DAILY SCIENCE
DÉCOUVREZ LA SCIENCE, LA RECHERCHE ET L'INNOVATION "MADE IN BELGIUM"

Good to go... into space!

By Laetitia Theunis

Before going into orbit, many satellites and space instruments are tested at the Centre Spatial de Liège (CSL), whose excellence is recognised throughout the world. This is the case with 3MI, a remote sensing instrument developed by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the European Space Agency (ESA). “We are finalising the analysis of the data. With 3MI, we have taken on global responsibility and have become fully involved in space instruments for the first time,” says Prof. Serge Habraken, Director of the CSL. This paves the way to new scientific insights for the Liège-institute.

A tool for monitoring climate change

The acronym 3MI reflects the multi-view, multi-channel and multi-polarisation capabilities of the instrument. Developed by Leonardo, an Italian company based in Florence, 3MI is a radiometer, i.e. an instrument that measures the radiant flux of electromagnetic radiation in different wavelength bands.

3MI will fly in a polar sun-synchronous orbit. “This means that it will pass over the same point on the Earth’s surface each time at the same solar time. It will therefore receive the same luminosity, making it easy to compare the images taken.”

“The instrument will pass from one pole to the other at an altitude of 800 km and will orbit the earth about every 100 minutes. Its aim is to observe aerosols and their interaction with clouds, but also to measure the albedo, i.e. the reflection of solar radiation from Earth. This series of analyses will provide information on climate change,” explains Christophe Grodent, CSL’s Commercial Director.

3MI will be built in triplicate. These will be launched on board meteorological satellites, developed jointly by EUMETSAT and ESA : MetOp-SG-A1, MetOp-SG-A2, and MetOp-SG-A3, respectively in 2023, 2030, and 2027.

Simulation in space environment

However, before it is placed in orbit, it must be ensured that the instrument, built on Earth, will be able to work properly in the space environment.

The cleanroom at the Liège Space Centre is classified as ISO 7 or class 10,000. “This means that there are fewer than 10,000 particles in the air contained in the volume of a

large shoebox. By way of comparison, between 1 million and 10 million particles are found in the same volume in a house," explains Christophe Grodent. A bit further along, in a laminar flow room, the standard is even stricter: ISO 5 and class 100. To get in, you have to swap your hairnet and white apron for an outfit looking something like a cosmonaut's.

Therefore, the space instrument to be tested comes into an extremely clean environment. It is placed in a vacuum tank called FOCAL (for Facilité Optique de Calibration A Liège (Liège Optical Calibration Facility)). The acronym is accompanied by a number indicating the diameter of the tank. For example, FOCAL 5 is an impressive tank 5 metres in diameter.

There, the space instrument is stimulated by equipment that will remain on Earth :OGSE (Optical Ground Support Equipment, optical equipment), EGSE (electrical equipment), MGSE (mechanical equipment) and TGSE (thermal equipment). "These instruments will never go into orbit : we use them to validate and calibrate the space instrument. This is done by putting the instruments in conditions simulating the space environment in terms of heat, vacuum, and optical stimuli injected from outside or inside the tank."

100 days under vacuum

3MI has been continuously under vacuum for no less than 100 days. "This was the time needed to inject all the stimuli necessary for its calibration,i.e. different wavelengths, different angles, different types of measurements. The aim was to check that the optical performance of the instrument met EUMETSAT's expectations and demands," explains Prof. Habraken.

Why so much time? "Because of the type of measurements required, but also the reaction of the Ground segment equipment. The instrument must be rotated to validate another viewing angle, which takes some time. If 2,000 angles must be measured, then it has to be turned 2,000 times…"

"Incidentally, when you take a photo with a camera, you have to set the aperture and the shutter speed to obtain a sufficient number of photons. Here, it's the same: the integration time for the light arriving can vary: it can be very short or very long. This depends on the instrument. The duration of the test is therefore also linked to the nature of the instrument itself," continues Christophe Grodent.

Model development

The mission of the Liège Space Centre with 3MI did not end with these tests. On the contrary, it just began.

Once in orbit, installed on its satellite, the instrument will observe light arriving at its detector. This will then transform the energy received into a digital signal consisting of bits. However, as the instrument suffers from imperfections, these bits will have to be reprocessed and corrected,so that they can be turned into scientifically interpretable signals. These must correspond energy by energy, wavelength by wavelength to the signal received by the instrument.

To obtain an image as close as possible to the incident signal, "we created an instrument model that includes all its imperfections, as well as a calibration model. We have validated

these models with specific measures (highlighting the imperfections of the instrument, editor's note) that we took in the vacuum tank during the instrument calibration campaign."

Stray light correction

In this way, the CSL has succeeded in eliminating stray light from the images that will be obtained by 3MI, due to a point object in the field of view or outside it.

An instrument looks from a specific angle. If a point object, for example a star, is in its field of view, it should theoretically illuminate a pixel. "But in reality, the incident light undergoes multiple reflections so that, in addition to the theoretical pixel, other pixels are illuminated. This stray light is due to an imperfection of the instrument. It can be numerically stimulated and characterised."

"There is also stray light outside the field of view. In theory, a light point outside the field of view should not illuminate any pixel. In practice, this is not the case, as the incident light is reflected many times before it reaches the detector. We managed to eliminate it by subtracting it from the signal," explains Christophe Grodent, with enthusiasm.

Serge Habraken hopes that this first experience will lead to others. "Usually, our clients send us a black box and ask us what it is worth. In the future, our aim is, as with 3MI, to get more involved in space instruments through calibration, to understand them, and to model them - and therefore to be more involved in the research part."