TECHNOLOGICAL FUTURES AND RECURRING DREAMS: THINKING ABOUT EMERGING TECHNOLOGIES THROUGH SPECULATIVE DESIGN.

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ABSTRACT | This paper examines how an emerging technology can transition from the habitat of the laboratory to everyday life, with a particular focus on the different roles design can play throughout this process. Design is intrinsically linked to notions of the future, through the arrangement of elements to accomplish predetermined goals. More familiar is design's near-future role – the arrangement of existing elements to create useful, marketable objects. However, design also has an important role in longer-term planning through the arranging of potential elements to create hypothetical objects and related future imaginaries – visions of how the future could be, should that technology reach maturity. First, we trace the typical journey of a technology through three distinct phases: from its 'genesis' in a scientific laboratory, through the 'imaginary' phase where the emerging technology's potential is transformed into a vision of how the future could be, to the development of an actual product or service for use in everyday life. Next, we present a list of reasons why dreams of the future have stagnated, with an emphasis on how design is implicated in this process. Finally, we present three speculative design projects by PhD students, each working in a different phase of the tripartite process: placing the designer in the laboratory to upstream prototype and infuse scientific research with social responsibility and/or domestic sensibilities; revisiting stagnant technological dreams and updating through the counterfactual history approach; and downstream 'super testing' using speculative methods to better understand the implications of technologies in everyday life.

1. Introduction

The practice of design is intrinsically linked to notions of the future, both near (months and years) and relatively near (years to tens of years), through the arrangement of elements to accomplish predetermined goals (Eames, 1972). More familiar is design's near-term role – arranging existing elements to create useful and desirable objects that can be sold on the market. However, design also has an important role to play in longer-term planning through the arranging of *potential* elements (for example, emerging technologies) to create hypothetical objects and related dreams and visions of how the future *could* be should that technology reach maturity.

In the second section of this paper, starting from a diagram, we trace the typical journey of a technology through three distinct phases: from 1) its 'genesis' in a scientific laboratory, through 2) the 'dream' phase where the emerging technology's potential is transformed into visions of possible futures (both utopian and dystopian), to 3) the development of an actual product or service for use in everyday life. During the 20th century, the middle 'dream' phase became increasingly important in shaping the technological future. Such dreams take on a variety of forms, exist for a plurality of reasons, and inform futures in complex ways. We will focus predominantly on socio-technical imaginaries (STIs) described by Jasanoff & Kim (2009) as 'collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology'. STIs are particularly helpful because they encode not only the visions of what developments in science and technology might bring but also an entrenched notion of a society's shared value system – the invisible forces that inform and define pathways into the future.

To illustrate the journey of a technology, we will present two case studies that represent the dominant 20th-century Western (US) imaginary, with a focus on the role of design. The belief systems at the core of this imaginary continue to influence contemporary visions of the future and what is seen as the 'good life' despite the mounting evidence against its ideals and methods. The third section offers a list of five reasons why future visions have stagnated or are simply inappropriate for the 'polycrisis'-ridden world of today.

We are in desperate need of new imaginaries. In the short term, we must develop better ways of challenging and exposing the limitations of the existing model. As a starting point towards more appropriate approaches, in the fourth section we present three ongoing speculative design projects by PhD students. Each project acts in a different phase of the tripartite process described above, and presents new design methods and approaches that address the limitations and flaws of the dominant socio-technical imaginary and design's role in shaping it.

2. The Journey of Technology

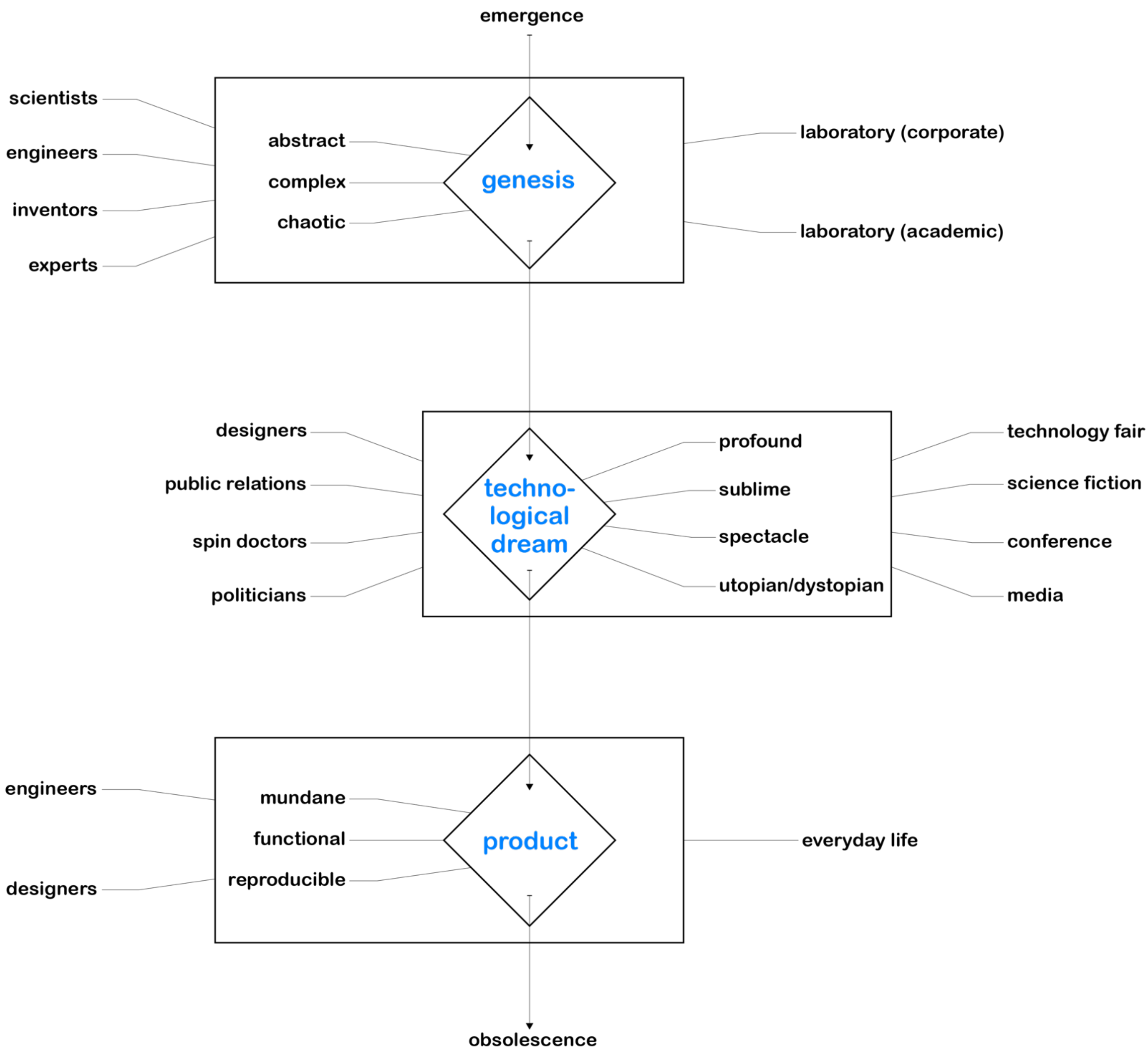

Figure 1. The journey of a technology: The diagram describes the (fairly typical) journey a technology makes from its genesis as an emerging technology in a laboratory, through the technological dream phase before transitioning into real products that exist in the context of everyday life. Finally, the technology descends into obsolescence as it is replaced by more advanced iterations. On the left are the actors involved at each stage and on the right are the contexts.

The diagram in Figure 1 describes, in general terms, the typical journey a technology makes, starting from its genesis in the laboratory through to its ultimate obsolescence. At its genesis the technology is abstract and complex, its behaviour and potential are only properly understood by the scientists responsible for its development.

Next is the technological dream phase. Here the *potential* of the emerging technology is translated into (typically) techno-utopian visions of the future. According to Basalla (1988):

> "Technological dreams are the machines, proposals, and visions generated by the technical community, whether in the Renaissance or the present time. They epitomise the technologists' propensity to go beyond what is technically feasible. Fanciful creations of this kind provide an entry into the richness of the imagination and into the sources of the novelty that is at the heart of Western technology."

Technological dreams take on a variety of forms, exist for a plurality of reasons, and inform futures in complex ways. In this paper we focus predominantly on socio-technical imaginaries (Jasanoff & Kim, 2009). During the last century this *imaginary* phase became increasingly important in cementing the fundamental belief in technological progress and the consequent shaping of the technological future.

The last phase of the journey is the translation of aspects of the dream into the products of everyday life. The iterative nature of technological evolution (Heilbroner, 1967) typically results in the new technology simply being applied to existing product lines. This has become the industry standard model of product development and facilitates generational iterative advances, typified by items such as the iPhone. As the (once) emerging tech reaches everyday life, it is usually quite conservative and familiar – just enough of an advance to make the new product slightly more desirable than its predecessor. Finally, the product descends into obsolescence as it is replaced by more advanced iterations. In certain cases, the dream gets recycled or regurgitated; for example, the recurring dreams of domestic robots, flying or driverless cars, or space tourism.

As discussed above, this process largely emerged in the early 20th century. We will now look more closely at two particular case studies: first, the internal combustion engine and the petroleum-based socio-technical imaginaries that were built around it, and how these evolved during the course of the century before finally become obsolescent; second, the rise of so-called 'smart' technologies, which are based on identical value systems and represent an almost seamless transition towards post-petroleum imaginaries.

2.1 Case Study 1: Petroleum and the Internal Combustion Engine

The new machines of the late 19th and early 20th century, such as the internal combustion engine or the coal-powered steam generator, revealed for the first time the true potential of fossil fuels. Petroleum, for example, is a naturally occurring liquid that stores a fragment of the solar energy that reached Earth during the Jurassic and Cretaceous periods (typically via algae and woody plants). While the first recorded use of petroleum can be found 4,000 years ago when natural asphalt was used in the walls and towers of Babylon, it was not until the early 20th century that the potential of petrol as a useful form of energy began to exert its influence on so many diverse aspects of human life.

The aeroplanes, automobiles and ships that were built around these engines became the symbols of the new machine age, as extrapolations of the *potential* of the internal combustion engine fed the utopian imaginaries of the near future. For a country emerging out of the despair of the Great Depression, *Streamline Moderne* (as it became known) represented the American dream of freedom and escape. Designers were for the first time beginning to play an instrumental role in linking technological progress to the notion of a better future, all in the service of American corporate capitalism. According to the design curator David A. Hanks, American Art Deco and Streamline Moderne differed from the European functionalism of the Bauhaus in that, while the former 'arose from an artistic vanguard', streamlining was 'aimed at the widest possible public and was based on an admiration for industry and speed' (Hanks & Hoy, 2005).

Figure 2. Buick LeSabre. By James Vaughan, 2010, Flickr.
Source: https://www.flickr.com/photos/x-ray_delta_one/4453386674/in/photostream/

The movement inspired the design of a new wave of domestic products, from toasters and kettles to radios and televisions to children's toys, that would give consumers a sense of buying into – and thus belonging to – the utopian American dream, the 'World of Tomorrow'.

Nothing exemplifies this period of techno-optimism better than *To New Horizons*, the promotional film of designer Norman Bel Geddes' *Futurama* exhibit in General Motors' 'Highways and Horizons' pavilion at the 1939 New York World's Fair. The film begins by invoking 'the mystery and the promise of distant horizons [that] always have called men forward' with the promise of a brighter future; a future driven by technological progress, but one which paradoxically never quite arrives. The imagery accompanying the voiceover is the settlers' view of America, complete with covered wagons and frontier forts: moving West to conquer and colonise new territory as well as the indigenous inhabitants, finding new ways to subjugate nature and apply the logic of extractive capitalism, always enabled by the advent of new technologies. In the film the frontier becomes a network of futuristic highways 'for men to go places', symbolising American freedom and dominance. The film represents perhaps the perfect sociotechnical imaginary, a means to 'engage directly with the ways in which people's hopes and desires for the future – their sense of self and their passion for how things ought to be – get bound up with the hard stuff of past achievements' (Jasanoff, 2015, p.32).

The core message of *To New Horizons* is that this new world is in a constant state of flux, 'opening before us at an ever-accelerating rate of progress' with the related imaginary representing 'a greater world, a better world, a world which always will grow forward.' As the (piston or intermittent) internal combustion engine transitioned to the final 'product' stage of the diagram, new dreams were necessary. In the 1950s the invention of the jet engine (Continuous combustion) allowed for supersonic flight, in turn expanding the horizons and moving the technological dream upwards and into the 'final frontier' of space (note again the colonising terminology).

Figure 3. Bell X-1 46-062, nicknamed *Glamorous Glennis*. NASA.
Source: https://commons.wikimedia.org/w/index.php?curid=22975326.

This provided the impetus for countless new visions including the Moon mission and related Cold War imaginaries (Barbrook, 2007). It also represented the final extrapolation of the petroleum dream, in the sense that within a few years these utopian dreams would be exhausted, deflated. As the novelist J. G. Ballard (1979) observed in an interview titled 'The Space Age Is Over':

> "The world of 'Outer Space', which had hitherto been assumed to be limitless, was being revealed as essentially limited, a vast concourse of essentially similar stars and planets whose exploration was likely to be not only extremely difficult, but also perhaps intrinsically disappointing … The number of astronauts who have gone into orbit after the expenditure of this great ocean of rocket fuel is small to the point of being ludicrous. And that sums it all up. You can't have a real space age from which 99.999 percent of the human race is excluded."

Elsewhere at the same expo in 1964, however, a new genesis was being revealed which introduced a refreshingly new direction for technological futures. The IBM Pavilion, with exhibition design and a film presentation by Charles and Ray Eames and architecture by Eero Saarinen, introduced visitors to the computer and its place in mainstream contemporary life. Again, quoting Ballard (1979), this time on the promise and allure of the Information Age:

> "The ability to pass information around from one point in the globe to another in vast quantities and at stupendous speeds, the ability to process information by fantastically powerful computers, the intrusion of electronic data processing in whatever form into all our lives is far, far more significant than all the rocket launches, all the planetary probes, every footprint or tyre mark on the lunar surface."

2.2 Case Study 2: Smart Futures

Ballard's prophetic observation segues neatly into the second case study: the dream of 'smart'. The term has relatively ancient roots, predating the emergence of computer technology, robotics, and notions of artificial intelligence. In the 19th century, the word 'smart' was used as an adjective to describe someone quick-witted, refined, or elegant. Davin Heckman (2008), in his book on the evolution of the smart home, cites the advertising campaign for the Oldsmobile Futuramic to illustrate the semantic evolution of the term:

> "In the truly modern home or the truly modern car, it's functional design that counts. Smart styling is styling with a purpose, as seen in this 1948 'Futuramic' Oldsmobile. Luxuriously appointed inside and out, the Futuramic Oldsmobile brings truly modern post-war design to the automotive field. There's utility as well as beauty in every smart detail, there's the safety of greater visibility, there's automatic shifting too and no clutch pushing thanks to GM Hydramatic drive. The smart way to go is the Automatic way, in a Futuramic Oldsmobile."

The connection between smart and automation evolved into one of the key STIs of the 20th century. The logic is relatively simple: automation builds on the early promise of modernism, where advances in technology lead to domestic products that reduce the need for human labour and increase notions of comfort and leisure in everyday life. The emerging technology behind these new imaginaries was the computer – the important advances made during WWII, in particular at Bletchley Park on encryption, had highlighted the vast potential of this technology, and research continued post-war with new impetus. In 1948, Norbert Wiener published *Cybernetics or Control and Communication in the Animal and the Machine*, which described how the function of machines and living organisms were governed by the same laws (feedback loops). What emerged from this scientific research was the notion of self-regulating thinking machines that would soon be used to generate, plan and control environments. Whilst research in the military domain continued in the background, in the foreground new imaginaries were flourishing, especially in the fields of transportation and the domestic – here with a strong focus on the kitchen.

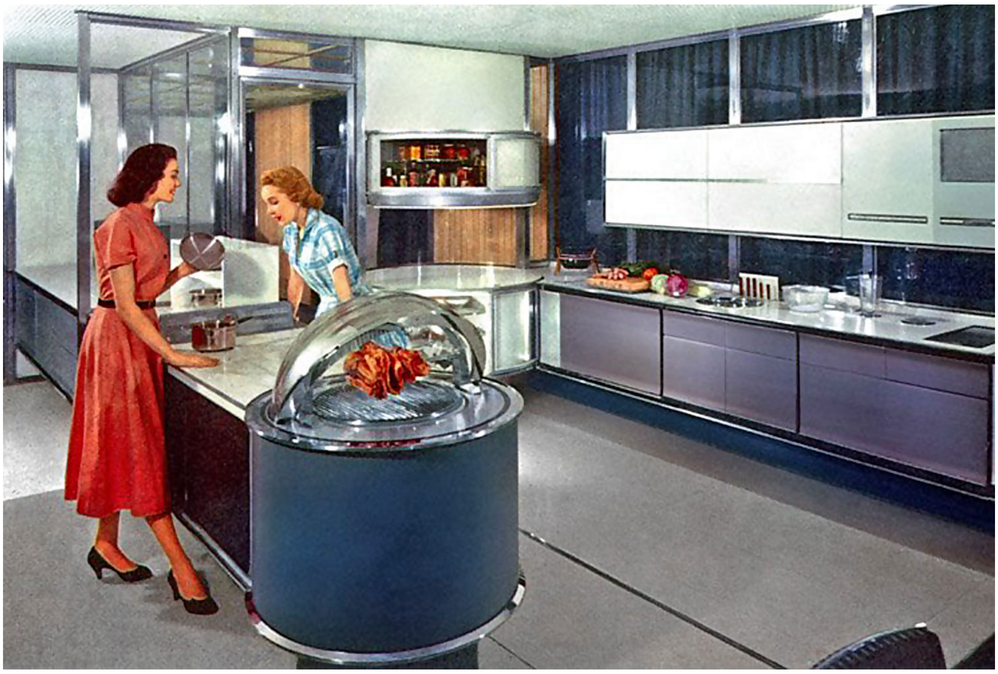

Figure 4. Frigidaire prototype kitchen (1957). By James Vaughan, 2009, Flickr. Source: https://www.flickr.com/photos/x-ray_delta_one/4189652500/in/photostream/. CC BY-NC-SA 2.0 DEED.

1950s *kitchens of the future* were not yet classified as 'smart', yet they represent the evolution of the dream that continues to this day. For example, RCA and Whirlpool's 'Miracle Kitchen' began travelling around the world in 1956 and made an appearance at the American National Exhibition in Moscow in 1959. It was meant to showcase a future where everything was controlled with the push of a button, so that 'the things women don't like to do are done automatically', according to a promotional video for the concept kitchen. As Anya Smirnova, curatorial assistant at the London Design Museum, explains: 'the features of the kitchen, like the autonomous vacuum cleaner, anticipated today's domestic robots and smart home devices. As a pre-history of the contemporary smart home, the RCA-Whirlpool Miracle Kitchen provides important historical context' (Whirlpool, 2018).

As in the case of petroleum dreams, the imaginary continued to evolve, informed by the latest developments in computer technology. In the 1980s, for example, the American entertainment industry began to adopt a global approach to technological planning, best exemplified by Walt Disney's Experimental Prototype Community of Tomorrow (EPCOT). More than just a theme park, EPCOT was described as:

> "A community of tomorrow that will never be completed but will always be introducing and testing and demonstrating new materials and new systems. And EPCOT will always be a showcase to the world for the ingenuity and imagination of American free enterprise."
> (Beard, 1982)

As a highly planned, controlled and automated 'living blueprint', EPCOT is a vision that heralded and contributed to the future global spread of automated systems in everyday life – described in a language that could have been taken almost directly from *To New Horizons.*

In the late 20th century, the computer completed the shift from the fields of research, military, and business to the homes and domestic lives of many people. However, whereas the normalisation of the motorcar led to the end of petroleum dreams, computer-related dreams continue to flourish, fed by various concepts such as Ubiquitous Computing (Weiser, 1991), Augmented Reality (Caudell & Mizell, 1992), the Internet of Things (Ashton, 1999 / 2009) and Artificial Intelligence (Turing, 1950)[1], and through marketing and branding exercises such as LG's 'HomeChat' (2014) and the Ericsson 'Social Web of Things' (2012). The fundamental challenge with future smartness relates to the ever-diminishing number of acts left to be automated. Bill McKibben in his aptly titled book *Enough* (2004) provides the following examples of how the industry was thinking in the early 2000s:

> "Eventually, says Mary Walker, of IBM's home automation division, 'smart ID' chips will be implanted inside you. Then 'your body temperature might give your stereo system cues as to your mood and it would select appropriate music'; the chip could also 'compute how much of your body weight is fat, and offer suggestions for diet recipes to the refrigerator'."
> (McKibben, 2004, p.121)

In the early twentieth century Sigmund Freud wrote about the pleasure principle (id) versus the reality principle (ego), the latter involving the delayed gratification that comes with adulthood. As science fiction has played on numerous times in recent decades (think of Disney's own *WALL-E*), 'smart' technologies – higher level automation combined with late capitalism – often invite us to override our adult selves, exchanging self-control and responsibility for the childish expectation of instant gratification in all aspects of daily life.

3. Five Insights: Why Visions of the Future Have Stagnated

In our present century, the future has become highly complex and contested. While Silicon Valley continues to present aggrandised versions of 20th-century techno-utopias[2], some observers have begun to

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[1] AI could be described as a recuring dream having passed through numerous iterations since its genesis in the 1940s

[2] See, for example, Elon Musk's recent announcements for his Neuralink – the longer-term goal for this research is human / AI symbiosis.

'comprehend that we live in a world that is taking away futures for ourselves and non-human others' (Fry, 2020). Berardi (2011) described the 'slow cancellation of the future' as a consequence of diminishing trust in the scientists and policy-makers who once exercised the kind of powers that made the Moon programme possible (exemplified by John F. Kennedy's speech at Rice University in 1962). Speculative designers have also been guilty of focusing too much on the technological future, albeit for more responsible ends. As Matt Ward points out: 'By focusing on futures … many believe that SCD [speculative and critical design] neglects the near and direct urgency of now' (Mitrović et al., 2021, p.185).

To reflect more broadly on the implications of the two case studies outlined above, we present five key observations on why visions of the future have stagnated or are simply not appropriate for the world of the 21st century, and why they are ripe to be revaluated and reappropriated using new design approaches.

1. **Those responsible for the creation of future visions are guilty of being overly optimistic, never acknowledging the possible negative implications of their dreams.**
   The constraint of positivity – what we might call 'progress dogma' – blinds future-makers and future-shapers (scientists, technologists, politicians, designers) from the potential negative implications of their proposals. Technology is good, the story of progress goes, and the future, as long as technology takes the lead, will be better than the present. This blind optimism and faith in technology is not limited to mere visions, either: it extends to designed artefacts such as the Amazon Echo, which bring with them into peoples' homes a host of unintended consequences.

2. **Those responsible for the creation of future visions are guilty of being overly simplistic – perfect worlds, perfect people, interacting perfectly – thus negating the complex and messy reality of human lives.**
   In advertisements for smart homes and smart products, the generic user is overwhelmingly young, able-bodied, and wealthy. He is often male, usually white, and heterosexual, a bachelor in a perfect luxury apartment of glass and steel. Advertisements for the LG 'HomeChat' (2014) or the Ericsson 'Social Web of Things' (2012) are two examples. Strengers (2014) has called one version of this idealised user 'Resource Man': 'a rational, individual, and masculine image of the energy consumer'. In contrast, what would a smart home for a multi-generation family look like – unharmonious, not necessarily wealthy, and full of complicated interactions? Or a smart home that favours connections to natural systems over technical systems?

3. **The reduction of technological dreams into singular experiences has resulted in the dislocation of means from ends – the systems (means) that facilitate the function of future artefacts (ends) are inherently complicated and restrictive.**
   Take, for example, the automated vehicle. Whilst the dream of a car that drives itself is relatively easy to imagine, its realisation is constrained by (amongst other things) the complexity of engineering and computation, legacy infrastructure, insurance laws, and road legislation. The dream is simple, reality is complex. Dreams represent a jump to another reality; socio-technical change is iterative for a reason. Dreams, in this sense, can provide future goals to aim for – but short-term time-frames constrain the political and corporate actors who have the power to act upon the social and the technical (for example through the need for near-future shareholder satisfaction or fixed-term democratic government). How then can dreams lead to systemic change in the context of everyday life?

4. **The reduction of visions into objects of desire leads to an increased instrumentalisation of operation and banal iterative development.**
   The motorcar again: travel has become instrumentalised as we focus on the object, rather than the act. Since the beginning of the 20th century, the car has iterated in small steps made possible by technological advances. Why is this a problem? Because it constrains designers to design only what the product could conceivably evolve into – narrowing the scope of future possibilities. Smart products, such as the automated vehicle, are simply existing products updated with sensors and computation. How can we step outside of the constraints of this sort of lineage to design more radical and appropriate solutions – not influenced by history?

5. **Many of the metrics through which we evaluate future imaginaries remain the same as those from the machine age – faster, more efficient, more automated – and as such are wholly inadequate for addressing the complex problems we face today.**
   In the first point of his influential 'ten principles', German designer Dieter Rams (n.d.) states simply that 'Good design is innovative', elaborating that 'Technological development is always offering new opportunities for innovative design.' But while 'new opportunities' are still being offered by emerging technologies, the straightforward exploitation of these opportunities has become complicated in our own time by a growing awareness of the impact we are having on the planet. The faith in technological enhancement expressed in Apple's early (1990) slogan – 'The power to be your best' – is no longer sufficient to meet humanity's complex needs. Rams' list does include the advice to keep 'physical and visual pollution' to a minimum, but it fails to acknowledge the larger extent to which design is implicated in or even responsible for catastrophes such as global warming.

4. New Dreams: The Promise of Speculative Design

'How, Taylor asks in the opening pages of *Modern Social Imaginaries*' – as Jasanoff (2015) writes – 'did modernity come about, with its distinctive complex of new practices and institutions, new ways of living, and new forms of malaise? His explanation can be summed up in two words: imaginaries changed.' At the turn of the last century modernism brought about a fundamental change in the socio-technical imaginary, facilitating an unchecked approach to the future driven by a fundamental belief in the positive progress of technology.

How then, can we develop approaches that change the current imaginary? And more importantly, what roles could designers play in this process? As a starting point, we present three ongoing speculative design projects by PhD students. Speculative design in this case denotes a type of experimental design practice that explores imaginary futures or alternative presents through the use of 'objects and images': for example, 'how domestic spaces change with the evolution of new communication technologies; how relationships shift under surveillance capitalism; … how work will be reconstituted through automation', and so on (Mitrović et al., 2021, p.168). More specifically, each of these three projects acts in a different phase of the tripartite process described in the 'journey' diagram (Figure 1): first, placing the designer in the laboratory to upstream prototype and infuse scientific research with social responsibility and/or domestic sensibilities; second, revisiting stagnant technological dreams and updating through the counterfactual history approach (Auger & Hanna, 2023); and third, downstream 'super testing' using speculative methods to better understand the implications of technologies in everyday life.

1. Placing the designer in the laboratory to upstream prototype and infuse scientific research with social responsibility and/or domestic sensibilities.

The transition towards a post-petroleum society is one of the main challenges addressed by a wide range of actors (activists, researchers, industrialists, designers, politicians, and consumers). Each vantage point or knowledge-base creates and feeds a different imaginary – a dream that is social, economic, or scientific in character. (This links to insight 4 above: interrogating and rethinking notions of materiality at the inception of the design, de-objectified and free from the outset.)

One effect of a post-petroleum shift that exerts a strong impact on industrial design, and on industries more widely, is the inability to create new petrochemical-sourced plastics. Time has shown that the discourse around sustainability and ecological thinking has not led to a substantial reduction in the production of plastics. This reluctance to slow or reverse consumption highlights the techno-solutionist position of industry – waiting for a scientific revolution that will lead to a new material paradigm.

Figure 5. Images from the project *Flower*: Long natural flax fibers are broken into shorter ones to be integrated as matrix inside a composite material.

Historically, such a rapid and drastic paradigm shift in industrial materials already occurred when plastics became the new standard. First used to replace animal-based material such as horn and ivory, plastics developed rapidly after WWII aided by military research and funding. Unlike any other material, its ‘plastic’ qualities were so extensive that it gave designers previously unimaginable freedom in terms of shape, colour, and performance. In this sense, plastic was a new horizon of infinite possibility, matching the desire of the post-war period for a bright and colourful future. Plastic was a ‘superlative material’ whose praises were sung even by poets like Raymond Queneau in *Le Chant du Styrène* (1958), a short documentary directed by Alain Resnais for the industrial giant Pechinay.

Today the view of plastics is far less optimistic. Plastic has become a major threat because of the pollution created during its production, its lack of effective recycling, and its degradation into microplastics that poison living organisms. The pressure of public opinion, taxes, and legislation on manufacturers has not made them change their practices so much as forced them to invest and transfer this pressure into the research field, waiting for a miraculous technological solution. We may be again at the dawn of a new materials paradigm shift, but this time it is a more complex and globalised world deeply rooted in consumption. To question the role of design in this transitory moment and speculate on the evolution of industrial objects, Axelos has chosen to focus on material research, working together with scientists at the Institut national de la recherche agronomique (INRAE).

At the beginning of this expected shift, materials are still quite weak in terms of performance, plasticity, and the shaping process. Low-tech experiments are already ongoing, especially in independent design studios, along with more technical materials and process-related experiments currently in development in laboratories. As designers, we can only speculate on new ‘potential materials’. This immateriality and potentiality of future matter radically alter the design process, which is normally involved in the late stages of technical projects. Traditionally, designers can experiment with industrial materials if they are stable enough, with a fully developed manufacturing process already available. This exploration process shapes the materiality of those designed objects. But how can designers experience the materiality of a material that has not yet been created? 'Potential matter' forces designers to rethink their position in the project timeline, to adapt and develop new methodologies and approaches regarding material-centred design, and to create new interactions with those involved in this early stage of development, especially researchers. By collaborating with active researchers and placing the designer in the laboratory, this practice-based PhD will offer the opportunity to experiment with new methodologies and document impacts on both design and research practices.

2. Revisiting stagnant technological dreams and updating through the counterfactual history approach (Auger & Hanna, 2023).

Valentin Graillat's project *Archaic Smartness* uses the counterfactual history approach to question and update stagnant smart home visions of the future. (This links to insights 2 and 3 above: reimagining 'smart' as something that goes beyond an instrumentalist focus on 'solving' human problems with technology to acknowledge complex ecosystems; the home is not simply the end, but a system of means and ends functioning in harmony with the local environment.) The project began by tracing the actual history of the smart home to identify the key moments[3] (political, cultural, technological, corporate, etc.) that led to the contemporary situation. The genesis of the smart home was traced to the *Houses of Tomorrow*, conceived in the United States during the Cold War by the hegemonic corporations of the time (Disney, Monsanto, General Electric). These seductive and spectacular future visions conditioned long-term expectations in the West by positioning as desirable a technology-driven lifestyle centred on consumption, disengagement, and entertainment. The legacy of yesterday's *Houses of Tomorrow* is the crystallisation of the desire for market-friendly technological futures constructed through a value system based on the application of smart technologies (as discussed above). The counterfactual approach acts to challenge this dominant and entrenched model through the generation of alternative narratives and imaginaries that bypass the constraints of historical lineages.

After tracing a timeline of the smart home concept, Graillat identified key historical events where a different outcome could have led to an *alternative present* more in line with current concerns for the environment and sustainable lifestyles. The project's counterfactual moment came in 1973 when the United States was violently shaken by the oil crisis. President Nixon signed the Independence Project and intended to initiate a strategic policy to develop domestic energy production. The counterfactual history postulates a radical alternative research group, similar to the Farallones Institute in Berkeley, receiving substantial government support facilitating the rise of an alternative path in which the term 'smart' bifurcates from a market-friendly automated culture towards one more symbiotically aligned with natural systems and habitats.

The practice-based element of the project speculates on various research outputs of a fictitious scientific institute based in California, presented through a variety of *historical evidence*, including blueprints, books, and models that would have been displayed at trade fairs and public exhibitions. These combine to present historical visions of an alternative future which acts as a manifesto – the term 'smart' no longer refers to house *automation* but instead to the *adaptation* of the home to its local living environment (such as approaches to materials and the production of bio-energy). The first concept imagines a radical form of cohabitation with local organisms through the development of vast termite colonies alongside the human home – this symbiotic relationship provides security for the termites and biogas for the human inhabitants.

[3] The Farallones Institute was a non-profit, educational organisation dedicated to the research, development, demonstration, and application of potentially appropriate community technologies. All their programs and projects placed an emphasis on the integrated nature of renewable sources of energy, land and resource planning, water and waste, recovery systems, and food production within the context of cultural and social acceptability, and local community self-reliance.

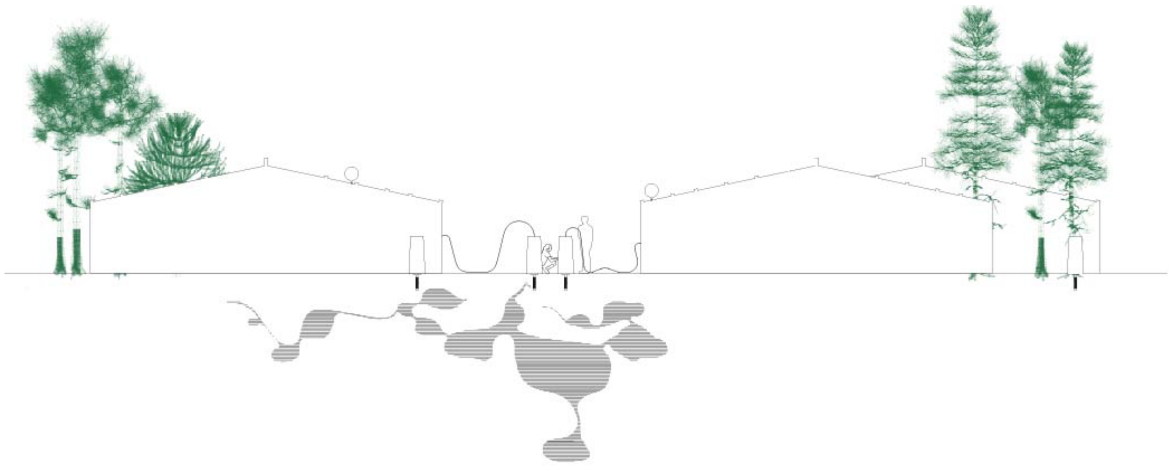

Figure 6. Habitat-scale domestication of termites to produce small quantities of biogas for food and lighting.

The counterfactual approach provides the designer with the opportunity to continue the evolution of the alternative timeline which becomes increasingly diverse as more time passes, offering the designer a ‘rich narrative potential for reimagining and critiquing technological developments and contemporary products’ (Auger, 2012).

3. Downstream ‘super testing’ using speculative methods to better understand the implications of technologies in everyday life.

The super-testing method operates as a crash test of future visions, public policies, services, and products enabled through speculative design methods. As practised by Estelle Hary, investigating the ramifications of AI and machine learning in public services, super-testing prompts the involved publics to identify and assess potential implications and externalities that may arise from the proposed speculative artefacts. (This links to insight 1 above: casting a cold eye on ‘progress dogma’ to explore possible consequences, negative as well as positive, when research enters the real world and takes shape as concrete products and policies.)

Super-testing aims to challenge dominant socio-technical imaginaries by changing the lens through which a particular issue is considered. It highlights issues that are often overlooked due to prioritisation of economic values such as efficiency and productivity – for example with the deployment of AI systems in public services. Indeed, as Hary identified through her research, a well-known narrative, conveyed through various institutional means (reports, public funding programs), underlies the deployment of AI in French public services: the technology is thought to be impartial and effective. It can handle vast amounts of information quickly and might potentially lead to automated decision-making, speeding up administrative processes. This would free up time for public servants to undertake more valuable tasks. The promise goes even further by suggesting a vision where public services would be customised to individuals' needs. In essence, AI systems are presented as a cost-effective magic wand, capable of solving the State's biggest (political) challenges while improving the quality of public services.

As with many such promises, however, blind spots and preconceived ideas are widespread. Promises based on AI systems do not take into account the body of literature on political, environmental, and social justice issues that come with their use. They also rely on the assumption that the economic, political, social, and material conditions of society are immutable. For example, projects to deploy AI in public services are conceived as if future societies will benefit from the same material conditions as today when the energy and raw materials needed to maintain the infrastructure required for AI systems to run are still relatively abundant. But what happens when such material conditions can no longer be met, while all public services have been digitised, 'algorithmised', and 'AI-ified'? This possibility has been explored through the Fail-Soft[4] mode in a degraded world scenario where several design artefacts suggest the intermittent availability of public services based on energy resources. A billboard at a bus stop displays the weather forecast of digital public services. Some of them are suspended, others are running normally, while still others run on a backup based on citizen mobilisation. To face the new material conditions of this scenario, the government has created the National Authority for Administrative Transparency, in charge of reviewing new projects aiming to deploy algorithms in public services based on environmental criteria.

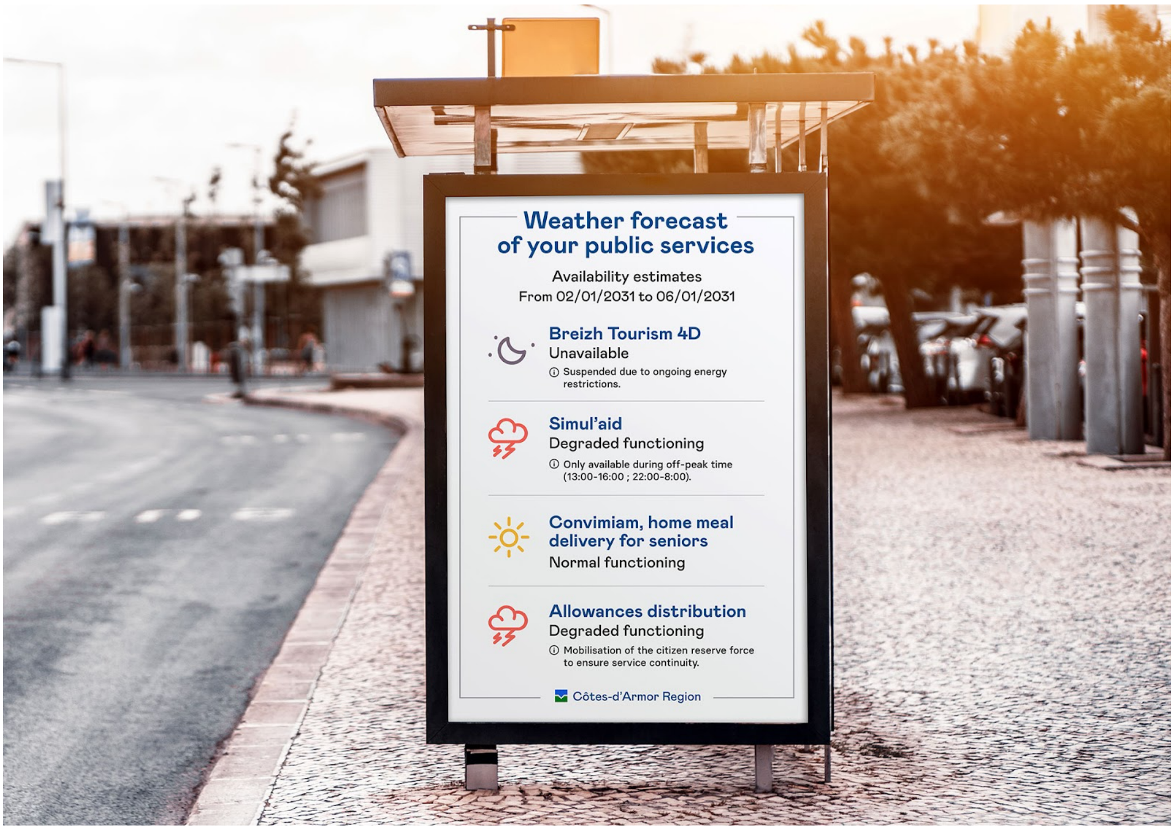

Figure 7. Speculative government information services at bus stops providing updates on the state of public services.

These artefacts raise many questions. How was the priority given to each public service decided, and who took part in this decision? Who reviews the applications for new algorithms and learning systems to be implemented? How was the criteria grid built? Why are such projects still supported when the world does not seem able to sustain them? Super-testing does not stop at the creation of speculative design artefacts that raise provocative questions about the shortcomings of technological promises. For the 'test' to happen, the design artefacts need to be confronted with the stakeholder publics: policymakers, public servants, citizens, civil society, unions. The design of the 'debate space' is in that regard also part of the super-testing method, where supporting the diversity of people taking part in the debate is critical to express a plurality of views coming from everyone's personal experiences. It enables a rich, detailed, and diversified mapping of the positive and negative externalities around a technological dream whose analysis might allow for an update of our collective vision of our future society. This in turn might lead to the adaptation, bifurcation, or even cancellation of public policies around AI and other smart systems.

[4] A Fail Soft System is one that shuts down non-essential functions when something goes wrong allowing the system to function at a basic level. The term can be applied to machines, vehicles, computer systems, other systems, and many types of equipment.

5. Conclusions

Following the SpeculativeEdu project conclusions, we aim to contribute to the dialogue on speculative design by contemplating ‘a plurality of futures beyond the techno-heroic’ and more importantly, ‘reclaim[ing] the present’ through ‘speculat[ing] on different versions of today’ (Mitrović et al., 2021, p.211). Design needs a revolution in order to keep pace and adapt to the rapidly shifting demands (social, political, ecological) of the 21st century. (This links to insight 5: the need for new metrics to reflect complex new 21st-century realities.) As Papanek (2019) suggests, we must learn from disaster. This revolution must begin in design education, and one way to bring it about is to create new approaches that are both speculative and pragmatic, linking alternative visions to urgently needed actions in the real world. Speculative design must abandon the simplistic and slavish game of extrapolating futures based largely on emerging technologies, and instead examine existing (and historical) conditions in order to imagine alternative presents, more appropriate futures - other ways of being.

At the beginning of this paper we traced the journey of a technology through a tripartite process, from the laboratory to the dream phase to the products and services of daily life, and examined the role design plays in this process. To illustrate this journey, focusing in particular on the dream or imaginary phase, we presented two case studies: petroleum and the internal combustion engine, and ‘smart’ technologies. In the next part we presented five insights to explain some of the reasons why visions of the future have stagnated. Then in the last part we presented the ongoing work of three PhD students, each of whom is focusing on a different stage of the journey – the designer upstream in the lab; the designer revisiting stagnant technological dreams; the designer ‘super-testing’ downstream in everyday life – and the different role design could play in each stage as a means of creating new visions and approaches that are better suited to the huge challenges we face in the 21st century.

We have tried to raise questions and introduce new possibilities to provoke changes in design education. What is the role of dreaming in design? How conscious are we of the dreams that shape our futures? What happens when technological dreams become repetitive and stale? How do our dreams relate to our waking lives, to practical necessities and urgent responsibilities? Should we stop dreaming about far-off futures and magic solutions, and wake up to the realities of our present? How can we dream differently, and actively, so that our dreams help us imagine and shape better realities? There are still many questions to investigate – many alternatives to imagine – and urgently. In the words of Ursula K. Le Guin (1979), ‘it is above all by the imagination that we achieve perception, compassion, and hope’ (p.53).

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