

# U.S. TELEVISION INDUSTRY AND THE 8K AGENDA



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## ABSTRACT

*Development of what has become the 8K UHD broadcasting television standard began in the mid-1990s, with the ensuing decade largely preoccupied with psychophysical research that ultimately produced the technical parameters underlying this system. Canon collaborated with the NHK laboratories in optical R&D that ultimately produced a series of lenses supporting a variety of their early 8K UHD camera developments. Since 2005 Canon has produced some five prototype 8K lenses.*

*Meanwhile, in 2012 the ITU published their Recommendation ITU-R BT.2020 which reflected the global consensus on parameter values for 4K UHD and 8K UHD production and international program exchange. 25 years following these developments a satellite 8K UHD television service has been launched in Japan, and other Asian countries appear likely to follow in the near future.*

*The aforementioned time frame is important because during this same period Canon had decided to enter the global digital cinematography market. The Cinema EOS system made its formal debut in Hollywood in September 2011 – a system that rolled out worldwide during the ensuing years in the form of a family of Super 35mm digital cameras (both HD and 4K) and high-performance 4K Super 35mm zoom lenses, and a family of 4K full frame 35mm prime lenses. The deep R&D optical technologies and strategies developed by Canon for their prototype range of 8K lenses became the underpinnings of the parallel high performance 4K Super 35mm optical agenda of the Cinema EOS system.*

*In November 2019 Canon announced two 8K UHD lenses as their first products in the global marketplace. A portable wide-angle lens 7x10.7 KAS S, and the world's first long zoom 8K UHD box field lens SP51x15.5B IESD-S, have already started deliveries to some of Japan's broadcasters. And, by now, some five camera manufacturers are delivering 8K UHD camera systems – both Super 35mm and 1.25-inch – in anticipation of coverage of a major sporting event in Japan that had been planned for the summer of 2020.*

## INTRODUCTION

In some sense, television in the United States has been in turmoil over the past decades. The transition to digital in the 1980/90s was followed by a quite protracted transition to HDTV that began in the late 1990s and still continues to this day. The somewhat messy separation into two camps of 1080i and 720P formats for HDTV over the air transmission now seems to be converging on 1080P at the production level. The limitations of the terrestrial transmission system designed for broadcast delivery of HDTV were soon exposed in the new era of multiple delivery services, and a recent gargantuan development effort on a totally new standard ATSC 3.0 has finally produced an advanced delivery system having far greater flexibilities.

With the national transition to HDTV in the U.S still not quite complete, 4K UHD has surfaced – although so far only at the production level for high-end episodic television production and for moviemaking. High Dynamic Range (HDR) and Wide Color Gamut (WCG) more recently came on the scene to challenge the long dominance of spatial resolution considerations in television’s march to the future. Broadcasters, cable and satellite operators are all, to one degree or another, presently engaged in experimental shooting in 4K UHD. However, other than satellite broadcaster DirecTV – none have yet made any moves to update their infrastructures in anticipation of 4K delivery services. Meanwhile, terrestrial broadcasters are wrestling with the highly complex implications of adopting the newly standardized ATSC 3.0 transmission system – a challenge fraught with some unknowns.

It is with all this as background that 8K UHD now looms over the global television world. A massive development project initiated by NHK in 1995 has evolved into their highly focused agenda that started satellite broadcasting of 8K UHD in Japan last December 2018, and is marching toward a flanking terrestrial 8K UHD service around year 2025. In the U.S., on the other hand, there is little interest among broadcasters in undertaking development of 8K UHD services at this time. While this does not eliminate such considerations in the future, it has been repeatedly stated by broadcasters, cable and satellite operators that no such plans are likely in the foreseeable future. Their collective near term priority is 1080P/HDR/WCG – a format formally identified as UHD by the ITU – followed, for some, by a move to 4K UHD.

Europe differs from the U.S. in having multiple public service broadcasters – who are largely funded by licence fees, various taxation systems, and, in some cases, direct government funding. This poses significant challenges when major financing is entailed for radical upgrading of television delivery services. It is for such reasons that European broadcasters, at various international broadcast conventions and conferences, have expressed low interest in considerations of any migration to 8K UHD. They too, are currently preoccupied with working toward some longer term 4K UHD world.

Canon is a global company – very invested in many aspects of digital imaging that immerses us in the broadcast industry (in all of its manifestations) and all levels of entertainment program production (television and moviemaking). The current status of 8K UHD – where it is squarely centred in Asia – demands high attention regardless of the low interest in the Americas and Europe. Fortunately, Canon Inc has been deeply involved in the paced developments of 8K UHD from the outset and is superbly poised to service the unfolding business related to the burgeoning 8K UHD services in Asia. Meanwhile, all of Canon Inc’s extensive investments in optical R&D for 8K are directly paying dividends in terms of the excellent performance 4K lenses we have today – both in the Super 35mm 4K Cinema EOS domain and in the 2/3-inch 4K BCTV lenses.

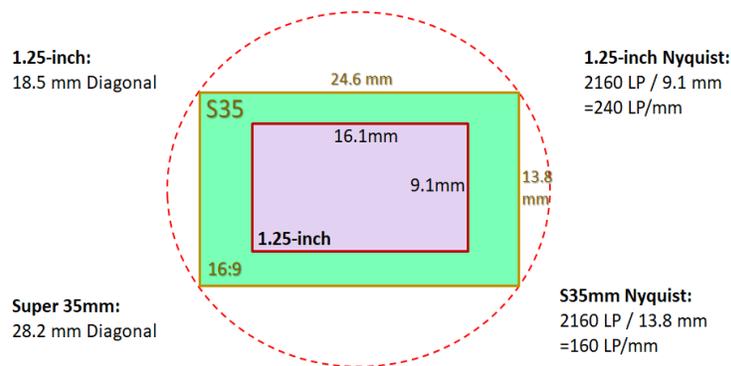
## 2.0 BACKGROUND

### 2.1 Quest for Ultra High Definition Television

The NHK Science & Technical Research Laboratories in Tokyo, Japan initiated research into a future Ultra High Definition Television system in 1995. In 2002, following an extensive R&D program, they demonstrated a working video system having 4000 scanning lines – which, in 2004, NHK termed Super HiVision (SHV). One of their early presentations on this emerging system was at IBC 2003 [1]. This system has today become known as 8K UHD on the global scene. Central to the advance of the overall system were some five generations of 8K UHD developmental cameras and lenses from various manufacturers – in pursuit of smaller sizes and higher overall performance levels that would credibly support live television broadcasting and high-end program production.

### 2.2 The Quest for an Image Format Size for 8K UHD Lenses and Cameras

Working with various camera and optical manufacturers, NHK developed preliminary developmental cameras and lenses that supported their initial deep investigations into the psychophysics of 8K imagery. Varieties of image format sizes (largely dependent on the sparse availability of the requisite high-resolution image sensors) were mobilized during those early years for trisensor. Some of the early cameras used a large 2.5-inch image format size [2]. This was followed by the first experimental live 8K television coverage of sporting events which proved critical to establishing an image format size that could deliver the requisite depth of field while also ensuring an individual image sensor photosite size that would sustain 8K MTF, adequate dynamic range, and Luma signal to noise. NHK finally established that a 1.25-inch image format size was an excellent balance among those imaging parameters in trisensor cameras for 8K UHD Live broadcast television [3]. NHK separately explored single sensor Super 35mm 8K UHD cameras and concluded this format was an important flanking system for more portable cameras, and for offering cinematic looks in television drama productions [4]. More recently, they explored full frame 35mm [5]. Today, available 8K lens-camera systems largely center around the two image format sizes shown in Figure 1. The 18.5mm image circle of the 1.25-inch format lies between the 29.6 mm image circle of Super35mm and the 11mm image circle of the traditional 2/3-inch 4K/HD broadcast television systems.



**Figure 1** Showing the Super35mm and the 1.25-inch image formats that underlie current 8K UHD systems

### 2.3 Canon Inc Undertakes 8K Lens Development in Support of NHK Research in 8K UHD

Canon’s initial involvement with 8K UHD started more than ten years ago with the development of two 8K lenses in support of the research on this highly advanced television system that was underway at the NHK Technical Research Labs. The 8K system has a 16 times higher resolution capability than 1080-line HD, which clearly set an unprecedented optical performance requirement for these lenses. The intense development effort required was believed to be a sound investment for the long term – especially as 4K was already looming on the digital cinema side – and the anticipated multiple optical advances would pay dividend in that arena.

The Super 35mm lenses and cameras support high-end television program production and help produce the cinematic look favored by most. On the live television side, a smaller format was favored – to help gain a reasonable depth of field when covering live sporting events – and here the 1.25-inch format emerged following considerable experimental live outside broadcast productions by NHK.

### 2.4 Canon’s Early 8K UHD Optical Developments

Following some years of optical R&D, Canon announced in 2009 their first 1.25-inch 8K Lens featuring a 10x zoom range for the NHK 8K SHV (then named Super Hi-Vision) system – the model number is 10x18BN shown in Figure 2. In 2014, Canon developed the second-generation 8K lens shown in Figure 2 that features a 7x zoom range – a more compact 1.25-inch lens intended for the portable 8K cameras that were now emerging from various manufacturers.



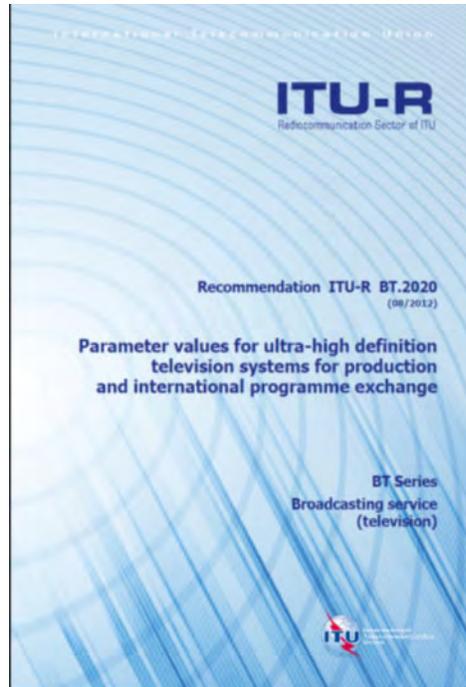
**2009    10x18BN    8K UHD  
1.25-inch**



**Figure 2**    *Some of the early developmental 8K lenses used to support R&D into the 8K UHD system*

## 2.5 International Standardization of 4K UHD and 8K UHD

Meanwhile in 2012 the international standardization body ITU produced a worldwide recommendation for both 4K UHD and for 8K UHD – the now well-known ITU-R BT.2020 [6]. This was widely seen as a long-term blueprint for the future of advanced television services. With attention at that time focused on expanding the transition from SDTV to HDTV, few regions of the world were contemplating offering 4K or 8K television services. Yet there was a strong international consensus that having a well-defined roadmap for the long term made sense. Technologies, business interest, competition – all would factor into the individual timing of each country’s move to 4K UHD, and ultimately down the road, to 8K UHD.



**Figure 3** *The international standard for 4K UHD and 8K UHD*

However, on the other side of the globe – especially in Japan, and more recently in China and Korea – there are vigorous activities underway to offer 8K UHD services. Called BS8K, the “Super Hi Vision” service by NHK began offering 12 hours of 8K Ultra HD content per day in December 2018. NHK also launched a second, sister channel called BS4K at the same time, which provides 18 hours of 4K Ultra HD content per day.

### 3.0 Current Status of 8K Camera Product Development

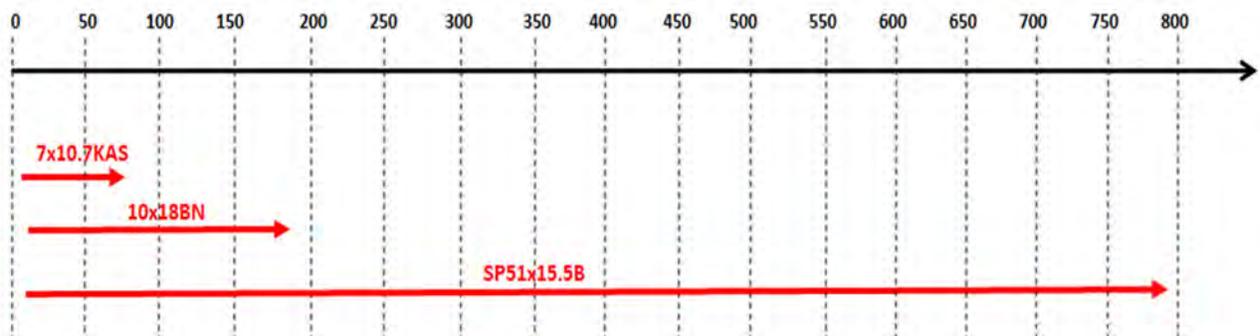
At this juncture (2020), the following table summarizes those manufacturers who have shown prototypes and early models of 8K cameras

<b>Super 35mm Cameras</b>	<b>1.25-inch Cameras</b>
<ul style="list-style-type: none"> <li>• Astro Design</li> <li>• Canon</li> <li>• Hitachi</li> <li>• Ikegami</li> <li>• Panavision</li> <li>• RED</li> <li>• Sharp</li> </ul>	<ul style="list-style-type: none"> <li>• FOR-A</li> <li>• Hitachi</li> <li>• Ikegami</li> <li>• Sony</li> </ul>

Separate to the 8K UHD broadcast television agenda – on the digital cinema side – RED has developed a large format 8K Camera whose model name is RED Monstro 8K VV, and they also offer the Super 35mm RED Helium 8K S35. Panavision has developed the 8K Millennium DXL2 cinematography camera.

### 3.1 Status of Canon Developments in 8K UHD 1.25-inch Lenses

By 2019, in anticipation of the formal launch of 8K UHD services in Japan and China, Canon had developed a total of three 8K UHD prototype lenses conforming to the 1.25inch image format – that were planned for deployed on various cameras during a major international sporting event this summer – see Figure 4.



**Figure 4** Two portable lenses and one long zoom box field lens have been developed by Canon

The two portable lenses are intended to offer wide-angle capabilities. The most significant innovation, however, is the third lens – SP51x15.5B – the world’s first long zoom 8K UHD field box lens having a zoom ratio of 51:1 – and it is shown in Figure 10. Its zoom ranges from 15.5mm to 790mm – a focal range having a 2/3-inch equivalence of 9.2mm to 470 mm. It has a 1.5x range extender that takes this to 705 mm.

### 3.2 Canon Announces 8K UHD Broadcast Lens Products

On Nov 6<sup>th</sup>, 2019 Canon formally announced the portable 7x10.7 KAS S and the UHD-DIGISUPER 51 (SP51x15.5B) as available 8K UHD lens products [7] – Figure 5. Considerable numbers of both products were to have been utilized at a major 2020 international sporting event. Figure 6 shows the UHD-DIGISUPER 51 lens mounted on the Sony three CMOS imager 8K camera – the UHC-8300 .



**Figure 5** Canon 8K UHD Field Box lens SP51x15.5 and the Portable 7x10.7 KAS S 8K UHD lens



**Figure 6** Canon 8K UHD 1.25-inch image format box field lens mounted on Sony UHC-8300 camera

## **4.0 WHERE DOES 8K UHD STAND ON THE WORLD SCENE ?**

### **4.1 Japan**

Japan is where 8K UHD was born and raised. The initiative was part of the longstanding agreement that the Japanese national broadcaster NHK would continue their agenda to continually expand the technologies underlying the world of broadcast television production and delivery services. Their leadership and technical contributions over the past fifty years are nothing short of legendary – exemplified by the prodigious R&D of their NHK technical Research Laboratories in Tokyo. They initiated the global movement in High Definition Television (HDTV) and followed this with their research into 4K and then 8K Ultra-High Definition (UHD) television. They were a central contributor to all of the decades-long international standardization work within the ITU and other standards-related organizations. They currently lead the world in driving a robust agenda for 8K UHD television broadcasting – that will gain a high visibility with their planned extensive 8K UHD coverage of the 2020 international sporting event.

### **4.2 China and Korea**

Over the past decade China has vigorously supported a planned transition to 8K UHD television broadcasting. They successfully realized 8K ultra-high-definition content transmission through 5G networks for the first time in June, 2019 -- the 8K UHD signals were transmitted from the headquarters of China Media Group in Beijing to display terminals at the venue of the Mobile World Congress 2019 in Shanghai.

### **4.3 United States**

In 2020 – some seven years after the standardization of 8K UHD, the United States has shown little interest in engaging in any preparations for 8K UHD delivery services. The newly standardized terrestrial broadcast standard ATSC 3.0 supports 4K and HDR/WCG and enhanced audio, as well as making it possible to watch broadcast video on mobile devices such as phones and tablets as well as in cars [8]. There is a vague reference to “future extensions” in the standard that might make 8K UHD possible sometime in the distant future. Broadcast networks, Station Groups, individual TV stations, cable and satellite operators are, however, currently preoccupied in searching for plausible approaches building out ATSC 3.0 future 4K services. However, there has been high interest in using some 8K cameras to support digital zooming (with 1080P extraction) at major sporting events.

Separately, on the digital cinema side, 8K has attracted considerable interest – with at least two manufacturers offering 8K cinematography cameras. This is expected to further advance.

### **4.4 Europe**

As in the U.S., the European broadcasters currently have no plans to initiate 8K UHD television broadcasting services. The European Broadcasting Union (EBU) in August 2019 published a document that sets guidelines for European television for the future [9] and it definitively does not include 8K UHD.

## 5.0 PARALLEL MOVEMENTS IN DIGITAL MOTION IMAGING

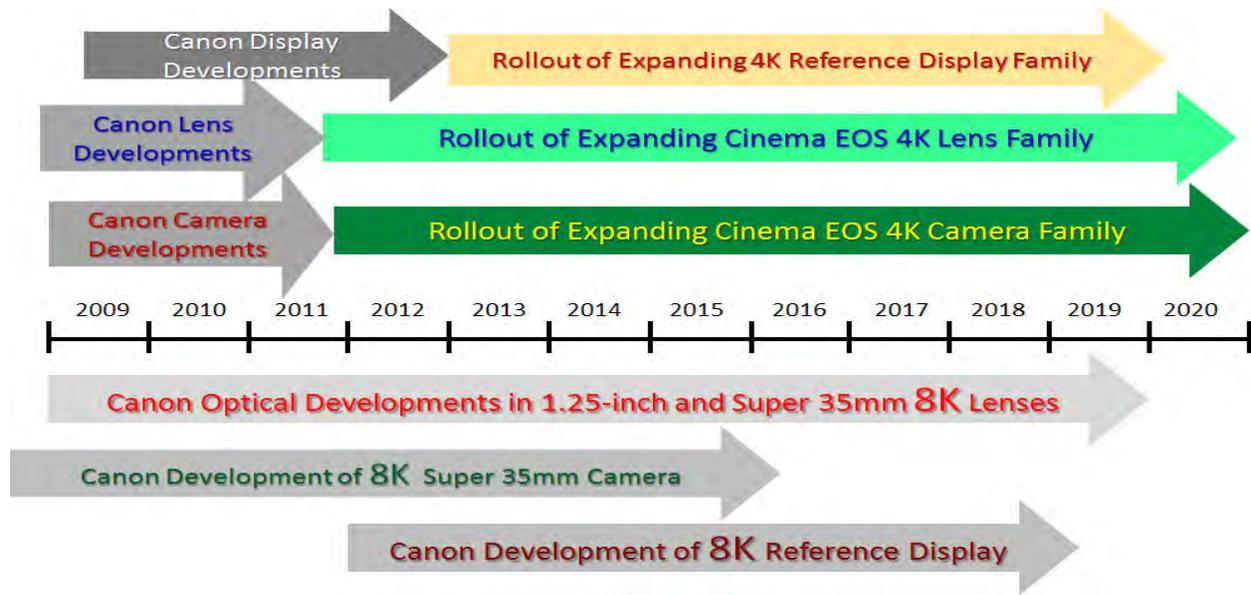
### 5.1 Canon Enters the Super 35mm Digital Cinematography Market

Canon introduced the Cinema EOS system in September 2011. The decision to enter the digital cinematography market was made on the basis that most related core technologies – optics, image sensors, video processors, recording, and display – had, over decades, been developed in-house and all had now reached a level of sophistication that would support a long term global cinematography business. The unique strategy adopted by Canon was the development of a family of Super 35mm-based digital cine cameras in concert with a broad range of cine zoom and prime lenses. The initial system introduction encompassed a family of 4K prime and zoom lenses and an emerging family of 4K and HD cameras. Separately, in 2012, Canon entered the 4K / HD reference display business as an extension to the Cinema EOS system. They would all constitute elements within the Cinema EOS system. Between 2011 and 2019 Canon broadened the Cinema EOS 4K camera product family – with the latest models originating in 6K – Figure 7.



**Figure 7** Showing the unfolding Cinema EOS Camera Lineup over the past decade

It is important to note that during the entire era of development of the Cinema EOS system – including lenses, cameras, and reference displays – Canon was also heavily preoccupied in R&D and prototype development of multiple 8K lenses, an 8K camera, and an 8K reference display. Especially on the lens front, the R&D and prototype developments bore directly on developments of our 4K lens products. Evolving computerized design tools, associated design software, new glass materials, and new optical coatings—all supported progressive advances in 8K optical performance while also making significant contributions to the parallel 4K lens developments in the Cinema EOS system – as shown in Figure 8.



**Figure 8** Canon technical developments in 8K paralleled the growth of the Cinema EOS product line

The steady rollout of a broadening range of Super 35mm 4K zoom lenses – having operational characteristics targeted to a diversity of high-end production genres – benefitted from the ever-increasing refinements to optical performance that spun off the ongoing work in 8K optics – Figure 9.



**Figure 9** Showing the current broad range of Canon 4K Cinema EOS lenses

## 6.0 CANON AND THE 8K UHD MOVEMENT

### 6.1 Canon Expands Developments in 8K UHD

Coinciding with the global standardization of 4K UHD and 8K UHD, Canon decided to expand developments of that system to prepare for possible long term extensions of Cinema EOS to 8K. Accordingly, Canon decided to broaden its R&D projects to encompass development of an 8K camera. It was also believed important to include development of an 8K reference display as part of the long-term digital cinema development agenda.

At the Canon Expo in 2015 (held in the Jacob Javits Center in NYC) Canon showed for the first time our expanding R&D developments in 8K imaging. This included the Super 35mm lens shown in Figure 10, a prototype Super 35mm 8K camera developed by Canon, and a prototype 8K reference display.



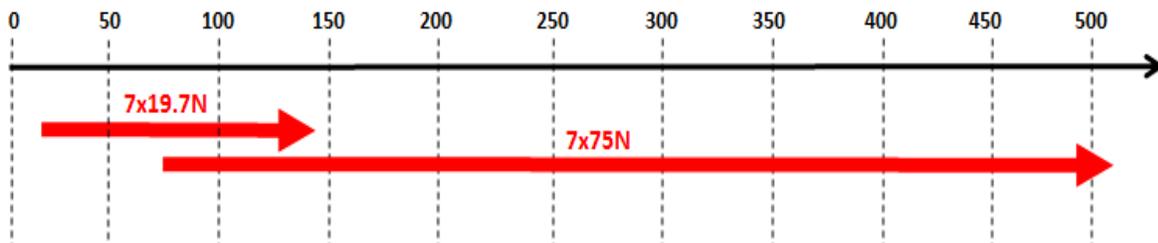
**Figure 10** *Developmental 8K imaging ecosystem developed by Canon and shown in the U.S in 2015*



**Figure 11** *The Canon 8K prototype camera coupled to a prototype 8K recording system*

## 6.2 Status of Canon 8K UHD Super 35mm Lenses

Separately, Canon has developed two prototype Super35mm 8K UHD lenses in support of the S35mm 8K cameras developed by Astro Design, Canon, Ikegami, Hitachi, and Sharp – and identified in Figure 12. At this time these remain as developmental models intended to support both Canon’s ongoing R&D into an 8K camera, and also other Super 35mm 8K cameras. The 7x19.7N lens will produce a wide 65-degree horizontal field of view at the wide setting. The second 7x75N lens is clearly optimized for telephoto imaging with a 7 – 525 mm focal range.



**Figure 12** Two Super 35mm lenses – one wide angle and the second is telephoto – developed by Canon

The 7x19.7 and 7x75 Super 35mm lenses are shown in Figure 13 and 14. At this time, neither of these lenses have transitioned to product status – they remain as developmental models.



**Figure 13** The Super 35mm 8K UHD Lens-camera system developed by Canon USA, Inc.



**Figure 14** *The developmental 7x75N KASD Super 35mm telephoto 8K lens*

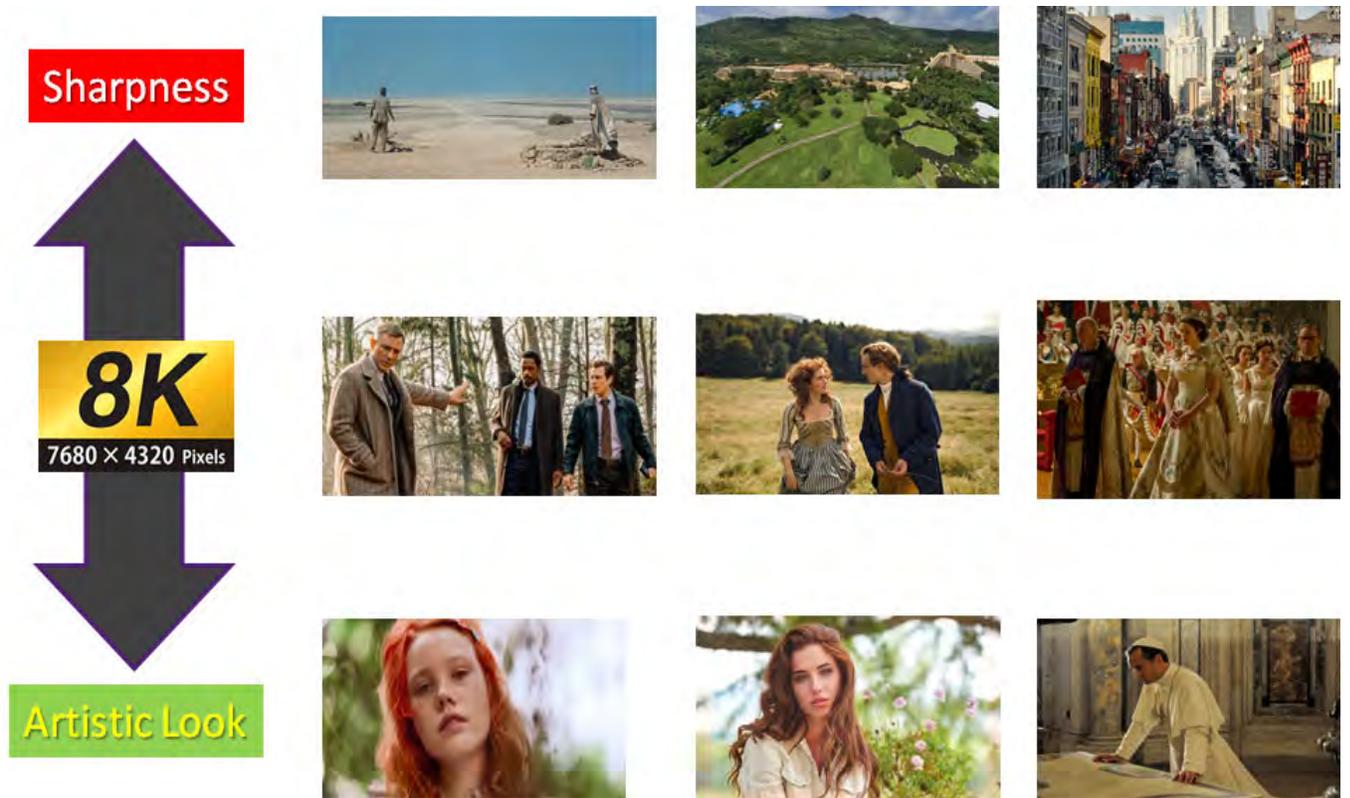
## **7.0 8K IN MOVIE MAKING AND EPISODIC TELEVISION**

### **7.1 The Desire for Higher Resolution in Digital Cinematography**

The motion picture film world long ago rationalized the usage of film formats of many sizes from 16mm, Super 16mm, through Super 35mm and on up to 65mm. The desire for high resolutions that anticipated unusually large screen viewing experiences was one important driver. The use of high resolutions to support movies that sought to capitalize on wide angle panoramic scenes (think “Lawrence of Arabia,” and “Dr. Zhivago” and many others) is another driver – one that remains to this day.

The interest in high-end moviemaking and television production to originate material in resolutions higher than 4K has been steadily growing. Digital cinematography cameras originating in 5K, 6K and 8K are readily available today. The advantages of both RAW and supersampling of the original capture is broadly recognized – supporting pristine 4K and 2K derivatives in postproduction for both cinema and television distribution.

The extraordinary resolution in 8K supports a vast range of imaging. At its highest level – the full 8K – it will do full justice to framed wide angle panoramic scenes containing a great deal of detail – as suggested by some of the imagery at the top of Figure 15. At another extreme of imagery, there might be close-ups where specific lenses are deployed to soften the image to achieve different artistic looks – as suggested in the bottom row of images in Figure 15. Between these extremes are a wide array of image possibilities.



**Figure 15** *Illustrating that 8K resolution can encompass an extremely wide range of imagery*

## 7.2 Broadening the Lens Portfolio in Support of 8K Imaging

To fully exploit the imaging potential of 8K requires a wide range of lenses. To date, Canon had developed two Super 35mm zoom lenses that were targeted at achieving the highest possible level of 8K optical performance. At this juncture these are developmental models and not saleable products.

More recently, Canon developed an additional specialty Super 35mm 8K lens – a very wide angle fisheye lens that is shown in Figure 16 and 17 – mounted on the Canon 8K Cinema EOS camera. Canon believes it will have useful applications in sports replays by capturing a far wider 8K image to add more freedom for multiple choices in extractions of 1080P. It possibly has applications in the cinema world for on-set virtual production image creation. At this time, the lens has not transitioned to product status – it remains a developmental model.



**Figure 16** *New Canon Super 35mm 8K fisheye lens mounted on Canon 8K Cinema EOS camera*

A sense of the extreme wide angle capture that is possible with this system can be gleaned from Figure 17 where the viewfinder image is showing the wide angle capture of the stadium.



**Figure 17** *The extreme wide angle capture of the stadium can be seen in the viewfinder image*

## 8.0 SUMMARY

4K DCI rapidly ignited the interest of moviemakers who were by now comfortable with the digital alternatives to motion picture film – and who saw four times the spatial resolution of 2K/HD as a solid format for high-end imaging. Those production communities originating high-end episodic television also saw the value of having 4K masters – in the form of a longer shelf life for their assets as well as higher quality downsampled 1080P for current distribution. Separately, the newly emerging OTT services capitalized on the astounding advances in internet delivery and some have boldly leaped into 4K distribution.

U.S. Broadcasters and cable operators, however, have so far remained extremely cautious about any commitments to 4K UHD delivery services. A far greater priority is unraveling how to migrate the industry to the high technological promises of the newly standardized ATSC 3.0 transmission system – which does also include 4K UHD. The vagaries of a marketplace driven transition remain daunting to many.

For all of these reasons 8K UHD broadcast television remains a far-future possibility in the Americas, Europe, and other regions of the developed world. History has, however, clearly and repeatedly shown that there is no stopping technological progress. Despite initial dismissal, 4K is a continuing discussion in the U.S and in Europe and elsewhere. It is inevitable that it will figure into the future after HDTV. In time, 8K UHD will almost certainly follow. However, business interests simply must align with technological progress. The most optimistic guesses in the western world (heard at television conferences and industry panels) is that 8K UHD broadcasting will not appear before 2030 – and quite possibly later.

Television delivery aside, on the production front 8K is already being enthusiastically embraced by the sporting world – exploiting the prowess of digital zooming within 8K imagery to produce high image quality 1080P for replay. A niche application – but, an increasingly important application.

In digital cinematography 8K is inevitable. 4K, 5K, and 6K are commonplace today in the moviemaking world and 8K has already appeared. Supersampled RAW data is widely recognized as supporting the very best results in postproduction. A number of high profile movies have been originated on either RED or Panavision 8K cameras. It can be anticipated that 8K will be increasingly adopted by those interested in high-end program assets – both movie and television.

Despite the ongoing debates on the business merits of 8K – there is no disputing that the huge technological developments associated with this extreme resolution system have propelled advanced technical developments in optics, image sensors, camera digital processing, recording, and reference displays. These developments have not been in isolation – but have been, and continue to be, directly influential in current 4K / UHD 2K / HD products presently in the marketplace. Canon has seen this firsthand, with striking advances in all facets of optical design that have helped elevate the optical performance of our current 4K broadcast and cinema lenses.

