

as suggesting that sexism is fundamental to black male and female relationships and that its locus is Africa. For the resisting spectator, the problem with this interpretation is that such juxtapositions might equally be read by a white male spectator as not only exonerating 'the white man' from sexism, but more importantly, calling for the punishment of the black man as the inevitable resolution to the conflict.

Throughout this article I have argued for an analysis of resistant spectatorship, but the question of how some black spectators identify with the representation of blacks in dominant cinema—through an act of disavowal?—remains to be explored. On a more positive note, however, resisting spectators are transforming the problem of passive identification into active criticism which both informs and interrelates with contemporary oppositional film-making. The development of black independent productions has sharpened the Afro-American spectator's critical attitude towards Hollywood films. Black directors such as Charles Burnett, Billie Woodberry and Warrington Hudlin practice a 'cinema of the real' in which there is no manipulation of the look to bring the spectator to a passive state of uncritical identification. The films show a world which does not position the spectator for cathartic purposes, but one which constructs a critical position for him or her in relation to the 'real' and its representation. Other directors such as Larry Clarke, Julie Dash, Haile Gerima and Alile Sharon Larkin use a mixed form of fiction and documentary in which the documentary element serves to deconstruct the illusion created by the fiction and makes the spectator question the representation of 'reality' through the different modes. Clyde Taylor describes Clarke's *Passing Through* (1977) as an attempt to 'subvert the Hollywood action genre, riffing its search, confrontation, chase and vengeance formulas with unruly notes from the underground'.<sup>8</sup> Women film-makers like Larkin and Dash practice the mixed form, to counter dominant sexist and racist perceptions of black women.

As more audiences discover such independent black films, spectatorial resistance to Hollywood's figuration of blacks will become increasingly focused and sharpened. In the influential 'Third Cinema' film, *The Hour of the Furnaces* (1968), Frantz Fanon is quoted as saying that 'every spectator is a coward or traitor', a comment which resonates in independent film practices that question the passive role of the spectator in the dominant film culture. One of the roles of black independent cinema, therefore, must be to increase spectator awareness of the impossibility of an uncritical acceptance of Hollywood products.

1988

## JOHN BELTON

### DIGITAL CINEMA: A FALSE REVOLUTION

André Bazin was intrigued by the "delay" in the invention of the cinema. Noting that the *idea* of the cinema—the duplication of external reality in sound, color, and relief—had existed for centuries, he was amazed at the slow pace at which technology was developed to make that idea a reality. What is interesting about Bazin's theory of technological development is not entirely his notion of "an integral realism" toward which the cinema teleologically evolves, but his acknowledgment of a counterforce, an "obstinate resistance" that is innate to the cinema and that steadfastly thwarts its development. Bazin's theory is both idealist and materialist, though his focus is ultimately idealist—on the drive toward what he called "total cinema." I want to explore the implications of the materialist thrust of Bazin's argument, to look at the significance of certain delays in technological development. (I shall be using the terms "invention, innovation, and diffusion," introduced to film studies by Douglas Gomery. "Invention" refers to the phase in which the necessary technology is developed; "innovation" to the manufacturing and marketing of the technology; "diffusion" to its widespread adoption by the industry.)

During the period of the cinema's actual invention—the two decades prior to 1900—motion pictures were made in sound, color, and widescreen (and even in 3-D). But, of course, sound wasn't successfully innovated and diffused until the late 1920s and it was not until the mid-1950s that widescreen cinema became the norm. Though color was more or less continuously being innovated and more or less successfully marketed in the mid-1930s in the form of Technicolor, it was not until 1965, when an ancillary market for color features opened up on network television, that Hollywood had an economic incentive to make most films in color.

Clearly, the diffusion of new technology depends upon a variety of factors. No one technology takes quite the same path to full diffusion as another. Nor do they necessarily ever achieve full diffusion. In our attempts to understand this uneven develop-

<sup>8</sup>Clyde Taylor, 'The I. A. Rebellion: New Spirit in American Film', *Black Film Review* vol 2 no 2, 1986, p 11.

ment of new technologies, it has become clearer to me over the years that we cannot look to the path taken by one technology to explain or understand that of another. That is because the conditions within which technological change takes place are continually changing. This is why contemporary comparisons of the advent of digital cinema to the coming of sound in the late 1920s are not only misleading but wrong.

The latest so-called technological revolution is the digital revolution, which, it would seem, is taking place in quite distinct phases—not all at once, as was the case for earlier technologies. For audiences, it began in the realm of special effects—a field that is now dominated by computer-generated imagery. Then there was digital sound. Now we are seeing a very slow movement toward digital production using digital cameras and digital projection. Within the history of digital sound, there has not yet been full diffusion of the technology. The number of theaters worldwide that have digital sound readers is under 50 percent. Moreover, every print carrying a digital sound track continues to rely on a back-up track of analog sound, usually Dolby SVA.

The digital revolution is more clearly being driven by home theater and home entertainment software and hardware technologies, and by corporate interests in marketing, than it is by any desire—as in the past—to revolutionize the *theatrical* moviegoing experience. In short, the digital revolution is part of a new corporate synergy within Hollywood, driven by the lucrative home entertainment market.

The first stage of this revolution within the cinema was the digitization of special effects. Digital technology has transformed the photographic image into a truly “plastic” object that can be molded and remolded into whatever shape is desired. As Lev Manovich has argued, digital technology has made the cinema a subset of animation. It is a world inhabited by the liquid-metal man, as in *Terminator 2* (1991) or multiple Eddie Murphys interacting with one another in *The Klumps* (2000). Computer-generated graphics have enabled filmmakers to realize fantasy in a way that was only dreamed of a few years ago.

Digital special effects led the way, but digital sound was not far behind. With the commercial popularity of the compact disc, film sound went digital. Audiences expected it; analog was dead. As one motion-picture exhibitor put it, “digital means progress and customers want it.” The digital revolution was and is all about economics—all about marketing new digital consumer products to a new generation of consumers—all about the home electronics industry using the cinema to establish a product line with identifiable brand names for home entertainment systems.

Among digital motion picture technologies, sound was most driven by consumer demand. In a marketplace in which the word “digital” sells consumer products, it is digital sound that marks, for consumers, the entry of motion pictures into the digital era.

Digital sound was introduced in 1990 with the release of *Dick Tracy*, then with *Edward Scissorhands* (1990), *The Doors* (1991), and *Terminator 2*. Because of the compact disc, the public increasingly associated digital sound with state-of-the-art sound. The marketability of digital sound drove its development and the advent of Cinema Digital Sound (CDS) clearly prompted Dolby and others within the industry to accelerate work on their own digital systems. At the same time, the sudden shift in

1990 to digital from analog in the development of a High Definition Television standard undoubtedly encouraged Dolby and others to try to dominate this potential market as well. Indeed, with the shift from analog to digital HDTV, Dolby's status in the highly profitable home electronics industry was suddenly in jeopardy. By 1992, Dolby had perfected a digital track that could be placed alongside an analog Dolby Stereo track. It was introduced with the premiere of *Batman Returns*. Digital Theatre Systems (DTS) introduced a different digital system in 1993 with the release of *Jurassic Park*. DTS is owned, in part, by Steven Spielberg and Universal/MCA and has been used on all Universal and Amblin Entertainment pictures. DTS is a double-system format in which a standard, stereo optical print is distributed with a special time code on it that is synched up with a compact disc.

Dolby began working on a digital sound format in 1987. Perfected in 1992 and introduced with the release of *Batman Returns*, Dolby digital, known as Dolby SRD, combined a conventional Dolby SR track in the standard sound track area alongside the image with a digital track that was located between the sprocket holes at the edge of the film. This permitted a single print inventory for distributors and provided immediate backup, via the analog track, in case of system failure. Although *Jurassic Park* provided a big send-off for the DTS system, DTS made a number of crucial mistakes in promoting the system. DTS encouraged theaters to play back the sound louder than they had with Dolby SR, in large part because DTS (and other digital systems) claimed to have greater headroom. The additional volume strained the amplifiers and loudspeakers, resulting in amplifier clipping, general system shock, and tweeter failure. The result was a harsh, metallic playback of the dialogue. DTS moved fairly quickly to control this potential disaster. And by 1994, DTS had secured an exclusive contract with MGM/UA and had contracted to do a series of films for New Line Cinema. DTS was owned, in part, by MCA, at that time a property of the Japanese electronics giant, Matsushita, which manufactured Panasonic equipment. Matsushita's chief rival was Sony. The emergence of digital sound in the theater served as a lightning rod to galvanize the electronics industry—especially the Japanese electronics industry—which was struggling to retain its dominance in the home entertainment market. In fact, as Paul Rayton has suggested, it is possible to view experiments with digital sound in the theater as the preliminary battle for the potentially much more lucrative market of digital sound in the home. It was a battle that took place on the level of both hardware and software. If MCA (or Sony) could produce enough box-office hits in DTS (or SDDS), it could effectively market playback hardware and film software to home consumers.

By the end of 1994, most studios were releasing exclusively in one format or another. However, during the summer of 1995, more and more studios began releasing their films in multiple digital formats in an attempt to take advantage of the different systems in the majority of digitally equipped theaters. Each of the three systems uses different areas of the release print to encode information. Digital sound has evolved into a three-system standard. As long as most digital theaters can get most big films in digital, the multistandard is likely to continue. Dolby's strategy of overseas domination guarantees its survival in a market dominated by software giants such as Universal, Columbia, and Tri-Star. The bulk of a studio's profits come from overseas distribution; domestic rentals are considered strong if they earn back nega-

tive, print, and distribution cost. Dolby is thus uniquely positioned. In order to reap these overseas profits, studios will ultimately need to make overseas prints available in Dolby. About 25,000 theaters worldwide are equipped to play Dolby Stereo. Since Dolby's analog optical track continues to be placed on most digital prints, theaters will undoubtedly resist digital and continue to rely on four-channel Dolby systems. The fact that all digital systems retain a stereo analog track means that all theaters can run these films without converting to 5.1 digital.

What has emerged is thus a marketplace in which all three systems exist alongside one another. The coming of digital sound is consequently quite unlike other, previous "revolutions" in motion picture technology. The initial transition to sound (1926–1929) led to a single standard—sound on film—that was met by a handful of proprietary technologies (Movietone, RCA Photophone, generic Western Electric). Digital sound is a technology of the new era of Macintosh and IBM; two standards can coexist in the digital marketplace. Consumers have adjusted/adapted to multiple standards; so long as they can run their computer programs or play back their home entertainment programs, they will tolerate multiple standards.

The history of digital sound suggests a need to rethink traditional models of technological determinism. In this particular instance, consumer demand for novelty drove the expansion of the technology. Technology did not determine the demand in the traditional linear, cause/effect pattern. Rather, there was an overlapping of technologies (computers, CDs) and an overlapping of demands (for commodifying/marketing information, for consumer entertainment). These overlapping technologies and demands mutually determined one another in a process of back-and-forth negotiation.

One of the legacies of digital sound has been the death of 70mm as an exhibition format. Digital sound was, of course, not necessarily any better than Dolby's six-track stereo magnetic sound. But it was cheaper. It cost over \$12,000 to strike and stripe a 70mm print from a 35mm negative; 35mm six-track digital prints cost almost the same as standard 35mm prints—about \$2,000. This particular phase of the digital technological revolution was more of a cost-saving effort on the part of the studios than anything else, although undoubtedly, the upgrade in 35mm sound from four to six tracks and the quality of digital sound did constitute significant improvements over standard 35mm Dolby SVA in the audience's theatrical experience. Even so, all it offered was what we already had in 70mm, Dolby Stereo presentations. And the projected image was far inferior to that of a 70mm print.

At the end of 1999, with the celebration of the faux-millennium, came the advent of a new, "revolutionary" technology—digital projection. Spearheaded by George Lucas, whose *Star Wars: The Phantom Menace* was projected digitally in four theaters in the U.S. in June 1999, digital projection was heralded as the newest technological revolution—a revolution that would change the face of the industry. Admittedly, the production and postproduction of many Hollywood blockbusters had grown more and more dependent on digital technology, and most films—even those without digital imaging—were currently being edited on computer. But this reliance on the digital domain was relatively invisible to the average moviegoer. The potential for a totally digital cinema—digital production, postproduction, distribution, and exhibition—caught the attention and imagination of the media. At the supposed turn of the

millennium, the one-hundred-plus reign of celluloid was over; film was dead; digital was It. The *New York Times*, *Wall Street Journal*, *Los Angeles Times*, and several national news magazines heralded the dawning of the new digital age, proclaiming that it was no longer a matter of *whether* it would happen but *when*. One writer noted that the age of Edison was over—the phonograph had been replaced by the compact disc, and film by digital signals; all that remained was Edison's lightbulb. Strategically, it was the perfect moment to introduce the new technology, since the popular media was looking for symbolic events to mark the advent of the new millennium.

George Lucas quickly emerged as digital cinema's poster boy. Lucas wrote that "In the twentieth century, cinema was celluloid; the cinema of the twenty-first century will be digital. . . . Film is going to be photographed and projected digitally. The recorded image will go automatically into a computer and most postproduction will take place in a computer. . . . We made it through the silent era to the sound era and from the black-and-white era to the color era, and I'm sure we'll make it through to the digital era. . . . The creator's palette has been continually widened." Like others, Lucas compared the digital revolution to earlier revolutions in motion picture technology.

Sound designer Walter Murch, who did the sound for Lucas's *American Graffiti* (1973) and Coppola's *The Conversation* (1974) and *Apocalypse Now* (1979), had won an editing and sound-mixing Oscar for *The English Patient* (1996). He now joined in the millennial hype. For Murch, the digital revolution, which had already swept the fields of film editing and film sound, was perfectly positioned to overthrow "the two last holdouts of film's nineteenth-century, analog-mechanical legacy"—projection and original photography.

Theaters showing *The Phantom Menace* digitally displayed banners linking it with other technological revolutions in the cinema—with the projection of the first motion picture, the introduction of sound, color film, CinemaScope widescreen, and digital audio. Interestingly, Cinerama was absent from this list, replaced by the development of CinemaScope, which was erroneously dated as 1955, the year that the Todd-AO Process was premiered. Rick McCallum, one of the producers of *Phantom Menace*, referred to the premiere as "a milestone in cinematic history" and said that "like the introduction of sound and color, these digital screenings represent the beginning of a new era in film presentation." Russell Wintner of CineComm Digital Cinema likened the premiere to that of *The Jazz Singer* in 1927 and the excitement generated by the coming of sound.

If the digital revolution begun in Hollywood's special-effects laboratories was completed in the digitization of projection, then it was hardly a technological revolution on the order of those to which it has been compared. It is really not quite clear in what way it *is* a technological revolution. It does indeed threaten to overthrow the dominance of 35mm film, which has been the chief format of the motion-picture industry for over one hundred years. But it is not revolutionary in the way that these other technological revolutions were. Digital projection as it exists today does not, in any way, transform the nature of the motion-picture experience. Audiences viewing digital projection will not experience the cinema differently, as those who heard sound, saw color, or experienced widescreen and stereo sound for the first time did. Cinerama, for example, did transform the theatrical experience, producing a dramatic sense of audience participation. It was as if the audience, surrounded with image and

sound, had entered the space of the picture. This sense of participation was exploited in Cinerama publicity photos that depicted spectators, sitting in their theater seats, going over Niagara Falls, water skiing, or sitting in Milan's La Scala opera house.

Digital projection is not a new experience for the audience. What is being offered to us is simply something that is potentially equivalent to the projection of traditional 35mm film. This, in fact, is what Steven Morley, vice-president of technology at Qualcomm, which has perfected techniques for delivering digitized motion pictures from studios to theaters via on-site servers or satellite, says was Qualcomm's mission. He writes that the goal of Digital Cinema is "to provide the image quality of a first run motion picture on 35mm film stock projected on opening night at a premier theater." The advantages of "digital"—whatever they may be—are not being exploited in the theater. Current digital projection technology is not interactive. It does not enable audiences to relate to the cinema in ways similar to those provided by the computer or the Internet. It may be digital for George Lucas and Walter Murch at their end of the film chain, but it might just as well be analog for us, since it does not give the audience the empowerment of digital. For it to be truly digital, it must be digital for the audience as well. There would have to be a computer mouse or a virtual reality glove at every seat in the theater. All that the proponents of digital projection are claiming is that it is comparable to 35mm. That does not sound like a revolutionary technology. As far as I can see, the only transformation of the motion picture experience for audiences that has taken place in the last forty years or so has been the development of stadium seating!

If this is not a real revolution, what exactly is it? What is going on? *The Phantom Menace* had "nearly 2,200 digitally generated shots, making up 90 percent of the movie." Lucas is currently filming the next episode of *Star Wars* entirely in digital, using a Sony, twenty-four-frame progressive-scan electronic camera. For George Lucas, digital cinema is clearly the realization of *his* dreams, a revolution in *filmmaking*. His commitment to sci-fi demands that he find new ways of realizing fantasy. In the wake of *Star Wars* (1977), *Close Encounters of the Third Kind* (1977), *E.T. the Extra-Terrestrial* (1982), the *Terminator* films (1984–) and others, sci-fi has emerged as a major Hollywood genre. Sci-fi and special-effects blockbusters from *Star Wars* to *Titanic* (1997) have transformed the motion-picture industry. Big budget blockbusters have driven up negative cost so that it currently hovers at around \$55 million. They have spawned saturation ad campaigns and saturation booking, so that these films now regularly open in as many as 3,500 theaters or more on the same day. This saturation marketing strategy has driven up advertising and prints costs to an average of over \$27 million per film. Sci-fi and special effects action films have become the dogs that wag Hollywood's tail. But it is not the only dog in Hollywood; there are still other genres. Other filmmakers rely less upon special effects and fantasy; there are scores of directors like Woody Allen, Martin Scorsese, Robert Altman, Stephen Frears, John Sayles, Paul Schrader, and Mike Leigh, who make films about more or less realistically conceived characters in more or less realistic settings. There is no reason for the digital fantasies of sci-fi to drive an industry that, since the sci-fi blockbusters of the late 1970s and early '80s, has become increasingly diverse in terms of narrative content. Indeed, the danger is that an all-digital cinema might very well lead to an all-fantasy cinema—to essentially one genre. Of course, filmmakers do not have to use digital technology

as Lucas does, but if they want to "be digital" and demonstrate what digital cinema can do, then they will surely be tempted to follow in Lucas's footsteps.

To be fair, digital cinema has not necessarily become the sole property of Lucas, James Cameron, and big-budget, commercial Hollywood. It has spawned a counter-cinema of sorts. The relative cheapness of the technology has brought new opportunities for making independent films to a variety of filmmakers. *Timecode* (2000), which cost only \$4 million, not only takes advantage of digital video to present events in a continuous way that outdoes Alfred Hitchcock's *Rope* (1948) by a factor of three, but it foregrounds the new technology in its script. The character played by Kyle MacLachlan introduces his client, a filmmaker named Ana, in apocalyptic terms: "Armed with nothing more than a digital camera and an incredible vision . . . Ana is prepared to drag us kicking and screaming into the new millennium." His remarks are suitably punctuated by one of the film's several earthquakes.

Francis Ford Coppola's Zoetrope Studios have gone digital, and he encourages independent filmmakers to work in that format. Next Wave Films, a subsidiary of the Independent Film Channel that furnishes finishing funds to independent filmmakers, has seen a dramatic increase in digital submissions for funding; roughly 51 percent of the films submitted are shot digitally. Sundance, Vancouver, and other independent film festivals have also seen a rise in the number of digital films—and have begun to project these films digitally as well. The question is what the ultimate effect of the "democratization" of the means of production will have—whether independent films will, as they did in the 1990s, evolve by becoming more and more like commercial Hollywood films, or whether they will be able to use the new technology for a different kind of film practice.

The pattern of acquisitions and mergers that has characterized Hollywood in the 1980s and 1990s may explain the fervor for digitization. As the major players in the industry divested themselves of companies that had little or no relation to the emerging media industry, they sought "synergy." Hardware producers of VCRs such as Sony and Matsushita bought software producers such as Columbia and Universal. Publishers, such as the *Time* organization, merged with studios (Warner) and cable companies (Turner) to create vertically integrated entertainment providers. The buzz word in the past few years has shifted slightly from "synergy" to "convergence." "Convergence" refers to "the union of audio, video and data communications into a single source, received on a single device, delivered by a single connection." Convergence looks back to economic structures of yore, such as the vertical integration of the motion-picture industry in the 1920s–1940s. Convergence consists of "three subsidiary convergences: content (audio, video and data); platforms (PC, TV, Internet appliance, and game machine); and distribution (how the content gets to your platform)." The recent \$100 billion merger of Time Warner with AOL is an example of both synergy and "convergence." The content provider *Time* and its publishing affiliates can distribute its material on film via Warner, on cable via Turner, and on-line via AOL. In this Age of Information, Hollywood has begun to redefine itself as an information provider and is currently building systems for the delivery of that information, expanding from television and cable to satellites and the internet. Indeed, AOL Time Warner has stated its long-range intentions that studios use AOL's digital networks to distribute movies to theaters. "Convergence" depends upon the development of broadband wired or wire-

less transmission. With the exception of satellite transmission or fiber optic cable, broadband transmission seems fairly far off.

As the motion-picture industry digitizes, it explores new markets that have arisen around digital technology. Most new films are being digitized for release on DVD. More and more of the studio's profits derive from ancillary markets such as video, cable, and broadcast television release. Indeed, 70 percent of the revenues generated by a film now come from these non-theatrical, ancillary markets. Profits from video retail in 2000 were \$20 billion, while box-office receipts from theaters totalled only \$7.7 billion. Digital projection finds the studios and digital projection companies situating themselves for a new marketplace in which the theater may well become an expendable casualty.

Currently, theaters play a crucial role in providing an initial platform for films, generating public interest in them and providing "buzz" that creates a mass market for future sales. But the role of theatrical release could slowly disappear; the economics of synergy and convergence could lead studios to release films directly to the home, relying upon existing techniques of saturation ad campaigns to bypass the theaters.

In short, digital cinema is a revolutionary technological innovation for filmmakers like Lucas and for the interests of corporate synergy that currently drive Hollywood. As we shall see, it is also a potential boon—in the form of cost saving—for film distributors. But it is not yet clear that it can do anything for motion picture audiences aside from eliminating jitter, weave, dirt, and scratches from the projected image. Even if we concede that these improvements result in better projection, they are not significant enough for them to be declared "revolutionary" in terms of the audience's experience of motion pictures.

On June 18, 1999, *Star Wars: The Phantom Menace* was projected digitally in four theaters in the United States using two different projection systems. CineComm Digital Cinema and its Hughes/JVC projector ran the film at Pacific's Winnetka Theater in Chatsworth near Los Angeles and at Loews' Route 4 Theater in Paramus, New Jersey. A Texas Instruments projector was used at AMC's Burbank 14 Multiplex and at Loews' Meadows 6 in Secaucus, New Jersey. Critical response to the Hughes/JVC system was fairly damning. *Variety* critic Todd McCarthy noted that "the imprecision of the system was woefully apparent the moment the *Star Wars* scene-setting backstory scrolled up the screen—pixilation was readily visible in the letters, which weren't well defined. In the film proper, the darker areas of the frames were murky, colors were flat, there were noticeable blurs in some movements and a general softness was prevalent in the images. Overall effect was akin to a so-so color photocopy." In a special edition of *Widegauge*, Scott Marshall reviewed both systems and noted that the Hughes system "looked like very good video projection" but was "not like film at all. Color registration seemed perfect all the way to the corners, but there was a 'ringing' in the video that added sharp artificial contours to vertical edges, contributing to the 'video look' . . . There was a faint flickering of horizontal lines in the closing credit scroll, a giveaway that the image was interlaced and not progressive scan."

The Texas Instruments Digital Light Processing cinema projector emerged as the clear winner in the digital cinema projector wars. McCarthy noted that DLP projection was "exceedingly sharp" and "bright." The "process has a cool, clear, hard-edged look." Scott Marshall, who subtitled his review of the DLP "A 70mm for the next

Generation?", attended the screening skeptical of claims that had been circulating that digital was as good as 35mm. When the previews of coming attractions began, he noted that he "was immediately astonished by the spectacularly bright image that also seemed very sharp and with excellent contrast and deeply saturated colors. . . . The picture was absolutely stunning, with deep reds, yellows, and oranges, convincing flesh tones, and sharp, steady superimposed titles. The picture had no dust, dirt, jitter, weave, scratches, or flicker. It was something like a beautifully exposed, new Kodachrome slide, only in motion. It gave me the same feeling in my gut that I get when I watch a perfect 70mm print of a 65mm film." Marshall was a bit less blown away by *The Phantom Menace*—mostly because of flaws in the original photographic style of the film itself.

The Texas Instruments DLP projector is essentially a picture head that is mounted on an existing theater projection lamphouse. This head is twenty inches wide and weighs seventy-four pounds; the projection lens weighs another five to ten pounds. The current method of data delivery to the theater projector is through optical disks. The film is stored on a server, consisting of as many as twenty or more eighteen gigabyte hard drives. The digital sound track is separate and was, for the *Phantom Menace*, played back on a Tascam MMR-8 eight-channel digital tape deck. Since the sound does not need to be digitally encoded on the film, it is not compressed and resembles, in quality, the track heard by the sound engineer in the film's final mix. Steve Morley notes that "it's possible to send sound tracks of six, eight, or more channels of full bandwidth audio, such as 24-bit, 48kHz sampled tracks directly compatible with the formats used by postproduction sound mixing facilities."

Digital information from the Texas Instruments server is decompressed and decrypted and then sent to the projector. The heart of the projector is a digital light processing chip—actually three chips in the cinema projector—known as the Digital Micromirror Device or DMD. A formatter board translates the digital signal into a pure digital bit stream. The chip functions as a digital light switch. Each chip has over 1.3 million tiny aluminum mirrors sixteen by sixteen micrometers square. Each mirror is mounted on a pair of hinges that tilt the mirror plus or minus ten degrees in response to binary code. Each mirror can switch on or off more than 5,000 times per second, depending upon the signal it gets. Amazingly, there have been no mirror or hinge failures to date, and Texas Instruments analysts put the life of these chips at twenty years of more or less continuous use.

Light from the lamphouse hits the mirror; if the mirror is in one position, the light is reflected through the lens and onto the screen. If it is in another position, the light is deflected and absorbed by the interior of the DMD; no light reaches the screen; the result is the projection of a black pixel on the screen. Texas Instruments has recently developed a new, so-called "dark chip." This chip is better than earlier chips in absorbing light. As a result, it can generate blacker blacks on the screen and improve contrast ratio. The function of the chip is to convert a digital electronic input into digital light, which is then projected on the screen. The spectator's eye performs the digital to analog conversion. In other words, what gets to the screen is digital light, not an electronic video image.

Over the past few years, a number of other companies have begun research and development on digital projection. Several of these display their wares regularly at

ShoWest, the annual gathering of movie exhibitors. Several big-name movie companies have become involved in digital projection. IMAX, for example, has purchased Digital Projection International. Through this subsidiary, IMAX will build and market digital projectors using the TI chips. Technicolor has also become involved in the development of digital projection technology using the DLP chips. Teaming up with Qualcomm, Technicolor is offering to distribute digital films for studios and to pay for the installation of digital projection in theaters for a small fee. Technicolor is also interested in offering alternative programming—such as rock concerts and sporting events—to theaters using digital transmission and projection. Texas Instruments, which brings its DLP projector to ShoWest each year and which has taken a commanding lead in the field, has campaigned to get the industry to establish standards for digital compression, encryption, and projection, possibly hoping that its dominance in the field will result in the adoption of standards compatible with its system. A SMPTE task force is currently working on establishing industry-wide standards. However, no standards currently exist, and this lack of standards is one of the chief roadblocks to the innovation and diffusion of digital projection technology.

Digital cinema is still very much a question mark on the cinema horizon. Although its proponents claim that within five or ten or twenty years it will have replaced film, this seems unlikely. The compelling reasons for digital cinema lie in the financial benefits it can provide to motion picture distributors and in the creative flexibility it can offer to a handful of very important Hollywood filmmakers like Lucas, Cameron, and others. Of course, the filmmakers who desire it already have the digital advantage in production and postproduction. It would appear to be the film distributors who would benefit the most from digital distribution and exhibition. The cost of 35mm prints—\$2,000 each—multiplied by the number of prints currently used on today's saturation market—3,000 to 5,000 (7,000 prints were struck for *Godzilla*)—add up to \$6 to \$10 million per title. Qualcomm's Steve Morley calculates that the cost to supply 100 or 10,000 theaters is roughly the same with digital cinema—approximately "\$450 per screen per year, compared to the previously computed film cost exceeding \$22,000 per screen per year." The chief selling point of Qualcomm and others is cost-saving for distributors.

But it is not clear, however, that exhibitors are willing to go along with this. Theaters are not necessarily reluctant to go digital. To some extent the idea appeals to them. John Fithian notes that the core of moviegoers is in the twelve to twenty-four-year-old range. They account for 39 percent of all tickets sold. He points out that the kids today are the children of the baby-boom generation and that their numbers will crest in 2010, producing more teenagers in the United States than at any other time in history. He believes that this population will have considerable influence over what happens in the theater. "Their life is digitized," he says. The fact that this new generation of "moviegoers" has grown accustomed to watching film on TV monitors and has probably never seen films at their optimum—projected on a big screen in 70mm with six-track Dolby stereo sound—means that they will have nothing to compare digital projection to but standard 35mm, third-generation release prints, which can be fairly poor, especially if they were printed on today's high-speed printers that run at the rate of 2,000 feet per minute.

The question is not one of exhibitors wanting digital. The fact is that they simply cannot afford it. The boom in theater construction that has seen the number of screens climb to around 37,000 has left many theater chains in massive debt. Nine of the largest theater chains in the country have filed for Chapter Eleven bankruptcy protection over the past few years. According to John Fithian, the new president of NATO, the only way digital projection will get into the theater is if "those who are making the savings pay for it." That means the studios and distributors will have to foot the bill. At a cost of \$100,000 per screen that comes to \$3.7 billion. Recent cost estimates for projectors run from \$150,000 to \$180,000 each, which would increase that estimate from \$3.7 to \$5.6 billion. And potential costs do not stop there. Hollywood just barely breaks even on domestic rentals. Profits—more than 50 percent of a film's total revenues—come from exhibition overseas, where there are an additional 22,000 screens in Europe and the UK alone. Distributors will need to foot the bill for digital projection in these and other theaters around the world as well.

Over the past year, Boeing aircraft began negotiations with several theaters to fund the installation of digital projection equipment in the expectation that these theaters would use Boeing's satellite-based delivery system as a distributor. Boeing did participate in the successful satellite delivery of *Bounce* to the AMC 25 theater in Times Square in November 2000 and of Miramax's *Spy Kids* to a recent ShoWest convention in March 2001.

And since digital technology changes every year—how many computer upgrades have we had to make in the last ten years?—these costs are not one-time costs, but will involve continual re-negotiation. Fithian also insists that before theaters even think of converting to digital, industry-wide compression, encryption, and delivery standards need to be established. In this matter, NATO and the MPAA are surely in agreement. At the same time, he argues that the delivery of digital cinema to the theater must be competitively structured. There can be no single gatekeeper; there must be multiple suppliers, if the film industry is to avoid the mistakes of the past associated with the Bell Telephone monopoly. Fithian also fears that exhibitors might lose control of the "show" and that the operations of their theaters might be under remote control of the studios.

Theaters have played a pivotal role in the innovation of revolutionary film technologies, but theaters have generally been dragged to the revolution against the exhibitors' will. Neither the major studios nor their theaters wanted the coming of sound, but when Warner Bros. and Fox forced the issue, the studios found that they had no choice. And, since most of the theaters were then owned by the studios, exhibitors made the transition as well. Color cost exhibitors nothing in terms of technological upgrade, though rental rates were more than for black-and-white films. But it was not until the 1950s that the resistance of exhibitors to costly new technology became a significant negative factor in the innovation of that technology. By this time, U.S. studios were no longer permitted to own theaters, and exhibitors were often cast in the role of adversaries to producers and distributors. The majority of exhibitors capitulated to the widescreen revolution, but they revolted en masse against the costly conversion to stereo magnetic sound that was packaged together with these new widescreen images. In the 1970s, the relatively inexpensive equipment required to

provide Dolby Stereo made an upgrade in theater sound affordable for most theaters. The most recent wave of digital sound technology, which, like Dolby Stereo, is relatively inexpensive, has found a place in many American theaters. However, even six or seven years after this revolution, only about 25 percent of European theaters have converted to digital sound. If theaters have to pay for it, they will not convert to digital projection.

Digital equipment manufacturers try to sell theaters on digital by reviving the dream of theater television and the new revenue streams it was always predicted to provide. Digital theaters could provide big-screen presentations of sporting events, such as prizefights, World Cup matches, or rock concerts, and other Pay-Per-View cable fare. But theater television has never become a viable entertainment format in the past. This was due in part to technological obstacles that digital projection has solved. But it is also due to the difficulty in marketing these events to a public that increasingly expects to see them at home on television either for free or for a modest Pay-Per-View charge.

One of the major threats facing digital cinema is film piracy. Several years ago, Jack Valenti noted that "unless we find suitable technological armor to protect the digital movie, we will soon be standing in the ruins of a once-great enterprise." The studios lose close to \$2.5 billion a year in piracy. Qualcomm boasts that it can put "watermarks" into its digital projection that can be used to identify when and where the copy was made. This might help track down the pirates. Encryption of the digital original is designed to protect it on its path from the studio to the theater. According to Dan Sweeney, Qualcomm has an expertise in "military-level encryption" for satellite delivery. It relies on a 128-bit key length and has a "a provision for changing keys during transmission several thousands of times." Each key, it is said, would take weeks to crack on a mainframe. But does encryption work? In the fall of 1999, the encryption code for the Digital Video Disc system was broken by a Norwegian teenager, who was a member of a radical group known as MoRE (Masters of Reverse Engineering). He then distributed the algorithms of the code on the Internet. Having been assured that DVDs could not be copied, Hollywood was traumatized by the event, realizing that millions of perfect copies of popular films could now flood the market.

Given the industry's concern about piracy, it is extremely unlikely that it will embrace satellite delivery of digital cinema, even though it is the cheapest and most efficient way of delivering digital films to the theater. For the present, it would seem that the physical delivery of disks to the theater—and high security storage of them there—or sending them on secure fiber optic lines would be the only viable means of getting digital films to the theater. (Fiber optics were used to deliver *Titan A.E.* [2000] from Hollywood to a theater in Atlanta.)

At present, the digital projection revolution is stalled, lacking product and theaters to show it in. Only thirty-eight screens in the country (two at the AMC 25 in New York City) are equipped with digital projectors, and only thirty-two major motion pictures have been made available for digital projection, including—in addition to those already mentioned—*Tarzan*, *Toy Story 2*, *The Perfect Storm*, *Dinosaur*, *Fantasia 2000*, *102 Dalmatians*, *Mission to Mars*, *Vertical Limit*, *Shrek*, *Jurassic Park III*, *Final Fantasy: The Spirits Within*, *Planet of the Apes*, and *Monsters, Inc.*

Film critic Roger Ebert, who saw a demonstration of digital projection at the May 1999 Cannes Film Festival, is one of the few people speaking out against digital cinema. Ebert's chief objection is that digital projection cannot duplicate the *experience* of 35mm film. In this respect, his argument is much subtler than my own in that all I am saying is that digital projection does not offer audiences a *new experience* in the theater.

Perhaps the most important concern about the digitization of the cinema is its implications for film preservation. At the moment, polyester safety film is the ideal medium for long-term storage of motion-picture images and sound tracks. Its longevity is estimated at about one hundred years—longer if it is placed in cold storage facilities. Digital data has been stored, for the most part, on magnetic tape or disc—a format that has an effective media life of five to ten years and an estimated time until obsolescence of only five years. Studios would be crazy to use digital formats for archiving their holdings. Films made digitally could be stored in that format, but they would have to be converted to a new format every five years. It would make more sense for them to be transferred to celluloid and stored as films. Given the rapid obsolescence of various past digital formats, is it not clear that digital information can be retrieved in the future.

One obvious problem with digital cinema is that it has no novelty value, at least not for film audiences. This being the case, what will drive its future development? Meanwhile, predictions by Lucas, Murch, and others of an all-digital cinema tend to ignore the often conflicting material forces of the marketplace that regularly reshape and even reject new technology. Nor do they take into account the inevitable development of other, nonfilm technologies that might impact upon the evolution of film, altering its ultimate form. Their predictions are idealist, not materialist. They take no note of what Bazin did factor into his quasi-idealist notions of technological development—the obstinate resistance of matter.