FullDome Standards Summit

The Past, Present, and Future of Full Dome, Full Color, Single Projector Digital Planetariums

Presented by Philip Groce

Introduction

With the greatest respect for all of the participants at this summit, I consider this event a great act of professional optimism. The track record for establishing technical standards in the planetarium industry is, at best, dismal. In fact, almost all current standards in our field are merely those forced upon us by other disciplines and industries. This has always been the case whether it is audio or visual technologies.

Even in long-ago days when the planetarium star projector was the only technology used, there was great diversity from manufacturer to manufacturer. This summit assumes that you (the planetarian) can control your technical future. However, I am here to inform you that planetarians have almost always lived by the kindness of strangers and that this circumstance is not likely to change. The General Rule of planetarium technology development and evolution is as follows:

"The audio-visual technologies with the largest installed base outside of the planetarium field will determine the technical future and standards of planetariums."

The recording industry, the motion picture industry, the business-presentation industry and the education-presentation industry have determined our technologies and standards. At best we are integrators of technologies developed for much larger installed bases than planetariums. The slide projector was not originally developed for planetariums, nor was the video projector, nor digital audio players nor laser projectors. The planetarium market is simply not large enough to support dedicated technologies.

For example, slide projectors and CRT video projectors are disappearing in spite of the fact that 99% of all planetariums still use them. My contention is that if you want to see the future of planetariums, you need to look at the future of other applicable industries and their standards. Having now depressed my fellow planetarians, I must say that this summit can be the beginning of taking charge of our future…of "carpe diem" and seizing the (technological) day. If we are ever to have any standards, we must start somewhere and this summit promises to be a good beginning.

A Brief History of Full Dome, Full Color, Single Projector Systems

Early 1970s

Video Projection introduced to planetariums, include full-color partial dome projections, multiple projectors producing separate images

1979

Evans & Sutherland introduces Digistar- B&W CRT full dome system

1996

GOTO introduces Virtuarium (with SGI)- Full dome, Full Color, Multiple projector, CRT system. It was followed later by V-Domes (Trimension Systems-SEOS), SkyVision (Sky-Skan), Electric Sky (Spitz), Star Rider/Digistar 3 (Evans & Sutherland and ADLIP(Zeiss)

Elumens also began marketing VisionDome in 1996 - a partial small dome video display system (not sold as a planetarium star projector technology until 2002)

2000

Konica Minolta Mediaglobe – The first Full dome, Full Color, Single projector planetarium system for domes 4 meters to 9.1 meters

Followed in 2002/2003 by Digistar3-SP by Evans & Sutherland and SciDome (Electric Sky II in higher resolution) by Spitz

2004

Various single and two-projector systems introduced for small portable domes by such companies as Sky-Skan and Zeiss.

Characteristics, Advantages and Technical Issues of Multiple Projectors and Single Projector Systems

Some Definitions:

Multiple projector systems: Digital dome projection systems that use two or more projectors, usually placed at the dome's perimeter.
The single "fulldome original image" is sliced into parts that are separately projected and blended to form a single continuous fulldome image.

Single projector systems: Digital dome projection systems that use a single fisheye type projection lens, usually placed at or near the dome's center. The single "fulldome original image" is projected as a single fulldome projection.

Technical Issue #1: Full Dome Standard (Portability from one theater to the next)

Advantage: Single projector systems.

To my knowledge, there have yet to be established two identical digital theaters with multiple projection systems or two multiple projector systems with identical projection geometry. In other words, when images are shared by two theaters they must be re-rendered (re-sliced) to accommodate each theater's unique projection geometry. There are many forces that determine a planetarium's theater's design. These forces often prevent precise duplications of projection geometry, even when they use the exact same projection equipment.

Retrofitting existing facilities for fulldome digital projection also makes it difficult to standardize multiple projector positions and geometry. Even if such positions could be standardized, differences over time of projector systems and their optics will foster incompatibility. We can already see the difference in LCD, CRT and LASER systems which have different projection optics and different blending (and therefore different slicing) characteristics and geometry.

I will now go one step farther. Except for very large domes (greater than 18 meters), multiple projector systems with more than two projectors will be extinct or obsolete in 5 years or less. Any investment in such systems must be looked upon as interim or temporary and the projection equipment should be viewed as a high-cost consumable.

Almost all single-projector systems of similar resolutions are compatible. Small dome systems based upon 1024 x 1024 pixel systems manufactured by competing companies can show each other's content without re-rendering. 1536 x 1536 systems are also likely to be compatible, regardless of the manufacturer. In the future, with just a few simple guidelines, transferring and showing content between single projector systems should be nearly as easy as playing a DVD video.

However, there are some issues and standards that must be addressed for this compatibility to be seamless.

1) We should agree on movie file formats and compression schemes, and graphic card configurations. Fortunately almost all small dome single projector systems playback AVI and MPG2 movies.

2) Almost all of these same single projector systems play back JPG and BMP still images and many also playback Targa frames.

3) 30 frames/second frame rate for movies should be the standard.

Technical Issue #2: Resolution and Image Quality/Brightness
Advantage: Multiple projector systems.

Resolution and Image Quality:

Currently, the highest resolution systems are multiple projector systems, ranging in dome images from 3000 pixels to 5000 pixels in diameter. Currently, the highest resolution single projector system is 1536 pixels in diameter. A 3000 pixel system theoretically produces 4 times the number of pixels than a 1536 pixel system. Yet almost anyone who has visually compared such systems will tell you that they have difficulty seeing significant differences in resolution between these two types of systems. There are many reasons for this perception. Among them is that blending areas of multiple projector systems are often “softer” than the rest of the image. Small misalignments and color inconsistencies also degrade the apparent resolution of multiple projector systems.

The resolution gap between single projector systems and multiple projector systems is closing. For instance, Sony is now marketing a new digital cinema projector with a resolution of 4096 x 2160 pixels. Single projector systems capable of projecting dome originals 3000 pixels in diameter are on the horizon.

Single lens systems suffer from more chromatic aberration at the edge of field than multiple projector systems. It is impossible to create a perfect short focal length fisheye lens with no chromatic aberration. Longer focal length lenses used in multiple projectors are generally sharper and suffer less from chromatic aberration at the edge of field.

Brightness:

Generally speaking, multiple projector systems are brighter than single projector systems. Using 6 projectors to cover a dome instead of one usually results in a brighter dome image. However, advances in brightness of LCD systems have narrowed this brightness gap.

We need a brightness standard for digital projector systems. The large-format film industry has adopted 10 to 12 foot-lamberts for flat screen projection and 6 to 8 foot-lamberts for dome projection. Not one of the digital fulldome systems demonstrated to date comes close to the large-format film standards for brightness, which is why they all look pretty dreadful when trying to project a daylight scene. As long as we are projecting dim, high-contrast objects such as stars and galaxies, current brightness levels are satisfactory. If you want to put bright realistic daylight scenes on your dome, then buy a 15/70 or 8/70 film system. You’ll save money, have a giant content library, and your audiences will be much more impressed.

Because there is so much variation in dome reflectivity from planetarium to planetarium, projection screen white-light foot-lamberts may be an impractical unit of measurement.

As a practical matter, manufacturers of digital dome systems should stop listing the ANSI Lumen brightness of the projectors. It means almost nothing. What matters is how much light reaches the dome (incident lux) and how much is reflected back by the dome screen to audience (foot-lamberts). A 1000 ANSI Lumen single projector system that uses an f/3.5 fisheye lens will produce a brighter dome image than a 2000 ANSI Lumen projector with an f/8 fisheye lens.

A better standard and/or measure of brightness would be incident lux at a specific dome distance such as 12 lux at 3.048 meters (radius of a 20' dome) and so on.

The other useless and often deceiving specification offered by manufacturers of fulldome digital systems is "contrast ratio." Often, the figure quoted is the contrast ratio of the OEM projector(s). With multiple projector and single projector systems, there are, however, many other factors that determine apparent contrast. The number of lens elements and the effectiveness of lens coatings can significantly change the resulting contrast ratio. General wisdom is that DLP projectors have a greater contrast ratio than LCD projectors. However, the difference in contrast between these competing technologies is almost insignificant compared to what happens to an image during its journey through the lens. An LCD with a great lens (good coating technology) will have a greater contrast ratio on the dome than a DLP (even with black chip technology) with a poor lens (poor coating technology.)

The reflectivity and resulting light cross-bounce of the dome is also a very large factor in the apparent contrast ratio. For this reason, we need to standardize maximum reflectivity for fulldome projection. Experience has taught me that the contrast and color saturation of all digital dome images greatly deteriorates on domes with more than 48% reflectivity. Currently, we have Mediaglobes on 6.1 meter domes as dark as 24% reflective. The general rule of digital domes is "the darker, the better". The perfect planetarium would be brilliant projection onto a nearly black dome. At that point, the projected sky would look like the real sky, and fulldome panoramas/all-skies would suspend the disbelief of the most ardent skeptic.

Technical Issue #3: Image Consistency/Stability, Seam Visibility

Advantage: Single Projector Systems

Contrary to claims by various manufactures, there has never been a multiple projector digital fulldome system that is seamless across all projected colors and at all light levels. Because of the color uniformity (or lack of uniformity) characteristics of projectors whether CRTs, lasers, LCDs, or DLPs, it is nearly impossible to create a seamless continuous image in all brightness and color

levels. I leave it to others to prove me wrong. The other problem is the different aging characteristics of individual projectors in multiple projector systems.

Single projector systems by their very nature do not exhibit seams and are generally uniform from edge to edge. It is only the chromatic aberration of the lens that creates color shifts at the edge of field. It has been my experience that audiences are more bothered by the seams of multiple projector systems than the chromatic aberration effects of single projector systems.

Technical Issue #4: Effects of Theater Geometry

Advantage: Single Projector Systems

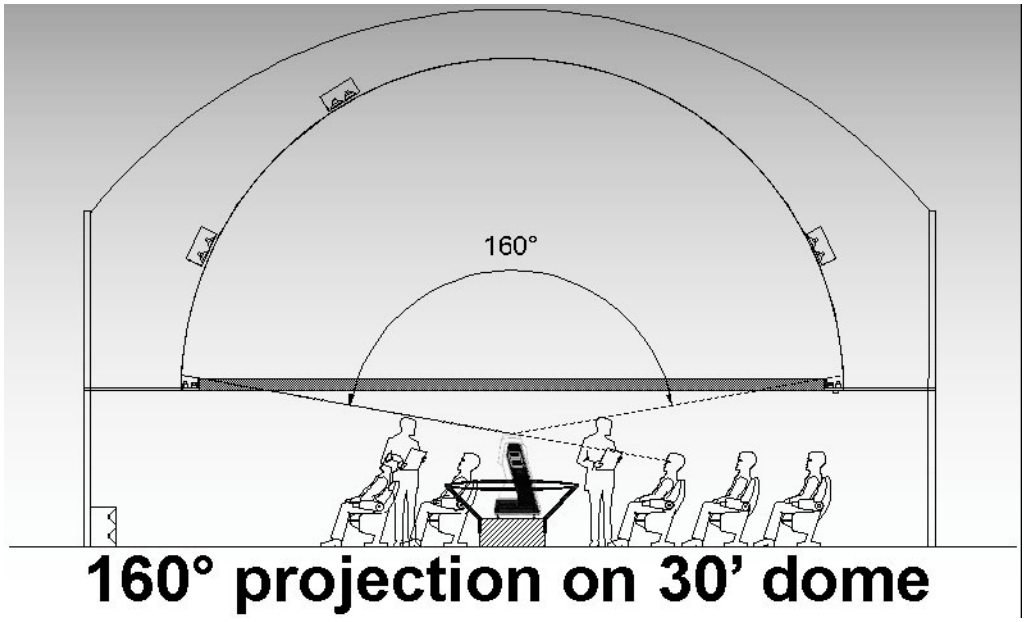
Multiple projector systems are constantly victimized by the theater's geometry …tilted or non-tilted…cove or no cove, 180 degree dome section or dome sections as small as 160 degrees. Single projector system images are relatively unaffected by such variations in planetarium theater geometry. Even so, there are some problems created by not having some standards.

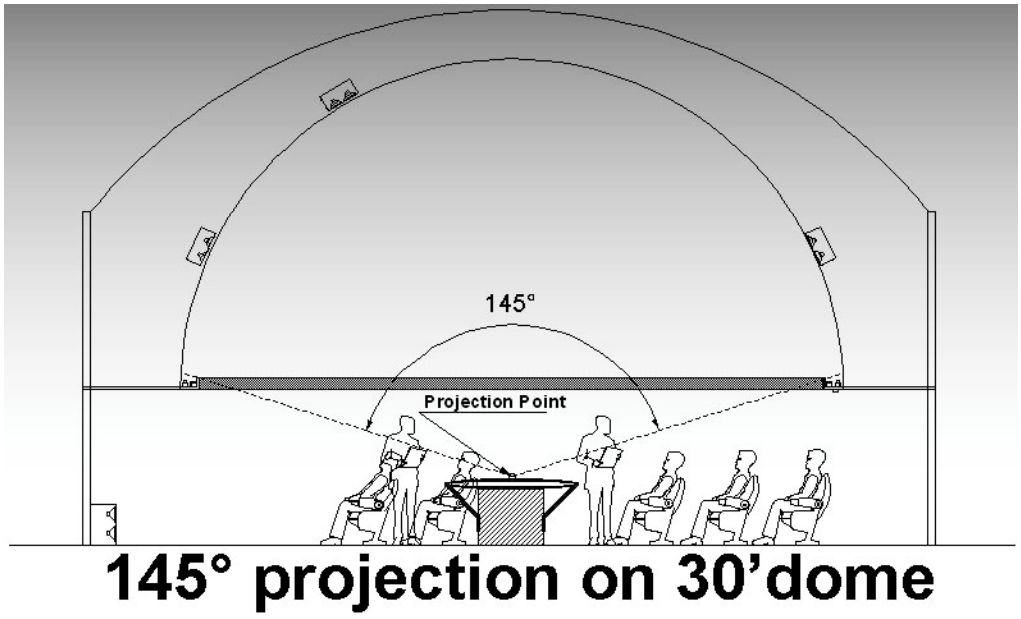
In planning productions, there should be a "safe area" dome original for critical action, information text and credits:

1000 pixels for 1024 systems
1500 pixels for 1536 systems
3125 pixels for 3200 systems, and so on.

We may consider reducing these "safe" dome originals even more to allow for smaller than 180 degree dome sections. Dome sections between 160 degree and 180 are becoming commonplace in today's planetarium theaters. Reducing the safe area of dome originals will allow more digital content to play without re-rendering or geometry correction.

Even within the single projector world there is very little standards when it comes to projector positions. Some manufacturers use a 145 degree lens that was originally developed for other purposes. Others such as Konica Minolta utilize a 160 degree projection lens. The two Illustrations below show the advantages and disadvantages of these two lens systems. Over time, I am convinced that 160 degree lenses will be the standard for all manufacturers.





Technical Issue #5: Space within the Theater

Advantage: Multiple projector systems.

Multiple projector systems can project from the dome perimeter, thus eliminating the need for a central pit. This means that this space could be used for seating. However, the price for such a system is the visibility of the front optics of these projectors. In many of these theaters, audiences are keenly aware of the projectors, destroying the mystery of the dome projections.

Single projector systems are getting smaller and take up less theater real-estate than traditional optical-mechanical projectors. Generally, single projector systems which use 160 degree lenses are far less noticeable to audiences than the front projectors of a multiple projector systems.

Technical Issue #6: Capital Costs, Cost & Ease of Maintenance

Advantage: Single Projector Systems

Obviously, the capital costs and costs and ease of maintenance of multiple projector systems is generally greater than simple single projector systems. Multiple projection systems require constant adjustment and alignment to maintain image quality. Except for cleaning a lens or changing a lamp, single projector systems are nearly maintenance free.

Technical Issue #7: Patent Issues

Advantage: Multiple Projector Systems.

One cloud for future development of single lens systems is the patents held by Elumens. I am not a patent reader or attorney and any discussion of the technical aspects or legal merits of the Elumens patent is beyond the scope of this paper. I do know that most, but not all, manufacturers of single projector systems sold in the US have acknowledged this patent in some way. Planetarians should be wary of single projector systems that have ignored these Elumens patents. The impact of Elumens' claim to single lens, single projector dome projection on planetariums is quite simple: It increases the cost of such systems and could discourage other companies from providing quality single projector planetariums. I don't know if the two-projector central projection system now offered by Zeiss/Sky Skan is affected by Elumens' patents.

Multiple projector systems that project from the perimeter of the dome seem to be exempt from these patent issues.

Conclusion:

Nearly fifteen years ago at a SEPA Conference, I proposed a multiple projector, full color, fulldome continuous image display system that I called a "Video Matrix System". No such system existed then, but I knew that one day they would arrive in planetariums. I have been a champion of such systems and have recommended them to my clients over the years. But that day has past. Today, I believe that we have come full circle to a single projector system or a two-projector system that covers the entire dome in bright and colorful high-resolution images. You can bet that by IPS 2008, we won't be seeing the three, four and six projector systems we saw at IPS 2002 and IPS 2004. They will be extinct by then. The irony is not lost on me that many of these simpler projector systems will come back to rest in the center of the room, occupying the central space of their optical-mechanical predecessors.

I still believe that optical-mechanical projectors produce brighter, much more realistic, and accurate star fields and will continue to do so for years to come. I still feel that large-format film projections are much brighter and much more realistic in their representation of daylight live action scenes. At the IPS 2004 conference, we had the opportunity to see ***Solar Max*** sequences projected via ADLIP and by IMAX.

As good as the Zeiss ADLIP system was (and it was very good), the IMAX version of ***Solar Max*** blew it away. Digital fulldome projection systems have come a very long way. They have much farther to go before they take on the mantle of quality of IMAX (a single projector system) and high-resolution optical-mechanical star projection. If we set our standards high and our goals even higher, someday fulldome digital projection systems may meet the high expectations I had some fifteen years ago. I look forward to that future.

Philip Groce