The Future Is Now: Diegetic Prototypes and the Role of Popular Films in Generating Real-World Technological Development

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ABSTRACT Scholarship in the history and sociology of technology has convincingly demonstrated that technological development is not inevitable, pre-destined or linear. In this paper I show how the creators of popular films including science consultants construct cinematic representations of technological possibilities as a means by which to overcome these obstacles and stimulate a desire in audiences to see potential technologies become realities. This paper focuses specifically on the production process in order to show how entertainment producers construct cinematic scenarios with an eye towards generating real-world funding opportunities and the ability to construct real-life prototypes. I introduce the term 'diegetic prototypes' to account for the ways in which cinematic depictions of future technologies demonstrate to large public audiences a technology's need, viability and benevolence. Entertainment producers create diegetic prototypes by influencing dialogue, plot rationalizations, character interactions and narrative structure. These technologies only exist in the fictional world – what film scholars call the diegesis – but they exist as fully functioning objects in that world. The essay builds upon previous work on the notion of prototypes as 'performative artefacts'. The performative aspects of prototypes are especially evident in diegetic prototypes because a film's narrative structure contextualizes technologies within the social sphere. Technological objects in cinema are at once both completely artificial – all aspects of their depiction are controlled in production – and normalized within the text as practical objects that function properly and which people actually use as everyday objects.

Keywords cinema, entertainment production, popularization, prototypes, science consultants, technical development, visualization

The Future is Now:

Diegetic Prototypes and the Role of Popular Films in Generating Real-world Technological Development

David Kirby

> I want to make humans-to-Mars real in the minds of the viewing public. (Film director James Cameron speaking to The Mars Society)[1]

> Space may be the final frontier but it's made in a Hollywood basement. (Red Hot Chili Peppers, 'Californication', 1999)

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How Film Establishes Technological Viability, Necessity and Benevolence

On 19 September 1981 audiences witnessed the first successful implantation of a permanent artificial heart. The patient, a 20-year-old woman, did not experience any physical complications after the surgery. As she walked out of the hospital the doctor told her that he had given her 'a heart as good as any God ever made'. We will never know how long this woman lived with her new heart because this transplant took place within the fictional film *Threshold*, not in the real world. A year after the film's release the first permanent artificial heart transplant on a living patient took place on 2 December 1982 at the University of Utah Medical Center (Jeffrey, 2001).

Audiences watching *Threshold* today could be forgiven for mistaking the film for a historical docudrama or a documentary re-enactment of the artificial heart's development. The film listed 11 medical doctors as science consultants, including Denton Cooley and Robert Jarvik, who played significant roles in the actual 1982 transplant. Given that Jarvik was the inventor of the artificial heart (the *Jarvik-7*) used in that operation, he, in particular, had valid reasons for participating in the production of a film such as *Threshold* that could ease public fears and demonstrate the possibilities of his future medical technology. Other controversial medical technologies, including test-tube babies, the pacemaker and artificial limbs, had seen fierce public resistance in the 1960s and 1970s as researchers moved towards clinical trials (Turney, 1998). After an initial wave of enthusiasm about the technology in the late 1960s, even heart transplants involving living organs had received heavy public criticism, including a ban in Great Britain (Nathoo, 2009).

In order to overcome public anxiety about the implantation of a permanent artificial heart in humans, scientists had to establish: (1) the *necessity* of this technology; (2) the *normalcy* of a person who receives an artificial heart and (3) the heart's *viability*. Jarvik, Cooley and the other consultants clearly believed that this film was an important public relations opportunity and they helped film-makers construct a narrative for *Threshold* that overtly addresses these three concerns.

A key theme in the first half of the film is the rarity and fallibility of donated hearts. One early plot thread follows the character of Henry who is waiting for a heart donor. As one character crudely puts it, Henry is actually waiting for 'one good motorcycle accident'. Henry's body rejects the donor heart, prompting the central protagonist Dr Vrain to rail against those who would prevent the development of an artificial heart (necessity). In addition, the film's dialogue highlights scientists' concerns about 'irrational' fears that accompany new medical technologies. Aldo Gehring, the character who invents the heart, for example, tells a sceptic:

> The fact is that fifteen years ago when the pacemaker was introduced it created a furore. People said it was unnatural. That it was better to let the sick die in peace. Now it is considered an everyday affair. No one questions its use.

The film also addressed the public's concern that a mechanized heart might make the recipient feel like a mechanized person. The surgeon and scientist repeatedly assure their patient that although the heart is a 'miracle', she will be the 'same person' (normalcy).

Most importantly, the film's visualization of a working technology within its realist orientation established the achievability of a permanent artificial heart (viability). Robert Jarvik designed the film's heart model, which he modelled after his own *Jarvik-7*. The film demonstrated how the Jarvik heart solved the problems associated with older technologies. In a crucial scene Dr Vrain inserts the Jarvik heart into the woman's body. After Dr Vrain attaches the heart, he switches it on. The audience then heard a sound recognizable to anyone familiar with modern electronic devices: a faint whirring sound that reassured the audience that the machine works. The subsequent close-up of blood flowing through the artificial heart shows the audience that it will indeed be a life-saving device. Through its plot, narrative, dialogue and visual effects the film made something unfamiliar and frightening seem familiar and desirable.

In a previous paper in this journal, I showed how science consultants can use popular movies to create highly plausible depictions of scientific disasters in order to arouse fear in the audience (Kirby, 2003a). I argued that popular cinema allows audiences to 'virtually witness' disasters in the hopes that such movies will stimulate public action so as to prevent the disasters from occurring in real-life.[2] In this essay, I extend that work by demonstrating how film-makers, scientists and engineers can also create filmic portrayals of technological possibilities with the intention of reducing anxiety and stimulating desire in audiences to see those possibilities become realities. I build upon work on prototypes as 'performative artefacts' (Schrage, 2000; Iacucci et al., 2002; Suchman et al., 2002), as well as the role of prototypes in contextualizing technologies within the social sphere (Winston, 1998; Carroll, 2000). For film-makers and science consultants, cinematic depictions of future technologies are what I term *diegetic prototypes* that demonstrate to large public audiences a technology's need, benevolence and viability. Although I will primarily focus on the actions of science consultants on popular films, there are also cases where film-makers have had financial or ideological motivations for advocating development of a proto-technology. Even film-makers who have no vested interest in seeing the real-world development of a technology play a role in how these technologies are depicted on the screen. At the very least, any cinematic depiction requires the consent of film-makers at the top of the production process such as directors and producers.

Diegetic prototypes have a major rhetorical advantage even over true prototypes: in the fictional world – what film scholars refer to as the diegesis – these technologies exist as 'real' objects that function properly and which people actually use. Diegetic prototypes extend the analytical utility of virtual witnessing by addressing the issue of how cinematic depictions can lead to real-world technological development. The notion of virtual witnessing – that cinematic narratives present scientific and

technological objects as conforming to natural reality – is central to a diegetic prototype. Witnessing a technology as a naturalistic part of a cinematic landscape is significant, but it is not sufficient to convince audiences of a technology's essential worth. Diegetic prototypes entail an additional visual and narrative rhetoric specifically framed so as to encourage audience support for the development of the technology on the screen. Equally important, the embedding of diegetic prototypes within narratives contextualizes emergent technologies within the social sphere. Within the film world, Robert Jarvik's artificial heart diegetic prototype worked properly, was safe and saved lives.

Social Contextualization and Diegetic Prototypes as Performative Artefacts

If scholarship in the history and sociology of technology has taught us nothing else, it has taught us that technological development is not inevitable, pre-destined or linear. Any number of obstacles can impede or alter the development of a potential technology including a lack of funding, public apathy over the need for the technology, public concerns about potential applications, or a fundamental belief that the technology will not work (Williams & Edge, 1996). For scientists and engineers, the best way to jump-start technical development is to produce a working physical prototype. Working physical prototypes, however, are time consuming, expensive and require initial funds. James Cameron's quote that opens this paper illustrates the faith that film-makers and science consultants place in cinema's ability to entice public support for technological development by revealing possible technological futures. As *Threshold* demonstrates, cinematic depictions can foster public support for potential or emerging technologies by establishing the need, benevolence and viability of these technologies. It is fictional film's ability to create images of 'technological possibilities' in the audience's mind that leads film-makers and scientists to believe that depictions embedded within cinematic narratives can help overcome developmental obstacles.

In *Serious Play*, Michael Schrage (2000) argues that the prototyping process has now become the driver of technological innovation. Models, simulations and virtual prototypes are the means by which engineers and futurists determine not only the viability of embryonic technologies, but also which aspects meet the social needs of users. As Schrage says, 'it's not enough to have brilliant ideas, you have to demonstrate them. You have to get people to want to play with them' (p. xiii). Schrage's contention about the importance of social context for technological development is in line with the work of Brian Winston (1998). Winston found in the development of communication technologies that patterns of innovation and technological diffusion were not separated from the social sphere but instead were highly dependent on social forces. Winston (1998: 6) argues that the transformation from prototype to invention – movement of a technology from the lab into the larger world – requires 'supervening social necessities'. Prototypes, then, are what

Lucy Suchman et al. (2002: 164) call 'performative artefacts' that establish in the social realm the viability and possibilities of a nascent technology.

The performative aspects of prototypes are especially evident in diegetic prototypes, because a film's narrative structure contextualizes technologies within the social sphere. Narratives in popular cinema require certainty from their technological devices to move their stories forward. That is, of course, unless a plot hinges upon technological uncertainty for dramatic purposes. Even in these cases, however, the closure required by most popular movies establishes certainty by the end of a film. So cinematic texts require technologies to work and provide utility to their users. Technological objects in cinema are at once both completely artificial – all aspects of their depiction are controlled in production – and normalized in their representation as practical objects. Characters treat these technologies as a 'natural' part of their landscape and interact with these prototypes as if they are everyday parts of their world. For technologist Julian Bleecker (2004: vi), fictional characters are 'socializing' technological artefacts by creating meanings for the audience 'which is tantamount to making the artifacts socially relevant'. Thus, the supervening social necessities for potential technologies are established as given within the framework of a popular film and are disseminated to a large audience through the highly popular medium of cinema.

Joseph Corn's and others' studies on the 'history of the future' demonstrate how visions of the future in popular culture have been a powerful force in creating and framing the desire for technological advances (see, for example, Corn, 1986; Corn & Horrigan, 1996). There is, in fact, a long tradition of scholars charting the ways in which popular cultural representations, including entertainment media such as cinema, have led to the production of real technoscience (for example, Hayles, 1999). Studies examining space science, in particular, have demonstrated how scientists, engineers and space enthusiasts have used science fiction literature to promote, and secure funding for, space initiatives (Bainbridge, 1991; McCurdy, 1997; Penley, 1997; Kilgore, 2003; Franklin, 2008). There has also been recent work done on the use of science fiction tropes and imagery within non-fiction texts, such as popular science books, magazines and documentaries, to promote the need for and potential of an emerging technology (Milburn, 2002; Haran et al., 2007; Mellor, 2007). These works all demonstrate the utility of speculative narratives in promoting technoscientific agendas across a wide variety of media. What separates out a diegetic prototype in cinema from other media is its combination of a visual rhetoric along with narrative integration. No matter how evocative a novel is in its descriptions and storytelling, it still lacks the visual element that is at the heart of a diegetic prototype. Movies can *show* audiences how a technology works, why it is safe and why they need it.

Despite numerous studies showing the importance and efficacy of science and technology in entertainment media, there has been surprisingly little academic attention paid to the production of these texts (for exceptions see, Frank, 2003; Kirby, 2003a, b). Cinematic texts are the sum total of film-making and consulting decisions made during production. In this essay, I acknowledge the agency of those who made these decisions by

examining the production context for entertainment media in order to show how process impacts content. The cases that I report below of consultants and film-makers using cinema to promote technological development are located within a larger research project concerning the role that scientists play in constructing cinematic texts and how such popularization affects real world technoscientific culture.

The goal of this essay, then, is not to explain the development of medical, computer or space technologies in cinema. Rather, its aim is to focus on the social actions of film-makers and science consultants in order to show specifically how they construct cinematic scenarios – their diegetic prototypes – with an eye towards generating real-world funding opportunities and the ability to construct real-life prototypes. Diegetic prototypes differ substantially from what I term 'speculative scenarios' in movies, such as manned missions to the centre of the Earth as in the film *The Core* (2003). Speculative scenarios represent highly implausible and impractical situations and technologies that film-makers and science consultants imbue with a sheen of plausibility, so that they look possible within a film's narrative. They make these technologies look plausible, knowing that they are impossible to achieve in real life. In contrast, technological advocates who construct diegetic prototypes have a vested interest in conveying to audiences that these fictional technologies *can* and *should* exist in the real world. In essence, they are creating 'pre-product placements' for technologies that do not yet exist. Film-makers and science consultants craft diegetic prototypes and enhance their realism by creating a full elaboration of the technological diegesis which includes any part of the fictional world concerning the technology. Through their actions they construct a filmic realism that implies self-consistency in both the real world and the story world. The creation of diegetic prototypes involves the inclusion of scenes that provide opportunities to demonstrate this realism as well as positing a real world need for the technology and the avoidance of scenes that would undermine the technology or cast it as risky. Popular cinema, then, provides scientists, engineers and technological entrepreneurs with the opportunity to promote visions of a shiny future in hopes that these visions will become self-fulfilling prophecies.

Below I explore four cases of technological development in which diegetic prototypes played a role in generating public excitement (and subsequent governmental or corporate action) for moving these technologies from the fictional into the real world. It should be mentioned that, although this study moves across several historical ranges and changing cultural contexts, the key point of the essay – the use of film to visualize, and thus realize, speculative technologies – holds across contexts. Cases were chosen to best demonstrate how diegetic prototypes have been constructed for a broad range of technologies that exhibit a range of real world obstacles to production.

I began the essay with the case of a medical technology that had already been built, tested in animals and made ready to use, but which required public willingness to allow human use because of ethical issues. In contrast, non-medical technologies, such as virtual reality or data gloves pose few

physical dangers to users, but incur huge financial risks to entrepreneurs because of high development costs amid uncertainties about potential consumer markets. What better way to generate market interest for a potential technology than to demonstrate its potential in a popular movie? In *The Lawnmower Man* (1992) and *Minority Report* (2001), diegetic prototypes of embryonic computer-based technologies directly resulted in funding opportunities and the ability to construct real-life prototypes. Audiences could see with their own eyes 'real' people effortlessly interacting with these futuristic computer technologies. But what if technologies have no obvious social benefits, an extremely high price tag and high risk factors? Technologies where the success or failure of development hinges upon whether or not scientists garner public support? Such is the case for space travel, which presents hard-to-define benefits alongside easily understood challenges and risks. Therefore, I examine two ground-breaking space-based films, *Frau Im Mond* [*Woman in the Moon*] (1929) and *Destination Moon* (1950), which provided scientists and engineers with the opportunity to create diegetic prototypes of rocket travel and promote visions of a shiny outer space future that played a role in convincing the public that space travel was essential.

Virtual 'Virtual Reality': Visualizing the Potential of Computer-based Technologies

Technological entrepreneur and film director Brett Leonard created an entire movie, *The Lawnmower Man* (1992), which highlighted the potential of virtual reality (VR) and three-dimensional (3-D) interactive technologies. The horror aspects of the film certainly angered many VR proponents. Especially scenes set within the virtual space where Jobe uses the technology to try and take over all the world's computers (see Fig. 1). Yet, the film's visuals were an important vehicle in promoting the *potential* of VR. According to Leonard, his exposure to these embryonic computer technologies came through his integration into 'the social network of digerati' in northern California in the 1980s.[3] The financial success of his first film *The Dead Pit* (1989) brought him to the attention of producers who owned the rights to 'a 7–10 page Stephen King short story called "The Lawnmower Man" about a guy who telekinetically controls a lawnmower to rip a guy apart'. As Leonard tells it, the minimalist nature of the source material presented him with an opportunity to create a film based around the VR technologies he had been discussing with digital pioneers such as Jaron Lanier: 'I told [the producers] "Well, I can't really make an entire movie out of this but I have this idea about something called virtual reality."' So the King short story became a single scene in a larger narrative involving VR technologies.[4]

The film's computer-generated visual effects served a dual purpose for Leonard. First, the state-of-the-art computer graphics would be the film's major selling point. Second, the VR world inhabited by the film's central character, Jobe, would illustrate for the audience VR technology's potential

FIGURE 1
The Lawnmower Man **took audiences for a 'virtual reality' ride as seen in this film still. While the film was criticized for its horror elements, the film's depictions of virtual reality technology increased the public's desire for their own virtual reality journeys**

applications in the real world. For Leonard, VR represented an extreme example of the types of interactive technologies he was publicly promoting, 'If you go back and read the profiles of that time, I was crying for a revolution. I saw an end of passive media and the beginning of interactive media.' His goal for *The Lawnmower Man* was to create a modern 'technological mythology' featuring interactive technologies. According to Leonard, a film director acts like a 'tribal shaman' who creates visions of the future that can define a culture's shared desires:

> If you study the work of Joseph Campbell, in particular his book *The Mythic Image*, you see that it presents a thesis of how visual, artistic and visionary storytelling creations define for cultures what the future will be because it creates this vision first. Cinema, because it is a visual story telling modality, fits this notion very, very strongly. The feedback loop for cinema is very quick and it is getting quicker all the time. So when I talk about myth, I am talking about creating iconography for a new landscape. That was one of the things that I was very focused on while creating the visual style of *The Lawnmower Man*.

As part of this myth-making process he created a 'narrative environment' for *The Lawnmower Man* in which the technologies on display became a natural part of the visual landscape in the film.

Leonard also understood that the inclusion of emerging but unknown Internet technologies enhanced the plausibility of this elaborate diegetic prototype. Through his social contacts he was able to discuss upcoming developments in digital technology with several people who were at the forefront of computer science including Lanier, Nicholas Negroponte and Steve

Wozniak. According to his production designer Alex McDowell, film-makers also toured various computer companies, such as Sun Microsystems, and talked to a number of computer scientists about recent developments in computing technology. They were looking for nascent technologies that would make the VR technology in the film seem more cutting edge and prescient:

> I met some interesting people at Apple. It was pre- any public access to web links or hyperlinks. I remember that the speed gleaning idea for Jobe in the film, seeing him scan all this stuff, came from this meeting. I was completely fascinated by this thing that is so commonplace now.[5]

While the horror aspects of the film angered many VR proponents, the film's visuals were an important vehicle in promoting the *potential* of VR. The film provided audiences with a VR 'experience' that contemporary VR technologies could not. An *Omni* magazine article from 1992 captures this sense of the film presenting an alluring vision of a VR future:

> In the graphics scenes you will see what such worlds might look like in the future. At present, most VR systems are fairly crude, but the technology is developing extremely fast. According to David C. Traub, an immersion computing expert from Centerpoint Communications who was a consultant on the film, by 'looking beyond the futuristic luster of these new toys to the somewhat pained fantasies they often portray,' *The Lawnmower Man* will give us some powerful hints about what might be in store. (Wertheim, 1992)

The Lawnmower Man was a financial success with an estimated budget of $10 million and a worldwide box office take of $150 million. Leonard followed up *The Lawnmower Man* with another VR-based film *Virtuosity* (1995).

As Leonard had hoped his cinematic depictions of VR technology created a 'modern myth', which whet the public's appetite for enhanced VR and immersive entertainment technologies. *The Lawnmower Man*'s success was a key component in his ability to acquire the venture capital needed to start L-Squared Entertainment where he could develop new interactive entertainment technologies: '[L-Squared] came out of my success as a young director on [*The*] *Lawnmower Man* and an acknowledgement of my futurist talents. I was very much wanting to create a company to extrapolate off of those things both from an entrepreneurial level and on a creative level.' After *Virtuosity* Leonard began to create the types of interactive experiences he hinted at in *The Lawnmower Man* including the first IMAX 3-D movie *T-Rex: Back to the Cretaceous* (1998) that Leonard believes:

> was the closest thing to an amazing immersive virtual reality experience as you could have in the context of a narrative. This work followed from my previous work on *Lawnmower Man* and *Virtuosity* in a natural kind of progression both from the interactive side and the IMAX 3-D side.

For Leonard, then, this 'immersive virtual reality experience' was only possible because of his successful diegetic prototypes.

Computer engineer John Underkoffler's engineering firm has also benefited from his opportunity to create cinematic depictions of computer-based technologies in films such as *Aeon Flux* (2005) and *Iron Man* (2008). He has worked as a science consultant on several other high-profile films including the Steven Spielberg technology-laden blockbuster *Minority Report* (2001), starring Tom Cruise, which was based on the Philip K. Dick short story 'The Minority Report'. Underkoffler is well aware of cinema's ability to instil public desire to see the real-world development of fictional technologies. In fact, he approaches every consulting opportunity with the explicit goal of creating cinematic technologies that enter into the 'technological imaginative vernacular' of actual scientific discourse.[6] To do this, Underkoffler treats his diegetic prototypes as if he were designing not only physical prototypes but also real objects that become part of 'everyday life' in the diegesis.

Production designer Alex McDowell and prop master Jerry Moss noticed Underkoffler's dissertation work on interactive technologies during a pre-production tour of MIT's Media Lab where he had just completed a PhD. They were impressed enough with his work and his knowledge of movies to hire him as the primary science consultant on *Minority Report* a few months later. Although Underkoffler was responsible for helping design all of the technologies in *Minority Report*, his chief concern was the gesture-based computer-interface technology that protagonist John Anderton uses to manipulate computer data with his hands (see Fig. 2). *Minority Report* was a golden opportunity for John Underkoffler to demonstrate to the public, and potential funders, that not only would his gestural interface technology work, but also that the technology would appear as if it were 'natural' and intuitive for users. The important factor was that Underkoffler conscientiously treated this cinematic representation as an actual prototype, 'We worked so hard to make the gestural interface in the film real. I really did approach the project as if it were an R&D [research and development] thing.'

The most successful cinematic technologies are taken for granted by the characters in the diegesis, and thus, communicate to the audience that these are not extraordinary but rather everyday technologies. These technologies not only appear normal while on the screen, but they also fit seamlessly into the entire diegetic world. In these cases audiences will accept as true that characters still use these technologies even when they are off-screen. Successful cinematic technologies conform to Lionel Trilling's (1972) notion of 'sincerity' in acting as the performance of not performing. 'Technological sincerity', then, means taking technological entities as part of the film's natural landscape. For *Minority Report*, this meant that the gestural interface technology appeared to be something John Anderton has used before it appeared on the screen and will use again even when the camera is somewhere else. Yet, for audiences they *do* represent extraordinary technologies because they do not exist in the real world. This means that these cinematic technologies come across to audiences as both ordinary and extraordinary. To achieve the sense of an extraordinary technology appearing as ordinary within the diegetic space, Underkoffler established

FIGURE 2
Police detective John Anderton uses science consultant John Underkoffler's gestural interface technology in a film still from *Minority Report*

the gestural interface as a 'self-consistent technological entity' that adhered not only to the rules of the diegetic world but also to its own internal logic and the constraints of real-world computer technologies.

To achieve self-consistency, Underkoffler worked out an entire new gestural language for his technology that he based on American international sign language, SWAT team commands, air traffic control signals and the Kodály hand system for musical notes. Although only a small fraction of the language appears in the film, Underkoffler believed it was essential to develop an entire system of commands and gestures. According to Underkoffler, previous incorporations of a gestural interface into movies were not formalized in any way:

> The way a gestural interface normally happens in a film, like *Johnny Mnemonic* (1995) that involves some suggestion of a gestural interface and *Paycheck* (2003) with which I was indirectly involved, the way you usually do that is the director says 'Argh, just have the actor out there and wave his hands around or her hands around and let the editor sort it out.' And the poor hapless editor is left with this task to piece together something. The best you can do at that point is to make it spatially continuous and consistent so that you can cut around and the same basic gestures are happening. But you cannot really put any meaning in at that point.

To make sure his diegetic prototype functioned appropriately and conveyed a sense of internal consistency with established protocols for use, he created training videos and manuals, and a dictionary of gestures. He worked

extensively with Steven Spielberg, the actors and special effects technicians before and during filming. For production purposes, Underkoffler's comprehensiveness allowed actors to engage in improvisation work on set. In terms of the technology's cinematic realism, a completely worked out gestural interface minimized the possibility of the types of logical inconsistency that call attention to cinema's constructed nature. In addition, a totally self-consistent technology would convey to the audience that they could operate this technology themselves:

> The gestural interface has real narrative and technological consistency. I think the lay audience look at the technology in the film and say, 'Wow. Okay, I see how that works. I think I could operate that myself in fact. I learned how from the film. I bet I know what that gesture means, and I bet I know what that command is.' Somehow that technological consistency has remained very, very resonant since the film came out.

Self-consistency of the gestural interface enhanced the film's realism but more importantly for Underkoffler it moved his technology into the technological imaginative vernacular by making it appear that anyone could operate the gestural interface.

In addition to fully working out a complete gestural language, Underkoffler established the gestural interface as a 'real' technology in the diegesis by acknowledging potential design flaws. 'Perfection' is a mistake made with most cinematic depictions of technology, because it is a portrayal that does not mesh with most audience's experiences. In the case of the gestural interface, Underkoffler reasoned that the technology's design would make it incredibly sensitive to the user's hand motions. Therefore, the data on the computer screen would follow any hand movements, intentional or otherwise. Underkoffler suggested to Steven Spielberg that he add a scene to the film in which someone extends his hand to Anderton while he is using the gestural interface. Anderton would instinctively move to shake this person's hand, and by doing so, he would shift all the data on the screen into a corner. Underkoffler successfully conveyed to Spielberg that rather than detracting from the technology's realism, this flaw would *add* to the believability because it highlighted the self-consistency of the technology. Spielberg found the idea visually interesting and so he incorporated it. This 'flaw' also served Underkoffler's goal of convincing the public that his technology could function in the real world. One concern with potential gestural interface technologies is the possibility that they will not be motion-sensitive enough to be considered useful. Thus, the 'flaw' in the movie was not really a design flaw, Underkoffler meant for it to highlight the fact that the technology worked *too* well.

In the end, Underkoffler's diegetic prototype was extremely successful on many fronts. His gestural interface quickly entered into the technological imaginative vernacular and has since become a focal point for discussions about interactive technologies. Underkoffler points out that, 'A simple internet search will turn up dozens of academic projects and products that identify themselves with or allude to the *Minority Report*'s

gestural interface technology.' Underkoffler himself was able to generate significant capital because of his diegetic prototype:

> In the wake of *Minority Report* there have been countless approaches from individuals, organizations, and companies that saw a piece of technology in the film and want to know from Alex [McDowell] or me is that real? Can we pay you to build it if it is not real? Chief among those technologies, of course, is the gestural interface.

These approaches led to the funds he needed to start the company Oblong Industries and to turn his diegetic prototype into a physical prototype. This real world prototype in turn led to a development contract with defence giant Raytheon to produce gestural interface technology for the US military.[7] From Underkoffler's perspective, his work as science consultant on *Minority Report* was not simply a minor component in this story; his well-worked out diegetic prototype was the *crucial* element in the development process.

Cinematic Test Rockets: Demonstrating Space Travel's Viability in *Woman in the Moon*

Diegetic prototypes can be particularly effective for technologies such as space travel that have no obvious social benefits, an extremely high price tag and high risk factors. Development of these technologies hinges strongly upon whether or not scientists can garner significant public support. Director Fritz Lang hired the Romanian rocket scientist Hermann Oberth, popular science writer Willy Ley, and the German Rocket Society to serve as consultants/assistants for his film *Woman in the Moon*. On the surface, the collaboration seemed a win–win situation. Lang created the science fiction classic *Metropolis* in 1926 and was one of Germany's greatest cinematic artists. In addition to increasing scientific verisimilitude in his film, Lang hoped that linking the well-known Oberth to his space-flight film would add significant publicity value. Lang and the film's production company, the world-renowned *Universum Film AG* (Ufa), even commissioned Oberth to build a 2 m gasoline–oxygen rocket to be launched as a publicity stunt at the premiere of the motion picture.[8]

For Oberth, a film by one of the world's most famous film directors provided a significant means for promoting the field of rocketry, especially his own research on liquid-propellant rockets, to a worldwide audience including potential financial backers. In addition, Oberth received vital research funds from Ufa and Lang for his work on a test rocket. Ultimately, Oberth's work on the Lang film provided a significant boost for his scientific research, improved his funding opportunities, and successfully promoted rocketry to a wide audience.

Oberth was in need of research funding and experimental validation of his ideas about liquid-propellant rockets since all of his work to this point was theoretical. Essentially, Oberth was in a catch-22 situation that would be familiar to any present day scientist who applies for funding through

granting agencies. The only way for Oberth to obtain funds for experimental research was to convince investors of the viability of his approach. Yet, Oberth could only show the viability of his ideas by successfully firing a test rocket and building that rocket, of course, required financing.

Although there were few channels for research funds in 1920s Germany, there was enormous public excitement about rocketry and space flight (Neufeld, 1990). The VfR was founded in 1927, in part to obtain funding for Oberth's research (Winter, 1983). Former palaeontologist turned popular science writer Willy Ley was one of the founders of the VfR, and its initial vice-president. Ley was an enthusiastic crusader for space travel in general and for Oberth's ideas in particular. While the VfR was able to gather some capital through donations and membership fees, there was still not enough money available for Oberth to pursue experiments to demonstrate the feasibility of his liquid-propellant rockets.

Like many in the Weimar Republic, rockets and the possibility of space travel fascinated Lang and his wife Thea von Harbou. Inspired by industrialist Fritz von Opel and Max Valier's 'rocket car' experiments, von Harbou published the novel *Frau im Mond* in 1928 which she and Lang adapted into a screenplay. Before contacting Oberth, Lang initially approached Valier about serving as science consultant on the film.[9] Valier seemed to be the perfect choice; his rocket car experiments had inspired the screenplay and Valier's book *Der Verstoss in den Weltraum* [*Breakthrough Into Space*] was immensely popular. Although Valier was an almost shameless promoter, he did not see the promotional value in working on a fictional film and turned down Lang's offer. He felt he was better served by directly promoting his ideas through the lecture circuit and traditional academic venues, and by continuing with his rocket car experiments. Upon actually meeting Valier, Lang also decided that he might not be the best on-set consultant because 'he talks too much'. It was unfortunate for Valier, someone trying to promote visions of the future, to have so clearly underestimated the power of cinema as a communication technology.

It was at this point that Fritz Lang approached Oberth about serving as consultant during production of *Woman in the Moon*. Oberth's acquaintance, cultural historian and writer Otto Folberth, recalled in an article in 1930 that Oberth was 'surprised by the offer of Ufa to be an advisor on the rocket film *Frau im Mond*' (quoted in Freeman, 1993: 43). Despite his own positive experiences with the fictional novels of Jules Verne and H.G. Wells, Oberth originally had misgivings about communicating the idea of space travel through a fictional medium. He worried that rather than conveying the feasibility of space travel, the film would add to cartoonish visions of space travel he had seen in other popular cultural portrayals. As Folberth states, 'Oberth had to overcome a number of misgivings before he decided to accept the offer. For the newspapers, magazines, novels, comic strips had already significantly compromised the scientific rigor of the idea' (quoted in Freeman, 1993: 43). Despite his misgivings, Oberth accepted Lang's invitation and moved to Berlin in Autumn 1928 to begin work on the film.

FIGURE 3
For Oberth and Ley the take-off scene was the most crucial element of *Woman in the Moon*. In this film still, the rocket is being moved into position for firing

Willy Ley, whose popular 1928 book *Die Möglichkeit der Weltraumfahrt* [*The Feasibility of Interplanetary Travel*] was also cited as a scientific source by von Harbou, joined Oberth in Berlin to serve as astronomical science consultant and write promotional articles for the film and the publicity rocket. Unlike Oberth, Ley had no misgivings and he foresaw great promotional possibilities in having Germany's most famous director make a movie on space travel. According to Ley:

> The news that Fritz Lang was going to make a film on space travel was very good news indeed. It is almost impossible to convey what magic that name had in Germany at that time .... A Fritz Lang film on space travel, consequently, meant a means of spreading the idea which could hardly be surpassed in mass appeal and effectiveness. (Ley, 1968: 115–16)

Ley was hoping that Oberth's diegetic prototype would galvanize public support for governmental research funds. Although Lang constantly battled with his consultants over depictions of the Moon, he gave Oberth wide latitude in designing scenes featuring the rocket, its take-off and technical details of its flight scenes. Oberth's input included advice on a lengthy scene featuring the movement of the rocket from a hangar into firing position (see Fig. 3). A 'Fritz Lang film' had the added bonus of being a major social event in Germany and invitations to the film's premiere requested 'tails or black-tie'.[10] This provided an opportunity to convey the message directly to important and influential individuals who might actually have the means to support rocket research:

> The first showing of a Fritz Lang film was something for which there was no equivalent anywhere as a social event. The audience – it was an unwritten but rigid rule that one had to wear full evening dress, not just a dinner jacket – comprised literally everybody of importance in the realm of arts and letters, with a heavy sprinkling of high government officials. It is not an exaggeration to say that a sudden collapse of the theater building during a Fritz Lang premiere would have deprived Germany of much of its intellectual leadership at one blow. (Ley, 1947: 128–29)

Of course Ley and Oberth were counting on many potential funders to attend the premiere of this particular Fritz Lang film. If done properly the scenes of space travel could 'demonstrate' the feasibility of space travel successfully enough to acquire funds for actual experiments. Thus, Oberth treated the design of the fictional rocket and the trajectory as if he really was designing a trip into space. Although Lang constantly battled with his consultants over depictions of the Moon, he gave Oberth wide latitude in designing scenes featuring the rocket, its take-off and technical details of its flight scenes.[11] For Oberth, the opportunity to create depictions of rocket travel in a Fritz Lang film outweighed any disappointment he may have felt about the scientific accuracy of the Moon.

In conjunction with their film-making duties, Oberth and the VfR were also constructing the publicity/test rocket. While the test rocket was nominally promotion for the film, Oberth, Ley and the VfR realized that the rocket was as much about promoting the rocket itself as it was about promoting the film. Moreover, Oberth and Ley saw a significant connection between the film and the test rocket. Since Oberth designed the fictional rocket – his diegetic prototype – based on his Model B liquid-fuel rocket, then a successful rocket launch at the premiere would ultimately legitimate the vision of space flight in the film. According to Ley (1947: 129), 'The idea was to say that this actual rocket represented the first step toward the solution of the problem shown in the movie.' In the end, Oberth envisioned the launching of the test rocket at the premiere as a way for him to validate the viability of the ideas that the audience was going to see on the screen.

By accepting Ufa and Lang's offer of research funds Oberth committed himself to constructing and perfecting in less than 4 months a rocket capable of soaring 90 km (50 miles) high. Unfortunately, Oberth's previous work consisted mainly of theoretical studies with few experiments. According to Ley (1968: 115–16), '[Oberth] was the greatest authority on rocket propulsion at that time, but he was a theorist, not an engineer.' Four months after construction had begun on the rocket, there was only a series of explosions – one almost blinded Oberth – to show for Oberth's efforts. Fearing that failure to produce a much-publicized rocket would endanger his reputation and call into question the feasibility of the liquid-fuel rocket, he fled Berlin when he realized that he could not get a working model ready in time for the film's premiere (Ley, 1947: 135).[12]

Despite Oberth's failure in the real world, the diegetic lift-off that he designed for the film was a complete success, since it visually and dramatically communicated the possibilities of rocket travel to potential funders

and government officials at the film's premiere. According to Ley, the take-off scene in the film achieved the goal of generating excitement in the premiere audience about the potential of space travel:

> There is without question no other scene, either on Earth or on the Moon, that would have ruffled the poise of this cool, reserved, expert audience – these journalists, scholars, diplomats, men of affluence, and film stars. In the face of these outstanding technical achievements, the audience exploded. Electrified, carried away. The fiery jets of this film rocket swept away their carefully prepared skepticism, indifference, and satiety with the same speed with which the rocket raced across the screen, giving their minds a small glimpse of the tremendous possibilities. (Ley, quoted in Freeman, 1993: 47)

Film critics also acknowledged seeing the 'tremendous possibilities' in that take-off scene. Despite overall mediocre reviews for the film, the take-off and rocket scenes impressed film critics throughout the world including art historian Rudolph Arnheim and French journalist Jean Arroy.[13]

Other rocket scientists quickly recognized the film's capacity to visually render rocketry and show audiences technological 'possibilities', and they used the take-off scene from *Woman in the Moon* as a promotional device and a fundraising tool (Geppert, 2007). A *New York Times* report on the showing of the take-off scene from *Woman in the Moon* at a 1931 fundraising event for space research captures the essential elements of a diegetic prototype:

> The moving picture graphically illustrated some of the amazing experiences which travelers to the moon could expect. Last night's spectators watched it [footage from *Woman in the Moon*] as if it were a newsreel of an actual happening today. (Anonymous, 1931)

Oberth and Lang certainly considered that a successful test rocket would have been the primary means of publicizing their ideas. Yet, the film served their purposes just as well. In the end Oberth's virtual rocket – his diegetic prototype – succeeded in ways that his test rocket could not. Like a Latourian immutable mobile (Latour, 1986, 1990), the cinematic demonstration provided advantages missing from an actual demonstration; the film was portable, repeatable, and larger than life. These advantages would again prove critical as space travel appeared in cinema 20 years later during the next big step in aerospace engineering: moving from rockets to manned space travel.

Documentary of the Future: Space Travel as a Dire Necessity in *Destination Moon*

Destination Moon reached theatres as the Cold War was heating up and propagandists in the US and the USSR were beginning to use technological supremacy as a symbol of ideological correctness (see McCurdy, 1997; McDougall, 1997). While the space-race was well underway scientifically by 1950, the public campaign started in earnest with the release of producer

George Pal's documentary-like film about a privately financed trip to the moon, *Destination Moon*. The film's financial and critical success launched a long-lasting space film cycle that was bookended in 1968 by director Stanley Kubrick's *2001: A Space Odyssey*. Producer George Pal was indeed interested in rocketry and considered *Destination Moon* a 'documentary of the near future' (Pal, quoted in Hickman, 1977: 42). Like all film-makers, Pal was most interested in making money, but he hoped that the film would be useful in promoting space travel to the public. The future of space travel was certainly of critical concern to the numerous scientists (astronomer Robert S. Richardson, rocket scientist Werner Von Braun and physicist Robert Cornog, among many others) and scientific experts (artist Chesley Bonestell, science popularizer Willy Ley and writer Robert Heinlein) who assisted film-makers during the construction of the film.[14] *Destination Moon* highlights cinema's power as a persuasive tool for those with an ideological, financial or research stake in promoting space travel and who had the capability to significantly influence the film's visual and narrative construction.

I will focus on *Destination Moon*'s initial scriptwriter and main science consultant, science fiction author and former US navy engineer Robert A. Heinlein, who also wrote the 1947 book on which the film was nominally based, *Rocketship Galileo* (Heinlein, 1950[1947]). Using Heinlein I will show that his role in constructing this 'documentary of the future' went well beyond technical recommendations. Whereas Herman Oberth was initially reluctant to lend his scientific credibility to a fictional film, Heinlein envisioned the film as a major opportunity to demonstrate the feasibility of and the need for rocket travel to the American public. Also unlike Oberth, Heinlein was not looking to acquire research funds. He was, however, a strong advocate for developing rocket travel in America. He held membership in several rocket societies, such as the Pacific Rocket Society, and had published several short stories and novels based on space travel. Although he received financial compensation for his script and his technical assistance, the film provided him an opportunity to advocate not only ideas about the viability of space flight itself but also to visually explicate the reasons for going into space. In fact, this one technology advocate fundamentally created a new genre – the space film. Before *Destination Moon* there were no preconceived expectations of what a space movie should look like. Heinlein's influence over the look of *Destination Moon*, his emphasis on realism and believability, and his anxiety about beating the Soviets into space shaped this new genre for the next 20 years.

According to Heinlein, the key to the film's rhetorical power was its adherence to scientific veracity, and his correspondence shows a consistent insistence that the film-makers approach the film as if they were planning a real trip to the Moon. Based on his archival material, I would argue that Heinlein had multiple reasons for insisting upon verisimilitude, all of which were in line with his belief that cinema was a legitimate and powerful means for promoting a vision of space travel. First, as a 'hard' science fiction author Heinlein thought it would be intellectually dishonest to make a space-based fictional text and disregard scientific accuracy.[15] In addition, he felt that it

would be deceitful of the film-makers to publicize the film as 'realistic' if they did not make a sincere effort to adhere to scientific principles.[16]

Fundamentally, Heinlein believed that scientific realism was the key to the film's box-office success – something film-makers and financial backers wanted to hear. Heinlein conveyed his belief in realism's box office benefit through various memos and letters:

> If people believe in our picture emotionally, accept it as real while they are seeing it, it will be a success – a box office success. … Those who see it will tell others what a wonderful, thrilling, out-of-this-world experience it was – 'My dear, you have no idea! They actually made you feel that you were on the Moon!'[17]

Heinlein also recognized that a scientifically accurate film would generate significant positive publicity within scientific circles and that it would be a picture 'the New York Times science editor would praise … and that scientists would commend publicly'. He also worried that an unrealistic film would lead to negative publicity from scientists and teenage audiences because he 'knows what the "hep kids in the first six rows" like'. Box office success meant that the largest possible audience would witness Heinlein's diegetic prototype.

For Heinlein, accurate representations spoke for themselves. A scientifically accurate film was 'truthful', thus; it was a legitimate promotional tool and *not* propaganda. As an ardent anti-communist and staunch libertarian, Heinlein was sensitive to the charge of sloganeering and propagandizing. Despite the fact that the film reeks of propaganda to present-day viewers, he believed at the time that the film's message was subtle. Heinlein was adamant that 'reality' was the key to political transparency. He warns film-makers on several occasions that the 'one purpose of this picture is to show what free men and free enterprise can do – but such an effect can never be achieved by blatant propaganda. It must be handled gently. Specifically, we must not *say* it, we must *show* it.'

Space travel on the screen had to be based on 'genuine' science and engineering; not science in the service of political motives. The only way an audience would support space endeavours was if the audience believed that the space flight in the film was actually *possible*.

Heinlein felt that audiences could 'sense' when something was authentic. Therefore, he approached the making of the film as if he were modelling an actual trip to the Moon. Like Underkoffler, Oberth and other successful science consultants, Heinlein approached this film project with the attitude that the film's fictional nature was irrelevant. Heinlein's archival material contains dozens of pages of hand calculations for every technical aspect of the cinematic space flight including the mass-ratio, jet speed, trajectory times and the fuel requirements. As he explained 'none of these calculations would appear on screen but the results do' (Heinlein, 1992 [1950]: 129). Similar to Hermann Oberth, he viewed the most crucial aspect of the film as the technical detail of the take-off, flight and landing on the Moon. Heinlein was so concerned about these scenes that he

generated a lengthy letter to the George Pal and production supervisor Martin Eisenberg entitled 'The Care and Feeding of Spaceships', which was to provide them with technical details 'in case I should be hit by a taxi, go to jail, or otherwise be unavailable'.[18] He complained during James O'Hanlon's script re-write that he 'was assured repeatedly that the part of the picture from takeoff to the end had not and would not be tampered with'. As with Oberth, Heinlein believed that the reputation of space flight as a serious scientific endeavour was at stake and he could not afford for the film to be sloppy or lenient with the technical details. Unlike Underkoffler, Heinlein could not afford to let any technical 'flaws' appear in the film, even ones that could add to the technology's realism.

Despite believing that these technical details would 'feel' authentic, Heinlein was concerned that audiences would not grasp the scientific principles well enough to actually believe the cinematic trip to the Moon was 'authentic'. His initial script treatment contains side notes to co-screenwriter Rip Van Ronkel expressing this concern:

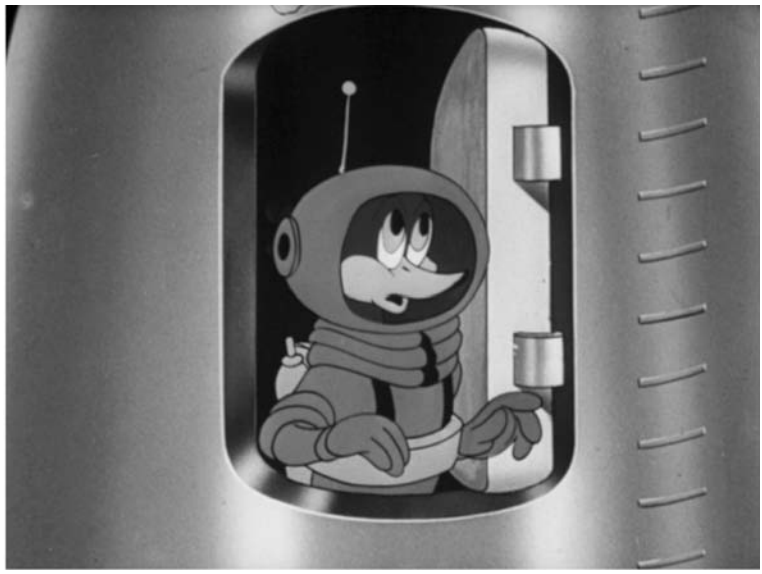
> I have a mild fear that, in attempting to maintain good story and strong drama, we may be skipping over explanations necessary in understanding *the issues on which our drama is based*. In a Western, one does not have to explain steers, revolvers, lariats, nor branding irons – whereas we are practically forced to explain acceleration, reaction, planet vs. star, vacuum, free flight, et cetera ad nauseam. Sad but true.[19] (emphasis in original)

To quickly educate the audience on complex technical principels, Heinlein recommended several didactic elements, which while common now, were groundbreaking at the time including expository dialogue, lecture scenes and, most famously, the use of a Woody Woodpecker 'animated movie', all of which appeared in the final film (see Fig. 4).[20]

The studio did not immediately embrace Heinlein's commitment to film realism. At the time, cowboys and musicals sold movies seats; not science lectures. The film-makers hired veteran script doctor James O'Hanlon to add elements with box office appeal. O'Hanlon radically altered Heinlein and Rip Van Ronkel's original screenplay by adding several sure fire movie staples of the period, including comedy, musical interludes and cowboys. The film's financial backers, including N. Peter Rathvon, preferred O'Hanlon's version of the script because it included elements they knew would make it profitable. Heinlein was furious when he saw the O'Hanlon re-write. He spent 'five days of unrelenting toil' composing a memo that he fired off to Rathvon and George Pal. He rants that their profit motives would be better served by spending money on the rocket and special effects. He tells them that in this script their money is needlessly spent on extraneous elements 'at the expense of that part of the picture on which it was agreed that money would be spent, to wit, the special effects needed to give it authenticity. We skimp the space ship to put in a dude ranch, a horse, a barbeque pit!'[21]

Heinlein's lengthy memo is a scathing critique of the script. While he points out the script's factual inaccuracies, he aims most of his criticisms at the additions of fantastical elements to the plot, such as the singing

FIGURE 4
Heinlein recommended that film-makers incorporate several didactic elements in *Destination Moon* to explain complex ideas to the audience, such as through a Woody Woodpecker cartoon as seen in this film still



cowboys. He knew that these clearly fictional elements would, by proximity, cast doubt upon the legitimacy of the cinematic space flight. The addition of a musical interlude, for example, created too great a disconnection from the real world and thus threatened the believability of the space flight. He complains, 'We put the audience into a musical comedy farce mood, where anything goes, when we are about to try and get them to believe in a trip to the Moon.'[22] He also understood that any money budgeted towards barbeque pits and dude ranches would detract from the money allocated to the space trip itself. In a later memo Heinlein sums up his belief that the audience's acceptance of the space flight scenario depended on their buying into the entire film:

> There is to my mind, a basic criterion which should be axiomatic in dealing with this picture: if the audience believes emotionally that they are making a trip to the Moon while they are seeing this picture, the picture will be a success, financially and other ways. If they don't, we're a flop.[23]

Heinlein successfully argued for the removal of every fantastical element. His strong comments as science consultant wiped out an entire script which the film's funders were keen on producing. Ultimately, the final filming script looked nothing like the O'Hanlon script because the director 'removed practically every objection I had to its predecessor'. [24]

Even if the technical details were completely accurate, Heinlein understood that the film would not be successful as a promotional tool for

rocketry research unless it engaged the audience at every level. Heinlein influenced the narrative so as to remove elements that portrayed the trip as risky, such as a meteor shower originally in the O'Hanlon script.[25] He was also able to enhance narrative elements to make the Moon trip appear to be a necessary and highly desirable future. He inserted dialogue that provided several justifications why a trip to the Moon would be advantageous including mineral deposits, scientific progress, and industrial patents. Most importantly, Heinlein believed that a trip to the Moon was essential for military reasons and his dialogue became part of the national rhetoric of the era.[26] In one scene, the General tells a group of industrialists that it is a matter of national security for America to be the first on the Moon:

> The reason is quite simple. We are not the only ones who know that the Moon can be reached. We're not the only ones who are planning to go there. The race is on, and we'd better win it, because there is absolutely no way to stop an attack from outer space. The first country that can use the Moon for the launching of missiles will control the Earth. That, gentlemen, is the most important military fact of this century.

Publicity material for the film also highlighted the military necessity of a Moon trip with several articles addressing the topic including one entitled 'Must America Engage in a Race to the Moon in Self-defense?'[27] The film's meticulously constructed diegetic prototype effectively enhanced Heinlein's cinematic argument about the Moon's military importance. If the film could convince American audiences that their scientists could make it to the Moon, it also needed to convince them that America's enemies could as well.

Judging from reviews of the film, Heinlein was successful in conveying both the excitement of space travel and its military necessity.[28] Bosley Crowther (1950) of the *New York Times*, for example, states, 'They make a lunar expedition a most intriguing and picturesque event.' Crowther also singles out the military rhetoric as particularly convincing, claiming, 'It is arresting to hear an eloquent scientist proclaim that the first nation which can use the moon for launching missiles will control the earth.' The intervention of real-world events heightened the effectiveness of the film's rhetoric. As if to underscore Heinlein's argument, the 1950 adaptation of *Destination Moon* on NBC's radio program *Dimension X* was actually interrupted by a news bulletin stating that North Korea had just invaded South Korea.[29] Not only were communists on our doorstep, they were threatening to invade the heavens as well.

Despite Heinlein's belief that his film was legitimate promotion of space flight, it was certainly viewed as propaganda by the Soviets who considered *Destination Moon* and subsequent space-based films such as *When Worlds Collide* (1951) and *Red Planet Mars* (1952) as attempts to scare Americans into space. One Soviet journalist even claimed that the American Department of Defense created the films in order to 'propagandize the idea of conquering the universe' (Anonymous, 1954). Of course, Heinlein was correct in stating that Soviet scientists also were aiming for the Moon. It was

not just American scientists who understood cinema's rhetorical power. Futuristic Soviet space films such as *Planeta Bur* [*Cosmonauts on Venus*] (1962) employed several science consultants, including astrophysicist Aleksandr Vladimirovich Markov. While a film such as *Doroga k Zvezdam* [*Road to the Stars*] (1958) inspired Soviet audiences with its depictions of colonies on the Moon and Mars, these same scenes caused 'heavy breathing' among American audiences (Thompson, 1958). One audience's shiny spaceship future is another audience's impending doom.

Diegetic Prototypes After the Moon: Missions to Mars and Beyond in Cinema

It is tempting to view the experiences of Hermann Oberth, Robert Heinlein and others on these space-based films as relics of a bygone era where film-making was a much simpler process. Such a view would not only be ignorant of film-making's history, it would also discount the fact that scientists still promote space travel through cinema. From 1920 when Robert Goddard advised Max Fleischer on the combination animation–live action short movie *All Aboard for the Moon* to NASA's involvement in recent films such as *Space Cowboys* (2000) and *Sunshine* (2007), scientists and film-makers have worked on space travel films for more than 80 years as a means of promoting outer space futures.

Even with space travel successes in the 1960s, culminating with the moon landing in 1969, scientists still considered fictional films as a useful vehicle for popularizing space ventures. *2001: A Space Odyssey* was a classic example of cinema creating expectations for space travel, as well as other technologies, with more than 65 private companies, government agencies, universities and research institutions providing free advice and material objects for the opportunity of shaping technological visions in a highly anticipated film about the future. They happily shared information on future designs for the chance to have 'pre-product placements' which established their brand as 'futuristic' in this high profile film.

The film – created with the assistance of scientists, engineers and futurists – contextualized space travel for audiences in the same manner that Fritz Lange's *Woman in the Moon* (1929) and George Pal's *Destination Moon* (1950) had done in previous eras. Unlike those two films, however, *2001* did not establish the technological capabilities and societal necessity of space travel. Manned space flights had been taking place since 1961. What *2001* did was contextualize for audiences the cultural and social potential of space travel. *2001*'s vision of space travel with its space stations, transport shuttles to the Moon and interplanetary space ships is still influential (McCurdy, 1997).

Outside of an institutional context, diegetic prototypes can still help individual scientists involved in space science. The Disney film *Mission to Mars* (2000) served as a high profile platform for Robert Zubrin's Mars Direct plan (Kirby, 2003a). There is no obvious reason to spend public money on a

FIGURE 5
This film still from *Mission to Mars* looks remarkably similar to an illustration from Robert Zubrin's (1996) book *The Case For Mars*

clearly risky manned mission to Mars. Film-makers brought in physicist Robert Zubrin, president of the engineering firm Pioneer Astronautics and founder and president of the Mars Society, to help them design a 'plausible' plan for colonizing Mars. The filmmakers also used his book as a model for the mission and several scenes of the colonization modules appear as near identical to images from Zubrin's book (see Fig. 5). Given the incredible expense involved in developing space-based technologies, *Mission to Mars* was the most effective form of advocacy Robert Zubrin could have hoped for. Not only was Zubrin paid for the rights to develop a cinematic version of his Mars Direct plan, he also received all the advantages associated a diegetic prototype. He was able to demonstrate to the public and other scientists that a trip to Mars was desirable and that his Mars Direct plan could work successfully without serious incident. As with Underkoffler, Oberth and Heinlein, Zubrin gained these benefits because he took his diegetic prototype seriously and planned it as if it were a real, not fictional, space trip.

Conclusions: Technological Development, Diegetic Prototypes and Happy Endings

In her influential study of science fiction films and American culture, *Screening Science*, Vivian Sobchack (1987) regards space films of the 1950s as a form of technology worship. According to Sobchack (1987: 69–70), films such as *Destination Moon* and *When Worlds Collide* (1951) 'visually celebrate the spaceship and dwell on its surfaces with a caressive photographic

wonder which precludes any ambiguous interpretation of its essential worth'. Sobchack singles out *Conquest of Space* (1955) 'with its lavish treatment of takeoffs, maneuverings, and landings' as a particularly blatant form of technological worship (p. 70), but she overlooks the fact that it is not only film-makers who are worshipping at this altar. *Conquest of Space*'s science consultants, including Chesley Bonestell, Robert Richardson and Werner Von Braun, significantly helped in creating these take-off and landing scenes because they had an enormous stake in establishing the 'essential worth' of space travel. Movies have provided many film-makers and scientists with the opportunity to create diegetic prototypes establishing the necessity, viability and minimization of risk associated with space travel.

These films then served as promotional tools for other scientists and scientific organizations who used the films, or at least the technical parts, to bolster their own lectures. Such public showings offered the public glimpses of a future that *could* happen. Hermann Oberth and the *VfR* were so successful in creating a sense of future possibilities that film stills from *Woman in the Moon* were routinely used as illustrations in journals and magazines until the 1950s (Geppert, 2007). Film footage was also spliced into several research films, and one such film was shown by the British Interplanetary Society in the War Office at Whitehall (Gatland, 1948, 1950). Likewise, it is telling that the only two films shown at the ground-breaking First International Astronautical Congress in Paris in 1950 were a film of V-2 launches at the White Sands missile range and *Destination Moon*.[30] These films gave the collected experts a vision of the present state of rocketry and a vision of where they wanted rocketry to be in the future. We have ample evidence from social studies of science and technology that space travel films made a difference; they were extremely successful in exciting the public and other scientists about the possibility of space travel (see, for example, Neufeld, 1990; Bainbridge, 1991; Freeman, 1993; McCurdy, 1997; Penley, 1997; Billings, 2007; Geppert, 2007; Franklin, 2008; Telotte, 2008).

The utility of the diegetic prototype may be most evident through space films, but their advantages are certainly not limited to this technology. Brett Leonard and John Underkoffler's diegetic prototypes of embryonic computer-based technologies directly resulted in funding opportunities and the ability to construct real-life prototypes. Audiences could see with their own eyes 'real' people effortlessly interacting with these futuristic computer technologies in *The Lawnmower Man*, *Virtuosity*, *Minority Report*, *Paycheck*, *Iron Man* and other computer-based films. Underkoffler, in fact, felt that the potential of cinema for technological development should be brought into the scientific and design community. After *Minority Report* Underkoffler and Production Designer Alex McDowell helped to form an organization called MATTER Art and Science, whose objective is to transfer the creative methods of cinema into scientific and engineering work. For MATTER Art and Science every potential technology should be treated as a diegetic prototype. This allows them to map out the social, political, economic and practical possibilities of a technology before it is even considered for development.

The presentation of science within the cinematic framework can convince audiences of the validity of ideas and create public excitement about nascent technologies. Fiction's lack of constraints and film-makers' creative assistance provides an open, 'free' space to put forward speculative conceptualizations; it also embeds these speculations within a narrative that treats these ideas as already actualized within a social context. The key to cinematic diegetic prototypes is that they allow scientists and film-makers to visualize *specific* methods and technologies within the social realm of the fictional world. Film-makers and/or scientists can use the narrative and visual framework of cinema to contextualize and model potential futures for their particular technology whether it be medical, computer or space-based. Cinema provided an ideal vehicle for establishing a technology's necessity, its viability and its benevolence within society. It is Robert Jarvik's artificial heart functioning perfectly on the screen, Brett Leonard's and John Underkoffler's computer-based technologies, and Hermann Oberth's and Robert Heinlein's visions of space travel. Disney's Touchstone Pictures provided Robert Zubrin with the opportunity to show the public that his Mars Direct plan *could* work and the narrative provided reasons why the public should *want* it to work. For any science consultant who is trying to get funding for their un-developed technology diegetic prototypes allow for 'happy endings'.

Notes

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1. James Cameron's speech to the Mars Society can be found at <www.spaceforum.com/articles/Cameron_Mars.doc> (accessed 22 April 2009).
2. On the concept of virtual witnessing see Shapin and Schaffer (1985).
3. All quotes from Brett Leonard come from Brett Leonard, phone interview by David Kirby, 8 February 2009.
4. For the producers it was crucial to maintain a tie to the original story so they could use Stephen King's name in publicity. The official title of the film was *Stephen King's The Lawnmower Man* and King's name was used heavily in marketing the film. King unsuccessfully sued to have his name removed from the film (see Winteringham, 1994).
5. All quotes from Alex McDowell come from Alex McDowell, interview by David Kirby, London, UK, 17 January 2005.
6. All quotes from John Underkoffler come from John Underkoffler, interview by David Kirby, Los Angeles, CA, 25 March 2005. In addition to his work on the interactive technologies Underkoffler was also responsible for developing the 'predictive surveillance' technologies depicted in the film. According to Underkoffler, many of these technologies have advanced further than what was predicted in the film, which for him represents a disturbing development:

> We have a lot of biometric stuff and iris scanners in the film. It turns out that iris scanning is a lot more reliable than retina scanning. Officially speaking our *Minority Report* scanners were iris scanners. Unfortunately, the US in particular, especially in

> the wake of 9/11, is starting to veer towards the panopticon society depicted in the film. So, the film accidently became really, really prescient. In the movie the notion was that this was by virtue of out of control consumerism. There was a desire on the part of vendors and manufacturers to track one's every move so that you could be appropriately advertised to. Instead in the name of security we are seeing the same kinds of civil liberties dissolving. Still, in that case that stuff is happening much faster than we said in the film.

Despite its role in influencing the development of these technologies, *Minority Report* ultimately conveys the same cautionary message shared by much of science fiction cinema by warning against excessive trust in technology.

7. There are several news accounts of Raytheon's acquisition of this technology (see, for example, Karp, 2005). Underkoffler's real-world prototype can be seen in CNN's coverage of the technology. Available at <www.g-speak.com/press/cnn-gspeak-19apr2005.avi> (accessed 22 April 2009).
8. See Ufa Press Release (1929), 'Die Ufa Meldet', 21 September, in the Willy Ley Papers, Smithsonian Institution Archives, Washington, DC.
9. Information and quotes in this paragraph come from an undated manuscript in which Willy Ley recounts the making of the film. Willy Ley (date unknown) 'Frau Im Mond, A Film by Fritz Lang', in the Willy Ley Papers, Smithsonian Institution Archives, Washington, DC.
10. Quoted in Ufa Invitation (1929) 'Ufa Programm Frau Im Mond', 15 October, in the Willy Ley Papers, Smithsonian Institution Archives, Washington, DC.
11. See Ley, Willy (date unknown) 'Frau Im Mond, A Film by Fritz Lang', in the Willy Ley Papers, Smithsonian Institution Archives, Washington, DC.
12. Ley indicates that Oberth returned to Berlin for the World Premiere of the film on 15 October 1929.
13. Summaries of film reviews can be found in Kaplan (1981). Most reviewers dismissed the story as fluff but all were impressed with the technology on display.
14. Several scholars mistakenly attribute the film's science consulting to Hermann Oberth (see, for example, Frayling, 2005 and Vieth, 2001). Oberth was living in Switzerland and Italy in 1949–1950 and did not work on the film.
15. For example, in one memo he tells film-makers that good storytelling requires scientific authenticity, saying that 'there is a way to please the overwhelming majority – by telling an honest story honestly, by being careful of little details, by not assuming that the audience is too dumb to catch you when you pull a phony on them'. Robert A. Heinlein (1949) 'Critique of the James O'Hanlon Script', Memorandum from Robert A. Heinlein to producer George Pal and financier N. Peter Rathvon, 18 September in the Robert A Heinlein Archive, University of Santa Cruz, Santa Cruz, CA, Special Collections, Box 19.
16. Heinlein emphasizes in several memos that the film can benefit from his publicity contacts but only *if* it is scientifically authentic. In one case he tells Pal and Rathvon that his book publisher is willing to promote the film 'provided it maintains the same high standards of technical accuracy as do my books. The proviso is important.' Robert A. Heinlein (1949) 'The Care and Feeding of Spaceships', Memorandum from Robert A. Heinlein to producer George Pal and production supervisor Martin Eisenberg, 30 September in the Robert A Heinlein Archive, University of Santa Cruz, Santa Cruz, CA, Special Collections, Box 19.
17. All quotes in this and subsequent paragraph come from Robert A. Heinlein (1949) 'Critique of the James O'Hanlon Script'.
18. This and subsequent quote from Robert A. Heinlein (1949) 'The Care and Feeding of Spaceships'.
19. Quoted in Robert A. Heinlein (1948) 'Initial Script Treatment for *Operation: Moon*', in the Robert A. Heinlein Archive, University of Santa Cruz, Santa Cruz, CA, Special Collections, Box 19.
20. Heinlein had suggested the use of Elmer Fudd and Buck Rogers, but George Pal was a personal friend of Walter Lantz, the creator of Woody Woodpecker.

21. Quoted in Robert A. Heinlein (1949) 'Critique of the James O'Hanlon Script'.
22. Ibid.
23. Quoted in Heinlein (1949) 'The Care and Feeding of Spaceships'.
24. Ibid.
25. Heinlein worried that such a scene would overstate the likelihood of a meteor hitting a spaceship while it was on the Moon: 'This is a question of probability. It could happen – but it is just as likely as the possibility that a meteor will hit your parked car and keep you from going home tonight' (Heinlein [1949] 'Critique of the James O'Hanlon Script').
26. Heinlein believed that the military argument for developing space travel was so essential that he fought throughout the production to keep this dialogue in the screenplay. A letter from his collaborator Rip Van Ronkel shows how one potential financier was concerned about how this dialogue would go over in foreign markets: 'Pal's oil company contact out here insisted that his company would *not* go for the war stuff nor would they ever accept even veiled references to Russia' (emphasis in original). Alford Van Ronkel (1949) 'Letter to R.A. Heinlein', 15 February, in the Robert A Heinlein Archive, University of Santa Cruz, Santa Cruz, CA, Special Collections, Box 19. Although the military angle survived through several script revisions, Heinlein continually found himself arguing for the importance of this dialogue. In one instance, he responds to a producer's concern that the Russians may not respond well to the inclusion of this dialogue by arguing, '*I* think the military angle is important and I think it is too late to worry about what Russia thinks about it' (emphasis in original). Heinlein (1949) 'Critique of the James O'Hanlon Script'.
27. See George Pal Productions (1950) 'Must America Engage in a Race to the Moon in Self-Defense?', *Facts About Destination Moon*, press kit, in the George Pal Papers, UCLA, Arts Library Special Collections, Los Angeles, CA, Box 1.
28. Heinlein was clearly correct about realism selling the picture. *Destination Moon* was on the *New York Times'* ten best pictures of 1950 and it was the third highest grossing film of 1950.
29. The radio adaptation was broadcast on 24 June 1950.
30. See Eric Burgess (1997) 'Paris, 1950, First International Astronautical Congress', from the Record of the Formation and First Decade of the International Astronautical Federation and its Annual Congresses. CD in the Eric Burgess papers, Manchester, UK.

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