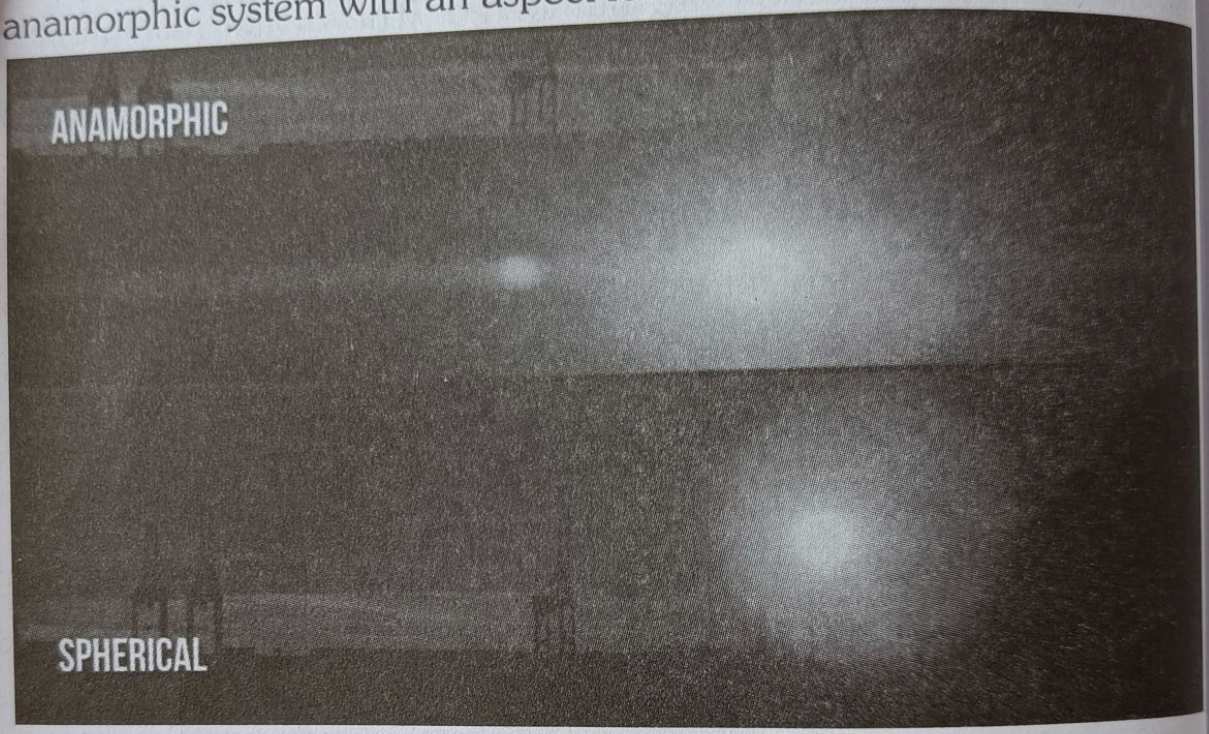
CELLULOID TO DIGITAL 1990-1999:

Since the early days of photographic film in the late 19th century, moving pictures have been captured and then projected via some form of celluloid print. The origin of the name "film" even comes from the process and has been the primary method for recording and displaying motion pictures for over a century. But with the advent of digital technology over the last decade the days of film-based production and projection are numbered. The digital revolution in how films are seen and made is currently spelling a slow death for celluloid. The rise of digital cinema projection began in 1999 just when digital optical discs were gaining traction in the home market with the DVD format. Until the early 1950s, the screen shape, or aspect ratio (expressed as the ratio of frame width to frame height), was generally 1.33 to 1, or 4 to 3. In the mid-1950s the ratio became standardized at 1.85 to 1 in the United States and 1.66 or 1.75 to 1 in Europe. These slightly wider images were accomplished by using the same film but smaller aperture plates in the projector and by using shorter-focal-length lenses. Many people have felt that, while vision at the extreme sides of the vision field does not usually contribute much information to the eyes, it does add substantially to the illusion of reality when it is present. Hence, there have been periods when film producers have attempted to introduce extremely wide formats. As early as 1929, Grandeur films were presented using 70-mm instead of the standard 35-mm film to give a wider field of view.

In 1952 a radical attack was made on wide-screen projection in the form of the Cinerama, which used three projectors and a curved screen. The expanded field of view gave a remarkable increase in the

illusion of reality, especially with such exciting and spectacular subjects as a ride down a toboggan slide. There were technical problems, including the necessity of carrying three cameras bolted together at the correct angles on the toboggan or other carrier, synchronization of the three separate films, and matching of the image structure and brightness at the joining edges on the screen. After 1963 Cinema replaced its three-film process with a 70-mm anamorphic system with an aspect ratio of 2.75 to 1.



The use of anamorphic lenses for wide-screen projection was introduced by Cinemascope in 1953. An anamorphic optical system photographs with a different magnification horizontally than it does vertically. The lens seems to squeeze the image so that on the film itself figures appear tall and thin. A lens on the projector reverses the effect, so that the images on the screen reacquire normal proportions.

In 1955 Todd-AO introduced a wider film (photographed on a 65-mm negative and printed on a 70-mm positive for projection), with several sound tracks added. Like anamorphic systems, the wider format could be achieved with a single projector. The first two Todd-

AO productions, *Oklahoma!* (1955) and *Around the World in 80 Days* (1956), were made at 30 frames per second for a nearly flicker-free image; 70-mm films are now photographed and projected at 24 frames per second.

The first system was presented at the Disneyland amusement park in 1955. At first, the projection involved 16-mm projectors and screens and, later, nine 35-mm projectors. The audience stood on a low platform in the middle. The result was extremely realistic. In one scene, showing the view from a cable car in San Francisco, the viewers were seen involuntarily leaning over on the curves, as if they were actually on the cable car. The format, however, has limited uses for general storytelling.

In the 1980s, efforts to improve picture quality took two routes: increase in frame rate (Shows can operate at 60 frames per second) or increase in overall picture size—height as well as width (IMAX and Future vision). In these formats the sound tracks are usually printed on a separate, magnetic strip of film.

Another project intended to improve the illusion of reality in motion pictures has been stereoscopic, or three-dimensional, cinematography. "3-D" films use two cameras or one camera with two lenses. The centres of the lenses are spaced 2 ½ to 2 ¾ inches apart to replicate the displacement between a viewer's left and right eyes. Each lens records a slightly different view corresponding to the different view each eye sees in normal vision.

Despite many efforts to create "3-D without glasses" (notably in the U.S.S.R., where a screen of vertical slats was used for many years), audience members have had to wear one of two types of special glasses to watch 3-D films. In the early anaglyph system, one

lens of the glasses was red and the other green (later blue). The picture on the screen viewed without glasses appeared as two slightly displaced images, one with red lines, and the other with green. Each lens of the glasses darkened its opposite colour so that each eye would see only the image intended for it.

Polaroid Camera

The Polaroid system, used for commercial 3-D movies since the early 1950s, is based on a light-polarizing material developed by the American inventor Edwin H. Land in 1932. In this method, known as Natural Vision, two films are recorded with lenses that polarize light at different angles. The lenses on the glasses worn by spectators are similarly polarized so that each admits its corresponding view and blocks the other. Early versions of Polaroid 3-D used two interlocked projectors to synchronize the two pictures. A later system, revived in the 1970s and 1980s, stacked the left and right components vertically on half-frame two sprocket holes high. The images were converged by means of a mirror and/or prism. Cinema on celluloid not only has the magical transported powers that associate with the escapism that movies bring to our lives but also has a strong sense of nostalgia

attached to it. However, just because something reminds us of the past, doesn't mean that is where it should belong. Filmmaker Christopher Nolan, who has been one of the most prominent advocates of shooting movies on celluloid. With the advent of digital technology, filmmaking isn't an exclusive profession anymore. Anyone anywhere can make a film and no one has to wait for big studios to back their projects. Digital is also physically easier to use and has lesser constraints in terms of shooting. With much less effort, a more polished film can be made on digital. Another boon that digital has is that there are no compulsory cuts after 11 minutes making it a more continuous medium. In celluloid cameras, as you're probably aware, the film itself has a red, green and blue filter layer stacked within the celluloid, as well as a silver bromide mixture that reacts when hit by photons to leave an impression of an exposed colour image. It's the chemistry of the film stock which determines the saturation, hue and luminance of an image. Digital is pretty different in this sense. Back when digital camera sensors were first created, processor technology wasn't fast enough to be able to record a red, green and blue layer of sensor information simultaneously, and even if it could, we weren't good enough at compressing this information — the size of the footage would've been enormous and impossible to edit. For many filmmakers, it represents the dawn of a new era in which workflows and resolutions has improved sensors, lenses and on-set data systems allow greater flexibility once they have adapted to the possibilities afforded to them by newer and ever improving technology. For celluloid though the end has already begun, as the photochemical process which sustained cinema for over a century slowly fades into an oncoming digital reality.

DIGITAL EXPLOSION 2000 ONWARDS:

Three years ago, Sony and Panavision took the first step toward a fully digital film industry when they introduced an integrated digital camera that records 24 frames per second, progressive scan at 1920×1080 resolution. The two partners went on to announce that Lucas film would use the film recorder for its next Star Wars title, Episode II: Attack of the Clones. Since then, Hollywood has begun a major technological transformation, retooling its production and distribution business to exploit computing, broadband networks, and digital displays. Inevitably, digital cinema will reshape the entertainment business and may further blur the lines between the theatrical and home entertainment markets. Indeed, many of the components necessary for digital cinema's emergence have already been tested and proven in film production and post-production.

DIGITAL IN THE STUDIO:

Studios often use digital technology exclusively to produce animated films such as Shrek, recording them to film only as the last step before theatrical release. Even movies filmed with traditional techniques are frequently translated into digital format for nonlinear editing in post-production, with substantial effects and tweaks made digitally for digital cinema's emergence. The current distribution system suffers from many costly drawbacks. For each title released, distributors must ship thousands of copies of a film, each weighing more than 60 pounds, worldwide. In North America alone, where a major release debuts on up to 4,000 of the continent's 34,000 screens, shipping costs constitute a major expense. Given these numbers, analysts conjecture that a fully digital exhibition system

could save the industry around $500 million annually. To put this figure in context, the industry's total worldwide box office revenue has yet. whether to remove an actor's blemish or to fix lighting, props, or set elements, digital technology now has a place in even the most straightforward, character-driven pictures. For example, filmmakers Joel and Ethan Coen produced Oh Brother, Where Art Thou? on film stock, then had special-effects house Kodak Cinecite digitize it with a scanner during post-production. Using digital techniques, technicians applied the primary post production effect—a period sepia tint—with far greater range, control, and selectivity than they could have accomplished with traditional photochemical means. Broadband distribution of digitized films has already become commonplace in the post production world. For example, TRW's Picture Pipeline transports high-resolution dailies, effects shots, and even complete motion pictures with high security—often between continents.

DIGITAL AT THE MULTIPLEX:

Profit offers the compelling reason to top $18 billion. About half that revenue goes to exhibitors, so distributors net only about 4 percent of the $9 billion that remains. A yearly savings of $500 million would thus exceed distributors' entire current income. The film industry has plenty of other good reasons to swap out projectors for digital-cinema rigs. Film quality deteriorates through the duplication process: The release prints shown in theatres —typically four generations removed from the camera negative — suffer from much lower image resolution than the original. Further, running the film through the projector subjects it to intermittent mechanical

movements that start and stop the film 24 times per second. This heavy wear produces physical defects on the film after repeated screenings, particularly if theatre owners don't pay to have their projectors and film booths meticulously maintained. Fortunately for audiences, studios' current release pattern of front loading—debuting a new film on the largest number of screens possible, then running it for only a couple of weeks— effectively diminishes this drawback. Although digital cinema eliminates the problem altogether, it raises another one: It's much easier to duplicate and pirate a digital download than several cumbersome reels of film. Internationally synchronized day-and-date releases should reduce piracy significantly, however. Moreover, digital distribution could offer studios the ability to adjust supply to meet demand—instantly. Suppose a small-budget movie generated enough word-of-mouth buzz to become a sleeper hit. Studios equipped with digital cinema technology could immediately send a download of that title to every theatre that wants it. On the other hand, unsuccessful films could be just as quickly withdrawn. At the exhibition level, to avoid turning away ticket buyers, multiplex operators could load-balance dynamically by quickly shifting popular films into their larger theatres. Digital technology makes dubbing, foreign language versions and alternate versions such as the director's cut much easier. It would also let exhibitors run festivals, niche and special-market features, midnight screenings, sporting events, music, and possibly group interactive games at low cost. While the potential for profit drives the development of digital-cinema technology, costs offer the major barrier to its adoption. When Texas Instruments rolled out its digital micro-mirror device technology, people saw for the first time a contrast ratio in digital projection that approached that of film. Prior

to DMD's development, contrast ratio had been video's biggest shortcoming. DMD's contrast ratios, which exceed 500 to 1, vastly surpass the performance of data-grade projectors like the ones that pump out PowerPoint presentations in conference rooms across corporate America. Technophiles have fussed over acceptable compression schemes and artifacts, colorimetric and resolution, transport, security, and the like. But most consumers would be delighted— at least based on anecdotal information the industry has gathered—to watch films exhibited with today's available digital-cinema technology. Currently, however, creating these devices is prohibitively expensive, principally because of a very low manufacturing yield rate.