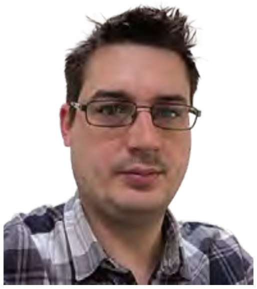
An interview with Rob Watkinson, Resolve Optics Ltd.



Designing and producing optics for use in space is a highly specialized area where expertise and experience are critical. Resolve Optics ltd. has been supplying lenses and optical systems for space applications for over 15 years. During this period, we have acquired a considerable amount of knowledge with regards to the do's and dont's for the designing for this harsh environment of space.

The firm's customers have benefited from their development and supply of novel and economic optical solutions. Several are currently world leaders in their niche high technology markets.

Drawing upon the firm's experienced team of optical designers, Resolve Optics is able to quickly gain an understanding of the basic physics of the technology associated with each customer's product enabling us to propose novel solutions. Our aim is to provide a fast and flexible optical and mechanical design assessment on all projects. A project engineer is assigned to closely liaise with customers at all points of a development to ensure complete satisfaction with the final product.

Mr. Watkinson, what experience does Resolve Optics have in minimizing the size and weight of satellite optics?

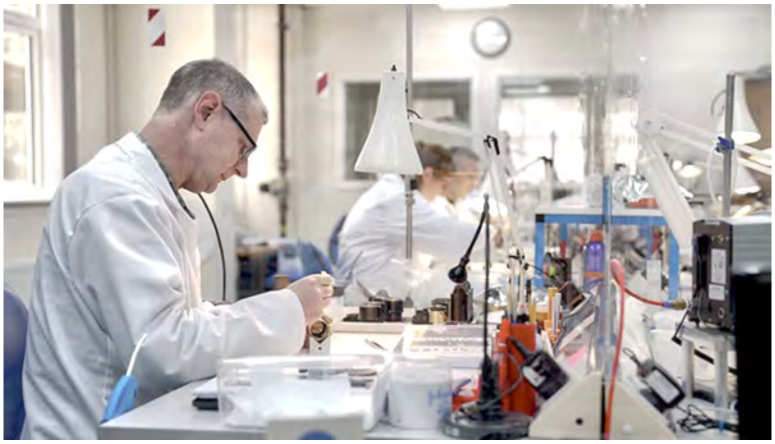
Rob Watkinson

Because launching payloads into space costs millions of dollars, the trend is for satellites to be decreasing in size and weight. Consequently, available space for optical systems in satellites is nearly always limited and most of the inquiries we receive for space lenses come with a size and/or weight limitation.

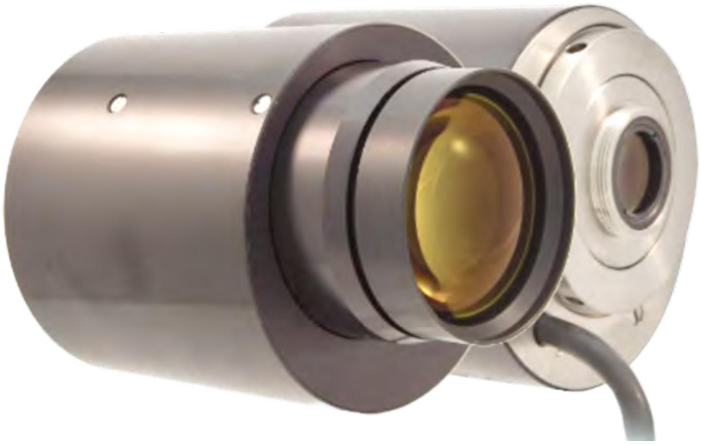
The requirement for small optics today is one of the most significant, driving forces in optical design. For this reason, it is important that the size and weight of lenses / optical systems be considered from the start of any satellite project. While our optical designers have ways to limit the size of a lens, these often come with trade-offs in terms of performance.

For example, designing a lens with a given f number requires a certain sized aperture and it is not possible to make a lens smaller than that aperture size while maintaining the required f number. The only way to make the optical component smaller is to stop down the lens and that will affect its performance.

Resolve Optics' offers sophisticated lenses for satellites.



Resolve Optics designers working on new optics products.



Radiation Tolerant Lenses

The size of optical sensors will also have a significant impact on the size of a lens—the larger the sensor, the larger the required lens to achieve optimum performance.

Which radiation tolerant optical materials do you recommend for use in satellite missions?

Rob Watkinson
It is widely known within the satellite community that radiation can significantly affect the transmission of glasses that are used to manufacture optical components. Standard glass types will turn brown when exposed to radiation, thereby steadily reducing transmission resulting in significantly reduced performance and, eventually, rendering the lens unusable.

To overcome this drawback, glass manufacturers developed Cerium doped versions of their classical glasses that display much less sensitivity to radiation. Depending on specifics of your satellite application, such as exactly where it will operate and for how long it will be used, a lens will be exposed to a lesser or greater amount of radiation.

For example, the level of cosmic radiation in Low Earth Orbit (LEO) will be lower than for a satellite optical system in a Geostationary Orbit (GEO).

In some LEO satellite missions of a limited time duration, where the total radiation exposure will be low, you can avoid the extra cost of radiation resistant glass and instead opt to use materials such as Calcium Fluoride.

We recommend that any LEO mission lasting a year or more should use radiation resistant optics to guarantee good transmission for the entire length of the mission.

What are the challenges in creating broadband and narrow band lens designs?

Rob Watkinson
The spectral range of an optical instrument or sensor defines the optical bandwidth that it can measure. The resolution of the optical instrument or sensor defines the minimal spectral feature that it can resolve.

A narrow band satellite application does not typically present us with an optical design challenge as it requires less color correction, thereby reducing the complexity of the lens.
As the bandwidth becomes larger, it becomes more difficult to keep everything in focus as well as to ensure good color correction.

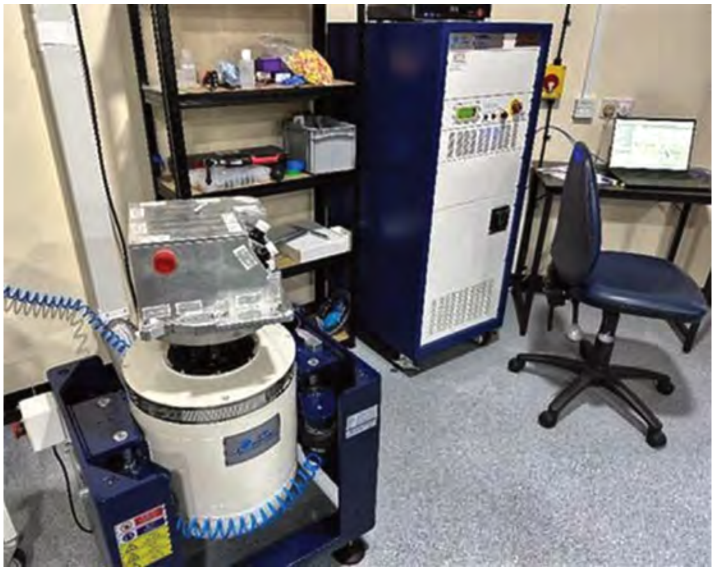
For applications that require very wide band widths, this can become particularly challenging necessitating the use of expensive glass types, aspheric lenses and multilayer coatings.

Space is a harsh environment—how do your lens designs survive the stresses of launch, cope with temperature extremes and work in a vacuum?

Rob Watkinson
All our custom satellite lenses are designed specifically to withstand the harsh environment of space. We typically work to a customer specification that will encompass key environmental factors including tolerance to vibration, shock, cosmic radiation, vacuum and temperature. Most environmental specifications we work with flow down from NASA or the ESA.

To ensure your satellite optics are sufficiently robust, all elements in our space-ready optics are secured and unable to break loose when subjected to the rigors of launch and other environmental factors.

We have in-house testing equipment that assures the lenses / optical systems meet stringent vibration and shock requirements before they get anywhere near a space launch.
Operating temperatures need to be considered in both the optical and mechanical aspects of a satellite lens design as space optics are subject to large temperature changes that can affect image quality.



Shock and vibration testing for satellites

To solve this challenge, Resolve Optics has experience in designing, passively and actively, athermalized lenses that are built to cope with the extremes of temperature with no variation in performance.

When it comes to vacuum proofing our space ready lenses, we use only NASA/ESA approved materials to ensure no outgassing can occur and vent any airspaces within the lens.

What are the typical trade-offs and limitations in designing optics for satellite imaging?

Rob Watkinson

With any custom lens design for a more demanding application, often compromises must be made from the '*we want all these performance specifications*' list.

As we discussed earlier, for satellite applications, the available operating envelope for optics is often a significant contributing factor to the need for compromise. As was discussed earlier, for satellite applications, the available space envelope for optics is often a significant contributing factor to the need for compromises. For instance, to design a long focal length lens requires that lens to be a certain length to provide good performance. There are ways to make it shorter, but you can only go so far with this design before you start to affect the performance.

In applications such as this, where a long local length is required in a short body, catadioptric (or mirror lenses) can provide a fantastic solution.

However, catadioptric lenses come with the downside of having higher *f* numbers. The larger the aperture (or smaller the *f* number) of a lens, the better its light collection capabilities. Although better light collection capability is often desirable it comes at a cost.

The larger the aperture, the larger the lens.

Another limitation can sometimes be the use of radiation resistant glasses in satellite applications. To color correct a radiation resistant lens you need to use a variety of different optical materials. This is a limitation as there are only a limited selection of radiation resistant glasses commercially available. For the many organizations focused on space applications that want higher performance from satellite lenses in order for them to match modern sensors, it is becoming increasingly difficult to achieve the required performance using only simple optical designs. We have found in such situations that aspheric lenses are often a useful tool to provide the desired higher performance.

Please describe a recent Resolve Optics lens development for a space industry customer?

Rob Watkinson

Specific details of most of the lenses we design for space applications are covered under non-disclosure agreements (NDA). However, one project I can tell you about is an order we received from a leading aerospace company to design and supply an optimized, wide waveband lens for a multi-spectral microscope required for a Moon exploration mission. The required lens was designed to provide best transmission across a wide spectral bandwidth and maintain best focus throughout.

To achieve this demanding specification, in the challenging lunar landscape, required the lens to be highly color corrected to the point that the design is almost diffraction limited. The optical performance of this specialist lens was further enhanced by custom designed MLAR coatings on the glass elements. The customer is delighted with the lenses we have supplied to them (see *resolveoptics.com/lens-innovation-newsletter-spring-2022/*).

Case Study: More than lenses...

Recently, the Resolve Optics vibration test center was used by Sen Corporation Limited to conduct sine sweeps and random vibration testing on their latest satellite payload.

Using the company's in-house ETS L215 Shaker, MPA101 amplifier and a DTS Venzo 800 controller, the testing consisted of a low-level sine sweep, followed by a random vibration test, and finished with another low-level sine sweep. The three tests were conducted in the X, Y and Z axis.

The output data provided to Sen was in the format of a run status CVS file for each test. This data enabled the sine test results to be overlayed so that any changes caused by the random test could be easily be identified. This fully calibrated test vibration test center enables Resolve Optics to offer this important service to customers. The company can currently provide Random, Random on Random, Sine and Classic Shock vibration testing for small test subjects of up to 30 kg, depending on the level Grms required.

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