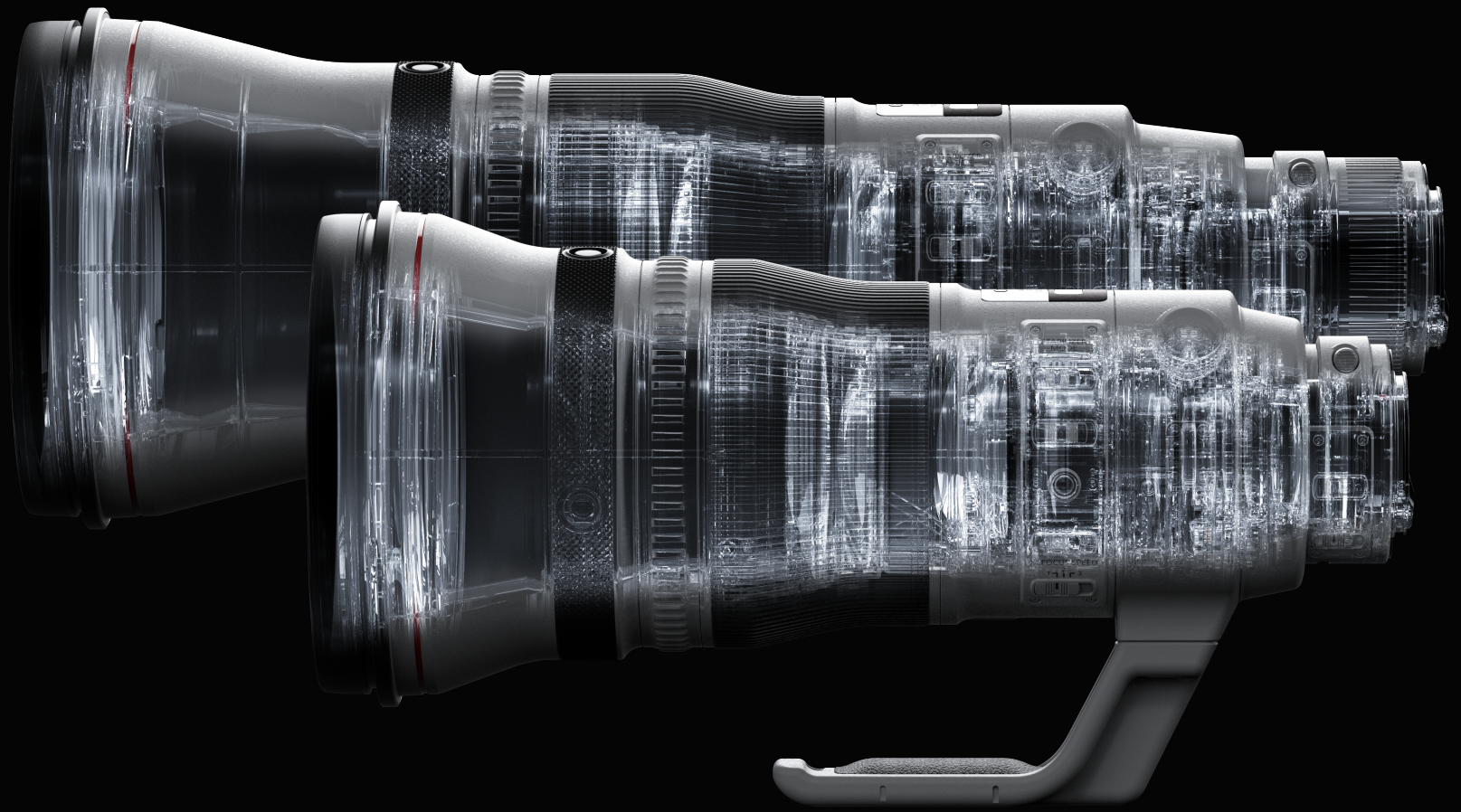
Canon

L

Developers' interview

EF400mm f/2.8L IS III USM / EF600mm f/4L IS III USM



1 Development Concept

A lightweight design that completely changes many previous concepts of weight, handling and portability

Image Communication Business Operations
ICB Optical Business Group

Shota Shimada
Product Planning

What is needed in a flagship super telephoto lens? While conducting repeated research, we reaffirmed that a lightweight design is the key to completely changing usability, and a common request among super-telephoto users. Achieving this dramatic lightweight design was a challenge that the entire development team needed to take on.

Rather than simply making the lens lighter, we retooled the lens from the ground up for an overall balanced weight.

Interviewer: *Please tell me about the background, design policy, and your enthusiasm at the start of development.*

Nagao (Development Leader): Pro photography situations require the ability to capture split-second, one-of-a-kind moments in high quality. I accompanied pro photographers as they shot, and I noticed how many times that they were all packed into a tight space while tracking a subject. In order to capture such photo opportunities, I realized just how important it is to have a piece of equipment that feels like a part of you and that can be manipulated with complete ease in such tense shooting situations. We then started research from the question of "what should the pinnacle of next-generation lenses be?" We listened to the opinions of experienced photographers, thinking of how we could provide the best piece of equipment to satisfy such users, and engaged in the development process with the ideal lens in mind, but without being caught up in the framework of the conventional lens.

Shimada (Product Planning): The foremost product concept was a lightweight design. This means a dramatic sense of lightness that one can feel when holding in the hand, as we achieved with the EF400mm f/2.8L IS III USM and EF600mm f/4L IS III USM. The reason we are committed to a lightweight design is because even though the pro and advanced amateur photographers who use super-telephoto lenses have their own ideals when it comes to specifications and style, they all invariably request a lighter lens. We also took into consideration the common view that simply lighter is not enough — rather, the weight balance when holding the camera is an important factor as a professional tool of the trade. Of course one requirement that absolutely must be met is high image quality. Just how light could we make the lens while achieving high image quality? That was the key point of this project.

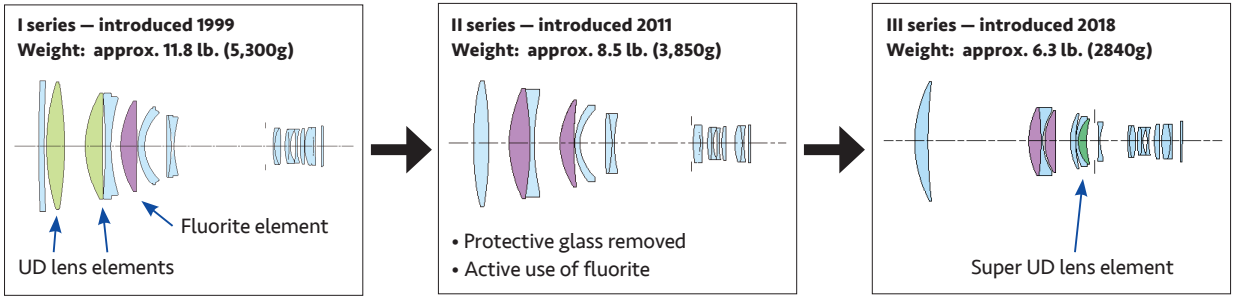
Improved mobility and portability, with reduced weight

Interviewer: *Please tell me a bit more about the background behind weight reduction as the most important point.*

Nagao: I believe that achieving a lightweight design and improving portability and mobility is an extremely important spec in line with image quality and AF.

Changes in glass materials and lens construction (EF400mm f/2.8L IS)

Although the II series took its basic inspiration from the optical system of the I series, the III series optical system was born from a completely different concept than the II. The III series weighs virtually half that of the first-generation Canon IS super-tele lenses.



400mm f/2.8 and 600mm f/4 super-telephoto lenses, light enough to consider for motorsports, wildlife, birds in flight, and more

We received feedback from pros saying "As long as you're considering the weight balance, it would be nice to have a lens as light as possible." Because a lighter lens means it is easier to carry, adding the element of a well-balanced center of gravity makes lens movement smoother, helping reduce arm fatigue and lessening the force needed when constantly changing the composition of a shot. On the other hand, the previous II lens series was very popular for its image quality, reliability, and controls. We could not lose any of these. The entire team, including Product Planning, Component Technology Department, Optical Design, Mechanical Design, Electrical Design, Quality Assurance, and production sites worked together as one to take on the EF lens flagship.

A significant — not average — reduction in weight

Interviewer: *Specifically how much was the weight reduced?*

Hayakawa (Mechanical Design): The EF400mm f/2.8L IS III USM weighs in at approx. 6.3 pounds (2,840g), which is approximately 2.2 pounds (1,010g) lighter than the 8.5 lb./3,850g of the II. This is a nearly 26% reduction in comparison, shedding a weight equivalent of full liter-sized bottle of water, making it a groundbreaking reduction in my opinion. The EF600mm f/4L IS III USM weighs approx. 6.7 pounds (3,050g), which is nearly 2 pounds (870g) lighter than the approximately 8.6 lb./3,920g of the version II 600mm f/4L IS lens. The area that shed the most weight is the optical system. Up to now we hadn't touched the mechanical system, but this time we looked at every nook and cranny, which helped make the lenses lighter.

Interviewer: *It has been seven years since the 400mm II debuted, and six years since the 600mm II. The III series is ready to welcome a new age with a significantly lighter design, thanks to the culmination of Canon technical progression.*

Hayakawa: These version III super-telephoto lenses are now lighter than the current* EF500mm f/4L IS II and EF200–400mm f/4L IS Extender 1.4x lenses. For the first time, serious Canon EOS users can consider a 400mm f/2.8 or 600mm f/4 lens for situations where mobility is vital — like motorsports.

** As of November, 2018*

Image Communication Business Operations
ICB Optical Products Development Center

Yuki Nagao
Development Leader

EF400mm f/2.8L IS III USM

For many pro sports photographers, the 400mm f/2.8 is the "standard" super-tele lens — and an ideal choice for low-light or night shooting. The version III lens is by far the lightest Canon 400mm f/2.8L lens, for full-frame cameras, to date.*

EF600mm f/4L IS III USM

The 600mm f/4 brings a new dimension to the serious photographer's arsenal: even more super-tele "reach," along with superb optical quality. And now, it adds unprecedented light weight (vs. 600mm f/4 lenses for full-frame cameras, as of November, 2018).

A complete reassessment of telephoto lens optical design is at the heart of these new, lightweight lenses — a product of ceaseless research.

Image Communication Business Operations
ICB Optical Products Development Center

Shinichiro Saito

EF400mm f/2.8L IS III USM Optical Design

A complete redesign from the ground up was necessary to reduce the weight, which presented great design obstacles. At this time, a light shone in the darkness, in the form of a new rear consolidated optical system layout. The fears of designing a completely new optical system were overcome by the passion of engineers.

We were convinced we could reach our goal thanks to the proposal of a new optical system.

Interviewer: *What were the initial weight reduction targets? Also, what convinced you that you could achieve a significant weight reduction?*

Shimada (Product Planning): During the start of the design phase, the team's mission was to stay under 3,000 grams (roughly 6.6 pounds).

Nagao (Development Leader): I think it's safe to say that the new optical system proposal came up from the Optical Design Department. We're constantly developing component technologies for future projects, and we've incorporated a variety of themes in searching for the optimal way to use and evaluate new glass materials, etc. Before the design process for the III series began, members of the Optical Design Department were almost in a competition to use new glass materials to create a number of ideas for Canon's lightweight optical systems. This new optical system is the result of a high level of competition, narrowed down to the best idea and nurtured for both weight reduction and performance.

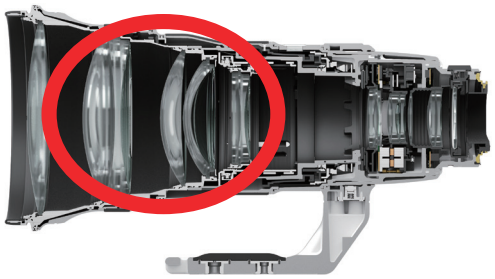
Saito (Optical Design): When developing the previous version II, we removed the protective glass from the front, and adopted fluorite lens elements at the front, resulting in a significant weight reduction compared to the II series, but a glance at the current lens configuration shows that the III is completely different than the II. The III series features fluorite and Super UD elements as well as new glass materials — now significantly smaller and lighter. These vital lens elements have been moved further back, with a rear consolidated optical system layout where all lens elements after the second are located toward the rear.

Nakahara (Optical Design): The thinking behind the optical system on the 600mm III is the same as that of the 400mm III. Although the weight reduction effect from the smaller lens diameter is significant, the overall optical system focal length and f-number are uniquely determined by the diameter of the first element, making it difficult to reduce this in size. To deal with this, we focused on making the second and subsequent elements lighter, widening the distance between the first and second lenses as much as possible, and making the second and subsequent lens diameters smaller. We started thinking about the optimal lens configuration from scratch as well as considering new glass materials, all while thinking about how to maintain the same level of high quality imaging as

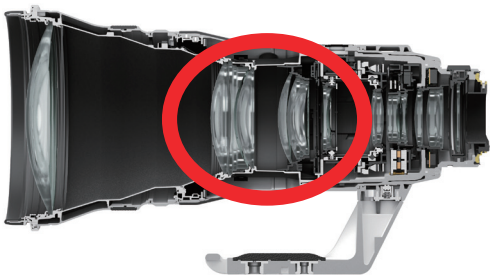
A very different lens design, compared to the version II EF400mm f/2.8L IS USM

A profound change in the version III lens' optics significantly reduces the size and weight, by moving the fluorite and Super-UD glass elements from the front toward the middle of the lens. This also improves the balance, making the version III lenses much less "front-heavy."

EF400mm f/2.8L IS II USM (II series)



EF400mm f/2.8L IS III USM (III series)



Combined efforts of Canon designers and Canon optical technologies deliver two superlative super-telephoto lenses.

on the II series while making it lighter. In addition to fluorite and Super-UD glass, these are the first Canon products to use new glass materials. This glass has a comparatively higher refractive index than general low-dispersion glass, and has a low specific gravity. By using the new glass material in the first, large-diameter lens element, the weight is reduced and spherical and chromatic aberration are suppressed.

Saito: By using different new glass materials with a high level of anomalous dispersion, the same extremely low level of chromatic aberration correction as on the II series is obtained, even when moving elements farther back in the lens. The ability to move elements to the rear enables us to make these diameters smaller, reducing the overall weight and placing the center of gravity toward the rear (close to the camera body), resulting in an optical system that kills two birds with one stone.

New challenges, one after the other, with tag-team efforts between Optical Design, Mechanical Design, Electrical Design, and Production that overcame these challenges.

Interviewer: What kind of challenges arose in developing a new optical system?

Saito: There were two major challenges we needed to solve in order to achieve the ideal weight reduction. The first was the increased size of the EMD (electromagnetic diaphragm) upon moving the aperture mechanism toward the front. The second was making the third lens element thinner. (Details on making the third lens thinner are explained in "Manufacturing Technology.")

Ichinose (Electrical Design): Placing the aperture further toward the front when compared to the II series resulted in the largest diameter aperture EMD unit on any EF lens to date. This resulted in a larger drive amount and larger drive load, making high-speed, high-precision aperture driving more difficult than on previous models. We added a new sensor to the stepping motor for driving the aperture, which detects the motor rotation speed in real time for control that matches the motor status. This helped us succeed in maximizing the electronic diaphragm's motor capabilities for faster speed than the II series, in spite of the entire EMD mechanism being larger.

The newly-developed optical system, incorporating new glass materials, was a breakthrough. It combines with the traditional fluorite and Super-UD (Ultra-low Dispersion) glass used in previous-generation Canon super-tele lenses, to deliver stunning image quality — and reduce the weight of both version III super-teles. Successfully creating new lens configuration blazed the trail for a dramatically lightweight design.

Image Communication Business Operations
ICB Optical Products Development Center

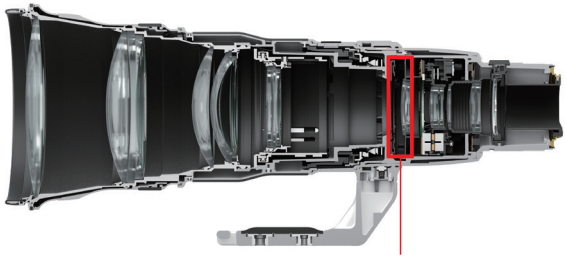
Makoto Nakahara

EF600mm f/4L IS III USM Optical Design

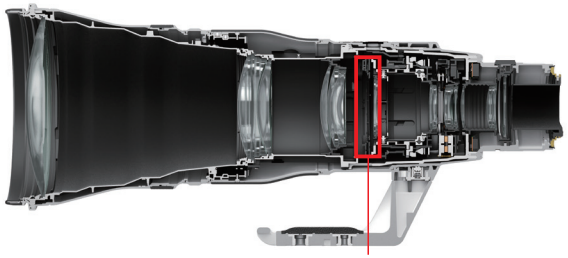
A very different lens construction compared to the II series EF600mm f/4L IS III USM

Both the 600mm and 400mm III series feature space between the front group and the consolidated rear group layout. When looking at the location of the tripod base plate, you can picture how the center of gravity has been moved to the rear of the lens. By moving the aperture toward the front, the EMD (electromagnetic diaphragm) was also increased in size.

EF600mm f/4L IS II USM (II series)



EF600mm f/4L IS III USM (III series)



Large, high-speed, high-precision movement

The stepping motor timing in the electronic diaphragm must be moved precisely at high speeds, in order to accurately and quickly open and close the large aperture blades.

3 Lightweight Design 2 — Mechanical

When we saw the limits of conventional thinking, we turned to a completely new direction for the lens barrel.

Image Communication Business Operations
ICB Optical Products Development Center

Makoto Hayakawa
Mechanical Design

We needed to make significant reductions in order to make the metal lens barrel lightweight. But we realized that alone was not enough for a dramatic weight reduction. We decided on a completely new approach with structure and materials, to achieve the high goal set by ourselves.

We raised the stakes and took on the challenge without being trapped by preconceived notions.

Interviewer: *Please tell us about the mechanically-related guidelines you had for weight reduction in regards to mechanisms, materials, etc.*

Hayakawa (Mechanical Design): When developing the 400mm f/2.8L II series that launched in 2011, we exhausted the possibilities for making it as light as possible, even going so far as to reducing the weight by that of a single hair, so further weight reduction was not a simple task. There are limits to how much we can remove from the lens barrel and exterior, which sometimes affects the strength and optical performance. So the foremost thing in mind for mechanical design was what we could do to reach such a high goal without sacrificing reliability and optical performance. Initially I set a personal goal that went beyond the already high team target of 1,000 grams (roughly 2.2 lb.) lighter than the II series. The three priorities were: *1*. change the existing basic structure while maintaining the same strength and optical precision; *2*. use completely new components; and *3*. adopt the latest optical adjustment mechanism. In the end, I believe we achieved a very practical lightweight design that does not compromise the optical performance or reliability.

Reducing the number of components results in both a lightweight design and increased strength.

Interviewer: *Did the electronic manual focusing ring work in your favor?*

Hayakawa: Yes, it did. The switch to an electronic manual focusing ring helped us optimize the mechanisms. Specifically, in order to mechanically link the focusing ring and the focusing unit on the previous version II series (physical link mechanism, with *mechanical* manual focus operation), the main lens barrel section consisted of a fixed barrel, median barrel, USM, and a first group lens barrel. The focusing ring is *electronic* on the III series. This change made it possible to encapsulate the focusing unit (USM), creating a structure consisting of the fixed barrel and first group lens barrel. Reducing the number of components not only contributes to a lightweight design, but also is beneficial for strength. There are also minimal connections for each part, making it beneficial for assembly and also improving the precision of lens element positioning.

Utilizing a completely redesigned structure, reviewing materials, and employing the latest processing technologies. The strongest support came in the form of the engineers' challenging spirit.

Using a new high-strength alloy

Interviewer: *It seems like you used a new alloy for the lens barrel.*

Nagao (Development Leader): When talking about materials, we decided to use a new high-strength alloy. This new carbon reinforced magnesium alloy contains carbon, which results in refined alloy crystal particles for improved mechanical properties. The high level of fluidity in this material enables injection molding (thixomolding) for a thin walled formation. For example, with the first group lens barrel on the 400mm model, we were able to achieve a barrel thickness of 0.8mm via injection molding, for a base that is 20% thinner than previous models, maintaining sufficient strength and lightness. The carbon reinforced magnesium alloy is also used for the tripod base plate and the exterior of the barrel.

Hayakawa: In addition to the carbon reinforced magnesium alloy, forged magnesium alloy — in other words, lumps of magnesium which are hammered into shape — was used to create other parts. This material helps prevent fractures from impacts. Also, optimal materials are selected considering their functionality from among multiple magnesium alloys and aluminum alloys to make external parts, and some components are made of aluminum alloy. We considered making the first group lens barrel for the larger 600mm lens in two sections, however, we conducted a thorough investigation in each department and decided to create it in a single piece.

The Mechanical department succeeded in reaching their target weight reduction while achieving a level of strength that can withstand pro usage thanks to a completely redesigned basic structure, new metals, and the latest processing techniques. One thing that must be remembered is the spirit of challenging oneself to reach an even higher goal. Although the exterior dimension of the super-telephoto lens cannot be changed drastically, the reason the goal was reached was not simply because of the accumulated level of experience. This revolutionary lightweight design was formed thanks to the eloquent transformation of ideas and the willingness of engineers to take on multiple new challenges.

First group lens barrel — an important factor in weight reduction

The change to an electronic focusing ring resulted in a two-component lens barrel construction on the III, whereas the version II consisted of four components. One of the two version III components is the first group lens barrel, made of carbon reinforced magnesium alloy — which is even lighter than the already lightweight aluminum alloy.

4 Image quality 1 — Optical adjustment and coating technology

We felt a sense of responsibility to go beyond the nearly aberration-free high image quality of the II series.

There is very little leeway to make improvements on the high image quality of a flagship lens.
On the other hand, the weight reduction goal, resulting in significant structural changes, presented a variety of challenges.
Maintaining a firm hold on image quality and achieving a lightweight design — how did the engineers clear such a high hurdle?

The proposition was to maintain a high level of image quality despite making significant changes to the lens construction.

Interviewer: *Did the significant changes made to accommodate a lightweight design affect lens image quality?*

Saito: (Optical Design): The II series had already reached an extremely high level of optical performance in its resolution and ability to withstand backlighting. Therefore, our proposition in the design department was to achieve dramatic weight reduction while preserving or improving upon the image quality with the III series.

Nakahara (Optical Design): With this in mind, we recreated the optical system from scratch, changing the optical adjustment lens layout, and adopting a latest optical adjustment method in order to stabilize optical performance potential.

Each and every day advances are made toward producing an optical adjuster at Canon to achieve the ideal lens.

Nagao (Development Leader): Daily efforts are made to research optical adjusters and measurement equipment at Canon in order to produce high-quality, stable lenses. The III series use a Canon-produced optical adjuster, specialized for super-telephoto lenses. Subdividing digital adjustment for each item helps us achieve the best aberration balance and high precision, something that is difficult with conventional methods such as visual and manual operations.

Optical design beneficial for lens construction, and bringing improvements to contrast in backlit situations

Interviewer: How well do the lenses handle backlighting?

Saito: Moving the second lens element toward the rear (lens mount side) makes it much more difficult for flare to occur, from light outside the angle of view, while improving contrast in backlit situations. A single front element (first lens) is also advantageous for minimizing internal reflection.

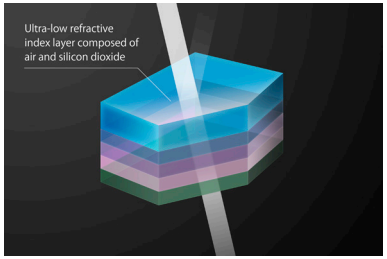
Nakahara: Also, ASC (Air Sphere Coating) appropriately suppresses flare and ghosting, originating from light sources both inside and outside the angle of view.

Saito: ASC is an original Canon technology where a thin film containing silicon dioxide and air formed on top of traditional multi-coating on the lens, suppressing light reflection. Think of it this way — by including a layer of air, which has a low refractive index, inside the coating, an extremely low refractive index layer is formed. When light passes through, it is gradually refracted, minimizing reflection. Above all, light entering directly into the lens is more effectively suppressed, making this a suitable coating for telephoto lens, depending on the location of the coating.

Nakahara: Simply using ASC coating on a lot of lens elements does not work. I believe it is best to combine it with multi-layered coating and use it selectively, on the optimal lens element surface.

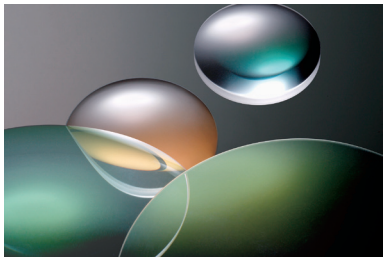
Users may be concerned that weight reduction might affect image quality. However, the development team was devoted to maintaining the superb image quality established on the previous version II series. The rear consolidated lens construction that incorporates fluorite, Super UD lens elements and new glass materials resulted in a markedly lighter lens. On the other hand, this resulted in a higher degree of difficulty in manufacturing. To save the day, the latest internally-produced optical adjuster proved to be a powerfully ally.

ASC (Air Sphere Coating) suppresses ghosts and flaring



A silicon dioxide and air layer is formed on top of a vapor deposited layer on the lens surface, suppressing light reflection. By including a certain ratio of coating that contains air with a lower refractive index than optical glass, an ultra-low refractive index layer is formed with excellent anti-reflection capabilities.

Super UD lenses have nearly the same properties and effects as fluorite



UD (Ultra Low Dispersion) glass elements were developed to obtain the superb optical qualities of fluorite, compared to ordinary optical glass. The UD lens performance is dramatically improved on Super UD lens elements, with nearly the same properties and effects as fluorite. These also contribute to a lightweight design on both the 400mm and 600mm.

5 Image quality 2 — IS advancements

Optical performance is not the only thing that affects image quality. This mindset was maintained when making advancements to the IS.

Image Communication Business Operations
ICB Optical Products Development Center

Daisuke Hirai

Electrical Design

The benefits of an IS mechanism are immeasurable for obtaining clear image quality in photos. The deciding factor in improving performance over the previous model is the experience and uncompromising spirit of the engineers in this pursuit.

Using the latest gyro sensor is insufficient for improved IS performance — it was necessary to build a new control algorithm that assumes a variety of situations.

Interviewer: *How did you achieve nearly five stops* of IS performance?*

Hirai (Electrical Design): From the start of development, our most important mission was achieving five stops of image stabilization on the image stabilizer mechanism. We made significant innovations on the vibration gyro sensors and microprocessors for both lenses, achieving five stops of image stabilization when converted to shutter speed. Because the III series is significantly lighter than the body of the II series, I believe there are more opportunities for handheld shooting with a super telephoto lens, and of course, this can be helpful when shooting with a monopod as well.

Interviewer: *Does this mean that switching to the latest vibration gyro sensor improved the effects?*

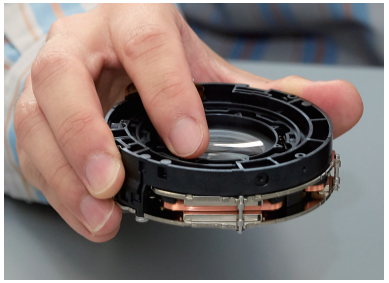
Hirai: No, simply switching to the latest high-performance vibration gyro sensor alone does not solve the problem. We must fully understand the qualities of the vibration gyro and develop the optimal control algorithm. We made improvements to the microprocessor, enabling us to incorporate new processes, which were mounted in the software for evaluation, then repeated adjustments to the control algorithm were made to improve performance. Because pros and advanced amateurs use the EF400mm f/2.8L IS III USM and EF600mm f/4L IS III USM in punishing shooting conditions, this information helps us minimize the way temperature fluctuations affect the vibration gyro sensors and characteristic changes due to IS unit temperature. Modifying the mechanical structure helps add variation to the algorithm operation.

Nagao (Development Leader): The new vibration gyro and latest microprocessor are the same as those included on the EF70-200mm f/4L IS II USM. However, because the operation unit size and focal length are different, these elements were fine tuned to meet the super-telephoto lens characteristics.

** When using the EOS-1D X Mark II. CIPA standard compliant.*

The latest high-precision IS

Not only has a new vibration gyro sensor been used, but the basic structure has also been changed. The unit itself has become lighter thanks to a compact actuator. It is more precise and easier to handle.



Ever since the launch of EOS more than 30 years ago, it has been the pride and reward of engineers to continue designing-in compatibility with all camera bodies.

Hayakawa (Mechanical Design): Also, the III series has a new IS mechanism. If the IS drive rotates around the optical axis, "roll" occurs, reducing the effectiveness of image stabilization, which is why this is equipped with a roll prevention mechanism. The roll prevention mechanism consists of many different components, but a new roll prevention mechanism was conceived for this product, with fewer parts for retaining the lens. This resulted in higher precision lens retention and contributes to maintaining stable optical performance. By reducing the drive load, it was possible to make the IS actuator smaller and lighter, which consists of a magnet and coil.

Not only has handheld IS performance improved, but it can now deal with vibration when using a tripod.

Interviewer: *A lot of attention goes to handheld IS, but what about when shooting with a tripod? The very high-frequency vibration from mirror slap in an SLR is a particular cause for concern.*

Hirai: During mirror slap vibration, the tripod is detected and the IS unit switches to control the higher-frequency vibrations from an SLR's mirror, so the IS switch can be left on in general even when shooting with a tripod. However, depending on the type of tripod and where it is placed, the frequency and strength of vibrations may differ, so there will be some type of difference in effectiveness depending on the shooting situation. The new IS unit features improved high-frequency tracking performance, so it is better equipped to handle mirror slap when using a tripod compared to the current II series. It is also beneficial to leave IS on when shooting with a monopod.

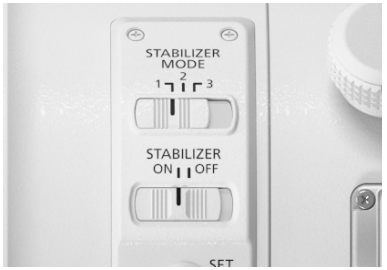
IS lens compatibility has continued without compromise since the first EOS model in the 35mm film camera era.

Interviewer: *Will the latest IS mechanism function even when the lens is used with an older camera body?*

Hirai: EF lenses will work without any problems even when combined with the very first 35mm film EOS 650 — Canon's first EOS film camera, from 1987. During IS development and design we don't simply confirm whether or not IS functions. Rather, we adjust the parameters to match camera features, so we take the time to verify that it matches past cameras as well. The system built over 30 years is a Canon asset, and the uncompromising pursuit of performance is deeply impressed on our minds, which is something we take seriously, day in and day out.

Ichinose (Electrical Design): As the person in charge of electrical systems, I need to make sure the lens is compatible with all past cameras as well, and that the latest cameras and lens functions work. There were some areas that made me scratch my head, such as designing for power saving and balancing power for timing control, but these made the job worthwhile.

It has been nearly 23 years since the image stabilization mechanism was first included on an EF lens (the Canon EF 75-300mm f/4–5.6 IS USM, launched in 1995). Not only has the effectiveness of optical stabilization increased, but it has been improved to cope with panning and been made more comfortable to shoot with. IS continues to evolve, due to a combination of a wide range of technologies including corrective optics, unit mechanisms, and electrical control as well as massive amounts of testing and repeated rebuilding of algorithms (software).



Lens barrel IS switch

In addition to the usual IS Mode 1, the III series is equipped with Mode 2 for panning. Like previous EF super-tele lenses, Mode 3 provides active IS *detection* when metering is active, but actual stabilization movement in the lens is limited to during actual shutter operation. The result is users get the effect of IS in their images, but it does not appear between shots, in the finder.

Image Communication Business Operations
ICB Optical Products Development Center

Masami Ichinose

Electrical Design

Comfortable, quick AF affects photo quality, and steady progress in digital technology helps advance AF.

The EOS and EF lens systems share information between the lens and body via electrical signals only. Improved electronic control speed via the latest microprocessor and improved mechanical component precision results in high-speed, high-precision AF (autofocus) performance.

High-speed, high-precision AF

Interviewer: *How is the AF performance?*

Nagao (Development Leader): Along with the lightweight design and image quality, I think this is a very interesting spec. The closest focusing distance on the 400mm was reduced from 2.7m to 2.5m (approx. 8.8 to 8.2 feet) from the II series to the III series, and despite the necessity of covering a wider area of image plane movement, the drive time for moving the focusing lens from close-up to infinity has been reduced. I believe you can feel the difference in speed and responsiveness, when the AF is operating in bright conditions while looking through the viewfinder.

Interviewer: *I see, it seems that you've achieved high-speed AF.*

Nagao: AF speed involves both the fastest focus motor drive speed capable on the lens, and the focusing calculation time on the camera. In bright situations, the focus drive speed of the lens is dominant, and I believe this is why you can see AF speed improvements on the III series 400mm and 600mm super-tele lenses.

All processing speeds are improved, thanks to the latest microprocessor.

Interviewer: *What was the key technology for improving AF performance?*

Ichinose (Electrical Design): A major point was including the latest microprocessor for improved calculation speed, which also raised the AF control frequency. Although it differs depending on various conditions, this resulted in improved subject tracking during AI servo AF. More microprocessor cores result in smoother parallel processing. For example, AF performance can be maximized even when the IS mechanism is on. The power management function has been modified for real-time, accurate detection of power used by AF to draw out the maximum performance of the ultrasonic motor (USM). Strictly speaking, this relies on the AF performance of the camera body. However, both the EOS-1D and EOS 5D series benefit from improved AF performance when used with the III series lenses.

Hayakawa (Mechanical Design): Mechanically-related AF improvements include reduced drive load, thanks to glass materials in the focus lens group that are nearly one-fifth the previous weight. The USM anti-backlash mechanism, incorporating a ball bearing, basically removes all play during full travel for autofocusing. This development contributes to improved performance for direct USM driving.

Improved lens focus drive speed even when an EF tele-extender is attached.

Interviewer: *Many photographers use an extender on both lenses. Is speed improved even this kind of situation?*

Nagao: Yes, users can benefit from a fast focus drive on the III series 400mm and 600mm lenses if they're used with a Canon EF1.4x or 2x version III* tele extender. However, the speed does have some limitations depending on shooting conditions, such as larger image plane changes per focus lens unit travel distance and a smaller effective maximum aperture, when an extender is being used.

** Please note that the version III 400mm f/2.8L IS and 600mm f/4L IS lenses are **not** compatible with previous version I or II Canon EF tele-extenders*

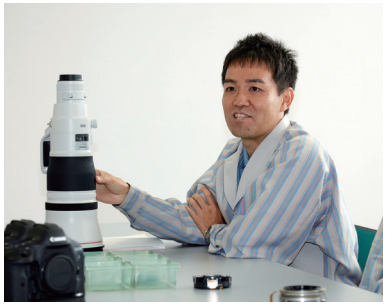
Ring-type ultrasonic motor (USM)

The Ring USM is a core technology and key device in the EF lens series. It's Canon's most powerful, high-torque AF drive system, and has been used in many professional EF lenses since the launch of the EOS system in 1987. The version III 400mm and 600mm series is packed with modifications to maximize the potential of this near-silent, precise AF drive motor.

L

7 Focus function 2 — Electronic focusing ring and MF

More delicate and precise manual focusing! Three-step mode for fine tuning the focus exactly where you want.



Wide-range focusing ring and manual focus speed switch

Select "2" or "3" for more precision manual focusing. We were also picky about an appropriate level of stickiness (feeling of torque) when using the focusing ring.

Manual focus is an essential option for precise focusing.

We decided on an electronic focusing ring to meet the demands of users for more exact and precise control.

Electronic focusing makes more delicate focusing possible compared to a mechanically-linked system.

Interviewer: *Why did you decide to use an electronic manual focusing ring?*

Nagao (Development Leader): The conventional mechanically-linked manual focus drive resulted in a large amount of image plane shift per unit of rotation angle, with user feedback saying that extremely precise focusing was difficult. For example, the amount of focus shift was sometimes too large for precise manual focusing when using the magnified display in Live View (LV).

Shimada (Product Planning): Although many people mainly use AF, quite a few users said that they'd like to have more precision focusing ability, such as when shooting landscapes, wild animals, and capturing impressive shots of players' expressions and antics in sports competitions, so we decided to be bold and include this feature. I believe in particular that users who record videos of wild animals and nature with a super-telephoto lens will find this convenient.

Users can choose from three different manual focus speeds, depending on how much ring rotation they desire, and the types of subjects they're focusing upon.

Interviewer: *Along with the switch to an electronic focusing ring, a manual focus speed switch was included.*

Nagao: The manual focus speed switch offers three different settings, so that users can control the manual focus sensitivity (amount of focus shift per unit rotation angle). Mode 1 is set at a slower manual focus speed than on the II series, offering more delicate control in manual focus, and Mode 2 offers even slower speed for fine tuning the focus, while Mode 3 is the lowest speed for fine control. For example, Mode 3 is recommended for users who want finer control over the focus for careful shooting in Live View.

Simply turn the focus ring to wake from sleep mode completely naturally.

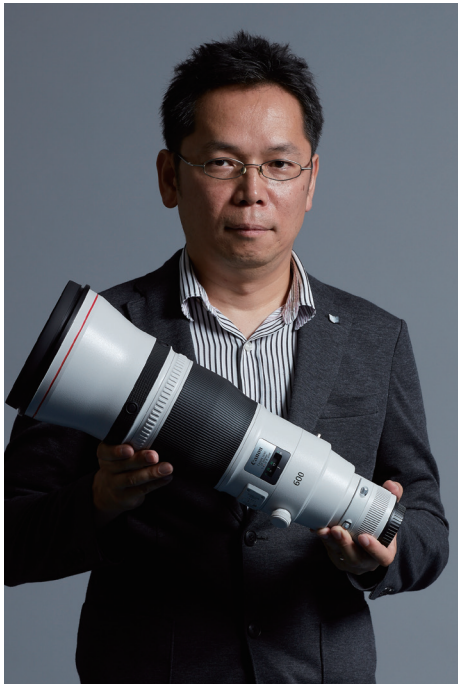
Ichinose (Electrical Design): To save power, the lens enters power saving mode when the user stops operating the camera (metering timer turns off). Unlike Auto Power Off, which is a power saving mode for the *overall* camera system, the meter timer off is a frequent function for slight power saving. While the camera is in meter timer off, the lens' processor is almost completely stopped, making it unable to detect rotation of the electronic focusing ring — which would normally make the focusing ring unusable. However, with the version III lenses, it's possible to wake the lens from sleep mode simply by turning the focusing ring, even without pressing the shutter button halfway, naturally transitioning to manual focusing operation. This was quite a difficult feat to accomplish personally, but it directly affects usability, so I was adamant on getting it right. I also wanted to make sure that controls felt the same as on previous models as much as possible.

Shimada: Manual focusing on the electronic focusing ring is also compatible with Full-time MF, a major feature of many Canon EF lenses — that is, being able to manually focus while the lens is still in AF mode. While taking on new challenges, we have to make sure we don't inconvenience our users. We always have to keep this in mind.

Nagao: Full-time MF is enabled when the camera AF operation is set to [ONE SHOT] and the shutter button is held halfway *after* AF has locked focus on a subject, or when AF activation is removed from the shutter button via Custom Function in the camera, and initiated by "back-button AF" (this can be done in either One Shot AF or AI Servo AF, by pressing the AF-ON button or if AF is assigned to the AE Lock button; as soon as the user's thumb is removed from the back button, he or she can immediately manually focus by turning the lens' electronic manual focus ring).

8 Controls 1 — Focus presets

Many modifications were incorporated in presets, so that photographers can feel confident in using them.



Design Center

Nobuhiro Takeuchi

Design

Focus preset is a function that memorizes a focus position for instant recall.

A variety of modifications and testing went into expanding this a function, making it one that many different types of photographers can benefit from.

The III series has *two* focus presets, compared to the single preset on previous Canon EF super-telephotos.

Interviewer: *It seems that the focus preset function has been improved.*

Shimada (Product Planning): The III series has two presets which allow users to memorize two focus distances, rather than one. Focus presets let users instantly switch to a preset subject with a slight turn of the playback ring. Previous EF super-tele lenses offered only one memorized focus position, but now with the version III 400mm f/2.8 and 600mm f/4 lenses, users can memorize two different distances, and return to either one immediately.

Nagao (Development Leader): Setting a focus position is very simple. First, you focus on the distance (subject) for the preset, then press and hold the focus preset button for longer than one second, and then turn the playback ring right or left to store that distance. A second preset is memorized the same way. The second preset is activated by turning the playback ring in the opposite direction of the first preset. Then, while shooting pictures, you simply turn the playback ring left or right to quickly switch to the memorized focus position stored in those directions. Then press the shutter button to shoot.

The sensation of focusing on two different subjects, with instant focusing at the slight turn of a ring

Interviewer: *Are there any recommended situations for using presets?*

Shimada: One way to use focus presets, for example, is to turn the playback ring left to set the focus on the kicker during a soccer set play, then turn it right to set the focus on the goal. That way the photographer can capture the moment the kicker kicks the ball, then instantly turn the ring right to shoot close-up photos of plays around the goal. In motor sports, the photographer can switch between near and far corners for more practical shooting than ever before. Two presets are not absolutely necessary, as this type of shooting is possible with a single preset as on previous models. With two presets, the photographer can turn right to switch to close-up shots, and turn left for infinity to search for the subject if they lose sight of it during shooting. Also, this feature can be used to start AF after using the preset for close-up or infinity.

Nagao: This feature can be tailored to the photographer's needs, such as using the electronic focusing ring for solid manual focusing, or for close-up and infinity presets when quickly changing the focus a significant amount. When the

Focus preset switch and button — The button is positioned for easy pressing when holding the lens

With two focus presets, this feature is even more versatile for photographers who need to quickly change from one focus distance to another. The focus preset switch and button were retooled for smoother operation.

This lens is designed for uncompromising usability as a tool for pros, while making sure that new functions do not interfere with shooting.

subject is at a fixed distance, the photographer can use a focus preset (MF), and when the subject distance changes continuously, AI servo AF can immediately be used to suit their shooting style and accommodate various situations.

In-depth tuning and modifications to prevent misoperation and improve usability

Interviewer: *What other modifications were made?*

Takeuchi (Design): With the two focus presets I assumed that this function would be used more frequently, so modifications were made to the playback ring. After making and studying a simple mockup of the playback ring, I made a number of knurling prototypes with slightly different pitches, asking different departments for their feedback. I also worked closely with the Quality Assurance Department while moving forward with design tasks. In the second half of the design phase I actually brought a prototype lens out into the field to conduct some control tests. This resulted in slightly widening the ring, changing the pitch of the bumps, finally resulting in controls with slightly improved finger rests and a natural feel.

The most important factor in manual focus control is the feeling of "direct" focus that gives you the exact control you have in mind. However, everyone has their own ideas about how the ring should feel depending on the subject and shooting style. Not only does the new electronic focusing ring offer the ability to select a manual focusing speed, it does not compromise the solid feeling of torque. Along with the more convenient focus presets, the worth of manual focusing has also improved.

The knurled pattern and finger rests on the playback ring were studied to fine tune controls.

The width of the playback ring and the finger rests were thoroughly studied to achieve the finest quality of controls possible. The photo on the left shows a mockup, and the one on the right is the actual 400mm f/2.8L IS III.

9 Controls 2 — Shape and touch

The user experience is Job 1 with our designers. From the time they first pick up the lens, we hope to surprise and delight the critical and demanding EOS user.

A collaborative development effort has resulted in a lens that everyone feels is much easier to use than previous models.

Even as we approached the deadline, we kept making one improvement after the other instead of calling it quits.

There were absolutely no compromises, including button position, dial engagement, and the shape when held in the hand.

Each and every department pitched in to help move the center of gravity.

Interviewer: *You can see how easy the lens handling is after moving the center of gravity toward the rear. Did you anticipate using a rear placed optical system in order to move the center of gravity?*

Nagao (Development Leader): The first thing was an optical design that enables weight reduction. In other words, we moved forward from the early stages on mechanical design and other design tasks with the goal of moving the center of gravity.

Shimada (Product Planning): From the bottom of my heart, I'm excited to see how happy pros and advanced amateurs will be when they see how easily the lens handles because we shifted the center of gravity. I believe that when held in the hand, you can actually feel how easy it is to use — that goes beyond anything that can be understood simply by looking at numbers.

Nagao: Although handling is likely a sensory aspect, it is an extremely important factor. Because the center of gravity has been moved toward the camera body, the moment of inertia is reduced when swinging the lens on an axis close to your body while holding the end of the lens with your left hand, making the lens easier to move.

Shimada: This makes shooting easier not just when panning during motor sports, birds, and aircraft photography, but also when changing the composition frequently. From this point of view, you can say that the lightweight design is directly linked to improved handling. Because such benefits are difficult to communicate with words and numbers alone, we'd like to have not just pro photographers, but as many people as possible pick up the lens and give us their feedback.

Actual-size mockups were made and many different improvements were implemented after feedback from various departments

Interviewer: *In addition to the overall shape, it seems like you were deeply involved in the design of buttons, rings, and controls.*

Takeuchi (Design): Yes, exactly. While engaged in the design process, we always kept the shape and texture of controls in mind such as the focusing ring and playback ring. We were particularly picky about the texture of the focusing ring's knurled pattern, when switching to the electronic manual focusing ring on the III.

Mockup for checking the texture of controls

This mockup was created to consider the texture of the knurled pattern on the playback ring and the exterior. Parts that differ from the actual product can be removed and attached to swap out a variety of different knurled rings.

The thoughtful design of each part is not simply an effort to make a point. Rather, every one is an important aspect of the lens as a tool of the trade, and underscores how important it is to fit comfortably in the hand.

Interviewer: *What kind of process did you go through during the design phase?*

Takeuchi: When engaging in the actual design, we created not just sketches but actual-sized mockups to get the shape just right. Because we can utilize 3D printers, the precision of our mockups is higher than ever before. We then used these and received feedback from various departments to form a more detailed set of opinions for a smooth development process.

Interviewer: *When looking closely, you can see that the rotating tripod mount has changed since the previous version II super-tele lenses.*

Takeuchi: Because the center of gravity has changed, a switchback shape has been adopted so that the lens can be carried more easily by the base plate. In other words, it is easy to grab. Some people hold the tripod base plate during hand held shooting. We rounded the edges of the base plate slightly so that it doesn't hurt the supporting hand when it is held. It goes without saying that we also made mockups of this section and received many different opinions, resulting in this shape. Because this is used as a tool for photography, how it fits in the hand is an extremely important spec.

Hayakawa (Mechanical Design): The lens tripod mount turns smoothly with the lens. Previously, a clicking roller mechanism was used for turning, but a ball bearing is used in the tripod base plate on the III series for smoother horizontal and vertical movement. Both the EF400mm f/2.8L IS III USM and EF600mm f/4L IS III USM are EF lens flagship models, so we kept working until we were satisfied.

Unlike image quality and AF performance, there are no absolute values that can represent the tactile feel and operation of controls. You could say that the developers are easily caught up in this aspect of design. That devotion is also evident in the mockups. When looking at the many mockups of the version III lenses, you can see the dedication to the experienced photographer that the developers have.

The rounded shape of the tripod mount, or base plate, is easy to hold, and does not hurt user's hands.

The end of the tripod base plate features a catch shape. This makes carrying the body and lens by the tripod base plate more secure. In addition to the tripod base plate, a smaller monopod base plate is also available, as an optional accessory (available through Canon service centers; additional fee required).

Vertical and horizontal movement is achieved through careful modifications

A fine pyramid-shaped anti-slip pattern was used for the orientation locking knob. Using a ball bearing between the tripod base plate attachment ring and lens barrel enables smoother rotation.

10 Durability and reliability — 1

We can't betray the trust users put in us with a new lens. Repeated tests gave us the confidence we needed

Doubts may arise as to strength and durability when creating a design which emphasizes light weight.

The confident design is backed by repeated testing from all angles.

Zero effects on strength because of the lightweight design and no change to the weather-resistant performance

Interviewer: *In the field, many working photographers may accidentally bump their equipment while struggling to capture a great shot.*

Nagao (Development Leader): Although some people may worry about strength when we've made such drastic weight reductions, I'd like to heartily reassure them that there is nothing to worry about. We never make excessive weight reduction, but carry out repeated, exhaustive testing including many strength tests on the actual product, which clears the rigorous Quality Assurance Department standards. We have also conducted drop tests, so it is not more susceptible to impacts compared to the II series due to the lightweight design.

Shimada (Product Planning): Above all, you could say that dust- and drip-resistance is an absolute requirement in sports and wildlife fields regarding reliability. The 400mm and 600mm both have the same weather-resistant construction as the II series. Just as with the II series, these models feature the same fluorine coating on the front and back lens surfaces, making it difficult for dirt to stick to the lenses, and easy to wipe off if it does.

Appropriate materials selection and design, and more repeated tests than ever before.

Interviewer: *I believe people will use this lens for a long time. Is it durable?*

Nagao: The USM, IS unit, aperture unit, and drive unit are all new for these models, and Canon engineers conducted painstaking reliability tests and durability tests, all of which were passed with flying colors. The durability has not been adversely affected by the weight reduction.

Hayakawa (Mechanical Design): We also took the sliding motion (rubbing) of the internal components into consideration that occurs when the electronic focusing ring is rotated. Although a combination of inner an outer magnesium alloys is best for reducing weight, we used aluminum alloy for the internal construction in consideration of durability. To achieve a lightweight design, reliability, durability — and excellent operational smoothness and precision — we optimized materials and modified the structure.

Interviewer: *What steps were taken to provide reliability against heat?*

Saito (Optical Design): We conducted a thorough analysis of how heat affects the lenses. During the design process we were not focused solely on weight reduction, but paid particular attention to changes in the optical refractive index due to heat conduction in the glass, creating a structure that does not easily conduct heat due to external temperatures, and building a lens barrel that helps minimize heat conduction to the glass, conducting many different temperature tests during the prototype phase.

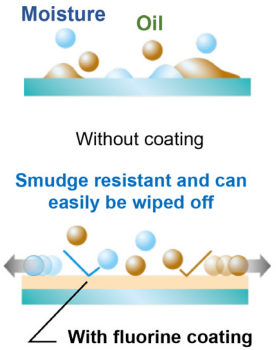
Hayakawa: Our basic concept in this regard was to form a lens barrel structure that made heat conduction to the inside of the lens difficult, so we thoroughly studied heat conduction channels so that external heat would not be conducted directly into the lenses. We conducted multiple simulations and took many measurements of prototypes to ensure that this design would minimize heat build-up, and still preserve our goal of significant weight reduction, compared to the previous version II 400mm and 600mm designs.

Shimada: Adopting heat shield coating for the first time was a heat countermeasure topic, and an important aspect of Canon's efforts to minimize probelms from heat. *(Heat shield coating details are provided in the next section)*

User requests for weight reduction on the EF400mm f/2.8L IS III USM and EF600mm f/4L IS III USM resulted in products that are almost something completely new, but the innovative design does not stop there. It continues with image quality, AF, controls, and an element that must not be forgotten — reliability that can withstand usage in punishing environments. Canon's lens developers were thoroughly prepared for this, and conducted exhaustive and repeated tests. The legacy of Canon L-series super-telephoto lens reliability was certainly handed down on these models.

Effects of fluorine coating

A fluorine coating is applied to the front and rear surfaces of the lens, to resist moisture and oil. Oil and moisture are easily repelled, and oil can be easily wiped off with a dry cloth without using solvents.



Dust- and drip-resistant construction (indicated by the red sections in the image)

Just as on the II series, the mount, switch, and focusing ring feature a dust- and drip-resistant construction.

11 Durability and reliability 2 — Heat shield coating

The story behind the birth of the traditional “White Lens” and a new chapter our devotion to heat resistance

The white super-tele lens is more than a symbol of the Canon brand. Developed originally in the 1970s to reduce heat build-up, Canon takes heat protection to a higher level with a heat shield coating in the version III 400mm f/2.8 and 600mm f/4 lenses.

Canon-developed heat shield coating

Interviewer: *It seems like you’ve put considerable effort into facilitating reliable protection from heat.*

Shimada (Product Planning): With the goal of providing equipment that offers stable optical performance even when shooting under severe conditions such as hot sunlight, we employed the maximum heat protection measures in lens optical and mechanical design. Canon telephoto and super-telephoto L lenses have a white lens barrel, and the history of this color began in the 1970s on lenses specifically made for SLR cameras. Super-telephoto lenses are larger than normal lenses, making them more susceptible to heat build-up from sunlight, and they are often used in harsh conditions such as hot, sunny weather. In order to suppress a loss in optical performance due to heat and difficulty in handling a hot lens, white was chosen instead of black, as the light color easily reflects heat. For these version III lenses, we studied how to improve the traditional so-called “White Lens.”

Nagao (Development Leader): One element we incorporated to improve the optical performance reliability in regards to heat was a new heat shield coating. For example, when shooting under very hot sunlight in the peak of summer, direct sunlight striking the lens for long periods of time results in uneven heating due to sections in sunlight and sections in shadow, regardless of the white lens coating. This resulted in the idea for an external heat shield coating. So we began to search for heat shield coating and found a number of practical products designed and sold for the construction industry. However, the qualities required for photographic equipment and construction materials differ, and we could not find an appropriate coating. So we ended up developing a coating on our own from scratch.

An expert coating team was formed with the cooperation of the Mechanical and Manufacturing departments within Canon, to aim for an ideal solution.

Interviewer: *Is weight reduction related to temperature properties?*

Nagao: The overall thermal capacity of the lens is reduced when reducing the weight. With the reasoning that the lens temperature easily rises with the same heat quantity, we began implementing various measures such as taking measurements of internal heat on prototypes. In addition to adopting the heat shield coating, as mentioned previously, we made mechanical modifications to the heat conduction channels to make it more difficult for heat to be conducted from external components to the glass inside the lens. After verifying that heat was thoroughly reflected on the external surface, we considered thermal transmission, reducing temperature increases in the glass and fluorite inside of the lens as much as possible. This enabled us to thoroughly compensate for the reduced heat capacity, which is a downside to weight reduction.

Saito (Optical Design): Some glass materials are comparatively resistant to heat and others are susceptible, so the Mechanical Department cooperated with the factory on manufacturing techniques to achieve a lens barrel construction that makes it difficult for heat to be conducted to temperature sensitive glass, as well as exhaustively modifying the lens retaining structure.

Interviewer: *How is the durability of the coating itself?*

Nagao: Of course we carried out multiple studies in this regard. We checked durability using tests that assumed changes over time due to ultraviolet rays, as well as physical scratching and sliding tests. The expert team operated on a trial and error basis, conducting may different tests, changing the components of the coating and changing the ratios during development.

Takeuchi (Design): Although it goes without saying that the heat shield coating performance and reliability are at a high level, we added design changes without changing the image of Canon white. With this in mind, we paid particular attention to the color. We created a number of different shades of coating and measured both the performance and the whiteness. In addition to brightness checks on the measurement equipment, we conducted visual checks under specified brightness levels. Because it becomes difficult to tell the difference when the person doing the visual tests is tired, we paid particular attention in this regard, conducting checks within a certain time frame only.

The “White Lens” is a synonym for Canon’s super-telephoto lenses. This feature, which was born of necessity for shooting under hot sunlight for long periods of time, became a symbol among Canon users. This latest “white” coating underscores both form and function, thanks to the honest efforts of the development team. It gives off a functional beauty that stands apart — even from previous-generation Canon EF super-tele lenses, while providing even better heat-resistance.

When compared with the 400mm II series (top), there is very little comparative color difference

The white color of the new model when compared to the previous model is very natural when viewed on its own. It has the feeling of the traditional white while representing a new quality.

EF 400mm f/2.8L IS II

EF 400mm f/2.8L IS III

Producing the ideal lens requires the latest equipment, solid technical ability, and the spirt of past and present manufacturing craftsmen.

Image Communication Business Operations
ICB Optical Business Group
Utsunomiya Plant

Yoshinori Kawano
Manufacturing Technology

Even after many confident prototypes, without a stable manufacturing process, a product cannot be made. With this in mind, the manufacturing process was reviewed while incorporating the intentions of the designers. Fully prepared, production on a revolutionary new lens began.

Requirements for producing the ideal lens

Interviewer: *The III series is a product packed with items to talk about. Was it a difficult item to accommodate for actual mass production?*

Kawano (Manufacturing Technology): It was. The III series is packed with innovations such as the multiple new glass materials, new lens construction, and new heat shield coating. From the very beginning, the development and design teams were involved in completely retooling the production process at the factory, including production technology involving lens polishing and vapor disposition coatings, optical and mechanical assembly, etc., helping to prepare for stable production of high-performance products exactly according to design specs.

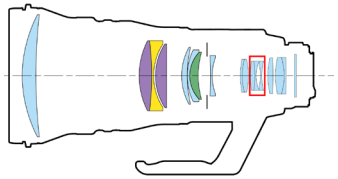
Interviewer: *What was the most difficult part of manufacturing and making arrangements?*

Kawano: The third lens element (a concave element, between the two fluorite elements) is particularly thin, and this was a new area in production for us.

Saito (Optical Design): This concave lens element is heavier than it looks. Production of this third element could not be avoided in order to establish a new optical system and achieve revolutionary weight reduction. I believe the reason we were able to produce such a thin element, and mount it with extreme precision in the product, is thanks to the technical abilities Canon has cultivated over the years.

Kawano: This lens element is so delicate that simply holding the edges of it in your hand can cause localized warping due to body heat. This makes controlling the temperature of the polishing liquid orders of magnitude more difficult. A major reason we were able to manage production of a product with such significant weight reduction and high optical performance was due to the continuous advances in the Canon-produced optical adjuster. Adjustments that were previously made by hand can now be controlled at a much more exacting rate than ever before, making more precise adjustments and accuracy possible.

EF 400mm f/2.8L IS III



Concave third lens element
Fluorite lens elements
UD (Ultra-low Disperson) glass element
Image Stabilization group

The concave third lens element
Highlighted in yellow, this extremely thin, concave lens element in both the 400mm and 600mm designs is an example of both the optical and manufacturing precision designed into the version III super telephoto lenses.

Showcasing the technical abilities of the production site

The photo on the left shows the high-precision and stable quality of the thin third lens element. Without this element, the III series would never have seen the light of day. The lens feels thick and heavy. The photo on the right shows the first group lens barrel, which can rightly be called a mechanical design part. Although the production process involving new materials, injection molding, and machining was never an easy task, it was overcome through collaboration with those on the production floor.

Third, concave lens element lens

First group lens barrel

The tag team efforts of the design and production departments overcame various obstacles, leading to the ideal product.

Accumulated knowledge and the latest technology

Interviewer: *What sticks in your mind from a mechanical standpoint?*

Kawano: Maybe the carbon reinforced magnesium alloy first group lens barrel. Particularly for the 600mm. Because it is bigger than the same unit on the 400mm, we wondered if it was possible to fabricate in a single piece via injection molding while maintaining precision and reliability. I remember clearly that we were successful in this regard, thanks to the cooperation between the Mechanical Division of development, in-house machining sites, and magnesium alloy producing companies. Although it may seem like a simple construction at a glance, this key lens barrel component is the embodiment of knowledge and experience built up over many years.

Development, design and production technology are truly wheels on the same vehicle. No matter how amazing the design drawings are, without a sufficiently high level of production technology, the product will obviously not live up to its design. On the other hand, if design comes to a halt, a breakthrough can sometimes be found on the production floor. The common ground that both have is their strong feelings of commitment toward the users. This is the stuff that makes a new flagship model.

The Utsunomiya Plant, where the white lens is born

This high-performance white lens is produced at Canon's Utsunomiya Plant, about 80 miles (130km) north of Tokyo. In addition to advanced technical abilities, the plant has incorporated the latest internally produced optical adjuster to ensure a stable supply of both new lens models.

Optical technology research

This is a research and development center for lenses and optical technologies. This building stands on the opposite side of the street facing the Utsunomiya Plant, with the close proximity resulting in seamless communication.

13 Design

The lightweight design is expressed first in its shape, lending a real sense of presence to the design.

Form following function. The version III 400mm and 600mm lenses are clear examples of this. So many aspects of their appearance and shape came from attention to functional details, how the lenses would work in the photographer's hands. It was time for the design team to do what they're best at!

The concept of the lens shape was incorporated from the very start of weight reduction efforts.

Interviewer: *Please tell me about the design concept.*

Takeuchi (Design): We designed the 400mm and 600mm lenses based on the concept of "beauty in light collection and control performance." The idea of "beauty in light collection" is a visualization of the image of light entering the front lens and being collected on the focusing plane. We planned the design with this elegant line in mind. The other idea of "control performance" is something that we made up, and refers to how much the user can concentrate on shooting when holding the lens — for example, whether or not they can control the lens easily without looking at their hand. In that way, you could say our design policy incorporates functional beauty based on ergonomics. In any case, we were keenly aware of the desire to design a lens that can be controlled easily as a tool for photography, and to ensure that it can be handled with accuracy in any situation. This, however, is not the basis of the design, but rather the major premise of the lens as a tool for photography.

Shimada (Product Planning): We also wanted to show the newness of the product through the design. However, the white super-telephoto lens has a lot of tradition, and there are a lot of people who show their support for that functional beauty. We needed to consider how to balance tradition and newness.

Takeuchi: We focused on how we could visually represent the carrying on of tradition with the new lightweight design. Specifically, we added a linear shape to the silhouette of the lenses. We intended to bring out a sharpness while showing a lightness in the lens body. One minor detail is that the name plate and distance window on the II series were separated, however, these were combined on the III series and horizontal and vertical lines of components such as switches, etc. were reduced for a simple, modern finish. The aluminum name plate was switched for an electroformed plate, which contributed slightly toward what we feel is a more lightweight design.

We didn't compromise on the white color, despite placing priority on functionality.

Interviewer: *Did developing the heat shield coating from scratch make design tasks more difficult?*

Takeuchi: The "White Lens" symbolizes Canon's many years of technology and tradition, so we were very picky about the color. Above all, we were focused on the effectiveness of the heat shield coating for these products, and skimping on that would defeat the purpose of the product.

Nagao (Development Leader): In order to ensure heat shield coating durability, make it difficult to peel, and create the texture required for the design, we applied multiple layers of coating on the base material.

Takeuchi: Our procedures for chasing down the right shade of white included creating four types of sample colors that served as a baseline, then creating four levels of each for roughly sixteen patterns. I believe you can tell when comparing the II and III series side by side, but the white of the III series is a brighter than that of the II, and a bit warmer as well. In development we call this "Aloof White." As the name implies, it is truly one of a kind and we meant for it to symbolize the EF white lens.

Now and again, industrial design ends up leaning on the concept of prioritizing functionality. The III series, however, did not conclude on a sort of pre-established harmony. Instead of putting one over the other, function and design are beautifully combined on these models. Anyone who takes the lenses in their hand will understand.

Comparison of the 400mm II series (left) and III series (right) — When viewed side by side, there are many noticeable differences and improvements in shape.

The playback ring, which rotates slightly, is wide, and the rings around the AF stop button, which does not need to be rotated, feature anti-slip patterns. The orientation locking knob is located close to the user for easier control.

Accessories that affect lens usability are well thought out, developed by asking ourselves what makes a practical accessory

SLRs have developed into a full-featured system with accessories such as extenders and Speedlites.

Because the EOS and EF system is nearly 30 years old, it was time to look back on its origins and review user feedback.

A wealth of options, the desire to provide usability, and simple, long-lasting appeal resulted in beautiful, functional accessories.

One can see the requests from pros in the accessories —their feedback has resulted in multiple new accessories.

Interviewer: *Were there many requests for accessories in the planning stages?*

Shimada (Product Planning): We talked to pro photographers and the Pro Support Department regarding accessories, receiving requests for functional accessories that were easier to use. In this process we discovered that there were more requests for soft cases than hard, so we decided a soft case was more practical for these lenses. We also offer an optional hard case that protects the lens as much as possible from external shocks during storage and transportation. Although it is used differently depending on the photographer, we realized that in many shooting areas photographers are congregated in tight spaces and that the usual hood was a bit too long to handle, so we listened to the many requests for a shorter hood which is available for the 600mm and 400mm. The front lens cap can not only be attached in the reverse direction, but can also be attached to the lens on its own for improved usability.

Training camp for developing new ideas to ensure that photographers can use the lens for a long time

Takeuchi (Design): We designed the soft lens case so that it can maintain its shape even after being used for a long time. Just as during lens development, we asked for input from a number of people, implementing their feedback in the design, for example, including a business card holder on the top part of the bag. We modified the bottom materials, and added performance cushioning to the shoulder straps in order to design accessories with total usability in mind. We of course kept globetrotting pro photographers in mind, designing for aircraft carry-on capabilities. Members of the Design Department each brought in sketches almost as if attending training camp until we reached the final design.

Nagao (Development Leader): With the lens case, for example, we discussed options with relevant departments, asking whether or not it should be able to store the camera as well, and a variety of accessories. However, increasing storage capabilities results in a much larger case. In the end, we made a specialized case for minimal functionality in order to carry the lens. It is simple and high quality. For this reason I believe it is an easy to use case.

Drop-in filter

The III series is equipped with a drop-in 52mm screw filter (left) as standard, and an optional drop-in gelatin filter (right). A Canon drop-in circular polarizing filter is also available, as an accessory.

Soft cap for greater attachment options

This draw-string style cap can be used even while the hood is attached, and can be attached to the lens on its own. The photo shows the cap on the lens only. The cap has been designed for easy attachment.

Two types of hoods

In addition to the normal hood (right), a new short hood (left) is also available as an optional accessory. This shape is the result of requests for a hood that is easier to handle, especially in tightly-confined shooting areas.

Convenient carrying case

Although we initially discussed making a long case, we ended up with a simple design that users will not grow tired of. It is easy to store and remove the lens in this case. There are separate soft cases for both the 400mm and 600mm models.

From the developers

Shota Shimada
Product Planning

Super-telephoto lenses are beloved by photographers looking to capture decisive moments while shooting under the most extreme circumstances. Hearing people say “I was able to capture this photo because of this super-telephoto lens” is our motivating force, and “a super-telephoto lens is all the more reason to expect great things” is what pushes our technical abilities to grow. This project has reaffirmed that having so many Canon super-telephoto users is an asset that there is no substitute for.

Ever since the previous model (II series) went on sale, we’ve received a variety of feedback, and one could say that the product planning for the new III series began when the II launched. We raised the bar quite high for this product, so that we could create something that would satisfy the many pro photographers who provided their opinions. The entire team worked without making compromises in order to reach an even higher summit, resulting in two lenses that exceeded the imaginations of the Product Planning Department.

Yuki Nagao
Development Leader

For this product, our goal was to create something that made the entire process easier, from carrying equipment to shooting. Many staff from development and the production floor worked together to create something completely new, from the lenses themselves to the accessories. We took particular care to help customers transition from the old to the new product naturally, changing some areas and leaving others as-is. Not only do these lenses have to fulfill their role as a piece of photographic equipment, but they should give owners joy in ownership in conjunction with the refined design. If you’ll allow me to say one more thing in conclusion, it would be — the future of the EF lens *is* the EF lens. Each and every one of us keeps that deep in our hearts, while we continue with development.

Shinichiro Saito
Optical Design

It is my honest opinion that lens precision has reached the ultimate level on the III series. One example is the benefit of a high-precision optical adjuster, which brings incredible consistency and precision to assembly of each lens. Thanks to digital technology and the unusual collective efforts of the Development and Design Team, Product Planning, and the manufacturing divisions, the ideal optical design we had in mind was brought to fruition. It is my sincere hope that users take these lenses out to shoot in their respective fields and enjoy them to their fullest. Also, please provide your frank opinions on their performance.

Makoto Nakahara
Optical Design

We received many requests from customers regarding reliable image quality and a lightweight design during the development of super telephoto lenses. In order to respond to our customers’ trust and hopes in good faith, a series of trial and errors led us to reduce the weight to the utmost extent possible, without compromising image quality in the slightest, as well as creating a new optical system for Canon super-tele lenses. I’m left with the impression that for these latest III series in particular, we were able to achieve this new optical system thanks to the collaborative efforts of the members in mechanical and electrical design, and relevant departments such as production technology. Staff at the factory have also tried their hand at a new lens fabrication method. Although each department has worked together closely on previous products, I feel like the III series is a completely new challenge, and that it brought us together even more.

Makoto Hayakawa
Mechanical Design

When conducting surveys with customers at the beginning of development, we knew about opinions on having no choice but to abandon the heavy 400mm f/2.8 lens. We wanted to provide the best lens for such customers that allow them to shoot preferred subjects without worrying as much about weight. We developed these lenses with such users in mind. We were keenly aware of reducing the weight while not compromising on the optical performance.

We took a fresh look at the basic construction of previous super-telephoto lenses, in order to create a quality mechanical design that allowed us to maintain or exceed the high-precision of existing lenses, completely reinventing main components such as the focus and IS. Finally, efforts to make individual components even a single gram lighter helped us to achieve our weight reduction goal.

Make sure to try this lens, which contains the soul of everyone from planning and design to manufacturing

Daisuke Hirai
Electrical Design

With the knowledge that veteran users often do not rely as heavily on IS, I rethought my ideas, realizing that something had to change — although it goes without saying, customers can use the lens however they like. Our mission is to help broaden the range of photographic possibilities, if even by a small margin. Although it is called the III series, it is such an innovative lens that I think it deserves a different name. I hope that even photographers who do not normally use image stabilization will turn the IS switch on when using these lenses.

Masami Ichinose
Electrical Design

I believe that one aspect of increasing system reliability is to ensure that the III series works with not only the latest DSLR cameras, but also models from 5 and 10 years ago, and even the first film EOS model. Although it may not be noticeable, my pride in the product as the person in charge of electrical systems is to never lose sight of this compatibility. One's footing must be secure when using such a flagship lens. Although pro photographers and advanced amateurs are less likely to use an older EOS model, I hope that they remember this compatibility as it represents the ability to use the lens far into the future.

Yoshinori Kawano
Manufacturing Technology

It is the mission of the Manufacturing Department to deliver the highest quality Canon products to the customer. Each and every person on the production floor was keenly aware of our mission to deliver a new generation flagship on this project. The time we took in preparing for the new heat shield coating, the third lens element fabrication — which was the most difficult process so far for the Utsunomiya Plant — the internally-produced optical adjuster, the new IS structure, EMD, and electronic focusing ring were all part of responding to the passion of the product planning and design departments. In the future, we see a long line of users. Instead of being content once mass production is under way, we will continue working earnestly.

Nobuhiro Takeuchi
Design

The adoption of a new optical system and a significant lightweight design makes the III series a product that carries on in Canon super-telephoto lens traditions, and communicates an advanced design. Honestly, the process of creating the product while remaining true to the concept led to a different form of motivation. For example, we discussed the position of the red line, symbolic of the L series, with the Mechanical Design Department, making adjustments in 1mm increments. Because the design process is composed of so many subjective elements, we had all the more reason for each and every team member to spark the engineering spirit and become involved with one another more closely than ever before.