



# ETM Internal Report

## **Digital Camera Innovation**

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## Digital Camera Innovation

### HISTORY OF DIGITAL IMAGING DEVELOPMENT

In December, 1975, Steven Sasson, an engineer working in Eastman Kodak Co invented a world first working prototype digital camera. The first prototype weighed 8 pounds, toaster-size contraption which captured a black and white image on a digital cassette tape as a resolution of .01 megapixels.

The whole development lifecycle of the digital camera started as early as 1951 when a team of engineers headed by John Mullin of Bing Crosby Laboratories invented the first video tape recorder (VTR) captured live images from television cameras by converting the information into electrical impulse and save it onto magnetic tape. By 1956, VTR technology was perfected and in common, use in both television and video cameras.

During 1960s, NASA converted from using analog to digital signals with their space probes to map the surface of the moon by sending digital images back to earth. Computer technology was also advancing at this time and helped to enhance the imaging that send the space probes. Government use of digital technology helped advance the science of digital imaging.

In 1969, George Smith and Willard Boyle from Bell Labs invented the Charge Coupled Devices (CCD). CCD is an electronic memory that can be charged by light and hold a charge corresponding to variable shades of light color and intensity. A digital image is thus produced.

Texas Instruments Inc had invented and patented a filmless but analog base electronic camera in 1972. Steven Sasson drew on whatever technologies available at that time; such as an analog-to-digital converter adapted from Motorola Inc components, Kodak own movie-camera lens and the tiny CCD chips introduced by Fairchild Semiconductor in 1973 and invented the world's first prototype digital camera in 1975.

In August, 1981, Sony released the world first commercial electronic still camera called ProMavica MVC-5000. The Images were recorded onto a mini disc and then put into a video reader that was connected to a television monitor or color printer. ProMavica cannot be considered a true digital camera even though it started the digital camera revolution.

Concurrently, Eastman Kodak Co. kept inventing several solid-state image sensors that were able to convert light to digital pictures for professional and home consumer use. In 1986, Kodak scientists invented the world's first 1.4 megapixel sensor, capable of recording 1.4 million pixels that could produce a 5x7-inch digital photo-quality print. The first digital camera model was produced by Toshiba and Fujifilm in 1989. These products did not gain immediate acceptance in the marketplace due to their high price and unavailability of sufficiently well-developed peripherals, i.e. PCs.

In February, 1994, first digital cameras for the consumer-level market that worked with a home computer via a serial cable were the Apple QuickTake 100 camera. Kodak introduced DC40 camera in March, 1995. Casio introduced QV-10 with LCD monitor in March 1995 and Sony introduced its Cyber-Shot Digital Still Camera in 1996.

Kodak also continued to move ahead to collaborate with Kinko's and Microsoft to create digital image-making software workstations and kiosks which allowed customers to produce Photo CD Discs and photographs, and add digital images to documents. IBM collaborated with Kodak in

making an internet-based network image exchange. Hewlett-Packard was the first company to make color inkjet printers that complemented the new digital camera images.

In 2000, digital camera was able to offer competitive priced comparing with film camera. For the next few years, digital technology slowed down as the industry was shifting from product research to process improvement as to meet the global market demand. At the sometime reduce the manufacturing cost and expand the production capacity as show in Figure 1 product lifecycle.

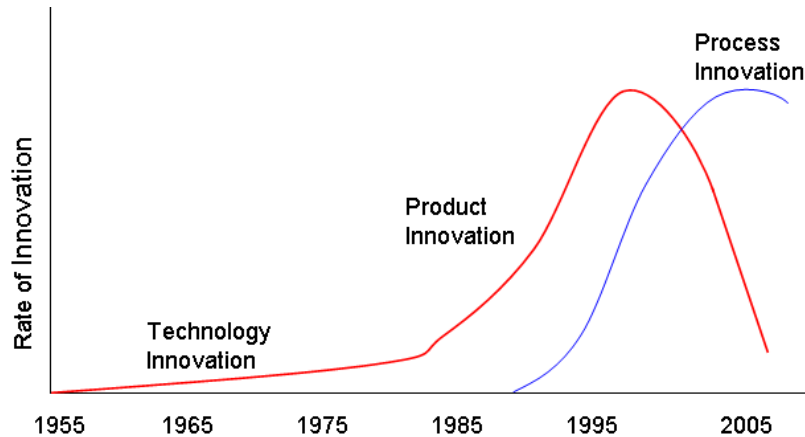


Figure 1: Technology, Product and Process Innovation Timeframe

## DIGITAL IMAGING TECHNOLOGY

The digital camera comprises an imaging device, imaging optics, image processor (DSP), LCD, buffer memory (Flash memory), electronic drive circuits and control mechanics as show in figure 2.

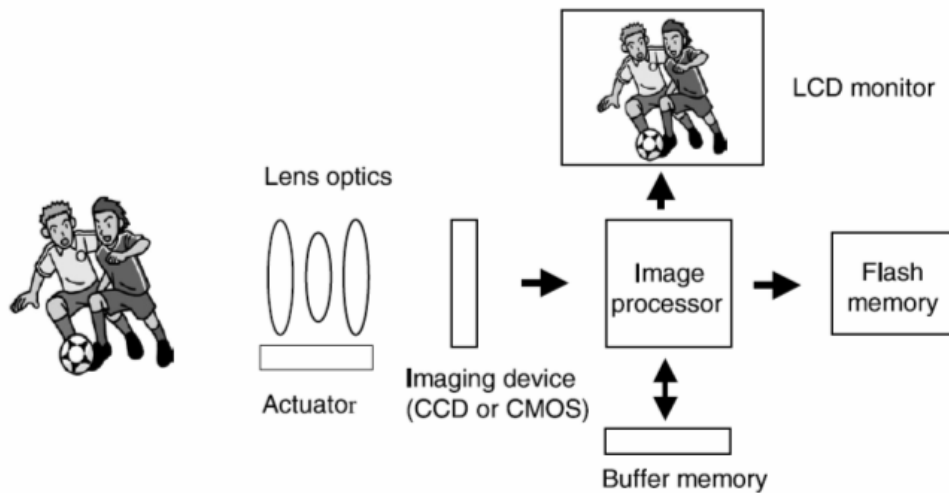


Figure 2: Basic digital camera construction, 'Source: Prepare by Science & Technology Trend Quarterly Review No. 18'.

There are two core components in digital imaging technologies:

Firstly, the imaging device is constructed using a charge-coupled device (CCD) or a complementary metal oxide to semiconductor (CMOS), which converts an optical image to analog electric signal. The analog signals are converted to digital form by image processor and buffer memory. The digital signals are stored in the card memory, which incorporate rewritable and non-volatile flash memory.

Another core device is the lens optics which focuses a picture on the imaging device. The optical lens combines several aspheric lenses in order to correct aberration. The optics required space to incorporate actuators and mechanics for zooming through which the focus length and the length between the lens and imaging device are adjusted.

### **MARKET-SHARE LEADER IN DIGITAL CAMERAS**

The market-share leader in digital cameras industrial today is not Kodak, or Sony, or Casio. It is Sanyo, the Japanese product manufacturer.

Sanyo lost the battle for market share in video cameras to Sony and others; they started to recognize that they had a lot of talented electronics and imaging people on their hands. Rather than lose them to competitors, they invested heavily in digital camera development, and came up with several significant advances. And then, rather than invest in promoting the relatively unknown Sanyo name, they figured that recognized cameras such as Olympus and Nikon could probably outsell the Sanyo brand. So they made marketing alliances, which quickly got results in a few years.

Other Manufacturers of digital camera and components include Canon, Casio, Eastman Kodak, FujiFilm, Kyocera, Minolta, Olympus, Nikon, Polaroid, Ricoh, Samsung, and Sony.

Digital cameras have won widespread acceptance for both business and personal use due to their usefulness as imaging devices that can linked with PCs. Sales have grown dynamically since 1999, with the ratio of exports to total sales increasing year on year as show in Figures 3 and 4

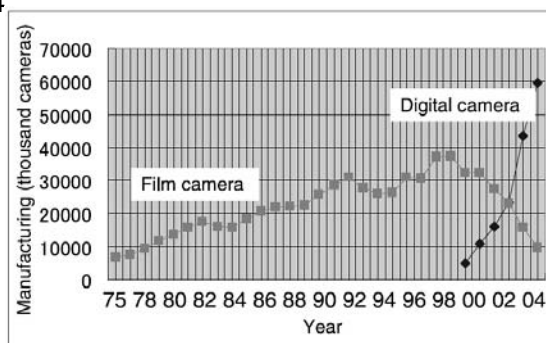


Figure 3: Production of digital and film camera, 'Source: Prepare by STFC based on Camera & Imaging Products Association report.'

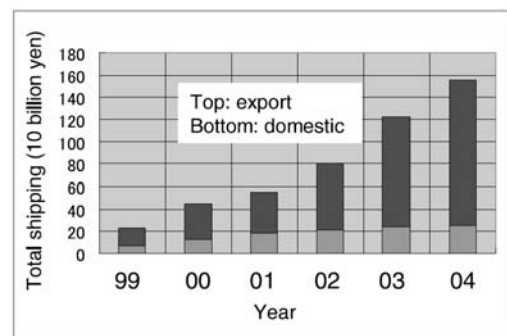


Figure 4: Domestic sales and exports of digital camera 'Source: Prepare by STFC based on Camera & Imaging Products Association report.'

The sale of digital camera before 1998 was not moving due to few particular reasons:

- Digital imaging quality and performance not as good compared to traditional cameras which offered sharper, crisper, clearer pictures. Most for the digital camera at that time only offered 1MPixel.
- Very expensive, professional ones with 1.5MPixel at \$3500-\$10000. Normal camera: \$300.
- Delay time for multiple shots
- Long process of waiting time for conversion to digital, compress, save, and recycle flash
- Can't capture range of continuous tones & colors
- Lack of camera accessories
- Shorter battery life
- Pixilated printing

With resolution improvements, expanded memory capabilities and plummeting prices, the market for digital cameras has been outstripping that of conventional film cameras since 2002. The Digital photography will replace traditional photography as digital camera eliminates the need for film and film developing; makes it possible to view recorded images immediately; allows pictures to be shared worldwide via the Internet; and enables PC-based manipulation and enhancement.

The Internet creates new opportunities for archiving and accessing images and scenes. The time is right as digital photography, Net-based storage and 3G wireless solutions are all falling into place. Those who develop more cost-effective ways of storing and transmitting images (particularly compression techniques) will be big winners.

Wireless technology will facilitate transmission, storage, display, and printing of images. Third generation wireless networks will allow digital cameras with minimal memory to take picture after picture. Wireless LANs enable sophisticated security systems for homes and small offices. Short-range wireless technology, such as Bluetooth or Wi-Fi, will let users beam images to desktop devices for display and printing.

In the following, we shall discuss the contributions of two major players, Casio (an entrant) and Canon (an incumbent in the camera market).

### **CONTRIBUTIONS BY CASIO**

Japan is well-known as an early adopter of cool, technology-intensive consumer electronics products in the world. And Casio Computer has been one of the trail-blazers in this fiercely competitive market and was best known for its pocket-size electronic calculators, digital watches and electronic musical instruments. With its core competence in electronics design, miniaturization and mass-manufacturing, it started to look at the potential of digital cameras in the 1990s.

In 1995, Casio launched the QV-10 without the benefit of a market survey. Its engineers focused on designing a user-friendly and affordable digital camera which could be used by the increasingly PC-savvy customers in Japan and the US. The resolution was chosen to be 250,000 pixels which was  $\frac{1}{4}$  VGA. In addition to using its miniaturization and mass-manufacturing expertise to achieve drastic weight and price reduction, its engineers added a 1.8 inch active matrix LCD display for instant playback. This proved to be a great feature as users could immediately delete unwanted shots and retake pictures of importance and eliminated the inconvenience to access a PC for viewing – its introduction forced competitors to do likewise and the LCD digital camera later on became a new dominant design for digital cameras. Although such an innovative product could not compete head-on with a much cheaper conventional film-based camera in terms of picture quality (resolution and colour intensity), it became a big hit for

consumers who liked a fun product which was good for taking snap shots at parties or special occasions, and gave digital cameras a strong-enough foothold to begin the disruption. Over the next few years, the CCD resolutions rapidly improved, from 0.3 megapixels to more than 2 megapixels (becoming sufficiently good for normal consumers); the storage improved drastically using first hard-disk microdrives and then affordable, removable flash-memory cards/sticks – enabling storing of thousands of pictures; the battery price also dropped while recharging intervals lengthened and weight reduced, all very significantly. Coupling with zero developing cost and film cost, and the emergence of convenient photo-printing service from memory cards/sticks, the digital cameras started to disrupt film-cameras since 2002 [27].

In addition to competing with other digital camera manufacturers which joined the race to capture the consumer camera market, Casio engineers continued to innovate by introducing the Exilim series starting 2002 again without a market survey. Using their core competences in miniaturization and mass-manufacturing developed from other successful consumer products, these engineers worked with suppliers of lenses and CCDs to further squeeze out space between parts to produce a stunning ultra-thin camera – just 13 millimeters, front to back. It could easily slip into a pocket, heralding in the new era of pocket-camera. The Exilim Z3 became the hottest-selling model of the year.

### **CONTRIBUTIONS BY CANON**

Canon was founded in 1937 to develop and manufacture precision cameras. Being a dominant incumbent in the film-based camera with superior performance and customer acceptance, Canon continued to make incremental innovations to sustain its camera market share. But it was alarmed after Sony released Mavica in 1981. Its R&D Dept undertook development which led to a still video camera, the RC-701 in 1986. The high price (about US\$3000) however was a stumbling block in the market.

An ambitious plan was then made to develop an image engine. A computer would be built into the digital camera to control its operations and to provide an improved output image. A single-chip or two-chip solution was the target as the camera had to be lighter, smaller and cheaper to produce. While developing the image engine, Sony introduced a compact digital camera, the PowerShot 600, in July 1996. But this was one year behind Casio's QV-10 LCD digital camera which was also sold at half the price of PowerShot. Casio continued to keep the lead by launching QV-10A. Sensing the danger of losing the competition, Canon established a new Digital Imaging Business Centre and allocated more resources to it. It released top-of-the-line digital SLR cameras, the EOS D2000 and EOS D6000, in 1998, as well as the cheaper PowerShot A5 and PowerShot Pro70. Consumer reaction was lukewarm. Canon felt an even higher pressure to innovate.

Canon finally was able to launch the brand new Digital Ixus compact camera, which had a small foot-print. Meanwhile, the earlier effort on image-engine R&D (completed in 1999) enabled an improved image engine to be installed in the Digital Ixus 200 and 300 models in 2001. The new engine was able to process at higher speeds and give better image quality. The Ixus models also featured a new generation of lens, which enabled further reduction in the size of the Ixus, and also an ultra-thin LCD display. Canon rapidly gained market shares and became the market leader in digital camera by 2005. In the process, its original film-based camera business was disrupted.

## DISCONTINUOUS INNOVATION

Digital imaging technology is a disruptive technology to film photography. As shown in Figure 3 shipment in 2004, film camera only shipped 1/6 of the volume of digital camera.

During the earlier stage in 1981, digital imaging technologies entered the photography industries as inferior performance. The digital camera could not meet the minimum expectation of the consumer; it was expensive, bulky/heavy and had bad imaging. In 1999, digital technology started to meet the low-end performance expectation from consumer with the improvement of digital resolution improvements, expanded memory capabilities and plummeting low prices. The global shipment for digital cameras has been outstripping the conventional film cameras since 2002.

As the diagram shows below in Fig 4; Digital Camera will also face a great challenge from digital camera phone as nowadays more and more cell phone is equipped with digital photography feature. Digital camera phones will be another disruptive technology for digital camera which also focusing digital camera technology to high end market.

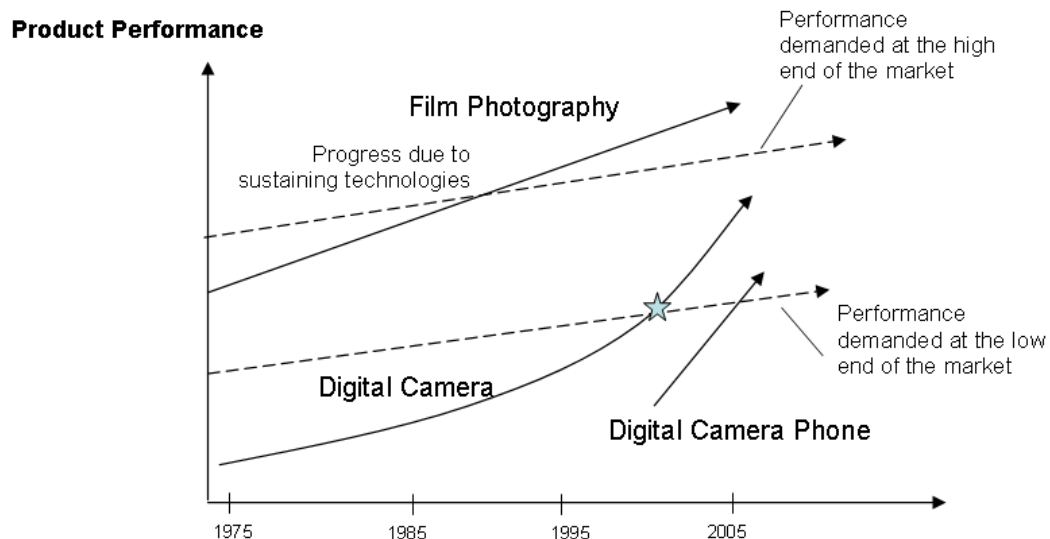


Figure 4: Image Photography performance chart.

## FUTURE DEVELOPMENT

The development of the digital camera market following the increase in pixels of imaging devices, future progress is projected to diverge along three paths as show in figure 5:

- Further increase in pixels
- Advance digital Single Len Reflex (SLR) Camera with imaging device of more than 5MPixals
- Camera Phone

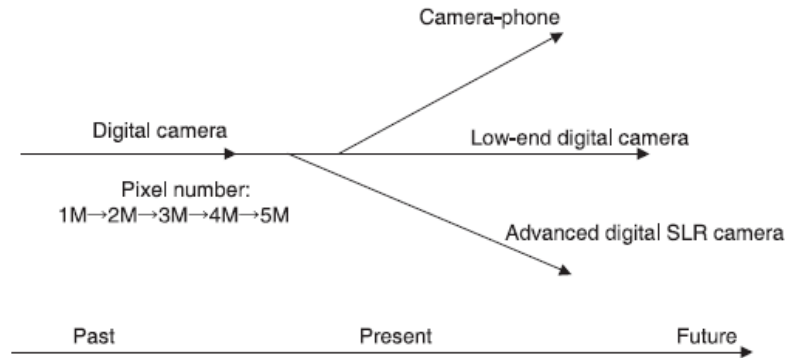


Figure 5: Diversifying market for digital camera, 'Source: Prepare by Science & Technology Trend Quarterly Review No. 18'.

SLR Camera grew 150% in 2004, mainly for professional or hobbyist considered. Camera phone has experienced a rapid increase in production equivalent to the digital camera. In 2004, out of the 500 million mobile phones purchased, 180 million were equipped with digital imaging technology. Analysts expect that in 2008, 700 million mobile phones sale, more than 90% will be camera-equipped and 60% will incorporate zoom function.

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