Inför seminariet på Nobelmuseet 30/11 2009: Detta är första versionen av de inledande kapitlen i en kommande bok: *A Story of HD-Divine or Digital Television on the Line.* Jag ser fram emot allehanda synpunkter och kommentarer i arbetet med att färdigställa boken!/Lena Ewertsson

A Story of HD-Divine or Digital Television on the Line

In July 1992, a prototype system for so-called ’high definition television’ (HDTV) called HD-Divine was demonstrated at one of the world’s most important radio and TV exhibitions and conferences, the International Broadcasting Convention (IBC) in Amsterdam. A few weeks later a specialist journal reported upon the event:

> The launch of HD-Divine (p. 6) absolutely stole the Amsterdam show, proving that clever technology still triumphs over the welter of hype that tends to swamp business-to-business shows. (*International Broadcasting*, 1992, August, Volume 15, No 6, p. 3)

The demonstrations of HD-Divine at IBC’92 were attended by research leaders, engineers, business executives and others who in their everyday work were struggling to shape the future of television. The HD-Divine demonstrations also gained extended coverage in the international specialist press. Yet, at the time most people among the general public did not know about HD-Divine and within a few years it had also become lost and forgotten by many in the worlds of communications systems designers and broadcasting engineers.

But even today, there are a few people who emphasize the success of the HD-Divine demonstrations at IBC’92 and how this innovative programme triumphed over alternatives and objections. If some of my sources are correct, HD-Divine had lasting effects on European television. There are, indeed, those who contend that the HD-Divine demonstrations at IBC’92 meant the death-blow to the Eureka HDTV project. They also say HD-Divine helped develop and establish some of the connections which have allowed the marriage between digital technology and traditional terrestrial (that is, earth-bound) TV networks in Sweden and other European countries during the past decade and half or so. HDTV and digital terrestrial TV really do exist today. But this was not the case when HD-Divine began to take shape.

This book exlores the genealogy of HD-Divine, seeking to give a richly detailed historical account of how this once innovative programme is connected to the past, the present and future development of television in Sweden and beyond. In short, I mobilize HD-Divine here as a useful example to analyse and question the history and sociology of innovation or what Joseph A. Schumpeter called ’the carrying out of new combinations’: to do new things, or the same things differently, by combining ’materials and forces within our reach’ in a new way (Schumpeter 1934/2007:65 f.; 14 f.).

My primary concern here is that of the historian–to describe what happened, and, as far as possible, to offer explanations of why it happened. But it is also my hope that the story I have to tell will offer a valuable contribution to the growing body of social and historical studies that in recent decades has explored theatrical demonstrations, performances or shows as powerful resources in the development of ’modern’ science and technology (for example: Collins 1988; Gooding et al 1989; Schaffer 1984; Shapin & Schaffer 1985; Smith 2009). This book builds on this rich research tradition, but it also seeks to extend the focus by exploring an issue that hitherto has attracted surprisingly little scholarly attention: the links between demonstrations and the (re)creation of technical standards. In exploring these links, the book will, in part, be a comment on some lucid arguments advanced by Andrew Barry a few years ago. With the distinction frequently made between political demonstrations and scientific or technical demonstrations as the starting-point, Barry encourages us to observe that *all* demonstrations may be interpreted as a *political* matter:

> On the one hand, because there is a politics of who can, and who should be allowed and trusted to witness a demonstration – under what conditions and in what ways. Being a witness is to adopt an ethical stance. As Steven Shapin has argued, the development of ’science’ in the seventeenth century involved an effort to regulate who could and who could not be properly called upon as witnesses to matters of fact about the natural world. On the other hand, public demonstration is political, because the telling of a truth in public can never be described as disinterested – it is always intended to have effects on, or challenge the minds, or affect the conduct of others. (Barry 2001:178; Barry 1999:77; ref. to Shapin 1994:355-407)

Also in relation to the issue of standards, Barry emphasizes the importance of rethinking an often taken for granted boundary between the technical-scientific and the political. He argues, for instance, that technological standardization is ’above all a political project’ and suggests that ’the critical importance of technical standards to government and politics is particularly clear in the case of the European Union’ (Barry 2001:26). Taking HD-Divine as an example, this book will demonstrate that Barry’s claims are hardly news to research engineers who have been involved in designing new television systems in recent decades.

There are several other reasons why HD-Divine deserves closer attention. One reason is to contribute to the academic literature that deals with the recent history of television but does not cover HD-Divine.[1] A related motive is to use HD-Divine as a window on to a particular moment in television: the emergence of HDTV as a new movement of experimentation and standardization in the 1970s and 1980s, spanning East and West in terms of sites, actors and issues. Here, it brings into scrutiny issues which are often discussed in terms of, for instance, local-global, government and truth, while making clear the cultural specificity and path dependent character of ’technological’ choices. The HDTV case is also interesting as it gave rise to a much publicized ’battle’ over standards and is frequently mentioned in scholarly discussions about the problems of reaching agreement on technical standards. Obviously, focussing on HD-Divine in relation to this ’battle’ also provides an exemplary opportunity for exploring issues related to the gradual merger of ’new’ digital technology with existing arrangements for terrestrial television in recent decades. At the least, here HD-Divine will serve as a fascinating alternative point of departure to cast new light on the shift from analogue to digital-based Swedish terrestrial TV as a nationally-organized, politically (Social Democratic) driven concern in the 1990s, assuming the identity of a fully-fledged national institution after the shutting down of the analogue terrestrial network was completed in February 2008.

The story that follows can speak for itself. I just want to give a brief introduction to its content. The ideas of HD-Divine began to circulate within Swedish Telecom in 1990 and had soon drawn participants from elsewhere in Scandinavia. By September 1991 it had been officially launched and framed as a new Scandinavian research, development and demonstration programme, designed to counter the claims and strategies of the hegemonic *Eureka HDTV project EU95* for the introduction of HDTV in Europe. Under the aegis of the European Commission, this Eureka project had been set up in 1986 with the mission of developing a common European route to HDTV, based on *satellite*-distribution and the transmission system–MAC–which at the time was under development for future European so-called direct broadcasting satellites. The publicly stated goal of the HD-Divine project was to develop and demonstrate at the IBC in 1992 a working prototype of an alternative–all-digital–transmission system that would show that it was indeed possible to transmit digital HDTV to the general public via existing *terrestrial* TV networks. With the technology of the day, many

[1] For example, hitherto HD-Divine has often been forgotten in the growing literature discussing the topic of digital terrestrial television in Europe in media economics, media history and the social sciences (for example: Brown & Picard 2005; Engblom & Wormbs 2007; Papathanassopoulos 2002; Severson 2004). Similarly, we seldom come across HD-Divine in the academic literature discussing the battle over HDTV standards in the 1980s and early 1990s (for example: Hart 2004; Tyson 1992).

specialists in the worlds of radio and TV engineering considered such transmissions of HDTV unrealistic. It was conventional wisdom that HDTV broadcasting would be only feasible from satellites and that it was impossible to transmit the huge amount of information in an HDTV signal via traditional terrestrial TV networks.

I started to collect material about HD-Divine when the programme was still in progress, in 1992 or 1993, and I had just begun to cultivate my research interest in television (Ewertsson 2001). But it was not until almost 15 years later, while doing research on digital terrestrial TV, that I became convinced that there are reasons to turn HD-Divine into the central focus of a research project in the social sciences.[2] My most important source, both in itself and in the documentary evidence to which it led me, has been interviews. In 2005-09 I conducted 26 interviews with people who were concerned with the HD-Divine project when it was still in progress, ranging from research engineers to civil servants.[3] Without their own perspectives, their interpretations, their stories and personal archives, I would not have been able to tell the following story of HD-Divine, of the demonstration at IBC'92 that became its first objective, of the historical circumstances and actions that framed it, and of the ways this particular demonstration has been remembered or forgotten in literature dealing with the recent history of television.[4]

I close this first section below by briefly discussing some concepts central to my book: innovation, technical standards and the analogue/digital divide. In the second, I provide a short history of how something called 'HDTV' emerged and evolved into a new social movement of experimentation and a common concern of two institutionalized transnational machineries of government: *the International Telecommunication Union* (ITU) and *the European Communities* (EC; now *European Union*, EU). In the third section, I move on to a more in-depth account of how a programme labelled HD-Divine came about and, among other things, led to the demonstration of an alternative–all-digital–transmission system for HDTV at the IBC'92.

[2] My research on HD-Divine has been funded by Vinnova (No 2008-02228), Wahlgrenska Stiftelsen and Bromanska Stiftelsen.
[3] Hitherto, all persons whom I have asked have been willing to be interviewed. I have also used interviews that I carried out in relation to my previous studies.
[4] I am extremely grateful to all the interviewees. Responsibility for the views expressed and remaining errors or omissions is, however, mine.

Innovation as the carrying out of new combinations

In this book, I follow Schumpeter (1934/2007:14 f., 65 f.) in his definition of innovation as ’the carrying out of new combinations’: to do new things, or the same things differently, by combining ’materials and forces within our reach’ in a new way. According to Schumpeter (op. cit. 15), ’all possible kinds of objects and ”forces”’ may be combined in innovation, material as well as immaterial, including ’natural forces’. As defined by him, *entrepreneurs* are those individuals and groups of individuals who hold a particular function in relation to the carrying out of new combination by acting as *leaders* (or ’captains of industry’); diverting the means of production into new channels and new ’circular flows’ beyond the boundary of routine (op. cit. 78 f., 89). For Schumpeter, innovation is never exclusively or purely ’technological’, but is the result of the recombination of different types of ’things’–none of which have to be new at all. He also tells us that a ’new combination’ always encompasses attempts at ’changing the existing state of the satisfaction of *our wants*, of changing the reciprocal *relations* of things and forces, of *uniting* some and *disconnecting* others’ (op. cit. 14; my emphasis). One of the interesting analytical features of innovation is the question: How is it possible that many disparate entities, relations and processes may come together in a new relatively large and stable combination, which retains its collective identity across time and space and local contingencies? Among the many social strategies that provide for predictable and durable connections–as well as disconnections–are technical standards and the work associated with some kind of written agreement about such standards.

A specific type of ’rules’: technical standards

In the parlance of the research engineers identified in this book ’a standard’ is commonly referred to as a set of parameter values that can be adhered to by a collective, either tacitly, or in accord with some formal agreement that defines the design, material composition, processing or performance characteristics of a technical system or product (cf David and Steinmueller 1992:2). I also invoke Joerges’ (1988:30 f.) definition of ’technical standards’ as norms that ’regulate what technical artifacts are allowed to do and forced to do, and how they are allowed to interact among themselves, with people and nature’. Technical standards are thus some of the regulatory devices that define what can be connected to what and what can not, what counts as boundaries and contents, what counts as legitimate and correct, and so on. Seen from this perspective, technical standards can be described as *rules* guiding or governing various kinds of interaction and relations. Such rules are sometimes called *institutions*, referring to that something (typically a practice or activity) has been established as a convention or norm in a society or some part of society.

Defined as ’rules of the game’, both formal and informal institutions set boundaries indicating what kinds of behaviour and interaction are appropriate and acceptable (North 1990).[5] Institutions provide continuity and contribute to stability by constraining the number of choices people can make, and by providing information about how others can be expected to act. Without institutions, there can be no remembrance, no repetition, no continuity, no unity, no stability, no prediction and hence no control, of interaction.

At the same time as the evolution and behaviour of entrepreneurs results (partly) from the boundaries set by established rules and routines, they in turn have to break, alter and establish such boundaries to be able to ensure the growth and stabilization of their recombinations. Thus, a crucial aspect of entrepreneurship can be seen as the work of actively using and (re)shaping not only formal regulations, but also regulatory authorities, opinions, beliefs and behaviour.

A comment on the analogue-digital divide

In the parlance of the research engineers identified in this book the word *analogue* is commonly referring to the continuous nature of some waveform. The word *digital* is commonly used where an analogue wave of information, via a sampling and quantization process, is converted into a binary numeric format where the video or audio data is represented by a sequence of "1"s and "0"s. As our senses of vision and hearing perceive the world in an analogue fashion, television cannot only rely on digital technology; analogue-to-digital and digital-to-analogue converters are needed at the input and output to the digital domain.

Decades before digital television became a household term, engineers took up the challenge to redefine the shape of existing television to catch up with digital visions and opportunities. Digital technology was first, in the early 1970s, put into practical use in the professional television studio and production with the introduction of devices such as digital noice reducers, graphics generators, standards converters, timebase correctors and synchronizers, amongst others (Baron & Wood 2005). In 1982 the *CCIR Recommendation 601* emerged as the international standard on the digital representation of component

[5] Following North (1990), institutional opportunities and constraints are set by both *formal* rules–such as written political and judicial rules, economic rules, official standards and contracts–and *informal*–such as unwritten customs, habits, norms, traditions, praxis and codes of conduct.

television signals for studios. It came to form the basis of most modern digital (HD)TV systems, including digital video tape systems and DVD recordings (Baron & Wood 2005).

Throughout the 1970s and the following decades, digital techniques were applied also to other parts of the television chain, from the studio to reception. As knowledge and techniques of turning analogue signals into digital ’bits’ improved and digital transmission methods were adopted in telephone networks, research engineers had began thinking on how to transform and compress the huge amount of information in an analogue TV signal into a stream of digital ’bits’ to be sent all the way to the home, that is, the broadcasting signal itself would become digital. In the words of Bell (2007:32):

> But there were two obstacles: first, the digital component bit-rates of 240 – 270 Mbit/s were very high: all right inside a building but uneconomical for long distance transmission. Some means of compressing them to manageable sizes had yet to be devised although some early work was looking promising. The second obstacle was that there was no over air broadcast transmission format available which would carry the components. In due course the interim analogue transmission format of MAC would appear, but a fully digital component system was still unexplored territory. In the early eighties, digital television to the home still seemed a long way off.

Section I.

With a heavy dependence on the development of digital technology and progress in electronic technology, something called HDTV began to circulate in a broader, transnational space during the 1970s and 1980s. Faced with a number of narratives we now know that this HDTV movement soon diverged and diversed in multiple dimensions and recombinations. Or, to put it another way, although it is easy to start from the point that interests one, there are many points from which a story of one particular recombination can be told.

Nonetheless, as told in mainstream histories, the ’founding story’ of HDTV begins with the birth of a particular research and development project at Japan’s national public broadcasting corporation NHK (Nippon Hoso Kyokai) in Tokyo. According to the writings of one of the insiders in 1980, a group research engineers at the Science and Technical Research Laboratories at NHK started research in 1968 into a future TV system which would deliver cinema-quality pictures, capable of display on considerably larger screens than at present used for television (Fujio 1980).[6]

[6] However, following the NHK Labs’ website (copyright 2002 NHK) and Hart 2004, the NHK Labs initiated studies on HDTV in 1964. Moreover, whether the Japanese were the original pioneers has been questionned (see, for instance, Inglis 1990:475).

When NHK began experimental work with wider and sharper images of TV, the movie industry had already moved to larger screens with wider aspect ratios and to (35 mm) films with higher resolution. The NHK experimental TV system was early endowed with an identity related to the routines and standards of the cinema, and, for instance, the opportunities of digital technology and the demands of future post-industrial societies.

Certainly, in defining and seeking credibility for *any* new TV system, one had to endow it with an identity related to the existing routines and standards for TV. These have always been split concerning the standards used for encoding, broadcasting and receiving TV-signals. All three of the co-existing TV-systems (and their subvariants) had been originally developed and designed for conventional terrestrial transmissions of colour-TV, and they were all compatible with earlier monochrome TV equipment. The German *PAL* was used in most West European countries. The French *SECAM* was used by francophone countries, much of the third world, the former Soviet union and some of its Eastern European satellites. The Central and North American countries had followed the US and Japan with the American *NTSC*. South America was divided between PAL and NTSC.[7] All three TV-systems were united in the *aspect ratio*, that is, the ratio of the TV screen's width to its height: 4:3. All three systems also relied on the method of *interlaced scanning*.[8] But NTSC operated on the standards of 525 scanning lines and a 59.94 Hz field rate whereas both PAL and SECAM used 625 lines and a 50 Hz field rate.[9]

[7] At the same time as the three TV-systems were a source of path dependence, they were themselves resulting from specific historical processes of innovation and research focus guided by the particular circumstances that led to the standards agreement arrived at in the 1930's (monochrome TV) and the standards agreement arrived at for colour-TV in 1953 (on NTSC) and in 1965 (PAL and SECAM) (Inglis 1990:237-276). Ever since the 1950s, when European engineers coined the expression, in some circles NTSC has been jestingly or derisively referred to as an acronym for *Never Twice the Same Colour*. SECAM has also been referred to as *Système Européen Contre l'Amerique*.

[8] In short, the method of interlace scanning ('2:1) can be compared with the reading of a text but with the important difference that here only half of the lines are displayed on each pass of electron-beam scanning (or equivalent techniques), both in cameras and displays. In a first round (a first field) is every odd numbered line (of pixels) scanned and the even lines omitted, in a second round (a second field) is every even line scanned and the odd numbered omitted.

[9] 'Fields' are groups of scanning lines that are scanned together at any given time in the imaging process. The *field rate* is twice the *frame rate* (i.e. the number of complete pictures–frames–that are transmitted per second). The traditional PAL, for instance, divides each 625-line frame into two separate fields (even-and odd-numbered lines). These two fields are then scanned separately and interlaced. Each 625-line frame is thus a composite of two fields (a field = ½ frame). This reduced the 'flicker' the viewer would otherwise see if only 25 fields (each representing a complete 625-line frame) were flashed each second. Thus PAL (like SECAM) has a 25 Hz frame rate and a 50 Hz field rate. NTSC, however, utilizes a 30 Hz frame rate and a 59.94 Hz field rate. As those familiar with power systems may observe, the field rate is in accordance with half the standard power source frequency used in the countries in question.

Like many others before them, the NHK Labs borrowed and re-used the old Anglo-Saxon term *high definition television* (HDTV) in attempts to mobilise broader support and establish an identity for a new, 'improved', TV system of tomorrow. Ever since the time of John Logie Baird's experimental TV broadcasts in the 1920s, almost every effort to improve the quality of the TV-picture and, in particular, the detail of the image, has been heralded as bringing 'high definition'–and the number of scanning lines has increased from 30 lines/picture to, for instance, 405, 625 and 819 lines.

While the research engineers at the NHK Labs together with a growing numbers of allies were developing and promoting a new (HD)TV system of tomorrow, they also, among other things, set out to (re)build an infrastructure necessary for linking their, still experimental system to the general public. During the 1970s, a range of prototype production and consumer equipment was developed as the experimental HDTV programme married a Japanese experimental programme directed towards the development of *broadcasting satellites* or *direct broadcasting satellites (DBSs)*. In contrast to the first generations of communications satellites which had been used ever since the mid 1960s, such DBSs would allow satellite-transmissions of TV *directly* to individual homes, without using terrestrial transmission networks.[10] Recognized for pioneering both HDTV and DBS, the NHK in league with other Japanese companies began real-world HDTV transmission tests, experiments and demonstrations in 1978, using the new equipment and what is often described as the first genuine DBS, the Japanese experimental 'Yuri. Throughout the 1970s and 1980s the Japanese continued to explore this particular combination vigorously: HDTV transmitted via DBSs.

By 1985 transmissions of NHK's experimental HDTV systems had been combined with *MUSE*, a new bandwidth reduction system designed to transmit HDTV signals via satellites, which was also under development in Japan.[11] MUSE offered a solution to the problem of the

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[10] Satellite technology has been a relatively 'fixed' and routinely used device in real-world-arrangements for basic telecommunications services ever since the launch of Intelsat's first satellite, Intelsat I (or the Early Bird), in 1965. For a long period of time communications satellites were only used for worldwide point-to-point communications, relaying primarily telephone calls, facsimile and data services, with long-distance point-to-point relays of TV-signals being but an occassional service used by broadcasters to cover major events. Long before any communications satellite had been successfully launched into orbit, a boundary had been drawn between the usage of (1) satellites for such *point-to-point* communications, that is, between a limited number of earth-stations (used for both reception and transmission) located at 'specified fixed points' on the globe, and (2) satellites for *broadcasting* directly to the individual households receiving TV signals from satellites on small (receive-only) dishes. By 1971 this boundary had been translated and enshrined in the ITU nomenclature in the form of a distinction made between *fixed satellite service (FSS)* and *broadcasting satellite service (BSS)* (Ewertsson 2001).

[11] During its development, MUSE spawned several variants, for instance, MUSE-T, MUSE-E; MUSE-6 and Narrow-MUSE.

huge bandwidth requirement of HDTV by making it possible to ’squeeze’ the 30 MHz of NHK’s experimental HDTV signal through a single 24-27 MHz satellite channel (Hatori and Nakamura 1989).

HDTV enters the procedures of the CCIR (and others)

Throughout the 1970s and 1980s, it became increasingly clear that NHK were interested in winning support for Japanese HDTV as a new world-wide standard.

By 1972 the work carried out in Japan on a future (HD)TV system had been brought to the standard-setting routines of the *International Radio Consultative Committee (CCIR)*. Headquartered in Geneva, the CCIR was a regular ’club’ of national network operators[12] and a creature of the governance structure that had evolved for an expanding range of telecommunications services since the mid-19th century. It was a sub-unit of the ITU, an agency of the United Nations, which was responsible for the regulation and planning of telecommunications worldwide.[13] At the time, the CCIR was still the only organization capable of (re)creating international technical standards for radio (wireless[14]) communications systems, TV systems included. Its roles also included managing the allocation and use of frequencies in the electromagnetic spectrum and satellite orbit resources for radio communications. Given its monopoly position, the CCIR acted as what Callon and Law (1982) have termed an ’obligatory passage point’ for individuals and groups who wanted to be able to influence the development of international agreements on frequency regulations as well as technical standards *(Recommendations)*[15] for radio communications systems.

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[12] All telecommunications administrations that were members of the ITU were automatically members of the CCIR. Broadcasting and telecom operators (e.g. CBS, AT&T) may become members by forwarding a request through the respective administration and paying an annual fee. Participation in an advisory capacity was open to scientific and industrial organizations (e.g. laboratories, manufacturers) on the same basis, and related international organizations (e.g. broadcasting and telecommunication organizations) might participate in an advisory capacity. By the mid 1980s, the CCIR consisted of about 150 nations.

[13] In 1865, twenty countries established the *International Telegraph Union (ITU).* In 1932 the ITU merged with the *International Radio-telegraph Union (IRU*), established in 1903, to form what became reorganized as the *International Telecommunication Union*. In 1947 the ITU achieved the status of a specialized agency within the UN. The *CCIR* was established in 1927 as a permant subcommittee of the ITU for coordinating the development and recommendations of standards for radio (wireless) communications systems worldwide. As part of the reorganization of the ITU in 1992, the CCIR was superceded by the *ITU-R*, the ITU Radiocommunication Sector, and the so-called Interim Working Parties (IWPs) were replaced by Task Groups.

[14] Norms and principles regarding the use of the electromagnetic spectrum for wireless communication were established at a series of international conferences held in 1903, 1906 och 1912. Among other things, already before broadcasting had begun, one of its fundamentals, the electromagnetic spectrum, had been defined as a public property and an important national resource and it was decided that wireless telegraphy from 1906 should be called *radio* telegraphy. The *International Radio-telegraph Union* was set up in conjuntion with the first of these conferences, held in Berlin in 1903 on the initiative of the German government. (Ewertsson 2001:103, 115)

[15] ITU/CCIR standards are referred to as *Recommendations*. The CCIR Recommendations were not binding in a legal sense. Implementation was voluntary, but, nevertheless, complience was high. An informal rule of

Following a Japanese proposal,[16] in July 1972, the meeting of the *CCIR Study Group 11* (responsible for TV broadcasting) decided that the CCIR initiate studies on HDTV. On that occassion, the UK and France suggested the launch of studies on digital TV.[17] The experimental work carried out in Japan on the development of a new (HD)TV system–and the issue of digital TV–had thus been given a framework for international standardization.

Work on HDTV in the CCIR began in 1974, with the adoption of Question 27/11.[18] Soon a growing body of friends and enemies all over the world were rushing in to help fix, contest or reject the boundaries as well as diagnose, shape and fill the content of something called HDTV. The movement of experimental HDTV to a diverse set of sites outside Japan from the mid 1970s to the early 1980s may be illustrated by the following actions:

1977:	The American-based *Society of Motion Picture & Television Engineers* (SMPTE) set up a new Study Group directed towards the achievement of an HDTV *production* standard.[19]
1980:	The results of the SMPTE Study Group on HDTV, with initial recommendations, were publihed in the February and March issues of the *SMPTE Journal*.[20]
1981:	In February, NHK demonstrated new, experimental, HDTV equipment before a broader audience for the first time outside of Japan, at an SMPTE conference in San Francisco. The *European Broadcasting Union* (EBU)[21] Technical Committee set up a Specialist Group to investigate HDTV and suggested the goal of a worldwide agreement on a single *production* standard by 1985 and on a *broadcast* standard by 1989.[22]
1982:	In June, NHK demonstrated HDTV for the first time in Europe, at the meeting of the EBU General Assembly, held in Killarney, Ireland (Wood 2007:2/6).

The CCIR had dealt with HDTV since 1972, but it was not until 1983 that it was becoming clear that moves were taken towards international standardization. It was also clear that HDTV standardization had become a matter of immediate concern for many individuals and

consensus–a vote was taken only as a measure of last resort–ensured that standards were generally acceptable by all actors concerned.

[16] CCIR Document 11/31, 17 March 1972.

[17] www.itu.int/ITU-R/information/docs/hdtv-speech-studies-en.doc, access 6/3 2009.

[18] Question 27/11 stated: ”The CCIR Unanimously Decides that the following question should be studied: what standards should be recommended for high-definition television systems intended for broadcasting to the general public?” (Robert Hopkins’ speech ’Demonstrations of High Definition Television to the Delegates of the ORB 1985 Conference”, Geneva, Switzerland, September 4, 1985).

[19] Streeter 1987:1108, Kennedy 1989:68. Within the SMPTE, study groups have traditionally been established to consider a particular issue of interest, to issue reports and make recommendations on standards. (Streeter ibid).

[20] Among the proposals were that the current 35 mm motion picture release print quality as projected on a wide screen should be the goal for the display image of HDTV; that the appropriate line rate should be approximately 1100 lines per frame; 30 frames per second interlaced two-to-one (2:1); and that the aspect ratio should not be less than 5:3 (Hopkins & Davies 1990; Kennedy 1989:68; Streeter 1987:1108).

[21] Founded in 1950, the EBU has an identity as a representative and defender of a large collective of broadcasters’ interest at European and international levels. The EBU has traditionally been highly involved in R & D of radio and TV systems, including partnership and cooperation for the development and introduction of new standards, systems and products. By the late 1980s, the EBU had about 35 member broadcaster organizations, who provided broadcasting services which were national in character, throughout Europe and around the Mediterranean.

[22] Wassiczek et al 1989, 279.

collectives. In March 1983, at the Fourth World Conference of Broadcasting Unions, held in Algiers, the nine members adopted a recommendation that they should work toward a single worldwide HDTV production standard.[23] In 1983 (or 1982 according to more contemporary sources), the *Advanced Television Systems Committee (ATSC)* was formed in the US to coordinate and develop voluntary national technical standards for ’improved NTSC, enhanced 525-line and high definition’ TV systems and to develop a national position within international standards organizations.[24] Also in 1983, the CCIR set up an Interim Working Party (IWP 11/6) to study and prepare a draft Recommendation for a single, world-wide HDTV studio production standard before the next CCIR Plenary Assembly (1986).[25] IWP 11/6 was chaired by Mr. Tadokoro of the Japanese NHK (Streeter 1987:1108).

The possible formulation of a worldwide HDTV *studio* standard[26] was widely discussed at the final meetings of IWP 11/6 and the whole Study Group 11 in 1985 before the 1986 CCIR Plenary Assembly. The US, Canada and Japan (all belonging to a 525line/60 Hz NTSC milieu) were pushing the CCIR to adopt a worldwide HDTV production standard involving the provisional HDTV standards that had been specified at the NHK by 1978: 1125 scanning lines, 60 Hz field rate, interlaced 2:1 scanning, but with the aspect ratio originally proposed by NHK (5:3) widened to 16:9.[27] At their September 1985 meeting, IWP 11/6 agreed to submit a revised Draft Recommendation for consideration to the full Study Group 11, which

[23] Streeter 1987:1108; Wassiczek 1987:5.5.3.

[24] The ATSC was established as a private sector organization by the Joint Council on Intersociety Coordination (JCIC). The five members of the JCIC were the charter members of the ATSC: *the EIA, the IEEE, the NAB, the NCTA* and *the SMPTE.* Altogether, there were 51 member organizations and 12 observer organizations in the ATSC. (Kennedy 1989; Streeter 1987; Robert Hopkins, ’Panel Discussion Montreux Television Symposium’, Montreux, Switzerland, June, 1985.) As an organizational invention, the ATSC was not dissimilar to the first NTSC that served from July 1940 to March 1941 and developed the US standards for black and white TV, or the seccond NTSC that served from January 1950 to February 1953 and developed the US standards for colour TV. (Robert Hopkins, ’Advanced Television Systems’, speech at Consumer Electronics Show, Washington, DC, January 1986)

[25] The work of the CCIR was organized into four-year study periods with an intermediate and a terminating meeting period. Its highest organ, the Plenary Assembly, met every four years to set standards and identify future standardization needs. In between, work was carried out by *Study Groups* of technical experts from the member administrations and from industry. In addition, activities could be going on in temporary working groups–*Interim Working Parties (IWPs)*–composed of a limited number of technical experts investigating specific issues.

[26] The initial emphasis in the CCIR on achieving a single world-wide standard for production and international program exchange (that is, a *studio* standard) obviously followed a pattern: ’In the CCIR, at least in the past, there has been no movement to establish emission standards before studio standards’ (Ninomiya, 1991:17).

[27] In relation to NTSC’s field rate (59.94), 60 Hz was claimed to be a better choice for HDTV for several reasons (see Hatori and Nakamura 1989). Following the then Executive Director of ATSC, it was the SMPTE that in 1985 proposed the 16:9 ratio because they wanted ’to permit a shoot and protect scheme to cover any released aspect ratio between 4:3 and 2.35:1’ (in the existing library of films, the narrowest pictures were generally 4:3 and the widest pictures were generally 2.35.1) (Robert Hopkins, ’Advanced Television Systems’, speech at Consumer Electronics Show, Washington, DC, January 1986; Hopkins, ’Comments on HDTV’, speech at ITS Lunch Meeting, May 8, 1996).

was to meet October 16 to November 2, based upon the 1125/60/2:1/16:9 parameters.[28] But, as pointed out in a footnote in the document, some of the countries using the 625/50 standard had reservations about the parameter values. As remembered by a US delegate:

> After approval at the Working Group level, it [the Draft Recommendation] was presented to the full Study Group 11 for final approval with a modified footnote. Two countries had, overnight, received instructions that they were to disapprove, thus blocking the document–the documents must be approved unanimously. The Draft Recommendation was resubmitted to the Working Group which modified its form to be a 'Proposal for a New Recommendation' rather than a 'Draft Recommendation.' This procedure, although not considered the norm, has been used before when unanimous approval could not be reached on a document. On the last day of the 17 day meeting, this document, also with a footnote, was approved by Study Group 11.[29]

The footnote attached to the 'Proposal for a new Recommendation' that was presented to the CCIR Plenary Assembly in May 1986 reads:

> A number of administrations using the 625/50 standard have reservations about the parameter values above, and at this time are not able to accept these as a basis for a single world-wide HDTV studio and international exchange standard.[30]

The only submitted HDTV standards proposal (1125/60/2:1/16:9) was supported by delegates from the USA, Japan, Canada, Brazil and Chile (all belonging to a 60 Hz NTSC milieu), while participants from certain governments and major corporations in Western Europe were strong opponents. According to one of the participants, this opposition was 'partly for industrial policy reasons but partly also because of the field rate conversion problems which would arise if a 60 Hz system were brought into the 50 Hz environment of the PAL/SECAM Europe.'[31]

After intense debate, in May 1986 the CCIR Plenary Assembly unanimously agreed to postpone taking a decision on a worldwide HDTV studio standard until its 1990 meeting. Although Study Group 11 and its IWP 11/6 had not been able to reach agreement on the parameter values, the Plenary reaffirmed the interest in establishing a single worldwide standard and furthermore stated the urgency of this action. The Plenary also stressed the

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[28] McKnight & Neil 1987:5.6.10.

[29] Robert Hopkins, 'Advanced Television Systems', speech at Consumer Electronics Show, Washington, DC, January 1986.

[30] 'Proposal for a new Recommendation: Parameter values for signal generation in HDTV studios and for international exchange of HDTV programmes', Annex II to Report 801-2, 'The Present State of High-Definition Television (1974-1978-1982-1986) (CCIR Document 11/499 (Rev.1).

[31] Charik, S. I (the British Government co-ordinator for HDTV): 'HDTV via Satellite – An Overivew', IEE Colloquium Digest 1990; No 092, pp. 1/1-3, CSR 3315.470000.

importance ’on the use of components, expressed in both analogue and digital form, the latter to be closely related to Recommendation 601.’[32]

The Eureka EU95 HDTV Project

By the mid 1980s, the Japanese NHK and its partners were hardly the only ones working on future (HD)TV systems. Conspicuously, many US and European companies and organisations that had long since been powerful in the design, working, networking and control of TV were conducting studies of HDTV and were exploring alternative systems–and names–each of which was shaped by local contingencies. Shortly after the 1986 CCIR Plenary Assembly, a particular experimental programme entered the public stage: the *Eureka EU95 HDTV Project*. The Eureka-95 or EU95 (as it variously came to be called) promoted an HDTV studio standard and an HDTV transmission system related to the MAC emission standards that was under development for future satellite broadcasts in Europe.

In the wake of ITU-regulation channelled through the *World Administrative Radio Conference for Broadcasting Satellites,* WARC-BS, convened in 1977 (’WARC77’), an inreasing number of research engineers at various sites in Europe had clustered around the development of a new transmission system intended for TV satellite broadcasting services called MAC– *Multiplexed Analogue Components*. At the time MAC was born, it was, of course, said to offer a number of advantages over existing TV systems. The MAC promoters said, for instance, that the reference system (PAL) used at WARC77 was obsolete and that it was not tailored for satellite broadcasting (cf Bell 2007:37 f). They also said that the MAC waveform would allow a more efficient use of the 27 MHz DBS channel bandwidth and lended itself more easily to the flexibility required for the introduction of new applications and services that had not been imaginable at the time the existing NTSC, PAL and SECAM systems had been designed and standardized. For example, satellite broadcasting, widescreen format and HDTV as well as scrambling techniques could be foreseen in the specification of MAC.

In the 1980s MAC spawned into a number of variants, for instance, C-MAC, D-MAC and D2-MAC. All members of the so-called MAC packet family used a system of time division multiplexing for sending the analogue picture signal. At the time MAC was born, digital technology could not process the *video* signal components, but the sound and data streams

[32] ’Current Position of Study Group 11 on HDTV’, Annex I to Report 801-2, ’The Present State of High-Definition Television (1974-1978-1982-1986) (CCIR Document 11/499 (Rev.1).

were encoded in digital form. The MAC variants differed primarily in the ways in which the digital sound and data were multiplexed (Ewertsson 2001:236).

What was called EUREKA came to play a key role in linking up HDTV to efforts to create a future European DBS market through the (re)definition and institutionalisation of the MAC-packet family of transmission standards. EUREKA was established in 1985 as a framework for vast pan-European R & D programmes for co-operation between governments, business and research institutes in certain areas of technologies. EUREKA was not launched as an EC research programme, but rather an inter-governmental initiative, of which the EC, represented by the European Commission, was a member. The national governments, rather than the Commission, supplied funding directly to the companies which were participating in the various EUREKA programmes.

Already before it had made its public appearance as a new giant actor, framed and officially launched as Eureka-95, European groups which had long since been influential in the (re)creation of TV systems had begun lobbying for research and development work to define a new alternative HDTV system and standard, based on the C-MAC transmission system under development for future European DBS and cable distribution. While the proponents were beginning to make public their endeavour to marry satellite-distributed HDTV with some 'advanced' form of MAC, they also, among other things, sought to make the task of securing this alternative path to HDTV a matter also for national governments and the EC. For example, in early January 1986 the readers of the *Electronics Weekly* were told about a series of presentations made by the IBA Director of engineering, Tom Robson, to officials from the Home Office, the Department of Trade and Industry, and representatives from the independent TV companies in the UK. Mr Robson should have told his audiences that a standard based upon the Japanese 1125-line 60 Hz HDTV system was not the answer for Europe, since it 'is not compatible with existing sets or studio equipment and could not be satisfactorily transmitted through a satellite channel'. Instead, he argued, the Enhanced C-MAC standard, developed by the IBA, provided an alternative route to HDTV which is 'evolutionary rather than revolutionary, compatible not incompatible.'[33]

In May 1986, another specialist journal reported that European TV manufacturers were set to begin a Eureka contract to develop their own HDTV standard. One of those involved, Doug Topping, technical director of Thorn EMI, said that the idea was 'to create a technology

[33] 'Japan HDTV bid gets IBA thumbs-down', in *Electronics Weekly*, January 8, 1986, 1.

which will allow high definition TV signals to be received alongside existing TV' using the MAC standard so that transmissions would be 'downward compatible'. According to the reporter, Thorn EMI and its partners–'which may include Philips of the Netherlands plus West German and French firms'–hoped 'that the Eureka research, plus the rejection of the Japanese NHK standards at an international meeting this week, will put them level with Japan in the early 1990s when the first HDTV broadcasts begin'.[34]

The proposal for an alternative HDTV standard based upon MAC and the development of equipment to demonstrate it was put to a June 1986 conference of EC ministers concerned with the Eureka programme. The proposal was accepted and given the project number EU95.[35] At the IBC held in Brighton in September 1986, four large European manufacturers with an identity as competitors–Bosch (West Germany), Philips (Netherlands), Thomson (France) and Thorn EMI (UK) which later became part of Thomson–publicly appeared as a united conductor of the new EU95, with the prestige and money of the European Commission behind. At the time, the project was described as linked to a 'fight with Japan and the US over a global HDTV standard' and portrayed as follows:

> The development will be under the Eureka project and will lay down the standards for a complete TV system from domestic sets to broadcast studios. The project will be the largest under Eureka and over 40 European companies have pledged support for the R&D. Development will be broken into three phases to provide a smooth transition from current 625-line TV to Direct Broadcasting by Satellites (DBS) and 1,000 line HDTV under a single MAC standard. Work on the project is due to start next month./…/ The next step, says de Greef [of Philips], is to develop the equipment before the next meeting of the world's ruling body on TV–CCIR–who meet next in 1990.[36]

In October 1986, a first meeting of the EU95 consortium was held, including government officials from the original principal countries (France, Germany, Netherlands and UK). Soon groups from Belgium, Italy, Sweden and Switzerland had joined as secondary, or 'B' participants (Ivall 1988:846). Shortly after this meeting, by November 3rd 1986, the family of MAC/packet systems had won the EC Commission's regulatory power in the form of a Directive (86/529/EEC) that compelled all the (then 12) member states to adopt the family of MAC standard for TV-transmissions via their future high-power DBSs (at the time this was the only category of satellites thought to deliver a signal strong enough for direct-to-home reception).[37]

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[34] 'Europe goes is alone on high definition TV standard', in *The Engineer*, 22 May 1986, p. 13.
[35] Ivall, Tom, "Eureka 95 – a world standard?", in *Electronics and Wireless World*, vol. 94, 1988, pp. 845-850.
[36] 'Philips strikes in HDTV battle', in *Electronics Weekly*, September 24, 1986, p. 7.
[37] European Communities: Council Directive of 3 November 1986 on the adoption of common technical specifications of the MAC/packet family of standards for direct satellite television broadcasting. (86/529/EEC).

In October 1987 some European administrations (Belgium, France, the Federal Republic of Germany, Italy, Netherlands and UK) presented their draft Recommendation for HDTV for the first time to the CCIR Study Group 11. Their HDTV studio standard candidate was based on the work within the EU95 and involved the parameters: 1152* active lines (1250 total lines), a 50 Hz field rate, a 16:9 aspect ratio, and a progressive (1:1) scanning method.[38] The confrontation between two competing HDTV systems and standards became evident.

The IBC in Brighton 23-27 September 1988 was selected as the public debut of EU95's HDTV studio standard and a related 1250 line 50 Hz *HD-MAC* transmission system as well as a range of equipment to demonstrate the entire HDTV chain, from studio/production and transmission to reception and replay. In 1989, a version[39] of HD-MAC was 'demonstrated in Montreux, in Madrid before the heads of state and government on 4 July at the European Summit, and in Paris on 14 July before the heads of state on government of the G7' (Carpentier 1989:24).

The demonstrations carried out on 'real-world' HD-MAC equipment seem to have interacted with the mobilization of broader support among 'significant others'. For instance, on 27 April 1989, the Council of Telecommunications Ministers (89/337/EEC) decided to give the European commission a clear mandate and the legal basis to promote and initiate a common action plan for HDTV centered around HD-MAC involving the parameters of 1250/50/16:9/2:1.[40] The publicly stated objectives of the action plan being prepared in 1989 included: 'to promote the adoption of the Europan proposal as the single world standards for the origination and exchange of HDTV material'; to promote the introduction, as soon as possible–and in accordance with a suitable timetable from 1992–of HDTV services in Europe'; 'to make every effort to ensure that the European TV and film industry achieves the capability, experience, and dimension required to occupy a competitive position on the HDTV world market' (Carpentier 1989:25 f). On 7 December 1989 the Council of the European Commission of the EC adopted a Decision (under Article 116 of the Treaty) on the common

[38] *This figure was said to be chosen 'to be exactly twice the number of active lines as defined in the interface specification for digital component video signals in 625-line television systems (CCIR Recommendation 656)' /'Draft Recommendation', Documents CCIR Study Groups Period 1986-1990, Document 11/161-E, 30 October 1987).

[39] The EU-95 worked on several versions of standards for HD-MAC, with the 1250/50/1:1 parameter set being referred to as 'HDP' (*progressive*). An analogue *interlaced* 1250/50/2:1 version was called 'HDI'; a 1250/50/1:1 digital *quincunx-sample* version designed to assist digital recording was labelled 'HDQ' (Wassiczek et al 1989:280).

[40] 'The European Approach to HDTV. Position Paper of the Eureka EU 95 HDTV Project.' 1992, p. 20; Carpentier 1989:24.

action plan for HDTV to be taken by the Member States.[41] The EC decision was adopted a month or so after the evening of Thursday 9 November, when the historical removal of the barriers between East and West Berlin began, allowing a dramatically reconfigured Germany to play particular roles in the (re)construction of European (HD)TV markets.

Sponsored primarily by the EC and participating members, in 1989 also a *European Economic Interest Group (EEIG)*, later called *Vision 1250*, was under way, assembling consumer-electronic companies, TV/film producers, broadcasters, transmission authorities and other interested parties to help promote and create a European HDTV/MAC market. The publicly stated ambition was to facilitate equipment trials, stimulate HDTV programme production and demonstrations throughout Europe by providing equipment, know-how and training among potential users–all centered around the 1250/50 standards and HD-MAC. The organisational invention of *Vision 1250* became fully operational in the first half of 1990.[42] To kick off the commercialization of HDTV in Europe, EU95 and Vision 1250 combined forces to introduce experimental satellite broadcasts and demonstrations open to the public, making use of HD-MAC equipment and covering major public events in 1992, for instance, the Winter Olympics (Albertsville, France), the Summer Olympics (Barcelona, Spain), and Expo'92 (Seville, Spain). By 1992, 42 organizations from 16 countries, several EBU-members included, had joined forces in Vision 1250 and more than 150 HDTV programmes had been produced, representing more than 600 hours.[43]

From its very start, the EU95 protagonists publicly announced that they proposed a world production standard, an HDTV transmission system and corresponding equipment, based on the principles of 'evolution' and 'compatibility' rather than 'revolution' and 'incompatibility'. Under the banner of 'evolution' and 'compatibility', they opposed the 'revolutionary' and 'incompatible' MUSE system and promoted instead a successive three-steps transition to satellite distributed HDTV services in Europe via MAC-based interim systems and standards before the implementation of HD-MAC.

[41] Commission of the European Communities, Communication from the Commission to the Council and Parliament on audiovisual policy, COM (90) 78 final, Brussels, 21 February 1990, p. 31.

[42] Commission of the European Communities, Communication from the Commission to the Council and Parliament on audiovisual policy, COM (90) 78 final, Brussels, 21 February 1990, p. 32 f.

[43] 'The European Approach to HDTV'. Position Paper of the Eureka EU 95 HDTV Project,' October 29, 1992, p. 20. By December 1990 all Nordic broadcasting corporations, with the exception of Iceland, had expressed their interest in taking part in the EC-project Vision 1250. For a yearly fee of about SEK 350,000 the members would be given access to extensive HDTV-resourses with an estimated value of about SEK 900 million (SVT, *Tekniken informerar*, Nr 3, årgång 17, 1990, December, p. 11).

In a first phase, a new 625 line transmission system for satellite and cable broadcasting–*D2-MAC*–was introduced, using the same number of scanning lines (625) and aspect ratio (4:3) as PAL and SECAM. At July 1st 1990 started officially the second phase: the introduction of a 625-line transmission system with the new 16:9 format–*D2-MAC WIDE*–compatible with D2-MAC 4:3 and PAL/SECAM services. In the third and final phase, expected to start by 1995, a ’full’ or ’true’ 1250 line HDTV system would be introduced–*HD-MAC*–in a 16:9 format ratio.[44] Although D2-MAC/WIDE-MAC and HD-MAC were said to be directly compatible with the 625/50 MAC emission standards, and thereby also indirectly with the 625/50 PAL (via a particular decoder), the potential viewer had to invest in new reception equipment. For the introduction of D2-MAC, existing receivers could be used but required the additional use of a parabolic antenna and a D2-MAC satellite tuner; the introduction of D2-MAC WIDE required a D2MAC wide screen receiver to be able to experience the new format; and a new widescreen HD-MAC receiver would be required to enjoy ’true’ HDTV.

By February 1989, at a time when it was ’important for the EBU to be able to act and voice its opinions independendly of the Eureka EU 95 project, and indeed national Administrations’ (Wassiczek et al 1989:279), the EBU had set up a System Evaluation Group (SC/EV) to make its own ’independent’ tests and evaluation of the HDTV production standard proposed by the EU95, the HD-MAC transmission system and corresponding equipment.[45] By April, the tests were planned to take place after the CCIR meetings in 1989, but not later than February/March 1990. Both RAI and CCETT had volunteered to house the testing.[46] By September 1989, Piet Bögels, Philips International (Netherlands) and also president of the EU95 directorat, had ’offered’ Deutsche Bundes Post’s premises in Mannheim to serve as the spot for the testing, at SC/EV’s disposal from November 1989 to May 1990.[47] Finally, on 4-6 April 1990 the SC/EV evaluated HD-MAC by means of a series of tests and demonstrations of transmissions from a Deutsche Bundes Post facility in Mannheim. According to an SC/EV member, the evaluation showed that the work on HD-MAC was progressing and that the

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[44] Information material from the EU95 HDTV Project in Swedish, ’Frågor och svar om HDTV’, ’Den gradvisa vägen mot HDTV’ 1990; ’The European Approach to HDTV. Position Paper of the Eureka EU 95 HDTV Project.’ 1992.

[45] SRTKFU/Kjell Engström: ’Rapport från möten med EBU EUREKA System Evaluation Group, SC/EV, och specialistgrupp V1/HDTV (Turin, 13-16 februari 1989)’, 1989-02-23.

[46] SRTKFU/Kjell Engström: ’Rapport från möte nr 2 med EUREKA System Evaluation Group (SC/EV) (Eindhoven, 25 april 1989), 1989-05-08.

[47] SRTKFU/Kjell Engström: ’Rapport från möte nr 4 med EUREKA System Evaluation Group, SC/EV (Kingswood Warren, 13 september 1989), 1989-09-15.

qicture quality probably was better than that of the Japanese MUSE system. It also showed that some fundamental problems still remained to be solved: the compability with MAC had not yet been proven; certain picture quality problems as concerned picture details; receivers for HD-MAC was now said to be availabe not until 1997-98 (that is, 2-3 years later than previously pointed out); and the introduction of MAC had been postponed because of several delays and setbacks, such as the plans of using PAL on the satellites TV-SAT (West Germany) and Tele-X (Sweden).[48]

From its very start, the EU95 was inextricably bound up with a number of ensembles, traditions, interests and concerns, such as European DBS projects and the MAC standards; a European electronic/audiovisual industry which at the time was widely promoted as holding a weak and fragile international position; and steps towards a single European market, with 1992 as the magic year. An excerpt from a conference paper presented in November 1990 can illustrate the size, expectations, investments and multiple entanglements of the EU95 at the time:

> The project's total research activity, covering the entire TV chain, was divided over 10 Project Groups. These groups met for the first time in January 1987. By the end of 1989 a total of more than 2,000 man years had gone into the project. And the work is far from over. Projections for the years 1990 to 1992 indicate that Phase 2 of the project will involve a further 3,150 man years. It's a lot of effort, and investment, but we are convinced the MAC/HD-MAC route to HDTV will work; technically, economically, socially.[49]

By December 1990, the directorate of the EU95 consisted of representatives from Philips (the Netherlands), Thomson (France), Bosch (Germany), Nokia (Finland) and CISAE (a consortium of 7 Italian companies).[50] By 1992, the EU95 was proud to embrace more than 80 participants from 13 countries, including prominent EBU Members (but not all EBU Members), broadcasters, satellite and cable companies, as well as companies and units from the electronics industry and universities. The investment in R&D up to then had been 625 million ECU 'with a purely research effort of 5,500 man-years and a development effort many times greater than this.'[51] By August 1993, the EU95 promoted itself as 'Europe's most successful research project'.[52] Nonetheless, today's Wikipedia tells us that 'The HD-MAC

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[48] Kjell Engström, 'Rapport från EBU:s första utvärdering av HD-MAC', 1990-04-11; See also, Rapport till Tekniska Styrkommittén från Koordineringsgrupp för HDTV, utkast 1990-04-28.

[49] von Oostenbrugge, Rob 'Implementing HDTV in a changing environment', IDATE 1990 (12)1.

[50] Draft CCIR Document: TG11/1-… December 1990, 'Eureka 95 HDTV project has started with second phase'.

[51] 'The European Approach to HDTV. Position Paper of the Eureka EU 95 HDTV Project,' 1992, pp. 1; 11.

[52] *HDTV Report 1250/50*, a publication of the Eureka EU 95 HDTV Directorate, issue 12, August 1993, p. 1.

standard was abandoned in 1993 and since then all EU and EBU efforts have focused on the DVB system (Digital Video Broadcasting) …'.[53]

Towards a single world-wide HDTV standard?

The EU95 appeared as the Japanese 1125/60 system's most vigorous opponent in what by then increasingly was reported upon as a 'war' or 'battle' over which technical standards and systems would ultimately carry HDTV and its market(s). At the time battle slogans and costumes became attached to HDTV, visions and experimental work had also begun to include other applications than broadcasting, covering sectors such as theaters, education, medicine, computer graphics, military, commerce and industry. By 1990 CCIR set up IWP 11/9 in order to harmonize the standards being developed for HDTV broadcasting with nonbroadcasting HDTV applications.

When the CCIR Study Period 1986-1990 was drawing to an end, research engineers and directors supporting various experimental HDTV systems all around the world had by no means given up their attempts at moving towards one single worldwide HDTV studio standard. By the time of the 1985 CCIR Final meetings, it had not been possible to unite all the CCIR members behind a single parameter set for an HDTV production standard. That situation in effect still existed at the time of the Extraordinary Meeting of Study Group 11 (SG 11) on 10-16 May 1989, but now *two* possible HDTV systems had been proposed as *the* candidate:

> The Extraordinary Meeting of the CCIR Study Group 11 [SG 11] in May 1989 discovered a rather unchanged situation. Both standard candidates stood unmoved and unmovable. In the meantime, IWP 11/6 had produced a *form sheet* containing a collection of all relevant parameters and started to fill in the empty spaces with agreed upon figures, a process that gained some success and continued during the Extraordinary meeting (Habermann 1991:10)

The Final meeting of SG 11 for the 1986-90 period was held in Geneva in October 1989. During this meeting were, among other things, discussed two alternative approaches that aimed at the world-wide harmonization of HDTV by means of achieving a common denominator to unify the existing 1125/60 and 1250/50 systems proposals. The *Common Data Rate* (CDR) approach, was supported, but not unanimously, by the EC countries. The US, Canada, Australia and the Nordic Countries appeared as the most prominent supporters of the

[53] http://en.wikipedia.org/wiki/HD-MAC, access 090821.

alternative approach, based upon a *Common Image Format* (CIF), with one suggestion being to use 1080 x 1920 lines per picture.[54]

One output of the SG 11 meeting in October 1989 was a Draft Recommendation (preliminary named Rec. XA/11) on an HDTV standard for the studio and for international program exchange: ’18 out of the 35 parameters in questions were defined, although a number of them still showed reservations, controversial alternatives, or were marked as interim figures’ (Habermann 1991:11). According to one of the participants, in addition to disagreement between the US and European delegates, there were also clashes of opinion within Europe, for instance, between the IBA and the BBC, between Philips and the Dutch Ministry, between Thomson and the TDF.[55] As about half of the parameter values remained to be agreed upon, SG 11 decided that a reinforced IWP 11/6 should hold an extra meeting in Atlanta in the US, 22-28 March 1990, with representation also from IWP 11/7 (digital TV standards). But many felt dubious that a worldwide HDTV standard would be accepted that year, as indicated by a report from the Commission of the EC in February 1990:

> There is a significant probability that the 1990 Plenary of the CCIR will not reach final agreement and that a further study period will be necessary before a single worldwide production standard can be adopted. Further harmonization work has already been planned for September 1990 and an Extraordinary Plenary meeting in 1992 is a likely possibility if the full 4-year study appears unnecessary for a final decision to be taken. The Commission intends to continue its tight coordination of the strategy and tactics to be adopted by the Europan parties until such time as our objectives are achieved.[56]

According to a memorandum from a CCIR European HDTV coordinating meeting in January 1990, the EC policy with regard to HDTV standardization was to avoid *de facto* standards;[57] to adopt the CCIR Draft Rec. XA/11 on HDTV ’with empty squares’; to work for

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[54] Protokoll från NR-MSK:s 42:a möte den 19-20 december 1989 på Danmarks radio i Köpenhamn. NR-MSK Dok. Nr 615. At the NR-MSK meeting in June 1989 the members agreed to support an international solution for HDTV standardization based upon a CIF (but the Danish members wanted to await the results from studies concerning CIF/CDR) (Östen Mäkitalo ’Nordiskt program för HDTV’, Stockholm 16 September 1989).

[55] Minutes from ’Extraordinaert NTCM 27-28 November 1989 i København’, Danmarks Radio, NR-MSK Dok.

[56] Commission of the European Communities, Communication from the Commission to the Council and Parliament on audiovisual policy, COM (90) 78 final, Brussels, 21 February 1990, p. 31.

[57] A distinction is often made between *de facto* and *de jure* standards. According to David and Steinmueller (1992:4), *de facto* standards emerge ’from market-mediated processes’ in contrast to standards issued ’from political (”committee”) deliberations or administrative procedures which may be influenced by market processes without reflecting them in any simple way.’ David and Steinmueller also point out, that both standards arrived at within voluntary standards-setting organizations and ’mandated standards, which are promulgated by legislative bodies, or by executive order from governmental agencies that have some regulatory authority’ are commonly called *de jure* ’although the standards have the force of law behind them only in the last case.’

filling in empty squares with 1250/50; to neither propose or oppose additional two years studies; and to avoid any action that may forward 1125/60.[58]

In May 1990, the CCIR Plenary Assembly approved *Recommendation 709: Basic parameter values for the HDTV standard for the studio and for international programme exchange*, incorporating worldwide agreement upon a few important parameters, such as the 16:9 aspect ratio, colour rendition and the equation for luminance. However, a number of basic parameters (such as the number of lines, field and frame rates) were still left undefined.[59] As formulated in a specialist journal in 1991:

> The cynics say, with some truth, that the only parameter on which agreement has currently been reached is the aspect ratio: the whole world seems to agree that 16:9 could be acceptable, even if their currently favoured system actually uses something different.[60]

Before exploring in closer detail how a new HDTV project called HD-Divine began to emerge in 1990, a few additional points need to be made. First, having deliberated the parameter values of HDTV since 1984, in 1987 the 1125/60/16:9/2:1 proposal submitted to the CCIR was adopted as the national studio standard by Japanese authorities (Okai 1987). In 1989 daily experimental HDTV broadcasts were introduced in Japan, using NHK's experimental 1125/60/16:9/2:1 HDTV system, a MUSE transmission system and an experimental broadcasting satellite. Back in 1989-1990 there was still no other HDTV system being used in daily broadcasts and commercially available.

During the 1980s, the 1125/60/16:9/2:1 parameters had also emerged as the SMPTE 240M standard for HDTV production equipment in the US. Two other important policy groups had given their endorsement to this HDTV production standard: the ATSC and the ANSI. However, by 1989 the ATSC had formally left their previous support for the 1125/60 production standard, favouring instead a 'common image' production standard based on 1920 pixels per active line and 1080 active scanning lines per picture (Jurgen 1989:30; Schaefer & Atkin 1991:413).

As to transmission and delivery to the home, back in 1989-1990, hegemonic projects in Japan and Europe as well as corresponding attempts to (re)shape the institutional conditions

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[58] Kjell Engström, 'Nordiskt agerande i CCIR IWP 11/6 och Plenarmötet. Förberedande diskussioner i NR-MSK/HDTV. 1990-02-05, NR-MSK/HDTV 108.

[59] *CCIR Recommendation 709: Basic parameter values for the HDTV standard for the studio and for international programme exchange*, Recommendations and Report of the CCIR, 1990, Volume XI, Part 1, ITU, Geneva, 1990.

[60] Archer, James: 'High Definition Television. Progress towards a world standard – the nineteen nineties', pp. 18-21, in *Electronics Today International* (ETI), August 1991, Volume 20:8 (quotation, p. 18).

for tomorrow's (HD)TV systems were still concentrated on satellite and satellite-cable as the primary delivery media of HDTV. But the doubters could point to the US, where the regulator, the FCC, since 1988 had made it increasingly clear that the US was putting primary emphasis on over-the air terrestrial transmissions of HDTV and, possibly, enhanced (ED)TV 'as a temporary solution that migh facilitate an orderly and effective transition to' HDTV.[61]

Since the set up of the ATSC in the early 1980s a growing number of friends and enemies had become involved in the development of various improved NTSC, enhanced 525-line and HDTV systems competing to replace NTSC as the new national advanced television (ATV) transmission standard. Aided and abetted by the ATSC and other organizational inventions, such as the FCC *Advisory Committee on Advanced Television Service*, established in 1987, and the private *Advanced Television Test Center (ATTC)*, set up in 1989, the FCC was expected to take the final decision by 1993. The Columbia Broadcasting System (CBS, one of the three largest TV networks dominating broadcasting in the US), among others, had lobbyied hard for an HDTV solution that would guarantee the survival of the existing 1,420 independent local TV broadcasting, using terrestrial transmission networks and cable TV systems.[62] Here is the Vice-President and General Manager of CBS Engineering and Development (1967-90) outlining the CBS viewpoint on the development of HDTV in 1988:

> Recognizing that VCRs, video discs, cable, and future DBS services will be able to deliver HDTV with fewer spectrum (or bandwidth) constraints than broadcasting, we must ensure that terrestrial broadcasters have a pre-eminent position in the HDTV-landscape, however difficult that may seem today. We must achieve competitive parity at the outset and, equally important, we must maintain that parity as HDTV evolves and improves with time.[63]

From the standpoint of the continued use of existing TV terrestrial transmission networks and cable TV systems, maintaining frequency plans currently in force when introducing HDTV was obviously considered as an important issue. The introduction of HDTV in the UHF and VHF bands would be constrained by the standard bandwidth for the existing TV channels used throughout the world, namely 6, 7 and 8 MHz.

Although satellite and cable as well as fiber optics were still expected to play a role, during 1990 and the following year it was becoming apparent that the US was going in the direction of over-the air terrestrial transmissions of HDTV, and in particular the development of 'all-

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[61] The June 1988 interim report of the FCC Advisory Committee on Advanced Television Service; quoted (p. 70) in Kennedy, M. Carlos, 'The global standards dilemma – agreement or anarchy', *Television: Journal of the Royal Television Society*, March/April 1989. 68-72.

[62] Flaherty, Joseph A, 'A World of Change', *HDTV World Review*, volume 2, winter 1991, 3-7.

[63] J.A. Flaherty, "Digital HDTV in America – The cutting edge", in *EBU Technical Review*, Autumn 1992, pp. 67-73 (quote, p. 68).

digital' transmission systems that would fit in the standard bandwidth allocated for existing terrestrial TV services in the US (6 MHz). The heightening of interest in digital transmission systems for HDTV was also coupled with the growing involvement of the computer graphics industry in potential multimedia applications (Connoly 1991).

In a first report adopted in August 1990, the FFC reiterated its intention to select a *simulcast* HDTV system for its advanced television standard. That is, they planned to make available terrestrial frequencies in the unused or 'taboo channels'[64] so that the new system, incompatible with NTSC, could deliver a second, high definition, version of the existing NTSC service, while the traditional NTSC signals would continue on existing VHF or VHF channels allocated for television. As explained by the Assistant Bureau Chief of the Mass Media Bureau, FCC, at the time:

> *Simulcast* is a contraction of *simultaneous broadcast* and normally means the broacast of one program over two channels in the same area at the same time. In this proceeding, simulcast has come to mean an independent ATV signal that can produce an advanced picture and be broadcast simultaneously with conventional television signals in the same area without causing interference. A licensee operating both a conventional and ATV station in the same market may or may not transmit the same program on both stations. (Hassinger 1991:24)

By late 1988, twenty-three experimental HDTV and EDTV systems had been submitted to the FCC for consideration as the new national advanced TV standard. By early 1991, that list had been modified and narrowed to six candidate systems, to become tested at the ATTC under the auspices of the FCC's Advisory Committee on Advanced TV Service. One proposal was for an EDTV system. Five proposals were for HDTV systems, all defined as analogue or hybrid analogue/digital concepts except one–in 1990 General Instrument Corporation had taken the lead in proposing an 'all-digital' HDTV system: *DigiCipher*™. By late 1990, a competing system proponent, the Advanced Television Research Consortium, including Thomson-Philips among others, had announced that they too would submit an 'all-digital' proposal for testing at the ATTC (Flaherty 1991; Schefer & Atkin 1991).[65] Here the Chairman of the 25 members ATTC is describing the remaining five HDTV proponents in 1992:

> Four of these five systems feature a digital transmission mode, something that was not considered likely or even possible for over-the-air broadcasting just a few years ago. Those proponent are: an alliance of General Instrument and the Massachusetts Institute of Technology (both U.S. entitites), with two different systems; a partnership of Zenith and

[64] In line with 1961 ITU regulation, the 'taboo channels' lied between frequency channels that were allocated for existing VHF and UHF terrestrial TV services and were traditionally unused because of the risk of interference.
[65] By July 1990, there were seven proposals for transmission systems for terrestrial HDTV; 2 were 'NTSC-compatible' and five were 'simulcast' systems. General Instruments' DigiCipher had by then appeared as a new proposal. (Staffan Nyström, Rlb, 1990-09-25, 'Reserapport från "HDTV Colloquium" i Ottawa 25-29/6 1990.'

> AT&T (each an American company); and a consortium composed of the David Sarnoff Laboratory (located in Princeton, New Jersey); NBC, and two leading European electronics companies, Thomson and Philips. Additionally, NHK, the Japanese broadcast company, has advanced an HDTV system employing an analogue transmission mode (Wiley 1992:5).

It should be emphasized that all HDTV systems under development at the time at various places around the globe were assisted by digital technologies in some way or the other, in the studio or reception part of the signal process. The new ’all-digital’ system proposed by General Instrument offered the potential to *transmit* HDTV signals in the digital form *all the way* from the production centre to the home over-the-air through satellite links, cable TV nets and terrestrial transmitters.

On the pattern of the US, back in 1989-1990, Europe saw the start of a number of collaborate projects in which the emphasis shifted from the development of HDTV for satellite broadcasting towards the investigation of terrestrial HD-like systems called Enhanced PAL/Secam which involved changing the aspect ratio from 4:3 to the new widescreen 16:9 format while preserving compatibility with existing terrestrial broadcasting networks, TV systems and frequency allocation.

By 1990, there were three major laboratory programmes in Europe for Enhanced PAL: the PALplus project; the ITVA/UKIBA project, and the BBC project. The German-initiated PAL plus project was the largest in terms of effort. It involved four large European consumer electronics concerns–Grundig, Thomson, Philips and Nokia–and broadcasters from Germany, Austria and Switzerland (eg. ZDF, IRT). There were those who thought that the PALplus group ’might dominate the European Enhanced PAL situation’ and that the group alone might itself be a ’critical mass’ for Europe. Being designed for terrestrial transmission (and cable) PALplus was not promoting itself as a competitor to satellite-based HD-MAC.[66]

At the end of 1989, Sub-group V1 of Working Party V of the EBU had decided to set up a new ad-hoc group to examine Enhanced PAL and SECAM: V1/EPS.[67] More specifically, holding their first meeting in February 1990, V1/EPS were tasked to investigate techniques–and to produce system proposals by December 1990–for enhanced PAL and SECAM transmissions preserving compatibility with: current receivers, existing broadcasting

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[66] EBU, David Wood, ’Notes on the third meeting of AD-HOC Group V1/EPS (Geneva, 12-13 July 1990)’, 26 July 1990. As concerned Enhanced SECAM, by 1990 there was no R & D programme. Successful investigations of a ’clean’ SECAM system had been made in the mid 1980s, but the hardware developed was no longer available. In France the need to restart the study was being considered, with a decision being expected shortly

[67] Staffan Nyström, Rapport från möte mellan PAL-plus och EBU, 24/1 1990. Plats: ZDF:s lokaler, Rue Goethe 4, Paris.

networks, and existing planning constraints. The enhancements would include the new 16:9 aspect ratio and increased resolution.[68]

By January 1990, the EU95 Project Group 04 (satelllite transmission) was to initiate studies on a version of HD-MAC designed for terrestrial transmissions.[69] And by April 1990, Mexiko had decided to start terrestrial HDTV transmissions over Mexico City the following summer using a variant of the Japanese MUSE system.[70] By August 1990, the BBC together with ZDF were pursuing the possibility of launching a Eureka project on Enhanced PAL, with several other organisations in Germany, Italy and Scandinavia having expressed interest in joining the project in due course.[71]

Moreover, back in 1989-1990, when the HD-Divine project began to take shape, R & D actvities on satellite digital transmissions of (HD)TV were going on all around the world, involving significant advances in digital modulations and channel coding techniques. According to a research engineer in the early 1991, one could identify at least three levels of ambitions for on-going experimental work on digital (HD)TV:[72]

1) Broadband HDTV (140 Mbit/s) for point-to-point satellite connections which required the allocation of new frequencies for satellite transmitted digital HDTV, possibly within the 12,7 to 23 GHz bands (this was an issue to be discussed at WARC 1992. Several experimental systems existed or were under development, in particular for point-to-point programme connections.

2) Digital HDTV being compressed to a maximum of 70 Mbit/s which could be transmitted on the same way as the one described above, but probably also in already existing satellite channels. Within the framework of the Italian-Spanish Eureka 256, Telettra had by March 1990 performed laboratory demonstrations before the EBU Working Party V (New Systems and Services) of a 70 Mbit/s digital TV signal transmission by satellite.[73] At NAB a

[68] Draft terms of reference. Ad-hoc Group V1/EPS (Enhanced PAL and SECAM). V1 Temp. 1, Aqaba, 11, 89, Rev. 1.

[69] Staffan Nyström, Rlb, Rapport från möte mellan PAL-plus och EBU, 24/1 1990 in Paris.

[70] Per Appelquist, SVT, 'HDTV-studiostandard', 1990-04-12.

[71] Letter from Brendan Slamin, Special Assistant to Director of Engineering, BBC, to Per Appelquist, Head of R & D Department, Swedish Television, 21st August 1990.

[72] If nothing else is mentioned, this section is built upon: Kjell Engström, utvecklingschef SR, 'Översikt över olika sändningssystem för TV och HDTV', bilaga till 'Införande av HDTV. Handlingsplan 1991-2001', 1991-02-15 (with contributions from Anders Ahl, Per Appelquist, Sven Olof Ekolm, Kjell Engström, Ulf Gartelius, Björn Kallner, Gunnar Kihlander, Kjell Kullberg), p. 29.

[73] The demonstration performed was on the transmission of 70 Mbit/s 8PSK signals, carrying PAL pictures DCT-encoded and a pseudorandon sequence, over a hardware simulated satellite channel. Lars Sundin, 'Italiensk digital HDTV – en tankeställare', internal PM broadcasting unit, Televerket, 1990-04-02; RAI Centro

few weeks later, Telettra had demonstrated before a wider audience a digital HDTV codek for the data speed 70 Mbit/s meant for point-to-point satellite connections.[74] Telettra's demonstrations had shown that it was possible to build a digital HDTV system that offered better picture quality and required significantly lower deposit of 'hardware' than HD-MAC.

3) Terrestrial digital HDTV had been studied by a few organizations that recently had publicly presented their results. Built upon picture coding with high data compression and new modulation techniques similar to the one used for digital audio broadcasting, there were information indicating that it would be possible to achieve enough high picture quality ('better than HD-MAC') on the low data speed at hand (about 24 Mbit/s).

Indeed, during 1990 and the following years, it became obvious to more and more (HD)TV engineers that the state of the art in digital video bit reduction schemes technology was a moving target.

One may also recollect here that back in 1989-1990, many European countries shared the conception of a completely new kind of TV landscape beginning to take shape. For instance, in the early 1980s, at a time when none of the European 'high-power' DBS projects had been realized, entrepreneurs had began to in a European context imitate and exploit the (originally North American) concept of using conventional 'low-power' communications satellites for distribution of TV directly to cable systems. During the 1980s, with an increased numbers of, primarily satellite distributed, TV services, Europe also saw new actors, new artefacts and new or alternative sources of funding and controlling the TV flow entering the field. Parabolic dishes, set-top boxes and smart-cards as well as an increasing number of pay-TV and advertisement financed services entered European homes. Looking around in Europe in the 1980s, this was a period when figures like Silvio Berlusconi and Rupert Murdoch had began to appear as highly visible mediators of the phenomenon of media mogulism of much greater proportions than ever seen before in European television, with satellite and cable TV as prominent ingredients. Moreover, in February 1989 the Luxembourg-based private consortium SES started to broadcast (in PAL) from its first 'medium-power' Astra satellite, introducing a first package of TV programmes and thereby opening a market for direct-to-home reception across Europe.

Ricerche, Torino, 'Demonstration to EBU WPV of digital TV signal transmission by satellite (Turin 13-14 March).

[74] Per Appelquist, 'HDTV på NAB', SVT, 1990-04-11.

Like always in innovation, the movements of recombination and imitation recollected here involved the (re)creation of rules and routines, some of which channelled through institutionalized machineries of government. For instance, the EC Commission published its Green Paper ’Television without frontiers’ in 1984[75] and on October 3 1989 was adopted the Directive 89/552/EEC, known as the Directive ’Television without Frontiers’, dealing with the content of television, especially distributed via satellite and cable (Ewertsson 2001).

By 1991 the EC Commission, with participation from the TV manufacturing industry, public and private broadcasters, satellite and cable operators, had proposed a new Council Directive to replace the 1986 MAC/packet Directive, which expired on 31 December 1991.[76] The original MAC/packet Directive mandated all the EC countries to use the family of MAC standards for satellite broadcasting of TV signals and concerned itself exclusively with satellites operating in the frequency channels in the 12 GHz band assigned by WARC77 to ’broadcasting satellite services’ (BSS) but not for other types of communications satellites and ’fixed satellite services’ (FSS). The proposed renewed Council Directive (91/C194/27) covered all type of satellite-distributed (HD)TV services and involved the following provisions: all wide-screen TV-sets must be capable of receiving D2-MAC; all new 625 line satellite services must transmit exclusively in D2-MAC and any HDTV satellite service must use HD-MAC; all satellites brought into operation after the date of implementation of the proposed difective must transmit in D2-MAC; from 1992, all new terrestrial redestribution systems (cable and microwave systems included) must be configurated to carry D2-MAC and HD-MAC to individual homes; existing satellite services using PAL/SECAM may continue to use these standards indefinitely.[77]

The renewed MAC/packet directive being prepared by the Commission became the subject of debate. One reason for the debate was that there was no agreement as to whether it would be feasible and desirable to follow a path towards future HDTV services based on MAC or to the necessity of a multi-steps approach of intermediate systems towards the introduction of ’full’ HDTV and HD-MAC. Another reason, among others, was that the proposed Directive did not apply specifically to terrestrial broadcasting and the MAC standards were not

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75 ’Television without Frontiers, Green Paper on the establishment of the common market for broadcasting, especially by satellite and cable’, Communication from the Commission to the Council of 14 June 1984, COM (84) 300 Final.

76 The proposed draft EC Directive became Council Directive 92/38/EEC of 11 May 1992.

77 ’The Impact on Consumers of the Proposed Council Directive on the Adoption of Standards for Satellite Broadcasting of Television Signals’, Coopers & Lybrand, London, August 1991.

designed for terrestrial broadcasting. In the words of two German engineers (Ziemer & Matzel 1990:4):

> …the MAC/-packet signal bandwidth is too broad for existing VHF/UHF channels, and, more particularly, the system is incompatible. On the other hand, in view of the improvement in quality that satellite broadcasting brings, terrestrial broadcasting must also be improved if it is to stay competitive. It is, after all, this broadcasting mode which at present supplies programmes to some 24 million TV households in the Federal Republic of Germany – with a total of about 32 million receivers (about 99% of the sets served by ARD and ZDF).

However, at stake was not only the destiny of people and ’things’ inextricable entangled with conventional terrestrial broadcasting services, but also the destiny of people and ’things’ already or possibly linked to the various existing or planned satellite TV services that used different transmission systems than those endorsed by the proposed Directive. Nonetheless, according to an analysis made in 1991, 81 % of the existing 160 million European TV households still received their TV signals exclusively from traditional national terrestrial networks.[78] In many European countries, broadcasting of public radio and TV programmes basically relied on terrestrial distribution. During the CCIR Study Period 1986-1990, a growing number of people all around Europe had began to address the question: Was there any future for public terrestrial TV services? It was in this context a project named HD-Divine was born.

SECTION II

A Swedish Radio Lab as a Basis for Recombinations

Virtually all of my sources are united in recalling that it was Östen Mäkitalo who in 1990 raised the idea of what became HD-Divine. Mäkitalo (born in 1938) was chief engineer, research leader and director of the *Radio Laboratory*, an R&D unit at *Televerket*, the Swedish Telecom, 1977-1991.[79] At the time Televerket had since long been a national monopolistic

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[78] ’The Impact on Consumers of the Proposed Council Directive on the Adoption of Standards for Satellite Broadcasting of Television Signals’, Coopers & Lybrand, London, August 1991.

[79] The same year as Mäkitalo became MSc EE, in 1962 he was employed by Televerket. Over the years he held a number of different positions within Televerket (Telia). e.g. Director of R&D at Televerket Radio, President of Telia Research, CTO Telia Group. He has also been Chairman in several International Working Groups and a boardmember in several telecom companies. He is member of the Royal Swedish Academy of Engineering Sciencies (IVA). Mäkitalo has received a number of prestigius awards, national as well international, because of his contribution to the development of several mobile systems, like NMT (Nordic Mobile Telephone), MBS (Paging System), RDS (Radio Data System), GSM (Global System for Mobile communications: originally from Groupe Spécial Mobile; an international standard for mobile phones) and ERMES (European Radio Messaging System; a pan-Europen radio paging system). When Televerket was transformed into *Telia AB* in 1991, Mäkitalo became head of the new subsidiary *Telia Research*, embracing all R & D units at the former Televerket. This meant that the about 60 research engineers working at the Radio Lab moved to Telia Research, which under the direction of Mäkitalo (1991-1996) had a staff of some 600 professionals. In 1996 Telia Research was

network operator for various telecommunications services, which included the copper wires of the telephone network, as well as the newer coaxial cables and microwave links, and later also satellite links. It also included the transmission facilities and communications circuits required for contribution and distribution of TV and sound programmes, with the *Swedish Broadcasting Corporation* (Sveriges Radio AB, SR, and its forerunner AB Radiotjänst) as the original customer. Within Televerket, *Televerket Radio* was, on behalf of the state, charged with the responsibility for the development, maintenance and operation of the stateowned terrestrial broadcasting network(s) for FM sound radio and TV. SR had developed a close working relationship with Televerket Radio, particularly its *Broadcasting Section* and *Radio Laboratory*. Although collaboration between Televerket Radio and SR had become institutionalized in a number of ways, they were organizationally and spatially separated.[80]

Within the space of radio technology, Mäkitalo and his collegues at the Radio Lab did not respect any boundaries between broadcasting and other telecommunications. Still they had an identity as belonging to the world of transmission/distribution, not the world of radio and TV programme production. With the old Televerket as the organizational habitat, some people would also ascribe them an identity as agents of the State. Above all, the about 60 research engineers working at the Radio Lab around 1990 envisioned themselves as agents of change, constantly working on the frontiers of transformation.

Indeed, the Radio Lab were highly involved in innovation: they were seeking to refine and recombine existing ’materials and forces’ to do new things, or existing things differently (Schumpeter 1934/2007:65), with radio (wireless) technology as one of the ingredients. To a large extent we now live with the electronic communications systems and products that the people at the Radio Lab amongst many other research engineers in the last decades of the 20th century laboured to (re)define, standardize and institutionalize. As they were developing and remodelling our means of communications, they had to their disposal three new building blocks that had not been available to communications systems designers of earlier times: satellites, digital technology and laser technology.

Mäkitalo was chief engineer and director of Televerket’s Radio Lab just at this point: communications satellites had been exchanging programmes between broadcasters since 1965; DBSs as well as fibre optics were coming, promising transborder television, an increase

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reorganised into Telia Research and Telia Engineering. Mäkitalo was Chief Technology Officer at the headquarters of Telia from 1996 to his retirement in September 2005.

80 During the period covered here, SR and its R & D units were located at Gärdet, Stockholm; Televerket Radio were located south of Stockholm, first at Farsta (Mårbackagatan) and from September 1988 at Haninge.

in capacity and the establishment of ’broadband’ services; digital technology had entered the experimental practices and routines of the Radio Lab and Mäkitalo and his teams were struggling to redefine the shape of existing communications systems to catch up with digital visions and opportunities. Like many others the Radio Lab were firmly determined to qualitatitively transform existing everyday life by leading (or pushing) the rest of society into ’the digital era’ and new–digital–worlds of communications, with ’convergence’ and ’flexibility’ evolving as some of the key mantras. One of the challenges was to find some means of turning and compressing the huge amount of information in analogue (HD)TV signals into manageable digital streams of ’bits’ to be sent over long distances via landlines, microwave links or satellite links.

In the 1980s, the Radio Lab did, among other things, work on the development of a digital mobile telephone system, later known and widely applied as GSM. There were also engineers who strived to shape and define a digital stereo sound system for terrestrial TV, later known as NICAM. The Radio Lab also took part in the development of a Digital Audio Broadcasting system for terrestrial sound broadcasting under the Eureka 147-DAB project. At a time when digital transmission methods had already been adopted in telephone networks (for instance, the Integrated Services Digital Network, ISDN), the lab was also involved in the development of digital transmission methods and coding techniques for radio relay transmissions of TV signals.

The Radio Lab had also become part of international efforts to develop a new transmission system intended for TV satellite broadcasting that became called *Multiplexed Analogue Components* (MAC), but also involved digital components, as mentioned previously. In relation to plans of a future common Nordic DBS called ’Nordsat’, a working group was set up which assembled research engineers from the telecom administrations and programming companies in the Nordic countries (Denmark, Finland, Norway, Sweden) to study transmission methods for satellite broadcasting: NR-MSK [*HJÄLP ÖNSKAS: vad står NR-MSK för*?]. According to Mäkitalo, who chaired NR-MSK, the MAC concept owes much to the pioneering work that was done by (in particular, Norwegian) members of this group. But in the collective memory publicly generated and dispersed through the worlds of broadcasting engineers and systems designers it is, in general, the IBA in the UK that is attributed the role as the founding father of MAC. Yet, the need in Scandinavia for a system that would provide further sound channels – so that one TV service could be broadcast via Nordsat (which never was launched) in four differrent language channels to serve the whole region – has survived as an important reason for developing MAC in the first place (cf Appelquist 1997:31; Bell 2007:38).

In the 1980s, people at the Radio Lab also became involved in the design, promotion and standardization of HDTV, initially as eager ’pushers’ of the MAC system. Mäkitalo himself had early started following and actively taking part in the development and standardization of HDTV through his participation in a number of international working groups. He was, for instance, the chairman (since 1980) of the CCIR Joint Interim Working Party (JIWP) 10-11/3, charged with studying *inter alia* satellite broadcasting of HDTV.

By the end of 1986, the Radio Lab had become a member of the EU95 HDTV project, struggling to define and institutionalize a path for future satellite distributed HDTV as a compatible, evolutionary, extension of the MAC transmission standard(s). In relation to this, the Radio Lab appointed two new posts directed towards the development and analysis of different methods for transmitting an HDTV signal via various transmission media. It became Staffan Nyström (born in 1957) and Erik Stare (born in 1959) who in 1987 got the appointments, involving plenty of international cooperation through EU95’s Project Group 05 (picture de/coding). For Stare it also meant plenty of work as Televerket’s representative in the CCIR IWP 11/6, which since 1983 had attempted to prepare the recommendation for an HDTV production standard (and later also for terrestrial HDTV).[81]

When Stare joined the Radio Lab on April 1 1987, he had been working at Ericsson since 1984, as a sales engineer with transmission equipment for the North African market. Nyström was internally recruited, from the south regional unit of Televerket Radio, based in Malmö, where he had been involved in R & D work on digital transmission systems and picture coding for TV since 1985. With the appointment of Nyström, the Radio Lab obviously strengthened knowledge and bonds linked to a particular series of events: 22-25 October 1985 Nyström together with Gunnar Kihlander, SR, and Björn Christensson from Televerket’s Radio Lab visited the CCETT labs in Rennes, France, the BBC labs at Kingswood Warren in Surrey and the IBA labs at Brompton Road in Knightsbridge, England, to study their pioneering work on digital technologies for the TV studio and coding systems.[82]

[81] As part of the reorganization of the ITU in 1992, the CCIR was superceded by the *ITU-R*, the ITU Radiocommunication Sector, and the so-called Interim Working Parties (IWPs) were replaced by Task Groups (TGs). For instance, the IWP 11/6 was replaced by TG 11/1, *High Definition Television for Studio and Program Exchange*.
[82] Nyström, interview 15/6 2009.

The work on HDTV at the Radio Lab was largely framed by the connections, traditions and interests of two collectives-the Broadcasting Section at Televerket Radio and the Swedish Broadcasting Corporation (SR)–which were inexorably intertwined with each other in the development of a state-owned nationwide terrestrial network for transmission and broadcasting of radio and TV. Like many other public broadcasters and EBU members, SR–with an identity as the sole national public service broadcaster–was by no means guaranteed access to satellites at a time when it faced a range of challenges related to the common conception of a completely new kind of TV landscape beginning to take shape in Europe mentioned earlier (see ' Towards a single world-wide HDTV standard?'). After decades of expansion and institutionalization, the license-see funded SR and its subsidiary Swedish Television (SVT), which produced the programmes of the two terrestrial TV channels, had to tackle problems with financing, legitimacy and the (re)creation of routines in a situation with a new type of competition from the introduction of home VCRs, an accelerating number of satellite and cable channels, so-called transfrontier and pan-European TV, future HDTV services, and eventually also a new terrestrial advertising-funded TV channel (1991).[83]

HD-PAL

At this point in the story, we may introduce Valdemar Persson, head of the Broadcasting Section at Televerket Radio which was responsible for the development and operation of the Swedish terrestrial broadcasting network(s). More than 600 small FM/TV stations acting as 'slaves' of 54 large FM/TV stations allowed SR's traditionally limited number of parallell programmes to reach virtually the entire population in Sweden. In addition to the terrestrial broadcasting network(s), Televerket Radio also had a nationwide network of radio links via which signals could be transmitted between large stations.

Like a growing number of people at the time, Persson was busy struggling to defend and shape the destiny of the relatively old terrestrial network(s) for FM radio and TV under the conditions of various types of challenges, the introduction of future HDTV services being but one. Related to both radical change in national TV policy and the almost parallell corporatisation of Swedish Telecom into *Telia AB* (now *TeliaSonera*), Persson was, for example, involved in discussions that resulted in the establishment of *Teracom Svensk Rundradio AB*, a new (state-owned) company, independent of Swedish Telecom and programming companies, set up specifically for the organisation of the terrestrial broadcasting

[83] The new terrestrial advertising-funded TV channel was bound by certain public service obligations, licensed and regulated by the Government (for the introduction of this channel, see Ewertsson 2005).

network(s). Having existed within Televerket since 1925, on 1 July 1992 the broadcasting activities–the personnel, the installations and equipment supporting the terrestrial broadcasting networks–were moved from Televerket Radio to Teracom, headed by Persson.

Back in October 1988, while the broadcasting activities still belonged to Televerket Radio, Mäkitalo had been commissioned by Persson to allocate Radio Lab resources to explore the possibilities of developing a PAL-compatible system that would allow an HDTV signal to be distributed within a single traditional terrestrial 8 MHz UHF or VHF channel.[84] It became Nyström and Stare who, while working in the satellite-based EU95 HDTV project, were entrusted the additional task to initiate studies of such a PAL-compatible system for terrestrial transmissions of HDTV.[85] Stare comments on these parallell engagements:

> Vi var färska på HDTV, men lärde upp oss. Östen såg Eureka-95 som ett bra sätt för Televerket att bygga upp kunskap [’insight and experience in HDTV’] inom HDTV-området. HD-PAL projektet drevs parallellt, men var ingen del av Eureka. Det gjorde vi helt på egen hand. Man kunde alltid argumentera för att vårt interna HD-PAL inte utgjorde en konkurrent till Eureka; vi föreslog ju inte en annan satellit-teknik; vårt interna HD-PAL projekt var *marksänt*. (Stare, in interview 14/12 2007)

A preparatory study on HD-PAL (as it came to be called) started in November 1988 under the working group for Terrestrial HDTV, subordinated to the Development Delegation of STYRK, a cooperation body involving R & D people from Televerket Radio and SR (see below). Eventually computer simulation work on HD-PAL with regard to picture coding was initiated, based, inter alia, on experiencies from the development of HD-MAC. By February 1990 the main goal was ’to develop a PAL-based HD-system that qualitatively could offer the terrestrial transmitting broadcasting companies a competitive alternative to satellite system corresponding to HD-MAC’.[86]

When, in the course of 1988-1990, Nyström and Stare at the Radio Lab were working on HD-PAL, similar activities were, as previously mentioned, going on in many other laboratories both in North America and other European countries. Here is Mäkitalo describing the situation in 1989:

> Parallellt med utvecklingen av satellitdistribuerad HDTV planeras runtom i världen terrestra HD-liknande system baserade på NTSC, PAL och SECAM. Ibland används begreppet EDTV

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84 Utvecklingsdelegationen (Tvt, SR/SVT), Projektbeskrivning 1988-10-14, ’Terrester högupplösningstelevision’.
85 Stare, in interview 16/11 2007. Cf. ’Terrester HDTV’, FoU Projekt, Utkast 18/4 1989, unsigned pro memoria distributed to the members of the Development delegation of TvT and SVT/SR.
86 Beställning: Utvecklingsuppdrag inom Rundradion, Projekt: HD-PAL, datum för beställning 1990-02-22, Handläggare/beställare: Per Mellberg, RrC

> (Enhanced Definition). I USA är den NTSC-baserade filosofin helt dominerande, ett 20-tal kandidater finns. För de terrestert sändande programbolagen är det av konkurrensskäl viktigt att möjligheten till förbättrad PAL noga studeras. Det är därför också av strategisk vikt att vid sidan av arbetet med de satellitdistribuerade HDTV-systemen även följa den internationella utvecklingen och aktivt bidra med studier kring terrester HD-liknande koncept baserat på PAL.[87]

HDTV enters STYRK and NR-MSK

As the ’80s turned to the ’90s, work with regard to the possible adoption of a single worldwide CCIR production HDTV standard was sintensifying with the next important meetings to be held in March in Atlanta followed by the CCIR Plenary in Düsseldorf in May. By October 1989, Mäkitalo belonged to those who still believed that there may be a chance that the present CCIR study period would allow for the adoption of a single HDTV studio standard at the Plenary in May 1990. A recommended CCIR standard would reduce uncertainty by providing a stable foundation for strategic decisions and further R & D work on HDTV, Mäkitalo argued as he attempted to mobilise broader support also beyond the CCIR, not least within the EC, for the feasibility and desirability of reaching a compromise agreement between the two competing system candidates proposed for a worldwide HDTV studio standard. He did, for instance, call on H. Kraayenbrink at the Ministry of the Netherlands on this matter.[88] He also tried to make CCIR’s work on a possible single international HDTV standard into the common concern of the national broadcasting companies and telecoms in Sweden, Norway, Denmark and Finland.

By December 1989, not only coordination of HDTV promoting activities but also actions towards one single international HDTV standard had become the stable tasks of two particular institutionalized groups of research engineers, both chaired by Mäkitalo: the *STYRK* (Swedish Technical Steering Committée), a permanent cooperation body with members from Televerket Radio and SR, and the *NR-MSK* (see above), a working group involving members also from the telecom administrations and programming companies in the other Nordic countries (Denmark, Finland, Norway).

By December 1989, STYRK had set up a subgroup, chaired by Mäkitalo, with the view to develop a joint programme covering system studies, transmission experiments, demonstrations and international standardization on HDTV. The new HDTV Coordination Group established between SR and TvtR should propose a common Swedish HDTV policy,

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[87] Östen Mäkitalo in ’Underlag till Tele- och Radiochefs mötet’, NR-MSK, 891005.
[88] Danmarks Radio, 89-11-30, JAH/LKH, minutes from ’Extraordinært NTCM 27-28. November 1989 i København.’

ranging from international standardization work to strategies for the introduction of HDTV in Sweden, the launch of certain projects and discussions with the industry included.[89] At their first meeting, on 4 December 1989, discussions were held, among other things, on approaching international meetings where members from the group would participate, for instance: the CCIR European HDTV coordinating group (January 8-12), the NR-MSK (December 19-20), the EBU V1/HDTV (December 12-14), the EBU SC/EV (January 11), the CCIR IWP 11/6 and 11/7 (March 22-28), the EBU Technical Committee (April 23-27) and the CCIR Plenary (May 21-June 1).[90] One also mentioned that the EBU had decided to set up a new ad-hoc group within Sub-group V1 on enhanced PAL/SECAM (later known as V1/EPS) and concluded that Sweden was prepared to take a great share in the project. One also discussed plans of arranging demonstrations and broadcasting tests of HD-PAL and HD-MAC at various sites in the Nordic countries in June 1992, covering the European Football Championships which then were to take place on 4 arenas in Sweden. For instance, Mäkitalo had written to the EUREKA-95 Directorate about support for the HD-MAC demonstrations.[91] It may be noted that at this meeting, held in December 1989, Mäkitalo articulated that he–’like many others’–believed that one should skip HD-MAC and insted go via enhanced PAL to the introduction of digital HDTV.[92]

At their second meeting, on January 4 1990, the Swedish HDTV Coordination Group decided that Erik Stare, Televerket Radio, and a representative of SVT (Per Appelqvist was later appointed) should participate in the new EBU-group V1/EPS by the agency of SR. One also discussed a first version of the joint action plan being prepared by Per Mellberg and Kjell Bergqvist, Televerket Radio, to be presented at the STYRK-meeting 22 February. Kjell Engström, head of the Technical development department at SR, presented a draft proposal to be submitted to the IWP 11/6 in order to find a solution towards the evolution of one single HDTV studio standard.[93] It was based on an idea that first had been suggested and ventilated by Stare to Engström at a dinner held in Geneva in relation to the SG 11 meeting in October 1989. Together they had then developed what became promoted as the Swedish compromise proposal or *the Common Image Part (CIP)*, deriving from the existing 1250/50 and 1125/60

[89] Lars Sundin, Televerket Radio, Radiolaboratoriet, 1989-12-11, ’Utvecklingsdelegationens koordinergingsgrupp för HDTV. Protokoll från det första mötet 4 december 1989’. The participants from TvtR were: Ö Mäkitalo, L. Sundin, P. Mellberg and K. Bergqvist. Per Appelqvist represented SVT and Kjel Engström SR.

[90] Kjell Bergqvist’s memos from HDTV-meeting group 8912-04.

[91] Letter from Mäkitalo, Televerket Radio Laboratory, to P.W. Bögels, Philips International B.V. , 1989-11-08.

[92] Kjell Bergqvist’s memos from HDTV-meeting group 8912-04.

[93] Lars Sundin: Styrkommitténs koordineringsgrupp för HDTV. Protokoll från det andra mötet 4 januari 1990.

standard candidates and a combination of the benefits of the CIF and CDR approches that had entered the CCIR discussions at the time.[94]

By January 1990, the HDTV Coordination Group had began wooing support for their draft proposal outside Sweden, for example, in the CCIR HDTV European coordinating group, in the EBU, the CBS (US), the CBE (Canada), Barton, FACTS (Australia) and Nokia (Finland) As formulated in a letter to the Director-General of the NHK Labs, the proposal was linked to the main objectives of trying ’to break the dead-lock within the CCIR and stimulate rapprochement between the different parties’.[95] Before the approaching CCIR-meeting in Atlanta in March, the Swedish proposal was submitted to the members of IWP 11/6 in a revised version. To meet the demands and recommendations of others, some parts of the proposal then became subject to further revisions. For instance, on the demand of the CCIR European HDTV coordinating group the word ’compromise’ was removed from the title: a ’Proposal for compromise HDTV studio standards’ was modified to a ’Proposal for certain HDTV studio standard parameter values’ (2048x1152, 72 Hz, 1:1).[96]

A few weeks after the Swedish HDTV Coordination Group held their first meeting in December 1989, the NR-MSK decided to set up a special subgroup to promote the introduction of HDTV in the Nordic countries by proposing and coordinating system studies, transmission experiments and demonstrations. The new NR-MSK/HDTV, lead by Kjell Engström, should also prepare and develop a joint Nordic position in HDTV matters in order to influence international standardization.[97] Their tasks involved planning of demonstrations and test transmissions of HDTV (in both HD-PAL and HD-MAC) in 1992, in relation to the

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[94] Stare, phone-call May 6 2009. The idea of the CIP approach was to define two closely related interim standards image formats that contained a maximum number of features based on the existing 1250/50 and 1125/60 proposals to allow the evolution of one single future target standard.

[95] ’Our proposal is to increase the number of lines in the 50 Hz standard to 1080, the number of lines in the 60 Hz standard to 2048 and adopt the concept of square pixels. All other relevant parameters are kept unchanged. The 60 Hz format would be inscribed into the 50 Hz format such that overlapping pixels are cosited. This means that the 50 Hz format would be slightly larger than the 60 Hz format.’ Letter from Kjell Engström, Swedish Broadcasting Corporation, Technical Development, to Dr Masao Sugimoto, Director-General, Science and Technical Research Laboratories, 1990-01-15; Sweden-Draft ’Proposal for Compromise HDTV Studio Standards Derived from the Existing 1250/50 and 1125/60 systems’, 3 January 1990; IWP 11/6 4001, 26 February 1990, Sweden ’Proposal for certain HDTV studio standard parameter values derived from the existing 1250/50 and 1125/60 systems’.

[96] Sveriges Radios och Televerket Radios Koordineringsgrupp för HDTV, Bilaga 2 till HDTV 32, 1990-02-16, Konfidentiellt: svenskt bidrag till CCIR i standardfrågan för HDTV.S

[97] Östen Mäkitalo ’Nordiskt program för HDTV’, Stockholm 16 September 1989 (1989-08-17); Protokoll från NR-MSK:s 42:a möte den 19-20 december 1989 på Danmarks radio i Köpenhamn. NR-MSK Dok. Nr 615. The NR-MSK/HDTV subgroup consisted of Kjell Engström (SR), Petter Brodal (TF), Per Böhler (NRK), Jens Anker Heegaard (DR), Per Mellberg (Tvt R), Kalevi Terässvou (PTV-TELE), Juha Vesaoja (YLE), Jörgen Weber (ST). (Förslag till reviderat mandat, 1989-12-20, 1990-10-29, NR-MSK/HDTV 100 Rev. 1.)

European Football Championships. At the first meeting of NR-MSK/HDTV, held January 25 1990, the Swedish CIP-proposal to be submitted to IWP 11/6 was discussed. Although not opposing the proposal, the support from within NR-MSK/HDTV was weak. As a member of the EC, Denmark was officially bounded by the EC Directive (7 December 1989) supporting the HD-MAC system and standards. Norway was, according to the Swedish group members, relatively passive and highly involved in the development of Wide-MAC, while Finland was influenced by its industries' (Nokia and RTT) participation in EU95, involving also financial support from the Finnish government.

NR-MSK/HDTV concluded that they did not have the mandate to act collectively in relation to the forthcoming CCIR-meetings. Only Sweden would be able to act more freely, possibly with Norwegian support during the Plenary Assembly. Sweden also participated in the CCIR European HDTV coordinating meetings, and was also in this context able to more freely (than Denmark and Finland) pursue a free-spoken policy.[98]

Kicking off an HDTV Project

During the first five months of 1990, the new HDTV Coordination Group established between SR and Televerket were preparing for the launch of a new more comprehensive 'HDTV project' that would involve R & D people from both Televerket Radio and SR/SVT. In relation to this, the Radio Lab at Televerket recieved new or renewed R & D commissions.

The launch of the new HDTV project became the subject of a special meeting at Dalarö, South of Stockholm, 21-22 maj 1990, assembling 12 (exclusively male) engineers from Televerket Radio's Radio Lab and Broadcasting Section.[99] At this meeting the joint action plan proposed by the HDTV Coordination Group was accepted. Also the new HDTV project, with the HDTV Coordination Group acting as the consultative group, became the subject of a certain consensus amongst the Televerket Radio people. The project was divided into two main subprojects: 'Terrestrial HDTV' and 'Digital HDTV'.[100] The goal of the subproject 'Terrestrial HDTV' was:

> Att utifrån krav från SR-koncernen och tillsammans med andra europeiska intressenter enas om ett terrestert sändningssystem som kvalitativt och ekonomiskt kan erbjuda ett konkurrenskraftigt alternativ till satellitsystem motsvarande HD-MAC och som ger en

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[98] Norway had not been involved in HDTV matters within the CCIR before and was not expected to be represented at the IWP 11/6 meeting to be held in March 1990. (Kjell Engström, 'Nordiskt agerande i CCIR IWP 11/6 och Plenarmötet. Förberedande diskussioner i NR-MSK/HDTV. 1990-02-05, NR-MSK/HDTV 108)

[99] The participants were: Kjell Bergqvist, Staffan Bergsmark, Christer Björk, Per Mellberg, Olle Myhrman, Östen Mäkitalo, Staffan Nyström, Christer Odmalm, Göran Roth, Jan-Olov Sköld, Erik Stare, Lars Sundin.

[100] Olle Myhrman, 'Protokoll Uppstart av HDTV projekt' 21-22 May 1990, 1990-08-27.

försumbar påverkan på den vanliga PAL-bilden. En publik introduktion skall kunna ske år 1995.[101]

The activities proposed to reach this goal included: further work on HD-PAL; popular demonstrations of HD-PAL; participation in EBU V1/EPS; and making clear the consequences of a non-compatible terrestrial HDTV system with regard to economical aspects and frequency planning. The Terrestrial HDTV project should also involve studies of 'simulcast' within existing frequency bands as suggested in the US. On the proposal of Nystöm and Stare,[102] if these studies would show that simulcast would be possible economically and with regard to frequency planning, the project ought to be redirected towards simulcast rather than HD-PAL.

The other subproject–'Digital HDTV'–was restricted to satellite distribution only. It had been formally initiated in February 1990, as an R & D commission on the directive of Per Mellberg, Televerket's Broadcasting Section, with the view to become closely related to the on-going projects on HD-PAL, HD-MAC and Satellite-TV. Its main goals were: to reach an agreement at WARC 1992 on a relevant frequency band for digital HDTV via satellite; contribute to the establishment of an international transmission standard that would offer a quality close to HDTV production based upon 140 Mbit/s or less.[103]

At the kick-off meeting of the HDTV-project in May 1990, it was pointed out that there was no R & D order for HD-MAC. Nonetheless, Televerket Radio was still participating in the development of HD-MAC through EU95 Project Group 5 (de/coding), but considered to change to Project Group 4 (transmission).[104]

A Eureka moment

If you ask Mäkitalo at what point the HD-Divine project began life, he will give you a date and place: March 1990, at the CCIR meeting in Atlanta, which also happened to be the site of NAB, one of the most important international industry exhibitions and conferences in the worlds of broadcasting research engineers.[105] There, in the CCIR meetings as well as amongst

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[101] Lars Sundin, Rlb, 1990-05-18, 'HDTV-projektet, underlag för delprojektbeskrivningar'; Sveriges Radios och Televerket Radios Koordineringsgrupp för HDTV, 'Projektplan för terrester HDTV', 1990-05-17.

[102] Erik Stare & Staffan Nyström, Televerket Radio, Rlb, 'Handlingsalternativ vid fortsatt arbete med HD-PAL', 27/4 1990.

[103] RrC/Per Mellberg: 'Beställning, utvecklingsuppdrag inom Rundradion', Projektnamn: Digital HDTV, 1990-02-22.

[104] Olle Myhrman, Televerket Radio, Rundradio, Protokoll 'Uppstart av HDTV-projekt' meeting at Dalarö 1990-05-21-22, 1990-08-27.

[105] Whereas Europe has *IBA*, Asia has *Broadcast Asia* and North America its *NAB* run by the National Association of Broadcasters, The NAB'90 was held in Atlanta 31/3-4/4.

the exhibition stands and in the accompanying sessions, he heard people talking about how the American company General Instruments was developing a new ’all digital’ HDTV system and that the technique and general understanding of digital manipulation were improving by leaps and bounds. One aspect of the new ’all digital’ HDTV system that caught Mäkitalo’s imagination was its potential to allow terrestrial HDTV within the present bandwidth used in the US, 6 MHz; in Europe the standard bandwidth was (and is) even wider: 7-8 MHz. No longer was digital HDTV broadcasting to the home over terrestrial transmitters something for the distant future. Mäkitalo gained support for his existing conviction: the future was digital and the experimental HD-MAC system of analogue HDTV was absolutely the wrong road to that future. As Mäkitalo put it:

> I was certain that it would be idiocy to invest in HD-MAC and other analogue or hybrid systems. It would be a gigantic wrong investment for several years to come when new digital worlds were at hand![106]

Mäkitalo wanted Europe to abandon HD-MAC and the analogue multi-steps approach to HDTV promoted by EU95. Instead Europe should prepare for a transition directly to HDTV from PAL/SECAM and follow the General Instrument and himself in this mission: the development and introduction of an all-digital HDTV system that allowed for full HDTV performance not only via satellites and cable systems but also via terrestrial broadcasting networks, while enabling interfaces to potential multimedia applications in new digital worlds. Like many others, Mäkitalo was also convinced that EU95’s multi-steps schemes toward ’real’ HDTV wasted time and money. Such an incremental, step-by-step approach was perhaps and industrial and political dream, but a consumer/user marketing nightmare, some of the critics said: it would maximize transition costs and do a great disservice to both broadcasters and the viewing public who would have to buy several versions of receiving equipment, and struggle through years of ’evolution’ on the way to ’true’ or ’real’ HDTV.

While still there at the CCIR meeting in Atlanta, Mäkitalo rose to the challenge and attempted to persuade spokespersons of HD-MAC about the importance of urgently redirecting the EU95 Eureka project away from their analogue multi-steps path towards HDTV and instead follow American companies and labs in the development of ’all digital’ HDTV systems. He tried to win the brains and hands of a number of HD-MAC supporters, ranging from executives in large European manufacturing companies and business organizations to officials at the Directorate General XIII, Telecommunications, Information

[106] Mäkitalo, in interview November 1, 2005.

Industries and Innovation, at the Europan Commission. But he was unable to convince them. According to Mäkitalo, this failure must be considered in the light of three facts. First, at the time the Eureka 95 had evolved into an enormous mega-apparatus, whose size, expectations, investments and multiple entanglements were closely intertwined with the EC and other powerful collectives in Europe. Second, Sweden was not a member of the EC at the time. Finally, the words of a research leader at the Swedish Telecom Lab probably neither had enough strength as Sweden is a country which is situated in the border areas of Europe and is relatively small in terms of population.[107]

Mäkitalo's lobbying at Atlanta in March 1990 thus took the form of a plea for the merits of all-digital HDTV systems and the importance of redirecting the EU95 programme immediately. Mäkitalo, it needs to be said, was hardly the first to call for, or even practice, digital methods for transmitting HDTV. Nor was he even the first to question the EU95 programme. But, only for its failure and the importance of the forum in which he made it, his plea was something of a landmark moment: Mäkitalo says his unsuccessful lobbying in Atlanta in March 1990 soon became transformed into a programme that later was christened HD-Divine.

Having returned to Sweden, in April or May Mäkitalo took the first steps to launch a research and development programme to fight against HD-MAC and the collective hegemonic power of which he and the Radio Lab by then still were a part: the EU95 programme. While preaching the gospel of all-digital HDTV systems, he began to discuss with collegues at TvtR and SR an idea that increasingly had occupied his thoughts after his sojourn in Atlanta: he wanted to use the promises of 'all-digital' HDTV transmission systems as the basis for a new research, development and demonstration programme whose main target would be to redirect the EU95 as quickly as possible.

More landmark moments

General Instrument's 'all-digital' HDTV system DigiCipher is a crucial element of the genealogy of HD-Divine. Having said that it would be mischievous not to mention its public debut at the IBC'90. IBC, then a biennial event, had, by 1990, already moved to Brighton from the venue of its formative years–the Grosvenor Hotel in London (Bell 2007:75). As told in many digital TV histories, at the IBC'90, held in Brighton 21-25 September, General Instruments demonstrated computer simulations of their all-digital HDTV system for the first

[107] Mäkitalo, interview 2005-11-01; 2009-10-20.

time in Europe. A few days later, a Swedish engineer reported upon the event, saying that the result was promising although the picture source material was limited. According to him, the presentation of DigiCiper at IBC'90 had initiated a new era in the development of tomorrow's TV-systems.[108]

A unique compression algorithm based on established methods called Discrete Cosine Transform (DCT) coding, variable-length coding (VCL) and 16-QAM modulation was a key element of the DigiCipher system. This system, the developers said, offered many advantages over analogue or hybrid HDTV systems. For example, it would provide digital transmissions *all the way* from the production centre to the home over-the-air through satellite links and cable nets *and* this could be readily applied also to other transmission media, including the delivery of full HDTV quality performance, CD quality digital audio, data and text services over a single 6 MHz VHF or UHF channel traditionally allocated for terrestrial TV services. Thus, it could deliver full HDTV performance to the consumer's home through satellite, cable *and* terrestrial channels. The developers also said that the lower transmitting power requirement of the DigiCipher system made it 'ideal for simulcast HDTV transmission using unused or taboo channels'. In addition, the all-digital transmission mode enabled 'seamless interface between various transmission media' (Paik 1990). Moreover, the developers claimed, the system could transmit 10 conventional NTSC services or two HDTV services over one single satellite transponder, or five NTSC services over the single 6 MHz terrestrial channel. (Mäkitalo + Schaefer & Atkin 1991:420) .

Faced with a number of digital TV narratives, we now know that the public exposure of the DigiCipher System at the IBC'90, indeed, helped transport information in Europe about the possibility of bit-reduction schemes (about 100 times) and digital moulation technique that could compress the HDTV signal into the surprisingly low total transmission data rate of 19.43 Mbit/s and 13.83 Mbit/s for the pure video signal. The story told by the former BBC programme producer Martin L. Bell (2007) about the event also makes us aware of that the IBC'90 had been selected as the site of yet another public première: in the conference session, the IBA engineer Arthur Mason presented a paper which he had written together with two collegues: 'Digital television to the home – when will it come?' Here is the abstract:

> Although there has long been interest in the concept of digital television transmission to the home, `digital' technology in domestic audio-visual products is already available and manufacturers are investing for the next generation of technology, such as MAC, where there is much digital signal processing in both the audio and video signal paths. Following a brief

[108] Ulf Gartelius, SRTK, in *Mediebrev*, Nr 45, 1990-09-29.

> discussion of the challenges facing broadcasters, the authors are concerned specifically with the further development of the UHF spectrum with a particular emphasis on exploring the possibilities for digital transmission at low bit-rates in the order of 12 Mbit/s. Work is underway at the IBA in a research topic called SPECTRA where the feasibility of digital transmission in the UHF band is being studied. SPECTRE is all about making efficient use of the spectrum by exploiting redundancy in television signals and the present UHF frequency band.[109]

Based on theoretical work only, the paper described ideas about how two existing techniques–a low bit-rate video compression system and a modulation technique called OFDM–could be combined, bringing the possibility of delivering additional TV services via existing terrestrial transmitters while co-existing with the incumbent analogue services.[110] According to Bell (2007:76), the mentioned paper presented by the IBA engineer at the IBC'90 described many of the features that today's digital terrestrial TV system has. In the words of Bell (2007:79 f):

> The importance of this paper should not be underestimated. Mason and his team may not have been the only researchers to be thinking about these issues of investigating their potential. But they were the first to work out a coherent and practical application for them, and most important of all, they were the first to publish these ideas.

In the perspective of recombination and imitation, it is worth noting that the OFDM technique was an essential element of the digital audio broadcasting (DAB) system that was under development in the Eureka 147 project at the time. Moreover, before the OFDM technique in the 1980s was proposed as a frequency-division multiplexing (FDM) scheme utilized as a digital multi-carrier modulation method in digital terrestrial audio and TV broadcasting, it had, for instance, been a key component in several high-frequency military systems in the 1960s (for instance, KINEPLEX, ANDEFT and KATHRYN) (Ramjee Prasad (2004) *OFDV for wireless communications systems*, Boston : Artech House).

Obviously, about the same time as the IBA researchers at the IBC'90 publicly spread their research about the feasibility of applying OFDM for delivering multiple additional *conventional TV services in existing terrestrial frequency channels,* two research engineers at the Swedish Telecom, Staffan Nyström and Erik Stare, had begun thinking of developing a demonstration system to prove the feasibility of transmitting new *HDTV services in existing*

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[109] Arthur Mason; Gordon Drury; Nick Lodge,: 'Digital television to the home-when will it come?'. Broadcasting Convention, 1990. IBC 1990., International, Volume , Issue , 21-25 Sep 1990 Page(s):51 – 57. (SPECTRE was an acronym for 'Special Purpose Extra Channels for Terrestrial Radiocommunications Enhancement'; Bell 2007:80)

[110] The first trials of DAB using the Eureka147 COFDM system were carried out in London in January 1990 (Bell 2007:70).

terrestrial frequency channels with a video codec and OFDM as the main building blocks. Here could be noted that Stare, but not Nyström, was among the participants at IBC'90. In the words of Stare (in e-mail 4/11 2009):

> Ja, Östen Mäkitalo bad mig fara dit (IBC'90) och spana in General Instruments demo av HDTV på 14 Mbit/s, vilken jag också såg. Man kan ju luras en hel del med demonstrationer och det bildmaterial som de visade var väldigt lättkodat, men resultatet såg bra ut. /…/Jag minns Masons artikel, som vi noga studerade hemma i Sverige, men jag minns inte om jag lyssnade på föredraget.

It is also worth mentioning that Nyström (together with Kjell Bergqvist and Per Mellberg, Televerket Radio, and Christer Björk, RoSa) participated in an 'HDTV Colloquium' in Ottawa, Canada, June 25-29, where he, among other things, received information about the 'all-digital' DigiCypher system.[111]

Digital terrestrial HDTV becomes a common concern of Televerket and SR

During the autumn of 1990, the possibility and consequences of a digital terrestrial HDTV system became a common concern of the new HDTV Coordination Group established between SR and TvtR too, framed as a new possible phenomenon to be investigated, analyzed, (re)interpreted, refined, measured and utilized. It became a usable kind of thing, usable in SR and Televerket Radio, usable in international standardization work and elsewhere. During this period, the emergence of digital terrestrial HDTV as an important common concern eventually closed off R & D work on HD-PAL and other possible candidate systems at the Radio Lab.

The earliest written trace that I have found about the formation of digital terrestrial HDTV as a common concern of TvT and SR is the minutes from the meeting of the HDTV Coordination Group 24 August 1990.[112] Here 'the development of a completely new incompatible digital terrestrial HDTV system' is emerging as an alternative to HD-PAL in a lively discussion, and an issue to be proposed to the Steering Committee. It was pointed out that a concentration on a digital simulcast system would require that one would be able to perform HDTV-picture quality with 20 Mbit/s as well as to perform terrestrial transmissions at this speed. One also stressed the need for cooperation with organisations and companies

[111] Staffan Nyström, Rlb, 1990-09-25, 'Reserapport från "HDTV Colloquium" i Ottawa 25-29/6 1990.

[112] Lars Sundin, 'Styrkommitténs koordineringsgrupp för HDTV. Protokoll från det nionde mötet 24 augusti 1990', 1990-09-07. The participants were: Per Appelquist (SVT), Kjell Bergqvist (tvtR), Kjell Engström (SR), Per Mellberg (tvtR), Östen Mäkitalo (tvtR, chairman), and Lars Sundin (tvtR, secretary). By November 1990 C. Odmalm (Tvt RlbC) had also become a participant and Sundin had been replaced by Erik Stare.

working on new digital systems, expemlified by General Instruments and EU256. One also discussed possible partners in Sweden and the other Nordic countries. Mäkitalo, who was the chairman of the group, was given the green light to discuss the issue with a 'relevant person' within the Ericsson group as well as to point out the possibilities of further cooperation within the directorate of Tvt. Appelquist and Engström were going to address the issue of a completely new terrestrial system within SR and SVT in a way they would consider appropriate. The group agreed that there were reasons to keep a low profile in EBU V1/EPS and that it was important that the Radio Lab summarized their work on HD-PAL. Obviously, at this meeting Mäkitalo stressed the need to make a distinction between a 'final' terrestrial HDTV system and the 'interim-system' HD-PAL.

At 11 September 1990, people at TvtR held a special meeting to discuss certain issues before the next meeting of the HDTV Coordination Group, September 14.[113] These issues involved a demonstration of 'ISO/MPEG'[114] digital 1 Mbit/s television; and the future work on terrestrial HDTV within TvtR. Before this meeting was circulated a written 'Basis for defining activities within the HDTV project'. It involved the suggestion that the subproject within TvtR called 'Terrestrial HDTV' possibly should change direction from HD-PAL to a digital (simulcast) terrestrial HDTV system.[115]

As Erik Stare recalls, shortly after he had returned from his summer holiday in August 1990, he unexpectedly was informed by Mäkitalo that he and Staffan Nyström immediately should discontinue their work on HD-PAL. Instead Mäkitalo wanted a team of engineers at the Lab to initiate studies that would show that digital transmissions of HDTV was indeed possible via terrestrial networks. The very first draft description of this project is from October 15 1990, with Mäkitalo as the commissioner and Nyström, Stare and Göran Roth as temporary project leaders until the project leader had been appointed (eventually Stare, at age 31, was appointed the project leader). The goals were formulated as follows:

> Målet med arbetet är att medverka till att en standard för digital sändning av HDTV etableras i Europa och att påverka standardiseringsarbetet så att lösningarna passar för Televerket och Sverige. Standarden skall kunna användas för alla bärare såsom t ex fiber, kabel, satellit och terrestra sändare.
>
> Delmål

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[113] Lars Sundin, Rad lab, 'Kallelse till möte om HDTV' (11/9), 1990-09-07. This call was circulated to P Mellberg, K Bergqvist, Ö Myhrman, Ö Mäkitalo, C Odmalm, E Stare, S Nyström, S Bergsmark, J-O Sköld; with copies sent to P Marklund, G Roth, B Sjöberg and Gunnar Betnér.

[114] Within the standardization work of ISO/MPEG was developed a 1.15 Mb/s-codek version for storing moving pictures on CD etc.

[115] Lars Sundin, Rlab, 1990-009-07, 'Underlag för att definitera aktiviteter inom HDTV-projektet'.

> Att genom bildkodnings- och transmissionsstudier få fram resultat som visar genomförbarheten av digital HDTV, speciellt för terrester sändning. Att genom demonstrationer och annan redovisning av resultat påverka internationella beslutsfattare i riktning mot detta projekts mål.[116]

At the end of September 1990 Staffan Nyström and Erik Stare had produced a four page report–'Terrestrial Digital HDTV–is it possible?', in which they proposed that a new type of modulation called COFDM (Coded Orthogonal FDM) would be 'extremely suited for terrestrial digital transmission'.[117] COFDM allowed the signal to become rather insusceptible for interference. COFDM could also with advantage be combined with transmission on one single frequency over a large area, which was a great advantage in the perspective of frequency planning; several TV-channels could be broadcast in parallell over the same area. In this context, they concluded:

> Med tanke på ovanstående är det klart att ett mycket effektivt och tilltalande sändarnät skulle kunna erhållas om nätet kunde byggas upp 'från scratch'. Tyvärr har vi existerande sändarnät för PAL att ta hänsyn till. PAL-systemet måste nog finnas kvar minst 10-15 år efter den första introduktionen av digitala sändningar, men en gradvis nedmontering av PAL-nätet borde vara möjlig parallellt med den digitala uppbyggnaden. Hur som helst bör man ha PAL-systements avveckling i tankarna redan när man planerar det nya digitala nätet. Med tanke på detta är det kanske inte så klokt att börja bygga upp ett helt nytt analogt nät för en tredje terrester PAL-kanal. Detta går kanske inte politiskt att stoppa, men Televerket bör kanske redan inom en snar framtid göra klart att det fjärde analoga nätet aldrig bör byggas.

Here one may recall that by September 1990, the Swedish Ministry of Education were in the midst of preparing for the (re)creation of rules and routines for terrestrial TV so as to include the introduction of a new, third, TV channel as well as TV-advertisement (Ewertsson 2005)

To be continued ….

Abbreviations

ANSI	American National Standards Institute
ARD	Arbeitsgemeinschaft der öffentlich-rechtlichen Rundfunkanstalten der Bundesrepublik Deutschland,
ATSC	American Television Systems Committee
BBC	British Broadcasting Corporation
CCETT	Centre Commun d'Etudes de Telediffusion et Telecommunications (France)
CCIR	Comité Consultatif International de Radio Communication International Radio Consultative Committee
DBS	Direct Broadcasting (by) Satellite
EBU	European Broadcasting Union
EC	European Communities (now European Union, EU)
EEC	European Economic Community

[116] Bredbandskontoret, Rl, 1990-10-15, 'OBS! Detta är ett första utkast. Projektbeskrivningen är fortfarande föremål för diskussion. Projektbeskrigning. Projekt: Digital HDTV'.
[117] Nyström and Stare: 'Terrester Digital HDTV–är det möjligt?' (28/9 1990)

EIA	Electronic Industries Association (US)
FCC	Federal Communications Commission
GSM	Global System for Mobile Telecommunications
IBA	Independent Broadcasting Authority (United Kingdom)
IEEE	Institute of Electrical and Electronic Engineers (US)
ITU	International Telecommunication Union
HDTV	High Definition Television
MPEG	Moving Picture Experts Group
MUSE	Multiple Sub-Nyquist Sampling Encoding
NAB	National Association of Broadcasters (US)
NCTA	National Cable Television Association (US)
NICAM	Near Instantaneous Companded Audio Multiplex.
NHK	Nippon Hoso Kyokai
NR-MSK	*Nordiska Kommittén för Radiotekniska frågor ????–Modulationsmetoder för satellitkringkastning?? HJÄLP ÖNSKAS: vad står NR-MSK för*?
NTSC	National Television System Committee
PAL	Phase Alternative Line
RAI	Radiotelevisione Italiana
RTT Oy	Radio- ja Televisiotekniikan Tutkimus (Finnish research firm focusing on radio and TV technology)
SECAM	Séquentiel Couleur avec Mémoire
SES	Société Européenne des Satellites
SMPTE	Society of Motion Picture & Television Engineers
IRT	Institut für Rundfunktechnik
ITVA	Independent Television Association
ZDF	Zweites Deutsches Fernsehen

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