BRAINSTORM

WHITE PAPER

Being at the cutting edge in technology for two decades, allowed Brainstorm to define the foundations of many technologies.

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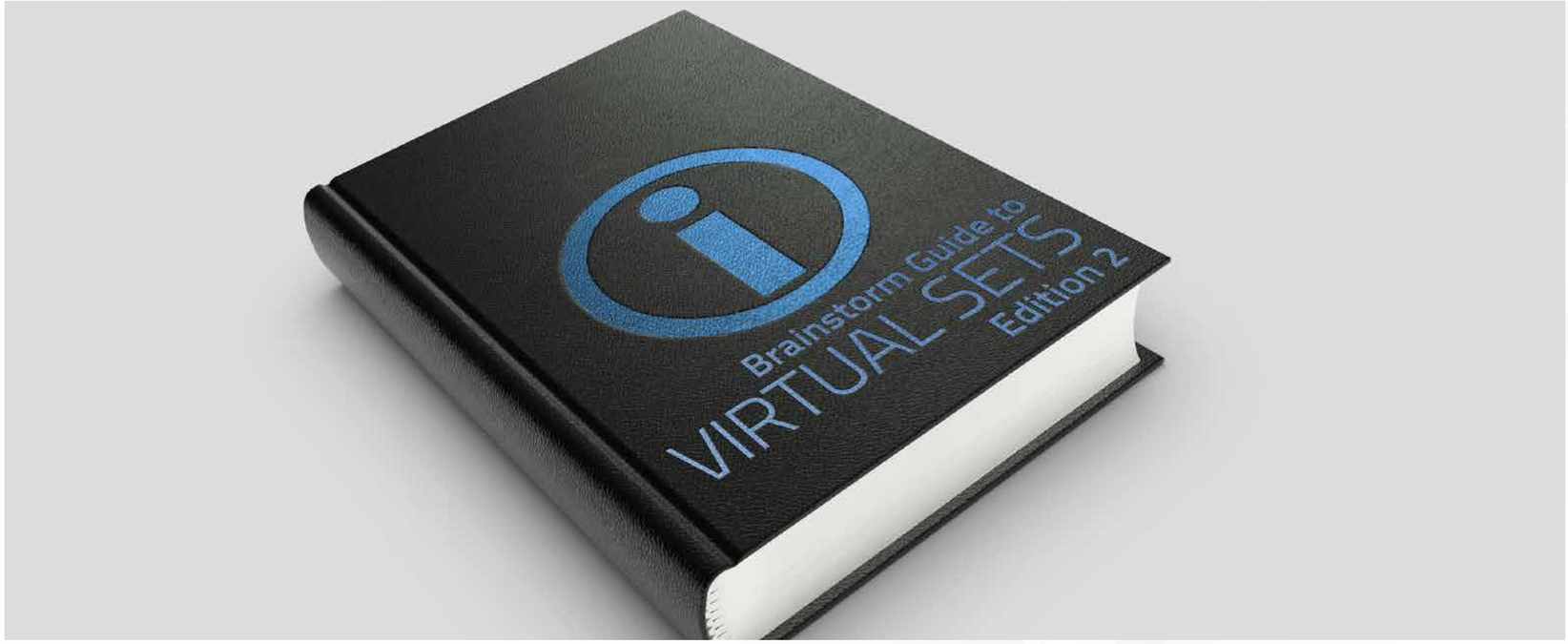
CONTENT



Virtual Sets have become increasingly popular over the years. The competition for the audience is intense, and viewers demand the better quality and the highest realism possible in what they see on television. So using virtual studios is quite interesting for broadcasters of any size, allowing for saving production costs while enhancing their content, therefore what once was a complex tool only reserved for the biggest companies is now a widespread solution.

Brainstorm pioneered the 3D virtual set technology for television, becoming the first company in creating a live real-time 3D virtual set at an interview with Mike Oldfield back in 1993. The company also started the development of technologies such as early camera tracking for 3D virtual sets.

Virtual sets can redefine and streamline every stage of the production process, enabling new formats and special effects that can be developed in hours rather than days or weeks. Since sets can be visualized, built, and dressed on a computer screen, and camera angles plotted with a series of keystrokes, expensive studio time drops dramatically. Sets are no longer limited by the physical dimensions available, as current technology allows set designers to recreate things such as a full-sized basketball court in a studio the size of a small room.

These digital scenarios can be developed anywhere in the world and then sent to another studio via the Internet for reuse. The great advantage of a virtual set is the power and flexibility to develop compelling programming faster and more economically than with traditional sets through the use of imaginative content.

This document provides an overview of the current technologies and an approach to virtual set production, from setting the studio to the software solutions and production requirements. We will also see how the virtual sets work, and the possibilities they provide using Brainstorm products such as eStudio or Infinity Set, possibly the most advanced solutions for virtual set production.

CONCEPT AND HISTORY

A virtual set or virtual studio is a television studio that allows the real-time combination of live characters, objects, images and computer generated environments and objects in a seamless manner, using a chroma keyer. A key point of a virtual studio is that the real camera can move in the set shooting the presenter, while a virtual renders the background in real-time from the same perspective, therefore, this virtual scene has to adapt at any time to the camera settings (zoom, pan, angle, traveling, etc.). This is what differentiates a virtual studio from the traditional technique of chroma key that has existed since the analogue television, as traditional chroma keying sets the character over one or more

images using a chroma keyer plus a studio mixer to produce the final result.

It also differs from techniques used in film or commercials, in which scenes are edited and refined later in post-production. A major difference between a virtual studio and the blue screen special effects used in movies is that the live characters, scenes and computer graphics are rendered in real-time, removing the need for any post production work, and allowing it to be used in live television broadcasts. In a typical virtual studio production, the talent performs in front of a blue or green screen. The three-dimensional virtual set or background is generated by real-time 3D graphics software. The foreground and background images are then digitally composited using a chroma keyer and a studio mixer to allow correct placement and sizing.

The virtual sets and virtual elements can be designed using graphic software such as Brainstorm's eStudio or Aston 3D, or imported from other graphic packages such as 3D Studio Max, Photoshop or many other. To build a realistic 3D set or at least one that is believable, the virtual studio software needs controls for proper texturing, lighting, shadows and model parameters. Brainstorm's eStudio and Infinity Set come with advanced features such as shaders, phong illumination, bump mapping, multitexture, multipass and real time shadows in addition to the complete list of ready-to-use OpenGL shading options.

During production, actors move inside the chroma set while camera operators follow the action and optional sensors on the cameras send tracking data to the real-time graphics software, enabling the virtual set to be rendered synchronized with the camera view. Both foreground and background objects may be moved and manipulated in real-time, meaning an actor can not only go in front or behind virtual objects, but can also walk or move inside them. That is performed using camera tracking techniques, but if the virtual set software is powerful enough to provide the movements to the virtual cameras some other approaches, such as trackless virtual sets, are also possible.

To achieve a seamless blending of the virtual scene with the real actors without jittering or jumping, the virtual camera requires a complete set of accurate position data from the real cameras. The Brainstorm software analyses the co-ordinates in space of the real world and the virtual world and matches them exactly. The required information of real world coordinates is XYZ positions plus pan, tilt and roll axis as well as distance units. Camera tracking technology sends a constant stream of data with this information providing the real-time graphic software with the position, orientation and scale data required to display the virtual set as the cameras move, pane, tilt or zoom.

DIFFERENT APPROACHES TO VIRTUAL SETS

Studio or real time video compositing has been around for years, since the days of the analogue television. Present in the cinema since the 1940's, the work of Petro Vlaho and the creation of the Ultimatte company made the foundation for the chroma keying in television, firstly via analogue blackboxes and now present in most video software packages.

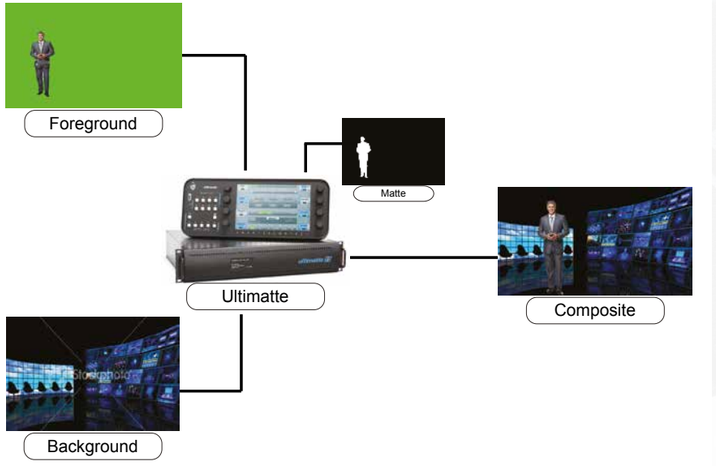
Here we will try to summarize the different uses of virtual sets and some other features similar to these. Every one of them has different hardware needs, that are also detailed.

TRADITIONAL CHROMA KEYING

Originally, the subject was shot with a fixed camera in its final position, and the chroma keyer removed the coloured background to reveal a picture or video signal behind the keyed subject. The character determined the shot, and could move in the set if staying inside the frame, but there were no further effects applied until the DVEs or studio mixers with DVE capabilities were introduced in production environments.

TRACKLESS VIRTUAL SET

The character and/or real objects are provided as video feeds from the camera and brought into the 3D virtual set via an internal or external chroma keyer. The camera is also fixed, so no tracking device is required, and both the background and talent can move and be animated. On this approach, the camera feed becomes a 2D surface (sticker) inside the 3D set. Then this 2D surface is internally DVEd to follow the virtual camera when this moves. The final result looks similar to a tracked camera, allowing XY+size movements with ease, but with some restrictions on the vertical movement that are especially visible if the camera spins or rotates on an axis, not mentioning that the actor can't move freely around the set.

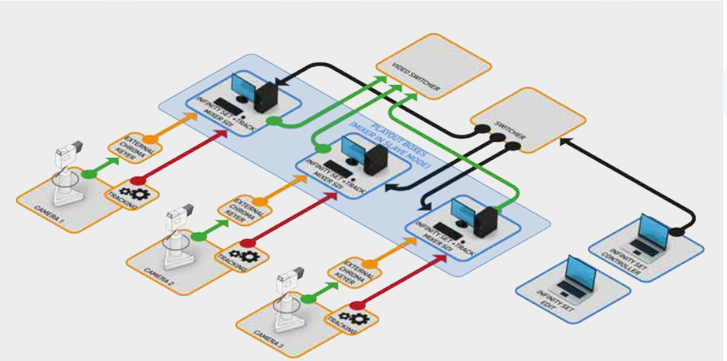


Ultimatte Chroma key workflow

Trackless Virtual Set

TRACKED VIRTUAL SET

A virtual set where the cameras in the live set have tracking systems that provide the information of the cameras' position, zoom, movement, etc., to the computer prior to compositing the scene. The complexity of the data provided from the cameras allow for different virtual set possibilities:



Virtual Set with tracked cameras and external chroma keyers

- **PTZF tracked virtual set.** A set where the camera position is fixed, however, axes pan, tilt and zoom/focus are tracked and provide data of the movements applied. A tracked head on the top of the camera tripod captures pan and tilt movement, whereas the zoom/focus tracking comes from either a set of external wheels fitting both zoom and focus wheels, or internal encoders. Both background and characters could freely move, but a calibration process is required to have a correct result.
- **Fully tracked virtual set.** The camera moves freely around the studio. It can be mounted on a crane, on a pedestal or handheld, depending on the tracking system we're using. Both background and characters could move freely on the set. Although this was traditionally linked to external chroma keyers, modern systems also accept internal chroma keyers, however the set-up still requires a careful calibration process. This provides the total virtual studio experience, with freedom to move around the space matching the camera and the character movements.

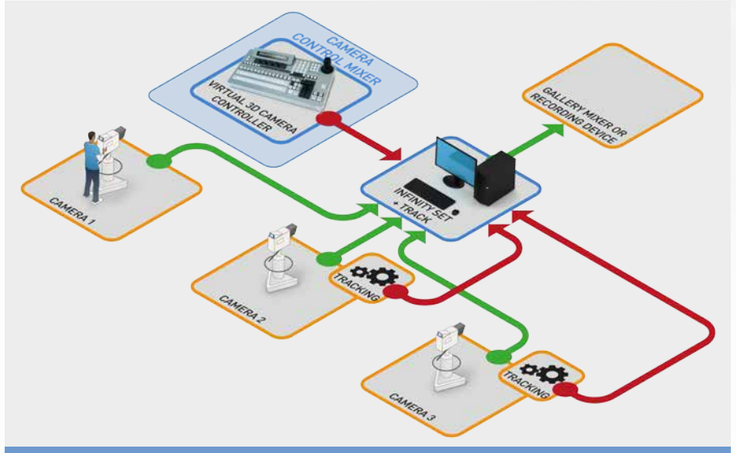
ENHANCED REALITY/ AUGMENTED REALITY

This is a special use of elements in the 3D space, an advanced application of the computer graph-

ics inside virtual sets. Basically it consists of virtual elements, information or data-driven graphics or images placed in the set along with the real character or other objects. Any of the above configurations could work with these graphics, although some will require additional tracking for moving objects in the scene displaying the mentioned graphics.

TRACKFREE™ VIRTUAL SET

TrackFree™ is a technology patented by Brainstorm which provides just what its name claims: the total freedom for operators to use any tracking system, trackless or fixed cameras, or a combination of these at the same time, while seamlessly integrating them if required, plus easily include Augmented Reality objects and compositions. As it is a camera-tracking independent technology, it combines the precision and higher quality of the most complex camera tracking system with the flexibility, freedom and ease of use of modern trackless systems.



TrackFree virtual set combining fixed and tracked cameras

TRACKLESS VIRTUAL SETS

Traditionally the trackless systems have been regarded as the lower end of virtual set, along with traditional chroma keying. However, modern software and real-time postproduction techniques are creating a new vision of the trackless virtual sets. The main advantage of the tracking systems is the ability to freely move the cameras all around the set creating a complex environment that resembles reality. On the other side, setting up a tracking system could be a complicated task, and the constant maintenance that requires end up in a fixed cost that prevents smaller companies to enter this arena.

Modern trackless systems provide a fairly flexible approach to the virtual set environment. They are significantly more affordable as they do not require tracked cameras, calibration, external chroma keyers, video delays or mixers, therefore reducing the total cost of the virtual set. Trackless systems compose the keyed character in the virtual environment, and use virtual cameras to create a final output where character and set move together. Additionally, this allows for internal real-time post processing such as shaders and effects that are not possible using external chroma keyers.

In Trackless virtual sets the talent is just a flat sticker with limited movements

However, the character is just a flat sticker within the virtual set, meaning that actors can't move from a given position, under the risk of losing the adjustment with the floor and in relation to the rest of the elements. Camera rotation and travelling are complicated as they will probably lead to perspective disarrangements and unrealistic behaviour on the whole composition. This also means that, although the character is placed in the 3D world, its interaction with the rest of the elements in the set is limited and the camera movements must be thoroughly prepared to avoid misalignments.

TRACKING SYSTEMS

A tracking system is a device, or several of them, that delivers information on camera movements to the 3D graphics computer. The computer receives them via serial port or UTP, using one of the existing data protocols. Then the 3D software creates a virtual camera that matches the position and every movement of the real camera, as accurately as to even apply the optical aberration inherent to the lenses. To accomplish that, it requires a calibration process that has slight differences depending on the tracking we're using.

We can establish a distinction between two main groups of tracking systems: mechanical and optical. Both have sensors for the lens (zoom and focus), which can be external, placed fitting the original zoom and focus ones, or internal from the same lens manufacturer.

MECHANICAL TRACKING

The mechanical tracking works by capturing pulses for every movement through a encoder. Types of mechanical tracking:

- **PTZF**. The most basic tracking system there is, consisting on a sensorized head placed on the top of the tripod which has to remain still in terms of position. Only Pan and Tilt movements are tracked, along with Zoom and Focus.

Tracked pedestals in studio

- **Pedestals**. Similar to PTZF systems, but allowing movement for the pedestal around the set as its XYZ position is tracked. Typically, it uses a couple of minicameras pointing towards the floor to see a zero point (a painted cross or even a couple of white straps) and then some internal encoders to count pulses from that zero to determine the distance covered.
- **Cranes**. They add to the basic PTZF another two sensorized axes, pan and tilt on the crane's arm. Depending on the model, the position might or might not be tracked.
- **Rails**. Along some rails sits a camera with PTZF tracking. The length of those rails is also tracked in terms of position.

OPTICAL TRACKING

The optical tracking captures the camera movement through an external device which locates the camera in 3D space and then sends the captured data to the virtual set or 3D software.

There are two different approaches to the optical tracking: active and passive. The active tracking triangulates the camera position by placing an infrared camera on the top of the video camera pointing towards the ceiling, which is populated by targets containing different codifications. The camera needs to see at least three of them at anytime to triangulate position and orientation. The "passive" approach places the infrared targets along the video camera while other infrared cameras cover some 3D space on the studio. When the camera moves around the studio, its position and orientation will be tracked. For both systems, optical tracking applies an external set of wheels or internal encoders.

More recent optical tracking systems rely on spatial reference using reflective reference dots strategically placed in the studio, which are referenced by the tracking system, or image analysis.

MANUFACTURERS

Brainstorm applications integrate with most tracking manufacturers, and support any standard communication protocols for tracking data. Some manufacturers are:

Vinten

Well known for their PTZF systems and pedestals. Vinten absorbed Radamec, inheriting their systems. One of them, Free-D, is an example of the first "active" optical tracking.

Vinten Vantage compact robotic head

Shotoku

Manufacturer of PTZF, pedestals and cranes. For spatial reference tracking, Shotoku has developed Free-d², built on Radamec's Free-D. Free-d² consists of a small upward-facing tacking camera, which provides referencing corresponding reference markers on the studio ceiling. Lens data is combined with the video image and presented to the Free-d² processor which precisely calculates the camera's

3D position. This is an 8-axis full 3D tracking system, fully referenced at everytime, that can be applicable to any camera.

Shotoku TP200VR/300VR system

Mo-Sys

Manufacturers of PTZF and cranes, but also developed the "StarTracker" system, consisting on a cloud of small retroreflective stickers that are randomly applied to the studio ceiling or the lighting grid with no additional structure required. An LED ring pointing at the stickers makes them "shine", reflecting the light in the tracking CCD camera to define the position of the camera in space. This technology can be applied to cameras, pedestals, jigs and cranes.

Mo-Sys StarTracker

nCam

Provides tracking abilities to standard ENG cameras, by using gyroscopes and image analysis to determine the position and movement of the camera, along with zooming information.

nCam on remote head

Tecnopoint

Tecnopoint produce external small PTZF kits that can be used with a range of small cameras, very good for small broadcasters. They also do cranes, like the PRIMO, primarily focused for augmented reality applications.

Tecnopoint PRIMO sensorized crane

EncodaCam

They can sensorize most crane models, but they also offer fully tracked cranes.

EncodaCam CamMate T11 with tripod

Motion Analysis

Pure optical tracking, one of the best-known examples of the "active" approach. It also works for motion capture that can be synchronised to Brainstorm eStudio.

Motion Analysis Raptor-12HS camera

Telemetrics

PTZF heads that can be mounted on their tracked rails.

Telemetrics PT-HP-S5 Servo Pan/Tilt Head

Trackmen

Sensorless optical system based on image analysis. The VioTrack coded floor uses a pattern in the floor which is captured by an auxiliary camera mounted on the video camera to provide the tracking data.

Trackmen VioTrack coded floor and camera

MORE INFORMATION

www.vinten.com
www.shotoku.tv
www.mo-sys.com
www.ncam-tech.com
www.tecnopointsrl.com
www.encodacam.com
www.motionanalysis.com
www.telemetricsinc.com
www.trackmen.de

ENHANCED REALITY: VIRTUAL, MIXED AND AUGMENTED REALITY

The term "Augmented Reality" (see Glossary), has been used lately to describe ways to enhance visual perspectives or views in a variety of media such as PCs, headsets or mobile phones, adding data such as advertising or cultural information on pictures or maps. We would use this term to describe information graphics applied to television programs when added to real shots in context.

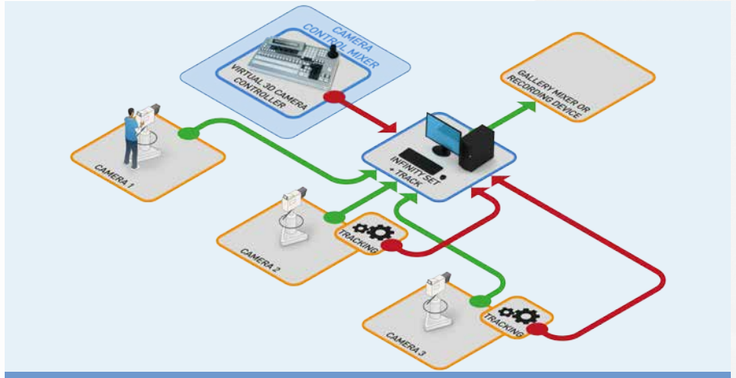
However, we can define Virtual Reality (VR) as the method to display synthetic images along with real ones. Some recent publications and companies have started to talk about Mixed Reality, understood as the combination of virtual and real environments, which in essence is yet another way to define Virtual Reality. Therefore, by extension, we could think that traditional chroma key could also represent a form of Virtual Reality, as the resulting image is not real but the result of compositing different images, either real or virtual. Continuing with this thought, any movie, composition or similar could be regarded as VR. On top of all that, we could understand AR as a special kind of Virtual Reality, meaning not all Virtual Reality images could be regarded as Augmented Reality.

Augmented Reality also requires the interaction between sets, talents and virtual objects, many of them created out of external data sources such as statistics, charts, bars, and many other. These data driven objects allow for visually engaging representations of the data which can be better explained by the presenters when placed in the set. During election nights, news, sports or entertainment programs, data bars and other statistics can interact with the talents creating an attractive augmented reality environment for the audience.

Some may assimilate or confuse Augmented Reality with "Digital Signage" (see Glossary), bringing confusion to both terms. Digital Signage is a method to display advertising in public spaces using digital media such as screens, tablets or PCs. Digital Signage could feature Augmented Reality to capture its audience, but Augmented Reality does not require Digital Signage to be displayed or delivered to the audience.

The term "Enhanced Reality" is often used to define any kind of the above "realities". Others use "Mixed Reality" to describe the shots resulting from combining real and virtual imagery, specifically 3D objects which are "enhancing" or "augmenting" the real footage. We will refer to Augmented Reality in this paper to describe any of the above "realities".

TRACKFREE™: THE BEST OF BOTH WORLDS



TrackFree can seamlessly combine fixed and tracked cameras

TrackFree™ is a new and advanced technology patented by Brainstorm that represents a totally new and revolutionary approach to virtual set production. It is a camera-tracking independent technology that enables broadcasters to combine the precision and high quality of tracking systems but at the cost of a trackless system, and with matching flexibility and user-friendliness.

TrackFree™ can be used in combination with the integrated internal chroma key software or external chroma key hardware, even within the same production. The whole composition is created within InfinitySet embedding the keyed feed into the virtual set, as opposed to standard chroma key layering. TrackFree™ technology also makes InfinitySet the ideal product for Augmented Reality applications, taking it to a new level of complexity, realism and data display never seen before, from simple virtual sets with fixed cameras to advanced and complex productions involving tracking cameras, external feeds and data driven graphics interacting in real-time with the set and the talents.

The TrackFree™ technology is the culmination of many different R&D projects Brainstorm has conducted over the last few years, and includes game-changing features such as TeleTransporter, 3D Presenter, HandsTrackin or FreeWalking, plus some recently released ones such as selective defocus and bokeh, VirtualGate and VideoCAVE.

TELETRANSPORTER

Allows the insertion of real people as Augmented Reality objects into remote scenarios in real-time,

TeleTransporter

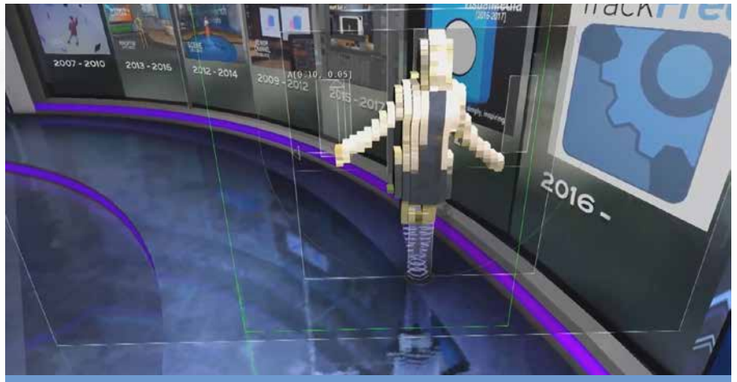
matching the tracking data of both the main studio and the remote location to create the illusion of absolute realism. This feature seamlessly combines 3D virtual sets with real characters and live or pre-recorded video feeds, all moving accordingly with precise perspective matching. This allows presenters, as well as 3D objects, to be inserted into videos from remote locations.

TeleTransporter not only permits real-time insertions of the live character in a live event or even in an event that happened in the past. It also enables inserting a pre-recorded character even in an event that occurs in the future.

Thanks to the TeleTransporter feature, InfinitySet can undistinguishably use real, live or pre-recorded footage to use it as the background set for the chroma keyed talent. This functionality allows a remote talent to enter any stage at any time, while seamlessly mixing real and virtual elements. In more practical terms, it allows for enhancing the corporate image of a large broadcaster, as it can reuse a single real set to be the background scenario for smaller stations in the network.

3D PRESENTER

This brand new feature enhances the realism of the talent inserted within the virtual set, achieved by generating a true 3D representation of the talent from a video feed, creating a real-time 3D volume that is continuously regenerated, repositioned and remapped based on the camera parameters. This means that the presenter is



3D Presenter

not a simple superimposed 2D sticker over the 3D virtual studio environment, but an actual 3D object embedded within the virtual set, casting real shadows correctly applied to the synthetic objects in the scene from the virtual lights defined on the set. 3D Presenter allows the talent to be seamlessly inserted within the 3D studio environment and to interact with both real and 3D elements within the scene, for example, shadows over a real desk and simultaneously with reflections on a virtual floor.

In addition to that, it allows for advanced features such as selective defocus and bokeh or volumetric lighting for the talent.

Selective defocus and bokeh

HANDSTRACKING

Permits the triggering of events and animations just with the simple movement of the bare hands and without the need for any additional tracking devices.

FREEWALKING

A feature which enables talents to freely move about the green screen theatre. Thanks to the FreeWalking feature presenters can move forward, backwards and sideways even though the real camera is in a fixed position.

TrackFree™ also allows including Augmented Reality applications within the virtual set, which are further enhanced by the features TrackFree™ allow for. The combination of TrackFree™ with Augmented Reality objects is a winning combination for the realism and impressiveness of the final composition.

VIRTUALGATE

Virtual sets allow for the inclusion of the talent into a virtual scene. Brainstorm takes this technology even further thanks to the VirtualGate feature, which allows to integrate the presenter not only in the virtual set but also inside additional content. Yet another consequence of the TrackFree™ technology, VirtualGate allows the talent in the virtual world to be tele-transported to any video (external source) with full broadcast continuity.

Thanks to VirtualGate, a presenter in the virtual set can walk into a virtual screen, into the featured news and be part of the video itself with full realism regardless it is shown full screen or as part of the set. The talent enters and exits the video with full precise and accurately matched perspective, and once inside the clip it behaves correctly in terms of spatial reference and with the inclusion of realistic shadows,

Volumetric lighting

defocus etc. This feature extends the virtual scenario beyond the virtual set and creates an infinite world for the presenters to be in, allowing for better real-time content possibilities and interaction.

VIDEOCAVE

It is a Mixed Reality application using monitors in a real set performing as a CAVE multiple window, with virtual elements coming in from the virtual windows to the real scene as viewed from a tracked broadcast camera.

COMBINED RENDER ENGINES

All Brainstorm products run on the eStudio render engine, considered the fastest in the industry. However, Brainstorm also supports gaming and architectural engines such as Unreal Engine. These highly complex engines provide realistic scenes with great possibilities, and played along with the eStudio render engine allows InfinitySet not only to show excellently rendered realistic background scenes, but also to integrate graphics elements in the final scene, like 3D motion graphics, lower-thirds, tickers, CG and many other elements. With the inclusion of these graphic elements, the scene can result in a highly complex composition, seamlessly integrating in real-time different render engines, virtual 3D backgrounds, real characters and synthetic graphics elements.

Brainstorm approach to external render engine support is unique in the industry, as it allows to control in real time any of the Unreal engine's parameters from InfinitySet, being the camera data just one of them, and allows merging both engines' render parameters and buffers to make them work as a single render engine.

VirtualGate

SETTING UP A VIRTUAL STUDIO

Virtual studios provide an excellent way to maximize the space required for program production, allowing less and less complex studios that could be immediately re-used for different shows throughtout the day. Also, space limitations for many broadcasters are a driving reason to decide the incorporation of virtual studio technology, so they could prepare bigger sets instead of phisically build them on stage. There are many technical solutions for creating virtual studios, but all of them require the following:

- **A blue or green screen**, as big as production requires, which provides the colored background to key out the subject.

Talent on green screen

- **Broadcast camera(s),** the number depending on the complexity of the production and/or the possibilities of the virtual studio software. They are likely to require an SDI output and a GenLock input, although certain camera tracking systems need proper broadcast cameras to be used due to their physical attachments and further requirements.
- A **video mixer** to combine the video feeds and the rendered set and graphics to produce a final composition for output. The mixer could also include the chroma keyer to replace a chroma key background, if not the keyed subject will be supplied as a keyed feed.
- **Real-time rendering software,** that uses the camera tracking data, if available, and video feed to generate a composite image combining all the elements. Such software could be Brainstorm's eStudio or InfinitySet, for instance. Most modern applications also provide mixing/compositing capabilities, excluding the need for an external video mixer to blend the camera feeds with the rendered set and additional graphics.
- **Lighting** for the set and characters to provide the correct quality and color temperature to the final result.
- **Audio delay systems** to compensate the de-synchronization of audio and video inherent to some configurations (especially with external chroma keyers). Audio delays can be external or embedded in the virtual studio software.
- **Camera tracking**, that uses optical or mechanical measurements to describe the position, focus, zoom and other data from the camera, received as a data stream. Some virtual studio software are trackless, meaning there is no need for camera tracking when using such solutions. More advanced solution such as InfinitySet are TrackFree™, meaning they can work in tracked, trackless environments or both at the same time.

The background screen is green or blue, and normally painted or covered in cloth, because these colours are not present in human skin. It needs to be as clean and tidy as possible, to key out smoothly. The background colour is extracted from the signal by the chroma keyer, isolating the subject (character or real object) so it could be further placed on the set. Other options available when shooting in small environments are solutions like Chromatte, a reflective cloth that receives the colour hue from a ring in the camera objective, which provides a similar end result.

A real-time 3D software, such as Brainstorm's eStudio or InfinitySet, running on a powerful computer generates the virtual background. These virtual studio software can also provide internal chroma keyer modules and image mixers,

InfinitySet user interface

simplifying the set up and delivering a one-stop solution. The chroma keyer could also be an external piece of hardware or an extra function of the video mixer. In any case, the final function is to seamlessly mix the keyed foreground signal from the camera with the background plus the rest of the graphic elements of the final compositing.

The illumination on the background screen or cyclorama must be completely uniform and provide an even colour to ensure an accurate placement of the shadows that make objects and talent appear as if they were located in the virtual set. This allows for specific lighting treatments and special effects such as reflections, shadows caused by moving persons or flying objects (e.g. ability to cast shadows on a wall) or the light of a virtual sunrise or twilight, to be placed and controlled in a way that results in a convincing and realistic broadcast image.

As an image is created, there is a small delay between the video coming out of the camera and the 3D graphics fed into the composition, because of the rendering process. Depending on the installation the typical delay could be of approximately 2-3 frames, so it is required to apply a video delay to match the timing between foreground and background. When using external chroma keyers an audio delay will also be needed to match the video delay, but most modern audio desks have one included for every channel.

Tracking systems are not mandatory on every virtual studio configuration. Some virtual sets don't require a tracking system because the camera position is fixed, and the software simulates the camera tracking moving the subject along with the camera on the final composition, changing the character's size and position virtually depending on the virtual camera movement.

TrackFree™ technology allows using tracked cameras, fixed cameras or a combination of both in the same setup. That is why InfinitySet can provide better results than standard trackless systems while maintaining a lower level of complexity.

COMPOSITING

Having the character in the chroma screen, it is required a device that could combine the resulting keyed signal in real time into a background and also add the graphic elements. Assuming our real time virtual studio software has chroma keying and mixer capabilities, as eStudio or InfinitySet have, the video and camera tracking data will both be fed into the computer hardware. Once the data from the camera and the different video feeds are fed into the software, it will be possible to compose the final output with the character, the virtual set and the graphics that will be required for the final broadcasted program.

The software then composes the keyed image over the computer-generated background and moves them accordingly to the camera movements or creates a virtual camera movement.

Later, the graphic elements, text, animations or pictures will be placed as needed to complete the program. Brainstorm's eStudio or InfinitySet are able to compose a number of images and video feeds together, adding camera tracking data or virtual camera movements, place text, animations and computer graphics and apply a rundown list to the program so the final result is as close to reality as the artists could accomplish.

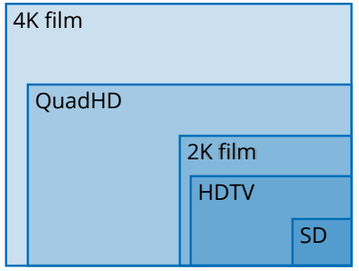
Photorealistic results can be achieved using advanced rendering techniques such as HDR (High Dynamic range), PBR (Physically Based Rendering) or using specialised render engines like Unreal Engine. This also requires careful material handling and enough computer power to achieve real-time results, especially when combining the character and the high quality set with data-driven real-time 3D broadcast graphics.

Talent and data-driven graphics composed in real-time on InfinitySet over a photorealistic background rendered using Unreal Engine

GLOSSARY

2K

Term used to define an image resolution of 2048x1556 in 4:3 format (1.33:1 open window). Widely used in film shooting and Digital Intermediate, other screen ratios inside the 2K family result in reducing the vertical resolution. 2K can also display anamorphic pictures.



3D

Term used to define a three-dimensional world (space), where objects can be defined as volumes (having height, depth and width) and positioned in space using 3 cartesian coordinates (XYZ), in contrast to bidimensional space where objects have no depth. In a 3D space planes could also be defined a depth = 0. Bidimensional space, or plane, could be fully defined with 2 coordinates (XY).

4K

Term used to define an image resolution of 4096x3112 in 4:3 format (1.33:1 full frame open window). Regarded as the maximum resolution modern 35mm film negative can achieve (the real resolution is closer to 3.6K, a resolution accepted for the Academic 4K format, with an image ratio of 1.37:1), it is now becoming increasingly used in film shooting and Digital Intermediate to ensure the best possible results on the grading and post-production processes. For broadcast operation, 4K is also used to name the Quad HD or UHD formats (see Quad HD, UHD).

Augmented Reality

AUGMENTED REALITY

Refers to a view whose elements are augmented or enhanced by computer-generated input such as sound, video, or data-driven graphics. As a result, the technology functions by enhancing the viewers' current perception of reality. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match. Artificial information about the environment and its objects can be overlaid on the real world.

BLUE SCREEN/GREEN SCREEN

Blue or green canvas used for chroma keying a subject for further composition (see chroma key, green screen) in 2D or 3D environments. This colour is used for keying characters as its hue is quite distinct from the human skin.

CALIBRATION

A comparison between measurements, one of known magnitude or correctness made or set with one device and another measurement made in as similar a way as possible with a second device. When used prior to camera tracking, it aims for the perfect match between the real camera movement and the resulting virtual camera movement produced by a 3D virtual studio software, matching the movements of the real and virtual cameras.

CAMERA TRACKING

Refers to the collection of the camera movements, zooming, etc., so they could be further applied to other objects, matching the movement of the camera with that of a given scene. It is primarily used to track the movement of a camera through a shot so that an identical virtual camera move can be reproduced in a 3D animation program. When new animated elements are composited back into the original live-action shot, they will appear with a perfectly-matched perspective and therefore can be integrated seamlessly.

CHROMA KEY

A method to superimpose several video layers using areas of a defined colour as a mask (matte). Chroma key compositing, or chroma keying, is a technique commonly used in video production and post-production for compositing two or more images or video streams together based on colour hues (chroma range). The technique has been used to remove a background from the subject of a photo or video or to compose an image over another. Chroma keying can be done with backgrounds of any colour that are uniform and distinct in contrast with the keyed subject, but green and blue backgrounds are more commonly used because they differ most distinctly in hue from most human skin colors.


Ultimatte Chroma keyer

COMPOSITION (COMPOSITING)

Describes the action of compositing together several video layers, titles, 2D and/or 3D graphics and other elements to create a final result.

FRAME (VIDEO OR FILM)

Any of the many still images which compose the complete moving picture. Slight differences between consecutive pictures provide the movement sensation. Video framesí size vary from SD standards to 4K and beyond.

GRAPHICS

A visual representation of a concept, idea, data or any information. Graphics can be as simple as an image or a word or as complicated as an animated audio-visual piece. Broadcast graphics cover a wide range of applications, from titles to opening sequences, OTS, lower thirds, etc. Depending on the final application, 2D or 3D soft-

ware can be used to prepare them (see Template).

GREEN SCREEN

See blue screen.

HDTV

Acronym for High Definition Television. Refers to TV signals or images with a higher resolution that PAL or NTSC (also called standard resolution), defined by the ITU specification ITU-R BT.709. HDTV is always displayed in 16:9 screen format (widescreen) and has several flavours determined by its vertical resolution, from 480P to 1080P, this last one also known as Full HD. In-between resolutions such as 1280x720 are also part of the HDTV standard but in consumer electronics is called HD Ready. HDTV also supports different frame rates, from 23.98 frames to 59.94 fields per second, both interlaced (I, field-based) and progressive modes (P, frame-based).

HDR - HIGH DYNAMIC RANGE

A dynamic range higher than what is considered to be standard dynamic range. The aim is to present a similar range of luminance

High Dynamic Range image

to that experienced through the human visual system. The human eye, through adaptation of the iris and other methods, adjusts constantly to adapt to a broad range of luminance present in the environment. In photography, HDR images can represent a greater range of luminance levels than can be achieved using more 'traditional' methods, such as many real-world scenes containing very bright, direct sunlight to extreme shade, or very faint nebulae. HDR for TV, however, aims for extending the contrast ratio and color range to allow for more realistic images. In traditional film, good quality negative stock was subject to capture HDR images, but the development process and the quality of the positive stock tend to reduced the dynamic range, which also happened during digitalization. To avoid this, 16-bit linear or 10/12-bit logarithmic (log) files were required -see Logarythmic (Log).

HPR - HEAD, PITCH, RADIUS

A term used in eStudio to describe a camera behaviour where a point of interest is set and the camera, while moving freely, always points to the selected POI. When using HPR, the camera follows an object all the time, pointing at it while it moves.

ILLUMINATION

See lighting.

LOGARYTHMIC (LOG)

Refers to a logarithmic translation curve, that is X = logY, when representing a captured signal, being X the value of the real object and Y its represented value in terms of luminance, chrominance or both. Log curves were defined in the Cineon (.cin or log .dpx) format of Digital Intermediate to better represent the behaviour and latitude of the original camera negative when scanning it to 12 bit or smaller resolutions. It is also accepted that the human eye perceives light in a logarithmic curve, as the human brain perceives more details on shadows than in highlights.

LIGHTING

Lighting or illumination is the deliberate use of light to achieve a practical or aesthetic effect. In broadcast, film, photography or scenic arts illumination is used both to achieve a desirable effect (daylight, night time, focus to a character...) and also to provide racord to the different scenes. In many cases lighting is required to provide an accurate appearance and final look of the scene, and its effect could be enhanced in post-production. Proper lighting is also essential when dealing with chroma keys, to provide even backgrounds and improve the keying process and quality.

LIGHTING (3D MODELLING)

The process of applying virtual lights with different properties (global, spot, coloured...) to a scene to create an artificial perception of reality. Lights have their properties defined by the 3D modelling/rendering software and they interact with the models depending on each one's properties (colour, specularity, bump...) and shaders applied.

PAN

Pan or panning refers to the rotation in a horizontal plane of a still camera or video camera. Video cameras normally pan by turning horizontally on a vertical axis, but the effect may be enhanced by adding other techniques, such as rails to move the whole camera platform. Slow panning could also be combined with zoom. The term is also used to define the reframing of an image bigger than the video output selected by horizontally scrolling the picture or video signal.

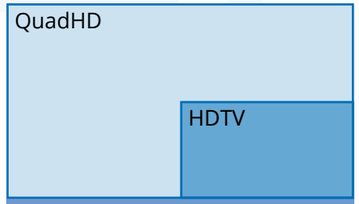
Camera Pan, Tilt, Zoom

PTZ

Acronym used to describe a camera's ability to Pan, Tilt and Zoom.

QUAD HD

Concept that defines an image size of 3840x2160 pixels, equivalent to four times the size of an HDTV signal. Also known as 4K UHD (see UHD).



QHD-HDTV frame comparison

REAL-TIME

Refers to the creation of video frames/images rendered as they occur in time, avoiding any need to wait for the images to be produced. The term used both in reference to 2D and 3D graphics, typically using a GPU, with broadcast applications and video games the most noticeable users, in contrast with non-real-time or delayed rendered 2D and 3D images, that take time to be produced and therefore cannot occur in real time. The term can also refer to anything from rendering an application's GUI to real-time image processing and image analysis. Real time 2D and 3D graphics applications do not

require additional render time as they render the image on demand.

RENDER

The process of generating an image by means of computer programs. 2D rendered images are the result of combining different video layers or pictures into a combined one. 3D rendered images are produced by a rendering software that processes a scene file containing geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene and outputs them to a digital image or raster graphics image file.

PBR - PHYSICALLY BASED RENDERING

A photorealistic rendering technique firstly developed for gaming purposes, resulting in an approach for materials and rendering that creates more accurate and predictable results and works very well with dynamic lighting conditions. As it is defined, it applies what is known about the real physical interactions between light and materials to real-time graphics, that is, it follows the physical behaviour of light as close as possible, instead of applying the intuition of "what it should be".

Scene rendered using PBR

SHADER

A term originally introduced by Pixar, defines a computer program that is used primarily to calculate rendering effects on graphics hardware with a high degree of flexibility. Shaders are used to program the graphics processing unit (GPU) programmable rendering pipeline, which has mostly superseded the fixed-function pipeline that allowed only common geometry transformation and pixel-shading functions; with shaders, customized effects can be used.

TRACKING

See Camera Tracking.

TRACKFREE™

A camera-tracking independent technology patented by Brainstorm that enables broadcasters to combine the precision and high quality of tracking systems but at the cost of a trackless system, and with matching flexibility and user-friendliness

TRACKLESS

Refers to 3D virtual set software that simulates camera movements with the set and the character without the need of providing camera tracking data.

TILT

Tilt or camera tilt refers to the rotation in a vertical plane of a still camera or video camera by turning vertically on a horizontal axis.

UHD - ULTRA HIGH DEFINITION

Ultra High Definition television today includes the 4K HD (See Quad HD) and 8K HD formats. The 8K HD has a is a resolution of 7680×4320 pixels per frame with an aspect ratio of 16:9.

VIRTUAL SET

A virtual set or virtual studio is a television studio that allows the real-time combination of characters, real objects, images and computer generated environments and objects in a seamless manner, using a chroma keyer. A key point of a virtual studio is that the real camera can move in the set, while the image of the virtual camera is being rendered in real-time from the same perspective.

XYZ

Defines the set of coordinates for a 3-dimensional space in the Cartesian coordinate system. A set of 3 numbers, one for each axis (x, y, z), specifies the position of any point in three-dimensional space by defining distances to three mutually perpendicular planes (or, equivalently, by its perpendicular projection onto three mutually perpendicular lines).

ZOOM

The use of a camera zoom to vary the depth of field while shooting, and therefore the angle of vision maintaining the image plane. The final result is the variation of the enlargement of distant subjects depending of the depth of field.