AVIONIC SYSTEMS STANDARDISATION COMMITTEE

VIDEO SYSTEMS WORKING GROUP

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ASSC ADVISORY DOCUMENT ON THE CHARACTERISTICS OF AVIONIC DISPLAY PERFORMANCE*

0 EXECUTIVE SUMMARY

The purpose of this document is to promote MoD (PE) Project Officers' understanding of the information supplied by vendors of display equipment and assist them in the procurement of displays. It is anticipated that its use will facilitate comparison between tenders from different equipment suppliers by ensuring that suppliers provide the information detailed in the document so as to facilitate the MoD decision making process.

This document is not prescriptive; its objective is to list the key characteristics of each type of display. It provides a description of each parameter, shows how it might be specified, and provides an example using typical "ballpark" figures.

* Copies of this paper are obtainable from the ASSC Agency as an Avionic Systems Standardisation Committee publication.

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1 PURPOSE AND SCOPE

The purpose of this document is to provide information on the characteristics of video displays for avionic applications to assist in understanding the design and development criteria of video display systems. Paragraph 3 details the general requirements, paragraph 5 details technology independent characteristics, which concentrate on characteristics peculiar to Cathode Ray Tube (CRT), and Liquid Crystal Displays (LCD) as they are currently the main display devices used in avionic applications future updates of this document will include other display devices such as Electroluminescent Displays (ELD), and Plasma Displays.

Not all display technologies are appropriate to each display type

2 RELATED DOCUMENTS

2.1 The following documents and publications are referred to or are relevant to this document :

IEC 244-5 - 1971	Measurements particular to transmitters and transposers for monochrome and colour television
IEC 50 (806) - 1975	International Electrotechnical Vocabulary, Recording and reproduction of sound and video
Def Stan 00-18 (Part 6)	Analogue video standard for aircraft system applications
STANAG 3350 AVS	Analogue Video Standard for Aircraft Systems
US MIL-STD-1472D	Human engineering design criteria for military systems, equipment and facilities
ARINC 725 - Nov 1979	Electronic flight instrumentation
EIA Standard RS-170	Electrical performance standard for high resolution monochrome closed circuit television camera
Defence Standard 00-970	Design and Airworthiness Requirements for Service Aircraft
Chapter 115 (Volume 1)	Design Criteria for Night Vision Imaging Systems (NVIS) Compatible Crewstation Lighting & Displays.
Leaflet 115/1 (volume 1)	Night Imaging Systems (NVIS) Lighting Compatible Design Criteria
Leaflet 105/4	Crew Stations - General Requirements Guidelines for the Design of Crewstation Lighting and Displays
AIR STD 61/116/P14	Integrated Helmet-Mounted Display Systems for Rotary Wing Aircraft
Defence Standard 00-25 (part 6)/Issue 1 :	Human Factors for designers of Equipment Part 6: Vision and Light
Defence Standard 00-25 (part 7)/Issue 1 :	Human Factors for designers of Equipment Part 7: Visual Displays

3 GENERAL REQUIREMENTS

The characteristics of the displays shall be valid over the range of environmental conditions defined in Section 6.

3.1 PICTURE SIZE AND ASPECT RATIO

Picture size is application dependent ranging from miniature CRTs for helmets (15 mm by 11 mm) through to large maritime displays (275 mm by 206 mm). The standard 4:3 aspect ratio has proved popular in many applications, however the 1:1 aspect ratio is regarded as being inherently more efficient for avionic display of map and other information in the limited space of the modern instrument panel. Some display types may use 4:3 aspect ratio for raster and 1:1 aspect ratio for cursive symbology. Some examples of picture sizes are given below:-

Merlin	275 mm by 206 mm (10.8 in by 8.12 in)
Comanche	203 mm by 152 mm (8.0 in by 6.0 in)
B-52, B-1	203 mm by 152 mm (8.0 in by 6.0 in)
F-22	198 mm by 198 mm (7.8 in by 7.8 in)
Merlin	196 mm by 146 mm (7.6 in by 5.7 in)
F-22, Tiger	159 mm by 159 mm (6.25 in by 6.25 in)
C-130, C-141	155 mm by 206 mm (6.0 in by 8.0 in)
F-4, F-5	127 mm by 127 mm (5.0 in by 5.0 in)

There is no industry standard picture size although the 8 in by 6 in is currently the most popular LCD possibly due to the lower cost arising from the developments of laptop computer displays.

3.2 RESOLUTION

Display resolution is described in two ways :-

a) the number of pixel elements that is physically produced on the display surface. This should be expressed both as the total number of pixels per picture height and as the number of pixels per inch.

b) the smallest line that the display can produce which an observer could resolve. This is can be represented in terms of the Modulation Transfer Function (MTF).

The modulation M is defined as :-

$$M = \frac{\text{Maximum luminance - Minimum luminance}}{\text{Maximum luminance + Minimum luminance}}$$

The input signal to the display will be sinusoidal whose amplitude will range from maximum white to black. The modulation should be calculated for various spatial frequencies and plotted on a graph (of modulation versus spatial frequency).

The generally accepted acceptance criteria for the display MTF is that it should match or exceed the MTF curve given by

$$MTF = \exp\{-(f/f_o)^{**}2\}$$

f = spatial frequency specified in terms of cycles per mm.
f_o is typically 2 cycles/mm

3.3 DISPLAY LUMINANCE

Cockpit head down displays which encounter high levels of ambient illumination should have a luminance which should be in the region of at least 800 Cd/m**2 (233 ft-L). {High levels of ambient illumination is in the order of 100,000 Lux (9294 ft-L)}. The most demanding requirement for 'day' legibility is for sun forward, sun rear and dusk (these lighting conditions are utilised in the PJND Model). Under night ambient lighting conditions display luminance levels are typically set to 0.35 Cd/m**2 (0.1 ft-L) when Night Vision Goggles are not being used and 1 Cd/m**2 when Night Vision Goggles are being used. There should be smooth control of luminance between the extremes.

3.3.1 Automatic Brightness Control

Automatic Brightness Control is normally a requirement to maintain constant contrast against varying ambient conditions. The atuomatic brightness control should normally have an operation range specified, typically 100 lux to 100,000 lux, a response time, a control law and the field of view over which the sensor works.

3.4 CONTRAST RATIO

There are two techniques of expressing the visual performance of displays.
ie that of using the ratio using CJND/PJND which is preferred or of using contrast ratio as shown below (refer to paragraph 6.1.10 for details of the PJND method).

As per MIL-L-85762A Table 2 Contrast $C_L = \dfrac{(L_{HIGH} - L_{LOW})}{L_{LOW}}$

Contrast C_L	Type of Display	Contrast Ratio (= 1+C)
>1	Numeric	>2:1
>2	Alphanumeric	>3:1
>3	Graphic	>4:1

>4.66	Video under worst case condition	>5.66:1
>10.3	Video under other ambient conditions	>11.3:1

3.5 COLOUR CO-ORDINATES

Colour should be specified in terms of CIE 1931 x,y or CIE 1976 u',v'.

3.6 COLOUR TEMPERATURE

The white point of a display should not be specified in terms of Correlated Colour Temperature (CCT). This is because the CCT is ambiguous in so far as all colours lying on the same perpendicular line to the Planckian locus will have the same CCT. The white point of the display is best specified as described in paragraph 3.5.

3.7 DISPLAY UNIFORMITY & LUMINANCE LINEARITY

The maximum constant shift in luminance from the centre of the display to the extremes is important and should be specified.

3.8 GEOMETRIC DISTORTION

It is suggested that no picture element should be displaced by more than 2% of the display height from its true position referenced from the centre of the display though tighter requirements may be needed for specific application.

3.9 ELECTRICAL INTERFACE

3.9.1 Power Requirements

Power interfaces shall be derived from standard aircraft supplies. The maximum power used should be specified.

3.9.2 Signal Inputs.

Video interface shall be to Def Stan 00-18 (Part 6) Class A (875 lines), Class B (625 lines), or Class C (525 lines). Where pixel for pixel registration is required, for example between FLIR sensor and display, some characteristics of Def Stan 00-18 (Part 6) will need to be tightened ie tolerances on synchronisation edges.

Control interfaces (eg US MIL-STD-1553B, ARINC 429, ARINC 629, EIA-422, etc.) shall be application dependent.

3.9.3 Signal Outputs

Details of signal output should be defined.

3.10 MECHANICAL INTERFACE

3.10.1 Size

Space envelope, reference a document - details should be defined.

3.10.2 Mass

Details of mass should be defined.

3.11 USER AND SUPPORT REQUIREMENTS

The following have been included to stimulate further thought, such that the general requirements and technology specific characteristics can be more clearly defined.

Display transients
Picture stability
Initialisation recovery
Cockpit compatibility
Protection-implosion/ionising radiation
Installation
Image Latency

3.11.1 Warm up time

A warm up time to full operational performance, shall take less than 2 minutes after cold soaking at -54^{o}C. This time will include start up BIT and initialisation.

LCD displays, which require heaters on the glass and backlight to warm up from cold, may take longer to warm up than 2 minutes. A specification could define a percentage of performance within a given time.

A warm up time to full operational performance, shall take less than 30 seconds after switch on at +15^{o}C This time will include start up BIT and initialisation.

3.11.2 Built in Test

Built in Test shall carry out failure detection and isolation and shall have operating modes as follows.

Start -up BIT
Continuous BIT

Initiated BIT

Operation of BIT shall not initiate a non reversible process.

A failure log shall record BIT failure information. The failure log shall discriminate between intermittent and steady state failures occurring within the display.

Typically SBIT should be capable of detecting 97% of all failures determined by FMECA and isolating 95% of detected failures to 3 LRIs.
Typically CBIT should be capable of detecting 95% of all failures determined by FMECA and isolating 95% of detected failures to 3 LRIs.
Typically IBIT should be capable of detecting 99% of all failures determined by FMECA and isolating 100% of detected failures to 3 LRIs.

100% of all safety and mission critical failures determined by FMECA will be detected. The false alarm rate will not exceed 2% of the total failure detected. IBIT shall include operator observation of test patterns.

4 ENVIRONMENTAL CHARACTERISTICS

4.1 ELECTRO-MAGNETIC COMPATIBILITY

As required by MIL-STD-461D (for military applications) or RTCA DO-160C and EUROCAE/ED 14C (for commercial applications).

4.1.1 Magnetic field emission

MIL-STD-454N (paras 4.6.1 to 4.6.3) and SAE STD AS 8034 (page 14, para 5.20) should be checked for detail on x-ray radiation for airborne electronic displays.

4.2 COOLING

Description: Details the maximum cooling requirement for the display

Implementation: Cooling Requirement < 3.0 Characters float Watts

Example: Cooling Requirement < 100 Watts

4.3 ACCELERATION

Description: Details the maximum acceleration

Implementation: Acceleration < 2.1 Characters float g

Example: Acceleration < 10.0 g

4.4 OPERATING TEMPERATURE

Description: Details the maximum operating temperature in Celsius

Implementation: Temperature < 3.1 Characters float C

Example: Temperature < 100.0 C

4.5 VIBRATION

Description: Details the maximum vibration requirement as a Power Spectral Density (g2/Hz), at a set of frequencies (Hz).

Implementation: List of 0.5 characters float PSD at 3 characters, float Hz

Example:

Frequency	10 Hz	PSD	0.01500
Frequency	40 Hz	PSD	0.01500
Frequency	500 HzPSD	0.00015	

4.6 SHOCK

Description: Details the maximum shock which must be withstood

Implementation: 3 Characters Integer g for duration 3.1 Characters float milliseconds, description of pulse shape

Example: 100 g for 6.0 ms, half-sine

4.7 ALTITUDE

Description: Details the maximum altitude required for operation

Implementation: Altitude Maximum 5 Characters Integer metre (m)

Example: Altitude Maximum 15000 m

4.8 RAPID DECOMPRESSION

Description: Details requirements for Rapid Decompression for cockpit mounted equipment

Implementation: Maximum Altitude < 5 characters integer metre (m)
Rapid Decompression 4 character integer m to 5 characters integer m in 1.1 characters float seconds and 5 characters integer m to 5 characters integer m in 1.1 characters float seconds.

Example Maximum Altitude < 15,250 m
Rapid Decompression 2500 m to 15,250 m in 0.2 seconds and 6100 m to 15,250 m in 0.1 seconds.

4.9 GENERAL

For cockpit mounted equipment the following environmental condition should also be considered: humidity, solar radiation, explosive conditions, dust / fine sand, rain, fungus, contamination and Nuclear environment if applicable.

5 DISPLAY TYPE

5.1 HELMET MOUNTED DISPLAY (HMD)

If the Helmet Mounted Display is to be used to display sensor imagery (image intensifiers and/or infra-red), then the parameters specified below must be defined appropriately to ensure that the sensor image is not unduly degraded.

GENERAL

5.1.1 Helmet Mounted Display Type

Description: Details the type of HMD ie monocular, binocular or biocular - A monocular HMD will present an image to one eye. A binocular HMD is designed for the simultaneous use of both eyes and normally provides unique and different image to each eye. A biocular HMD will present the image from a single monocular device to both eyes.

Implementation: HMD Type: *10 characters.*

Example: HMD Type: **Binocular**

OPTICAL

5.1.2 Field of View

Description: The Field of View is dependent on the HMD type and need not be circular for displays. For non-circular Field of Views, the FoV needs to be described more accurately. Provides the generic FoV shape: rectangular, circular or elliptical, and the total horizontal and vertical FoV and tolerances, per ocular.

Implementation: FOV Shape: *10 characters.*
FOV Horz: *3.1 characters, float*°
Tolerance ± : *last significant character, float*°
FOV Vert: *3.1 characters, float*°
Tolerance ± : *last significant character, float*°

Example: FOV Shape: **Elliptical**
FOV Horz: **040°** Tolerance ± 0.02°
FOV Vert: **033°** Tolerance ± 0.15°

5.1.2.1 Binocular overlapping field of view

Description: The proposed EF2000 HMD has a partial overlap where the field of view for each monocular is 30 degrees but the total azimuth field of view is 40 degrees. A complete overlap would be preferable but other compromises (such as mass) of the design should be evaluated against offering this.

Implementation: Binocular overlapping field of view : *3.1 characters float*¯

Example: Binocular overlapping field of view : **030¯**

5.1.3 Image Type

Description: Details the image type either: raster, stroke, or both.

Implementation: Image Type: *20 characters*

Example: Image Type: Raster and Stroke

5.1.4 Exit Pupil

Description: Determines the maximum amount of distance the eye may move horizontally and vertically outside the design eye position and maintain an image on the retina.

Implementation: Exit Pupil Horz ±: *2 characters, unsigned integer* mm
Exit Pupil Vert ±: *2 characters, unsigned integer* mm

Example: Exit Pupil Horz ±: **8** mm
Exit Pupil Vert ±: **8** mm

5.1.5 Eye Relief

Description: Determines the minimum distance to the centre of the design eye position from the display surface.

Implementation: Eye Relief: *3 characters, unsigned integer.* mm
Tolerance ± : *2 characters, unsigned integer* %

Example: Eye Relief: **61** mm
Tolerance ± : **1** %

5.1.6 Display Focus

Description: Provides the distance for display focus, it may be quoted in meters, or as a variable between two distances.

Implementation: Display Focus: *40 characters.*

Example: Display Focus: **Variable: 20 Metres to Infinity**

5.1.7 Combiner Type

Description: Details the HMD image combiner type.

Implementation: Combiner Type: *40 characters*

Example: Combiner Type: **Visor Projected Dichroic Patch**

5.1.8 Optical Transmission

Description: Provides the percentage amount of transmission through the optical axis of the display.

Implementation: Optical Transmission: *3 characters, unsigned integer* %

Example: Optical Transmission: **80** %

5.1.9 Display Luminance

Description: Helmet Mounted Displays which encounter high levels of ambient illumination should have a luminance, which should be such that displayed imagery (both sensor and computer generated) will remain clearly visible under all ambient lighting conditions. {High levels of ambient illumination is in the order of 100,000 Lux (9294 ft-L)}. The most demanding requirement for 'day' legibility is for sun forward and dusk (these lighting conditions are utilised in the PJND Model). Under night ambient lighting conditions display luminance levels are typically set to 0.35 Cd/m**2 (0.1 ft-L). There should be smooth control of luminance between the extremes.

5.1.10 PJND/Contrast

Description: There are two techniques of expressing the visual performance of displays. ie that of using the ratio using CJND/PJND which is preferred or of using contrast ratio.

5.1.11 Grey Levels

Description: The number of grey levels required will depend on the application of the display. If sensor imagery is to be projected on the display then at least 64 grey levels should be available. Elementary symbology/sighting displays will require only a single grey level (ie, peak luminance).

5.1.12 Display Chrominance

Description: The display may be monochrome, partial colour or full colour. The option chosen will depend on the application of the display. Colour co-ordinates should be as defined in 3.5.

5.1.13 Collimation Error

Description: Details the amount of allowable collimation error within the FOV, The collimation error is the angular error associated with a line of sight emanating from the optical system, compared with an adjacent line of sight or assigned reference line of sight.

Implementation: Collimation Error: *1.2 characters, float* mRad

Example: Collimation Error: **1.25** mRad

5.1.14 Binocular Parallax

Description: For a binocular/biocular HMD, at design eye and across the exit pupil. This is just as important a specification item for HMD's as HUD's. The binocular parallax tends to degrade away from the boresight but should still remain with the comfort limits of normal vision. Targets for binocular parallax performance should be similar to HUD's :

Implementation: Horizontal Binocular Parallax (Disparity):
Convergence: *2.2 characters float mRadians*
Divergence: *2.2 characters float mRadians*
Vertical Binocular Parallax (Disparity) also called
Dipvergence or Supervergence:
2.2 characters float mRadians

Horizontal Binocular Parallax (Disparity):
Convergence: *2.5 mRadians*
Divergence: *1.5 mRadians*

Vertical Binocular Parallax (Disparity) also called Dipvergence or Supervergence: *1.5 mRadians*

These figures will also take into account image rotation differences between each channel.

5.1.15 Resolution

Description: This can be stated in terms of line-width, chromatic line spread and also Modulation Transfer Function Value - MTF value.

The line width should be provided with the display source line width included (e.g. CRT) and can be stated at 25%, 50%, 75% of peak.

Implementation: Chromatice Line Spread:
Horizontal: *2.2 characters float mRadians*
Vertical: *2.2 characters float mRadians*

Across: 10 characters spectrum

Example: Chromatic Line Spread:
Horizontal: **1.3** mRadians
Vertical: **1.3** mRadians

Across: P53 spectrum

The chromatic linespread should be stated using the spectrum emission of the display source. The optic can be re-focussed between vertical and horizontal since the eye can cope with this (astigmatic focus) to some degree but the system must not be re-focussed between wavelengths.

The MTF figures are generally calculated independent of the display source (i.e. optical system only) although there are methods to allow for discrete and continuous display types. The polychromatic MTF should be stated over the display source bandwidth and should be weighted according to the spectrum profile.

Implementation: Modulation Transfer Function (MTF)

	20cycles / mm	40cycles / mm	50 cycles /mm
MTF (Vertical):	*1.2 characters float*	*1.2 characters float*	*1.2 characters float*
MTF (Horizontal)	*1.2 characters float*	*1.2 characters float*	*1.2 characters float*

Example: Modulation Transfer Function (MTF)

	20cycles / mm	40cycles / mm	50 cycles /mm
MTF (Vertical):	**0.9**	**0.7**	**0.5**
MTF (Horizontal)	**0.95**	**0.85**	**0.65**

Note: MTF is sometimes stated as a percentage and may be specified in cycles per mR.

5.1.16 System Accuracy

Description: This should be treated as total system accuracy and should include the head tracking system. This will affect the overlay of the image with the outside world and is important for target acquisition and flying with the use of night vision enhancement systems (e.g. image intenisfiers and head slaved FLIR).

Specification figures should be similar to HUD's

System accuracy should be looked at for the boresight and also around the display and also around the field of view of the cockpit since all will vary. It is very important to treat the system as a whole and try to establish the systems specification.

System accuracy will take into account:

- Head tracking errors
- Collimation errors
- Magnification errors
- Image rotation errors
- Boresight errors
- Latency
- Update rate

Implementation: Boresight accuracy:

Vertical : *2.2 characters float mRadians*

Horizontal : *2.2 characters float mRadians*

Accuracy @ 2/3rds total field of view:
Vertical : *2.2 characters float mRadians*
Horizontal : *2.2 characters float mRadians*

Example: Boresight accuracy:
Vertical : **01.0** mRadians
Horizontal : **01.0** mRadians

Accuracy @ 2/3rds total field of view:
Vertical : **05.0** mRadians
Horizontal : **05.0** mRadians

5.1.17 Head Tracking System

Description: This is an intrinsic part of the helmet display system and should not be forgotten.

Specifications for head tracking systems include:

5.1.17.1 Head Tracker Update Rate

Implementation: Up-date Rate: *3 characters Hz*

Example: Up-date Rate **100** Hz

5.1.17.2 System Accuracy

Description: This contributes to the HMD system accuracy and should be included in the overall system error budget. The error should be stated as RMS or 3 sigma

Implementation: Head Tracking System Accuracy: (RMS or 3 sigma):
Boresight:
Azimuth : *2.1 characters float mRadians*
Elevation : *2.1 characters float mRadians*
Roll: *2.1 characters float mRadians*

Measurements made at aircraft boresight
Azimuth : *2.1 characters float mRadians*
Elevation : *2.1 characters float mRadians*
Roll: *2.1 characters float mRadians*

Measurements made at aircraft azimuth 3.1 characters float degrees
elevation *3.1 characters float degrees*

Example: Head Tracking System Accuracy (RMS):

Boresight:

Azimuth : **01.1** mRadians
Elevation : **01.1** mRadians
Roll: **01.1** mRadians

Measurements made at aircraft boresight

Azimuth : **01.1** mRadians
Elevation : **01.1** mRadians
Roll: **01.1** mRadians

Measurements made at aircraft azimuth 20.0 degrees
elevation **20.0** degrees

5.1.17.3 Angular Coverage

Implementation:

Azimuth *3.1 characters float degrees*
Elevation *3.1 characters float degrees*
Roll *3.1 characters float degrees*

Example:

Azimuth: **3.1** characters float degrees
Elevation **3.1** characters float degrees
Roll **3.1** characters float degrees

5.1.17.4 Latency

Description: Defines the latency of the headtracking data

Implementation: Data latency shall be less than 2.1 characters float ms

Example: Data latency shall be less than 20.0 ms.

5.1.17.5 Headbox

Description: Defines the three dimensional space envelope over which the head tracking system will operate. This may be by reference to a cockpit drawing or it may be defined by providing dimensional information.

Implementation: The headtracker shall operate within the volume defined: (Drawing (ref) or within stated dimensions) Fore/Aft + 3, -3 character integer mm, Left/Right + 3, -3 character integer mm, Up/Down + 3, -3 character integer. All dimensions with respect to design eye.

Example: The headtracker shall operate within the volume defined:
Fore/Aft +800 mm, -200mm
Left/Right +/- 300 mm
Up/Down +50 mm, -100mm

All dimensions with respect to design eye.

MECHANICAL

5.1.18 Percentile Fitting Size and Inter-Pupil Distance (IPD)

Description: Details the percentile range and IPD over which the helmet will fit, including fitting systems.

Implementation:
Fitting Size Minimum: *2 characters, unsigned float* th percentile
Fitting Size Maximum: *2 characters, unsigned float* th percentile
IPD range: *2 characters integer mm to 2 characters integer mm*

Example:
Fitting Size Minimum: **5** th percentile
Fitting Size Maximum: **95** th percentile
IPD range: **59** mm to **74** mm

5.1.19 Anthropometric Features

Description: A more sophisticated method of defining helmet fit is to define a range of anthropometric features. Examples of such features are cornea to brow, cornea to back of head, head width and pupil to top of head dimensions over a population spread.

Implementation: Tabular presentation as below.

Example:

Anthropometric Feature	**5th Percentile (mm)**	**99th Percentile (mm)**
Cornea to brow	5.5	25.0
Cornea to back of head	169.0	203.0
Head width	144.0	171.0
Pupil to top of head	92.5	138.0

5.1.20 Head Supported Mass

Description: Details the total head support weight including liners, helmet, visor, display source, etc. for both day and night.

Implementation: Max Day Head Support Weight: *1.2 characters, float* Kg

Max Night Head Support Weight: *1.2 characters, float* Kg

Example: Max Day Head Support Weight: **2.05** Kg
Max Night Head Support Weight: **2.05** Kg

Guidance on acceptable head supported mass and C of G combinations are given in figure 1 and 2 of AIR STD 61/116/P14.

5.1.21 Centre of Mass

Description: This should be compared against accepted standards. For instance compared with standard aircrew helmets. The Centre of Mass should include the head mass.

Guidance on acceptable head supported mass and C of G combinations are given in figure 1 and 2 of AIR STD 61/116/P14.

5.1.22 Moment of Inertia

Description: Moment of inertia is a key design aim. The term 'moment of inertia' refers to the tendency for the helmet to continue to move even after the wearer has decided to stop head movement. Motion of inertia applies to all head movements be it head rotation or fore/aft/sideward head movement. If moment of inertia is excessive and the helmet is firmly fixed to the head then this will result in strain to the neck muscles; otherwise there shall be some slippage of the helmet on the users head. The overall effect of excessive 'moment of inertia' is to restrict head mobility.

The moment of inertia depends on the mass of the helmet and how this mass is distributed. The further out from the centre of the helmet the mass is distributed the greater the moment of inertia.

Typical wording for a specification regarding moment of inertia :-
"Moment of inertia must be minimised in order to ensure that head mobility remains adequate under all operational conditions."

ELECTRICAL

5.1.23 HMD / Aircraft Disconnect Method

Description: Details the HMD disconnect method from the aircraft, including voltage switching with reference to CRT

Implementation: HMD Disconnect: *40 characters*

Example: HMD Disconnect: **Low Voltage with Arbitrary Connector**

5.1.24 Video Signal Type

Description: see paragraph 8

5.2 HEAD UP DISPLAY

5.2.1 Total Field Of View (TFOV)

Description: Provides the HUD horizontal and vertical TFOV and tolerances. The TFOV is given by the maximum limits of the display field provided by the optic, where the maximum limits may be acquired with eye or head movement, and need not be totally visible from a single viewing point.

Implementation:
TFOV Horz: *3.1 characters, float*° Tolerance ± : *last significant character, float*°
TFOV Vert: *3.1 characters, float*° Tolerance ± : *last significant character, float*°

Example:
TFOV Horz: **30.0°** Tolerance ± **0.01°**
TFOV Vert: **24.5°** Tolerance ± **0.15°**

5.2.2 Instantaneous Field of View (IFOV)

Description: Provides the HUD horizontal and vertical IFOV and tolerances. The IFOV is that part of the field of view that is visible from a single viewing position.

Implementation:
IFOV Horz: *3.2 characters, float*° Tolerance ± : *1.3 character, float*°
IFOV Vert: *3.2 characters, float*° Tolerance ± : *1.3 character, float*°

Example:	IFOV Horz:	**30.0°**	Tolerance ± **0.01°**
	IFOV Vert:	**17.5°**	Tolerance ± **0.05°**

5.2.3 Binocular Overlapping FOV

Description: Provides the HUD horizontal and vertical binocular overlapping FOV and tolerances.

Implementation:	Binocular Overlapping FOV Horz:	*3.2 characters, float*°
	Tolerance ± :	*1.3 character, float*°
	Binocular Overlapping FOV Vert:	*3.2 characters, float*°
	Tolerance ± :	*1.3 character, float*°

Example:	Binocular Overlapping FOV Horz:	**30.0°**	Tolerance ± **0.01°**
	Binocular Overlapping FOV Vert:	**24.5°**	Tolerance ± **0.05°**

5.2.4 Monocular Instantaneous FOV

Description: Provides the HUD horizontal and vertical monocular instantaneous FOV and tolerances.

Implementation:	Monocular Instantaneous FOV Horz:	*3.2 characters, float*°
	Tolerance ± :	*1.3 character, float*°
	Monocular Instantaneous FOV Vert:	*3.2 characters, float*°
	Tolerance ± :	*1.3 character, float*°

Example:	Monocular Instantaneous FOV Horz:	**30.0°**
	Tolerance ± :	**0.01°**
	Monocular Instantaneous FOV Vert:	**17.5°**
	Tolerance ± :	**0.05°**

5.2.5 Head Motion Box (HMB)

Description: Provides the three dimensional region in space surrounding the eye reference point to see the TFOV. A reference position should be defined against which head movement can be measured.

Implementation:	HMB Horizontal:	*4 characters, unsigned integer* mm
	HMB Vertical:	*4 characters, unsigned integer* mm
	HMB Depth:	*4 characters, unsigned integer* mm

Example:	HMB Horizontal:	**125** mm
	HMB Vertical:	**56** mm
	HMB Depth:	**200** mm

5.2.6 Design eye

Description: Provides the eye reference point from which mechanical and optical parameters are defined and measured. It is usually defined by an installation drawing showing the installation of the HUD within the cockpit and the relative position of the Design Eye in 3 dimensions. The Design Eye represents the expected nominal pilot centre eye position. It is the position from which the Instantaneous Field of View can be seen.

Implementation: By HUD Installation Drawing.

Example: Not Applicable

5.2.7 Display Line width

Description: Provides the display line width at the eye reference point at 50% display intensity, including tolerance.

Implementation:	Display Line Width:	*1.2 characters*, *float* mRad
	Tolerance ±:	*2 characters, unsigned integer* %

Example: Display Line Width: **1.0** mRad Tolerance ±: **20** %

5.2.8 Display Binocular Parallax Errors

Description: Details the maximum amount of binocular parallax: Convergence, Divergence & Dipvergence error allowable (to see, for example 95% of the points, given 15 pupil positions and 200 field positions).
A HUD provides information from a single display point to both eyes. Due to collimation errors within the optic, a sight line visible to the left eye may be different to that viewed with the right. Where errors of sufficient magnitude exist between the two, an observer may have difficulty viewing the display. The binocular parallax error establishes the difference in angle between the two lines of sight emanating from the optic by deriving the horizontal and vertical error components. The horizontal error includes Convergence where the eyes converge together to view a target image, and Divergence where the eyes are being forced to diverge apart to view a target image. The vertical error is known as Dipvergence and occurs when one eye is forced up to view a

target image and the other eye is forced down to view the same target image. Dipvergence and Divergence are unnatural conditions for the eyes and should have tighter specification limits.

Implementation: Binocular Parallax Convergence Error <: *1.1 characters, float* mRad
Binocular Parallax Divergence Error <: *1.1 characters, float* mRad
Binocular Parallax Dipvergence Error <: *1.1 characters, float* mRad

Example: Binocular Parallax Convergence Error <: **2.5** mRad
Binocular Parallax Divergence Error <: **1.0** mRad
Binocular Parallax Divergence Error <: **1.5** mRad

5.2.9 Boresight Accuracy

Description: Details the allowable tolerance with the boresight accuracy along the optical reference axis.

Implementation: Boresight Accuracy ±: *1.1 characters, float* mRad

Example: Boresight Accuracy ±: **3.0** mRad

5.2.10 Total Display Accuracy

Description: Details the accuracy of the image displayed on the HUD with respect to the eye reference point.

Implementation: 0 - 5 degrees Display Accuracy ±: *1.1 characters, float* mRad
5 - 10 degrees Display Accuracy ±: *1.1 characters, float* mRad

10 - TFOV degrees Display Accuracy ±: *1.1 characters, float* mRad

Example: 0 - 5 degrees Display Accuracy ±: **2.0** mRad
5 - 10 degrees Display Accuracy ±: **3.5** mRad

10 - TFOV degrees Display Accuracy ±: **7.0** mRad

5.2.11 Combiner to Eye Reference Point (ERP) Distance

Description: Provides the distance between the combiner to the eye reference point.

Implementation: Combiner to ERP: *4 characters, unsigned integer* mm

Example: Combiner to ERP: **2431** mm

5.2.12 Combiner / Collimator Off Axis Angle

Description: Provides the combiner / collimator off axis angle.

Implementation: Combiner / Collimator Off Axis Angle: *2.1 characters, float* ^{o}

Example: Combiner / Collimator Off Axis Angle: **34.5**^{o}

5.2.13 Combiner Type

Description: Provides a description of the HUD and Combiner Type

Implementation: Combiner Type: *40 characters*

Example: Combiner Type: **WFOV HUD with Holographic Combiner**

5.2.14 Display Luminance

Description: Head Up Displays which encounter high levels of ambient illumination should have a luminance, which should be such that displayed imagery (both sensor and computer generated) will remain clearly visible under all ambient lighting conditions. {High levels of ambient illumination is in the order of 100,000 Lux (9294 ft-L)}. The most demanding requirement for 'day' legibility is for sun forward and dusk (these lighting conditions are utilised in the PJND Model). Under night ambient lighting conditions display luminance levels are typically set to 0.35 Cd/m**2 (0.1 ft-L). There should be smooth control of luminance between the extremes.

5.2.15 PJND/Contrast

Description: There are two techniques of expressing the visual performance of displays. i.e. that of using the ratio using CJND/PJND which is preferred or of using contrast ratio.

5.2.16 Grey Levels

Description: The number of grey levels required will depend on the application of the display. If sensor imagery is to be projected on the display then at least 64 grey levels should be available. Elementary symbology/sighting displays will require only a single grey level (i.e., peak luminance).

5.2.17 Display Chrominance

Description: The display may be monochrome, partial colour or full colour. The option chosen will depend on the application of the display. Colour co-ordinates should be as defined in 3.5.

5.2.18 Resolution

Description: This can be stated in terms of line-width, chromatic line spread and also Modulation Transfer Function Value - MTF value.

The line width should be provided with the display source line width included (e.g. CRT) and can be stated at 25%, 50%, 75% of peak.

Implementation: Chromatic Line Spread:

Horizontal: *2.2 characters float mRadians*
Vertical: *2.2 characters float mRadians*

Across: 10 characters spectrum

Example: Chromatic Line Spread:

Horizontal: **1.3 mRadians**
Vertical: **1.3 mRadians**

Across: P53 spectrum

The chromatic linespread should be stated using the spectrum emission of the display source. The optic can be re-focussed between vertical and horizontal since the eye can cope with this (astigmatic focus) to some degree but the system must not be re-focussed between wavelengths.

The MTF figures are generally calculated independent of the display source (i.e. optical system only) although there are methods to allow for discrete and continuous display types. The polychromatic MTF should be stated over the display source bandwidth and should be weighted according to the spectrum profile.

Implementation: Modulation Transfer Function (MTF)

	20cycles / mm	40cycles / mm	50 cycles /mm
MTF (Vertical):	*1.2 characters float*	*1.2 characters float*	*1.2 characters float*
MTF (Horizontal)	*1.2 characters float*	*1.2 characters float*	*1.2 characters float*

Example: Modulation Transfer Function (MTF)

	20cycles / mm	40cycles / mm	50 cycles /mm
MTF (Vertical):	**0.9**	**0.7**	**0.5**
MTF (Horizontal)	**0.95**	**0.85**	**0.65**

Note: MTF is sometimes stated as a percentage and may be specified in cycles per mR.

5.2.19 Night Vision Goggle (NVG) Compatibility

Description: Contains the MIL-STD and version for Night Vision Goggle compatibility. Note: the HUD display should be compatible such that it can be seen through the NVG's and any HUD control panel should be compatible such that it does not interfere with the NVG's.

Implementation: MIL-STD NVG Compatibility : *25 characters*

Example: MIL-STD NVG Compatibility **MIL-L-85762 type II class B**

5.3 HEAD DOWN DISPLAY

5.3.1 Display Image Area

Description: Contains the active display image area, vertical and horizontal components.

Implementation: Horizontal: *4 Characters width, Unsigned Integer* mm
Vertical: *4 Characters Width, Unsigned Integer* mm

Example: Horizontal **115** mm, Active Lines **115** mm

5.3.2 Viewing Angle

Description: Contains the viewing angle about the centre of the display image area, without degrading the display quality eg Contrast ratio and MTF.

Implementation: Horizontal: ± *3.2 characters, Float* ^{o}
Vertical: ± *3.2 characters, Float* ^{o}

Example: Horizontal ± **90.00**^{o}, Vertical ± **90.00**^{o}

5.3.3 Optical Filter

Description: Contains the details of the filter fitted to the display surface.

Implementation:

Filter Type	: *25 characters*
Transmission	: *2 characters, integer* %
Wavelength(s)	: *25 characters*

Example:

Filter Type	**Contrast Enhancement**
Transmission	**16** %
Wavelength(s)	**All in Visual Spectrum**

5.3.4 NVG Compatibility

Description: Contains the MIL-STD and version for Night Vision Goggle compatibility.

Implementation: MIL-STD NVG Compatibility : *25 characters*

Example: MIL-STD NVG Compatibility **MIL-L-85762 type II class B**

5.3.5 Dumb / Smart Display

Description: A Smart display is one which contains the interfacing, processing and symbol generator capability to provide the required symbology using high level aircraft data. A Dumb display expects to receive raw display source drive signals which are directly related to the display medium being used. In each case the details of the interface to the display would be defined in an Interface Control Document.

Implementation: Specify display type indicating form of interface.

Example: 1) Dumb display using X, Y and Z (brightness) analogue deflection inputs.

2) Smart display type using MIL-STD-1553 data inputs.

Description: Should specifiy whether the Symbol Generator contains a dumb or smart display.

6 DISPLAY TECHNOLOGY

6.1 CATHODE RAY TUBE (CRT)

6.1.1 Phosphor Type

Description: The phosphor type is generally defined using the JDEC categorisation which identifies phosphors by general characteristics, each with a single letter followed by a number. Although this nomenclature indicate a general phosphor type, where needed, it is best to define specific requirements, such as spectral intensity as below or persistence time.

Implementation: One letter followed by a one or two digit number.

Example: P43.

6.1.2 Phosphor Spectral Intensity Profile

Phosphor Spectral Intensity Profile - SUMMARY ONLY

		R	G	B
Peak Brightness				
5% -	wavelength (nm)			
50% -	wavelength (nm)			
100% -	wavelength (nm)			
50% -	wavelength (nm)			
5% -	wavelength (nm)			

note if monochrome use green

may also reference actual tests and charts

6.1.3 Colour Coordinates

Description: Contains the colour to **CIE 1976**, for four colours. If the display monochrome the colour nearest to the display output hue will be used. Under all specified lighting, temperature, ageing and switch on conditions.

Implementation:

White x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
White y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Red x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Red y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Green x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Green y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Blue x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Blue y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %

Example:

White	x	**0.3500** Tolerance **0.02** %
	y	**0.3500** Tolerance **0.02** %
Red	x	**0.6500** Tolerance **0.02** %
	y	**0.3000** Tolerance **0.02** %
Green	x	**0.3000** Tolerance **0.02** %
	y	**0.5000** Tolerance **0.02** %
Blue	x	**0.1500** Tolerance **0.02** %
	y	**0.1500** Tolerance **0.02** %

6.1.4 Horizontal Jitter

Description: Contains the allowable amount of horizontal image jitter. Not including variations in video timing of synchronisation pulses.

Implementation: Horizontal Jitter < : ± *2 characters, integer* mm

Example: Horizontal Jitter < : ± **1** mm

6.1.5 Vertical Jitter

Description: Contains the allowable amount of vertical image jitter per line. Not including variations in video timing of synchronisation pulses.

Implementation: Vertical Jitter < : *0.2 characters, float* line

Example: Vertical Jitter < : **0.5** line <correct units>

6.1.6 Horizontal Linear Distortion

Description: Provides the maximum allowable amount of horizontal linear distortion, across the image area. No more than 0.5% if this figure will be in more than 10% of the screen horizontal axis.

Implementation: Horizontal Linear Distortion < : *1.2 characters, float* %

Example: Horizontal Linear Distortion < **1.25** %

6.1.7 Vertical Linear Distortion

Description: Provides the maximum allowable amount of vertical linear distortion, across the image area. No more than 0.5% if this figure will be in more than 10% of the screen horizontal axis.

Implementation: Vertical Linear Distortion < : *1.2 characters, float* %

Example: Vertical Linear Distortion < **1.25** %

6.1.8 Diffused Reflectivity

Description: Contains the value for display diffused Reflectivity.

Implementation: Diffused Reflectivity = : *1.2 characters, float* %

Example: Diffused Reflectivity = **0.01** %

6.1.9 Specular Reflectivity

Description: Contains the value for display Specular Reflectivity.

Implementation: Specular Reflectivity = : *1.2 characters, float* %

Example: Specular Reflectivity = **2.01** %

6.1.10 Perceived Just Noticeable Difference (PJND) Values

One Perceived Just Noticeable Difference (PJND) is the smallest difference in luminance and chrominance which can just be perceived. The PJND is composed of Luminance Just Noticeable Difference (LJND) and Chrominance Just Noticeable Difference (CJND). One LJND is the smallest luminance difference that can just be perceived if there is no chrominance difference and one CJND is the smallest chrominance difference that can just be perceived if there is no luminance difference. In order for two colours to be acceptably discernible for utilisation in a cockpit the PJND must be greater than 40 (the actual value will depend on the category of the display {ie, warning, emphasis, complex, status or informative}). The CJND that is required in order to ensure that there is a perceivable chrominance difference is in the order of 10. The PJND and CJND are calculated through measurement of the displays lighting parameters (spectral emission and diffuse and specular reflectivity); these parameters are than passed into a mathematical model which adds the ambient illumination to the display and includes the performance of the eye. Defence Standard 00-970 Leaflet 105/4 and BAe-WSE-RP-EFA-CPT-056 provides further description of the PJND model.

Description: Contains the test values for PJND, sun forward and sun rear. testing the colours white, red, green and blue.
R*eference to PJND :*
R*eference to test documentation :*

Implementation:

White	Sun Forward	= : *2 characters, unsigned integer*
	Sun Rear	= : *2 characters, unsigned integer*
Red	Sun Forward	= : *2 characters, unsigned integer*
	Sun Rear	= : *2 characters, unsigned integer*

	Green	Sun Forward	= : *2 characters, unsigned integer*
		Sun Rear	= : *2 characters, unsigned integer*
	Blue	Sun Forward	= : *2 characters, unsigned integer*
		Sun Rear	= : *2 characters, unsigned integer*
Example:	White	Sun Forward	= **50**
		Sun Rear	= **60**
	Red	Sun Forward	= **24**
		Sun Rear	= **30**
	Green	Sun Forward	= **38**
		Sun Rear	= **47**
	Blue	Sun Forward	= **20**
		Sun Rear	= **24**

6.1.11 Veiling Glare

A specification of the above should be included.

6.1.12 Surface coating of total package

CRT displays suffer from poor contrast under high ambient luminance due to the reflection of the ambient light off the phosphor. Contrast enhancement filters are applied to the surface of the CRT in order to raise the contrast by causing the emitted light from the display, to be absorbed once and the reflected ambient light to be absorbed twice. The most popular contrast enhancement filter is the neutral density filter which absorbs light evenly across the spectrum.

For displays where the frequency of the emitted light is known, a Notched Filter can be used, which absorbs more of the ambient light and transmits the emitted light at the known frequencies.

Avionic displays require anti-reflective coatings to minimise glare and specular reflection. Viewable surfaces of the display shall be coated with a hard anti-reflection coating which shall reduce reflections to less than 0.5%.

6.1.13 Modulation Transfer Function (MTF)

The modulation transfer function is the industry standard measurement of performance and quality for CRT displays. Where the CRT is part of a FLIR imaging system, it is important to be able to calculate the system performance by cascading the MTFs of the component parts (see paragraph 3.2 for a description of MTF).

6.2 ACTIVE MATRIX LIQUID CRYSTAL DISPLAY (AMLCD)

Note: A draft of a standard for colour active matrix liquid crystal displays for military applications is available from the Avionic Systems Standardisation Committee (ASSC) as reference ASSC/130/3/71.

Definitions: Colour Pixel is a number of individual pixels (sub pixels)
Sub Pixel is an individual pixel

6.2.1 Dimming Range

Description: Provides the Dimming range control and ratio over the back light.

Implementation:
Dimming Control: *12 characters*
Dimming Ratio: *8 characters, unsigned integer* : 1

Example:
Dimming Control: **Logarithmic**
Dimming Ratio: **100,000** : 1

6.2.2 Pixel Arrangement

Description: Provides the colour and sub pixel arrangement.

Implementation:
Colour Pixel Arrangement: *6 characters*
Sub Pixel Arrangement: *4*2 characters array*

Example:
Colour Pixel Arrangement: **Quad**
Sub Pixel Arrangement: **RG**
GB

6.2.3 Pixel Defects

Description: Provides the number and arrangement of allowable sub pixel defects over the whole screen area. This encompasses sub pixel failure and yield (on and off) over the total image area.

Implementation:
Central Display Area of Diameter:
3 characters, unsigned integer mm
Total Allowable Sub Pixel Defects:
3 characters, unsigned integer
Shortest Distance Between Sub Pixel Defects:
3 characters, unsigned integer mm

Outside Central Display Area
Total Allowable Sub Pixel Defects:
3 characters, unsigned integer

Shortest Distance Between Sub Pixel Defects:
3 characters, unsigned integer mm

Example:	Central Display Area of Diameter:	**100** mm
	Total Allowable Sub Pixel Defects:	**5**
	Shortest Distance Between Sub Pixel Defect:	**25** mm
	Outside Central Display Area	
	Total Allowable Sub Pixel Defects:	**10**
	Shortest Distance Between Sub Pixel Defects:	**25** mm

6.2.4 Lighting Module

Description: Provides a description of the number and type of lighting modules.

LCD displays are dependent upon their backlights for most aspects of the performance of the display. Backlights should be specified directly or indirectly for the following characteristics:

Luminance Uniformity	- minimise hot spots	- +/- 20%
Reliability	- MTBF	- > 10,000 hrs
Life	- loss of output with time	- < 3% per 1000 hrs
Replaceability?	- if life short	- modular design
Failure Mode	- graceful degradation	- no sudden loss
Redundancy?	- to avoid total loss	- multiple lamps
NVG Compatibility	- effective filters	- MIL-L-85762A

Implementation:	Lighting Module Number:	*2 characters, unsigned integer*
	Lighting Module Type:	*15 characters*
Example:	Lighting Module Number:	**2**
	Lighting Module Type:	**Cold Cathode**

6.2.5 Resolution

Description: Provides a description of the colour and sub pixel resolution.

Implementation:	Colour Pixel Resolution H * W:	*4 & 4 characters, unsigned integer*
	Sub Pixel Resolution H * W:	*4 & 4 characters, unsigned integer*
Example:	Colour Pixel Resolution H * W:	**400** * **400**
	Sub Pixel Resolution H * W:	**800** * **800**

6.2.6 Number of Grey Levels

Description: Provides the number of grey levels per colour.

Implementation: Number of Grey Levels per Colour: *3 characters, unsigned integer.*

Example: Number of grey Levels per Colour: **256**

6.2.7 Update Rate

Description: Provides the image update rate on the display.

Implementation: Update Rate: *4 characters, unsigned integer* Hz

Example: Update Rate: **100** Hz

6.2.8 Colour Coordinates

Description: Contains the colour to **CIE 1976**, for four colours. If the display monochrome the colour nearest to the display output hue will be used. Under all specified lighting, temperature, ageing and switch on conditions.

Implementation:

White x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
White y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Red x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Red y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Green x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Green y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Blue x: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %
Blue y: *1.4 characters, Float.* Tolerance: *1.2 characters, Float* %

Example:

White	x	**0.3500**	Tolerance **0.02** %
	y	**0.3500**	Tolerance **0.02** %
Red	x	**0.6500**	Tolerance **0.02** %
	y	**0.3000**	Tolerance **0.02** %
Green	x	**0.3000**	Tolerance **0.02** %
	y	**0.5000**	Tolerance **0.02** %
Blue	x	**0.1500**	Tolerance **0.02** %
	y	**0.1500**	Tolerance **0.02** %

6.2.9 Horizontal Jitter

Description: Contains the allowable amount of horizontal image jitter. Not including variations in video timing of synchronisation pulses.

Implementation: Horizontal Jitter < : ± *2 characters, integer* mm

Example: Horizontal Jitter < : ± **1** mm

6.2.10 Vertical Jitter

Description: Contains the allowable amount of vertical image jitter per line. Not including variations in video timing of synchronisation pulses.

Implementation: Vertical Jitter < : *0.2 characters, float* line

Example: Vertical Jitter < : **0.5** line <correct units>

6.2.11 Horizontal Linear Distortion

Description: Provides the maximum allowable amount of horizontal linear distortion, across the image area. No more than 0.5% if this figure will be in more than 10% of the screen horizontal axis.

Implementation: Horizontal Linear Distortion < :*1.2 characters, float* %

Example: Horizontal Linear Distortion < **1.25** %

6.2.12 Vertical Linear Distortion

Description: Provides the maximum allowable amount of vertical linear distortion, across the image area. No more than 0.5% if this figure will be in more than 10% of the screen horizontal axis.

Implementation: Vertical Linear Distortion < :*1.2 characters, float* %

Example: Vertical Linear Distortion < **1.25** %

6.2.13 Diffused Reflectivity

Description: Contains the value for display diffused Reflectivity.

Implementation: Diffused Reflectivity = : *1.2 characters, float* %

Example: Diffused Reflectivity = **0.01** %

6.2.14 Specular Reflectivity

Description: Contains the value for display Specular Reflectivity.

Implementation: Specular Reflectivity = : *1.2 characters, float* %

Example: Specular Reflectivity = **2.01** %

6.2.15 Perceptible Just Noticeable Difference (PJND) Values

Description: Contains the test values for PJND, sun forward and sun rear. testing the colours white, red, green and blue.

Implementation:

White	Sun Forward	= : *2 characters, unsigned integer*
	Sun Rear	= : *2 characters, unsigned integer*
Red	Sun Forward	= : *2 characters, unsigned integer*
	Sun Rear	= : *2 characters, unsigned integer*
Green	Sun Forward	= : *2 characters, unsigned integer*
	Sun Rear	= : *2 characters, unsigned integer*
Blue	Sun Forward	= : *2 characters, unsigned integer*
	Sun Rear	= : *2 characters, unsigned integer*

Example:

White	Sun Forward	= **50**
	Sun Rear	= **60**
Red	Sun Forward	= **24**
	Sun Rear	= **30**
Green	Sun Forward	= **38**
	Sun Rear	= **47**
Blue	Sun Forward	= **20**
	Sun Rear	= **24**

6.2.16 Number of colours displayed

The number of colours required to be displayed should be defined.

6.2.17 Viewing angle.

The structure of LCD causes leakage of light (from the backlight) with increasing angle from the normal resulting in reduced contrast and limited viewing angles for full performance. Currently LCD displays can cover a viewing angle of +/- 40^{o} horizontally and $+30^{o}$ -10^{o} vertically. Several manufacturers are working on methods to widen the viewing angle (for example Allied Signal's optical polariser) so that this will no longer be a problem.

Viewing angles are application dependent.

6.2.18 Surface coating

The surface required should be defined.

6.2.19 Pixel Defects

LCD displays should be specified with the minimum number of visible pixel defects that technology, yield and cost will allow. As a minimum there shall be:

- no Rows or Columns failed on or off
- no clusters of failed pixels
- no more than 0.005% random sub pixel failures

A display specification, must use caution when specifying an 'acceptable' level of pixel failures (based upon 1994/95 estimates), since with the passage of time and technology the specification will become out of date.

Where cost limitation and performance relaxation allow a greater number of random sub pixel failures and a limited number of clusters, then a specification could define a central 'priority' region on the display in which such failures would be deemed unacceptable.

6.3 OTHER DISPLAY TYPES

Future revisions of this document will address other display technologies that may be encountered, they include the following. Details of some of the more significant parameters listed should be defined.

LCC Shutter	Phosphor, Number of colours displayed, Viewing angle, Surface coating
Electroluminescent displays	Number of colour displayed, Viewing angle, Surface coating
Plasma	Number of colours displayed, Viewing angle, Surface coating

7 WRITE MODE

7.1 CURSIVE

7.1.1 Cursive Inputs

Description: Provides the inputs to control the cursive mode

Implementation:
X deflection: *2.2 characters*, *float* Volts
Y deflection: *2.2 characters*, *float* Volts
White: *details should be defined*
Red: *details should be defined*
Green: *details should be defined*
Blue: *details should be defined*

Example:
X deflection: *2.2 characters*, *float* Volts
Y deflection: *2.2 characters*, *float* Volts
White: *details should be defined*
Red: *details should be defined*
Green: *details should be defined*
Blue: *details should be defined*

7.1.2 Horizontal Resolution

Description: Contains the number of vertical lines, or pixels, horizontally across the active display area.

Implementation: Horizontal Resolution: *4 characters, unsigned integer* lines or pixels

Example: Horizontal Resolution: **1250** lines
or Horizontal resolution **4096** pixels

7.1.3 Vertical Resolution

Description: Contains the number of horizontal lines, or pixels, vertically across the active display area.

Implementation: Vertical Resolution: *4 characters, unsigned integer* lines or pixels

Example: Vertical Resolution: **1000** lines
or Horizontal resolution 4096 pixels

7.1.3.1 Update Rate

Description: Provides the cursive update date rate for the display.

Implementation: Update Rate: *3 characters, unsigned integer* Hz

Example: Update Rate: **50** Hz

7.1.4 Luminance

Description: Contains the luminance levels at maximum brightness output from the display. Four colours are quoted which will be referenced to the colour coordinate field. If the display monochrome the colour nearest to the display output hue will be used.

Implementation:

White:	*4.2 characters, Float* cd/m^2	
Red:	*4.2 characters, Float* cd/m^2	
Green:	*4.2 characters, Float* cd/m^2	
Blue:	*4.2 characters, Float* cd/m^2	

Example:

White	**500.00** cd/m^2
Red	**200.00** cd/m^2
Green	**200.00** cd/m^2
Blue	**200.00** cd/m^2

Details of day & night requirements should be given.

7.1.5 Contrast ratio

Description: Contains the display contrast ratio under various ambient illumination conditions. All filters should be attached to the faceplate

Implementation: 150,000 lux to 20,000 lux

White > : *3.2 characters, float* : 1
Red > :*3.2 characters, float* : 1
Green > : *3.2 characters, float* : 1
Blue > : *3.2 characters, float* : 1

20,000 lux to 1 lux

White > : *3.2 characters, float* : 1
Red > :*3.2 characters, float* : 1
Green > : *3.2 characters, float* : 1
Blue > : *3.2 characters, float* : 1

1 lux to 0.005 lux
White > : *3.2 characters, float* : 1
Red > : *3.2 characters, float* : 1
Green > : *3.2 characters, float* : 1
Blue > : *3.2 characters, float* : 1

Example: 150,000 lux to 20,000 lux
White > : **4.00** : 1
Red > : **4.00** : 1
Green > : **4.00** : 1
Blue > : **4.00** : 1

20,000 lux to 1 lux
White > : **10.00** : 1
Red > : **10.00** : 1
Green > : **10.00** : 1
Blue > : **10.00** : 1

1 lux to 0.005 lux
White > : **10.00** : 1
Red > : **10.00** : 1
Green > : **10.00** : 1
Blue > : **10.00** : 1

7.1.6 Modulation Transfer Function (MTF)

Description: Contains the MTF contrast index, for the display as a result of a modulating video signal to the input of the display.

$$\text{where } M = \frac{Lmax - Lmin}{Lmax + Lmin}$$

Implementation:
1.0 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.9 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.8 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.7 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.6 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.5 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.4 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.3 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.2 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.1 : *3 characters, unsigned integer* Spatial Frequency per Display Width

Example: 1.0 : **0** Spatial Frequency per Display Width
0.9 : **10** Spatial Frequency per Display Width
0.8 : **20** Spatial Frequency per Display Width
0.7 : **50** Spatial Frequency per Display Width

0.6 : **75** Spatial Frequency per Display Width
0.5 : **100** Spatial Frequency per Display Width
0.4 : **150** Spatial Frequency per Display Width
0.3 : **200** Spatial Frequency per Display Width
0.2 : **300** Spatial Frequency per Display Width
0.1 : **400** Spatial Frequency per Display Width

7.1.7 Line Width

Description: Provides the line width over the usable screen area for all colours, at the required update rate and line writing speed.

Implementation:
0% to 50% Max Brightness, Line Width: *1.2 characters, float* mm
51% to 100% Max Brightness, Line Width: *1.2 characters, float* mm

Example:
0% to 50% Max Brightness, Line Width: **0.34** mm
51% to 100% Max Brightness, Line Width: **0.43** mm

7.1.8 Writing Speed

Description: Provides the writing speed in cursive mode, for drawing lines and symbols. The units used to define the writing speed depend on the display type.

Implementation:
Straight line drawing speed: *2.2 characters, float* mm/µs. (HDD)
Straight line drawing speed: *3 characters integer* degrees/ms. (HUD & HMD)

Symbol drawing speed: *2.2 characters, float* mm/µs. (HDD)
Symbol drawing speed: *3 characters integer* degrees/ms. (HUD & HMD)

Example:
Straight line drawing speed: **1.2** mm/µs. (HDD)
Straight line drawing speed: **200** degrees/ms. (HUD & HMD)
Symbol drawing speed: **0.95** mm/µs. (HDD)
Symbol drawing speed: **200** degrees/ms. (HUD & HMD)

7.1.9 Settling Time

Description: Provides the facility in cursive mode for a variable beam settling time after each writing point positioning activity. Small movements having a reduced settling time, using the law:

$$t = kd + a$$

where: t is the time required in µs before new symbology can be drawn
d is the greater of the x or y distance slewed.
k and a are constants with preset defined values.

Implementation: Settling time k constant =: *2.2 characters, float.*
Settling time a constant =: *2.2 characters, float.*

Example: Settling time k constant =: **4.56**
Settling time a constant =: **12.34**

7.1.10 Video Amplifier Bandwidth

Description: Provides the display stroke video amplifier bandwidth between the -3 dB points. Video bandwidth is normally a parameter which is a small part of the overall system design. If system MTF / resolution are defined then video bandwidth may not be separately specified.

Implementation: Lower Bandwidth Limit: *5 characters, unsigned integer* Hz
Upper Bandwidth Limit: *2.2 characters, float* MHz

Example: Lower Bandwidth Limit **20** Hz
Upper Bandwidth Limit **10.5** MHz

7.1.11 Stroke / Raster Luminance Ratio

Description: Provides the luminance ratio between the stroke symbol and a peak white raster image.

Implementation: Stroke / Raster Luminance Ratio : *1.2 characters, float* : 1

Example: Stroke / Raster Luminance ratio **1.25** : 1

7.1.12 Stroke / Raster Mis-Registration

Description: Provides the amount maximum amount of mis-registration when a symbol is overlays a raster image per display width.

Implementation: Stroke / Raster Mis-Registration *1.2 characters, unsigned integer* %

Example: Stroke / raster Mis-Registration **1.5** %

7.1.13 Stroke Symbol peak to Raster Image peak ratio

for example only 1.3:1

7.2 RASTER

7.2.1 Aspect Ratio

Description: Contains the active display image area, aspect ratio.

Implementation: Aspect Ratio: *5 characters*

Example: Aspect Ratio **4:3**

7.2.2 Gamma

Description: Contains the display Gamma Value.

Implementation: Gamma: *1.2 characters, Float*

Example: Gamma **2.8**

7.2.3 Luminance

Description: Contains the luminance levels at maximum brightness output from the display. Four colours are quoted which will be referenced to the colour coordinate field. If the display monochrome the colour nearest to the display output hue will be used.

Implementation:

	White:	*4.2 characters, Float* cd/m^2
	Red:	*4.2 characters, Float* cd/m^2
	Green:	*4.2 characters, Float* cd/m^2
	Blue:	*4.2 characters, Float* cd/m^2

Example:

	White	**500.00** cd/m^2
	Red	**200.00** cd/m^2
	Green	**200.00** cd/m^2
	Blue	**200.00** cd/m^2

7.2.4 Contrast Ratio

Description: Contains the display contrast ratio under various ambient illumination conditions (see paragraph 3.4).

Implementation: 150,000 lux to 20,000 lux

White > : *3.2 characters, float* : 1
Red > :*3.2 characters, float* : 1
Green > : *3.2 characters, float* : 1
Blue > : *3.2 characters, float* : 1

20,000 lux to 1 lux

White > : *3.2 characters, float* : 1
Red > :*3.2 characters, float* : 1
Green > : *3.2 characters, float* : 1
Blue > : *3.2 characters, float* : 1

1 lux to 0.005 lux

White > : *3.2 characters, float* : 1
Red > :*3.2 characters, float* : 1
Green > : *3.2 characters, float* : 1
Blue > : *3.2 characters, float* : 1

Example: 150,000 lux to 20,000 lux

White > : **4.00** : 1
Red > :**4.00** : 1
Green > : **4.00** : 1
Blue > : **4.00** : 1

20,000 lux to 1 lux

White > : **10.00** : 1
Red > :**10.00** : 1
Green > : **10.00** : 1
Blue > : **10.00** : 1

1 lux to 0.005 lux

White > : **10.00** : 1
Red > :**10.00** : 1
Green > : **10.00** : 1
Blue > : **10.00** : 1

7.2.5 Grey Shades

Description: Contains the display grey shades under various ambient illumination conditions.

Implementation: 150,000 lux to 20,000

White > : *2 characters, unsigned integer*
Red > :*2 characters, unsigned integer*
Green > : *2 characters, unsigned integer*
Blue > : *2 characters, unsigned integer*

20,000 lux to 1 lux

White > : *2 characters, unsigned integer*
Red > :*2 characters, unsigned integer*
Green > : *2 characters, unsigned integer*
Blue > : *2 characters, unsigned integer*

1 lux to 0.005 lux

White > : *2 characters, unsigned integer*
Red > :*2 characters, unsigned integer*
Green > : *2 characters, unsigned integer*
Blue > : *2 characters, unsigned integer*

Example: 150,000 lux to 20,000

White > : **4**
Red > :**4**
Green > : **4**
Blue > : **4**

20,000 lux to 1 lux

White > : **10**
Red > :**10**
Green > : **10**
Blue > : **10**

1 lux to .005 lux

White > : **10**
Red > :**10**
Green > : **10**
Blue > : **10**

7.2.6 Modulation Transfer Function (MTF)

Description: Contains the MTF contrast index, for the display as a result of a modulating video signal to the input of the display.

$$\text{where } M = \frac{\text{Lmax - Lmin}}{\text{Lmax + Lmin}}$$

Implementation:

1.0 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.9 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.8 : *3 characters, unsigned integer* Spatial Frequency per Display Width

0.7 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.6 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.5 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.4 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.3 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.2 : *3 characters, unsigned integer* Spatial Frequency per Display Width
0.1 : *3 characters, unsigned integer* Spatial Frequency per Display Width

Example: 1.0 : **0** Spatial Frequency per Display Width
0.9 : **10** Spatial Frequency per Display Width
0.8 : **20** Spatial Frequency per Display Width
0.7 : **50** Spatial Frequency per Display Width
0.6 : **75** Spatial Frequency per Display Width
0.5 : **100** Spatial Frequency per Display Width
0.4 : **150** Spatial Frequency per Display Width
0.3 : **200** Spatial Frequency per Display Width
0.2 : **300** Spatial Frequency per Display Width
0.1 : **400** Spatial Frequency per Display Width

7.2.7 Video Amplifier Bandwidth

Description: Provides the display raster video amplifier bandwidth between the -3 dB points. Video bandwidth is normally a parameter which is a small part of the overall system design. If system MTF / resolution are defined then video bandwidth may not be separately specified.

Implementation: Lower Bandwidth Limit: *5 characters, unsigned integer* Hz
Upper Bandwidth Limit: *2.2 characters, float* MHz

Example: Lower Bandwidth Limit **20** Hz
Upper Bandwidth Limit **10.5** MHz

7.2.8 Raster Image Symbol Peak to Raster Image Scene Ratio

Details of the above should be included in any specification.

7.3 MATRIX ADDRESSING

7.3.1 Aspect Ratio

Description: Contains the active display image area, aspect ratio.

Implementation: Aspect Ratio: *5 characters*

Example: Aspect Ratio **4:3**

7.3.2 Analogue video signal processing.

Description : The processing will involve conversion of the analogue video signal to a digital signal which can be fed to the matrix display

Implementation : Description of how analogue video signal will be digitised and stored prior to being fed to matrix display. Description of how a digitised signal is fed to matrix display. Description of any artefacts of this process (lag in dynamic images etc.)

7.3.3 Interpolation Method

Description : Where the pixel matrix does not match the analogue video signal in term of number of lines per picture frame then some form of interpolation between lines will have to be incorporated.

Implementation : Description of interpolation method together with discussion of effect of interpolation on image quality.

7.3.4 Grey Level

Description : A matrix display will typically have a finite number of grey levels (between 16 and 256). The grey level law will be chosen to match the response of the eye. (This function is achieved by the gamma in a raster display).

Implementation : Description of the grey level law and justification for its choice.

8 VIDEO STANDARD

8.1 ANALOGUE VIDEO STANDARD

include title, number, issue level and date.

Description: Provides the title, issue and date of the video standard the display complies

Implementation: Analogue Video Standard : *30 characters*

Example: Analogue Video Standard **STANAG 3350 AVS, Edition 4, October 1995**

8.1.1 Number of Lines Per Picture

Description: Filled with the number of lines in the picture, plus the number of active lines.

Implementation: Total Lines: *4 Characters width, Unsigned Integer*
Active Lines: *4 Characters Width, Unsigned Integer*

Example: Total Lines **625**, Active Lines **575**

8.1.2 Line Frequency

Description: Contains the line frequency and the tolerance.

Implementation: Line Frequency: *6 Characters width, Unsigned Integer ,Hz*
Tolerance ±: *1.2 Characters width, Float* %

Example: Line Frequency **15625** Hz, Tolerance ± **0.02** %

8.1.3 Interlace

Description: Contains the interlace, between the frame and the field.

Implementation: Interlace: *1 Character width, Unsigned Integer* :1

Example: Interlace, **2**:1 (non-interlace 1:1)

8.1.4 Field & Frame Frequency

Description: Contains the field & frame frequencies including tolerances.

Implementation:

Field Frequency :	*2 Characters width, Unsigned Integer* Hz
Frame Frequency :	*2 Characters width, Unsigned Integer Hz*
Field Tolerance :	± *1.2 Characters width, Float* %
Frame Tolerance :	± *1.2 Characters width, Float* %

Example:

Field Frequency **50** Hz,	Tolerance ± **0.02** %
Frame Frequency **25** Hz,	Tolerance ± **0.1** %

8.1.5 Waveform Luminance Amplitude

Description: Contains the waveform luminance amplitude, including

Implementation:

Blanking Level:	*1.2 Characters, Fixed, signal* V
Black Level WRT Blanking Level:	*3.2 Characters, Fixed, signal mV*
Sync Level WRT Blanking level:	*3.2 Characters, Fixed, signal mV*
White Level WRT Blanking Level:	*3.2 Characters, Fixed, signal mV*
Black Level Tolerance ± :	*2 Characters, Unsigned Integer %*
Sync Level Tolerance ± :	*2 Characters, Unsigned Integer %*
White Level Tolerance ± :	*2 Characters, Unsigned Integer %*

Example:

Blanking Level	**+0.00** V	
Black Level WRT Blanking Level	**-35** mV	**± TBA** %
Sync Level WRT Blanking level	**-300** mV	**± TBA** %
White Level WRT Blanking level	**+700** mV	**± TBA** %

8.1.6 Aspect Ratio

Description: The ratio of picture width to height

Implementation: Width : Height
2 Characters, Unsigned Integer : *1 Character, Unsigned Integer*

Example: Aspect Ratio : **4:3**
Aspect Ratio : **16:9**
Aspect Ratio : **1:1**

8.1.7 Line to Line jitter

Typically quoted in nanoseconds.

8.1.8 Colour Subcarrier Frequency

Description: The frequency of the Chroma reference frequency burst

Implementation:

Colour subcarrier frequency : *1.8 Characters width, Unsigned Integer MHz*
Tolerance : *1 Character width, Signed Integer %*

Example: Colour Subcarrier frequency : **TBA** %

8.1.9 Display Resolution

The display bandwidth is not necessarily the same as the video bandwidth.

Description: The number of alternate black/white contrast vertical lines, as seen by an observer (computer-based), which can be resolved by the display.

Implementation: Display bandwidth : 4 Characters width, Unsigned Integer Lines

Example: Display bandwidth, **700** lines

8.1.10 Signal Termination Impedance

Description: The characteristic impedance at the interface connector of the display subsystem. Measured at a frequency of 5 MHz.

Implementation: Signal termination impedance : *2 Character unsigned integer*, *Ohms*

Example: Signal termination impedance : **75** ohms

8.1.11 Coupling

Description: The type of video signal coupling employed between the transmission network and the display device.

Implementation: Signal coupling : *2 Characters, Alpha-numeric*

Example: Signal coupling : **AC**
Signal coupling : **DC**

8.1.12 Waveform Chrominance Amplitude

Description: The highest value of Chrominance signal, for colour yellow, that can be accepted and accurately displayed by the display device.

Implementation: Waveform Chrominance Amplitude WRT Blanking Level :
3 Characters, Signed Integer mV

Example: Waveform Chrominance Amplitude WRT Blanking Level :
+ **934** mV

8.1.13 System Timing Control

Description: The method used to ensure that all pictures from video sources or video generators are in synchronisation. Video pictures not in general-locking (GENLOCK) synchronisation may scroll on the display when selected by the pilot. Master synchronisation across the system may be provided by use of a Master Sync Pulse Generator (SPG).

Implementation: System timing control : *30 characters, Alpha-numeric*

Example: System timing control : **Master SPG, GEN-LOCKED**
or : **Uncontrolled**

8.1.14 Other parameters

Details of the following should also be defined: active line period, under / over scanned, number of inputs, loop through, latency.

8.2 DIGITAL VIDEO STANDARD

Description: Provides the Standardisation Authority, title, issue and date of the video standard, with which the display equipment complies.

Implementation: Digital Video Standard : *30 Characters*

Example: Digital Video Standard :
International Telecommunications Union (R), Encoding parameters of digital television for studios, Issue BT 601-5, 1996

8.2.1 Vertical Image resolution

Description: Indicates the number of horizontal raster lines which comprise a frame.

Implementation: Vertical Image resolution : *Unsigned Integer*

Example: Vertical image resolution **625 Lines**

8.2.2 Field rate

Description: Indicates the number of image fields per second.

Implementation: Field rate: *Unsigned Integer*

Example: Vertical image resolution **50 Fields s^{-1}**

8.2.3 Signal Format

Description: Provides an indication of the signal types which are presented for digitisation. Signals which are termed “component” require three signals, directly derived from the Red, Green and Blue constituents of the original images. Signals which are termed “composite” require one or two signals, the reduction in signal requirements being achieved by compositing two of the Red, Green and Blue signals**.**

Implementation: Signal Format : *12 Characters*

Example: Signal Description : **Component or Composite**

8.2.4 Signal Names

Description: Nominates the signals which are to be digitised.

Implementation: Signal Names: *6 Characters*

Example: Signal Names **:** **Y** (Luminance signal) **and**
C_R (Chrominance signal) **and**
C_B (Chrominance signal

8.2.5 Digital Samples per total line

Description: Indicates the number of samples which are taken for each total line of an image.

Implementation: Samples per Line: *Unsigned Integer*

Example: Samples for Line **:** **864** Samples (For Luminance signals) and **432** Samples (For Chrominance signals)

8.2.6 Sampling structure

Description: Defines the scheme to be used to determine where digital samples must be taken.

Implementation: Sampling structure: *Free text, 100 Characters*

Example: Sampling structure **:** Samples are to be Orthogonal, line, field and frame repetitive. Chrominance samples are to be co-sited with odd Luminance sample in each line.

8.2.7 Sampling frequency

Description: Defines the frequency of the sampling clock and thereby the number of samples per second. Sampling rate should be specified for both the Luminance and Chrominance signals, since in may schemes these are not the same.

Implementation: Sampling frequency: *2.2 Characters width, Float, MHz*

Example: Sampling frequency **:** **13.5 MHz** (Luminance signal) **and** **6.75 MHz** (Chrominance signal)

8.2.8 Sample Coding Format

Description: Defines the quantization scheme and the number of bits resolution per sample

Implementation: Sample Coding Format: *Free text, 100 Characters*

Example: Sample Coding Format **:** **Uniformly quantized PCM 8 bits per sample for both Luminance and Chrominancesignals.**

8.2.9 Samples per Digital Active Line

Description: Indicates the number of samples which are taken for the active video (excluding line sync.) portion of each line of an image.

Implementation: Samples per Digital Active Line: *Unsigned Integer*

Example: Samples per Digital Active Line **:** **720** Samples (For Luminance signals) and **360** Samples (For Chrominance signals)

8.2.10 Analogue to Digital Horizontal Timing Relationship

Description: Indicates the time period between the end of digital active video and the start of the next line synchronisation pulse

Implementation: Analogue to Digital Horizontal Timing Relationship :
Unsigned Integer, Luminance clock-periods

Example: Analogue to Digital Horizontal Timing Relationship :
12 Luminance clock-periods

8.2.11 Luminance Signal Quantization scaling

Description: Defines the relationship between the Luminance signal and its quantized value. Reserved quantized codes may be required for Black and peak White, these need to be indicated.

Implementation: Luminance Signal Quantization scaling:
Maximum scaling, *Unsigned Integer*
Black quantization value**,** *Unsigned Integer*
Peak White quantization value, *Unsigned Integer*

Example: Luminance Signal Quantization scaling**:**
Maximum scaling, 0-255
Black quantization value, 16
Peak White quantization value, 235

8.2.12 Chrominance Signal Quantization scaling

Description: Defines the relationship between the Chrominance signal and its quantized value. Reserved quantized codes may be required for the zero signal level, which needs to be indicated.

Implementation: Chrominance Signal Quantization scaling:
Maximum scaling**,** *Unsigned Integer*
Zero signal value**,** *Unsigned Integer*

Example: Chrominance Signal Quantization scaling:
Maximum scaling, 0-225
Zero signal value, 128

8.2.13 Reserved Quantization values

Description: Defines the quantization values which are reserved for synchronisation.

Implementation: Reserved Quantization values**:** *Unsigned Integer*

Example: Reserved Quantization values**:** **Synchronisation 0 and Synchronisation 255**

9 ADDITIONAL FUNCTIONALITY

Additional functionality including details of the following should also be included in any specification :

* Controls
* Soft Keys (eg Input required eg number, boresight
* Rotary Controls eg Contrast, Brightness, Gamma, Symbol Brightness
* Rocker Switches eg on/off, day/night, raster/stroke
* Pause
* Zoom
* Touch Screen
* Comments eg include any further areas of interest - superscan etc.
* Documentation/Reports
* Test/Evaluation
* Lighting Rig
* Integration
* Acceptance
* MTBF
* Details of Supplier, Model, Aircraft Installations
* Documentation
* Contact People eg technical people to contact

10 GLOSSARY OF TERMS

AMLCD	Active Matrix Liquid Crystal Display
ASSC	Avionic Systems Standardisation Committee
BIT	Built in Test
CBIT	Continuous BIT
CCT	Correlated Colour Temperature
CJND	Chrominance Just Noticeable Difference
CRT	Cathode Ray Tube
ELD	Electroluminescent Displays
ERP	Eye Reference Point
EUROCAE	European Organisation for Civil Aviation Electronics
FLIR	
FMECA	
FOV	Field of View
GENLOCK	general-locking
HDD	Head Down Display
HMB	Head Motion Box
HMD	Helmet Mounted Display
HUD	Head-Up Display
IBIT	Initiated BIT
IFOV	Instantaneous Field of View
IPD	Inter-Pupil Distance
LCC	
LCD	Liquid Crystal Displays
LJND	Luminance Just Noticeable Difference
LRI	Line replaceable Item
MTBF	Mean time Between Failures
MTF	Modulation Transfer Function
NVG	Night Vision Goggle
NVIS	Night Imaging Systems
PCM	Pulse code Modulation
PJND	Perceived Just Noticeable Difference
PSD	Power Spectral Density
RTCA	

SBIT	Start -up BIT
SPG	Sync Pulse Generator
STANAG	Standardisation Agreement
TBA	To Be Advised
TFOV	Total Field Of View
WRT	With Respect To