JetSend™ Digital Photography Application Note

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Contents

1. Overview

This JetSend application note for digital photography devices defines how pairs of these devices use the JetSend protocol to exchange digital still images. Please submit comments and questions to this document via the developers feedback section on the JetSend web site: http://www.jetsend.hp.com

1.1 Background

JetSend is a peer-to-peer protocol developed by Hewlett-Packard. An open specification for Internet connected office devices was publicized July 1997. Numerous companies have since then licensed the JetSend technology for their products, and a number of office products with JetSend have been announced.

For more information about JetSend, see the HP JetSend web site: http://www.jetsend.hp.com

HP is currently applying the JetSend technology to IrDA devices, which involves a number of areas:

- Defining how the JetSend protocol works on the IrDA protocol stack (using TTP, IAS, etc.)
- Implementing a lighter protocol stack that will fit in smaller devices
- Refining data types and protocol to accommodate digital photography devices

HP aims at using existing and emerging industry standards for as many aspects of the JetSend technology as possible:

- The IrDA protocol stack is used as a transport between devices with Infrared transceivers [IrDA]
- sRGB is the recommended color space for color devices [sRGB]
- Baseline JPEG is used as the compression mechanism for color images [JPEG]
- Exif 2.1 is recommended as the compressed format for digital photography devices [Exif]

1.2 Scope

This document contains detailed technical information about the protocol and data formats. It does not contain information about the business aspects related to JetSend and digital photography. The target audience is software and firmware engineers that are implementing or evaluating JetSend for their digital photography device(s).

This document describes those parts of the JetSend protocol that are useful to digital photography devices interacting in pairs using IrDA. It describes extensions to the protocol that are not (yet) a part of the JetSend specification posted on the JetSend web site.

It is assumed that the reader is familiar with the overall aspects of the JetSend specification [JetSend]. In particular, the reader should be familiar with e-material negotiation and the image encoding. The JetSend specification is openly available on the JetSend web site. It is important to realize that this document is specific to a digital photography application of JetSend, and thus does not describe all features of the protocol. For example, JetSend contains a mechanism that allows a device to protect access to a device with a PIN code, and gateways can be built that connect infrared devices to Internet devices. These (and other) possibilities are not described here.

The following sections from the JetSend specification are useful background for this document:

- JetSend architectural overview
- E-material formats
- Image encoding (vImage)
- Association encoding (vAssociation)

Most of the information here concerns application level protocol and data formats. See [JetSend] for details on session and transport protocol.

2. Push

Push is a **sender initiated** transfer of information. In its simplest form, this is a transfer of a digital still image or a sequence of images. In more complex interactions, other information might be exchanged such as layout information, audio clips, status information, and remote device control. This section reviews the JetSend mechanism surrounding the transfer of one or more images. The actual image formats are defined in section 3.

2.1 Sessions

Before any interaction can take place between two devices, they must establish a **session**. A session can take place on a number of different **transports**, each with different characteristics. Internet devices will use IP as a transport and addressing is done with IP addresses, hostnames, or directory look-up. Although this applies to some digital photography products, more devices in this class will use a direct-connect transport such as Infrared.

The methods used for JetSend devices to establish sessions using the IrDA transport protocols, and service discovery mechanisms [JS-IrDA] are defined in a separate specification. The remainder of this document discusses the JetSend protocol independent of the transport used—it applies to IrDA, Internet, and other transports.

JetSend can co-exist with other application protocols, such as IrTranP or OBEX, by using IAS, the IrDA service discovery mechanism. If a device supports both JetSend and one or more other application protocols, when establishing a session it should try to do so first with JetSend.

Once a session is established, devices can exchange information using the JetSend protocol. Two devices may exchange device information such as icons and labels, and they may start transferring images or sequences of images. A device indicates that it is capable of receiving, by transferring an *in-surface* to any device to which it connects. Two send-only devices may establish a session; however, since neither of them have *in-surfaces* they may not exchange information. For more detail, see Sections 2, 3.5 and 3.6 of [JetSend].

In the following, it is assumed that a session is established between a sending and a receiving device.

2.2 Single Image

The transfer of an image requires three steps in JetSend, allowing two devices to negotiate the data format for the image:

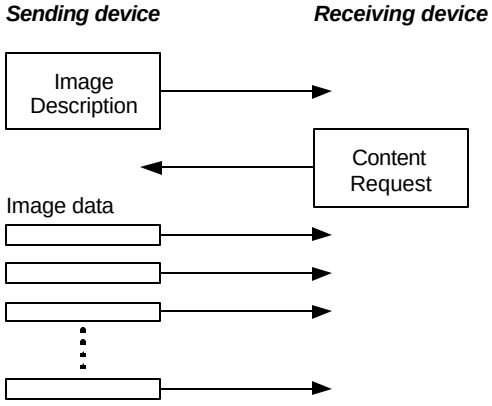

Figure 1: Image Transfer between Sending and Receiving Device

2.2.1 Image Description

The first step is the **image description**, which contains information about salient characteristics of the image data: including pixel dimensions, compression, color space, and more. Section 3.1 contains a summary of these attributes. The syntax in which attributes are defined (and the format of requests and replies) is called *e-material* in JetSend.

For each image attribute, the sending device can offer the receiver choices of formats of the image data. The image description is essentially a menu of data formats (called *encodings*) from which the receiver picks. For example, the sender might offer the receiver a choice between 1) JPEG VGA-size sRGB, 2) JPEG SXGA-size sRGB, 3) uncompressed VGA-size sRGB, and 4) uncompressed SXGA-size sRGB. The description is normally written in a tabular format, like this:

Level	**Attribute**	**Value**
	`vEncoding`	`vImage`
`vImage`	`vColorSpace`	`vSRGB`
`vImage.vSRGB`	`vPixelDepth`	`24`
`vImage.vSRGB.24`	`vResolution`	`vNone`
`vImage.vSRGB.24.vNone`	`vPixels`	`(640,480) (1280,960)`
`vImage.vSRGB.24.vNone.(640,480)`	`vCompression`	`vJPEG vNone`
`vImage.vSRGB.24.vNone.(1280,960)`	`vCompression`	`vJPEG vNone`

Attributes, each describing a given image property, are listed on separate rows. For each attribute, one or more values are listed in the right column—with more than one value listed, the sender is offering the receiver a choice. In the table, the attributes with choices are ***vCompression*** and ***vPixels***. The level column indicates previous choices that apply to a given attribute. This allows the sender to provide different choices for an attribute, depending on previous attributes.

2.2.2 Content Request

The second step is a **content request** from the receiver, containing a choice of which format it wants. It is also written in a tabular format. For example, if the receiver chooses option 3 from above, the content request looks like this:

Attribute	***Value***
`vEncoding`	`vImage`
`vColorSpace`	`vSRGB`
`vPixelDepth`	`24`
`vResolution`	`vNone`
`vPixels`	`(640,480)`
`vCompression`	`vNone`

2.2.3 Content Reply

The actual data transfer takes place with a number of content messages containing the raw image data. At this stage, the sending device may need to perform conversions of the data, depending on which format the receiver picked. The data is flow-controlled by TTP and can be sent to the receiver, as it becomes ready.

The data is fragmented according to the buffer size of the underlying transport—in case of IrDA; this is the negotiated IrLMP packet size. Each device must do SAR (segmentation and reassembly) to a minimum of a 4K buffer size. This is done in the JetSend Session Protocol (JSP). It is also possible for a device to open additional TTP connections for sending streamed data.

For more details on the JetSend protocol's use of the IrDA services, see [JS-IrDA].

2.3 Multiple Images

Sequences of pictures are needed when users of cameras select multiple images for sending. Sequences are encoded as **associations** (encoding: ***vAssociation***) of images. An association is simply a description message that contains references to one or more images (or other associations). A reference is a simple ASCII string that can be used to request a particular image.

The figure below illustrates the association concept.

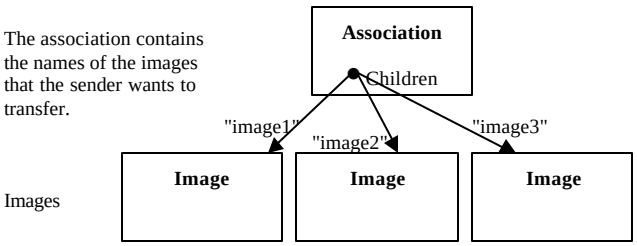

Figure 2: Association Concept

Transferring an association of images requires the sender to send a message to the receiver listing all the image names[1]. Then the receiver requests the images one-by-one. Most receivers will request the images from the first to the last; a few might request them in the opposite order if that is required by their rendering mechanism. When an image is requested, it is sent using the same messages described in the previous section.

[1] There are variations of *associations*, which allows the sender to specify that it has an unknown number of child images. The receiver will request them one at a time until sender says that all the children have been provided.

The figure below illustrates the transfer of three images. The gray boxes indicate a standard single-image transaction as it was defined in the previous section. A separate negotiation of data format takes place for each image.

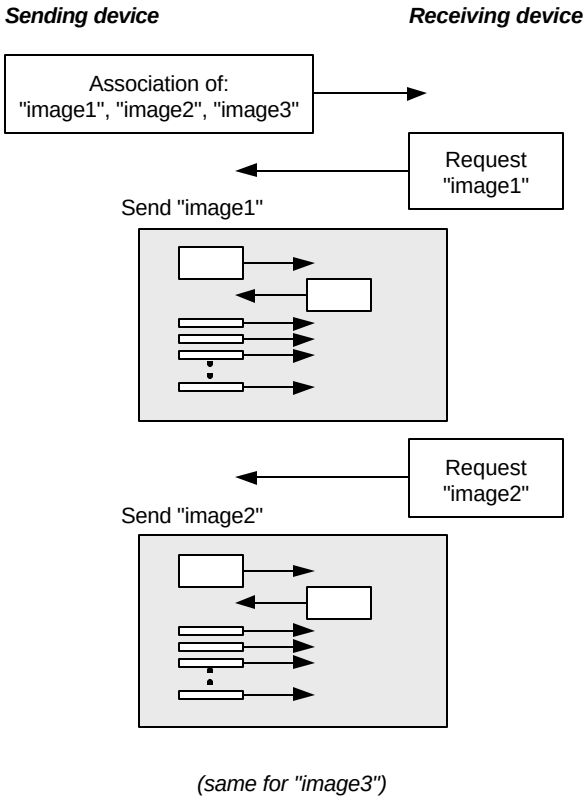

Figure 3: Transfer of 3 Images

It is required that receivers, such as a printer or a camera, support the transfer of multiple images using ***vAssociation***. It is also required that receivers are able to receive the ***vPlane*** encoding, which is used for layouts. However, receivers that cannot process the layout information in a plane are free to ignore it and treat the images on the plane as a simple sequence of pictures.

The following section discusses the format of image descriptions and image data in more detail.

3. Image Formats

JetSend e-material defines a wide variety of image formats: raster images in any combination of color space, pixel depth, compression, resolution, sub-sampling, and so forth can be exchanged between two devices. An overview of the variety of image formats is provided in section 3.1.

To ensure optimum interoperability a small number of image formats are recommended for photography devices.

Two color formats are defined; here they are called photo-1 and photo-2. Photo-1 is uncompressed, byte-interleaved RGB, which is defined in section 3.2. Photo-2 is Exif, which is an image format based on the JPEG File Interchange Format with extensions for digital photography, and is defined in section 3.3. Both are 24-bit per pixel in the sRGB color space.

To maintain compatibility with other imaging devices, the JetSend default encoding **must** be supported by sending and receiving devices. This is required to pass JetSend certification, a condition for use of the JetSend logo. This encoding is 1-bit monochrome; RLE compressed raster, as defined in section 3.4.

It is the intent that all digital photography devices will use photo-1 as a base format when they interconnect with each other. Photo-2 is negotiated for devices that prefer a compressed format for transports such as on IrDA, particularly SIR. It should only be necessary to fall back to the monochrome default encoding in unusual cases of connecting to non-photo devices, such as monochrome printers. Native photography devices will most likely exchange some form of color format using photo-1 or photo-2.

3.1 The “vImage” Encoding

This section contains a brief description of the ***vImage*** encoding. It is defined in detail in [JetSend]; however this section contains a number of extensions that are not part of the current specification.

The key part of the image encoding is the **image description**. Senders use this to offer receivers a choice of encodings. For example, one sender might include three different formats in the description of a given image: photo-1, photo-2, and monochrome.

The image encoding (called ***vImage***) defines a number of **attributes** and **values** that are arranged in a hierarchy. Senders can list more than one value for a given attribute, which is how it presents a choice of two or more encodings to the receiver. For example, a sender might specify “JPEG” and “none” for the ***vCompression*** attribute meaning that it can provide the image in both JPEG compressed and uncompressed formats. This is used for the **negotiation** of image formats.

The following table lists the attributes of interest to digital photography devices and explains their use (refer to [JetSend] for a complete list of all defined values):

Attribute	*Values*	*Comments*
vColorspace	***vSRGB*** ***vGray***	Indicates the color space in which the data is calibrated.
vPixelDepth	1 8 24	The sRGB color space is 24. Gray color space can be either one (1) (bi-level) or 8 (grayscale).
vResolution	***vNone*** X x Y (in dpi)	This can be used to specify a DPI for the data. If the DPI is unknown, ***vNone*** is specified instead.
vPixels	N x M (in pixels)	This indicates the pixel dimensions of the image. ***Note:*** A list of pixel dimensions can be specified if the sender can provide the image in more than one fixed size. This is useful for accommodating a variety of receiving devices, which may prefer images in different pixel sizes.
vCompression	***vNone*** ***vJPEG*** ***vRLE***	The compression method of the data. For ***vNone*** and ***vRLE***, a 32-bit line-alignment of the data is implied (before compression). For ***vJPEG***, the data is in JFIF format. The compression is base-line JPEG encoded as YCrCb.
vSubsampling	"420" "422"	For JPEG compressed images, this indicates the sub-sampling of the data. This attribute is optional—if unspecified, the data may contain any subsampling. (not negotiated)
vComponents	"Exif"	For JPEG data, this attribute indicates more information about what the file contains and how to access the file. If "Exif" is specified, the data is a valid Exif file.
vSize	W x H (in 1/72000 inch)	This indicates the physical size (in inches) of the image. (not negotiated)

3.2 Photo-1 — Uncompressed sRGB

The photo-1 image format is a base encoding for photo devices. It is highly recommended that devices on slow transports (such as SIR) support photo-2 as well, to ensure fast data transfer.

3.2.1 Image Description

The following table shows the details of the photo-1 encoding:

color space	sRGB	
compression	none	Data is encoded as uncompressed RGB, pixel interleaved, with lines padded to a 4-byte boundary.
pixel size	N x M negotiated	This allows the sender to offer the same image in multiple pixel sizes. For example, 640x480, 1024x768, and so on.
physical size	nominal, not actual	The JetSend image encoding requires the specification of a physical size (in inches) for any image (attribute: ***vSize***). For photo devices, this attribute is still specified, though it is considered “nominal” meaning that receiving devices can ignore it if they like.

Example

Below is an example of a minimal photo-1 image description (not including other encodings). The image description is the data that the camera provides to the receiver, which it uses to negotiate the characteristics of the image data before it is transferred:

Level	***Attribute***	***Value***
	vEncoding	vImage
vImage	vColorSpace	vSRGB
vImage.vSRGB	vPixelDepth	24
vImage.vSRGB.24	vResolution	vNone
vImage.vSRGB.24.vNone	vPixels	(640,480) (1024,768)
vImage.vSRGB.24.vNone.(640,480)	vCompression	vNone
vImage.vSRGB.24.vNone.(1024,768)	vCompression	vNone

The example above shows an image that is offered in multiple pixel sizes, 640x480 and 1024x768. The image is provided in sRGB, uncompressed, and with an orientation of 90. The receiving device looks at this information and makes a **content request** for the data in the preferred format. For example, if the receiver is a VGA camera, it will most likely take the 640x480 image using the following content request:

Attribute	***Value***
vEncoding	*vImage*
vColorSpace	*vSRGB*
vPixelDepth	*24*
vResolution	*vNone*
vCompression	*vNone*
vPixels	*(640,480)*

In response, the sender will send the image data in the requested format. This is done using the message (or stream) service defined in the JSP session protocol. See Sections 2.7 and 3.6 of [JetSend] and [JS-IrDA] for a description of these services.

3.2.2 Device Implications

Sending devices that support photo-1 must be able to provide uncompressed data in the sRGB color space. A device that stores its images as JPEG files must be able to decompress the files before they are sent using photo-1. A sending device that supports a different color space than sRGB must be able to process a color transformation into sRGB. High-resolution sending devices that store or produce images that exceed the pixel size limitations given above, must be able to scale the image data to a lower pixel size. Sending devices that produce images that are within the limitations, do not have to scale.

Receiving devices that support the photo-1 encoding must be able to consume the uncompressed data. A printer will pass this data directly to its rendering system. A storage device such as a camera will most likely compress the incoming data as it is written to a file. In the case where the size does not fit the internal constraints of the receiver (due to memory or display limitations), the receiver must either scale (preferred) or crop the incoming data to a suitable size.

Photo-1 is almost identical to the JetSend base color encoding, which is 150dpi uncompressed RGB. Senders can support this easily by pretending that its data is in 150dpi and specifying this in the description. Receivers can look for 150dpi data in the case where they encounter a device not offering a ***vResolution*** of ***vNone***.

3.3 Photo-2 — Exif-Based JPEG

This encoding is defined to allow the exchange of Exif image data using JetSend.

Note: Other variations of JPEG compressed data can be exchanged as well, using optional encodings. The photo-2 encoding is negotiated for devices that support compressed data, which includes most or all of the devices using IrDA transport.

Exif specifies two formats for image data—an uncompressed format and a JPEG compressed format. The latter leverages the JPEG File Interchange Format (JFIF), which is the format contained in photo-2. In short, Exif defined a fixed sequence of JPEG marker segments as well as digital photography extensions that are kept in the APP1 marker segment.

The Exif extensions include:

- Photo-related information (“picture-taking conditions,” shutter speed, aperture, GPS position, and so forth)
- Thumbnail (uncompressed or JPEG compressed)
- Audio segment (for cameras with audio annotation)

3.3.1 Image Description

The following table lists the detailed characteristics of the photo-2 encoding:

color space	sRGB	It is required that the sending device can provide the Exif data as sRGB, not "uncalibrated."
sub-sampling	Default: 4:2:0 centered Optional: 4:2:2, 4:4:4	It is useful for a device to know the sub-sampling of the image data contained in the JPEG file.
compression	Baseline JPEG	
JPEG format	Exif format indicated in description	It is indicated in the description, whether the file is arranged as Exif and if it contains Exif extensions. It can be advantageous for receiving devices to accept not only Exif files, but also other variations of JPEG, such as CIFF or baseline JFIF without extensions.

Example

Below is an example of an image description with the photo-2 encoding:

Level	***Attribute***	***Value***
	`vEncoding`	`vImage`
`vImage`	`vColorSpace`	`vSRGB`
`vImage.vSRGB`	`vPixelDepth`	`24`
`vImage.vSRGB.24`	`vResolution`	`vNone`
`vImage.vSRGB.24.vNone`	`vPixels`	`(640,480)`
`vImage.vSRGB.24.vNone.(640,480)`	`vCompression`	`vJPEG`
`vImage.vSRGB.24.vNone.(640,480).vJPEG`	`vSubsampling`	`"420"`
`vImage.vSRGB.24.vNone.(640,480).vJPEG`	`vComponents`	`"Exif"`

Sending devices that provide their image data as Exif files indicate this in the image description in the ***vComponents*** attribute. If ***vComponents*** is not present, the file is JFIF containing image data as specified in the description.

3.3.2 Device Implications

The pixel sizes and scaling implications for photo-2 are the same as for photo-1. Senders must provide at least one version of any image in a pixel size that will satisfy the limitations—in some cases, this requires senders to scale. Receivers must be able to handle any pixel size that will satisfy the limitations, requiring them to scale (preferred) or crop in the case that a given size is not suitable for the device.

A sending device that provides photo-2 is required to produce JPEG data in the sRGB color space, encoded as YCC, and sub-sampled to 4:2:0 centered. The data can be provided as an Exif file, in which case the sender must supply the ***vComponents*** attribute as indicated above. If desired, the sender may also provide JPEG files without Exif extensions.

Receiving devices must be able to consume the image data in the form provided by the sender and, if necessary, convert it to its native format.

It would be advantageous if receivers are able to handle files *without* Exif extensions in APP1, in case the sender does not provide these extensions. Receivers should also be prepared to handle a different arrangement of the JPEG marker segment than specified by Exif. It is generally very straightforward to generate an Exif file from this information, in the case where it is required by the receiver. In case the receiver cannot interpret a given variation of the compressed data, it must then request the photo-1 encoding.

3.4 Monochrome Encoding (default)

Devices are required to support the default encoding, in order to be certified as conforming to the JetSend protocol specification and thus be eligible to use the JetSend logo.

The encoding is:

1-bit Gray (monochrome), **300dpi**, **RLE compressed** (32-bit line padding before compression)

The exact format for this encoding is defined in [JetSend] Section 3.2.4.

3.4.1 Offering Monochrome

This section describes how the default encoding can be offered alongside the photo encodings. There is some potential confusion when expressing the physical size of an image.

A description of an image offered in both photo-1 and default mono is shown below.

Level	***Attribute***	***Value***
	`vEncoding`	`vImage`
`vImage`	`vSize`	`(460800,345600)`
`vImage`	`vColorSpace`	`vGray vSRGB`
`vImage.vGray`	`vPixelDepth`	`1`
`vImage.vGray.1`	`vResolution`	`(300,300)`
`vImage.vGray.1.(300,300)`	`vPixels`	`(1920,1440)`
`vImage.vGray.1.(300,300)`	`vCompression`	`vRLE`
`vImage.vSRGB`	`vPixelDepth`	`24`
`vImage.vSRGB.24`	`vResolution`	`vNone`
`vImage.vSRGB.24.vNone`	`vPixels`	`(640,480) (1024,768)`
`vImage.vSRGB.24.vNone.(640,480)`	`vCompression`	`vNone`
`vImage.vSRGB.24.vNone.(1024,768)`	`vCompression`	`vNone`

In this case, the (640,480) version of the color image is used to provide the half-toned 300dpi monochrome data using, for example, a 3x3-dither matrix. This results in 1920x1440 pixels of monochrome data, which is used to calculate ***vSize*** for the description (specified in 1/72000-inch), equal to (6.4", 4.8").

Note: This specification allows a non-photo device to receive the information.

Photo devices will ignore the ***vSize*** field when receiving images.

3.4.2 Device Implications

Any given sending device is free to implement its own algorithm, which will provide a monochrome version of its images. Exactly how good this algorithm is designed, is a device choice. HP has demonstrated a simple implementation of half-toning from raw luminance data (the uncompressed Y-component of JPEG'd YCC) in less than 1K of code. This implementation is expected to be publicly available. Sending devices must scale the data to 300dpi. In case this is not possible, the sender can provide the image data in a different resolution and pretend that it is 300dpi, in which case it may be scaled to a different size at the receiver.

Receivers must be able to consume monochrome data. Storage devices (such as cameras) should consider storing the data as monochrome; however, if necessary, it can be converted to the native storage format of the receiving device. If this is a form of JPEG, the receiving device must be aware that JPEG compression can significantly *disturb* a half-toned image.

3.5 Other Formats

As mentioned previously, JetSend allows for a wide range of image formats to be transferred. This section describes a few optional data formats that might be of interest to some digital photography devices.

Note: Support is not required for any of these image formats.

3.5.1 Grayscale

Generating the monochrome encoding involves extracting the gray component from the color data. It is therefore natural for a device that does this to also offer some form of grayscale encoding—it requires little (if any) additional processing to generate. The base grayscale encoding in JetSend is RLE-compressed, 150dpi, 8-bit gray. This base encoding fulfils the expectation for interoperability when the receiver is a monochrome device.

3.5.2 Files

The existing ***vFile*** encoding can be used to exchange files. A potential problem with this encoding is that the image data may contain information that cannot be interpreted by the receiver. For example, a JPEG file can contain a variety of image data, including progressive encoding, uncalibrated color spaces, and sub-samplings that cannot be handled by the receiver. If ***vFile*** is used, these attributes of an image (or another file type) are not visible to the receiver prior to transferring the file. The ***vImage*** encoding exposes interesting attributes to the receiver before transferring data, which means that the receiver knows up-front if it can interpret the information from the sender.

Therefore, the file encoding must be used with care and it is still *required* that the image encodings described previously are supported.

3.5.3 Proprietary Formats

It is possible to exchange proprietary formats between devices from the same manufacturer. The previously described formats must still be supported. Although, it can be advantageous to exchange proprietary formats to optimize the exchange of information and to avoid transcoding between certain pairs of devices. However, it is strongly recommended that manufacturers only implement the encodings defined in the previous sections in the first round of products. This will facilitate resolving initial interoperability issues.

4. References

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[sRGB] IEC TC100, 100/43/NP: Color measurement and management in multimedia systems and equipment, Part 2.1 of approved project 61966 : Color management in multimedia systems — Default RGB color space—sRGB