Futures 177 (2026) 103770

Contents lists available at ScienceDirect

Futures

journal homepage: www.elsevier.com/locate/futures

Science fiction and innovation: A literature analysis on science fiction-related methods mapped into the innovation process

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ARTICLE INFO

Keywords:
Innovation
Foresight
Innovation process
Science fiction
Methods

ABSTRACT

In the development of innovations over the past decades, data-driven methods have become commonplace. Alongside advantages in effectiveness and efficiency comes the danger of relying on data describing past rather than future developments which can result in a loss of imagination and creativity. In parallel, a growing awareness of the interface between innovation and science fiction can be observed in academia and among practitioners. This awareness is most often based on the hypothesis that taking inspiration from science fiction can create value in the development of innovations. Despite numerous case studies in the literature describing this interface, a major part of methods applied seem to have been chosen in an unstructured, almost random way. This study investigates the literature in search of science fiction-related methods able to support the development of innovations. With around 60.000 publications considered based on a high-level search, a refined search combined with a manual search led to 17 science fiction-related methods to support the development of innovations. Using a six-phase generic innovation process, the methods identified were mapped into the process based on semantic similarities between the objectives of each method and the objectives of innovation process phases. This mapping is understood as an overview and conceptualization offering a baseline for future academic research and guidance for practitioners on choosing the most appropriate science fiction-related methods for developing innovations.

1. Introduction

The innovation management toolbox has been continuously restocked over the last decades. With greater availability of data and better computing performance, analytical assistance to understand and simulate complex systems is being frequently applied to support the development of innovations. In addition to the potential benefits in efficiency and effectiveness analytical systems, there is the danger of over-reliance on ex-post data collection, retrospectively related to past events or activities and thereby sacrificing imagination and creativity. Unexpected future options often find no place in established structures, evaluation schemes, or analysis patterns. Science fiction as an art form with scientific elements offers the possibility to look beyond previous innovation paths into

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https://doi.org/10.1016/j.futures.2026.103770
Received 14 May 2024; Received in revised form 4 December 2025; Accepted 27 January 2026
Available online 31 January 2026

unexpected futures. It enables imagination by incorporating unexpected, desirable, or dystopian aspects into innovation activities. The relationship between innovation and science fiction can be considered an integral part of the interface between science and fiction (Clarke, 1962, 1999; Elkins, 1979). For many years, this relationship seems to have experienced a renaissance (Zaidi, 2019). Science fiction is said to stimulate the imagination, arouse the emotions and, most importantly, inspire (Sigma Xi, 2010). Furthermore, it can help to overcome cognitive biases (Burnam-Fink, 2015; Schwarz, 2015), support the change of perspective (Schimpf & Lauster, 2021) or help to break down psychological barriers on the way to seemingly crazy ideas (Altshuller, 2007: 230). These potential benefits underline the potential contribution of science fiction to the development of innovations. In summary, science fiction seems capable of providing insights into future worlds beyond incremental advancements, enhancing imagination and thereby challenging previous paradigms and innovation paths.

Literature has many examples of science fiction inspiring innovations. Similarly, some books and articles have process steps to provide structures and make the inspiration replicable in different situational contexts. However, there is no overview of science fiction-related methods or decision criteria to select most appropriate methods existing. Furthermore, it can be observed that most examples of science fiction-inspired innovations seem to have been developed without taking advantage structured and replicable processes. In case methods are applied, they appear to have been chosen in an unstructured, almost random way. Following this understanding, the research gap addressed in this paper is the lack of a comprehensive conceptualization, followed by the research question of how science fiction-related methods can be mapped to the phases of a generic innovation process. To answer the research question, a cross-disciplinary literature review of academic literature databases, non-reviewed publication repositories and literature not available digitally was conducted. The methods identified were then analyzed and mapped to the phases of a generic innovation process model, using semantic similarities between the objectives of each method and those of each phase of the generic innovation process. The results are presented alongside this process and the methods are discussed. The presentation of results follows the conceptual framing, providing the baseline of this research with insights on the understanding of the terms ‘science fiction’ and ‘innovation’ as well as the research methodology, followed by a conclusion and outlook.

2. Conceptual framing

2.1. Science fiction and innovation

In a 2002 analysis of science fiction literature by the European Space Agency ESA, Dunyach (2002: 5) entitles his outline of the term ‘a touch of science in your fiction’: fiction with a scientific component. Whilst elements of fiction with scientific components can be found in stories written two millennia ago, and numerous definitions have been developed over time, the work of Roberts (2016), containing at least 16 definitions, can be referred to a central baseline to provide an understanding of potential meanings of the term science fiction. Going back in time, Gernsback (1926: 3) is credited with coining the term ‘science fiction’. He characterized the concept of scientification in 1926 via the components of narratives, scientific information, and foresight. Using the term *science fiction* the exploratory research encompasses different understandings, considering that they all stand at the intersection of science and fiction. The media considered as science fiction in science fiction-related methods encompass all possible media for documentation, including literature, film, comics, radio plays, and books (Steinmüller, 2010: 19–20).

To define the term *innovation,* this paper uses the OECD[1] definition as a baseline. According to this definition, innovation is a ‘new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)’ (OECD/Eurostat, 2018: 20). To highlight the role of social and organizational innovations in reference to earlier definitions such as innovation as an ‘implementation of new combinations of knowledge’ (Schumpeter, 1912), and considering the development of the term over the last century (see for example Baregheh, Rowley, & Sambrook, 2009; Baskaran & Mehta, 2016; Bauer & Schimpf, 2020; Garcia, 2002; Janssen, Stoopendaal, & Putters, 2015; Linton, 2009), *innovation* is defined as an ‘idea that is successfully implemented, whereby the implementation can take the form of new technologies, products, services, business models, or integrated solutions in markets, organizations, or society’ (Fraunhofer Group for Innovation Research, 2018: 6). Both the idea and its successful implementation are necessary prerequisites to differentiate innovations and innovation activities from non-innovations such as ideas without implementation (for example, pure inventions) or from technologies, products, services, business models, or integrated solutions without any degree of novelty. The implementation field is considered as the system where implementation takes place and in relation to which the degree of novelty is specified. The degree of novelty is most commonly specified in reference to standards or solutions commonly in use to fulfil a functionality comparable to the one of the innovation.

At the interface of science fiction and innovation, science fiction is credited with inspiring innovators (Macfadyen, 2014) and enhancing their imagination (Darbellay, 2022). Zaidi (2019: 17) speaks about a tangled relationship between science fiction and innovation, in which science fiction authors are responsible for creating a larger reality that extends beyond single stories. Whereas Michaud (2011) points out that science fiction in the innovation process is perceived in a professional setting as both helpful or childish (Hougron, 2000), the understanding of the effects created by linking science fiction with innovation activities seems to require additional academic evidence (Black & Barnes, 2021). The perceived usefulness has recently been validated in an empirical analysis by Zoccarato, Lettieri, Radaelli, Ghezzi, and Toletti (2024), looking into how and why individuals experiment with science fiction-related

[1] OECD: Organization for Economic Cooperation and Development

innovations. It seems necessary to differentiate between domains where science fiction can and cannot enable imagination and support creativity. In the case of one major foresight analysis enabling the comparison between data-driven foresight with a science fiction inspired foresight workshop, it was revealed that technology-driven areas tend to show the highest variation (Schimpf, 2025). Michaud and Appio (2022: 127) explain how to create the transition between speculative sources and real contexts enhancing the development of innovations especially in the fuzzy front end of the innovation process. The statements that the application of science fiction-related methods supports openness to and enhancement of real-world science (Menadue & Jacups, 2018) combined with the statement that science fiction encourages the ability to think the impossible (Black, Capps, & Barnes, 2018) provide the baseline for the motivation of this paper and the consideration that science fiction-related methods can add value to the development of innovations.

As pointed out in the introduction, there are numerous examples from different thematic fields where science fiction and innovation are interlinked. This includes the future of cities (Pätsch, Maikämper, Krämer, Rukschcio & Rott, 2015), product and production systems (Le Blanc, Seibel, Gaul, Reitzenstein & Wolf, 2022), the future of human computer interaction (Russell & Yarosh, 2018), the future of work (Schmeink & Schneider, 2021), organizational behavior in extreme contexts (Heinrichs & Vakilzadeh, 2022), nanotechnologies (Le Blanc, 2014), virtual reality (Michaud, 2018), electronically monitored control (Nellis, 2013), cyberspace (Michaud, 2014), tourism (Yeoman, McMahon-Beattie, & Sigala, 2022), or energy and climate research (Raven, 2017). Beyond thematic fields, a variety of companies link science fiction to innovations in their fields. Among the examples documented are companies such as France Telecom (Douani, Michaud, & Ponthou, 2023), Deutsche Telekom (Reventlow, Thesen, Le Blanc & Haas, 2017), SAP (Rosenberg, 2019), Audi (Schwarz & Hofmann, 2019), the European Space Agency (Battrick & Warmbein, 2002), or Qualcomm (Michaud, 2017). There are presumably many more unpublished examples interlinking science fiction and innovation in companies.

Beyond supporting the development of innovations through its inspirational nature, the potential of science fiction can be associated with its narrative format. Not only can future worlds be imagined or memorized better when they are described in a narrative format, but fictional narratives also contribute to the social construction of reality (Schwarz, 2015; Schwarz & Wach, 2022). A prime example is the 'Communicator', which appeared in the original *Star Trek* series as a communication device for the 23rd century, inspiring the development of the Motorola StarTAC mobile phone. Beyond narratives, cinematic representations of technological possibilities have been created in collaborations between filmmakers and science consultants, both stimulating the audience's desire for these technologies and generating funding opportunities to develop them (Kirby, 2010). Science fiction narratives can even become models for entire sectors or industries. Examples are Asimov's law in robotics (Feitelson, 2007), *Minority Report* in computing (Bleecker, 2009: 35), or *Star Trek* in space travel (Michaud, 2020: 137). Recently, it was empirically validated that science fiction can even have a positive impact on social media engagement and patent filing, as exemplified in the series *Black Mirror* and a related increase in social media activities and patenting (Messeni Petruzzelli, Mora, Natalicchio, Platania & Toscano Hernandez, 2024). Options for the transfer of narratives into the development of innovations include direct analogies, metaphors, or associative suggestions (Dirlewanger, 2016: 35).

2.2. A generic model of the innovation process

A conceptual framework is needed to provide an overview of science fiction-related methods and to support the selection of most appropriate methods in specific contexts. With the purpose of breaking down the development of innovations into more specific innovation phases, a generic innovation process was chosen (see Table 1). Considering that innovation processes are seldom linear, this generic process model is meant to represent major innovation activities in subsequent phases that can also be applied in iterative, random or split order.

As a baseline, the generic innovation process model reflects considerations of innovation process models from Myers and Marquis (1969: 4) up to the recent design-oriented model to solve wicked problems (Jobst & Meinel, 2014: 106). Following the logic of strategic planning as a first step in the innovation process (Booz & Hamilton, 1982: 12), vision, mission and strategic goals provide the basis for any further activity. This phase is also termed *recognition* (Hippel, 1976: 228; Myers & Marquis, 1969: 4), or *discovery* (Cooper, Edgett, & Kleinschmidt, 2002: 20), integrating both strategic development, foresight and future analysis. Recognizing that both phases might be linked, these are separated in two phases due to the distinctiveness of objectives, allowing a more detailed mapping of supporting science fiction inspired methods. The term *foresight* describes activities concerned with identifying changes or trends in the business environment, describing possible futures and triggering organizational responses (Rohrbeck, Battistella, & Huizingh, 2015). Scenarios are considered here as the development of multiple futures with the purpose of preparing decision makers for potential future developments. They therefore require a degree of plausibility and follow specified development processes. Scenarios can be developed,

Table 1
Phases of the generic innovation process considered for the analysis.

Phase	Key activity related to the realization of innovations	Objectives of the phase of the innovation process
1	Strategic planning	Development of visions, missions, and strategic goals
2	Foresight and future analysis	Outlook into the future and assessment of possible future developments
3	Technology analysis and assessment	Analysis of technological opportunities and development trends and their assessment
4	Market and user analysis	Analysis and evaluation of market developments and user behavior
5	Idea generation and evaluation	Creative inspiration as well as generation, development, and evaluation of ideas
6	Concept development and validation	Elaboration of concepts for possible innovations up to the validation of these concepts with the help of simple prototypes

for example, bottom up, considering the interlinkage and potential future developments of key influence factors in a specified system (Pillkahn, 2008). Since the 1980s, the term has gained importance and, in addition to its original use for technology-related future analyses at the macroeconomic level, is now frequently used for all levels, from organizations to regions or entire economies (Miles, 2008: 24). Foresight activities in organizations, also known as *strategic* or *corporate foresight*, have been described as activities that foster innovation (Rohrbeck & Gemünden, 2011). This allows us to perceive foresight as part of the early innovation process including all future analyses. For phases 3 and 4, the logic of recognition, split into a technology and a market perspective, was adopted (Myers & Marquis, 1969: 4), also known as *preliminary technical* or *market assessment* (Cooper, 1983: 7). Referring to potentially different information sources and stakeholders, the technology perspective is explicitly separated from the market perspective. The phase of idea generation is the most common phase in the processes found in literature with the least semantic variation. For the allocation of science fiction-related methods, generation and evaluation of ideas are integrated into a single process phase (Hippel, 1976: 228; Myers & Marquis, 1969: 4), also referred to, for example, as *invent* and/or *produce analytic design* (Kline & Rosenberg, 2009: 290), or the *generation of alternatives* (Wheelwright & Clark, 2011: 224). The activities considered in this generic innovation process end with the phase of concept development and validation, also called the phase of *design*, *development* and *testing* (Booz & Hamilton, 1982: 12). In this phase, it is important to highlight the role of prototypes, often referenced to in a testing phase (Cooper, 1983: 7), gaining importance especially in design- and software-oriented innovation process models (Boehm, 1988: 64; Brown, 2008; Hayes, Wheelwright, & Clark, 1988: 279).

3. Research methodology

The objective of this study is the identification of science fiction-related methods able to enhance the development of innovations and to support the selection of most appropriate methods for specific process phases. The identification of science fiction-related methods was conducted in a mixed-method publication analysis following the steps shown in Table 2. This iterative process started with a high-level search, followed by a more specific search providing the input for a manual analysis and evaluation. This search method was adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff & Altman, 2009), including the search, categorization and grouping of publications (Tranfield, Denyer, & Smart, 2003). The IT-supported process was complemented by manual search, categorization and grouping to cover books, articles and grey literature not available digitally. Manual search might also be termed *hand-searching* or *hand-search* where key sources have to be identified before a closer page-by-page examination (Chapman, Morgan, & Gartlehner, 2010: 23).

The understanding of the term *method* is a baseline for the literature analysis. Following the general principle that methods provide structure and enable learnings on specific procedures (Descartes, 1637), they can be described, for example, through their provision of a structure or template for orientation and replication (Herrman, 2009: 5) or the provision of a structural guidance from an initial to a final stage (Callaos & Callaos, 2014). *Method* thereby represents a sub-group of methodologies, a 'network of methods with their respective tools and techniques'. Often however, the terms *method* and *methodology* are used synonymously. For this study, a method is considered as the provision of structure from an initial to a final stage and can be translated into the availability of steps or phases provided in the form of a structured procedure or process. This translation is a necessary requirement during the search for science fiction-related methods. Based on this understanding, the keyword search in literature was carried out using the terms *method*, *methodology*, or *typology* as well as *steps*, *process* or *process phases*.

SCOPUS, ScienceDirect and Google Scholar were searched with search options provided. WoS was searched with the help of the KATI System,[2] providing additional search and visualization functionalities. Whereas Google Scholar and ScienceDirect were analyzed with the help of a full-text search including a prioritization of relevance based on a specific algorithm, SCOPUS and WoS were searched based on titles, keywords and summaries. Whilst the number of search results in Google Scholar was considerably higher than in SCOPUS, ScienceDirect or WoS, the access is restricted to a maximum of 1000 results per query. Other information sources such as books, grey literature and reports were searched based on the availability of supporting search structures, including the usage of search engines for digital publications or manual search for literature not available in digital form. Taking benefit from the international usage of the key search terms *innovation* and *science fiction*, publications were also considered in German and French in addition to English.

For the mapping into the phases of the innovation process, all methods identified were then analyzed according to the semantic similarities of their objectives with the objectives of each of the phases of the innovation process. This follows the logic of natural language processing using semantic relationships through the measurement in a vectorized distance. Whereas in natural language processing, machines can simulate an understanding by vectorized distances referred to in the automatic identification of semantic overlaps in big data analyses (see Cohen & Moore, 2006; Vasconcelos & Campelo, 2024; Zhou, Xu, Liu, Chang & Xiao, 2019), the research team was estimating the vectorized distance to evaluate semantic similarities between objectives in this analysis to being able to map methods identified to the phases of the innovation process. The semantic distance between the objectives of each method and the objectives of innovation process phases was therefore rated on an ordinal scale indicating the applicability through the overlap between objectives with three options: *most applicable*, *partly applicable* and *hardly applicable*. This categorization considers that most methods can be applied in many contextual environments. The categories shall provide guidance for the context, in which an application is most suited within the innovation process – and where there are no or just minor overlaps between the objectives of

[2] KATI: Knowledge Analytics for Technology and Innovation, a tool for literature analysis and data-driven foresight developed by Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE: https://www.fkie.fraunhofer.de/de/forschungsabteilungen/int/kati-lab.html

Table 2
Steps of the mixed method publication analysis.

Step		Description
1	High-level search	Identification of publications covering overlaps between the thematic areas of innovation and science fiction with a combined search prompt for the terms 'innovation' AND 'science fiction' in SCOPUS, Web of Science Core Collection (WoS), Science Direct and Google Scholar publication databases
2	Refined search	Refinement of search results towards the identification of methods with the help of the terms *method*, *methodology*, or *typology* as well as semantically related terms such as *steps*, *process* or *process phases*
3	Accompanying search	Manual high-level and refined search in additional publication databases including international libraries through the meta search engine KVK[a], search engines such as google, and crowd-based publication databases such as Researchgate, Academia, and Mendeley
4	Qualitative investigation	Manual search for publications describing methods related to science fiction, potentially supporting the objectives along the innovation process in the results of search steps 1–3
5	Mapping	Analysis of semantic overlaps between the objectives of identified methods and the objectives of the phases of the generic innovation process (see Table 1)

[a] Karlsruhe virtual catalogue KVK: https://kvk.bibliothek.kit.edu

methods identified and the objectives of the phases of the innovation process.

4. Results

The first publications were found in the 1950s, not pointing at innovation but rather at social content (Shaftel, 1953), or the historical illustration of concept formation (Plank, 1955). The number of publications found through the high-level search considerably increased in the last 20 years. Until 2012 (SCOPUS) and 2013 (WoS) significantly fewer than 10 papers per year were published. This is followed by a steady linear growth phase, leading to 20 in SCOPUS in recent years and 10 in the Web of Science. Consequently, one can ascertain a slowly but steadily growing interest and discussion on the topic of science fiction and innovation within the scientific community.

A major share of publications identified in the high-level search (exemplified by the WoS data) comes from the disciplines of computer science and business and management (see Fig. 1). To display the temporal development of disciplines, the color is used to encode the mean age of the publications published in a specific category (John, Fritsche, & Gülden, 2021). Here blue tones depict older, whilst red tones mean more recent publications. It becomes evident that the first publications on this topic were in computer sciences (hardware & architecture and artificial intelligence). In later phases, business, economics and management (in that order) increase in importance. More recently, the topic has been addressed in fields such as industrial engineering.

The publications identified through the high-level search led to a large sample (see Table 3), mostly in the following categories: (1) papers that use the term *science fiction* to highlight the degree of innovativeness of, for example, technologies or new processes that are put into practice, (2) the use of metaphors from science fiction to highlight specific functionalities or developments, and (3) publications that address the use of science fiction to enhance other disciplines or thematic areas. In this paper the third category is addressed, focusing on the identification of methods for the integration of science fiction to support the development of innovations.

The results of the refined search, in which publications in the third category were filtered with the help of additional keywords (see step 2, Table 2 and Table 3), were analyzed manually. Starting with the title and the abstract in the search for the provision of structure from an initial to a final stage, these were searched in the table of contents or in related chapters of the publications. A key aspect to be

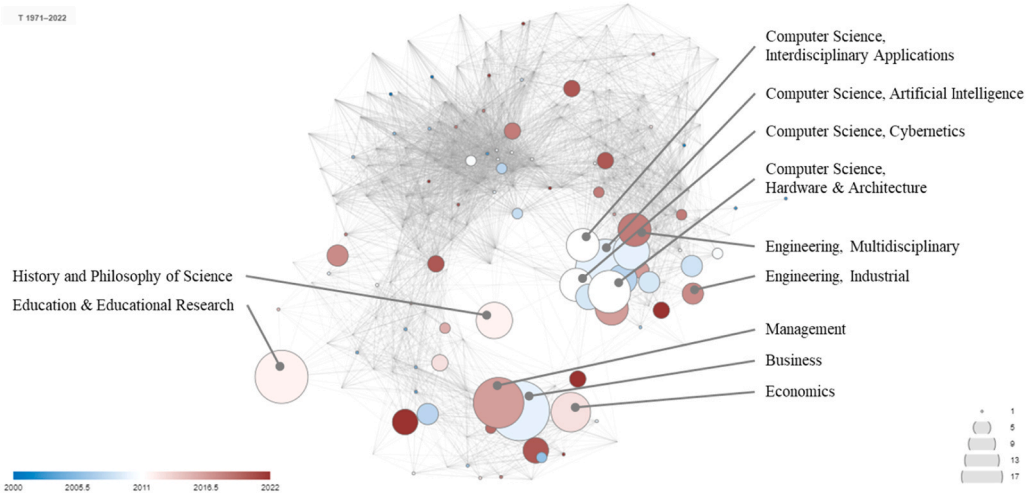

Fig. 1. Overlay map related to WoS Categories based on the WoS core collection from 1971 to 2022 visualized with the KATI system (Rafols, Porter, & Leydesdorff, 2010).

Table 3
Publications identified through automated scanning with a keyword search for the terms science fiction AND innovation in the high-level search and refined through additional keywords added to the search string in the refined search.

Literature Database	Years of publication	High-level search Number of publications Keywords	Refined search Number of publications					
			Keywords added each individually with AND to the high-level search					
		science fiction AND *innovation*	*method*	*methodology*	*typology*	*steps*	*process*	*process phases*
SCOPUS	1982–2023	269	40	25	1	11	77	0
Web of Science	1971–2024	169	39	30	1	8	52	0
ScienceDirect	1999–2025	2.767	2.059	1.289	156	1.750	2.490	8
Google Scholar*	1910–2024	58.600	40.300	27.200	22.500	23.300	43.300	83

* restricted to access a maximum of 1000 search results per query

considered in this search for science fiction-related methods was that methods are often available only in figures, tables or in the Annex of publications. Search capabilities for these types of objects with the help of automatic data analysis is still limited, mainly due to lack of accessibility or common taxonomies. This restriction led to the logic of combining keyword searches for the identification and filtering of publications, with a manual search for covering not only textual but also visual and tabular descriptions of methods. Additionally, publications that were not available digitally were incorporated into the manual search process.

In the qualitative investigation, methods identified were clustered according to similarities, sufficiently differentiable from each other. This involved especially descriptive elements for the provision of structure from an initial to a final stage and the linkage to related components of other, non-science fiction-related methods. For example, all processes or stepwise approaches identified that are aimed at the development of future scenarios with the help of science fiction were considered as a single category, then subdivided for mapping into the phases of the innovation process.

The presentation of methods identified follows the phases of the generic innovation process. Additionally, an overview is provided in Table 4. Based on the literature analyzed, 17 methods were identified in 16 publications. For each method identified, steps or phases provided in the form of a structured procedure or process are presented in combination with a short discussion.

Considering that several approaches are applicable to most phases of the innovation process, it is important to note that this study is meant as an indication of where the application of each science fiction-related method makes sense based on overlaps in their objectives with the objectives of innovation process phases. Not being a strict allocation, this study acknowledges that an application might also make sense in other project phases depending on the context. Educational or training methods meant to enable people who are involved in the innovation process to consider science fiction-related aspects as a general learning experience can hardly be mapped to specific process phases and are excluded from the mapping. This involves, just to mention one example, the provision of science fiction stories for guided or non-guided reading (Dirlewanger, 2016: 54).

4.1. Phase 1: Strategic planning

The objective of strategic planning is the development of visions, missions, and strategic goals, to provide direction in all phases of the innovation process. In this context, science fiction provides input for goals that can go far beyond the incremental advancement of previous solutions (Michaud, 2020: 113). Furthermore, science fiction does not only provide a view into the future itself, but can also contribute to the acceptance of strategic planning in technocentric environments (Chouteau & Nguyen, 2020: 16–17). In the publication analysis, the methods for the development of visions and mission statements with the help of science fiction and the reflection of strategic objectives using science fiction were identified, overlapping with the objectives of strategic planning.

4.1.1. Vision and mission statement development with the help of science fiction

Shared visions or mission statements, in the form of collective projection, synchronous pre-adaptation, or the functional equivalent, can support the purposeful preparation, development, and implementation of innovations as a cognitive activator, individual mobiliser, or interpersonal stabilizer (Hoffmann & Marz, 1992: 205–208). Pragmatically formulated, a shared vision combined with common guiding principles serves as guardrails and objectives for the preparation, development, and implementation of innovations. For the development of visions and mission statements, science fiction prevents an excessive selection and elimination of options and supplement reality-oriented visions of the future with desirable or currently inconceivable aspects. To this end, Hoffmann and Marz (1992) propose a look into the past as well as an examination of the tense relationship between mission statements, science fiction, and present reality (Table 5).

Using the examples of the car-free city or cashless payment, the authors show that visions, mission statements, and science fiction are often in tension with reality. The boundaries between reality and fiction can become blurred when depicting the future. Likewise, the authors emphasize the inspiring aspect of science fiction, especially for technology-savvy employees, partners, and users, as an important success factor for the development and acceptance of visions and mission statements. The strength of this method seems to be the identification and analysis of parallels between science fiction and reality in a certain context to create a clear link, and to enable imagination for a defined group of stakeholders. Furthermore, the use of science fiction-based options for the extension or integration with visions or mission development seems especially valid, as it is enhancing, not replacing, more traditional processes of strategic planning. A key challenge is to identify options from science fiction that can become reality, as options from pure fiction or fantasy

Table 4
Mapping of methods related to science fiction into the generic innovation process.

#	Method	Reference	Phase 1: Strategic Planning	Phase 2: Foresight and future analysis	Phase 3: Technology analysis and assessment	Phase 4: Market and user analysis	Phase 5: Idea generation and evaluation	Phase 6: Concept development and validation
1	Vision and mission development with the help of science fiction	(Hoffmann & Marz, 1992)	●	○	○	○	○	○
2	Reflection of strategic objectives using science fiction	(Bina, Mateus, Pereira & Caffa, 2017)	●	○	○	○	○	○
3	Search field identification from a science fiction perspective	(Dirlewanger, 2016)	●	◐	◐	◐	○	○
4	Structured collection of possible future aspects from science fiction	(Pätsch et al., 2015)	◐	●	◐	◐	◐	○
5	Value and technology scenarios related to science fiction	(King, 2021)	○	●	◐	○	○	○
6	Scenario archetypes from science fiction	(Fergnani & Song, 2020)	◐	●	◐	○	○	○
7	Science fiction wild cards	(Hauptman & Steinmüller, 2018)	○	●	◐	○	○	○
8	Inventory of technologies from science fiction	(Battrick & Warmbein, 2002)	○	○	●	○	◐	○
9	Technology assessment through science fiction	(Zweck, 1992)	○	○	●	○	○	○
10	Future personas in science fiction worlds	(Fergnani, 2019)	○	◐	○	●	○	◐
11	Analysis of atypical users in science fiction pastiche scenarios	(Blythe & Wright, 2006)	○	◐	○	●	○	◐
12	Idea generation with the help of science fiction	(Dirlewanger, 2016)	○	○	◐	◐	●	○
13	Evaluation of ideas from a science fiction perspective	(Dirlewanger, 2016)	○	○	○	○	●	◐
14	Development of concepts for science fiction worlds	(Arnold, 1952; Dirlewanger, 2016)	○	○	○	◐	●	◐
15	Science fiction prototyping	(Johnson, 2011; Wu, 2013)	○	◐	○	○	◐	●
16	Combination of science fiction technology and science fiction context prototypes	(Potstada & Zybura, 2014)	○	◐	○	○	◐	●
17	Impact assessment of artefacts from science fiction	(Birtchnell & Urry, 2013)	○	◐	◐	◐	◐	●

●: most applicable ◐: partly applicable ○: hardly applicable*
* Evaluation criteria and process are described in more detail in Chapter 3

Table 5
Method for developing vision and mission statements with the help of science fiction (Hoffmann & Marz, 1992: 204–217).

Step	Objective	Description
1	Examining previous parallels between science fiction and reality	Looking into the past and examining previous parallels between science fiction and reality in an application field makes it possible to make previous overlaps transparent and to work out development options presented in science fiction that have not or have not yet been realized
2	Developing options from science fiction	In a second step, the development options from science fiction that have not yet been realized can then be integrated with the development of visions or mission statements

would lead to unrealistic visions or mission statements. Also, the authors of the method focus on technical innovations, without noting whether the method is valid for other, non-technical innovations.

4.1.2. Reflection and refinement of strategic goals using science fiction

Strategic goals are an essential component of strategic planning to provide organizations and companies with a longer-term orientation or to overcome major challenges. The time horizon addressed by these objectives must correspond to the industry and the implementation field of innovations. To identify patterns of solutions based on the use of science fiction, Bina et al. (2017) evaluated science fiction works looking at the seven grand societal challenges of the European Commission's Horizon 2020 program, using the steps shown in Table 6. Based on the results, strong relationships with science fiction are confirmed in the areas of warning signals and the identification of complementary areas and dimensions not covered by traditional strategic processes (Bina et al., 2017: 179–180).

The authors see the added value for strategic planning, in this case related to strategic planning on a research policy level, in two points: (1) identification of warning signals for future developments; and (2) identification of possible developments that are given little or no consideration in current strategic orientations. In addition, they note that science fiction can bring desirable futures into sharper focus than other strategic planning methods would. Putting strategic goals on the test bench in relation to developments described in science fiction is therefore a much more detailed undertaking than reflecting vision and mission statements with the help of science fiction. Again, the distance from science fiction stories and future realities is among the key challenges of this method, implied by the authors through recognizing the dystopian character of many science fiction stories. This includes a tendency towards states of isolation, of need, of confusion, and meaninglessness in sub-human states.

4.1.3. Search field identification from a science fiction perspective

The identification and specification of search fields for technology or market analysis and idea generation are key elements of strategic planning. Dirlewanger (2016): 131–146) describes the use of science fiction in search field identification, specification, and evaluation through the involvement of science fiction perspectives. Table 7 shows the steps for the identification of search fields from science fiction perspectives exemplified by taking the perspective of Star Trek characters by teams rather than individuals. Although the author gives no practical examples, the science fiction perspective is meant to complement the more traditional methods for search field identification (Dirlewanger, 2016: 131). The identification of search fields is a prerequisite for strategic planning and thus can be mapped to the first phase of the process. Furthermore, the objectives overlap with phases 2 (foresight and future analysis) to 4 (market and user analysis), in which the identification of search fields is necessary as a precondition for information retrieval and analysis.

The role play based on Star Trek-inspired teams represents different perspectives on how to identify search fields, similar to lateral thinking represented in the six hats method of de Bono (1967). Team Spock represents the logical perspective (*Why not?*), Team Captain Kirk that of risk taking and emotion (*Let's try!*), and Team Scotty the one considering both (*This could work if…!*). The author insists that science fiction characters are better suited for abstraction than for methods that are closer to the participants' situational environments. Furthermore, it inspires searching for options in a wider, *extraterrestrial* area. The use of a role play inspired by science fiction for identifying future areas of activity as well as potential business field can help break barriers based on previous and current activities or application areas. This method is inspirational and thus does not create any major risks other than the loss of participants due to distance from current and predominant challenges in a specific situation.

4.2. Phase 2: Foresight and future analysis

The objective of foresight and future analysis is to explore or anticipate the future, either trying to foresee or identify potential future developments and assess those in the context of specified systems. Many possibilities and solutions that are today perceived as normal can be found in science fiction works of the past. This includes solar collectors, translation devices, and space travel (Steinmüller, 2010: 19). A journey into the last century of science fiction and technology development shows parallels in which science fiction often moves close to actual technology development (Michaud, 2020: 138). Often, however, the future described in science fiction works of the past does not (yet) correspond to the present: *Fiction is not fact— not even if it is science fiction* (Bassett, Steinmueller, & Voss, 2013: 11). Because of the thematic proximity between foresight, futures analysis, and science fiction, juxtapositions can be found in the literature (Bina et al., 2017: 170; Hauptman & Steinmüller, 2018: 54; Steinmüller, 2010: 29, Steinmüller, 2016). The view into the future is used in the innovation process as a basis for backcasting, the derivation of possible and promising options for action,

Table 6
Method for reflecting and refining strategic goals using science fiction (Bina et al., 2017).

Step	Objective	Description
1	Specifying information sources	Specification of information sources from science fiction, in this case, science fiction books and movies about humanity on earth
2	Specifying focus themes	Translation of strategic goals or challenges into focus themes, such as urbanization and economic development
3	Creating a historical and future timeline	Placement of science fiction content on a historical and future timeline
4	Analyzing content	Content analysis and formation of dimensions and sub-dimensions along with the focus themes
5	Specifying patterns	Identification and specification of patterns to describe potential futures and related challenges
6	Discussing outcome	Discussion of patterns and challenges considering strategic goals

Table 7
Method for the identification of the search field from a science fiction perspective (Dirlewanger, 2016: 131–146).

Step	Objective	Description
1	Collecting options	All options imaginable for relevant search fields are collected
2	Assigning roles	Role assignment in which characters from science fiction are each assigned to three teams: (1) Team Spock; (2) Team Scotty; and (3) Team Captain Kirk
3	Scanning options	Each team scans and selects options from the perspective of the assigned role
4	Identifying strengths	Strengths of the organization with an influence on the competitiveness are identified and described
5	Selecting options	Options selected in the teams are put in relation between strengths and additional evaluation criteria for presentation and evaluation in the entire group

and the handling of resulting opportunities and risks (Dreborg, 1996). At the interface of foresight, future analysis, and science fiction, the list of methods includes the collection of possible future aspects from science fiction, the integration into the scenario technique, the use of predefined scenario archetypes, and the integration of science fiction into wild cards.

4.2.1. Structured collection of possible future aspects from science fiction

The use of science fiction for foresight and future analysis is exemplified by urban development. In the research program Experimental Housing and Urban Development of the Federal Ministry in Germany, researchers from the University Cottbus-Senftenberg considered urban complexity, social and political reality, structural and sectoral aspects as categories of urban development for an in-depth analysis of science fiction (Pätsch et al., 2015). Table 8 shows the steps of the structured collection of possible future aspects from science fiction. Whereas the study focuses on the analysis and consolidation of insights, the impact is envisioned through the creation of transparency at the interface of science fiction and sector expertise (Pätsch et al., 2015: 54). Beyond the application in the phase of foresight and future analysis, this method overlaps in its objectives with all other phases of the innovation process that can benefit through possible future aspects of science fiction: phase 1 (strategic planning) and phases 3 (technology analysis and assessment), 4 (market and user analysis), and 5 (idea generation and evaluation).

A variety of elements from science fiction were collected in a structured way, grouped thematically, and evaluated according to their relevance to current challenges. The result is an extensive and inspiring collection of details depicted from science fiction that can be used for the preparation, development, and implementation of innovation in the field of urban development. The collection of a variety of elements from science fiction without predefined structure or following a structure for stakeholder, system or ecosystem analysis will considerably enhance traditional systems analyses, especially breaking with organizational or sectoral paradigms. Although the example is carried out independently from any other foresight activity, this method can be applied in combination with other system analyses or as an additional feature in other foresight approaches. A key challenge mentioned by the authors based on their experiences with city planners was the connectivity to real-life decision making, described by the feedback that science fiction is more of a step to the side than a step to the future. It is also mentioned, however, that those aspects not connected to current challenges might be the ones adding most value to the planning process. These aspects are said to provide insights independently from the solutions currently in use. Like other methodologies, the narrative tendency of science fiction towards dystopian futures was mentioned as an obstacle to the collection of possible future aspects. Interestingly, science fiction was called an enabler for discussions with a wider audience and especially stakeholders not directly involved in the community of city planners.

4.2.2. Value and technology scenarios related to science fiction

The scenario technique identifies opportunities and risks at an early stage by anticipating multiple possible future developments (Gausemeier, Fink, & Schlake, 1995; Pillkahn, 2008; Sontheimer, 1965). With the move away from the short story format, the boundary between science fiction and future scenarios has become blurred. On the one hand, the science fiction genre has developed utopian and dystopian visions of the future, not least to point out the potential dangers and opportunities of possible and impossible future developments (Marzin, 1992: 242–244). On the other hand, the scenario technique has led to the consideration of not only probable, but also improbable futures. Idier (Idier, 2000: 263), for example, provides a comparison of science fiction and the scenario technique for understanding this borderline. An extension of scenario-based design approach are value scenarios. They can be characterized through five elements that are emphasized: (1) direct and indirect stakeholders, (2) pervasiveness of a technology throughout the scenarios, (3) long time horizon, (4) consideration of multidimensional systemic effects, and (5) envisioning of positive and negative effects (Nathan, Klasnja, & Friedman, 2007). To develop *value scenarios*, understood here as 'crafted, speculative account of a proposed technology's interaction with society using science fiction', King (2021: 70–71) suggests the steps shown in Table 9. The value add to innovation is seen in the provision of insights into future social constructions in which an innovation occurs and a baseline for discussion of different perspectives (King, 2021: 72). Beyond the application in this phase, the objectives of value and technology scenarios related to science fiction overlap with phase 3 (technology analysis and assessment).

The use of science fiction as value scenario can generate insights into the social interplay of an era in the future far beyond the status quo and create a framework for unexpected innovations. The method can be used either in the context of scenarios that are developed for a certain organization or be applied in the context of scenarios publicly available for a broader context to extend those with an additional layer or time horizon. Overall, science fiction extends the horizon of scenarios and of all other process phases. It thus can help to avoid the biases associated with more traditional approaches centered on specific organizations or sectors (see also Schirrmeister, Göhring, & Warnke, 2020). With this method, science fiction can cover a long time horizon, from decades to centuries or even

Table 8
Method for collecting possible future aspects from science fiction (Pätsch et al., 2015: 33).

Step	Objective	Description
1	Collecting data	Data collection from science fiction
2	Developing guiding principles	Development of guiding principles for the systematic analysis of collected data considering the application field
3	Establishing comparability	Establishment of cross-media comparability
4	Preparing data	Data preparation and documentation for traceability and interpretation of results

Table 9
Method for creating value scenarios using science fiction (King, 2021: 70–71).

Step	Objective	Description
1	Describing roles in a dedicated science fiction scenario	Description of the roles of direct and indirect stakeholders in a dedicated science fiction scenario
2	Analyzing impact	Analysis of the impact of a specific solution or innovation on the stakeholders of this scenario
3	Considering the future beyond the scenario time horizon	Consideration of further development over months and years within this scenario beyond the scenario time horizon
4	Analyzing systemic effects	Analysis of systemic effects in the science fiction scenario that result from the application of the selected solution or innovation

millennia. The risk of adding unrealistic aspects is, however, limited, if science fiction-related scenarios are used as a complementary and inspiring element in more systemic scenario or foresight processes.

Only recently, the list of methods presented for developing scenarios in a specific context with the help of science fiction was complemented by Wolf et al. (2024), who allowed users to produce far-future consumer science fiction stories as an input for future scenarios. Their seven-step process consisted of demographic data collection, creative writing sessions and the development of a common understanding of desirable and undesirable future worlds.

4.2.3. Scenario archetypes from science fiction

The use of archetypes as predefined and quasi-standardized images of the future in scenario development has an appealing simplicity of application and the provision of a common basis for discussion and work (Del Pino, 1998: 490–492). Based on the analysis and interpretation of 140 science fiction movies, Fergnani and Song (2020) extracted the following six scenario archetypes (Table 10). A case study is used to explain the adaptation of the archetypes whereas the impact of their application is left to future research (Fergnani & Song, 2020: 19). Whilst these scenario archetypes overlap in their objectives with the phase of foresight and future analysis, there are also some overlaps with phases 1 (strategic planning) and 3 (technology analysis and assessment) of the innovation process.

As with the science fiction-based value scenarios presented, the authors believe that these six archetypes are particularly suitable for supplementing other, more traditional future scenarios by adding unexpected future situations. The idea of extracting patterns from examples given is a powerful way to open perspectives to new solutions, opportunities, or in this case, new scenarios. Other examples include the options for problem solving provided by the TRIZ methodology (Altshuller, 2007), or the business model patterns in the business model navigator method (Gassmann, Frankenberger, & Choudury, 2020). In terms of efficiency, the proposed six science fiction based scenario archetypes seem to be among the most time- and cost-efficient approaches for the integration of science fiction into foresight and future analysis. In addition, the scenario archetypes are not meant to cover all aspects of potential future developments. Rather, they are meant to prepare the mindset of individuals and organizations for crises that would be inconceivable today. For the application of this method, it must be considered that most of the 140 films analyzed for the development of the scenario archetypes originate in North America and thus inherit a bias towards the science fiction perspective of the western world order.

4.2.4. Science fiction wild cards

Wild cards introduce the possibility of including events that seem very unlikely at the current point in time into future studies. When these events occur, they have a very high impact. Hauptman and Steinmüller (2018) describe the use of wild cards based on project examples from the European research projects *iKNOW* and FESTOS. Technologies, their development, as well as their use or abuse are in the center of each science fiction-inspired wild card. Table 11 lists the steps proposed for the integration of science fiction wild cards. The benefits are described with the help of a case study in which science fiction wild cards were applied in a European-funded research project. Non-consensual perspectives, weak signals or *unthinkable* trends were integrated into the foresight process (Hauptman & Steinmüller, 2018: 66). In addition to the usage in foresight and future analysis, there are overlaps with the objectives of phase 3 (technology analysis and assessment) of the innovation process.

The interface with science fiction is described as (1) a possible source of wild cards; and (2) a narrative element for describing and communicating the wild card itself and its impact (Hauptman & Steinmüller, 2018). Based on this, the added value is seen both in the use of imagination from science fiction sources and in the communicative power of narratives. Science fiction-inspired wild cards can thus be considered a supplement to all forms of future studies. Especially in methodologies that rely on algorithms and statistical analysis, wild cards are an important approach to add potential future events that are not in the center of attention in analytical foresight exercises. Science fiction, in a way, extends the unlikely nature of wild cards through an additional fictional layer into

Table 10
Scenario archetypes extracted from science fiction (Fergnani & Song, 2020: 14).

Name	Scenario description
Growth and decay	Continuation of the current, capitalist status quo whilst allowing for the growing use of technology
Threats and new hope	Heavy reliance on the current situation, which is or can be thrown off course by a singular event
Rubble world	Orientation in a world after a catastrophic event that destroyed the status quo
Powers that be	Illustration of a future in which a cataclysmic event has taken place including a subsequent change of the power balance in a less than desirable manner
Mess	Summary of futures in which the world is in chaos with no apparent control mechanisms
Reversal	Referral to the reversal of the world order to the extent that another form of power dominates humanity

Table 11
Method for science fiction wild cards (Hauptman & Steinmüller, 2018).

Step	Objective	Description
1	Specifying the search field	Specification of the search field based on relevant themes or thematic areas
2	Collecting wild cards	Collection of many possible wild cards through individual searches or in an expert workshop with representatives from each theme or thematic area
3	Evaluating the impact	Evaluating the impact of the wild cards selected
4	Prioritizing wild cards	Prioritization of wild cards by stakeholders

unimaginable futures. Like previously described methods, science fiction-inspired wild cards are meant to be used in combination with other foresight approaches to overcome the present bias and avoid the denial of major disruptions or surprises.

4.3. Phase 3: Technology analysis and evaluation

The objective of this phase is the analysis and assessment of technological opportunities and trends. The influence of science fiction on technology development can be broken down into two areas (Bassett et al., 2013: 3). Science fiction might influence technological development through the complete adoption of solutions. This form of influence is rare. Common examples include the communications satellite described by Arthur C. Clarke or the submarine described by Jules Verne. In addition, science fiction inspires technological development more generally. This form of influence is difficult to track but is presumably far more common.

For technology analysis and assessment, the collection of technologies from science fiction in a kind of inventory; and the assessment of possible consequences of technologies in a science fiction-oriented technology assessment can be found as methods in the literature.

4.3.1. Inventory of technologies from science fiction

In technology and market analysis, the most frequently cited form is the inventory of named technological solutions from science fiction as input to the innovation and technology development process. One example is the European Space Agency's 2002 analysis, where concepts drawn from science fiction were collected in areas such as propulsion technology, launch systems, or robotics and kinetic creatures (Battrick & Warmbein, 2002: 10–45). The procedure for developing such an inventory is shown in Table 12. The impact of the study is only vaguely described in the form, that the results of the study lead to the suggestion of promising areas for further investigation (Raitt, 2002: 2). Whilst the method of the science fiction-based technology inventory overlaps considerably with the phase of technology analysis and assessment, there are only minor semantic overlaps with other phases. The authors acknowledge, however, that this method might add value as a complementary approach also in other phases of the innovation process.

This method considers different levels of maturity and realism, and includes technology concepts that may have been found to be unrealistic or may have already proven unsuccessful (Raitt, 2002: 2). The inventory of technologies from science fiction seems to be particularly suitable for the identification of emergent technologies and technology fields, where more traditional and retrospective methods of technology management reach their limits (Alexander, 2009: 26). Interestingly, the inventory of science fiction technologies set a baseline for more traditional technology evaluation methods and their categorization based on concepts like the technology

Table 12
Method for collecting, categorizing and taking inventory of technologies from science fiction (Battrick & Warmbein, 2002: 2–9).

Step	Objective	Description
1	Investigating science fiction	Investigation of past and present science fiction literature, graphic concepts, and films
2	Identifying technologies and concepts	Identification of innovative technologies and concepts described therein
3	Evaluating and selecting technologies and concepts	Evaluation and selection based on (1) suitability for the field of application, in the ESA case, space application; or (2) long-term implementation of specific projects, in this case corresponding to European space flight
4	Documenting and communicating results	Documentation and communication of identified technologies and concepts in datasheets and technical dossiers

readiness level TRL (Olechowski, Eppinger, Joglekar & Tomaschek, 2020). Whilst collecting, categorizing and taking inventory of technologies from science fiction, it must be considered that these are often pure imagination. Sometimes, however, they accurately cover potential future developments or pave the way to desirable long-term developments. The availability of information on scientific developments influences technologies in a way that brings them much closer to science than they were in the past. Like other methods, the inventory of technologies from science fiction is not only meant to be an input for the innovation process as such, but also to stimulate thoughts beyond the technologies or applications described as such.

4.3.2. Technology assessment through science fiction

The term *technology assessment* can be summarized as identifying and evaluating the consequences of technology throughout its life cycle at an early stage of development (Zweck, 1992: 184–185). Possible benefits of the use of science fiction in technology assessment range from people-centrism to capacity building for reflexive governance, and consideration of the sociotechnical effects of technology use (Miller & Bennett, 2008: 600–603). Zweck (1992: 193) categorizes the contributions of science fiction to technology assessment (Table 13). The benefit of science fiction in technology assessments is described as a contribution to *hypothetical thinking*, with the awareness that public discourse might be based on both consciousness and reality.

The author summarizes the contribution of science fiction as a kind of trial thinking, in which hypothetical thinking about science is extended to the unexpected and brought into technology assessment with an eye on the sociotechnical implications (Zweck, 1992: 192–193). This method is oriented towards the analysis of socially desired solutions in the innovation process, detached from what is possible given today's natural and technical constraints. For the selection of aspects to be considered, the author refers to Suvin's two axes (Suvin, 1979: 41), one classifying the content between naturalistic versus alienated and the other between epistemic and non-epistemic. This differentiation filters out unrealistic aspects that are, for example, close to the genre of fantasy. Furthermore, it is recommended to exclude science fiction that does not describe future societal aspects, such as inner space or metaphysical science fiction. This method inspires hypothetical thinking on the technological impacts that cannot be derived from today's trends.

4.4. Phase 4: Market and user analysis

The objective of this phase in the innovation process is the analysis and evaluation of market developments and user behavior. Market and user analysis from the perspective of applying science fiction is very much oriented towards human and life-centered design, looking especially at innovations from a user-centered perspective (IDEO, 2015: 9; Lutz, 2020). User-centered approaches have been extended to consider not only human users but all form of non-human users and associated aspects (see for example Lutz, 2020).

For the phase of market and user analysis, the methods identified include the integration of future personas from science fiction worlds as users or stakeholders in the market and the consideration and analysis of atypical users in science fiction pastiche scenarios.

4.4.1. Future personas in science fiction worlds

The concept of future personas is based on the fundamental principles of the notion of personas coined by Cooper (2006), according to which each persona represents a group of users and is described and named to enhance empathic understanding of user needs. Future personas are a complement to the original personas, in which the view is directed beyond current user groups into the future. Fergnani (2019: 447–448) describes the development of future personas as a component of scenarios. His recommendation for the development of future personas contains the steps shown in Table 14. Beyond providing a step-to-step guidance for the creation of future personas in science fiction worlds illustrated with the example of the future of work, the benefits described include an increase of liveliness, playfulness and empathy (Fergnani, 2019: 463). In addition to the application of this method in market and user analysis, there are overlaps in the objectives with phases 2 (foresight and future analysis) and 6 (concept development and validation) of the innovation process.

Future personas can be used in all kinds of scenarios, not only science fiction-related future situations. Portraying personas for the future and in the context of science fiction-related environments allows to address needs that might arise in (un)imaginable futures. According to the author, the method is meant to be applied to previously developed scenarios with the aim of enhancing their communication to different stakeholders.

4.4.2. Analysis of atypical users in science fiction pastiche scenarios

Pastiche scenarios consider implicit aspects of a user experience by closely observing and reproducing patterns of behaviors like a script for books or movies. Blythe and Wright (2006) consider science fiction as a possible source for the creation of pastiche scenarios in user-centered design. For example, they incorporate current user situations into excerpts from science fiction. The steps for incorporating and analyzing atypical users in science fiction pastiche scenarios are shown in Table 15. The authors justify the benefit of the application of science fiction scenarios by citing numerous examples of elements in past science fiction work that have become reality. Potential benefits of the method of science fiction pastiche scenarios thus include the consideration of aspects not integrated in other persona-based approaches (Blythe & Wright, 2006: 1159–1162). Like the method of future personas in science fiction worlds, the objectives of this method overlap with those of phases 2 (foresight and future analysis) and 6 (concept development and validation) of the innovation process.

Science fiction as a source for pastiche scenarios is, according to the authors, a method for incorporating unusual, future situations and people into the user-centered design process. Thus, they complement more classical ethnographic approaches based on representative users and known situations with fictional aspects (Blythe & Wright, 2006: 1159–1162). The notion of pastiche scenarios that

Table 13
Method for using science fiction for technology assessment (Zweck, 1992: 189–192).

Step	Objective	Description
1	Guided reading and discussion	Reading science fiction in terms of responsibility for a potential, utopian future development and the associated discussion of psychological and social consequences
2	Extrapolating literature	Literary extrapolation of consequences of already existing or foreseeable developments to derive possible aspects for the future
3	Detaching from natural law and status quo	Detachment from constraints of natural laws and the closely related status quo of the level of technological development

Table 14
Method for the creation of future personas in science fiction worlds (Fergnani, 2019: 448–452).

Step	Objective	Description
1	Defining scope and focus	Definition of scope and focus for the future personas regarding the intended target audience
2	Developing Scenarios	Development of scenario datasheets and illustration of key uncertainties, value propositions, and impacts
3	Describing future personas	Description of future persona in datasheets for higher-level representation and mapping in each scenario
4	Specifying future personas	Specification of future personas through integral detailing of scenario and future persona datasheets
5	Portraying future personas	Portraying of future personas through personal narratives to communicate value systems, world views, and prevailing ideologies
6	Illustrating future personas	Illustration of future personas in simple sketches
7	Communicating future personas	Communication of future personas in the organization

Table 15
Methodology for incorporating and analyzing atypical users in science fiction pastiche scenarios (Blythe & Wright, 2006: 1140–1157).

Step	Objective	Description
1	Selecting science fiction characters	Careful selection of science fiction characters to be considered for the pastiche scenarios
2	Collecting and processing information on characters	Collection and processing of comprehensive information about the characters, their behavioral patterns, and life circumstances
3	Combining characters with science fiction stories	The combination of the characters with excerpts from science fiction provides the communication basis of the pastiche scenarios
4	Inspiring the development of solutions	Correspondingly emerging excerpts from science fiction then serve as inspiration for the development of concrete solutions, for idea generation, or the discussion of the space of possibility with stakeholders

is derived from science fiction rather than taken 1:1, seems to be a more appropriate approach for the integration in traditional market and user analysis tools than, for example, the direct use of science fiction based scenario archetypes. The challenge of using pastiche scenarios, according to the authors, is that the person developing the scenarios needs a strong understanding of the personality described, combined with a gift for storytelling and writing. A participatory approach able to overcome this challenge would include experts discussing the scenario collaborating with writers or scripters to follow the discussion and create the science fiction pastiche scenarios.

4.5. Phase 5: Idea generation and evaluation

The objective of this phase is creative inspiration as a baseline for innovation and the generation, development, and evaluation of ideas. Collecting ideas from science fiction is among the most obvious interrelations between science fiction and innovation. Numerous overviews such as the *Historical Dictionary of Science-Fiction*[3] or the platform *Technovelgy*[4] have been created. Already this collection of imaginary ideas from science fiction can support inspiration on the way to idea generation and development of innovations. Others have described how narratives from science fiction have been used to inspire the generation of new products and services but also business models. Interestingly, the advantages of using text rather than film have been emphasized. Due to polyvalent nature of text, more and different pictures of future products and services can be derived based on differences in imagination of each reader (Schwarz, 2015)

Methods in idea generation and evaluation mentioned in the literature include scouting for ideas in science fiction, developing ideas for science fiction worlds and evaluating ideas from a science fiction perspective.

4.5.1. Idea generation with the help of science fiction

As presented in the context of technology analysis and assessment, many of the solutions known to us today have already been

[3] Historical dictionary of science fiction HD/SF, a quotation-based dictionary of the language of science fiction: https://sfdictionary.com
[4] Technovelgy, a collection of inventions, technology and ideas of sciece fiction writers: http://www.technovelgy.com

described in the science fiction literature of the past. Many of these yet unrealized solutions depicted in science fiction will presumably be realized in the future. Many books and stories contain detailed examples of science fiction ideas from the past either influencing or becoming reality (Bülow et al., 2014; Michaud, 2022). However, for idea generation, the realization of many science fiction ideas is far from the total number of ideas stated. This relegates the responsibility for evaluation and selection to the organizations trying to benefit from those ideas and concepts (Michaud, 2014: 219). Furthermore, ideas introduced in science fiction are nearly always fractions of the solutions that are in use today. This list is complemented by Lem's (1977: 245–290) method for generating science fiction ideas, based on the principles of substitution, inversion, and the clash of teleologies. For idea generation, the author suggests do add elements of science fiction into a variety of creativity methods. Table 16 provides an overview of how science fiction is integrated in these creativity methods, with the one proposed by Lem (1977) at the end. The impact of drawing from science fiction to generate ideas is based on commercial and scientific solutions that originated in the genre (Dirlewanger, 2016: 171). Beyond the application in idea generation and evaluation, this method overlaps with the objectives of phases 3 (technology analysis and assessment) and 4 (market and user analysis), the two phases of the process meant to gather and evaluate information on markets and technologies. The overlap is attributed to the need to manage new developments in both areas, requiring the generation of ideas as an extra activity in some cases and therefore implied in the objectives.

The methods described can be used to generate single ideas and can also be used as an input or accompanying inspiration for a variety of innovation and creativity methods. Whereas idea generation, with the help of science fiction, is especially valid early in the innovation process which has more freedom than the later phases of concept development, idea generation also plays a role in later phases, for example to generate ideas for concept development and validation or the transfer of results into application.

4.5.2. *Evaluating ideas from a science fiction perspective*

For evaluating ideas from a science fiction perspective, characters from science fiction are assigned in a role play with the objective of evaluating ideas from their perspective. Dirlewanger (2016: 199–210) describes this method using the Star Trek teams based on the steps shown in Table 17. This method is meant to overcome the restrictions of other evaluation methods biased in favor of ideas with little uncertainty (Dirlewanger, 2016: 200). Beyond the applicability of this method in the phase of idea generation and evaluation, the objective of this method overlaps with those of phase 6 (concept development and validation).

The use of the perspective of Star Trek characters to evaluate ideas, like other evaluation techniques based on the principle of role play, can produce a portfolio of ideas representing different perspectives. By involving extraterrestrials in idea generation and evaluation, basic paradigms are either questioned or must be explained. According to the author, this enables the reconsideration of ideas that have been rejected in the past (Dirlewanger, 2016: 165–170). The evaluation of ideas from a science fiction perspective is meant to create a workaround of evaluation models or mindsets that are blocking ideas incompatible with the current worldview of the evaluators or evaluation models. Two-sided portfolio graphs are an example of evaluation models that are easy to understand and communicate. In innovation management, the most popular models are suited for incremental innovations with few uncertainties. Ideas for radical innovations with more uncertainty are almost automatically filtered out. In a similar approach, but without providing a dedicated method, Zybura (2014) proposes the use of science fiction prototyping to identify potential application areas for inventions during patent filing. This concept puts patents into a future context to identify opportunities for commercialization. Like the concept of innovation roulette that is suitable to select innovation activities with a high level of uncertainty (Pillkahn, 2013), the evaluation of ideas from a science fiction perspective is meant to complement other evaluation criteria or methods from an unconventional perspective and enable the acceptance and further development of ideas that an organization would most likely reject.

4.6. *Phase 6: Concept development and validation*

The objective of concept development and validation is to refine and validate potential innovation concepts using prototypes. These prototypes can range from basic, user-oriented design models to fully functional prototypes that resemble the final version of a product, process, service, business model or solution. In science fiction, the notion of prototype tends to be understood as simple and non-functional (Birtchnell & Urry, 2013: 26). The method of science fiction prototyping was strongly influenced by Johnson (2011: 26–32) and developed in special issues of the journals *Futures* (Graham, Greenhill, & Callaghan, 2013) and *Technological Forecasting & Social Change* (Graham, Greenhill, & Callaghan, 2014). Kymäläinen (2016) compiled an extensive overview of previous scholarly work on science fiction prototyping with a focus on sociotechnical implications of emergent technologies.

Prototype-related approaches to using science fiction in concept development and validation include science fiction prototypes and the adoption and use of science fiction artefacts as prototypes.

4.6.1. *Development of concepts for science fiction worlds*

Arnold (1952) introduced the first methods of using science fiction for product development and innovation. In the case study Arcturus IV,[5] he describes the use of the imaginary planet Arcturus IV to simulate the perspective of aliens and resolve challenges for the inhabitants (Arnold, 1952). In a three-week project, the author suggests the steps shown in Table 18. The method is meant to force imagination to complete concept developments based on the materials and steps provided. Although this method is termed *concept development*, its greatest overlap with the objectives of the innovation process is in idea generation and evaluation. This is mainly due to

[5] The Arcturus IV Case Study was made available 2016 in its original version by John E. Arnold, Jr., including additional appendix material: https://stacks.stanford.edu/file/druid:rz867bs3905/SC0269_Arcturus_IV.pdf

Table 16
Methods for idea generation with the help of science fiction (Dirlewanger, 2016: 171–197; Lem, 1977: 245–290).

#	Creativity method	Specification of how science fiction aspects are integrated
1	Science fiction analogies	Specification of a problem to solve and search for solutions and ideas in science fiction. Identification of transfer options using the proximity between science fiction concept and a potential solution going from 1:1–1:1000
2	Science fiction storytelling	Developing ideas through writing a science fiction story about potential contextual situations and related solutions. This can be enhanced though the specification of fictional technologies, ideas, locations, extremes, or personas to be integrated in the storytelling approach
3	Semantic intuition	Random (re-)combination of semantic elements in a matrix for the creation of new, science fiction ideas
4	TRIZ and science fiction	Applying the principles of TRIZ, Altshuller's theory of inventive problem solving (Altshuller, 2007), independently of the technical feasibility to real artefacts or contextual parameters
5	Operators for phantastic creations	Application of the operators on one or multiple elements of a real situation, once or multiple times: (1) substitution; (2) inversion; and (3) clash of opposing teleologies

Table 17
Method for evaluating ideas from a science fiction perspective (Dirlewanger, 2016: 199–210).

Step	Objective	Description
1	Assigning roles	Role assignment in which characters from science fiction are each assigned to three teams: (1) Team Spock, (2) Team Scotty, and (3) Team Kirk
2	Evaluating ideas individually	Each member of the group individually evaluates the ideas for the perspective of the assigned role
3	Selecting ideas in each team	Best ideas are selected in each team
3	Presenting ideas in the overall group	The best ideas chosen are presented and discussed among all groups

Table 18
Method for developing concepts for science fiction worlds (Arnold, 1952: 125–126).

Step	Objective	Description
1	Communicating the challenge	The starting point of the project is a letter from the chairman of the board of the Massachusetts Intergalactic Traders Inc., briefly describing life on Arcturus IV
2	Understanding, studying, and analyzing the science fiction world	Three thematic groups are formed among the participants of the project to (1) better understand physical frameworks in an engineering group; (2) study physiological and psychological aspects of inhabitants; and (3) analyze marketing and production conditions
3	Designing products	Participants are given the task of designing products for the planet Arcturus IV, which are manufactured on earth and shipped to the destination in a trade relationship

the understanding of concept development, where ideas are developed in to more mature and market oriented concepts. Beyond the application in the phase of idea generation and evaluation, the objectives of this method overlap those of phases 4 (market and user analysis) and 6 (concept development and validation) of the innovation process. This is due to the use of science fiction as an input for imagining future markets and the use of these worlds as a baseline for evaluation, not only of ideas but also of more mature concepts.

According to the author, the added value of this method is its speculative nature as a success factor for scientific progress and the increased attention to the fit between technological solution and user requirements in an alien world. The basis for this task is the author's comprehensive handbook of information about the planet Arcturus IV (Arnold, 1952). A more recent example with a similar approach is the development of concepts for parallel worlds and their integration into science fiction application stories (Dirlewanger, 2016: 211–232). Although Arnold's approach was intended for teaching, it is suitable to develop prototypes that open the space for new solutions beyond previous innovation paths. Being focused on developing activities beyond real-world challenges, this methodology is appropriate for long-term inspiration, training or motivation.

Table 19
Method for developing narrative science fiction prototypes (Johnson, 2011: 26–28).

Step	Objective	Description
1	Defining the object of exploration	Defining the object of exploration and science fiction world including people and places involved. This step might also be referred to as vignette (Roberts & Middleton, 2014: 16)
2	Transferring the object into science fiction	Application of the exploration object in the science fiction world
3	Analyzing the impact	Analysis of the impact on the science fiction world and especially on the characters involved. This is where science fiction stories are developed as prototypes, which can make use of all media available such as sketches, comics, or films
4	Inspecting problem areas	Inspection of possible problem areas of the application and discussion of possible solutions
5	Analysing insights and lessons learned	Analysis of previous steps in terms of useful insights and lessons learned

4.6.2. Science fiction prototyping

Science fiction prototypes are stories written or media created for the development and implementation of innovations and physical prototypes. Johnson introduced science fiction prototyping in his 2011 book of the same name. In *Science Fiction Prototyping*, Johnson defines a *prototype* as a rough approximation of the thing to be built, using storytelling techniques to convey its key characteristics and systemic features (Johnson, 2011). Bell, Fletcher, Greenhill, Griffiths, and McLean (2013) then discuss science fiction prototypes as a source of inspiration for innovators. Following the same process steps, Wu (2013) proposes a workshop concept for business managers to apply science fiction prototyping for creating real and narrative prototypes for technological business innovation. In summary, the process for creating science fiction prototypes can be broken down into the steps shown in Table 19. The benefit of science fiction prototyping is described as promoting innovative thinking that can lead to product or business innovation (Wu, 2013: 54). Beyond the application in the phase of concept development and validation, overlaps between the objectives also exist with phases 2 (foresight and future analysis) and 5 (idea generation and evaluation). This can be explained through the close relationship between science fiction prototyping and storytelling, both of which are themselves linked to the communication of future scenarios and the contextual generation and evaluation of ideas.

Like the principle of design thinking, the process of narrative science fiction prototyping emphasizes the 'What if…?' question to integrate futures and solutions beyond the status quo into the innovation process. There are no guidelines for the creation of these prototypes. According to the author, the advantages of using science fiction prototypes can be seen in the possibility of communicating potential or unexpected future developments. According to Roberts and Middleton (2014: 26), science fiction prototyping can be used as an input for foresight activities. Whereas narratives are most often in the center of science fiction prototypes, these can be enhanced through artefacts and all kinds, for example physical prototypes, comic books, or cartoons (Johnson, 2011: 111–142). Brucker-Kley et al. (2021) propose a three-step method: (1) describing multilinear narratives; (2) creating immersive VR scenarios; and (3) discussing the scientific results in a public discourse (Brucker-Kley et al., 2021: 819). The qualitative nature of science fiction prototypes is mentioned as a limitation. It is also said to be better suited to enhance creative thinking than to produce more specific short-term results (Wu, 2013: 54).

4.6.3. Combination of science fiction technology and science fiction context prototypes

Potstada and Zybura (2014) developed a science fiction prototyping typology by incorporating a technology prototype into a of science fiction context. As an example, advanced 3D printed prototypes combined with printed electronics were embedded in a futuristic science fiction context environment (Table 20). Like the more generic science fiction prototyping, this method fosters creative thinking and the creation of a common vision among stakeholders. It also introduces a typology to differentiate between speculations about the evolutive development of familiar solutions and radical science fiction prototyping breaking with previous solutions or applications (Potstada & Zybura, 2014: 112). The objectives of this method are comparable to those of science fiction prototyping, making it partly applicable to the phases of foresight and future analysis and of idea generation and evaluation.

Although valid for the fuzzy front end of the innovation process, the analysis shows that a clear picture of the capabilities of a technological solution is required to describe its future context of usage and impact. The authors identify the unpredictability of the future as one of the biggest challenges in working with science fiction prototyping to develop future innovations.

4.6.4. Impact assessment of artefacts from science fiction

Comparing the actual development of 3D printers with developments described in science fiction, Birtchnell and Urry (2013) label science fiction itself as a kind of prototype developer, comparable to early, non-functional, design prototypes. They propose to benefit from this relation by considering artefacts from science fiction as prototypes in the innovation process. To do this, they propose the steps shown in Table 21. With the example of 3D printing, the authors show that impact assessment related to science fiction allows early visioning of social and economic consequences (Birtchnell & Urry, 2013: 33). Beyond the application of this method in concept development and validation, there are overlaps with the objectives of phases 2 (foresight and future analysis), 3 (technology analysis and assessment), 4 (market and user analysis), and 5 (idea generation and evaluation), which can be explained by the importance of the indirect impact of innovations in these phases.

Combined with scenarios, this method enables a broad evaluation of the possible sociotechnical consequences of future technological developments pointed out in science fiction. According to the authors, the visionary idea of artefacts from science fiction can radiate into other future analyses, where it can serve as a lodestar to unexpected futures (Birtchnell & Urry, 2013: 33). The authors report that the method was well received by workshop participants and applied also to other parts of the innovation process.

5. Discussion

The analysis presented in this paper revealed 17 science fiction-related methods whose objectives overlap with those of the phases of a generic innovation process. Through an analysis of these overlaps, the research question of how science fiction-related methods can be mapped to the phases of a generic innovation process was answered. A presentation and critical discussion of each method were included in this answer. The results contribute to the objective of providing an overview on science fiction-related methods and supporting the selection of most appropriate methods for application in the development of innovations, both as a baseline for future academic investigations and for practitioners.

The availability of steps or phases provided in the form of a structured procedure or process was a requirement for the identification of science fiction-related methods and implemented through a keyword search using the terms *method*, *methodology*, or *typology* as well as *steps*, *process* or *process phases* during the refined search phase of the research methodology. Structured procedures or processes

Table 20
Method for the development of science fiction prototypes (Potstada & Zybura, 2014: 104–109).

Step	Objective	Description
1	Describing today's status	Provide the background in the form of the current status quo in the state of technology
2	Describing the future context	According to the time horizon chosen, describe the future context, for example how a technology has developed and is integrated in daily life
3	Creating a story	Bring together the science fiction technology prototype, sketching the technology at the core of a solution, with the context prototype looking at contingencies and social interactions

Table 21
Method for assessing the impact of artefacts from science fiction (Birtchnell & Urry, 2013).

Step	Objective	Description
1	Specifying the solution space	Specification of solution space
2	Examining previous developments	Examination of previous development paths in reality
3	Examining outlooks	Examination of previous development paths and outlooks in science fiction
4	Analyzing overlaps	Analysis and evaluation of the overlaps and design dimensions
5	Extracting possible developments	Extraction of future possible developments in the solution space and identification of artefacts that can be tested and validated as prototypes

might be presented in figures, tables or Annexes of publications that are not annotated or accessible through an automated keyword search. Thus, it is assumed that additional science fiction-related methods exist that might have escaped the research methodology. Similarly, the manual search, both in the direction of publications not available digitally and the publications from companies that are not publicly available might add to the number of science fiction-related methods identified.

The mapping process, based on the evaluation of semantic similarities between the objectives of each method and those of the phases of the generic innovation process provides solid support for the selection of appropriate science fiction-related methods during the development of innovations. We expect that this support leads to considerable improvements selecting the appropriate science fiction-related methods to reach specific objectives in the innovation process and will thereby be able to improve the efficiency and effectiveness of applying these methods. Whereas this study is focused on supporting the development of innovations, most science fiction-related methods might also be applied to other objectives. The transfer of the results achieved in this study can thus be seen as a potential benefit to other areas of application. The usage of semantic distance for mapping science fiction-related methods to the phases of the innovation process should thereby be seen as a first step in understanding the relationship and requires additional empirical validation. This can be envisioned either in a set of case studies or in a wider empirical analysis.

Whilst the potential benefit of applying science fiction to support the development of innovations is used as a basic assumption and a baseline for this study, it is far from evident where and in which form this potential benefit is best realized. Given its importance to the research field of investigating the interlinkage of science fiction to other fields, this relationship needs further research to fully understand the potential benefits, the implications and the impact of applying science fiction-related methods. In addition, thoroughly understanding the effects of science fiction along the process of innovation would add to the understanding of when and why to apply methods inspired by science fiction. This could encompass the analysis of interrelations of potential benefits with types of science fiction media or the time horizons. Another aspect is the differentiation between utopian and dystopian science fiction. Further research could also consider science fiction video games, benefiting from the emotional activation players experience in these games. From the outcome perspective, the implicit or explicit impact of science fiction on supporting the development or responsible and ethical innovations would also be an important thematic area for future research.

6. Conclusions and outlook

The areas of application of science fiction, as shown along the innovation process, are both numerous and diverse. Whilst one could argue that the application of fiction in a business environment might be counterintuitive, the list of identified methods and the examples that can be found in literature suggest that this is already happening. The lack of information on the value-add of applying these methods, however, calls for a broader research agenda and a better understanding of the benefits of applying science fiction along the innovation process.

The possible added value of the usage of science fiction seems to lie to a major part in its power of imagination concerning potential future developments. Whilst rooted in current research, technological or societal developments, science fiction stretches imagination beyond what is known so far, adds different perspectives, and through its narrative structure, has the power to inspire and to remain impactful along the innovation process. It has also been discussed that science fiction is relevant to the social construction of reality. Artefacts from science fiction might turn into what is imaginable or even desirable. However, it is important to keep a critical eye on the distance of science fiction from the current reality and on distortions of science fiction works. In general, it seems advisable to complement structured and analytical approaches in the innovation process with the methodical integration of science fiction.

The main purpose of the research presented in this paper was to provide an overview of the application of science fiction-related methods along the innovation process. The research methodology included the analysis of grey literature. This implies that we are also

referring to literature which, from an academic perspective, is not well researched or documented but related to practical experiences or applications. Beyond commonplace methods like idea generation with the help of science fiction, inventory of technologies from science fiction or science fiction prototyping, the research revealed some unconventional approaches such as developing innovations for science fiction worlds or the creation of pastiche scenarios. The mapping of science fiction-related methods thereby provides guidance both for the targeted integration of science fiction into innovation processes in industry and research organizations.

Unexpected events occur more often than expected in all areas of human life. The interdisciplinary combination of science fiction and innovation can help us prepare for the unexpected future and inspire us to create it. Through its narrative structure, science fiction has the potential to bring memories, emotions, and visions to life.

CRediT authorship contribution statement

Sven Schimpf: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Michael Lauster:** Writing – review & editing, Conceptualization. **Jan Oliver Schwarz:** Writing – review & editing. **Marcus John:** Writing – review & editing, Visualization, Formal analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data availability

Data will be made available on request.

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