Cosmological Cinema: Pedagogy, Propaganda, and Perturbations in Early Dome Theaters

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I. INTRODUCTION

Cultures from around the world have long turned to the dome of the heavens to better understand the cosmos. As this perceived curvature has manifested architecturally throughout the world, domes have been used to enclose the most sacred environments of many cultures. The rounded enclosures have often been used as canvases upon which to represent psycho-cosmological constructs, painted with artistic renderings of incorporeal ideals. From Buddhist stupas to Islamic mosques to Christian cathedrals, these structures have been used as places of ritual, indoctrination, and transcendence. With both internal and external surfaces often steeped in visually symbolic and geometric meaning, domes have artistically and architecturally represented the worldviews from which they arose and were meant to sustain.

In the 20th century, it became possible for the first time to radially extend mental images onto the dome screen using projections of light. Made possible by advancements in engineering, mechanics, and electronics, the ability to completely immerse the visual field of audiences in a mediated environment was seized upon by numerous pioneers in a wide range of contexts. Like their predecessors, these modern multi-sensory sanctuaries continued to reflect the cosmologies and motivations of their creators, subtly affecting the evolutionary trajectory of the cultures from which they emerged.

By exploring the motivations behind their construction and the applications for which they were used, I venture to provide insights into the worldviews and cultural trends that shaped their evolution. This is an attempt to make new connections between seemingly disparate efforts by shedding light on a largely forgotten history, one that is increasingly relevant as dome theaters become a common medium for education, outreach, and experimentation in the early 21st century.

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II. The Opto-Mechanical Universe

The first immersive dome projection theater was the Zeiss Planetarium, unveiled in 1923 by the Carl Zeiss Optical Company of Jena, Germany. The system was comprised of two revolutionary innovations: a highly accurate opto-mechanical star projector and a sixteen meter thin-shell concrete dome supported by a lightweight iron rod framework, both patterned on the 20-sided icosahedron. The projector, called the Zeiss Mark I, provided a means by which high fidelity spatial/temporal astronomical simulations could be projected onto the dome surface, controllable in real-time by a single operator. This enabled an effective approximation of a time machine, allowing audience members to experience both visual-spatial immersion within a seemingly infinite dome of the night sky and the temporal acceleration of celestial mechanics.

Figure 1: Zeiss Projection Dome

Jointly conceived of by museum director Oskar von Miller and Zeiss engineer Walther Bauersfeld, Miller felt that this type of environment could teach scientific concepts in a direct, experiential way to museum visitors, clarifying "the underlying theories and yet convey the variety and excitement of a world's fair" (Alexander 1983, 353). The Zeiss Planetarium made its public premiere at the Deutsches Museum in Munich shortly after initial demonstrations at Zeiss, where Bauersfeld gave the first public demonstrations in the museum's newly constructed 9-meter dome. After witnessing one of Bauersfeld's presentations, the director of the Copenhagen Observatory proclaimed that it was "a school, a theater, a cinema in one; a schoolroom under the vault of heaven, a drama with the celestial bodies as actors" (Marché 2005, 19). David Todd, the first American astronomer to report on the planetarium, confirmed the success of Miller's experiential learning device, suggesting that it could broaden audience perspectives "intellectually, ethically, and esthetically" by enabling them to directly experience the "influence of vision." He was so taken by the experience that he described it by claiming that the planetarium provided a means to (quoting William Blake) "hold Infinity in the palm of your hand and Eternity in an hour" (Todd 1925, 446).

Zeiss continued to refine their design, introducing the improved Zeiss Mark II by 1926. As word spread of what Bauersfeld coined the "Wonder of Jena," orders came rushing in from other European and Russian cities. By the end of the 1920s, Zeiss had constructed planetarium theaters in a dozen German municipalities, made possible through the support of local and federal government funding. They had also been commissioned to build theaters in Vienna, Rome, Moscow, and Sweden. Attendance steadily grew throughout the decade, with records revealing that millions of visitors had experienced the simulated heavens in Germany alone.

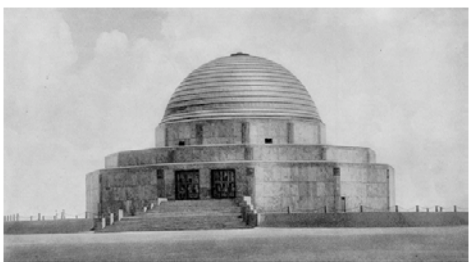

Figure 2: Adler Planetarium, 1933

It wasn't until 1930 that the Adler Planetarium, the first in the United States, opened its doors to the public in Chicago. Four additional Zeiss theaters were constructed throughout the decade at museums in Philadelphia, Los Angeles, New York, and Pittsburgh. Lack of federal funding for education had delayed earlier entry into the United States, which necessitated the support of wealthy private donors and prohibited the installation in all but some of the largest cities. Regardless, attendance at American planetariums, and by extension popular interest in astronomy, increased throughout the decade as audiences sought to escape the economic realities of the Great Depression. The planetariums provided a vicarious experience of the heavens rarely experienced within urban environments.

Many of the donors and proponents that helped finance planetariums in America believed the near-metaphysical experience of these celestial simulators could affect cultural and social evolution by increasing social equality, spiritual appreciation, and even environmental awareness. Concerned with rising anti-Semitism, Sears and Roebuck vice president Max Adler hoped that his namesake would show that "all man kind, rich and poor, here and abroad constitute part of one universe" and that "under the vast firmament, there is no division or cleavage but rather interdependence and unity" (Kaempffert 1928, 21). Similarly, stock broker Charles Hayden, backer of the American Museum of Natural History's planetarium in New York, believed that they could give visitors a "sincere appreciation of the magnitude of the universe and of the belief that there must be a very much greater power than man" (Times 1934). At the dedication of the Hayden Planetarium, one presenter foreshadowed modern environmental awareness by expressing his hope that the new theater would impart a "geographical planetary consciousness" and that visitors might better comprehend "the common fate of the human race in one spherical boat out upon the boundless ethereal sea" (Laurence 1935).

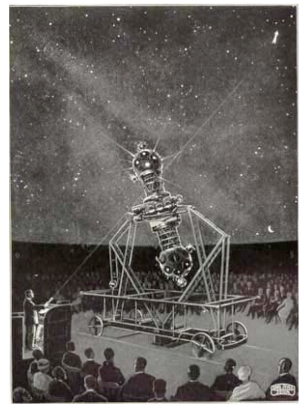

Figure 3: Zeiss Mark II

This mystical appeal of these domed theaters was furthered illustrated by the development of the first American planetarium instrument. Created by Harvey Spencer Lewis, founder and Imperator of the Ancient and Mystical Order of the Rosae Crucis, it was installed in 1936 in his Moorish-influenced Rosicrucian Planetarium in San Jose, CA. Known as the "Theater of the Sky," the device consisted of multiple optical projectors emanating from a centrally mounted sphere that projected onto a 40-foot diameter dome. In addition to the stars of the night sky, it simulated the daytime sky, the movement of the sun (including sunrise and sunset), and clouds of fog to "show how in the beginning of the creation of the universe moisture preceded the creation of everything else." Additionally, it was claimed that visitors could witness "the mysteries of the ancient mythologies demonstrated in a surprising manner." Other eccentric inventions developed by Lewis were also on display, including the Luxatone color organ, the Cosmic Ray Coincidence Counter radioactivity tracker, and Sympathetic Vibration Harp (Rosicrucian 1937, 14). Not surprisingly, the Zeiss-based planetarium community that represented the institutional status quo of scientific outreach and education largely ignored the Rosicrucian Planetarium.

Figure 4: The Rosicrucian Planetarium, Constructed in 1936

By perceptually opening the frontiers of space and time, these first domed projection theaters provided a means by which the general public could vicariously experience the movements of the celestial screen. In an era of intense political, economic, and scientific upheaval and uncertainty, the Zeiss planetariums provided awe-inspiring mechanized reassurance of the underlying order of the clockwork universe. At the same time, Lewis' investigations into multi-sensory metaphysical knowledge spaces were a harbinger of the spiritual, artistic, and technological experimentation of later decades.

III. The Race to Space

By the end of the 1930s, the construction of new Zeiss planetariums came to a halt with the onset of World War II. The final installation was Pittsburgh's Buhl Planetarium, which opened its doors to the public less than two months after Hitler's invasion of Poland. At the dedication ceremony, the city's mayor acknowledged the irony of the situation, commenting, "The skilled hands and brains, which made this very Planetarium possible, are today forging weapons of destruction for a war of conquest and subjugation, a war to spread the divine right of dictators" (Scully 1939). Indeed, the Jena factory was converted to manufacturing bomb sights for Nazi aircraft during the war. However, just as German engineering had allowed Americans to conceptually "reach for the stars" in the previous decade, it also provided the foundation for more literal attempts after the war.

Figure 5: German V-2 Rocket

In 1951, the Hayden Planetarium hosted the *First Symposium on Space Flight*, detailing the technologies and plans brought to the United States by German rocket scientists after the war. Led by Wernher von Braun, who later became chief architect of the U.S. space program, the symposium popularized many concepts of space flight that to most Americans seemed like science fiction. Topics covered at the symposium, including manned orbiting space stations, lunar space ventures, and questions of international law and sovereignty in space (Newkirk et al. 1977), were further elaborated by a series of widely read Collier's magazine articles the next year. Soon thereafter, a fruitful art/science collaboration between Walt Disney and von Braun produced a series of Disney television shows on the theme of space travel as well as the *Trip to the Moon* theme park ride that was placed in Disneyland's newly opened *Tomorrowland* (Wright 1993, 151-160).

As interest in astronomy and space-related subjects continued to grow in the first decade of the post-war America, over a hundred new planetariums were installed nationwide. Made possible by the development of an inexpensive planetarium projector by Armand Spitz of Pennsylvania, many of these systems were for the first time installed at schools and universities instead of major museums.

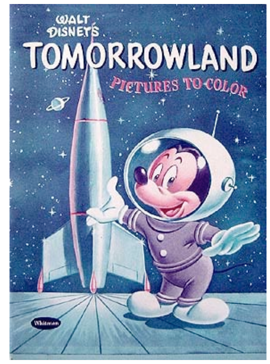

Figure 6: Tomorrowland coloring book, 1955

The Russian launch of Sputnik I, in conjunction with the 1957 International Geophysical Year, fully catalyzed the "Space Race." American scientists and politicians were caught off guard, assuming that the U.S. had superior technology and would be the first to launch a manmade Earth-orbiting satellite. Within 4 months, the U.S. successfully launched Explorer I, followed by Congress' passage of the "Space Act" for the creation of the National Aeronautics and Space Administration (Garber 2003).

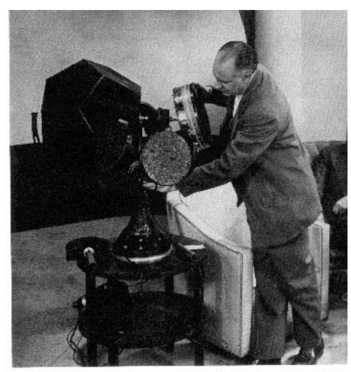

Figure 7: Armand Spitz and his Model A Planetarium

Widespread public anxiety after Sputnik's launch also caused the U.S. government to fully embrace science education as a vital component of cultivating a national defense-oriented *weltanschauung* amongst the public. Citing the need to remedy "existing imbalances in our educational programs…as rapidly as possible" to compete in a cold scientific war with the Soviets, the US Congress enacted dramatic changes in federal policy to direct federal funds to support local education. Entitled the National Defense Education Act of 1958, it included provisions that provided matching funds for the construction of planetariums in schools. Prior to Sputnik, relatively few schools could afford their own star theaters, but the passing of the NDEA enabled them to become the primary sites of planetariums in America. Additionally, astronomy education was reintroduced into school curricula for the first time in nearly 60 years (Marché 2005, 124).

IV. Expanded Frontiers

The ongoing campaign to shape the public's perception of an American-dominated Space Age reached an expensive and elaborate pinnacle with *Century 21*, the nine million dollar U.S. Science Pavilion at the 1962 World's Fair in Seattle. After the humiliation of Sputnik, members of the Department of Defense and National Science Foundation determined that an international science fair focused exclusively on space travel and rocket science could "awaken the U.S. public to the significance of the general scientific effort and the importance of supporting it." Designed specifically for middle-class Americans skeptical or indifferent about the importance of science, they determined that *Century 21* could offer "the first opportunity" to "illustrate our attitude of moral responsibility in international relations that go along with scientific progress" (Gilbert 1997, 301-302).

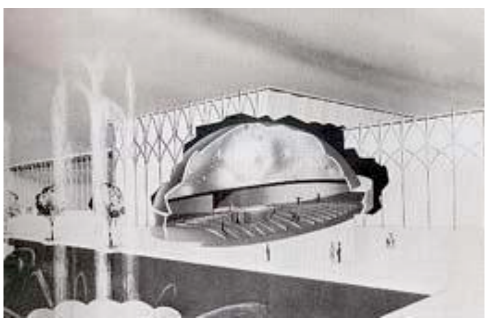

Figure 8: Boeing Spacearium Theater, 1962

Determined to create a thrilling experience, members of the government's planning committee visited Disneyland in early 1960 for inspiration. After experiencing Disney and von Braun's *Trip to the Moon* ride and the 360-degree panoramic Circarama film *America the Beautiful* at *Tomorrowland*, they developed a concept for a film production that would combine space age themes with panoramic immersion on a planetarium-style screen. In October of 1960 it was announced that the U.S. Department of Commerce would collaborate with Seattle-based aerospace contractor Boeing Airplane Company to create "the first production of an outer space voyage among the moving heavens in the world's first spacearium" (Gilbert 1997, 306).

Fine Arts Productions, whose founder had previously directed Disney's *Bambi* and *Snow White* (Hand 2007) was contracted to develop the film. The Cinerama Camera Corporation, which had previously developed a dome-based aerial gunnery trainer during World War II, was hired to develop a lens, camera, and special projector. Cinerama's "space" filmmaking process involved capturing and projecting scenes through a custom fisheye lens to provide undistorted imagery and animation when displayed onto the dome's surface. Coined *Cinerama 360*, the 70mm film image was projected as a 360 degree horizontal by 160 degree vertical image to fill the inside of the dome, "completely enveloping the spectator on all sides from above."

After two years of development, the result was *Journey to the Stars*, the first immersive large format film production for a dome theater. In the course of ten minutes, visitors were taken "on an extraordinary simulated flight through space, exploring the galaxies and the planets of outer space and finally returning to earth." The Boeing Spacearium Theater was claimed to be the largest screen in the world, with a 70-foot diameter, 8,000 square feet of viewing area, and room for a standing audience of 750. In the course of the World's Fair, it was seen by approximately 7 million visitors (Cinerama 1961).

The Cinerama 360 system was used once again for *To the Moon and Beyond*, an ambitious animated film exploring the Universe at every scale. Installed at the 1964 New York World's Fair's Travel and Transportation Pavilion and sponsored by KLM Royal Dutch Airlines, this 18 minute 70mm film was projected onto an even larger 80-foot domed screen (Crowther 1964) housed under the pavilion's 96-foot tall "Moon Dome" (Cotter and Young 2005, 33).

One report, echoing earlier accounts of the psychological effect of planetarium domes, said that visitors were transported into a darkened 80-foot dome to "free the viewer from conventional ideas of size and time." The film began by compressing "million years into one second," showing animations of galaxies forming out of groups of gas clouds. Returning to the Earth, users were flown through the middle of a forest and to the bottom of the sea. The presentation concluded with a journey into a single cell, completing the tour from the macrocosm to the microcosm (Business Screen Magazine 1964).

Figure 9: To the Moon and Beyond advertisement, 1964

To the Moon and Beyond was produced by Graphic Films Corporation, whose founder had worked as an animator on Disney's *Snow White*, *Bambi*, and *Fantasia*. Graphic Films specialized in the development of simulation films for "training and scientific purposes" to show to "Senators and appropriations committees in order to stimulate the necessary flow of cash," with clients including NASA and Jet Propulsion Laboratories (Finch 1984, 103-104). The film was narrated by

Rod Serling of *Twilight Zone* fame and illustrated by special effects artist Douglas Trumbull, who later supervised effects for *Close Encounters*, *Star Trek: The Motion Picture,* and *Blade Runner*. Director Stanley Kubrick was so impressed after visiting the pavilion film that he tracked down Graphics Films to solicit their technical assistance with his upcoming *2001: A Space Odyssey* (Finch 1984, 103-104).

Figure 10: The Moon Dome at the 1964 World's Fair in New York

Though the Cinema 360 format was short-lived, it was the precursor of later and more popular large format dome theaters such as Omnimax and Astrovision. Furthermore, in moving beyond space travel and rocket science, the subject matter of *To the Moon and Beyond* foreshadowed other influential mediated attempts to take audiences on imaginary trips through micro as well as macro scales, including the science fiction film (and later television series) *Fantastic Voyage* (1966), Monsanto's *A Trip Through Inner Space* ride at Disneyland's *Tomorrowland* (1967), and Charles and Ray Eames' classic film *Powers of Ten* (1977).

A peculiar mixture of art, science, education, and propaganda shaped the aesthetics, technologies, and messages of the Space Race. New planetarium technologies and unprecedented federal funding for education dramatically increased the number of planetariums throughout the 1950s and 60s, increasing the knowledge of and fascination with outer space amongst generations of Americans. After the absorption of the Third Reich's rocket program into the U.S. space program, fruitful collaborations between Walt Disney and Wernher von Braun not only influenced public perspectives about the importance and goals of space travel but also the designs of the first large format film dome theaters. These early experiments in immersive cinema propelled audiences into new cosmic and molecular frontiers while simultaneously launching the careers of some of the primary forces behind science fiction filmmaking for decades to come.

V. Pedagogical Yearnings

While dome theaters were primarily being used to focus audiences on astronomy, a number of new media pioneers were conceptualizing other applications that could leverage the pedagogical advantages domed immersion. Believing that direct communication of spatialized multi-sensory input would enhance the capacity and speed of human cognition, these pioneers elaborated detailed visions that were often decades ahead of what the technology of the day would allow.

R. Buckminster Fuller, the polymath best known for his icosahedron-based "geodesic dome", put one such proposal forth. Ironically, this invention for which Fuller was most famous was almost identical to the design patented by Zeiss engineers a quarter century before. First realized at the experimental Black Mountain College in 1948, Fuller's geodesic dome, like the Zeiss dome, was conceived and engineered as a highly efficient structure to enclose a very large volume with the least amount of possible structural weight. However, Fuller's design evolved from the development of his comprehensive mathematical/design/philosophy system, and he viewed the geodesic dome as the physical realization of his theory of "energetic-synergetic geometry." Hundreds of thousands of geodesic structures have since been built worldwide, the most famous of which was the Montreal *Biosphere* constructed for the U.S. pavilion at Expo 67 (Krausse 1993).

Like the Zeiss engineers, Fuller also imagined that his structurally efficient designs could be used as highly effective immersive display environments. In 1962, he published plans for what he called the *Geoscope*, a "giant, 200-foot diameter... miniature earth -- the most accurate global representation of our planet ever to be realized." Instead of internal projections, he proposed that the massive geodesic display be covered with miniature light bulbs to be controlled by a computer, enabling the real-time visualization of world data.

Figure 11: Fuller at Black Mountain College, 1948.
Photo by Hazel Larsen Archer

The purpose behind the *Geoscope* was to address Fuller's belief that many global problems stem from humanity's inability to comprehend numerous phenomena with our unaided senses. By bringing extra-sensory phenomena into the realm of conscious understanding through these visualizations, he believed that observers on the inside and outside would be able to "recognize formerly invisible patterns and thereby to forecast and plan in vastly greater magnitude than heretofore." Though never fully realized in his lifetime, Fuller believed the *Geoscope* would perceptualize "phenomena that are not at present communicable to man's conceptual understanding," such as natural resource consumption, world hunger, and weather patterns. Through a network of *Geoscopes*, he hoped that people of all nations could intuitively understand the interconnectedness of our species and the global repercussions of individual and collective actions (Fuller 1962).

Figure 12: *Geoscope* concept rendering by Tom Shannon

Another attempt to utilize visual/spatial immersion for educational purposes was initiated in 1960 by planetarian O. Richard Norton. Calling it the *Atmospherium*, Norton incorporated a 35mm dome projection system into the planetarium at the Desert Research Institute at the University of Nevada-Reno. His motivation was to open the possibilities of dome-based learning environments, extending the available subject matter to include numerous non-astronomical topics. Though his experiments with fisheye filming were limited to the natural phenomena he could film (including time-lapse cloud sequences and underwater photography), he understood the potential of the medium to explore topics that would be good at "attracting current interest or raising controversy." Reflecting numerous emerging interests of the day, his suggestions for program topics included "space travel, quasi-stellar radio sources, Stonehenge, UFOs, Life in the Universe, theories of cosmology" and "experimental art programs" (Norton 1968, 145).

A more complex hybrid system was proposed in 1967 by artist and community college professor Roger Ferragallo. Heavily influenced by "virtual reality" pioneer Morton Heilig, Ferragallo developed numerous drawings, models, and descriptions of his ideas to extend the concept of Heilig's pioneering single-user multi-sensory simulator, the *Sensorama Machine*, to a large, multi-user environment. The result was his *Total Environment Learning Laboratory (TELL) Sensorium*, an elaborate vision for a highly controllable, multi-sensory, and fully immersive domed theater. Designed for the Laney College campus in Oakland, CA, Ferragallo's primary objective was to demonstrate that "learning at the adult level is substantially enhanced by the simultaneous stimulation of several sensory receptors at the time of presentation of specific subject matter."

The ambitious *TELL Sensorium* proposal incorporated numerous types of visual projections (hemispheric, planar, stereoscopic, cinematic, and television), spatialized surround sound, atmospheric effects, an olfactory delivery system, and a fully controllable light and color environment. Enclosed inside of a 60' geodesic dome screen, the audience was to sit on a "revolving, tilting, lifting, vibrating hydraulic platform and floor" (Ferragallo 1967). Though his ideas were enthusiastically received by the community college, which provided initial concept development funding, Ferragallo's "perceptual learning center" was never realized due to monetary and technical constraints as well as political upheavals.

VI. Perturbing the Gestalt

In response to the cultural and technological climate of the U.S. in the 1950s and 60s, numerous avant garde media artists and engineers were experimenting with electronic and multi-media technologies and environments. Collectively known as the "expanded cinema" movement, they initiated a broad array of explorations into various aspects of consciousness, aesthetics, and communication. In contradistinction to many of the entertainment-oriented and science fiction dominated themes of the day, they utilized new communication approaches to critically explore a wide variety of media and topics, including computer graphics, multiple projection techniques, multi-channel audio, synaesthesia, cybernetics, kinetics, interaction, and improvisation.

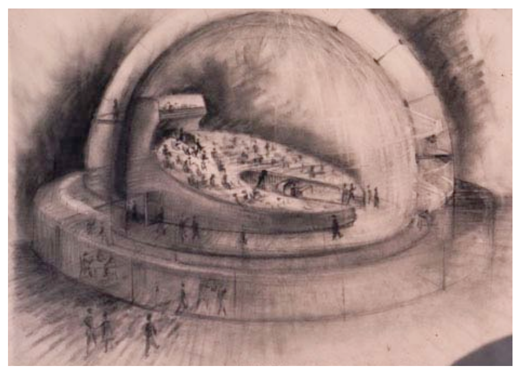

Figure 13: *Total Environment Learning Lab* concept drawing, 1967

One of the earliest expanded cinema experiments, initiated months before the launching of Sputnik I, was *Vortex: Experiments in Sound and Light*. Orchestrated and performed by audio composer/engineer Henry Jacobs and filmmaker Jordan Belson, this series of immersive performances was performed at San Francisco's Morrison Planetarium from 1957 to 1959. Experienced by over 10,000 people during its run, *Vortex* was conceived as a "new form of theater based on the combination of electronics, optics and architecture…a pure theater appealing directly to the senses".

In addition to featuring the custom planetarium projector that had been developed for the Morrison by the California Academy of Sciences after the war, the live performances incorporated "all known systems of projection," including 16mm film, slides, and custom optical instruments. Belson projected and manipulated the works of fellow abstract filmmakers and early computer graphics pioneers, including Hy Hirsh and James Whitney, as well as his own abstract mandalic films that he viewed as extensions of his own consciousness. Jacobs mixed and panned effects and music through a custom-built rotary console, controlling one of the first surround sound systems ever developed, composed of multiple loudspeakers around the dome's perimeter and at its apex. The audio source materials, including mix tape collages, electronic music, and ethnic field recordings, featured his own work as well as pieces by John Cage, Karlheinz Stockhausen, Vladimir Ussachevsky, Tōru Takemitsu, Luciano Berio, and many others.

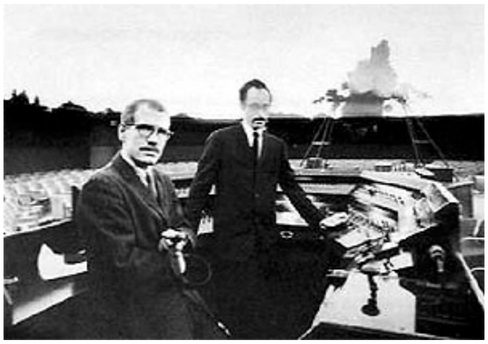

Figure 14: Henry Jacobs and Jordan Belson at the Morrison Planetarium, 1959

Though the program broke attendance records at the planetarium and was invited to participate in the 1958 Brussels World's Fair, the planetarium management did not appreciate the types of clientele it attracted and cancelled the event after thirteen performances (Jacobs 2006). Jacobs, a self-proclaimed Zen surrealist, was unapologetic. He viewed the improvisatory and evolving nature of the performances as a necessary and self-justified provocation in the context of "pre-fabricated dreams, pre-fabricated houses, and indeed pre-fabricated lives." In contrast to the planetarium's usual fare, he acknowledged the "non-intellectual, non-educational and non-reformational" nature of the experiments, with their value instead arising from the "purely accidental aesthetic experience which is so overpowering that even memory is obliterated by the dominance of that moment" (Jacobs 1959, Jacobs 2006, Jacobs and Belson 1958, Jacobs and Belson 1959, Youngblood 1970).

Filmmaker and animator Stan Vanderbeek, also intrigued by the ability to communicate non-verbally within immersive environments, later explored approaches similar those of the *Vortex* performances. After meeting Buckminster Fuller at Black Mountain College in the late 1940s, he became interested in concepts of social consciousness and intrigued with the idea of using domes for surround projection. In 1957, Vanderbeek began creating materials for his evolving concept of a *Movie-Drome*, the prototype of which was finally built in 1965 in Stony Point, NY. The home-built hemispheric theater was constructed from a metal silo cap, through which audience members would enter through a trap door in the center and lie on the floor (Ditto 2007). Inside, 16mm film and slide projectors on wheeled carts and turntables projected computer-generated animations, collage films, found footage, contemporary newsreels, and appropriated advertisements, combined with the reverberant audio from a quadraphonic sound system playing pre-recorded soundtracks (Sutton 2003). Vanderbeek described this cacophonous gestalt as a "newsreel of ideas, of dreams, a movie-mural…an image library, a culture de-compression chamber, a culture inter-com."

Vanderbeek viewed the *Movie-Drome* as a rudimentary prototype for "international audio-visual research centers" for the development of a "new non-verbal international picture-language." The goal of these proposed research centers was to "encourag(e) international dialogue and cultural understanding through the direct transmission of emotion" via this new visual language. Anticipating the eventuality of networked and interactive computing capabilities, he further envisioned a "real-time programmable communication network" that could "transmit and play back imagery from a world-wide library." Like Belson and Jacobs, Vanderbeek felt that these "movie-murals…penetrate(d) to unconscious levels," reaching for the "emotional denominator of all men, the nonverbal basis of human life" (Vanderbeek 1964). Though technological and financial limitations prohibited Vanderbeek's dream of realizing a network of *Movie-Dromes* in his lifetime, he continued to explore networked and electronic communication during later residencies at NASA, Bell Labs, and elsewhere.

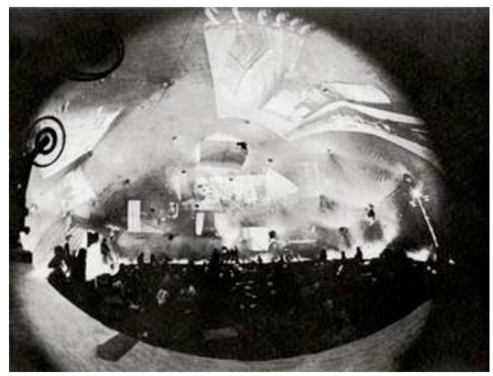

Figure 15: Stan Vanderbeek's *Movie-Drome*, 1965

The concept of an experiential domed environment was later pushed to its extremes by the art/engineering collective Experiments in Art and Technology (E.A.T.). Approached by the Pepsi Corporation to develop a pavilion for Expo '70 in Osaka, the collective, spearheaded by Bell Lab engineer Billy Klüver and artist Robert Rauschenberg, worked with over 60 American and Japanese artists to develop what Klüver called a "theater of the future," and a "living responsive environment." Klüver envisioned it as a "total instrument" to be played by the participants, providing them with "choice, responsibility, freedom, and participation" (Rose 1972). The resultant *Pepsi Pavilion* was composed of a 210-degree spherical mirror made of aluminized Mylar enclosed within a 90-foot diameter geodesic frame. The improvisatory actions of the audience and performers were reflected on the spherical surface as a 37-speaker surround sound system and audience-held handsets emitted pre-recorded sounds. Numerous other kinetic and tactile elements were combined to create chaotic multi-sensory experiences that were designed to encourage maximum audience interaction.

Enclosed within a geodesic dome and enshrouded in a vapor cloud, the *Pepsi Pavilion* was a hybrid of efficiency and ephemerality. Its psycho-cosmological significance, as well as those of numerous Zeiss planetariums and Fuller's *Geoscope*, went well beyond the imagery displayed within them. In 1985, the geodesic structure was discovered to mirror the molecular structure of Carbon 60 (named "buckminsterfullerenes"), thought to be the strongest molecular structure and the foundation for the new science of nanotechnology. Like the encoded geometric of mosques and stupas, the icosahedral configuration of these constructions echoed the architectural designs of nature.

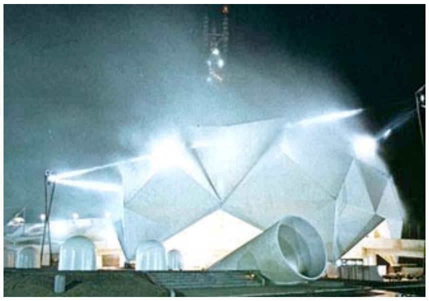

Figure 16: Experiments in Arts and Technology's *Pepsi Pavilion*, 1970

Serving as an antidote to the perceived superficiality of Space Age American consumer culture, the *Vortex* performances expanded the dome theater medium by using new media technologies and improvisatory processes to explore the effects of spatialized, synaesthetic, and omnidirectional gestalt on audience perceptions. The overwhelming audience response anticipated the quest for new modes of experience that would become prevalent throughout the following decade. The *Movie-Drome* conceptually extended the potentials of these environments to include networked interaction and a combination of abstract and representational imagery to explore an emerging international visual language. Finally, the *Pepsi Pavilion's* metaphorical and literal self-reflectivity, as well as its yet-to-be discovered structural significance, symbolized a chaotic and paradoxical apex of a complex era. Defined by ideological conflicts, techno-utopianism, technological determinism, new media experimentation and consciousness exploration, it was an era when even seemingly countercultural experiments often occurred under the watchful eye and active participation of the American military-industrial-entertainment complex.

VII. Future Directions

A diverse range of motivations continue to influence contemporary experiments within dome theaters as media artists, scientists, mystics, educators, engineers, and marketers experiment with the possibilities of working beyond the confines of the rectilinear frame. The convergence of digital video projection, real-time computer graphics, data visualization, networked interaction, and persistent 3D worlds has given rise to a new generation of multimodal spherical displays, with hundreds of dome theaters having been installed worldwide in the past decade. However, limited historic, cognitive, or pedagogical research has been conducted about or within these spaces, leaving the cogency, potential, and implications of many aspects of the proposals and concepts presented here largely unexamined.

This review has revealed that early developments of dome projection theaters emerged from attempts to simulate the spherical gestalt of the human visual field. The frequently explicit associations between visual perception and cosmological constructions suggest that ancient heavenly symbolism of the dome have arisen from humanity's common physiological traits. By recognizing and mimicking this embodied sphericity, these experiments endeavored to demonstrate the potential of visual immersion to both exploit and extend the possibilities of sensory perception. As similar experiments continue in the 21st century, it is the author's hope that insights into the unique visions driving these nascent efforts might inspire new explorations into the potential of dome theaters to experientially illuminate perspectives on the inextricable interconnections between consciousness and the cosmos.

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