METAMATERIALS AND RECONFIGURABLE ANTENNA SYSTEM FOR SPACE-AIR-GROUND INTEGRATED 6G WIRELESS COMMUNICATION NETWORKS

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Agenzia Spaziale Italiana

Workshop "L'impegno italiano nel settore dei CubeSat: tecnologie e missioni future" – 2° edizione

OUTLINE

- Introduction
- Reconfigurable antenna systems for Space
- High-gain Metasurface Antennas



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DII al primo posto in Italia nell'area "Ingegneria Industriale e dell'Informazione"



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Introduction

- The ubiquitous and seamless wireless connectivity, one of the many 5G goals, <u>cannot be satisfied</u> by exploiting only terrestrial infostructures.
- Terrestrial base stations <u>cannot be</u> <u>deployed</u> in <u>off-grid</u> or <u>inaccessible areas</u> such as rural zones, deserts, oceans and, in general, in harsh and remote environments.



 \rightarrow the integration of <u>satellite</u> and Unmanned Aerial Vehicle (UAV) wireless communications is vital.

 \rightarrow the concept of <u>anytime</u> and <u>anywhere</u> network access requires the integration of space, air and ground networks in the framework of a Vertical Heterogeneous Network (VHetNet).









Introduction

- Accommodating the antennas to achieve the desired performance while keeping the <u>stowed volume</u> in line with launcher restrictions is often a challenging task.
- The challenge of making <u>compact and lightweight antennas</u> is particularly hard when the physical size of the structure is less or comparable to the wavelength of the RF signal as in the case of small satellites working in the UHF and S-Band.
- Some radiating systems need any deployment system (potential critical failures avoided).
- □ Few of the proposed designs are able to switch between linear and circular polarization but only very few exhibit the <u>pattern reconfigurability</u>, which is achieved by using multiple patch antennas on the same face that, in turns, requires obviously a larger area (no phased array).



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Reconfigurable antennas for Space

- A reconfigurable-pattern antenna can be useful for improving data transfer by offering the chance to have longer connection with a ground station;
- Communications with UAVs, airplanes ;
- A radiation pattern able to scan the main beam saves energy consumed for changing the attitude of the satellite thus increasing the satellite operational life (both for C2G as well as C2C);
- Optical communications can also benefit from a reconfigurable RF antenna system that can be used as a **beacon** (mostly for C2C);
- Mega constellations (C2G) or swarms (C2C);
- Disaster managements, remote areas, balloons (stratospheric communication)







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Reconfigurable antennas for Space



- Non-resonant elements (small footprint required) that excite the platform itself. Exciters located along the borders to not interfere with solar panels or other platform payload or system. No need any deployment system.
- ✓ <u>Great area saving: overall extra CubeSat volume of 0.52 cm³ for the considered case (solutions relying on patch antennas require from 12 cm³ up to 50 cm³ or more due to the dielectric substrate).</u>
- ✓ Adopted excitation paradigm <u>only requires to change the phase</u> of the excitation and leaves the <u>amplitude constant</u>.
- ✓ Beam scanning: control on AR \leq 3dB and a gain within the HPBW.



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High gain Metasurface Antennas

Increase antenna gain by using 'metamaterials' that can enhance radiative performance, or structures that can manipulate the wavefront generated by a near-field source.



 The non-uniform MTS is tailored by CMT and can be exploited as a superstrate in the design of a novel compact and low-profile antenna for nanosatellite applications in Earth Exploration Satellite Services (EESS) frequency band (2025-2290 MHz).

✓ By tailoring the MTS through CMT it is possible to achieve a superior aperture efficiency within a wide 3dB AR bandwidth.

✓ Low profile: 0.068 λ_0



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High gain Metasurface Antennas

- Steerable simultaneous multi-beam antennas can be achieved electronically or mechanically.
- Mechanically scan provides a valuable solution for steerable SMA.



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Thank you!

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