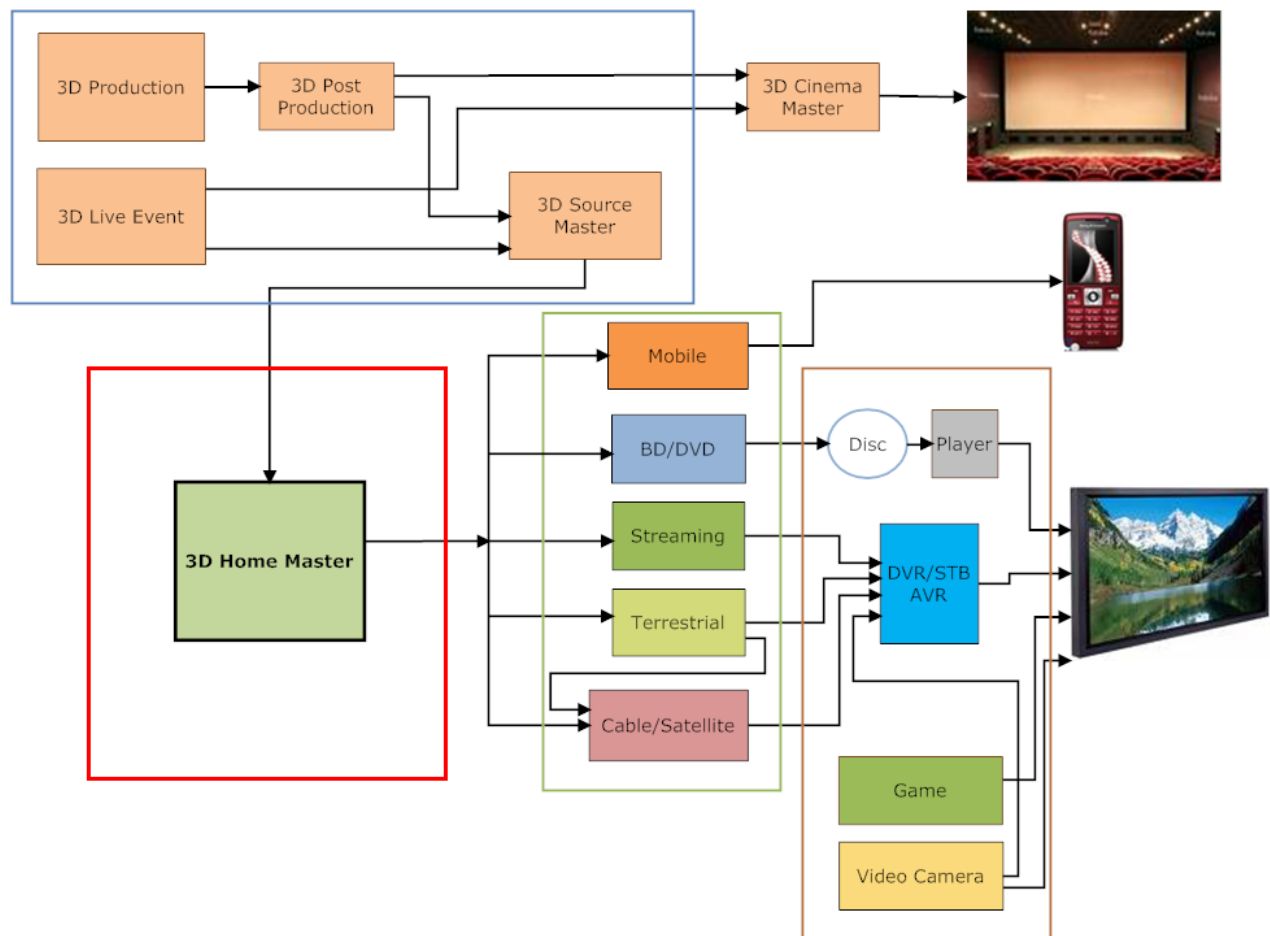




Society of Motion Picture and Television Engineers

REPORT OF SMPTE TASK FORCE ON 3D TO THE HOME





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Edited and laid out by SMPTE Task Force on 3D to the Home.

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1 INTRODUCTION

This report has been generated by the SMPTE Task Force on 3D to the Home. The effort was initiated on Aug 19, 2008. At the initiation of the effort, the task force was chartered with defining “what standards would be needed to establish rapid adoption of stereoscopic A/V content from content mastering to consumption in the home via multiple types of distribution channels (e.g., packaged, broadcast, satellite, cable, internet) with consideration for downward scalability (e.g., portable/mobile).” The charter was broad and potentially included standards for content mastering and distribution formats, common interfaces for 3D display, performance requirements related to human factors, and backwards compatibility related to distribution infrastructure and legacy devices.

During the initial phase of this effort, the task force redefined the scope and goals of the effort to be more sharply focused, and to specifically address the standards needed for the 3D Home Master that would be distributed after post production to the ingest points of the distribution channels, e.g., Blu-ray Disc or DVD authoring facility, or an ingest center of a broadcast operator. The 3D content will be rendered on different types of 3D displays. It is important to note that neither the 3D Home Master itself, nor the format used to store/represent 3D content in the Master is meant for distribution to the home. The ingest point in each of the types of distribution networks are expected to convert the content in the 3D Home Master into the appropriate format as needed by the distribution system.

The 3D Home Master is defined later in the document to be an “uncompressed and unencrypted image format or file package derived from a 3D Source Master. The 3D Home Master is intended to be used in the creation of 3D Distribution Data.” The primary objective of the task force has been to generate requirements for the 3D Home Master, which would drive specifications for the 3D Home Master in a subsequent phase of SMPTE standardization activity.

The task force first identified various use cases from the perspective of various entities in the supply chain of the 3D content to the home, and those use cases that had an impact on the format of the master were used to generate requirements. In generating use cases, priority was given to distribution via physical media, broadcast channels, and online mechanisms. Consumer viewing of the content on TV-type devices was also given a higher priority than viewing on mobile devices such as mobile phones and in-car devices. However, the task force did consider use cases and requirements that included downward scalability (e.g., portable/mobile).

The report is organized as follows:

- Section 2 presents a definition of terms and concepts that are used in this report.
- Section 3 presents a high level description of the end-to-end supply chain of the 3D content, and defines the scope of the task force's consideration in view of this high level view of the chain.
- Section 4 lists use cases considered by the task force, and also whether and to what extent each use case impacts the specification of the 3D Home Master.
- Section 5 lists the requirements for the 3D Home Master as identified by the task force for consideration in a subsequent standardization effort by SMPTE to generate technical specifications for the master.
- Section 6 provides additional context to the completed effort of the task force and lists specific areas that were not considered due to the nascent aspect of the field. Caveats and areas for further study are indicated.
- Section 7 contains recommendations on standardization activity that SMPTE needs to pursue to support commercially successful deployment of 3D content to the home.
- The report includes an appendix that cross-references the use cases to the requirements generated by the task force. This is meant to provide the subsequent standards generation activities detailed context for the requirements.

2 GLOSSARY

To ensure that discussions and documents within the SMPTE 3D Task Force remain coherent, the following 3D terminologies are suggested. Some of the terms have been adopted from previously published glossaries and documents. References indicate the original sources of definitions, however, almost all definitions have been edited slightly from their referenced version. Other terms have been generated in order to be specifically unambiguous, especially in cases where ambiguous terms have been popularly used with multiple definitions. These definitions have no references.

Since terminology in this field is continuing to evolve and is also being addressed/established in other standards groups, future work by SMPTE in this area should also ensure that the terminology used by SMPTE is aligned with terminology that is used in other standards groups and industry forums to the extent possible.

2.1 *Display Types*

Stereoscopic Display Systems: Systems that provide a binocular depth cue, the sense of depth due to different images reaching the left and right eye.

GB3D: Glasses-based 3D display (both active and passive).

AGB3D: Active glasses-based 3D display (e.g., LCD shutters).

PGB3D: Passive glasses-based 3D display (e.g., polarized, anaglyph).

When GB3D devices are used to direct a Left eye and a Right eye image into the appropriate eye, the display is also known as **Plano-Stereoscopic** [2].

NG3D: Non-glasses-based 3D display (also known as “**Auto-stereoscopic**”).

MPPP: Multiple pixels per point (e.g., lenticular, parallax barriers, and various multiple projector displays).

SPPP: Single pixel per point, where a single pixel is time-multiplexed and actively steered to generate the light field (as in the USC ICT 360 degree light field “spinning mirror” display, or displays that steer pixels via electrowetting systems or micro-mirrors).

HMBD: Head Mounted Binocular Display

Holographic Display: A 3D display that is based on spatial light modulation using a pattern of light wave interference.

2.2 *Image Format Representations*

Image: A digitized representation of the 2D optical projection of a 3D scene - comprising a 2D set of image points or pixels. The representation includes scene brightness as a scalar valued function at each point at a minimum and may include color information as a vector valued function at each point [16].

Image Frame: A 2D representation of an image resulting from a specific sampling structure. This representation allows the frame to be divided into multiple **Image Fields** [16].

Image Field: A component of an image frame. One or more image fields comprise an image frame.

Le/Re: Left eye and right eye images of a scene, also known as **stereo** images.

Image Pair: A pair consisting of a left eye image and the corresponding right eye image, also called **Stereoscopic Image Pair**.

Stereoscopic Image Pair: same as **Image Pair**.

Stereoscopic Content: same as Stereoscopic **Image Pair**.

Multiview: More than two images of a scene.

2D+Depth: A single image along with depth data of a scene, also known as **2D+Z**.

2D+DOT: A single image along with **depth**, **occlusion**, and **transparency** data of a scene.

2D+Delta: A single image along with data that represents the difference between that image view and a second eye image view along with other additional metadata. The delta data could be spatial temporal stereo **disparity**, temporal predictive or bidirectional motion compensation.

Stereo+Depth: Le/Re images along with depth data of a scene, also known as **Stereo+Z**.

Stereo+2Z: Images obtained and depth maps measured from two separate camera images of a scene.

2.3 *Basic Concepts*

3D Content: Content which results in two or more simultaneous views of a scene to create the perception of depth at the display.

Absolute Parallax Transition Limit: The maximum rate of parallax change (dZ/dt) that allows a viewer to fuse views into a 3D image [13].

Accommodation: The ability of the eyes' lenses to change shape in order to focus [2].

Accommodation/Vergence Relationship: The relationship between the focusing of the eyes and verging of the eyes when looking at a particular object point in the visual world [2]. When accommodation and vergence match, the time required to fuse stereoscopic stimulus is reduced, distortions in perceived depth are reduced, and viewer fatigue and discomfort are reduced [10]. Also called the **accommodation/convergence relationship**, or the **convergence accommodation relationship**.

Anaglyph: A selection device that uses complimentary colored images and color filters [2].

Binocular Symmetries: Identical visual parameters between a stereo pair of left and right eye images with the sole exception of horizontal disparity (parallax). The symmetrical parameters consist of illumination, focus, geometry, color, registration and temporal symmetry.

Blur Gradient: In real scenes, the retinal image is sharpest for objects in focus and blurred for objects not in focus. In many 3D display systems with flat screens, the entire screen is in focus at all times, reducing the Blur Gradient depth cue [8].

Camera Parameters: These parameters completely determine the transformation between 3D coordinates in the world reference frame of an object being imaged by a camera and the 2D image plane coordinates of the resulting image.

Intrinsic Camera Parameters: A set of parameters that relate the geometry of ideal perspective projection to the physics of the camera. These parameters consist of the camera constant f (the distance between the image plane and the lens), the principal point which is the intersection point of the optic axis with the image plane in the measurement reference plane located on the image plane, the geometric distortion characteristics of the lens, and the horizontal and vertical scale factors, i.e., distances between rows and between columns. In the field of Analytic Photogrammetry, this set of parameters is also called the Interior Orientation or the Inner Orientation of the camera [14], [15].

Extrinsic Camera Parameters: A set of parameters that determine the pose of the camera in the 3D world reference frame. The parameters determine the rigid body transformation between the world coordinate frame and camera-centered 3D coordinate frame. In the field of Analytic Photogrammetry, this set of parameters is also called the Exterior Orientation of the camera [14], [15].

Color Rivalry: A condition where the color information of homologous points creates a depth cue that is inconsistent with other depth cues, notably parallax. Note that this does not imply that the color information of multiple points must be the same [13].

Convergence: The inward rotation of the eyes, in the horizontal direction, producing **fusion**. The more general term is **vergence**, which includes inward and outward rotation [2]. Convergence is also sometimes used to refer to the **toe-in** of stereo cameras.

Corresponding Points, Conjugate Points, or Homologous Points: The points imaged in the left and right eyes (or the points in the left and right stereoscopic image channels) referring to the same point on the depicted object [2].

Cue Conflict: A condition that occurs when multiple depth cues indicate different Z ordering (e.g., when monocular depth cues such as size difference conflict with binocular depth cues such as parallax) [13].

Depth Range: The range of distances in camera space from the background point producing maximum acceptable positive parallax to the foreground point producing maximum acceptable negative parallax [2]. This is also known as the **depth budget**, **Maximum Allowable On-Film Deviation (MAOFD)**, or **Fusible Range** [13]. It may be given as a ratio of screen width [3]. When referring to the related parallax, the term **parallax budget** is used [2].

Diplopia: also called “Double vision,” which in stereo viewing is a condition where the left and right homologues in a stereogram remain separate instead of being fused into a single image [7].

Disparity: The distance between conjugate points on a stereo imaging device or on recorded images. On human retinae, this is known as **retinal disparity**. The corresponding term for the display screen is **parallax** [2].

Display Parallax Transition Limit: The maximum rate of parallax change (dZ/dt) for a particular display system that allows a viewer to fuse views into a 3D image. Note that this takes into account display characteristics, such a refresh rate, update frequency, image display multipliers, etc. [13].

Edge Violation: When objects in front of the screen plane (**negative parallax**) intersect the edge of frame. This can lead to contradictory depth cues for the viewer. Causing an edge violation is sometimes called “**Breaking the Frame.**” This problem may be reduced through the use of a dynamic window [12].

Floating Window: A black or partially transparent mask that can be placed on the left of the left image and/or on the right of the right image in order to reduce the depth cue confusion due to edge violations [12]. Floating Windows create the illusion of moving the physical borders of the screen surround forward. A floating window can be a **Dynamic Window** by changing window depth or tilting the window at different times during playout, and may either be pre-rendered into the image or generated by the display using metadata.

Focal Volume: The volumetric space in a 3D image that is in focus. This is the focal plane multiplied by the depth of field [13].

Fusion: The combination, by the mind, of the images seen by the left and right eyes into a single image [2].

Ghosting: Crosstalk between stereoscopic image channels. This may impair stereoscopic depth cues. Sometimes this is due to imperfect selection devices.

Horizontal Image Translation (HIT): Moving left and right eye images with respect to each other to adjust the zero parallax position for image points [2].

Horopter: The locus in space of zero binocular **retinal disparity**. The theoretical horopter in the horizontal plane (if eye fixation is directly ahead) is known as the **Vieth-Müller Circle** [9].

Interaxial: The distance between the lens axes of stereo camera heads, also denoted as t_c [2].

Interocular or interpupillary: The distance between the eyes, also denoted as t [2].

Inversion: The visual effect achieved when the planes of depth in a stereoscopic display are seen in reverse order; e.g., when the left-hand image is seen by the right eye, and vice-versa, often referred to as **pseudostereo** [7].

Lenticular: A system of many small lenses. Some MPPP NG3D displays use a fixed lenticular optical element to steer the images of pixels in order to create an appropriate light field for stereoscopic viewing.

Light Field: The radiance as a function of position and direction, in regions of space free of occluders (free space). In free space, the light field is a 4-dimensional function [1].

Luminance Rivalry: A condition where the perceived brightness of homologous points is unbalanced (e.g., brighter in one eye than the other; common in many anaglyph processes) [13].

Panum's Fusion Area: The maximum **retinal disparity** angle that will allow for fusing together of left and right eye images, typically +/- 15 to 30 arc minutes [9].

Parallax: The distance between corresponding points in two stereoscopic images as displayed. It may be measured with a ruler (especially in the case of a stereoscopic display) or in terms of angular measure. In the latter case the parallax angle directly provides information about **disparity** [2].

Positive parallax appears to be within a screen or behind the surface of a screen (e.g., in screen space). On stereoscopic screens, the left eye image is to the left of the right eye image [3].

Zero parallax appears to be in the plane of the screen. On stereoscopic screens, the left eye image and right eye images are coincident.

Negative parallax appears to be in front of a screen (e.g., in **theater space** also known as **audience space**). On stereoscopic screens, the left eye image is to the right of the right eye image [3].

Parallax Barrier: A selection device for some NG3D displays that blocks the view of some pixels from a particular eye.

Percival's Zone of Comfort: The approximate range of vergence and accommodation responses for which the viewer can fuse left and right eye images without discomfort. This region is smaller than **Panum's Fusion Area** [8].

Quincunx: A term for the "checkerboard" pattern where left eye and right eye pixels are carried in the positions of the "white" and "black" squares of the checkerboard. The term Quincunx comes from an X-shaped pattern of five dots found on the five twelfths (quinque + uncia) of the "as" Roman bronze coin [11].

Stereopsis: The binocular depth sense, from a Greek word meaning "solid seeing" [2].

Super-Multiview: A multiview display with more than two view images passing through each pupil of a viewer's eye. This may lead to the reduction of accommodation/vergence mismatch because multiple views are incident to each eye with the parallax angle corresponding to the focus accommodation [5].

Selection Device: The mechanism in a stereoscopic display for providing a left image to the left eye and a right image to the right eye. In GB3D displays, the selection device is a kind of glasses, in NG3D displays the selection device helps to produce a non-uniform light field (such as lenticular optical elements or parallax barriers) [2].

Toe-in: The angle between the lens axes of stereo camera heads.

Vertical Misalignment: Vertical deviation between corresponding points, also known as **Vertical Alignment Error** [13].

Z Distortion: Geometrical mismatch between two or more views, commonly caused by asymmetrical toe-in angles, zoom mismatch, camera rotation, etc., causing a warp along the Z-axis most commonly noticeable at the horizontal borders of the image [13].

2.4 *Use Case Terms*

Formatting: A process for converting stereoscopic content into another format/representation. It could involve spatial and/or temporal decimation, interpretation, extraction, etc., to create a new image structure with quality that is equal to or less than the original stereoscopic content.

Compression: A lossless or lossy process on 3D content to reduce the size of the image data in order to be able to store or transmit data in an efficient manner.

Encoding: A generic term for processing or transforming information from one format into another. Encoding and formatting may be used interchangeably. Compression is a type of encoding or formatting.

3D-Exclusive Content: 3D TV content designed or intended only to be viewed in 3D, and not designed or intended to be converted to 2D for 2D display. Examples of 3D-Exclusive content might include movies, concerts or other productions that are produced specifically for 3D viewing that are either not made available for 2D or that require separate mastering for a 2D viewing version.

Compatible 3D Content: 3D TV content which is designed to include or enable conversion to and viewing of the content in 2D. Users with 3D-Enabled equipment supporting the distribution format will display Compatible 3D Content in 3D, while those without such equipment will still enjoy the same program as a 2D representation.

3D-Compatible Device: A device (such as a receiver or STB) that can identify 3D content and pass-through that 3D content data stream (without change) to downstream devices.

3D-Compliant Device: A device (such as a receiver or STB) that can identify, decode, scale, and otherwise properly process 3D content for a downstream 3D display.

3D-Ready Display: A 3D display that requires the addition of a decoder before it can properly display 3D content encoded using a standardized 3D distribution format.

3D-Enabled System: A system that can decode standardized 3D distribution formats and properly display them in 3D. This system may include a display along with additional devices (receiver, STB, and/or IR transmitter), or be integrated into a single display. A 3D-Compliant Device, a 3D-Ready Display, and additional devices (such as a stereoscopic selection device) may combine to form a 3D-Enabled System.

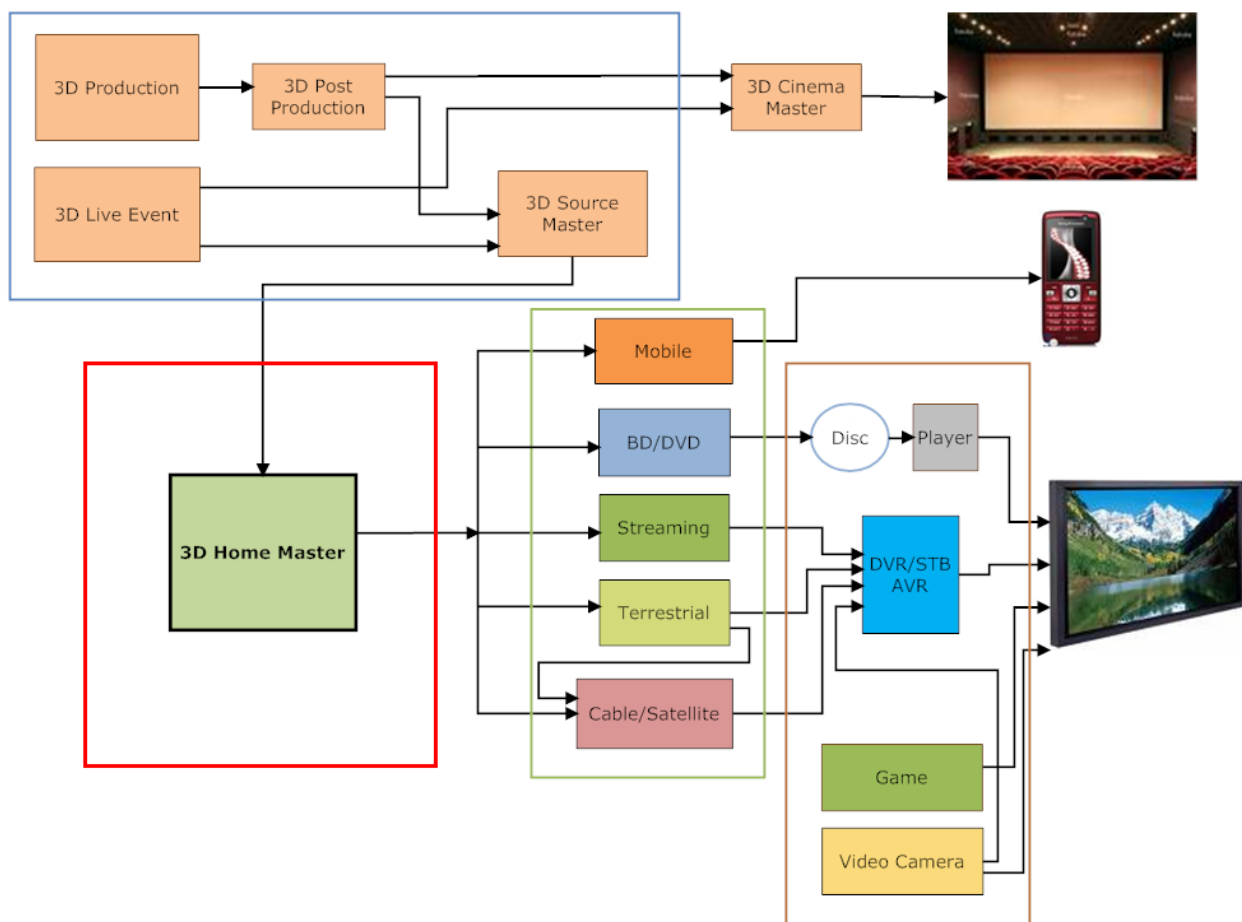
3D Source Master: The image format or file package where content originates (parallel to the DSM, outside of TF3D scope).

3D Home Master: Uncompressed and unencrypted image format or file package derived from a 3D Source Master (parallel to the DCDM and within TF3D scope). The 3D Home Master is intended to be used in the creation of 3D Distribution Data.

3D Distribution Data: Compressed and possibly encrypted data file or stream derived from the 3D Home Master used for actual distribution to the home (parallel to the DCP, outside of TF3D scope).

3 END-TO-END SYSTEM DESCRIPTION

The end-to-end flows for various types of 3D content distribution systems are illustrated below. The scope of the effort of this task force is shown – outlined in red, and consists of the requirements for the format of the 3D Home Master provided to each distribution system (outlined in yellow) leading to the home. It is assumed that a single 3D Home Master is used for all distribution channels. With that said, any future standards creation should adequately study this to ensure that it is feasible to create a single 3D Home Master versus multiple masters (each for a different distribution channel or set of channels). The 3D Home Master as essence is uncompressed and unencrypted. Generally, the master package will undergo additional processing (compression, storage and physical transport) before being ingested into the distribution system. Ultimately, each distribution system will adapt and format the 3D Home Master to meet their specific uses.



4 USE CASES

This section lists and describes Use Cases from various points of view including viewers at home, different types of multichannel video programming distributors (MVPD), broadcast stations, TV/Cable networks, production/post-production companies, etc. Use Cases from these domains are listed here since they are expected to impose requirements on the format of the 3D Home Master that is provided by the content mastering entity to the distribution system. The Use Cases described in this section are intended to be used to generate requirements for the format of the 3D Home Master. The format of the content in the distribution link that enters the home is outside the scope of this effort, and the latter is expected to be addressed in other standards development.

In the table that follows, the “Relevance” column indicates whether the use case is likely to impose any requirements on the format of the 3D Home Master. A “Yes” indicates that the use case is highly likely to impose a requirement on the format of the 3D Home Master. A “No” indicates that the use case is highly unlikely to impose a requirement on the format of the 3D Home Master. A “Perhaps” indicates that the use case may or may not impose a requirement on the format of the 3D Home Master. The “Priority” column indicates the priority of the use case for consideration in drafting requirements. A priority of 5 indicates that this use case is an important, near-term, and well understood use case that will impact the format of the 3D Home Master. A priority of 5 is the highest level, while a priority of 1 is the lowest.

Number	Title	Description	Priority	Relevance
1	In Home Television Viewing	Various use cases related to in-home viewing including viewing from physical media, broadcast and online distribution.		
1.1	Interoperability between Receiver/Decoder/Player and Display Types	Different display types may be driven by different types of receiver/decoder/players. Use cases related to interoperability between the former and the latter are listed.		
1.1.1	With Glasses	The consumer turns on the TV and the player/receiver. The TV detects the presence of 3D content being sent to it.	5	Yes
1.1.2	Without Glasses	The consumer turns on the TV and the player/receiver. The TV detects the presence of 3D content being sent to it.	5	Yes
1.1.3	Upgrades Needed for Legacy Receiver/Decoder/Player	The consumer needs to install a firmware upgrade to a legacy player/receiver/decoder in order for it to be 3D-ready.		No
1.1.4	No Upgrades Needed for Legacy Receiver/Decoder/Player	The consumer does not need to install a firmware upgrade to a legacy player/receiver/decoder in order for it to be 3D-ready.		No
1.1.5	Adapter between Display and Receiver/Decoder/Player	The consumer needs to install an adapter between a 3D-ready receiver/decoder/player and a 2D display for the consumer to view 3D content.		No

Number	Title	Description	Priority	Relevance
1.1.6	No Adapter between Display and Receiver/Decoder/Player	The consumer does not need to install an adapter between a 3D-ready receiver/decoder/player and a 2D display for the consumer to view 3D content.		No
1.1.7	User Controllable 3D Effects	<p>The viewer can vary the strength of the 3D effect via the remote control associated with the receiver/decoder/player and/or the 3D display.</p> <p>Note: This scored a 3 based on the need for metadata support, but is mostly a consumer device feature.</p>	3	Yes
1.1.8	3D User Interface	<p>The user can invoke the 3D user interface that is superimposed over the 2D or 3D video content that he is watching on his 3D display driven by a 3D receiver/decoder/player.</p> <p>Note: Data that identifies the incoming content is 3D will trigger devices that provide 3D OSD to display menus in 3D.</p>	1	Yes
1.1.9	Location of Subtitles	The default location of the subtitles is specified in the content being viewed.	5	Yes
1.1.10	Child Mode	<p>The display and/or receiver/decoder/player has a Child Mode which compensates for the small optical axes separation in children.</p> <p>Note: This is a downstream feature.</p>	1	Yes
1.1.11	Ease of Setup	The display and/or receiver/decoder/player can be interconnected and configured in a simple, straightforward, automatic manner.		No

Number	Title	Description	Priority	Relevance
1.1.12	Display Type Agnosticism	A user has an autostereoscopic (NG3D) in the living room and a stereoscopic (AGB3D) display in the bed room. He sometimes also plays his 3D Blu-ray discs bought for the NG3D display on the AGB3D display in the bed room. Note: The format of the master package being display agnostic is noted.	5	Yes
1.1.13	Display-Size Agnosticism	A user has a 60" NG3D display and a 20" TV set. He expects the same 3D quality on his 20" TV as he gets on the larger 3D display. In the future, he even anticipates viewing the content that he owns on his 3D cell phone. The format of the master package being display agnostic is noted.	5	Yes
1.1.14	Signaling Agnostic to Display Type	A user has a NG3D and an AGB3D 3D TV set and he watches 3D programs on both TV sets. The 3D programs from the program provider are marketed as generic 3D content (not specifically for a certain type of 3D display).		No
1.1.15	Source Geometry Metadata	Metadata describing the "camera" position in the source scene would be used by a 3D processor to format the imagery for the display, such that the viewing perceived by the consumer is modified for the specific Viewing Geometry environment (e.g., source material short for IMAX 3D formatted by processor for display on consumer 37" TV with consumer 10' away). Note: Need to define better exactly how this will be used.	2	Yes
1.1.16	Viewing Geometry Metadata	Metadata describing the intended viewing environment (e.g., screen size, viewing distance and other applicable geometry information utilizable by a 3D processor along with the Source Geometry Metadata to format the proper parallax for display and viewing).	2	Yes
1.1.17	Split Screen with 3D and 2D Rendering	In the store, the sales associate displays the 2D version and the 3D version of a media asset in a side by side format. This allows demos/comparison of 2D vs. 3D viewing experience.		No

Number	Title	Description	Priority	Relevance
1.1.18	Retail 3D Demos with Close Viewing Distance	In retail spaces, viewers are typically much closer to the screen than in a home setting. A demo mode on the display supports close viewing, e.g., infinity is not at 65mm parallax, but less, as in the child mode, and provides comfortable out of screen effect (parallax less than 1.5 degrees).		No
1.1.19	Change Location of Subtitles	The location of the subtitles as specified in the content being viewed can be overridden by the user and can be repositioned in (x, y, z) space. Note: This is a product feature.	1	Yes
1.1.20	Floating Windows	Floating Windows create the illusion of moving the physical borders of the screen surround forward. They are often used to prevent edge violations. Note: Floating Windows can be encoded on a per frame basis via metadata or embedded in the essence.	5	Yes
1.1.21	Viewer Control of Floating Windows	A user who does not prefer to view Floating Window can eliminate the black pixels on either side of the image - to have full screen left and right images. This is especially useful in viewing a 2D version (which is not cropped) of the 3D content.	4	Yes

Number	Title	Description	Priority	Relevance
1.2	Viewing of Broadcast Content			
1.2.1	Closed Captions for 3D-TV Content	While viewing 3D TV content of any kind the user turns on closed captions via the television or associated set top box remote control. The captions are presented as intended and appear within the focal range of the 3D content. Note: The addition of z axis data is required in order to carry this function out. This may require a modification to the Closed Caption Standards.	5	Yes
1.2.2	Automatic Identification of 3D Display Capabilities			
1.2.2.1	Receiver/Player Identification	Subscriber's (player/receiver) communicates with display using digital interface ports to identify the 3D capabilities of the display and stores or reports this information to applications on the player/receiver that delivers or selects content to the display.		No
1.2.2.2	Automated Content Formatting	Based on either the automated identifications or manual user settings, the subscriber's player/receiver will automatically decode, recode, transcode or otherwise reformat any type of 3D content delivered as needed into the necessary format for the 3D display.		No
1.2.3	Manual Identification of 3D Capabilities & Preferences	In the absence of automated reporting capabilities (for example use with existing "3D-Ready" display or other compatible products built before the necessary communications and signaling standards are completed) the subscriber enters preferences into set-up menus to identify specific 3D capabilities or preferences. These preferences are stored and reported to applications in the external receiver/player that deliver or select content to the display. Standardized and consumer-friendly terminology is used to describe certain 3D capabilities.		No

Number	Title	Description	Priority	Relevance
1.2.3.1	Setting Preferences	User indicates preferences such as preferred content types (2D or 3D when available) that are saved.		No
1.2.3.2	Content Pass-through	A subscriber is using an existing (legacy) digital receiver/player and selects a 3D program for viewing. Without any updates to that receiver/player, the box provides a fully decoded video stream on the uncompressed video output (DVI/HDMI), which contains formatting that is understood and processed by the subscriber's 3D display as a full 3D image.		No
1.2.4	Viewing 2D Versions of 3D Broadcast Channels			
1.2.4.1	3D-Exclusive Content	<p>Based on subscriber capabilities and/or preferences, a subscriber selects a broadcast channel that contains 3D TV content (based on a transmission format or signaling that is designed or intended not to provide a 2D decimated or compatible version) and views the channel in 3D. The channel or program may not be available to subscribers without 3D capabilities. Examples of this might include movies, concerts or other productions that are produced specifically for 3D viewing that are either not made available for 2D or that are mastered separately for 2D viewing.</p> <p>Note: This case would be addressed in the contract that exists between content owner and distribution channel.</p>		No

Number	Title	Description	Priority	Relevance
1.2.4.2	Compatible 3D Content	<p>Without regard to subscriber's capabilities and/or preferences, a subscriber selects a broadcast channel that contains 3D TV content (which is transmitted and/or signaled in a way designed to include or enable a 2D decimated or compatible version) and views the program. Examples of this might include live sports or other content aimed at the largest possible audience from a single production. Subscribers with 3D-capable equipment supporting the signal format will display the content in 3D, while those without such equipment will still enjoy the same program as a 2D representation.</p> <p>Note: This case would be addressed in the contract that exists between content owner and distribution channel.</p>		No
1.2.4.3	Incompatible 3D Content	<p>During 3D content creation, the 3D effects may create frames of left and right images that cannot be used in a 2D rendition of the content, in that the 2D presentation is unnaturally distorted or alternate frames are completely different from the combined left and right fusion in the 3D presentation. A separate 2D image sequence is needed, and the 3D content should be marked as being not suitable for the generation of 2D compatible content.</p> <p>An example follows: In the case where the 3D effect generates negative parallax it is possible that the right (left) image appear as coming from left to right (right to left); if the left or right frame is used for a 2D version in this case, the object that appears to be central in 3D presentation switches on a frame by frame from a central image to coming from either side, depending on which eye is selected in the 2D presentation as the image transitions to negative parallax.</p> <p>Two situations are relevant: (1) the same Master is used to author separate 3D and 2D titles of the movie, and/or (2) the studio decides to release a single BD title that has both 3D and 2D versions, and the Master needs to contain both the 2D and 3D version.</p>	4	Yes
1.2.5	Fast Channel Change	A subscriber "channel surfs" between 2D and 3D content and between channels that deliver 3D content and notices no perceptible differences in acquisition time and no added delay to tune 3D programming.		No

Number	Title	Description	Priority	Relevance
1.2.6	Ad-Insertion			
1.2.6.1	Ad Insertion (Baseband)	Ad-insertion in the uncompressed domain at the headend or content distribution point does not degrade the viewing experience of the consumer. Note: It is important to identify where ads would be inserted, and indicate a z axis value at the time of the ad insertion.	5	Yes
1.2.6.2	Local and Client-Side Ad Insertion (Compressed Domain)	For the purposes of these use-cases, “Local Ad insertion” refers to the splicing of encoded MPEG streams done at the headend or content distribution point. “Client-Side Ad Insertion” refers to the splicing of encoded MPEG streams within the customer premises equipment (DTV or STB). Note: This was submitted as a definition only.		No
1.2.6.2.1	2D Ads Inserted into 3D Content Streams	A subscriber is viewing a 3D content stream and either the local headend or STB inserts one or more 2D ads directly into the encoded stream, e.g., based on SCTE ad insertion signaling protocols. The subscriber’s viewing is uninterrupted with a smooth transition between the 3D and 2D content and back again. Note: It is important to identify where ads would be inserted, and indicate a z axis value at the time of the ad insertion.	5	Yes
1.2.6.2.2	3D Ads Inserted into 2D Content Streams	A subscriber is viewing a 2D content stream and either the local headend or STB inserts one or more 3D ads directly into the encoded stream, e.g., based on SCTE ad insertion signaling protocols. The subscriber’s viewing is uninterrupted with a smooth transition between the 2D and 3D content and back again. If the viewers’ preferences are set to 2D, the inserted 3D ad plays as if it were a 2D ad.		No

Number	Title	Description	Priority	Relevance
1.2.6.2.3	3D Ads Inserted into 3D Content Streams	<p>A subscriber is viewing a 3D content stream and either the local headend or STB inserts one or more 3D ads directly into the stream, e.g., based on SCTE ad insertion signaling protocols. The subscriber's viewing is uninterrupted with a smooth transition between the main program and the ad content and back again, while preserving and observing the user's preferences for 2D or 3D playback throughout. When 3D viewing is used, a "neutral focal distance" is provided between the transition points.</p> <p>Note: It is important to identify where ads would be inserted, and indicate a z axis value at the time of the ad insertion.</p>	5	Yes

Number	Title	Description	Priority	Relevance
1.2.7	V-Chip for 3D TV Content	A subscriber has set certain Content Advisory (such as V-chip) controls on the 3D capable receiver and when 3D content is selected, the Content Advisory parameters are delivered to the receiver when available in a way that enables operation consistent with 2D receiver and 2-D content behavior.		No
1.2.8	OSD Presentations for 3D-TV Content			
1.2.8.1	Full Screen Local Menus & Graphics	A subscriber tunes his receiver/player or integrated receiver/display to any type of 3D content compatible with his display and views the content in a 3D mode. The subscriber activates any locally generated OSD, menu or GUI and sees a smooth transition from viewing the 3D content to viewing the local graphics.	2	Yes
1.2.8.2	Partial Graphical Overlay and Blending	Anytime the subscriber is viewing any type of 3D content, the graphical user interface may generate objects intended to overlay or blend with the video content. Such blended graphics work as designed for 3D content, placing any graphical objects within the depth range for the 3D content.	3	Yes
1.2.8.3	Sub-pictures, Preview, PIP & POP	Anytime the subscriber is viewing any type of 3D content, the applications may place the video content in a scaled sub-picture within the graphical menus, or may generate a multi-screen preview of several programs or services or may place two different programs on the screen at the same time using PIP or POP. In each case the display system must be able to present usable sub-pictures or scaled pictures that may or may not be a true 3D image.		No
1.2.9	Conditional Access for 3D-TV Content	When a subscriber cancels payment or a subscription to a pay service delivered as any type of 3D video, existing conditional access systems and infrastructure must be able to prevent the subscriber from continuing to receive that content.		No

Number	Title	Description	Priority	Relevance
1.2.10	Content Protection for 3D-TVC	When a subscriber attempts to duplicate or redistribute any type of 3D content in a manner that violates the content protection limits placed on the content by its owner or distributor (within the bounds of the FCC's encoding rules), the existing video content protection system will be able to prevent such unauthorized use.		No
1.2.11	In-home Storage of 3D-TV Content (time-shifting)			
1.2.11.1	Complete Recording of 3D Signals	A subscriber has selected 3D video content and wishes to record or schedule a recording of that content for later viewing. A recording is possible (when permitted by content protection) that preserves the signal sufficiently to regenerate the 3D experience at a later time. The recording should also preserve any associated metadata that identifies playback requirements, display requirements or format identification of the content so user-preferences or changes to a connected display can be accommodated.		No
1.2.11.2	Random Access & Trick-Play for 3D Content	A subscriber is able to record 3D content using DVR/PVR technology that provides random access and trick-play transport controls including pause, FFW, REW and slow motion with the same performance and ease he is able to do so with 2D programming.		No
1.2.12	Seamless Switching between 2D and 3D Modes			
1.2.12.1	3D to 2D Switching	A subscriber is viewing 3D content in 3D mode and decides to change the viewing mode to 2D mid-program, for the benefit of others in the room. The delivery system or content formatting should permit a seamless transition from 3D viewing to 2D viewing.		No

Number	Title	Description	Priority	Relevance
1.2.12.2	2D to 3D Switching	A subscriber is viewing 3D content in 2D mode and decides to change the viewing mode to 3D mid-program. The delivery system or encoding system should permit a seamless transition from 2D viewing to 3D viewing.		No
1.2.13	Signaling of L/R Identification	The user selects any 3D content for viewing and the display is able to automatically recognize and direct the appropriate signals for left and right eye perspectives. This implies there is an unambiguous method to identify the separated images for left and right eye throughout the distribution, transport and interface chain.	5	Yes
1.2.14	Transcoding	The distribution system may require the 3D content to be transcoded or decoded/re-encoded at one of more points in the path to the home. These processes will preserve all information needed in the final distribution package to home – so as to enable a high quality viewing experience.		No
1.2.15	Cable Distribution-Specific Use Cases			
1.2.15.1	Switched Digital 3D Video			
1.2.15.1.1	Capability Directed Channel Change	A subscriber selects a given service (e.g., ESPN or HBO) and based on the stored or reported 3D capabilities, the subscriber is directed to a switched digital video service that is transmitted in a format that matches his 3D capabilities.		No
1.2.15.1.2	Preference Directed Channel Change	A subscriber selects a given service (e.g., ESPN or HBO) and based on the stored or reported 3D preferences, the subscriber is directed to a switched digital video service that is transmitted in a format that matches his 3D preferences.		No

Number	Title	Description	Priority	Relevance
1.2.15.2	On-Demand 3D TV	For the purposes of these use-cases, “on-demand 3D TV” includes all variations of interactive video on demand, including but not limited to traditional movies-on-demand, user-generated content, subscription-on-demand, services that make use of on-demand technology like “Star-Over” or “Catch-Up” and so-called “Remote-Storage DVR” services.		
1.2.15.2.1	Capability Directed On-demand	A subscriber selects a given on-demand program, title or service and based on the stored or reported 3D capabilities, the subscriber is automatically delivered the digital video content that is formatted and transmitted in a way that matches his 3D capabilities.		No
1.2.15.2.2	Preference Directed On-demand	A subscriber selects a given on-demand program, title or service and based on the stored or reported 3D preferences, the subscriber is automatically delivered the digital video content that is formatted and transmitted in a way that matches his 3D preferences.		No
1.2.15.2.3	Random Access & Trick-Play for 3D Content	A subscriber is able to view 3D content using on-demand technology that provides random access and trick-play transport controls including pause, FFW, REW and slow motion with the same performance and ease he is able to do so with 2D programming.		No

Number	Title	Description	Priority	Relevance
1.2.15.3	Emergency Alert for 3D-TV Content	While viewing 3D TV content, a SCTE-18 emergency alert message is received. In response to this message, the 3-D capable receiver must be able to respond as intended by the message, including support for all modes of operation such as on-screen instructions, forced-tune to another channel or service.		No
1.2.16	Compatibility with 2D Distribution Channels			
1.2.16.1	Bandwidth Constraints for Broadcast Systems	<p>For broadcast systems which by nature have significant bandwidth constraints, the 3D content is distributed in a backwards compatible manner where the 2D component is decodable by existing 2D decoders and the additional bandwidth requirement for delivering the full 3D content rather than just the 2D component of the content is minimized.</p> <p>An example of this is where the 2D decoder is based on the MPEG-4 Part 10 or MPEG-2 Part 2 video compression standard and the MPEG-2 Part 1 specified transport stream delivery of such data.</p>	5	Yes

Number	Title	Description	Priority	Relevance
1.3	Viewing of Content on Physical Media			
1.3.1	Blu-ray Disc			
1.3.1.1	Playback of 3D and 2D Content from Blu-ray Disc	User plays back a Blu-ray disc that contains 3D and 2D content [hereafter denoted as “3D + 2D Blu-ray disc”] in their Blu-ray player. The user selects the 3D version of the film from the BD menu, after which, the 3D version of the movie plays (i.e., the user is able to view the disc as either 3D or 2D). Depending on the television type the user may or may not be required to wear glasses to enable the 3D effect.	5	Yes
1.3.1.2	Graphical Overlays for 3D + 2D Blu-ray Disc	While playing a 3D + 2D Blu-ray disc graphical overlays appear over the 3D video at programmatically determined times (e.g., Pop-up video). The graphics may be in 2D or 3D. The 3D position (i.e., z position) of each graphic is set during the Blu-ray authoring process, e.g., graphics are authored to appear in front of the primary object of interest.	5	Yes
1.3.1.3	User Controlled Graphics Locations	A user's Blu-ray discs contain interactive games. Some of these games are in 3D and some are in 2D. The 3D games are dynamically composited over the 3D video that he is watching. The 2D games are presented on screen location, or at discretion of content creator placed in z domain. Note: The following is a consumer device feature – and not important to the prioritization. The user can place have the 3D video content behind the 2D game, while flattening the 3D video somewhat.	5	Yes
1.3.1.4	Interactive Graphics for 3D + 2D Blu-ray Disc	While playing a 3D + 2D Blu-ray disc interactive graphical menus appear over the 3D video in response to a user operation and present the user with the ability to navigate to any point within the 3D video. The graphics may be in 2D or 3D. The 3D position (i.e., z position) of each graphic is set during the Blu-ray authoring process, e.g., graphics are authored to appear in front of the primary object of interest. However, since the graphics will not appear deterministically (i.e., they will appear only in response to user input), the 3D position of each graphic may be authored to be dynamic, based on additional information that is available in the 3D Home Master, e.g., depth map.	5	Yes

Number	Title	Description	Priority	Relevance
1.3.1.5	Subtitles for 3D + 2D Blu-ray Disc	While playing 3D video from a 3D + 2D Blu-ray disc the user activates a subtitle stream language (e.g., Spanish subtitles are turned on) from the interactive graphical menu or via the remote control. The 3D position (i.e., z position) of each subtitle is set during the Blu-ray authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	5	Yes
1.3.1.6	Transition between 3D and 2D Content	While playing 2D video, if any, on a 3D + 2D Blu-ray disc, the user selects an interactive graphical button that jumps out of the 2D video and plays 3D video. Before jumping to the 3D video an onscreen message appears directing the user to put their 3D glasses on, if applicable. After finishing playback of the 3D content the player returns to the 2D video and resumes normal playback. Note: 3D material is not in the master – separate from the 2D master.		No
1.3.1.7	Upgrade of 2D Content to 3D via BD Live (downloading)	Via a BD Live application the user downloads additional data that, once downloaded to the Blu-ray player, enables playback of otherwise 2D content (on the Blu-ray disc) in 3D.		No
1.3.1.8	Upgrade of 2D Content to 3D via BD Live (streaming)	Via a BD Live application the user streams additional data that enables playback of otherwise 2D content (on the Blu-ray disc) in 3D.		No
1.3.1.9	Upgrade of 2D Content to 3D via External Storage Device	Via a BD application the user transfers additional data provided from a player's removable storage input port, e.g., thumb drive slot, that enables playback of otherwise 2D content (on the Blu-ray disc) in 3D.		No
1.3.1.10	Player Supports Branching – Frame/Scene/Chapter Based	Playback device supports frame/scene/or chapter branching to alternate views/content. There is a video that has a scene where elements are being pointed directly at the camera to achieve a 3D effect. These elements work well in 3D but are not as visually pleasurable in 2D. This video also has alternate content suitable for viewing in 2D instead of the 3D version. When playing a 2D version of a video stream (possibly by using the left eye view) The content may branch to an alternate version of the scene that is more acceptable for 2D viewing.	4	Yes

Number	Title	Description	Priority	Relevance
1.3.1.11	Branching – Time Correlation	Alternate video sequence information is stored separately and time-correlated. By use of time correlation the player can know exactly when to branch off of the primary stream and retrieve the alternative 2D content as well as when exactly to branch back to the primary content stream.	4	Yes
1.3.1.12	Branching – between Left/ Right/Center Streams	When playing a 2D version there may be points in the video where the 2D could be derived from the left view, the right view, or the center view, based on artistic considerations. Branching may be between all three dynamically.	4	Yes
1.3.2	DVD			
1.3.2.1	Playback of 3D and 2D Content from DVD Disc	User plays back a DVD disc that contains 3D and 2D content [hereafter denoted as “3D + 2D DVD disc”] in their DVD player. The user selects the 3D version of the film from the DVD menu, after which, the 3D version of the movie plays (i.e., the user is able to view the disc as either 3D or 2D). Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	5	Yes
1.3.2.2	Graphical Overlays for 3D + 2D DVD Disc	While playing a 3D + 2D DVD disc, graphical overlays appear over the 3D video at programmatically determined times (e.g., Pop-up video). The 3D position (i.e., z position) of each graphic is set during the DVD authoring process, e.g., graphics are authored to appear in front of the primary object of interest.	5	Yes
1.3.2.3	DVD Menus for 3D + 2D DVD Disc	While playing 3D content from a 3D + 2D DVD disc the user presses the “Menu” button on their remote control. The DVD menu appears full-screen (i.e., not over the 3D video) in either 2D or 3D, during which time the user can navigate in the same way as in conventional DVD menus.		No
1.3.2.4	Subtitles for 3D + 2D DVD Disc	While playing 3D video from a 3D + 2D DVD disc the user activates a subtitle stream language (e.g., Spanish subtitles are turned on) from the DVD menu or via the remote control. The 3D position (i.e., z position) of each subtitle is set during the DVD authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	5	Yes

Number	Title	Description	Priority	Relevance
1.3.2.5	Captions for 3D + 2D DVD Disc	While playing 3D video from a 3D + 2D DVD disc the user turns on closed captions via the television remote control. The captions are in 2D and appear to be in front of the 3D video. Note: Assumes that caption information along with z-axis metadata is passed through to the 3D display device.	1	Yes
1.3.2.6	Transition between 3D and 2D Content	While playing 2D video, if any, on a 3D + 2D DVD disc the user selects a button from the DVD menu to play the 3D video. Before jumping to the 3D video an onscreen message appears directing the user to put their 3D glasses on, if applicable. After finishing playback of the 3D content the player returns to the DVD menus.		No

Number	Title	Description	Priority	Relevance
1.4	Digital Distribution			
1.4.1	Internet Download			
1.4.1.1	Internet download and playback of 3D content package to PC	User downloads a media file containing audio, 3D video, and subtitles [hereafter denoted as a “3D content package”] to their PC and subsequently plays it back using a PC application (e.g., Windows Media Player). Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	5	Yes
1.4.1.2	Internet download and playback of 3D content package to set top box with internet connection	User downloads a 3D content package to their internet connected set top box (e.g., Apple TV) and subsequently plays it back by accessing it via the user interface specific to the set top box. Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	5	Yes
1.4.1.3	Subtitles for downloaded 3D content package	While playing the 3D content package the user selects a subtitle stream from the playback software’s menu system (e.g., option built into Windows Media player or Flash player) or via the set top box remote control. The 3D position (i.e., z position) of each subtitle is set during the content programming/authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	5	Yes
1.4.1.4	Upgrade of 2D content package to 3D via additional download	A user has previously downloaded the 2D version of a movie. Via a second download containing additional data, the film now plays back in 3D. The user can still play the 2D version if he wishes.		No
1.4.2	Internet Streaming			
1.4.2.1	Internet streaming and playback of 3D content package to PC	User streams a 3D content package to their PC and plays it back using a PC application (e.g., Windows Media Player). Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	5	Yes

Number	Title	Description	Priority	Relevance
1.4.2.2	Internet streaming and playback of 3D content package to set top box with internet connection	User streams a 3D content package to their internet connected set top box (e.g., Roku, internet connected cable STB, etc.) and plays it back. The stream is accessed via the user interface specific to the set top box. Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	5	Yes
1.4.2.3	Subtitles for streaming 3D content package	While streaming the 3D content package the user selects a subtitle stream from the playback software's menu system or via the set top box remote control. The 3D position (i.e., z position) of each subtitle is set during the content programming/authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	5	Yes

Number	Title	Description	Priority	Relevance
2	Viewing on Mobile Devices			
2.1	Viewing on Mobile Phones			
2.1.1	Mobile Phone Downloading or Streaming	A single user downloads or streams a 3D content package to their mobile phone and views the content without glasses.	5	Yes
2.1.2	Mobile upgrade of 2D content package to 3D via additional download	A single user has previously downloaded the 2D version of a movie. Via a second download containing additional data the film now plays back in 3D. The user can still play the 2D version if they wish. No glasses are required to view the 3D version.		No

5. REQUIREMENTS

This section defines the minimum requirements for the specification for a single 3D Home Master that can be used to service any or all of the various downstream distribution channels, therefore the following requirements include the superset of requirements for all potential downstream distribution channels. With that said, any future standards creation should adequately study this to ensure that it is feasible to create a single 3D Home Master versus multiple masters (each for a different distribution channel or set of channels). The order in which each requirement is listed does not denote the priority of said requirement. Furthermore, the requirements do not presume the use of any specific 3D technology or 3D technology provider.

Reqmnt Number	Title	Detailed Requirement
1	Image Content	
1.1	Image Content Type	The image content shall consist of stereoscopic content from source material including film content, progressive video, or interlaced video in its native frame rate and aspect ratio.
1.2	Resolution and Frame Rate	<p>The image file definitions shall include video resolutions up to and including 1920x1080 and native frame rates up to and including 60p per eye view. Since 3D content may coexist with 2D content in various distribution scenarios and 2D content may be extracted from the 3D content for distribution, strong consideration should be given to existing related specifications (e.g., SMPTE 274M and 296M) when defining the image parameters of any future 3D Home Master specification.</p> <p>*Note: There was significant discussion within the task force whether the bit depth, spatial resolution, and/or color subsampling of each eye perspective of the stereoscopic content should be the same or can be different. While binocular symmetry is encouraged, any future standards work should adequately study this issue in detail.</p>
1.3	Image Pairing	For each stereoscopic image pair there shall be a left-eye and right-eye image.

Reqmnt Number	Title	Detailed Requirement
2	Audio Synchronization	There shall be a corresponding audio frame for each stereoscopic image pair.
3	Graphical Overlays	The 3D Home Master shall include a structure to optionally contain 3D depth information to enable real-time downstream composition with graphics (e.g., graphical menus). Also see section 7.0 Metadata.
4	Subtitles	The 3D Home Master shall include a structure to optionally contain 3D depth information to enable real-time downstream composition with subtitles (either graphical subtitles or subtitles rendered by the playback device). Also see section 7.0 Metadata.
5	Closed Captions	The 3D Home Master shall include a structure to optionally contain 3D depth information to enable real-time downstream composition with closed captions. Also see section 7.0 Metadata.
6	Backward Compatibility with 2D	
6.1	Segment Insertion	The 3D Home Master shall be defined to anticipate that segment insertion may be used for local and client side ad insertion as well as for the insertion of alternate footage (e.g., branching). Such segment insertion may include 2D segments inserted into 3D content streams, 3D segments inserted into 2D content streams, and 3D segments inserted into 3D content streams. The 3D Home Master shall be defined such that when transitions between 2D and 3D content occur the transitions should be uninterrupted and smooth.
6.2	2D from 3D	The 3D Home Master shall be defined to optionally enable the ability to extract or generate a 2D version from the 3D version.
7	3D Metadata	For each metadata item outlined below, the 3D Home Master shall include a structure to reference the metadata item to the appropriate source image frame or image sequence. For example, this would enable synchronizing a frame of depth map to a particular image frame.

Reqmnt Number	Title	Detailed Requirement
7.1	2D Compatibility	The 3D Home Master shall include a structure to contain metadata to identify the method, if allowed, by which a 2D version can be extracted or generated from 3D content.
7.2	Stereoscopic Identification	
7.2.1	Stereoscopic Identifier	The 3D Home Master shall include a structure to contain an identifier indicating that the content is a 3D Home Master.
7.2.2	Start of Image Sequence identifier	The 3D Home Master shall include a structure to include metadata identifying the start of the image sequence.
7.2.3	Stereoscopic Perspective Identifier	The 3D Home Master shall include a structure to include metadata for each image frame/field that identifies whether said frame is the left eye or right eye perspective.
7.2.4	Frame Pair Identifier	The 3D Home Master shall include a structure to include metadata for each image frame/field identifying a continuous frame/field count from the start of image sequence identifier for each image sequence.
7.3	3D Depth Information	The 3D Home Master shall enable carriage of 3D depth information.
7.3.1	Depth Map	The 3D Home Master shall include a structure to optionally contain depth information for each image frame of at least one of the eye-views (i.e., depth map of the 2D version). The depth map information, when provided, may have a spatial resolution equal to that of the source image content or less.

Reqmnt Number	Title	Detailed Requirement
7.3.2	Depth Range	<p>A depth map can be utilized to calculate the depth range of each image frame, specifically the depth (z) position of the maximum negative parallax (object coming furthest out of the screen) and maximum positive parallax (object going furthest into the screen). However, in some instances it may be sufficient to only include the depth range for each image frame (and not the entire depth map). The 3D Home Master shall include a structure to optionally contain the depth range information.</p> <p>*Note: During discussion within the task force it was not clear whether the inclusion of the depth range was truly required, since as noted above if the 3D Home Master contains a depth map the depth range may be calculated from it. It has also been pointed out that it may be overly burdensome in all cases to include the depth map for each image frame into the 3D Home Master, and therefore it should be permitted to only store the depth range. As no consensus has been reached within the task force we point this out with the expectation that any future standards work will adequately study this issue in detail.</p>
7.3.3	Position of Primary Attention	The 3D Home Master shall include a structure to contain optional information for each image frame indicating the 3D position of the primary object of interest. The method of representing the 3D position needs to be studied (e.g., x-y-z coordinate of center of the object of interest versus 3D volume of the object of interest).
7.4	Multi-view Rendering Support	The 3D Home Master shall be defined to include optional metadata in addition to depth maps to enable high quality multi-view rendering.
7.4.1	Occlusion Information	The 3D Home Master shall include a structure to optionally contain information indicating portions of the image that are occluded behind foreground objects.
7.4.2	Transparency Information	The 3D Home Master shall include a structure to optionally contain information indicating objects which are semi-transparent.
7.4.3	Resolution of Occlusion and Transparency Information	When present the occlusion and transparency information shall have a spatial resolution equal to that of the source image content or less.

Reqmnt Number	Title	Detailed Requirement
7.5	Composition Metadata	The 3D Home Master shall include a structure to optionally contain metadata for each image frame or image sequence associated with one or more potential downstream viewing environments as well as the source camera. Specific metadata parameters include intended screen size, optimum viewing distance, optimum brightness level, intrinsic camera parameters (e.g., focal length) and extrinsic camera parameters (e.g., position and orientation of cameras) – this is not an exhaustive list and should be studied in detail during any future standards creation process.
7.6	Floating Window Metadata	The 3D Home Master shall include a structure to optionally contain metadata for each image frame describing attributes of the floating window associated with the video content, including the location, color, and transparency.
8	Ancillary Metadata	The 3D Home Master shall be defined to carry ancillary metadata. Informative examples include the carriage of captions, subtitles, timecode, AFD data, and bar data – note this is not an exhaustive list. Any future standards should adequately study these items in detail.
9	Evaluation Criteria	The specifications for the 3D Home Master generated to meet the above requirements should also meet the following general criteria.
9.1	Completeness	The specifications for the 3D Home Master shall meet the minimum requirements that have been presented by the task force, and satisfy all of the relevant use cases (as identified in the cross-reference list in Appendix A).
9.2	Extensibility	Future display technologies and distribution channels may require additional data/metadata than could be defined today (e.g., see discussion in section 6. Issues and Challenges). The specifications for the 3D Home Master needs to take into consideration this future growth and allow for extensibility that will minimize the impact to current systems.

9.3	Efficiency	The specifications for the 3D Home Master should consider the viability and efficiency of implementation – be it in terms of representation, storage, transport, computation, etc.
9.4	Human Readability of Metadata	The specifications for the 3D Home Master container format should consider readability of various elements of metadata where applicable.

6. ISSUES AND CHALLENGES

The use cases and requirements described above are framed in the context of various unknowns which may (in the future) impact the format of the master package. Some of these factors are listed below.

6.1. *Evolving Display Technologies*

The current generation of displays that are feasible from a manufacturability and affordability (for the consumer) perspective are essentially based on 2D display methods with some technology extensions to allow them to render two views (one for each eye) that are either temporally interleaved with shutter glasses used to separate views for each eye, or spatially interleaved with polarization on lenticular screens used to separate the views for each eye. It seems reasonable to expect that future displays will be based on completely different technologies and principles. The needs of these display methods have not been considered in this report, and the impact on the format of the mastering package could be substantial. Some examples of such new types of display technologies are listed below. This is not meant to be an exhaustive list but is used to illustrate the possible future diversity of technologies.

In 1908, Gabriel M. Lippmann proposed the use of a series of lenses at the picture surface to reproduce the entire light field, which he called “Integral Photography” [23], a technique of capturing many 2D pictures of an object simultaneously from different angles, and then optically projecting the pictures back to the geometric location of the object to create the 3D image. Lenslet arrays are generally used in both capture and reconstruction in integral imaging [24]. A similar technique for display involves the use of multiple telecentric light source arrays [25].

Many displays have been developed which use a parallax barrier applied to a standard 2D video display. The parallax barrier serves as a means to convert pixel offsets into different angular views to generate the required light field. Like all multiple-pixels per point (MPPP) displays, the resolution of the 2D base display is reduced by the need for pixels to be steered to particular views.

A 360-degree multiview display has been created using a cylindrical parallax barrier and a spinning 1-dimensional light source array [19]. A parallax barrier can be created from an LCD element, and dynamically modulated in position and spatial frequency to allow for a better autostereoscopic effect when a viewer is moving position (using head tracking) or in the presence of multiple viewers [20]. A parallax barrier can have time-varying polarization to allow for greater screen resolution [21]. And a parallax barrier can also consist of

wavelength-selective filters where differently colored image elements can be seen from different spatial positions in front of the screen [22].

Lenticular techniques use a series of small lenses (generally in the form of thin lines) to provide horizontal parallax by directing thinner strips of the image behind them in particular directions so that the viewers see the different images required for stereopsis. As with other MPPP displays, the larger the number of required views of horizontal parallax, the greater will be the reduction of horizontal resolution. A technique to reduce the effect of this problem slants the lenses slightly to trade off some vertical resolution for enhanced horizontal resolution. A prototype NG3D lenticular display has been shown with 46 views based on a Quad-HD LCD display [26]. A related technology is diffractive “partial pixels,” a MPPP technology that uses diffractive optical elements to steer light individual pixel elements into different view zones [27].

In the April 1932 issue of the Society of Motion Picture Engineers Journal, Herbert Ives wrote about the use of as many as thirteen projectors upon a lenticular screen. Multiple projectors can be used to create a multiview display by rear projection on a double lenticular screen that has an internal optical diffuser element, rear projection on a diffuser with a parallax barrier, or by front projection with a single-lenticular screen layered onto a retro-reflective layer [28]. Examples have been shown using 64 XGA projectors [29] and 128 SVGA projectors [30]. Projection can also be done using a scanned focused light array (FLA). Each beam in the FLA is used to generate the light field in a particular horizontal angular direction from the screen [31].

Several time sequential techniques have been used to steer multiview images to form an appropriate lightfield for NG3D. Sequential light bars can steer illumination through an LCD display, or fast LCD shutter bars can steer the projected output from a 2D display with a projection lens [32, 33].

A 360-degree multiview display has been created using a high-speed DLP projector projecting images onto a spinning mirror-like holographical optical element (HOE) [34]. The HOE reflects the image from the DLP in only a single direction. The DLP projected image is generated by a fast computer, and changes every degree or so that the HOE spins to provide for a large number of parallax views.

Holography was developed by D. Gabor in 1947. In traditional holography, a coherent reference light wave interferes with coherent light scattered from a 3D object, and a recording is made of the interference pattern (generally with a transparent photographic plate). When a coherent reference beam is projected against the recorded interference pattern, a 3D image of the original object can be obtained. The recording of holograms is difficult because any stray light or movement of the objects or recording plate can destroy the interference pattern. Thus it is very difficult to record motion holograms of moving objects using film.

Computer Generated Holograms (CGH) were developed to mathematically calculate the required interference pattern to generate holograms of 3D modeled objects without needing the traditional holographic image capture. In 3D video applications, an electronically controlled spatial light modulator (SLM) is used to produce the required interference pattern. SLMs can be made of acousto-optical materials, magneto-optical materials, liquid crystal materials, or digital micromirror arrays [35]. The diffraction grating pitch required for practical CGH is on the order of a micron or less [36]. The calculation of computer generated holograms is very computationally complex. If the eyes of the viewers can be tracked, it is possible to compute only a part of the hologram (the “sub-hologram” technique) to reduce the complexity [37]. Another simplifying technique is the use of pre-computed basis fringes that are modulated by the visual content of a particular scene [38]. Color CGH video displays have been developed [39] and CGH video displays have been shown with 440 scan lines @ 30 fps [40].

6.2. *Future Distribution Channels*

Distribution channels of the future may consist of much “fatter pipes” and are likely to allow richer information to be transmitted and consumed. This may place additional requirements on the 3D Home Master. Conversely, 3D content is likely to be transmitted by “thinner pipes,” e.g., low bandwidth wireless mechanisms. These may also place requirements that have not been considered in the current effort.

6.3. *Production and Authoring Techniques and Needs*

Given that the 3D content production, distribution and consumption industry is in the initial stage of evolution, it is reasonable to expect that production and authoring techniques will evolve, and may place new unforeseen requirements on the 3D Home Master format, in the future. One specific area of current experimentation where it is too early to predict future requirements is in the placement of graphics in 3D content.

Many of the emerging display technologies require the display to be driven by more than two simultaneous views of the scene. Indeed, many display manufacturers already have non-glasses-based 3D displays on the market (for digital signage and other commercial applications) based on lenticular screens, that require up to 25 simultaneous views of a scene. The 3D distribution master that is ideally suited for such displays should include a full resolution depth map, along with occlusion and transparency information. Although the “Requirements” for 3D Home Master state that this information is optional (since a depth map can be computed from a stereoscopic pair of images), it is to be noted that such depth (as well as occlusion and transparency) maps should be computed as early as possible in the content supply chain, since the accuracy, reliability, and complexity of this depth map extraction becomes considerably worse if it takes place at more downstream locations in the chain. Another solution for these types of displays is for the master and the distribution chain

to carry the separate simultaneous views needed for each scene. However, given the early state of this technology, more study is required before capturing requirements for this type of solution. Unknowns include the minimum set views needed, the tradeoffs between number of viewing cones and views per cone, the bandwidth requirements, compression that the views can sustain, etc.

6.4. *Unexplored Psychophysical Characteristics of the Human Visual System*

When compared to the vast amount of industry experience and the body of research that exists on the response of the human visual system (HVS) to stimuli received from 2D displays, there has been relatively little research regarding the effect of 3D display systems on the HVS, and issues related to capture and representation of 3D content based on new discoveries related to the HVS. As this nascent field matures, experience and research may prescribe new ways of representing image essence and perhaps new types of metadata required for an acceptable 3D viewing experience.

An area that needs more consideration, for example, is Stereoscopic Acuity, i.e., the smallest disparity interval that produces reliable depth discrimination by the HVS. This may be a factor in the depth/disparity resolution requirements for the 2D stereoscopic images and/or the depth maps handled by the 3D Home Master. At regions close to the horopter, many viewers can detect a disparity of around 2 arc-seconds (0.00056 degrees), which is actually smaller than the smallest photoreceptors in the human retina. Stereoacuity decreases as distance increases, with retinal disparities becoming negligible at distances beyond 30 meters [41]. These factors, along with the observed coarser resolution for spatial changes in disparity across the visual field (on the order of about 20 arc-minutes or 0.33 degrees) may lead to future requirements on non-uniform sampling of depth/disparity values [42].

6.5. *Miscellaneous*

Various other factors may also impact the 3D Home Master. For example, it is not clear if new (yet to be developed) schemes for distributing the 3D content such that the viewing experience is gracefully degraded in the presence of partial data loss in the distribution channel will place new requirements on the 3D Home Master. Nor is it clear that schemes that may be developed to restrict the changes that content can be subjected to as it flows downstream will require additional features in the 3D Home Master. Left and right images in a stereo pair may need to be represented and treated differently, and may require annotation(s) in the 3D Home Master to support this.

7. RECOMMENDATIONS

SMPTE should undertake standardization effort to generate specifications for the 3D Home Master that meet the requirements listed above. The intent of the standards creation should be to create a single 3D Home Master versus multiple masters.

SMPTE should establish liaisons as needed with other relevant Standards Development Organizations (SDOs), as well as industry consortia and forums to:

- (a) ensure compatibility/interoperability with the technical solution/specifications /standards being developed by those organizations,
- (b) to foster the use of the 3D Home Master (resulting from future SMPTE standardization activity) for content creation, storage and ingest in downstream authoring and distribution,
- (c) align terminology and concepts with the work of these organizations, and
- (d) identify gaps in standards required that fall within SMPTE's charter and generate solutions for these gaps.

The types of organizations SMPTE should consider for liaison activity include those that consider distribution formats (broadcast, online, physical media), device interfaces, display technologies, etc., within the 3D content to the home eco-system.

SMPTE should continue to study and investigate solutions to the issues and challenges listed in this report in the course of developing a 3D Home Master standard. SMPTE should also embark on a review of how 3D content to the home affects the body of SMPTE publications.

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APPENDIX A

Cross Reference of Requirements Against Use Cases

The following table lists the key requirements that are generated by each relevant use case, and are not necessarily an exhaustive list of the requirements that are generated by each use case.

Number	Title	Description	Rqmnts	Relevance
1	In Home Television Viewing	Various use cases related to in-home viewing including viewing from physical media, broadcast and online distribution.		
1.1	Interoperability between Receiver/Decoder/Player and Display Types	Different display types may be driven by different types of receiver/decoder/players. Use cases related to interoperability between the former and the latter are listed.		
1.1.1	With Glasses	The consumer turns on the TV and the player/receiver. The TV detects the presence of 3D content being sent to it.	7.0, 7.2.1	Yes
1.1.2	Without Glasses	The consumer turns on the TV and the player/receiver. The TV detects the presence of 3D content being sent to it.	7.0, 7.2.1	Yes
1.1.3	Upgrades Needed for Legacy Receiver/Decoder/Player	The consumer needs to install a firmware upgrade to a legacy player/receiver/decoder in order for it to be 3D-ready.		No
1.1.4	No Upgrades Needed for Legacy Receiver/Decoder/Player	The consumer does not need to install a firmware upgrade to a legacy player/receiver/decoder in order for it to be 3D-ready.		No
1.1.5	Adapter between Display and Receiver/Decoder/Player	The consumer needs to install an adapter between a 3D-ready receiver/decoder/player and a 2D display for the consumer to view 3D content.		No

Number	Title	Description	Rqmnts	Relevance
1.1.6	No Adapter between Display and Receiver/Decoder/Player	The consumer does not need to install an adapter between a 3D-ready receiver/decoder/player and a 2D display for the consumer to view 3D content.		No
1.1.7	User Controllable 3D Effects	The viewer can vary the strength of the 3D effect via the remote control associated with the receiver/decoder/player and/or the 3D display. Note: This scored a 3 based on the need for metadata support, but is mostly a consumer device feature.	7.3.3, 7.5	Yes
1.1.8	3D User Interface	The user can invoke the 3D user interface that is superimposed over the 2D or 3D video content that he is watching on his 3D display driven by a 3D receiver/decoder/player. Note: Data that identifies the incoming content is 3D will trigger devices that provide 3D OSD to display menus in 3D.	3.0, 7.2.1, 7.3, 7.5	Yes
1.1.9	Location of Subtitles	The default location of the subtitles is specified in the content being viewed.	4.0	Yes
1.1.10	Child Mode	The display and/or receiver/decoder/player has a Child Mode which compensates for the small optical axes separation in children. Note: This is a downstream feature.	7.5	Yes
1.1.11	Ease of Setup	The display and/or receiver/decoder/player can be interconnected and configured in a simple, straightforward, automatic manner.		No

Number	Title	Description	Rqmnts	Relevance
1.1.12	Display Type Agnosticism	A user has an autostereoscopic (NG3D) in the living room and a stereoscopic (AGB3D) display in the bed room. He sometimes also plays his 3D Blu-ray discs bought for the NG3D display on the AGB3D display in the bed room. Note: The format of the master package being display agnostic is noted.	5	Yes
1.1.13	Display-Size Agnosticism	A user has a 60" NG3D display and a 20" TV set. He expects the same 3D quality on his 20" TV as he gets on the larger 3D display. In the future, he even anticipates viewing the content that he owns on his 3D cell phone. The format of the master package being display agnostic is noted.	5	Yes
1.1.14	Signaling Agnostic to Display Type	A user has a NG3D and an AGB3D 3D TV set and he watches 3D programs on both TV sets. The 3D programs from the program provider are marketed as generic 3D content (not specifically for a certain type of 3D display).		No
1.1.15	Source Geometry Metadata	Metadata describing the "camera" position in the source scene would be used by a 3D processor to format the imagery for the display such that the viewing perceived by the consumer is modified for the specific Viewing Geometry environment. (e.g., source material short for IMAX 3D formatted by processor for display on consumer 37" TV with consumer 10' away). Note: Need to define better exactly how this will be used.	7.5	Yes
1.1.16	Viewing Geometry Metadata	Metadata describing the intended viewing environment (e.g., screen size, viewing distance and other applicable geometry information utilizable by a 3D processor along with the Source Geometry Metadata to format the proper parallax for display and viewing).	7.5	Yes
1.1.17	Split Screen with 3D and 2D Rendering	In the store, the sales associate displays the 2D version and the 3D version of a media asset in a side by side format. This allows demos/comparison of 2D vs. 3D viewing experience.		No

Number	Title	Description	Rqmnts	Relevance
1.1.18	Retail 3D Demos with Close Viewing Distance	In retail spaces, viewers are typically much closer to the screen than in a home setting. A demo mode on the display supports close viewing, e.g., infinity is not at 65mm parallax, but less, as in the child mode, and provides comfortable out of screen effect (parallax less than 1.5 degrees).		No
1.1.19	Change Location of Subtitles	The location of the subtitles as specified in the content being viewed can be overridden by the user and can be repositioned in (x, y, z) space. Note: This is a product feature.	4.0, 7.3, 7.5	Yes
1.1.20	Floating Windows	Floating Windows create the illusion of moving the physical borders of the screen surround forward. They are often used to prevent edge violations. Note: Floating Windows can be encoded on a per frame basis via metadata or embedded in the essence.	7.6	Yes
1.1.21	Viewer Control of Floating Windows	A user who does not prefer to view Floating Window can eliminate the black pixels on either side of the image - to have full screen left and right images. This is especially useful in viewing a 2D version (which is not cropped) of the 3D content.	7.6	Yes

Number	Title	Description	Rqmnts	Relevance
1.2	Viewing of Broadcast Content			
1.2.1	Closed Captions for 3D-TV Content	While viewing 3D TV content of any kind the user turns on closed captions via the television or associated set top box remote control. The captions are presented as intended and appear within the focal range of the 3D content. Note: The addition of z axis data is required in order to carry this function out. This may require a modification to the Closed Caption Standards.	5.0, 7.0, 7.3	Yes
1.2.2	Automatic Identification of 3D Display Capabilities			
1.2.2.1	Receiver/Player Identification	Subscriber's (player/receiver) communicates with display using digital interface ports to identify the 3D capabilities of the display and stores or reports this information to applications on the player/receiver that delivers or selects content to the display.		No
1.2.2.2	Automated Content Formatting	Based on either the automated identifications or manual user settings, the subscriber's player/receiver will automatically decode, recode, transcode or otherwise reformat any type of 3D content delivered as needed into the necessary format for the 3D display.		No
1.2.3	Manual Identification of 3D Capabilities & Preferences	In the absence of automated reporting capabilities (for example use with existing "3D-Ready" display or other compatible products built before the necessary communications and signaling standards are completed), the subscriber enters preferences into set-up menus to identify specific 3D capabilities or preferences. These preferences are stored and reported to applications in the external receiver/player that deliver or select content to the display. Standardized and consumer-friendly terminology is used to describe certain 3D capabilities.		No

Number	Title	Description	Rqmnts	Relevance
1.2.3.1	Setting Preferences	User indicates preferences such as preferred content types (2D or 3D when available) that are saved.		No
1.2.3.2	Content Pass-Through	A subscriber is using an existing (legacy) digital receiver/player and selects a 3D program for viewing. Without any updates to that receiver/player, the box provides a fully decoded video stream on the uncompressed video output (DVI/HDMI), which contains formatting that is understood and processed by the subscriber's 3D display as a full 3D image.		No
1.2.4	Viewing 2D Versions of 3D Broadcast Channels			
1.2.4.1	3D-Exclusive Content	<p>Based on subscriber capabilities and/or preferences, a subscriber selects a broadcast channel that contains 3D content (based on a transmission format or signaling that is designed or intended not to provide a 2D decimated or compatible version) and views the channel in 3D. The channel or program may not be available to subscribers without 3D capabilities. Examples of this might include movies, concerts or other productions that are produced specifically for 3D viewing that are either not made available for 2D or that are mastered separately for 2D viewing.</p> <p>Note: This case would be addressed in the contract that exists between content owner and distribution channel.</p>		No

Number	Title	Description	Rqmnts	Relevance
1.2.4.2	Compatible 3D Content	<p>Without regard to subscriber's capabilities and/or preferences, a subscriber selects a broadcast channel that contains 3D content (which is transmitted and/or signaled in a way designed to include or enable a 2D decimated or compatible version) and views the program. Examples of this might include live sports or other content aimed at the largest possible audience from a single production. Subscribers with 3D-capable equipment supporting the signal format will display the content in 3D, while those without such equipment will still enjoy the same program as a 2D representation.</p> <p>Note: This case would be addressed in the contract that exists between content owner and distribution channel.</p>		No
1.2.4.3	Incompatible 3D Content	<p>During 3D content creation, the 3D effects may create frames of left and right images that cannot be used in a 2D rendition of the content, in that the 2D presentation is unnaturally distorted or alternate frames are completely different to the combined left and right fusion in the 3D presentation. A separate 2D image sequence is needed, and the 3D content should be marked as being not suitable for the generation of 2D compatible content.</p> <p>An example follows: In the case where the 3D effect generates negative parallax it is possible that the right (left) image appear as coming from left to right (right to left); if the left or right frame is used for a 2D version in this case, the object that appears to be central in 3D presentation switches on a frame by frame from a central image to coming from either side, depending on which eye is selected in the 2D presentation as the image transitions to negative parallax.</p> <p>Two situations are relevant: (1) the same Master is used to author separate 3D and 2D titles of the movie, and/or (2) the studio decides to release a single BD title that has both 3D and 2D versions, and the Master needs to contain both the 2D and 3D version.</p>	6.2, 7.1	Yes
1.2.5	Fast Channel Change	A subscriber "channel surfs" between 2D and 3D content and between channels that deliver 3D content and notices no perceptible differences in acquisition time and no added delay to tune 3D programming.		No

Number	Title	Description	Rqmnts	Relevance
1.2.6	Ad-Insertion			
1.2.6.1	Ad Insertion (Baseband)	Ad-insertion in the uncompressed domain at the headend or content distribution point does not degrade the viewing experience of the consumer. Note: It is important to identify where ads would be inserted, and indicate a z axis value at the time of the ad insertion.	3.0, 6.1, 7.0, 7.3, 8.0	Yes
1.2.6.2	Local and Client-Side Ad Insertion (Compressed Domain)	For the purposes of these use-cases, “Local Ad insertion” refers to the splicing of encoded MPEG streams done at the headend or content distribution point. “Client-Side Ad Insertion” refers to the splicing of encoded MPEG streams within the customer premises equipment (DTV or STB). Note: This was submitted as a definition only.		No
1.2.6.2.1	2D Ads Inserted into 3D Content Streams	A subscriber is viewing a 3D content stream and either the local headend or STB inserts one or more 2D ads directly into the encoded stream, e.g., based on SCTE ad insertion signaling protocols. The subscriber’s viewing is uninterrupted with a smooth transition between the 3D and 2D content and back again. Note: It is important to identify where ads would be inserted, and indicate a z axis value at the time of the ad insertion.	7.3, 6.1	Yes
1.2.6.2.2	3D Ads Inserted into 2D Content Streams	A subscriber is viewing a 2D content stream and either the local headend or STB inserts one or more 3D ads directly into the encoded stream, e.g., based on SCTE ad insertion signaling protocols. The subscriber’s viewing is uninterrupted with a smooth transition between the 2D and 3D content and back again. If the viewers’ preferences are set to 2D, the inserted 3D ad plays as if it were a 2D ad.		No

Number	Title	Description	Rqmnts	Relevance
1.2.6.2.3	3D Ads Inserted into 3D Content Streams	<p>A subscriber is viewing a 3D content stream and either the local headend or STB inserts one or more 3D ads directly into the stream, e.g., based on SCTE ad insertion signaling protocols. The subscriber's viewing is uninterrupted with a smooth transition between the main program and the ad content and back again, while preserving and observing the user's preferences for 2D or 3D playback throughout. When 3D viewing is used, a "neutral focal distance" is provided between the transition points.</p> <p>Note: It is important to identify where ads would be inserted, and indicate a z axis value at the time of the ad insertion.</p>	7.3, 6.1	Yes

Number	Title	Description	Rqmnts	Relevance
1.2.7	V-Chip for 3D TV Content	A subscriber has set certain Content Advisory (such as V-chip) controls on the 3D capable receiver and when 3D content is selected, the Content Advisory parameters are delivered to the receiver when available in a way that enables operation consistent with 2D receiver and 2-D content behavior.		No
1.2.8	OSD Presentations for 3D-TV Content			
1.2.8.1	Full Screen Local Menus & Graphics	A subscriber tunes his receiver/player or integrated receiver/display to any type of 3D content compatible with his display and views the content in a 3D mode. The subscriber activates any locally generated OSD, menu or GUI and sees a smooth transition from viewing the 3D content to viewing the local graphics.	3.0, 7.3, 8.0	Yes
1.2.8.2	Partial Graphical Overlay and Blending	Anytime the subscriber is viewing any type of 3D content, the graphical user interface may generate objects intended to overlay or blend with the video content. Such blended graphics work as designed for 3D content, placing any graphical objects within the depth range for the 3D content.	3.0, 7.3	Yes
1.2.8.3	Sub-pictures, Preview, PIP & POP	Anytime the subscriber is viewing any type of 3D content, the applications may place the video content in a scaled sub-picture within the graphical menus, or may generate a multi-screen preview of several programs or services or may place two different programs on the screen at the same time using PIP or POP. In each case, the display system must be able to present usable sub-pictures or scaled pictures that may or may not be a true 3D image.		No
1.2.9	Conditional Access for 3D-TV Content	When a subscriber cancels payment or a subscription to a pay service delivered as any type of 3D video, existing conditional access systems and infrastructure must be able to prevent the subscriber from continuing to receive that content.		No

Number	Title	Description	Rqmnts	Relevance
1.2.10	Content Protection for 3D-TV Content	When a subscriber attempts to duplicate or redistribute any type of 3D content in a manner that violates the content protection limits placed on the content by its owner or distributor (within the bounds of the FCC's encoding rules), the existing video content protection system will be able to prevent such unauthorized use.		No
1.2.11	In-home Storage of 3D-TV Content (time-shifting)			
1.2.11.1	Complete Recording of 3D Signals	A subscriber has selected 3D video content and wishes to record or schedule a recording of that content for later viewing. A recording is possible (when permitted by content protection) that preserves the signal sufficiently to regenerate the 3D experience at a later time. The recording should also preserve any associated metadata that identifies playback requirements, display requirements or format identification of the content, so user-preferences or changes to a connected display can be accommodated.		No
1.2.11.2	Random Access & Trick-Play for 3D Content	A subscriber is able to record 3D content using DVR/PVR technology that provides random access and trick-play transport controls including pause, FFW, REW and slow motion with the same performance and ease he is able to do so with 2D programming.		No
1.2.12	Seamless Switching between 2D and 3D Modes			
1.2.12.1	3D to 2D Switching	A subscriber is viewing 3D content in 3D mode and decides to change the viewing mode to 2D mid-program, for the benefit of others in the room. The delivery system or content formatting should permit a seamless transition from 3D viewing to 2D viewing.		No

Number	Title	Description	Rqmnts	Relevance
1.2.12.2	2D to 3D Switching	A subscriber is viewing 3D content in 2D mode and decides to change the viewing mode to 3D mid-program. The delivery system or encoding system should permit a seamless transition from 2D viewing to 3D viewing.		No
1.2.13	Signaling of L/R Identification	The user selects any 3D content for viewing and the display is able to automatically recognize and direct the appropriate signals for left and right eye perspectives. This implies there is an unambiguous method to identify the separated images for left and right eye throughout the distribution, transport and interface chain.	7.2, 8.0	Yes
1.2.14	Transcoding	The distribution system may require the 3D content to be transcoded or decoded/re-encoded at one of more points in the path to the home. These processes will preserve all information needed in the final distribution package to home – so as to enable a high quality viewing experience.		No
1.2.15	Cable Distribution-Specific Use Cases			
1.2.15.1	Switched Digital 3D Video			
1.2.15.1.1	Capability Directed Channel Change	A subscriber selects a given service (e.g., ESPN or HBO) and based on the stored or reported 3D capabilities, the subscriber is directed to a switched digital video service that is transmitted in a format that matches his 3D capabilities.		No
1.2.15.1.2	Preference Directed Channel Change	A subscriber selects a given service (e.g., ESPN or HBO) and based on the stored or reported 3D preferences, the subscriber is directed to a switched digital video service that is transmitted in a format that matches his 3D preferences.		No

Number	Title	Description	Rqmnts	Relevance
1.2.15.2	On-Demand 3D TV	For the purposes of these use-cases, “on-demand 3D TV” includes all variations of interactive video on demand, including but not limited to traditional movies-on-demand, user-generated content, subscription-on-demand, services that make use of on-demand technology like “Star-Over” or “Catch-Up” and so-called “Remote-Storage DVR” services.		
1.2.15.2.1	Capability Directed On-demand	A subscriber selects a given on-demand program, title or service and based on the stored or reported 3D capabilities, the subscriber is automatically delivered the digital video content that is formatted and transmitted in a way that matches his 3D capabilities.		No
1.2.15.2.2	Preference Directed On-demand	A subscriber selects a given on-demand program, title or service and based on the stored or reported 3D preferences, the subscriber is automatically delivered the digital video content that is formatted and transmitted in a way that matches his 3D preferences.		No
1.2.15.2.3	Random Access & Trick-Play for 3D Content	A subscriber is able to view 3D content using on-demand technology that provides random access and trick-play transport controls, including pause, FFW, REW and slow motion with the same performance and ease he is able to do so with 2D programming.		No

Number	Title	Description	Rqmnts	Relevance
1.2.15.3	Emergency Alert for 3D-TV Content	While viewing 3D TV content, a SCTE-18 emergency alert message is received. In response to this message, the 3-D capable receiver must be able to respond as intended by the message including support for all modes of operation such as on-screen instructions, forced-tune to another channel or service.		No
1.2.16	Compatibility with 2D Distribution Channels			
1.2.16.1	Bandwidth Constraints for Broadcast Systems	<p>For broadcast systems which by nature have significant bandwidth constraints, the 3D content is distributed in a backwards compatible manner where the 2D component is decodable by existing 2D decoders and the additional bandwidth requirement for delivering the full 3D content rather than just the 2D component of the content is minimized.</p> <p>An example of this is where the 2D decoder is based on the MPEG-4 Part 10 or MPEG-2 Part 2 video compression standard and the MPEG-2 Part 1 specified transport stream delivery of such data.</p>	6.2, 7.1, 7.2.1, 7.3.1	Yes

Number	Title	Description	Rqmnts	Relevance
1.3	Viewing of Content on Physical Media			
1.3.1	Blu-ray Disc			
1.3.1.1	Playback of 3D and 2D Content from Blu-ray Disc	User plays back a Blu-ray disc that contains 3D and 2D content [hereafter denoted as “3D + 2D Blu-ray disc”] in their Blu-ray player. The user selects the 3D version of the film from the BD menu, after which, the 3D version of the movie plays (i.e., the user is able to view the disc as either 3D or 2D). Depending on the television type the user may or may not be required to wear glasses to enable the 3D effect.	1.0, 7.1, 7.2, 7.3, 7.4	Yes
1.3.1.2	Graphical Overlays for 3D + 2D Blu-ray Disc	While playing a 3D + 2D Blu-ray disc, graphical overlays appear over the 3D video at programmatically determined times (e.g., Pop-up video). The graphics may be in 2D or 3D. The 3D position (i.e., z position) of each graphic is set during the Blu-ray authoring process, e.g., graphics are authored to appear in front of the primary object of interest.	3.0, 7.3	Yes
1.3.1.3	User Controlled Graphics Locations	A user's Blu-ray discs contain interactive games. Some of these games are in 3D and some are in 2D. The 3D games are dynamically composited over the 3D video that he is watching. The 2D games are presented on screen location, or at discretion of content creator placed in z domain. Note: The following is a consumer device feature – and not important to the prioritization. The user can place have the 3D video content behind the 2D game, while flattening the 3D video somewhat.	3.0, 7.3	Yes
1.3.1.4	Interactive Graphics for 3D + 2D Blu-ray Disc	While playing a 3D + 2D Blu-ray disc interactive graphical menus appear over the 3D video in response to a user operation and present the user with the ability to navigate to any point within the 3D video. The graphics may be in 2D or 3D. The 3D position (i.e., z position) of each graphic is set during the Blu-ray authoring process, e.g., graphics are authored to appear in front of the primary object of interest. However, since the graphics will not appear deterministically (i.e., they will appear only in response to user input), the 3D position of each graphic may be authored to be dynamic, based on additional information that is available in the 3D Home Master, e.g., depth map.	3.0, 7.3	Yes

Number	Title	Description	Rqmnts	Relevance
1.3.1.5	Subtitles for 3D + 2D Blu-ray Disc	While playing 3D video from a 3D + 2D Blu-ray disc the user activates a subtitle stream language (e.g., Spanish subtitles are turned on) from the interactive graphical menu or via the remote control. The 3D position (i.e., z position) of each subtitle is set during the Blu-ray authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	4.0, 7.3	Yes
1.3.1.6	Transition between 3D and 2D Content	While playing 2D video, if any, on a 3D + 2D Blu-ray disc, the user selects an interactive graphical button that jumps out of the 2D video and plays 3D video. Before jumping to the 3D video an onscreen message appears directing the user to put their 3D glasses on, if applicable. After finishing playback of the 3D content the player returns to the 2D video and resumes normal playback. Note: 3D material is not in the master – separate from the 2D master.		No
1.3.1.7	Upgrade of 2D Content to 3D via BD Live (downloading)	Via a BD Live application the user downloads additional data that, once downloaded to the Blu-ray player, enables playback of otherwise 2D content (on the Blu-ray disc) in 3D.		No
1.3.1.8	Upgrade of 2D Content to 3D via BD Live (streaming)	Via a BD Live application the user streams additional data that enables playback of otherwise 2D content (on the Blu-ray disc) in 3D.		No
1.3.1.9	Upgrade of 2D Content to 3D via External Storage Device	Via a BD application the user transfers additional data provided from a player's removable storage input port, e.g., thumb drive slot, that enables playback of otherwise 2D content (on the Blu-ray disc) in 3D.		No
1.3.1.10	Player supports Branching – Frame/Scene/Chapter based	Playback device supports frame/scene/or chapter branching to alternate views/content. There is a video that has a scene where elements are being pointed directly at the camera to achieve a 3D effect. These elements work well in 3D but are not as visually pleasurable in 2D. This video also has alternate content suitable for viewing in 2D instead of the 3D version. When playing a 2D version of a video stream (possibly by using the left eye view) The content may <i>branch</i> to an alternate version of the scene that is more acceptable for 2D viewing.	6.0, 7.1	Yes

Number	Title	Description	Rqmnts	Relevance
1.3.1.11	Branching – Time Correlation	Alternate video sequence information is stored separately and time-correlated. By use of time correlation the player can know exactly when to branch off of the primary stream and retrieve the alternative 2D content as well as when exactly to branch back to the primary content stream.	6.0, 7.2.1	Yes
1.3.1.12	Branching – between Left/Right/Center Streams	When playing a 2D version there may be points in the video where the 2D could be derived from the left view, the right view, or the center view, based on artistic considerations. Branching may be between all three dynamically.	6.0, 7.1, 7.2,	Yes
1.3.2	DVD			
1.3.2.1	Playback of 3D and 2D Content from DVD Disc	User plays back a DVD disc that contains 3D and 2D content [hereafter denoted as “3D + 2D DVD disc”] in their DVD player. The user selects the 3D version of the film from the DVD menu, after which, the 3D version of the movie plays (i.e., the user is able to view the disc as either 3D or 2D). Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	1.0, 7.1, 7.2, 7.3, 7.4	Yes
1.3.2.2	Graphical Overlays for 3D + 2D DVD Disc	While playing a 3D + 2D DVD disc, graphical overlays appear over the 3D video at programmatically determined times (e.g., Pop-up video). The 3D position (i.e., z position) of each graphic is set during the DVD authoring process, e.g., graphics are authored to appear in front of the primary object of interest.	3.0, 7.3	Yes
1.3.2.3	DVD Menus for 3D + 2D DVD Disc	While playing 3D content from a 3D + 2D DVD disc, the user presses the “Menu” button on their remote control. The DVD menu appears full-screen (i.e., not over the 3D video) in either 2D or 3D, during which time the user can navigate in the same way as in conventional DVD menus.		No
1.3.2.4	Subtitles for 3D + 2D DVD Disc	While playing 3D video from a 3D + 2D DVD disc, the user activates a subtitle stream language (e.g., Spanish subtitles are turned on) from the DVD menu or via the remote control. The 3D position (i.e., z position) of each subtitle is set during the DVD authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	4.0, 7.3	Yes

Number	Title	Description	Rqmnts	Relevance
1.3.2.5	Captions for 3D + 2D DVD Disc	While playing 3D video from a 3D + 2D DVD disc the user turns on closed captions via the television remote control. The captions are in 2D and appear to be in front of the 3D video. Note: Assumes that caption information along with z-axis metadata is passed through to the 3D display device.	5.0, 7.3	Yes
1.3.2.6	Transition between 3D and 2D Content	While playing 2D video, if any, on a 3D + 2D DVD disc the user selects a button from the DVD menu to play the 3D video. Before jumping to the 3D video an onscreen message appears directing the user to put their 3D glasses on, if applicable. After finishing playback of the 3D content the player returns to the DVD menus.		No

Number	Title	Description	Rqmnts	Relevance
1.4	Digital Distribution			
1.4.1	Internet Download			
1.4.1.1	Internet download and playback of 3D content package to PC	User downloads a media file containing audio, 3D video, and subtitles [hereafter denoted as a “3D content package”] to their PC and subsequently plays it back using a PC application (e.g., Windows Media Player). Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	1.0, 2.0, 7.3	Yes
1.4.1.2	Internet download and playback of 3D content package to set top box with internet connection	User downloads a 3D content package to their internet connected set top box (e.g., Apple TV) and subsequently plays it back by accessing it via the user interface specific to the set top box. Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	1.0, 7.3	Yes
1.4.1.3	Subtitles for downloaded 3D content package	While playing the 3D content package the user selects a subtitle stream from the playback software’s menu system (e.g., option built into Windows Media player or Flash player) or via the set top box remote control. The 3D position (i.e., z position) of each subtitle is set during the content programming/authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	4.0, 7.3	Yes
1.4.1.4	Upgrade of 2D content package to 3D via additional download	A user has previously downloaded the 2D version of a movie. Via a second download containing additional data the film now plays back in 3D. The user can still play the 2D version if he wishes.		No
1.4.2	Internet Streaming			
1.4.2.1	Internet streaming and playback of 3D content package to PC	User streams a 3D content package to their PC and plays it back using a PC application (e.g., Windows Media Player). Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	1.0, 7.3	Yes

Number	Title	Description	Rqmnts	Relevance
1.4.2.2	Internet streaming and playback of 3D content package to set top box with internet connection	User streams a 3D content package to their internet connected set top box (e.g., Roku, internet connected cable STB, etc.) and plays it back. The stream is accessed via the user interface specific to the set top box. Depending on the television type, the user may or may not be required to wear glasses to enable the 3D effect.	1.0, 7.3	Yes
1.4.2.3	Subtitles for streaming 3D content package	While streaming the 3D content package the user selects a subtitle stream from the playback software's menu system or via the set top box remote control. The 3D position (i.e., z position) of each subtitle is set during the content programming/authoring process, e.g., subtitles are authored to appear in front of the primary object of interest.	4.0, 7.3	Yes

Number	Title	Description	Rqmnts	Relevance
2	Viewing on Mobile Devices			
2.1	Viewing on Mobile Phones			
2.1.1	Mobile Phone Downloading or Streaming	A single user downloads or streams a 3D content package to their mobile phone and views the content without glasses.	1.0, 7.3, 7.4	Yes
2.1.2	Mobile upgrade of 2D content package to 3D via additional download	A single user has previously downloaded the 2D version of a movie. Via a second download containing additional data the film now plays back in 3D. The user can still play the 2D version if they wish. No glasses are required to view the 3D version.		No

APPENDIX B

TASK FORCE PARTICIPANTS AND COMPANY AFFILIATIONS

Committee Chair: William Y. Zou. DTS Inc.

Name	Company
Ray Zone	3-D Zone
Howard Postley	3ality Digital
Carroll Lastinger	3DH Communications
Lars Borg	Adobe Systems, Inc.
Adam Goldberg	AGP, LLC
Aaron Wells	Ambarella
Thomas Eubanks	AmericaFree.TV
Sebastian Sylwan	Autodesk
Al Kovalick	Avid Technology, Inc.
Chris Johns	B Sky B
David Haines	Best Practices Laboratory for Entertainment Technology
Ingo Hontsch	BFE Studio und Medien Systeme GmbH
Sunkwang Hong	Broadcom Corp.
Yusuf Broachwala	BSAT Inc
James Brown	Buckeye CableSystem
David Broberg	Cable Television Labs
Jun-ichi Takeda	Canon, Inc.
Richard G. Streeter	CBS
Nabil Abujbara	CDA
Arturo Rodriguez	Cisco Systems
Wa James Tam	Communications Research Centre
Andre Vincent	Communications Research Centre
Lenny Lipton	Consultant
Ryan Sheridan	Consultant
Brian McCarty	Coral Sea Studios P/L
Harry Tarnoff	Dataplex, Inc.
Jay Wiskerchen	DDD Inc.
Chris Yewdall	DDD Inc.
Alex Shows	Dell Inc.

Name	Company
Tom Mc Mahon	DelRey
Bryce Alden	Deluxe Digital Cinema
Gary Sasaki	DIGDIA
C. Bradley Hunt	Digital Media Directions, LLC
Bernard Mendiburu	Digital Stereographer
Kuriacose Joseph	DirecTV
Josh Derby	Discovery Communications
Keith Foston	Discovery Communications
Cyril Rickelton-Abdi	Disney ABC Television Group
Theodore Szypulski	Disney/ABC/ESPN
Stephen Lyman	Dolby Laboratories
Patrick Griffis	Dolby Laboratories, Inc.
Limin Liu	Dolby Laboratories, Inc.
David Schnuelle	Dolby Laboratories, Inc.
Walt Husak	Dolby Labs
William Y. Zou	DTS, Inc.
John Card II	EchoStar Technologies LLC
Kevin Blake	Entertainment Technology Ctr.
David Wertheimer	Entertainment Technology Ctr.
Hans Hoffmann	European Broadcasting Union
Alan Lambshead	Evertz
Steven Somers	Extron Electronics
James M. DeFilippis	Fox Technology Group
Thomas Edwards	Fox Technology Group
Ralf Tanger	Fraunhofer HHI
Akira Nakagawa	Fujitsu Laboratories LTD
John Hudson	Gennum Corporation
Manabu Kuromori	Gennum Corporation
Nigel Seth-Smith	Gennum Corporation
David Bancroft	Grass Valley, Inc.

Name	Company
Bob Edge	Grass Valley, Inc.
J. Patrick Waddell	Harmonic Inc.
Paul Briscoe	Harris
Christopher Lennon	Harris Corp.-Bcast. Comm. Div.
Andres C. Colpa	HBO
Peter A. Wilson	High Definition & Digital Cinema Ltd
Tibor Balogh	Holografika
Kommer Kleijn	IMAGO
Rajendra Bopardikar	Intel Corp.
Gregory Stoner	Intel Corp.
Derek Flickinger	Interactive Homes, Inc.
Tanja Johnston	Iosono Inc.
Jordan Isailovic	JRI Technology
Rod Sterling	JVC
Steve Storozum	Level 3 Communications
JinSoek IM	LG Electronics
Nagaraj Nandhakumar	LG Electronics
Jong-Yeul Suh	LG Electronics
Kun Suk Kim	LG Electronics
Jeong-Hyu Yang	LG Electronics
William Warga	Liberty Global International
Simon Cho	masterImage
Wang-He Lou	MDEA
S. Merrill Weiss	Merrill Weiss Group LLC
Akihiro Hori	Microsoft Corp.
Kilroy Hughes	Microsoft Corp.
Ann Marie Rohaly	Microsoft Corp.
Yoshiaki Kato	Mitsubishi Electric Corp.
Ryuta Suzuki	Mitsubishi Electric Corp.
Anthony Vetro	Mitsubishi Electric Research
Ernesto Santos	MOG Solutions
Gary Hughes	Motorola
Faisal Ishtiaq	Motorola Inc.
Sean Mc Carthy	Motorola Inc.
Stefan Petrat	MTV networks
Graham Jones	NAB
Michael Karagosian	National Association of Theatre Owners
Mark Sauerwald	National Semiconductor
Robert Slutske	National TeleConsultants

Name	Company
Thomas Bause	NBC Universal
Eyal Farkash	NDS Technologies
Kohji Mitani	NHK
Hideaki Tabuchi	NHK (Japan Broadcasting Corp.)
Kimio Hamasaki	NHK-Sci. & Tech. Res. Labs
Hidehiko Kikuchi	Nippon TV Network Corp.
Christoph Cavigioli	NoWires Strategy Group
Arnaud Bourge	NXP Semiconductors
Bill Hogan	Panasonic B'cast & TV Sys. Co
Hideki Ohtaka	Panasonic B'cast & TV Sys. Co
John Wus	Panasonic B'cast & TV Sys. Co
Tao Chen	Panasonic Hollywood Laboratory
Taisuke Matsumoto	Panasonic R&D Company of America
Robert Kisor	Paramount Pictures Corp.
Paul Treleven	Paul Treleven Design
James A. Kutzner	PBS
Jeroen Brouwer	Philips Electronics
Martin Oerder	Philips Electronics
Viji Raveendran	Qualcomm Inc.
Mark Stockfisch	Quantum Data Incorporated
Matthew Cowan	Real D
Joshua Greer	Real D
Rolf Henkel	realityfabrik GmbH
Troy English	Ross Video Ltd.
Stephen Rush	Rush Law Group
Kyong-Sok Seo	Samsung Electronics Co Ltd.
Aron Baik	Samsung Electronics Co Ltd.
Jaewoo Jung	Samsung Electronics Co Ltd.
Jaewoon Lee	Samsung Electronics Co., Ltd.
R. Norman Hurst	Sarnoff Corp.
Gad Elmoznino	Sensio Technologies Inc
Etienne Fortin	Sensio Technologies Inc
Richard LaBerge	Sensio Technologies Inc
Daniel Malouin	Sensio Technologies Inc
Dale Rochon	SEO
Norio Itoh	Sharp Corporation
Keith Jack	Sigma Designs
Matthieu Sintas	SmartJog

Name	Company
Peter Symes	SMPTE
David Brooks	Snell & Wilcox
Tim Shuttleworth	Snell & Wilcox Ltd.
Hiroshi Nakano	Sony Corp.
Teruhiko Suzuki	Sony Corp.
Rob Engle	Sony Electronics, Inc.
Paul Gardiner	Sony Electronics, Inc.
Yoshihisa Gonno	Sony Electronics, Inc.
Peter Lude	Sony Electronics, Inc.
Ian Matthews	Sony Electronics, Inc.
Al Barton	Sony Pictures Entertainment
Karen Broome	Sony Pictures Entertainment
George Joblove	Sony Pictures Imageworks
John Rupkalvis	StereoScope International
Johnny Wang	Super Perfect Ltd.
Jay Spencer	Supernal Entertainment
Dave Hartmann	Tamuz USA
Matthew Goldman	Tandberg Television
Michael Dolan	TBT, Inc.
Manuel Novelo	TDVision Systems Inc.
Ethan Schur	TDVision Systems Inc.
Michael Zink	Technicolor Inc.
Reiner Doetzki	Texas Instruments
Keith H. Elliott	Texas Instruments
Philip B. Lelyveld	The Walt Disney Co.
Benn Carr	The Walt Disney Studios
Izzat Izzat	Thomson
Richard A. Dean	THX Ltd.
Michael Rudd	THX Ltd.
Geoffrey Tully	THX Ltd.
Tsutomu Shimizu	Tokyo Broadcasting System
Yoshihiro Kikuchi	Toshiba
John Gawe	Toshiba America Consumer Products, LLC
Tomoo Yamakage	Toshiba Corporation
Josh Perkins	TrioScopics, LP
Sebastian Schwarz	Tu Ilmenau
Merrick Ackermans	Turner Broadcasting
Don Lohiede	Turner Broadcasting System Inc
Steve Fish	Turner Broadcasting Systems
Peter Dare	Unaffiliated Individual
Ralf Frieser	Unaffiliated Individual

Name	Company
Johann Safar	Unaffiliated Individual
Michael Smith	Unaffiliated Individual
Bill Mandel	Universal Pictures
Perry Hoberman	USC School of Cinema-TV
Mark Hartney	USDC
Michael DeValue	Walt Disney Studios
Wendy Aylsworth	Warner Bros.
Brad Collar	Warner Bros.
Spencer Stephens	Warner Bros.
Russell Wintner	WinterTek, Inc.
Eric Kurland	Workprint Films
John Snow	Xilinx, Inc.
Ami Dror	XpanD
Eric Granlund	Zoo Digital