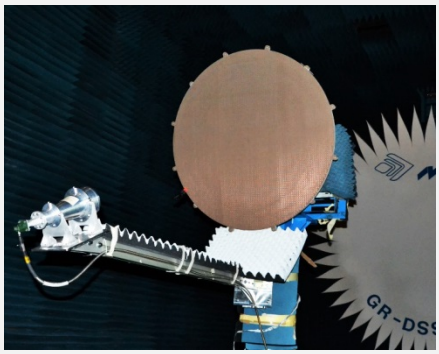
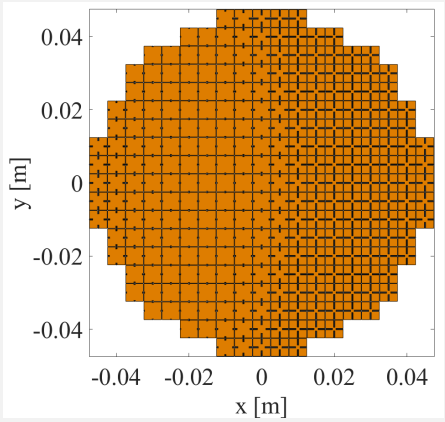
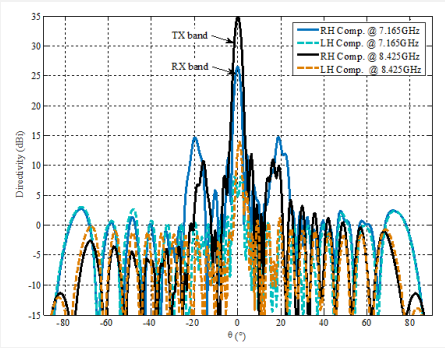
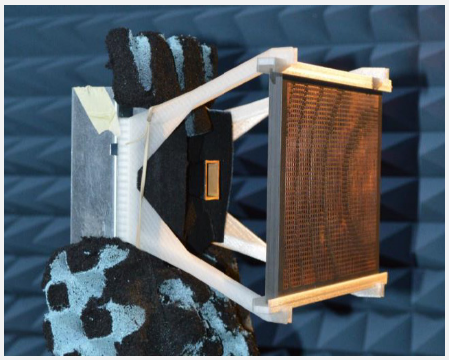
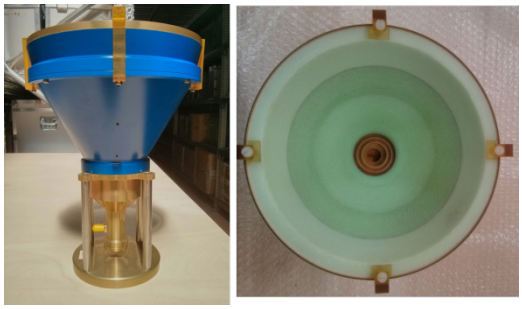
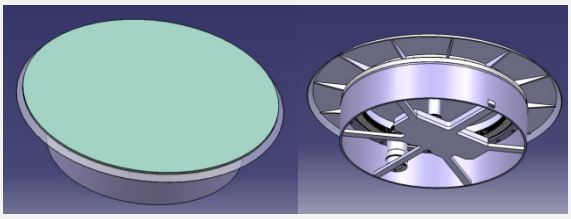
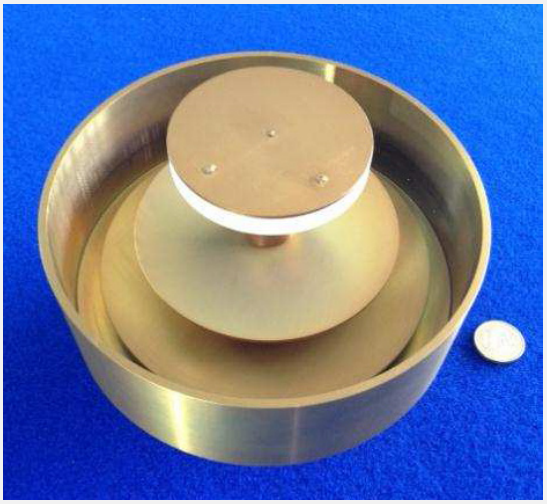
Final Presentation Day – 9 December 2016 (Newton 2)

Enabling Technologies and Techniques for Space and Ground Antennas

9:15	**Introduction**
9:30	**Reflectarray antennas with improved performances and design techniques (TRP, 300 k€)** *Universidad Politecnica de Madrid (ES)*
	 This activity includes the development of effective analysis and design techniques for reflectarray antennas, the design and test of a breadboard, in order to demonstrate the benefits of advanced passive reflectarrays for Transmit and Receive satellite antennas in Ku band. Some improvements in both the reflectarray cells and design procedures have been implemented to achieve stringent requirements. New multi-resonant reflectarray cells have been proposed to improve the reflectarray performance in terms of gain, ohmic losses, bandwidth and cross-polarisation, and to reduce the number of layers, in order to simplify the manufacturing processes and to reduce the cost of the antenna. A Software tool has been implemented and validated to design and analyse the proposed reflectarray antennas. A 1.1 m reflectarray breadboard has been designed, manufactured and tested to fulfil the requirements of a South American coverage in Tx and Rx. The performance of this antenna has been compared with the performance of two reference antennas: a 1.2 m reflectarray made of 3 layers of stacked patches and a 1.1 m conventional reflector, showing that the new breadboard performs slightly better than both reference antennas. The reflectarray breadboard has fully demonstrated the viability of this technology with very promising capabilities for Ku-Band TX/RX antennas.
10:30	**Thin metasurface lenses for antenna pattern shaping and polarisation control (NPI, 171.5 k€)** *Università di Siena (IT)*
	 Research on metasurface lenses has been concentrated in the past on uniform structures and on very slowly varying metasurface characteristics. The results obtained show, however, that it is only when the variation rate becomes comparable with the wavelength that it is possible to achieve a wide control of the metasurface properties and therefore of the transmission and reflection properties of the lens. This activity addressed modulated metasurface lenses designed to achieve beam shaping, with very low reflection and transmission losses, while having a very small thickness, compared to wavelength. The latter feature being expected to make them quite attractive for many applications, especially for space where mass and volume are a critical element. The activity delivered a design methodology for ultra-thin metasurface lenses and the results achieved are currently being applied in the frame of an ARTES AT activity.
11:00	**Multiple and wide band metasurface antenna structures for telecommunication applications (NPI, 171.5 k€)** *Università di Siena (IT)*
	 One the major limiting factors of the first modulated metasurface antenna design was the rather limited bandwidth. Yet the shortcoming was known to be linked to the design methodology rather than to modulated metasurface characteristics. This activity has been dedicated to the definition and implementation of a methodology enabling the design of circularly polarized wideband and dual band broadside apertures. The methodology is based on a combination of dedicated tools allowing all steps from initial sizing to the detailed design of the physical layout of the modulated metasurface. It has been validated through full-wave analysis for a number of application cases, most notably a dual-band solution for medium and high gain TM/TC antennas at X-band. The results achieved confirm the feasibility of both wideband and dual-band modulated metasurface antenna solutions.
11:30	**Coffee break**

11:45	**Compact lens-based mechanically steered Ka-band user terminal antenna (ARTES 5.1, 200 k€)** *Instituto de Telecomunicações (PT)*
	 The next generation of Ka-satellites and high altitude platforms (HAPs) have the potential to boost the market of small user terminals for mobile broadband applications. This anticipates the need for compact, low-profile and low-cost antennas appropriate for mass market production. High gain is required for the link budget, with beam agility to maintain the link on-the-move. Traditional approaches for beam steering are based on electronic steering, mechanical steering or hybrid solutions. There is a trade-off among these antenna solutions in terms of complexity, size, performance and cost. Purely mechanical steering solutions promise very low cost antennas, while competing in terms of performance. One of the downsides of mechanical approach tends to be the antenna volume and mechanical complexity. The focus of this project is on the fully mechanical beam steering user terminal antenna solutions with the goal to find and demonstrate new ways to counter the above volume and complexity factors while keeping the performance in terms of high gain, wide-angle elevation beam scanning for full 360º azimuth and circular polarization. The project proposes a new concept of mechanically steered Ka-band antenna based on a planar metamaterial lens that scans the beam just with in-plane lens translation with a fixed single feed (or mixed translation of the lens and a single feed). This favours antenna low profile and light weight. It is a single aperture antenna that operates simultaneously in the downlink and uplink bands in circular polarization. The project main challenges, which were accomplished, are finding the appropriate planar lens type and design, finding a way to lower the F/D without sacrificing significantly the scanning performance, finding the appropriate phase delay cell configuration, its design and cell planning methodology, developing a viable simulation strategy compatible with the size and complexity of the electromagnetic numerical model, developing a viable antenna fabrication technology and finally demonstrating all the above with fabricated prototypes and measurements at Ka-band.
12:45	**Lunch break**
14:00	**Beam shaping by surface impedance control (TRP, 150 k€)** *Università di Siena (IT)*
	 Beam shaping is one of the most demanding antenna features required by virtually all applications. The novel concept of pattern control by impedance surface modulation is likely to offer a very effective alternative to existing solutions with the potential of reducing complexity and costs. The concept is of interest for a wide range of purposes, including reflector antenna surfaces, their feed (array) as well as individual horns. The activity explored ways to exploit metasurfaces to improve shaped beam antenna designs, addressing a range of potential antenna concepts based on curved metasurfaces, which included: bifocal reflector for GEO telecom satellite, shaped and shallow metasurface lined reflectors (MetaRefractor), metasurface lined horn (Metahorn). The latter was selected as most promising concept in the short term due to its apparent ability to achieve a shaped beam with low cross-polarisation with a conical geometry. A prototype for global Earth coverage at Ku-band was manufactured and tested.

15:00	**Low complexity data downlink antenna (TRP, 300 k€)** *Università di Siena (IT)*
	 Past activities on modulated metasurface antennas have shown that a proper layout of sub-wavelength features on antenna surfaces is very effective in controlling the antenna pattern of a flat disk-shaped antenna fed from a single point. In particular sectorial-beam isoflux-shaped patterns with good cross-polarisation appeared to be feasible achieving a EOC directivity between 20 dBi and 30 dBi. The activity has therefore been focusing on the development of specific solutions for data down-link antennas for LEO missions, with minimum complexity and as small a foot-print as possible offering the possibility for azimuth and elevation scanning at Ka-band. Different antenna and scanning configurations where addressed, resulting in the design, manufacturing and test of a demonstrator. The design relies on a 250 mm flat-disk modulated metasurface, fed by a circular waveguide and radiating a fan-shaped beam. Full coverage of the visible area on ground is achieved by an in-plane azimuth rotation driven by a small motor housed in a cylindrical compartment below the disk hosting also the feeding network. The assembly is about 50 mm thick.
16:00	**On-board navigation antenna architecture and technologies for pattern flexibility and high EIRP (TRP, 400 k€)** *TAS-I (IT) and Viasat (CH)*
	 The subject of this activity is dedicated to the second generation of Galileo Navigation antennas; specifically, it is aimed to the definition of the navigation antenna architectures solutions and critical components bread-boarding. The objective of the study activities are: · To investigate and trade-off antenna architectures for GNSS advanced navigation payload satisfying the new needs for higher EIRP and re-configurability. The trade-off shall address three major designs coping with different navigation payloads/services. · To select a baseline configuration and carry out the design for the three major antenna architectures. · To identify most critical components of the three architectures and to perform detailed design, manufacturing and validation of selected bread-board(s). The activity was led by TAS-I (Prime) with VIASAT as subcontractor. Several antenna architectures and radiating elements were traded-off for two different scenarios (MEO and IGSO coverage). Two quasi-fully metallic radiating elements for high power application were designed and one of them was bread-boarded and tested against RF and power handling. Tests results show generally good performance of the bread-boarded element for what concern RF and multipaction. Passive Inter Modulation (PIM) performance needs to be further improved, improving the manufacturing process and material selection of the hardware.
17:00	**Closure**