Social Innovation
~Case Study on Broadcasting Industries~

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Abstract: Words including “innovation” have been overused as if they were phrases in vogue, e.g. “ seeds innovation ”, “ product innovation ”, “ needs innovation ”, “ process innovation”, “ disruptive innovation ”, “ sustainable innovation ”, etc. The concept of innovation proposed by Schumpeter has greatly contributed to expanding and revolving the modern economy in the various areas of science, engineering, economics, and business developments.

We had been working long for a broadcasting station as research engineers and were deeply involved in the development of HDTV, also known as Hi-vision, not only involved in the engineering aspect of HDTV but also in its related business developments. HDTV has been diffused throughout the world, typically observed where rapid penetration of digital TV sets featuring high definition, a large viewing area, and thinner profile are available.

Needless to say, the success in Hi-vision diffusion originates in solutions to technological challenges reached through the ceaseless efforts to pursue the synergistic effects between Hi-vision programs and technologies. We named this innovation “social innovation” because it has greatly influenced not only technological industries but also cultural industries, namely those involving total social systems.

This paper is an overview on the history of individual Hi-vision componential innovations mainly focusing on technological challenges, including the development of fundamental audio and visual systems, technical standardization, satellite broadcasting systems, image sensors, and displays. Then, it describes what factors caused Hi-vision to be accepted worldwide. Finally, we conclude the paper by recognizing that all success achieved was supported by “entrepreneur engineering”.

1. Introduction

According to the history of broadcasting around 1965, TV program services had been transitioning from black and white to color. The technology for color services however, was still at an early stage, particularly for the receivers in the home. Home color receivers were still using unreliable vacuum tubes, and home recording equipment had yet to be developed. NHK (Japan Broadcasting Corporation) launched the Hi-Vision concept when the conventional TV system was not even fully developed. In 1967, USA succeeded in launching a manned spacecraft to the moon in its Apollo program. The scene of astronauts walking around on the moon created a worldwide sensation. This was the era in which we kicked off the R&D for Hi-vision. We had to change our mindset by catching up, in becoming the front runner of the world [1] as shown in fig.1.

This paper traces the history of the Hi-vision from the seeds innovation to the needs innovation mainly from the view point of entrepreneur engineering, and clarifies what kind of revolutionary technologies and business administration factors led the Hi-vision system to the creation of new social systems both for broadcasting cultures and businesses[2],[3].

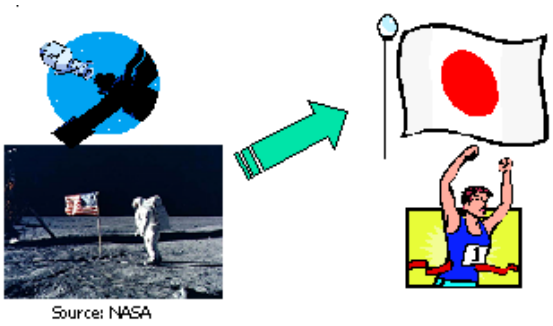

Fig.1 From catch-up to front runner in the TV world

2. Overview ~seeds innovation to a global standard~

Fig.2 shows the empirical law for the broadcasting media life of thirty years. This

law corresponds with Kondratiev"s well-known wave law supported by the technology lifecycle.

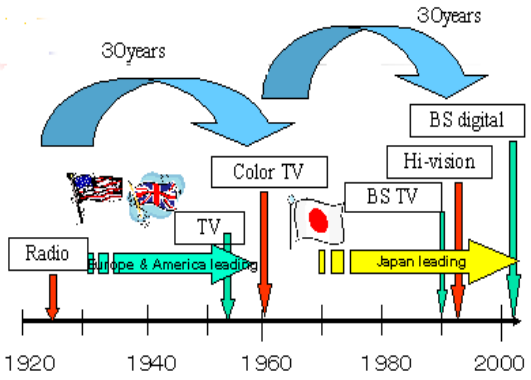

Fig.2 Empirical law for broadcasting media life of thirty years (following Kondratiev's law)

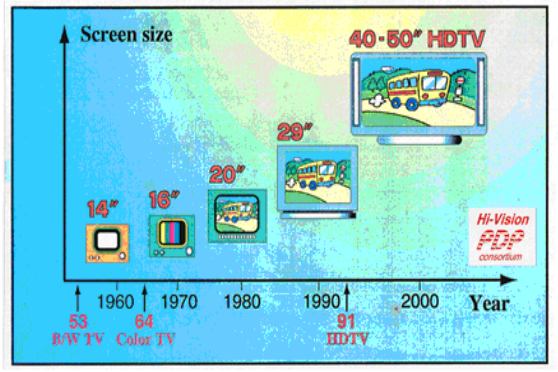

Fig.3 The Never-Shrink empirical law for TV screen size

Fig.3 shows another empirical law, named as the Never-Shrink law, for TV screen size. The most popularized TV screen size in Japan was 14 inches in the 1960's, and then enlarged to 16"-20" from the 1970's to the 1980's.

Furthermore it reached 29" around 1990 as the so-called "Bubble Economy" was approaching. Nowadays the most diffused size for TVs is 32 – 42 inches in accordance with the popularization of thin, flat screens.

The empirical laws mentioned above indicated that large-size TVs would be in demand in the period from 1990 to 2000, when more than thirty years would have elapsed since TV broadcasting has started. That prompted NHK to begin tackling the R&D for high definition TV.

Fig.4 shows the schematic history of Hi-vision innovation. Needless to say, the earliest challenges were technological

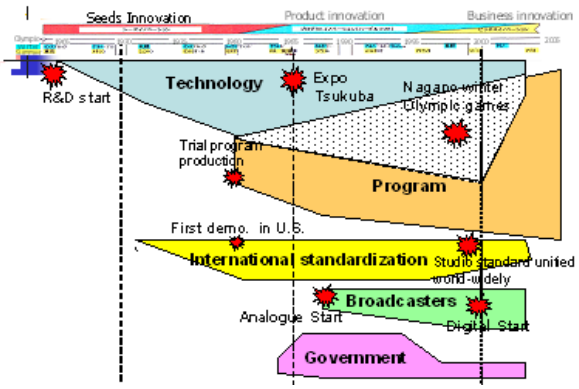

Fig.4 Schematic history of Hi-vision innovation

challenges, or seeds innovations. The first step was to search for optimal technical standards in the area of audio visual science. The second step was to develop elemental technologies for trial program production e.g. cameras, recordings, and displays. Other transmission technologies were later produced. In the 1985 Tsukaba Expo, researchers were able to demonstrate that the whole HD system was lined up and ready to go, from the image pick-up method to the displays and the program transmission method. However, most of these were still prototypes. Program productions mainly tried to show the potential these new technologies had and create social awareness.

3. Product innovation

3.1 Global standardization

The effort to create unified technical standards started at the beginning of 1980s. However, it took about twenty years to achieve worldwide standardization. Hi-vision was a rare case of worldwide standardization that had originated in Japan.

The HD experimental broadcasting started in 1989 with an analogue transmission using a direct broadcasting satellite and at the year 2000, HD broadcasting was fully digital.

Governmental support had just started before the Tsukaba Expo in 1985. Its purpose was mainly to serve as financial back-up for the Expo but it was also used to promote and introduce HD broadcasting around the nation.

. The new system which is incompatible with prior systems, such as the Hi-vision system, generally needs about thirty to forty

years from the seeds stage to the product stage. Discontinuous innovation generally takes a long period, sometimes as long as several decades to reach the product stage.

Fig.5 is the cartoon I carried around the world in the 1990s as a missionary of Hi-vision when I intended to accelerate the R&D for plasma display panel (PDP) TVs. The process by which the bulky CRT TVs evolved into thin, large-screen TVs will be described later.

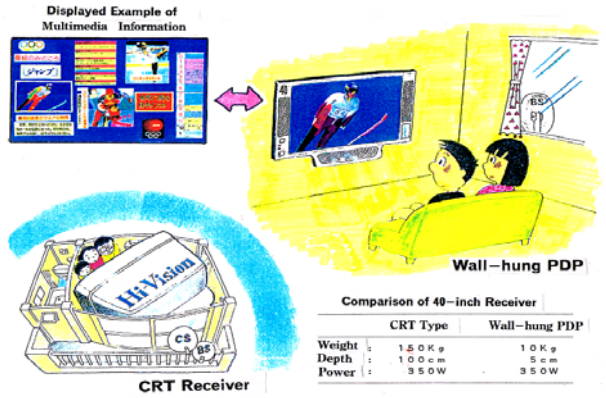

Fig.5 The cartoon I carried around to propagate thin HD TVs

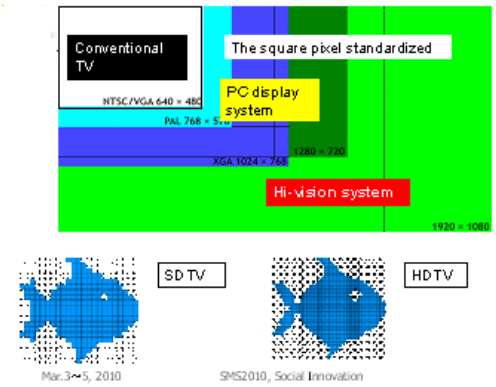

Fig.6 Hi-vision specification with super resolution, compatible with computer displays

Fig.6 compares the resolutions specified for Hi-vision and computer displays. The resolution of Hi-vision exceeds that of computer displays, with a total of 1920 pixels (V: vertical) x 1080 pixels (H: horizontal) pixels (the green painted area), while the typical computer display resolution specification, or that of SXGA, is 1280(H) x 1024(V) (within the green area). Furthermore, Hi-vision resolution was designed to be equivalent to the 35mm movie

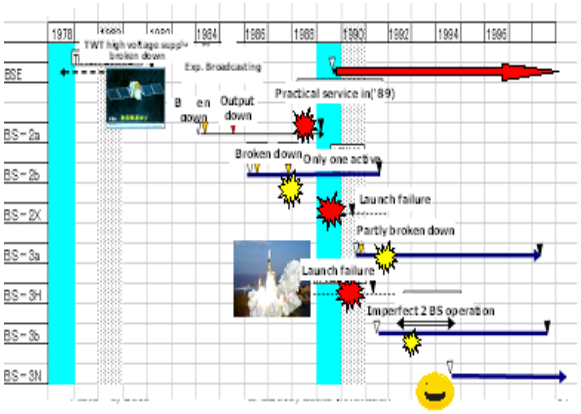

Fig.7 A timeline on the adversity to attain practical BS (Broadcasting Satellite) services

film format. In other words, the resolution of Hi-vision is designed to cover a the wide variety of image medias.

3.2 Forty years of adversity spent for direct satellite broadcasting

Fig.7 shows the road map which illustrates the challenges faced during the promotion of direct satellite broadcasting services. Broadcasting via satellites features wider transmission capability and wider area-coverage, which can cover all of Japan and do so with more channels. The first engineering BS (Broadcast Satellite Experimental) to examine the possibility of direct BS broadcasting was launched in 1980, but soon after the operation the high voltage supply system broke down; in other words, the first BS was failure.

However NHK never gave up and kept working on launching renovated BS's, naming one by one BS2a, 2b, 2x, BS3a, 3b from 1984-1992. All of them however, encountered either partial or total failure. It was in 1994 when the first perfect launching was achieved. All the while, pay broadcasting BS services had started in 1989 even under imperfect conditions. Engineers however, were able to overcome the failures encountered because of the engineers' entrepreneurship towards the dream of broadcasting from outer space.

Fig.8 shows the transition of BS receiver diffusion. Analogue broadcasting began in 1989 while digital broadcasting started eleven years later in 2000. BS services are simultaneously running both analogue and digital until 2011 when analogue services will be shut down.

The figure shows the rapid diffusion of BS receivers, particularly of the digital ones. Needless to say, the steep diffusion is owed to broadcasters' diligent efforts, but other factors,

which will be described later, attributed to TV set manufacturers should not be overlooked.

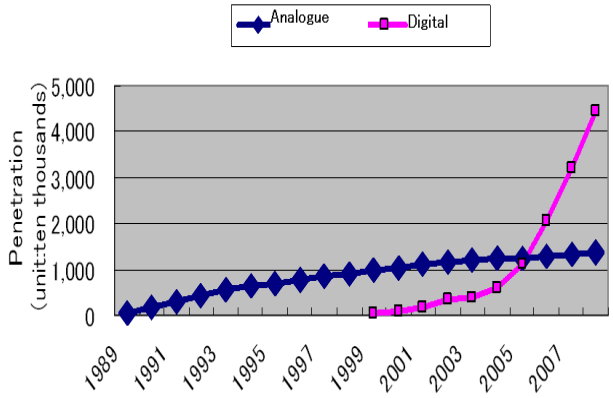

Fig.8 Transition of BS receiver diffusion

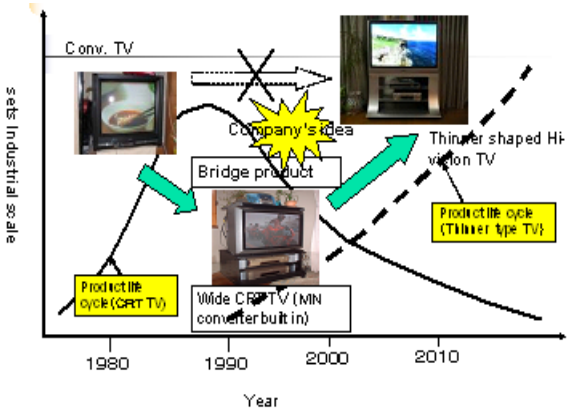

Fig.9 Companies' idea to diffuse Hi-vision ~business creation by bridge products~

In the early stage, a Hi-vision TV set was unbelievably expensive, almost comparable in a price to a luxury car due to the tiny production scale and huge R&D expenditures.

Fig. 9 illustrates how TV set manufacturers devised wide TV sets with even wider screens featuring the aspect ratio of 16:9, despite the resolution staying at the conventional TV level by omitting expensive Hi-vision signal processors.

However, the wide TV sets were cheap and sold well, contributing to the decrease in the cost of glass valves for CRTs which are compatible with the Hi-vision ones. This accelerated the diffusion by cutting down the cost of a Hi-vision TV set.

Bridge products such as the wide TV sets, have shown to be indispensable in aiding the diffusion of newer innovative products, although they themselves are discontinuous technologies having no compatibility with prior products.

Fig.10 shows another example of bridge products. The resolution of Hi-vision has

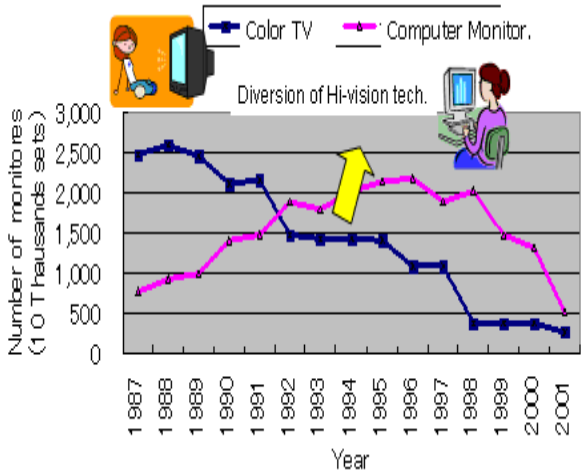

Fig.10 Companies' idea to diffuse Hi-vision ~creating a HD computer monitor market~

resolution high enough for computer display as shown in Fig.6. Hi-vision set manufacturers created a new market of computer monitors as shown in Fig.10 by making the best use of their super resolution technologies. The shipment of CRT computer monitors exceeded those of the TV sets in 1992. The trend continued until 2000 when they were replaced by liquid crystal display monitors.

3.3 Innovation in image sensors and cameras

Fig.11 shows the history of image sensors and cameras. Of all electronic TV systems, the world's first success was when Dr. Takayamagi displayed the Japanese Katakana letter " ㋑" being displayed on CRT in 1926, although the total number of scan lines was only about 40 lines. Thereafter, the compactness and the fundamental performances of image sensors and cameras, e.g. the sensitivity, the resolution, have been advancing yearly. TV broadcasting in Japan began in 1953, and about forty years later, both satellite broadcasting and HD broadcasting started in 1989. R&D on HDTV had started in 1964, as mentioned before.

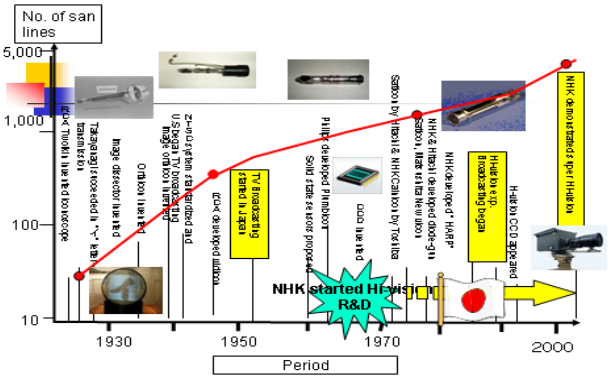

Fig.11 History of image sensors and cameras

In 2002, NHK demonstrated to the world the first, super Hi-vision which had a total number of 4000 scanning lines. Looking back, there are two factors that contributed to this epoch in Hi-vision history; the first being the dramatic progress of technological innovation leading to a one hundred fold increase in the total number of scanning lines over the past ninety years, and the second being the shift in technological leadership from Europe and America to Japan during the 1960s when Japan kicked off the R&D of the Hi-vision program. Broadcasters created not only huge new AV product markets, but also richer AV cultures through Hi-vision innovations. It developed a new market for AV home appliances typically seen in the digital still camera market.

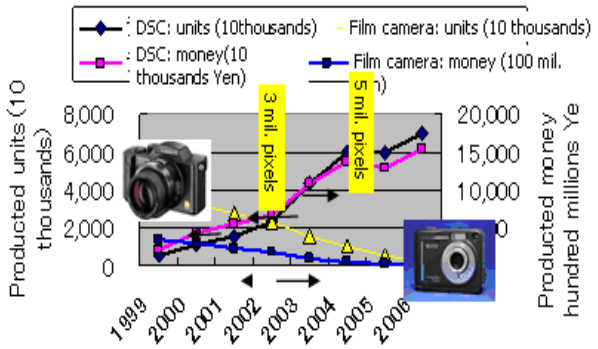

Fig.12 New market creation by image sensor innovation ~ the market transition of digital still cameras and film cameras ~ (source: CIPA market report)

Fig.12 shows the diffusion transition for film cameras and electronic cameras. In 2002, the digital camera market exceeded the film camera market and now has entirely replaced it, mainly owing to the evolution of image sensors.

3.4 Large areas, thin displays, and receivers

In the early 1990's, we carried around a picture (illustrated Fig. 5) to advocate thin, large displays for the coming Hi-vision era. The most promising display suitable for Hi-vision was considered the plasma display panel (PDP) because it has inherent advantages such as a larger screen size due to having no need for built-in thin film transistors (TFTs). Fig.13 illustrates the history of PDP innovation.

PDP was invented at Illinois University in 1964. It was the Alternate Current (AC) type PDPs that led to the commercialized products we see widely distributed today.

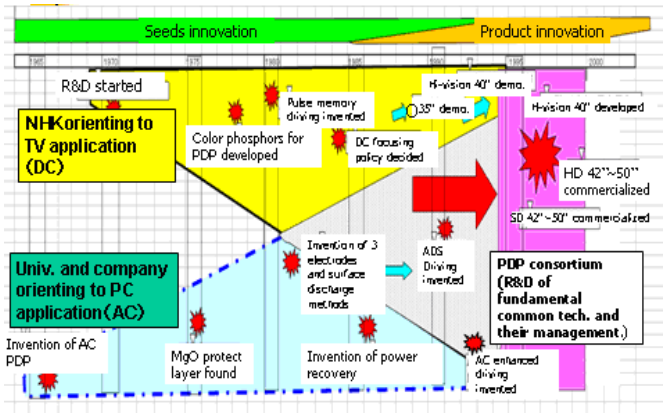

Fig.13 History of PDP innovation

Since then, commercialization became competitive until the 1970s. Companies such as Owens Illinois and IBM etc. released the world's first PDPs one after another. Many Japanese corporations e.g. Fujitsu, NHK followed. Their future targets were divided into two streams, namely toward the computer display oriented and the TV display oriented.

The PDP market was once built up, however, soon shrank due to their insufficient performances, mainly the lack in the capability of a full color display.

During 1970-1990, many technological break-thorough inventions such as phosphors specialized for PDPs, a MgO layer to protect the electrodes from discharge damage, and the feasible addition of a memory function, contributed to improvements in PDPs. In other words, technological barriers that were encountered during commercialization were almost all removed around 1990.

However, the movements toward market dominance had not accomplished this goal yet, because competitive products or LCDs were being introduced into new markets and being improved upon. Furthermore, Japanese electronic industries were faced with an economical hollowing due to the production site shift overseas. In other words, PDP had just encountered the Death Valley, illustrated in Fig. 14. So many people were acting too cautiously; it was like they were walking on eggshells.

NHK had strong intentions to propagate HDTV as early as possible and made a decision to establish a consortium to supply seeds money, seeds technologies and human resources without soliciting any governmental support.

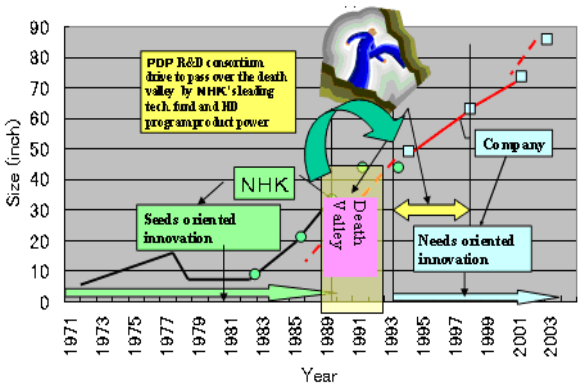

Fig.14 Driving the PDP commercialization by the consortium

The consortium was named the Hi-vision PDP Consortium and 26 corporations joined. The reasons behind the consortium establishment are the following:

- No industrial infra-structures at all for PDP
- PDP production was seen as a high-risk industry
- No related industries, no leaders
- NHK strongly desired to diffuse Hi-Vision as a part of its future
- Then, a consortium formation was established!

The consortium's technology roadmap is illustrated in Fig. 15. It had a clear, fixed target accepted by the consortium members, or the 1998 Nagano Winter Olympic Games. The specifics of the target are the following:
(1) a 40" practical model of Hi-vision PDP
(2) a 50" prototype Hi-vision PDP

I led the consortium as the secretary-general, and constructed the well functionalized collaboration system. I also induced competitive R&D activities among members by using unique MOT (Management of Technology) methods, e.g. matrix management between the themes assigned and the organizations responsible, the parallel run of .centralization, decentralization of R&D activities, etc.

Let's introduce an anecdote behind the R&D initialization and activation. At the early stage of PDP, functions such as brightness and resolution were

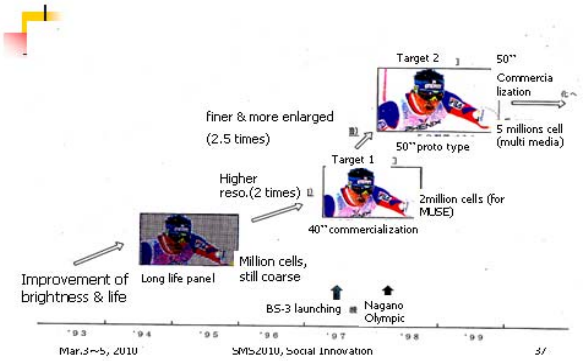

Fig.15 the consortium's technology roadmap

still behind the practical level; and then, an idea came into place.
Imagine a "karaoke room" where the lighting is dim and characters are displayed large enough to be readable even far away from the screen. I thought PDPs, even though they were at an early stage, could be available in the "karaoke room", and I invited the companies' VIPs to demonstrate the world's first PDP Karaoke as shown in Fig. 16.

That stratagem, though a little bit tricky, hit the nail on the head and instigated the motivation to accelerate the commercialization of PDPs.

Fig.16 World's first PDP Karaoke

Fortunately we accomplished all in the scheduled period of five years. The key factors in success are listed below:

- Optimal build-up timing: changed the company presidents' uncertainty even though the PDP's future was unclear.
- Clear target settlement (the Nagano Olympics and diffusion of Hi-vision)
- Exquisite balance between collaboration and competence

□Removal of governmental interference (no funding from the government↗
□Semi-open innovation
□Existence of a powerful leader (NHK: leading technologies and excellent Hi-vision production abilities)
□Intense promotion by the consortium

Fig.17 shows the public demonstration of a PDP that has been developed; where a Hi-vision program of the Nagano Winter Olympic Games was received.

Fig.17 Public demonstration of the Nagano Winter Olympic Games on a developed PDP TV

The Nagano Olympic Games became a turning point for digital Hi-Vision, resulting in the start of BS digital broadcasting in 2000 and digital terrestrial broadcasting in 2003. Hi-vision receivers were steeply popularized as shown in Fig. 18.

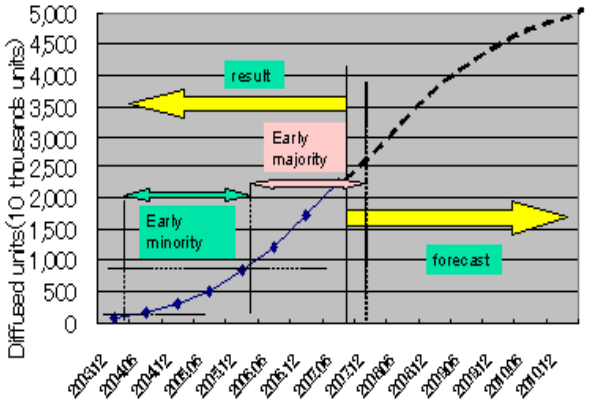

Fig.18 Diffusion curve of digital Hi-vision receivers

7↜ Conclusion

This paper describes the Hi-vision success story from the beginning to the practical stage from the view point of entrepreneurial engineering and is summarized below:

□Introduced the Hi-vision success story which originated in Japan
□Hi-vision contributed to create not only new industries, but also cultural revolutions as well.
□The innovation should be named a! pivotal social innovation because it has enriched a number of social lives.
□Finally concluded that a determined, innovative mindset or entrepreneurship led the success.

Acknowledgement

I would like to express sincere thanks to the SMS 2010 secretariat for giving me this honorable opportunity and also to my colleagues for sharing their research and development for the HDTV system with me.

Reference

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