Preparation of a CubeSat LEO Radiowave Propagation Campaign at Q and W band

Félix Cuervo[1*†], Arturo Martín-Polegre[2], Fernando Las-Heras[3]
Danielle Vanhoenacker-Janvier[4], Joel Flávio[1],
Michael Schmidt[1]

[1]*JOANNEUM RESEARCH DIGITAL, WKT, Graz, Austria*
[2]*European Space Agency, ECSAT, Harwell-Oxford Campus, United Kingdom*
[3]*Electric Engineering Department, University of Oviedo, Gijón, Spain.*
[4]*Université Catholique de Louvain, Louvain-la-Neuve, Belgium*

Abstract
Due to the congestion of the spectrum and the need for wider bandwidths, ultra-high throughput satellites (UHTS) are moving towards the use of higher frequency bands (Q/V and W band). These frequencies are however severely impaired by atmospheric phenomena causing attenuation, scintillation and depolarization and compromising the quality of service (QoS). In order to study the Earth-space link, several experimental campaigns have been performed up to the Q band with geostationary (GEO) satellites. This paper introduces a new propagation experiment which will extend the characterization of the Earth-space channel up to the W band and low Earth orbits (LEO).

Key words: satellite communication, tropospheric propagation, low Earth orbit, W band

*Corresponding author.
†E-mail: Felix.Cuervo@joanneum.at

1 Introduction

The continuous development of payload and ground segment technologies enables the exploitation of higher frequency bands for satellite communication systems. The use of higher frequencies brings advantages such as the availability of wider bandwidths, the smaller antenna size for the same antenna gain and the reduced interference from existing commercial systems. However, the impairments induced by the atmosphere (attenuation, scintillation and depolarization) become more severe.

The sources of atmospheric attenuation are gaseous components (oxygen and water vapour), clouds and, mainly, rain. Scintillation causes rapid fluctuations of the signal amplitude due to variations of the refractive index along the propagation path. Depolarization is critical for systems employing frequency reuse and consists in the leakage of copolar signal power to the orthogonal polarization in the presence of rain and/or ice particles. The impact induced by the atmosphere depends also on the path length, being more significant for low elevation angles.

The goal of the radiowave propagation campaigns is to develop channel models able to reproduce the temporal and spatial characteristics of the atmospheric effects. These models serve to improve the characterization of the ground segment requirements and the design and employment of fade mitigation techniques (FMTs) such as uplink power control (UPC), adaptive coding and modulation (ACM) and site diversity [1]. The campaigns consist in receiving a beacon signal (of constant amplitude and frequency) transmitted from a satellite. Ancillary radio-meteorological instrumentation such as microwave radiometers, rain gauges and meteorological stations is used to complement the experimental dataset.

A long tradition of propagation campaigns have been carried out since the 1970s; e.g. Olympus F1 (beacons at Ku and Ka band), Italsat 1 (Ka and Q band) and the ongoing Alphasat Scientific Experiment (Ka and Q band) [2] [3]. All of these experiments contributed to the improvement of the Earth-space channel characterization. Nevertheless, there is a lack of measurements for frequency bands beyond Q band. Moreover, the propagation experiments for which measurement results are available are limited to geostationary (GEO) satellite links. Preliminary propagation measurements were made at 29 GHz with the demonstration LEO satellite Teledesic T1 [4], but the constellation was canceled and the propagation data remained commercial-in-confidence. The Iridium LEO constellation used 20/30 GHz for their gateways but propagation data were not accessible either. A Ka-band payload was installed on the Australian LEO microsatellite FedSat. A complete description of the experiment and the receiving station can be found in [5], with examples of measurements being presented in [6]. Only event-based analysis was performed during the FedSat experiment, no statistics were produced due to various problems encountered during the experiment.

One of the particularities of Earth-LEO links is the predominance of low elevation angles. A few low-elevation propagation campaigns have been carried out at high latitudes with GEO satellites [7], [8] and [9]. The results helped to improve the models for low elevation links. They are, however, representative of arctic climates and not necessarily helpful for temperate or tropical and equatorial climates. Therefore, it is necessary to foresee LEO propagation campaigns worldwide in order to develop adequate models for low elevations. To study further the Earth-space channel, in this case extending its characterization to the W band and low Earth orbits, this paper presents a new propagation campaign which will be carried out measuring beacons at 37.5 and 75 GHz transmitted from a CubeSat located on a low Earth orbit [10]. The satellite launch is planned for 2020, followed by the measurement campaign lasting 2 years. The LEO permits measuring the combination of the atmospheric fluctuations in space and time with the dynamics of the orbit.

Section II introduces the system architecture and the two main subsystems: the satellite and the ground station. Section III lists challenges foreseen for a LEO propagation campaign at W band and limitations of the current standard channel models. Section IV presents the analysis of the impact of the propagation effects. Section V introduces the Numerical Atmospheric Simulator (NAS), which will be used to complement the measurements. Finally, in Section VI, the conclusions are drawn.

2 System Architecture

This section presents the architecture of the system implemented to carry out the propagation campaign. The block diagram is shown in Figure 1. Two main parts are considered: the satellite and the ground station. These parts are discussed in the following.

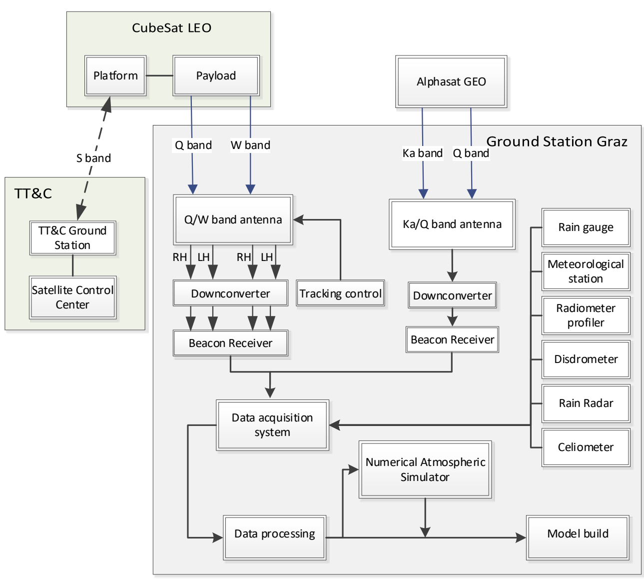


Figure 1: System architecture

2.1 Satellite

A 3U CubeSat of 4.5 kg weight will accommodate the payload of 15 W power consumption. The satellite will be placed on a circular orbit (non-sun-synchronous in order to achieve time of day variation) at 500 km altitude with an inclination between 52° and 98°, depending on the eventually chosen launch vehicle.

Two coherent and unmodulated beacon signals will be radiated from the spacecraft; Table 1 summarizes their characteristics. According to the design and specifications, the frequency stability of the beacons will be 1.2 ppm. In order to obtain the complete transfer matrix of the atmosphere, the circular polarization of both beacons will be switched between left-hand (LHCP) and right-hand (RHCP) with a selectable frequency higher than the rain decorrelation time.

The telemetry data, transmitted over S band to the TT&C ground station in Helsinki, will include, along the usual housekeeping and control information, timestamped parameters such as the transmitted power and the polarization switching frequency, in order to aid the propagation data analysis.

A CubeSat was chosen for this experiment due to the reduced production and launch costs. On the other hand, because of the limited power budget of the platform, a tradeoff between satellite size and payload power had to be considered during the design phase; hence the reduced EIRP compared with conventional values of GEO satellite beacons, e.g. Alphasat, with 53 and 59 dBm at Ka and Q band respectively. Nevertheless, due to the shorter distance to the satellite, the power flux density on ground will be very similar for both experiments as seen from Graz (Alphasat at 35º elevation and considering the most challenging case for the CubeSat, i.e. 10º elevation). State-of-the-art MMICs are used, and the great effort was put into the design and optimization, in order to reach the required attenuation measurement accuracy.

The fundamental-mode circular patch antenna has a radiation pattern with the maximum towards the broadside direction. Choke rings have been placed around the patch in order to modify and approximate the radiation pattern to the isoflux for visible Earth coverage from LEO. The measured antenna patterns are shown in Figure 2, the gain is 7 dB at Q band and 6 dB at W band. The Attitude Determination and Control System (ADCS) will keep the antenna pointed towards nadir (i.e. 0º). The payload will be switched on whenever it is visible from the measurement ground station(s), with minimum elevation angle of 10º.

Table 1: Beacon characteristics

Frequency-band	Frequency [GHz]	Polarization	EIRP [dBm]
Q-band	37.5	Circular (adjustable switching 0 – 1 KHz)	29.2
W-band	75		25.9

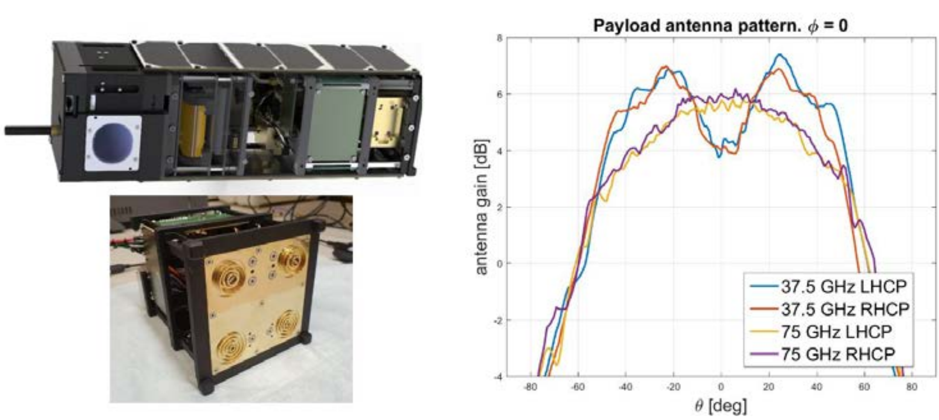


Figure 2: Left: CubeSat and payload © Reaktor Space Lab. Right: Measured antenna patterns © VTT Technical Research Centre of Finland

2.2 Ground Station

A ground station able to track the CubeSat and measure the beacons at both polarizations is being developed purposely for this activity by LC-Technologies/Aveiro-Portugal. The ground station and the ancillary equipment will be installed on the rooftop of the JOANNEUM RESEARCH office building in Graz, Austria (47.06 N latitude, 15.45 E longitude, 387 m height). The experimental site location and antenna design are shown in Figure 3.

The antenna is an offset feed type with an 84 cm aluminum reflector. Relevant specifications are given in Table 2. A radome is used to protect the antenna from the weather. It is 6 mm acrylic Plexiglas with 0.15 dB loses at 75 GHz and negligible at 37.5 GHz.

Figure 3: Left: Installation site for the measurement equipment at the JOANNEUM RESEARCH office building in Graz, Austria. Right: Ground station antenna © LC-Technologies

Table 2: Ground station antenna characteristics

Frequency [GHz]	**Gain [dBi]**	**Half-power beamwidth (HPBW) [º]**	**Cross-polar discrimination (XPD) [dB]**
37.5	47	0.75	15
75	53	0.31	25

Satellite tracking will be performed in program track mode based on the orbit ephemeris message (OEM) data distributed by the satellite control center. In order to follow accurately the passes and minimize the impact of pointing errors on the beacon measurements, an active tracking system based on interferometric phase measurement will be used to fine-tune the antenna pointing. The system calculates the phase difference between the wave fronts reaching four auxiliary horn antennas placed on the main antenna reflector (see Figure 3). The calculated phase offset depends on the aiming tilt towards the signal source.

The beacon receiver is able to handle Doppler frequency rates greater than 100 kHz/s and measure the excess attenuation with 40 dB dynamic range and accuracy better than 0.5 dB. The measured parameters will include the copolar attenuation level, the cross-polar discrimination (XPD) level and phase; and the differential level and phase between the switched transmitted polarizations.

A set of ancillary equipment including a microwave radiometer, a disdrometer and a weather station equipped with a tipping bucket rain gauge will be used to measure radio-meteorological parameters such as sky noise, ambient temperature, atmospheric pressure, relative humidity, rain intensity and drop size distribution (DSD). Finally, the concurrent measurements from the Alphasat Aldo Paraboni Scientific Experiment [2] [11] and simulations from the NAS will complement the dataset.

The data acquisition system will collect the measurements and perform the data pre-processing, aimed at removing from the measured signals the effects induced by the space and ground equipment, identifying valid data samples and archiving raw and processed beacon and radio-meteorological measurements.

3 W Band Challenges and Limitations

A long tradition of propagation campaigns have been carried out to study the atmospheric channel in Earth-space links but no experiment has been reported at W band so far. This section presents some challenges and limitations imposed by such high frequencies.

The sensitivity of the receiver will allow measuring the impact of the atmospheric effects on the transmitted beacons. This will be particularly challenging at W band, where disdrometer measurements predict that, for low elevation angles, attenuation higher than 40 dB can be caused by rain rates of just 5 mm/h. Hence, the measurement dynamic range will be critical during rain periods. In order to overcome this challenge, the receiver will lock to the lower frequency beacon (i.e. Q band) and exploit the inter-beacon coherence.

The ITU-R Recommendation P.838 includes a model to predict the specific rain attenuation, γ (dB/km):

$$\gamma = k \cdot R^{\alpha}$$

where k and α are coefficients which depend on the frequency, polarization tilt angle and elevation of the transmitted signal; and R is the rain rate in mm/h. However, disdrometer measurements have shown that the rain attenuation does not depend exclusively on the rain rate but also on the shape of the DSD [12] [13]. Figure 4 shows the comparison of specific attenuation at W band derived from DSD and predicted by ITU-R P.838 with the rain rate as a parameter. As it can be seen, for a constant rain rate of 10 mm/h, the specific rain attenuation varies with the DSD between 2 dB/km and 7 dB/km. Such observations call for a reformulation of the current model at high frequencies.

In order to predict the impact of the rain on the signal depolarization, the method presented by S. Okamura et al. [14] was followed, calculating the scattering amplitudes of the raindrops to derive the transmission matrix of the medium. A Marshall-Palmer DSD and 0º canting angle were assumed for the raindrops. The melting layer height was set at 3 km. Figure 4 shows the cross-polar discrimination (XPD) as a function of the copolar attenuation with the elevation angle as a parameter. The obtained results highlight the need for a large measuring dynamic range: For low elevation angles (12º and 30º), a dynamic range of 45 dB is required to measure a depolarization of 25 dB. As the elevation angle increases, the rain depolarization measurements become even more challenging.

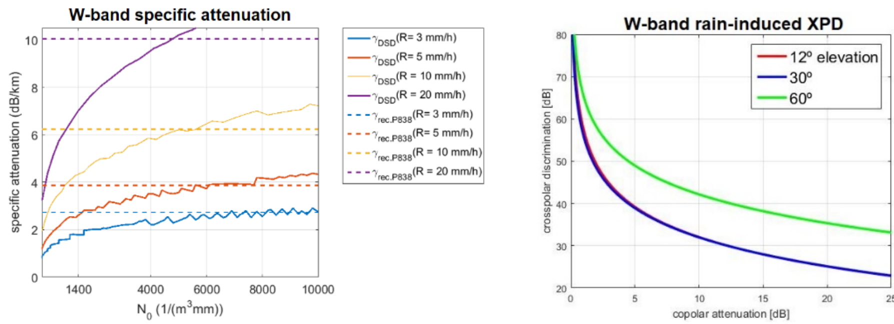


Figure 4: Left: Comparison of specific attenuation at W band derived from DSD and predicted by ITU-R P.838 with the rain rate as a parameter. Right: W-band cross-polar discrimination as a function of the copolar attenuation with the elevation angle as a parameter

During the pre-processing of the beacon data, special care must be taken with unwanted effects caused by inaccuracies or instabilities of the payload output power detector, transmitter signal frequency and gain, ground station antenna pointing, receiver gain and Doppler correction. All sources of uncertainty have been reflected in the link budget and measurement error analysis calculations.

The current standard channel models present limitations for LEO propagation at Q and W band, arising from:

- The limit of validity of the models in frequency and/or elevation angle
- The combined dynamics of the satellite and the troposphere
- The fact that all the models have been tested with GEO satellite links for which the elevation angle is linked to the latitude

In general, the predictions for low elevation angles are not accurate and lead to very high fade predictions that are not observed in real links. Furthermore, discontinuities appear at the transitions between models for low elevation angles. The present activity will address these limitations and the critical issue of scintillation fading at low elevation angles.

4 Impact of Propagation Effects

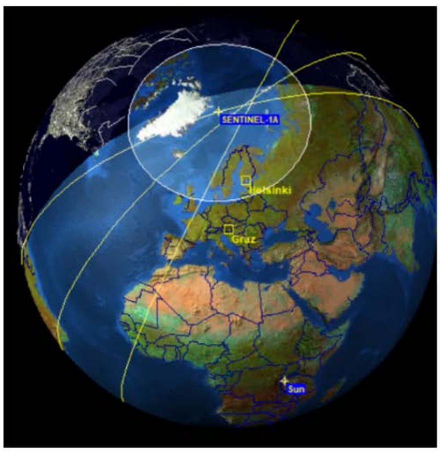
The availability of a satellite communication system is determined by the amount of time the system is above a minimum signal-to-noise ratio (SNR). A target availability figure corresponds to a margin to be allocated to atmospheric losses based on statistical assumptions. The higher the required link availability, the higher the atmospheric losses.

The link availability depends on the location of the ground station. Assuming the same link availability, there are large differences between high and mid/low latitudes. The orbit characteristics also affect the availability, and the statistics of elevation angle have to be taken into account for the analysis of the impact of the propagation effects.

4.1 Leo Orbit

The Setinel-1A satellite orbit serves as reference for the analysis: a Sun-synchronous orbit (SSO) 693 km above ground with an inclination of 98.18° and a period of rotating the Earth of approximately 96 min, leading to a 12-day repeat cycle, corresponding to 176 orbits.

The Sentinel-1A contact time statistics from Graz were obtained for one repeat cycle. The contact time varies from approximately 10 to 700 s. Around 50% of the passes have 600 s duration or less. The relevant parameters and the impact of the orbit on the distribution of elevation pointing angles are given in Figure 5. As it can be seen from the distribution, the CubeSat will spend a considerable amount of time at low elevations, which is detrimental from the propagation point of view. At such low elevation angles, the behaviour of the Q- and W-band channels is unknown as there have been no previous data, and even clear sky effects may create critical atmospheric losses.



Average contact time [min]	8.96
Orbits with contact	65
Total contact time [min]	583
Time available [%]	3.38

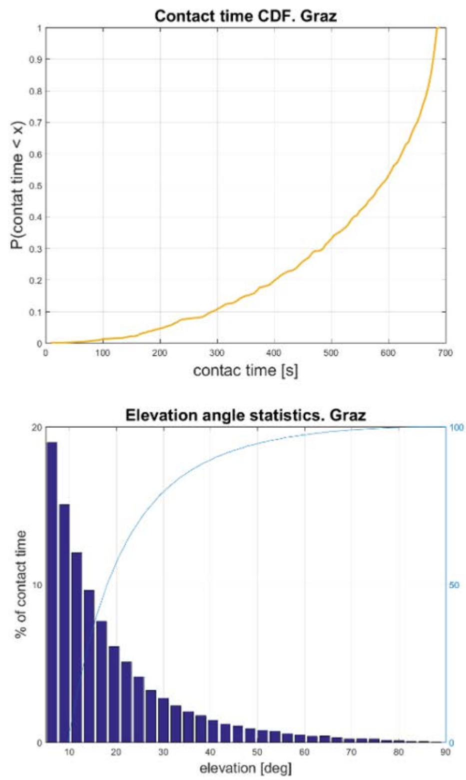


Figure 5: Sentinel-1A orbit contact time and elevation statistics from Graz

4.2 Atmospheric propagation

The ITU-R Recommendation P.618-13 [15] “Propagation data and prediction methods required for the design of Earth-space telecommunication systems” contains the model for the prediction of total attenuation statistics for frequencies above 18 GHz. The model was run for elevation angles from 5 to 90°. Figure 6 presents the results obtained at Q band, plotting the total attenuation exceeded at each elevation angle for different time percentages. The prediction methods employed in the model were derived for applications where the elevation angle remains constant. The Recommendation indicates the way of calculating the link availability for non-GSO systems in which the elevation angle is varying. The results are also shown in Figure 6.

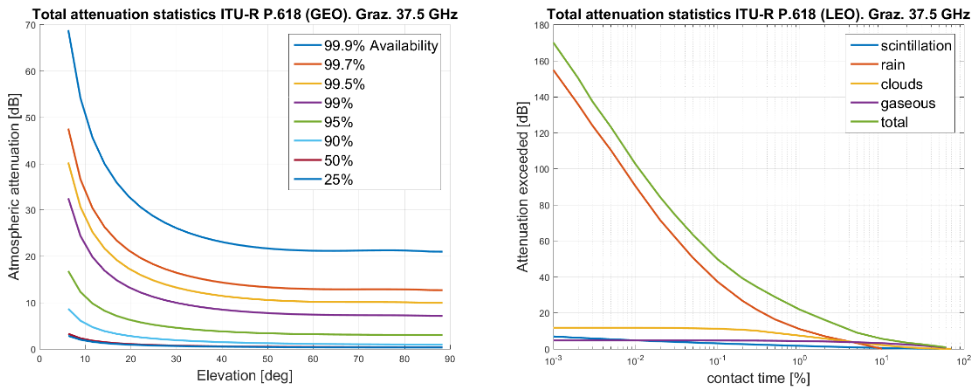


Figure 6: Q-band total atmospheric attenuation statistics in Graz computed with ITU-R P.618. Left: GEO link attenuation vs. elevation angle with availability as a parameter. Right: LEO link attenuation vs. percentage of contact time for the Sentinel-1 orbit.

5 Numerical Atmospheric Simulator

In LEO systems, only a fraction of the day will be available as measured propagation data due to the limited contact time with the ground station imposed by the orbit characteristics. Since long-term statistics of propagation parameters are required for model development and system planning, the measurements will be complemented in post-processing by a Numerical Atmospheric Simulator (NAS), which converts meteorological data to propagation parameters.

The Weather Research and Forecasting (WRF) model is a non-hydrostatic mesoscale numerical weather prediction (NWP) system able to produce simulated high-resolution 4D meteorological data from NWP products such as ECMWF’s ERA5 (i.e. European Centre for Medium-Range Weather Forecasts Re-Analysis 5). These meteorological data are the input for the LEO channel simulator [16]. Mainly temperature, pressure, wind and relative humidity profiles are used, in addition to hydrometeor content (i.e. rain and cloud water mixing ratios given by WRF). The conversion to specific attenuation is described in detail in [17]. Previous NAS experiments have been successfully carried out at Ka-band [18]. Based on these simulations, long-term statistics of atmospheric attenuation can be obtained.

The NAS simulations will be compared with the propagation measurements to validate their capability to reproduce the spatial and temporal characteristics of the propagation parameters on a LEO. The collected measurements will help tuning the NAS. The output of the whole system will then be used for propagation modelling as far as possible. Additionally, the NAS can be employed to set the clear sky level (recover the attenuation in non-rainy conditions) in place of the radiometer [19].

Two years of NAS simulations (2016 - 2018) have been run for the experiment frequencies and location. In this case, the TIMED satellite has been used as reference (circular orbit, 625 km altitude, 74.1° inclination, 96.8 min period) [20]. The comparison at Q band between the NAS simulations and the ITU-R P.618 predictions is given in Figure 7.

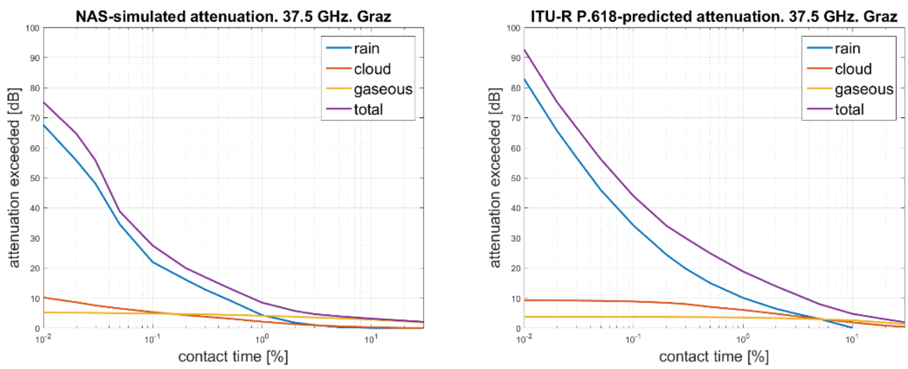


Figure 7: Simulated and predicted attenuation statistics at Q band in Graz with the TIMED satellite orbit. Left: NAS simulations. Right: ITU-R P.618 model predictions.

6 Conclusion and Outlook

A new radiowave propagation campaign to extend the characterization of the Earth-space channel up to the W-band and low Earth orbits has been presented in this paper. Beacons at 37.5 and 75 GHz transmitted by a payload on-board a CubeSat satellite will be measured along with extensive radio-climatological data and simulations provided by a Numerical Atmospheric Simulator.

The system architecture has been introduced. The challenges foreseen for a LEO propagation campaign at W band and the limitations of the current standard channel models have been listed. The analysis of the impact of the propagation effects has been presented.

The limited contact time imposed by the LEO characteristics will not allow the development of empirical stochastic propagation models; nevertheless, expected outcomes of the activity include:

- Operational “lessons learnt” from a LEO propagation measurement campaign, including the development of new LEO propagation data processing techniques, aimed at removing all systematic effects induced by the space and ground segments, extracting the channel effects from the measurements. These techniques are different (and more complex) from the ones currently stablished for GEO propagation experiments
- Better understanding of the impact of the atmospheric effects on the performance of LEO satellite communication systems, leading to a potential refinement of the space and ground segment requirements

Furthermore, with the advent of the “mega-constellations” consisting of hundreds and even thousands of LEO satellites, the knowledge and experience gained in this activity could be applied to a constellation transmitting beacon signals. Such large number of satellites (and ground stations) would provide longer satellite contact times and enable measuring all different pointing angles and climate situations.

Other experimenters are welcome to join the measurement campaign. Concurrent measurements at different locations will allow investigating site diversity. Interested parties are invited to contact the authors or refer to the group of the Alphasat Aldo Paraboni propagation experimenters (ASAPE), where information is regularly distributed.

7 Acknowledgments

This activity is performed under the ESA Contract No. 4000122347/17/UK/ND, “Cubesat-based W-band channel measurements”.

References

[1] A. D. Panagopoulos, P. M. Arapoglou, P. G. Cottis, National Technicahl University of Athens, “Satellite Communications at Ku Ka and V Bands Propagation Impairments and Mitigation Techniques”, IEEE Communications Surveys & Tutorials, Third Quarter 2004

[2] F. Cuervo, A. Martellucci, J. Rivera Castro, M. Schmidt, M. Schönhuber. “The Alphasat Aldo Paraboni Scientific and Communication Experiments at Ka and Q/V bands in Austria”. May 2019. International Journal of Satellite Communications and Networking 37(13). DOI: 10.1002/sat.1308

[3] S. Ventouras, A. Martellucci, R. Reeves, E. Rumi, F. P. Fontan, F. Machado, V. Pastoriza, A. Rocha, S. Mota, F. Jorge, A. D. Panagopoulos, A. Z. Papafragkakis, C. I. Kourogiorgas, O. Fiser, V. Pek, P. Pesice, M. Grabner, A. Vilhar, A. Kelmendi, A. Hrovat, D. Vanhoenacker-Janvier, L. Quibus, G. Goussetis, A. Costouri, J. Nessel, “Assessment of spatial and temporal properties of Ka/Q band earth-space radio channel across Europe using Alphasat Aldo Paraboni payload”, https://doi.org/10.1002/sat.1313

[4] D. Kohn (Teledesic Corporation USA), “The Teledesic Network: Using Low-Earth-Orbit Satellites to Provide Broadband, Wireless, Real-Time Internet Access Worldwide,” 1996. [Online]. Available: http://www.isoc.org/inet96/proceedings/g1/g1_3.htm

[5] T. Kostulski and R. Sam, “Spectral analysis of experimental Ka-band propagation measurements over the Australian LEO microsatellite ‘FedSat,’” Lect. Notes Inst. Comput. Sci. Soc. Telecommun. Eng., vol. 15 LNICST, pp. 41–48, 2009.

[6] T. Kostulski, “Ka Band Propagation Experiments on the Australian Low Earth Orbit Microsatellite ‘ FedSat ,’” Univ. of Technology, Sydney, 2008.

[7] D. D. Morabito, “Detection of tropospheric propagation effects from deep space links of the Cassini spacecraft,” Radio Sci., vol. 42, no. 6, pp. 1–14, 2007.

[8] R. Acosta, J. Morse, J. Nessel, M. Zemba, and K. Tuttle, “Ka-Band Site Characterization of the NASA Near Earth Network in Svalbard, Norway,” Ka band broadband Commun. Navig. Earth Obs. Conf. Palermo, pp. 655–661, 2011.

[9] T. Tjelta, M. Rytir, L. E. Braten, P. A. Grotthing, M. Cheffena, and J. E. Hakegard, “Results of a Ka band campaign for the characterisation of propagation conditions for SatCom systems at high latitudes,” 2017 11th Eur. Conf. Antennas Propagation, EUCAP 2017, pp. 1481–1485, 2017.

[10] J. Flávio, F. Cuervo, M. Schönhuber, M. Schmidt, D. Vanhoenacker-Janvier , A. Martín-Polegre1, A. Martellucci, “A New Earth-LEO Propagation Campaign at Q and W-band”, 2018, 9th Advanced Satellite Multimedia Systems Conference

(ASMS). Berlin, Germany

[11]F. Cuervo, K. Plimon, M. Schonhuber, A. Martellucci, and J. R. Castro, “Alphasat Aldo Paraboni propagation experiment in Graz - Frequency scaling analysis,” 2016 10th Eur. Conf. Antennas Propagation, EuCAP 2016, pp. 1–5, 2016

[12]M. Schönhuber, F. Cuervo, N. Knoll, and V. Mitterauer, “Reliability of Disdrometer-derived W-Band Attenuation Predictions,” in EuCap2018, 2018, pp. 3–6.

[13]L. Luini, G. Roveda, M. Zaffaroni, M. Costa, and C. Riva, “EM Wave Propagation Experiment at E Band and D Band for 5G Wireless Systems : Preliminary Results,” EuCap2018, pp. 1–5, 2018.

[14]S. OKAMURA and T. OGUCHI, “Electromagnetic wave propagation in rain and polarization effects,” Proc. Japan Acad. Ser. B, vol. 86, no. 6, pp. 539–562, 2010.

[15]ITU-R Recommendation P.618 “Propagation data and prediction methods required for the design of Earth-space telecommunication systems”. https://www.itu.int/rec/R-REC-P.618/en

[16]M. O. García, N. Jeannin, L. Féral, and L. Castanet, “Use of WRF Model to Characterize Propagation Effects in the Troposphere,” in EuCap2013, 2013

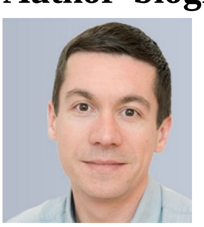
[17]N. Jeannin et al., “Atmospheric channel simulator for the simulation of propagation impairments for Ka band data downlink,” 8th Eur. Conf. Antennas Propagation, EuCAP 2014, pp. 3357–3361, 2014.

[18]G. Fayon, L. Féral, L. Castanet, N. Jeannin, and X. Boulanger, “Use of WRF to Generate Site Diversity Statistics in South of France,” in 32nd URSI GASS, Montreal, 2017, no. August.

[19]L. Quibus , L. Luini , C. Riva , D. Vanhoenacker-Janvier, "Use and Accuracy of Numerical Weather Predictions to Support EM Wave Propagation Experiments", IEEE Transactions on Antennas and Propagation, Vol. 67, No. 8, August 2019

[20]J. Yee, E. Rodberg, R. J. Harvey, D. Y. Kusnierkiewicz, W. Knopf, P. Grunberger, D. Grant, G. E. Cameron, "Advanced technology and mission operations concepts employed on NASA's TIMED mission"

Author biography



Felix Cuervo received his Diploma of Telecommunication Engineering in 2013 from Escuela Técnica Superior de Ingenieros Industriales y de Telecomunicación, Santander (Spain). He joined the Space and Communications Technology Group of JOANNEUM RESEARCH DIGITAL, Graz (Austria) where he is currently working in propagation channel modelling for Earth-space communication systems. He enrolled the PhD Programme in Information & Communication Technologies in Mobile Networks in Universidad de Oviedo (Spain). He is involved in various working groups dealing with Earth-space propagation modelling such as ASAPE, and ITU-R Study Group 3.

Arturo Martín-Polegre was born in 1970,in Santa Cruz de Tenerife, Spain. He received the Ingeniero de Telecomunicación degree from the Polytechnical University of Catalonia, Barcelona, Spain, in 1993. From 1996 to 2014, he waswith the Electromagnetics Division of the European Space Research and Technology Centre of the European Space Agency (ESA), in Noordwijk, The Netherlands, giving support on the field of antennas to ESA projects such as Herschel/ Planck and GAIA. Since 2014 Arturo hasbeen with The European Centre for Space Applications and Telecommunications (ECSAT) in Oxfordshire, United Kingdom, helping the European and Canadian space industry's productsacquire flight heritage through ESA's ATLAS programme and helping developing spacehardware for telecommunications satellites.

Fernando Las-Heras received the M.S. in 1987 and the Ph.D. in 1990, both in Telecommunication Engineering, from the Technical University of Madrid (UPM). He was a National Graduate Research Fellow (1988-1990) and held a position of Associate Professor at the Department of Signal, Systems and Radiocommunications of the UPM (1991-2000). From December 2003 he holds a Full-Professor position at the University of Oviedo where he was the Vice-dean for Telecommunication Engineering at the Technical School of Engineering at Gijón (2004-2008). As of 2001 he heads the research group Signal Theory and Communications TSC-UNIOVI at the Dept. of Electrical Engineering of the University of Oviedo. He was a Visiting Lecturer at the National University of Engineering in Peru in 1996, a Visiting Researcher at Syracuse University, New York, in 2000, and a short term Visiting Lecturer at ESIGELEC in France from 2005 to 2011. He held the Telefónica Chair of "RF Technologies", "ICTs applied to Environment" and "ICTs and Smartcities" at the University of Oviedo (2005-2015). Member of the board of directors of the IEEE Spain Section (2012-2015), member of the board IEEE Microwaves & Antennas Propagation Chapter (AP03/MTT17) (2016-2018) and member of the Science, Technology and Innovation Council of Asturias (2010-). He has led and participated in a great number of research projects and has authored over 450 articles published in academic journals and proceedings of international conferences, mainly in the areas of antennas, propagation, metamaterials and inverse problems with application to antenna measurement (NF-FF, diagnostics and holography), electromagnetic imaging (security and NDT) and localization, developing computational electromagnetics algorithms and technology on microwaves, millimeter wave and THz frequency bands.

Danielle Vanhoenacker-Janvier received the M.S. degree in electrical engineering and the Ph.D. degree in applied sciences from the Université catholique de Louvain (UCL), Louvain-la-Neuve, Belgium, in 1978 and 1987, respectively. She has been a Professor and Full Professor with the UCL, since 2000 and 2007, respectively. She was the Head of the MicrowaveLaboratory, Louvain-la-Neuve, from 2001 to 2006 and in charge of Student Affairs at theLouvain School of Engineering, Louvain-la-Neuve, from 2001 to 2011. She has been the Chair of the Doctoral Commission, since 2015. She has authored more than 120 technical papers. She is the coauthor of one book. Her main activity domain is the study and modeling of atmosphericeffects on propagation of radio waves above 10 GHz for more than 30 years, with a special interest in the propagation through turbulent troposphere and in the use of numerical weather prediction software for the simulation of atmospheric effects. New applications are foreseenat optical wavelengths. Her group is also involved in the simulation of the radar cross section of airplanes wake vortices and the evaluation of the Doppler spectrum. She is also active in microwave circuit design. Prof. Vanhoenacker-Janvier is a reviewer for various international conferences and IEEE and IEE journals. She has acted as an expert for the evaluation of research teams in various countries. She is the Secretary General of the European Microwave Association.

Joel Flávio holds a master’s degree in Electronics and Telecommunications Engineering. He received his degree from University of Aveiro (Portugal) in 2016. He joined Joanneum Research (Austria) in 2018 where he works as a researcher in the microwave propagation field. He is currently involved in the Alphasat propagation experiment and in the design of the LEO W-CubeSat project. His research interests include microwave propagation along Earth-satellite paths and microwave remote sensing.

Michael Schmidt received his Master’s in electrical engineering from Graz, University of Technology in 1993. From 1993 to 1995 he worked in the Rutherford Appleton Laboratories (UK) and the Buckingham University (UK) on the design of broadband communication systems. Since 1996 he is employed at JOANNEUM RESAERCH, Graz/ Austria working in the fields of satellite communication with the focus on hardware and system design and the project management for ESA and EU projects. He is co-principal investigator (PI) in the Alphasat Aldo Paraboni communication experiments and he is member of the IEEE