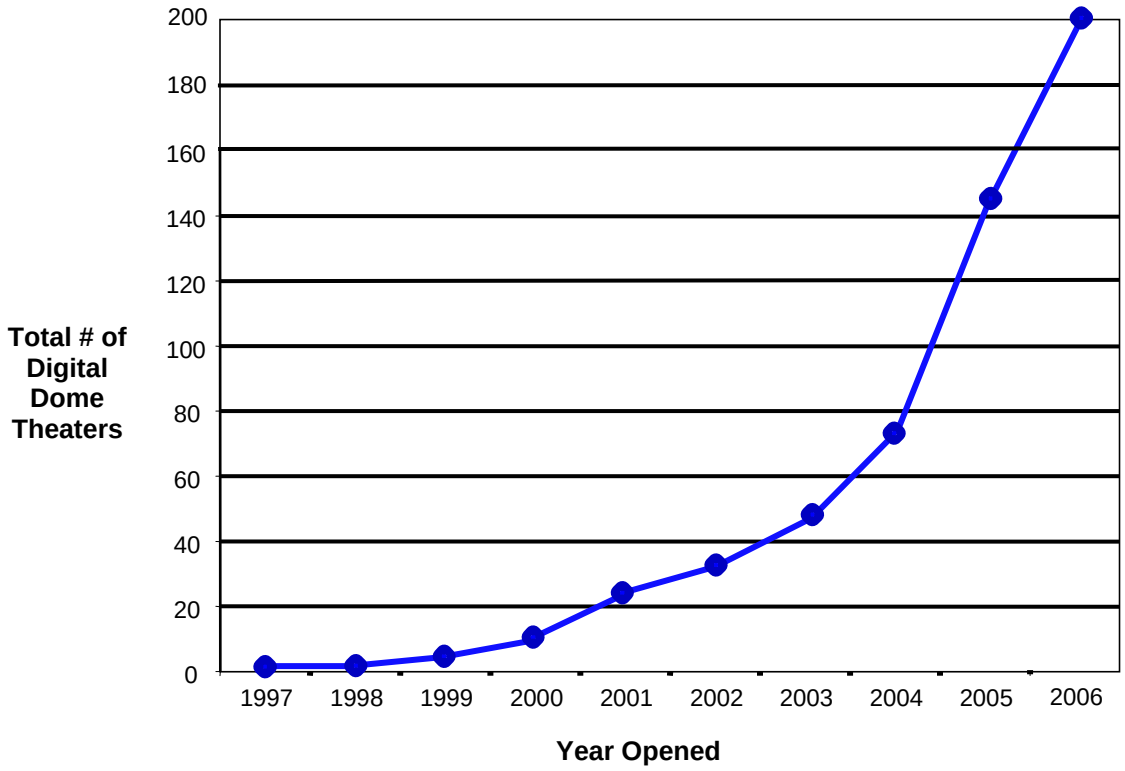
Digital Domes and the Future of Large-Format Film

by Ed Lantz

Debates on large-format digital cinema have recently reached a crescendo within the LF community. Some say the digital writing is on the wall, while others predict it could be a decade or more before digital reaches the alleged 100 million pixels of LF film.

In the mean time, a parallel community has quietly embraced LF digital cinema, installing over 200 theaters worldwide. I am referring to digital domes, or "full-dome" video, the projection of megapixel digital imagery on dome screens. Full-dome technologies have taken the planetarium profession by storm in the last decade, as shown in the accompanying graph. (See www.lochness.com for the free Full-dome Theater Compendium *Online*.)



Digital Dome Theater Openings

It is no wonder — these digital domes allow the planetarian to explore the night sky with unprecedented freedom, zooming in on deep sky objects, displaying the paths of celestial objects, and randomly jumping to any time period. As if this were not enough, the operator can then leave the earth entirely and observe the solar system from any desired angle, with accurate models of all planets and their many moons, or leave the solar system and galaxy entirely to view the large-scale structure of the universe, all based on the latest observational databases. Furthermore, digital planetariums also operate as LF cinemas, showing astronomical simulations, archeoastronomy sites in 3D, and a variety of science and entertainment programming.

The full-dome field is also bursting with creativity unlike anything in the LF film industry. Spectacular animations are being produced on inexpensive PC clusters. Stunning multi-megapixel time-lapse cinematography is being shot with consumer and professional digital still cameras tethered to a laptop. Spherical compositing and editing is being performed using simple desktop tools with custom software plug-ins and low-end fisheye projection dome monitors. There are full-dome film festivals with "domie" awards for best immersive films, courses on immersive cinema, a highly active full-dome listserv, and a Web site devoted to full-dome discussions.

But it doesn't end there. There are more than 15 full-dome theater vendors and an equal number of full-dome show producers vying for a share of this growing market. Major science centers such as the **Denver Museum of Nature and Science**, the **American Museum of Natural History**, and the **Houston Museum of Natural Science** are collaborating on high-end full-dome productions and have received millions in NSF funding to do so. There are over 40 quality full-dome science programs with five or six new titles per year. Show topics include astronomy and space science, earth science, biology, and chemistry, and range from children's programming with animated characters to high-end programs with scientific visualizations and simulations. There are even several music entertainment programs, one of which — ***SonicVision*** — was recently presented as a stunning 15/70mm trailer. The **International Planetarium Society** has established a Full Dome Video Committee which is actively pursuing open technical exchange and industry standards for full-dome show transfer, technical specifications for projection, and guidelines for full-dome workflow. Two special issues of the *IPS Planetarian* have been devoted to full-dome. Digital domes are quickly growing into an industry of their own.

Disruptive Technology?

In his book *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, **Clayton Christensen** coined the term "disruptive technology." A disruptive technology is a new entrant to a well-established technological base that initially does not match up to the superior performance of the incumbent technology. However, due to unique features that might include economic advantages, ease of distribution, ease of use, etc., the disruptive technology gains momentum and, driven by market forces, it quickly overtakes the incumbent, eventually exceeding performance of the prior art as a result of market-supported R&D. Digital domes exhibit the classic signs of a disruptive technology, having already disrupted the traditional planetarium market, and they are likely soon to disrupt dome LF theaters as well.

Display system engineers claim that it could be a decade before digital technologies can rival the image quality of LF film. While this may be true in the strictest sense, there is more to the equation than pixels and lumens. For starters, LF film has some serious drawbacks compared to digital, including film grain that worsens with duplication, film gate jitter, strobing (due to the 24 fps frame rate — most digital systems are capable of 60 fps), and the usual suspects of image degradation: scratches and dust. Then there are the economic drivers. Film is expensive to shoot, edit, print, and distribute. This not only burdens the industry with a slow production cycle and limited theater market, it also limits creative innovation. There are very few experimental or student films shot on LF film. In contrast, the digital dome has democratized the immersive theater.

One must not forget the power of immersive visualization. When **Evans & Sutherland** first introduced the CRT-based fisheye star projector known as **Digistar**, most planetarians were not impressed. The stars were big, green, and fuzzy. Since it was a vector graphics projector, it was only capable of drawing points and lines. Yet this projector could do something that no other planetarium projector was capable of: take the audience through a virtual environment, a dynamic 3D database with moving stars and wireframe objects. I have seen an entire theater of children scream and duck in their seats to hide from a fuzzy green wireframe asteroid that appeared out of the black depths of space and hurtled on a collision course towards them. Even without high resolution or brightness, immersive graphics have a powerful effect on deep layers of the brain, due to the effect of optic flow across large areas of the retina, and the brain's opto-vestibular response that uses visual stimuli to determine spatial orientation. This immersive effect is also one of the primary differentiators of LF film.

So while the brightness and resolution of 15/70 is not quite obtainable with current digital projection technologies (although some who saw the recent Digital Dome Demo at the **Reuben H. Fleet Science Center** might disagree), a powerful immersive effect can be obtained on a small portable dome screen with a $20,000 fisheye projector. And make no mistake: it is the immersive effect that is attracting much of the full-dome community to this new medium. Should brighter, higher resolution systems become available, this would only be gravy for the full-domers. The same techniques and skills used to produce a 1K resolution production will easily scale to a 4K production, given the appropriate technology upgrade.

The full-dome medium is fostering a new generation of immersive cinematographers and artists, many of whom may join the ranks of, or even displace, today's LF talent. And as a reality check, full-dome programs are routinely produced today with many times the spatial resolution of early CG films made for 15/70, such as ***The Magic Egg*** (1984), which was produced and directed by **Eddie Garrick** of **Garrick Films** for **ACM SIGGRAPH** in cooperation with the **Science Museum of Minnesota**.

Also, it is no secret that very few LF films are shot completely in dome fisheye format. While recent efforts to digitally re-master flat-screen LF films into fisheye geometry are noble, there is no substitute for true spherical geometry. Many IMAX Dome theaters are left feeling neglected, adding to the digital dome momentum.

The Digital Edge

Beyond pixels, lumens, democratization, and economics, digital technology offers an element that film will never provide: real-time interactivity. While many who hear this term envision seats equipped with button boxes, the most robust real-time applications are interactive journeys led by a skilled presenter. Led by planetarians with strong roots in traditional planetarium shows, these digital-age storytellers, such as AMNH's **Carter Emmart**, navigate audiences through the most extensive and advanced visualization databases available. The modern digital dome essentially holds a navigable 3D visual model of the known universe, from geospatial imagery all the way out to the large-scale structure of the universe. Even quantum phenomena are being explored with these systems.

With video game revenues now exceeding the income of Hollywood movies, one can imagine that it is only a matter of time before a "killer app" is introduced into the digital dome that provides a "sticky" (i.e. addictive) interactive gaming experience. The next-generation digital dome is likely to allow real-time simulations of planets, life-forms, and even civilizations, created by individuals, classes, or universities, and brought together on the big screen for an entertaining simulation or "educational shoot out." **Will Wright**'s SPORE video game is perhaps a portent of what is to come in these spaces. Real-time artistic performances are also on the horizon, and are already being pioneered by several digital theaters worldwide.

Screening LF films will likely be a subset of future digital dome capabilities, not the primary application. Even here, the real-time capabilities could provide enhanced features, including rapid updating and customization of LF programs. Immersive cinema could become a seamless hybrid of interactive simulations, game-based storytelling, journeys using immersive telepresence, collaborative projects using networked domes, and other digital cinema devices.

Business Impact of Digital

Perhaps just as interesting as the technological waves of change that will ripple through the LF industry in the coming decade will be the repositioning of the dominant manufacturers in the field. Will **Imax Corporation** retain its leadership position in the LF dome, or will the future brand be **D3**, **E-Sky**, **ADLIP** or **DigitalSky**? Might we some day find a single unifying label that stands out in the minds of the public for these unique spaces? Will it be called a Cyberdome, Digital Dome, Imaginarium, or IMAX? Will there be a single proprietary standard dictated by a powerful corporate brand, or will there be an open standard that all vendors can strive to achieve? **Visual Acuity**'s **Blair Parkin** and **Jim Costigan** persuasively argued at the IPS 2004 Full-dome Summit that having a single vendor dominate the LF field was ultimately an unhealthy state of affairs. (See www.full-dome.org for the full set of summit papers).

Some in the full-dome field see a window of opportunity for the development of open standards for the next-generation of LF digital theater, before a dominant player emerges. This would be a pro-active standard that would dictate requirements for manufacturers to meet, rather than passively adopting proprietary technologies from vendors that rarely play well together. Much as **THX** is an open standard for motion picture sound systems that require vendor qualification, the next-generation digital theater standard could provide a new brand name and level playing field for digital dome vendors, defining both display requirements (resolution, brightness, contrast, frame rate, etc.) and software requirements (database format supporting multiple vendor playback engines and effects).

Others point out that such an effort would require an unprecedented level of cooperation between institutions and vendors (read: it's impossible), and that conforming to a proprietary format from a single powerful vendor does have its advantages. Time will tell how this scenario will play out. In the mean time, with the support of NSF and others, the IPS continues to pursue forums, preliminary standards, and guidelines designed to facilitate show distribution, common technical specifications, and technical exchange between digital dome theaters. Fortunately, the fact that full-dome programming is digital makes image format conversions a fairly straightforward, albeit machine-intensive, affair.

The Digital Future

Whatever the future holds, it will likely be digital. However, there is still a way to go before digital will meet the image standards expected by the LF community. Quality control in digital theaters varies widely from institution to

institution, with few standards for image quality and color control, despite early efforts by IPS and individual vendors.

But digital domes are thriving, in part because the productions are largely based on 3D animations, simulations, and real-time image generation, not live-action cinematography. Most early experiments in digital LF live-action production, such as **John Weiley**'s *Heart Of The Sun*, based on his 15/70 film ***Solarmax*** — have relied on film for image capture. A digital LF camera is clearly vital for an all-digital workflow.

And the full-dome community is still waiting for the holy grail: an LF spherical projector that combines high resolution, high brightness, and high contrast into a compact, affordable, and maintainable system. The momentum of the digital dome market has firmly captured the interest of **Sony**, **JVC**, **Barco**, **E&S**, and other advanced projector manufacturers, so new advances are likely just around the corner.

The original Omnimax theater debuted at the Reuben H. Fleet Science Center in 1973 as a combination planetarium and LF film theater. Thirty years later, at the invitation of director **Jeffrey Kirsch**, the Fleet hosted the first Full-dome Video Showcase as a part of SIGGRAPH 2003, with over 70 minutes of original programming. The digital dome is driving towards a seamless integration of planetarium and LF film — and a whole lot more.

Ed Lantz is an entertainment technology engineer, entrepreneur, and digital dome pioneer with 22 years experience in photonics, LF film, and digital projection. He is chair of the IPS Full Dome Video Committee, engineering consultant for Visual Bandwidth, Inc. and CEO of Harmony Channel, a national visual music cable television network. He can be reached at ed@visualbandwidth.com.