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Case: Casio QV-10

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1. Introduction

In March of 1995, Casio released their first LCD digital camera. This small LCD camera, weighing 190 g. and priced at 65,000 yen, sparked off the digital camera boom in Japan. The initial monthly production target of 3,000 units had to be revised immediately. By May, it was set at 10,000 units per month and by the end of 1995, it was set at 30,000 units per month, ten times more than the initial target. As personal computers and the Internet gained popularity, the digital camera market also saw a rapid expansion. A 200,000 unit market in 1995 grew to become a 1,000,000 unit market by 1997, and manufacturers ranging from camera manufacturers to home appliance and games equipment manufacturers entered the market.

The following three factors have been generally held to be the reasons for making QV-10 such a mega hit product:

Firstly, the concept of an input device for personal computers fitted in with the spread of use of personal computers and Internet. Users were provided with a simple means to take in photographic images into their computers.

Secondly, it's was priced at a relatively affordable price at 65,000 yen. While its competitions were priced at over 100,000 yen, the street selling price of QV-10 was less than 50,000 yen. It marked the arrival of an affordable digital camera for the layman.

Thirdly, by equipping it with a LCD screen, it allowed the user to check the recorded image on the spot. More expensive digital cameras were on the market before QV-10, yet it was the first digital camera to be fitted with a LCD screen.

How did Casio, who had hitherto no experience with cameras, conceive a product like QV-10. Camera manufacturers should have had more intimate knowledge on the product and the user characteristics. Home appliance manufacturers producing video camera-recorders possessed technological advantage, while semiconductors manufacturers held a definite edge over CCD (Charge Coupled Device) and LSI technologies. Yet it was Casio, who pioneered the digital camera market in Japan. What made it possible for Casio to develop and market a product that others could not? Let us review the development of the digital camera business at Casio.

2. Establishing Electronic camera Business – Development of VS-101

2.1. Establishing The Electronic Camera Business

SUETAKA Hiroyuki, who was engaged in designing LSI for watches at the Development Division, initiated the development of electronic cameras in Casio in the early 80's. Sony announced their digital still camera, the MAVICA (Magnetic Video Camera) on August 24, 1981. This event made Suetaka to look towards the electronic camera business. This announcement was coined the "Mavica Shock", and caused many in the industry to speculate that it may eventually replace the traditional camera.

In view of the in-house technical capabilities of Casio, the concept of electronic camera seemed very attractive to Suetaka. The process of developing an electronic replacement of a mature existing product was right up Casio's alley. Successful Casio products, such as calculators, watches and electronic musical instruments, were all developed by replacing the traditional mechanical core technologies with electronic means. By taking advantage of innovative technologies in semiconductors in a timely manner, Casio had been able to put products ahead of its competitors. Suetaka knew instinctively that electronic cameras would become the next core product in Casio's lineup.

Suetaka's conviction to develop electronic cameras was confirmed in the exchanges held with engineers of competitors at the Electronic Still Camera Conference that was established in February 1983. The purpose of the Electronic Still Camera Conference was to establish the 'MAVICA Standard" as the industry standard for processing and recording electronic signals of images. 42 manufacturers from the camera and electronics industries gathered to establish a standard and to explore the possibilities of electronic camera business. Through out these exchanges, Suetaka's confidence grew in developing electronic cameras as a viable business.

Having decided that Casio should develop electronic cameras, Suetaka presented his concept to his senior manager. In May 1985, a special project team lead by Suetaka was formed within the R & D Division: the "K Project". Once the K Project was formally approved, Suetaka began the selection process to staff project from all sectors of the company. He submitted a list of names to his senior manager at the R & D Division and began interviewing them individually. Selection process was completed and he now had an eight-member project team in place. In addition to Suetaka, the final selection for the

special team included the following. An engineer working on development of page printers at Casio Electronics Industry, who had left a camera manufacturer to join Casio, was included to bring in expert knowledge on optics and camera mechanism. Suetaka recruited a freshman that had just joined Casio when the K Project was established. He was put in charge of developing and designing LSI's and other electronic components. The third person he recruited was en engineer developing "MSX software" at the Electronic Calculator Division. His role was to develop software. The remaining four positions went to Suetaka's colleagues at the Time Piece Division.

2.2 Announcement of VS-101 and Startup Process

After the design phase of K Project was completed, and the final form of the product was established, it was announced as the "VS-101" in December 1986. Because video camera-recorders were mainly priced around 200,000 yen, its price was set at 125,000 yen. It had a 1/2-inch Hitachi MOS type sensor with 300,000 pixels as its image sensor. Image signal processing and recording utilized video technology, following the Mavica Standard. Image signal from the sensor was analogically processed and then FM modulated to be recorded on Mavica standard 2-inch floppy disk.

"Snap away as many shots as you wish, keep what you like and erase the rest." has been the concept for digital photography at Casio starting with the VS-101. Although VS-101 was still an analog device, product development concepts, such as providing TV monitor output terminal and printer output port, were the same as for today's digital cameras. In fact Casio offered a video printer, supplied by Hitachi on OEM basis, as a peripheral device for VS-101.

As soon as the product was announced in December 1986, K Project became a joint operation with the Visual Equipment Division in preparation for the production and marketing of the product. Although members of K Project retained their status as belonging to the R & D Division, they were seconded to the Visual Equipment Division. Production Management, Material Procurement and Quality Control personnel joined the team from the Visual Equipment Division.

Because the project involved an analog device that processed images, the Visual Equipment Division was thought to be technologically better qualified to handle startup

phase, although K Project was developing an electronic camera. However, production of VS-101 was based not at Aichi Casio where LCD TV and other Visual Equipment Division products were manufactured, but at Yamagata Casio where watches were mainly produced. The fact that Aichi Casio had no more for an additional production line was one of the reasons, however, the Project leader, Suetaka's background of coming from the Timepiece Division, and having a number of well acquainted colleagues at that plant was another reason. This happened before a complete divisional grouping corporate structure was implemented and there was some latitude to make inter-divisional arrangements such as this one.

VS-101 was priced at around 100,000 yen and released to the market as the first digital still camera for private use in January 1987. However, the consumer market failed to respond to VS-101. Not only did it fail to attain the target monthly production of 10,000 units per month, it only managed to sell between 3,000 to 4,000 units in aggregate. As a result of this poor performance, development of the successor was shelved. It looked as though electronic camera development at Casio had come to an official end.

3. Five years of Void – 1988 through December 1992

3.1. Unofficial Development at Applied Research Department of R & D Division

When K Project was officially abandoned in 1988, members of the project team were transferred to the Applied Research Department that was established at the R & D Division when Casio implemented its divisional structure. Under the protecting wings of SHIMAMURA Noriaki, General Manager of the R & D Division, the Applied Research Department became a haven for engineers pursuing development of products that could not be put into production in the near future.

Even after being transferred to the Applied Research Department, Suetaka did not give up on the electronic cameras. He simply refused to accept that photography would forever be based on films. He analyzed the reasons for VS-101's failure in order to make the next attempt a success. He concluded that being an analog product, it was technologically immature. "It has to be digital," was the reaction by most people when shown the VS-101, because they saw that it came with a floppy disc drive. This was what stuck in Suetaka's mind. Therefore, he made it his goal to resolve, one by one, the technical problems

involved in digitization. However, as electronic camera development was no longer viewed as promising theme, he found it difficult even to secure necessary staff for the development work. Although all the members of K Project were initially pooled at the Applied Research Department, the four engineers that came form the Timepiece Division were later transferred out to other sections because of consensus that there was no future in developing electronic cameras. Only four members, the optics engineer, the electronics engineer, the software engineer and Suetaka remained.

Despite such set back, the team lead by Suetaka did not give up on digitization of the electronic camera and continued with the basic technical development. There were several technological problems to be resolved for digitization. The first problem was compression and extraction technology of digital image information. JPEG protocol was established at around the same time, so they adopted it for their compression and extraction technology. The second problem was color processing of optical signals from CCD and converting them to images. The third problem pertained to optical technologies associated with zoom lens and auto-focusing. And the last problem pertained to the product architecture, the technology to put together a system that is a viable product.

Suetaka recalls this period as follows:
“You know, it was a tough period. It is quite overbearing to spend five years not producing anything.” During this “Five years of void”, some of the technical problems in digitalization were overcome through development of several prototypes. The experience gained during this period eventually contributed to the development of the mega hit digital camera, the QV-10,

The first prototype was a digital camera code named DC-90. DC-90 carried 256 SRAM’s with a total memory of 12 mega bytes on the memory board fitted at bottom to process digital signals. Since data compression technology had not yet been well-developed, image data were stored without compression. However, other technologies required in a digital camera, such as lens and other optical technologies, color processing and camera system engineering were almost all resolved during the development of DC-90.

There was also an unexpected by-product as a result of developing DC-90. Because DC-90 used PLD (Programmable Logic Device), its power consumption was fairly large, and it had an inherent problem with the resultant high heat output. There was a reason for the first prototype to be nicknamed “ATSUKO” (Hot Child). It happened to have a void to

accommodate a LCD viewfinder used in a video camera. However, because of the amount of heat generated, a cooling fan had to be installed in that void. Now, this made it impossible to see the viewfinder. This problem was resolved by attaching a LDC TV on the top of the camera. This experience eventually lead to the idea of incorporating a LCD screen on a digital camera when developing the QV-10.

DC-90 was never put into production as it was seen only as a toy. However, in the process of showing it off to various people, many uses were discovered that were helpful in developing a digital camera. Because DC-90 was equipped with a serial interface to connect with a computer, it was used as input and output device in a television phone demonstration. The birth of the idea of connecting a digital camera to personal computers can be found in the development of DC-90. However, it was still very difficult to produce clear color images with the capabilities of the then available personal computers.

The next prototype to be developed was the scanner camera CT-300. A serial interface (RS-232C) was incorporated in the initial design of CT-300 as connection to computers and other periphery devices was contemplated from the beginning. A Sanyo monochrome CCD and a Hitachi CPU were used in CT-300. This combination of a Sanyo CCD and a Hitachi CPU is later found again in QV-10.

Although CT-300 was developed with the intention to connect to a personal computer, it was never approved for production as a personal computer periphery device. So, Suetaka took it to the Electronic Calculator Division, which were marketing Nameland, a seal printer. CT-300 was put on the market as an periphery device for Nameland to input images of faces to be printed on the seals.

Although the Five years of Void was a testing period for Suetaka and his team, it was also the period in which the foundation for developing QV-10 were laid. Taken on their own, DC-90 and CT-300 were each an incomplete prototype. However, when taken together, we can see attributes that formed the core concepts of QV-10, such as LCD screen, connection to PC, small input device and combination of Sanyo and Hitachi parts.

3.2. Initiatives from Product Planning Sector

As Suetaka and his development group were steadfastly pursuing their dream, support for their efforts began to emerge from the Planning sector. The resurrection of the idea to

develop electronic cameras can be attributed to the arrival of NAKAYAMA Hitoshi to the Planning Department that oversaw planning strategies of the various projects and the R & D of all audio-visual products. Up until that time, he had been in charge of planning for B Project dealing with electronic business devices. Nakamaya wanted the electronic camera technology to become viable, and he wanted the ex-K project members to receive credit due to them. Therefore, Nakayama held a meeting with Suetaka to exchange technical information and suggested that they focus on developing a digital camera using a memory card. However, this plan failed to gain formal approval.

Nakayama then came up with another idea: a digital camera code-named "V^2 Memo". Proposal for V^2 Memo was made when the Consumer Product Development Research Center (MINKEN) was established within the R&D Division in November 1991. The project was approved at a "Product Evaluation Committee", chaired by the President and held once or twice a month. It became a new product development project of MINKEN under the code name of "RS". Nakamaya was involved in a number of projects developing new businesses, among them was the "RS-20" project for development of electronic camera business.

The first idea for RS-20 project was the V^2 Memo that Nakayama had suggested to Suetaka at their meeting in December 1991. V^2 Memo stood for "Visual Voice Memo". It was to be a highly portable electronic camera fitted with a three-inch LCD monitor. Connecting it to a computer never entered the formula. The product development concepts for this product were "Record every and anything, check the result on the spot, and show it on TV. Store the recorded images on IC memory. Erase when on longer needed." In accordance with the product concept, it was to have audio recording capability in addition to image capture and recording capabilities. However, this product concept failed to gain top management approval. It was difficult to measure how much of a consumer appeal the proposed product would generate. The failed attempt of VS-101 had also had some influence. Because of the failure of ten years ago, the term "electronic camera" had become somewhat of a taboo among the top management. Unfortunately, the concept proposal for the V^2-Memo did not have sufficient impact to overcome the taboo.

4. **QV-10 Development Project**

4.1. Proposal for a Camera TV and Formation of RS-20 Project

In December 1992, almost one year after making the proposal for V^2 Memo, Nakayama met again with Suetaka. This time Nakayama suggested that they put forward an idea for a “Camera TV”, a digital camera with emphasis on LCD TV rather than on the camera aspect, as a special research project for MINKEN. Instead of a digital camera with a LCD screen, it was to be a LCD TV with a built-in digital camera.

At that time, the “CV-1” which was the world’s smallest 1.4 inch LCD TV had captured worldwide attention. Yet, business wise, Casio’s LCD TV business was not doing too well. This was a huge miscalculation for Casio, which had invested 20 billion yen in building a new LCD (TFT panel) plant in Kochi.

One of the reasons for these portable LCD TV’s not gaining market share was because of the reception problems; the locations in which they can be viewed were limited. Although they were equipped with high-resolution LCD screens, owners could not watch it anytime that pleased them. This lead to Nakayama to come up with the idea that, ”If one cannot watch commercial broadcasts, let it show images taken by the user.” A LCD TV with an eye. He had a small wooden design mockup model made for presentation to the President. When shown this mockup, unlike the time when presented with the proposal for V^2 Memo, the President commented, “This is very interesting.” This development program was approved in December 1992. In March 1993, it became MINKEN’s special development project “RS-20”. Thus began the formal development of a digital camera TV.

4.2. Overview of the Development Process

As soon as its selection as a special research project was authorized in December 1992, design work for mass production also received the go sign. Financial and personnel resources were allocated to the project. The four members of the VS-101 team consisting of Suetaka, the optics/mechanical engineer, the electronics engineer and the software development engineer, formed the core of a ten-man project team. However, the target-selling price of 50,000 yen and the basic product specifications were the only items set at that time. The four months between research theme selection approval (December 1992) to formal launching of RS-20 project (April 1993) was used for preliminary preparation. Product architecture, performance target and development schedules were established during this period.

When the project formally started in April 1993, tasks such as design of LSI circuits, performance evaluation of devices, design of lens, production of shop drawings were allocated to the various members of the team and the detail design phase began. Frequent meetings were held with the CCD development staff at Sanyo's Gifu plant and with the semiconductor engineers at Hitachi's Musashino Plant, with whom they already had established working relationships through the CT-300 and VA-101 projects.

The first product sample was ready in December 1993, exactly one year after the development theme of a camera TV was approved. It must be reminded that the sample produced then was a camera TV, and as such, it had an internal TV tuner.

Its product characterization was later revised to be a digital camera, and by June 1994 a target monthly production rate was set at 3,000 units. By the summer of the same year, the product in its final form was ready and shown to the distributors. As a result of this pre-view to the distributors, the original intention to distribute the product through "audio-visual" cannels that sold LCD TV's was changed to distribution through the "information, media and home appliance" channels that sold word processors and telephones.

Official release of QV-10 as a product was made in November 1994, six months behind schedule. Once the product was announced, RS-20 project moved to the mass production phase and structurally it came under the control of the PI Division. Project members retained their status as belonging to the R&D division, but they were seconded to the Visual Equipment Division and their physical base of activities were moved to that Division. At the same time, additional staff for production management, material procurement and quality control joined the project team from that Division, bringing up the team size to 20.

Production took place at the Komaki Plant of Aichi Casio where the Visual Equipment Division was producing LCD TV's. Fortunately, people involved in the K Project in producing the VS-101 at Yamagata Casio had been transferred to Aichi Casio by that time. The basic production policy was not to require special production facilities or production technologies. Therefore, except for setting up a new production line and new jigs, existing general-purpose mounters to mount components on circuit boards, calibration instruments and computers were utilized.

4.3. Perception of RS-20 within Casio and Negative Reception

QV-10 was developed under rather an oppressive atmosphere that cannot be imagined from the explosive success it later enjoyed in the market. After the RS-20 project theme was approved in December 1992, the enthusiasm waned within the company. Project Theme Committee to evaluate the progress status was held every few months in the presence of the President. Even the President, who had been initially supportive of the project, began to voice cautious views. The discussion often revolved around what other uses it has other than the sanctioned use as a LCD TV. Nakayama and his staff presented a listing of one hundred other uses for it, but it did not have sufficient impact on the committee to turn around the general cool reception the project received within the company.

At that time, the price of LDC TV's were set to increase proportionally to the screen size. In comparison to the then current market price scheme, 50,000 yen for an 1.8 inch screen was too expensive. The majority opinion within the company then was that, even though it may have others uses, such capabilities were only worth an additional 10,000 yen or so. This was the main reason for Nakayama to change the product concept for QV-10 from being "an LCD TV with a built-in camera" to "an image input device for personal computers". Nakayama recalls, "You see, it was impossible to justify the price of 50,000 yen for an LCD TV even with a built-in camera. We had to sell it as being something other than an LCD camera." Even this change in the product concept failed to eradicate the negative feel that existed for the product within the company.

The following three factors may have contributed towards this negative reception of the product within Casio. Firstly, being unfamiliar with computers, the top management, who had great influence in shaping corporate consensus, failed to comprehend the full implications of the product concept of an image input device for personal computers. Secondly, digital cameras being offered on the market at around 100,000 yen were not selling well. Thirdly, the failure of VS-101 had left a lasting impression of negativity toward digital cameras in Casio. Nakayama recalls, "Yes, there were these negative feelings inside the company, you can say the legacy of VS-101. People saw that the same people are doing a similar camera again. No one was willing to bet on us."

The manner in which QV-10 was announced in November 1994 reflected the way the project was perceived within Casio. It had been the established practice to hold a special presentation whenever a new product from a MINKEN project were announced, and the President always attended such presentations. However, the RS-20 project received a

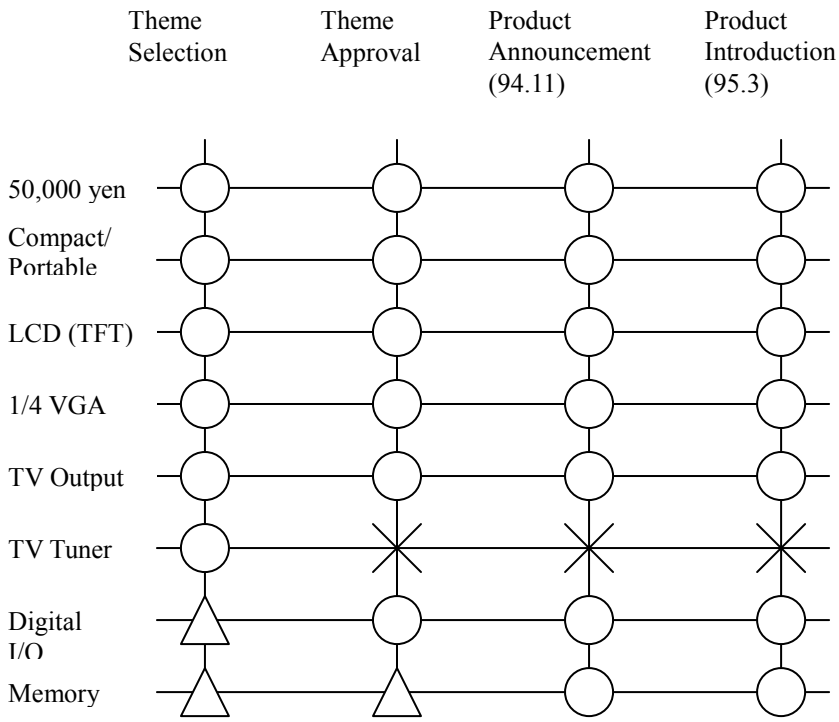
different treatment, for on two occasions, it was suggested that QV-10 be presented as an additional announcement at another MINKEN project product announcement. It never came down to this joint announcement format, but the announcement of QV-10 turned out to be a rather somber occasion, It was just a pamphlet distribution occasion with no speech from the President.

This negative attitude towards QV-10 was also reflected in the expectations of the marketing department. In June 1994, the production rate of QV-10 was set at 3,000 units per month. Yet, the sales people regarded this figure as just a target set on paper. Most thought that it would sell at the most around 300 units per month. The memories of the hard time they had marketing the VS-101 were making them pessimistic.

4.4. QV-10 Product Specifications and Changes Thereof

Product specifications and concepts of QV-10 underwent several changes since it was first approved as a “camera TV” for product development in December 1992, until its ultimate announcement as a “digital camera” with emphasis on being an input device for personal computers in November 1994. (refer to Figure 1 for how product characterization changed over time.) This history of having undergone several changes in its product specifications and concepts is one of the most important aspects of the development process of QV-10. It did not start by a single person defining the product concept of the QV–10. Rather, the product concept gradually evolved into its final form through a process of taking heed of divergent opinions that various people in the company held of digital cameras and by also watching the changes occurring in the market over time.

Figure 1: Change of QV-10 Specifications



○: Same as the final product specification

△: Different from the final specification

×: Deleted function

Product attributes assigned to QV-10 during its course of development can be classified into eight categories. (Please refer to Table 2 on specifications of QV-10.) ① Street selling price of ¥50,000, ② Small size and Portability, ③ TFT LCD Monitor ④ 1/4 VGA Image Recording at 320 x 240 pixels. ⑤ Video output terminal (ability to show images on home TV sets) ⑥ TV(television) Tuner ⑦ Digital I/O port (ability to exchange data with personal computers) ⑧ Internal Memory (Recording medium, determine maximum number of storable images).

The following section describes how each of these attributes were conceived by different persons within Casio and how it evolved to their respective final form.

(1) Retail price of 50,000 yen and image resolution

Street selling price of 50,000 yen had been the most stringent stipulation since the initial

approval to develop QV-10. This figure of 50,000 yen was something that Nakayama had arrived at through his varied and long involvement in planning mass-produced consumer products. Nakayama says of this magic figure, “There are several pricing points in planning for mass consumer products. This ¥50,000 point seems to be point from which the market really expands.”

One of the cost shaving ideas that the project team came up with was to concentrate most of the internal data processing in the camera to the CPU (Central Processing Unit), thereby reducing the number of assembly components. They design an architecture that employed a relatively fast CPU to let the software replace most data hardware based processing. A Hitachi SH microcomputer, a 32-bit RISC CPU, was used together with a co-processor that carried most of the minimum required hardware circuitries. This product architecture that depended on software for data processing was the most important design attribute of QV-10.

The advantages of using software based processing, instead of hardware based processing, are reduced number of components, reduced power consumption and resultant reduction in production cost. However, increasing the amount of data to be processed by software means heavier load on the CPU, and the time to process data for one image tends to take longer. It may take 30 seconds to process a high-resolution image after pushing the shutter button. It was not a problem that could be solved by simply replacing the CPU with a faster one. This made it necessary to drastically compromise on the resolution quality.

Where competitors used CCD with around 350,000 pixels, QV-10 used Sanyo’s CCD which only had 250,000 pixels. In video cameras, CCD signals are read into image (one frame) in two steps. However, in QV-10, only the first set of signals is used to read in an image (field image). By reducing the amount of signals to be processed by half, the designers reduced the load on the processor. Another example of reducing load on the processor can be seen in the choice of quarter VGA image size of 320 x 240 pixels adopted in QV-10, rather than the standard 640 x 480 pixel VGA image size used by its competitors.

Because of the past collaborations in developing DC-90 and T-300, CCD was supplied by Sanyo, ASIC that converts CCD signals to A/D was jointly developed with Sanyo, and ASIC for image compression and video signal generation was jointly developed with Hitachi. This continuity was another factor that made development of QV-10 easier.

Although a rather drastic compromise was made on image quality, the market did not perceive this as a fatal flaw. In fact the image quality of QA-10 was preferred for images for inserting on homepages on the Internet, as the processing speed of the personal computers and the Internet communication speed at the time were slow. Yet, to say that someone at Casio had the foresight to predict this consumer preference for the smaller image size would be farther from the truth. Holding down the street selling price at the prescribed ¥50,000 level was the justification for this compromise on image quality. However, it is also true to say that there were other thoughts and opinions that made it easier to accept this compromise on image quality.

There is no denying that Suetaka and his team, who had been working in the shadows to develop digital cameras in the wake of the failure of VS-101, wanted to build a technologically satisfying product, like the ones their competitors were offering in the ¥100,000 price range. Yet, Suetaka's desire to resurrect the digital camera business at Casio made him swallow his pride as an engineer and to accept compromises on certain aspects of the product.

The fact that QV-10 was first portrayed as a camera TV also made the idea to compromise on image quality easier to accept. Nakayama, who played a pivotal role in the evolution process of VQ-10 from the concept for V^2 Memo through to camera TV recalls as follows.
"We never conceived of it as an input device for personal computers. It basically started with a more or less simple idea to feed the image to a TV. In this respect, image quality similar to a VHS frame was quite acceptable. If we started out with the intention to build a specialized digital camera to be used as an input device for personal computers, we would not have made such a compromise. We would have said that the quality must be VGA of such and such quality from the beginning."

Although image quality was an important attribute in a product such as the V^2 Memo, which was a portable image recording business tool, and for a TV with built-in camera, "a clean image on LCD" was the minimum requirement. In fact, this "clean image on LCD'" was one of the selling points presented to the top management. The then top management had little inkling for personal computers, thus being told that the image format is not at full VGA did not register as a flaw. Therefore, it was no surprise that the only judging criteria for image quality was whether it was clearly displayed on LCD or not. Unlike its competitors, having an integrated LCD may have been a decisive factor in being able to allow drastic compromise on the image quality.

(2) LCD Monitor

A built-in LCD monitor is also another attribute of QV-10 that had been set from the beginning. No one voiced any objection to this idea throughout the development process. The ability to be able to check the recorded image on the spot was one of important functions that gave QV-10 an edge over its competitions. However, in terms of its main use as an image input device for personal computers, being equipped with an LCD was not a requisite condition. How then was the decision to integrate an LCD into QV-10 arrived at?

For Nakayama, who started with the idea of a memo tool, such as the V^2 Memo, an integrated LCD was a key attribute of the product concept. When Nakayama came up with the idea for V^2 Memo, he never thought in terms of exporting images to personal computers. He saw it primarily as a portable recording tool that stores voice messages and images. Nakayama himself had said that an integrated LCD would not have been considered if he had started out with the idea of building an input device for personal computers.

Nakayama's background of having spent a number of years at the visual equipment business was another factor that made an LCD an integral part of QV-10. Prior to being put in charge of planning solely of digital cameras, Nakayama had been charged with strategic planning of LCD TV's for the Visual Equipment Division. It was during this period when his idea of an LCD TV's began to incline toward "cameras" and eventually evolve into "portable image recording device".

Compared to when the concept for V^2 Memo was presented, more emphasis was placed on QV-10 having an Integrated LCD. This was a conscious attempt to gain approval of the top Management. It had been held that the reason for turning down the concept for V^2 Memo was that the product concept projected an image that V^2 Memo was foremost a camera. The term "camera" was easily associated the failure of VS-101. Therefore, by emphasizing the TV aspect, and by portraying it as being a vehicle to revamp the LCD TV business, they had sought to clear these hurdles. In this context, there had to be an LCD monitor incorporated in the QV-10.

There were other internal corporate factors that favored the idea of incorporating an LCD monitor in the product. Lagging behind its competitors, Casio had built a TFT liquid crystal panel manufacturing plant in Kochi in 1991. However, the LCD market was already showing signs of being over supplied when the new plant came on line. Furthermore, Casio's plant

was designed to produce LCD's for use in electronics home appliances such as video cameras and TV's, which market had already been saturated. To make maters worse, the LCD TV business was not living up to the initial high expectations and sales of LCD TV's failed to meet the target. Under these circumstances, Casio was encouraging development of new products that utilized LCD's. Therefore, it was imperative that the new product utilized TFT LCD panels.

However, for Suetaka, who had been pursuing digital cameras from the very beginning, it was not necessary to include an LCD. He could have seen it as just being an additional cost factor. However, Suetaka had no reservations in having a built-in LCD. His experience of having to fit a LCD when developing the prototype DC-90 must have made the engineer inside him more accommodating to the idea. Having taken various shots with the proto-type in the field and verifying the captured images on the built-in LCD on the spot, he had already experienced first hand, the usefulness of a built-in LCD.

(3) Digital Input / Output Port

Digital I/O (Input and Output) port is necessary to exchange image data with personal computers. Considering the fact that QV-10 turned out to be primarily used as a digital image input device for personal computers, hindsight indicates that provision of this facility was perhaps the most important attribute of QV-10. Yet, it is interesting to note that priority given to this important attribute had undergone changes throughout the history of its development, The idea to take out the digital I/O port was never contemplated during its development, however this is not to say that the importance the market would later give it was recognized by the development team from the beginning. Because it started out as a camera TV, digital I/O port was given a lower priority compared to the video output terminal. SHIMIZU Tomohiro, who later became the General Manger of QV Development Division, recalls those early days:

"(It was fine if we could see it on the TV screen.) In the beginning, we thought that it was sufficient if one could see images on the LCD, or if it can show images on LCD and on TV via the video terminal."

It was Suetaka that voiced the strongest objection to this line of thinking. He had persisted on having digital input / output capabilities. One reason for his persistence was his commitment to digital cameras after the failure with VS-101. The proto-type was used on many demonstrations of other products and the ability to connect with personal computers had turned out to be quite useful. This experience was another factor.

However, it would be far from the truth if one were to say that Suetaka had foreseen that so many end users would be using QV-10 to take in images to their personal computers. Suetaka himself explains the reason for his insistence on keeping the digital I/O port as follows:

“Why was it important to have digital I/O? When one needs to debug the image processing logic, it’s all done in the CPU. So, you cannot debug without the digital I/O ports to access the CPU. That’s why I said only over my dead body can they remove it.”

In other words, Suetaka needed the digital I/O port for product development purposes. It was imperative that they be able to extract the digitally processed image form to CPU to verify the accuracy of the digitization algorism. It was for this reason that the digital I/O port was provided. The product concept for QV-10 that started as a camera TV was transformed to that of a digital camera with emphasis on connectivity to computers after the Development Theme Committee held in January 1994. With this change in product concept, the importance of the digital I/O capability increased and the characterization of the product towards the outside world gradually began to emphasize it as a periphery device for personal computers.

By the summer of 1994, the distribution section advised the development team that according to feedback from the computer retail market, it looks like there would be quite a demand for the product once it reaches the market. Based on this input, utility software for transferring image data to personal computers was developed before its product release in November 1994. At the same time, the decision was taken to switch the distribution channels for QV-10 to information / home appliance channel from the originally planned audiovisual products channel. This change in the distribution channel affected the position of the RS-20 project within the corporate structure. The RS-20 Project was transferred from the Visual Equipment Division to the Word Processor Division in June 1995 after the product was released to the market. The main reason for this transfer was that it was believed that the Word Processor Division would be better equipped to technically evaluate software development than the Image Recorder Division.

The change in product concept was to take advantage of the tremendously growing personal computer market. On the other hand, it reflected the fact that Nakayama began to perceive the limitations in the product concept of a camera TV. Here is how Nayakama put it in his own words.

“The prescribed street selling price of ¥50,000 was still perceived as being too expensive

for an LCD TV. You might call it a new culture, but it takes time to catch on. I felt that it would be wiser to focus on the input device for PC angle. I thought other usages would be discovered in time."

For Nakayama, changing the product concept to that of a periphery device for PC's was a milestone for the image communication culture that he had envisioned. In a sense it was a compromise for him.

(4) TV Tuner

Considering the fact that QV-10 started off as an LCD TV with a built-in camera, a TV tuner was a necessary component. In fact the product mockup readied in December 1993 that closely resembled the final form of the QV-10 when it was eventually put to the market, had a TV tuner and an earphone jack built-in. The TV tuner was one of the attributes that had caught the interest of the top management. However, when the product concept was changed at the Development Theme Committee in 1994, the TV tuner component was to be deleted. The obvious reason for deleting the TV tuner was that it was no longer required on a product that was now characterized as a periphery device for computers. However, development team members were considering deletion of the TV tuner form different perspectives.

As development work progressed, Suetaka began to incline towards the idea of deleting the TV tuner from QV-10. Suetaka gives his reasoning as follows:

"There are a few reasons why I began to consider deleting the TV tuner function. Some people began to question why the broadcast images cannot be stored within the product. Then, there is always the problem of deteriorated screen image of LCD TV's associated with poor broadcast signal reception. I always hated that aspect. Yet, on the other hand, for a long time, (top management) insisted that a TV tuner must be incorporated in the product. (They say) that, if we have problems with poor reception of broadcast signals, that was an indication that there were inherent problems with the liquid crystals. We needed to do something about that and that included improving the liquid crystal technology."

Suetaka, who had been struggling with the development of digital cameras for a number of years, wanted desperately to turn it into a viable business and to that extent, he had accepted the concept of a camera TV. Yet, there were no quick solutions in sight for these problems associated with the TV tuner aspect of the product. It occurred to Suetaka that the advantage that this function will give the product in the digital camera market seemed to

be quite marginal in comparison to the degree of difficulties the problems were presenting.

On the other hand, Nakayama was considering deleing the TV tuner function from quite a different perspective. When the product concept was changed, Nakayama had also thought about shifting the target market to the commercial / business segment. If its primary target market segment were to be the business community, then it would be better not to have a built-in TV tuner. When QV-10 eventually went on sale, it sold mainly among the mass consumers. Yet it should be noted that this switch in targeting for the business community was one of the reasons for the TV tuner function to be deleted from the final product. This is how Nakayama puts it in his own words:
“When the decision was taken to change the product concept towards image input device for personal computers, I thought that the business community would find many uses of the product. If the primary usage would be for business, having a built-in TV-tuner might actually turn into a liability.”

(5) Internal Memory

Another specification that was changed during the development phase pertained to the internal memory. The size of the internal memory remained at 512 KB from the incept until the Development Theme Committee of January 1994. That gave the product a storage capacity of 24 frames. However, when the distribution people previewed the product in 1994, some claimed that storage capacity of only 24 frames was too small. In response to those claims, it was decided to increase the storage capacity. By the time of its official product release in November of the same year, it came equipped with a 2 MB flash memory, i.e. with four times more memory than the original specification. This gave the product an internal storage capacity of 96 frames.

5. **Summary Discussion**

The path that development work of QV-10 took was far from being smooth. It did not start with a clearly defined product concept, nor was there any structured support in place. Suetaka, Nakayama and the top management each held different ideas for the product. There was no consensus on how to prioritize the attributes of the product. The final characterization of QV-10 was formed gradually by ramming together differing opinions coming from different perspectives, compromising on some and at times searching for

avenues to accommodate multiple objectives.

When one compares the final product concepts for QV-10 such as “Connectivity to Computers”, “Use of LCD”, “Easy Portability”, to how the production model turned out, one can see components that were initially intended for different purposes working together in realizing those attributes. The development process of QV-10 that underwent several changes, stating first as a still photography camera, then evolving into the V^2 Memo, then to an LCD TV with built-in camera and finally to a digital camera, can be said to be a process of constant merging and finding ways to allow differing concepts to co-exist.

The problem of not being able to reach a consensus on product development policy because it is difficult to read where the market might be heading is an inherent problem when developing an innovative product such as QV-10. At the same time, it takes a flexible organizational process and flexible problem solving methodology when one needs to successfully navigate through the complex internal corporate consensus building process, while adopting product development concepts and performance criteria to meet the ever-changing demands of the market. We saw such a process working in the development of QV-10.