An R&D Planning Method Integrating Science Fiction and the History of Technology — A Backcasting Approach Based on the Novel Tomorrow's Asphalt

AUTHOR

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ABSTRACT

In today's Japanese business environment, where uncertainty continues to intensify, SF prototyping has attracted attention as an alternative approach to conventional incremental forecasting methods. The author, in collaboration with Nikko Co., Ltd. and with the support of external experts, produced the future-oriented novel "Tomorrow's Asphalt" and related content. As a result, through leap-oriented, science-fictional thinking, a range of provocative and compelling ideas were generated. A remaining challenge, however, lies in connecting these ideas with engineering realism. Accordingly, this paper proposes an original framework that combines SF thinking with the author's expertise, specifically a "history-of-technology perspective." The framework conceptualizes imagined future technologies (gadgets) and examines them in light of past history of technology and analogous cases. Historical technological transitions and the potential for revival or reinterpretation of past technologies are considered, so as to bridge the gap between imagination and reality and identify the necessary technological and societal breakthroughs required for realization. In sectors such as infrastructure development, where different stakeholders are involved, co-creation grounded in fictional imagination can be effective. The approach proposed in this paper is expected to be applicable to R&D planning across the manufacturing sector, as well as to prepare for unknown business risks and opportunities.

Keywords: SF prototyping, backcasting, R&D planning, history of technology, innovation, co-creation

1. Introduction

The future is inherently uncertain. Even without referring to concepts such as VUCA (Volatility, Uncertainty, Complexity, and Ambiguity), it is difficult to predict future technologies and social developments with precision. Numerous examples demonstrate that technologies once deemed impossible have eventually been realized, including core technologies that have since become indispensable. For example, in the field of motive power, it was once believed that automobiles would not replace horse-drawn carriages. There was also a time when gasoline engines were not regarded as a viable option due to concerns about safety. Likewise, although the alternating current (AC) power transmission system is now the global standard, serious doubts were raised regarding its feasibility when it was first proposed. A critical weakness at the time was the absence of a practical AC motor capable of functioning as a load. Such technological challenges are often overcome by breakthrough inventions. By contrast, there are also technologies that have yet to achieve full-scale social implementation despite the passage of decades since their initial conception. Examples include nuclear fusion power generation and artificial general intelligence.

What can be derived from these observations is that incremental approaches to technological forecasting, no matter how meticulously they may appear to be constructed, are highly likely to fail. Accordingly, rather than pursuing the ambitious goal of predicting the future with precision, it is possible to adopt a mode of thinking that embraces a wide range of possibilities—including ideas that may at first seem far-fetched—and examines them side by side through free and unconstrained imagination. Such an approach can serve as an alternative or complement to data-driven forecasting methods.

Moreover, particularly in the context of product development and marketing, the difficulty of social forecasting inevitably arises. For reasons distinct from technical feasibility, many technologies fail to achieve full-scale social implementation at the time of their development. Among these "shelved" technologies are some that later achieve rapid and widespread adoption as a result of changes in society. One example is the explosive spread of online conferencing systems during the pandemic. Similarly, foamed asphalt technology, which has rapidly expanded in recent years, is one example of a technology that required a considerable period from research and development to full-scale domestic implementation. Adding a small amount of water to molten asphalt produces foaming, and this technique was already proposed overseas in the 1950s as a means of improving workability. In recent years, however, its ability to maintain workability while reducing heating temperatures has led to renewed recognition of its effectiveness as an energy-saving technology, and its applications have consequently expanded in Japan as well. A review of such historical developments reveals that examples of technologies once dismissed as premature but later revived abound. Accordingly, even when a given technology is adopted despite the existence of multiple viable alternatives—owing to constraints such as cost considerations or prevailing user values—it may be worth questioning whether such dominance is merely a temporary historical contingency. Adopting such a perspective can be effective in preparing for future business opportunities.

In this way, the author believes that possessing both the imagination to consider the diverse possibilities of the future and the disposition to learn from history is essential as a mindset for adapting to forthcoming changes in today's increasingly uncertain business environment. Guided by the above concerns, the author has therefore engaged in the practice of SF prototyping to turn attention toward the future.

2. SF Prototyping

SF prototyping is a method that combines science fiction and prototyping (trial production). In the following section, a case study of its implementation at Nikko Co., Ltd. is introduced, and an overview of the framework and challenges associated with this method is provided.

2.1 Case Study at Nikko Co., Ltd.

At Nikko Co., Ltd., a project was launched in fiscal year 2024 under the direction of Mr. Dohjin Miyamoto (CEO of SF Implementation Lab Inc., and invited futurist at Nikko Co., Ltd.). In the summer of the same year, diverse members from various internal departments and Nikko Group companies participated, and a total of four workshops were conducted. These efforts resulted in the future-themed novel Tomorrow's Asphalt[1], set in the year 2058.

Furthermore, at the NIKKO MESSE 2025 exhibition held in the autumn of 2025, artworks derived from the fictional world of the novel were displayed in collaboration with artist Jun Kosaka and others.

In this way, through the process of creating an SF novel and accompanying artworks as "prototypes of the future," various possibilities for future road infrastructure and plant facilities were explored on a preliminary basis, giving rise to a range of speculative science-and-technology gadgets (tools). In addition, the project envisioned a broader configuration of business ecosystems including social contexts and digital technologies (DX).

2.2 Framework of SF Prototyping (SF Thinking)

In the context of utilizing science fiction as a method for fostering innovation within corporations, the process of arriving at a shared image of a future society, such as in the above case at Nikko Co., Ltd., is referred to as SF prototyping in the narrow sense.

A further process beyond this stage is "SF backcasting" which involves working backward from a shared image of the future society to explore points of connection with the present society. Such SF backcasting has been proposed. The entire process incorporating this backcasting phase is referred to as "SF thinking"[2)3)].

This framework of SF thinking, which moves back and forth between present and future, and between reality and fiction, can be explained in four steps based on the existing literature:

1. Create: Roughly construct a future vision within an SF-inspired worldview.
2. Express: Develop the future vision into an SF novel (story).
3. Apply: Identify links between the novel and present reality.
4. Realize: Translate ideas derived from the novel into real-world implementation.

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Among these four steps, SF prototyping corresponds to Steps 1 and 2, while SF backcasting corresponds to Steps 3 and 4.

The existing framework of SF thinking is illustrated in **Figure 1**[3].

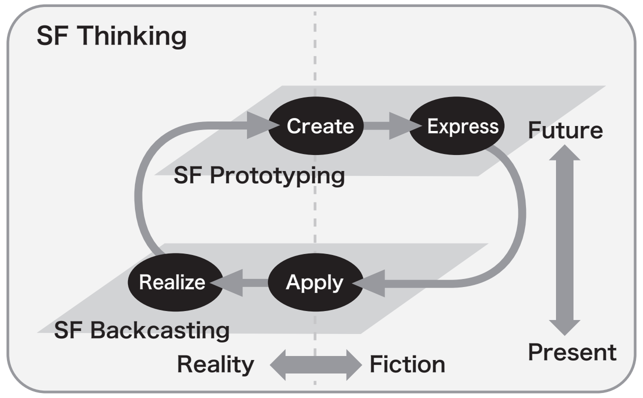


Figure 1: Framework of SF Thinking
(Figure provided
by the author from Reference 3, p. 142)

2.3 Challenges of SF Prototyping (SF Thinking)

With regard to the challenges of SF prototyping—the first phase of the broader SF thinking process—the following points have been identified in prior research[4]:

- Compared with scenario planning (another method for examining the future), SF prototyping tends to generate more provocative and enjoyable ideas.
- On the other hand, its level of reliability is lower than that of scenario planning.
- However, there is not a strong correlation between reliability itself and whether a proposal is ultimately advanced; rather, factors such as provocativeness and enjoyment contribute more significantly.

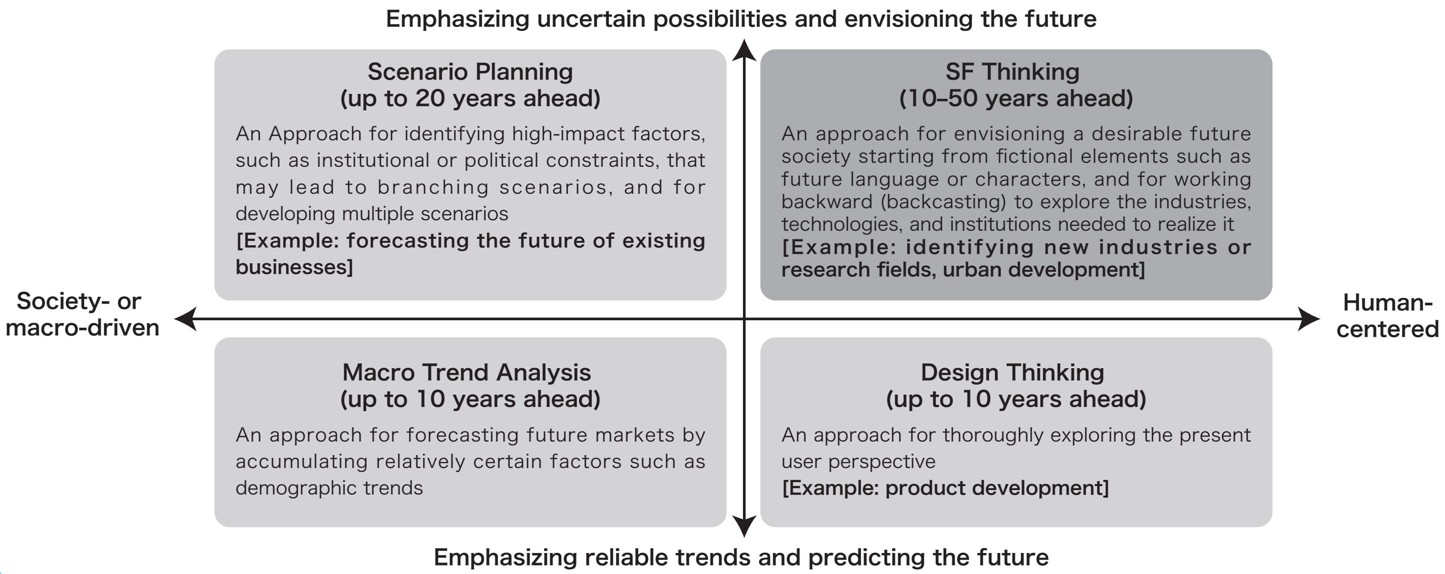
To restate this in the author's own terms, while well suited to envisioning a desirable future or a preferred direction of progress, SF prototyping presents challenges in terms of realism.

Figure 2[5] illustrates the characteristics of SF thinking in comparison with other existing methods used for future exploration.

Naturally, within the overall process of SF thinking, backcasting may be regarded as the phase that compensates for this lack of realism.

Nevertheless, as the author has personally experienced, translating speculative science-and-technology gadgets—resembling the "secret tools" of Doraemon—into real-world technologies grounded in engineering reality is highly challenging.

In particular, the challenges involved in applying SF thinking to R&D planning in the manufacturing sector, as well as the need for methodological refinement, have been examined in the author's previous work[6]. The following section proposes specific measures for improving the methodology.



Source: Mitsubishi Research Institute, Inc.

Figure 2: Characteristics of SF Thinking Compared with Other Methods
(Source: Reference 4)

3. Proposed Refinement of the Framework

This paper proposes a framework that integrates a history-of-technology perspective into SF thinking to incorporate consideration of the developmental processes of existing technologies and the potential revival of conventional technologies, thereby enhancing the realism of SF backcasting.

3.1 What Is the History-of-Technology Perspective?

In envisioning the future of technology, the author considers it useful to analyze the processes through which technologies have been established. Existing technologies that have achieved widespread adoption may appear to be stabilized as part of an encompassing system. However, as history demonstrates, they are not permanent. Among multiple alternatives, the selection of a particular technology and its firm embedding within a system may be influenced by various factors including contingency and regional specificity. The history-of-technology perspective revisits the trajectory of a given technology and places current technologies, which are often regarded as absolute, into a broader comparative context. In doing so, it reframes them as just one option among many and encourages consideration of alternative possibilities.

3.2 The Case of the Electric Power Network

The historian of technology T. P. Hughes, in his seminal work Networks of Power[7], conceptualizes the electric power network as a large-scale technological system and describes its patterns of development as well as the turning points in technological choice. The principal concepts Hughes employed in his historical analysis are introduced below.

According to Hughes, the development of the electric power network proceeded through the following stages: (1) invention, (2) technology transfer, (3) system growth, and (4) stabilization.

(1) Invention

During the early stages of electric power technology, individual investors were also active contributors. Several groundbreaking inventions were made that marked turning points in addressing the challenges of building electric power networks. The famed Thomas Edison not only conducted organized R&D within a research laboratory but was also a skillful entrepreneur who skillfully coordinated diverse stakeholders to build an electric power system.

(2) Technology Transfer

The localization of electric power networks proceeded in parallel with system growth across different countries and regions. For example, in London, strong municipal authority led to inconsistencies in regulatory legislation, and the rapid expansion of small-scale power stations hindered economies of scale, resulting in the development of the electric power system lagging behind that of other nations. Moreover, the availability of natural resources for hydroelectric power generation such as the Alpine and Niagara water sources was inherently dependent on geographical conditions. Accordingly, political and geographical factors were key determinants shaping the growth of electric power networks in each region.

(3) System Growth

In the course of the expansion of electric power networks, bottlenecks that constrain development are metaphorically described as "reverse salients," a term borrowed from military strategy that refers to a section of the front line that lags behind. In the case of electric power systems, for example, minimizing load fluctuations requires the enlargement of power stations and the expansion of consumption areas (which may be one of the factors that hindered the development of electric power in London, as noted above). In this case, mergers among electric power companies eliminate these reverse salients, enabling further expansion of the power network.

As described above, once the elimination of a reverse salient has been recognized as indispensable, it is defined as a "critical problem." When the resolution of such a critical problem involves significant technical difficulties, breakthrough innovations are required. For example, the efficiency limitations of direct-current (DC) transmission constituted a reverse salient. In order to replace it with alternating-current (AC) transmission and sustain continued network growth, the invention of a new AC motor capable of serving as an effective load was indispensable. The widely known "battle of the systems" between Edison's DC and Tesla's AC can be understood as centering on this critical problem. In the end, Tesla's AC system, which provided a technical solution to the issue, ultimately prevailed.

(4) Stabilization

As electric power networks expanded significantly and became deeply embedded in society, they attained a high degree of stability, leading to the current three-phase alternating-current (AC) system.

Thus, in the case of the electric power network, there existed a turning point in technological choice between "direct-current (DC) transmission vs. alternating-current (AC) transmission," and AC transmission was selected in response to demands for greater transmission efficiency. However, AC transmission was not an absolute choice; in recent years, for example, there has been renewed interest in high-voltage direct current (HVDC) transmission technology.

The case of the electric power network contains insights applicable to technology more broadly. That is, in response to the development of peripheral technologies and changes in societal demands, the configuration of technology may vary across time and region, and technologies different from those currently prevailing may be selected in the future.

3.3 Proposed Framework

The framework that the author proposed integrates a history-of-technology perspective into SF thinking and consists of the following steps:

1. Selection and explanation of speculative future science-and-technology gadgets
2. Abstraction of the concept
3. Identification of existing elemental technologies corresponding to the concept
4. Investigation of the history of technology related to the concept and relativization of current technologies
5. Identification of gaps between the concept and the present state
6. Identification of technological and/or societal breakthroughs required for future realization

To illustrate an application of the proposed framework, the example of the "Take-copter," one of the secret gadgets from Doraemon, is used below. It should be noted that, as the author is not a specialist in the field of aeronautical engineering, the reader is kindly requested to overlook any technical inaccuracies in the following discussion.

1. Gadget name: Take-copter
   Description: When attached to the head, a bamboo-copter-like propeller rotates, enabling the user to fly through the air.
2. Abstraction: Personal ownership of aerial transportation and on-demand mobility.
3. Existing elemental technologies: Drones; platform-based applications.
4. History of technology perspective: "Land transportation vs. air transportation."
   The origins of drone technology can be traced back to remotely operated weapons for military use. Subsequently, its applications expanded into civilian domains, including agricultural pesticide spraying and infrastructure inspection. Advances such as the miniaturization of sensors and other electronic components have further driven improvements in flight stability and attitude control, as well as research into autonomous operation. At present, however, air transport by drones has not yet surpassed other forms of land transportation, partly because transportation costs relative to payload weight remain comparatively high.
5. Identified gaps: Flight endurance; regulatory constraints; dependence on user skill.
6. Required breakthroughs
   Technological: Battery life; route optimization (air traffic control systems); payload capacity.
   Societal: Aviation regulations; risk acceptance; demand for immediate delivery.

Scenario Forecast

"If improvements in cost structure and the creation of demand for immediate delivery are realized, personalized on-demand air transport may become a promising technology."

In this way, while acknowledging that the selected future gadget itself (Step 1) is currently difficult to realize under existing physical constraints, the concept embodied by that gadget is extracted (Step 2). From a marketing perspective, the "desirable future" depicted through SF prototyping may reflect latent user needs. Working backward from this concept, points of contact with existing technologies and business models are explored (Step 3), and the trajectories of technological evolution are examined through a history-of-technology perspective, including the investigation of analogous cases. At this stage, it is desirable to make explicit the principal axes of opposition through which current technologies can be relativized (Step 4), identify the gaps between the concept and the present state (Step 5), and then specify potential technological and societal breakthroughs that could constitute turning points (Step 6).

In particular, the identification of breakthroughs in Step 6 may be reinterpreted as specifying the conditions under which technological transitions occur. In regulated industries such as civil engineering and construction, regulatory relaxation and shifts in cost structures (including subsidies and other financial incentives) may rapidly accelerate the implementation of new technologies. From this perspective, a scenario of the following form can be derived: "If X is realized, Y will become a promising technology." In R&D planning, preparing multiple future-oriented scenarios can help establish organizational systems capable of responding promptly to needs arising from societal change.

The following section presents an application of the proposed revised framework to a case of SF prototyping at Nikko Co., Ltd.

4. A Tentative Backcasting Analysis of Tomorrow's Asphalt

In the following section, several gadgets appearing in the future-themed novel Tomorrow's Asphalt, as well as gadgets created by the artist Jun Kosaka based on the work, are examined, and the framework proposed by the author is applied to them.

Figure 3: Tra-Factory
Artwork by Jun Kosaka

4.1 Tra-Factory

1. Gadget name: Tra-Factory
   Description: As shown in **Figure 3**, the Tra-Factory is a next-generation asphalt production system composed of mobile and reconfigurable factory units that can be disassembled and reconfigured. The units are responsible for functions such as transportation, crushing, heating, and mixing, and each unit is equipped with self-propulsion capabilities and can operate independently as a small-scale plant. This system is designed to respond flexibly to diverse situations, including disaster recovery sites, infrastructure repair projects, and remote areas with limited resources.
2. Abstraction: Decentralization and on-site recycling enabled by mobile plants.
3. Existing elemental technologies: Mobile plants (e.g., concrete plants, crushing plants).
4. History-of-technology perspective: "Stationary vs. Mobile."
   The earliest asphalt plants in the United States[8] were equipped with wheels and operated as mobile or semi-stationary facilities.
5. Identified gap: Differentiation from the currently dominant stationary plant system.
6. Required breakthroughs
   Technological: Dramatic increase in recycled material mixing ratios; autonomous control systems.
   Societal: Revision of technical standards; changes in maintenance and repair cycles.

Discussion

At present, there is a societal shift toward reducing dependence on fossil fuels, accompanied by rising crude oil prices. In the past, road paving was demanded during the motorization process dominated by gasoline-powered vehicles. Asphalt pavement is presumed to have possessed advantages due to the synergistic utilization of petroleum residues generated in the fuel production process; however, in light of recent advances in refining technologies, it is difficult to equate current conditions with those of the past. At the same time, from the perspective of its advantage as a thermoplastic binder that can be repeatedly reused once laid, asphalt pavement is likely to remain in use for the time being. Nevertheless, asphalt is subject to property degradation through repeated recycling, and therefore, the trend toward increasing recycling rates is expected, in the author's view, to require further technological innovation. Turning to manufacturing technology, asphalt plants play a critical role in post-disaster recovery when severe natural disasters occur; however, from an operational perspective, the industry has been experiencing a trend toward consolidation and a decline in the number of plant locations. Accordingly, in addition to centralized production based on stationary plants,[*2] on-site recycling may represent an alternative axis of development. Historically, semi-stationary asphalt plants existed during the early stages of industry development; therefore, provided that breakthroughs in recycling technology occur, the revival of mobile or semi-stationary plants may be anticipated as one possible future development.

Interim Summary (Scenario Forecast):

"If breakthroughs in recycling technology occur, on-site recycling through mobile plants may become a promising technology."

4.2 Pet-Plant

1. Gadget name: Pet-Plant

   Description: **Figure 4** shows a Pet-Plant that is an ultra-compact, semi-automated, self-propelled asphalt and concrete plant. The Pet-Plant automatically produces high-quality asphalt mixtures and fresh concrete simply by loading dedicated binder cartridges and mixing them with locally available materials such as gravel and sand. Roads and ground surfaces can be repaired in a manner reminiscent of crafting mechanics in simulation games.
2. Abstraction: Personal ownership of production plants and the DIY-ification of road repair.
3. Existing elemental technologies:

   Citizen-participatory road repair using cold-mix asphalt[9].
4. History-of-technology perspective: "Private roads vs. Public roads."

   In the early stages of paving history, roads were reportedly constructed through joint investment schemes by local influential figures, who collected usage fees[10].
5. Identified gap: The prevailing perception of roads as public goods and the current low proportion of private roads.
6. Required breakthroughs

   Technological: Autonomous control; binder supply systems; production capacity.

   Societal: Regulatory reform; shifts in prevailing social norms.

Discussion

In recent years, constraints on the resources available for maintenance and repair, together with demands for extended service life as a countermeasure to aging infrastructure[11], suggest that the operational lifespan of road pavements may be prolonged compared with the past. Furthermore, in line with the trend toward compact-city policies[12], infrastructure maintenance in remote areas outside designated priority zones may become increasingly difficult to sustain (e.g., under location optimization plans). In light of these circumstances, the emergence of DIY-based repair initiatives by residents may represent one possible development. Furthermore, with respect to road infrastructure that requires maintenance by private companies including logistics routes and access roads to factories, trends such as an increase in the proportion of private roads and the revival of joint investment schemes may also be conceivable. While the scale of facilities need not necessarily be limited to ultra-compact devices like the imagined gadget, recent demands for automation and labor-saving measures suggest that, prior to full-scale paving operations, processes such as curing and simple repairs could first be automated using small-scale equipment. It should be noted that decentralizing manufacturing functions may also be consistent with the concept of resilience (the capacity for flexible recovery) in disaster management.

Interim Summary (Scenario Forecast):

"If challenges in road maintenance become more pronounced, pavement (repair) systems led by the private sector may emerge as a promising technology."

Figure 4: Pet-Plant
Artwork by Jun Kosaka

[*2] A central plant that consolidates existing plants into a large-scale production hub represents a technological solution that provides advantages such as economies of scale. Nikko Co., Ltd. has proposed a future concept that combines this approach with asphalt mixture heat-retention system ("Okamochi").

4.3 Asphalt Architecture: Bituminous Baroque

1. Gadget name: Asphalt Architecture: Bituminous Baroque

   Description: **Figure 5** shows an Asphalt Architecture representing an architectural style—Bituminous Baroque—that pushes the potential of asphalt materials to their limits. Constructed through seamless shell structures enabled by 3D printing and robotic fabrication, complex curved surfaces themselves distribute loads and function as self-supporting structures. The appearance shifts dramatically with changes in light across seasons and times of day.
2. Abstraction: Soluble structural bodies (thermoplastic, recyclable circular architecture and structural systems).
3. Existing elemental technologies: 3D printing of mortar; limited applications of asphalt as a building material (e.g., insulation materials).
4. History-of-technology perspective: "Concrete architecture vs. Asphalt architecture."

   Precedents have been identified in art works that use asphalt as a motif; however, historical examples in which asphalt has been applied as the primary structural material remain scarce.
5. Identified gap: Thermoplasticity.
6. Required breakthroughs

   Technological: Structural strength; mitigation of thermal softening.

   Societal: Regulatory reform; resistance in terms of landscape aesthetics.

Figure 5: Asphalt Architecture: "Bituminous Baroque"
Artwork by Jun Kosaka

Discussion

There are reported cases in which temporary structures are constructed using mortar-based 3D printing; however, the generation of so-called concrete debris upon dismantling may present a problem. If the thermoplastic properties of asphalt (recycled aggregates) are effectively utilized, there may be advantages in implementing both the expansion and removal of temporary structures within a closed-loop resource circulation system. The author, however, considers the technical hurdles associated with using asphalt as a structural material to be substantial, particularly with regard to ensuring structural strength and mitigating softening under elevated temperatures. Possible starting points might include the incorporation of specialized fibers or initial applications in cold regions. Furthermore, from the perspective of expanding the applications of asphalt beyond road paving, the present project has envisioned several gadgets that seek to realize the material's potential in areas such as furniture, small objects, and everyday goods.

Interim Summary (Scenario Forecast):

"If structural strength can be ensured, the application of asphalt (recycled aggregates) to buildings and structural systems may become a promising technology."

4.4 Asphalt Swimming

1. Gadget name: Asphalt Swimming

   Description: **Figure 6** shows a poster for 2055 Asphalt Swimming Championship. As illustrated by the poster, a competitive discipline known as Asphalt Swimming has developed as a philosophical sport that tests both mental resilience and technical skill, in which athletes swim through highly viscous, high-temperature bitumen. The trails left behind by the athletes form beautiful wave patterns that can be interpreted as "fluid sculptures." The fully sealed suits worn by them function not only as life-support systems but also evolve into customized gear that enhances propulsion and thermal insulation.

Figure 6: Poster for the 2055 Asphalt Swimming Championship
Artwork by Jun Kosaka

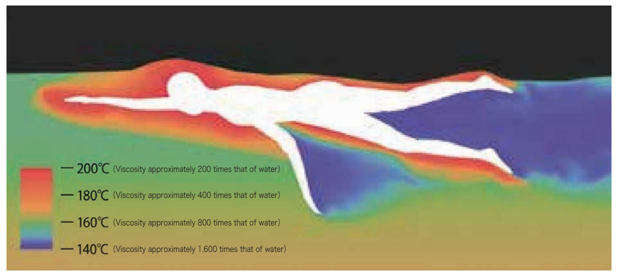


Figure 7: Fictional Simulation of Swimming Methods
Artwork by Jun Kosaka

※As indicated in the thermographic illustration in **Figure 7**, a temperature differential is intentionally created around the suit: the temperature is raised in the direction of movement to reduce viscosity, while selected contact points are cooled to increase viscosity, thereby enabling powerful propulsion techniques such as the crawl stroke.

2. Abstraction: Safe human activity within fluids under extreme environmental conditions.
3. Existing elemental technologies: Diving suits; fluid-dynamics simulation.
4. History-of-technology perspective: "Infrastructure as a living environment vs. Infrastructure as an artificial construct."

   Within artistic expressions that take civil engineering materials as their motif, there have been works that explore on the boundary between artificial urban environments and nature. As a related example of swimming within a fluid medium, fluid-dynamical analyses have been conducted in the case of "syrup swimming" [13].
5. Identified gap: The need for a safer operational environment (including not only thermal protection but also the mitigation of health effects arising from the physical properties of asphalt).
6. Required breakthroughs

   Technological: Safety enhancement.

   Societal: Social acceptance; the cultural promotion of civil engineering materials.

Discussion

The author considers that civil engineering materials and infrastructure technologies have the potential to become more familiar and safer presences for citizens and workers than they are today. Although Asphalt Swimming may appear at first glance to be an unrealistic future sport, it occupies a significant position in the novel Tomorrow's Asphalt. In the story, Kurokawa Asuha, a female plant employee and Asphalt Swimming athlete, plays a central role. In ordinary times, she acts as an influencer who communicates the appeal of civil engineering to the public. In times of disaster, she operates the plant as a key agent of recovery and works alongside citizens in reconstruction efforts. The gadget is positioned as a symbolic embodiment of this ideal. From the perspective of work safety, it is reported that in Europe for example, attention has long been directed toward the reduced construction temperatures enabled by the above-described foamed asphalt technology, and that such approaches have been implemented early with consideration for improved working conditions. In Japan as well, amid recent trends of declining labor force and the pursuit of greater social diversity, ensuring safety and improving working environments in the civil engineering and infrastructure sectors have become priority issues. Nikko Co., Ltd. is likewise advancing various initiatives in this regard.

In addition, as a related technological element from a mechanical perspective, our R&D Center is engaged in fluid-dynamics simulation. Within the product development roadmap aimed at advancing digital transformation (DX) to support automation and labor-saving initiatives, we recognize the necessity of conducting research and development on manufacturing processes such as mixing and heating through approaches based on material properties. It should be noted that, during the aforementioned NIKKO MESSE 2025 exhibition, a visitor suggested that the elemental technologies embodied in this gadget might be useful in contexts such as subsurface resource exploration.

Interim Summary (Scenario Forecast):

"If the cultural promotion of civil engineering materials and the assurance of safety are realized, closer interaction between infrastructure technologies and people may become a promising technological direction."

8. Conclusion

Innovation literally means "new combinations." It is beneficial in R&D planning not to remain confined to ideas generated solely within our company, but rather to incorporate external knowledge. In this respect, SF-inspired thinking may serve as a catalyst for cross-industry collaboration.

The backcasting framework proposed in this paper is characterized by its integration of a history-of-technology perspective with the provocative visions generated through SF. As a method capable of providing concrete engineering insights in preparation for future technological turning points, it may be applicable to the infrastructure sector, as well as to manufacturing industries.

Amid growing calls for national resilience and the advancement of infrastructure DX, ensuring sustainability under rapidly changing conditions requires more than mere labor-saving measures or the digitalization of existing operations; it demands a fundamental transformation of value systems. This paper has presented an approach that envisions a "desirable future" through SF-inspired imagination and explores "pathways to realization" through insights drawn from the history of technology. The author intends to further develop and refine this approach as one possible cognitive framework for enhancing resilience—the capacity for flexible and adaptive recovery—in the face of unknown crises.

Building on this initiative of SF prototyping, the author seeks to gradually break down the boundaries created by specialization in the civil engineering and manufacturing sectors. The goal is to turn this effort into concrete action by creating opportunities for "co-creation" that involve diverse stakeholders, including those from other industries.

9. Acknowledgments

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