AVIONIC SYSTEMS STANDARDISATION COMMITTEE

VIDEO SYSTEMS SUBCOMMITTEE

Doc No : - ASSC/130/2/134*

Issue 1 – May 00

DIGITAL VIDEO TECHNIQUES AND THE POSSIBLE ADOPTION OF COMMERCIAL DIGITAL VIDEO STANDARDS IN FUTURE MILITARY AVIONIC SYSTEMS *

SUMMARY

This discussion paper is intended to contribute to determining the way forward in the use of digital video techniques and the adoption of commercial digital video standards in future military avionic systems. This document will also be used as an input to the NATO AVSWG meeting to be held in July 2000 (Exchange of Information on Digital Video Standards).

The immediate aim is to identify key aspects, issues and problems associated with the application of digital video to military avionics. This paper does not identify solutions to these issues and problems.

The long-term aim (beyond the scope of this paper) is to prepare a proposal for a NATO STANAG covering the use of digital video in military avionic systems.

Aspects addressed herein include:

- Display technology.

- Technology required for generating, propagating and manipulating digital video.
- Processing including synthesis, manipulation, analysis and enhancement of video images.
- Compression and its suitability/requirement for avionic applications.
- Merging, overlaying and synchronising images with other data.
- Image and data fusion.
- Latency.
- Transmission of digitised video.
- Effects of corruption/loss of data.
- Sensors.
- Upgrade of legacy video systems.
- Interfacing to legacy systems.
- Trade-offs.
- Commercial off the shelf.

RELATED DOCUMENTS

ASSC/130/2/116*-Issue1 December 1999, Requirements for Distribution and Transmission of Video Images for Airborne Platforms

ASSC/130/2/122 Image Fusion

ASSC/130/2/38 Characteristics of Avionic Display Performance

ASSC/130/2/56 F-22 Cockpit, Lockheed Boeing Controls and Displays IPT

ASSC/130/2/97*-Issue 2 draft 2, Guide to Avionic Video Systems

ASSC/130/3/191 Overview of the MPEG-4 Standard, ISO.IEC JTC1/SC29/WG11 N1730 Stockholm, July 1997

ASSC/130/3/235 French Helmet Visors Clear the Skies for Combat Pilots, Signal Magazine 1996

ASSC/130/3/216-draft 6 Project Paper 661, Cockpit Display System Interfaces to User Systems, May 2000, ARINC

ASSC/130/3/6 Cockpit Displays, Avionics Magazine May 1996

ASSC/130/6/1-draft 4, Chapter Five: Video Data Processing**

* These documents are available on the ASSC web site at www.era.co.uk/assc.htm

** This document will shortly be included in ASSC/130/2/97-Issue 2.

GLOSSARY

2D	2 Dimensional
3D	3 Dimensional
601	ITU-R recommendation BT601
AAL	ATM Application Layer
ASW	Anti-submarine Warfare
ATM	Asynchronous Transfer Mode
AVSWG	Avionic Standards Working Group
CCD	Cursor Control Device
CGI	Computer Graphics Interface
COTS	Commercial off the Shelf
CP	Compression and Packetization
DIF	Data Interchange Format
DV	Digital Video
DVI	Digital Video Interface
EMC	Electromagnetic Compatibility
FC	Fibre Channel
FC-AV	Fibre Channel Audio Video
IP	Internet Protocol
IR	Infrared
IRST	Infrared Search and Track
Mbits/s	Megabits per second
MOE	Measure of Effectiveness
MPEG	Motion Picture Experts' Group
NATO	North Atlantic Treaty Organisation
PS	Program Stream

RSVP	ReSerVation Protocol
RTP	Real Time Protocol
SDH	Synchronous Digital Hierarchy
SDI	Serial Digital Interface
SDTI	Serial Digital Transport Interface
SONET	Synchronous Optical NETwork
STANAG	Standardisation Agreement
STOL	Short Take-off and Landing
TCP	Transmission Control Protocol
TS	Transport Stream
UDP	User Datagram Protocol
VSTOL	Very Short Take-off and Landing

Collation page

1 INTRODUCTION

This discussion paper is intended to contribute to determining the way forward in the use of digital video techniques and the adoption of commercial digital video standards in future military avionic systems. This document will also be used as an input to the NATO AVSWG meeting to be held in July 2000 (Exchange of Information on Digital Video Standards).

The immediate aim is to identify key aspects, issues and problems associated with the application of digital video to military avionics. This paper does not identify solutions to these issues and problems.

The long-term aim (beyond the scope of this paper) is to prepare a proposal for a NATO STANAG covering the use of digital video in military avionic systems.

2 BACKGROUND

Until the last decade video has remained one of the last bastions of analogue technology. However, that situation is changing rapidly. Advances in the performance and cost effectiveness of digital processing, data storage and transmission technology mean that digital techniques now rival or exceed analogue in their ability to capture, manipulate and display video images. These advances are a repeat of the phenomenon already witnessed in most other areas of electronics, ranging across telecommunications, radio, instrumentation, audio etc.

The use of digital displays (or at least displays with digital input interfaces) offers the prospect of ensuring that all content is transferred in digital form, from creation to consumption, with data integrity maintained at a very high level. The human user can thus be provided with much sharper and crisper images. Digital techniques also enable gamma correction and features such as picture within a picture to be readily achieved at low cost.

Digital video promises major advantages over analogue (e.g. STANAG 3350) in terms of relative ease of manipulation. This manipulation may take the form of generation, propagation, synthesis and analysis of images; together with fusing, merging, overlaying and synchronising of images and other data.

All of these functions may be achieved by processing the mass of data representing digitised video images. To achieve such ends to the same levels of performance using analogue technology is at best technically very difficult and most often impossible. Digital methods are likely to be unique in capability or superior in performance, and cheaper. Furthermore, application of digital error detection and correction techniques may permit achievement of superior quality images with higher immunity to interference than with analogue systems. However, if data corruption does occur then the consequences for picture quality may be more severe in digital systems, particularly if image compression has been used.

The advances in digital video over the last decade have been made almost exclusively in the commercial sector. Hence the implementation of digital video in military avionics will inevitably be heavily reliant on exploitation of commercial off the shelf (COTS) technology.

Replacement of analogue by digital is inevitable, only the timescale is uncertain. However, the migration to digital video in military avionics will not be simple or problem free. The following sections of this paper aim to identify the key aspects, issues and problems that will be encountered in this process.

3 SUMMARY OF KEY ASPECTS, ISSUES AND PROBLEMS

3.1 Aircraft Types, Roles & Missions

In order to identify the issues to be addressed in a standard for digital video in military avionics it will be necessary to identify the wide range of video systems in use (and to be used in future) in the great variety of aircraft types, roles and missions. These include the following among others.

- Helicopters:
    - attack
    - transport
    - ASW.
- Fast jets:
    - fighter
    - ground attack
    - recce
    - VSTOL.
- Carrier based aircraft.
- Trainers.

- Fixed wing ASW.
- In flight refuelling aircraft.
- Transport aircraft:
    - jet
    - prop
    - air drop
    - STOL.
- Unmanned platforms:
    - missiles
    - reconnaissance aircraft

Each of these is likely to have different video systems and different mission dependent modes and configurations.

There is a need to define the roles and requirements for digital video in the wide range of aircraft types, roles and missions in order that the scope of a digital video standard may in turn be defined.

3.2 Digital Video Applications

A crude summary of the likely applications of digital video in military aircraft includes:

- Image enhancement (eg night vision).
- Surveillance.
- Debrief.
- Targetting.
- Tactical reconnaissance.
- On platform applications.
- Strategic reconnaissance.
- Off platform transmission.
- Threat detection.
- Navigation.
- Flight Safety – landing at night or in poor weather.

- Windshear detection.

These applications will influence the differing technical parameters of the digital video systems designed for each case. Hence there is a need to define the scope of a digital video standard taking into account the range of applications involved and the relevance of digital technology to each.

3.3 Picture Quality

Methods are needed for defining and assessing picture quality.

3.4 Display Technology

3.4.1 Display Types

Displays come in a variety of fundamentally different types, including:

- Head up (exceptional brightness required).
- Head down.
- Helmet mounted.
- 2D & 3D.
- Colour/monochrome.

Hence there is a need to define the differing requirements for different display types.

3.4.2 Display Interface

Currently there is no widely accepted digital display interface standard. There is a need for a standardised display interface, that should take into account:

- Possible adoption of DVI.
- Ability to interface processing or communications technology to any display.
- Desirability of locating display remote from processing – implications for interface and / or transmission systems.
- Need for a bi-directional interface to provide for keyboard, cursor control device etc.
- EMC issues.

3.4.3 Cockpit Lighting Issues

Currently there is no widely accepted standard covering cockpit lighting issues. There is a need for a standard that should take into account:

- Definition of human needs without regard to technology.
- Effects of technology on human factors.
- The impact of lighting issues on the choice of cockpit display and generation of images.

3.4.4 Variations in Displays

It will be necessary to cope with various:

- Display sizes (range form 15mm x 11mm to 275mm x 206mm).
- Pixel densities or resolution (a standard definition of resolution is required)
- Aspect ratios etc.

(See Document Nos. ASSC/130/2/116 & ASSC/130/2/97 Chapter 9 Section 4.5 re VESA standard)

3.4.5 Graphics drive hardware and software

There is a need to define and standardise graphics drive software, taking into account:

- Many COTS graphics devices are only 8 bit, while many avionic sensors require more bits. (There are many COTS graphic devices and software programs available for display generation. These are usually based on colour or 8 bit monochrome. Some monochrome sensors [such as IR cameras] use many more bits [12 –14 bits/pixel] to achieve the required dynamic range. This will require pre-processing to optimise the pixel data for display on a conventional display. This pre-processing may not be available in COTS hardware/ software. Note that the full dynamic range pixel data would normally be used for autoprocessing.)
- Low level software.
- Flexibility (including addition of new graphical entities).
- Application specific issues.
- Throughput efficiency.
- Open v closed system approaches.

- Number of layers, colour depth and memory requirements.
- Synchronisation management.
- Combination of synthetic and sensor video (in front / behind)
- Cursor control device (CCD).
- Object definition.
- Display formats.
- Repertoire of display elements.
- Simultaneous multiple display formats.

3.5 Technology Required to Generate, Propagate and Manipulate Digital Video

3.5.1 Processing capabilities

Processing capability requirements are driven by requirements for:

- Latency.
- Resolution.
- Colour depth.
- etc.

3.5.2 Availability of Technology for Military Avionics

There are likely to be problems with procurement of technology for military avionic applications in relation to.

- Environment (see 3.15.1 below).
- Packaging (see 3.15.2 below).
- Obsolescence (see 3.15.3 below)

3.6 Processing Including Synthesis, Manipulation, Analysis and Enhancement of Video Images

3.6.1 Visual images versus autoprocessing applications

There is an overarching need to consider the different processing requirements for:

- Images for human viewing.
- Images/data for autoprocessing

The latter being less likely to be amenable to commercial standards.

3.6.2 System Architecture Issues

System architecture issues need to be addressed, taking into account:

- Distribution / concentration of processing versus transmission bandwidth etc.
- Dumb sensors versus smart sensors.
- Switching between large numbers of sensors.

3.7 Compression and its Suitability/Requirement for Avionic Applications

3.7.1 Application areas for compression

It is considered that compression is not generally appropriate for transmission within aircraft.

Appropriate areas for use of compression are not currently defined.

There is a need to define compression application areas these may include:

- Image storage.
- Transmission within the aircraft (where bandwidth is limited).
- Off-platform transmission.
- After the event viewing.

3.7.2 Latency introduced by compression

Compression invariably introduces latency. There is a need to understand, define and quantify the trade off between latency, compression ratio, picture quality and processing power etc.

There is a need to understand the effects of compression (and their acceptability or otherwise) in terms of:

- Loss of information.
- Lack of understanding of effects of compression on images etc.
- Effects on picture quality.
- Levels of compression.
- Susceptibility to errors.

- Mixing compressed signals.

3.7.3 Visual images versus autoprocessing applications

There is a need to consider the effects of compression on:

- Images for human viewing.
- Images/data for autoprocessing.

Compression may prevent certain forms of automated processing, and the requirements are not well understood. Examples of automated viewing include:

- Target cueing.
- CGI/real image overlay.

There is a need to understand the different constraints on use of compression in different applications.

Methods for assessment of picture quality are an important related issue.

3.7.4 Compression standards

There is a need to identify appropriate compression standard(s) for military avionic applications taking into account the issues listed above. It may be that different forms of compression will prove appropriate for different applications.

3.8 Merging, Overlaying and Synchronising Images with other Data

There is a need to define the other data types, such as symbology, to be merged overlaid, etc. with images, and to investigate the suitability of commercial standards e.g. are they tight enough?

3.9 Sensor Fusion

There are a number of airborne sensors exploiting differing technology, the outputs of which are either real images of the outside environment (e.g. Low Light Television Camera, Forward Looking Infrared sensor), a Radar type image, or positional information etc. Sensor fusion is the combining of all the available relevant data to produce a better overall situational awareness of the outside environment. However, Sensor fusion is normally subdivided into its component parts of:

- Image Fusion.
- Fusion of data with image e.g. symbology overlay.

- Data fusion (fusion of computer generated images e.g. terrain wire frame etc.).

3.9.1 Image fusion

3.9.1.1 Image fusion requirements

There is a need to define fusion requirements given a particular operational requirement. There is a very large range of possibilities and this needs to be bounded. It may be useful to define a series of "standard" operational requirements, for which a range of fusion techniques would be appropriate. Note that the fusion requirement cannot be divorced from the sensor specification for a particular operational requirement.

3.9.1.2 Computational cost of fusion

The computational cost (complexity, processing power, memory, requirements, latency, programming and financial cost etc.) of implementing fusion algorithms to operate at video frame rates is likely to be high and needs to be investigated and defined.

3.9.1.3 Image fusion system performance

The following image fusion performance issues need to be addressed.

- Absence of methods for specifying image fusion systems and their performance.
- Absence of methods for assessment and testing of image fusion system performance.
- Lack of a fusion algorithm measure of effectiveness (MOE) taking into account:
    - Differences for different scenario/mission/platform.
    - Mission specific fusion algorithms.
- Ensuring that artefacts and noise in one image do not corrupt the fused result.
- Fusion processing time.
- Differing latencies in images from different sources.
- Misregistration of input images due to:
    - Sensor parallax.
    - Sensor geometry.
- Sensor sight line stability.

- Sensor distortion.
- Fusion of visual images.
- Fusion of images for autonomous processing.

3.9.1.4 Operator intervention

The need for / desirability of operator intervention for image manipulation should be addressed.

3.9.1.5 Image fusion techniques

Appropriate image fusion techniques need to be identified and defined these may include fusion at:

- Pixel level.
- Feature level.
- Object level.

3.9.1.6 Fusion interface standard

There is a need for a fusion interface standard to include:

- Data formats and types
- Data/image coordinates.
- Time tagging of data.
- Fusion of interlaced and non-interlaced images.

3.9.2 Data Fusion

Data fusion is the combining of parametric information from different sources to provide an overall situational awareness. e.g. Combining aircraft speed, attitude and heading data either for use within the mission systems or the generation of display symbology.

Data fusion is outside the remit of this paper and will not be discussed further, however problems with latency (see 3.10 below) should be noted.

3.10 Latency

For the purposes of this document latency is defined as the time delay between the detection of a change by a sensor and its appearance on the display. This also includes persistence, i.e. the time for which a feature continues to be displayed after it ceases to be within the sensor's view.

3.10.1 Acceptable latency magnitude

There is a need to define acceptable magnitudes of latency for various applications. 100ms has been suggested for most human viewing applications. However, systems such as Infrared Search and Track (IRST) that work in real time are particularly vulnerable to the effects of latency.

This activity should include consideration of the consequences of latency such as:

- Tracking errors.
- Blurring of images when sensor moved.
- Delay between aircraft manoeuvre and manoeuvre observed in the displayed sensor imagery.

3.10.2 Identify and quantify causes of latency

There is a need to identify and quantify causes of latency these will include:

- Transmission.
- Processing.
- Demand time.
- Sensor characteristics and performance.
- Latency within display equipment.

3.11 Transmission of Digitised Video

(see Document No. ASSC/130/2/116 Issue 1)

3.11.1 Data transmission standard(s)

Given the objective of achieving end to end digital systems, transmission of digital video is a crucial issue. There is a need to identify appropriate standard(s) for transmission of video data. Candidates include Fibre Channel (for data transmission), and ATM and SDI (for video transmission).

This activity should involve consideration of issues such as:

- Various transmission paths e.g.:

  - Sensor to processing.
  - Processing to display.
  - Sensor to display.
- Data rate/bandwidth requirements (some sensors require up to 1Gbit/s).
- Data transmission overheads.
- Error detection/correction requirements (including in relation to compressed video data).
- There may be a need for additional error protection beyond that provided by the chosen standard.
- Error detection/correction requirements versus bandwidth trade off
- Jitter / determinism requirements.
- Handling of multiple video streams.
- Avoidance of multiple conversions.
- Number of signal wires.

Figure 1 shows the relationship between existing streaming video technologies on the one hand, and network technologies on the other. To aid comprehension of the relationships, the standards and protocols are allocated their position within the ISO 7-layer model. The diagram is especially useful, in that it identifies standards that require development and publication - for example FC-AV (currently [June 2000] under development) which will specify how streaming video data, is mapped to containers, for transport on Fibre Channel networks. It is not clear how comprehensive AAL is, for the distribution of video over ATM.

See the Glossary on page vii for definitions of the acronyms and initials used in the figure.

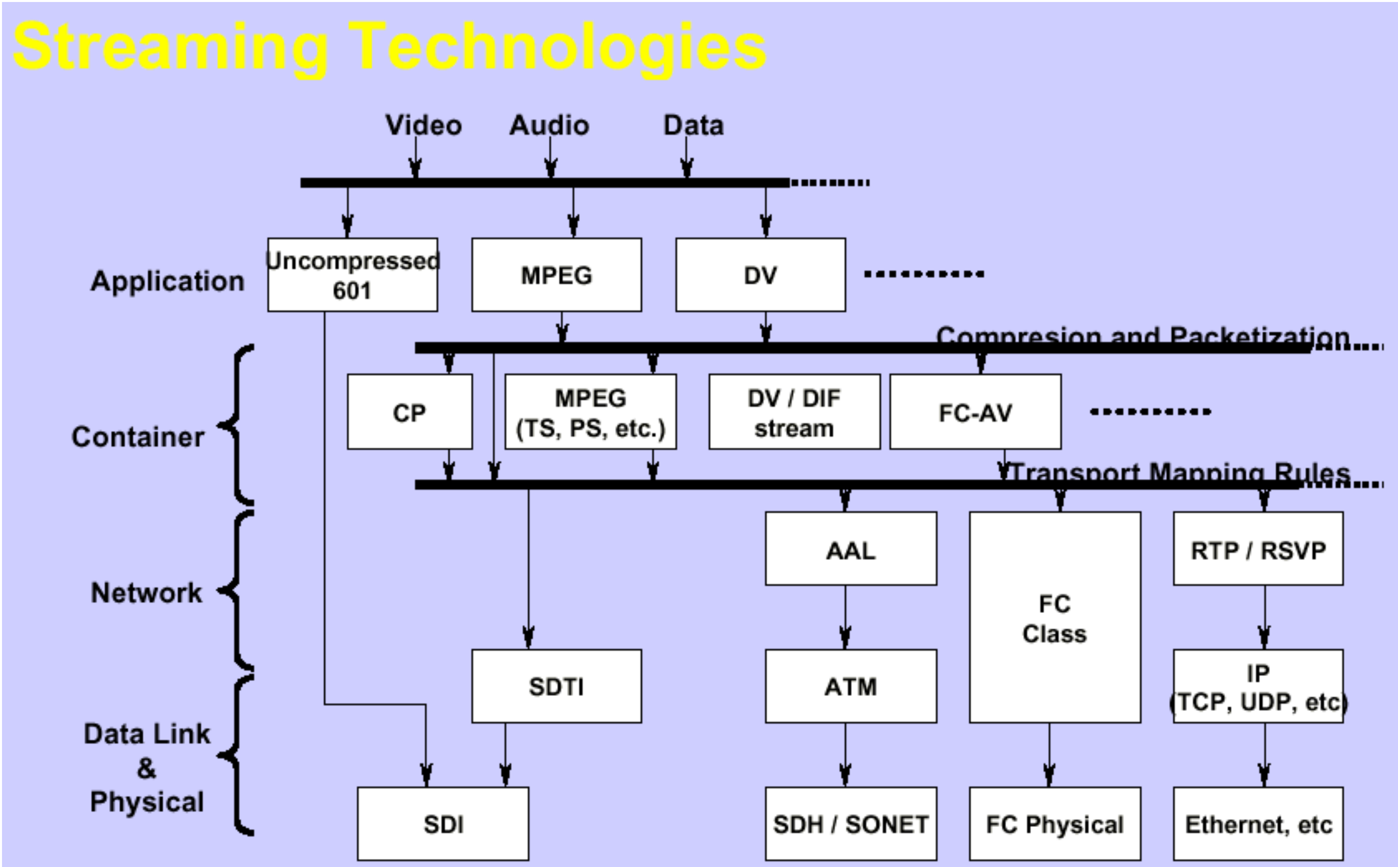

Figure 1: Relationship between Streaming Videotechnologies and Network Technologies

3.11.2 Transmission between moving parts

Cases where digital video is to be transmitted between moving parts of a system (e.g. from a sensor mounted above a helicopter rotor) pose special difficulty, since currently available transmission methods, such as slip rings, generally lack adequate bandwidth capability.

3.12 Effects of corruption/loss of data

It is not clear how serious this problem is, since modern data storage and transmission systems have sophisticated error detection and correction mechanisms providing high levels of integrity. However, in some circumstances loss of data may have severe consequences.

However, there may be a need to characterise the following:

- Differing importance of corruption/loss of data for viewing versus autoprocessing.
- Effects of corruption/loss of data on uncompressed images.
- Effects on compressed images.
- Required data integrity performance.
- Levels of integrity provided by candidate solutions for system elements such as data storage and transmission.

3.13 Sensors

There is a need to characterise requirements in relation to different sensor types such as:

- Line scan arrays (large bandwidth output).
- Staring arrays (large bandwidth output).
- Conventional imager (general scene).
- Video data output.
- Video output.

Possible sensor applications include:

- Low noise/large dynamic range sensors (12 — 14 bits per pixel hence high bandwidth).
- Threat detection (very low latency requirement).

Missile warning (very low latency and high number of bits per pixel, hence very high bandwidth requirement).

Multi-spectral sensors.

3.14 Upgrade of legacy video systems

Issues that need to be addressed include:

The need to define probable upgrade scenarios and objectives.

Utilisation of existing transmission media.

Desirability of avoiding multiple conversions.

Interfacing to legacy (analogue) sensors.

Interfacing to legacy (analogue) displays.

Conversion issues including:

- Digital to analogue conversion.
- Analogue to digital conversion.
- Conversion between interface standards.

Transmission issues including many of those listed in 3.11 above.

Probable low bandwidth of legacy transmission systems.

Replacement of analogue test equipment and laboratory monitors.

3.15 COTS

The declared aim is to use Commercial Off The Shelf (COTS) hardware and software whenever possible. However, this approach brings significant risks principally in relation to environment and obsolescence, as discussed below. An approach commonly used seems to be for the procurement authority to pass the problem over to industry. However, experience in other areas suggests that this may be just postponing the confrontation with the issue.

Clearly while the COTS approach has significant benefits in bringing advanced technology into defence it also has significant potential problems, extending into areas far beyond the current subject of digital video. Hence this issues merits wide ranging investigation aimed at finding ways of mitigating the problems discussed below.

In parallel with the investigation into the desired aim of using COTS equipment, a review and overhaul of qualification, reliability and maintainability/support requirements is necessary, since these were written using the assumption that equipment was to be designed specifically to meet them. COTS equipment should not realistically be expected to meet these requirements to the letter.

3.15.1 Environment

Most digital video technology is only available specified for the commercial environment, and is thus unsuitable for use in the much more onerous military avionic environment.

Hence the capability (or otherwise) of COTS hardware to survive, or be protected against the avionic environment needs to be addressed. This should include:

EMC susceptibility.

EMC emissions.

Radiation.

Temperature.

Vibration.

Shock.

Impact.

Acceleration.

Humidity and moisture.

Rate of change of temperature.

Shock.

Altitude.

Rapid decompression.

3.15.2 Packaging

The packaging issue is a closely related to that of environment. It is possible that packaging used for commercial video devices (e.g. processors) will prove inadequate for the military environment.

In the same vein it is most unlikely that the board level packaging used for commercial video products (mostly aimed a PC computer use) will be adequate.

3.15.3 Availability / Obsolescence

Commercial digital video is a technologically fast moving business in which products rapidly become obsolescent, out of production and unobtainable. This contrasts starkly with the military avionics business in which systems may be operational for decades.

Hence there is a high risk of COTS hardware (e.g. semiconductor devices) becoming unobtainable due to commercial obsolescence.

4 TRADE-OFFS

The implementation (and standardisation) of digital video systems for military aircraft will involve trading off many of the different issues discussed above including:

Data bandwidth.

Compression.

Image resolution.

Latency.

Image update rate.

Picture quality.

Integrity.

Cost.

Complexity.

There may be a need to achieve a better understanding of the relationships between the above issues, and to define how they may be traded off.

5 CONCLUSIONS

This discussion paper has attempted to identify key aspects, issues and problems associated with the application of digital video to military avionics.

This process has highlighted the immaturity of existing digital video standards; and the fact that, since they may not survive, it may not be appropriate to adopt any of these for military avionics within the foreseeable future.