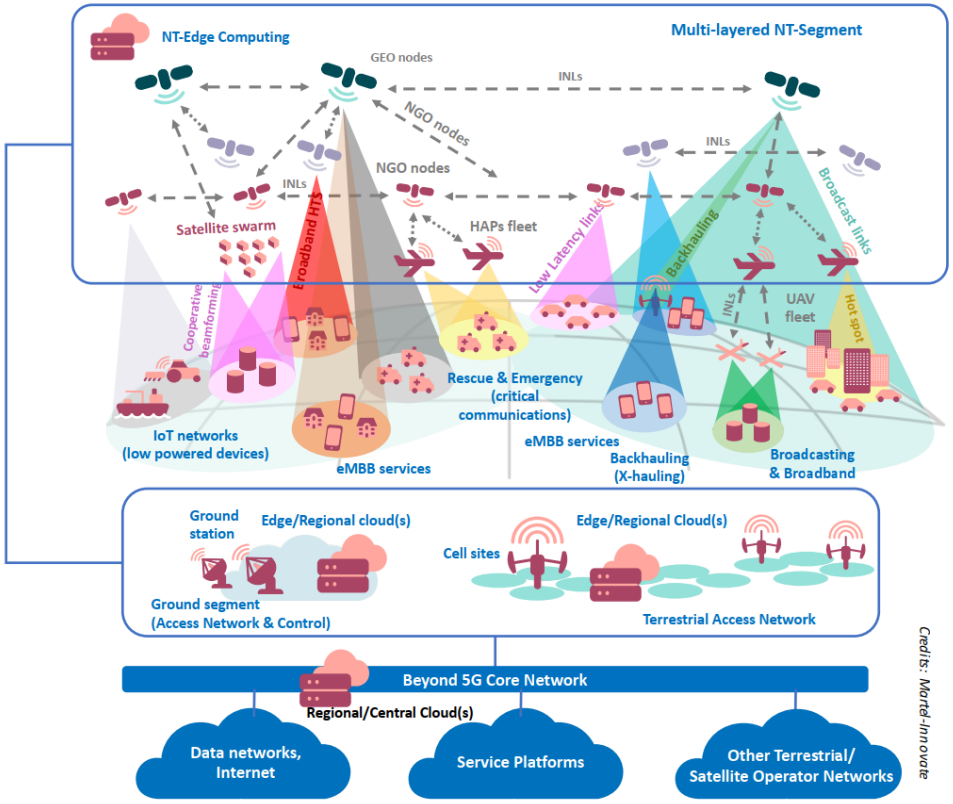


Standard implementation



Joint IBO and MODCOD optimisation

Satcom in 6G



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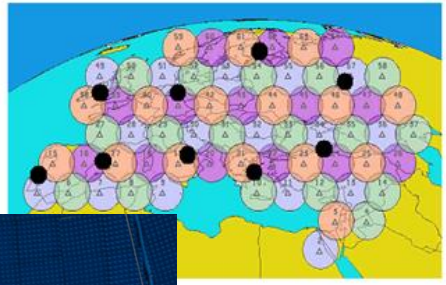
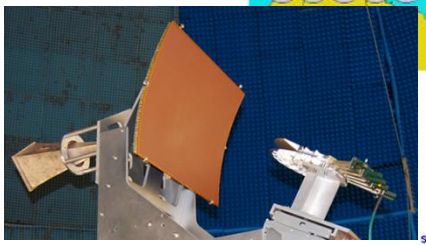
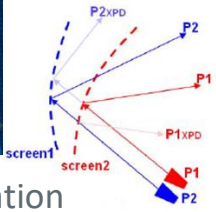
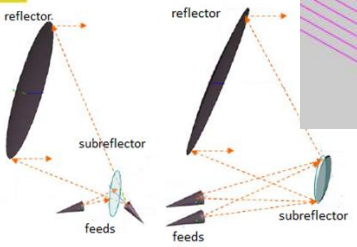
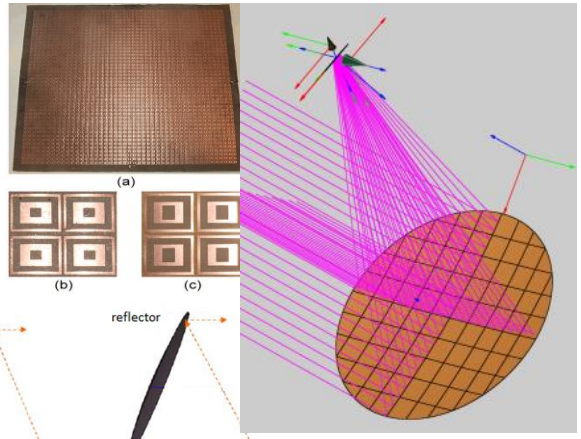
Passive antenna technol.





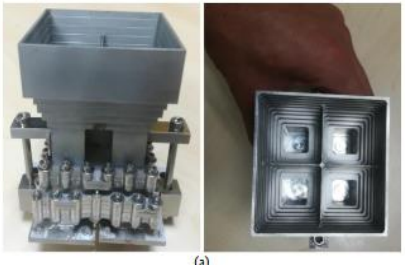


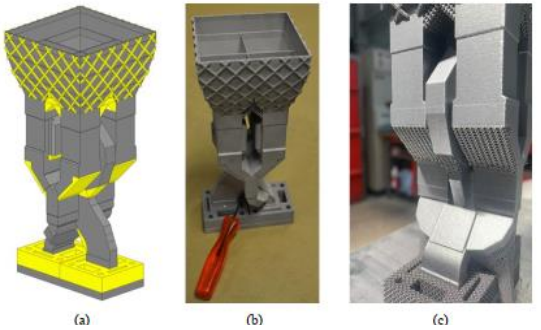


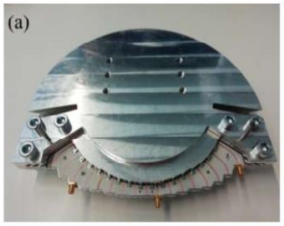


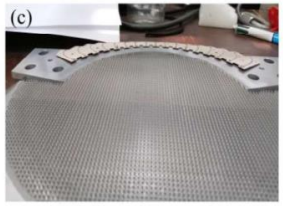
Multibeam SFPB: polarisation and frequency diplexing

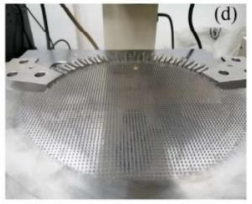
High efficiency feeds in CNC and Additive Manufacturing



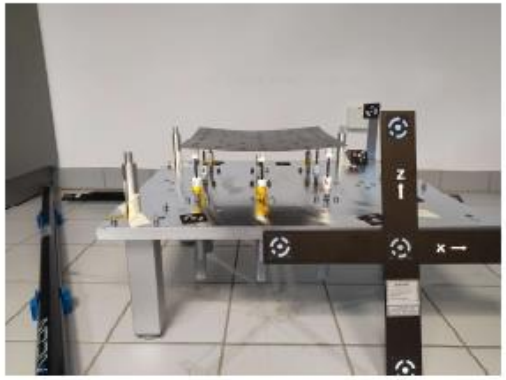




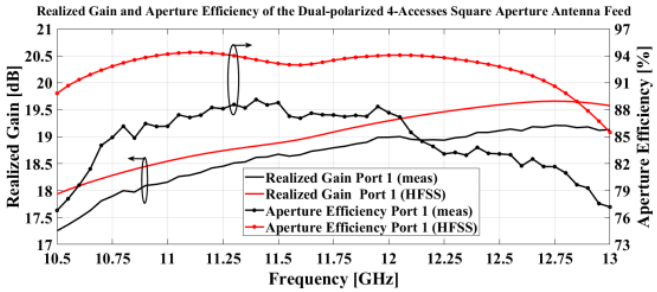




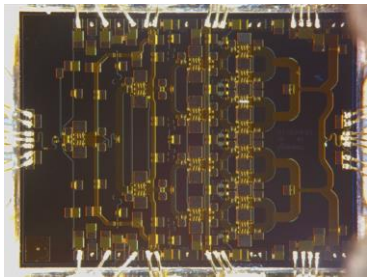
All-metal Gutman lens



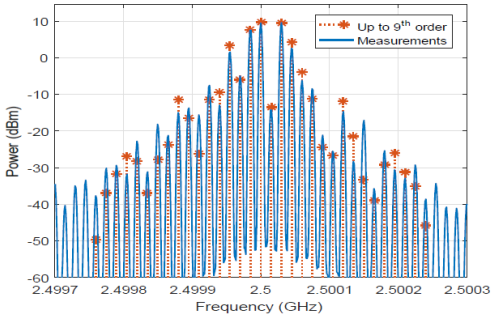
Reconfigurable reflectarrays based on actuated flexible membranes

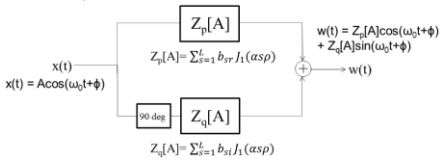


Active antenna technologies

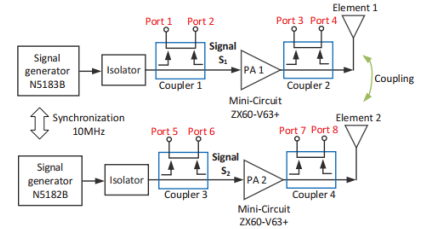


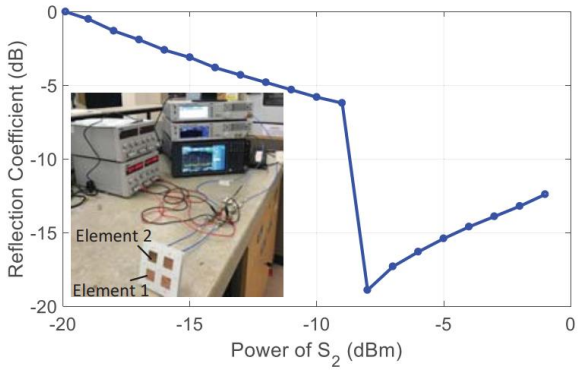
GaN HPAs



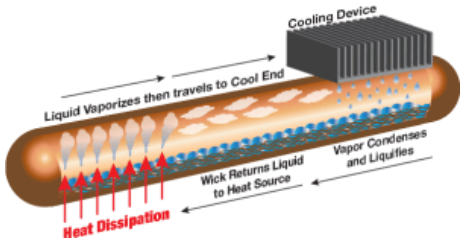


Behavioural models



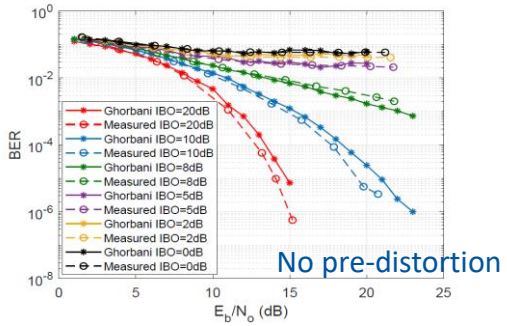


Load-pull effects due to mutual coupling in active arrays

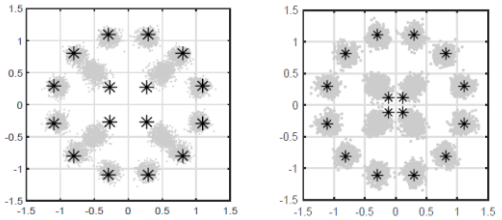


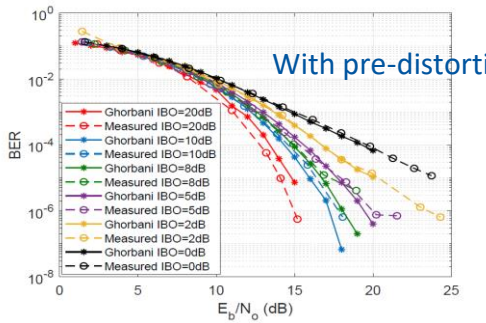
Thermal management

Low complexity pre-distortion



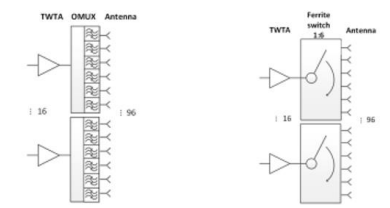
No pre-distortion

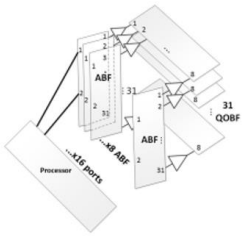




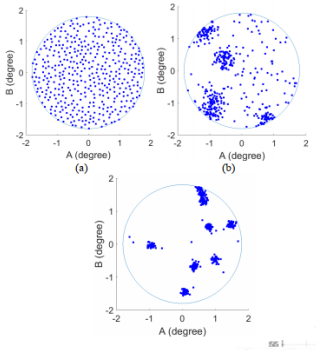
With pre-distortion

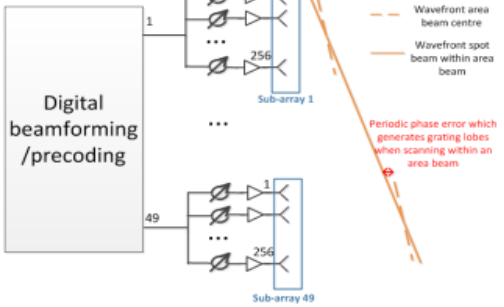
System context

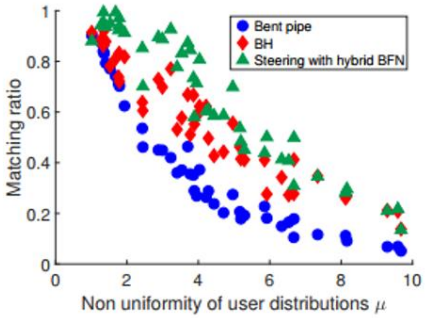


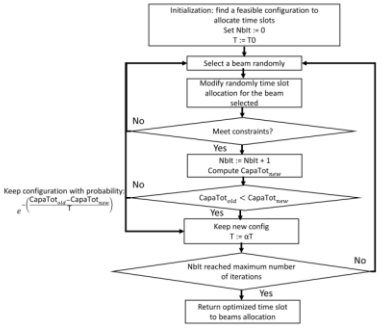


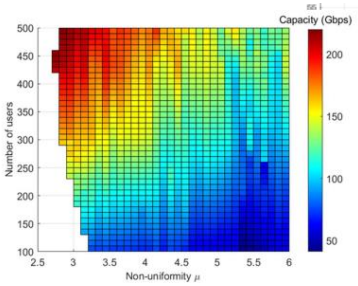
Payload benchmarking with resource allocation

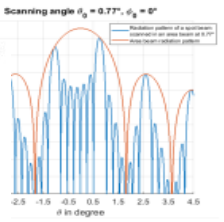


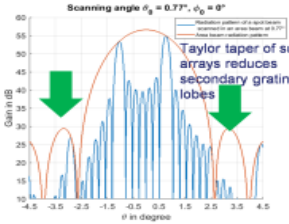




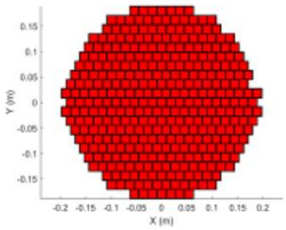


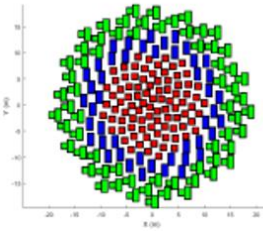






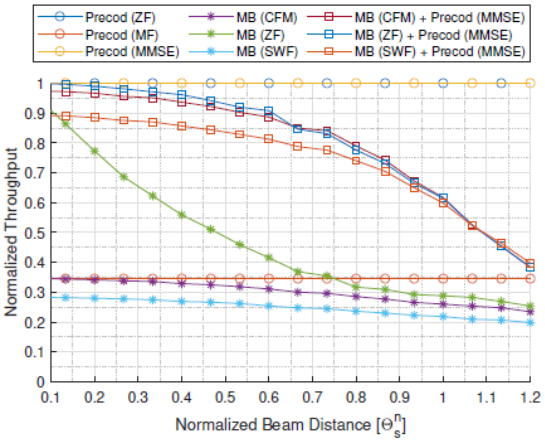
Joint beamforming and precoding for hybrid BFN direct radiating arrays

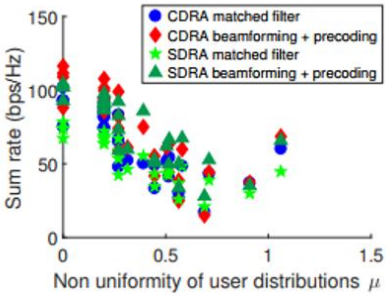


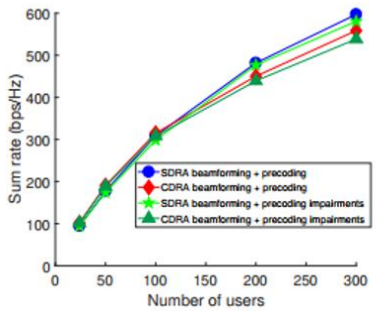


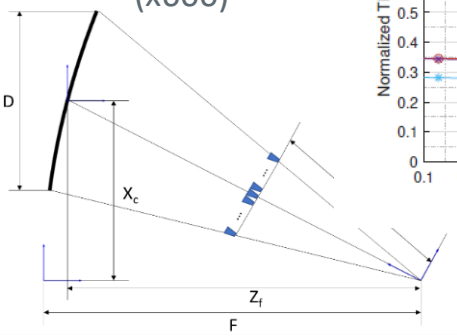
Sparse array with precoding

Rapid coverage estimation (x600)









Total throughput using precoding (Monte Carlo)

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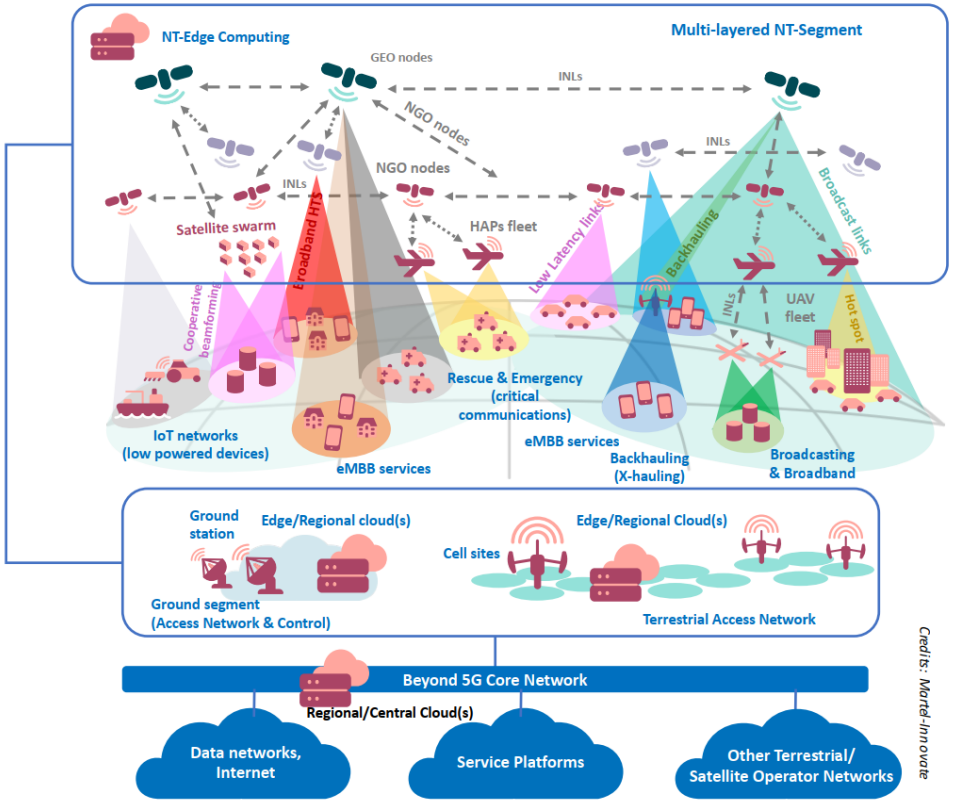

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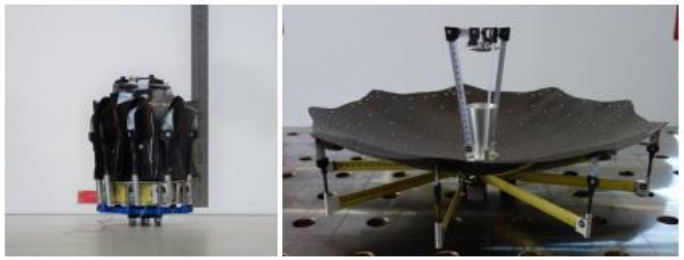
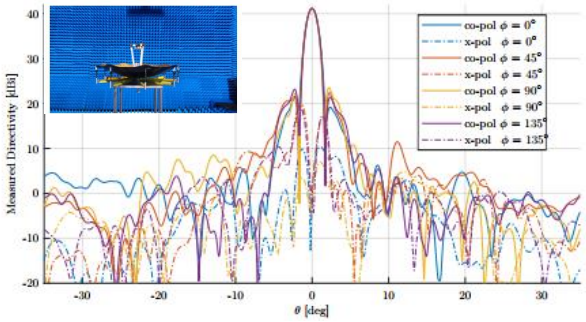
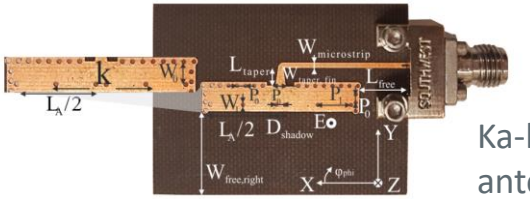
LEO

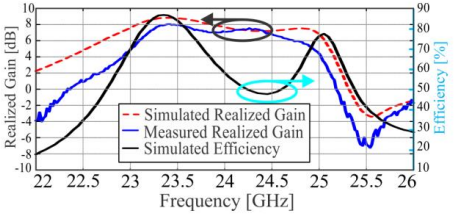


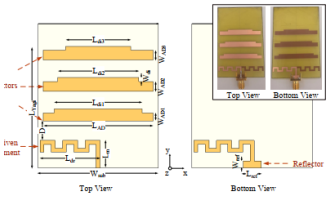


1U deployable Ka-band reflector

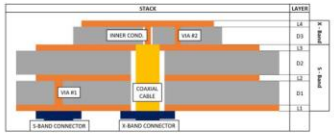


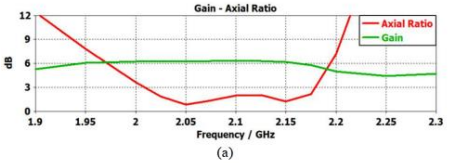
Ka-band SIW antenna

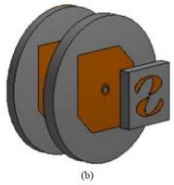


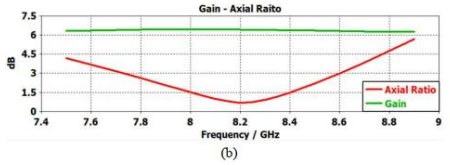


Deployed PicoSat Unicorn2 from Alba Orbital



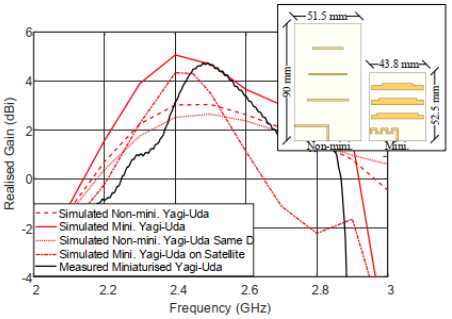




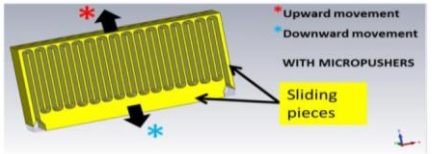


Ka-band CP antenna element

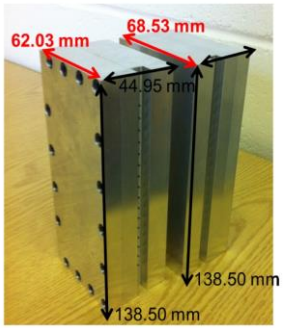
Miniaturised Yagi antenna for solar panel integration

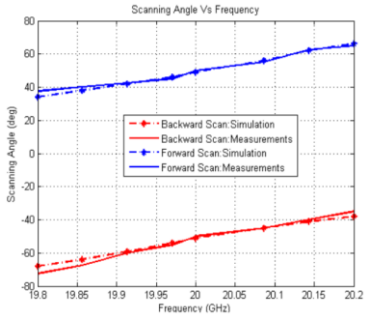


User terminal

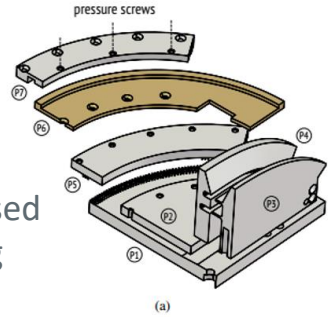


Waveguide scanning antenna



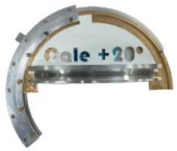


Lens-based scanning antenna

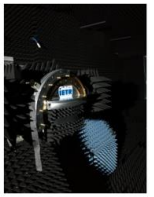


(a)


(b)



(c)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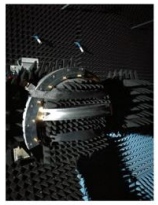
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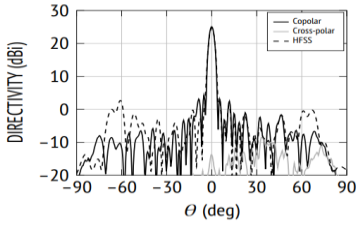

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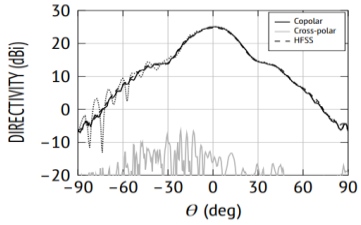
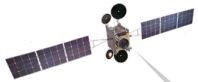
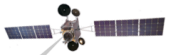


(b)

Inmarsat



Iridium



L-band: 2 Inmarsat antennas
1 Iridium antenna

Ka-Band kit: Dawson

4 MNOs

Survey and deployment capability

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Some concluding remarks

- Rapid developments within the past decade from broadcast to broadband: shaped coverage -> passive antennas -> to active antennas
- Feeder link shifting to higher mm-wave and eventually optical bands
- Reducing the per-bit cost: flexibility & capacity
- Digital on-board processing emerges as the payload bottleneck
- Payload development increasingly within system context
- New Space drives rapid developments, very short time scales, higher acceptance of failure, …
- Flat panel terminal for broadband connectivity on the move at low prices remains a bottleneck

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- ***Efficient estimation of antenna performance in multiple beam satellite systems*** ESA-SATENX 4000127115/19/NL/FE
- ***Directive PocketQube Satellite Antenna Integrated on a Solar Panel*** ESA – ITI 4000124905/18/NL/CRS
- ***Passive RF Electronics For High Power Payloads*** ESA - ITI 4000124877/18/NL/CRS ***Optimising resources in future heterogeneous mm-wave communication systems*** EPSRC EP/P025129/1
- ***REVOLVE: Managing the Radio Link in the Evolving Space Ecosystem*** H2020-MSCA-ITN-2016, Grant 722840
- ***CSA-EU: Highly Disruptive and Compact Antenna Systems for Small Satellites with Application to Surveillance, Environmental and Crop-Growth Analysis, Enabling European Union Dominance in the Space Industry*** H2020-MSCA-IF-2015 Grant 709372
- ***QV_LIFT: Q/V Band Earth Segment Link For Future High Throughput Space Systems*** H2020-Space-COMPET-2016 Grant 730104
- ***Dual-Band Polarising Surfaces for Single Feed per Beam Broadband Antennas*** ESA TRP 4000118901/17/NL/AF
- ***W-Band Technology Developments Towards First Beacon-Based Propagation Campaign*** ESA TRP 4000118502/16/NL/HK/hh
- 2016 ***Microwave filters with improved power handling capabilities for satellite applications***
- ***AMC/Metamaterial Antennas For Broadband Connectivity*** ESA TRP 4000112870/14/NL/MH
- ***Circular Polarisation Dual-Optics Proof-of-Concept***, ESA TRP 4000107415/12/NL/MH
- ***Low Loss Dual Polarised Frequency Selective Surfaces in Ku and Ka Band,*** ESA ARTES 5.1 4000107415

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