Dome Theaters: Spheres of Influence

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Abstract

For decades dome theaters have provided the greatest sense of awe and wonder of all theater experiences. These visually immersive environments transform the entire theater space into a virtual environment in a way no other media can. Modern immersive theaters began with planetaria, leading to film-based theaters such as Cinerama, IMAX™ Dome, Iwerks Cinedome and others. Military and commercial simulators also use domes to create synthetic environments for aircraft and weapons training, ship simulators, and automobile simulators.

Recent advances in digital image processing, computer graphics, and video technologies are enabling a new class of immersive theaters based on video projection. Video-based “digital dome” theaters are visually compelling and posses unique interactive, multi-format, and multi-use capabilities. Affordable shows can now be produced using a variety of source material with inexpensive desktop video and graphics tools. Alternately, fully interactive shows can be generated in real time with the latest three-dimensional computer graphics image generators. To date, some very interesting and cutting edge applications have evolved from users of these theaters.

Key guidelines for dome theater design and use are presented. Such theaters offer a thrilling, immersive experience which can breathe new life into existing facilities or provide added dimension to new facilities. We believe that dome video theaters, properly designed and managed, will play a major role in future community-based entertainment.

The History of Domes

Domes as architectural elements have been around for thousands of years. However in the 1920’s the Zeiss company introduced the first real use of domes as projection screens. In order to recreate the nighttime sky, Zeiss’ instrument accurately projected the celestial sphere onto a dome screen. This unique demonstration of a projection system became the first planetarium.

Planetaria inspired a sense of awe and wonderment to audiences with their immersive simulation of the night sky. Their ability to manipulate astronomical simulations by speeding up natural phenomena such as eclipses, stellar and planetary motions provided for an educational and entertaining experience. By 1940 there were 27 such planetaria in Europe, Japan, and the United States.

In the 1940’s Armand Spitz left as director of the Fel’s planetarium in Philadelphia,
then equipped with a Zeiss instrument, in order to start a company to provide lower cost planetariums so that more people could be exposed to the phenomenon of astronomy [Abbatantuono]. His first domes were manufactured from surplus military parachutes to provide the necessary geometry and projection surface.

Further improvements in planetariums required better dome screens so the manufacture evolved from cloth parachutes to compoundly curved perforated aluminum panels. The perforations were provided initially for acoustic reasons to prevent audience sound from reflecting inside the theater chamber. For solid domes, the spherical geometry was such that people properly positioned on each side of the sphere could whisper and hear each other, and a whole audience would provide a cacophony of sound. Perforations prevented this acoustic problem. Perforated domes also allowed speakers to be placed on the back side of the dome and the sound to be projected through the dome. This permitted the sound to be properly placed in the image. In addition, the perforated surface of the dome allowed architects to design the theater chamber so the ductwork could be out of sight of the audience, and placed behind the screen, since the dome is transparent regarding design of the HVAC system in the theater.

In the 1970’s dome projection screens found their way to other industries. Technology had progressed to where military applications could use computers to generate and project real time video images. Projection onto domes allowed the simulation of immersive environments for training and research. Domes are today used for flight, combat, weapon, ship, and vehicle training. Wide-angle dome coverage is provided through multiple projector placements and various screen geometries as required.

**Aircraft Simulator Dome**

Computer generated imagery allows a pilot for instance to fly a mission or testing scenario which accurately represents actual flight conditions. For example a 28 foot diameter dome with a down angle of -60º provides an environment where a pilot can see the ground below him as well as aircraft in front, behind, and to the sides. His ability to actually “fly” the aircraft is possible because of computer simulated aircraft response, computer generated imagery and a dome projection system. Such a dome was used for the USAF Y22 combat aircraft to program the characteristics of the aircraft prior to ever manufacturing or testing the real one.

The entertainment industry also saw the advantage of immersive environments. Imax Corporation placed one of their 15/70 projectors in a 76 meter diameter Spitz planetarium in San Diego, CA in 1972. This became the first Omnimax theater. The now common tilt of 30º for these theaters puts the audience “into” the film in a way no other medium had been
able to do. Iwerks has created the same environment as have others. The success of large format film theaters exemplifies the acceptance of this phenomena.

The entertainment industry has taken this one step further by placing motion bases inside of domes to provide a multi-sensory immersive environment. The best rides in the world have provided experiences never before available. Some of these rides include “Back to the Future - The Ride” at Universal Studios in Florida and California, “Race for Atlantis” at Caesar’s in Las Vegas and “Star Trek” at the Hilton in Las Vegas. Audiences were able to participate in experiences only the imagination of film producers could provide without any real risk - despite what the theming intimates.

Why Domes?

Real life experiences completely envelope our senses. The more closely we invoke natural neural responses, the more “real” a synthetic environment becomes. The human eye provides a field-of-view of about 200° horizontal x 130° vertical. As noted by Heilig in his classic paper, El Cine del Futuro, standard movie theaters cover only about 5% of our visual field, while Cinerama (the now defunct three-screen film format) covers maybe 25% [Heilig]. As an image approaches complete coverage of our retina it appears frameless and lacks the visual cue that our brain uses to identify it as a dimensionless picture. Larger field-of-view images increase the subjective feelings of expanse, naturalness, depth and powerfulness [Barbour]. Dome screens provide such an image.

Domes also present images which are rendered to a view sphere rather than a view plane. Spherical perspective was favored by Leonardo da Vinci as “natural” perspective, as opposed to the flat plane “artificial” perspective pioneered in his day [Kelso]. Some modern cognitive scientists agree and have adopted a spherical model of our visual field to explain wide-angle vision [Johansson]. These models rely on the fact that our retina lies on a spherical surface, not a flat plane. The result is that domes reproduce a more natural looking image with an unlimited number of vanishing points in all directions.

The immersive feature also allows image understanding in ways that are not possible using a flat screen. A flat screen is limited to a visual field of less than 180 degrees. Domes allow wide angle spatial relationships to be visualized which cannot be represented by a flat screen image. This is particularly useful when attempting to convey geological or astronomical scales. The perceived presence in a virtual space is enhanced by spatial immersion as well. Cognitive mapping, the mind’s ability to visualize and understand one’s presence in three-dimensional space, is facilitated by wide field imagery. Also, since our peripheral vision feeds the brain’s opto-vestibular response, dome imagery produces the most powerful motion cues possible without an actual motion base. Care must be taken to prevent motion sickness in dome presentations.

In addition to the visual fields that domes provide, they have always represented a unique space. The way they are lit with theatrical lighting, the hushed environment, and the enveloping feel have all added to the mystique that an audience feels when entering a domed theater chamber. Their expectation is to have a
unique experience, and this expectation is often fulfilled. The large fields of view, surrounding audio, and perhaps a motion base, all provide for memorable and desirable experiences.

Since reality is immersive, are we not better served by making our entertainment and education environments immersive?

**Video Based Dome Theaters**

Recent advances in digital image processing and projection technology allow new forms of projection to take advantage of the immersive qualities of dome theaters. For the first time dome theaters can have a single panoramic video image that provides an immersive environment allowing the audience to be completely captured by the content of the show. Spitz Inc. has provided a 200° HFOV x 60° VFOV format system using a three projector configuration. The three images are seamlessly edge-blended to produce a single wide-field panoramic image. Spitz has introduced a new format called ImmersaVision™, a 10:3 cylindrical panoramic format which accommodates spherical warping to correct for distortion on the dome.

Local production of digital imagery for large format video is perhaps the biggest advantage for these theaters. By using off-the-shelf desktop software packages and a few custom plug-ins, cost effective and creative show productions are possible using in-house capabilities. Since standard video and computer graphics tools are used, third party productions can also be provided by local media professionals.

One major advantage of this format is the ability to use different sources for creating shows. Print downs of existing film footage, video based material, scanned artwork, and post processing allow content
to be created easily. By combining the panoramic video with all-sky (full dome slides) projection, laser systems, star projection and multi-channel sound, impressive environments and productions can be created at affordable cost.

Video-based dome systems can bring new life to old theaters, or provide new venues to sites not previously considered. Visitors may experience a scientifically accurate flight through the universe, or a simulated deep sea underwater adventure, providing an educational experience during a time of immense entertainment. Other audiences may enjoy a laser/video light show which makes their favorite MTV video look like a postage stamp in comparison. Video conferences, internet-based education, and digital film theaters are all possible within the same multi-use, multi-format facility.

One of the first such theaters is the Northern Lights Centre in Watson Lake, Canada. Watson Lake is small town along the AlCan highway that was looking for an attraction for their tourist industry. Being a small town, there was no budget or facility for a large, or expensive attraction. After searching, they decided on a 50 ft. diameter video dome theater configured to provide a planetarium for local schools, laser/video shows for residents, and entertaining shows on the myth, folklore, and science of the Northern Lights for tourists. While tourism was originally expected to be the only significant source of revenue, this small town successfully pioneered other off-season uses for their facility including a second-run DVD-based film theater and a video game tournament site. The Northern Lights Centre has provided increased tourism appeal and new entertainment for the Watson Lake community, and is a successful model for other small towns.

**Theater Design Considerations**

A number of unique design considerations are critical to making sure a dome theater is successful. The dome must be properly sized for the demographics of the area. Dome tilt, sight lines, equipment mix and placement, acoustic materials, lighting, HVAC considerations, theater seat size, seat placement, and ingress and egress into the theater chamber all have an impact on the success of the theater. Even details such as electrical outlet placements and architectural details need to be scrutinized for maximum utilization. These items all have an impact on the building cost, theater cost, type of shows, show production costs, comfort and experiential success of the theater. It is important for people considering a dome theater to have an experienced dome designer so that the

Northern Lights Centre in Yukon, Canada

successes and failures of other theaters can
be utilized to make sure that the venture is a positive one.

Future Potential

As elsewhere, film presently dominates as the medium of choice for live-action presentations in dome theaters. Before video can compete favorably with film on its own turf, future improvements in dome video resolution, brightness, and contrast will be required. However the advantages of video cannot be ignored. Recent forward-looking experiments include virtual reality cinema and group telepresence using a robotic rover. Future possibilities include audience interaction with real-time simulations of artificial life forms or ecosystems, immersive video simulcasting of live events or remote locations, and networked video games between theaters located in competing cities. Some day soon audiences will collectively steer rovers on the surface of the moon or mars while enjoying a virtual presence on a distant world.

Conclusion

Dome theaters offer a thrilling, immersive experience as either a stand-alone theater or a simulation ride. Video-based dome formats can breathe new life into existing facilities or provide added dimension to planned facilities. We believe that dome video theaters will play a major role in future community-based entertainment.

References

Abbatantuono, Brent, Armand N. Spitz and His Model A Planetaria, Masters Thesis, University of Florida, August 1994


