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Using the Q/V-band Aldo Paraboni payload to validate future satellite systems: test campaign and preliminary results of the QV-LIFT project

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Abstract

In future communication satellite systems, the adoption of higher frequencies as Q/V-band (around 40 GHz for downlink and 50 GHz for uplink) is seen as a promising step forward to achieve higher performance in terms of total system throughput.
The subsystems developed in the course of the project will be tested in a real environment using the Q/V-band Aldo Paraboni (AP) payload on Alphasat (25° east) and its associated ground segment, made available by the Italian Space Agency (ASI). This project has been granted by the European Commission and involves a consortium of companies and universities coordinated by ASI. The consortium consists of: Martel GmbH, Erzia Technologies SL, Eutelsat SA, MBI Srl, Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), OMMIC SAS, Heriot-Watt University and SkyTech Italia Srl. In preparation of the on-field test campaign using the Aldo Paraboni payload (to be started in July, 2018), two earth stations have been equipped with the QV-LIFT gateways component, whereas a third station hosts the fixed user terminal. This paper describes the preparatory activities carried out to assess the performance of the hardware and software components specifically designed for the Q/V-band satellite communications system. The QV-LIFT project also includes the development of a Q/V-band Airborne Terminal providing a two-way on-the-move communication link for aircrafts. However, this activity is not presented in this paper.

1. Introduction

Signal fading in Q/V-band can exceed 30 dB due to tropospheric phenomena including rain and clouds. Fade mitigation techniques, such as the adaptive power control (APC) and the adaptive coding and modulations (ACM), do not provide a sufficient dynamic range by themselves. To overcome that, strategies have been proposed in literature. Promising ones for future VHTS systems were published as smart gateway and soft diversity [1] and [2]. The QV-LIFT project investigates on the applicability of such techniques and provides technological solutions with high level of technology readiness so as to foster the competitiveness of European industry as key technology providers for Q/V-band.
This paper focuses on the description of the activities carried out in the last months to prepare the two earth stations and the user terminal that will compose the QV-LIFT test platform. Those preparatory activities include laboratory tests and simulations aiming at the performance assessment of the ad-hoc developed software and hardware components. In particular, the activities described in this paper are: (*i*) performance assessment of the block up-converter (BUC, L-band to Q/V-band) and of the low-noise block (LNB, Q/V-band to L-band) specifically designed to for one of the earth stations; (*ii*) development of an algorithm that, based on real-time observation of the signal level, is in charge of triggering the gateway switch; and (*iii*) implementation of two mechanisms that allow the traffic re-route from the vanishing to the replacement carrier considering the availability or not of a spare gateway.

2. The QV-LIFT platform

The QV-LIFT platform uses the AP payload on Alphasat. The payload is able to connect two beams, located in southern and northern Italy and respectively referred to as “Beam South” and “Beam North” in this paper. Two earth-stations, named “Tito Scalo” and “Matera”, host the QV-LIFT gateways in Beam South, while the user terminal is located in Beam North at the “Spino D’Adda” station. In Figure 1, which shows the test environment, the components whose development and tests are described in this paper are highlighted in red. A 10-MHz channel is available for each link. The Eutelsat-proprietary F-SIM [3] protocol is used over the return link (the link connecting the terminal to the gateway), while DVB-S2 is used over the forward link (connecting the gateway to the terminal). The F-SIM physical layer is based on a spread spectrum waveform and an ALOHA protocol which guarantees high robustness to interferences and asynchronous access for the terminals, at a maximum user data rate of 128 kbps in a 10-MHz channel. Each earth-station of Beam South hosts an F-SIM demodulator, developed by MBI, for the return link reception and a DVB-S2 modulator for transmissions over the forward link. Eutelsat will provide the SmartLNB terminal to be installed at the "Spino D'Adda" station. This is the current implementation of the interactive satellite terminal (IST), commercially deployed for machine-to-machine applications. The earth-station "Matera" does not offer Q/V-band up and down conversion capabilities. Hence, the missing components have been specifically designed by Erzia for the on-field test campaign. The QV-LIFT Hub, developed by MBI, is in charge of handling the switching requests that occur when a gateway gets impaired due to severe weather conditions. In the context of the QV-LIFT project, the time-varying channel is emulated via the Multisite Time Series Synthesizer [4], a tool recently developed to generate concurrent space-time correlated tropospheric attenuation time series on two (or more) sites while the requests for switching are the output of a decision algorithm. These components are developed by the Politecnico di Milano (PoliMi).

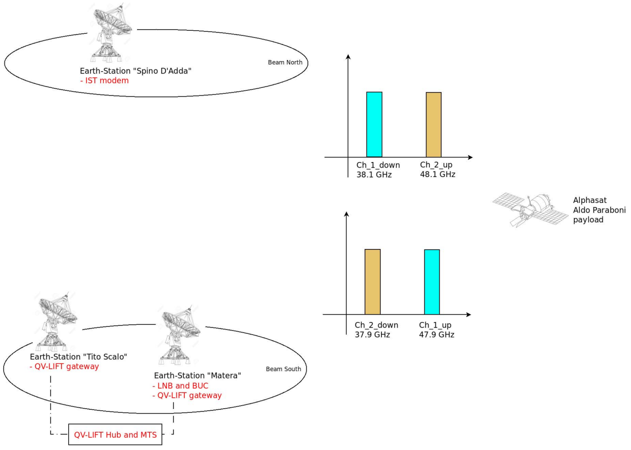

Figure 1. A schematic view of the test environment highlighting in red the components described in this paper and showing also the frequencies used for the on-air tests.

3. On-going activities

This section briefly describes the activities that Erzia, PoliMi and MBI are carrying out in preparation of the on-field test campaign. These activities regard the buc/lnb design, the design of the switching decision algorithm and the implementation of the carrier switch procedure.

BUC and LNB is being developed by ERZIA in two different modules. BUC will convert from an input frequency in the range [1.25-1.75] GHz to an output in [47.2-50.2] GHz with an expected output power of 15W and an overall gain around 50 dB. The BUC module will include the up-converter stage and a solid state power amplifier (SSPA) to guarantee the power level of 15W. The SSPA will combine four monolithic microwave integrated circuits (MMICs) specially developed for this project in a waveguide magic T that minimizes the insertion losses in the combination strategy. BUC's overall size will be around 280x150x150 mm with coaxial input and waveguide output.

The LNB will convert from [37.5-42.5] GHz to [1.25-1.75] GHz, with an overall noise figure below 3.5 dB and a gain around 50 dB with a very low power consumption and in a very compact size of 100x50x30 mm with waveguide input and coaxial output.

The switching algorithm will be jointly developed by the University of Rome Tor Vergata, PoliMi and MBI starting from the analysis of tropospheric attenuation data collected during past and ongoing experimental campaigns (e.g., ITALSAT and Alphasat Aldo Paraboni EM wave propagation experiments), as well as of the outputs of the Multisite Time Series Synthesizer. The obtained results (e.g., statistics of the number of switches in a given period and of the number of gateways concurrently undergoing outage) will drive the optimization of the switching algorithm.

The carrier switch procedure is implemented by MBI. MBI has developed a component named "carrier master" which acts as a proxy between the QV-LIFT Hub and the machines implementing the return link demodulation and forward link modulation. The QV-LIFT Hub interacts with the carrier master to retrieve and/or change the configurations of the F-SIM demodulators and of the DVB-S2 modulators. The *smart-gateway* technique is implemented in two different versions. The first, named *gateway switching*, lies in creating a copy of the (return link or forward link) vanishing carrier given the availability of a spare gateway. When this is not true, the second approach named *soft diversity*, is used. In this case, terminals are requested to tune to a different frequency. The QV-LIFT Hub is in charge of handling the configuration messages sent to the terminals to trigger the frequency change. In this phase, all the QV-LIFT platform components have been installed in the MBI laboratory to perform tests (which are carried out in the L-band) aiming at estimating the time required to create a new carrier (in case of gateway switching) and the time required by the terminal to tune to a new frequency (in case of soft diversity).

4. Conclusions

This paper presents the test platform of the QV-LIFT project. The preparatory activities, regarding the BUC/LNB design, the design of the switching decision algorithm and the implementation of the carrier switch procedure, have been presented. These activities are on-going (they will be completed by the end of April, 2018) and will lead to the on-field test campaign using the Aldo Paraboni payload on Alphasat starting in June, 2018. It is desire of the authors to take advantage of the *AT-RASC*

Conference to present the preparatory laboratory test campaign results.

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6. References

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