Doc No : - ASSC/130/2/37

Draft 8 - January 1999

REVIEW OFCOMMERCIAL VIDEO STANDARDS *

0 EXECUTIVE SUMMARY

This report into commercial video standards is a revision of a report written during 1993 and published in May 1994. In these five years the art of digital video has progressed enormously to huge public deployments. To a first approximation the primary avionics need was to identify the successor(s) to PAL/NTSC. The scope of the work is to assess civil developments in aspects of video technology and to identify standards that might be economically translated into avionics systems.

It was decided that a wide range of opinions should be sought within MoD and within avionics. In the event there is a common political/economic posture, namely that provided the requirements are met, value for money and demonstrability prevail. technical elegance is not of prime consequence. Nevertheless, expectations are driven by experience.

This report provides details of several different areas of technology. Broadly, HDTV, video transmission, Broadband Integrated Services Digital Network (B-ISDN) components including Frame Relay, Asynchronous Transfer Mode (ATM) with Synchronous Digital Hierarchy (SDH), Switched Multi-megabit Data Services (SMDS). Later standards in compression standards are also covered such as those developed by the Joint Photographic Experts Group (JPEG), Moving Pictures Experts Group (MPEG), and Multimedia and Hypermedia Experts Group (MHEG). The report details some aspects of these initiatives that are relevant to avionics. Some of these are now significant civil implementations, for example, ATM borne on Synchronous Optical Network

---

* This report is published by the Avionic Systems Standardisation Committee (ASSC) to advance the role of standardisation in avionics. The use of this is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user. Copies of this paper are obtainable from the ASSC Agency as an Avionic Systems Standardisation Committee publication.

(SONET)/SDH fibre optic bearers have been nominated as the global telephone/data network. Others, notably domestic HDTV is still in a state of flux. However, video in the civil arena has fractioned into discrete markets with different needs. Examples are CD-ROM, Medical X-ray, TV studio applications, as well as TV preparation, distribution, and recording. Across these important subjects there is clearly an underlying coherent technical community of knowledge and at the same time an increasing spectrum of applications. The respective interests of ITU-R (International Telecommunication Union-Radio) (broadcast), ITU-T (cable), International Standards Organisation (ISO)/International Electro-technical Commission (IEC) (Information Technology) meet together in a serious attempt to rationalise and harmonise standards across markets.

The report shows that some video bearer technologies, notably ATM and SDH, separately or jointly, or Distributed Queue Dual Bus (DQDB) or Scaleable Coherent Interface (SCI) all have a claim for consideration as avionics video bearers. Current Integrated Services Digital Network (ISDN) demonstrates the need to separate control paths from data paths and proceeds to demonstrate that video is not implicitly a constant bit-rate service. ISDN has in turn required a fundamental re-appraisal of bearer protocols and evolved ATM transported by SONET/SDH. It is clear that ATM is a radical departure and a watershed in the development of data exchange protocols. ATM has, in a relatively short time, become the torch bearer for data exchange technology. Some long standing data bus initiatives, for example FDDI II, which grafts telephone attributes to what was a data Local Area Network (LAN), are virtually rendered still-born by ATM-like thinking. Others have their projected market curtailed in a serious way. The decision by ITU-T to nominate ATM and SDH as the primary bearer for the next generation of public switched network is likely to have a profound effect on video applications. That is to say that the applications will be constructed according to the limitations and freedoms of ATM and with corresponding low-cost ATM interfacing components.

With regard to video the report concludes that the benchmark broadcast HDTV standard, which will replace PAL/NTSC, is still undecided and that the eventual solution is not yet visible. More importantly the report finds that broadcast TV and studio practices are separating. Studio practice has more commonality with avionics and the standardisation is both satisfyingly more advanced and less political. Currently much domestic digital video is concerned with a perceived quality comparable with current analogue techniques and offers no radical progress beyond applying ITU-R 601 to STANAG 3350 AVS. With civil video, data compression is economically inescapable and 'irreversible algorithms' can only deliver the compression ratio required. For military needs within an airframe, compression does not produce economies, consequently compression is not apparently a requirement. However, recording or up-linking is a different issue. When compression, as in the civil case, means the difference between two minutes or one hundred minutes of recording time then compression is a serious technical issue.

In summary, an aircraft video system implemented today would use STANAG 3350 AVS analogue or comparable ITU-R 601 digitisation standards since there is no feasible technical/economic alternative. Conversely, an aircraft to enter service in 2010 with 1993 technology would be archaic as a result of the rapid evolution of civil technology. The general form, and source, of relevant civil video standards is already visible. Simultaneously, civil video technology is embracing digital methods and video is becoming entwined with novel data services, telecommunications and multi-media applications. The avionics industry is technically satisfied that 'all digital, HDTV' video is the way of the future, at the same time there is a wariness that 'expediency rules', leading to significant commercial risks. Moreover the idea of adopting civil video technology is not an issue since all existing avionics video is at present based on PAL/NTSC. The matter does not end with identification and promulgation of the new techniques, it entails the greater costs of prototyping and proving a new generation of video functions.

Table of contents **Page no.**

Table of contents (cont) **Page no.**

Figures and tables

1 INTRODUCTION

The work was complemented with several interviews with interested parties, the particular individuals cannot readily be attributed and have not been named. All companies corresponding with the ASSC Video Systems Working Group companies were encouraged to submit their views. These inputs were supplemented with constructive literature searches and extensive reading of technical literature, primarily on telecommunications, HDTV, and current compression standards. The telecommunications literature was largely confined to the component parts of B-ISDN. Specifically SONET, SDH, DQDB, ATM, Frame relay, Fibre Channel (FC). The following text expands on these subjects as appropriate to distinguish one technology from another and to justify a decision that the subject warrants serious study. The current literature is voluminous, exhausting and difficult to assimilate. It is notable that there is a convergence and cross fertilisation of technique but at the same time a divergence of application. In other words there will be, not one, but many high definition video applications.

1.1 Analogue v digital video, technical overview

It is now apparent that many readers of this document have a keen interest in the utility and end user functions of video but do not have the requisite technical background to understand the factors with which digital video will displace the existing analogue systems. This text is a brief introduction and a substantiation of a main theme which is that the displacement of analogue video is inevitable. Only the timescale is uncertain.

A technical appreciation of the differences between analogue and digital video demands considerable knowledge of circuit theory and the mathematical basis of communication theory. With that knowledge the ultimate superiority of digital methods is plain. The text here is targeted at those people who need to gauge the certainty of that superiority without the basic technical knowledge.

Digital methods are amenable to computation. Digital methods propagate numbers that can be manipulated by computer, with all the mixing, overlaying, target processing, and graphics potentials. However, there have been and remain problems. The first problem is that the semiconductor technology required to generate, propagate and manipulate digital video is comparatively recent, namely the same micro-electronic revolution which spawned PCs. The second is that 'communication theory', the principles of propagating digital signals, is also recent. The third is that understanding of techniques to implement communication theory at video data rates is very recent. Current military and domestic video is 'analogue'; PAL in Europe and NTSC in US and Japan. STANAG 3350 AVS is a NATO endorsement of the domestic system. That domestic system was essentially designed in around 1938 (Monochrome) and modified for colour in the mid sixties. Current video is technologically roughly 30 years old, in other words still in the thermionic valve age.

Digital methods maximise the use of numerical (computational) methods that are absolutely repeatable, each instance behaves exactly the same. In respect of video, CDs, PCs, CD ROMs, telephone or whatever in electronics the goal is to get the data (picture) expressed as a sequence of numbers. Thereafter it is a matter of computer programs to manipulate the image in any desired way. There is almost no limit except that operating on high definition full motion video quickly reaches the limits of current computational power. Digital video offers very substantially more than 'better pictures'. Avionics video is moving from being point to point camera/display and will be inextricably associated with computational methods and inter-connected by data-communication methods, along with all the other aircraft data. Images need to be synthesised, merged, synchronised, analysed, processed, enhanced, tiled, transmitted, interconnected, recorded and so on. In all these aspects, digital methods are likely to be unique or superior and ultimately cheaper.

The digital video interconnect path has very high speed data however, the electrical/optical design of the interface is only required to propagate two symbols and with a signal to noise ratio requirement which is substantially less than the equivalent fidelity for an analogue picture. In general digital video will require fibre optic instead of coax as used by analogue video. This introduces a further novel technology however, fibre optic is ultimately capable of higher speeds, is lighter, and has already revolutionised telecommunications. Propagating digital pictures over a fibre optic would use conventional data communication principles namely the sequence would be numerically protected against error. Any noise which corrupted the sequence would be detected and possibly corrected, but note that noise sufficient to corrupt a signal is a serious but very unlikely situation. The received digital image has a significant property which analogue images don't have. A correctly received image, being a sequence of numbers, is exactly and completely the same as the original. Analogue pictures suffer two irreversible distortions and are plagued by many others. The dominant distortions are loss of detail due to relatively poor high frequency response and the inescapable 3 dB loss of signal to noise ratio. Each time the analogue signal is repeated, including recording, there is a loss of detail. These factors mean that propagating analogue video is problematic, conversely modern telecommunications can readily propagate digital video.

On a cost/benefit basis digital techniques climb in performance, fall in cost and offer desirable facilities which cannot be matched by analogue techniques. Conversely analogue implementations have reached a technical and economic plateau. At some time there must be a cross-over when the benefits of digital video are irresistible. That time is imminent although some future aircraft will have a mixture of the two technologies.

Digital video, compatible with STANAG 3350 AVS, is a stable and feasible proposition now. ITU-R have standardised the process to turn PAL, NTSC (STANAG 3350 AVS) into a stream of bits using ITU-R 601, and ITU-R 656. NATO has not chosen to endorse ITU-R 601, and ITU-R 656. This process is embedded in ITU-T H.261, MPEG-1 and JPEG. ITU-T/ITU-R has standardised the means of interconnection. What is not evident to a casual student is that H.261, JPEG, MPEG-1, MPEG-2 (see section 4.8) are architecturally similar and intended to perform different purposes. In other words they are very similar technically but separately refined to fit specialised requirements. They are not competitors.

As above, avionics digital video, compatible with STANAG 3350 AVS, is a stable and feasible proposition now. However, the route to HDTV is still in flux. It is plain that commercial High Definition TV will be digital.

2 CURRENT AVIONIC VIDEO STANDARDS

2.1 Standards

The primary military video standard is STANAG 3350 AVS. Def Stan 00-18 (Part 6) is the UK implementation of STANAG 3350 AVS (Edition 4). However, these are actually endorsements of European PAL and US NTSC. These are confined to analogue video on coaxial cable and their scope is confined to single-source single-sink. There are no other relevant NATO standards. Perusal of recent military avionics specifications found that conformity with PAL, NTSC, EIA 170, (in composite, RGB and YUV) were all on offer. Thermal Imager and Laser Designator (TIALD) actually references STANAG 3350 AVS.

In 1986 the CCIR (now ITU-R) published recommendation 601 entitled 'Encoding parameters of digital Television for Studios' that lays down how PAL/NTSC should organised and sampled. ITU-R 601 is a programme exchange standard and it defines a single source and implies a single sink. Complementary ITU-R recommendation 656 formalises bit parallel and bit serial interfaces. These ITU-R recommendations have been extensively referenced in ASSC literature. Anyone contemplating digital video, with current frame formats, would encounter ITU-R 601.

2.2 Equipment

The most relevant aircraft has to be EF 2000 (Eurofighter) or F-22. Unfortunately detailed information is not available for reasons of sensitivity. However the generality of equipment can be guessed or referenced from published texts. The equipment can be divided into two; synthesised and imaging systems. Imaging systems are Thermal Imaging (TI) such as Forward Looking Infra-Red (FLIR), Low light TV, Daylight TV, and Radar. The synthesised systems are engine management, weapon status, digital maps, and general instrumentation.

3 INTERVIEWS

In the course of preparing the first draft of this report it was a requirement to seek a wide range of opinions and a number of interviews were conducted with MoD and industry. A record of those interviews exists in the correspondence file of the ASSC Video Systems Working Group. In order to make this document available to a wide audience it proved necessary to remove the attributions and merge the texts into a single consolidated opinion.

3.1 Technical issues.

There was a general technical consensus that 'all digital' is certainly the future for avionics video in the medium to long term. Digital methods can be applied now to existing video line standards as STANAG 3350 AVS and could use the existing ITU-R 601. Currently the commercial High Definition initiatives are in a state of flux and not sufficiently stable to be fit for any use but are progressing at a very high rate. Other than STANAG 3350 AVS (Def Stan 00-18 (Part 6) there are no military video standards. Even STANAG 3350 AVS only standardises point to point links. There is no accommodation for synchronising several sources or over-laying images.

Tracked Reconnaissance Armoured Combat Equipment Requirement (TRACER) is for an armoured scout vehicle whose requirements are written and scheduled to enter service after the year 2000. This imminent procurement is illustrative of the current state of digital video for military purposes and not too dissimilar to avionics. It is clear that an all digital approach to video would be viable for a vehicle entering service after 2000. However, there are many obstacles. The obstacles are cost, demonstrability, and standards. The problem is that it is not a simple matter of choosing between conventional practice and a novel solution. The conventional analogue system performs most of the requirement but not everything. Digital technology would make up the difference however, this is a technical judgement which cannot be demonstrated, and for which there are no nominated STANAGs or Defence Standards. This is in the area of digital interconnect of images compatible with STANAG 3350 AVS and concerns synchronisation and over-laying where computer generated graphics need to be merged with camera images.

Returning to avionics there are other issues which are best summarised as a bullet list.

- Reconnaissance is moving to ever higher definition and inevitably to digital methods. These methods are being standardised by the reconnaissance community and the NATO Imagery Interoperability Data Links (NIIDL) see STANAGs 7023, 7024. (STANAG 7023 (based on a US document) enables the replay of data, including ancillary information to re-create the scenario existing when it was acquired. STANAG 7024 is similar but applies to recorders.)

- Compression in the airframe interconnect is viewed with suspicion. Firstly the incremental cost of higher bandwidth channels appears to be tiny. The cost of bandwidth is likely to be less than the all-up cost of compression, expanding, extra weight and needless complexity. Use of compression depends on requirements. Issues such as incremental cost, latency, and reliability should be considered when considering the use of compression for real-time applications.

- Compression will be needed for in-flight data links or recorders however, these will be embedded rather than visible in the aircraft interconnect.

- Digital video implies fibre optic interconnect and other implications. The shift from analogue to digital has implications for sensor, interconnect, display, synchronisation, overlaying, system functions and so on. All these implications bring design costs, risks and new possibilities.

- HDTV is of limited use for conventional cockpit displays because the pilot suffers large differential vibration. Helmet mounted displays might be different.

- Digital video offers very substantially more than 'better pictures'. Video is moving from being single camera/display and is inextricably associated with computational methods and inter-connected by data-communication methods, along with all the other aircraft data. Images need to be synthesised, merged, synchronised, analysed, processed, enhanced, tiled, transmitted, interconnected, recorded and so on. In all of these aspects digital methods likely to be unique or superior and ultimately cheaper (see also section 2.1).

3.2 Economic/strategic issues.

There are two perspectives, one for the supplier and one for the procurer/user.
Firstly the procurer; technical excellence is desirable but not the primary goal. The goal is an aircraft which meets the operational requirement in the most cost effective overall manner. It is the responsibility of the contractor to determine how the requirements are to be achieved and to bid accordingly. Requirements arise due to ageing/replacement or new threats or new weapons and have always thrown up questions regarding the readiness of the latest technology. In a scenario of rapid evolution the decision will have to be made one way or the other. Cost/benefit analysis will be the deciding factor. Increasingly the lifetime of an airframe substantially exceeds the viable lifetime of the avionics. The result is substantial re-fits during the airframes service life. A decision to stay with established technology, for reasons of cost or risk, has the effect of shifting the need for update to an earlier time frame.

There are some sub-systems, for example reconnaissance and smart weapons, whose functions might require leading edge technology. These tend to be managed and procured as separate entities. The technology requirements for these functions are determined on a cost benefit basis exactly as the airframe however, the nature of the requirement might only be met by the very best technology.

Secondly from the airframe manufacturer/avionics supplier viewpoint, although digital video is the way of the future, many current requirements are based on established analogue designs as they have a firm price and delivery, and can be demonstrated to the customer. The cost of the re-work of existing functions to create proven designs in the superior technology has to be considered. A commercial company will defer such a commitment until the economics are right. This means that each video function will be judged separately leading to a situation where an aircraft has new functions implemented digitally and established functions remain using analogue technology. In the short to medium term, this means that the step from entirely analogue video to entirely digital video is unlikely and that airframes will have a mixture depending on the requirement. The application of digital video systems requires a new set of skills and has implications throughout the airframe in respect of technique, durability, interconnect, feasibility and so on. The best decision regarding the optimum time to step to the new technology can only be made with knowledge and operational data. Acquiring that knowledge is expensive. This places commercial organisation in a dilemma where a strategic technical investment is required but a financial return might be a decade away.

There is a further consideration namely that the US will likely take the lead in choosing the avionics video technology. It is not enough to study and comprehend new commercial initiatives it is required to study those nominated by the USAF/SAE.

3.3 Summary of Interviews

The current position is that there is an analogue video standard (Def Stan 00-18 (Part 6) - Analogue video standard for aircraft system applications) that is the UK implementation of STANAG 3350 AVS. There is little else that is endorsed by NATO or MoD Directorate of Standardisation (D. Stan).

The circumstances of TRACER correspond with the situation which would arise if an aircraft were commissioned today. TRACER is scheduled to enter service after the year 2000. For reasons of cost determination and demonstrability TRACER is likely to use existing analogue video. Current proven analogue hardware in TRACER has not yet been shown to meet all the operational requirements. The digital option will offer significant advantages over analogue technology. There are no STANAGs or clear routes to resolution. This situation will persist for some years to come.

Whilst Land Systems platforms to be fielded in the next few years may utilise analogue video distribution, it is clear that the inherent advantages of digital video distribution, its robust signal, facility for digital processing and growing commercial utilisation, argue for its introduction to Military service. It is already the case that systems designers for video applications are encouraged to consider digital video techniques, rather than analogue. As a minimum requirement, an evolutionary path to digital video techniques needs to be prepared for each new platform or major upgrade. The only factors operating against this case, at the present time, are those of cost and the availability of suitably packaged solutions.

Digital video is well served by the availability of a range of international and open standards, which now cover the full spectrum of requirement; from low-bandwith video conferencing applications, through 525/625 line studio quality video and further to high definition applications. It is anticipated that as these video applications are gradually adopted for service; STANAG agreements will endorse, and provide guidelines for, the use of these them.

Practical experience has shown that digital video techniques are easy to use. Equipment to the required specification may be Internationally-sourced and integrated with no problems. Furthermore, the enhanced capability of such equipment permits better solutions to be engineered for typical Military video applications, and facilitates the provision of previously impossible enhancements.

4 HDTV

4.1 TV General

The civil TV, military video and many other civil applications, for example surveillance, are based on a scheme which was standardised in the 50's. In Europe PAL dominates whereas in North America and Japan the older NTSC is used. US avionics tends to use NTSC, in line with its domestic TV service, Europe tends to follow PAL which is its domestic TV service. STANAG 3350 AVS includes both. This is to say that military video is technically the same system as domestic TV (not including the broadcasting part). Thus the proposition that the military should adopt commercial standards in HDTV should not be a precedent. A move towards HDTV as a domestic service has been underway for almost two decades. PAL has 50 frames/s with 625 lines (625/50), NTSC has 60 frames/s with 525 lines (525/60). HDTV is to be a broadcast service with say 1250 lines at between 50 and 80 frames/s. This will deliver a picture quality approaching common 35 mm film and comparable to today's workstations for computer graphics. There is also an interim EDTV 'enhanced' option which is a halfway house. The matter is a unique mixture of technique and political interest. Within two decades HDTV has moved from barely feasible and uneconomic, to feasible, desirable, and the biggest single consumer market in sight. In principle the civil technology, especially regarding studio standards will lead directly to components for avionics applications. The investment by the service providers and by the public will be huge. Broadly speaking there are three contenders for HDTV. Europe (EU), Japan and North America. In the case of USA, a 'Grand Alliance' has agreed a set of standards (see Section 5.6).

4.2 Europe

Europe invested heavily during late eighties, early nineties in a hybrid digital/analogue technique called HD-MAC. The investment was 'dirigiste' and designed to stimulate European demand for set makers whose market had saturated. In the event HD-MAC is already obsolete and completely overtaken by a wholly digital distribution with MPEG-2 at the core.

4.3 Digital Video Broadcasting (DVB)

Within Europe the driving force for broadcast video is the 'DVB project' that is an adjunct to the European Broadcasting Union (EBU) in Geneva. The DVB project had small beginnings and was originally an outgrowth of CEC Esprit projects. All DVB systems are based on MPEG-2 audio and video compression. DVB adds to the MPEG transport stream multiplex, the necessary elements to bring digital broadcast services to the home through cable, satellite and terrestrial broadcast systems. DVB is now the definitive 'industry forum' within Europe but has global ambitions, representation and liaison. DVB scope is the whole propagation chain from studio, landline, transmitter, receiver for cable, satellite and terrestrial broadcast.

DVB has a technical forum and a commercial forum. The commercial forum makes financial and strategic decisions, the technical forum generates solutions to commercial requirements. Principally DVB are assembling what JTC1 term 'profiles' i.e. a suite of standards that collectively implement end to end applications. This does mean that some missing pieces are revealed and DVB has a 'fast track' standardisation route into ETSI however, DVB is not otherwise in the business of standards making. DVB have an extensive WWW site at http://www.dvb.org. Details of DVB standards and other useful sites are contained in the ASSC Video Systems Guide (ASSC/130/2/97).

4.4 DAVIC

The Digital Audio-Visual Council is a non-profit Association based in Geneva, Switzerland, aimed at promoting the success of digital audio-visual applications and services based on specifications that maximise interoperability across countries and applications/services. Established in August 1994, the DAVIC membership currently includes more than 200 companies from more than 25 countries around the world. It represents all sectors of the audio-visual industries: manufacturing (computer, consumer electronics, telecommunication equipment) and service (broadcasting, telecommunications, CATV) as well as a number of government agencies and research organisations. The DAVIC initiative sprang from the chairman of JTC1/SC29 who is also the chair of MPEG. The extensive DAVIC web site lies at http://www.davic.org/ . DAVIC specifications are available from the site.

4.5 Japan

Japan is the only country with a public service approximating to HDTV. The system is called MUSE, pre-dates HD-MAC and is outdated for essentially the same reasons. MUSE was finalised in the early eighties and public broadcast (by satellite) has been available since 1988. For all manner of reasons MUSE is out of the running as a global standard. Nevertheless most HDTV progress relies on MUSE pioneering and proving. With now a prospective 8 hours/day of TV Japanese programme production equipment is extensive and well tried. Whilst MUSE has failed in the bid to be the global TV standard the production equipment experience, for example tape recorders, has been taken up extensively.

In respect of HDTV Japan has shifted from pioneer to follower. They have now established a new group called DiBEG (Digital Broadcasting Experts Group) which is supported by their Ministry of Posts and Telecommunications.

This group has prepared a "draft standard of DTTB transmission system based upon the OFDM system standardised by DVB. The main difference is that the overall bandwidth of the signal can be segmented into a number of small integral bands in multiples of 432 kHz. This is to allow tight interleaving with existing analogue broadcasts. The situation in Japan for spectrum usage is much worse than in Europe!

4.6 North America

The FCC is the US regulatory body for broadcasting and telecommunications. In years gone by FCC held competitions to choose the national TV system; NTSC was adopted after such a competition. In 1987 the FCC were stimulated to begin the formal process of choosing the US HDTV successor to NTSC. The commission formed an advisory committee (ATSC) to prepare the framework and goals for the competition.

The entire scheme, bidders, techniques, test centre, goals are described in a dedicated issue of 'IEEE Transactions on Broadcasting' Vol. 37 No 4, December 1991. The result of the FCC inspired competition was political pressure applied to the contenders to hammer out a consensus solution. The formation of the so called ‘Grand Alliance’, an industry club. That process is almost complete. The Grand Alliance DTV system has extensive cross liaison into DAVIC and DVB and is based on MPEG-2. The FCC approved the

DTV system in Dec. 1996 and a trial transmission is already available from WRAL in Raleigh Carolina. The FCC has required the US top ten network stations to deliver the digital service by Nov 1 1999.

There is very extensive material on the Grand Alliance web site at http://www.wral-hd.com. There is more in the FCC sponsored ATSC web site at http://www.atsc.org. Readers should note that these web sites contain the system standards in addition to comprehensive status information.

For example:-
ATSC Standards
The following ATSC technical documents are available for download.

ATSC Document A/49 is the ATSC Standard "Ghost Cancelling Reference Signal for NTSC".

ATSC Document A/52 is the "Digital Audio Compression (AC-3) Standard".

ATSC Document A/53 is the "ATSC Digital Television Standard".

ATSC Document A/54 is the "Guide to the Use of the ATSC Digital Television Standard."

ATSC Document A/55 is the Standard "Program Guide for Digital Television." TSC Document A/56 is the Standard "System Information for Digital Television."

ATSC Document A/57 is the Standard "Program/Episode/Version Identification."

ATSC Document A/63 is the "Standard for Coding 25/50 Hz Video".

ATSC Document A/64 is the "Transmission Measurement and Compliance Standard for Digital Television."

ATSC Document A/65 is the Standard for "Program and System Information Protocol for Terrestrial Broadcast and Cable.

4.7 Studio

The first issue document contained a review of long established standardisation fora in the field of broadcast and studio production standards. In the review of this document it became apparent that the best quality achievable by MPEG-2 is ‘good enough’ for service as a video production standard. The combination of JTC1 MPEG standardisation and the huge commercial drive of DAVIC, DVB ATSC present new ways of working for the same parties. An integrated market driven fora has replaced piecemeal standardisation. It remains to be seen whether dedicated video production standards can survive the competition from an ‘all digital’ format that is inherently compatible with the broadcast standard.

4.8 Clubs: DAVIC, DVB, Grand Alliance (ATSC)

These organisations have transformed the prospects of full motion digital video. In the past standardisation was piecemeal, uncoordinated and subject to ‘due process’ consensus following long standing procedures. The present problem is that the chain of source to screen is a technically complex 'system of systems'. These new fora are focused on 'system level' standardisation. The DVB and DAVIC fora are ‘market led’ and focus on end to end problems. In the process extant standards are endorsed or a task group is set up to develop a solution. Where novel solutions are required the relevant liaisons are set up and ultimately ‘fastrack’ draft standards are fed into the appropriate committee e.g. ISO, ETSI, ITU. In this way DVB promote voluntary ‘industry agreements’ that cite International standards. Despite the ‘voluntary’ nature of e.g. DAVIC pronouncements the statement ‘DAVIC compliant’ is a powerful symbol.

4.9 DTV summary

Digital TeleVision, (DTV) is now being broadcast. The US had determined that NTSC transmissions should end by 2006 however, due to delays in DTV deployment that has been modified. The end of NTSC transmissions will be scheduled when national coverage by DTV reaches 85%. Due to the efforts of ATSC, DVB and DAVIC the suite of standards for broadcast TV are more ‘global’ than their analogue predecessors NTSC, PAL, SECAM. At the core of each nations' future plans lies MPEG-2. The market driven efforts of DAVIC and DVB ensure what are termed ‘open interfaces’ otherwise known as ‘exposed interfaces’. DTV has always anticipated SDTV (Standard definition TV), Enhanced EDTV and High Definition, HDTV. It happens that MPEG-2 'scales' and is able to deliver all three.

4.10 Advanced Television Systems Committee (ATSC)

There are six video formats in the ATSC DTV standard which are ‘High Definition Television’. They are the 1080-line by 1920-pixel formats at all picture rates (24, 30 and 60 pictures per second), and the 720-line by 1280-pixel formats at these same picture rates. All of these formats have a 16:9 aspect ratio.

A remaining twelve video formats, while representing some significant improvements over analogue NTSC, are not High Definition Television. They are referred to as "Standard Definition Television". These are the 480-line by 704-pixel formats in 16:9 widescreen and 4:3 aspect ratios, at the picture rates listed above, and the 480-line by 640-pixel format at a 4:3 aspect ratio, at the same picture rates.

The Advanced Television Systems Committee, composed of 136 member corporations, industry associations, standards bodies, research laboratories, and educational institutions, is an international organisation developing voluntary standards for the entire range of advanced television systems. The ATSC also is developing DTV implementation strategies through its Implementation Subcommittee. ATSC members include broadcasters, broadcast equipment suppliers, consumer electronics manufacturers, motion picture companies, computer hardware and software companies, telecommunications firms, and other entities interested in advanced television. In promoting its Standard, the ATSC has conducted major HDTV demonstrations in the U.S., Switzerland, China, Australia, Brazil and Mexico.

5 OTHER VIDEO : ITU, JPEG, AND MPEG STANDARDS

Essentially these standards arise from the computer, CD ROM, tele-conferencing markets. These standards are referenced within ITU-R literature and liaison activities are visible. This is to say that these activities are not technical islands but specialisations. Both standards are technically relevant to military avionics in the sense that they are architecturally similar to the avionics requirement. It is probable that none of these standards will directly support avionics applications. However, they point to the general form of the eventual solution. Both of the standards are concerned with bandwidth or storage limited applications and consequently data compression is a feature of each standard. Note that for inter-unit propagation on an aircraft bandwidth is not a limiting factor and compression consequently represents cost, complexity and additional weight to meet no purpose. However, any radio up-link or on-board data recorder would demand compression. This is to say that the avionics interconnect does not need compression. However, some on-board end-systems will include a compression function.

5.1 ITU-T Recommendation H.261

This is primarily a coding/compression scheme for propagating video on ISDN (Integrated Services Digital Network) and is designed for n*64 kbit/s up to a top rate of 1.9 Mbit/s. Basically it is intended for propagation on multiple telephony bearers. H.261 is technically interesting, available, inexpensive and demonstrable however, a system optimised for a bandwidth (cost) limited telephony bearer is not a contender for avionics. H.261 is complementary with ITU-R Rec. BT 601, which formally organises PAL/NTSC into a form suitable for digitisation. It is also complementary with ITU-R 656 which details the optional bit serial or bit parallel output streams. Both of these Recommendations are acknowledged within NATO and would be an automatic choice for digital video using existing line standards. These recommendations are 6 years old and suitable for STANAG 3350 AVS. (JPEG and MPEG-1, similarly nest ITU-R Rec. BT 601)

5.2 Joint Photographic Experts Group (JPEG) - (extract of paper by Richard Clark, Elysium Ltd. from ADVICE conference - July 97)

This initiative was primarily intended to compress/store/transmit still pictures. The Joint Photographic Expert's Group (JPEG) is a working group (WG1) of JTC 1/IEC Subcommittee29 which produced its first standard JPEG-1 (ISO/IEC 10918-1) in 1994. This is, in fact, the first part of a multi-part standard created under the joint auspices of the International Standards and relates to still pictures, but encompassing videotext, security, weather, surveillance and so on. The JPEG Working Group was established in 1986 and whilst the name suggest 'stills', JPEG can be applied to full motion video. JPEG compression is 'intra-frame', compress a frame send it, compress the next, send it. Inter-frame compression exploits the similarity of frames. JPEG and H.261 are technically similar and the main interest for avionics would be educational or for inexpensive 'all digital' demonstrators where the LSI devices provide a convenient data stream for fibre optic multiplexing inter-connection trials. Where H.261 aimed compression at reducing line charges JPEG is aimed more at conserving storage space in computer peripherals. In other respects the technology is similar.

5.2.1 JPEG-1 (IS 10918)

Following the eventual publication of IS 10918 Part 1 in 1994, JPEG have now created and published two further standards, and have a further document available as a stable working draft with sample code. BSI's own "Technical Guide to JPEG" is available as PD0006:1995.

JPEG Part 1 itself delivers a set of compression algorithms and encoding for.

- sequential encoding
- progressive encoding
- Lossless encoding
- Hierarchical coding

The JPEG Frequently Asked Questions (FAQ) on the WWW (*http://www.cis.ohio-state.edu/hypertext/faq/usenet/jpeg-faq/top.html)* is one of the best free sources of current information about JPEG Part 1

IS 10918-2 (JPEG Part 2) - conformance testing was released in 1996 to provide a wide range of suitable test streams, coupled with documentation on the testing process.

Part 3 of the standard was however a different and more positive story. This part deals with extensions to the work covered in the original JPEG research. The key issues delivered by Part 3 include:

- selective refinement, with a variety of choices to allow users to define 'areas of interest' where there is a need for extra spatial or sample resolution, or additional components - for example a colour overlay in a monochrome image
- breaking the picture into tiles - either as:
    1. simple tiling, where the objective is perhaps to allow random access to a part of an image through some form of retrieval system
    2. pyramidal filing, allowing for systematic distortionless enlargement of selected image sections
    3. complex tiling, where an image may be composed of multiple adjoining overlays with different characteristics - for example where several aerial photographs have been taken and need to be overlaid into a composite image
- variable quantisation, in a similar and hopefully compatible manner to that which is applied in MPEG encoding, with application where fixed encoded file sizes are required, transcoding from MPEG images, or in a similar manner to selective refinement to encode areas of interest
- some changes to parameters, for example allowing more samples per Minimum Coded Units (MCUS) to counter problems experienced when some types of image with several differently sub-sampled component images are encoded
- a defined file format, the Still Picture Image File Format (SPIFF). This latter feature is now regarded as one of the most important attributes of the standard, and arose because of some concern in the committee about the simple and non-extensible nature of the de facto file format used for JPEG baseline files. SPIFF includes capabilities to add a wide range of technical and other information to a single image. These may help for example in providing better colour rendition and accuracy, or in defining owner and copyright issues. SPIFF is rapidly being extended to allow for the inclusion of a range of user specified tags, and their registration (see IS 10918-4) and to allow it to be used as a more general format to convey other encoded information.

5.2.2 JPEG - LS; a new lossless standard

A new and improved lossless compression standard, to be known as JPEG-LS. JPEG-LS will eventually become IS 14495 (assuming successful progression through the levels and votes of ISO committees). It is a simple predictive technique with a number of novel features designed to improve its performance.

JPEG-LS uses a simple context model based on the preceding adjacent sample values in an image. From this context, the information is either encoded in 'run mode' when the context estimates that successive samples are identical , or 'regular mode' when this is not the case. The context modelling process is more sophisticated than that adopted in IS 10918-l's lossless mode, and includes a context dependent bias cancellation stage to overcome consistent errors in the prediction process.

JPEG-LS compression is similar to, or as good as most published lossless compression techniques, with the additional benefit of allowing a bounded 'near-lossless' mode in which the user can specify to the encoder the allowable error limits in the reconstructed image. This is particularly useful when dealing with the problems of scanner or camera introduced noise, as a bound which is approximately equal to the known noise error can be set - this empirical offering seems to improve performance by perhaps 2-300% with very little perceptual effect.

In general, JPEG-LS offers compression ratios of around 2:1 on 'normal' photographic image material - this can be much higher in the case of computer generated or other similar information.

5.2.3 JPEG 2000 image coding systems (ISO/IEC 15444)

JPEG 2000 is a new standard for the compression of still imagery. The scope of the JPEG 2000 development includes potential new compression algorithms and/or flexible compression architectures, processes and/or formats.

The standard will attempt to unify (and use wherever relevant) existing compression standards within a single image coding system, meeting the following objectives:

- Superior low bit-rate performance: - superior to the current standards at low bitrates (e.g. below 0.25 bps for highly detailed grey-scale images) without sacrificing performance on the rest of the rate-distortion spectrum. Examples of applications that need this feature include network image transmission and remote sensing. This is the highest priority feature, and is readily demonstrable at the algorithmic level using some wavelet based techniques.
- Continuous-tone and bi-level compression.
- Lossless and lossy compression.
- Progressive transmission by pixel accuracy and resolution.
- Fixed-rate, fixed-size, limited workspace memory:
- Random codestream access and processing.

- processing could allow operations such as rotation, translation, filtering, feature extraction, scaling, etc.
- Robustness to bit-errors.
- Open architecture.
- Sequential build-up capability (real time coding).
- Backwards compatibility with JPEG.
- Content-based description.
- Protective image security.
- Interface with MPEG-4:.
- Side channel spatial information (transparency).

5.2.4 Motion JPEG

One area that the JPEG committee has as yet not worked on is that of time related JPEG frame sequences, dealt with to some extent under the loose umbrella of 'Motion JPEG'. In the same way that JFIF is perceived as being part of the JPEG standard range, with a very limited basis in fact, Motion JPEG is often seen as being related to the work of the JPEG committee. Until now, the JPEG committee has always wished to leave moving picture standardisation to its sister committee, MPEG. The continued pressure for a true standard to be created for the interchange of moving image sequences with characteristics outside the scope covered by the MPEG committee, and the disparate range of 'Motion JPEG' products and de facto standards has caused JPEG to re-visit this issue.

It seems clear than in some areas (for instance medical imaging, or video editing) there is a need to link time sequences of images in a manner not permitted by current MPEG standards. These include where the time intervals between frames, and their resolution may be variable. In addition, the proliferation of company file format 'standards' for 'Motion JPEG' suggest a move to rationalise this area would be generally welcomed by the user community.

In the first instance, the JPEG committee has established a small working group to examine this area, with a view to the production of an Internet style 'Frequently Asked Questions' (FAQ) list. Any suppliers or other interested parties are encouraged to contact the author to input to this work.

5.3 Motion Picture Expert Group (MPEG)

MPEG (ISO/IEC JTC1/SC29/WG11) is an evolution of JPEG, has fractioned into a hierarchy but is primarily aimed at full motion video. MPEG is an international standards group that is accessible in the UK through membership of the appropriate BSI

Technical Committee (IST/37). MPEG standards are being applied to a wide spectrum of applications but the dominant ones are the huge domestic video market. In the time since the first issue document, the MPEG work has advanced in a spectacular manner.

The following text is cited verbatim from the MPEG 'Home Page', the web site contains extensive and graphically illustrated definitive material at http://drogo.cselt.stet.it/mpeg/
"The Moving Picture Experts Group (MPEG) is a working group of ISO/IEC in charge of the development of international standards for compression, decompression, processing, and coded representation of moving pictures, audio and their combination. So far MPEG has produced:

1. MPEG-1, a standard for storage and retrieval of moving pictures and audio on storage media
2. MPEG-2, a standard for digital television and is now developing:
3. MPEG-4 a standard for multimedia applications
4. MPEG-7 a content representation standard for information search. "

5.3.1 MPEG-1

MPEG-1 is primarily aimed at the video from a CD and consequently the data-rate is low relative to HDTV however, full motion video (and stereo sound) is achievable at subjective qualities comparable with current domestic TV. MPEG-1 is concerned with code rates up to 1.5 Mbit/s.

5.3.2 MPEG-2

MPEG-2 was concerned with data rates between say MPEG-1 and towards those required for HDTV. In the end MPEG-2 imagery at the highest rate is comparable to current SMPTE studio production standards. There was an MPEG-3 at the higher end but this has been subsumed into an extended MPEG-2. The target for MPEG-2 is broadcast video. The principal attribute of MPEG-2 is scaleability and flexibility. Choosing the relevant parameters customises the process to serve a particular need as illustrated by

Level	**Max. dimensions**		**Max. bitrate**	**Significance**
	sampling fps	**Pixels/sec**		
Low	352 x 240 x 30	3.05 M	4 Mb/s	CIF, consumer tape equiv.
Main	720 x 480 x 30	10.40 M	15 Mb/s	ITU-R 601, studio TV
High	1440 x 1152 x 30	47.00 M	60 Mb/s	4x 601, consumer HDTV
High	1920 x 1080 x 30	62.70 M	80 Mb/s	Production SMPTE 240M std

In other words 'main' is the so-called Standard Definition TV (SDTV) with fidelity as good as present TV. High is for consumer HDTV and the highest rate is a prospective studio production standard. (MPEG-2 also standardises the audio channel at a fidelity comparable to CD).

Use of MPEG-2 in avionics possibly has to be limited to mission reporting due to the delays in encoding which can be as high as 1/2 second. It should also be noted that compression is not advised for use in areas where latency could be a problem so that MPEG-2 is not useful for real time applications.

5.3.3 MPEG-4

MPEG-4 is a current initiative initially aimed at very low bit rates for videophones and such-like at rates between 5 kbit/s and 4 Mbit/s. With the passage of time the scope of MPEG-4 has enlarged and art has advanced with the experience of MPEG-2. The following quote was extracted from Image Communication Journal, Special Issue on MPEG-4 Volume 1 Editorial. "The objective of MPEG-4 is thus to provide an audio-visual representation standard supporting new ways of communication, access, and manipulation of digital audio-visual data, and offering a common technical solution to various communication paradigms telecommunications, broadcast, and interactive between which the borders are disappearing. MPEG-4 should supply an answer to the emerging needs of application fields, including interactive audio-visual (AV) services (such as content-based AV database access), games, AV home editing, advanced AV communication services (such as mobile AV terminals), improved PSTN AV communications, tele-shopping, and remote monitoring and control (such as field maintenance or security monitoring). "

A comprehensive discussion on MPEG-4 can be found at :
http://drogo.cselt.stet.it/mpeg/standards/mpeg-4.htm (ASSC/130/3/209). The schedule for, whose formal ISO/IEC designation will be ISO/IEC 14496, is to be released in 1999.

MPEG-4 has image decomposition techniques that take the art beyond simply compressing images better than MPEG-2. The following was extracted from ISO/IEC JTC1/SC29/WG11 N1909.

"MPEG-4 achieves these goals by providing standardised ways to:

1. represent units of aural, visual or audio-visual content, called "audio/visual objects" (AVOs). (The very basic unit is more precisely called a "primitive AVO").

2. These AVOs can be of natural or synthetic origin; this means they could be recorded with a camera or microphone, or generated with a computer;
3. compose these objects together to create compound audio-visual objects that form audio-visual scenes;
4. multiplex and synchronise the data associated with AVOs, so that they can be transported over network channels providing a QoS appropriate for the nature of the specific AVOs; and
5. interact with the audio-visual scene generated at the receiver’s end.

MPEG standardises a number of such primitive AVOs, capable of representing both natural and synthetic content

1. types, which can be either 2- or 3-dimensional. In addition to the AVOs mentioned above and shown in Figure 1,
2. MPEG-4 defines the coded representation of objects such as:
3. text and graphics;
4. talking heads and associated text to be used at the receiver’s end to synthesise the speech and animate the head;
5. animated human bodies.

In their coded form, these objects are represented as efficiently as possible. This means that the bits used for coding these objects are no more than necessary for support of desired functionalities. "

5.3.4 MPEG-7

For completeness there is new initiative in the MPEG camp. Proposals are being considered. MPEG-7 will be different from MPEG-1, -2, and –4. Its goal is not to define a representation for faithful reproduction, but to define a description that can be used for (automatic) search and identification of multimedia content. At present it is unclear how the information coded within an MPEG-4 sequence could be integrated with the information held outside the data through MPEG-7. It is probable that there will be high- and low-level descriptors, with low-level descriptors being derived directly from the data and high-level descriptors being added by human classifiers. MPEG-7 will not concern itself with how the descriptors are ascertained or how they are searched. It will only concern itself with how they are recorded."

In other words MPEG-7 is not 'video' but a content definition and retrieval scheme.

5.3.5 Summary

The principal video initiative is MPEG-2. MPEG-2 is at the core of a global HDTV initiative. MPEG-2 is the 'successor' to PAL, NTSC. In the time since this report was first issued the issued there has been enormous standardisation activity and progress in ever widening application areas. There is now too much related material to be assimilated and described in one place. For example some mention should be made of MHEG, VRML, MCI, AVI and so on. However, much of the effort is aimed WWW and 'multi-media' entertainment applications on PCs. In other words commercial 'video' is now much richer than encoding transmitting and displaying images.

The DGXIII of the CEC has developed and maintains a linked web site that gathers all current video and multi-media (and much more) standardisation into one place. The page has links to all the relevant standards bodies and industry fora.
http://www2.echo.lu/oii/en/oiistand.html#oiistand
Perusal of this site and chasing down the significant links to ITU-T, MPEG home page, ISO/IEC will provide information overload.

6 B-ISDN AND OTHER NOVEL PHYSICAL BEARERS

6.1 Introduction

It was determined that this study should concentrate on the video aspect, and steer round the bearer implementation which is the topic covered by Sensor video Implementation Task group (SVIT) in SAE. For completeness and for alignment of civil video plans with the civil bearer plans it is appropriate to summarise the various schemes which are prominent in civil telecommunications. The total subject is huge and inter-locked and with very strong historical dependencies. The primary subject of interest for avionics is that subject which ITU-T call B-ISDN which is summarised in section 7.2. There are several subordinate techniques notably Frame Relay and DQDB which should not be ignored because they have such high profiles in civil telecommunications. Frame Relay and DQDB are included for completeness and to set them in context. Their utility for avionics is considered to be low and further explanation is deemed inappropriate.

Any place where ITU-R HDTV standards, or ISO MPEG-2 touches telecommunications then the default bearer is B-ISDN. This is to say that within the civil standards bodies there is an inter-dependence where resources and requirements are juggled until they fit. It will be found that SDH, the nominated physical bearer for international telecommunications, is a near ideal bearer for HDTV and that the interface components become commodities. This is not accidental.

6.2 B-ISDN

At the beginnings of the micro-electronics revolution the ITU-T embarked on a radical initiative to create a digital switching fabric for the worlds telephone network. This initiative was called Integrated Services Digital Network (ISDN) and predicated on the 64 kbit/s switched virtual circuit (SVC) which is the simple digital form of the original analogue telephone network. ISDN has been in gestation for 15 years and is now available in most western countries. Put simply, the Public Telecommunications Operators (PTOs) needed to convert their system from mechanically switched wires and uniselectors to micro-electronic forms. In the process it became possible to offer novel digital services and they called them ISDN. During that time there has been a revolution in the micro-electronic and in fibre optic technology such that ISDN is now very pedestrian. ISDN is a digital form of the ubiquitous telephone. That was caused by the absolute domination of telephone as a revenue source. The ability of ISDN to bear data has high utility however, the channel has characteristics designed for voice. A 64 kbit/s channel cannot propagate full motion High Definition video or readily interconnect two high rate computer sites. The ITU-T has embarked on a successor to ISDN which is called Broadband ISDN (B-ISDN) which is maturing very fast. ISDN is then dubbed Narrow-band-ISDN (N-ISDN). The ITU-T has determined that B-ISDN is to be implemented with ATM and SDH and effectively mandates ATM and SDH as the worlds telecommunications system (see section 7.5). The timescales for implementing B-ISDN to create a global interconnect, with a subscriber capacity initially set at 155 Mbit/s followed by a 622 Mbit/s service, is still this decade. B-ISDN is the general name for a global switching fabric, like the telephone network, which brings dial up multi-megabit world-wide connectivity.

In the interim there will be users who have communication needs which cannot be met with N-ISDN and who cannot wait for the generalised switching fabric B-ISDN. These users are being served with expedients notably Distributed Queue Dual Bus (DQDB) (see 7.4) which is described in section 7.4. The public plans of BT regarding tele-communications are attached as an appendix. This places ATM, DQDB, Frame Relay and FDDI and their relative importance, into context as generalised bearer technologies.

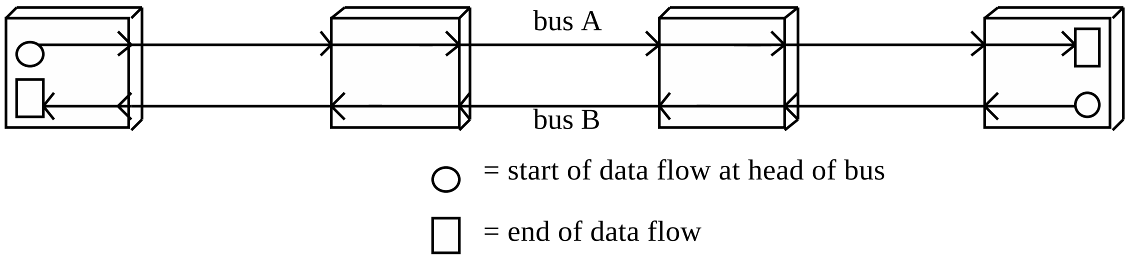
6.3 Frame Relay

In the limit Frame Relay is not much more than ITU-T X.25 with the flow control and error recovery overhead deleted. Frame Relay arose from attempts to streamline X.25 in the pursuit of what is generically known as 'fast packet'. X.25 was designed many years ago when Bit error rate (BER) was so high that errors were frequent. X.25 has in-built error recovery and flow control. With the transition of public networks to fibre optic the BER is significantly lower. It can be demonstrated that as BER lowers so there is a point at which a 'send and hope' strategy gives overall superior throughput and facilitates lower cost and higher speeds. Error recovery becomes the responsibility of a higher layer of protocol belonging to the user(s). Frame Relay is actually an interface specification not a bearer specification. The experience of streamlining X.25 to create Frame Relay led directly to ATM. Within civil telecommunications Frame Relay might well become established as a 'Link layer' interface but the dominant bearer will be ATM over SDH (B-ISDN). This is to say that Frame Relay is an interface specification, not a switching fabric, and consequently of little or no bearing on avionics in spite of its prominence in telecommunications literature.

6.4 MAN, IEEE 802.6, DQDB, SMDS

Metropolitan Area Network (MAN) is the network which is 'wider' than a Wide Area Network, (WAN) IEEE 802.6 is a MAN, with DQDB architecture. Switched Multi-megabit Data Services (SMDS) is a minor variant of 802.6 described by Bell telephone to describe DCEs when subscriber WAN networks are attached to long haul Public Telecommunications Operator (PTO) routes. (MAN is the generic description, DQDB is the technique, SMDS and IEEE 802.6 are based on DQDB and are the same except for perspective. SMDS is the point to point PTO service, 802.6 is the users local protocol). DQDB is illustrated in figure 1 and figure 2. The main characteristic of DQDB is a data exchange mechanism specifically designed to bear mixed data and telephone signals. In other words DQDB is designed to support synchronous traffic, primarily telephone, or other constant bit-rate services but can utilise all or the residual capacity to propagate asynchronous data. The primitive cell is remarkably similar to an ATM cell, which is not accidental, however, unlike ATM, DQDB has a basic timing reference which is 125 µs which is the telephone PCM octet period for digitised voice. DQDB (and ATM) render FDDI II still-born. FDDI II is an attempt to graft isochronous properties onto a bus designed for data. The stereotype application for DQDB is mixed telephone, video and data across large corporations. SMDS is available now, is being implemented in USA at a high rate. The PTO service is essentially leased on a 'point to point' basis from the PTO.

What use DQDB might have on an airplane is uncertain. The easy answer is that ATM (with SDH) is probably superior. There are 'fairness' problems being uncovered with DQDB, one of which is termed the Bandwidth Domination Problem where an early active node with heavy demands can prejudice service for a late-active node with higher priorities. Discovering and evaluating deficiencies in DQDB is a current rich field for academic honours.



Dual bus flows

- Two active unidirectional buses
    - Opposite directions of transmission
    - Protocol-based on co-operation of both buses
    - Slots originate at head end of bus, and may be used only once
    - Transmit-node determines which bus direction to use
    - Auto-reconfiguration in presence of faults
    - A distributed queuing packet access protocol
    - Ultimately, an integrated voice/data network
    - 125 µs periodicity in slots

Figure 1 : SMDS/802.6 Distributed Queue Dual Bus (DQDB)

LLC-PDU
↓

datagram

I-header	MAC data	PAD	Res (2)	BE (1)	LEN (1)	
24	= 9188	0-3		4		Bytes

segment payload

SEG type (2)	MID (14)	derived payload	LN (6)	CRC (10)	
2		44	2		(bits) Bytes

slot (cell)

5

ACF	*segment header*	segment payload	
1	4	48	Bytes

←¾¾¾¾¾¾¾¾¾¾¾¾¾ segment ¾¾¾¾¾¾¾¾¾¾¾¾¾→
←¾¾¾¾¾¾¾¾¾¾¾¾¾¾¾¾¾ 53 bytes ¾¾¾¾¾¾¾¾¾¾¾¾¾¾¾→

headers:

I-header

Res	BE	BAS	DA	SA	PI	QOS/HEL	Bridge	HDR EXTN	
(1)	(1)	(2)	(8)	(8)	(1)	(1)	(2)	(0-20)	(Bytes)

ACF

BSY	slot type	Res	PSR	REQ (4)			
(1)	(1)	(1)	(1)	H			L

segment header

VCI	payload type (2)	SEG PRIO (2)	HCS	
(20)			(8)	(bits)

ACF	= Access Control Field
BAS	= Buffer Allocation Size
BE	= Beginning-End Tag
BSY	= Busy
CRC	= Cyclic Redundancy Check of segment payload
DA	= Destination Address (MAC-SAP)
HCS	= Header Check Sequence
HDR EXTN	= Header Extension
LEN	= Length of datagram
LN	= Length of Derived Payload
MID	= Message Identifier
PI	= Protocol Identification
PRIO	= Priority
PSR	= Previous Segment Read
QOS HEL	= Quality of Service/Header Extension Length
REQ	= Request
Res	= Reserved
SA	= Source Address (MAC-SAP)
SEG	= Segment
VCI	= Virtual Channel Identifier

Figure 2 : SMDS ; 802.6 Frame Formats

6.5 Asynchronous Transfer Mode (ATM)

X.25 is the classic packet switched service which, in civil telecommunications, performs for data what the Public Switched Telephone network (PSTN) does for telephony. X.25 has extensive error checking, flow control and recovery mechanisms which are required on noisy lines. Frame Relay began the process of removing the flow control and error recovery. ATM takes this process to the limit to create a single 'packet switched' scheme which is close to optimum for a mix of asynchronous and synchronous traffic.

ATM treats all subscriber information sources as data with particular burstiness characteristics. Voice, video, computer data or whatever, are chopped into 48 octet gobbets (cells), concatenated and streamed out like sausages into the switching fabric. Provided that all paths are operated within capacity then source streams periodicity can all be re-constituted at the destination. The 5 octet header overhead steers the cell through the switching fabric. The network is 'connection oriented' which is to say that once a route is charted the header directs all subsequent cells along the same path. Additionally the fabric has scheduled capacity for the connection according to the parameters declared at connect time. ATM is characterised by a fixed length cell with header and payload as shown in figure 3 and 4. The choice of a fixed length cell is a direct result of the need to carry synchronous traffic. The smaller the cell the better the resolution and the better the ability to carry synchronous payloads. With smaller cells the overhead becomes a larger proportion of the total. The choice of 53 octets is a compromise between granularity and efficiency. ATM is complementary to SDH which is a physical bearer with a hierarchy of data rates beginning at 155 Mbit/s. The relationship of ATM with SDH is shown in figure 5 and is the basis for International B-ISDN. This is to say that the capital investment in ATM SDH over the next decade is destined to be huge. The corollary is that much of civil video will be organised and interfaced for easy propagation over ATM and or SDH. SDH is the hierarchy standardised by ITU-T resulting from the US submitting 'SONET' as a candidate. Synchronous Optical NETwork (SONET). The structure and technology of SDH are outside the scope of this study however the bit-rates and the hierarchical structure is illustrated in table 1 and figure 6.

control plane	user plane
SL3 sublayer 3	sublayer 3
SL2 sublayer 2	sublayer 2
ADP adaptation sublayer	adaptation sublayer
ATM ATM sublayer	
SYN synchronous channel/synchronized cells sublayer	
PFR periodical physical frame sublayer	
PHY physical medium dependent sublayer	

Figure 3 (a) : General Layering Architecture

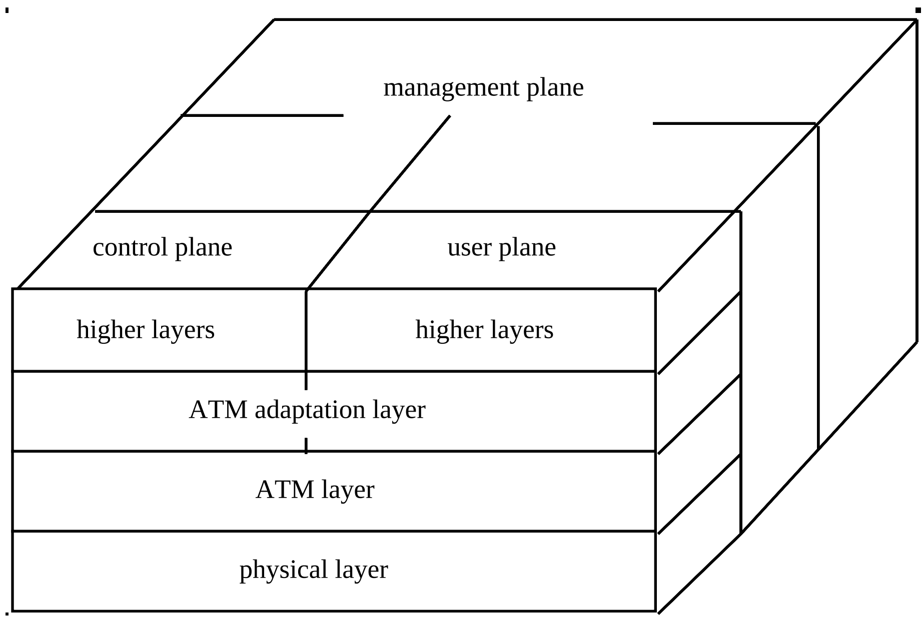
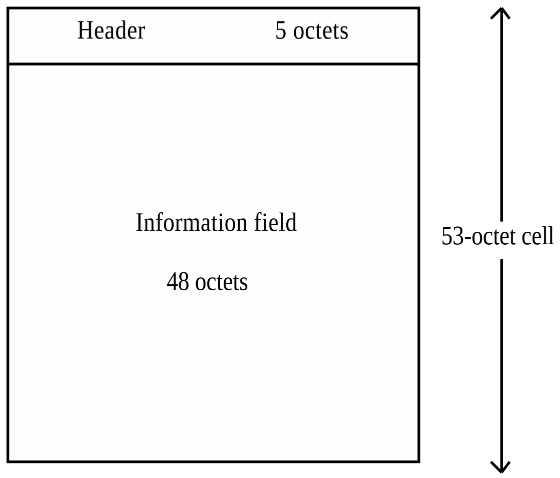


Figure 3 (b) : B-ISDN Protocol Reference Model



(a) Overall cell structure

8	7	6	5	4	5	3	2	1
Generic flow control				Virtual path identifier				
Virtual path identifier				Virtual channel identifier				
Virtual channel identifier								
Virtual channel identifier				Payload type		Reserved	Cell loss priority	
Header error control								

(b) Header format at user-network interface

8	7	6	5	4	5	3	2	1
Virtual path identifier								
Virtual path identifier				Virtual channel identifier				
Virtual channel identifier								
Virtual channel identifier				Payload type		Reserved	Cell loss priority	
Header error control								

(c) Header format at network node interface

Figure 4 : ATM Cell Format

SONET Designation	ITU-T SDH Designation	Data Rate (Mbit/s)	Payload Rate
STS-1		51.84	50.112
STS-3	STM-1	155.52	150.336
STS-9	STM-3	466.56	451.008
STS-12	STM-4	622.08	601.344
STS-18	STM-6	933.12	902.016
STS-24	STM-8	1244.16	1202.688
STS-36	STM-12	1866.24	1804.032
STS-48	STM-16	2488.32	2405.376

Table 1 : SONET/SDH Signal Hierarchy

Imagine a network of duplex SDH bearers at ATM end-points and several ATM routers to steer 'head of the line' data around according to the route nominated in the fixed format header. The routers are not much more than 5 octet wide ECL switches. There are no state machines, no throttles. If any route becomes congested then the overload is discarded and the destination informed. Recovery is a matter for the end systems. In reality the recipient is always receiving performance information inter-mixed with the data such that the recipient can notify the source regarding the state of the route. In practice the source 'negotiates' with the network by nominating the service parameters in respect of mean rate, burst rate, burst rate duration, acceptable cell loss probability and so on. Termed 'admission control'. The network decides whether the connection can be supported and connects or not. For avionic applications, all the 'connections' can be modelled to scope a bearer fabric which is always capable of serving the worst case offered traffic pattern with a known performance.

6.6 B-ISDN, ATM summary

ATM has gripped the commercial world like no other bearer technology ever. The potential for data transfer, the rapidity of transition from notion to consensus, and the fabulous size of investment/revenues, is awesome. ATM operation is brutally simple, very fast and scaleable. ATM proves that complexity and speed are antagonistic and in LAN (HSDB) technologies nothing will be quite the same again. In the civil arena ATM is a remarkable phenomenon leading to a state which can only be described as ATMmania. A cautionary note is in order. ATM still consists essentially of paper principles which have not yet been implemented in any major way by the PTOs.

The important message for avionics is that B-ISDN is being standardised in the same time-frame as HDTV. The two are inter-related and are being juggled to optimise services with requirements.

7 DISPLAYS

7.1 Video Electronics Standards Association (VESA)

VESA Members are part of a leading organisation dedicated to developing and promoting open standards for the high-tech marketplace, focusing on display and display interconnect developments that ensure interoperability and encourage innovation and market growth. The VESA objective is to promote and develop timely, relevant, open display and display interface standards, ensuring interoperability, and encouraging innovation and market growth and to be one of the internationally recognised voices in the video electronics industry. They aim to :

- Create unbiased standards
- Encourage short time to market
- Always be non-exclusionary
- Maintain product benefit to industry and consumer
- Promote quality and accuracy of industry standards

The following VESA standards are possibly of interest :

VESA Extended Display Identification Data (EDID) ™ Standard :

VESA has developed the EDID data format as a compact method to specify the capabilities of various types of monitors as well as integrated displays. This standard defines data formats to carry configuration information to allow optimum use of displays. It is anticipated that EDID format data will be transported by a variety of communication protocols.

VESA Plug and display (VP&D) Standard :

This standard provides a digital interface and, optionally, an analogue interface for video data allowing a wide range of display devices to be attached to a single video port on the host system which may be a personal computer (PC), workstation, or other device. This standard only defines the interface at the connector on the host system and provides additional recommendations regarding system implementation.

Display Data Channel (DDC) Standard 2.0, with The Extended Display Identification Data Standard (EDID) 2.0:
This standard defines a communication channel between a computer display and the host system. It includes the VESA Bios Extension/Display Data Channel (VBE/DDC) specification and the Extended Display Identification Data (EDID) Standard.

7.2 Other display standards

Digital Flat Panel Port Specification,
A commercial group has developed the above specification. Its purpose is to provide for a standard interface between a personal computer and a digital flat panel monitor. The Digital Flat Panel Port (DFP) allows a host computer to connect directly to an external flat panel monitor over several meters of cable without the need for analogue-to-digital conversion found in most flat panel monitors today.

This interface will make use of the above existing VESA standards to allow for the simplest implementation as a simple low-cost industry standard. This includes the graphics controller interface functions to support the digital video data, configuration management, and power management. As the standard embraces only the essential components necessary for digital display monitor functions, it provides a low-cost implementation in both the host and monitor while allowing the possibility for future expansion.

8 SUMMARY

In the beginning the extent of literature and the richness of applications regarding civil video and B-ISDN was exhausting. First impressions are of a mass of unconnected and competing techniques some of which might be appropriate to avionics. With further study it becomes clear that the global nature and inter-dependence of mass video means that the underlying technologies are much more compact. It is 'application diversity' which creates a specialisation or refinement.

8.1 Video

Superficially ITU-T H.261, ITU-R 601, ITU-R 656, JPEG, MPEG standards are discrete independent subjects. With further study all have their roots in PAL/NTSC frame formats, with a common digital structure, ITU-R 601, 656 and a common bit-rate reduction principle, Discrete Cosine Transform (DCT). NATO avionic companies already see ITU-R 601, 656 as a natural step from STANAG 3350 AVS to produce digital video bit-streams. Bit-rate reduction, within an airframe interconnect fabric, has no significant advantage and some disadvantages. To a first approximation the civil approach to digital video is already acknowledged in the avionics arena and is a natural step.

The broadcast considerations and local geographic constraints or historical compatibilities compound domestic HDTV. The broadcast authorities and programme production companies have recognised the need for a 'production standard' with Common Interface Formats. They are seriously engaged in developing such a standard complete with frame formats, cameras, monitors, fibre optic propagation formats, recorder formats, etc. integrated with the telecommunications infrastructure which the PTOs currently provide or schedule. This 'studio format' has been so chosen that it will be feasible to transform into the local transmission format. Some transformations are easy, some are expensive, some produce unacceptable content sensitive visual artefacts. For avionics purposes, studio format appears to offer a solution which is preferable to any broadcast format. Such a course also offers a route with which novel avionics equipment might be progressively implemented. Where new sensors are introduced it would be prudent to implement an agreed digital HDTV format but be able to readily transform this into a form suitable for display on existing PAL/NTSC analogue equipment. It is recognised that this is a simplistic view of a problem which is easily solved in the civil application, simply lose part of the picture to recover a different aspect ratio.

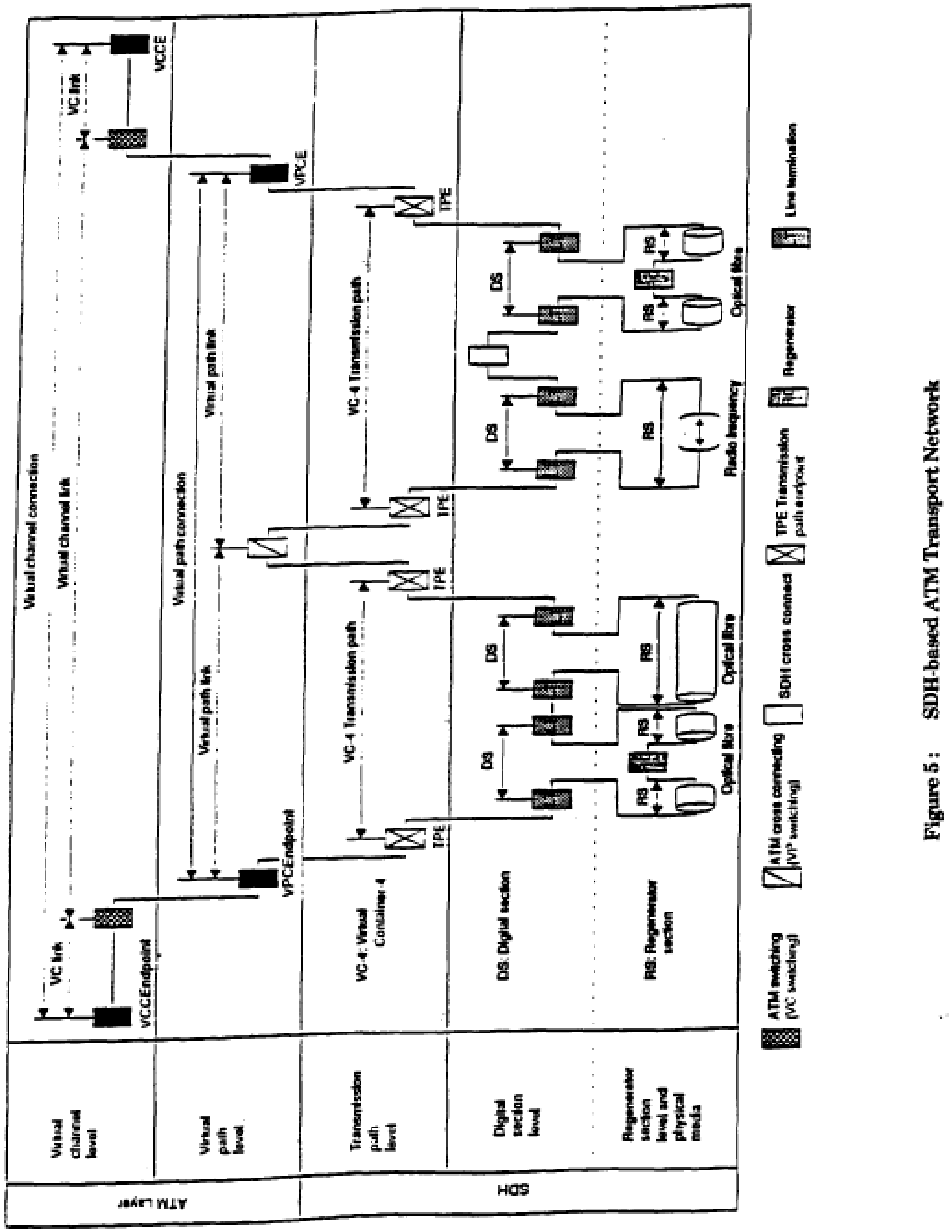


Figure 5 : SDH-based ATM Transport Network

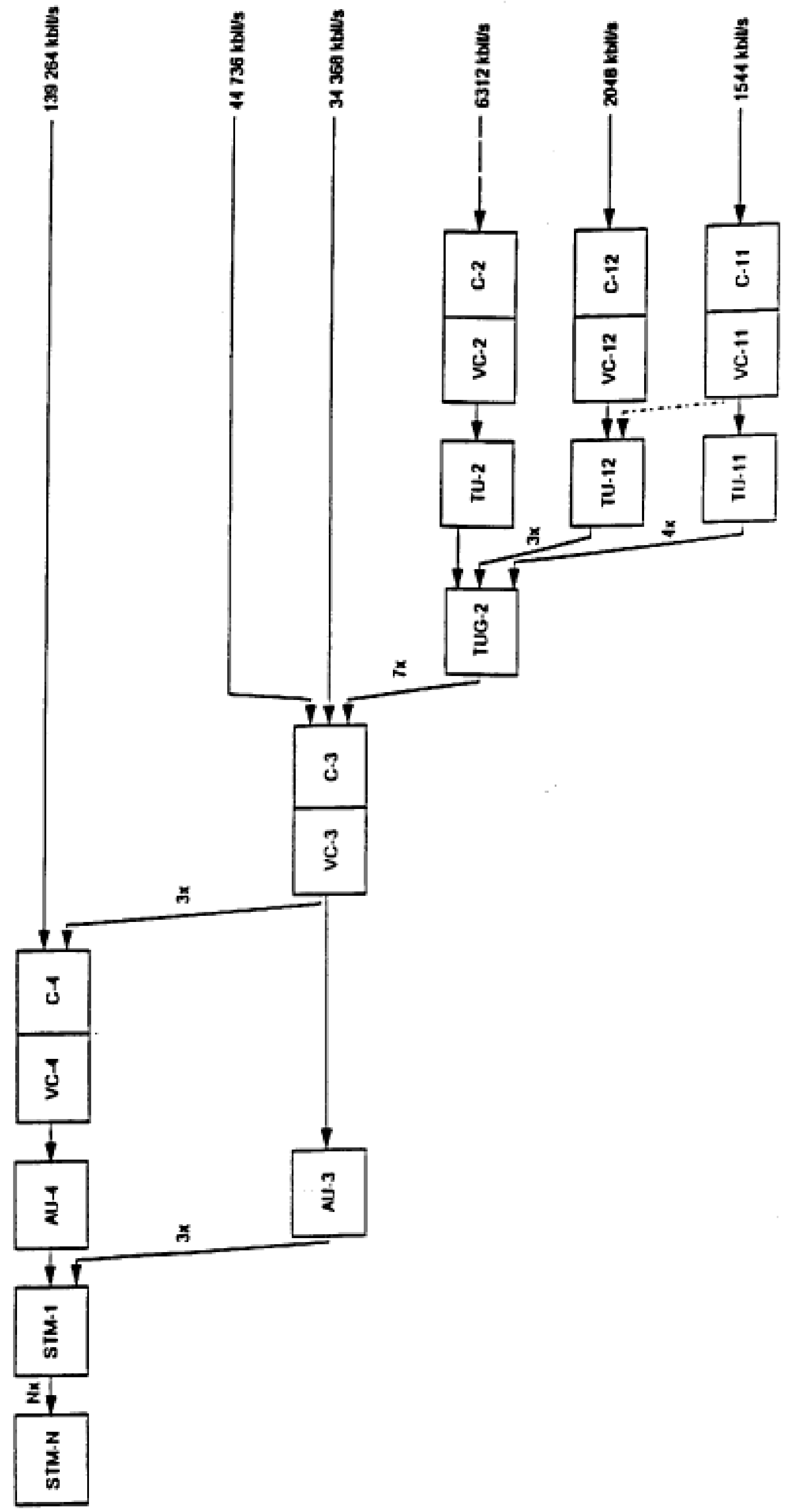


Figure 6 : SDH Multiplex Structure

Figure 6 : **SDH Multiplex Structure**

In simple terms the HDTV frame format will be organised according to ITU-R 601 and 656 and propagated at raw rates, in the low Gbit/s or undergo compression.

Where the potential audience is huge, for example live broadcasts from the Olympic Games, then preserving the very best picture, with insignificant cable propagation errors, is normal. Nevertheless the application of small compression ratios of say 10:1 yields a bit-rate around 140 Mbit/s, ideal for long haul transmission on current and future civil interconnect and with no subjective degradation. Degradation can be detected on particular still frames or with instruments but not by human observers of the full motion picture. When the programme feed arrives at the transmitter then it will undergo a transformation into the local format. It is these local formats which are currently under intense study.

In those applications where the audience is tiny then economics requires low transmission costs and a larger compression ratio is needed with a corresponding loss of fidelity.

8.2 Bearer Options

The ITU-T have nominated ATM over SDH as the global scheme, B-ISDN, for the evolution of the worlds switched telecommunications fabric. Currently there are no competing solutions. The spend on B-ISDN within the next decade is going to be huge. Every communications application which is currently in preparation will be bent towards compatibility with B-ISDN. The mass user will interface to ATM which best serves a set of uncorrelated bursty users. ATM is very well suited to bursty sources. Where single sources are constant bit-rate streams of long duration and high rate then ATM becomes less able to provide service where the source rates become large fractions of the bearer rate. With such users as TV programme suppliers the intention appears to be to provide a switched physical route and bypass ATM by loading the synchronous bearer directly. With current plant such switching takes perhaps days of scheduling, new plant will provide millisecond set-up for privileged users. Obviously the ATM solution implies concurrent access to many destinations for discrete logical streams. Direct loading of the SDH bearer is for point to point communications at synchronous capacity.

It was said that ATM and SDH have no competitors as the solution to B-ISDN. Frame relay is often offered as a competitor whereas it is complementary. Frame relay is little more than a streamlined X.25. In avionics context Frame Relay is not a bearer technology but a data link protocol providing logical multiplexing. IEEE 802.6 MAN whose long haul variant is called SMDS is ideally suited to mixed telephone and data between sites of large corporations or across an airport. IEEE 802.6 is available now in the US and BT also intend an 'overlay' service. Essentially SMDS is leased on a point to point basis. Frame relay might well be offered as the link layer interface for the data fraction of an SMDS link.

8.3 Recommendations and conclusions

If military applications are to effectively and economically adopt civil standards then there should be a calculated and methodical approach to monitoring the civil process. In order to anticipate the optimum route and timescales to adopt civil technology it is required to intercept the work in progress rather than waiting for the finished texts to appear. This rate of evolution is dramatic and is destined to reach a development plateau and yield extremely high revenue products within the next few years. This report provides a step along the road to identifying the relevant commercial standards. Four years ago the means of interception was essentially searching databases of abstracts and obtaining paper copies 10 days later. In just four years that process has been replaced by web browsing.

Whereas the primary goal is to identify a successor to PAL/NTSC it is clear that commercial applications of video have widened into many novel areas principally 'interactive' and wrapped into a subject called 'multi-media'. The application of multi-media technology to avionic military systems needs to be addressed.

9 GLOSSARY OF TERMS

ADS	Active dipping sonar
AES	Aircraft Equipment and Systems
AGARD	Advisory Group; Aviation R & D
ATM	Asynchronous Transfer Mode
ATTC	Advanced Television Test Centre
B-ISDN	Broadband Integrated Services Digital Network
BER	Bit error rate
BSI	British Standards Institution
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CD-ROM	Compact disc-Read Only Memory
CEC	Commission of the European Community
D Stan	Directorate of Standardisation (MoD)
DBS	Direct Broadcasting by Satellite
DCE	Data Circuit-terminating Equipment
DCT	Discrete Cosine Transform
DERA	Defence Engineering Research Agency
DISC	Delivering Information Solutions to Customers (BSI based)
DQDB	Distributed Queue Dual Bus
DVTR	Digital Video Tape Recorder
ECL	Emitter Coupled Logic
EDI	Electronic Data Interchange
EDTV	Enhanced Definition Television
EIA	Electronic Industries Association (US)
FCC	Federal Communications Commission (US)
FDDI	Fibre Distributed Data Interface
FLIR	Forward Looking Infra-Red
FOAS	Future Offensive Aircraft System
HD-MAC	High Definition Multiple Analogue Components
HDTV	High Definition Television
HSDB	High Speed Data Bus

IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers (US)
ISDN	Integrated Services Digital Network
ISO	International Standards Organisation
ITU-T	International Telecommunication Union-Telecommunications (formerly CCITT)
JTC1	Joint Technical Committee 1. ISO/IEC IT Standardisation
JPEG	Joint Photographic Experts Group (JTC1)
LAN	Local Area Network (LAN)
LTPB	Linear Token Passing Bus Standard (SAE)
MAN	Metropolitan Area Network
MPEG	Moving Picture Expert Group (JTC1)
MBT	Main Battle Tank
MMI	Man/Machine Interface
MUSE	Multiple sub-Nyquist Sampling Encoding (Japan)
NIIDLS	NATO Imagery Interoperability Data Links
NTSC	National Television Standardisation Committee
OR	Operational Requirements
PAL	Phase Alternating Line
PSTN	Public Switched Telephone network
PTO	Public Telecommunications Operator (also called network operator, carrier, or PTT)
RGB	Red, Green, Blue (colour video components)
SAE	Society of Automotive Engineers (US based)
SCI	Scaleable Coherent Interface
SDH	Synchronous Digital Hierarchy (Almost=SONET)
SDTV	Standard Definition Television
SMDS	Switched Multi-megabit Data Services
SMPTE	Society of Motion Picture and Television Engineers
SONET	Synchronous Optical Network (Almost=SDH)
STANAG	Standardisation Agreements (NATO)
STM	Synchronous Transfer Mode
SVIT	Sensor/Video Implementation Task group (SAE)
TI	Thermal Imaging

TIALD	Thermal Imager and Laser Designator (TIALD)
TRACER	Tracked Reconnaissance Armoured Combat Equipment Requirement
VCR	Video Cassette Recorder
VERDI	Vehicle Electronics Research Defence Initiative
VLSI	Very Large Scale Integration
WAN	Wide Area Network
WDM	Wavelength Division Multiplexing
YUV	Luminance, Chrominance; L, R-Y, Y-B

10 USEFUL WEB SITES

Site	Outline of content	URL (http://)
BSI	Information on BSI with link to IST/37 site	www.bsi.org.uk
IST/37	IST/37 information and documents	www.bsi.org.uk/html/ist/homepage.htm
DISC	Information on DISC	www.bsi.org/disc
JTC 1	Information on JTC 1	www.jtc1.com
SC29	Documentation and information (ftp site available)	www.chips.ibm.com/.sc29
JPEG	JPEG and JBIG information	drogo.cselt.stet.it/jpeg
	JPEG information	www.jpeg.org
MPEG	MPEG information	drogo.cselt.stet.it/mpeg/
	MPEG information (more general)	www.mpeg.org
MPEG-4	Discussion on MPEG 4	drogo.cselt.stet.it/mpeg/standards/mpeg-4.htm
MHEG	Information on MHEG	www.mheg.org
Multimedia standards	Additional source on standards related to multimedia	cuiwww.unige.ch/OSG/MultimediaInfo/mmsurvey/standards.html
Open Information Interchange and INFO2000 (DGXIII of the CEC)	Linked web site that gathers all current video and multi-media (and much more) standardisation. The page has links to all the relevant standards bodies and industry fora.	www2.echo.lu/oii/en/oiistand.html #oiistand
DVB	Extensive web site	http://www.dvb.org
DAVIC	Extensive web site	http://www.davic.org/
US TV	Grand Alliance web site	http://www.wral-hd.com
ATSC	FCC sponsored ATSC web site	http://www.atsc.org