Canon

EOS R
RF LENSES

EOS R SYSTEM

Developer's interview

Creating a system camera on ce again.

EOS R system developer’s interview

EOS R SYSTEM

The EOS system debuted in 1987. A camera system with large diameter, fully electronic mount, and in-lens motor drive was so innovative and rational that it was unthinkable in terms of common sense and the level of technology at the time.
All information communication between the lens and the camera body was digitized. By eliminating mechanical linkage mechanisms, it improves reliability and at the same time achieves high speed and high precision control of focus and the aperture. With this and the large diameter mount, it is now possible to develop lenses with a variety of specs that include bright, high image quality lenses.
The fact that Canon's development philosophy was right is apparent when you look at the progress of the EOS system, which continues to develop even now after more than 30 years.

However, in the meantime, several significant paradigm shifts occurred in the world of SLR cameras. Imaging went from film to digital. Viewing went to displays in addition to prints. In addition to sharing and announcing works utilizing the Internet, the boundary between still images and movies is disappearing. From now on, the values, needs, and environment surrounding image expression will be increasingly diversified and advanced.

The development concepts of the EOS system, "Fast - Comfortable - High image quality" are timeless. However, in the future, the answer to what is fast, comfortable, or high image quality will be completely different depending on the user. Image input systems need greater flexibility and potential that can meet the demands of each individual.

Based on such future prospects, Canon developers brings a new system to the market. It is the EOS system. The background of the birth includes the strong determination of the developers and a message to the users.

Reimagine opt ical excellence

EOS R SYSTEM

[System]

KEY WORD Large diameter mount, and short back focus

Expanding of the range of shooting even further.

Image Communication Business Operations
ICB Optical Products Development Center Deputy Senior General Manager
Manabu Kato

Image Communication Business Operations
ICB Products Development Center General Manager
Shintaro Oshima

Image Communication Business Operations
ICB R&D Center 2 General Manager
Masami Sugimori

Resolution for the next 30 years of the EOS system.

"It has been about 30 years since our predecessors created the EOS system.
Even though times have changed dramatically, such as digitization, increasing pixel counts of cameras, and support for movies, the EOS system is far from becoming obsolete, and we are leading the world of still images and movies today.
Our goal was to create an image input system that would continue to develop over the next 30 years." —Manabu Kato

"With cameras, it is no longer possible to think of them separately as lenses and devices.
What will we send out for the next 30 years as Canon, who opened up the era of the system camera?
We decided to foresee the future once again." —Shintaro Oshima

The EOS R system is, with RF lenses at its core, a new image input system that consists of a 35mm full-frame mirrorless camera and accessories.

Hearing this, you might think that Canon has developed this system with the focus on mirrorless, but that would be a misunderstanding. In the first place, when Live View shooting or movie shooting is performed with the existing EOS system, the camera technically functions without the mirror. By adopting an electronic viewfinder, it would not have been difficult for Canon to evolve to a 35mm full-frame mirrorless camera itself.

Canon, however, chose a different path. The whole point of development was to attempt to develop the RF lens series, and to use it as the core of the system. This is where you will find the developers' passion, and the true meaning of the EOS R system.

It has been about 30 years since EOS was introduced in 1987. The technological innovation that has occurred since its introduction is remarkable. Canon possesses a large amount of proprietary technology such as Dual Pixel CMOS AF, starting with its own development of 35mm full-frame CMOS sensors. Of course, the development of such technologies was based upon Canon's confidence as to how advantageous the future camera systems would be.

How will we incorporate those results into the future image input system? This is where the long-awaited EOS R system development projectstarted.

"We began by reexamining the strengths of the EOS system. The answer was the EF mount. Its true meaning lies in achieving an image input system with a new form, in which the camera and lens demonstrate high performance working together." (Kato)

Those who joined in the discussions were not only optical, mechanical, and electrical engineers. People in charge of cinema cameras, surveillance cameras, and new projects under consideration also participated in discussions crossing over boundaries within the organization.

We looked at the future and made a list of issues and demands, with an eye on all the imaging product fields that Canon can analyze. The solution was the construction of a new image input system with enhanced system properties, but this was only possible by Canon.

The future of the RF mount.

"We did not want to create a small, lightweight camera.
The ideal lens was what Canon has strived for.
This new mount, and the 35mm full-frame mirrorless structure were at the minimum distance to achieving our ideals." —Manabu Kato

Canon has what they call "ideal lenses". Up until now, Canon's optical designers have been working to develop, aiming for "lenses with as close to zero aberrations as possible." There is also optical fate and it is not possible to seek perfection, but with outstanding technological innovation it is possible to get significantly closer to the ideal.

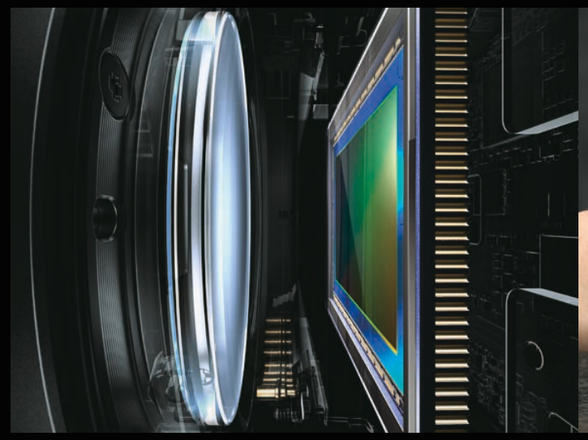
Canon has optical simulation software, glass materials, special elements, coating technology, and production technology in its hands. Increasing the degree of freedom of optical design more than ever is the challenge. The mount was the key to this issue.

The larger the mount diameter, the shorter the back focus*, the more the optical design flexibility increases. Short back focus is one of the main reasons why the EOS R camera uses the mirrorless system. The question was the mount diameter.

For example, what would happen if they used the EF-M mount? Being a mount developed for APS-C sized sensors, the camera can be reduced in size. However, if you attempt to increase the optical performance of the lens, the lens will become enlarged. This defeats the purpose.

What we should be aiming for is not "a small SLR camera capable of the same image expression as up until now". It is a new image input system that expands image expression and the range of shooting.

* Back focus: Distance from the back of the lens to the focal plane.



Inheriting the persistent concepts of EOS.

"The EOS R system was developed envisioning the elements necessary for all image input devices regardless of still images or movies.
However, the development concepts of EOS, which have been passed down are still alive. Our answer is the integration of tradition and innovation." —Shintaro Oshima

Members of the optical engineers were like a fish that had been given water. Before discussions, some of the engineers went so far as to say "Even with a short back focus, it is not worth designing if the mount diameter is small". In other words, this meant that they were confident that they can design a lens that was never seen before if only they were given a large mount diameter. Because they can demonstrate it, this was the most appealing story for the engineers.

The optical designers themselves raised their hands and participated in the discussions. They endeavored to design lenses with unique specifications that would have been impossible to foresee with existing EF lenses. By doing so, the obtained result is a mount with an inner diameter of 54 mm. By chance, this is the same value as the EF mount.

"By being able to place a lens with a large diameter close to the focal plane, the degree of freedom of optical design is enhanced dramatically. The four lenses developed as the first stage of the RF lenses have realized these advantages." (Kato)

Symbolic of this is the zoom lens RF28-70mm F2 L USM with a maximum F2 constant aperture. It may seem rather bulky at first glance, but such specifications would have been too large to be marketed using an EF mount. The fact that a lens with these high specifications can be used handheld, proves the high potential of the RF mount.

Flange back*. The inner diameter of the mount was decided. The next problem was the flange back. If the flange back is shortened, it is possible to make the overall length more compact when mounted. However, if reduced too much, it is difficult to ensure the rigidity of the camera supporting the lens.

Ease of handling and reliability. The optimal solution arrived at was 20 mm. Compared to the flange back of the EOS system (44 mm), it was significantly reduced.

The camera body is more compact and lightweight, but rigidity is no less than EOS cameras. Even if you attach a super telephoto or large aperture EF lens using the mount adapter as well as an RF lens, you can focus on shooting without any worries.

* Flange back: Distance from the mount surface to the focal plane's surface.

The development concepts of EOS are “Fast - Comfortable - High image quality”. Actually, the EOS system has a key phrase that can be said to be its more specific concept. It is "expanding the range of shooting".

So far, Canon has put out all kinds of cameras and lenses into the world, with the result of expanding the range of shooting. The zoom lens with a maximum F2 constant aperture is no exception. When shooting with a large aperture prime lens, changing the lens every time you change the subject or composition will result in missing out on the best photo opportunities. If you have the same depth of field and an even higher quality zoom lens, you can record moments you could not up until now by just turning the zoom ring. The range of shooting also expands accordingly.

The EOS R camera and RF lenses are new options that line up with the 35mm full-frame EOS and EF lenses, which are part of the full-fledged SLR camera system. “There are some scenes that will be easier to shoot with the optical viewfinder. Electronic viewfinders, however, are overwhelmingly advantageous for specific conditions such as night scene shooting. We believe that by adding EOS R cameras to the lineup in addition to the existing EOS cameras, you will be able to make selections that match your shooting style and shooting theme." (Oshima)

Unchanging concepts and technologies that will continue to evolve. With the introduction of the EOS R system developed based on these, Canon will further expand the image expression and the range of shooting.

Drawing out the maximum characteristics of the lens.

"Canon's ideal form of image creation is to provide pictures as the user has envisioned.
For this reason, it is important to maximize the optical performance of the lens and make use of the camera's resolution.
Image quality of the EOS R system is designed to draw out the RF lens characteristics as much as possible.”
—Masami Sugimori

Achieving images as users have envisioned. That is the aim of high image quality for the EOS system. Depending on the resolution of the camera's image sensor, it produces the image clarity as expected. It reproduces the memory color that the user wants to express. Pursuing this is Canon's basic stance on image creation.

With the EOS R system, this basic stance does not change. With this system, thanks to improved lens performance, we were able to get one step significantly closer to the ideal that Canon is aiming for. However, by seeking even higher image quality, with the EOS R camera we are thoroughly pursuing image creation to maximize the characteristics of the RF lenses.

"Because the optical performance of the RF lenses is further improved, if this can be utilized to the utmost, it will naturally get closer to the ideal image. If you compare it with cooking, while making use of the flavor of the ingredients, image processing is like seasoning it to enhance it further. This is where you can show what can be done with image design.” (Sugimori)

One example of this seasoning is to change the policy for the strength of sharpness. To make the best use of the RF lens's characteristics, the concept of sharpness on EOS R cameras has changed from the EOS 5D Mark IV. This achieves images with contrast while enabling more subtle rendering.

Another example is significant innovation of the lens optical correction. The EOS R system refines the system with future development in mind. One example is to include optical data on all the lenses.

In the past, although lenses were able to retain basic optical data and convey it to the camera, correction data requiring a large capacity such as Digital Lens Optimizer has been left to RAW processing software and cameras. That is why data was downloaded every time a new lens was released and registered on the camera using EOS Utility.

This is not necessary with the RF lenses. In addition to aberration and diffraction, even the Digital Lens Optimizer data is retained by the lens itself and conveyed to the camera. As we were pursuing qualities as a system camera, this was quite an accomplishment.

"RF lenses are high resolution and high contrast. But on top of that, Digital Lens Optimizer can be used as one of the tools for maximizing the image quality. The starting line of image quality design itself can be set higher than that of existing EOS cameras.” (Sugimori)

Canon's ideal image creation is achieved by the lens, sensor, and imaging processor, the three key parts all together. Even if only one excels dramatically, it will only result in unnatural images.

The most obvious example is images shot with the EOS R camera and the RF 50mm F1.2 L USM lens. Image quality designers also achieve resolving power and feeling of depth, saying "This is amazing". The results of preview shots are breathtakingly exquisite even for large format prints, and the beauty of background blurring is also exceptional.

The EOS R system asserts Canon's stance of image creation with image quality, not theory.

Digital Lens Optimizer for EF lenses is retained on the EOS R camera, except for certain lens models. A mount adapter is necessary for attaching an EF lens on the EOS R camera. EF-M and CN-E lenses (EF Ciname lenses) cannot be attached.

KEY WORD | New mount communication system

Always ahead of the times. A communication system between lens and camera.

Image Communication Business Operations
ICB Products Development Center Senior Project Manager
Yoichi Sato

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ICB Optical Products Development Center General Manager
Junichi Murakami

Developing next-generation standards.

"All of the past EF lenses work as expected with the latest EOS cameras.
This is proof that the EOS communication system had great expandability and flexibility.
With the EOS R system as well, I wanted to achieve a large system potential that would live up to our predecessor's achievements." —Yoichi Sato

A fully electronic mount. This is one of the reasons the EOS system continued to evolve for about 30 years. The camera and lens coordinate to control the autofocus and aperture with high precision. This system, which was released in 1987, is still used today for optical correction, and it has become a standard in the world of cameras.

It is not easy to change the communication system between the camera and the lens with its once defined standard. Like the EOS system, developers of the EOS R system wanted to build a communication system that can withstand the hardships of the times.

As the EOS R system continues to evolve, there is no doubt that the amount of information communication between the lens and the camera will increase further in the future. In order to ensure its expandability, the EOS R system incorporated a different concept from the EOS system.

A significant difference is to have all the optical information and optical correction data stored in the lens, not the camera. In this case, even when a new lens makes an appearance, there is no need to register new data on the camera.

On the other hand, as for the EF lenses*, like the EOS 5D Mark IV, as much data as possible is stored in the camera.

While ensuring the potential of the RF lenses, consideration is also made for users of the EF lenses. This is a logical concept for new development of a Canon camera,

* A mount special adapter is necessary for attaching EF lenses. In addition, EOS-M lenses, and EF Cinema lenses are not supported.

The New Mount Communication System is one of the major features of EOS R system and the RF mount.

In order to control the autofocus and the aperture with high precision, more detailed optical information is necessary. Accordingly, the data for optical correction also increases in volume.

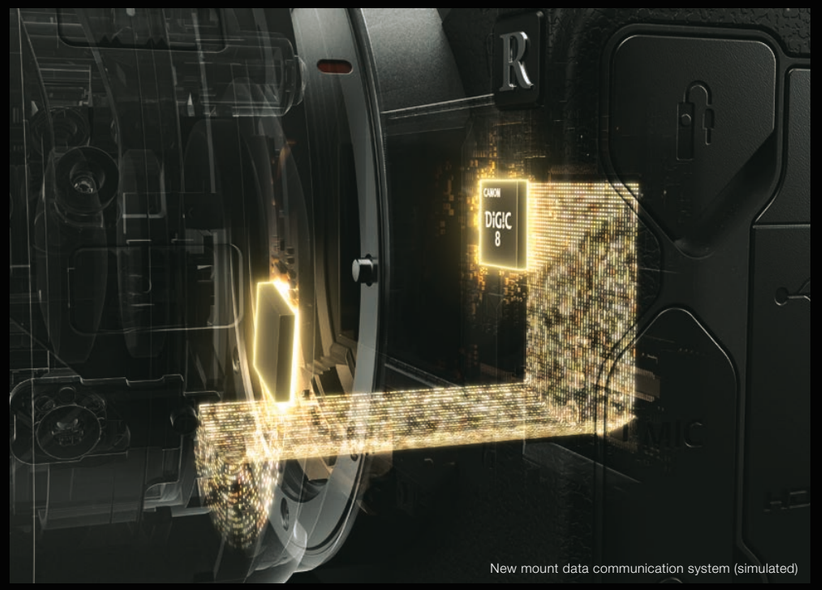
With the EOS R system, whenever a lens is exchanged, this data is handed over to the camera. However, this slows down the startup, which can break the shooting rhythm. More importantly, you will not be able to respond to decisive moments.

The developers decided to renew starting with the protocol which is the basis of the communication system in order to solve this problem.

"Thirty years ago, engineers invented the EOS communication system. There is no surprise in their foresight. With the EOS R system as well, I wanted to build such a system that would satisfy engineers 30 years from now." (Sato)

A circuit capable of high-speed data transfer is used for hardware responsible for communication. Furthermore, the number of communication contacts is eight for the EOS mount, and twelve for the RF mount.

As the hub of the system network, the RF mount has the potential to far surpass the EF mount.



New mount data communication system (simulated)

High performance provided by the new mount communication system.

"With the EOS system, lenses and cameras are actively communicating.
By making the communication more exciting, the possibilities of expression and ease of use will reach a new generation.
Operating with the control ring.
High precision autofocus and aperture control, and image stabilization.
The communication system of the EOS R system is anticipating such a future."
—Yoichi Sato

What does the new mount communication system make possible?

An easy to understand example is improved performance of the image stabilization function. With IS where the lens and camera work together, in addition to the sensor included in the lens, the CMOS sensor is also used for shake detection. In order to improve the correction effect more, the camera supports the control of the IS unit. As a result, shaking that could not be detected by the sensor in the lens can also be corrected. The merit of high-speed communication that can control the lens almost in real time is being utilized here.

We cannot forget the improved operability and power of expression. One of the features of the RF lens, the control ring, is a benefit of the new communication system.

With the new mount communication system, the camera can constantly control the lens, and it can also respond to setting changes via ring operations at the same time.

"With near real time high-speed communication and communication command innovation, it is now possible to use the in-camera Digital Lens Optimizer and real time display of shooting distance information on all RF lenses. I think these are straightforward messages to the user that the EOS R system expands the possibilities of expression." (Murakami)

The EOS R system's communication system has plenty of extra capacity in consideration of the future. Someday, there may be major changes in image expression and camera systems. The new camera system should continue to meet user's expectations at that time also.

KEY WORD Lens mechanical design and component development

Optics and mechanics. RF lenses evolve by each motivating the other.

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ICB Optical Products Development Center General Manager
Seichi Kashiwaba

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ICB Optical Products Development Center General Manager
Masanori Ishikawa

RF lens development, and the high-spirited mechanical designers.

"No matter how outstanding the optical design is, it will not make sense unless there is technology to shape it.
The RF lens is the crystallization of a new effort not only in optical but also in mechanical design." —Seichi Kashiwaba

Seeing the lens configuration for the first time, the developers in charge of mechanical design of the RF lens could not hide their bewilderment when they saw the cross-section diagrams of the optics entrusted to them by the optical designers.

The configuration differs significantly from EF lenses of the same focal length. One of them with a lens with a larger diameter than the front was placed that lens at the very back. The developers who have seen optical cross sections of lenses for many years thought, "There is something wrong with this." So, the optical design approach will change due to large diameter mount and short back focus.

This was a big challenge for the mechanical design. In accordance with the new optical system, the mechanics designers would also need to devise ways to store the components. It was difficult, but Canon mechanical designers also had a feeling of elation at the same time.
"Attempting something new. That is the source of innovation in design and production technology. It is also Canon's strength which can be dealt with consistently from optical design to mechanical design and production." (Kashiwaba)

Reviewing the structure that has been followed up until now. If necessary, they are prepared to redesign proven components. Upon receiving the optical designers' difficult demand of "for image quality" in advance, the mechanical designers made further repeated new development efforts.

With the L series lenses, a higher density mechanical structure is achieved while maintaining the same durability and toughness as the EF lens L series. Electronic manual focus is used for the focus mechanism. High-speed autofocus and customization of manual focus is achieved. The value of "ease of use" is added to the image quality-oriented optical design. It is the crystallization of the developers' commitment.

RF50mm F1.2 L USM

Surpassing the boundary between still images and movies.

"With the EF lenses, which was developed for still images, there were limitations in movie performance by the communication system. That is not the case with the EOS R system.
It will maximize the merits of the components, and higher precision exposure and stable images will be obtained in movies.
Envisioning a wider range of expression than the EOS system.This is why a new system was needed." —Masanori Ishikawa

Between still images and movies, the specifications required of lenses are different. Slight fluctuations in brightness due to the aperture drive, which is normally not an issue with still images, can be very noticeable in movies. To overcome this, the EMD* control is renewed for the RF lenses. By controlling the aperture diameter with high resolution, compatibility with movies has been greatly improved over the EF lens L series, which were designed with the premise of still images.

Operation of the aperture by the control ring is controlled from the camera side utilizing the new mount communication system. Meanwhile, control of the EMD accompanying zooming is performed by the lens alone, achieving linear and smooth aperture control.

As a result, RF lenses can suppress changes in the amount of light even with a slow zoom in and zoom out typical of movies, and can record natural images. This type of movie handling capabilities cannot be described on spec sheets. Movie shooting with an SLR camera is now much closer to perfection with this system.

* EMD = Electro Magnetic Diaphragm

The RF24-105mm F4 L IS USM is worth a special attention in terms of movie support. Being the first L-lens to equip a Nano USM, this is a lens that is suited for movie shooting that offer smooth autofocus..

In order to incorporate a Nano USM unit in a slim lens barrel, Canon redesigned the proven Nano USM and tried to make it significantly slimmer. The actuator makes it possible to autofocus faster for still images, and control focus smoothly for movies.
"The EOS R system aims to be a system that can handle any type of expression. One of our goals in lens design was to equip this Nano USM in an L lens so that we can offer quiet operation and high controllability. In order to achieve this, both optical and mechanical design of this lens were very challenging." (Ishikawa)

At first glance on the spec sheet, it may not have as strong an impact as the RF50mm F1.2 L USM or the RF28-80mm F2 L USM. However, it is this RF24-105mm F4 L IS USM that most clearly conveys the system concept of an input device for all kinds of images. The EOS R system reaches the dimension beyond the boundary between still images and movies.

RF24-105mm F4 L IS USM

KEY WORD Dual Pixel CMOS AF

The future of focal plane phase-difference AF that only Canon can talk about.

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ICB R&D Center 1 Manager
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ICB R&D Center 3 Manager
Mineo Uchida

Innovative technology created by Canon's elite.

"With Canon's proprietary Dual Pixel CMOS AF, which is the crown of the researchers' creativity, all are imaging pixels and are phase-difference AF pixels at the same time.
It is the ultimate aspect of focal plane phase-difference detection AF, and enables high-speed, high-precision phase-difference detection AF even under severe optical conditions that were impossible up to now.
Its potential backed up by theory makes the EOS R system decisively different from other mirrorless cameras." —Koichi Fukuda

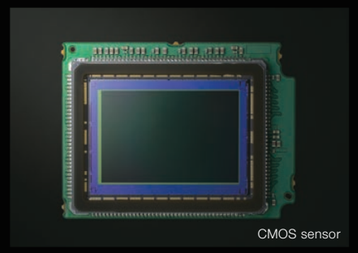
Dual Pixel CMOS AF is used as the AF system of the EOS R system. Two photodiodes are mounted on each microlens. It is Canon's proprietary focal plane phase-difference detection AF technology which achieves two functions of imaging and phase-difference AF on one pixel.

The simple concept of this technology was created in 1981, three years after the idea of phase-difference AF. It was still the era of film cameras, and it was not put into practical use. At the dawn of digital cameras in 1999, Canon first came up with the idea of the CMOS sensor configuration and started research. However, the barrier of technical challenges in achieving both imaging and phase-difference AF on one pixel was high, and it was forced to abandon the idea of putting it into practical application right away.

Dual Pixel CMOS AF started getting closer to realization in 2010. At that time, a new AF system optimum for Live View shooting was sought after. Up-and-coming engineers in each specialized field got together, and a Canon elite team was formed. They would pioneer the way towards practical application.

At the beginning of development, other people were not encouraging. This technology in principle, however, has great potential to overcome the challenges of today's AF system. The elite were convinced of this. The moment the new AF system worked for the first time, their confidence in its high AF performance increased. They were convinced that it is an innovative technology that will someday become the mainstream of camera systems.

Canon's elite team built up one technological breakthrough after another, and in 2013, Dual Pixel CMOS AF was introduced to the world with the launch of the EOS 70D. It was finally put into practical use. It was the moment when the pioneering spirit of Canon developers came into fruition, after continuing to challenge difficulties for 32 years since the birth of the theory.



CMOS sensor

Why was only Canon able to achieve Dual Pixel CMOS AF? It is because Canon has a unique presence in the imaging products industry, and consistently develops and produces not only lenses and cameras, but also key devices.

If there is better semiconductor manufacturing technology than Canon, could it have achieved a similar AF system? The answer is no. With this AF system, in addition to imaging with high image quality, micro optics for obtaining parallax unique to phase-difference AF must be designed and mounted on a CMOS sensor. Furthermore, it is necessary to design and implement a computation algorithm for each interchangeable lens and CMOS sensor, and for phase-difference AF adapted for each shooting condition. Optimized design to maximize phase-difference AF performance is impossible unless we assume various features of lenses from wide-angle to super telephoto lenses, the identity and productivity of each individual CMOS sensor and the knowledge of phase-difference AF cultivated through EOS.

"Dual Pixel CMOS AF technology is the crystallization of creativity of the designers of CMOS sensors, lenses and imaging processors. If even one of them was missing, it would not have been achieved. It is because the AF technology is unique to Canon, and we design and produce it by ourselves." (Fukuda)

Dual Pixel CMOS AF is the integration of all joined forces of elite amongst Canon's engineers, and it were not for their efforts, it would not have supported the RF lenses that makes use of the large diameter mount and short back focus to the full potential. Long-awaited. This word is appropriate for the EOS R system.

As an advanced image input system, the EOS R system aims for a high level of perfection. Dual Pixel CMOS AF also required performance exceeding that of up until now. Higher speed and higher precision AF. More AF points. Improved low-illuminance performance. AF area expansion. To incorporate various methods for subject detection in each AF point, the amount of data used for processing autofocus on the camera has increased to about 40 times the maximum of the EOS 5D Mark IV (during Live View shooting).

Also, the amount of information received from the lens has also increased compared with the EOS system up until now. Information such as zoom, focus position, and aperture are detected in high resolution and sent to the camera via the new mount communication system. By making full use of this various information, faster and higher precision autofocus has been achieved.

The DIGIC 8 imaging processor instantly processes enormous amounts of information. With the conventional EOS system, autofocus and lens control sometimes had to go through distributed processing by dedicated microcomputers. Today, however, development is being carried out toward the direction of controlling the imaging processor to processing all data. If the performance of the imaging processor allows, it is easier to coordinate control inside the system, including lenses and CMOS sensor.

"We are improving processing capacity by expanding Dual Pixel CMOS AF dedicated circuits in the imaging processor. This is dramatically increased from the older versions of DIGIC. Development of the imaging processor takes a long period of time. It is a hardware process that would not have been achieved if we had not planned and worked for many years." (Uchida)

Although it is the RF lenses that can fully enjoy the benefits, with more than 90 EF lenses* from the past until the present, advanced AF functions can be utilized. Moreover, by collaborating with optical engineers, the autofocus is developed to function to its full potential even if an RF lens with unique features or focal lengths is launched in the future.

Mirrorless cameras will enter a new era with the EOS R system and Dual Pixel CMOS AF.

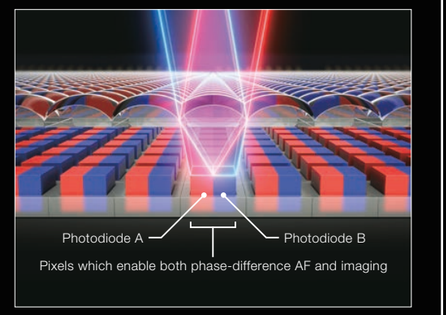
* A mount adapter is necessary for attaching EF lenses. EOS-M lenses, and EF Cinema lenses are not supported.

Speed and precision achieved by increased amount of data processing.

"With the RF mount and the newly developed imaging processor, the size data used for processing the phase-difference detection AF has increased dramatically.
Scenes that can be autofocused are far more extensive than with the EOS system up until now."
—Mineo Uchida

Attaining both high image quality and multi-point focus

Advantages of the Dual Pixel CMOS AF. It will be easier to understand when compared with Hybrid CMOS AF, which Canon previously used.
Hybrid CMOS AF allocates AF-dedicated pixels on the CMOS sensor in order to detect the phase-difference. There are also many advantages such as simple structure and achieving lower costs, and at present similar technology is being widely used in numerous other mirrorless cameras. However, with such AF systems, it is impossible to utilize the output of the AF-dedicated pixels as is for imaging information. It is interpolated by image processing, but correction is difficult under specific conditions. Also, as the number of AF points increases, the influence on image quality also increases.
One Dual Pixel CMOS AF has no influence on image quality even if the number of AF points is increased. AF is possible even in places where the image at the screen periphery tends to deteriorate, and a wider area can be achieved. Canon believes that it is the most ideal and unique focal plane phase-difference AF technology that combines practicality and future potential.



Lens Optical Design

Revealing uncharted territory. Canon’s optical design technology.

Image Communication Business Operations
ICB Optical Products Development Center Manager
Shigenobu Sugita

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Satoshi Maetaki

Challenging the "limited area" of optical design.

"It is an opportunity to challenge optical design that had been impossible.
If it is a single focal length standard lens, I want to aim for the highest image quality with a maximum aperture of F1.2.
Although it is an extremely high hurdle, there was never an idea of compromising the maximum aperture at F1.4."
—Shigenobu Sugita

Drawing out as much potential of the RF mount as possible. Expanding users’ world of expression with lenses that have appealing specs and rendering power. It was the designers of the Optical Products Development Center who took on the challenge of this theme.

The first thing they needed to prepare was a standard lens, but the developers had a strong preference for an " large aperture prime lens with a maximum aperture of F1.2." Expanding expression with large diameter lenses. This is because it is one of the best examples of preparing the RF mount.

There is only a 1/2 stop difference F1.2 and F1.4, but the difficulty of optical design is a whole other level. With a 50mm F1.2 lens for 35mm full-frame, it is extremely difficult to develop a lens that supports autofocus. Developers felt they wanted to challenge the "limited area of lens development," to demonstrate the ability of the RF mount.

Also, there was a strong desire to break down the "evolutionary barrier" of standard lenses with their own hands. The basic form of the standard lens is the Gauss type. With this lens type, comatic aberration increases as the diameter becomes larger, and it is difficult to maintain image quality around the periphery of the image. As the brightness increases, the decrease in the amount of peripheral light becomes relatively noticeable. In the optical world, how to improve standard lenses has become a big issue.

Canon’s answer is the RF50mm F1.2 L USM. The RF mount has the largest inner diameter of 54mm in its class for 35mm full-frame mirrorless cameras. If this was attempted with 50mm, the image quality aimed for would have been much harder to achieve.

In addition, back focus* can be set much shorter than the EF mount. Utilizing these advantages, large diameter lenses are placed close to the focal plane. Aberration correction not possible in the past was applied.

"Aberration occurs when light bends. The key to high image quality is how to bend the light. However, if the mount has a small inner diameter, it will force the light to bend and pass through. As the aberration increases, correction becomes difficult. If there is a mirror, it can only be done on the front side. As higher image quality is aimed for, lenses will be added to the front side, and both the total length and the front lens diameter will be enlarged.” (Sugita)

A large diameter RF mount can reduce the amount that light bends. In addition, it is possible to place lenses for image quality improvement in the space where the mirror was up until now. It is possible to pursue the miniaturization and higher image quality of the lens at the same time.

The RF50mm F1.2 L USM is extremely sharp from the maximum aperture. The smoothness of the background blurring effect stands out even more. The first ones to see the preview shot results were the designers who are in charge of the camera's image processing. They also knew what F1.2 images taken with an EF lens looked like, and they said breathlessly, "We could not have imagined such image clarity and amazing background blurring."

* Back focus: Distance from the back of the lens to the focal plane.

In the case of a wide-angle lens, specifically, a lens with a short focal length, the merit of a short back focus increases even more.

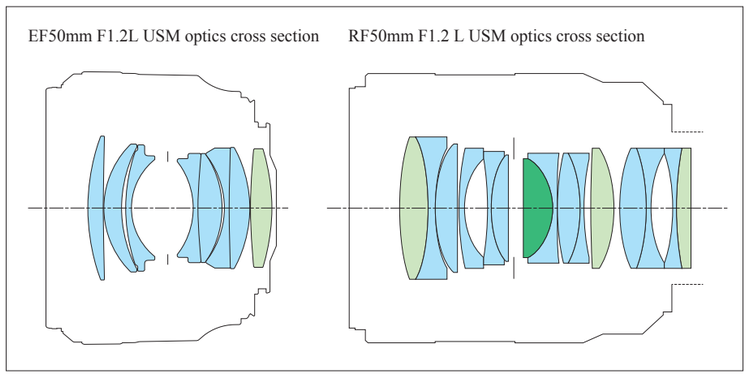
The basic lens type of wide-angle lens is retrofocus. Normally it is characterized by expanding the light to be converged by a convex lens with a concave lens.

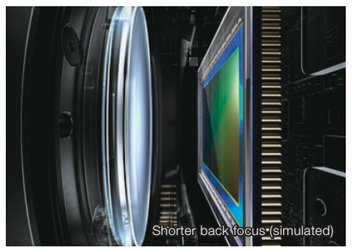
A lens with a shorter focal length requires a higher power concave lens. However, spreading light is a problem as aberration increases. Inevitably the correction optical system also becomes larger, and the rear lens group space becomes more desirable.

This dilemma is easy to overcome if it is an RF lens. As the back focus is short, the amount of movement of the principal point can be small.

"It is no longer necessary to place a high-power concave lens in the front group, so even wide-angle lenses will be able to straightforwardly gather light. Each lens works to increase the imaging performance, so it is easy to make it compact." (Sugita)

This advantage was fully utilized in the RF35mm F1.8 MACRO IS STM as well as the RF24-105mm F4 L IS USM and RF28-70mm F2 L USM zoom lenses. It is also possible to develop unique wide-angle lenses and zoom lenses that were not possible up until now. With the RF mount, Canon lenses have the potential for new developments.





Overcome the limits of yesterday.

"No matter how advanced the optical design is, it will not make sense if it cannot be marketed.
If necessary, both the design tools and the manufacturing machines are developed in-house.
Without the collective strength of Canon, which continues to pursue cutting edge technology and tools,
these RF lenses would not have been created." —Satoshi Maetaki

With a lineup of more than 90 lenses*, the EF lenses have recorded a cumulative production of 130 million lenses. That technical strength and collective strength are the backbone of the RF lenses.

The RF28-70mm F2 L USM is a symbolic lens. It is not just bright. High image quality comparable to a single focal length lens has been achieved at all zoom positions. That is the true value of this lens.

"If you try to achieve the specifications and image quality of the RF28-70mm F2 L USM with an EF lens, it will be even larger and heavier." (Maetaki)

In fact, regardless of the large diameter mount, and short back focus, it would have been impossible to develop this lens for only that. The RF28-70mm F2 L USM uses a high precision glass-molded aspherical lens which overcomes the barrier of molding precision up until now, located at the position where it is most effective for miniaturization and high image quality. A new type of glass molding machine that was being developed for some time has been completed.

* Including EF-M lenses, and Cinema EOS lenses. As of September 2018.

The latest molding machines can produce a significantly higher level of aspheric accuracy than before. With the aspherical lenses made using molding machines up until now, the sought-after optical performance could not be achieved.

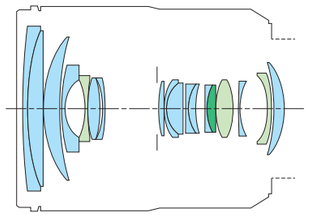
Optical design that cannot be achieved with just the accumulation of existing technologies. The RF28-70mm F 2L USM is the crown of research and development, design and manufacturing technology that is always looking ahead and prepared for the future.

In addition, this time, we introduced high precision ground aspherical lenses. Even from glass materials that cannot be molded, there is a significant advantage to being able to manufacture aspherical lenses.

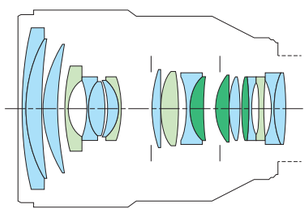
"Canon has a long history of developing and manufacturing high-precision ground aspherical lens elements, and our technology has developed vastly over time. Without technology like this, it would be difficult to commercialize a standard zoom lens with a maximum F2 constant aperture with this image quality, and practical size." (Maetaki)

For users seeing it for the first time, it will most likely look like a bulky lens. However, in terms of the common knowledge of photographic lenses, it is compact enough to be phenomenal, and it is so lightweight that you could say it is epoch-making.

RF24-105mm F4 L IS USM optics cross section



RF28-70mm F2 L USM optics cross section



The advantages of a large diameter mount and short back focus are significant. However, there is one demerit. It is that flaring and ghosting can occur more easily.

If the back focus is longer, you can let harmful light escape outside of the screen. However, if you place a large lens close to the focal plane, that will not work.

Of course, even existing tools are capable of simulation, but the optical designers wanted to analyze flaring and ghosting with even more precision.

Canon has the technology and tradition of developing its own optical design tools. There is also a specialized unit for that purpose. Therefore, we decided to develop a special simulation tool only for countermeasures against flaring and ghosting, and use it for the RF lens design.

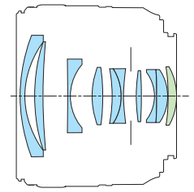
Canon also has its own anti-reflection technologies, SWC (Subwavelength Structure Coating) and ASC (Air Sphere Coating). By utilizing these assets and the latest tools, we successfully suppressed the disadvantages of a large diameter mount and short back focus.

Canon has continuously challenged the unknown areas. The development system and collective strength cultivated therein supports the outstanding image quality of the RF lens.

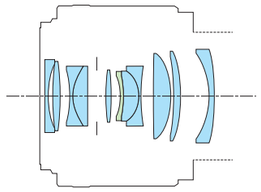
Retrofocus and back focus

By placing a concave lens in the front group, the principal point is moved to the focal plane side from the lens at the back, which is called retrofocus. Because it can ensure a large amount of back focus, on SLR cameras which need to consider the operating space of the mirror, this is the leading lens type used for wide-angle lenses.

EF35mm F2 IS USM optics cross section



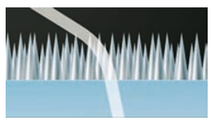
RF35mm F1.8 MACRO IS STM optics cross section



Cutting-edge Anti-Reflective Coating Technology

Highly anti-reflective SWC and ASC coating help to reduce ghosting.

SWC is used for: RF28-70mm F2 L USM
ASC is used for: RF50mm F1.2 L USM, RF24-105mm F4 L IS USM and RF28-70mm F2 L USM



SWC (Subwavelength Structure Coating)
SWC is an anti-reflection technology that uses a multitude of tiny wedge-shaped structures, smaller than the wavelength of visible light. By covering the surface of the camera lens with these structures, reflection can be minimized.

ASC (Air Sphere Coating)
ASC is an anti-reflective coating that employs a low-refraction film of silicon dioxide and oxygen and vapor deposition coating. This coating contains enough oxygen to give it a refractive index lower than optical glass and closer to that of air, thus reducing reflections on the lens surface.

Advanced mechatronics that support “fast and comfortable.”

Image Communication Business Operations
ICB Optical Products Development Center Senior Engineer
Masahisa Tamura

Image Communication Business Operations
ICB Optical Products Development Center Lead Engineer
Katsuhiro Inoue

Image Communication Business Operations
ICB Optical Products Development Center Manager
Koji Sato

Not being bound by the traditional way of thinking.

"Is it possible to move a heavy focus group with a small amount of force, and maintain a stable orientation?
This theme was solved with a new mechanism.
I think this is one of the breakthroughs in RF lens development."

—Katsuhiro Inoue

Innovative ideas, with advanced mechanical engineering and electronics. That is what supports Canon's lens development. In the background of creating the RF lenses, the mechanical designers had a strong motivation for development.

One of the breakthroughs made with RF lenses is the newly developed focus group retention mechanism. As the diameter of the photographic lenses increases and the image quality improves, the focus group becomes heavier, and the load at the time of focusing tends to increase. Moving the heavy focus group smoothly with a small amount of force. Maintaining stability at the correct orientation within the focus cam. Canon has devised various ways to achieve these requirements at the same time.

Nevertheless, this time, the height of the hurdle was different. The first thing we started development on was a 50mm large aperture standard lens. The mechanical designers who were consulted by the optical designers were surprised. They said that they wanted to control the focus group that extends to 11 lenses with high-speed and high-precision.

No matter how you look at it, this is just too heavy. With existing mechanisms, it would be impossible to achieve "fast and comfortable."

The problem is that a large amount of resistance is generated at the connection between the focus group and the focus cam, and the movement of the cam slows down. If resistance is reduced, it becomes easier to move, but now the focus group fluctuates, and the original optical performance cannot be obtained.

The developers worked out this new retention mechanism as a solution. A lead groove is opened in the lead cam for moving the focus group back and forth. In photographic lenses, it was common to use this method of pressing the focus group against the groove with a spring and stabilizing it using a pushing force.

With the new mechanism on the other hand, the six pins on the outer periphery of the focus group assist in maintaining the orientation. Even if the pushing force of the spring is reduced, the focus group will not fluctuate.

The RF50mm F1.2 L USM focus group is approximately 340 g. It has the weight of a lightweight lens (for example, one EF 50mm f/1.4 USM lens is about 290 g). It moves smoothly, and it can demonstrate stable high optical performance because the newly developed mechanism works effectively.

"Up until now, the focus cam and the focus group were caught up in complicated conditions and designing freely was difficult. This new mechanism eliminates one such limitation. I believe that the potential of RF lenses will expand greatly due to the flexibility created in this fashion." (Inoue)

With RF lenses, not only optical design but also mechanical design as well are technologies oriented toward at the next generation which is breathtaking.

The electronic ring that creates system freedom.

"Digitization of the focus ring does not contradict professional needs that emphasize delicate focus operations.
While supporting the latest optical design, it inherits the user-friendliness of the EF lens L series, and allows for customization.
I believe that it was the best decision for this.”

—Masahisa Tamura

A direct operational feeling. Therefore, with the EF lenses, we have taken the design philosophy of connecting the focus ring and the focus cam with a mechanical mechanism.

The RF lenses on the other hand use an electronic ring. The amount of ring rotation is detected by an optical sensor, and the focus group is driven by the actuator during manual focusing as well.

The ideal aimed for does not change. That ideal is that the photographer can control the focus as desired. However, this "as desired" is diversifying. It was a logical decision that the RF lenses use a different approach from the EF lenses in order to expand the user's choices.

So, what are the advantages of the electronic ring? It significantly improves the degree of freedom as a system. Let’s take operability for example. With the L lenses, there is a fundamental idea that you can adjust the focus from the closest point to infinity by rotating the focus ring by approximately 90 degrees. That is why even if the lens is exchanged, it can be used without hesitation, but in the case of the mechanical coupling type, it was also a factor limiting the rotation amount of the focus cam.

The electronic ring does not have this limitation. According to the weight of the focus group and the stroke amount, it is possible to set the optimum focus cam rotation amount. In the case of the RF50mm F1.2 L USM, the focus cam actually rotates by 130 degrees or more with respect to the operation amount (about 90 degrees) of the focus ring. This is a good example of optimizing mechanical design without changing the operability for existing users.

Although it is a logical electronic ring, there was also a problem in the utilization. With the electronic ring method, a sensor is required to detect the position of the focus group. Although the same sensor is included on the EF lenses, it

RF24-105mm F4 L IS USM: Dual Pixel CMOS AF + Nano USM (simulated)

could not necessarily be converted for the RF lenses as is. This is because some of the RF lenses have cam lead grooves many times longer than EF lenses. With the RF lenses, it was necessary to start by making the sensor and encoder compatible with the long stroke.

Mechanical designers started by designing the focus group's position detection system. In order to expand the stroke, it is necessary to fundamentally change the computation algorithm, and to design a new encoder configuration in order not to use the resolution for bartering. The actuator control program was optimized for each lens.

"No matter how we go over the optical design, it will be no good if we cannot focus on the objective. With the RF lenses, all the electronic elements are being renewed so that the focus unit can be stopped with high precision by any of the focus cams. This is the backbone and it can demonstrate high optical performance." (Tamura)

The electronic ring achieved this way also makes it possible to customize the operability. For example, the focus ring's sensitivity setting. Even with the same amount of rotation, we can handle the needs of each individual such as "I want to move the focus slowly," or "I want to catch the subject instantly." This will also expand the EOS concept of "fast and comfortable."

Improvement of movie compatibility for L lenses.

"Components are for producing the ideal lenses.
Even with proven components for example, if necessary, start over from the design.
Without this developmental stance, we could not have produced the lenses that did not exist up until now." —Koji Sato

The L lenses were originally developed with the premise of shooting still images, and have continued to evolve. The EOS R system on the other hand aims to deal with every kind of image input. I would like include one lens in the RF lens L series that would make me want to use it for movie shooting. That is how the RF24-105mm F4 L IS USM was planned.

I wanted to use Nano USM for the lens actuator. It is compact, but has a high lift. It is also extremely controllable and quiet, making it ideal for shooting movies.

However, there was one problem. For commonly used lenses only, we want to miniaturize as much as possible considering handling ability, but even with existing Nano USMs, the unit is too thick. Image quality priority RF lenses have large optics. To make it slimmer, through repeated trial and error the designers tried to reduce the thickness of the lens barrel and mechanical structure as much as possible.

How much can the outer diameter be slimmed, and how neat can the form be? The Nano USM has important keys to making it slimmer.

Nano USM transfers the vibrations generated by the piezoelectric ceramic element to the slider via a chip-shaped metal elastic body. The metal elastic body is thin and small enough to rest on your fingertip. However, it was difficult to reduce the size of the structure that supports it.

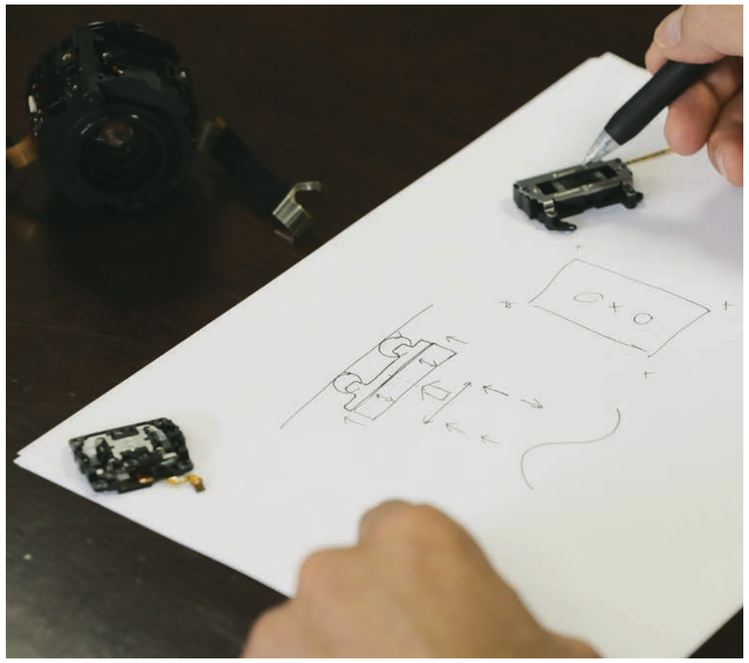
There is a reason for this. Movement of the metal elastic body is precise and microscopic. In order to generate a high lift, the two protrusions must be brought into pressure contact with the slider with good balance. The spring structure etc. used for that purpose was stacked, which made the unit thick.


Left: Conventional-type Nano USM
Right: New Nano USM

In the component design requested for the mechanical design, I thought about achieving the same principle with the new design philosophy. The great idea I had then was to eliminate the spring that pressed the piezoelectric ceramic element from the back side and place them at the four corners of the unit instead.

"This made it possible to dramatically reduce the thickness. This unit was developed for the lenses this time, but of course it can also be expanded to the EF lenses." (Sato)

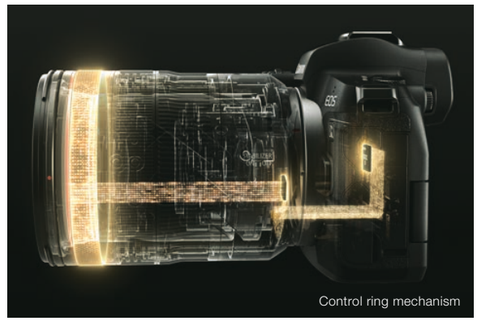
The new Nano USM fits within a small space of the focus unit, which contributes to making the RF24-105mm F4 L IS USM slimmer. RF lenses and EF lenses. The technological innovations of both will be assets, and Canon's lens development will continue to accelerate further.



The secret function of the RF mount. A high-speed network hub.

Image Communication Business Operations
ICB Optical Products Development Center Senior Engineer
Akihiro Kawanami

Image Communication Business Operations
ICB Optical Products Development Center Senior Engineer
Shinji Imada



Large capacity, high-speed communication based on future plans.

"The exchange of electronic information between the lens and the camera is expected to increase more and more in the future.
In order for the system to continue to develop, the RF mount makes a significant increase in communication speed possible." —Akihiro Kawanami

Reconstructing the communication system was also an important development theme of the EOS R system. A modern camera system that expands the power of expression and functions by linking lenses with the camera. It is Canon's mission to continue developing the system as its pioneer. Additionally, some of the developers wanted to strengthen the link between the lenses and the camera in order to achieve new functions and high image quality.

The RF mount is also a hub of such a network. One of the development themes was large capacity, high-speed communication that would be able to guarantee future development of the system.

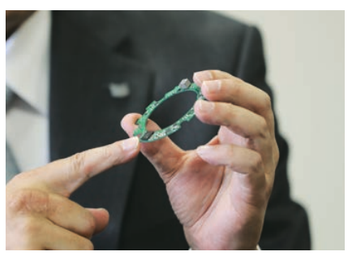
Future prospects for the world of images and the EOS R system will be needed for that purpose. If a unique lens, a zoom lens with ambitious specs is released, more optical information will be needed for autofocus and optical correction. There may be a need to "wanting to control the aperture more smoothly" when shooting movies, and it is also expected there will be an acceleration towards higher frame rates.

Increasing the communication speed between the camera and lens dramatically. This was Canon’s answer. The developers had never seen a camera system with such a high communication speed. However, instead of "today's high performance", in order to aim for "continuing the high performance even in the future," they estimated what the required specs would be.

With the EOS R system, in addition to the optical information, the lens also holds optical correction data including the Digital Lens Optimizer which was stored in the camera's memory before.

"The faster the communication speed, the more possible it is to send this data to the camera in a shorter time. In other words, the system can start up even faster after replacing the lens. In addition, it is possible to improve various functions such as image stabilization by coordinating the lenses and camera." (Kawanami)

The microprocessor included in the lens is the latest one developed by Canon. The processing capacity and the memory capacity are also significantly improved. Diversification of future needs, and the ability to deal with more sophisticated functions. This is also one aspect of the performance hidden in the RR mount.



New functions not found in the EOS system.

"There are several benefits of a new communication system such as the control ring and lens information display. However, I believe that high-speed communications have value for raising the basic qualities of cameras such as "Being able to capture the images you want."
—Shinji Imada

Due to the benefits of high-speed communication, the EOS R system was equipped with various new functions. An obvious example is the dramatically improved image stabilization function (IS: Image Stabilizer).

Optical image stabilization in the existing EOS system does not depend on control from the camera. With the EOS R system on the other hand, there is an advantage that subject information can be acquired at any time by the CMOS sensor and imaging processor, and camera shake can be detected. Using this, Combination IS is the lens and camera cooperating to enhance the correction effect.

With normal image stabilization, it detects camera shake with a sensor built into the lens. However, for extremely slow motion, the output of the sensor was weak, meaningful information could be mixed in with noise, and errors occurred.

Dual Sensing IS captures slight fluctuations with the camera's CMOS sensor and assists the control of the IS unit. Furthermore, when shooting movies, Combination IS, which combines optical image stabilization and electronic correction with the camera, is also available.

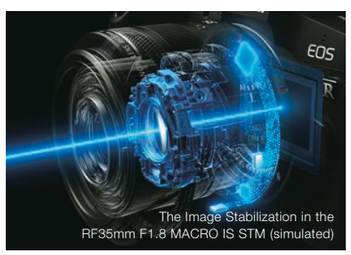
It is important that IS by the lens and the camera is performing optical image stabilization in two stages. First, the lens performs correction independently. The camera detects blurring and error components that could not be corrected and sends feedback to the lens. It assists so the next correction will be highly accurate.

Even though it is correcting two times, the process is fast and nearly in real time. The speed of the camera's image processing is also important, but just the same, the communication speed between the lens and the camera is effective.

"It has been effective for low frequency shaking, which had been difficult for image stabilization. This is an example of the lens and camera exchanging information at high speeds and coordinating to enhance functions." (Imada)

In the first group of RF lenses, the same processing is carried out with two lenses, the RF24-105mm F4 L IS USM standard zoom lens and RF35mm F1.8 MACRO IS USM wide-angle macro lens.

Functions that are no longer legacy for Canon will be further developed and contribute to expanding the range of shooting. The renewed communication system is the backbone.



The Image Stabilization in the RF35mm F1.8 MACRO IS STM (simulated)

RF lens lineup

RF50mm F1.2 L USM

A maximum aperture F1.2 large aperture standard lens. By taking advantage of the characteristics of the RF mount, it takes a different approach from the Gauss type, achieving high image quality that far surpasses existing models.

With the mechanical design, in order to deal with a focus group that has some mass, a focus group retention mechanism was newly developed. Simulations, prototypes, and evaluation tests were repeated to achieve vibration resistance, impact resistance, and durability equivalent to the EF lens L series.

"Due to the advances in optical design and mechanical design, the minimum focusing distance has also been shortened. The EF50mm f/1.2L USM was 0.45 m with a maximum shooting magnification of 0.15x, whereas with this lens it is possible to shoot up to 0.40 m, 0.19x. In addition, a focus range selector is also included. This lens is a compilation of Canon's technologies that combines the breadth of expression and "fast and comfortable." (Tamura)

Speaking of portrait lenses that made use of natural light, 85mm has been the standard up until now. However, one step further, and you want to get closer to the subject and aim with a 50mm. The rendering power that will make you think so is hidden in this lens.

RF28-70mm F2 L USM

Canon's first maximum F2 constant aperture large aperture standard zoom lens. Utilizing the advantages of the large aperture mount and short back focus, it achieves high image quality in all zoom positions across the entire image.

“The EF24-70mm f/2.8L II USM has been highly evaluated with excellent image quality. In comparison, high resolution and high contrast equal to or better than when shooting at maximum F2. If you stop down to F2.8, higher image quality can be obtained. In theory, one size in terms of print size, in other words, the resolution equivalent to that obtained until now when printing with A3 size, even if it is enlarged to A2 size, it is an image with a resolution to spare”. (Sugita)

Focus is inner focus, a two group zoom. Although it has an orthodox configuration, it uses a newly developed focus group retention mechanism, and in the mechanical design careful attention was made, and proprietary technology is included. In addition, we placed emphasis on the "feel" of the focus ring and zoom ring desired for the L lenses. Furthermore, when a force greater than a certain level is applied from the front, the lens barrel also has a shock absorbing mechanism (a damper mechanism) that retracts to the rear, achieving excellent impact resistance, toughness, and durability.

At one time, a standard zoom lens with large aperture and high image quality was beyond the limits of optical design. With the RF mount, the dream has become a reality.

RF24-105mm F4 L IS USM

It is a standard zoom lens which includes Nano USM for the first time for an L lens and pursues compatibility with high-speed AF and movie shooting.

By making full use of the features of the RF mount, the overall length is shortened by about 11 mm, while the image quality is equal to or higher than the EF24-105mm f/4L IS II USM. Even with the mechanical design, the lens barrel and mechanical structure are completely thinned down, and the finished product is a slim and easy to handle lens.

"In terms of specs, the overall length is only shortened by 11 mm. However, the flange back of the EOS R camera is 24 mm shorter than the EOS cameras. I would like users to pick it up in the state with the lens attached to the camera, not the lens by itself. It is smaller than you think, and it should be easier to handle.” (Maetaki)

While achieving both high image quality and compactness, it also achieves the toughness and durability suited to an L lens. The image stabilization affect is 5 steps* slower in terms of shutter speed. As a Canon lens, it demonstrates the maximum correction effect, covering a wide range of scenes and shooting conditions with just one lens. It is a normal zoom lens with a high level of completion.

* CIPA standard. 105mm, when attached to the EOS R camera.

RF35mm F1.8 MACRO IS STM

This is a large aperture, wide-angle macro lens with a focal length suitable for snapshots. By utilizing the features of the RF mount, demerits of the retro focus type are minimized. It achieves the brightness of maximum F1.8 as well as compactness and weight saving.

The maximum shooting magnification is 0.5x. At this time, the exposure magnifying factor is one stop, but if it is the large aperture of the maximum F1.8, the effective F value of F2.4 can be obtained. A lens capable of macro shooting with such brightness is unparalleled even for Canon.

The front lens diameter is smaller than a 35mm EF lens, but by placing a lens with a large diameter in the rear lens group, it corresponds to the large light rays of the maximum F1.8 and the wide focal plane of a 35mm full-frame. Peripheral image quality of both normal shooting and macro shooting is improved. The focus group is nine elements, with front focus. Focus, aperture and the IS drive system are integrated into one unit.

"In order to achieve high image quality and macro shooting, the weight of the focus group and the stroke length are both largest of their class at Canon as an STM driven lens. It can be conceptualized as if another lens in the focus cam is moving. Still, in order to achieve "fast and comfortable," mechanical measures such as reducing weight of the focus group are repeated." (Inoue)

The image stabilization effect is the maximum of 5 stops* (in terms of shutter speed) as a Canon lens. Hybrid IS with a proven track record is included on the EF 100mm f/2.8L Macro IS USM etc., and angle camera shake and shift camera shake are simultaneously corrected during macro shooting. It has complete specifications suitable for a normal single focal length lens.

* CIPA standard. 35mm, when attached to the EOS R camera.

Mechanical Design

Doing our best for the users. Mechanical design of the EOS R.

Image Communication Business Operations
ICB Products Development Center Lead Engineer/Architect
Kazuaki Yamana

The harmony of tradition and innovation.

"The EOS R is a camera based on a new concept.
However, the tradition of the EOS system that has pursued user benefits for more than 30 years is a background factor.
The assets are fully utilized, in pursuit of a degree of completeness that is not expressed in the specifications."

—Kazuaki Yamana

Benefits for the users, and the future of the system. The EOS R was developed with pursuit of an optimal balance of these. You can catch a glimpse of the care taken in the mount part.

The flange back of the EOS R is 20 mm. Although it is possible to shorten it further, there are two reasons for the 20 mm.

One is the strength of the mount. Honestly, it was possible to shorten the flange back and make it compact as a system, but it would not be beneficial for the users to decrease the strength for that reason. The important thing is that they can freely use the lens they want to use with confidence. For the users, this was a point that we could not compromise.

One more thing is the communication reliability of the electronic contacts. The RF mount has a 12-pin electronic contact. When aligned on the same surface, it can help contribute to making a smaller camera body, but the contact points between the camera and the lens excessively rub against each other each time the lens is attached and detached, and the risk of wear and foreign objects getting inside increases. Therefore, the engineers cleared this problem by separating the height of the contacts into two levels. "If the contacts are separated and arranged on each surface, the number of times they rub against together is also reduced. Due to this structure, although the flange back extends, it make a difference in reliability which cannot be compromised if the benefit to users is taken into consideration." (Yamana)

The utmost attention was paid to heat dissipation. Compared to the EOS 5D Mark IV, the imaging processor has significantly improved performance, but due to the benefits such as miniaturizing the semiconductor process, the heating value itself is equal or even less. However, as there is no mirror box, it is not as bulky as an SLR camera. More elaborate measures were needed for heat dissipation.

Therefore, with the EOS R we decided to use magnesium alloy not only for the exterior, but also for the body. Magnesium alloy excels at heat dissipation, and it is an ideal material for a heat sink. This effect has been demonstrated on the EOS-1D X Mark II with the same magnesium alloy body.

The heat generated by the imaging processor etc. is distributed efficiently within the camera through this body, and escapes to the outside through the exterior. It is a tough body that "Even when shooting movies for long periods, it will not shut down easily". (Yamana)

The viewfinder was designed by the same Optical Products Development Center that design RF lenses. A 0.5-type, high-resolution, highly responsive organic EL panel with approx. 3.69-million dots is used.

What the designers placed emphasis on with the viewfinder optics was "visibility". It seems that there was blurring and distortion when the eye moves away from the optical axis, or when looking at the periphery of the screen, and this was disappointing. The designers did not only focus on improving the specs, but more on actual benefits to the end-users.

The viewfinder unit of the EOS R is actually laid out to be offset to the back side of the camera, and the lens is brought as close as possible to the inner side of the exterior.

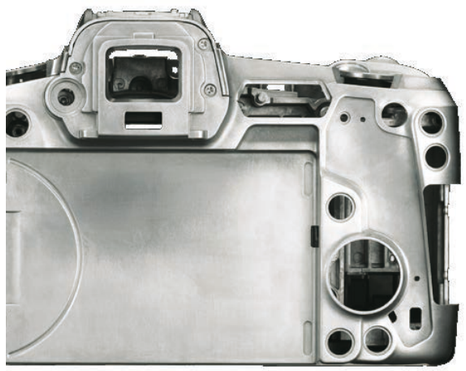
When holding the camera, you can see that the eyepiece lens sticks out beyond the back of the LCD monitor, and the rearmost lens is arranged to be close to your eye. This technique is made possible as it is an electronic viewfinder. Because of this, the actual eyepoint is extended to the back.

Viewing is easy while wearing glasses, and there is less chance of your nose touching the monitor.

Furthermore, an aspherical lens is used for the optical system, and it achieves a clear and sharp field of view. Because every corner of the field of view is clear, it takes advantage of the electronic viewfinder with its large amount of information.

The user faces the subject through the viewfinder. The EOS R lets you know that if you have agreeable "visibility", you will be more focused on the subject, and you can immerse yourself in creating.

Optics in Electronic View Finder



The only technology that can tell the future of high image quality and AF performance.

Image Communication Business Operations
ICB R&D Center 1 Lead Engineer/Architect
Hideyuki Hamano

The true ability of Dual Pixel CMOS AF.

"To demonstrate a high level of focus accuracy at maximum aperture f/1.2, and deal with the darkness of EV-6 is difficult even with the phase-difference detection AF of the EOS system.
It is no exaggeration to say that Dual Pixel CMOS AF that made this possible goes beyond Canon's ideal of "Autofocus approaching the naked eye". —Hideyuki Hamano

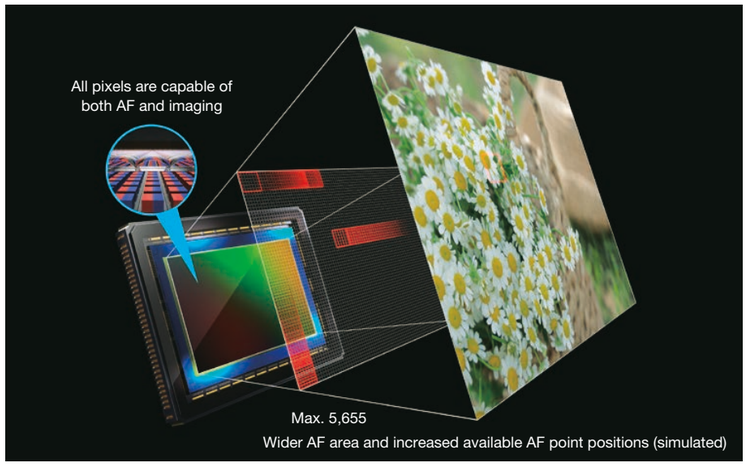
Expansion of AF area and more AF points. The EOS R maintains a vast AF area that you could say is virtually the entire screen in practical use, approximately 88% horizontal by 100% vertical of the screen*. It is not just a matter of simply expanding the AF area and increasing the number of AF points. The processing performance of each AF point is also improved.

The amount of information processed by the imaging processor for autofocus far surpasses the EOS 5D Mark IV (during Live View shooting). This large amount of data was needed to support scenes where conventional phase-difference detection AF has had difficulty. It detects the focus state of the subject accurately even when it is extremely blurred. Even in dark situations, or with subjects with low contrast, it achieves a high level of focus accuracy. To this end, various processing methods not included in the existing Dual Pixel CMOS AF are incorporated into the algorithm.

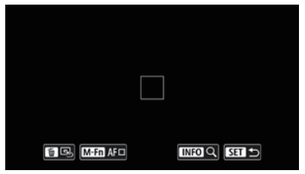
"Existing EOS cameras receive two types of different data for autofocus from the lens; one for viewfinder shooting and the other for Dual Pixel CMOS AF. On the other hand, with the RF lenses, which does not require data for optical view finder shooting, Dual Pixel CMOS AF can be increased in place of the data for viewfinder shooting that became unnecessary. The imaging processor and AF algorithm were advanced with consideration for using up this rich data. The worse the conditions are, the more you can experience the merits of the EOS R." (Hamano)

Thanks to this, even with scenes that are dark and difficult to focus manually and low-contrast subjects that are difficult to see with the naked eye, it is easier to focus more reliably than ever. The EOS R's Dual Pixel CMOS AF enables autofocus shooting even in scenes where shooting was difficult even with the phase-difference detection AF of EOS, which has been improved over time.

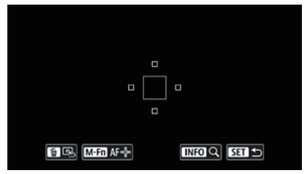
* Using an RF lens, or current EF lens.



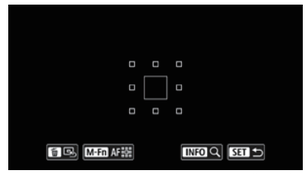
AF methods and customization of Servo AF



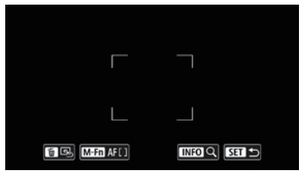
Single-point AF



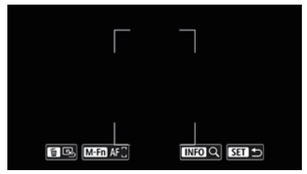
AF point expansion (4 points)



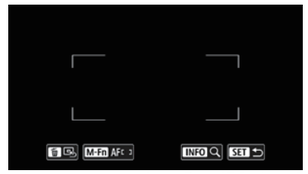
AF point expansion (8 points)



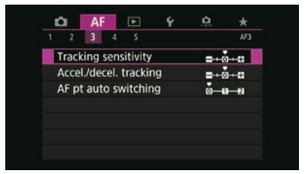
Zone AF



Large Zone AF (vertical)



Large Zone AF (horizontal)



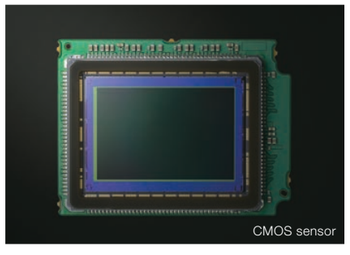
EOS R equips numerous AF methods and customizing functions for Servo AF. These AF functions help ensure high performance in various shooting scenes and situations. Also, the menus and settings are designed so that current EOS users can enjoy shooting through the view finder with comfort.

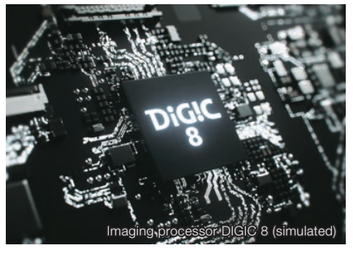
One of the outstanding qualities of the Dual Pixel CMOS AF is focal plane phase-difference AF that does not affect image quality at all. The development of technology that is capable of this took a long time even with Canon's highly advanced expertise in this field. Since the basic theory was established in 1999, the technology was only put into practice in 2013 with the introduction of the first APS-C camera with this autofocus mechanism. Further development effort was necessary to apply this for 35mm full-frame cameras, and it was finally achieved in 2016.

However, the enormous time spent on the development was worth it. From the start at Canon, the engineers were aware that this technology was essential for the future development of the mirrorless cameras as they we focused on the development of Dual Pixel CMOS AF. The EOS R can be said to be the first camera that draws out this characteristic without compromise.

In the method common to current mirrorless cameras where "certain pixels are dedicated for autofocus and arranged separately from the imaging pixels," there is a limit to increasing the number of AF points. If you increase the number of AF points excessively, there will be an undeniable impact on image quality. If there were no Dual Pixel CMOS AF, there might have never been a development of the EOS R system by Canon.

Improvement of autofocus performance and image quality. The EOS R system which can guarantee future development potential is the crystallization of Canon's foresight and development efforts over many years.


CMOS sensor



Imaging processor DIGIC 8 (simulated)

Making the most of RF lenses' maximum potential by Image Processing

Image Communication Business Operations
ICB R&D Center 2 Lead Engineer/Architect
Takashi Akahane

High image quality that was only made possible by the RF mount.

"On the premise of the RF lens's outstanding optical performance, with the EOS R camera, we implemented image creation that can express subtle photographic expression by maximizing DIGIC 8 performance.
Even the trees in a distant view are subtly rendered naturally as if to resolve individual leaves.
Extremely realistic images can be obtained." —Takashi Akahane

EOS R image creation. The premise of this was the outstanding optical performance of the RF lenses and Digital Lens Optimizer.

Digital Lens Optimizer is proprietary a technology that Canon is well known for, that corrects various aberrations, diffraction phenomena, and image deterioration caused by the low pass filter due to the optical characteristics of the lens. Just by performing processing based on a large amount of optical data, on the EOS cameras up until now, the initial setting was set to [Disable] to prevent the continuous shooting speed from being affected.

The EOS R, on the other hand, equips the new mount communication system. The new communication system allows the camera to receive Digital Lens Optimizer data from the lens instantly, and lets the camera to start operating after changing the lens. The camera is also equipped with the newly developed DIGIC 8 imaging processor. Development of the imaging processor is carried out over a span of several years, however, Canon has been promoting the creation of a new imaging processor aimed at processing the Digital Lens Optimizer in-camera and during shooting as soon as possible. Those efforts were a success, with the EOS R achieving an initial setting of [Enable] for the Digital Lens Optimizer.

With Servo AF, advanced optical correction is possible while shooting without decreasing the continuous shooting speed.

Furthermore, in addition to the optical performance of the RF lenses, the EOS R's CMOS sensor is a high resolution of approximately 30.3 megapixels. With image quality design, to take maximum advantage of these merits, we decided to emphasize performance of rendering the details.

"On the premise of RF lens characteristics and Digital Lens Optimizer, the EOS R changes the initial sharpness value from that of the EOS 5D Mark IV. As a result, this makes even more subtle rendering possible." (Akahane)

Results can of course be obtained when using EF lenses as well. People's hair, and leaves on trees, etc. If you enlarge the images, you will notice that the outlines are thin and detailed, and the rendering is natural.

Image quality of EOS MOVIE as well has been improved. As the output resolution of movies is standardized, it is not easy to increase the image clarity. However, this is why the lens's characteristics dramatically affect the appearance. Movies shot using an RF lens are exceptional.

"The EOS R also performs precise sharpness processing for movies that is equivalent to that of still images. In addition, the powerful performance of the imaging processor and the rich optical data loaded on the lens are utilized, and distortion aberration correction is achieved." (Akahane)

Even at the same 4K, the impression of the images can differ dramatically according to the system. Developers of the EOS R system are hoping that this system is also used for high-end video production such as for the cinema.

Among the first 4 RF lenses, the RF50mm F1.2 L USM and RF28-70mm F2 L USM are designed to offer high image quality without compromise. The image processing of the EOS R camera are developed to maximize the lenses' potential.

A new operation experience, letting you “immerse yourself” in shooting.

Image Communication Business Operations
ICB R&D Center 2 Lead Engineer/Architect
Koji Yoshida

Everything you want is completed in the viewfinder.

“With the EOS R, you can consistently perform everything from shooting preparation, to shooting, playback and checking, while looking through the viewfinder.
By taking advantage of these merits, we wanted to achieve a sense of immersion, as well as flexible and intuitive operability that could not be obtained with an SLR camera. —Koji Yoshida

Being able to concentrate on subjects and be immersed in creative activities without looking away from the viewfinder. That is the operability that was emphasized in the user interface development of the EOS R.

To be sure, there is no delay with an optical viewfinder. If you have an EOS camera with a clear field of view, you can concentrate more on shooting. However, since most settings are performed while looking at the buttons on the body or the LCD monitor, it has not been possible to complete a series of shooting preparations while concentrating on the subject, and to provide "a sense of immersion for creative activities" as a result.

The EOS R on the other hand is a mirrorless camera. The viewfinder is high-resolution, has great visibility, and is also excellent at transmitting information. It is an accomplishment because the EOS R which is a mirrorless camera can seamlessly perform all the processes in the viewfinder from shooting preparation, to exposure and white balance can be confirmed, then shooting as is, and even playback.

With the EOS R user interface, developers wanted to make full use of the advantages unique to mirrorless cameras. If creative activities can be completed within just the viewfinder, you can immerse yourself more in the image expression. You can enjoy new shooting experiences and expressions.

For this reason, it is not enough to just transplant the controls of the SLR camera as is. Compared to the EOS 5D Mark IV etc., there are limitations to what controls could be included on the compact EOS R. The developers decided to try out a new user interface.

Integration of the Mode Dial and Quick Control Dial. There were two logical reasons for this.

One is to pursue the operability of "remain looking through the viewfinder" and "remain concentrated on the subject." For that purpose, it is logical to change the mode freely within the viewfinder angle of view, rather than physically operating the Mode Dial.

Another reason is to make movie expression easier to enjoy. The EOS R which is a mirrorless camera can shoot movies while looking through the viewfinder, as well as still images. Being able to enjoy the two expressions with the same operability is a benefit. However, there are many users who change the shooting mode and various function settings for still images and movies. Despite being able to start shooting movies right away with the REC button, it is annoying to redo all the settings every time.

"With the EOS R, we chose to make the interface so that it can store the settings for stills and movies separately. Furthermore, it has the Custom Shooting mode where users can register their preferred settings for stills and movies individually.” (Yoshida)

The mode can be confirmed on the dot matrix display panel on the top of the camera even when the power is turned off as well.

Eliminating the dedicated Mode Dial made it possible to operate the shooting modes flexibly. Regular users of EOS cameras of course, and users who use a serious SLR camera for the first time should also be able to experience ease of use.

Of the new controls, the one that will probably catch your eye is the multifunction bar included on the back of the camera. One control corresponds to three operations, slide and left/right tap. By assigning different functions to each operation, it is possible to make multiple settings quickly.

Unlike customization up until now which only assigned one function to one control, you can set multiple settings with small space and small finger movements, so it is ideal to operate while looking through the viewfinder.

Multi-function bar

However, there is a risk that your finger will inadvertently touch and change a setting. How can you make use of only the advantages of these controls?

Canon has proprietary data on the "hand size" of people from around the world. Developers selected users with large, small, and typical hand sizes, and tested repeatedly.
"It was mainly on the right side of the bar that fingers easily touched inadvertently. So, make it so it does not react until you press and hold the left side of the bar. By making this as the initial setting, it is now possible to prevent erroneous operation." (Yoshida)

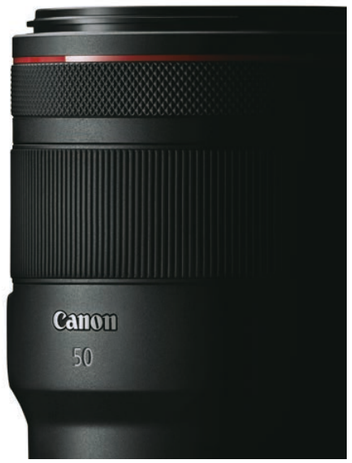
This achieves a balance between the convenience of the bar, and the sense of reassurance that you can shoot with the settings you intended at any time. Together with the control ring on RF lenses, customizability has improved dramatically. Even with limited controls, outstanding operability is achieved.

Viewfinder

The "Mount Core” design philosophy announces the new EOS.

Design Center Lead Analyst/Specialist
Seishiro Takano

Design Center
Yasuaki Matsuura



Pursuit of innovativeness and universality.

"Unifying the design language of cameras and lenses.
Achieving an even more powerful universal shape.
The design of the EOS R system was the job of creating a new "shape standard."
—Seishiro Takano

Creating a new icon.

"There is now no need take your eyes off the viewfinder.
To encourage this kind of operation, we made use of various shaping techniques.
Experience the next generation of ergonomics."
—Yasuaki Matsuura

Approximately 30 years since its introduction, the EOS system has come to embody a different design language, even though the cameras, lenses, and accessories have concepts in common. You could say that the individual histories, which have been optimized for each function, gave birth to its appearance. However, from now on we would like to place emphasis on the appearance of the overall system.

The EOS R system development project was a good opportunity to tackle this theme. The product designers began discussions early, even before the specifications were decided.

A feature of the new system is the mount. The mount is the core of the camera system and is a symbol of the future and reliability. Would we be able to put that presence into a strong message?

With that, the product designers thought about a design that would be common to the cameras and lenses, and each of the mounts. A high-quality metal cylinder is used around the circumference of the mount. It projects an image that ties in precisely and firmly, and appeals innovation and universality as a system.

The individuality unique to the EOS R system, "Mount Core design", was thus created.

RF lenses are designed to envision the beauty of light convergence.

Furthermore, in pursuit of a more aesthetic exterior design suited for products that users typically keep using for a long time, product designers and mechanical engineers had close communication. The notions on the lens barrels were brushed up in different ways than was the case with the EF lenses. The legibility of information was improved by organizing the notation, such as eliminating the unit of focal length (mm). Using ink as well, consideration is made for differentiation. Since it is simple, it has attention to detail, for a reliable construction. As a result, we aimed for a design that tells a brief description of the identity as optical equipment.

"Compared to EF lenses, the differences should be easy to see. The design philosophy of EF lenses include a lot of lines and notions on the lens barrel. In contrast, RF lenses express powerfulness and ease of use by eliminating unnecessary elements." (Takano)

On the other hand, there are some products that make the optical design convenient. An example is the RF28-70mm F2 L USM. Although it is extremely ambitious and has attractive specs as a photographic lens, the size of the front lens undeniable.

Therefore, the designers ventured to incorporate its optical conditions into the design and gave thought to combining the design and function. The identification of each ring of zoom, focus, and control is expressed by the ring diameter and optimized knurling respectively. The intuitive operation feeling of operating while looking through the viewfinder, and the distinguished appearance as an optical device are both made possible.

The RF lens also conveys refinement, ruggedness, and universality in shaping. A "legendary lens" that attracts users throughout the generations may be born from such consideration.

Front view of the simple and impressive EOS R. The shape of the flat shoulders gradually lowering with the viewfinder part as the top silently insists that this camera is "a device for shooting while looking through the viewfinder."

Regarding the top cover of the camera, it has long been meaningful as "a stage for 'placing' and 'showing' controls." However, with the EOS R, it is possible to complete all the creative processes without looking away from the viewfinder. The product designers are venturing to convey the idea of a new camera different from existing ones by daring to make the top cover with an almost flat, slanted style.

To achieve this appearance, it was laid out so that the dial is embedded in the top cover. Buttons are also designed to fit in with the cover. Still, subtly changing the shape and texture of the buttons so they can be identified simply by feeling with your fingertips gives it the feel of an EOS.

The viewfinder part flows from the front side to converge at the eyepiece part, and the design leading to the eyepiece is new. It clearly expresses that light can be delivered directly to your eye without going through a mirror or a pentaprism.

The essence of photographs is looking at light, and this does not change even with mirrorless cameras. That "flow of light" was expressed by designers with a minimalistic shape.

The designers also placed emphasis on the grip.

In general, the ideal grip on an SLR camera has a shape that can be gripped firmly. Canon, however, does not believe that this is the real goal. This is because your fingers are also required to hold the camera, move around freely, and perform various operations at the same time.

In particular, the EOS R is equipped with a multifunction bar. Finger freedom was important for encouraging positive mastery of the camera.

"Dozens of mock-ups were made, and we verified the ease of grip and operability. The grip is compact, with a finger-friendly shape. However, by smoothing the shape of the front side which regulates the finger positions, we devised it so your fingers can move freely on the back of the camera. “(Matsuura)

The mechanical designers also understand the commitment of the designers, and this is reflected in the design. The battery holder was arranged diagonally so that the battery can be stored in the grip with the best shape. The power switch and Quick Control Dial are trapezoidal shapes that are narrower towards the top so that the finger fits the side of the dial. Consideration for users is concentrated in the compact body.

The advanced, iconic EOS R appearance. It is also a strong message from the product designers and mechanical designers, "We want you to enjoy the new shooting experience."

The EOS R system and RF mount bring you the future that keeps you excited.

Image Communication Business Operations
ICB Products Group Group Executive
Yoshiyuki Mizoguchi

"As the first products of the EOS R system, we will introduce the EOS R camera and four RF lenses with specs that did not exist before. Specs that did not exist before means that you can create images that could not be captured before. In addition, the EOS R camera has achieved compactness and light weight while pursuing "Fast - Comfortable - High image quality." This also means that the range of activities of the camera will be expanded, which should essentially contribute to expanding the range of shooting. That is the value that Canon strive to offer, and the reason for establishing a new system. I am proud to say that we were able to get that message across clearly with this camera and the series of lenses.
However, that is not the goal of the EOS R system development project. It should continue to be developed for years, and decades from now.
How the new system will develop will depend on the needs of the users. However, there is no question that high image quality rendering will be obtained with even more compact systems than ever before.
In addition, Canon has a mission to contribute not only to people with photography as a hobby, but also to more industry specialists through images. With the EOS R system and RF lens, it can support even higher resolution CMOS sensors and various applications. As an example, large drones are required for 8K aerial photography, but they could also be made smaller. As a consumer product, and as a commercial equipment, it has great potential. Look forward to the EOS R cameras and RF lenses in the future."

A new system created from the developers' passion.

Image Communication Business Operations
ICB Optical Business Group Group Executive
Naoya Kaneda

“When I saw the RF50mm F1.2 L USM and the RF28-70mm F2 L USM for the first time, I thought "These are lenses that really make me feel like shooting photos." Since the EF lenses also have large aperture lenses of the same brightness, I thought I knew what to expect in terms of the depth of field. However, when looking through the electronic viewfinder, the depth of field was shallower, and the background blur effects were richer than I had expected. What matters to professionals and advanced amateurs is that you can express yourself as you imagine, and that you can obtain final results that differ from other people’s. In fact, I have been involved in the development of the EOS system for a long time, and the fact that a system capable of this is right in front of us fills my heart with pride.
As an interesting aside, what impressed me with this project is an incident at a meeting to make a final decision on commercialization. Dozens of related engineers and personnel including the development departments of optics, mechanical, production, and electronics, as well as the production department, quality assurance department, and product planning department, gathered to clear up any final concerns or issues. When we finally concluded that "There is no problem with this," all of the attendees naturally broke into a round of applause. Although I have had the same kind of meetings countless times in my decades career at Canon, this was the first time that this happened. Because the developers knew the significance and the weight of developing a new system, concentrating on development and not compromising, they applauded themselves. I felt proud of the developers.
The EOS R system contains the passion of the developers that are behind it. I can hardly wait for the day when it will be in the hands of the users."

Canon