Introduction - Overview

IMAX, like early cinema and popular amusement forms before it, developed out of a tradition of mass viewing experience and public exhibition. Unlike many film or video formats, IMAX is not just a film, tape, or camera type, but a technology dependent on a complementary combination of camera, film, projection and exhibition space technology that work together to give the most intense viewing experience available today. IMAX's unusual history has roots in, and successfully combines, the avant-garde, independent filmmaking, a governmental entity, educational content, non-profit institutions, commercial studios, and public corporation savvy. This report seeks to give a brief overview of the IMAX system by looking at the roots of its development, the technology and systems used, and the history of its organizational structure.

IMAX stemmed from an exhibition at Expo '67 in Montreal. [1] Wanting to develop an immersive viewing experience, a group of Canadian filmmakers and engineers, with the support of the National Film Board of Canada developed a multi-screen, multi-projection display entitled *Labyrinth.* [2] The exhibition consisted of walking through a large, domed, tunnel-like room where images were projected on all surfaces. Accompanying this exhibit was a music soundtrack that was produced on separate equipment and played simultaneously. Despite positive response, there were troubling problems, specifically revolving around the fact that the viewing experience was never the same. Viewers, arriving at different times, did not see the same exhibition. Due to the various projection devices, the images did not synch for

[1] Whitney, Allison. *The Eye of the Daedalus: A History and Theory of IMAX Cinema.* Pg. 19
[2] This group comprised of independent filmmakers Graeme Ferguson, Robert Kerr, and Roman Kroitor, along with audio designer Teijo Ito. Bob Shaw would join a year or so later to develop film and projection technology.

uniform viewing across the exhibit. While visually interesting to behold, the lack of consistency troubled the creators.[3]

During the next three years, the filmmakers and engineers worked to perfect the idea of an immersive viewing environment. The challenges they faced stemmed from developing a visual/film format large enough to allow large-scale projection and the means to project large images. They needed to engineer an entire complimentary system that would synchronize film format, projection, and camera. (Unlike Cinerama or similar earlier film technologies, the developers wanted a streamlined, single camera and single projector arrangement.) They experimented with various film types before settling on 70mm. However, to get the visual impact they desired, they also needed to develop projection technology that could project a large, highly detailed image. Regular motion picture projectors did not have an image span that could encompass the image capacity of the human viewing eye. Lastly, they needed to tweak existing motion picture cameras to accommodate the special 70mm film's needs. The development of these technologies will be described in further detail later in this report.

After overcoming these obstacles, the team debuted their new technology at Expo '70 in Osaka, Japan. With the backing of Fuji Film, the group premiered *Tiger Child.* The film was a nonlinear piece that presented the theme of human experience.[4] The audience did not hold static in seats, but like *Labyrinth* before it, moved throughout the viewing space. Of interesting note, IMAX, a film form that would become mainstream in later years, had its developmental roots in avant-garde

[3] Whitney, pg. 9.
[4] Whitney, pg. 45.

filmmaking. Both *Labyrinth* and *Tiger Child* were nonlinear filmic experiences whose developers had either worked or apprenticed with a host of early cutting-edge filmmakers such as Maya Deren.[5] *Tiger Child* was the hit of the expo, which in turn encouraged its creators to develop long-term viewing installations/environments.

Technology – Film and Projection

The first obstacle in developing the IMAX technology was selecting an appropriate film format. Since the goal was large, immersive image projection, the film, when projected, had to cover a large physical screen/space that would encompass the viewing range of the human eye. Standard 35mm stock could not project images large enough to accomplish this goal. The developers looked to other high resolution formats before settling on a 70mm hybrid. 70mm film was used as early at 1896 and became relatively common by the 1920's through distribution of film such as Fox's Grandeur.[6] By the mid-twentieth century there were multiple manufacturers, with Todd A-O being perhaps the best known for feature-length films. However, the standard 70mm was still not large enough to project the desired IMAX image. After multiple experiments, the developers came up with several solutions. Removing the sound track from the film gave additional image surface and turning the film on its side and running it horizontally through camera and projector gave them the additional space to meet their goal. Regular 70mm film is five perforations high; IMAX film is 15 perforations wide — 5/70 vs. 15/70 respectively. At 69.6mm wide by 48mm tall, the IMAX image surface is almost three times larger then regular 70mm. (See figure 1 in appendix for size comparison.)

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[5] Ferguson worked extensively with Deren, while Teijo Ito, the sound designer for *Labyrinth,* was Deren's last husband.

[6] Wikipedia. *70mm Film.* http://en.wikipedia.org/w/index.php?title=70_mm_film

Once film size selection/development was completed, the next issue to confront was camera and projection utilization. Camera usage turned out to be relatively straightforward and will be discussed shortly. Projection of the newly developed film turned out to be one of the most troubling aspects of the technology/system. Due to the size of the film, it needed to be projected and run at high speeds. The developers were unable to find a way to achieve the image clarity and quality they desired. Either the image was blurry due to slow projection speed or when run at required speed, the film would shred. The developers turned to Ron Jones, an Australian projectionist who had invented a rolling loop system. [7] The film is advanced in an undulating motion or arc that reduces stress. Bill Shaw, an engineer and friend of Ferguson's was asked to develop a projector that would use the rolling loop system. [8] Shaw used compressed air to accelerate the film through the projector. When the film is run through the gate, a vacuum pulls the frame against the lens for a split second, this allows the film to flatten against the lens and flatten the image surface — creating great clarity of image on screen. The lens also has 'wipers' that removes dust to keep the process clean when needed.[9] The projection uses pin registration, not sprockets to guide frame placement. Since the film moves as such a high rate, sprockets would shred the film — the pins (along with air compression) allows for accuracy of placement at high speeds, with little or no damage. To handle both the weight and considerable length of the film, the film is plattered on large plates. The platters lie horizontally (allowing for the oxymoronically titled 'horizontal pull down) and are often arranged on top of each other in a tower-

[7] Whitney, pg. 42
[8] *Ibid.*
[9] *Imax Technology.*

like formation. (See figure 2 in appendix.) Currently, the IMAX system uses Kodak Estar film (a PET based film) for accuracy. Since the projection system is so fine tuned, it tolerates very little variation in film thickness or size. Estar is very consistent across the board and does not alter in size during filming, printing, or projection. And, it tolerates the high speeds and temperatures required.

Another part of the projection challenge was developing a light source and projector housing that could achieve the desired image size. To light the large and high-resolution film, large xenon lamps were developed. IMAX lamps are made of thin-shelled quartz crystal around a hollow electrode-cooled core and range in size from 12-18 kW. They are filled with roughly 25 atmospheres of pressurized xenon gas and operate at approximately 1200° Fahrenheit. Due to the extreme pressure, temperature, and size, technicians are required to wear full protective body armor when handling the lamps because flying shards of crystal could be fatal.[10] To house the large lamps and handle the high volume of film, the projector housing and mechanics had to be sized accordingly. An IMAX projector is roughly the size of a refrigerator and weighs up to two tons.

Sound remains one of IMAX areas of challenge and continued innovation. Since the soundtrack space is removed off the film stock, IMAX sound is recorded off-camera and is synched to the film in post-production and projection. This has created shortcomings in both educationally and entertainment oriented productions. Often the sound is not precisely synched to the image, a great challenge considering the speed that the film moves through projection. Originally, IMAX used a 35mm magnetic tape dubbed to synch with the film. In the 1990's IMAX moved to a digital

[10] *Ibid.*

six-track source using SMPTE time code synchronization.[11] IMAX audio files play directly off a hard drive as a single uncompressed audio file. The signals are distributed directly to the amplifiers rather than decoded like Dolby Digital. IMAX theatres use a six-channel, multi-way speaker system with sub-bass using forty-four speakers grouped in six clusters behind the screen and in the rear of the theatre.[12] However, as IMAX continues to expand its viewing formats (i.e. moving to more feature-length films) it continues to search for new ways of creating a more 'real-time/real-sound' audio experience.

Technology – Camera

Once film format was chosen and projection challenges solved, the other complimentary piece of the puzzle was developing cameras that could handle the film/format. Initially, the IMAX team took regular motion picture cameras and altered them to fit the large film. Part of this alteration involved developing a film compartment that could hold the large volume of film. Average IMAX cameras hold between 500 and 1,000 feet of film, which requires frequent reloading. Additionally, new lens needed to be developed to work with the large emulsion surface. However, unlike other aspects of IMAX, the camera design/reconfiguration was the least problematic. The major drawback to IMAX cameras is the size. The "Lightweight" camera weighs thirty pounds empty. When loaded with 1000 feet of film it weighs almost sixty pounds.[13] Another major technological development was the IMAX 3D camera. The camera uses two lenses, set apart from each the distance of the human eye. This replicates the human viewing experience. The image recorded through each

[11] *Ibid.*
[12] *IMAX Corporate Profile.* IMAX Corporation, http://www imax.com
[13] *Imax Corporation.* Also see attached camera details at end of paper.

lens is directed onto separate film stock. (The camera loads two separate reels of film.) The film is processed and run together, giving a three dimension viewing experience. Over the history of the corporation, IMAX has developed various cameras for specific shooting conditions: underwater, aerial, high-altitude, temperature variations, and portable versions.

Technology – Exhibition Space

With film, projection, and camera conundrums solved, the next piece in the puzzle was developing the viewing environment. While the halls used in Expo '67 and Expo '70 were temporary exhibit spaces, the experience proved valuable and gave the developers the knowledge they needed. As stated earlier, the first permanent IMAX theatre opened in Toronto in 1971. Additionally, some of the earliest institutions (such as the San Diego Hall of Science) interested in the IMAX system were planetariums that were building large screen auditorium spaces and wanted a large-format film system to utilize the space during off times. Two years later in 1973, IMAX opened its first OMNIMAX (now named IMAX DOME) in San Diego.[14] Currently there are several different types of IMAX exhibition space designs/layouts: Original IMAX, IMAX DOME, IMAX 3D, and modified multiplex theatres which can project the newer DMR format. (See figure 3 and 4.) IMAX DOME technology utilizes domed shaped venues such as planetariums. The film is projected from the ground up upon the viewing surface (compared to projecting from rear of space) and gives the most immersive experience in the IMAX family. Original IMAX format theatres screens are roughly fifty feet tall and seventy feet wide and it the most commonly used formed of IMAX (as of this writing). IMAX 3-D venues are larger (usually) than original IMAX, but

[14] Ackland. Pg 431.

the main difference is the image is shot on double film as discussed above. In 2002, the IMAX Corporation debuted a new Digitally Remastered (DMR) technology which allowed it to transform any Hollywood film into the IMAX format. This new technology opened the door for additional venues on smaller screens in multiplex theatres around the world.

Corporate Profile

In 1970, coinciding with the Osaka Expo, Graeme Ferguson, Robert Kerr, and Roman Kroitor formed a business enterprise called the IMAX System to support the commercial development of their technology.[15] IMAX stood for "maximum image". The first permanent IMAX theatre opened in Toronto in 1971.[16] Original viewing sites were predominantly educational in orientation and situated in educational or scientific institutions. Part of this was due to the fact the technology suited itself towards scientific and educational subjects that could take advantage of large-scale format (i.e. underwater worlds, space, and various wilderness environments). And, without the pressure of commercial interests from the mainstream entertainment industry, these institutions (often governmentally funded) were able to financially support IMAX productions. Additionally, the average IMAX film was forty-five minutes and roughly three-miles or 15,840 feet long — reducing the practicality of using it for feature-length films.[17] Over the next thirty-five years, IMAX would expand its technology to include several different viewing formats and an affordable IMAX system for smaller theatres/spaces.

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[15] Actual date of the formal business organization is sketchy. The Imax Corporate Web Page lists 1967, while various other sources list 1967 as the date when the three started working together. 1970 has been cited in multiple sources as the actual date of existence as a business entity.
[16] Ackland, pg 431.
[17] *IMAX Technology.* http://www.bookrags.com/IMAX

Throughout the 1970's and 1980's, IMAX worked on several sides of business development. They made or sponsored educationally oriented films for cultural institutions, renting out camera equipment to other filmmakers, and continued building theatre spaces, in conjunction with other institutions initially around Northern America, before branching out globally. Originally, they sold their projection systems to theatres, but after some maintenance and projection issues, reversed that decision and leased projection technology to venues. Throughout this time, they continued researching and perfecting their technology, including developing new film types and a range of cameras for different shooting conditions. They experimented with high definition technology in the mid-1990's, but the costs involved were too prohibitive and the project abandoned. Throughout its history, IMAX has put its money back into research and development of new technologies. In 1994, the three owners sold IMAX Systems to a private group of investors, who still run the corporation today out of Toronto and New York. Currently IMAX revenue comes from four main sources: long-term theatre leasing systems and maintenance agreements for the systems (over fifty percent of revenue), film production, and distribution.[18] This tight integration allows IMAX to be involved with all aspects of the content, development, production, and distribution of their brand. The new addition of transferring Hollywood feature films to the IMAX format allows the corporation to compete and obtain a market share of mainstream entertainment dollar. IMAX is one of the few companies that has roots as a governmentally backed organization (National Film Board of Canada), worked with the non-profit sector (cultural institutions), and is a player in mainstream corporate America. Over the next year

[18] Ackland, pg. 432.

IMAX will premiere blockbuster Hollywood films such as the latest *Harry Potter* installment and *Spiderman 3* (in the summer of 2007) as well as continue work in educational products. As of fall 2006 there are 239 IMAX theatres in thirty-five countries with sixty-five currently in development. [19]

Conclusion

The IMAX Corporation proves fascinating material, whether viewed from a film/technology standpoint or an organizational development model. The fact that it specialized in developing new technologies across several different areas of arts and sciences is unusual. IMAX developments in film formats, new projection methods, viewing spaces, and camera technologies have impacted an entire industry in ways too various to mention. IMAX started out as a vision of creative and scientific minds to give an alternative viewing experience. It stands out as entity that spans developmental roots in avant-garde filmmaking, old-style public exhibition to become a contender in large-scale commercial entertainment. Ultimately, IMAX is an example of how a single creative vision — pushed to its scientific and creative limits — can alter the viewing experience and expectations of many.

[19] *Imax Corporation*

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15/70 mm
Standard 70mm
Standard 35mm
FILM FRAME COMPARISON
At the heart of The IMAX Experience™ is a 15/70mm film frame that is 10 times the size of a conventional 35mm movie.

Figure 1

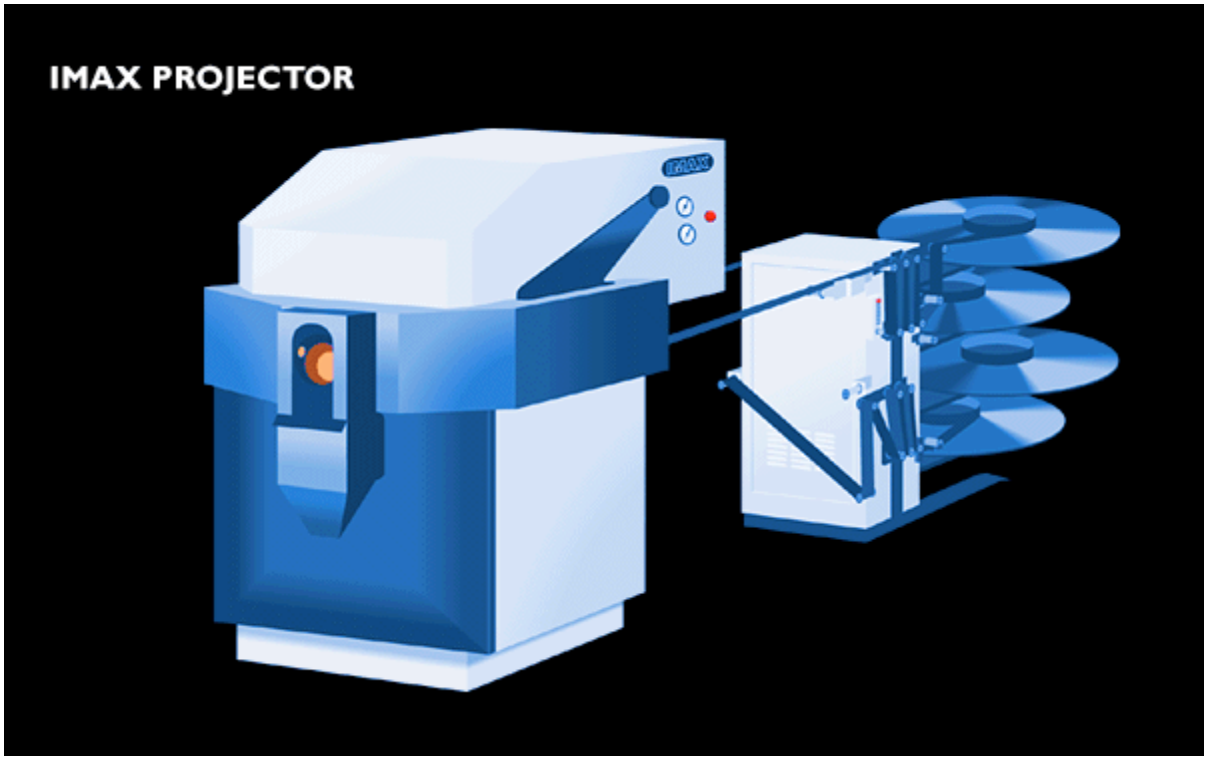

Figure 2

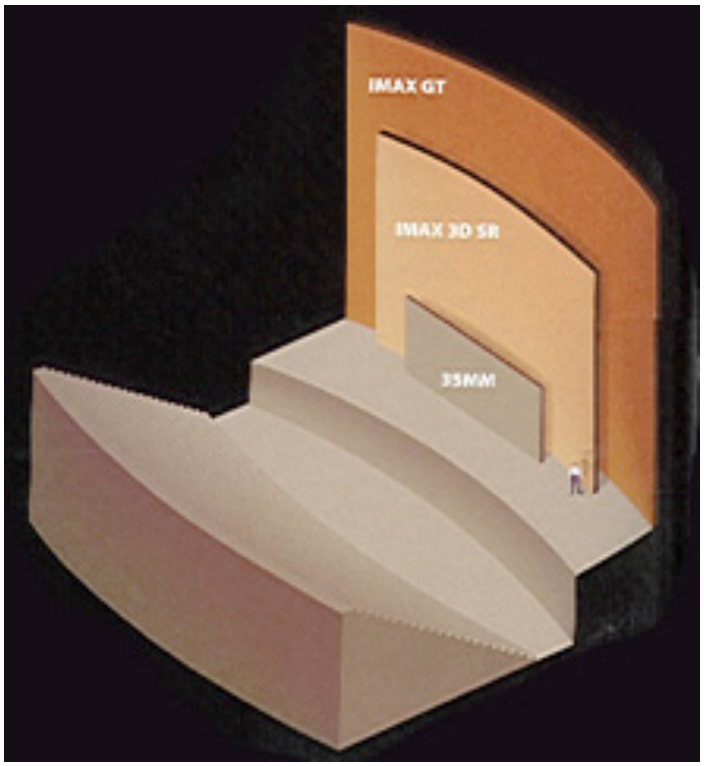

Figure 3

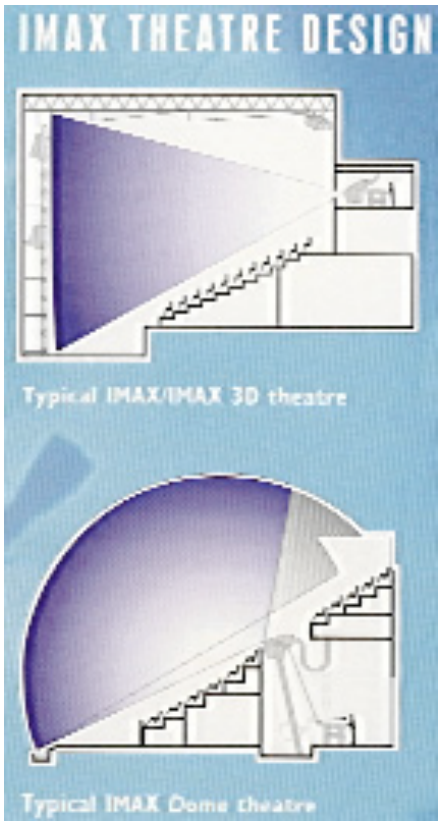
IMAX THEATRE DESIGN
Typical IMAX/IMAX 3D theatre
Typical IMAX Dome theatre

Figure 4