Attempts at correlation between DSCQS and objective measurements

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Which role does picture quality play in the new competitive world of multi-channel digital television services? In order to suggest an answer to this and other questions, RAI Research Centre – in collaboration with TDF-C2R – is committed to studies which relate to the quality evaluation of compressed digital video sequences.

This Article collects together the preliminary results obtained within the framework of the ACTS Project, QUOVADIS*, and briefly describes the future planned studies to be carried out within the ACTS Project,* TAPESTRIES.

1. Introduction

Today, it is possible to provide direct-to-home (DTH) reception of a large number of digital television channels – thanks to the development of very effective digital transmission techniques and the standardization of audio-video compression techniques. In order to exploit this new technology, many new types of services have been planned such as video-on-demand (VoD), pay-per-view (PPV) and thematic channels.

While the technical feasibility of these new digital services has undoubtedly been demonstrated, the biggest question that still hangs over this scenario is the acceptance of multiple new services by the viewer: will there be enough people who are willing to part with good money in order to make these services profitable for the operator?

Various different factors will determine whether or not these new services are successful, including:

- the interest of the viewer in the channel content;
- the starting price of these new services;
- the commercial competition between different operators.

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It is easy to maintain that only "what" you transmit – and at "which price" – are the important issues, not the technical quality of the images. Yet, although the economic considerations will surely play a vital role in the success of these new services, the importance of the picture quality should not be underestimated as the viewer will almost certainly take this into account when making a choice between the available new services.

The technical quality offered by these digital services will depend on the bit-rate used to deliver them. If it is too high, the transmission costs (due to the need for increased bandwidth) will be great, without offering a visible improvement in the picture quality; conversely, the use of too low a value for the bit-rate (thereby degrading the picture quality) may turn away some viewers, to the detriment of the provider.

A television programme coded at 15 Mbit/s is undoubtedly better than one coded at 2 Mbit/s, but the relationship between bit-rate and perceived quality is not linear; there is no expert who would maintain that the quality of a picture sequence coded at 8 Mbit/s is twice that of the same sequence coded at 4 Mbit/s. Conversely, there *is* a linear relationship between the bit-rate used and the transmission cost; if you double the bit-rate (and hence double the bandwidth requirement), the transmission cost is generally twice as great.

Another factor to be considered is that different programme categories require different bit-rates. For example, Sport sequences require a higher bit-rate than that used for the encoding of Tele-teaching, not only because of their different features (motion portrayal, colour saturation etc.) but also because of the different picture quality expected of them.

In an attempt to resolve these dilemmas, studies have been carried out to determine the optimum range of bit-rates to be used for a particular service. Two important questions arise:

1. *How far can the bit-rate be increased, raising also the transmission cost, in order to obtain a quality difference that can be perceived by the viewer?*
2. *How far can the bit-rate be decreased, with the risk of dissatisfying the viewer, in order to save on the transmission cost?*

These are very difficult questions to answer, mainly because of the number of variables involved. Although we can perform many subjective assessments when defining a new digital television service, it would be totally unrealistic to use panels of observers to monitor the picture quality after the service had begun. Similarly, it would be unreasonable to resort to subjective assessments every time a new coder was purchased.

Given the aforementioned, there is clear need for a means of using objective measurements to evaluate the picture quality in digital television systems. To date, a precise method of measuring the picture quality is not available but we could accept a less precise method – provided the measurements could be computed in real time at the output of the encoder. During this first phase of using ob-

Abbreviations

ACTS	Advanced Communications Technologies and Services
CCD	Charge-coupled device
CCETT	Centre Commun d'Etudes de Télédiffusion et de Télécommunications (France)
DCT	Discrete cosine transform
DSCQS	Double-stimulus continuous quality scale
ETSI	European Telecommunication Standards Institute
FIR	Finite impulse response
IRT	Institut für Rundfunktechnik GmbH (German broadcast engineering research centre)
ISO	International Standards Organisation
ITU	International Telecommunication Union
MOSAIC	Methods for Optimization and Subjective Assessment in Image Communications
MP@ML	Main Profile at Main Level
MPEG	(ISO) Moving Picture Experts Group
QoS	Quality of service
QUOVADIS	QUality Of Video and Audio for DIgital television Services
RAI	Radiotelevisione Italiana
SI	Spacial information
SSCQE	Single-stimulus continuous quality evaluation
TI	Temporal information
TAPESTRIES	The Application of Psychological Evaluation to Systems and Technologies in Remote Imaging and Entertainment Services
TDF	TéléDiffusion de France

jective measurements, we would still continue to use subjective assessments in order to satisfy ourselves that the picture quality is acceptable.

The next part of this Article collects together the preliminary results obtained in the framework of ACTS Project *QUOVADIS*, whose goal is to find a correlation between objective evaluation and subjective assessment of picture quality, in order to be able to monitor a digital television service. The final part of the Article briefly describes the work planned by RAI in the framework of ACTS Project *TAPESTRIES*, whose goal is to suggest an answer to the two important questions given above. With thematic channels particularly in mind, these studies will take advantage both of objective measurements and of the new **S**ingle-**S**timulus methodology for subjective **C**ontinuous **Q**uality **E**valuation, referred to as SSCQE (see *Section 4* and also the Article commencing on *page 12* [1]).

2. Main goals of the QUOVADIS project

The main objective of the ACTS QUOVADIS project is to demonstrate that Quality of Service (QoS) has to be taken into account before the great advent of digital television in Europe – for the benefit of not only the viewers but also the business partners (i.e. the service providers, network operators and equipment manufacturers). The project encompasses the study of practical concepts, processes and technical means to ensure the QoS in digital television operations which involve multiple providers in a multinational environment. Another important goal of this project is to offer recommendations to the appropriate standardization bodies.

The project, which focuses on digital television encoded by the MPEG-2 standard, involves a consortium of eleven partners (see the text panel below)

QUOVADIS Consortium

TDF-C2R, France (Prime contractor)
CCETT, France
EBU, Switzerland
Fondazione Ugo Bordoni, Italy
IRT, Germany
Matra Communication, France
RAI, Italy
Retevisión, Spain
Rohde & Schwarz, Germany
Telmat, France
Teracom, Sweden

3. Attempts at correlation between DSCQS and objective measurements

In order to investigate the effectiveness of objective measurements when evaluating and monitoring the picture quality, the work was carried out in three steps:

1. Subjective assessments were carried out on a number of picture sequences. The main goal of these studies was to obtain subjective results that would be used in the third step.
2. Objective measurements were developed and subsequently performed on the same set of picture sequences assessed in step 1.
3. The results of the subjective assessments (step 1) and the objective measurements (step 2) were studied and correlated.

3.1. Subjective assessments

The subjective assessments were performed on fifteen different picture sequences, each 10 seconds long, using the **D**ouble-**S**timulus method with the scores represented on the **C**ontinuous **Q**uality **S**cale – a methodology referred to in ITU-R Recommendation BT.500-7 [2] as DSCQS.

At least twenty assessors were used for each test. The sequences were selected from three different libraries:

– nine sequences chosen from live material shot by the RAI Production Centre, Turin;

– three sequences taken from the test material used for the MPEG tests;

– three sequences obtained by down-conversion of HDTV material.

The sequences from RAI were shot using digital component CCD cameras, recorded on analogue Betacam machines and subsequently transferred to digital D1-format tapes. The chosen sequences covered the two main programme categories of Sport and News/Documentary.

The original sequences were processed by the MPEG-2 software encoder, available at the RAI Research Centre, and were assessed one-by-one. The results of these subjective assessments are shown in *Table 1*. The numbers in the *Table* represent the scores (on the continuous quality scale) obtained by each sequence during assessment at three different bit-rates: 4, 6 and 9 Mbit/s. The lower the number, the less noticeable is the impairment and, hence, the less critical is the sequence to digital compression.

Table 1
Results of subjective assessments performed by RAI and TDF in the framework of the ACTS QUOVADIS project.

Sequence *(abbreviation)*		DSCQS score (%) 4 Mbit/s	6 Mbit/s	9 Mbit/s
Live Sport	Canoe *(can)*	52.55	33.73	2.59
	Cyclists	13.71	5.41	5 29
	Juve–Parma (football) *(juv)*	40.94	22.06	4.65
	Pallacanestro (basketball)	10.96	1.75	3.63
	Rugby	39.27	29.55	10.05
Live News/ Documentary	Dorelli	7.25	6.25	1.42
	Husky *(hus)*	40.47	41.41	33.24
	Limone Piemonte	8.17	8.33	2.29
	San Salvario *(sal)*	22.09	11.18	–3.05
Others	Baruffa	20.74	13.43	8.65
	Basket *(bas)*	45.68	18.20	6.88
	Mobile & Calendar *(mob)*	25.04	11.36	8.40
	Olympic Sea	32.22	18.09	9.74
	Renata & Butterflies	23.92	8.84	11.04
	Tamburini *(tam)*	21.04	13.00	5.78

There were nine live sequences, grouped together in the following two categories:

News/Documentary: Dorelli, Husky, Limone Piemonte and San Salvario.

Sport: Canoe, Cyclists, Juve–Parma (football match), Pallacanestro (basketball in Turin) and Rugby.

Referring to *Table 1*, the least critical live material belonged to the News/Documentary category, with the exception of the sequence called Husky which was already impaired (33.24% on the continuous quality scale) at the highest bit-rate used (9 Mbit/s). In fact, except for this particular sequence, good picture quality – subjectively transparent to the original video quality – was obtained by all the live News/Documentary sequences: their impairment scores were generally less than 12%, even when coded at only 4 Mbit/s.

The Sport category included material that was satisfactorily encoded at 9 Mbit/s (DSCQS scores of less than 11%) but which was severely impaired when encoded at 6 Mbit/s (scores of between 22% and 34%).

In general, the picture content of News is very diverse: it can also include material derived from other categories such as Documentay, Sport, Drama, Entertainment and Educational programmes, as well as from Out-door Events. Nevertheless, the picture quality expected by the viewer for News is certainly less than that expected of the other aforementioned programme categories. At present, the precise level of quality expected by the viewer for the News category is not known.

As a general guide, it seems that a bit-rate of 6 Mbit/s (equivalent to PAL picture quality) or less can be used for News services. At least 8 or 9 Mbit/s must be considered for Sport programmes, to guarantee good picture quality across the full range of sports offered by broadcasters.

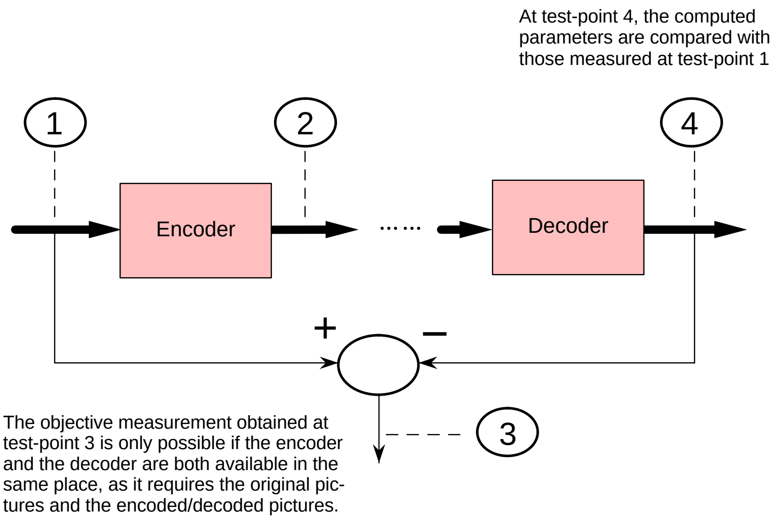
3.2. *Objective measurements*

Objective measurements can be divided into those made to detect the *source criticality* and those which give some information correlated to the picture quality.

In the case of source criticality, the measurements can be aimed at, for example, evaluating the *spatial* and *temporal* information in each frame, and the average and standard deviation of the *motion vectors*.

In the case of picture-quality measurements, we have to consider that , on the one hand, the picture quality may depend on the encoder used. With the MPEG-2 MP@ML encoder, we can take into account the *quantizer_scale* and other parameters available in the MPEG-2 bit-stream; it should also be possible to extend this same methodology to other coders such as the ETSI version. On the other hand, there are parameters such as *tiling* and/or *blurring effect* which may be measured independently of the compression system used.

Figure 1
Test-points for the objective measurement of picture quality.



Different strategies can be devised to define objective measurements that correlate with the assessed picture quality. As shown in *Fig. 1*, four different test-points can be used to make the objective measurements.

In the framework of the present work at RAI, we have taken into account various parameters of the source material (test-point 1) and of the MPEG-2 bit-stream (test-point 2).

3.2.1. Source criticality measurements

Digital video can be characterized by parameters which indicate the spatial and temporal information that determines how easy or difficult the signal is to compress.

One method of computing both the spatial information (*SI*), using Sobel filters, and the temporal information (*TI*) is given in [3]. It applies the following formulas:

$$(1) \quad SI(n) = STD\left\{\sqrt{[Sobel_h\ Y(i,j,n)]^2 + [Sobel_v\ Y(i,j,n)]^2}\right\}$$

where: i and j indicate the horizontal and vertical positions of the pixels, and $Sobel_h$ and $Sobel_v$ are the horizontal and vertical FIR values of the filter.

$$(2) \quad TI(n) = STD\{Y(i,j,n) - Y(i,j,n-1)\}$$

where: n and $n\text{–}1$ indicate the current frame and the previous one.

The overall spatial information and temporal information concerning the picture sequence can be given either by their *average* values or by their *maximum* values in each frame. In reference [3], the maximum values were used.

The spatial and temporal information defined at test-points 1 and 2 in *Fig. 1* are related to the activities of the video sequences, but they give no information regarding the spatial and temporal redundancies that could be removed by a compression algorithm such as MPEG-2. On the other hand, we expect that the coding difficulty of a sequence depends on the residual spatial and temporal information after motion compensation and DCT, and therefore the above parameters could provide only a first approximation of the coding difficulty. In fact, these parameters could only be used to rank the video sequences correctly if they presented the same percentage of temporal redundancy that can be removed by the MPEG-2 video encoder.

The standard deviation of motion vectors takes into account – better than *TI* – the information about removable temporal redundancy. Studies carried out by RAI provide interesting results on this matter.

3.2.2. Objective measurements of picture quality

Picture-quality measurements can be performed by taking into account, on the one hand, only those parameters that are accessible from the bit-stream or, on the other hand, by merging these ones with the parameters which relate to source criticality.

a) MPEG-2 bit-stream parameters

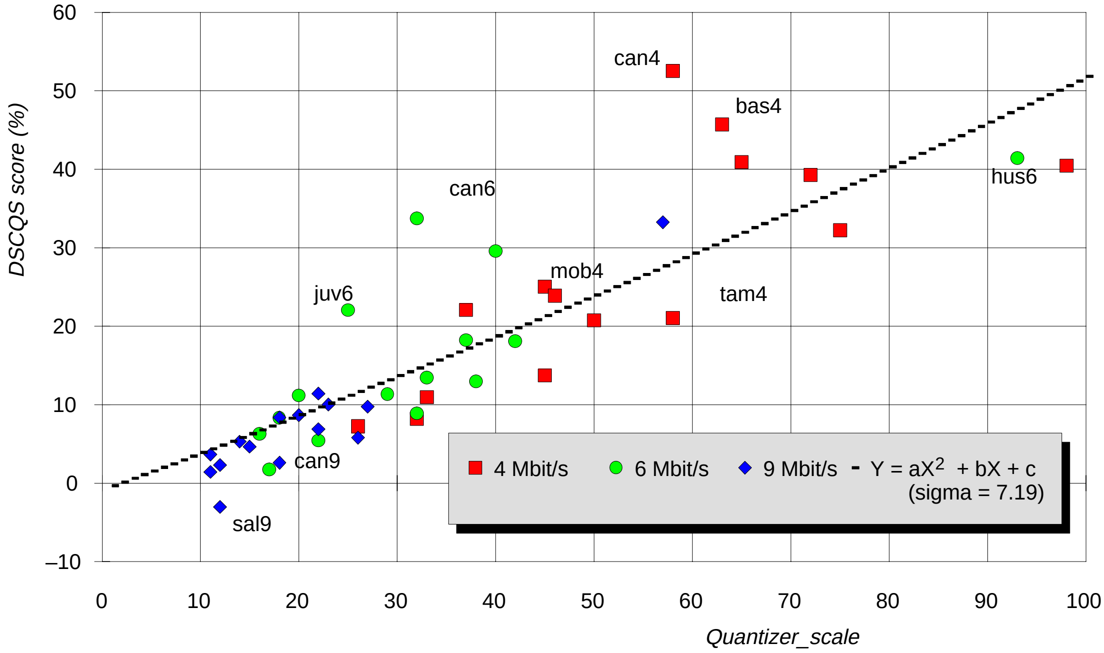
The MPEG-2 video bit-stream includes several encoding parameters that must be delivered to the MPEG-2 decoder in order for it to decode the compressed signal correctly. The *quantizer_scale*, the motion vectors and the coding modes are available in each macroblock. Some parameters are immediately available from the MPEG-2 bit-stream, while others must be computed.

The *quantizer_scale* contributes to the scaling factor of the DCT coefficients, and therefore it is related to the quantizing noise introduced by the encoder. Furthermore, the quantization of the DCT coefficients is performed by adapting the visibility threshold matrix, so that it also takes into account the sensitivity of the eye at different spatial frequencies. What is not taken into account by the *quantizer_scale* is the sensitivity of the eye to visual stimuli in picture areas with different activities. This aspect – which relates to eye-masking of the stimulus – could be taken into account by the criticality of each macroblock: for example, a parameter could be computed inside the encoder and used to move the major part of the coding noise to picture areas where the perception of noise and coding artefacts is assumed to be limited.

The *quantizer_scale* is a function of both the criticality of each macroblock and the “buffer fullness”. Probably, the effect of the buffer fullness is stronger than that of the criticality; in any case, by looking at the changes in the *quantizer_scale*, it is not possible to separate the effects caused by the criticality and those caused by the buffer fullness.

The maximum values of the *quantizer_scale*, measured on B-frames, have been correlated with the results of the subjective assessments. The scores given by the assessors were based on the picture quality of a complete 10-second sequence, taking into account not only those impairments that affected the complete sequence but also those that impaired just a part of it. An impairment must

Figure 2
DSCQS results compared with the maximum values of the parameter *quantizer_scale*, measured on B-frames. Also shown are: the second-order curve that minimizes the square differences, and the standard deviation of the random variable which indicates the dispersion of the DSCQS values.



last quite a long time – several frames – in order for it to be perceivable by an assessor. Taking into account these considerations, the maximum value of the *quantizer_scale* parameter has been defined as the maximum value found over at least six B-frames.

It is useful to know the subjective picture quality that corresponds to the measured objective parameter. Consequently, *Fig. 2* shows the relationship between *quantizer_scale* and DSCQS score. A second-order curve, computed using the Least Square method, is also shown, together with the standard deviation of the random variable which indicates the dispersion of the DSCQS results.

Regarding the maximum value of *quantizer_scale*, the results obtained using the procedure just described seem to indicate that:

- if the maximum value is lower than 30, it is very likely that the coding process will be nearly transparent (i.e. a DSCQS score of less than 12. 5%);
- if the maximum value is higher than 60, it is very likely that a DSCQS score of higher than 30% occurs;
- if the maximum value is in the range 30 – 60, it is difficult to foresee the picture quality precisely; in this case it is only possible to state that the DSCQS score is probably in the range 12.5% to 30%.

When considering the method used to detect the maximum value of *quantizer_scale*, it is worth noting that the correlation between objective parameters and subjective assessments relies on the DSCQS results. In the case of continuous evaluation using a Single Stimulus method (i.e. SSCQE – see *Section 4* and the article beginning on *page 12* [1]), the correlation between subjective quality and objective measurement would probably be performed on a frame-by-frame basis, or using a few frames at a time. If that were the case, then the difficulties concerning the definition and evaluation of the maximum values for *quantizer_scale* could be overcome.

It is important to note that the results of subjective assessments usually give rise to a standard deviation of 10 – 20, and that the reported DSCQS values provide an estimate of the picture quality, with a 95% Confidence Factor.

b) Parameters from the MPEG-2 bit-stream and the source material

The analysis of the results has shown that the spatial information must be considered not directly in relation to the quality, but indirectly.

This fact has been highlighted by looking at the spatial information on a frame-by-frame basis, i.e. *SI(n)*. An example is given by the sequence called Husky, which got very bad DSCQS scores even at the highest bit-rate (9 Mbit/s); in particular, it was easy to notice very important impairments (distortion and block effects) for two or three seconds before the end of the sequence. In fact, the objective parameter *SI(n)* suddenly decreased at that point in the sequence while the average value of *quantizer_scale* remained quite constant over the whole sequence.

Subsequently, the *quantizer_scale* values were divided by the spatial activity values (see *Fig. 3*) and the resulting values of this new parameter, here referred to as *(100 X q_s)/SI*^{2}, were correlated with the results of the subjective assessments, in a similar manner to that described in *Section 3.2.2.a*.

The results (see *Fig. 4*) obtained using this new parameter seem to indicate that:

- if the maximum value is lower than 5, it is very likely that the coding process will be nearly transparent (i.e. a DSCQS score of less than 12.5% is present);
- if the maximum value is in the range 5 – 10, it is very likely that a DSCQS score of between 12.5% and 25% is present;
- if the maximum value is in the range 10 – 15, it is very likely that a DSCQS score of between 25% and 35% is present;
- if the maximum value is higher than 15, it is very likely that a DCCQS score of higher than 35% to 40% is present.

Looking at *Figs. 2* and *4* together, it can be seen that some sequences are better suited to being evaluated by one of the two parameters just described, while other sequences align more closely with the other one. For example, the *quantizer_scale* values for the two sequences Juve-Parma and Canoe, both coded at 6 Mbit/s (i.e. *juv6* and *can6* respectively), were quite different from their DSCQS scores while their *(100 X q_s)/SI*^{2} values were very close to their DSCQS scores. The converse was true for sequences *mob4* and *can9*.

These preliminary considerations allow us to foresee that merging of these two parameters (and probably others) may give even better correlation results.

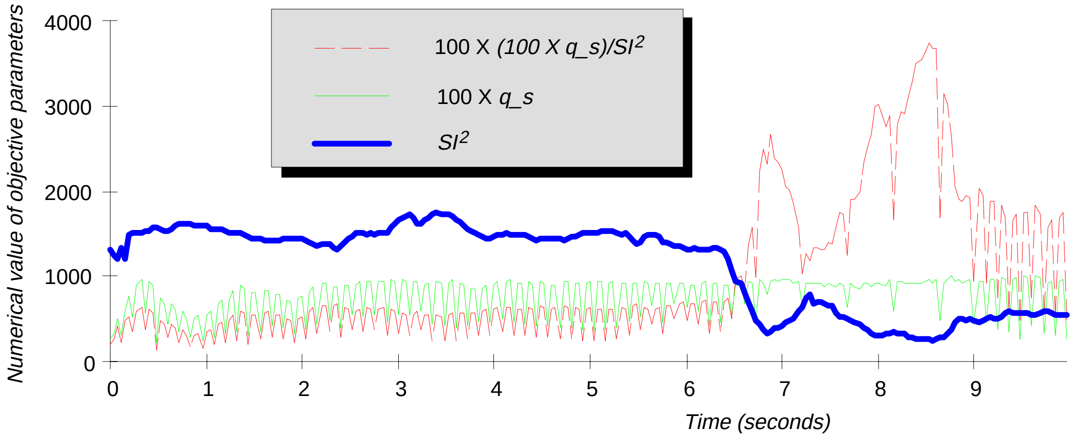


Figure 3
The objective parameters $SI^2(n)$, *quantizer_scale*, and *quantizer_scale* divided by SI^2 for the sequence *Husky*, coded at 4 Mbit/s .

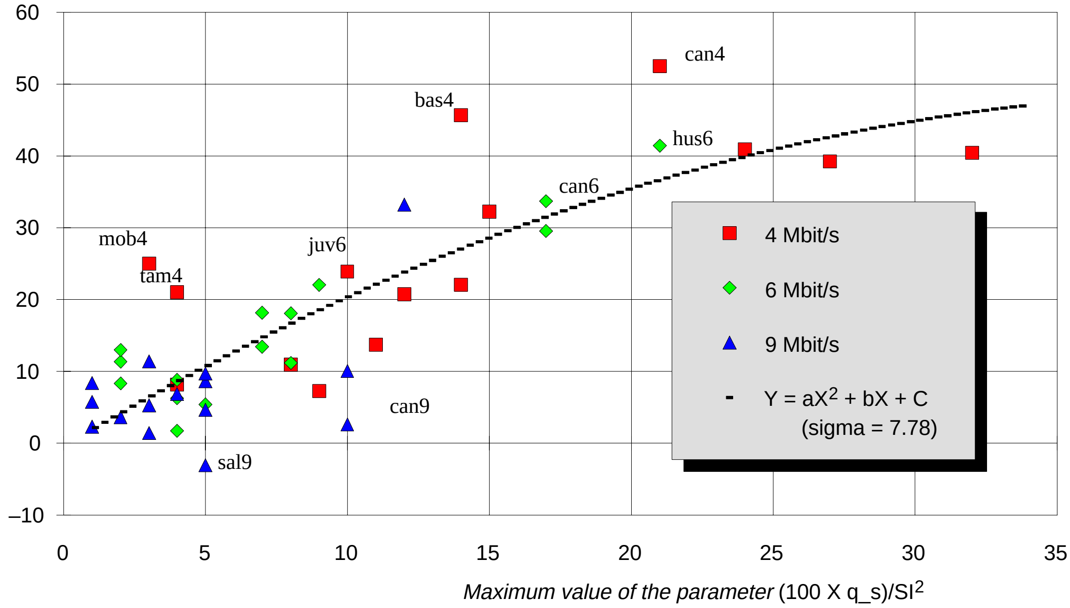


Figure 4
DSCQS results compared with the maximum values of the parameter *(100 X q_s)/SI*^{2}, measured on B-frames. Also shown are: the second-order curve that minimizes the square differences, and the standard deviation of the random variable which indicates the dispersion of the DSCQS values.

4. Can SSCQE improve the correlation?

In the previous *Section*, correlation was found between (i) certain computed parameters of a digital video bit-stream and (ii) the subjectively-assessed quality of the associated picture sequences. Nevertheless, correlation was not always satisfactory as some sequences, such as *can4*, did not follow the average behaviour. These anomalies may have occurred because we tried to correlate objective measurements with the results obtained with DSCQS, which proved not to be the best choice for assessing digitally-encoded sequences. In fact, as noted in [4]:

> *The most fundamental drawback of DSCQS is the use of 10-second test sequences. This is useful for images exhibiting a single impairment level, but with scene-dependent images it is not possible to include all the possible quality fluctuations in any test. Secondly, to simply lengthen the test sequence, so that a greater quality variation range is incorporated, does not solve the problem, as memory-based biases are introduced where the assessor is influenced primarily by the quality of the most recent pictures.*

With these considerations in mind, a new methodology – the **S**ingle **S**timulus **C**ontinuous **Q**uality **E**valuation (SSCQE) [3] – has been developed by the MOSAIC partners (see the article starting on *page 12* [1]). Basically, this method consists of using a panel of observers to assess continuously the picture quality of the material under investigation.

It is reasonable to suppose that stronger correlation could be found between objective parameters and continuously-assessed picture quality, than is the case between the computed parameters and the DSCQS impairment scores discussed in *Section 3*.

Following on from this thought, RAI Research Centre – within the framework of the ACTS TAPESTRIES Project – is now carrying out an experiment on eight 1-minute sequences. The work consists of three steps:

1. software co-decoding of the sequences according to the MPEG-2 standard, and making measurements on their encoding quality parameters as defined in *Section 3.2.2*.
2. making subjective assessments of the same sequences used by the single-stimulus methodology (but with the length of each sequence shortened from five minutes to one minute.)
3. finding a correlation between the temporal behaviour of objective and subjective data.

The categories, bit-rates and resolutions of the 1-minute sequences used in this experiment are given in *Table 2*.

4.1. Category quality versus bit-rate. Does a law exist ?

Two important questions were raised in *Section 2* about the best bit-rate to employ for different categories of material (e.g. Sport, Movies, Fiction). RAI Research Centre is trying to suggest an answer to these questions for a particular scenario: the thematic channel.

An experiment has been planned whereby the same categories, bit-rates and resolutions given in *Table 2* – in the form of a hypothetical "bouquet" of programmes – will be investigated. The sequences will be 15 minutes long and will be encoded by hardware devices.

We are aware that it is impossible to define "closed" categories of material, because in every thematic channel you will find every kind of sequence; for example, on a Movie channel, a film based on the life of an athlete could contain a lot of Sport action; similarly, on a Sport channel, there are likely to be interviews carried out in a studio environment. We feel it is of primary importance to investigate if a programme material from a par-

Category	2 Mbit/s Half Res.	3 Mbit/s Half Res.	4 Mbit/s Half Res.	4 Mbit/s Full Res.	6 Mbit/s Full Res.	8 Mbit/s Full Res.
Sport			X	X	X	X
Film			X	X	X	X
Fiction			X	X	X	X
Documentary			X	X	X	X
Music			X	X	X	X
News		X	X	X	X	
Cartoons	X	X	X	X		
Tele-teaching	X	X	X	X		

Table 2
Video bit-rates and resolutions used by RAI for the SSCQE subjective assessment tests.

ticular category can be encoded in an optimum way, taking account of both the expected quality and the technical parameters, irrespective of the channel in which it will be broadcast.

This experiment – in the framework of the ACTS TAPESTRIES project – will be carried out on both audio and video sequences using the first stage of the new SSCQE methodology.

Dr Denis Abraham (left) *obtained a French post-graduate degree (DEA) in Metrometry/Digital Television in 1987 and received a doctorate from the National Polytechnic Institute of Lorraine (INPL) in 1990. He then began his career as a Research Engineer in the Biological and Medical Engineering Laboratory of INPL, working on digital imaging, shape recognition and reconstruction in the field of medical applications.*

Later, Dr Abraham joined the research and development centre of Tonna Electronique (a manufacturer of cable network equipment) as the manager in charge of their digital television studies. In 1995 he joined the Quality and Trials Department of TDF-C2R as an engineer. His main responsibilities there are focused on video subjective assessments and digital television trials. He is involved in the European ACTS QUOVADIS project where he is in charge of the workpackage dedicated to field trials.

Mr Maurizio Ardito (right) *joined RAI in 1970. At the end of 1996, he was appointed Director of the RAI Production Centre in Turin and, currently, he is also Head of the Research Centre department that is involved in the introduction of new studio production technologies. He is also concerned with picture and sound evaluation methodologies, in particular the aspects which relate to compression systems and their suitability for new services.*

Mr Ardito is Chairman of the EBU Production Management Committee (PMC), which co-ordinates the studies of new television production systems and promotes the necessary standardization.

Mr Laurent Boch (left) *received a degree in Electronic Engineering from* Politecnico di Torino *in 1990. His thesis was on the vector coding of DCT coefficients for video compression, carried out at RAI Research Centre which he joined in 1992. His fields of interest include video coding and compression.*

Mr Boch participates in the activities of EBU Project Group P/BRRTV (which deals with the distribution of compressed video in the studio) and is also involved in the activities of three European ACTS projects (DVP, QUOVADIS and TAPESTRIES). Currently, his main involvement is in the objective evaluation of video quality.

Mr Alberto Messina (right) *graduated in Electronic Engineering from* Politecnico di Torino *in October 1996. His thesis, entitled "Definition, calculation and analysis of objective parameters on picture quality of MPEG-2 video coding", was prepared at the RAI Research Centre in Turin. He is presently carrying out studies at the Polytechnic – in co-operation with RAI Research Centre – on objective quality measurements for compressed pictures.*

Dr Mario Stroppiana (left) *received a doctorate in Mathematics from the University of Turin in 1970. Since 1968, he has worked at RAI Research Centre in Turin and was involved for many years with modelling and computer simulations of analogue transmission broadcasting channels. Since 1985, his interests have moved towards digital signal processing, coding and quality evaluation.*

Dr Stroppiana was involved in the European EUREKA and RACE projects and currently participates in two ACTS projects (DVP and QUOVADIS).

Mr Massimo Visca (right) *obtained a degree in Electronic Engineering from the Politecnico di Torino in 1992. In 1994, he joined RAI Research Centre in Turin, working in the "Advanced Production Techniques" department.*

Mr Visca is currently involved in studies concerned with the perceived quality of compressed images and in studies on the correlation between objective image quality measurements and subjective quality assessments. He is a participant in the European ACTS project, TAPESTRIES.

During the experiment, two scenarios will be investigated:

– different categories will be assessed at the same bit-rate, in order to ascertain if there is a real difference between them – from both a technical viewpoint and in terms of encoding criticality;

– for each single category, the variation in quality caused by increasing the bit-rate and, hence, the relationship between achievable subjective quality and bit-rate, will be investigated.

This investigation should help to give a preliminary answer to the two important questions raised in *Section 2*.

5. Conclusions

Broadcasters are interested in the commercial feasibility of specialized thematic channels which address specific sectors of the market. Nevertheless, this new business opportunity raises many questions, mostly based on the acceptance by the viewer of lower picture quality which could reflect negatively on the effectiveness of the service itself.

Do the specific characteristics of various types of programmes – for example, Sport, News, Films and Cartoons – offer the possibility of optimizing the bit-rate? To suggest an answer to this question, a big effort in subjective assessment is required; the traditional assessment methodologies such as DSCQS will not be the best solution for the testing of digitally-encoded sequences.

RAI is carrying out studies on these matters, using assessment methodologies which take advantage of the new techniques already devised by the RACE MOSAIC project [4].

Moreover, broadcasters will need tools that are able to perform continuous monitoring of the new digital services. For this task, real-time objective measurements are needed. It should be possible to accept a lower precision with these evaluations than is achievable by using time-consuming subjective assessments.

The preliminary results have been most encouraging and RAI is now in the process of developing new methods for carrying out objective measurements.

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[2] ITU-R Recommendation BT.500-7:
Methodology for the subjective assessment of the quality of television pictures.

[3] Beakley, G., Cressy, C. and Van Pelt, J.:
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SMPTE Journal, Vol. 104, No 11, pp 742 – 750, November 1995.

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RACE R2111, page 7, January 1996.

George T. Waters honoured in Las Vegas

George T. Waters *(right)*, Director of the EBU Technical Department, was this year's recipient of the *Award of Honour* presented by the National Association of Broadcasters (NAB) at their annual convention in Las Vegas during March. Dr Waters is the first European to be honoured in this way.

In presenting the award, Mr Lynn Claudy *(left)* – the Vice-President of NAB Science and Technology – said that, after more than forty years in broadcasting, Dr Waters was well known and widely respected throughout the community for his world-wide understanding of broadcasting matters.

The citation on the award reads: *George T. Waters for leadership in international co-operation and technical liaison on broadcasting matters.*