# SPACE INSTRUMENT CALIBRATION


*$NO_2$ levels measured by OMI, a space instrument calibrated by TNO. $NO_2$ is released by the burning of fossil fuel. Considering the political consequences of these kind of data, a good calibration is mandatory*

TNO innovation for life

Calibration is an essential part of any space instrument. It translates raw instrument data into the physical units of interest so one knows exactly what, where and how much the instrument measures at any moment in time. Without a proper calibration the data from the instrument cannot be interpreted and science is not possible.
Space Instrument Calibration at TNO provides world class calibration technologies for Earth Observation Instruments; instruments that are unique in their application and for which no calibration standard exists.

## CALIBRATION OF EARTH OBSERVATION INSTRUMENTS

Earth Observation Instruments observe earth from orbit and are intended for purposes such as environmental monitoring, meteorology and map making. Each unique purpose requires a unique calibration approach. For a dedicated calibration it is essential to understand the key parameters needed from the instrument, which requires excellent understanding of the instrument and its use.

Typically the calibration approach is a combination of an *on-ground* prior to launch calibration and an after launch *in-flight* calibration throughout the mission. Both calibrations share certain measurements and both have their own unique advantages. As such they are complementary. TNO can offer a complete calibration approach providing a calibrated instrument throughout its complete life time.

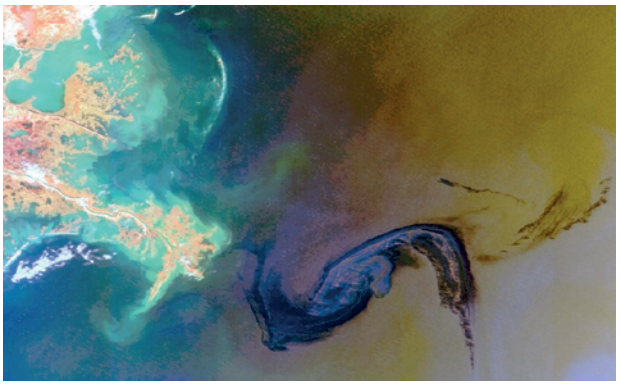
## ON-GROUND CALIBRATION OF COMPLETE INSTRUMENTS

After an instrument has been built and its performance has been verified, the last step before integration on the satellite is a proper and complete calibration. During this on-ground calibration phase, a dedicated set of optical stimuli provides the instrument with known scenes. In this way, the instrument's response is precisely characterised.

For Hyper Spectral Imagers, narrow band spectral imaging instruments, these measurements usually include:
- Radiometric calibration;
- Polarisation characterisation;
- Wavelength calibration;
- Slit-function characterisation;
- Stray-light;
- Field of view.

TNO has successfully performed the entire on-ground calibration for space instruments


*The GOME-2 instrument in preparation for calibration in the cleanroom at TNO. In the back, the Thermal Vacuum Chamber can be seen*



*Gulf of Mexico oil spill seen from space by the space instrument MERIS. TNO calibrated the diffusers of MERIS (credits to ESA)*

such as GOME, SCIAMACHY, OMI, GOME-2 and MSI. To mimic the space environment, TNO has a specialised Thermal Vacuum Chamber (TCH) at the Van Leeuwenhoek Laboratory of TNO in Delft. Several instruments have been calibrated inside this facility using TNO tailored optical stimuli for calibration.

## ON-GROUND CALIBRATION OF COMPONENTS

Many Earth Observation Instruments use the sun as a calibration source. In most cases a diffuser is used to reduce the light from the sun and to illuminate the complete field of view. One can look at a diffuser as a reference piece of earth inside the instrument.

TNO has developed its own Advanced Radiometric Calibration Facility (ARCF); a dedicated measurement set-up for space-grade optical component characterisation. This set-up has been used to calibrate the flight diffusers of the MERIS instrument and is also used to measure the reference diffuser for on-ground calibration of instruments such as GOME-2.

Although designed for diffuser measurements, the large dynamic range of the detection system enables the set-up to measure very low levels of stray-light of optical components like gratings. This makes the set-up also useful for accurate component level tests.

## ON BOARD CALIBRATION HARDWARE FOR SPACE INSTRUMENTS

As part of the overall calibration concept, TNO has developed, designed and built multiple calibration units for space instruments. These calibration units monitor critical changes in parameters during the instrument's operational life time in space. A typical source of these units can be the sun (via a diffuser), but for more demanding instruments sources like white light sources or spectral line sources can be implemented.

For hyper spectral instruments diffusers can introduce speckle effects. These speckles give structures in the data that can be wrongly interpreted by the users of the instruments. TNO has developed a new type of diffuser called the Quasi Volume Diffuser (QVD), which produces smaller speckles and has a better scattering performance. This type of diffuser is implemented in the OMI and GOME-2 instruments.

## TNO CALIBRATION SUMMARISED

- TNO offers the whole concept of calibration; from the design of complete instruments or calibration units to the calibration of components and entire instruments;
- TNO calibrates one of a kind applications;
- TNO owns unique facilities for calibration, such as the Absolute Radiometric Calibration Facility (ACRF), the Vacuum Calibration Facility (VCF) and several unique calibration stimuli;
- TNO has a track record for calibrating space instruments, in particular hyper spectral imagers;
- TNO has a large network in the scientific world, including the end users.

## TNO

TNO is an independent innovation organisation that connects people and knowledge in order to create the innovations that sustainably boost the competiveness of industry and wellbeing of society.

TNO works for a variety of customers: governments, the SME sector, large companies, service providers and non-governmental organisations. Working together on new knowledge, better products and clear recommendations for policy and processes. As a 'knowledge broker', TNO advises her customers on finding the optimum solutions that are geared precisely to the questions they have.

**TNO.NL**

CONTACT
Gerard Otter
T +31 88 866 65 47
E gerard.otter@tno.nl

TNO
Stieltjesweg 1
2628 CK DELFT
The Netherlands

P.O. Box 155
2600 AD DELFT
The Netherlands

TNO.NL/OPTICS

JRV140227-03