

LUME-1

Nanosatellite

Case Study

DATA SHEET

- Form factor: 2U CubeSat
- Dimensions: 100x100x225 mm
- Net weight: 2.3 kg
- Operation band:
 - 430-440 MHz amateur band
 - 1090 MHz (L-Band)
 - 2.4 GHz (S-Band)
- Launch: Soyuz rocket from the Vostochny Cosmodrome (Russian Federation) on 27 December 2018
- Orbit: 480 km × 513 km, 97.30°
- Time in orbit: Still running (operative in-orbit since December 2018)



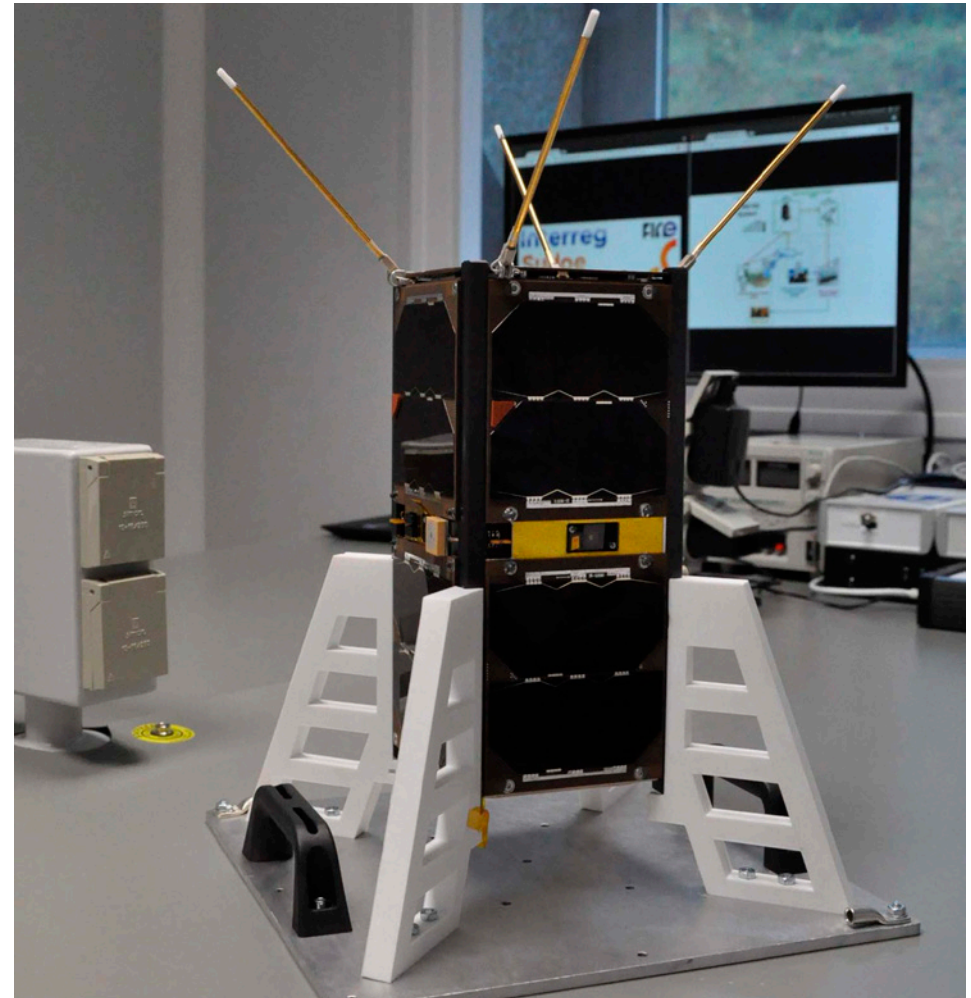
Cover photo:

© Roscosmos / Real image of the launch of the Lume-1 nanosatellite on a Russian Soyuz rocket on 27 December 2018.

IN SUMMARY

Lume-1 is a 2-unit CubeSat type nanosatellite belonging to the University of Vigo, designed and manufactured by the Alén Space team. The satellite is a key element of the European FireRS project, in which two other entities participate: the University of Porto and the Laboratory of Analysis and Architecture of Systems (LAAS) in Toulouse.

Lume-1 was launched into space on 27 December 2018 on board the Soyuz rocket from the Vostochny Cosmodrome in Russia. Lume-1 is the fourth satellite designed, manufactured and operated by the Alén Space team that has successfully fulfilled its main objective, meaning Alén Space has maintained a 100% success rate in all of its missions.



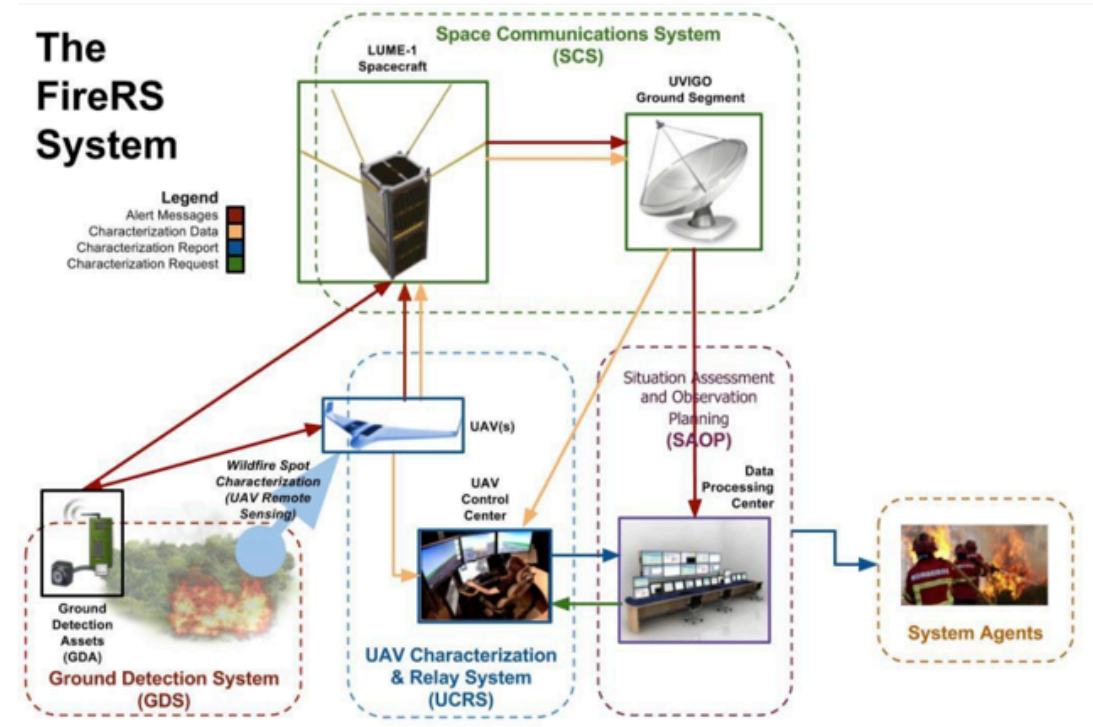
THE CHALLENGE

The **European FireRS** project aims the early detection of fires, as well as their monitoring and continuous follow-up in order to provide real data to emergency systems. It brings together three elements that make up the system:

- Ground sensors.
- A satellite that collects data from sensors.
- Software for predicting the progress of the fire.

The idea is simple. Infrared sensors geolocate the source of the fire and send a satellite alarm via a small modem. The satellite automatically forwards this alarm back to earth to be processed by the prediction software. This software generates a flight plan for UAVs that will go to the site of the fire to collect more data, upload it to the satellite and receive new flight plans updated via satellite, depending on the spread of the fire.

As a result, emergency systems have real on-site data of the situation of the fire, and can draw up more effective action plans.



THE SOLUTION

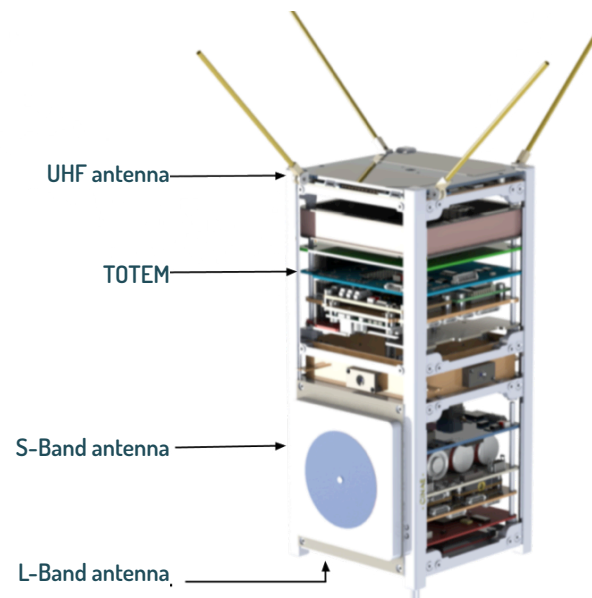
Lume-1

Lume-1 is a 2U CubeSat nanosatellite weighing 2.3 kg. It is one of the key elements of the project, as fire alarms are received through it. It has a payload developed by Alén Space called TOTEM, which is a software-defined radio (SDR), capable of executing different radio applications and being reconfigured in orbit remotely.

TOTEM is a very flexible radio that can work on different frequency bands to meet different needs, such as collecting data from sensors in the FireRS project. This application, also known as M2M (Machine-to-Machine) is the main application of the satellite and works in the amateur UHF band.

However, Lume-1 not only has UHF communication capabilities, but also includes two patch antennas for the L-Band (1090 MHz) and

S-Band (2.4 GHz). Thanks to TOTEM's wideband operation (70 MHz - 6 GHz), Lume-1 was able to perform secondary missions to validate in orbit other applications such as aircraft tracking through the ADS-B system or/and the spectrum monitoring in UHF and the S-Band.



THE SOLUTION

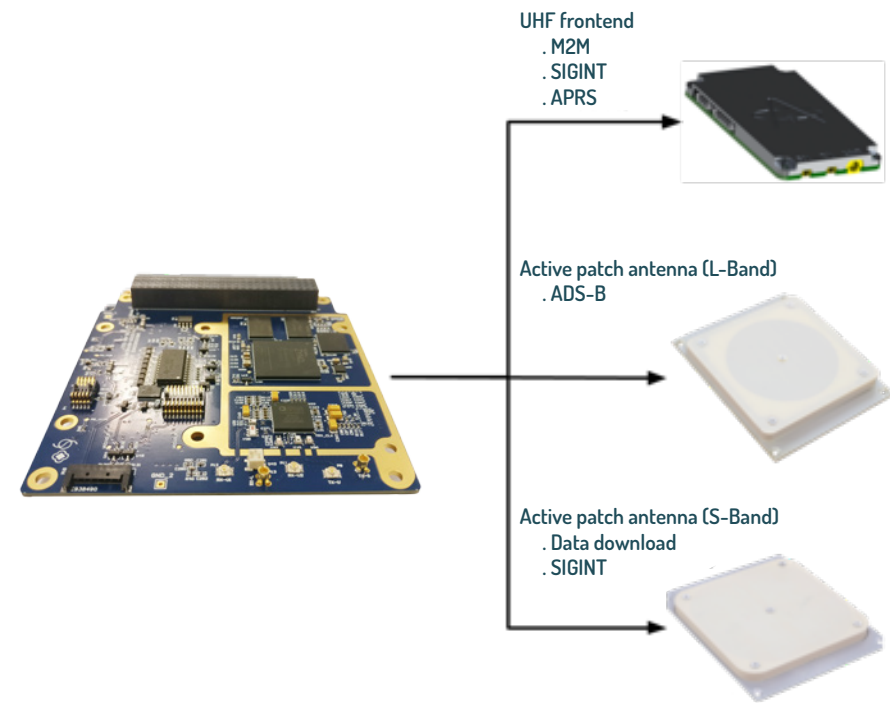
TOTEM

TOTEM is a software-defined radio for nanosatellites, reconfigurable in flight with several missions worth of experience in orbit. Lume-1 is the payload in charge of executing the main application: M2M. But thanks to its multiple RF ports and flexibility, it can operate in other frequency bands.

TOTEM's core consists of a System-On-Chip: a dual ARM processor and an FPGA. Along with an embedded Linux operating system, it supports GNURadio, a widely used open source software package for developing SDR applications in a fast and agile way.

Thanks to its features, TOTEM can efficiently run different radio applications on different frequency bands.

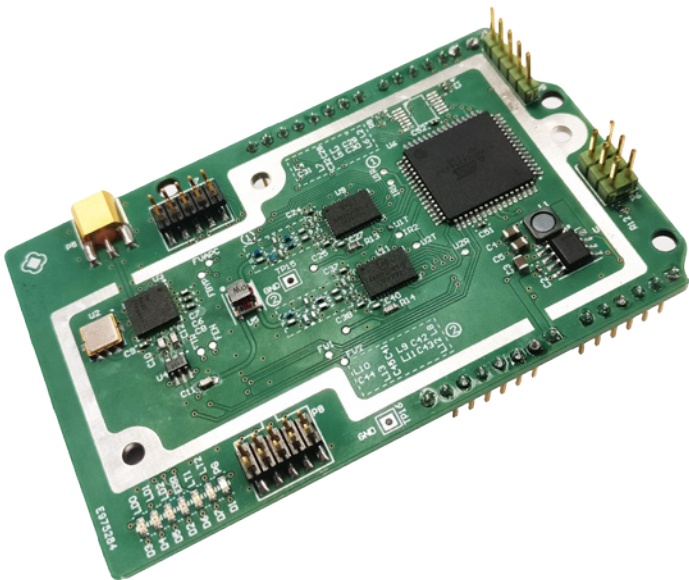
Moreover, since all these applications are defined by software, new applications or changes in them can be made remotely.



RESULTS

M2M Results

This is the main application of Lume-1 for **satellite communication with ground sensors**: infrared cameras and UAVs. It is a low rate short message communications application that allows multiple remote sensors to communicate with each other. To do so, the sensors have a small modem to send the generated data to the satellite.



The operating band of this application is the UHF amateur radio band, which has a high level of interference. Once in orbit, and after characterizing the channel, it was possible to readjust certain radio parameters in both TOTEM and ground modems to secure the link.

More than 160 M2M operations have been performed, all of them between the Vigo area (Spain) and Portugal, making it possible to validate the application and communications protocols of TOTEM for this type of applications. All demonstrations were held in scenarios with live fire and drones.

RESULTS

ADS-B Results

The -Z side of Lume-1 has a built-in active L-Band (1090 MHz) patch antenna. This is the frequency on which the ADS-B system works, which airplanes use to send data in order to be located. TOTEM performs on-board processing consisting of 30-second filtering between positions and data compression prior to download. The application decodes the ADS-B streams to extract the relevant information for aircraft tracking.

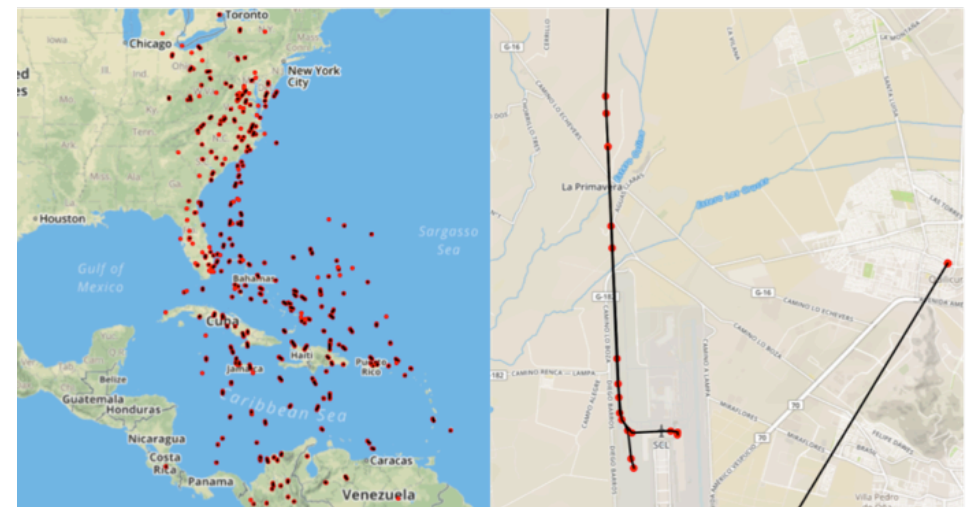
Parameters	
ICAO	Identifier
Position	Altitude
Speed	Destination

It is important to note that during these tests, the satellite was without attitude control, which is expected to provide a substantial

improvement following its implementation and the correct alignment of the antenna.

Below are some statistics obtained by TOTEM in a single 10 minutes operation:

- o **3,359 messages gathered (10 minutes)**
- o **1,334 ICAOs**
- o **850 positions**
- o **305 ICAOs with complete positions.**



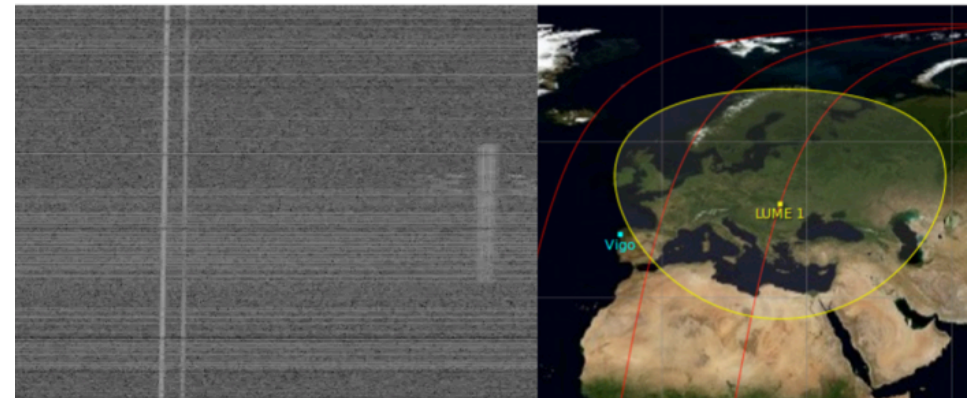
RESULTS

Signal Intelligence Results

Signal intelligence consists of analysing the radio spectrum in search of radio emissions for characterization and analysis purposes. In previous missions (Humsat-D and Serpens), UHF spectrum analysis campaigns had already been carried out with a payload that was not specifically designed for this purpose.

Now, with TOTEM these studies can be improved in order to detect unauthorized emissions or interferences between many other applications. To do this, TOTEM is capable of scanning frequencies in the target band and generating a preview image to download to the

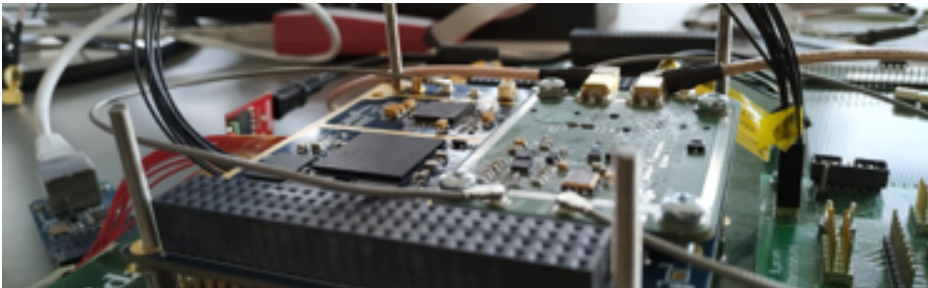
ground for analysis. An instruction can then be issued to download the raw data, even applying additional filters and minor processing in order to reduce the downstream data. The following image shows a preview of the spectrum in UHF for 5 seconds in a bandwidth of 25 KHz.



RESULTS

APRS Digital Repeater Results

Additionally, once the satellite was in orbit, the Spanish radio amateur community proposed creating a digital repeater for radio amateurs using TOTEM.



This new application, correctly designed and tested on ground using the engineering models, was uploaded to the payload (TOTEM SDR) as a new software service and tested with the cooperation of radio amateurs.

S-Band Communications Results

S-Band communications are already developed, pending uploading to TOTEM. Amongst other possibilities, this will make it possible to download telemetry or payload data at high speed, maximizing the efficiency of operations.

HERITAGE

Lume-1 has completely fulfilled the mission for which it was designed. Thanks to its payload, TOTEM has also been able to meet secondary and additional objectives that were not foreseen at the start of the mission. This makes it the ideal demonstrator for carrying out more tests and new applications in order to validate and test a new satellite concept in orbit: software defined satellites. A constellation of this type of satellites is used to put a totally reconfigurable infrastructure in orbit, at the disposal of the end user.

To date, and especially in the case of larger satellites, while their missions have been defined from the outset and they have been designed and

manufactured in accordance with these requirements, these small software-defined satellites offer a flexible platform capable of being reconfigured on demand to cater for different applications.

For Alén Space, the success of Lume-1 and its payload represents a new example in flight of the quality of our products and services. And in particular, Lume-1 also successfully illustrates the paradigm of software-defined satellites that opens up promising and exciting avenues of development towards the deployment of new businesses in space and the definitive reduction of barriers to space.

MEDIA



Flynews

El nano satélite español Lume-1 cierra los lanzamientos espaciales de Rusia de 2018

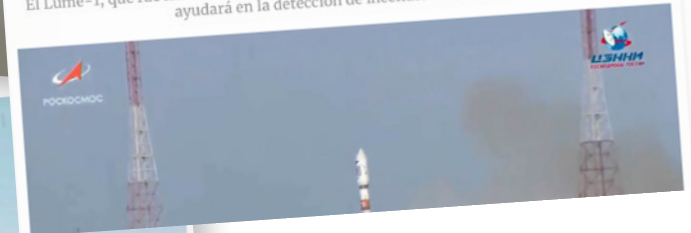
10 meses · Añadir comentario · Juan Pons



La Voz de Galicia

El cuarto satélite de la Universidad de Vigo ya está en órbita

El Lume-1, que fue lanzado con éxito esta madrugada en el cohete Soyuz 2 desde Siberia, ayudará en la detección de incendios forestales



LA VANGUARDIA

Prueban con éxito satélites, sensores y drones para detectar y combatir fuego

tve

infoespacial.com

La Universidad de Vigo y Alén Space lanzan su nanosatélite Lume-1



Noticia en TVE sobre el éxito del lanzamiento del Lume-1

38 visualizaciones · 28 dic. 2018

CADENA
SER

El Lume 1 ya está en órbita

La Universidad de Vigo lanza su cuarto picosatélite al espacio



ABOUT ALÉN SPACE

Alén Space is a spin-off of the Strategic Aerospace Group of the University of Vigo, which has been working for more than 10 years on the consultancy, manufacture and operation of small satellites, with 100% success in all its missions.

The Alén Space team has developed projects in which it has collaborated with the European Space Agency (ESA), NASA, the Agência Espacial Brasileira (AEB) and the United Nations Office for Outer Space Affairs (UNOOSA).

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