resolveoptics

lens innovation

Welcome to the Spring 2022 edition of 'Lens Innovation' – a twice yearly eNewsletter from **Resolve Optics Ltd**. Each issue of Lens Innovation is designed to keep you informed about the latest technological developments, applications advances and breaking news in the optical design and manufacture industry.

If a particular feature interests you do not hesitate to contact us or follow the link for further information. We welcome your feedback.

Mark Pontin – *Managing Director*

INFORMATION GUIDELINES:

Environmental considerations when designing optics for satellite applications

The advantages of optical systems, over the competing technologies traditionally for use in spaceborne instruments, includes low power consumption, improved bandwidth, smaller size and weight, electromagnetic interference immunity as well as higher transmission and processing speeds.

However, designing lenses for use in in spaceborne optical systems is not straightforward. The challenges you must overcome include making sure your optics survive the vibration and shock of launch and are able to withstand the extremes of temperature, high vacuum and cosmic radiation encountered in space.

Consequently, for a lens or optical system to be considered space ready it must meet some very strict requirements. These requirements typically flow down from international space organisations, such as NASA or ESA. The last thing you would want is for a component to fail and jeopardize or hamper the mission. The cost of launching payloads into space is considerable, incorporating only 'space ready' lenses or optical systems into your satellite or space observation system is therefore critical for realising longer term, high-performance operation.

Let us now look at the key environmental considerations when designing lenses for use in spaceborne optical systems

Vibration and Shock

It is critical to design your optical system to survive the considerable vibration and shock encountered when a payload is launched into space and in some cases during landing on the surface of another planet.

To reduce the effect of vibration and shock it is important to keep your optical components small and light. The less mass you have the less effect the vibration and shock of launch will have, yes, it's the old $E=MC^2$ thing.

Another issue is to stop components in your optical system from moving. This requires that all parts are retained as tightly as possible and that retaining rings cannot work loose. This can be achieved by staking the retaining rings so that they cannot come loose. However, if your required optical components are heavy then it may be preferential to bond all the elements in position. In summary, it is vital that the mechanical design of space ready optics must consider the mass of the elements and determine what method of retaining is required.
Also, importantly the effects of vibration and shock must be considered across the operating temperature range of space launch to ensure components cannot become loose due the temperature cycling.

Resolve Optics has invested in in-house testing equipment to ensure all lenses and optical systems can withstand the vibration and shock profile forecast for launching the payload into space.

Vacuum

The difference between the refractive index of air versus a vacuum is so small as to have little to no effect on the final image when designing lenses or optical systems to operate in the visible spectrum. By contrast, when designing an optical system to operate in the UV spectral region you should consider that the differences in performance in a vacuum compared to air are now significant.

It is also vital that the mechanical design of your spaceborne lens or optical system consider that the materials, coatings, glues, and greases are carefully chosen to ensure their vacuum outgassing properties are known. At Resolve Optics we look to use tried and tested materials with known vacuum outgassing data. Therefore, we can ensure that detailed material certificates are available, and these certificates are supplied to the customer with the finished lenses or optical systems. These certificates provide proof of materials used and complete traceability back to their source.

In addition to using only approved materials – the mechanical design of space ready optics must also account venting of voids and trapped airspaces to avoid elements cracking or pressure affecting the performance of the lens or optical system.

Temperature

The biggest impact of temperature on an optical system is the expansion and contraction of the components which if left unaccounted for could lead to your optical system going out of focus.

To eliminate this negative effect – an optical system design must be athermal to ensure they maintain focus throughout the typically wide operating temperature range encountered in space.

Achieving passive athermalisation is possible for most optical designs but as the required bandwidth and resolution increase then this becomes more and more difficult. In these cases (which are rare) we work closely with customers to find the most appropriate solution that ensures best performance across their desired temperature operating range.

Radiation

Unfortunately, most standard optical glass types turn brown or grey when exposed to cosmic radiation encountered in space. As a result, the light transmission of the lens will degrade markedly. If your space mission duration is short, for instance just 1 or 2 weeks, then you can probably get away with using standard glass types as the level of discolouration over this period is likely to be relatively small.

However, for longer term missions, it is vital that cerium doped glass elements should be considered to prolong the life of your spaceborne lens or optical system to years. Cerium doped glasses often have a yellow tint, so careful selection of doped glass types should ensure the yellow tint does not adversely affect the produced optical image.

In addition to selected radiation resistant optical materials, all other materials used in the construction of your lens should also be carefully selected to eliminate the chance of components becoming brittle after time exposed to radiation.

Testing and qualification

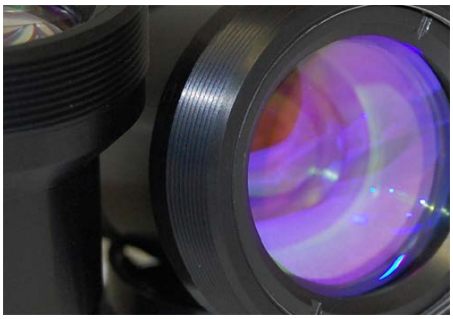
Once a lens or optical system has been designed to withstand the environmental challenges of launch and operation in space it must then be built and finally tested to qualify that it meets the optical performance specification.

Using our in-house state-of-the-art MTF test centre, we can provide accurate and repeatable test results for MTF/resolution, distortion, field of view and register distance on all supplied space ready lenses and optical systems in the form of a test acceptance report.

For further information or to discuss development of a space ready lens or optical system please **click here.**

VIEWPOINT:

Which comes first in new optical product design – the lens or the sensor?



For many engineers selecting a sensor is often their first consideration when designing a new optical product for a vision application. But really the selected camera sensor and lens should be considered as a package as one is not much use without the other.

However, 20+ years of experience have demonstrated to us that, despite the inherent advantages of selecting a lens optimised to your application first, that many optical product developers surprisingly choose their sensor first and then scramble around trying to find a suitable lens.

Currently demand is for new optical product designs to use sensors with higher and higher resolution, increased efficiency in low light conditions and to be able to capture images across wider and wider spectral bandwidths. To feed this demand there are a myriad of sensor / cameras available with new ones launched every year. Having selected a camera or sensor, one of the most common mistakes optical product developers make is thinking that lens selection will be a simple. To optimise image quality there are many variables that need to be considered such as lens field of view, aperture and increasingly the available space envelope into which the lens must fit. If you have already selected a large format sensor and require a high-resolution image it becomes harder and harder to keep a lens design compact as more elements are required for colour correction.

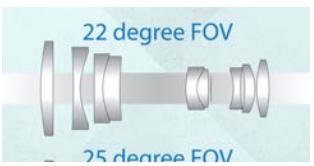
In summary – sensor resolution comes down to the number of pixels, more pixel's equal higher resolution. However, as you can see from the discussion above, choosing a lens optimised for your application at the same time as you are considering the sensor has many advantages. At Resolve Optics, we always first determine if there is an off the shelf lens that best suits your application. This information is offered free of charge. Only if no suitable off-the-shelf lens is available do we recommend designing an application optimised custom lens.

To arrange a no-commitment TEAMS call to discuss your application and if an off-the-shelf lens can fulfil your optical product needs please **click here.**

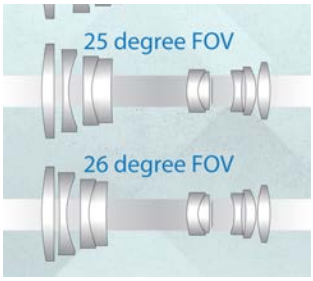
TECHNOLOGY FORUM:

Designing a versatile lens for multiple applications

Traditionally lens design has generally been a trade-off between creating a lens that offers operational convenience against designing a lens that excels at a particular application. However, in recent years, we have created some remarkable lens designs that change the traditional defining factors that characterize zoom lenses.



A key benefit of creating a versatile, high-performance lens usable for multiple applications is that it avoids the need to design several lenses incorporating slightly different optics, which can be very costly.



Recently, Resolve Optics was approached by an organization wanting to create a camera capable of servicing a range of applications. We proposed a lens design that offered Field-Of-View (FOV) flexibility through having multiple set-up positions where slightly different FOV's could be achieved.

For this customer, Resolve Optics developed a simplified zoom lens that covered all the FOV's required. Instead of incorporating a complex zoom movement, which the customer did not need, the elements of the zoom design were fixed to achieve the desired focal lengths. Adopting this approach, we were able to create a single optical design, with just different metalwork required to be able to offer versions of the lens optimised to operate at different focal lengths. This approach proved to be very cost effective for the customer. For instance, when the customer required 5-off of three lenses optimised for different focal length lenses. The metalwork was purchased in 5-off quantities because it was different for each FOV. But for the entire common parts including the optical glass elements, 15 sets could be produced in one go providing a considerable saving to the customer.

Our approach is always to maximise the return for the customer, increasingly over the past few years this has been achieved by creating a versatile lens capable of running multiple applications.

To enquire about versatile lens design for your optical product please **click here**.

DESIGN FOCUS:

Developing lenses that operate over a wide temperature range

A question we are often asked is 'What is the operating temperature range of a particular lens". As refractive index is a function of temperature, you could reasonably expect that a lens will experience some performance degradation with changing temperature. In addition, you should remember in an optical system that a lens is not acting in isolation. It is important to understand that the thermal performance of a lens can only be properly viewed in the context of an overall optical system design which considers how it is mounted and how it is oriented to the camera imaging sensor.

Increasingly design specifications we receive for new lens developments, particularly from space, military, and aviation customers, require the lens to hold focus over a wide temperature range, for instance -40° to +60°C which is a 100° temperature span. As the operating temperature changes, a lens will contract or expand, if the expansion is too great the lens could defocus or in a worst-case scenario the glass could crack or permanently shift positionally. Sometimes developing a lens to operate over a wide temperature range can be partly, or even occasionally completely, accomplished by the optical design and careful selection of glass types. However, often, the optical design needs the back-up of the mechanical design (mounting arrangement, orientation to the sensor etc.) to ensure that any expansion and contraction is as uniform as possible to enable the lens to maintain focus throughout the temp range. This approach is called Passive Athermalisation, which basically means there are no moving or active parts in the lens that promote refocusing.

Passive athermalisation is a popular route to achieving lens operation over a wide temperature range due to its simplicity, but there are limits to what can be achieved by this methodology. If your lens is required to operate at high resolution, over a wide spectral bandwidth or cover a large aperture then you will probably need the ability to refocus the lens as expansion due to temperature forces the lens out of focus. Manually refocusing the lens is straightforward, however the fun starts when automatic refocusing is required as this starts to get complicated and requires moving parts within the lens – a technique called Active Athermalisation. This technique is generally not as popular because of the complexity, which just presents more chances of mechanical failure within a lens assembly.

To discuss a new lens design for an application that requires 'in focus' operation over a wide temperature range – **click here**.

PROJECT NEWS:

In this newsletter feature we share with you the latest news on some of the interesting OEM lens design, development and manufacture projects that we are currently working upon.

Ultra-High-Definition satellite video streaming

Earlier this year – UK satellite video streaming specialists – Sen successfully launched their first ETV-A1 satellite aboard the SpaceX Falcon 9 rideshare mission that lifted off from Cape Canaveral Space Force Station.

Incorporating low mass, high performance radiation resistant lenses, designed by Resolve Optics to withstand the harsh demands of space, the first ultra-high-definition video images from the ETV-A1 satellite are being described as outstanding. The satellite has four video cameras on board to image Earth with different spatial resolutions, from continents and oceans to regions and cities. Sen's cameras are capable of streaming recorded and live Ultra High Definition (UHD) video including 8K video from its highest resolution camera that can see down to around 1.5m of the ground.

ETV-A1 is the first in Sen's planned constellation of video satellites in Low Earth Orbit.

Rob Watkinson, Production Manager at Resolve Optics said "To make technology work in space you must overcome the extreme temperature changes and high levels of radiation that can damage electronics and hardware. Sen recognised that commercially available camera lenses were not suitable for their application because the glass would increasingly suffer from radiation 'browning' – meaning that image quality would gradually deteriorate over the lifetime of their satellite. The excellent video imagery from the ETV-A1 video cameras demonstrates that our low mass lenses have met Sen's challenging specification in terms of optical performance, radiation resistance and mounting arrangement able to withstand the satellite launch into space".

For information on the Sen ETV-A1 satellite launch – **click here**.

For further information on space ready lens design and development – **click here**.

HOT OF THE PRESS

This newsletter feature is written to inform you about what's new at Resolve Optics.

New Video Content

Resolve Optics has created a series of new eye-catching videos that provide an informative introduction to the company, our in-house facilities and capabilities that enable us to produce high performance custom zoom, radiation tolerant and ruggedised lenses.

Click here to watch videos.

Why not meet us at VISION 2022?

After an extended period of only virtual communication being possible between suppliers and users of photonics and imaging products. We are pleased to announce that Resolve Optics will be exhibiting at VISION 2022 in Stuttgart, Germany. Bookmark these dates (4th-6th October 2022) to attend the world's leading trade fair for machine vision – we look forward to meeting you there.
To visit website, **click here.**

THE LAST WORD:

Solving the mystery of the Moon's magnetic swirls

Due for launch in 2024 – a new solar powered land rover – the Lunar Vertex will explore the Reiner Gamma swirl, one of the most distinctive natural features and so-called "magnetic anomalies" on the Moon.

Scientists believe the Reiner Gamma swirl can help them answer many questions about conditions on the Moon and other airless worlds throughout the solar system. To get that data, the US-based Johns Hopkins Applied Physics Laboratory (APL) leads a project not just to visit Reiner Gamma but to drive right across it.

A NASA-provided commercial lander will deliver Lunar Vertex to a location within Reiner Gamma, where it will conduct complementary investigations both from the lander and from a small rover that will explore just over a mile (up to 2 kilometres) of the 43-mile (70-kilometer) wide surface feature. The Lunar Vertex payload includes an ion-electron plasma spectrometer and cameras that will remain on the lander, magnetometers on both the lander and rover, and a multispectral microscope on the rover.

The project combines the expertise of several leading space institutions and commercial companies. Leading Canadian aerospace company – Canadensys (www.canadensys.com/) has been selected by NASA to develop the multi-spectral microscope that will incorporate application optimised lenses developed by Resolve Optics Ltd.

To read more about this exciting project: **click here**.

Printable version (pdf)

OFFICE HOURS
Monday: 8.00 – 5.30
Tuesday: 8.00 – 5.30
Wednesday: 8.00 – 5.30
Thursday: 8.00 – 5.30
Friday: Closed (See contact page for details)