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SCIENTIFIC **INSTRUMENTATION**

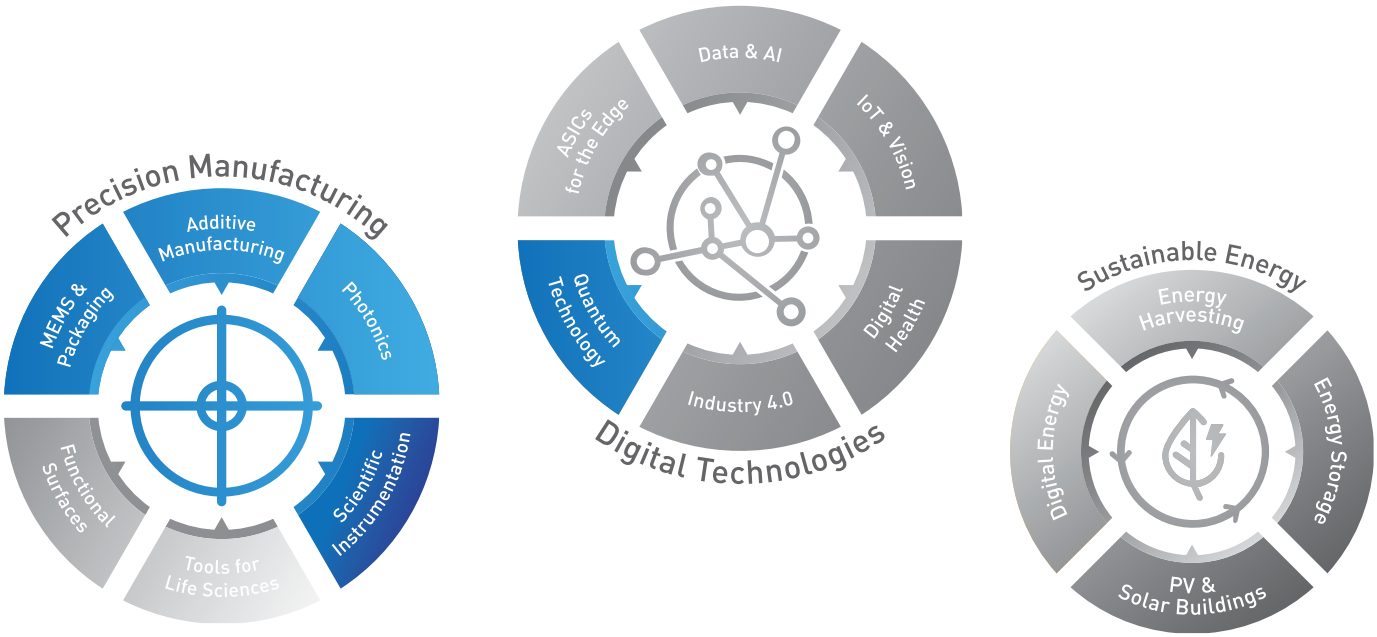
CSEM

Since its creation, CSEM has been a cornerstone of technology development and transfer for micro precision and digitalization technologies. These innovative technologies are the foundations on which smart systems are built, promising all industries new opportunities for economic growth.

CSEM has long been renowned as one of Switzerland's major research institutes—in the precision manufacturing domain as well as in low-power microelectronics and microtechnology—with our innovations being eagerly adopted by several key partners, including the watchmaking industry.

Pushing ahead into the new digital economy, our expertise extends into advanced technologies, analytics, and algorithms, which enable the Industrial Internet of Things (IIoT) and strengthen manufacturing processes. In domains as diverse as health, energy, aeronautics, space, security, agriculture, and consumer electronics, we provide our partners with the personalized tools, hardware, and software they need to take them forward into the digital age.

From precision manufacturing and sustainable energy to digitalization, we provide the expertise, technologies, processes, and services that can deliver a decisive advantage to all our industrial partners. CSEM is committed to advancing digital technologies in the economy across a competitive and global industrial environment. With 500+ employees, we are passionate about helping our partners achieve success in our rapidly evolving world.



Scientific instrumentation

Scientific instruments are now more intricate than ever and are increasingly created with precise, complex, multi-tech systems made from distinct physical layers. Keeping its partners at the forefront of this advancing scientific knowledge is CSEM.

For over thirty years, we have been investing our knowledge into the development, design, simulation, manufacturing, integration, testing, and transfer of hybrid precision systems based on compliant structures into industrial and manufacturing applications, and large-scale international science missions. We are experts in creating tools and instruments that meet even the most stringent requirements in terms of precision, resolution, operating environment, mass, and consumption.

We also support the Swiss space policy along the technology axes of high-precision mechanisms, atomic clocks, photonics, and scientific instruments. By leveraging our knowledge in precision mechanisms with our extensive microelectromechanical systems (MEMS) know-how, we have helped catapult forward space exploration and science missions in Europe and abroad. Our technological portfolio aims to increase longevity and reduce maintenance by limiting our designs to a smaller number of movable parts, thus enabling easier production at lower costs. As a spillover effect, this has helped advance innovation within the Swiss watchmaking industry and the industrial metrology and medical instrumentation domains.

Our core mission is the open transfer of technologies for integration into our partners' products or services so they can expand their market share and profitability. Discover in this brochure the benefits of working with CSEM in the domain of scientific instrumentation.

FlexMEMS

Lidar systems

High-precision space mechanisms

Instrumentation in astrophysics

Metrological instrumentation

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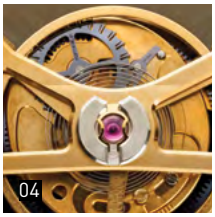
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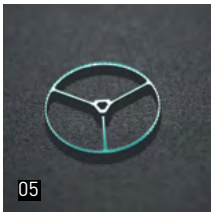
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01: Flexure-based escapement with high-power reserve
02: Two balance wheels in resonance
03: Mechanical oscillator
04: Tourbillon with detent escapement
05: Escapement wheel
06: Balance wheel with a virtual pivot
07: Monolithic escapement and oscillator
08: Silicon wafer for watch parts

FLEXMEMS

Within the watchmaking industry, silicon is a material of choice. Amagnetic, highly elastic, and requiring no lubrication, to name but a few of its beneficial properties, silicon has it all. Capitalizing on our microfabrication knowledge inherited from the microelectronics sector and mastery in developing compliant mechanisms, CSEM specializes in designing, manufacturing, and characterizing high-precision flexure-based parts made with silicon, or as we call it: FlexMEMS technology.

For over thirty years, CSEM has been growing its microelectromechanical systems (MEMS) and FlexMEMS portfolio. The core of our work focuses on the design, simulation, and advanced micromanufacturing of novel mechanical oscillators and escapement mechanisms that offer incomparable performances and are adapted to the thermal and shock environment of modern, high-end watches and timepieces. However, FlexMEMS technology can also benefit a wide range of other domains including, medical and space instrumentation, and microrobotics. With our sophisticated cleanroom and MEMS manufacturing facilities, we pride ourselves on equipping our industry partners with high-quality, high-performance, and reliable FlexMEMS solutions.

Our pioneering work in the FlexMEMS domain includes the invention of a novel FlexMEMS escapement. A key feature is its high-power reserve, which is three times higher than the conventional Swiss anchor escapement. Moreover, using FlexMEMS, we have developed several different mechanical resonators, which consume very little energy by combining the restoring function of a hairspring with the guiding function of a pivot.

Other examples of our FlexMEMS solutions already benefiting those from outside the watchmaking community include a high-precision XY table and silicon microgripper. Additionally, the compactness, precision, and frictionless motion FlexMEMS provide means that they are crucial within the microrobotics domain and applications where micromanipulation is required.

CSEM can cover all your FlexMEMS needs from design to manufacturing and characterization of your future product.

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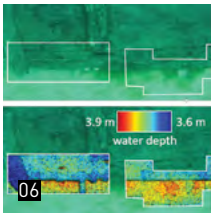

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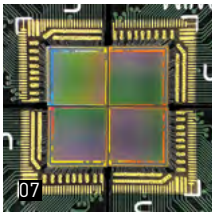
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01: RemoveDEBRIS's launch as seen from the International Space Station (ISS)
02: Airborne flash lidar for underwater imaging
03: Flash lidar prototype underwater (autonomous boat)
04: Unmanned Aerial Vehicle (UAV) undertaking airborne 3D imaging
05: Lidar and camera images obtained in orbit during the RemoveDEBRIS mission
06: Underwater 3D imaging of a shipwreck
07: Focal plane of 4 time-of-flight detectors created by CSEM | Detectors designed by the Fondazione Bruno Kessler (Italy)

LIDAR SYSTEMS

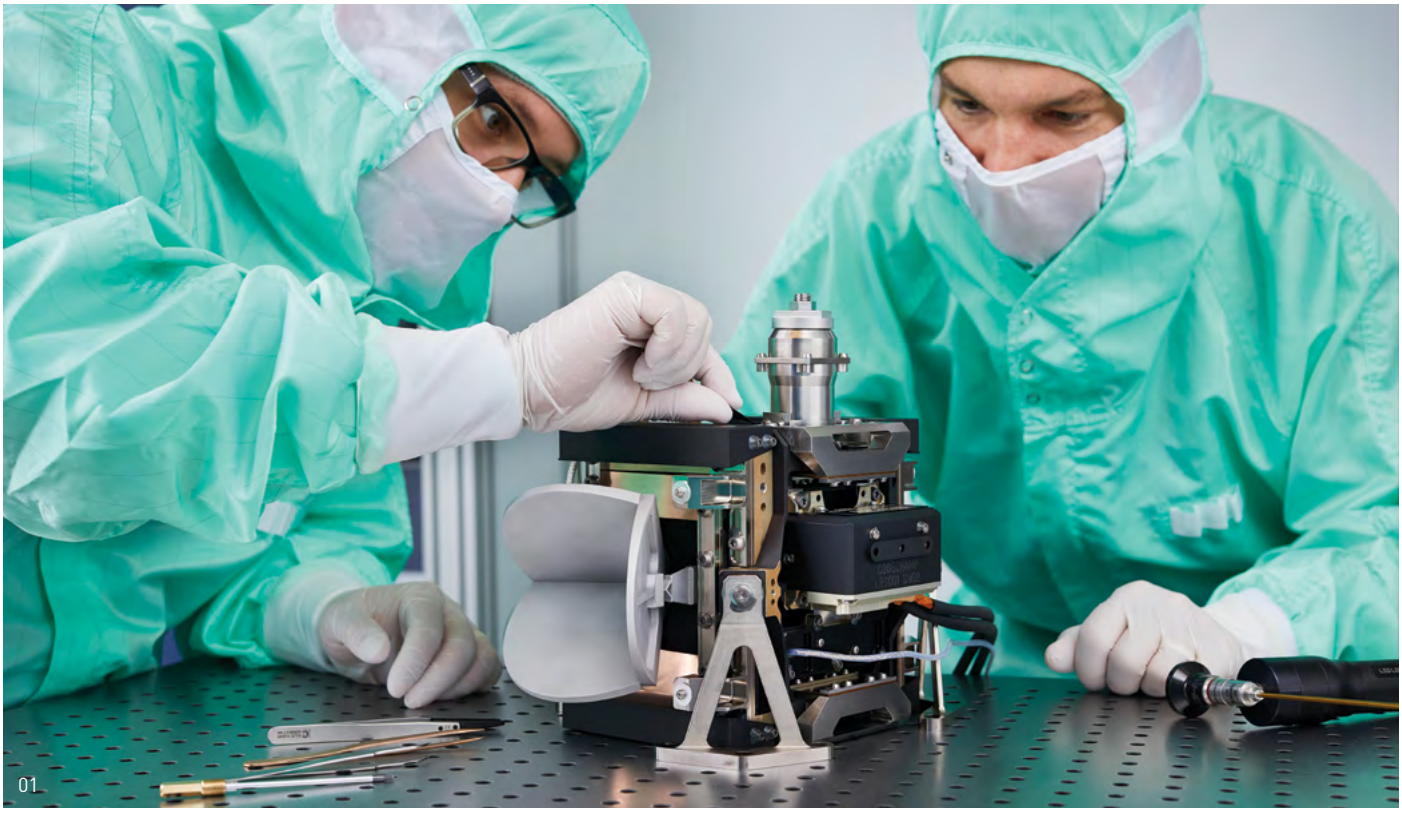
CSEM began developing light detection and ranging lidar systems over twenty years ago. Now we have entered into the lidar age, with the technology finding its way not only into everyday objects like smart vehicles but also orbiting in space.

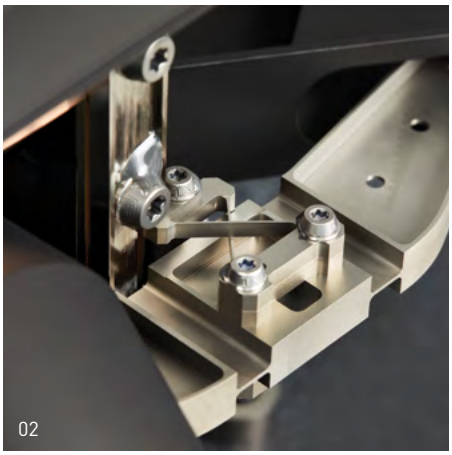
Comparatively to state-of-the-art scanning lidars, CSEM's advanced flash architecture makes no compromise when it comes to spatial resolution, measurement rate, or platform stability thanks to its snapshot acquisition of high-resolution 3D images. Based on matrix detectors with centimetric ranging precision and high throughput (approx. 10 Hz), our systems benefit from increased versatility with configurable illumination and receiver field-of-view that allows adaptation to environmental light conditions, obscurant presence, and target reflectivity.

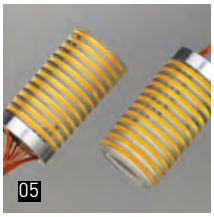
We have already successfully validated a flash lidar instrument within an eight-month in orbit mission, which targeted the removal of space debris (RemoveDEBRIS). The next-generation lidar featured an integrated system-on-chip for on-board processing to help tackle the challenge of extracting relevant positioning information in real-time, and enable semi-automatic rendezvous maneuvers.

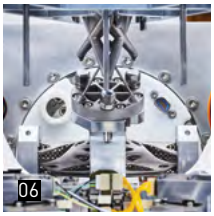
Alongside lidar for space applications, today the advent of low-cost unmanned vehicles has increased the need for precise, real-time 3D mapping. In this situation, CSEM's miniature lidar can be seamlessly integrated onto surface (USV), aerial (UAV), and underwater (ROV and AUV) unmanned vehicles for bathymetry, i.e., underwater imaging and mapping, object detection, or infrastructure monitoring. By taking advantage of the high transmission of green wavelengths underwater and combining it with our miniature lidar's inherent time-gating feature, our system can detect multiple echoes in turbid water. This latter capability also paves the way towards all-weather navigation, circumnavigating elements such as fog, smoke, or rain that might hinder visibility.

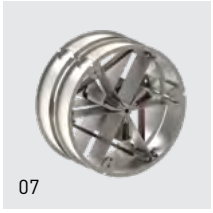
In parallel to flash technology, CSEM can also provide sub-millimeter resolution lidar, based on coherent architecture (i.e., interferometry) for surface metrology and gas sensing.











01: Corner Cube Mechanism (CCM) for the Meteosat Third Generation (MTG) interferometer
02: Flexure pivot for the MTG satellite's CCM
03: Close-UP Imager (CLUPI) focus mechanism for the ExoMars rover
04: Compliant Rotation Reduction Mechanism (CRRM) made with additive manufacturing (AM)
05: SMARTES: Slipring rotor made with AM
06: PULSAR: Successful integration of AM compliant mechanisms in a complex system
07: Large angular flexible pivot

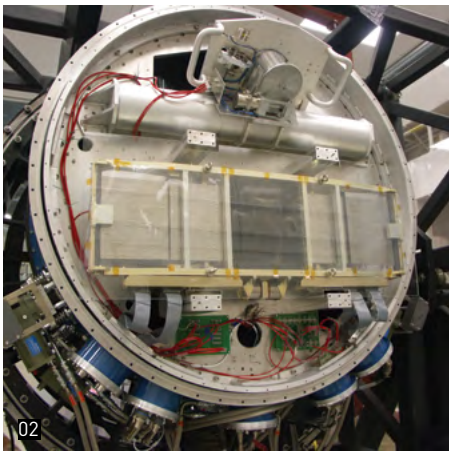
HIGH-PRECISION SPACE MECHANISMS

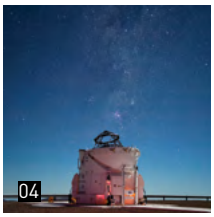
From the early 1980s, CSEM has designed, fabricated, tested, implemented, and sent into orbit space mechanisms for Earth observation. Since then, we have made continual efforts to improve the performance and reliability of our space mechanisms.

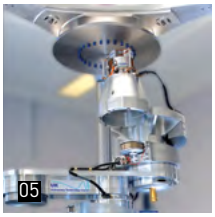
Now, not only does CSEM specialize in developing compliant mechanisms for high-precision applications, but we are also taking advantage of advanced technologies like additive manufacturing (AM). With the advances AM brings, we can integrate electrical functionalities in the manufacturing process, creating multi-functional mechanisms with increased performance, precision, and miniaturization, as well as reduced weight and friction.

Additionally, we realize the importance of minimizing any disturbances that may affect the performance of our developed space mechanisms. And, as a result, we have installed a fully dedicated micro-vibration characterization facility at our Neuchâtel headquarters, Switzerland. Our specifically developed micro-vibration test bench can detect even the smallest of disturbances and assess the performance and quality of our high-precision mechanisms. We are a one-stop-shop for all your space mechanism needs.

Our most recent successes in this domain highlight just what we can achieve for our partners. We developed the Corner Cube Mechanism found in the Meteosat Third Generation (MTG) mission (launch date set for 2023). Our Focus Mechanism in the Close-UP Imager (CLUPI) of the ExoMars rover, will help acquire high-resolution close-up images of Mars. And, using AM, we have created a topologically optimized and monolith Compliant Rotation Reducer Mechanism, with integrated interlocked lattice flexures for the European Space Agency. Moreover, at our micro-vibration facility alongside our partners, we recently contributed to the development of a prototype reaction wheel with magnetic bearings that offers the possibility of suppressing unwanted vibrations by control, achieving performances and speeds greater than anything we have seen before.







01: The twin telescopes at the W.M. Keck Observatory, Mauna Kea, Hawaii
02: MOSFIRE: configurable slitmask unit for the Keck II Observatory
03: SOFIA: the Stratospheric Observatory for Infrared Astronomy | ©NASA/Jim Ross
04: Hexapods for auxiliary telescopes at Cerro Paranal, Chile | ©ESO/José Francisco Salgado
05: Starpicker: a cryogenic positioning system for pick-off mirrors
06: SOFIA: secondary mirror measuring 350 mm in diameter | ©University of Stuttgart
07: Nasmyth Adaptive Optics System (NAOS)

INSTRUMENTATION IN ASTROPHYSICS

CSEM is well known within the space community for its highly precise optomechanical solutions and high-precision systems for astrophysics instruments. Since the 1990s, it has designed and produced state-of-the-art mechanisms for new generation telescopes, which combine precision, stability, and complex construction with high reliability. Our developments support world-leading observatories, and several of our solutions in compliant mechanisms are active in harsh environments e.g., withstanding cryogenic operating temperatures, being situated in remote high-altitude deserts, and even working within an airborne observatory 13 km above the Earth's surface.

At CSEM, we work actively with our partners to comprehend their needs when defining a conceptual design and we then transform these scientific goals into mechanism specifications. By collaborating closely with our clients, we can provide integrated solutions that optimize the overall design, from the instrument level requirements to the mechanism's performance.

Recent examples of CSEM's successfully completed projects include the Field Selector Mechanisms (FSM) that formed part of the Nasmyth Adaptive Optics System (NAOS) for the NAOS+CONICA instruments, which were integrated into the Very Large Telescope (VLT). We also designed and delivered the secondary mirror for the Stratospheric Observatory for Infrared Astronomy (SOFIA) telescope, as well as its complete and highly accurate control system. Moreover, as part of the W. M. Keck Observatory's instrument upgrade in 2005, CSEM provided the Configurable Slitmask Unit (CSU), a critical sub-system incorporated in the MOSFIRE instrument. Since 2012, the high-precision mechanism has allowed astronomers to remotely configure 46 programmable slits in a cryogenic environment.

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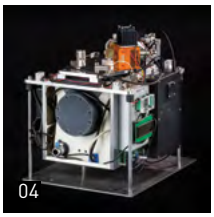
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01: Optical sensor head developed for the characterization of mechanical watch movements
02: Tridimensional measurement metrology
03: Close-UP Imager Focus Mechanism: linear motion control
04: A prototype of an optical spectroscopy system for airborne trace gas detection
05: Optical spectroscopy system for airborne trace gas detection—ready for take-off
06: Concept for blade manipulator for Aerial Image Metrology System (AIMS)
07: Flat form-factor miniature atomic clock physics package, including a patented planar optical waveguide

METROLOGICAL INSTRUMENTATION

Whether we realize it or not, virtually every domain relies on metrology. As technological change continues to accelerate at an unprecedented pace, the need for accurate measurements is more crucial than ever. CSEM's experts can meet the rapidly advancing needs of its partners, creating high-end metrological instruments for a variety of industrial applications, thanks to its cross-disciplinary R&D infrastructure and hybrid technology expertise.

We combine our years of knowledge in high-precision mechanisms, micro and nano electronics, photonics, intuitive software development, system optimization, and quantum technologies to create highly reliable measuring instrumentation. We support numerous industrial sectors, from the watchmaking, automotive, aerospace, healthcare, and communication industries, to the environmental monitoring, meteorology, time and frequency, and energy sectors in Switzerland and abroad.

CSEM builds customized metrology instruments according to our partners' requirements, making carefully selected trade-offs at the system level to find the most suitable solution, ensuring that it fits any budgetary or design constraints. We then guide our partners through the entire development chain, from multiphysics simulation and design up to the final realization of the instrument.

In line with CSEM's mission to transfer technologies and reinforce high-tech business in Switzerland, our scientific instrumentation sector is well supported by local and regional networks of highly skilled subcontractors and workshops. Moreover, our large-scale science projects and industrialization processes for producing metrological instruments are reinforced by the expertise and world-class reputation of our Swiss manufacturing partners.

Scientific instrumentation powered by CSEM technologies

Armin Strom

Two balance wheels in resonnance

Thanks to the support of CSEM, we succeeded in optimizing the coupling of two independent oscillators. A milestone in the history of watchmaking.

Claude Greisler
Co-Founder
Biel-Bienne (Switzerland)
www.arminstrom.com

ClearSpace

Making space sustainable

In our effort to make space sustainable, CSEM is a strong ally, offering years of experience in the space application field. Currently, in the framework of the ClearSpace-1 Service, our team has very different projects in robotics and navigation with CSEM. Their expertise, pragmatism and diligence allow us to advance ClearSpace's cutting-edge in orbit servicing.

Luc Piguet
CEO and Co-Founder
Renens (Switzerland)
www.clearspace.today

ESA—NASA

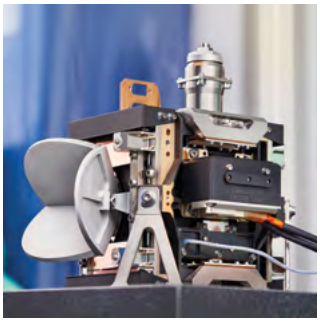
LISA mission

In the context of the LISA mission, CSEM successfully delivered upon the challenging development of a laser system breadboard and of the associated metrology setups. As a result CSEM was able to demonstrate the excellent performances of its system and its cutting edge laser system metrology expertise. ESA thanks CSEM's team for their hard and excellent work, as well as their positive and proactive collaboration.

Brian Shortt
Head of the Payload Validation Section
Noordwijk (The Netherlands)
www.esa.int

Thales Alenia Space

MTG



We have a very positive experience of working with CSEM for the European Space Agency, which is why we wanted CSEM to develop the Corner Cube Mechanism, a key element of our interferometer, in the MTG satellite, thus creating a new kind of meteorological instrument.

Jean-Philippe Chessel
Procurement Manager
Paris (France)
www.thalesgroup.com

Orolia

Chip-scale atomic clock

CSEM and Orolia Switzerland have had a long and successful partnership. We are grateful to have such a close relationship with this organization. Our ongoing project with CSEM is the development of a Chip Scale Rubidium Oscillator to complete Orolia's mRO-50™ product line.

Thanks to CSEM's MEMS expertise and micromachining facilities, Orolia Switzerland will now be able to access new types of markets and provide our clients with affordable and reliable components based on the latest technologies.

Serge Grop
R&D Program Manager
Neuchâtel (Switzerland)
www.orolia.com

Space Exploration Institute

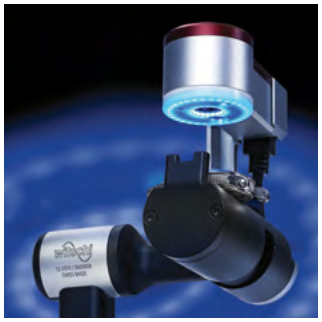
Focus Mechanism

CSEM has many years of knowledge and experience in designing moving mechanisms that perform reliably, frictionlessly, and with the precision of a few micrometers, which is a key performance characteristic of the instrument. Thanks to this know-how, the CLUPI has the potential to discover past life on Mars.

Dr Jean-Luc Josset
CLUPI Principal Investigator
Neuchâtel (Switzerland)
www.space-x.ch

Witschi Electronic AG

Instrument WisioScope S



The project was conducted with a very constructive attitude. Continuous and strong communication was always present and was a key success parameter. Measos* is considered as an example for future projects.

Daniel Hug
CTO and Vice-President
Büren an der Aare (Switzerland)
www.witschi.com

*Measos is the project which leads to WisioScope S

W. M. Keck Observatory

Keck's key instrument

CSEM is by far the best company we have worked with in the past 20 years. We not only recommend them without reservation but also hope for a future project in which we can once again benefit from their exceptional expertise and unique skills.

Ian McLean
Former Director of the UCLA Infrared Lab
Santa Cruz, CA (USA)
www.ucobservatories.org

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