Bowen Technovation
designers of electronic media

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"Digital Video and Graphics for Planetaria and Exhibits"

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Section 1.0 Workshop Synopsis

As we are heading into an era in which all visual media in the planetarium will be digital, attendees will learn what are current and forthcoming visual file formats and production methodologies. What is MPEG...DVI...when do you import an avi or mov? What are SD files...is 16:9 HD? Why is editing MPEG a bad idea? How do you archive and access digital files? What formats will soon be obsolete and which new ones will stay? Which of the new DVD formats will stick around? Jeff Bowen will share his extensive experience in producing award-winning digital media for education, planetariums, exhibits and broadcast.

Section 2.0 Qualification of Attendees

Number who have worked with video editing?	Number who have worked with Photoshop?
Number who have worked with digital video editing?	Number who use digital playback in the dome?
Number who have worked with digital audio editing?	Number who have worked with digital editing?

Section 3.0 Digital Video Terminology and Specs

Analog Video is represented as a continuous (time varying) signal.
Digital Video is represented as a sequence of digital images.

NTSC Video-
525 scan lines per frame, 30 frames per second (or be exact, 29.97 fps, 33.37 msec/frame)
Interlaced, each frame is divided into 2 fields, 262.5 lines/field. 20 lines reserved for control information at the beginning of each field.
So a maximum of 485 lines of visible data
Laserdisc and S-VHS have actual resolution of ~420 lines
Ordinary TV -- ~320 lines

Frames-
American television is interlaced with a frame rate of just under 30 Hz. The first field of each frame contains only the odd numbered lines of the frame (numbering the top frame line as line 1). The second field contains only the even numbered lines of the frame and is sampled in the video camera 20 ms after the first field. It is important to note that one interlaced frame contains fields from two instants in time, totaling about 60 fields which matches the frequency of power in the US.

In video systems other than television, non-interlaced video is commonplace (for example, most computers output non-interlaced video). In non-interlaced video, all the lines of a frame are sampled at the same instant in time. Non-interlaced video is also termed 'progressively scanned' or 'sequentially scanned' video.

Color-
The red, green and blue (RGB) signals coming from a color television camera can be equivalently expressed as luminance (Y) and chrominance (UV) components. The chrominance bandwidth may be reduced relative to the luminance without significantly affecting the picture quality.

The terms *4:2:2* and *4:2:0* are often used to describe the sampling structure of the digital picture.
4:2:2 means the chrominance is horizontally subsampled by a factor of two relative to the luminance;
4:2:0 means the chrominance is horizontally and vertically subsampled by a factor of two relative to the luminance.

Video Types-
Component Video –
Each primary component is sent as a separate video signal.
The primaries can either be RGB or a luminance-chrominance transformation of them (e.g., YIQ, YUV).
Best color reproduction
Requires more bandwidth and good synchronization of the three components
Composite Video –
Color (chrominance) and luminance signals are mixed into a single carrier wave. Some interference between the two signals is inevitable.
S-Video-
(Separated video, e.g., in S-VHS) -- a compromise between component analog video and the composite video. It uses two lines, one for luminance and another for composite chrominance signal.

Chroma SubSample
4:4:4 --> No chroma subsampling, each pixel has Y, Cr and Cb values.
4:2:2 --> Horizontally subsample Cr, Cb signals by a factor of 2.
4:1:1 --> Horizontally subsampled by a factor of 4.
4:2:0 --> Subsampled in both the horizontal and vertical dimensions by a factor of 2.
4:1:1 and 4:2:0 are mostly used in JPEG and MPEG

Digital TV-
The video scanning formats supported by the ATSC Digital Television Standard are shown in the following table.

Vertical Lines	Horizontal Pixels	Aspect Ratio	Picture Rate
1080	1920	16:9	60I 30P 24P
720	1280	16:9	60P 30P 24P
480	704	16:9 & 4:3	60I 60P 30P 24P
480	640	4:3	60I 60P 30P 24P

The aspect ratio for HDTV is 16:9 as opposed to 4:3 in NTSC, PAL, and SECAM. (A 33% increase in horizontal dimension.) In the picture rate column, the "I" means interlaced scan, and the "P" means progressive (non-interlaced) scan. Both NTSC rates and integer rates are supported (i.e., 60.00, 59.94, 30.00, 29.97, 24.00, and 23.98). At 1920 x 1080, 60I (which CBS and NBC have selected), there will be 1920 x 1080 x 30 = 62.2 millions pixels per second. Considering **4:2:2** chroma subsampling, each pixel needs 16 bits to represent, the bit rate is 62.2 x 16 = **995 Mb/sec.**

Compression-

Codec- COmpressor/**DEC**ompressors (CODECs) are software algorithms/processors used to read and write the digital files.

One thing to watch for when using CODECs to encode a video that you intend to send to someone else is that the video can only be viewed if they have the same CODEC installed on their system.

Intraframe Compression-The first type is typically called **intraframe** compression. When manipulating video using intraframe compression, each individual frame of video is treated separately. As an example, **Motion JPG (M-JPG)** video uses intraframe compression – typically in the range of 8:1 to 40:1. The 8:1 video will look pretty good. The 40:1 video is really just to give you an idea of the image when working with a nonlinear editing system.

Interframe compression- Unlike intraframe compression in that it refers to **changes** in the video data and only carries forward those changes, allowing for highly increased compression. Various forms of **MPEG** video use interframe compression. It is possible to get signals with 200:1 compression rates and a decent picture.

M-JPEG-
Very high quality digital video format adopted for use in production workstations internationally. Methodology allows hi-res video with lotsa color and frame data but with very large file size.

MPEG-
Very low to very high quality digital video format adopted for Digital TV Broadcast internationally. Methodology allows hi-res video with small file size.

Data Rate or Bit Rate
Measured in megabits per second (mb/sec). An initial measure of quality and bandwidth for decoding. A low data rate would be 1-4mb/sec. DVD is 4-9.4 mb/sec. Specialized MPEG decoders and other DV formats run at even as high as 100mb.sec.

Section 5.0 Summary of File Formats

VIDEO v5.1

Format
Support
Uses
Advantages
Disadvantages
Bitrate
Standards

AVI
(Audio Video Interleave)
Windows Media Player (now for Mac too) and RealPlayer; most widely used compressor is Cinepak, free with Video for Windows, though dozens of others are available
Most common format for audio/video data on the PC, as well as very common on the Internet
Data is arranged in chunks, lowering file size; every option is definable from display size and frames per second to bit depth for audio and video; some compressors can achieve up to 100:1 compression
Unless a good compressor is used, transmitting raw files over the Internet is impractical as files are very large
Typically 8 or 16-bit waveform sound in stereo or mono, sampled at 11, 22, or 44.1kHZ; 24-bit color is usual
Microsoft; Open Digital Media (OpenDML) Consortium has defined extensions to support additional features for a more professional video production

DV and Mini-DV
Digital video cameras and non-linear video editing applications
Intraframe compression of digital video
High-quality, raw footage
A range of DV standards have emerged, all based on one format. But they continue to diverge, creating some incompatibilities. This can complicate interfacing and system integration.
On average, 25Mbits/s for video, up to 44.1kHz and 16bit for audio; the HDCAM format records video as high as 100Mbits/s
Each manufacturer has their own particular version of the format.

MPEG
(Motion Picture Experts Group)
*mp4, *.mg4, *mp2, among others

MPEG has produced multiple standards, each with different applications

Numerous applications, including Windows Media Player and QuickTime
MPEG-4 could become the video standard for the web, like MP3 is for audio; MPEG-2 used for DVD codecs generally, and web, satellite and terrestrial broadcast; VCDs use MPEG-1
Maintains impressive quality over very constrained bandwidth; streamable; MPEG-4 compresses at a ratio of up to 10:1 of original DVD-quality size, with little loss; MPEG-4's object-based coding allows interactivity
Was not available for Mac users until recently; MPEG-4 charges licenses for de/encodes under the MPEG LA plan
Varies per standard
All developed by Motion Picture Experts Group; open format distributed by ISO; Joint Video Team still working on MPEG-4

QuickTime
*.mov
Requires free download of QuickTime Movie Player to view; QuickTime Pro can be used for creating and editing
Multimedia tool offering the most creativity and flexibility; many believe it to be the best quality
Can layer up to 99 tracks of audio, video, 3D, text, Flash, HTML, VR; simply embedded into a webpage; superior compression; maintains good quality over constrained bandwidth
Inconsistencies in playback can occur because unlike AVI which bundles audio/video data per frame, QuickTime in larger .5 to 1 second blocks

Apple

RealMedia and RealVideo
*.rm, *.rv
RealPlayer; RealNetworks provides a number of apps for editing, streaming, capturing, and creating
Streaming or direct-downloadable multimedia on the Internet
High compression rate, allowing for small files
Not always backwards compatible with older players; quality can be greatly reduced due to the compression, resulting in artifacts or motion that is not smooth
Handles up to 16bit sound, 24bit color
RealNetworks

Flash and Shockwave
*.swf
Requires free download of Macromedia Flash or Shockwave Player to view, purchase of Macromedia Flash or Director to create, though free 30-day trial versions exist
Integrate interactive content into webpages, or use as movies like the other formats

To each other: Director's interface is simpler, Flash files are more streamlined. Flash content loads almost immediately, Shockwave gives you an ad. Director can be extended with Lingo for interactivity, and can embed Flash content.

To other types: Vector graphics have smaller file sizes; plug-in distributed with every major browser so the majority of your audience should have it (77% and 69% respectively), many print resource guides are available; integrates with all other Macromedia products

Macromedia

The world of video, particularly online, does not seem to be changing as rapidly as still images, but the above list is still not all-inclusive. New formats are still emerging, however. VP5 by On2Technologies, released in February 2002, for example, claims to deliver higher quality at lower bit rates than MPEG-2, MPEG-4, Real 8, Windows Media, and QuickTime, but has yet to take hold.

Listed below is the interoperability of the formats already looked at, with links to more information about the file format.

AVI:
DV and Mini-DV:
MPEG: Since MPEG is an open standard, all major multimedia players support this format, in many including conversion capabilities.
QuickTime: QuickTime Pro can create MPEG-4 files, and can be exported as a DV file in order to work with it in a video editing program such as iMovie.
RealMedia and RealVideo:
Flash and Shockwave: Only playable with Flash or Shockwave player in a browser or within the editing program itself; Flash 5 can export files for RealPlayer or QuickTime.

AUDIO v5.2

Format	Support	Uses	Advantages	Disadvantages	Bitrate	Standards
AAC (Advanced Audio Coding)	Decoder implementations are available from ARM, Cirrus Logic, Fraunhofer IIS, and Texas Instruments	High-quality audio much smaller than MP3; used for all digital broadcasting (SDTV, HDTV, digital radio) in Japan	Claims to be 30% more efficient at encoding than MP3, so a 128kbps AAC file would have the same perceivable quality as a 192kbps MP3; no royalties for content distribution	There is currently no commercial software codec, but the hardware is gaining momentum (Rio, the first maker of portable MP3 players, has bought a license); expensive Dolby licenses	Up to 48 channels with a maximum sample rate of 96kHz	ISO and IEC as part of the MPEG-2 specification
AC3	The standard in DVD audio	High-quality multi-channel audio	Converts 6 channel surround sound into 2, making really high bitrate mp3s; much smaller than aiff and wav; better than CD quality		Up to 448kbps	Dolby
MIDI (Musical Instrument Digital Interface) *.mid	All music composing software, most music editing software, and nearly all synthesizers, though support in computer audio programs is not as widespread	Designed for synthesizers and digital equipment to talk to each other, later developed for the computer	Very small size; if creating from a synthesizer or music composing software, the music will sound the same on all computers since it doesn't take into account different tracks and channels	Lacks specific sound control so though it will sound the same on all computers,after converion it may not sound the same as what you originally wrote	8-bit serial transmission, 31.25kbps data rate	General Midi (GM) by MIDI Manufacturers Association; GS by Roland; XG by Yamaha
MP3 (MPEG-1 layer 3)	Playable in portable MP3 players, or in programs like Winamp, RealPlayer or Windows Media Player; recent audio CD and DVD players	The most widespread form of audio on the Internet; usually downloaded directly, though it can be streamed	Maintains high quality at low bitrates, compressing to 12:1 of waveform audio; streamable	Most audio CD players will not play MP3s burned onto a CD - a separate program is needed to decompress the files into WAV before burning	The bitrate is variable, but typically files are saved at 128kbps - about 1mb per 1min music	Developed under sponsorship by MPEG, formalized by ISO
RealAudio * ra, * ram	Playable through the free RealPlayer as	Most widespread form	Streamable	Since it is compressed so much, the audio may	File is saved according to	RealNetworks

*.ra, *.ram	well as other players and editors from RealNetworks that are available for purchase	of streaming audio		sound like radio or telephone-quality	bandwidth preferences since it is usually streamed: 20kbps for dial-up modems, and as much as 220kbps for T1 lines	
Waveform *.wav	Now readable on Macs (Apple's AIFF format is equivalent to WAV as it is also uncompressed); most systems come with a basic music program that supports WAVs	This is the format audio must be in to be burned for an audio CD	When ripped from CD, it retains all audio data	Since it is uncompressed raw data, very large files result	44.1kHz, 16-bit, stereo	Microsoft
WMA (Windows Media Audio)	Windows Media Player; becoming increasingly widespread on the web	Steaming or downloaded	64kbps files sound just as good as 128kbps MP3 files and are half the size; streamable	Not all audio software and portable devices recognize this format, or will be allowed to due to proprietary restrictions	48kHz, stereo	Microsoft

This is not an all-inclusive list of audio file types. Dozens more are out there, but these seem to be the most popular, or those "on the cutting edge." Some formats would be worth looking at due to their superior compression, but only appeal to a small sector because they are native, proprietary formats. In the case of MDLP formatted audio, it is only used by Sony MiniDisc's Net MD Walkman series. Others work similarly to other, more popular file types, like AIFF (Mac) to WAV (PC).

Listed below is the interoperability of the formats already looked at.

AAC: Encoding used by Universal, BMG and Liquid Audio, but due to different encryption may not be compatible with some software and hardware players; increased interoperability hindered by AAC Licensing Agreement.
AC3: Since AC3 is primarily used for DVD audio, it is not as common on a user-level or on the Internet, but that is changing as many are realizing its superior quality over even CD audio without massive file sizes. A few programs exist to convert AC3 into more popular user-level formats like MP3 and WAV.
MIDI: Designed for interoperability between different synths, but its interoperability with other audio formats is limited.
MP3: A number of independent programs exist to de-encode MP3 to WAV very simply.
RealAudio: As a proprietary format, conversion programs are limited.
Waveform: Numerous freeware and shareware programs exist to convert WAV to MP3 and vice versa, other file formats more limited
WMA: Available programs most commonly convert to WAV, MP3, and OGG. (OGG is an open-format file format from Vorbis that is still in its infancy. It supports 48kHz, 16-bit, multi-channel high-quality audio.)

IMAGE v5.3

Format	Support	Uses	Advantages	Disadvantages	Bitrate	Standards
Bitmap *.bmp	Browsers, various image viewing and editing programs (freeware, shareware, and proprietary)	Works well cross-platform	Flexible image format	Very little is compressed leaving large files	1 bit to 24 bits-per-pixel color data	Microsoft
GIF (Graphics Interchange Format) "jif"	All browsers, most image viewing and editing programs - low to high-end	Images with broad areas of flat color such as comics or logos	Interlacing; transparancy; compression ratio of 4:1 to 10:1; lossless of 256-color images; animated GIFs; palettes	Vertical patterns are not converted well; posterization may occur if the color-depth is too low	8 bits-per-pixel	GIF89a; Unisys retains royalties
JPEG (Joint Photographic Experts Group) "jay-peg"	All browsers, most image viewing and editing programs - low to high-end	Photographs, or any image with transitional tone	Doesn't prejudge how many colors to use, displaying a truer image on any computer; up to 100:1 compression; progressive display	Image quality is compromised with greater compression, resulting in artifacts; doesn't handle straight edges or text very well	24 bits-per-pixel color data	IS 10918-1 (ITU-T T.81)
JPEG 2000 *.jp2	The W3C is not yet behind it, but there are a number of other projects trying to increase its support	Web images, pre-press, medical imaging, security	All of the advantages of JPEG; lossy or lossless compression; security features like watermarking; wavelet compression; Regions of Interest coding	Limited support	Variable, up to 24 bits-per-pixel	Joint Photographic Experts Group; Migrator 2000 developing Intellectual Property Right protection, access control, and more
MNG (Multiple-Image Network Graphics) "ming"	No browser integration yet, but since the W3C is behind PNG it is likely not too far in the future	It is the animated version of PNG, just like GIF supports multiple-image animation	All of PNG's advantages; beats GIF compression ratios by factors of 10 to 100; much smaller file sizes compared to GIF due to sprites and loops	Limited support		Developing a subset of MNG - JNEG (JPEG Network Graphics) for single-image lossy compression
PNG (Portable Network Graphics) "ping"	Varies widely among browsers and programs (list of supporting applications)	Designed to replace GIF, as well as TIFF to some extent	Greater compression than GIFs; alpha channels for variable transparency; gamma correction for system-independent color; 2D interlacing; lossless; patent-free	Not widely supported, though the W3C is behind it	24-bit, grayscale and 8-bit per pixel (where it works best)	PNG Specification 1.2, non-proprietary open-source
SVG (Scalable Vector Graphics)	It is described in XML; Adobe provides a plug-in for Netscape and MSIE, but there are many programs for viewing/editing; W3C supported	Web, wireless devices (with subsets of SVG called SVG Basic and SVG Tiny)	Very small file sizes with mathematical equations; gradients are possible, as are a number of other effects like drop shadows through filters	Few programs, but expected to grow		SVG 1.0 Specification, as recommended by the W3
TIFF (Tagged Image File Format)	Supported by many applications; cannot be embedded into a webpage	Most accepted type for printing	Lossless; colors can be stored in RGB or CMYK and IBM or Mac bit-order	Large files	1 to 64-bit integer signed or unsigned; 32 or 64-big IEEE floating point	TIFF 6.0

There are dozens of different image formats, and these are only a small sampling. They are however, those most widely used, or those primed to become most widely used. Plenty of formats that seemed to have potential didn't, or haven't, gotten off the ground, such as JPEG-LS. There are also numerous formats that are native to only one particular program, such as **Adobe Photoshop's PSD.**

As many formats as there are, there are even more programs to create, edit, and convert them.

Listed below is the interoperability of the formats already looked at, with information about the file format.

Bitmap: Converts well to other image formats.
GIF: GIFs are bad source images for JPEGs because images are color-reduced.
JPEG: Old decoders may not handle progressive JPEG; does not convert well to GIF; some software does exist for

lossless compression.
JPEG 2000: There are a few plug-ins that have been produced for PhotoShop, in which files can be saved in other formats.
MNG: List of applications that support MNG.
PNG: Easy conversion to other image formats due to lossless compression; list of applications that support PNG.
SVG: Increasing numbers of drawing tools export to SVG; can be viewed on many platforms from desktops to handheld devices.
TIFF: Flexible with multiple formats.

TEXT v5.4

Format	Support	Uses	Advantages	Disadvantages	Bitrate	Standards
ASCII *.txt	Any text editor or word processor will open it, the most simple of which are Notepad or SimpleText	Common format for text files in computers and on the net; can be written in ASCII but saved as another type	Extremely small file sizes	Limited formatting capabilities (basically spaces, tabs and returns) and character set	128 possible characters represented by 7bit binary numbers	American National Standards Institute
DOC (Microsoft Word Document)	Microsoft Word, but can be opened by WordPerfect and other higher-end word processing apps	Word processing	Great flexibility in designing the look of a document from varying margins and indentations to tables and bullets	If pictures are included, they are embedded rather than linked, increasing file size		Microsoft / Corel
EBCDIC	IBM OS/390 systems	Text files for IBM S/390 servers; corporations use for and databases.	Supports more characters than ASCII; most common alternate character code	IBM's PCs and workstations don't use it, nor do other OSes; proprietary	256 characters represented by 8bit binary numbers	IBM
HTML (Hypertext Markup Language)	All browsers support HTML, though the advanced features are implemented differently in each and provide non-standard extensions	For view in internet browsers on the World Wide Web, though can be viewed offline	Allows a great deal of control over the look and layout of a document, including animations (dynamic HTML) and interactivity; can combine several computer languages seamlessly; pictures are linked to rather than embedded	In order to take advantage of all the capabilities, learning the coding language is necessary - a WYSIWYG editor will not do it all; older browsers do not support all tags		HTML 4.0 by the World Wide Web Consortium
OEBPS (Open eBook Publication Structure)	Used by a variety of electronic publishing systems and reading devices	Based on XML, HTML, CSS, and Unicode, among others, to define content, structure, and presentation of eBooks	Can embed r ich media but there must be an alternate version (either XML, CSS, JPEG, or PNG) in case the device cannot read it; incorporates accessibility features from HTML; non-proprietary			Open eBook Publication Structure 1.0.1 maintained by the Open eBook Forum
RTF (Rich Text Format)	Can be opened, edited, and saved using MS Word	Allows for more control over the look of the document than ASCII	Since RTF uses ANSI, PC-8, Mac and IBM PC character sets, you can exchange text files between different word processors and different operating systems	Not as much control as MS Word and WordPerfect		RTF Specification
Unicode	NT and Win2000 systems; required by modern standards such as XML, SQL, etc.	Documents to be distributed to users on multiple platforms and countries	A unique number for every character, independent of platform, program, or language - the text will display correctly		34,168 characters in 24 languages	Unicode Worldwide Character Standard, Version 3.0
WPD (Word Perfect)	Windows only	Word processing	Supports hyperlinks and watermarks, HTML, CSS, XML, SGML; customizable macros	Proprietary		Corel
XML (Extensible Markup Language)	Opera browser has most complete implementation, DocZilla has even more, but is still in the alpha phase; MSIE 5.5 and	Used on the Web, but can store any structured info	Non-proprietary; can design own document types (more control); removes complexities of SGML (Standard Generalized Markup Language) while			SGML approved by International Standards Organization; XML specification 1.0 approved by World Wide Web

Netscape 6 support also	retaining flexibility; more linking capability than HTML	Consortium

The majority of digital information is stored textually, so naturally, there are many different text formats. However, in order to increase interoperability between different systems the file types are more flexible than other media types, so the list is shorter. Still, this is not meant to be representative of every text format out there.

ASCII: Unix and DOS-based systems use it; programs to convert to Unicode or EBCDIC exist.
DOC: HTML can be copied and pasted from web browsers, hiding the code while retaining the look; Word allows you to import/save to a number of other different text formats including HTML, RTF, and TXT.
EBCDIC: Programs to convert to ASCII or Unicode exist.
HTML: HTML code can be opened in any text editor or word processor, with all the tags exposed; copied and pasted directly into MS Word from web browsers retains much of the original page's look.
OEB:
RTF: Designed for use on multiple systems.
Unicode: Programs exist to convert into ASCII or EBCDIC.
WPD: Import/export MS Word, Excel, and PowerPoint; PDF.
XML: Can enclose info to pass between systems otherwise unable to communicate.

Section 6.0 Digital Video File Formats In Depth

There are numerous formats for storing video in digital formats. These formats are generally used for the storage and viewing of video by and on computer systems (with the exception of the MPEG formats).

AVI CODEC Formats

There are numerous AVI file formats. All of these other formats involve the use of COmpressor/DECompressors (CODECs) to read and write the AVI file. CinePac and Indeo are common used CODECs. You can view the CODECs installed on your system by going to the Control Panel, activate Sounds and Multimedia, click the Hardware tab, select

MPEG-1

MPEG-1 (Moving Picture Experts Group format 1) is an industry standard encoding format that is widely used. It's normal format is a frame size of 352 x 240 and a constant bit stream of around on megabit per second, a rate well within that of any CD player. MPEG-1 at this size consumes around 10 megabytes for each minute of video, so a typical CD can hold about 1 hour of video.

MPEG-1 is roughly equivalent to VHS in quality, although would might not think so when watched on a computer. Video CDs (VCDs) use the MPEG-1 format, and look good when viewed on a television.

MPEG-2

MPEG-2 is the standard used with DVD and is of a much higher quality than MPEG-1. This format provides for 720 x 480 resolution and with much less loss of detail over MPEG-1. However the file sizes are 3 to 4 times larger than MPEG-1.

A DVD can contain many hours of MPEG-2 video, but the cost of DVD writer are still quite high. MPEG-2 on CD is possible, a format known as SVCD but can only contain about 20 minutes worth of video.

Quicktime

Quicktime is the video format devised by and used by Apple and can be used at varying quality and file sizes. It is quite widely used and influenced the design of the MPEG formats.

Real Video

Real video is a streaming video format used for distributing video in real-time over the internet. With streaming video, you do not have to download the complete file before beginning to watch it. Rather the viewer will download the first section of the video (say a minute's worth) a being the viewing of the video while the remainder download in the background.

Due to typical bandwidth restrictions most people face on the internet, the size and quality of streaming video is usually pretty poor.

Windows Media Format (WMF)

WMF is Microsoft's latest streaming video format replaces ASF. WMF uses MPEG-4 encoding which is designed specifically for streaming media application. WMF provides a high quality audio and a varying quality video stream that is sensitive to the bandwidth selection made at the time of viewing. At the high bandwidth setting, the video quality can be quite reasonable.

Section 7.0 MPEG Basics

History

What is MPEG ?
"Moving Picture Coding Experts Group", established in 1988 to create standard for delivery of video and audio.
MPEG-1 Target: VHS quality on a CD-ROM or Video CD (VCD) (352 x 240 + CD audio @ 1.5 Mbits/sec)

MPEG Video measures differences between frames and only stores the differences.

'Intra' Frames (I-frames) are coded without reference to other frames. Moderate compression is achieved by reducing spatial redundancy, but not temporal redundancy. They can be used periodically to provide access points in the bitstream where decoding can begin.

'Predictive' Frames (P-frames) can use the previous I- or P-picture for motion compensation and may be used as a reference for further prediction. Each block in a P-picture can either be predicted or intra-coded. By reducing spatial and temporal redundancy, P-frames offer increased compression compared to I-frames.

'Bidirectionally-predictive' Frames (B-frames) can use the previous and next I- or P-frames for motion-compensation, and offer the highest degree of compression. Each block in a B-picture can be forward, backward or bidirectionally predicted or intra-coded. To enable backward prediction from a future frame, the coder reorders the frames from natural 'display' order to 'bitstream' order so that the B-picture is transmitted after the previous and next frames it references. This introduces a reordering delay dependent on the number of consecutive B-frames.

Typical pattern is IBBPBBPBB IBBPBBPBB IBBPBBPBB This is called a **GOP…Group of Pictures**
Actual pattern is up to encoder, and need not be regular.

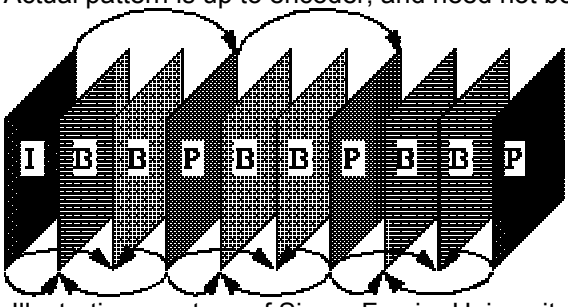

Illustration courtesy of Simon Frasier University.

Higher density of I-frames is higher quality…greater file size.

Not good for editing because so much information is missing between I-frames.

MPEG-2
In MPEG-2, three 'picture types' are defined. The picture type defines which prediction modes may be used to code each block.
Unlike MPEG-1 which is basically a standard for storing and playing video on a single computer at low bit-rates, MPEG-2 is a standard for digital TV. It meets the requirements for HDTV and DVD (Digital Video/Versatile Disc).

MPEG-2 Level Table:

Quality	***Resolution***	***fps***
Low	352 x 288	30
Main	720 x 480	30
High	1440 x 1152	60
High	1920 x 1152	60

Other Differences from MPEG-1:
Besides 4:2:0, also allow 4:2:2 and 4:4:4 chroma subsampling
Scalable Coding Extensions: (so the same set of signals works for both HDTV and standard TV)

Frame sizes could be as large as 16383 x 16383

MPEG-4
Version 1 approved Oct. 1998, Version 2 approved Dec. 1999.
Originally targeted at very low bit-rate communication (4.8 to 64 Kb/sec), it now aims at the following ranges of bit-rates:
video -- 5 Kb to 10 Mb per second
audio -- 2 Kb to 64 Kb per second
It emphasizes the concept of *Visual Objects* --> Video Object Plane (VOP)
Good for video composition, segmentation, and compression; networked VRML, audiovisual communication systems (e.g., text-to-speech interface, facial animation), etc.
Standards being developed for shape coding, motion coding, texture coding, etc.

Section 8.0 DV Basics

History

More than 60 individual companies support the Digital Video (formerly known as Digital Video Cassette or DVC) format. Originally, ten companies agreed to work together to create a uniform tape and video format that could be used in a wide variety of applications. Many of these companies had previously competed and produced proprietary tape formats, leading to consumer frustration andshort life spans for products and technologies.

The original players in the DVC development process included the following: Hitachi, Ltd., Matsushita Electric Industrial Corp (Panasonic), Mitsubishi Electric Corporation, Philips Electronics, N.V., Sanyo Electric Co. Ltd, Sharp Corporation, Sony Corporation, Thomson Multimedia, Toshiba Corporation, Victor Corporation of Japan (JVC), DV and its variants are now used in hundreds of products, and thanks to high-speed transfer technologies such as FireWire (IEEE1394) and Fiber, DV is being used for personal video as well as motion picture, documentary, sports, commercial and other users.

Video data is sampled at 720 pixels per scanline (the same rate as Digital Betacam and D-1 video), although the color information is sampled at a reduced rate (4:1:1 with NTSC and 4:2:0 with PAL).

M-JPEG vs DV

If you've been around computer-based editing for some time, you may be familiar with motion-JPEG compression. DV uses Discrete Cosine Transform (DCT) compression, which is very similar, but provides for improved frame compression or optimization. The result is quality superior to the 5:1 compression that a similar sized motion-JPEG frame would display. Unlike MPEG video, DV uses intraframe (inside the frame) compression to reduce the size of the file being recorded. Each individual frame is compressed and there is no relationship between previous or following frames. Also unlike most other compression formats, DV adds interfield compression as well – small variations between frames are compressed together, providing a higher quality image, while keeping the frame size down.

DVC 25

The file size is approximately 25 megabits per second (25 Mbps). As an example, DVC 50 records at 50 Mbps per second and DVC 100 (or HD) records at 100Mbps per second. DV 25 files are actually larger in size than 25Mbps per second, due to the inclusion of audio, subcode (user bits, timecode, etc.),

Insert & Track Information (ITI), plus error correction. The total file size is approximately 36Mbps per second. DV compression is consistent and file sizes will not vary as a file is recordedor played back.

Section 9.0 Summary

Use the following files fomats for the following applications:

Format	Use For	Not best for
AVI Video	Video Edit Compositing Chromakey Scaling Animation	Presentation Playback because of file size
DV Video	Video Capture Video Edit Compositing Scaling Animation	Chromakey
Quicktime Video	Video Edit Compositing Chromakey Scaling Animation	Presentation Playback because of file size
MPEG 1 Video	Web or Video CD playback	Video projection, plasma, or other large display
MPEG 2 Video	Excellent broadcast and presentation projection, plasma, etc	Editing, compositing, production
MPEG 4 Video	Web playback	Video projection, plasma, or other large display
AC3	5.1 Surround Playback Mac/PC/Other	Stereo
WAV Audio	Stereo playback PC	5.1 Surround Playback
MP3 Audio	Stereo playback Mac/PC other	5.1 Surround Playback
AIFF Audio	Stereo playback on Mac	5.1 Surround Playback

Section 10.0 Credits

Pete's Video.com

R/com Networks-R/com Networks, California.

NIST agency of the U.S. Commerce Department's Technology Administration.

ATSC -- Advanced Television Systems Committee

ISO/IEC 11172: 'Coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s'.

ISO/IEC 13818: 'Generic coding of moving pictures and associated audio (MPEG-2)'.

'Encoding parameters of digital television for studios', CCIR Recommendation 601-1 XVIth Plenary Assembly Dubrovnik 1986, Vol. XI, Part 1, pp. 319-328.

JAIN, A.K.: 'Fundamentals of digital image processing' (Prentice Hall, 1989).

WELLS, N.D.: 'Component codec standard for high-quality digital television', *Electronics & Communication Engineering Journal*, August 1992, **4**, (4), pp. 195-202.

CARR, M.D.: 'New video coding standard for the 1990s', *Electronics & Communication Engineering Journal*, June 1990, **2**, (3), pp. 119-124.

RAO, K.R. and YIP, P.: 'Discrete cosine transform: algorithms, advantages, applications' (Academic Press, 1990).

Section 11.0 From Sky-Skan, Minolta, Evans and Sutherland, Spitz

The following are responses from various planetarium system manufacturers and do not reflect any opinions of Bowen Technovation staff. They are provided here as topics of interest.

Michael Daut: Evans and Sutherland
Digistar 3 renders 3D real-time geometry using the Microsoft DirectX .x file format. There are freely available plug-ins for several modeling packages that allow a .x file to be exported. E&S also provides an enhanced plug-in for 3D StudioMAX which supports the additional features of Digistar 3.

Digistar 3 accepts any valid MPEG2 stream. A MPEG2 stream is defined as a number of 16x16 MPEG blocks. Digistar 3 can playback all-dome video at any resolution, provided that it is evenly divisible by the standard 16x16 MPEG2 block. The only limitation is on the number of blocks / second, which has a maximum of 243000. E&S provides plug-ins for Adobe AfterEffects to create MPEG2 video. If the advanced video editing capabilities of AfterEffects are not required, the E&S application ESVideo may be used instead to create MPEG2 files. It is a very streamlined application that is considerably faster.

Digistar 3 also supports video as a texture on a model. For texture video E&S recommends MPEG1 and AVI but Digistar 3 also supports other common video formats. Digistar 3 can playback any stream, so long as the appropriate DirectShow compatible codec is installed on the system. Digistar 3 also supports streaming Internet video.

Digistar 3 supports 5.1 or 7.1 multi-channel uncompressed .wav files for surround audio. E&S provides a tool which allows you to create the multi-channel .wav files from individual .wav files. It is also possible to attach .wav sound files to objects providing 3-D audio effects. Digistar 3 also supports .mp3 audio files.

The native output resolution for a full Digistar 3 is 1600 x 1200 per projection channel, with six such channels making up a typical system. Digistar 3 supports all-dome video at the native resolution of the display, and does not have to upsample a lower resolution (HD) video stream, although it can do so if the original stream was generated at a lower resolution.

Paul Tetu: Sky-Skan
As I'm sure you are aware, Sky-Skan popularized the Dome Master format that virtually every company in the industry as since adopted. This is the basis of nearly all pre-rendered fulldome systems.

Just like the others who use this format, our system currently plays back dome masters that are encoded as high-definition MPEG2 files. Creation of these files is typically done through a process involving 3D animation work resulting in 5 panels that are then stitched together to form a single dome master frame. The resolution of each panel is what is of interest to producers since it defines how their work can be used now and in the future. Those serious about compatitility and future use are currently producing these panels at resolutions between 3200x3200 and 3600x3600 pixels. Higher resolutions are, of course, possible and are only limited by the computing power and patience the show producer has.

As one who is no doubt experienced in creating MPEGs, you know that the encoding process is not an exact science, but varies depending upon the hardware and software used. Every system uses different hardware and software as well as different codecs. I think that you will also find that the major system manufacturers in the pre-rendered fulldome video field consider the specifics of codecs, etc. highly proprietary as each company has spent months, if not years finding and/or refining codecs for use with their specific system.

For someone who is simply looking to produce pre-rendered fulldome video content, the most important thing to know (from a technical standpoint) is how to set up the 3D animation camera rig -- that is, five cameras for L, F, R, rear, top set at 90 degree angles -- and to produce each rendered panel at a high enough resolution that it will be useable for

the forseeable future. With these panels, any owner of a fulldome video system that receives these files should be able to stitch and slice the panels for use in their own theater.

Shigeki Ogawa and Todd Mortenson: MEDIAGLOBE:
1) "Anything that can be rendered on or for a computer can be shown on the MEDIAGLOBE."
2) "Provide an AVI file and we'll show you how to get from there to projecting your content in "MEDIAGLOBE" format.

Additional information includes:
Codec used: Lygos
"Abbreviated-steps re: content production for MEDIAGLOBE:"
Step 1 - visuals produced, i.e., (3DStudio, Lightwave, etc), then...
Step 2 - stiching software is used for migrating the image to full dome
Step 3 - combining "visuals/graphics" with "audio/sound" files (WAVE files) to create MOVIE file via production software such as adobe AfterEffects, etc.
Step 4 - at the conclusion of steps 1 thru 3, the desired end-result would then be an AVI file (Intel Indo Vedio 5.11 or later version)
Step 5 - compression step: process the AVI using a codec such as Lygos to end up with an MPEG2 file
Step 6 - using MEDIAGLOBE'S STL (script language) the MPEG file can be accessed and consequently projected after "selecting it" on the MEDIAGLOBE Program Menu, via the touchscreen (or remote control PC) running from either the MEDIAGLOBE'S hard-drive (OR) from the CD-R (W) or DVD-R(W)

Resolution: 1024 X 1024 (Safe Area: 1000 X 1000, Title Area: 970 X 970)
Frame rate: 30fps
File Type: MPEG2

Mike Bruno: Spitz, Inc
Scidome--
Fulldome video -- 1024x1024 nested in a 1280x1024 composition
Video in window -- any size up to 1024x1024. Resolution in power of 2 preferred.
Codecs -- any standard windows codec playable by Windows Media Player.
On2's VP6 suggested for high quality.
Audio -- Any interleaved audio, including AC3.

ElectricSky --
Video: 3600x3600 seqentially numbered Targa, 24-bit, RLE compression preferred. Encoding specs vary depending on playback system.
Audio: up to 6 channels of 16 bit, 48khz aiff, wav, for video frame rates of 30fps

ElectricSky II --
Video: 1536x1536 seqentially numbered Targa, 24-bit, RLE compression preferred. No encoding required.
Audio: up to 6 channels of 16 bit, 48khz aiff, wav, for video frame rates of 30fps

Mark Trotter: Bowen Technovation, Inc
AstroFX and ExhibitFX MPEG Servers-
MPEG 2 Video Encoding Parameters. MPEG 2 ISO-13818 Program
Data rates from 1 Mbs to 10 Mbs (1.1 Version Players) Older players up to 6 Mbs
Data rates from 1 Mbs to 16 Mbs (2.1 Version Players)
GOP Adjustable from 1 to 15, Full IBP, IP or I only.. GOP markings are preferred.

Video Resolution: NTSC 720-480, 30 fps Full D1 SIF
Audio Sampling: NA Mono, Dual Mono,Stereo or Joint Stereo Sampling rates of 44.1 kHz or 48 kHz.

AstroFX players support MPEG Layer 1 or Layer 2 and multiplexed with Video in either System or Program stream. AstroFX players are designed to play high performance MPEG 2 MP/ML ISO13818 constant bit rate files and decode them to analog NTSC video format.

AstroFX and ExhibitFX MediaManager Real Time Servers-

MediaManager supports and plays back nearly all forms of all file types discussed in this paper for still image graphics, motion video, and stereo and 5.1 audio. Resolutions up to 3000 x 3000 have been verified in single screen and three screen Barco projection configurations and up to thirty-two 1024 x 1024 simultaneous plasmas displays.