



All-Digital Fulldome Immersive Theater: Technical & Cost Considerations

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Introduction

A business plan covers all aspects of the immersive digital theater, with revenue and costs being featured prominently. Revenue projections are just that, projections, there are a lot of factors that will have an impact on actual results whereas the area of cost can be more predictable. What drives the cost is in the area of technical choice. Recognize that the technology chosen must support the content and the use of the facility. It all starts with the mission, goals and objectives of the organization ... what will make your Immersive Theater special? Obviously an iconic facility will attract attention and have visitors come for a first time; however, it is the visitor experience, the content, that will keep the visitors coming back. We do not recommend using exotic technology as a drawing card, as it does not inherently attract repeat customers.

There are as many technical scenarios as there are organizations. Each facility is different in ownership, Board of Directors, mission, audience, and visitor experience, so it is expected that each facility will be unique. The following summary will outline technical considerations and ultimately impact costs.

Facility Use

You will need to understand the various uses for the facility, as different uses require different infrastructure.

- Astronomy education at the (grade and high) school level, teaching State mandated content.
- Sciences or other topics beyond astronomy, for example earth sciences - climate change.
- Digital theater for large format (digital) movies – not literally IMAX® content, but rival IMAX® with high production values. This content can be either astronomy or other sciences.
- Public attraction for tourists and a local destination location.
- Rental facility for corporate events or events like weddings or receptions.
- Live entertainment that will exploit the intimate environment and visual capabilities of the immersive environment. Examples are art and music.

Visitor Experience

Today we see a trend toward an all encompassing visitor experience, starting with having a primer on the website, enterprise solutions (featuring kiosks, mini-theaters, classrooms), to after visit reinforcement through internet contact. The key here is “enterprise” solution and the impact on the visitor experience.

Secondly is a trend toward the use of live presentations, everything from musical or visual or photographic presentations by artists, linking up of facilities/collaboration where there are remote presentations, and live presenters including interaction with the audiences. This can provide an experience that can become personal. The dome is an intimate setting, so a connection with a presenter is more possible.

Regardless of how the content is delivered, the key attribute is **CONTENT**.

Content - Content - Content

Content options include;

- Content can be purchased. There are several high quality fulldome space shows, that can be purchased, but all are for playback only (i.e. typically without a live presenter or interaction with the audience).
- Content can be produced. For a show with high production values, it takes a notable team and a lot of money, \$500,000 to \$2,000,000 is common. There are several groups who are either doing this now, or have done it recently, such as Denver Museum of Nature & Science, California Academy of Science, the American Museum of Natural History, the Clark Planetarium, the National Space Centre, and a few more in Europe. The biggest issue is the funding for a major project, and a secondary issue is the production team. You need to consider the personnel to be fulltime or for only this project.
- Production to meet a specific need ... As each organization is different the content needs are different as well. We are seeing a trend where individual facilities need specific content that they create with a small production team. The imagery of the show still needs to be high quality; typically there is a live presenter, with audience interaction, designed for a specific topic. Examples of specific topics include State mandated curriculum, or a topic funded for a specific purpose such as aboriginal studies, or earth related topics, really anything for the local market where major productions do not exist.

Global Immersion has been involved with a project in the UK, where the staff astronomer/teacher needed to tell a specific story. She created the storyboard, and subcontracted the visuals to Global Immersion for which Uniview™ was used as the prime source of content. We created flight paths and added imagery using standard off the shelf software tools.

- The digital promise of incorporating data/information and digital media, into digital systems with live presenters, audience interaction, for presentation in a fulldome, is reality. Almost all systems can be tailored to your requirements using off the shelf components, along with system ingenuity and creativity.

One last comment on content ... technology in itself has limited draw capability ... it's all about the content. We caution organizations that want to use exotic technology, example 3D (stereoscopic displays), to draw audiences.

Fundamental Questions

- Will there be a Starball?
 - A Starball can create a magnificent representation of the night sky. More stars than a digital system can reproduce.
 - Highly reliable operation with low predictable costs. Will last for decades.
 - Limited to an earth view (when used standalone)
 - Occupies the best seat in the house.
 - We see a trend to all-digital solutions as the displays get better, with higher resolution.
- Seating array - uni-directional or omni-directional seating?
 - Basically omni-direction seating works best with a Starball.
 - Uni-directional seating allows the full audience to see the same image, whereas omni-directional seating will force a portion of the audience to turn around to see the key content.
 - The trend heavily favors uni-directional viewing.
- Will the dome be horizontal or tilt?
 - A flat floor (horizontal dome) allows for (re)moveable seating that can increase the physical flexibility in the theater. However the seats tend to be less comfortable. When a Starball is used, the seating array can be omni-directional and simulate sitting around a camp fire.
 - A tilt dome allows for uni-directional stadium seating. This is sometimes referred to as a hill-side view.
 - A tilt dome will allow the audience to be more immersed in the dome due to a lower spring line.
 - With a tilt dome, every seat has a great view.

Trends in Immersive Theater

We do see differing system requirements; however, there are some clear trends, particularly with public facilities;

- Visitor experience is critical ... you need revenue paying visitors.
- Science visualization is much more common than astronomy alone. Our planet earth is getting a lot of attention.
- While pre-rendered shows are typical, there is a trend toward the use of live presenters, quite often in conjunction with some level of real-time content and audience interaction.
- Collaboration is a requirement, not only from a content creation point of view, but also from a presentation point of view. An example of the latter is a presenter in NY giving a presentation to an audience in Minneapolis.
- The user interface must work for the various levels of user, and not limited to a staff astronomer. The technology must be transparent to the user/presenter.
- Interaction is becoming more than voting systems. We are seeing requirements where teachers/presenters want feedback on the content, was it understood? Can we test the each student's knowledge?
- Starballs must be integrated with fulldome systems.
- We are seeing a trend where digital systems are considered a reasonable substitution for starballs. The starfield may not be as good, but the advantages of a digital system are substantial, and a new Starball consumes capital dollars.
- Most important is the requirement for content with high production values.
- Costs must be predicible and affordable
- There is a requirement of a long term plan for content and technology refresh. Visitor expectations are not static.

System Requirements

The system must be media savvy. The ability to bring widely differing digital media into the fulldome space is a must. The show producer must be able to manipulate the media, incorporate all available theater resources, to create the desired effect/impact. The ability to incorporate pre-rendered images, with real-time information, with lighting effects, bringing in a webcast, or interrogating a data base, audience interaction or testing, all controlled from an easy to use wireless touch panel.

For the visuals to deliver on the potential impact, the system infrastructure must support the content. The system/electronics are not an end in itself, but are there to deliver the content/presentation to the audience.

A digital theater system is only as good as its weakest link. The content, the display, and the playback/real-time server need to be consistent in display performance. For example, if your content is 4k x 4k, the display must offer 4k x 4k display resolution, and playback at 4k uncompressed video. MPEG inherently compresses the video, and once compressed, it will not recover.

The digital fulldome systems have the following base line requirements:

The Display

- Today the standard for (large theater) fulldome is 4k x4k resolution. As the cost of both the display devices and the cost of image generation, including storage, drops, the bar will get higher.
- Brighter is not always better. Brighter projectors tend to add to light scatter, which in turn reduces contrast ratio and dynamic range. Today there are projectors that are able to project black and work extremely well (look very bright) in the fulldome environment which has no ambient light.
- Must appear to be one image. This can be done using projectors with panels that offer large pixel-arrays, or multi-channel systems. The optical system must include components to make up for any deficiencies inherent with the chosen technology solution.
- Must be reliable.
- Must have predictable cost of ownership.
 - Lamp technology, low cost and long lamp life.
 - UHP lamps cost \$700 to \$1,000 each, and the life is typically 2000 to 3000 hours for dual lamp system.
 - Xenon arc lamps cost \$2,500 to \$5,000 each, and the life expectancy is typically 700 hours to 1500 hours.
 - Does the technology have other consumable costs, such as optical elements that need to be replaced over time?
 - Is the display technology commodity or exotic? LCoS and DLP technologies are commodity. (High volume production). Commodity technology brings predictability in cost, performance, and reliability. They have a proven record, over time.
 - Color bit depth; currently the standard is 8 bit color, however as costs go down for image generation and data storage, we do expect this to rise to 10 bit. At least one installation exists at this level today.

Image Generator – Server - Playback

- The media server should be able to playback the content at native resolution. Where the system offers multi-channel or multi-panel displays, the image should be gen-locked to ensure the appearance of one image. (Vs. a mosaic).
- The system needs to handle digital content/fisheye dome masters from any supplier.
- The Server software should also be able to slice content onto the clients server directly (i.e. not have a third party do the slicing).
- Video compression ... there is not much value in having 4k content on a system that uses MPEG compression. It may save space, but you will not see the resolution in the content. Uncompressed video playback is in use today.
- Compression should be scalable by the user. While some content does not contain a lot of detail and can handle higher compression, there is content being created with detail intended to be shown. Video once compressed does not un-compress. The choice should be with the exhibitor.
- The system should be robust, commercial grade, with redundancy built in.

Real-time Application

- The real-time software chosen must allow for the interrogation of any volumetric data base. Obviously the Digital Universe data base from the AMNH is valuable for astronomy; however, the real-time software should be adaptable for other data bases such as data from WMS servers.
- The real-time software should allow for linking up of several (remote) theaters simultaneously.
- The real-time software should allow for some level of show production. This is important as good application software will allow for total freehand navigation of the data base, but the software should also allow for creating shows ... a story teller will want to be able to create flight-paths, or pull together imagery into vignettes and add other content to create the visuals to support the talk.
- Show production should be done in various ways. Recording of the navigation, writing the navigation out for playback, and potentially writing of scripts.

Multiple IGs

We are seeing theaters wanting to have more than one image generator in their theater. The reason for this is there may be an advantage in production to have a second playback system, or to have the real-time system being on a second cluster. We have also seen end users wanting to have systems from more than one supplier. Of course having system redundancy provides comfort.

Where multiple-IGs are in a system, users are now asking for video mixing of the IGs, and layer of content.

Windowing of Media – Picture-in-picture

Theaters need to be flexible. The ability to bring in any media into a window(s) can add to presentations. An example could be ... while your real-time system is running a simulation of an astronomy event, a window could be displaying streaming video from the web of the actual event, while a presenters image or PowerPoint presentation are in other windows.

In-House Production

Large scale production is desirable for only a limited number of larger organizations. However, we are finding more organizations would like to ability to produce content applicable to their local audience. This could be creating content specific to an educational requirement, or vignettes to tell a local story, or to build on a feature presentation, or to enable other users (and their content) to use this immersive environment. This could broaden the use of the facility. When compared to the cost of a fulldome system, a small production capability can be a prudent investment.

Lighting

LED lighting is now the standard for dome and cove lighting. Aside from low cost of operating and long life, LED lights are programmable. Visual effects can be created and incorporated into shows. The triggers can be either ad hoc from the control system or triggered in the time line during a playback sequence of a movie.

Theater Automation and Asset Control

Theater Automation is the user interface that connects with all electronic/controllable assets in the theater.

- It should be comfortable for the various users of the theater.
 - An interface for the casual user, such as the weekend show operator.
 - An interface for the theater operator who want to run assets using manual or automated control.
 - An interface to allow the show programmer to make changes, such as adding new digital sources, or changing the effects, or changing the cue points.
- We do recommend 2 touch panels, one that is wireless to allow freedom of movement throughout the theater for a presenter, and a hard-wired panel at the control desk, for redundancy.

- All assets should receive communication by either IP connection or RS232. This will allow for certain communication (unlike wireless) and allow for system monitoring.
- Preview of content is important to allow for staging of media, or video signals.
- The user interface must meet the needs (work flow) of the facility ... the operators, the presenters, and the show programmers.

Audio

Audio is a significant part of any visitor experience in the dome. The audio must have impact, and in some cases seat rumbles are used to augment the experience. The larger the dome, the greater number of channels of surround sound required.

There is talk of spatial audio being required in a dome in order to be fully immersed. True spatial audio can be very expensive; however today there are good processors/software that create a spatial-like audio effects that work well.

Audio is one of those items where money you can always spend more money for a better system; however and good system need not be expensive.

Interactivity

This is a term that can be applied to several scenarios;

- Audience interaction with the Presenter, basically Q&A with the audience.
- Audience interaction with the content such as a voting system to prioritize the next movie.
- Presenter interaction with a real-time application; who, how and where will the presenter/pilot interact with the real-time application.
- Presenter interaction with the system; see theater system control theater automation.

Audience Feedback

This is much more than a 4 or 5 button voting system. First of all, this can provide feedback to the presenter regarding audience understanding of the topic. It also allows the presenter to engage the audience. Today there are systems where the presenter could actually hold a mini test with multiple choice questions and the individuals can be graded on their response.

Digital Infrastructure

Digital has progressed to a point where digital equipment is the standard. An all-digital infrastructure, including DVI signal routing and switching, will allow your system to be upgraded over time. It will also allow for remote system monitoring and control. An all-digital construction, will allow for the best performance as no analog/digital conversion takes place in the signal path.

Open architecture; ask questions about the system architecture and the system components. You are looking for an open architecture, something that is not proprietary. For example, you will want to run any suppliers digital movies on your system. Where would you get parts from in the unlikely event the supplier was unable to provide ongoing support for your system? Think through some workflow scenarios, present them to the integrator and ask how they would approach the solution? What restrictions will there be in a (future) partial system upgrade?

Cost of Ownership

The planetariums of the last millennium used a Starball as the primary display device, and augmented the display with slide projectors and other machines to provide effects. The Starball typically had a 30 year life, and the cost of lamps was minor. The slide projectors were low cost, reliable and used equipment was plentiful.

The digital world is much different. Organizations/companies do not expect more than 3 or 4 years from the computers their employees use. The cost of hardware is always coming down and software capability is always improving.

Remember your new theater will be competing for entertainment dollar expenditure.

The digital fulldome of today is much like the computer industry. The serviceable life span may be up to 10 years, depending on usage; however, you should have a plan to refurbish or replace your system in 4 to 6 years. You need to pay attention to your visitor experience as your audience expectations will continually raise.

In lieu of a new capital drive, you should consider the use of an operating lease. We have seen leasing used by a number of organizations for this stated purpose. There are lease companies that specialize in the government market, offering competitive financing.

Content is the most important investment made. Outside of their school programs, organizations tend to launch with one main show for the public, along with a children's show, which can be supplemented at the 6 to 9 month mark, and then new shows are added at 6 month intervals. The goal is to keep the content fresh, with a visitor experience that keeps visitors returning.

In the main show category are shows like *Black Holes - the Other Side of Infinity*, *Cosmic Collisions*, *Astronaut*, and *the History of the Space Race*. In the children's category would be *Secret of the Cardboard Rocket* and *One World One Sky*.

In house production can require;

- In-house production workstation – initial capital investment and subsequent hardware and software upgrades over time.
- Show production.
- Live presenters.

Other internal personnel requirements;

- Theater operator
- IT support/internal service.
- Show producer.
- Be careful that your system does not require a truly unique skill set to operate the theater system.

Equipment support/service;

The electronics systems of today can be designed to be quite robust. However, given the high duty cycle and need for high operational time, all systems require support.

- Service contract; these should be tailored to you specific requirements. For example, if you do not have an IT or technical person in-house, you will need greater support from your supplier.
 - Does your system provide for remote access? This would allow an operator to system access/control from a remote location such as home. It also allows for a service person to troubleshoot a problem, remotely. This also allows for software updates to be uploaded to the system, without an engineer travelling to site to perform this task.
 - Quarterly, semi, or annual technical visit, sometimes called preventative maintenance. This is usually 3 to 4 days, used to recalibrate the system, retrain your staff on system alignment and operation. This can be coordinated with lamp replacement.
 - All system components/parts are covered under a 1 year warranty. Some projector manufacturers offer 2 years on parts, and additional years can be purchased.
 - Spare parts kit; given the high duty cycle requirement, we do recommend the client maintain a spare projector, matched to the system, along with a few other critical parts.
 - System redundancy, robust operation; you must understand what your system provider can offer in the form of redundancy. Certain components like a UPS or redundant power supplies, can add robustness. Of course the more layers of redundancy require additional cost.
 - Labor and travel for emergency callouts; does your supplier offer this as included or optional. What will be the need? We have found that our all digital systems are quite robust. Where service has been required, we have been able to troubleshoot the issue remotely, and have the user rectify the situation themselves, with our guidance, and parts supply.

- Training; not only at time of system commissioning, but with ongoing refreshers for your staff, or more in-depth training for new staff.
- Software upgrades; in any system there will be several software products included, however, not all software upgrades available are required, and some that are may require hardware upgrades as well. Ask the question of your supplier as to what licences are provided, and where will upgrades be typical, and at what cost.
- Consumable items; lamps - usable life and cost – technology dependant UHP or Xenon
- Other consumable costs, such as optical elements. This is particularly important with any new or exotic technology where the long term performance is not yet established

Final Questions...

1. What will make our new facility special?
2. What will make the visitor experience special?
3. Opening day is one day, what to do plan for years 2, 3 and beyond?