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Imagining technology.

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Abstract

This review of the evidence about influences which science fiction may have on technology and innovation touches on a series of questions: does imagining technologies and societies in which they are used make innovation more or less likely? Easier or harder? Does it increase or decrease the chance it will take particular forms or that specific ideas will be realised in practice? Can it help forestall undesirable innovations? The later part of the paper concentrates on how the answers to these questions can be put to practical use. It builds on two observations. One is that, over time, our technological societies have become more conscious (and self-conscious) about the way we tell stories about technology yet to come. The second is that there are already scattered efforts to make more direct use of story-telling as an aid to thinking about new technological possibilities, or even direct inputs into development. This goes beyond conventional science fictional media - in print and on screen - and includes a range of ideas conveniently gathered under the heading of "design fiction". The typical result of such efforts is a proposition, or a provocation, sometimes in the form of a designed object, sometimes not. Invariably, it is an invitation to ask, if the world contained things like this, how might life be like? That is a science fictional question, but there may be new ways of asking it which can usefully be taken further.

Keywords: science fiction, speculative futures, experimental futures, foresight

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Introduction

This paper was commissioned by Nesta to review the evidence about influences which science fiction may have on technology and innovation. That's a general brief which points to a potentially long list of specific questions. Does imagining technologies and societies in which they are used make innovation more or less likely? Easier or harder? Does it increase or decrease the chance it will take particular forms or that specific ideas will be realised in practice? Can it help forestall undesirable innovations? And so on.

The essay that follows touches on these questions. Unsurprisingly, as these are questions involving people, culture and history, none have simple answers, and details vary a lot from case to case.

One point of reviewing what we know, or has been suggested, about these things is to consider if it can be put to practical use. So the main part of the paper, which necessarily focusses on the past, is followed by some thoughts on the future. They build on two observations. One is that, over time, our technological societies have become more conscious (and self-conscious) about the way we tell stories about technology yet to come. The second is that there is already a selection of efforts - scattered, but adding up already to quite a rich array - to make more direct use of story-telling, of various kinds, as an aid to thinking about new technological possibilities, or even direct inputs into development. This goes beyond conventional science fictional media - in print and on screen - and includes a range of ideas conveniently gathered under the heading of "design fiction". The typical result of such efforts is a proposition, or a provocation, sometimes in the form of a designed object, sometimes not. Invariably, it is an invitation to ask, if the world contained things like this, how might life be like? That is a science fictional question, but there

may be new ways of asking it which can usefully be taken further.

The paper begins with a look at some of the key terms - science, technology, and fiction, and asks what story-telling and technology have in common. One answer is that all technologies, or designs for technologies, imply narratives.

Section 2 looks at the history of science fiction, and ventures a couple of generalisations about the influence of the entire genre on the way a technological society developed. Most simply, SF is good at promoting cool stuff, lousy at slowing things down with awful warnings.

Section 3 discusses some of the special properties of what has become the main medium for propagating science fiction stories - the cinema. It reviews recent suggestions that cinematic visualisation is an especially powerful way of conveying the idea of (some) new technologies.

The next three sections look at some of the most often mentioned examples of technologies where science fiction is supposed to have mattered to developers – cyber and nanotechnologies, and robotics, and review the current views of interactions between stories and technologies of a small sample of authors, and some other observers.

Finally, the paper considers explicit efforts to harness story-telling to debating technologies, leading on to a discussion of design fiction and similar projects, and how they might be developed as part of a broader discussion of the meaning and purpose of innovation.

1. **The future that was**

As you sip your perfect coffee, you scan the morning's personalised news on your vidscreen. Finance: yields on your undersea city bonds look poor after the pressure seal scare on the prototype dome, but asteroid mining shares are up. Win some, lose some.

Your wrist phone chimes with a message from your spouse. Her business trip to review the Sahara forest project will finish early and she ought to make the noon hypersonic shuttle and be home by teatime. Maybe you can still make the premiere of that new zero-G dance show tonight.

Time to leave. You signal the table to resorb the scant remains of your nutritionally balanced breakfast. The kids couldn't wait. They are already in the media room for the day's first lesson – their artificially intelligent tutor-cum-playmate is conducting a virtual reality tour of the first Olympic Games, reconstructed from the latest time probe results. You don't want to interrupt, so you record a farewell reminder to check their gear for the afternoon's sub-aqua games at the local leisure park.

The autopilot banks your flying car over the scattered houses, course set for the city, and you see clouds breaking up as the neighbouring county's early morning shower clears on schedule. Here, robot cultivators tirelessly tend the fields below. On the horizon the nuclear reactor that powers them all gleams in the sun...

And so it never quite came to pass. We slightly jaded, technology fatigued, 21st century citizens recognise the story I have just invented as a parody of the future as it used to appear. Some of the inventions that earlier writers conjured up really exist.

Some don't. Some they never imagined have also entered our lives. But everyday life is as gloriously imperfect as ever, and few expect that to change.

What does science fiction have to do with any of this?

Technology's place in science fiction.

The brief for this working paper is to appraise science fiction's influence on technological development. Science fiction - henceforth SF - does look like a good place to seek such influence. It is a genre with fuzzy boundaries, so it is fruitless to look for a watertight definition of SF (or even, perhaps, "science" and "fiction"). But one which critics agree is useful is an old formulation by Darko Suvin. He defined SF as "a literary genre whose necessary and sufficient conditions are the presence and interaction of estrangement and cognition, and whose main formal device is *an imaginative framework alternative to the author's empirical environment*" (my emphasis). Another world, a future world, or a different version of this world, in other words.

Suvin goes on to suggest that an SF story has at least one "*novum*" - a feature which defines a key difference between the reader's everyday world and the world being portrayed. They come in a variety of forms, but in a large portion of SF the novum has a scientific origin. Well, that is not quite right. Despite the label, as critic and SF novelist Adam Roberts observes, "the great majority of SF written in the nineteenth and twentieth centuries is actually 'extrapolated technology fiction'". Hence, the novum is generally technological. Generalisation is hazardous, as Roberts emphasises, but he suggests that "We find tools and machines at the core of most science fiction: such that spaceships, robots, time-machines and virtual technology (computers and virtual realities) are the four most commonly occurring tropes of the field."

There is more to the technology of science fiction than this. And there is more to

science fiction than technology. The generalisation is broadly right, though. That means SF as a whole is an important arena for imagining the effects of technologies, existing and yet to come. Its imagined worlds are ones in which life is enabled or constrained by technologies in ways we have not yet seen in our world. Whether we do see them realised may then be influenced by the role technologies play in these alternate realities.

The influence is strengthened by the fact that many SF authors love technology, and many technologists love SF. The latter may be a love that dare not speak its name, though. Science fiction has sometimes been dismissed as a juvenile literature – the Golden Age of SF is always 14, it has been said. And it is still not quite respectable (less so, perhaps, in the UK than in other Anglophone countries). Written SF has always been riven by tensions between an urge to grow beyond its roots in pulp fiction and a wish to celebrate them. While printed SF has been increasingly accepted as sufficiently literary to be worth discussing with literary critical tools, the image of SF in general as crude and not quite grown up has been perpetuated to some extent by its growing cultural presence in films, comic books and computer games.

Whether or not this image is justified, crude and not quite grown up fictions can still have great power, and popularity. They provide some of the most readily accessible images of possible technologies and figure continually in public discussion of those technologies. At the same time, their dubious (to some) cultural standing influences the rhetoric of those discussions. What is, or is not, considered science fiction – as opposed to, for example, "serious" speculation, extrapolation, or technological goal-setting – is often the subject of boundary disputes energised by an inferiority, or superiority, complex.

Science fiction's place in technology.

Technology is more than just clever stuff. It is about ways of doing things, as well as the gadgets and devices, the artifacts, that often stand in for technology in public discussion. As with science fiction, definitions abound, and it is more fruitful to consider what they have in common than to try and arrive at a definitive version.

A useful survey by two innovation scholars, James Fleck and John Howells, finds that taking all definitions together suggests considering a "technology complex", rather than technology per se. Any example includes, in varying combinations, a basic function, an energy source, and artifacts or hardware. But it also extends to such things as layouts, procedures, skills, work organisation, management techniques, capital, industry structures, social relations and culture. They add up to what others have called a socio-technical system. For Fleck and Howells, the main thing about the technology complex is that artifacts always operate as part of human activity in a social context. This suggests that working out what effects a new technology might have, or how it might fit into future ways of life, involves exploring a very large space of possibilities. The kind of space, in fact, that fiction is good at exploring.

This affinity is underlined by another way of putting this notion of the technology complex. Every technology begins in the imagination, and needs a description of what it will achieve. Along with the technical specification of a new invention, there is a built-in narrative. Every patent tells a story. Make this device, or follow this process, and certain things will be possible – things not seen before.

The twinning of technologies with stories is emphasised by historian of technology David Nye. Conceiving a tool entails thinking in time and imagining change, he says. Tools are aids to future action. "A tool always implies at least one small story".

As technological development has become more conscious, and systematic, these stories have grown more elaborate. Every technology, already realised or merely sketched, is always already embedded in stories. They run from the explanation of its

basic operation, to its place in a collection of futuristic scenarios, whether those scenarios are business plans, paths to national economic competitiveness, environmental good deeds, effective military strategies, or simply advertisements for aids to domestic comfort.

Just as technologies have always come with stories, there have long been fictional stories about technology. Prometheus, Deadalus and Icarus still symbolise the perils and rewards of innovation. Like technology itself, the stories we tell about it have evolved. As the effects of technological change became more obvious, science fiction was one powerful cultural response. It forms a large subset of the stories about technology we have accumulated, which can be separated conceptually (though not always in practice) from the stories inherent in plans for technological development.

Stories beget stories

Stories are malleable. They can be mixed and remixed. In the technology complex, stories about technology in science fiction form part of the cultural context in which a particular technological narrative is read. And stories attached to technologies – technologies extrapolated, wondered at, or treated with suspicion - feed into the creation of science fiction. These stories readily interpenetrate. Either can easily incorporate elements of the other, and often do.

Storytelling is a major mode of human cognition, so looking at stories and technology one needs to keep in mind all the other things that stories do, too. The narratives in question may be very simple - “this is how your car will drive itself in ten years time” - but may at any time link up with other stories, up to and including the grandest of narratives and myths. Progress, human destiny and even the fate of the universe (SF staples all) are always available for invocation if it suits the storyteller’s purpose.

In between, there is more immediately political storytelling going on. Stories of technologies yet to be made are prospective, speculative, futuristic. They are typically debated or argued over. Innovators would like it if their simple stories of how things will work, and what the benefits will be, were accepted at face value, and eased the path to realisation. In real technological development, what happens is much more complex and more often contested. As Cynthia Selin puts it, in a study of that most speculative field, nanotechnology, "technologies are not merely tools that are used or applications of science that are discovered, but rather are made through claims and counterclaims and constructed in one way rather than another, which is stabilized in social and material structures."

So the set question for this review, "What is the influence of science fiction on the trajectory of technological development?" is a tricky one. Causal claims are made in both directions. They are hard to stand up. Close examination shows that even commonly accepted ones are almost always overstated, as I will argue below.

Stories also frame questions, and the question here is no exception. Pointing to a "trajectory" for technology is a metaphor which implies a narrative. Technology is a thing which is moving, going somewhere, and its trajectory can be altered, maybe tracking different co-ordinates in some technology space. There are other ways of thinking about it. Try an evolutionary metaphor, for instance. Many technological possibilities are generated, imaginatively in the first instance. Does science fiction affect which ones come to fruition, and how rapidly? If this evolution is somewhat Darwinian, does SF affect variation, selection, or extinction?

Maybe all of those things. But the Darwinian metaphor isn't a particularly good one, either. Technology and fiction-making as parts of culture blend, cross-react and recombine in non-Darwinian ways. Each is part of the environment in which the other takes shape, depending on your momentary point of view. Each can be a source for the other. Each can perhaps, in different ways, promote or retard the other.

Each, also, has a history. That is, it is subject to one of the other modes of storytelling. As that history has unfolded, there have been more stories told about science fiction's interaction with science and technology. Even when heavily coloured by the image-boosting or myth-making of authors or inventors, these give indications of how those involved thought about what was happening. Those stories outline a trajectory, an evolution or perhaps a network of recombination which can also be traced.

So this look at how SF and technology interrelate will outline another narrative. Over time, we have become more aware of the way the stories we tell help shape the collection of technologies we live with. That raises another question, to keep in mind as we go. As we grow more self-conscious about stories and technological innovation, how does that affect the way they interact? Could we even make use of the interaction, deliberately contriving effects we seek, rather than just observing them? Well, people are trying.

2. **Prophecy, prediction and propaganda.**

The field under review here is large, to say the least. Its most interesting boundary is the present, when technology, images of technology and speculations about technological possibilities all co-exist in such profusion. It extends back deep into history.

The history matters. Limiting consideration to science fiction would mean confining comment to stories which involve doing things by methods we recognise as technological. That is helpful in ruling out much recent fantasy writing, yet it excludes many older tales with discernible influence on attitudes to technology. Magic, or supernatural aids, are the staples of ancient stories about acquiring power to do new things. Such stories still have imaginative purchase because they key into

perennial human desires. Like us, our storytelling ancestors dreamt of invulnerability or immortality, reanimation or resurrection. They pondered making artificial creatures or people – especially doubles of existing individuals – and were fascinated by metamorphosis and monstrosity. They conjured fantasies of invisibility, remote vision, speech or hearing, instantaneous travel, or irresistible long distance weaponry.

This inventory suggests several things. There is direct continuity between many of these ancient wishes and the accoutrements of SF futures. Add faster-than-light spaceships and time travel and you have a pretty good first approximation of what SF technologies, based on current science or not, can do. Recently, the inclusion of ideas from nanotechnology has offered a blank cheque, or a new kind of fairy dust, to writers invoking technological power to transform, but the results still tend to map on to the old wish list.

The old ideas also put an often-made, but rather shopworn, claim about SF – that it can be mined for predictions about technology – in perspective. The fixation on prediction encourages scorecards and cherry-picking of (often spurious) matches. When it comes to technology, it also tends to neglect the larger, older picture.

The evolution of flying can illustrate this. Evolution by natural selection is a good method for living things to explore design space. In that light, the history of the life of Earth shows that it is reasonably likely that in an environment with the air density and gravitational field we see on this planet some creatures will take flight. Birds, mammals, insects, even the odd fish, can all move through the air.

All this happened before humans appeared. When we did, we saw other creatures in flight while our feet stayed on the ground. No wonder the fantasy of human flight would be part of human storytelling.

It has certainly featured in a long history of myth, fiction and technological speculation. To say that any previous depiction of humans in flight "predicted"

modern air travel seems a poor way to describe this. Rather, our construction of flying machines is one, partial, realisation of an aspiration which grows out of the human condition. This is underlined by the fact that the jetpack endures as a symbol of the dream of individual flight.

Some stories normally included under the SF banner, such as those of J. G. Ballard, gain power from their recognition of this. They tap in to the psychoanalytic reading of technology implied by Robert Romanshyn's assertion that "technology is… the enactment of the human imagination in the world. In building a technological world we create ourselves, and through the events which comprise this world we enact and live out our experiences of awe and wonder, our fantasies of service and control, our images of exploration and destruction, our dreams of hope and nightmares of despair." Those experiences, fantasies, images and dreams are how SF gains its power, too, but their roots go deeper into the history of the human psyche.

The oldest stories also still affect reception of modern technologies more directly. Depictions of human cloning, for instance, are heavily imbued with imagery from tales of doppelgangers, evil twins and stolen identities which long predate cell biology. "Mythology comes down strongly against cloning", writes critic Wendy Doniger. But myths are not SF.

When, then, does SF begin for our purposes? Francis Bacon catalogued many wonderful (if vaguely specified) non-magical inventions in his unfinished *New Atlantis* (1624) to convey his excitement about the application of systematic inquiry, and the Baconian vision certainly informs much later writing about science.

Somewhat later, a fictional expression of the Baconian project in biology, *Frankenstein* (1818) presents a tale which is sometimes cited as the *ur*-SF text because Mary Shelley's creator turns away from magic and learns chemistry. But the story still weaves in many older tropes.

By the end of the same century, though, the catalogue of clearly recognisable science fiction was growing rapidly – the works of the two best-known authors of the period, Jules Verne and H.G. Wells, get recognisably modern SF under way.

They and other early SF authors witnessed a period which saw an astonishing flood of important innovation. Never mind late 20th century "future shock". The four or five decades after 1860 saw probably the highest rate of important inventions coming into widespread, world-changing use. The dynamo, electric light and electric trains. The telephone, telegraph and phonograph. The internal combustion engine. Typewriters and skyscrapers and transoceanic cables. Anaesthetics, vaccination and X-rays. Plastics, moving pictures and – soon after – aeroplanes.

Some of those who saw this, and thought it good, became science fiction writers on a mission to inspire the next generation of innovators. Their prototype, and eventual leader, was Hugo Gernsback.

Gernsback, an engineer fascinated by electrical technology, grew up in Luxembourg and emigrated to the US in 1905. Six years later he published a novel, *Ralph124C 41+ : A Romance of the Year 2660* (1911) which featured a long list of future inventions. When he founded the first science fiction magazine *Amazing Stories* in 1926, it had a clear prospectus: science-based stories making predictions which might become self-fulfilling by inspiring readers to make them come true. The slogan which he printed above his editorials, "Extravagant Fiction Today: Cold Fact Tomorrow", remains an idea which much media commentary on science fiction fixates on. Such commentaries are about evenly split between breathless admiration of science fiction writers' supposed predictive powers and pooh-poohing the idea that they have any special insight into what comes next. The idea that they think their fictions prefigure potential future technologies gets reinforced either way.

The stories Gernsback published often, though not invariably, conformed to his didactic intent. Collectively, Gernsback-inspired texts amounted to propaganda for the

benefits of the high-tech future they prophesied. He wanted to inspire his mainly young, male audience to pursue scientific careers, and make the future he showed them real. There are still one or two people, mainly in scientific institutions, who think this should be the purpose of SF. Most of it, fortunately, is more interesting than that.

Looking forward, but glancing back

There has been a vast outpouring of science, technological innovation, and fiction in the century since Gernsback wrote his novel. Science fiction is more diverse than his pedagogic commitment would ever have allowed. But stories written to explore technological possibilities, and their consequences, have been one continuing thread in the exuberant tangle of trends, movements and sub-genres that have grown up in and around SF. Contemporary authors whose stories feature future technologies are generally more interested in what their characters do with it, and in its social consequences, than in how it works. Occasionally, as writers in a genre which can be inward-looking and has a well-developed sense of its own history, they comment on the gung-ho attitude to technology of their predecessors. The epitome of this is William Gibson's short story *The Gernsback Continuum*, in which the protagonist in an averagely decayed Gibsonian city keeps catching glimpses of a not quite discernible alternate universe in which Gernsbackian technology abounds.

That story was written in wry recognition of the passing of the future Gernsback cherished, by one of the authors who helped to fashion a quite differently textured future, in which technology still loomed large. The cyberpunk movement which Gibson helped to energise has had its own influence on technology, but is only one of the identifiable trends in a genre that has had its fair share of manifestos, reactions and counter-reactions, new waves and backwashes over the last century.

The next section looks at some of the detail of this history, an essential effort when such diversity means it is one of those loosely defined genres where any generalisation can usually be dented by counter-examples. But it is worth first stepping back far enough to try a few tentative conclusions about SF and technology which emerge from an examination of the science-fictional past.

Cheerleading works, doom saying doesn't

There are definitely *some* important cases of links between fiction and future technology. H. G. Wells named the atomic bomb in *The World Set Free* in 1913, a time when science was making superweapons and a war to end war thinkable. He drew on the new physics of radioactivity to imagine a devastating bomb, lobbed over the side of an aeroplane, which could destroy a city. Leo Szilard, reading the book in 1932, still had it on his mind when he conceived the idea of a chain reaction the following year. It is hard to believe that without Wells priming Szilard's thinking there would have been no nuclear weapons. But we do know that Szilard sent passages of the novel to potential backers of experiments he wanted done to prove his idea. This is one of many examples of a project proponent using an easily understood fictional representation to gather support for something which somewhat resembles what is depicted. In such cases, SF enlarges on a particular concept by allowing the reader to visualise how it might be used in a particular context. It is a common and continuing use of the genre.

Bombs must be delivered, and the developing science of rocketry was also entwined with early science fiction. Robert Goddard, the pioneer of rockets in the US, sent Wells a fan letter after reading *War of the Worlds*, a book that also caught the imagination of Wernher von Braun. Von Braun's mentor in Germany, Hermann Oberth, was similarly inspired by Jules Verne's *From the Earth to the Moon*. In the Soviet Union, Nikolai Rynin produced a multi-volume encyclopedia of space travel

between 1927-1932 which drew freely on science fiction as well as technical literature. Here, we see fiction helping establish a creative echo-chamber. Ideas bounce back and forth, not always coming across clearly but being amplified and altered over time. Sometimes this is a matter of detail. Oberth, with the 18 year-old von Braun in attendance, advised on the details of Fritz Lang's film *Frau im Mond* (1929), which featured the first depiction of the launch countdown which has become the real world convention. Sometimes it is of more consequence. Hitler had Lang's models destroyed a few years later because they were too close to the rocket designs Oberth and von Braun were working on for the Nazis.

In general, it is well to be wary of supposed links between fiction and new technologies. Similarity, or even direct connection supported by personal testimony, is not the same thing as demonstrating an effect. Post hoc fallacy is a constant temptation. Affinity or resemblance can be coincidental. Personal recollection is often self-serving. And the circuits of cultural exchange are so complex that influence is always going to be hard to trace. But these two old examples confirm that science fiction can, at least, encourage technologies into being, if other conditions are right. The popularisation of rocketry and space travel is often taken as one of SF's major cultural effects after World War Two as well as before. Thomas M. Disch, whose overall thesis about SF's influence is captured in his book title, *The Dreams Our Stuff is Made Of*, reckons that "there is no more persuasive example of 'creative visualisation' than the way the rocket-ship daydreams of the early twentieth century evolved into NASA's hardware". In the late 1950s, science fiction imagery was also used extensively in advertising, especially by aerospace companies, as Megan Prelinger documents in *Another Science Fiction: Advertising the Space Race*. So there was much more than written SF giving impetus to space developments, but there were certainly a fair few rocket scientists and popularisers of the technology turning their hands to fiction as part of a deliberate effort to spread their ideas.

SF as cheerleader, then, has some successes, even if the post-Apollo history of human space flight so far suggests that they may be short-lived. In contrast, it rarely succeeds in putting a block on technology. Take just two examples. New reproductive technologies have appeared in innumerable stories. Usually they are tools of oppression and dehumanisation. *Brave New World* (1932), with its assembly-line "decanting" and alpha-to-epsilon graded people, remains the ur-text. Along with its venerable ancestor *Frankenstein*, it was the governing image of the reporting of early efforts to achieve *in vitro* fertilisation, or "test-tube babies". But once IVF was accomplished, the technology was adopted by millions worldwide (five million births at the last count), and press stories typically featured cute newborns and ecstatic parents rather than threats to life-as-we-know-it, at least as long as the parents were married and heterosexual.

Nuclear weapons are a more regrettable example of the failure of fiction as warning. Post World War Two science fiction has too many tales of nuclear horrors to count. The only silver lining which might be glimpsed in a mushroom cloud (ignoring some later survivalist fiction which sees an upside to the removal of most of humanity) was that its results were so shocking it might bring people to their senses and usher in an era of peace and co-operation overseen by a world government. But this vision, tirelessly propagated in the first half of the 20th century in its technocratic version by Wells, was overwhelmed by the large majority of stories which foresaw the end of civilisation, even of life itself. These stories spoke to the awful fear underlying the post-war economic boom during the Cold War. However, the mass cultural verdict that nukes are appalling, and strategies for using them insane, did not significantly impede the superpowers' efforts to build bigger, better ones. This is also where influences harder to fathom from surface readings of fiction have to be reckoned with. Did the fear of nuclear holocaust help ensure that the weapons were not used after Hiroshima and Nagasaki? Or do all those post-apocalyptic tales have a perverse appeal, speaking to a dark desire for destruction? Either seems plausible, up

to a point.

More straightforwardly, it seems SF is more likely to prefigure actual technological achievements than to offer effective warnings against them. As Csicsery-Ronay says, “The desires and anxieties crystallised in the playful myths of sf prepare the ground for real scientific projects”. The anxieties do so as readily as the desires.

3. Seeing is believing

The unchoreographed *pas de deux* between science fiction and technology continues to unfold, even as SF alters its forms and styles. Since the “Golden Age” of hard science fiction we have had waves of fiction which explore “inner space” in preference to outer space, cyberpunk fiction which depicts futures *noir*, with dirt in the corners, and a raft of other new genre blends and style shifts. The older pleasures of hard science fiction and space opera remain on offer, often from authors with a broad command of the genre. Many SF authors began as fans, and cherish the writers who first drew them in.

More important in terms of cultural influence has been a large shift in popular awareness of SF storytelling through cinema. This now extends to regular SF blockbuster movies, but the influence of earlier film and TV efforts such as *2001* and *Star Trek* also lingers. Often the stories are very familiar and rather simple. In terms of technology, film has a strong, and complex influence. Developments in cinematic technology are vital to the continuing success of these films – ever more spectacular effects are part of the appeal. Most of the effort, properly and often satisfyingly, has gone into showing us other worlds, aliens, monsters brought back from extinction and *really* big space ships. But modern effects also allow convincing visual depiction of

more plausible technologies, providing memorable reference points for real-world developers.

In addition, this influence is designed , as it were, more often in film than in print. The history of hiring technology experts to help develop the "look" of a film goes back to *Frau im Mond*, and has added many layers since. Increasingly, SF film-makers are consciously designing possible futures; the images they create have become the touchstones for most media commentary on SF and technology, as a few classic examples illustrate.

Star Trek

The original *Star Trek* episodes have, over time, spawned new series, a movie franchise, novelisations, a fan-generated literature filling out (fictional) details of much of the hardware – not to mention alternative sexualities for favourite characters - and, not least, a number of retrospective analyses of how the visions of the makers have influenced subsequent technologies.

These last tend to feature claims from developers that they were inspired by *Star Trek*. For instance, Martin Cooper, who led the team behind the first cellphone – demonstrated in 1973 – has said it was inspired by the *Star Trek* communicator. Look closer, though, and it seems more likely that he used the image to help him put his idea across. He was already working for Motorola's Communications Systems Division on hand-held police radios, so the personal phone was hardly a giant conceptual leap. In the 1970s and 80s, *Star Trek* was more noteworthy for conveying a general, geeky enthusiasm for one brand of Americanised future. The first personal computer was named the Altair 8800 after a fictional galaxy from *Star Trek*. Naming NASA's first space shuttle "*Enterprise*" testified to the devotion to the series among many senior engineers, including Marc Raymon of the Jet Propulsion Laboratory.

More recent claims that R&D is working toward, for instance, Dr McCoy's tricorder, are more to do with convenient ways of promoting one's project than any more tangible connection with the props of the *Star Trek* universe.

2001: A Space Odyssey

The Clarke/Kubrick classic is a different case. The film saw existing and already planned space technology extrapolated with great care and attention to detail, with full-time help from consultants deeply involved with contemporary space programmes. The depiction of future space travel seemed astonishingly convincing, to the extent that later commentaries often express surprise or regret that the kind of routine access to orbit seen in the film has yet to be offered to paying passengers. It is seen as a prediction that failed (so far) for social, political and economic, rather than technical, reasons. The other notable technology in the film, the intelligent computer HAL, is a more standard addition to the lineage of computers-with-personality.

Visualising technologies to make them seem real

As SF films exploit the growing technological sophistication of the medium, the cinematic realisations of not-yet existing technology became more and more convincing, and often more memorable. In a few interesting cases, this has been used more deliberately to give particular technologies, themselves visually oriented, a higher profile.

Lawnmower Man (1992) was the result of the director's effort to create a modern "technological mythology" around interactive technologies, and introduced the idea of virtual reality (VR) to the wider public. What is "real" and what is artifice here gets a tad confusing. As film scholar David Kirby notes, the film-makers were "not creating an actual VR experience, but rather visualising an imagined VR experience". That is, they were using the non-immersive, but nonetheless powerful, medium of cinematic visualisation to convey an idea of what VR *could be like*.

This imagined VR is depicted in the context of a horror film which tells a story of technology gone awry. But we still see it in action. Using computer-generated imagery to show something called VR, a term then recently popularised by Jaron Lanier, helped draw attention to the possibilities of immersive digital media yet to come. And it boosted R&D and investment in VR. Kirby tells us that the director "was asked to give numerous speeches at scientific and business gatherings on the topic. Most significantly, *the film became a shorthand reference that researchers used to easily convey the concept of VR*" (my emphasis). Film, like SF in print, offers resources for technology promoters to use in many other contexts.

The computer interface in *Minority Report* (2002) is similar in looking unusually convincing as a cinematic visualisation. It came from an even closer relationship between film-makers and technologists. The script-pivotal technology here is a predictive capacity based on analysing information about who is going to commit a crime in future, allowing preventive action. This fantasy, though, is set in the context of an intelligence HQ adorned with gestural computer interfaces.

The interface is convincing, Kirby points out, because the film's technical consultant devised an entire vocabulary and syntax for the gestures the actors – most memorably Tom Cruise – use to issue commands to the computer. The fluid interaction between gestures and visual display, familiar now in some ways when touch-screen tablets and phones are ubiquitous, seemed magical and rather beguiling at the time, in spite of the sinister overtones of the computer's surveillance functions.

Kirby argues that promoting a technology in film is sometimes intentional, and more effective at displaying a technology's worth than an actual prototype – even if a real prototype is possible. The film *Threshold* (1981), for instance, follows a script which makes it a more or less a feature-length commercial for artificial heart transplants, using technologies then under development.

Minority Report is a slightly different case. The depiction of the technology is

certainly convincing, but it was not feasible at the time the film was made. However, as Kirby points out, “cinematic texts require technologies to work. And for this one visual realism was achieved by enlisting help from people who *wanted to develop* precisely what was being depicted”. It is a new kind of self-fulfilling prophecy, “creating ‘pre-product placements’ for technologies that do not yet exist”. The consultant John Underkoffler worked up the cinematic depiction as if it were an actual prototype. He was already on the path from experimental set-ups at MIT to a company commercialising this kind of interface, but the film made it easier to sell the whole concept to investors.

4. **Favourite examples- Futurism and neologism: Cyberspace and nanotech.**

These specific links between SF and technology remain unusual, and mainly derive from the affinity between film and the technologies in question. The more complex interactions between fictions and technology have also deepened. Technologies which feature prominently in SF at various times and R&D efforts which may be related to them still exhibit diffuse but real influences in both directions.

Two conspicuous examples in recent decades have been the integration of computer networks which has come to called cyberspace, and the harder to define cluster of ideas covered by the umbrella term nanotechnology.

The cyberspace story is well-known. William Gibson was struck by the intimate relationship some early personal computer users had with their kit. It seemed to him that they wanted to get inside their computers. What would it be like if they did? Where would they be? A little reflection on compound words led him to *cyberspace*, and he described what it was like to enter cyberspace in a novella, *Burning Chrome*

and then in his 1984 *Neuromancer* and subsequent novels. He and a few fellow SF authors were consciously striving to produce fictions which updated the genre's technological visions to take account of what they saw happening around them – at least according to Bruce Sterling in 1986:

"The cyberpunks are perhaps the first SF generation to grow up not only within a literary tradition of science fiction but in a truly science-fictional world. For them, the techniques of classical "hard SF" – extrapolation, technological literacy – are not just literary tools but an aid to daily life. They are a means of understanding, and highly valued." (From intro to *Mirrorshades*, 1986.)

The idea that late twentieth-century life was happening in "a science-fictional world" has become popular, along with the notion that life after 2000 is living in the future. Both testify to the way science fiction permeates the culture, and reinforce the notion that it is a kind of fiction that allows glimpses of future technologies. Many maintain that happened again with the creation of cyberspace.

Gibson is no technologist, as he is the first to admit, and his richly imagined sensory immersion in a virtual dataspace bears scarcely any resemblance to the contemporary experience of web-surfing. Nevertheless, *Neuromancer*, and other "cyberpunk" novels were widely read by computer hackers and coders. Julian Bleecker describes reading *Neuromancer* as a "rite of passage" for computer and virtual reality researchers. The term cyberspace has had many uses – as an inspiration for software and hardware designers, as a general shorthand for the information environment to which networks afford access, and as a subject of weighty academic analysis and political promotion or critique. The spatial metaphor is particularly easy to relate to, and it seems likely – though maybe not inevitable – that it would have been invoked at some point in the development of computer networks. Metaphors, like technologies, always constrain as they enable. Someone should (or maybe has?) combine a technical-historical-cultural analysis and critique, and consider whether the

dominance of the spatial metaphor has made the internet better or less good than it might have been otherwise But that would go well beyond the bounds of a review of SF and technology.

Meanwhile, there are claims that the actual work of computer scientists and software engineers was strongly shaped by a collection of key cyberpunk texts. The arguments here are overplayed. Mark Pesce claims that recent science fiction "has been *the* defining influence on the direction of software systems development". What he then describes is a role for particular texts in crystallising a hacker subculture, and energising efforts to realise particular goals. He does not, though, consider how these relate to influences from the internal development of the disciplines involved, or from demonstration projects in key labs. Yes, the fiction mattered to some of the people involved, but how it mattered is less clear.

More specifically, Jeremy Bailenson and colleagues document how "well-known virtual reality researchers collaborated with cyberpunk authors" and that "cyberpunk texts are treated as serious academic texts in virtual reality courses and research". They too go on to make a strong claim, based on close study of four key SF novels: Gibson's *Neuromancer*, Verner Vinge's *True Names*, Neal Stephenson's *Snow Crash* and Rudy Rucker's *Software*. They say they can "demonstrate that *the research agendas chosen by scientists… as well as the specific hypotheses tested… are either implicitly or explicitly shaped by earlier works of science fiction*" (my emphasis). However, the research agenda they examine – involving aspects of virtual reality such as avatar realism, presence, plasticity of behaviour, and virtual social interaction – could equally well arise logically from consideration of the ways the metaphor of "virtual reality" might be realised. The fact that three of the authors cited – Stephenson, Vinge and Rucker – have worked in computer programming or mathematics at a high level, also indicates that the technical informs the fictional here as much as the other way round. Once again, we have an echo chamber, with selective

amplification, rather than a simple matter of influence.

Nanotechnology is an even harder case to analyse clearly. It is partly an extension of materials science, with finer control over the composition of the product, down to the molecular or even atomic level. It is also a label for a much broader collection of ideas, involving nanometre scale devices – equipped with some power source and computing and communication capacity – which would be able to do many wonderful things. The ostensibly non-fiction accounts of the latter prospectus often draw on science fiction tropes, a habit that extends on occasion to government reports.

These science-fictional roots of the more exotic possibilities of nanotechnology often attract comment. It is pointed out, for example, that the now well-known talk by Richard Feynman, "*There's Plenty of Room at the Bottom*", which has been retrospectively interpreted as a founding text for nanotechnology was almost certainly informed by Robert Heinlein's 1942 novella Waldo, in which robot manipulators meake ever-smaller versions of themselves. Conclusions about the significance of these SF influences differ widely. Some say that nanotechnology concepts are inherently science fictional and that this is a bad thing. Others maintain that it is true but does not matter. Science fiction either helps or hinders funding, confuses or informs policy-makers, inspires support, or raises unrealistic expectations and evokes public fears. It is not necessary to adjudicate all these claims. The field of interactions is complicated enough that all of them may have been true at some point. But it seems inescapably true that discussion of nanotechnology and its potential has always been a science fiction discourse, even when the point being made is that some claims are "science fiction" and therefore illegitimate.

The specifics of nano are at the moment both too broad, and too vague, to allow the kind of retrospect favoured by SF-as-predictor of future technology advocates. It seems fair to say, though, that nanotechnology would not be where it is today, in terms of public awareness and, probably, institutional support, without the large body

of nano-infused SF which emerged from the 1980s onwards. As Chris Toumey puts it, "Nanotechnology needs a language that describes the future because, no matter how good the science is now, most of the technology is still over the horizon." In that sense, the language used *is* inherently science-fictional.

Daniel Thurs notes that there were numerous invocations of "science fiction" in media discussion of information technology and biotechnology in the 1990s. Such mentions were more commonly found linked to nanotech after 2000. In his view, science fiction was significant not as the origin of ideas, but as "a place where such ideas and their various implications could be depicted and explored without the usual restrictions imposed by grant proposals, peer review, technical arguments, or the inconveniences of natural law".

The way he elaborates on this sums up one role SF plays in familiarising lay publics with imagined technological possibilities. "Science fiction has provided the resources to imagine the fine details and multiple layers of scientific futures by spinning a wide variety of potentially useful interpretations, building an array of bright and interesting potential worlds, and generating reservoirs of cultural value and significance around ultimately imaginary objects". The result in nanotechnology has been extended argument between researchers who are comfortable with the science fictional implications of their visions for the field, and others who deny that the actual work has anything to do with science fiction.

5. Favourite examples - Old but still new: robots in myth, SF and science

Some areas of technology which were not readily imagined when science fiction began to grow 100 years ago now appear in fiction. One, though, continues to develop which has figured in stories of technology futures throughout. Fictional robots still

abound – especially in films. They are also an increasingly widespread technology, in various forms, and the focus of work in many academic and industrial labs trying to develop next generation robotic technologies.

Robotics has been as intimately intertwined with science fiction as nanotechnology, perhaps even more so, and for much longer. Both the words "robot" and "robotics" were coined by fiction writers. Robot comes from Karel Capek's play *RUR* in the 1920s. Even though his robots were biological, so would now be termed androids, and the play is a parable of class warfare, it has its place in science fiction history. Robotics was coined by Isaac Asimov, the hard SF, pro-science author famous for fictional robots, and for the three laws of robotics – supposed guides to machine conduct which are still discussed in academic seminars on robot ethics.

The history here is extremely rich, and extends back long before the origins of SF. So what can we make of it? One interesting observation is that, in contrast to nanotechnology, researchers often cheerfully acknowledge their science fiction inspirations. The founder of the first successful industrial robot company, Joseph Engelberger, cited Asimov as a direct inspiration, even though the one-armed paint sprayers and spot welders his company sold were far from humanoid. Asimov wrote the foreword to Engelberger's book *Robots in Practice* (and discussed his three laws again).

The field in general seems to hold science fiction in great affection. Artificial intelligence pioneer Marvin Minsky (whose work ties in with many robotics projects) maintains he reads no other kind of fiction, a conviction, or possibly aesthetic self-denial, he shares with much of SF fandom. He also collaborated with SF author Harry Harrison on the novel *The Turing Option*. MIT roboticist Rodney Brooks says that seeing HAL in *2001* as a teenager inspired him to dedicate his life to building intelligent machines. Minsky and Brooks are part of a continuing strand of influence at MIT. Stuart Brand, in his portrait of MIT's Media Lab in the 1980s reported that

"science fiction is *the* literature of MIT". Robert Geraci, whose study, *Apocalyptic AI*, traces links between the popular science works of Hans Moravec, Ray Zurzweil and others, and religious visions of transcendence of the human condition, also remarks how these visions have been re-worked in science fiction novels such as Clarke's *The City and the Stars* (1953), which features mind-uploading. Although the pop-science of Moravec and Kurzweil is not, apparently, a big presence in robotics research, science fiction probably is. Geraci reports doing an online survey of "robotics enthusiasts" which found that 80 per cent of them occasionally or regularly read science fiction, and another 13 per cent used to read it.

Commercial robotics displays SF influences too. According to P.W. Singer's study of military robotics, *Wired for War*, the robotics research group at iRobot (makers of many successfully marketed robots including the Roomba cleaner and bomb-disposal robots) could not decide whether "making science fiction reality" or "practical science fiction" was the better slogan. Cynthia Breazeal, who fashions media-friendly "social robots" at MIT, tells interviewers that her interest in robots began with *Star Wars* and "seeing R2D2 and C3PO. I fell in love with those robots".

There are also innumerable demonstration projects, exhibits and media stunts, going back to the 1930s or earlier, which play to media appetites for humanoid robots. Direct tributes to science fiction in this form are common nowadays. An animated figure with the lovingly sculpted face of Philip K. Dick and equipped with artificial intelligence software allowing it to synthesise a conversation from a database of the great man's own words is an endearingly extreme example. The robot scene in Japan, in fiction and media, is rather different from that in English-speaking countries. The fictional robots in comic books and animated film are typically friendlier. Still, Honda's walking robot is called Asimo, and was taken to Prague to place a bouquet before a bust of Capek. And so on.

Amid all this, it is difficult to weigh up whether the welter of SF depictions of

robots have directly affected research, or simply share common roots. The popularity of fictional and non-fictional robots is partly a result of the age-old fascination with the possibility of creating machines which are human-like. The imagery is clotted, over-familiar and often visual. What, then, has been the influence of SF on actual technology in robotics?

As with nuclear weapons, innumerable fictional and filmic depictions of robots menacing humans have done little to dampen enthusiasm for real-world robot projects. They may even add to their appeal. As Paul Brins records, early audiences cheered Arnold Schwarzenegger's back-from-the-future robot assassin *The Terminator*, not Sarah Connor.

So, as ever, the effects are complex and hard to trace clearly. It is safe to infer that robot fictions have made it easier to communicate ideas about (some) potential real world projects. They help sell research. But the emphasis, near-obsessive, on humanoid robots means that much actual research has moved further and further away from the kind of robots that predominate in fiction.

Robotics researchers who answered questions on the topic for this review all agreed that SF has both helped and hindered research, for that reason. "People have unreal expectations for what the machine can do and what the technology is currently capable of achieving." (Brian Duffy). More elaborately, "The problem is that most people's understanding of what a robot is comes from TV and the movies and many are disappointed to discover that real robots fall far short of the ones in SF movies. This leads to an 'expectation gap' and also to the sense that roboticists have failed to deliver. Although it's true that early roboticists over promised (and frankly some still do), the perceived failure of robotics is – in my view – primarily a failure to live up to a fictional expectation, and therefore not a failure at all." (Alan Winfield) Similarly, for Uwe Zimmer "a movie like 'I Robot' exploits the pretty looking and emotional side of storytelling by depicting unnecessary and undoable developments. This

hinders robotics as it raises utterly unrealistic and not even meaningful expectations."

As Thomas Disch puts it, real robots "lack the anthropomorphic robot glamour of 'iron men', the pathos of being intelligent but soulless, and the high drama of rebellion against one's creator."

6. Shaping technology - consciously or otherwise

What the authors say

With occasional exceptions in cinema, the examples examined so far fit the generalisation that influences of SF on technology are largely inadvertent. The creativity of actual writers broke the bounds of Gernsback's programme, even while SF remained pulp literature, and authors were usually more interested in other goals than in being didactic about science or promoting technological wonders to come. When that happened it was unintentional.

In print SF, broader aesthetic and social intentions still rule, and many authors – be they ever so scientifically well-informed – are better equipped to realise them. Some, perhaps a minority, retain a concern to write at least some stories firmly rooted in actual technology. This is apparent in responses from two dozen authors – predominantly ones who have a science background – who responded to questions about SF and technology for this paper. Larry Niven, for example, says that his stories are usually inspired by some current discovery, and that he tries to make valid predictions. The majority of this small sample, though, emphasise that the technology should ideally be plausible, but they will stretch the bounds of plausibility if the story requires it. Nor do they set out to influence technology – though they do cite a range of other technology-related motivations. For example: "Science fiction is more concerned with exploring the human consequences of technological development rather than influencing its development" (James Gunn). Peter Hamilton concurs: "I'm

more interested in the impact technologies have on societies than the actual gadgets themselves. I'll try and avoid endless detail of the machine, and concentrate on how people use it and to what effect."

Kim Stanley Robinson owns up to a wish to influence technology, "only if you define justice as a technology (which I do)". Similarly, John Courtney Grimwood suggests that "If I could influence anything I would want it to be social structures". Others have turned to non-fiction when they had a specific intent to influence discussion of technology. David Brin cites his non-fiction analysis in *The Transparent Society: Will Technology Make Us Choose Between Privacy and Freedom?* "In that work, the notion is that technological enhancements in vision should be openly shared, so that top down surveillance is countered by bottom-up 'sousveillance'." As well as these responses, though, there was a larger group of these relatively tech-savvy writers whose response to being asked whether influencing technology had been any part of their intent as writers was a simple "no". Some still agreed that SF can influence technology, though perhaps because, as Damien Broderick pointed out helpfully, "anything can influence anything".

The meta-narrative: Becoming conscious of fictions, technology and their interactions

However, there are other reasons to think that the influence of fiction on technology in the future will continue. There is one simple thing to notice in a literature review about the interactions between (science) fiction and technology: there is literature to review. These reflections try and distil a fair mass of material that comments on the interchanges between science fiction and technology. It blends several currents. As well as ever-more extensive catalogues of science fiction inventions, there are more scholarly historical analyses of the exchanges between science and science fiction.

There are also more and more retrospectives of futures past, in print and on the web, often lavishly illustrated with old images of high-tech futures and cataloguing their predictive hits and misses. The more interesting ones go beyond flip commentary or mere nostalgia, and reflect on how we think of futures and technology, and what past envisioning might teach us about the technological futures we imagine from now on.

The back and forth between fictional storytelling and the narratives implicit in new technological projects is a feature of late industrial culture of which we are increasingly aware. Laying bare the way this interaction has developed historically evokes a new self-consciousness of the possibilities it may hold for the future.

A good example of how this self-consciousness manifests is the paper *"Resistance is Futile": Reading Science Fiction Alongside Ubiquitous Computing* by Paul Dourish and Genevieve Bell.

The authors are noted researchers in ubiquitous computing (ubicomp to its friends). They present an analysis of several US and UK television series – ubiquitous SF – chosen because they watched them when young. Now, as experienced researchers, they see them as texts which can be read illuminatingly alongside the subsequent history of ubiquitous computing, as part of the cultural background which shaped that research and how it was deployed.

Whether or not they are right to claim that ubicomp stands out for the breadth and depth of science fictional influences which are apparent in the way aspects of the technology have materialised – and a case can be made for numerous other fields of technology – their essay stands out as an example of this influence moving up a level. It is an effort to look back on these narrative and technical trajectories, and reflect on their entwining. That kind of thing feeds in to the awareness of future authors of stories, but also of technologists, designers, and even policy-makers.

7. Exploiting fiction

Data mining – getting tech ideas out of science fiction

One response to the growing corpus of SF is to go back into the archives and see if there are ideas worth pulling out. The fact that science fiction often contains ideas about not yet existing technologies, and what they might be able to do, has prompted some attempts to exploit science-fictional thinking directly.

The European Science Foundation took a close look at existing science fiction a few years ago to see if there were any ideas in the stories which might be worth considering for planned space projects. Might older stories contain ideas which were potentially realisable using technology developed since?

"The main objectives of the study", they said, "were to review the past and present science-fiction literature, artwork and films in order to identify and assess innovative technologies and concepts described therein which could possibly be developed further for space applications. In addition, it was hoped to garner imaginative ideas, potentially viable for long-term development by the European space sector, which could help in predicting the course of future space technologies and their impact."

The resulting publication covers a range of technologies, including propulsion, computers and communications, robots and cyborgs, and launch systems. They are delineated in suitably deadpan fashion. Thus, for propulsion of starships we are told that "Much more advanced technologies are based on systems that do not require reaction mass, the stuff that pushes the rocket forward. The control of gravity is very popular here. David Weber describes a powerful drive in '*Path of the Fury*' (1992). Each ship can generate a small black hole in front of itself. As the ship falls toward the hole, the hole is moved by the ship – thus the ship continuously falls and

accelerates.". There is no comment on the feasibility, or otherwise, of this plan, beyond the observation that "Going to the stars will require a great leap in the conversion of known science into usable tools".

A similar piece of proto-data mining is on offer in a 1980s study of robots. Neil Frude's study, *The Robot Heritage*, surveyed all the robot stories he could find, and treated them as thought experiments about how humans might respond to robots of many different designs and capabilities. His work is not linked to any actual technological projects. He argued that in the absence of the actual robots, well-wrought fictions were the best way to investigate human-robot interaction, and assess what kind of robots might find favour with future customers. "Science fiction can be used to put flesh on the bones of technological promise." The comment is in line with my introductory interpretation of the technology complex and how to visualise it.

Not to be outdone by ESA, NASA has also taken an interest in science fiction, but by sponsoring new work rather than scanning existing stories. The Goddard Space Flight Centre has a deal with publisher Tor Forge books to develop a series produced by partnerships between scientists and engineers and writers. This is more of a science awareness project than an attempt to influence future technology directly, but it signifies that the centre thinks science fiction matters, at least. It has also joined with the Defence Advanced Research Projects Agency (DARPA) on a 100 Year Starship Study – aimed at outlining a path to building a craft capable of interstellar travel a century from now – which began with a workshop of "visionaries" including science fiction authors.

DARPA is widely known as a research sponsor with an extremely open agenda which readily accommodates science fictional ideas. This is typical of defence and national security agencies, which can be positively avid users of SF, especially in the

US. The high-point of this influence is probably Ronald Reagan's 1983 prospectus for a "Star Wars" programme, the Strategic Defence Initative (SDI), keeping America safe from missile attack with lasers and particle beam weapons. Some of the SF writers who do have ambitions to influence technology have helped build these links between imagining technology and R&D. This is not so much a matter of direct influence on technologists. Science writer William Broad's Star Warriors, which chronicles a week spent with young designers trying to make laser anti-missile weapons a reality at the Lawrence Livermore Laboratory, makes scarcely any mention of SF. Rather, SF feeds into the unacknowledged underpinnings of policy. Former space programme engineer turned fiction writer Jerry Pournelle was one of the most active influencers, helping assemble the Citizen's Advisory Council on National Space Policy, which also included authors Poul Anderson, Greg Bear, Robert Heinlein, Greg Benford and Dean Ing. Their main mission was stoking enthusiasm for space technology, but they also helped convince Reagan that ballistic missiles might be destroyed in flight, if you had a working ray gun. Mind you, the actor President may have been half convinced much earlier in his career, when he starred in the 1940 spy movie *Murder in the Air* as an American secret agent. The agent's task: protecting a new superweapon, the "Inertia Projector" which destroyed enemy planes in the air. As the vast investment committed to the Strategic Defense Initiative has been credited with adding to the economic stresses on the Soviet Union which led eventually to the end of the Cold War, this may be the largest ever consequence of a technology which began – and remained – essentially fictional.

Whatever the verdict on *Star Wars*, the US Defense Advanced Research Projects Agency continues to fund speculative projects with a distinctly science-fictional flavour, and to draw on science fiction writers as consultants and brainstormers. Shaun Jones, the former Director of DARPA's Unconventional Countermeasures programme recently described it as "the US government's science fiction agency".

Sometimes fiction and ostensible non-fiction get mixed up, as when the Institute of Soldier Nanotechnologies filched an image from a science fiction comic to publicise its effort to fashion the gear for the "soldier of tomorrow". More often, the two are deliberately brought together, to fertilise technological agendas with far out, even fanciful ideas. The same is true for the Department of Homeland Security, the extra defence department which the US added after 9/11. We may safely assume that this will continue. There is even a "public service think tank" run by Arlan Andrews, SIGMA, which "comprises forty science fiction authors who provide pro bono futurism to the Federal government and appropriate NGOs. As professional writers who have spent our literary careers exploring the future over an extreme range of possibilities, we have brought a new way of thinking to some government officials. SIGMA members have consulted with many Federal agencies in recent years, most publicly the Department of Homeland Security, about innovative ideas for dealing with issues of national concern. We offer practical futurism for the benefit of the nation and humankind."

Design fiction – putting tech ideas into science fiction

Science fiction as a resource for research agencies anxious not to miss any possibilities may be useful, up to a point. More interesting is another scattered, but growing, effort which follows from the increased consciousness of the relations between science fiction futures and technological development. This is a collection of deliberate attempts to make use of science-fictional products – sometimes actual stories but in a range of other forms as well – to evoke discussion of particular technological possibilities which are on the horizon but not yet presentable as real artefacts.

Some of these, ironically, have a slightly old-fashioned air. Neal Stephenson, for example, is currently editing an anthology, known as the *Hieroglyph Project*, which

will feature stories depicting ambitious technologies. The title follows the Hieroglyphic Theory, that "Good SF supplies a plausible, fully thought-out picture of an alternate reality in which some sort of compelling innovation has taken place. It has a coherence and internal logic that makes sense to a scientist or engineer, and provides them with a template that they and their colleagues can use to organize their work. Examples include Asimovian robots, Heinleinian rocket ships, Clarke towers, and Gibsonian cyberspace. As Jim Karkanias of Microsoft Research put it, when I was discussing this with him later, such icons serve as hieroglyphs – simple, recognizable symbols on the significance of which everyone agrees." His thesis it that there is not enough of this kind of thing appearing nowadays, because so much science fiction has become dystopian. The project will try and overcome this. He elaborates: "The ideal subject matter would be an innovation that a young, modern-day engineer could make substantial progress on during his or her career. It's linked to a new entity at Arizona State University called the Center for Science and Imagination which will foster direct collaboration between SF writers, researchers, engineers, and students."

If this is avowedly old-fashioned, deliberately harking back to the style of SF more commonly seen in the 1950s, the Arizona State Center has also taken an interest in some of the more novel efforts to link SF with technologies in the making. These go by various different names, including *speculative design*, *design fiction, science fiction prototyping* and *interaction design* They all tie realistic technological possibilities to efforts to imagine worlds in which they might be used. Sometimes, the starting point is a design. Sometimes it is a story. Sometimes the two are presented together. Sometimes one is intended to help provoke the other. Sometimes science fiction is not even mentioned, but the affinities are still clear.

Always, the point is to make use of imagined futures to refine or challenge thinking about design projects and innovation. Some examples help show what this means.

Intel's futurist Brian Johnson promotes "science fiction prototyping", which he describes as using "science fiction based explicitly on science fact as a design tool in the development of technology". The old technology of storytelling is reframed in new terms. In science fiction prototyping, the story functions as "a virtual reality in which the implications, problems and benefits of the technology can be explored. This exploration could uncover both best case and worst case scenarios but it can also explore the subtleties of how people will use and interact with the technology."

He suggests that this takes some recent trends in science fiction a step further. "Authors such as Vernor Vinge (*A Fire Upon the Deep*, *Rainbows End*, *True Names*), Greg Bear ([Moving] *Mars*) and Cory Doctorow (*Down and Out in the Magic Kingdom, Makers, Little Brother*) readily point out that their fiction is not only based upon emerging science but they are in fact looking to use their fiction as a means to not only affect that science but also how that science is perceived and used in the real world".

Johnson defines his ambition with two questions: "Can we use science fiction as a means for understanding and exploring science before it is invented? Can we use science fiction as a tool for the development of science fact? The framework of the SF prototype allows us to accomplish just this goal."

His project has grown to include anthologies of stories which meet his brief of imagining worlds in which specific technologies – usually information technologies – have found a place. They explore the possibilities of what he calls "a productive middle ground between fact and fiction".

In another essay, he expands on this as follows:
"Science fiction prototypes allow us to create multiple worlds and a wide variety of futures so that we may study and explore the intricacies of modern science. They are a

powerful tool meant to enhance the traditional practices of research and design. The discoveries that we make with these prototypes can be used to question and explore current thinking on a level we have not approached in the past; namely using multiple futures and realities to test the implications and intricacies of theory. Additionally the output of the science fiction prototype can inform a technology's consumer experience architecture, investigating and shaping how a user might encounter, explore and ultimately use that technology. Science fiction allows us to see ourselves in a new light, in the light of a new future; one that is not our own but reflects directly upon who we are and where we might be headed. The science fiction prototype brings this same lens to science fact; allows us to see the multiple futures in the theory we are constructing today." Again, it seems fair to summarise this as using stories deliberately to explore possible configurations of a technology complex.

Johnson's work is design-oriented but text based. Julian Bleecker writes about texts, film and actual designs in an essay reviewing design fiction. He suggests that each product of design fiction is a conversation piece. The conversation is about "the kinds of experiences that might surround the designed object". This leaves open whether the object needs to be built – and realised design fictions range from text with illustrations, to objects which model the design without actually doing what is proposed, to more or less working prototypes. All generally come with explanatory framing which invites further discussion of the technology and its place in possible futures.

The focus is on the near-term future (or futures). As he puts it, "Design fiction prototyping fashions tangible, materialized story elements that are simultaneously speculative and imminently possible". It is ambiguous whether the designs in question can or ever will be made. "Design fiction does not create specifications for making. Rather design fiction creates specifications for imagining… It is also a way to begin

conversations that question assumptions about what the future is for, what it contains, and what counts as an advancement ‹forward› towards a better, more habitable near future world."

James Auger has another formulation, Speculative Futures, the "hypothetical products of tomorrow". Design fictions depict such futures, and "effectively act as cultural litmus paper, either offering tasters of how it might be to live with the technology in question or challenging contemporary applications of technology through demonstrable alternatives".

One of the more influential contributors to design fiction, through his own practice and through the work of numerous students, is Anthony Dunne, who writes of "critical design". Again, the point is to illuminate alternatives. "Critical Design needs to be closer to the everyday, that's where its power to disturb comes from. Too weird and it will be dismissed as art, too normal and it will be effortlessly assimilated. If it is regarded as art it is easier to deal with, but if it remains as design it is more disturbing, it suggests that the everyday as we know it could be different, that things could change."

What's new?

Design fiction is partly a new label for an old practice. All design can be read as design fiction before it is built, for the reasons already given. The artfully rendered images on the billboards around construction sites, showing people enjoying the finished plaza or mall, are a kind of design fiction, though one designed to close down discussion rather than open it up.

Alexandra Midal goes further and suggests that the entire history of design is entwined with the history of science fiction, from at least as early as William Morris's *News From Nowhere* in 1890. That may be overstating the case, but even if design fiction is confined to construction of actual objects which are representations of possible technologies rather than fully working prototypes, there are examples from the past which fit the frame. The multitude of demonstration robots and mock-up space ships come to mind. So do the motor industry's fondness for "concept cars", and the many World's Fair exhibits, such as the often discussed Futurama display at the New York fair in 1939. Indeed, you can read the entirety of Worlds Fairs as a collection of design fictions in "Sfnal" spaces where time and space are compressed in a way which moves visitors towards future-oriented speculation. A more isolated instance is the use by John C Arnold, a mechanical engineering professor at MIT, of a fictional planet with very different physical and biological features to our own, to teach "creative engineering". His 1950s students were invited to design products which would suit the inhabitants of Arcturus IV in the year 2951. The exercise went down well with his students, but did not catch on at MIT. It turned out that "not all the members of the faculty felt completely comfortable training their undergraduates to, as they saw it, illustrate the covers of science fiction magazines".

The newer element in current design fictions, which is helping them spread their influence, is the self-consciousness about the cultural work that such depictions do, and might yet do. The story we are telling ourselves about the relation between imagination and technology is changing, and so the way we try and tell stories about technology is changing, too. Stuart Candy's term "experiential futures", which he uses to denote "a range of interventions and media from immersive performance to stand-alone 'artifacts from the future'", is another useful shorthand for the intent to find ways of thinking about possible worlds.

The growth of a playful, freewheeling design practice, open to ideas from many sources, inviting conversation, technically informed but not constrained by *immediate* feasibility, does have many affinities with science fiction, as well as with the growing catalogue of sci-art projects. The diegetic prototype in cinematic or video realisations is more costly to pursue, but is a closely related idea which could also be taken up in ways not confined to the kinds of narratives seen hitherto.

Recognising these possibilities can open up a range of uses of design fictions. They may appeal to corporations which are serial innovators, which always need to configure new offerings to reduce the chances of an innovation being lost in the "valley of death" between a bright idea and a successful product. They find wider use among those who want to encourage wider debate about possible futures and their technological ingredients. The two are not necessarily incompatible. There is mutual interest in harnessing technological potential to best effect to improve the chances of living the lives people wish for.

8. A new role for stories?

So this paper ends where it began, with stories and their place in the technology complex, and as shapers of that complex, but perhaps those stories are now sometimes treated in a more sophisticated, open-ended way.

We have seen that the connection between the stories embodied in technologies, or designs, and fiction form an intricate, evolving web. Efforts to pinpoint causes and effects are rarely convincing. They might not be especially useful even if they were. We are discussing the weaving of culture, and no individual case is likely to be repeatable. But there does seem to have been a gradual, general movement over time.

It can be roughly summarised.

- Technology, and plans for technology, revolve around stories. These, minimally, say: we will make a thing that does this.
- Science fiction asks, if we made a thing like this, how might the world look? What effects might it have?
- Design fiction says: here is a thing we could make: what do you feel about a possible world that has such things in it?

These kinds of stories are not mutually exclusive. Each can influence the other. Technologists promoting their projects can adopt ideas from science fiction to say: the thing we will make will be *like this*. In film, they can sometimes insert the image of what they hope to make. People who want to discourage particular technological projects can of course do likewise. Design fiction is more like an open question. If the capacity to make things like this comes about, what would we like to do with it? Nor do any of the stories necessarily have the effects their authors hope for. But all three benefit from the illimitable flexibility of fiction. As Rudy Rucker put it, before design fiction was conceived: "The reason why fiction thought experiments are so powerful is that, in practice, it's intractably difficult to visualize the effects of new technological developments. Only if you place the new tech into a fleshed-out fictional world and simulate the effects on reality can you get a clear image of what might happen." Or, more briefly, when it comes to technology assessment, "inspired narration is a more powerful tool than logical analysis".

A few further questions…

Some of the limitations of this paper will be clear by now. Time, authorial inadequacies and the inherent difficulty of tracing "influence" are all part of the reason. There are some limits which might be overcome with further research, though. They can be put as questions.

The most obvious is which generalisations hold up if one looks more closely at a broader range of technologies. This paper looks at some technologies which have featured strongly in science fiction – rocket ships, biotechnology, computers, robots and nanotechnology. It has paid less attention to, for example, energy generation, food production, personal transport and medical care. Discussion of science fictions and technologies most often features the topics highlighted above. There is relatively little in science fiction about food, for example (though we do see food pills, GM, cultured meat, synthetic food and Soylent Green), and energy generation, if it is mentioned at all, is usually achieved by the same kind of hand-waving physics that furnishes faster than light drive. Still, there are enough examples of both to bear further scrutiny.

More generally, it would be interesting to investigate in more depth whether there are some areas of technology (or potential technology) which are more "science fictional" than others – at least for now (the boundary of course shifts over time). The suggestion that nanotechnology, in its more exotic incarnations, is science fictional because it exists only in the future (if then) seems sound. Are there other technological projects of which this is true? Faster than light travel and time travel are obvious candidates, but less interesting to discuss because according to the best current science they will remain impossible. The cases to examine are those non-fantastic ones where the idea cannot be pursued at present, but is in principle perfectly plausible. One which is important in current debates is terraforming – altering the conditions of other worlds to make them more Earth-like. This is an entirely notional project at the moment as we do not have access to any other planets. However, the extensive fictional accounts of how it might work, most often on Mars, play with ideas which are also relevant to the more recently fashionable idea of geoengineering, which is easily read as terraforming Earth.

The same authors have certainly touched on both topics. James Lovelock, originator of Gaia theory, turned to fiction – with co-author Michael Allaby – to

describe the terraforming of Mars. He has subsequently proposed schemes for geoengineering on Earth to combat the effects of climate change. Kim Stanley Robinson, whose Mars trilogy has by far the most detailed fictional account of terraforming, went on to elaborate some geoengineering scenarios in his subsequent near-future Earth trilogy about climate change. Gregory Benford has written both fiction and non-fiction about terraforming, citing Heinlein as an inspiration, and was an early proponent of geoengineering as a possible response to climate change, in 1997. It would be interesting to trace these and similar connections and consider what effect they may have had on broader discussion on the merits of geoengineering. Alastair Reynolds makes a similar point: "Sf can provide us with an imaginative toolkit enabling us to formulate ideas in a more condensed and easily transferable way. For example, terraforming is an SF idea but it encapsulates many concepts in a single, easily remembered word. This makes it easier for people to talk about and could influence the way we approach and discuss real world issues such as geoengineering."

The collection of diverse items – texts, discussions, projects, artworks, events and videos – which can be gathered under the heading of design fiction also deserve more investigation. It is not easy to know what effect or impact they have had, individually or collectively. Have they influenced any subsequent real-world design projects or prototypes? What has been their public reach compared with other influences on public attitudes to technology, or other images of possible futures – including more conventional science fiction texts? Finally, what scope it there for making more use of design fiction, and who might support such efforts? There are interesting affinities emerging, for example, between design fiction and art/science/design projects intended to provoke discussion about synthetic biology – an area of technology which promises to make design a meaningful notion in the life science. For example, Alexander Ginsberg's *Irrational Genome Project* is, in effect, a challenge to others to create design fictions drawing on the ambitions of synthetic biologists. It also points

toward other, more participatory modes related to design fiction, such as biohacking

There seem to be an increasing number of routes to using our increased awareness of the importance of images of possible future technologies in shaping what actually gets developed. More research and thinking about the whole collection, gathered under the heading of design fiction, might help us see more clearly how they can be exploited to help selection and development of technologies which can be part of our preferred futures.

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