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From Constructing Future Landscapes to Developing Conceptual Narratives: Promoting Design Innovation in the Vehicular Metaverse through Forecasting and Backcasting

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Abstract: The fusion of automotive and metaverse, the vehicular metaverse, is considered the next Internet revolution, bridging physical and virtual spaces. Innovation in the vehicular metaverse requires a bold visionary design while addressing real-world needs and industry concerns. This article proposes a novel transformation paradigm for the automotive metaverse, consisting of two stages: constructing future scenarios and developing scenario narratives. It also introduces an innovative design method for the automotive metaverse that integrates strategic foresight (SF) and design thinking (DT), which is structured into Phase–Key Assumptions–Methodology–Steps–Examples of Methods. In the Constructing Future Landscapes stage, we established a future sign library of 60 cases based on four dimensions, which serve as important materials to construct future scenarios; in the Developing Conceptual Narratives stage, we provided a domain case library of eight case types through LDA topic modeling, helping participants form innovative solutions. Various tools such as future wheels, metaverse product matrices, and conceptual aggregation templates were integrated into the six-step process to form a heuristic innovation methodology. Practical application through an online workshop yielded good results.

Keywords: future landscapes; vehicular metaverse; conceptual narratives; conceptual innovation approach

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1. Introduction

The metaverse represents an immersive, shared virtual space that enables individuals to interact through avatars, thereby unlocking the potential for global communication, commerce, and novel experiences [1,2]. By combining generative artificial intelligence, the metaverse facilitates seamless transitions between the physical and digital realms [3]. Vehicular metaverses [4], which serve as a bridge between physical and virtual spaces, are widely regarded as the next revolution in Internet technology. The market potential in this field is substantial [5], stimulating extensive academic interest [6]. However, the metaverse remains "vaguely defined yet seemingly imminent" [7]. This ambiguity can be attributed to several factors. First, our future is undergoing rapid transformations, which contribute to the systemic roots of ambiguity. The metaverse emerged in a volatile, uncertain, complex, and ambiguous (VUCA) environment of change, initiating far-reaching impacts across various aspects. Second, the metaverse is not only a newly emerging concept but also a rich one, encompassing numerous industries, technological directions, and research topics, thereby presenting numerous critical uncertainty areas [8]. Stakeholders possess varying visions, motivations, and technological bets [8], leading to different interpretations of the metaverse concept: "most industry leaders define it in a way that aligns with their own worldview and/or company capabilities" [7]. Third, the vehicular metaverse, as an interdisciplinary concept, encompasses a multitude of unconfirmed opportunities and challenges, with diverse disciplines comprehending it from distinct perspectives. In summary, the ambiguity of the definition of the vehicular metaverse poses challenges for innovative design in this field.

To address the rapid changes in the environment, organizations need to develop the capability to update their competitive advantage: dynamic capability [9]. Consequently, technologies that demonstrate this dynamic capability, such as strategic foresight (SF) [10] and scenario planning (SP) [11], are becoming increasingly important. Research reveals that perceiving change as a resource rather than an enemy of planning enables future-oriented innovation by recognizing unconscious assumptions [12,13]. Among these, forecasting and backcasting serve as valuable techniques for future strategic planning [14]. Forecasting relies on the deduction of current and historical trends to identify potential impacts of possible evolutions, project alternative futures, and construct future scenarios [14]. Backcasting, on the other hand, envisions ideal conditions in the future, determines the steps to achieve these conditions, and develops a traceable strategic planning process to bring these idealities to life [15,16]. Therefore, we can boldly declare that forecasting and backcasting represent a useful paradigm for addressing ambiguous definition issues: combining planning visions with the realization of these visions and serving them in the context of design innovation. However, due to the sequential nature of strategic planning and innovative design, rather than parallel relationships, the connection between the two is weak. To further utilize the momentum of forecasting and backcasting to address innovative design issues in the automotive metaverse, it is necessary to explore methods that combine strategy and design.

Intelligent vehicles must evolve into tools that make our human societies safe in the physical space, secure in the information or cyberspace, and sustainable in the ecological and artificial/knowledge space, are sensitive to our individual needs (such as privacy and the desire for well-being), and provide smart services to everyone in ways that benefit our humanity and well-being [17]. Cao et al. [18] emphasize that to achieve this goal, interdisciplinary and multidisciplinary thinking and methods must be adjusted with new emphasis and efforts in the field of intelligent vehicles. Therefore, a transformative and convergence methodology that accommodates more disciplinary approaches and paradigms is the order of the day (economics and management, future studies, design, engineering, etc.). We believe that the conceptual innovation of the vehicular metaverse should be driven by constructing future scenarios and developing conceptual narratives, reflecting the deep integration of strategic foresight (SF) and design thinking (DT), as well as the integration of forecasting and backcasting at different stages with design thinking. Therefore, on the new basis of paradigm innovation, a complete set of innovative methods for the conceptual innovation of the vehicular metaverse should be constructed and implemented to enable practitioners' creative solutions and application development.

This article consists of five parts. Section 1 is the introduction. In Section 2, we first introduce the current situation and issues of the vehicular metaverse, explore the concepts of forecasting and backcasting, and propose a conceptual innovation framework based on the transformation paradigm. In Section 3, we establish a conceptual design method for the vehicular metaverse toward the transformation paradigm, consisting of Phase–Key assumptions–Methodology–Steps–Examples of Methods, including two stages, a four-step process, four tools, and two resource libraries to assist participants in quickly forming metaverse-related solutions. In Section 4, we report on a Vehicular Metaverse Online Workshop that we conducted, applying the proposed method and achieving promising results. In Sections 5 and 6, we discuss the characteristics of the method and its application and draw corresponding conclusions.

2. Related Works

2.1. Vehicular Metaverse and Design Innovation

The metaverse is built on various technologies, including augmented reality (AR), virtual reality (VR), cyber-physical systems, high-speed networks, edge computing, artificial intelligence (AI), and computer vision [19]. At the same time, the rapid development of wireless communications, AI, and high-performance computing in less than five years has been reshaping mobility concepts and systems [20]. With the convergence of the automotive industry and the metaverse, the vehicular metaverse bridges the physical and virtual spaces, shaping the future of mobility and further extending the application of the metaverse concept. For example, the metaverse and intelligent transportation systems (ITS) merge to form a metaverse transportation system (MTS) [21]. Moreover, the metaverse is considered the embodiment of cyber-physical social systems (CPSS), enabling us to design meta-vehicles or parallel vehicles [22] with transparent virtual-real interaction for future intelligent transportation and smart mobility [18]. From the perspective of the intelligent cockpit, the progress of technologies such as intelligent connected vehicles and the metaverse promotes the transformation of traditional car cabins into intelligent cabins. These cabins provide services to humans through capabilities such as human–machine integration, networking services, and scene expansion. The metaverse in intelligent cabins is envisioned to offer a safe, efficient, and enjoyable experience for users [23]. Li et al. [23] proposed a framework for intelligent cockpits in the metaverse, including perception, cognition, decision-making, and interaction at three levels, aiming to provide a safe, efficient, and enjoyable experience for humans in intelligent cockpits. It has been suggested that designing a metaverse solution for future mobility is strongly motivated by the ambition of achieving a frictionless, fun, and personalized mobility society [20]. Applications are widespread, such as tactile live maps [20], collaboration in building virtual 3D maps of road networks to form shared vehicle perception [24], continuous monitoring of the environment in intelligent vehicles (intelligent mobility space [25,26]), communication with residents and communities to make decisions and take actions, and perceivable avatar generation [20].

The following is clear: (i) The development of metaverse technology and the transportation sector are mutually reinforcing, with this deep cross-cutting relationship manifesting at various levels, ranging from large-scale intelligent transportation systems to small-scale smart cockpits. (ii) The vehicular meta-universe is witnessing the emergence of a plethora of applications that promise to reshape future mobility systems. However, the integration of metaverse technology within the automotive domain is complex, involving numerous fields and diverse stakeholder visions. Therefore, a solely technology-driven approach cannot provide sufficient imagination for the field's development. (iii) In essence, the vehicular metaverse is driven by a combination of visions and emerging applications. We aim to advance the development of prototypes through concept innovation based on ideal visions. In the future, we hope to leverage design as a disciplinary lubricant to drive cross-disciplinary resource integration and practical implementation.

2.2. Concept Innovation Framework Based on Forecasting and Backcasting Transformation Paradigm

2.2.1. Forecasting and Backcasting

One of the biggest challenges for any organization looking to incorporate long-term planning into its development cycle is being able to provide an effective and efficient process for identifying and transitioning to future environments [14]. Forecasting and backcasting are valuable techniques for future strategic planning [14]. Forecasting is characterized as "a purposeful and systematic attempt to predict and comprehend the potential directions, speeds, characteristics, and impacts of technological transformations, particularly inventions, innovations, adoptions, and usages" [27]. However, it is crucial to recognize that our capability to predict the future is significantly constrained [28]. On one hand, this is due to the inherent uncertainty of future events [29], and on the other hand, even if the future is predictable, the most likely scenario may not be the most ideal in the context of long-term societal issues such as sustainability [30]. Therefore, it is essential to explore the feasibility and desirability of alternative futures rather than focusing solely on potentialities.

Backcasting aims to investigate the feasibility and consequences of achieving specific desired endpoints [31] and has been employed in numerous scenarios (energy and ecology [32], sustainable city planning [33], military modernization [34]). Essentially, backcasting is "a method where future desired conditions are envisioned, and subsequent steps are defined to fulfill those conditions, rather than pursuing steps that merely prolong present methods into the future" [15,16]. As a result, backcasting can be effectively integrated to provide a stringent and traceable strategic planning process. Nonetheless, since backcasting is built on an ideal future vision, which is itself uncertain, mediation between the desired future and the unwanted future is necessary.

Based on literature research, we believe the following: (i) Although forecasting and backcasting have some inherent defects, they are useful techniques for strategic innovation, crucial for solving ambiguous problems (such as the yet-to-be-defined vehicular metaverse), and help to address the lack of a long-term vision in design thinking. (ii) Forecasting and backcasting remain inherently at the strategic level, with the former involving the exploration of multiple alternative futures based on causal relationship clues (projection) and the latter involving the provision of steps to achieve an ideal vision. In a general sense, strategic planning and design innovation often follow one another rather than occurring in parallel, resulting in a weak connection between the two. In this sense, it is necessary to explore methodologies that can more closely integrate strategy and design in order to serve the resolution of ambiguous problems.

2.2.2. Conceptual Innovation Framework Based on Transformation Paradigm

We live in an era of transformation driven by technological opportunities, and the speed of disruption in industries is accelerating [13]. In a rapidly changing era, practitioners should enhance their potential to address a series of challenges in a dynamic environment [12]. On the one hand, design thinking (DT) is centered on problems and rooted in the present. However, the literature suggests that DT cannot address future challenges, customer needs, and emerging technologies [35]. On the other hand, strategic foresight (SF) has been found to support a company's dynamic capabilities, especially in highly uncertain environments [36,37]. Therefore, the integration of DT and SF may be beneficial and relevant, especially when planning to produce meaningful solutions and products for the future [35]. Schwarz [35] examines the use of forecasting methods in design thinking projects. Hara et al. [38] analyze the impact of using "imagined descendants" on research and development (R&D) strategies through future design practices with workers at a hydraulic engineering company. From the perspective of conceptual innovation in the vehicular metaverse (a yet-to-be-defined ambiguous problem), it is not only necessary to integrate current real needs and industry development concerns but also to construct a bold picture of the future scenario and vision. Both are indispensable. In this article, constructing future scenarios and conducting scenario narratives represent two stages of enabling metaverse conceptual innovation, manifesting as the deep integration of strategic foresight (SF) and design thinking (DT), as well as the integrated relationship of forecasting and backcasting with design thinking at different stages (Table 1).

Table 1. The conceptual innovation framework based on transformation paradigm.

Phase	Constructing Future Landscapes	Developing Conceptual Narratives
Methodology	Forecasting (SF) + Design Thinking (DT)	Backcasting (SF) + Design Thinking (DT)
Tools	Scenario Building + Value Insights	Target Setting + Conceptual integration
Resources	Future Signs	Domain Examples

- Constructing Future Scenarios: This refers to depicting future scenarios based on the methodologies of "forecasting + design". Starting from future indicators and stimulated by future indicators (such as STEEP), alternative multiple future scenarios are constructed through scene-building tools. Therefore, it is essentially a process of processing and deducing the emerging signs in the fields of society, technology, economy, environment, and politics, with its inherent logical clues and development context. We can focus on this level based on the following two aspects: (i) There are often multiple alternative futures in the deduction of future scenarios, so it is necessary to select a desirable vision and follow the ethical design to achieve future well-being. (ii) Constructing future scenarios is not only about projecting the future we want, but we should also actively discover the existence value and demands from the constructed future scenarios, and these values and opportunity points will serve as the link between the two stages. Therefore, constructing future scenarios inherently adopts a methodology that integrates strategy (forecasting) and design. The relationship between strategy (forecasting) and design is parallel and interwoven, rather than separated.

- Conducting Conceptual Narratives: This refers to a scenario narrative that is carried out using the methodology of "backcasting + design" for conceptual innovation. In this stage, concept narratives take the future scenarios as the background, value points as the starting point, and realistic cases in the vehicular metaverse domain as the stimuli. Through concept deduction integration tools, the development and improvement of concepts are achieved. We can focus on this level based on the following two aspects: (i) Traditionally, backcasting signifies a practice that seeks traceable solutions while orienting toward an ideal vision, with a single ideal future serving as the baseline [14,39]. (ii) In this article, since our aim is to drive the generation of design innovation solutions, we embarked on a more open-ended exploration. Instead of aiming at the desired future scenario, we target the values and opportunity spaces within these scenarios, planning traceable solutions (design proposals) and the existing technologies needed to complete these design proposals. This approach essentially reverses the process of strategy before design and instead fully integrates the two.

In summary, the conceptual innovation framework based on the transformation paradigm consists of phases, methodologies, tools, and design resources. The conceptual innovation framework provides guidance for further constructing the conceptual innovation methods for the vehicular metaverse while also raising more questions. These questions involve the choice of tools, the extraction of design resources, and the proposal of the design process. We will study these issues in the Section 3.

3. Innovative Methods for the Concept Development of the Automotive Metaverse

3.1. Research Objectives

Objective 1: During the stage of constructing future scenarios, our goal is to employ the integrated approach of "foresight + design" to further propose the specific steps, tools, and resources to develop vehicular metaverse conceptual solutions.

Objective 2: During the stage of conducting scenario narratives, we aim to utilize the integrated approach of "backcasting + design" to further propose the specific steps, tools, and resources required to develop vehicular metaverse conceptual solutions.

Objective 3: Our intention is to forge a heuristic innovation method with a coherent internal logic, laying the foundation for further application.

3.2. Building Future Landscapes

This part revolves around Objective 1. Firstly, we developed a future signal repository to provide materials for scenario deduction; secondly, we proposed an improved future wheel, which aims to deduce future scenarios with future signals and discover values and needs in the scenarios to generate initial opportunity points; thirdly, we established a metaverse product matrix for the layout of the initial opportunity points.

3.2.1. Resource Library: Establishment of the Future Signal Library

Step (i): Establishment of evaluation criteria: Ansoff believes that weak signals are the initial symptoms of strategic discontinuity in enterprises, indicating potential future changes and serving as warning signals or indicators of new possibilities [40,41]. Although the information conveyed by weak signals is vague when they first emerge, presenting a sense of threat or opportunity, as more information becomes available, the sources, characteristics, and required responses of these threats or opportunities gradually become evident, shaping anticipated outcomes [40,41]. Future signals encompass information from various domains, including social, technical, economic, environmental, and political aspects. To ensure quality, we developed a set of evaluation standards for collecting future signals. These standards draw on key concepts from the future studies literature and incorporate insights from Ansoff [40], Coffman [42], and Kamppinen [43], among others. Through multiple rounds of feedback, we established a discriminatory framework consisting of four dimensions (Table 2).

Table 2. Evaluation criteria for future signal library.

F	Criteria	Definition
1	Predictive	"Symptoms of potential future changes", factors that may influence future thoughts or trends
2	Inspirational	Endowed with the capability to stimulate contemplation or emotional response in individuals
3	Surprising	From the perspective of the signal receiver, having novel and surprising characteristics
4	Unexpected	Uncommon, occasionally masked by other signals or noise, exhibiting sudden occurrences

Step (ii): Case Screening and Library Building: An initial future signal library with a sample size of 300 was formed based on an extensive collection of future signals. To ensure the quality of the resources, we invited 2 expert panelists (faculty members) and 7 participants (students) to rate the cases individually based on four dimensions. The scoring range for each dimension was 1–5, representing the degree of conformity with the signal (low, lower, moderate, higher, and highest). Following that, we computed the weighted average score for each case using the weighted average method. The weights assigned to experts and students were 0.6 and 0.4, respectively.

For each case j (j = 1, 2, . . ., 300) and for each dimension F (F = 1, 2, 3, 4), the weighted average score of the case on dimension F can be expressed as

$$Score_{jF} = \frac{\sum_{i=1}^{2} w_E \cdot E_{iFj} + \sum_{k=1}^{7} w_S \cdot S_{kFj}}{2+7} \quad (1)$$

where w_E = 0.6 is the weight for the experts, w_S = 0.4 is the weight for the professional participants, E_{iFj} is the score given by the i-th expert for the j-th case on the F-th dimension, and S_{kFj} is the score given by the k-th professional participant for the j-th case on the F-th dimension.

For each case j, the total weighted average score of the case $\overline{S}_j$ can be expressed as

$$\overline{S}_j = \frac{\sum_{F=1}^{4} Score_{jF}}{4} \quad (2)$$

This score is the average of the weighted average scores of the case across all 4 dimensions.

By sorting the weighted average scores, we ultimately establish a future signal library with a sample size of 60, encompassing five categories: social, technical, economic, environmental, and political. We convert the collected content into relevant cards, which, when paired with corresponding scenario tools, serve as essential inputs for constructing future scenarios. As illustrated in Figure 1. See Figure 2 for a specific example of selected future signals cards.

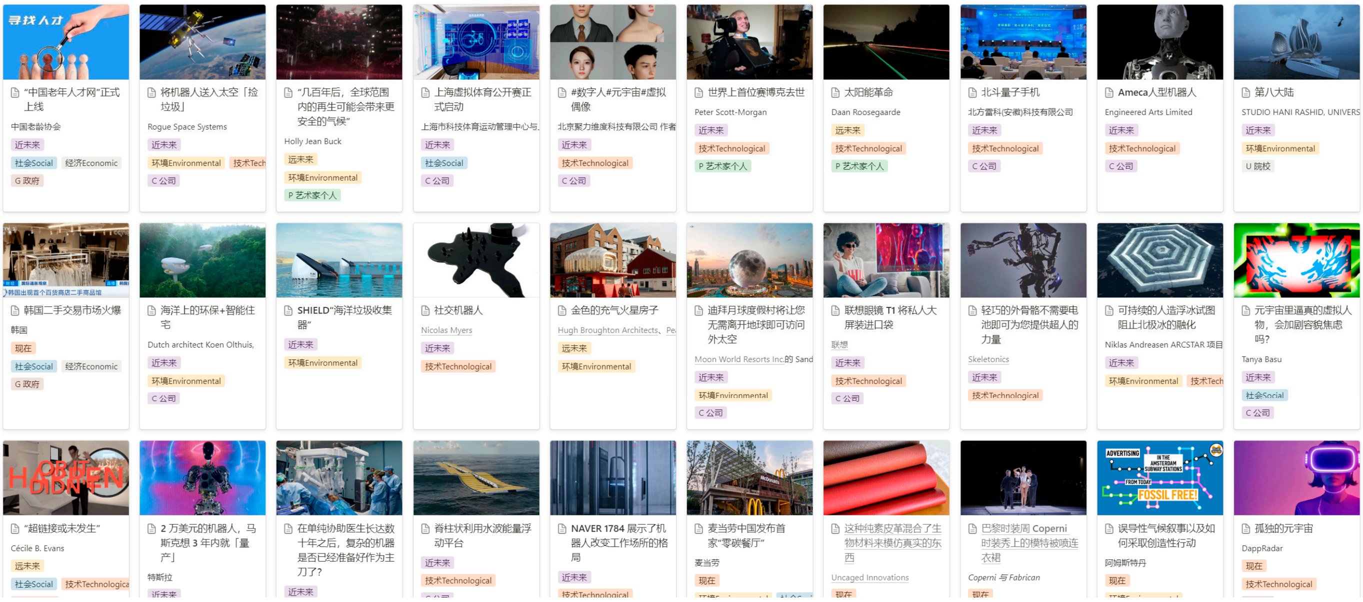

Figure 1. Part of the future signals in the future signal library. These future signals will be combined with the future wheel for scenario deduction.

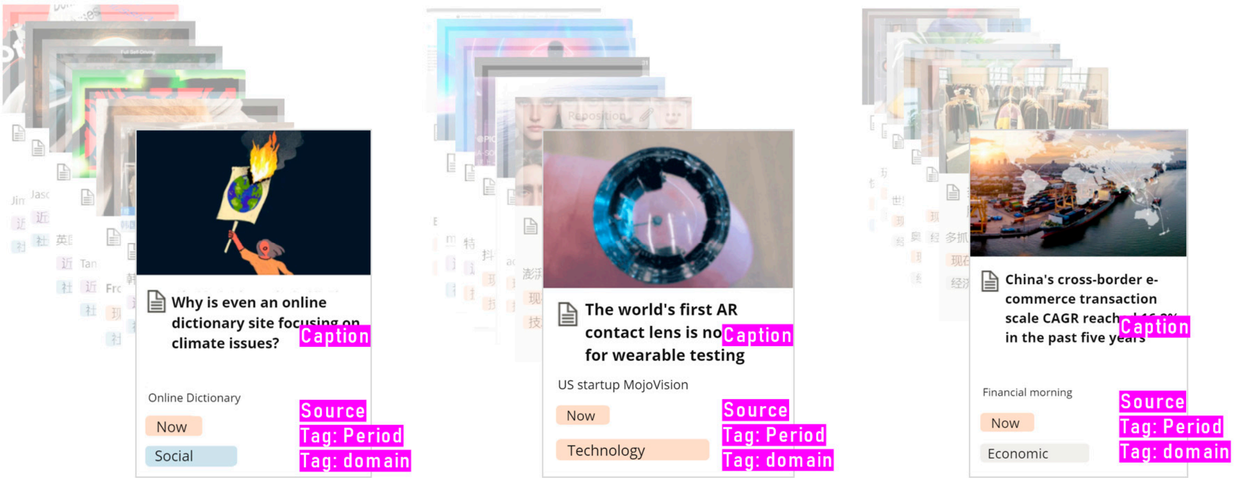

Figure 2. A selection of selected future signals is presented here. These signals come from the social, technological, and economic domains and support the user in further speculating on subsequent impacts.

3.2.2. Toolsets

- Future Wheel for Enabling Opportunity Point Layout: Predictions are shaped by causal relationships [29]. The future wheel, a tool for scenario deduction and brainstorming, explores the implications or changes suggested by initial modifications and displays the causal relationships between elements and their varying levels of influence [44]. These changes are implemented in a set of interconnected circles, wherein first-order changes lead to second-order changes, and so on. The process continues until all ideas have been exhausted [39]. In this study, we integrate the Future Signal Library with the future wheel, providing a wealth of future signals that serve as essential inspiration and material for constructing multiple future narratives. This thereby offers a certain basis for the future wheel's scenario deduction. Secondly, we believe that developing a more intuitive perception of scenario deduction and description can directly uncover opportunity points and values that may exist in the future time-space context. Therefore, we necessitate further exploring possible opportunity points outside the future wheel and pasting ideas beyond its different links. Essentially, the future wheel in this article combines scenario deduction with opportunity point discovery (Figure 3).

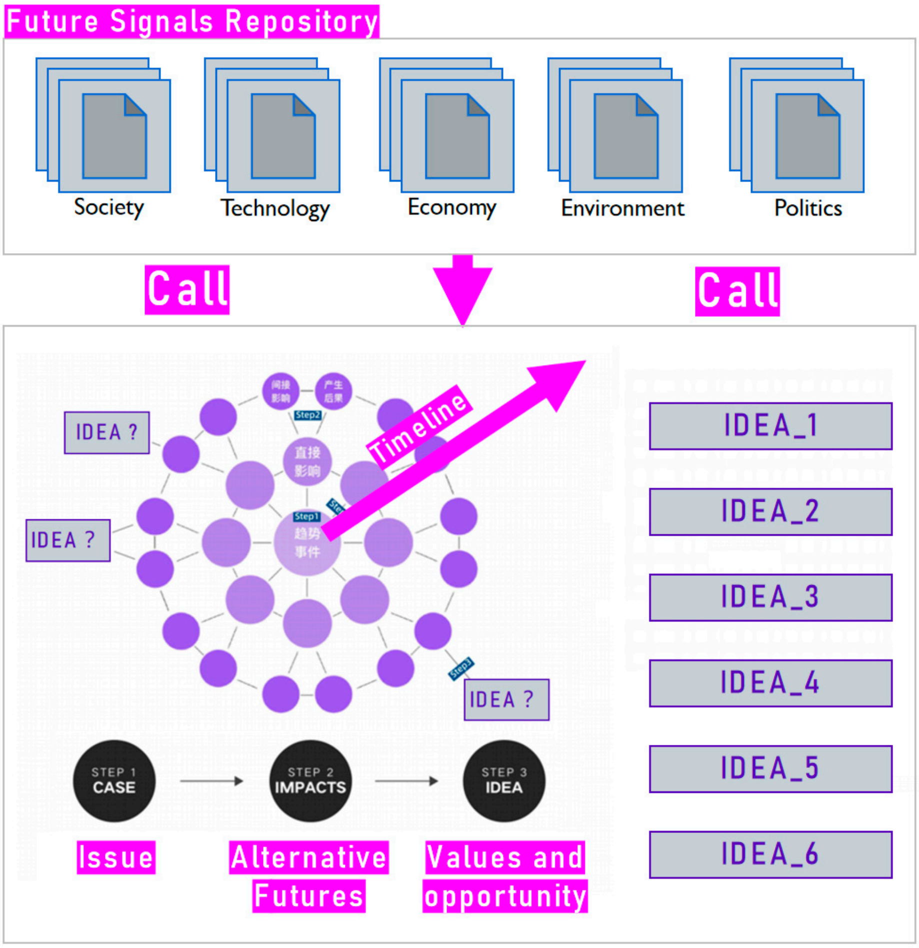

Figure 3. Combining future wheel with Opportunity Point Mining. This tool not only constructs alternative futures but also requires discovering value and forming initial ideas from them.

- Metaverse Product Matrix: Schwartz and the Global Business Network have developed the "2 × 2 Matrix" (or dual uncertainty) method, which utilizes a quadrant model to classify driving factors and focuses on key uncertainties as a way to construct organizational scenarios. In this study, to lay out the opportunity points derived from the future landscape, we created a metaverse product matrix. Unlike conventional 2 × 2 matrices, this matrix places greater emphasis on product types or usage scenarios, rather than broader macroscenarios [45]. The matrix consists of four quadrants divided by two axes: augmentation–simulation and external–internal. Specifically, Quadrant 1 (internal–augmentation) represents life logging, Quadrant 2 (external–augmentation) represents augmented reality, Quadrant 3 (external–simulation) represents the mirror world, and Quadrant 4 (internal–simulation) represents the virtual world. These four quadrants comprehensively summarize the types of solutions for the metaverse product service system. During usage, participants can further place the derived opportunity points in their corresponding quadrants, thereby enhancing their understanding of the opportunity points. Meanwhile, the description of the opportunity points can be continued, including summarizing the future landscape corresponding to the idea in one sentence and describing the innovative aspects (along with naming them) in one sentence (Figure 4).

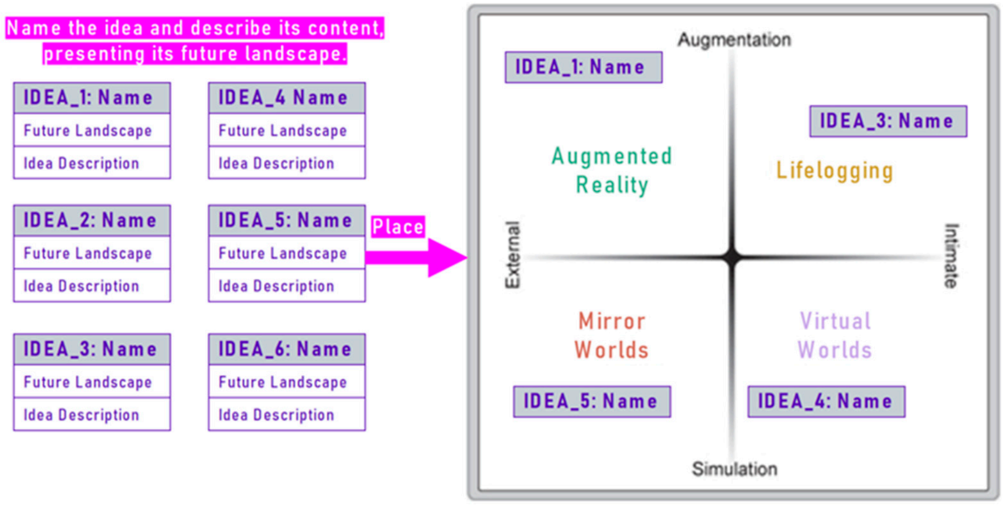

Figure 4. Metaverse product matrix. Each quadrant in the product matrix focuses more on product types or their usage scenarios, rather than the broader macrolandscape.

3.3. Conducting Conceptual Narratives: Backcasting Stage

This section revolves around Objective 2. Firstly, we developed a domain case library, providing domain perspective and case resources to further refine the innovative opportunities for the automotive metaverse. Secondly, we established a concept aggregation tool, which reassembles the initial opportunity points from the first stage with domain cases, making the opportunity points more feasible. Thirdly, we created a narrative template for innovative solutions, helping to form a more complete innovative concept.

3.3.1. Resource Library: Establishment of the Domain Case Library

Establishing a domain case library requires covering as many research topics as possible in the emerging field of the automotive metaverse. Therefore, we first attempted to use the LDA (Latent Dirichlet Allocation) topic modeling method [46–49] to construct the topic categories of the vehicular metaverse from literature data. LDA topic modeling is used for information retrieval and text classification, relying on statistical associations between words in text data to identify potential topics without the need for predefined dictionaries or interpretive rules. Subsequently, we collected domain cases corresponding to the obtained topic categories. Although the distribution of domain cases may not perfectly correspond to topic categories, the complete topic categories still provide a global perspective and important directions and inspirations for us to collect domain cases.

Step (i): Data Acquisition and Cleaning: In the data acquisition stage, we primarily focused on obtaining high-quality domain-related literature by searching the Scopus database with the following query: metaverse OR metavehic* AND automo* OR car OR transport* OR vehic*. The time span was from 2020 to 2023. Eventually, we obtained 135 papers. In the data cleaning stage, basic text cleaning was performed, including the removal of stopwords [50], unigram phrase modeling, and stemming.

Step (ii): LDA Topic Modeling: We estimated the required number of topics for the final modeling through a series of model comparison metrics, including coherence, perplexity, harmonic mean, and four additional metrics [51–54]. The results showed that selecting 14 topics could better cover lexical information. To reduce the cognitive and comprehension burden, we further clustered the 14 topics into five major theme directions. These five theme directions are as follows: “C1: Digital Twin and Experience Enhancement”, “C2: Mobile Computing and Communication Networks”, “C3: Internet of Things and Multilateral Decision-making”, “C4: Autonomous Driving and Deep Learning”, and “C5: Visual Art and Domain Expansion” (Figure 5).

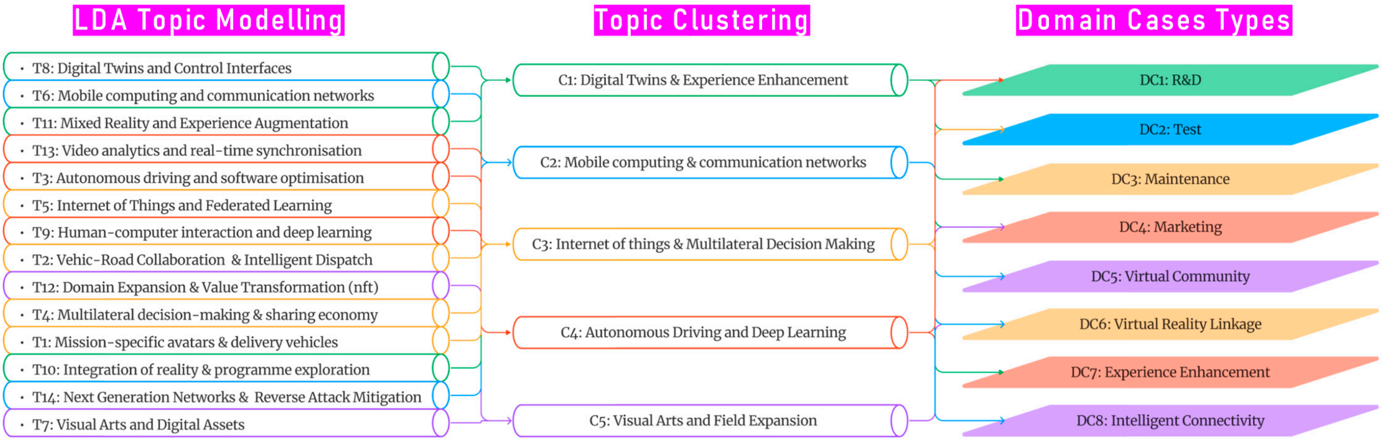

Figure 5. We conducted topic modeling based on Latent Dirichlet Allocation and then performed topic clustering on 14 topics, providing guidance for further establishing domain case types.

Step (iii): Domain Case Collection and Domain Case Cards Based on Topic Modeling: We obtained 35 cases, belonging to 10 types, including research and development, testing, maintenance, marketing, virtual communities, virtual-real integration, experience enhancement, and intelligent connectivity. Subsequently, we cardified the collected 35 cases. Each card includes information such as type, title, content description, and keywords (tags) (Figure 6).

Figure 6. Domain case cards with 35 cases of the vehicular metaverse based on type classification. Each card includes information such as type, title, content description, and keywords (tags). These cases will be developed into initial ideas during the conceptual integration stage.

3.3.2. Toolsets

- Concept Aggregation Tool: The concept aggregation template is used in conjunction with the domain case library. Firstly, participants select suitable cases from the domain case library and gather information on opportunity points from the foresight stage (including future landscape description, opportunity point description); secondly, participants rewrite the keywords (tags) for the opportunity point based on the aforementioned clustering. As the domain case cards provide rich and professional keyword descriptions (tags), these keywords can be integrated into the innovative concept in this form (Figure 7).

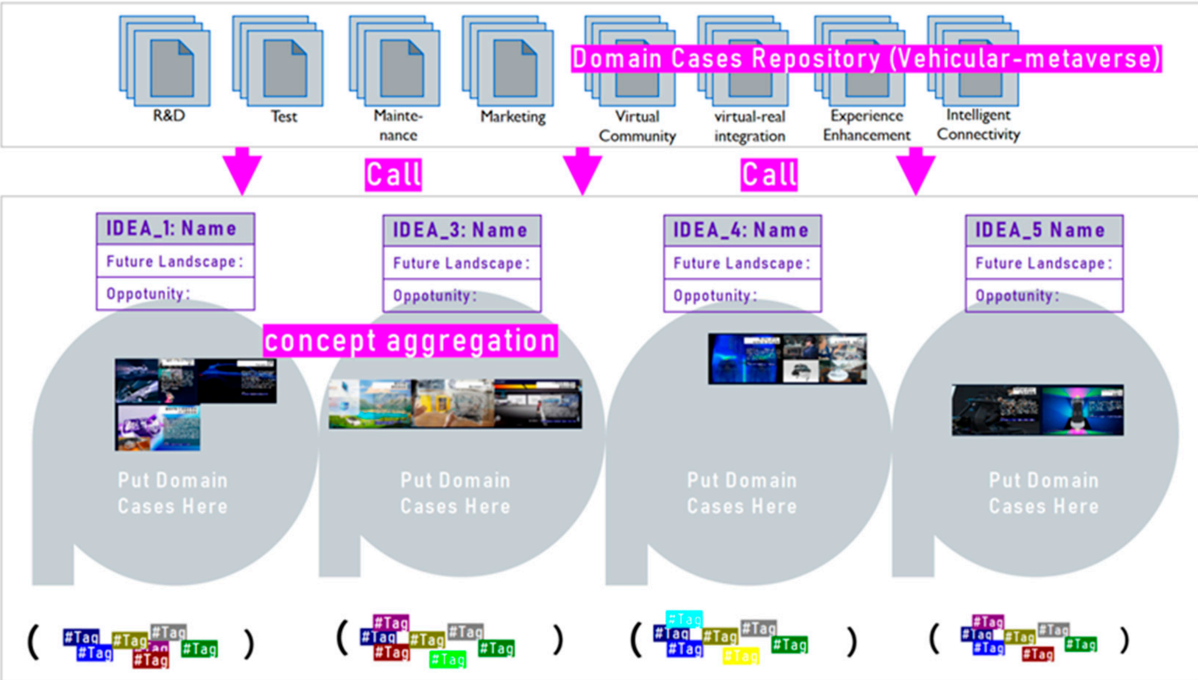

Figure 7. The concept aggregation tool.

- Innovative Concept Narrative Template: This template enhances the quality of generated concepts by standardizing and sorting case content. The concept template includes descriptions (final concept description), tags (concept aggregation tool), industry attempts (including domain cases), and future landscapes (presented in the form of future wheels). Additionally, it requires providing space in the appendix for future wheels and product matrices, serving as process materials for concept development, thus forming a complete solution (Figure 8).

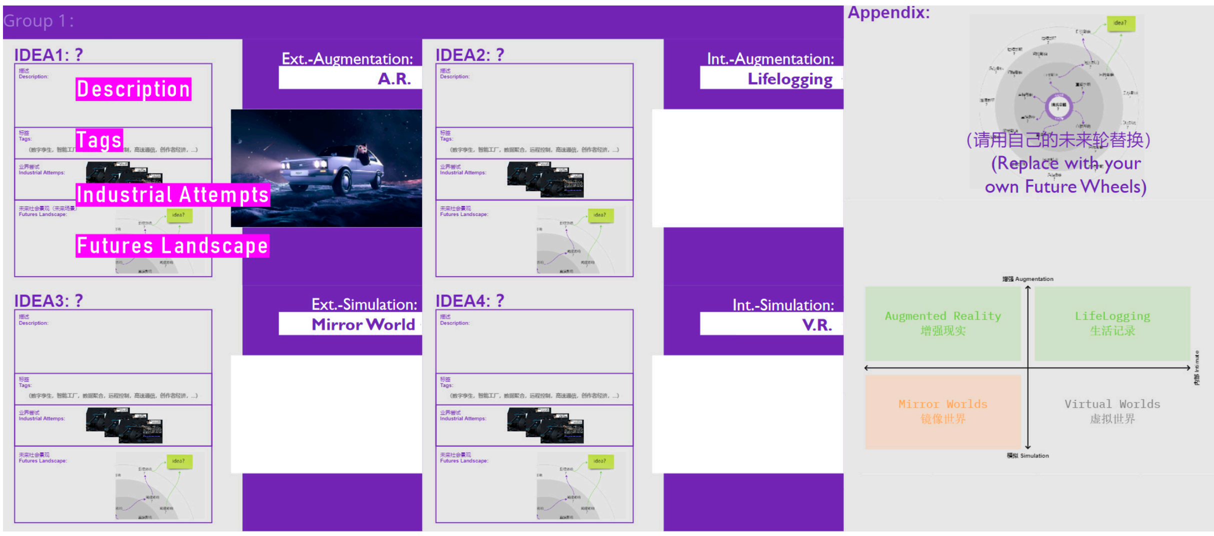

Figure 8. Innovative Concept Narrative Template.

3.4. Methodology for Innovative Concepts in the Vehicular Metaverse

This section revolves around Objective 3. By integrating the two stages of constructing future landscapes and conducting conceptual narratives, we propose a heuristic innovation method (Figure 8). To make the method more straightforward and understandable, we refer to the research framework on backcasting methods proposed by Aumnad [33]. This framework consists of three parts: Key Assumptions, Methodology (steps), and Examples of Methods. They discuss and compare three different backcasting methods [31,55,56] in detail within this framework. Based on the structure of Phase–Key Assumptions–Methodology–Steps–Examples of Methods, we elaborate on the conceptual innovation methodology for the vehicular metaverse (Figure 9, Table 3).

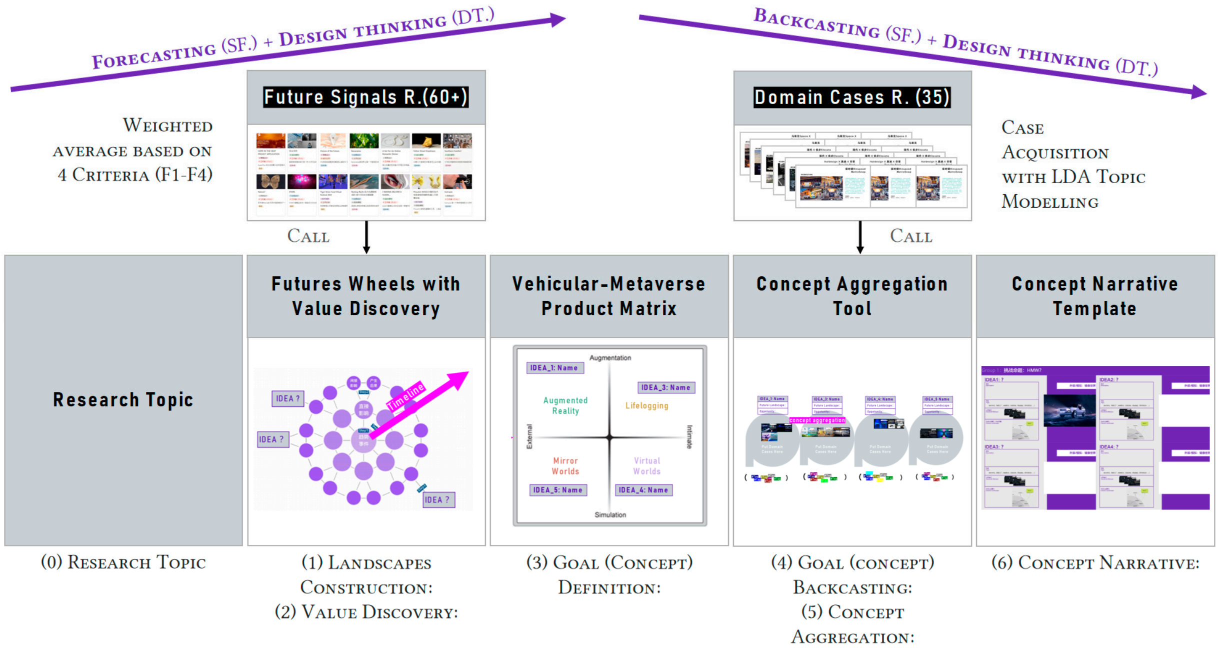

Figure 9. Methodology for Innovative Concepts in the vehicular metaverse.

Table 3. Methodology for Innovative Concepts in the vehicular metaverse.

Phase		Constructing Future Landscapes	Developing Conceptual Narratives
Key assumptions		√. Transformation Paradigm √. Strategy (Forecasting/Backcasting) + Design √. Value-oriented √. Design Concept-oriented √. Convergence Methodology	
Steps		(1) Landscape construction: Extrapolating alternative future narratives using future signal repository and future wheel; (2) Value discovery: Discovering value and opportunity points in future spatial-temporal contexts; (3) Goal (concept) definition: Conceptualize concept types, usage scenarios, etc., in the metaverse product matrix	(4) Goal (concept) backcasting: Searching for existing conditions or similar cases that are needed to realize the concept; (5) Concept aggregation: Rewriting the keywords of the initial concept based on clustering; (6) Concept narrative: Structuring all of the above to form the final concept.
Examples of methods	Resources	√. Future Signal Repository (60+)	√. Domain Example Repository (35)
	Tools	√. Future Wheel with Opportunity Point Mining √. Metaverse Product Matrix	√. Concept Aggregation Tool √. Innovative Concept Narrative Template

4. Application

During the annual conference of the Information and Interaction Design Special Committee (IIDC) of the China Industrial Design Association, the research team held a student-oriented workshop titled "Future Vision and Service Experience of Automotive

Metaverse" to verify the feasibility and effectiveness of the proposed method in this study. The process was as follows:

4.1. Obtaining Propositions

To understand the concerns in the field, we first invited professionals from automotive companies' strategic and management levels to extract five propositions through roundtable discussions focusing on production, marketing, and experience. These propositions include the following: "Production: Data-enabled production and sales integration ecosystem", "Experience: Gamified learning and educational scenarios for family travel", "Experience: Seen-is-gotten intelligent connected vehicle and virtual travel", "Marketing: Creator platform for automakers-game companies-users collaboration", and "Marketing + Experience: A Symbiotic Space for Enhancing Personalized Experiences through Digital Twins and Variability".

4.2. Proposal Design

To assess the utility of the toolset, resource library, and workflow we had developed, we conducted an online co-creation workshop with young designers and students. The 32 participants, from seven Chinese and American colleges and universities, were organized into six groups. The workshop began with the facilitator introducing five propositions and providing a concise overview of our innovative method for automotive metaverse concept development.

Following this introduction, each group was tasked with "constructing future landscapes" and "developing concept narratives" within a fixed time frame. As participants finished each stage, the facilitator shifted focus to the next set of tasks and rules, ensuring a seamless transition throughout the workshop.

The entire online workshop, which utilized Miro as the collaborative platform, spanned a duration of 5 h. By the end, the participants had produced 6 comprehensive narrative templates and a total of 24 unique concepts.

4.3. Evaluation and Communication

In this phase, we invited seven experts and scholars from the automotive industry ecology and metaverse fields to evaluate the proposals. Prior to this, the six group leaders presented their results. Following the presentations, the judges assessed the outputs and presentations, with the evaluation consisting of quantitative assessment and communicative feedback.

In the quantitative assessment phase, the judges used consistency (Mi) and creativity (Ci) as indicators to comprehensively evaluate the six sets of proposals. When calculating consistency, only the degree of alignment between the proposal and its respective topic was considered (with no distinction made between topics). Additionally, it was assumed that consistency and creativity were of equal importance (with no consideration of their weights). Therefore, the total score for each proposal was the sum of Mi and Ci. Then, the proposals were ranked according to the average of their total scores, and first, second, and third-place awards were determined. Figure 10 displays the award-winning solution of the team in the workshop. The proposal, based on the challenged proposition "Marketing + Experience: A Symbiotic Space for Enhancing Personalized Experiences through Digital Twins and Variability" established four automotive metaverse design innovation concepts, including "Real high-fidelity" (mirror world); "Chain" car (life record); Car Space-Time Presence (augmented reality); and Car Creation Universe (virtual world).

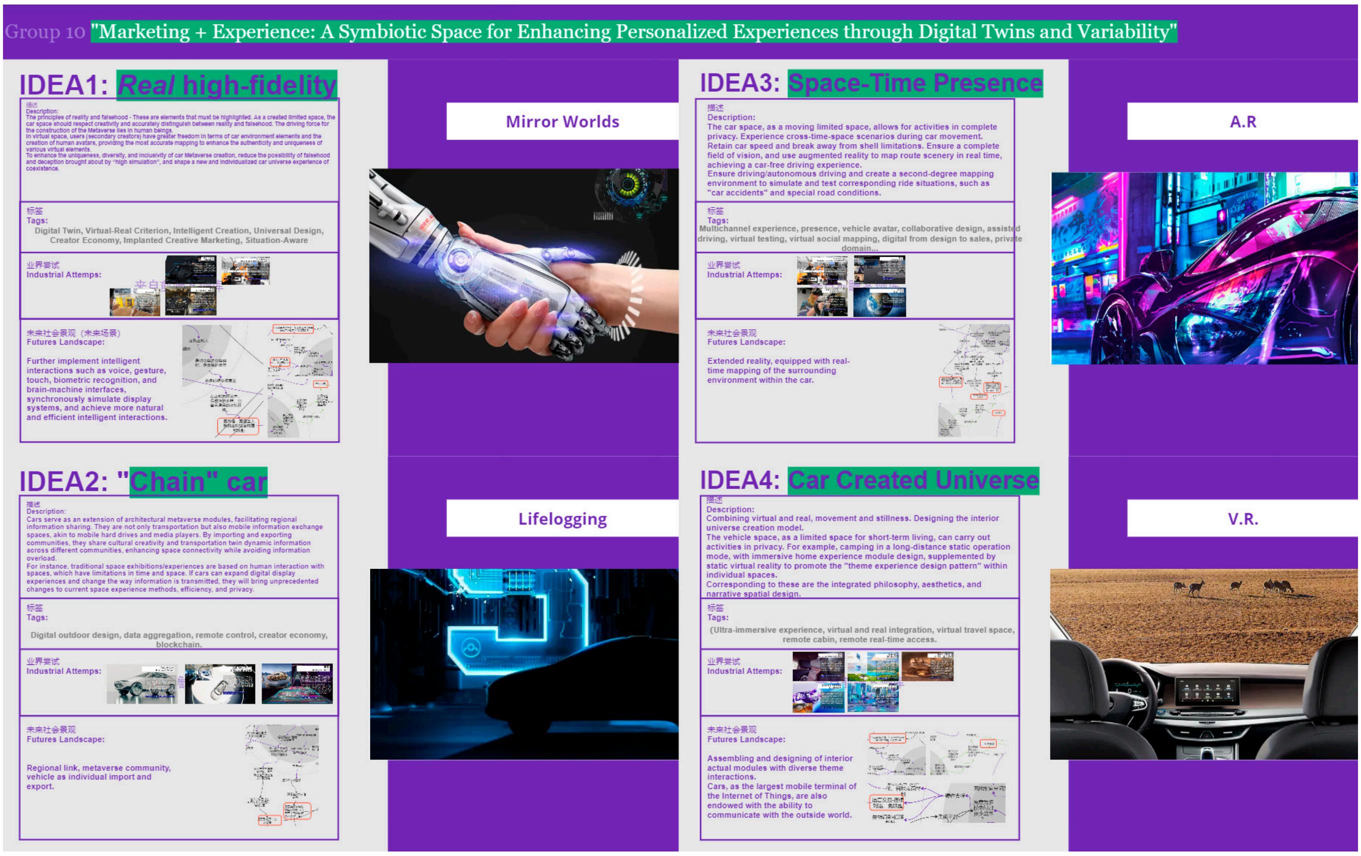

Figure 10. Presentation of the winning proposal from the team in this workshop.

In the communicative feedback phase, industry experts spoke freely, discussing not only the proposals themselves but also the methods and practical effects. Overall, industry experts gave positive feedback on the participants' performance and the application of innovative methods, considering them significantly helpful in promoting early-stage conceptual development in emerging fields. Key comments included the following:

- Industry experts highly praised the novelty (creativity) of all the proposals;
- The methods assisted participants in submitting preliminary conceptual ideas with a certain degree of completeness;
- Experts particularly emphasized the important role of this innovative method in rapidly forming preliminary conceptual proposals for the metaverse, especially considering the emerging nature of the automotive metaverse, the knowledge threshold of mobility design, and the fact that most participants lacked relevant experience;
- Notably, while experts acknowledged the progress made by the output proposals in forming novel concepts and reaching an entry-level standard in a short period, they also emphasized the need for deeper refinement and continued development of the proposals to address industry-specific concerns in order to achieve a professional level. Therefore, a more in-depth involvement of the industry (and guidance on the proposal) is a must in the follow-up.

5. Discussion

5.1. Characteristics of the Application of the Methodology: Derived from Two Phases of Observation

In the Constructing Future Landscapes stage, participants used the future wheel and the provided future signal library to construct future scenarios. Generally speaking, the future wheel should start from a specific event and deduce its subsequent impacts. Since the provided five propositions are not events, they should be converted, and then their impacts should be deduced using the future wheel. In the case application, most groups (except for one group) did not convert the propositions into events but directly deduced their subsequent impacts based on the propositions. This is a reminder to further optimize the development of tools and step-by-step guides. In addition, we combined the future wheel with value discovery, which has been proven to be feasible in practice. After the scenario deduction, all groups were able to discover potential values and repeatedly improve the initial concept (Figure 11) by laying out product matrices (different from the conventional scenario matrix). Thus, this creates a process of uncovering insight from foresight.

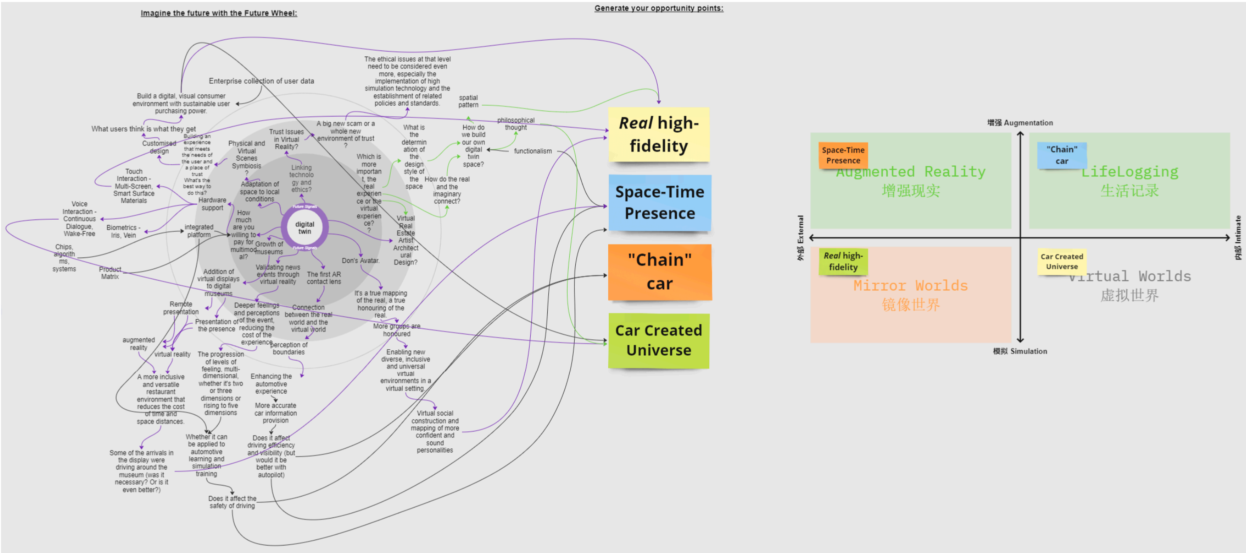

Figure 11. During the forecasting stage, after the scenario deduction, all groups were able to uncover potential value and repeatedly enhance the initial concept by laying out the product matrix (which is different from the conventional scenario matrix).

In the Developing Conceptual Narratives stage, the goal of backcasting is not the vision itself but the opportunities within a particular vision. It is important to note that these opportunities, as long-term design concepts, are built upon multiple (as yet unmaterialized, even nebulous) future scenarios. Therefore, in the backcasting phase, rather than emphasizing the need to align with these unprovable and unfalsifiable future demands and concepts, a more appropriate approach would be to develop these demands and concepts to make them more refined and feasible. In the case practice, we observed that participants used the provided domain case cards (35 cards, 10 types) to develop the initial concepts proposed in the first stage, rather than directly targeting the intended concept (Figure 12). This led to a reinterpretation of "backcasting": a dynamic goal-oriented perspective. Nevertheless, the final output is still only a preliminary concept, lacking the form of a product or service, and requires further product transformation and design (Figure 10). This necessitates the integration of more travel experience innovation processes and methods, and the establishment of a truly innovative theoretical framework for the automotive metaverse, rather than stopping at the idea stage. We hope to further establish a corresponding domain innovation theoretical framework by combining the metaverse product matrix, automotive metaverse LDA topic modeling, and other results, gradually clarifying issues that are conceptually ambiguous.

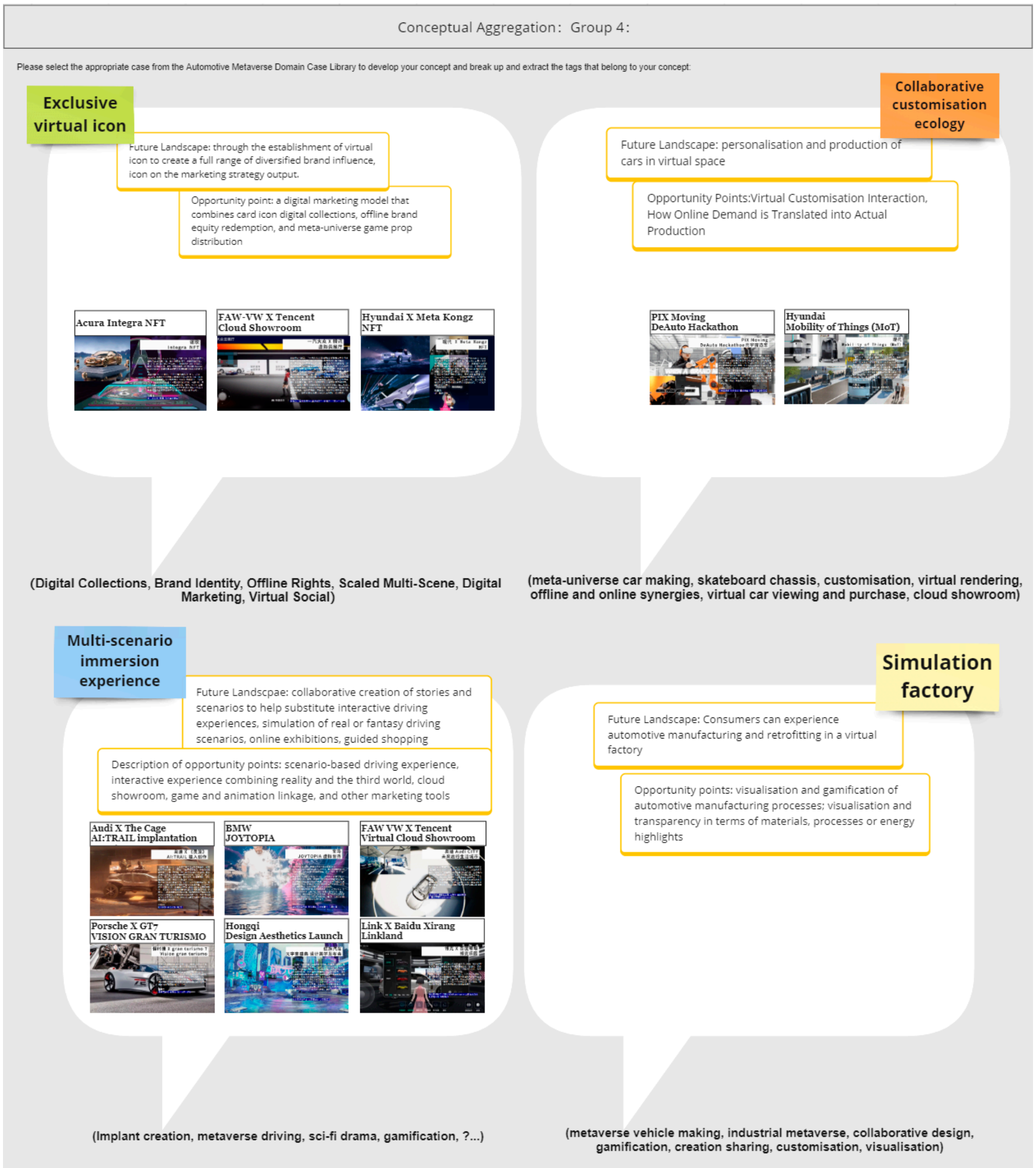

Figure 12. Process achievements of a certain group during the concept aggregation stage.

5.2. Value-Orientated: Connecting Forecasting and Backcasting through Value

Dr. Grisanti from the RCA Intelligent Mobility Design Centre at the 2023 International Intelligent Mobility Design Conference in Shanghai, China, suggested that when developing a new product, it often includes two layers of meaning, one being to project the future we want and the other being to construct the objects from the value. In other words, the transition from envisioning a future scenario to developing a narrative is driven by value, following the steps of "desired future—value or opportunity points—products or services". Therefore, in this paper, value or opportunity points are mediators between foresight and backcasting. At the same time, the goal of backcasting is not vision in the traditional sense (the development of normative scenarios [31]) but the concept of value under vision. Value exists in different forms across various temporal and spatial scenarios. For instance, although the product form or interactive methods may differ between the digital space and the physical space, the underlying proactive value remains consistent. This consistency enables the further translation of these values into design solutions based on different practical conditions. This is a feasible approach provided by this paper for the deep integration of strategic foresight (SF) and design thinking (DT): value orientation.

This is because the pursuit of value orientation helps to transform the innovation process into concrete solutions.

We argue that there are two types of value. The first one is constructed on the bold speculation of alternative futures, which is leading and forward-looking (as planned and applied in this paper). The second one originates from experience research [57,58], obtained through insight from user behavior. The second type of user value was integrated into the methodological framework of experience innovation. We expect the first type of value to play a more practical role.

5.3. Convergence Methodology: Resolving Difficult Issues through Interdisciplinary Integration

In this article, we present our innovative approach to designing the vehicular metaverse, which converges the intrinsic logic of constructing future scenarios and concept narratives in a clear and heuristic manner. The greater value of this approach lies in the harmonious collaboration of processes, stages, tools, and resources. This collaboration represents a fusion of methodologies and a combination of interdisciplinary technologies, demonstrating strong innovation. For example, when constructing two resource databases, we not only established stringent standards but also attempted to incorporate machine learning (Latent Dirichlet Allocation topic modeling [59,60]) and other means. Meanwhile, the conclusions of topic modeling are not presented as research reports but are further transformed into design resources that can be utilized and coordinated with tools derived from the design field, thus aiding the generation of creativity. Essentially, this approach integrates emerging technological acquisition methods with design thinking tools. In conclusion, throughout the innovation process, external information collected (future signs, domain cases) is constantly integrated into the participants' thinking processes through tools derived from future thinking or design thinking in the innovation process of "desirable future-value or opportunity points-products or services".

We believe that the convergence methodology composed of interdisciplinary methods is of great significance for resolving problems [61]. On the one hand, from a macroperspective, this approach helps to unleash the significance of design as a marginal discipline, which involves consolidating different disciplines and fields around specific goals to achieve innovative architecture at the macro-level. Here, "design" leans toward regarding design as human beings' unique intelligence [8]. On the other hand, from a microperspective, this approach integrates thinking patterns and innovative tools from design with technological means or theoretical models from other fields to address unsolvable problems in design and enhance overall productivity. Here, "design" leans toward the concept of an independent discipline. We believe that design should play a role from both macro- and microperspectives, which is the key to solving problems.

5.4. Toward a Transformational Paradigm: Limitations of the Study

In this paper, the conceptual innovation methodology for the automotive metaverse is grounded in the "transformational paradigm", emphasizing the integration of strategic foresight and design thinking within the project. This integration has garnered attention, as seen in Jan's study on the experiential evidence of using strategic foresight in design thinking projects [35]. The progressive significance of the transformational paradigm is clear: on one hand, it provides a broader temporal and spatial context for design thinking, moving beyond product thinking's narrow focus on solutions and the resulting homogeneity and competition; on the other hand, it incorporates strategic foresight into value-oriented and design-concept-oriented considerations, translating strategic foresight into tangible product and material outcomes, rather than confining them to reports and texts. In this study, the macro-level strategic foresight and the micro-level product-focused design thinking intertwine in a relationship that is more synergistic than sequential, serving the design innovation of the vehicular metaverse.

The limitations of this study are evident in several aspects:

(i) The research still overemphasizes market potential, neglecting broader social impacts. For instance, while a vision of a frictionless, personalized mobility society is proposed, there is a lack of in-depth debate about the desirability of such a societal model. We argue that the transformative value of the paradigm lies in shaping a more desirable future. Therefore, there is a need to move away from the traditional market potential-driven mindset of "the newer the better" or "more and cheaper" [62]. The rationale behind this is that "both we (as a species) and the natural resources upon which we depend are finite" [63]. In the future, we hope to further integrate the exploration of socio-cultural conditions with the identification of market potential, deepening society's understanding of possible and ideal futures.

(ii) In the process of methodological design, while the importance of stakeholder visions is emphasized, there is a lack of in-depth exploration of the types of stakeholders involved in the discussion and visioning process, and they are not effectively integrated into the innovation process. In the future, we aim to optimize the proposed convergence methodology through multi-party collaboration (social design [64], crowdsourcing [65], collective intelligence [66], open innovation [67]) and multi-channel interventions (academia, industry, government, and communities), reaching a broader audience and unlocking greater value.

(iii) The development and evaluation of the toolkit still require further refinement. Specifically, guidance on transforming initial propositions into events during the use of future wheels is needed. Moreover, while the contents from the two libraries play a significant role in constructing future scenarios and narratives, the timeliness of these materials is problematic in the long run. If considered as data assets, there is a need to explore a data-centric approach to building information systems that allows for real-time data access and utilization. For example, Isam Faik and others [68] studied the role of information technology in societal change. At the same time, we must be cautious of data-driven determinism and further leverage the agency of future thinking to explore "possibilities". Kuosa and others [69] proposed the Future Signals Sense-Making Framework (FSSF) as a tool for analyzing and categorizing weak signals, wild cards, drivers, trends, and other types of information. We hope that the proposed convergence methodology provides a prototype for building such a system. Lastly, since this practice is aimed at students and is exploratory in nature, the evaluation of the solutions is still too simplistic. We hope to further adopt or develop appropriate evaluation scales (such as the Assessment Scale for Creative Collaboration, ASCC [70]) and engage in empirical studies on multidisciplinary design collaboration [71]. We also believe that, given the provisional and exploratory nature of the conceptual solutions, the focus of evaluation should be on the prototypes that follow these concepts. In summary, the most important aspect of solution evaluation is its integration with the overall knowledge framework of the vehicular metaverse and its specific application scenarios (such as R&D, testing, maintenance, marketing, virtual communities, virtual-reality integration, experience enhancement, and intelligent connectivity), which requires further deepening of our research in this field.

6. Conclusions

The metaverse, blending virtual and reality, enhances global communication, transactions, and experiences. The vehicular metaverse is hailed as the next Internet revolution, offering vast market potential and stimulating academic research. However, its definition remains unclear due to rapid future changes, diverse stakeholders, and varying visions. A paradigm shift is needed to address issues in this field.

The contributions of this paper are as follows:

(i) The study first proposes that the conceptual innovation of the automotive metaverse is driven by constructing future landscapes and developing conceptual narratives, embodying the deep integration of strategic foresight (SF) and design thinking (DT), as well as the integration of forecasting and backcasting with design thinking at different stages, forming a conceptual innovation framework based on the transformational paradigm.

(ii) The study further establishes a methodology for conceptual innovation in the automotive metaverse, consisting of Phase–Key Assumptions–Methodology–Steps–Examples of Methods, including two stages, a four-step process, four tools, and two resource libraries to assist participants in quickly developing metaverse-related solutions. In the stage of constructing future landscapes, we established a library of 60 future indicators based on four dimensions of evaluation criteria, serving as important materials for participants to build future landscapes; in the stage of developing conceptual narratives, we provided a case library of the automotive metaverse domain composed of eight types of cases through LDA topic modeling, helping participants form innovative solutions through concept aggregation. Additionally, tools such as future wheels, metaverse product matrices, and concept aggregation templates were integrated into a six-step process to form a convergence methodology that combines strategic foresight and design innovation, data mining, and participatory design, which is of groundbreaking significance.

(iii) The application of the method shows that the conceptual innovation method can assist participants in quickly forming early-stage conceptual solutions related to the metaverse. In addition to enhancing the completeness of the solution, this method is more effective in enhancing the novelty (creativity) of the solution, laying the foundation for further integrating industry concerns to develop the solution in depth.

The novelty of this approach lies in its synthesis of several critical elements, collectively known as the "Convergence Methodology". This methodology encompasses Strategy (Forecasting/Backcasting) + Design, Value-oriented, and Design Concept-oriented. The "Transformational Paradigm" it embodies offers a broader temporal and spatial context for design thinking, diverging from the narrow focus on specific solutions that characterizes product-oriented thinking. This shift not only avoids the pitfalls of solution accumulation and homogenization but also aligns strategic foresight with value orientation and design concept orientation, ensuring that strategic foresight is translated into tangible products and material outcomes, rather than being confined to reports and documents. In this method, macro-level strategic foresight and micro-level product design thinking interweave to create a symbiotic relationship. This integration is instrumental in driving design innovation within the automotive metaverse domain. Overall, the conceptual innovation methodology for the automotive metaverse represents a comprehensive approach to addressing complex problems through interdisciplinary collaboration. It synergizes strategic foresight with design innovation and integrates data mining with participatory methods, providing a robust framework for advancing the field.

The study has several limitations: first, the research focuses on market potential and neglects considerations of social impact and resource limitations, which require future integration with socio-cultural conditions and market potential; second, the methodological design lacks in-depth exploration and effective integration of stakeholder types, which requires future optimization of the convergence methodology; and third, the development and evaluation of the toolkit need further refinement, particularly in balancing data-driven and future thinking, as well as improving evaluation methods, which requires in-depth exploration in conjunction with specific application scenarios and the overall knowledge framework of the vehicular metaverse.

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