CCITT SGXV
Working Party XV/1
Experts Group for ATM Video Coding

Document AVC-261
May 1992

CCITT
STUDY GROUP XV
Geneva, 4-15 May 1992

Temporary Document (XV/1)

Questions: 3/XV, 4/XV

SOURCE: CHAIRMAN OF THE EXPERTS GROUP FOR ATM VIDEO CODING
TITLE : THIRD PROGRESS REPORT

----

1. General

We have met three times since we presented the second progress report (Annex 1 to COM XV-R72-E) at the previous Working Party XV/1 meeting in November 1991;

4th meeting	18-29 November 1991 in Yokosuka (Japan) at the kind invitation of JVC and Ministry of Posts and Telecommunications
5th meeting	6-9 January 1992 in Singapore (Singapore) at the kind invitation of Asia Matsushita Electric and with financial support of NTT.
6th meeting	18-27 March 1992 in Stockholm (Sweden) and Haifa (Israel) at the kind invitation of Telia Research AB and Zoran Microelectronics.

We had joint sessions with ISO/IEC JTC1/SC29/WG11 (MPEG) as well as CCITT sole sessions in these three meetings. The list of participants appears in Annex to this report.

This document reports major achievements toward defining Recommendation H.26X for video coding in the ATM environments, and particular items for consideration of the Working Party XV/1.

2. Overall workplan

The overall work plan for H.26X is summarized in Figure 1. The current work is proceeding as intended toward completion of the Recommendation in 1994.

3. Technical discussion

3.1 Picture format

3.1.1 Background

An increasingly diverse range of picture formats is likely to be important for visual communications in the future, reflecting developments in computer-based video manipulation and display, and convergence of the telecommunications, computing and broadcasting industries. Window-based computer-screen presentation, for example, is likely to be increasingly used. However, one of the most important video service qualities will continue to be that near broadcast TV quality, where there are 625/50 and 525/60 versions of CCIR Rec. 601, future progressive scan television signals, etc. The Experts Group has been discussing what approach be taken in H.26X to cope with these situations.

At the Santa Clara meeting in August 1991 the Experts Group had determined to make a decision on video formats at the earliest opportunity in 1992.

3.1.2 Possible solutions

One proposal was the Super Common Intermediate Format (SCIF), being an upscaled version with twice the number of pixels in horizontal, vertical and temporal axes of CIF from Recommendation H.261. The SCIF concept would provide the guaranteed compatibility between all equipments including connections between 525 and 625 line regions in the same way as CIF in H.261. The other benefits of more commonality in equipments and ease of multipoint working would also apply.

Another proposal offered much more flexibility of the internal format used for coding. A modest number of classes would be defined, characterised by maximum numbers of pels in the three axes. Decoders belonging to a class would be able to decode any image smaller than the relevant maxima. (Spatial dimensions could be restricted to integer multiples of 16 to fit the macroblock configuration.) In this proposal the issue of possibly different capture and display formats (pels per line, lines per picture, pictures per second, pel or picture aspect ratio) would be handled entirely by the receiving terminal. Coding would take place in the originating scanning format thus avoiding any quality degradations from unnecessary standards conversion in connections where the display format was the same as the originating format. Conversion might or might not be employed in receiving terminals after decoding in connections where display and originating formats were not the same.

These two proposals can be regarded as the extreme ends of a range with many others in between. These would comprise a number of defined formats available for use in the coding kernel, probably comprising the natural formats of the major applications requiring the highest quality. Other source formats could be converted before coding to the nearest suitable one of the set of defined formats. Receivers would display the decoded version directly or after conversion to any other required format.

3.1.3 Experimental results

For the March 1992 meeting much work had been done on the proposed SCIF, including simulations of various conversions and coding performances. Facilities were available at the meeting for viewing all the relevant formats, some for the first time such as SCIF directly. After these informal assessments the Experts Group agreed that:

1) Line number conversion can be achieved with small or invisible quality loss.

2) Conversion from interlace to progressive format is not totally satisfactory from a quality viewpoint though several methods have been tried.

3) Picture rate conversions are almost always accompanied by visible defects.

Thus it was concluded that the use of SCIF in circumstances requiring conversions other than of line number cannot, at least with the methods tried, yield the picture quality expected of H.26X at bit rates in excess of about 5 Mbit/s.

One demonstration where the progressive format was used throughout the capture, coding and display processes was acknowledged to provide very pleasing pictures and showed the potential benefits of progressive over interlaced formats.

3.1.4 Agreements at the March 1992 meeting

A contribution at the March 1992 meeting pointed out the approach adopted so far by ISO/MPEG would result in their video coding algorithm being able to cover all the formats discussed in the CCITT Experts Group. The Experts Group anticipates that H.26X will be the same or fundamentally the same as the MPEG one. Therefore, a decision by the Experts Group would not hasten the algorithm development and can be deferred.

The Experts Group agreed:

1) to defer a final decision on picture formats to be specified in H.26X.

2) to continue to use both 525/60 and 625/50 versions of CCIR-601, and where possible the related Extended Definition (EDTV) and High Definition (HDTV) formats, in the development of the H.26X coding algorithm.

3) to continue investigation of format conversion methods. In some circumstances these will be unavoidable and availability of satisfactory methods is highly desirable even if not subject to standardisation. Guidelines are listed at the end of this section. (More advanced methods exist, such as motion compensated techniques, though they may be uneconomic for widespread use in terminals.)

4) to study application scenarios to identify issues which really need solutions and the performance targets which should be met, and try to have a common understanding by the London meeting (November 1992).

5) to be aware that square pixels are utilized in some potential applications. (Currently displays with square pixels are available, but the corresponding digital acquisition equipment is not.)

6) to be aware that formats other than those from the television industry may be applicable for some applications. An example is computer displays.

7) that the specification of complete systems giving interworking is required by CCITT. Though it is not yet clear whether the format issue will be dealt with entirely by the video coding Recommendation H.26X or entirely by the terminal Recommendation H.32X or by both in combination, the expertise of the Experts Group is needed by SGXV.

8) to recognise the potential of progressive formats and endeavour to support them in H.26X/H.32X for eventual use sooner or later.

Requirement guidelines for format studies

1) Degradation from standards conversion must be consistent with intended use.
2) Any loss of coding efficiency caused by standards conversion must be acceptably small.
3) Delay introduced by standards conversion must be acceptably small for the intended use.
4) Equipment complexity overhead must be acceptable. More study is required to determine the true impact of formats with higher numbers of pels.
5) In circumstances when standards conversion is required there are the two approaches of going directly from one to the other or of going via a third (intermediate) format (such as SCIF). The two approaches should be compared.

3.2 Framework for H.26X/MPEG-2

3.2.1 Aim of H.26X/MPEG-2

The aim of H.26X and MPEG-2 (second phase of MPEG) is to cover a range of video applications, bit rates, resolutions, qualities, and services; thus the video coding algorithm should be "generic". Functional requirements for this generic video coding have been collected, out of which CCITT Experts Group are particularly concerned with the following;

- low end-to-end delay (Note),
- compatibility with H.261,
- cell loss resilience, and
- lower bit rate operation.

Note: The Experts Group analyzed and clarified the delay caused by each element of the coding and decoding process.

Though the current efforts of coding algorithm optimization are focused on coding of CCIR-601 signals, it is being discussed that perhaps we need not another standard for coding of HDTV signals. Extension to higher formats is identified as one of the study items.

3.2.2 Clarification of "generic standard"

There are three possibilities to structure a generic standard which is applicable to wide range of applications as illustrated in Figure 2.

The first option (single standard solution) means that all the decoders conforming to the standard can understand all the bitstreams and reconstruct full pictures as far as the bitstream conforms to the standard. In the third option (toolkit solution), on the contrary, the standard provides all the necessary elements to cover wide range of applications. Application standards specify the elements to be used for their purposes. Decoders for a particular application may not understand the bitstreams of another application. The second option (toolkit with maximum core solution) is intermediate between the first and the third solution. There may be some standardized elements which are used only for a particular application.

One benefit of the generic standard is to achieve scale merit, allowing use of the same hardware and/or software in various application fields. Another benefit is more importantly to allow cross application bitstream interchange. Some application fields may require very cheap implementation dedicated to respective particular applications. These factors are indicated in Figure 2.

In view of the intention of the generic standard we concluded that the objective of our work should be to achieve the first option as far as possible, but in practice the second option with maximum core may be the solution.

3.2.3 Materializing the "generic standard" philosophy through the Test Model work

To reflect the above mentioned objectives into the Test Model work currently being carried out, we reached the following common understanding;

1) Since the generic standard is intended to meet the performance and functionality requirements of each particular application, one way is to emulate the situation in the Test Model work.

2) Each contributor may have some application in mind as user of the standard and be willing to do his/her best efforts to optimize the Test Model for the particular application. Test Model refinement should be integration of such efforts in a harmonized way.

3) To avoid divergence in the current convergence phase work, above mentioned improvement efforts should be done using a single syntax defined in the Test Model.

4) Based on the analysis to relate functionality with necessary elements in the standard, the following items are identified as possible inclusion in the Test Model experiments;

a. Basic performance
b. Scalability (Note)
c. Low delay
d. Simplest decoding (for such as broadcasting environments)
e. Robustness to bit error and cell/packet loss
f. MPEG-1/H.261 compatibility
g. Trick mode
h. Extension to higher formats

Note: A scalable bitstream is one where we can neglect some of the bits in the bitstream, and still decode a useful picture. Syntactically, this implies that the bitstream is formatted so that bits within it can be ignored. Resolution scalability is when the video can be decoded at different resolutions or sizes directly. Temporal scalability is when the decoded bitstream results in a sequence of different frame rate. Complexity scaling is when a bitstream can be decoded by systems of varying complexities.

5) The improved syntax should be reviewed each time to implement the "maximum core" objective as well as to reflect the coding efficiency and implementation consideration. Use of good engineering sense is expected.

3.2.4 Procedure for improvement of the test model

The procedure for incorporating new ideas in the test model was clarified as follows;

- Assume that a promising idea is presented at a meeting. If more than one lab finds the idea interesting for further testing, sufficient documentation is included in the test model to be able to make comparative tests at different labs.

- If the result of this test is positive (the definition of "positive" is not clearly defined) the idea is incorporated in the test model.

3.3 Video coding algorithm

3.3.1 Kurihama tests

Subjective tests for the thirty algorithm proposals were carried out at JVC-Kurihama R&R Center in November 1991 according to the double-stimulus continuous quality-scale method defined in CCIR Rec. 500-3. Three test sequences were used for the 4 Mbit/s test and four sequences for the 9 Mbit/s test. According to the average scores, rank orders for 525 and 625 systems were obtained. Furthermore, the top ranking group whose members are mutually indistinguishable in a statistical sense was identified by using Duncan's method.

Top ranking proposals were in the frame work of hybrid coding which consists of motion compensated interframe prediction and DCT and had been employed in H.261 and MPEG-1 (first phase of MPEG). General feeling was that we could start with MPEG-1 syntax using simple field merging.

3.3.2 Test Model definition

Test Model is a reference video coding scheme against which proposed improvements are tested. If tests results are convincing, those improvements are incorporated into the next generation Test Model.

A preliminary working draft document (PWD) for definition of the first test model was made available as outcome of the Singapore meeting. The goal of the Haifa meeting was to complete the definition of the first test model (TM1) and define experiments to be performed until the next meeting.

The coding standard shall be "generic". It must therefore fulfil requirements set by different applications. In order to ensure that all the requirements are fulfilled, a set of profiles is defined.

A profile is a subset of the features defined in the test model and is intended to correspond to specific applications. The intention is that experiments shall be performed within each profile to ensure that the standard fulfils the corresponding requirements.

Four different profiles have been defined:

- High quality profile. Within this profile there is no constraint concerning e.g. scalability, low delay etc.

- Compatibility. The main restriction within this profile is compatibility with MPEG-1 and/or H.261. This profile is also somehow connected to spatial and temporal scalability.

- Scalability. Within this profile the constraint is more general scalability.

- Low delay. The main applications connected to this profile is two-way communication.

Definitions of the different profiles and corresponding core experiments were produced at the Haifa meeting and will be part of the revised version of the TM1 description.

One of the outstanding requirements for the new coding standard H.26X/MPEG-2 is that it should deal with both interlaced and progressive scan signals as input to the source coder (note that H.261 and MPEG-1 encode only progressive scan signals).

Many experiments had been performed and the results were presented at the Haifa meeting. Most of the experiments focused on improving the picture quality. Much focus was on the use of different prediction modes. A small group was therefore set up to define the set of prediction modes to be included in TM1. This resulted in a considerable increase of prediction modes and therefore also complexity of the test model. The intention is that experiments shall make it possible to point out the most useful prediction modes and that a large amount of the others may be discarded at a later stage.

3.4 VBR vs CBR

Advantages of VBR over CBR could be expected in statistical multiplexing gain, reduced coding-decoding delay, picture quality, etc. VBR coding benefits, however, largely depend on the UPC (usage parameter control, or policing) mechanism in the network by which the average bit rate of the source is monitored and the input cells are regulated.

The current status of the study is summarized in Figure 3, leaving most of the questions open.

3.5 Network aspects

3.5.1 Background

Since B-ISDN is still in the formative stage, the Experts Group are studying network related issues from the user point of view and identifying requirements to the network. We are having close liaison with SGXVIII in this respect.

3.5.2 Cell loss

The Experts Group received SGXVIII's response to our question concerning the network performance; cell error ratio and cell loss estimated from the G.82X specification. It was noted that these values are based on the radio transmission systems and optical fibre systems are used in actual B-ISDN, thus much better performance is expected. It was also noted, however, that the estimation in this liaison document does not include cell losses which may be caused by ATM nodes at the time of congestion, thus worse performance than this may be provided.

We felt it safe that the video codec be resilient to this level of network performance; by means of e.g. including FEC to cope with bit errors as in H.261, and cell loss resilience techniques in the video source coding. Possible elements for cell loss resilience are as follows though they are not exhaustive;

- use of CLP bit (transmission coding)
- layering (source and/or transmission coding)
- leaky prediction (source coding)
- FEC/interleave (AAL)
- structured packing of video data into cells (transmission coding)
- concealment (outside the standard)

The question is what elements should be standardized for the cell loss resilience. This is one of the areas we need further extensive study.

3.5.3 Timing synchronization - AAL (ATM Adaptation Layer) Type 1

Based on the agreement that we provide a mechanism in H.26X which allows video sampling clock recovery (note that H.261 does not explicitly support this feature), we considered whether this be achieved using AAL's SRTS function or as part of video codec functions.

This should be further studied considering VBR operation of the video codec and clock recovery for multiple sources. The following facts should also be taken into account;

- At T/S reference points, 150 MHz network clock is available, but its submultiples may have to be generated inside the terminal.
- Some NT2 equipment, such as LAN and PBX, does not provide precise clock frequency nor are locked with B-ISDN clock frequency. SRTS method is based on the availability of the identical clock at both ends.

3.5.4 Required functions of AAL Type 2

SGXVIII intends to finalize the protocols for video transport in the 1994 Recommendations, thus welcomes the input from this group on required functions. We listed some possible items on a "may be required" basis, awaiting further study; multiplexing capabilities, sequence number, cell payload length indication, requests for priority level, alignment of packet data to cell boundary.

Related to this topic, we recognize that study is required on implications of LAN/MAN characteristics on the ATM video coding standard. LAN/MAN may be used as the access to B-ISDN.

3.5.5 CLP

We agreed that CLP bit be used only for cell loss priority indication, not for indication of video coding layers.

3.5.6 UPC (Usage Parameter Control)/TD (Traffic Descriptor)

SGXVIII intends not to standardize the UPC mechanisms. This causes fundamental problems to VBR realization.

- Difference of methods to monitor the traffic between the terminal and the network may cause cell discards which the terminal can not predict.
- If a UPC mechanism is not standardized, different UPC methods in different networks may further cause unpredictable cell discards.

Since these are quite serious for achieving VBR video coding, the issues should be kept on the agenda for liaison with SGXVIII until they can be resolved.

A contribution also brought up the issue of using performance metrics for UPC performance evaluation. As long as different UPC algorithms conform to the performance metrics bounds specified, no standardization of a UPC algorithm may be needed. Its implication on the VBR coding should be addressed.

3.5.7 Multimedia multiplexing

The Experts Group is considering audiovisual and other multimedia services support on the B-ISDN, and therefore the possible multimedia multiplexing alternatives. VC-based multiplexing has been identified as a long-term target, but early service implementation may have to use other means of multiplexing, since

- interworking with audiovisual equipment on other networks (64 kbit/s ISDN) will require a user multiplex mode of operation;

- we understand that the network will not be able to support VC-based multimedia multiplexing at the early stages of standardisation.

Table 1, which summarises our current perceptions regarding multiplexing approaches.

3.5.8 Reference terminal configuration

We recognized the importance of reference configuration of the audiovisual ATM terminal toward the following;

- identification of reference points and interface signals at those reference points
- clarification of responsibility for specification
- identification of missing elements for designing audiovisual communication terminals connected to B-ISDN

and identified Figure 4 as a useful input for further elaboration.

4. Harmonization with other groups

4.1 Work method

4.1.1 SGXVIII

Since our video coding design depends heavily on the B-ISDN characteristics, the Experts Group are very keen to have close contacts with SGXVIII on the network aspects. The Experts Group are exchanging liaison statements with SGXVIII, and we also had the following mutual attendance in respective meetings;

- Mr. M. Biggar (AOTC, Australia) participated in the SGXVIII meeting in December 1991.
- Mr. K. Yamazaki (KDD, Japan) participated in the Experts Group meeting in March 1992.

4.1.2 TG CMTT/2 Special Rapporteur's Group

We are communicating through exchange of liaison statements.

4.1.3 CCIR Ad-Hoc Group on Digital Coding

CCIR has initiated the study on digital coding for broadcasting. Since the impact of digital broadcasting on communication terminals is great, the Experts Group decided to send this progress report for consideration of its second meeting held in Bologna during 8-9 May 1992.

4.1.4 ISO/IEC JTC1/SC29/WG11 (MPEG)

The Experts Group has been holding joint sessions with MPEG since May 1991 to seek a common video coding standard H.26X/MPEG-2. We have already had five such occasions as indicated in Figure 1.

MPEG (Convenor: L. Chiariglione - CSELT) has six sub-groups;

- Audio (P. Noll - Technische Universitaet Berlin)
- Implementation (D.G. Morrison - BT)
- Requirements (S. Okubo - NTT)
- Test (T. Hidaka - JVC)
- DSM (T. Kogure - Matsushita)
- Video (D. LeGall - C-Cube)
- System (A.G. MacInnis - IBM).

Joint sessions are being held in Requirements, Video, Implementation and System sub-group meetings.

We will make continuous efforts to achieve the above mentioned objectives.

4.2 Liaison statements

As outcome of the three meetings, the Experts Group submitted the following liaison statements as contained in a companion TD;

To SGXVIII

- Addendum to liaison statement	November 1992
- Liaison to CCITT SGXVIII	March 1992

To CCIR Ad-Hoc Group on Digital Coding

- Progress report of the Experts Group	May 1992

5. Future activities

The 7th meeting

CCITT sole sessions	1-3 July 1992	USA
Joint sessions with MPEG	6-10 July 1992	Brazil

The 8th meeting

Joint sessions with MPEG	September 1992	USA

The 9th meeting

CCITT sole sessions	28-30 October 1992	UK
Joint sessions with MPEG	2-6 November 1992	UK

6. Specific items requiring the consideration of Working Party XV/1

1) Framework for broadband audiovisual recommendations

Though the video coding standard H.26X may be one of the key elements for the B-ISDN audiovisual systems, the Experts Group need a clearer view for the total system framework: service, network, terminal and its constituent functional components, MCU and other special equipment, etc.

One of the crucial questions we face is what applications are most likely on B-ISDN; visual telephony, video program distribution, or storage and retrieval? The answer may affect the technical solutions for picture format, multimedia multiplex method, and other issues.

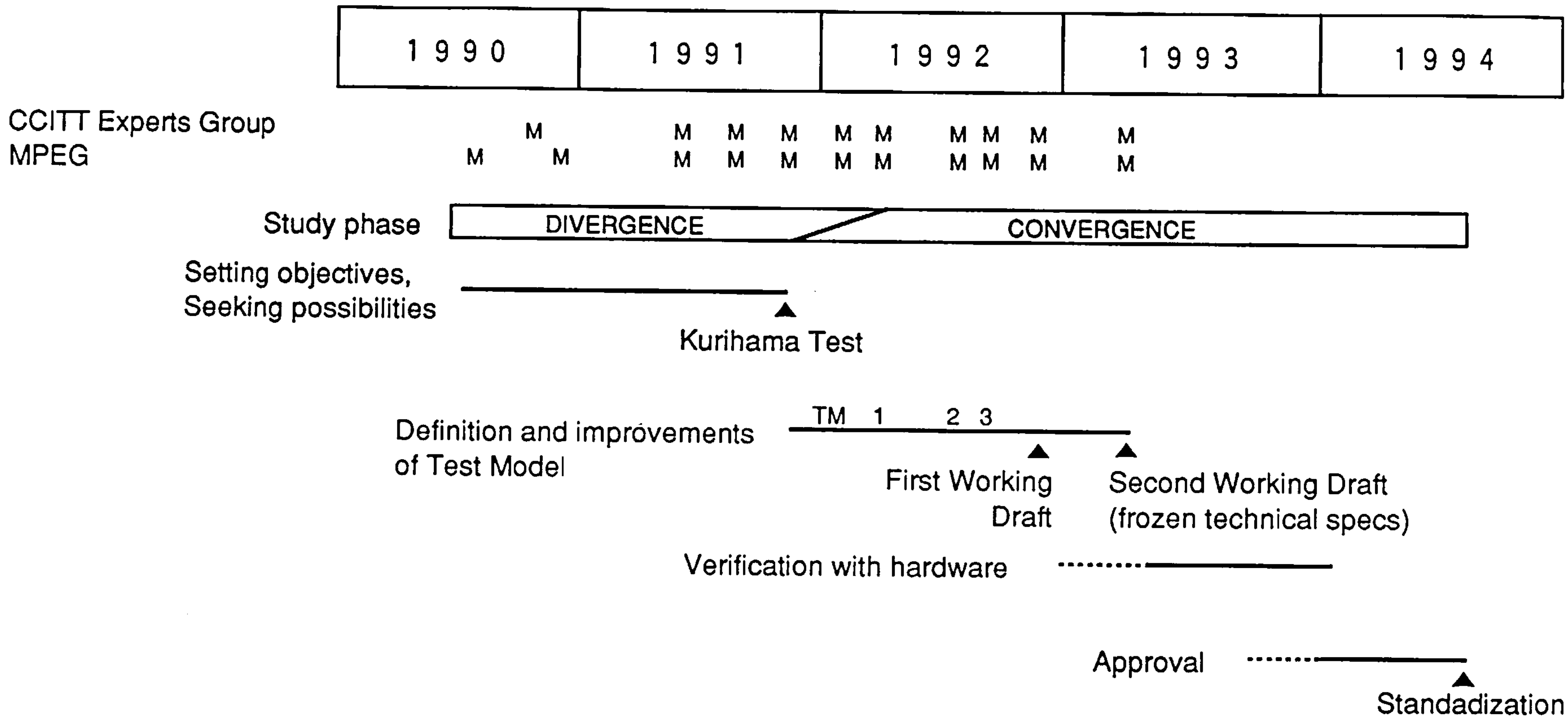
We suggest that these be discussed in Working Party and guidance be given.

2) Formalization of collaborative work with MPEG

We are now concentrating on solving the technical problems, but some formality should also be sought. Consideration of the Working Party is requested. MPEG's higher body is now newly established ISO/IEC JTC1/SC29 (Chairman: Dr. Hiroshi Yasuda - NTT).

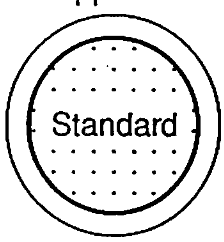
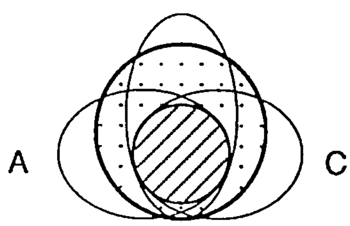
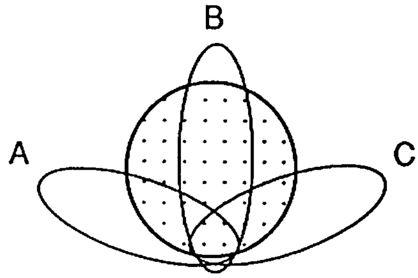
END

Figure 1 WORK PLAN FOR H.26X/MPEG - 2 VIDEO CODING



Kurihama test : Subjective picture quality test for simulation results of 30 proposed algorithms

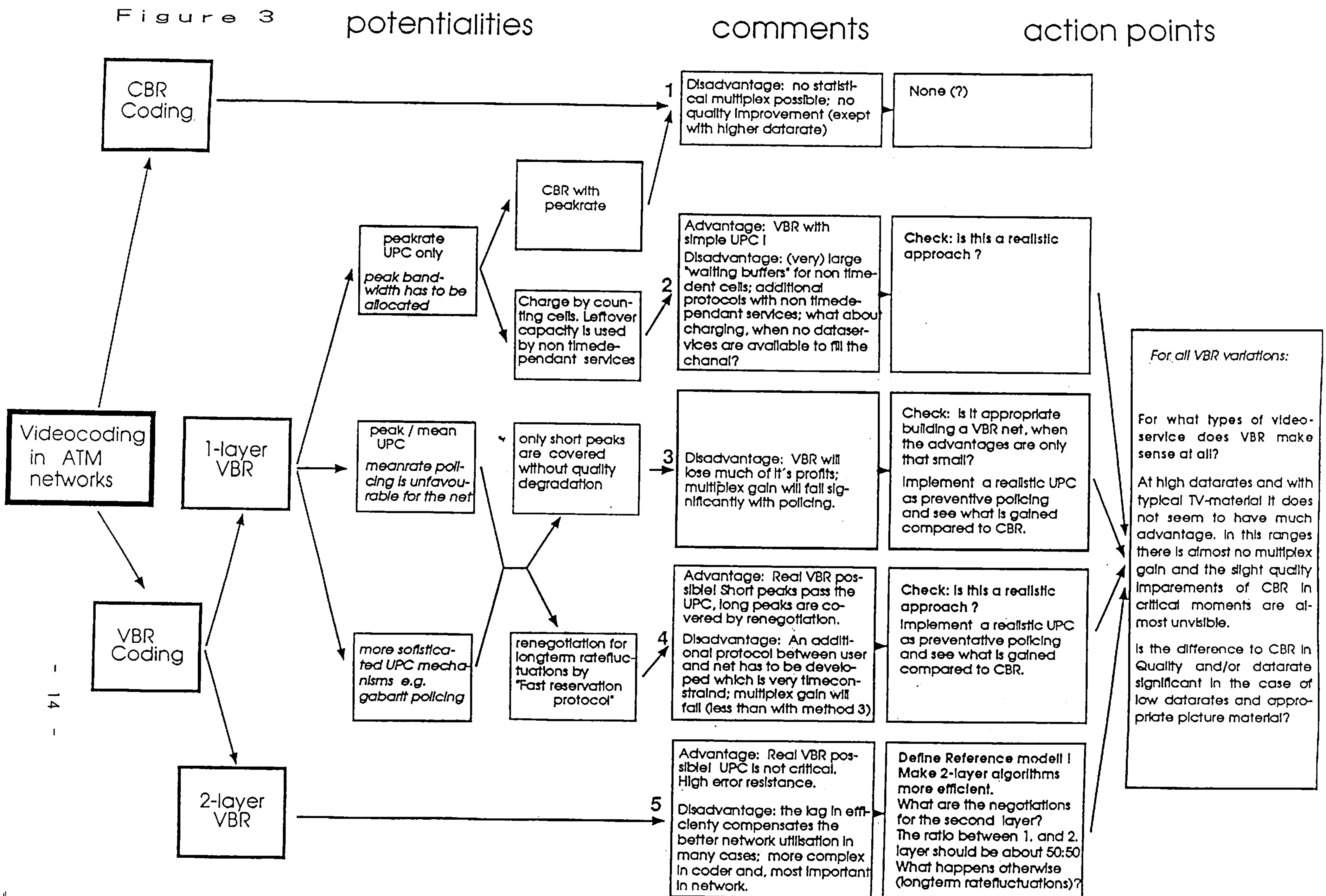
TEST MODEL : A reference coding model against which improvements are experimented. Convincing improvements are incorporated into the next version of Test Model.

		Scale Merit	Cross-application Bitstream Interchange	Cheap Imple. for Particular Application
	Single standard	yes	yes	no *
	Toolkit with common core	yes		
	Toolkit standard	yes	no	yes

* cost: unnecessary elements, sub-optimum parameters

Figure 2

Figure 3



potentialities
comments
action points
Videocoding in ATM networks
CBR Coding
VBR Coding
1-layer VBR
2-layer VBR
peakrate UPC only
peak bandwidth has to be allocated
peak / mean UPC
meanrate policing is unfavourable for the net
more sofisticated UPC mechanisms e.g. gabarit policing
CBR with peakrate
Charge by counting cells. Leftover capacity is used by non timedependant services
only short peaks are covered without quality degradation
renegotiation for longterm ratefluctuations by "Fast reservation protocol"
1
Disadvantage: no statistical multiplex possible; no quality improvement (exept with higher datarate)
None (?)
2
Advantage: VBR with simple UPC !
Disadvantage: (very) large 'waiting buffers' for non timedent cells; additional protocols with non timedependant services; what about charging, when no dataservices are available to fill the chanal?
Check: Is this a realistic approach ?
3
Disadvantage: VBR will lose much of it's profits; multiplex gain will fall significantly with policing.
Check: Is it appropriate building a VBR net, when the advantages are only that small?
Implement a realistic UPC as preventive policing and see what is gained compared to CBR.
4
Advantage: Real VBR possible! Short peaks pass the UPC, long peaks are covered by renegotiation.
Disadvantage: An additional protocol between user and net has to be developed which is very timeconstraind; multiplex gain will fall (less than with method 3)
Check: Is this a realistic approach ?
Implement a realistic UPC as preventative policing and see what is gained compared to CBR.
5
Advantage: Real VBR possible! UPC is not critical. High error resistance.
Disadvantage: the lag in efficienty compensates the better network utilisation in many cases; more complex in coder and, most important in network.
Define Reference modell ! Make 2-layer algorithms more efficient.
What are the negotiations for the second layer?
The ratio between 1. and 2. layer should be about 50:50
What happens otherwise (longterm ratefluctuations)?
For all VBR variations:
For what types of video-service does VBR make sense at all?
At high datarates and with typical TV-material it does not seem to have much advantage. In this ranges there is almost no multiplex gain and the slight quality imparements of CBR in critical moments are almost unvisible.
Is the difference to CBR in Quality and/or datarate significant in the case of low datarates and appropriate picture material?

Table 1 : The comparison of three multi-media multiplex methods

REQUIREMENTS \ SCHEMES		Cell multiplex (VC multiplex : VCI approach) merit : Variety of services	SAR multiplex (SAR-PDU multiplex : Packet approach) merit : Easiness for VBR?	User multiplex (Bit multiplex : H.221 approach) merit : Compatibility with H.320
1.Efficient channel utilization	Over head	0	192/(packet size+192) + 4/384 - (UW) (dummy bits) (IT bits) (Unique Words) *1)	16/p*640
	Sharing with other media	Impossible	Possible	
2.Multiplexing delay		No delay due to multiplexing.		
3.Compatibility	with H.320	H.221 is necessary (switchable)		Easy (Embedded)
	with MPEG	MPEG bit stream should be transmitted as data. MPEG demultiplexer is necessary.		
4.Multi-media	Media identification	HLC or user information at call setup	Indicated by IT?	BAS
	Bit rate identification	Call signaling	User protocol?	BAS
	Cross media synchronization	Not guaranteed now	Guaranteed	
5.Media selectability in Multi-point conference		Easy but copy function for each medium in network or MCU is required. Otherwise mesh type connection is required.	Difficult but possible by MCU with some transmission efficiency loss.	
6.Real time transmission for the low bit rate (eg. 2400bps) data		Delay and transmission efficiency is a trade off. delay = 384bits/bit rate*efficiency		300/1200/4800 bits etc.
7.The influence of one cell loss		One medium Recover at the next packet?		Several media Recover at the next packet? (The probability of FAS,BAS errors due to cell losses is assumed significantly low.)
8.Easy to implement		Easy by using media-VCI's table	Easy by using media-IT table	Already implemented in H.221 using LSI chip
9.QOS(Quality of Service)		Any QOS for each medium	QOS must be that of the most demanding medium	
10.Transmission cost		Multiple VCs may be expensive because of OAM for each VC	-	

*1) If GOB is aligned with cell, UW is GOB start code. If such alignment is not used, first term and third term can be deleted.

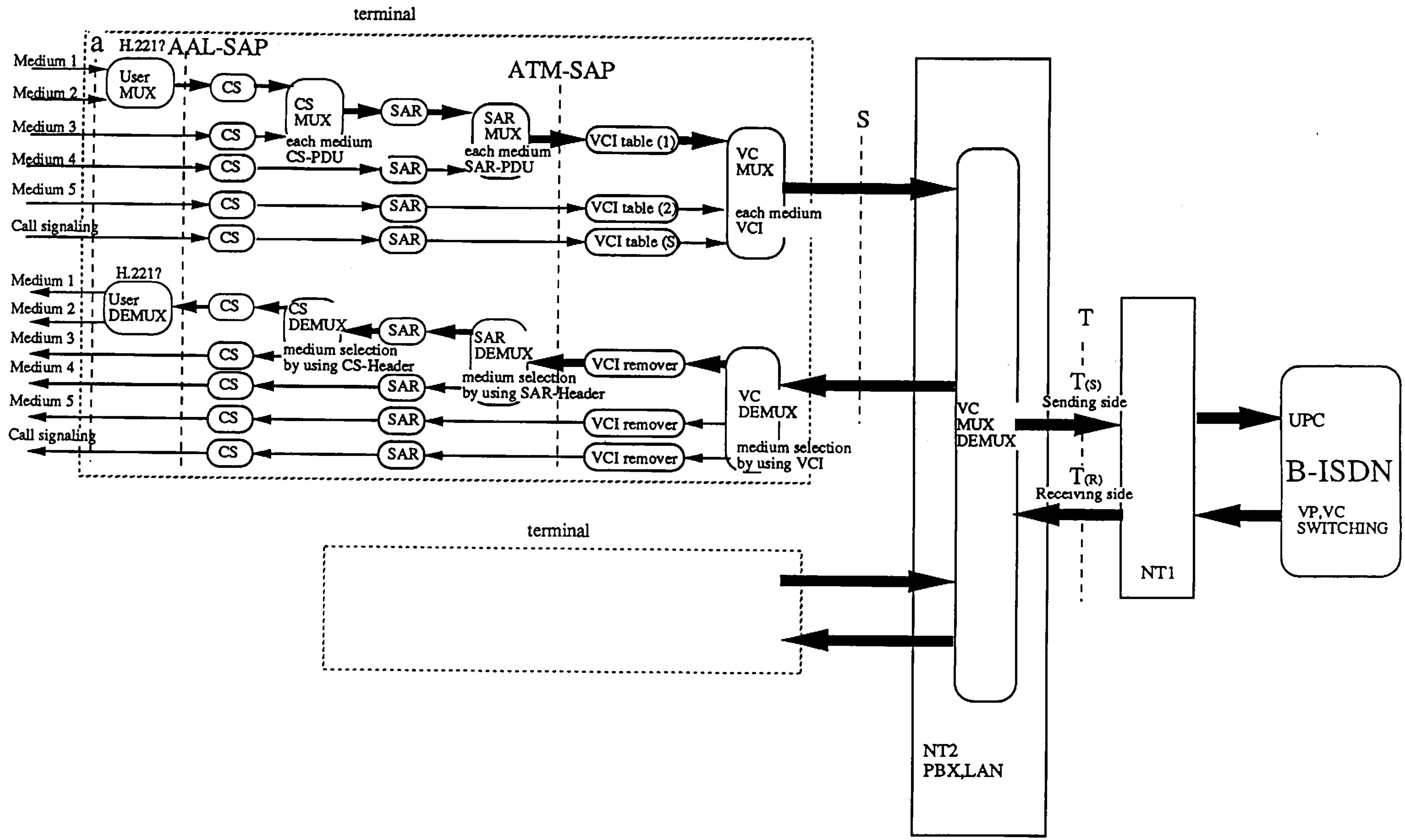


Fig. 4 Terminal configuration

Annex 1

Participants of the fourth meeting of Experts Group for ATM Video Coding

(18-29 November 1991, Yokosuka)

FRG	Mr. G. Zedler	*	DBP Telecom	CM
Australia	Mr. M. Biggar		Telecom Australia	CM
	Mr. G. Smith		AUSSAT	
Belgium	Mr. O. Poncin		RTT Belgium	(CM)
Canada	Mr. R. O'Shaughnessey		BNR	(CM)
USA	Mr. K. Dallas		National Semiconductor	
	Mr. B.G. Haskell		AT&T Bell Labs	
	Mr. K. O'Connell		Motorola	
	Mr. R.P. Rao	+	Compression Labs	
	Mr. A.J. Tabatabai	*	Bellcore	CM
	Mr. J. Zdepski		David Sarnoff	
France	Mr. G. Eude		France Telecom	
	Mr. J. Guichard		France Telecom	CM
	Mr. G. Nocture	+	L.E.P. (Philips)	
Japan	Mr. K. Hibi		Sharp	
	Mr. K. Matsuda		Fujitsu	
	Mr. K. Matsuzaki		Mitsubishi Electric	
	Mr. S. Okubo		NTT	Chairman
	Mr. K. Sawada	*	NTT	
	Mr. Y. Takishima		KDD	
	Mr. M. Takizawa		Hitachi	
	Mr. T. Tanaka		NTT	CM
	Mr. H. Tanihara	*	Ministry of Posts and Telecom.	
	Mr. M. Tsujikado		Oki	
	Mr. A. Tsuzuku	*	Ministry of Posts and Telecom.	
	Mr. H. Ueno		Toshiba	
	Mr. M. Wada		KDD	CM
	Mr. M. Yamashita	*	NTT	
	Mr. M. Yano		NEC	
	Mr. H. Yasuda	*	NTT	
	Mr. T Yukitake		Matsushita Communication	
Norway	Mr. G. Bjontegaard		Norwegian Telecom	(CM)
	Mr. J. Bording	+	Norwegian Telecom	
Netherlands	Mr. H. Carbiere	*	PTT Research	LR-CMTT
	Mr. A. Koster		PTT Research	
	Mr. D.A. Schinkel		PTT Research	CM
UK	Mr. I. Parke		BT	
	Mr. D.G. Morrison		BT	CM
Sweden	Ms. C. Verreth		Swedish Telecom	
	Mr. H. Brusewitz		Swedish Telecom	CM
Korea	Mr. Y-H. Kim		ETRI	Observer

CM: Coordinating Member
(CM): Substitute for CM
LR: Liaison Representative

* Sole sessions (27-29 November) only
+ Joint sessions (18-26 November) only

Participants of the fifth meeting of
Experts Group for ATM Video Coding
(6-9 January 1992, Singapore)

FRG	Mr. F. May	Daimler-Benz	CM
	Mr. G. Zedler	DBP Telecom	CM
Australia	Mr. H.G. Lim	Monash University	
	Mr. J. Princin	Telecom Australia	(CM)
	Mr. G. Smith	AUSSAT	
Belgium	Mr. O. Poncin	RTT Belgium	CM
Canada	(advised that no one can attend)		
USA	Mr. B.G. Haskell	AT&T Bell Labs	
	Ms. A. Wong	Bellcore	(CM)
France	Mr. G. Eude	CNET	CM
	Mr. J. Guichard	CNET	
Italy	Mr. Gandini	CSELT	(CM)
Japan	Mr. T. Fukuhara	Mitsubishi	
	Mr. K. Hibi	Sharp	
	Mr. Y. Katayama	GCT	
	Mr. S. Okubo	NTT	Chairman
	Mr. K. Sakai	Fujitsu	
	Mr. T. Tanaka	NTT	CM
	Mr. M. Tsujikado	Oki	
	Mr. H. Ueno	Toshiba	
	Mr. T Yukitake	Matsushita	
Norway	Mr. G. Bjoentegaard	Norwegian Telecom	(CM)
Netherlands	Mr. A. Koster	PTT Research	(CM)
UK	Mr. I. Parke	BT	
	Mr. D.G. Morrison	BT	CM
Sweden	Mr. H. Brusewitz	STA	CM
	Ms. C. Verreth	STA	
Korea	Mr. J-G. Choi	ETRI	Observer
	Mr. J-Y. Nam	ETRI	Observer

CM: Coordinating Member
(CM): Substitute for CM

Participants of the sixth meeting of
Experts Group for ATM Video Coding
(18-27 March 1992, Stockholm and Haifa)

Country	Name	Organization	S	H	
FRG	Mr. P. List	DBP Telekom		X	
	Mr. F. May	Daimler-Benz	X		CM
	Mr. G. Zedler	DBP Telekom	X	X	CM
Australia	Mr. M. Biggar	AOTC Labs	X	X	CM
	Mr. G. Smith	AUSSAT	X	X	
Belgium	Mr. O. Poncin	RTT Belgium	X	X	CM
	Mr. B. Voeten	Bell Telephone	X		
Canada	(advised that no one can attend)				
USA	Mr. B.G. Haskell	AT&T Bell Labs	X	X	
	Mr. N. Randall	DIS	X	X	(CM)
	Mr. A. Tabatabai	Bellcore	X		CM
	Mr. F. Tobagi	Starlight Networks	X	X	
France	Mr. J. Guichard	CNET	X	X	CM
Italy	Ms. L. Conte	CSELT	X	X	CM
Japan	Mr. S. Okubo	NTT	X	X	Chairman
	Mr. K. Sakai	Fujitsu	X	X	
	Mr. Y. Takishima	KDD	X		(CM)
	Mr. T. Tanaka	NTT	X	X	CM
	Mr. K. Yamazaki	KDD	X		
	Mr. T Yukitake	Matsushita	X	X	
Norway	Mr. G. Bjoentegaard	NTA	X	X	
	Mr. H. Sandgrind	NTA	X		CM
Netherlands	Mr. D.A. Schinkel	PTT Research	X		CM
UK	Mr. I. Parke	BT	X	X	
	Mr. D.G. Morrison	BT	X	X	CM
Sweden	Mr. H. Brusewitz	Telia Research	X	X	CM
	Ms. C. Verreth	Telia Research	X	X	
Korea	Mr. J-H. Jeon	Korea Telecom	X	X	Observer
	Mr. J-Y. Nam	ETRI	X	X	Observer

CM: Coordinating Member
(CM): Substitute for CM