Future Innovation Framework for Smart Product Service System Design

Exploring an Innovative Design Approach for Global Manufacturing Companies

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Department of Mechanical Engineering

18th of December 2024

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- Exploring an Innovative Design Approach for Global Manufacturing Companies

Yan Zhang

Blekinge Institute of Technology, Sweden

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Department of
Mechanical Engineering

My Context

"**Product-Service System is my research area**,
and I have been on a long journey of exploration in this field"

A research-driven entrepreneur

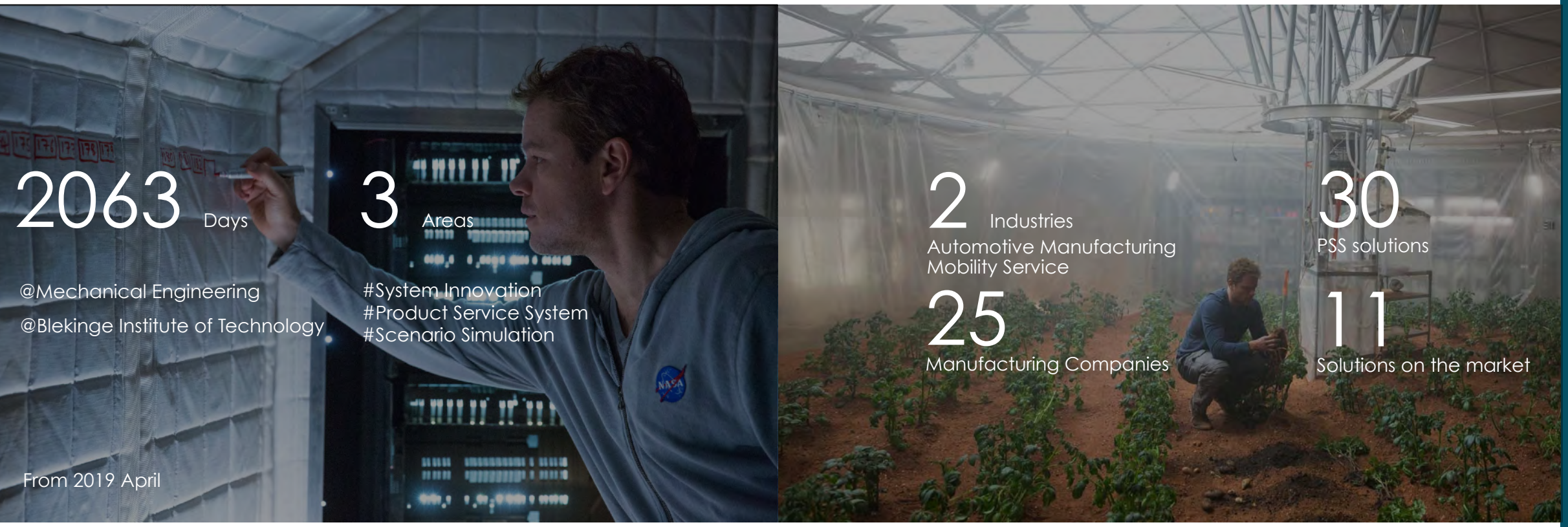


Photo download from Google, The Martian, 2024

Research-based innovation services

Service Design Lab
2016 – 2018

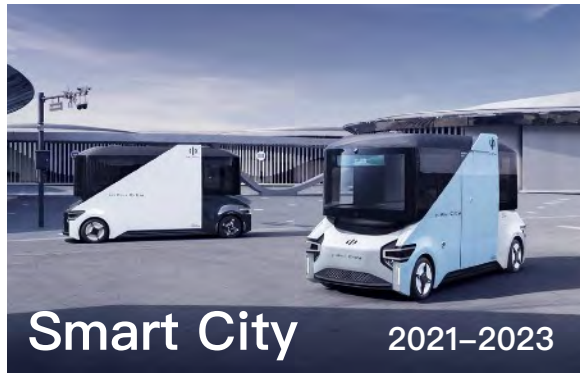
PSS Design Lab
2018 – 2020

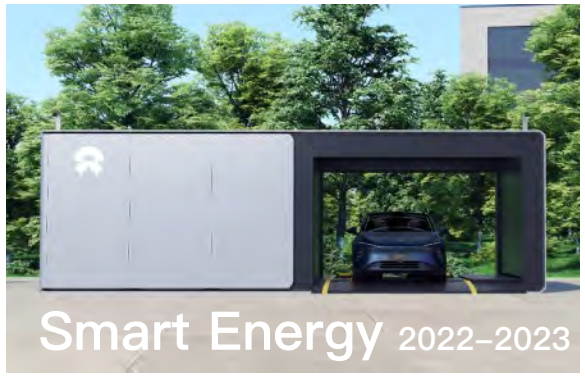
Scenario Innovation Lab
2020 – 2022

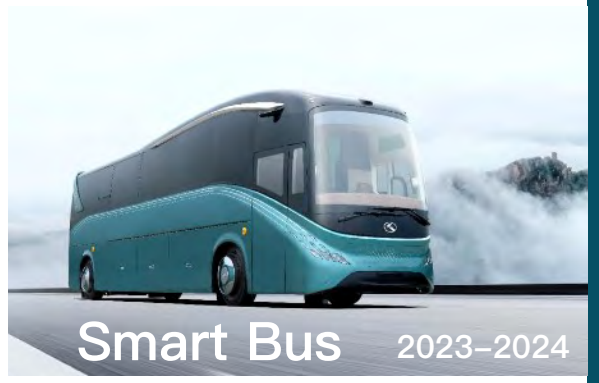
Virtual Simulation Lab
2022 –

Photo by the author, 2024

Transformation of PSS research into industrial application







Audi VW MAXUS TANK 华人运通 HUMAN HORIZONS 華潤 China Resources NIO KING LONG

Smart PSS Innovation for Global Industrial 4.0

NEOLIX 新石器无人车 CAINIAO CHERY pix moving UISEE SAIC MICHELIN

Photo download from the official home page of each brand and Yan's work, 2024

Agenda

- Introduction
- Theoretical Background
- Methodology
- Results
- Conclusions
- Q&A

Manufacturing companies' transformation through digitalization & servitization

Product Development

Product -Service System

Smart PSS Transformation

New product model

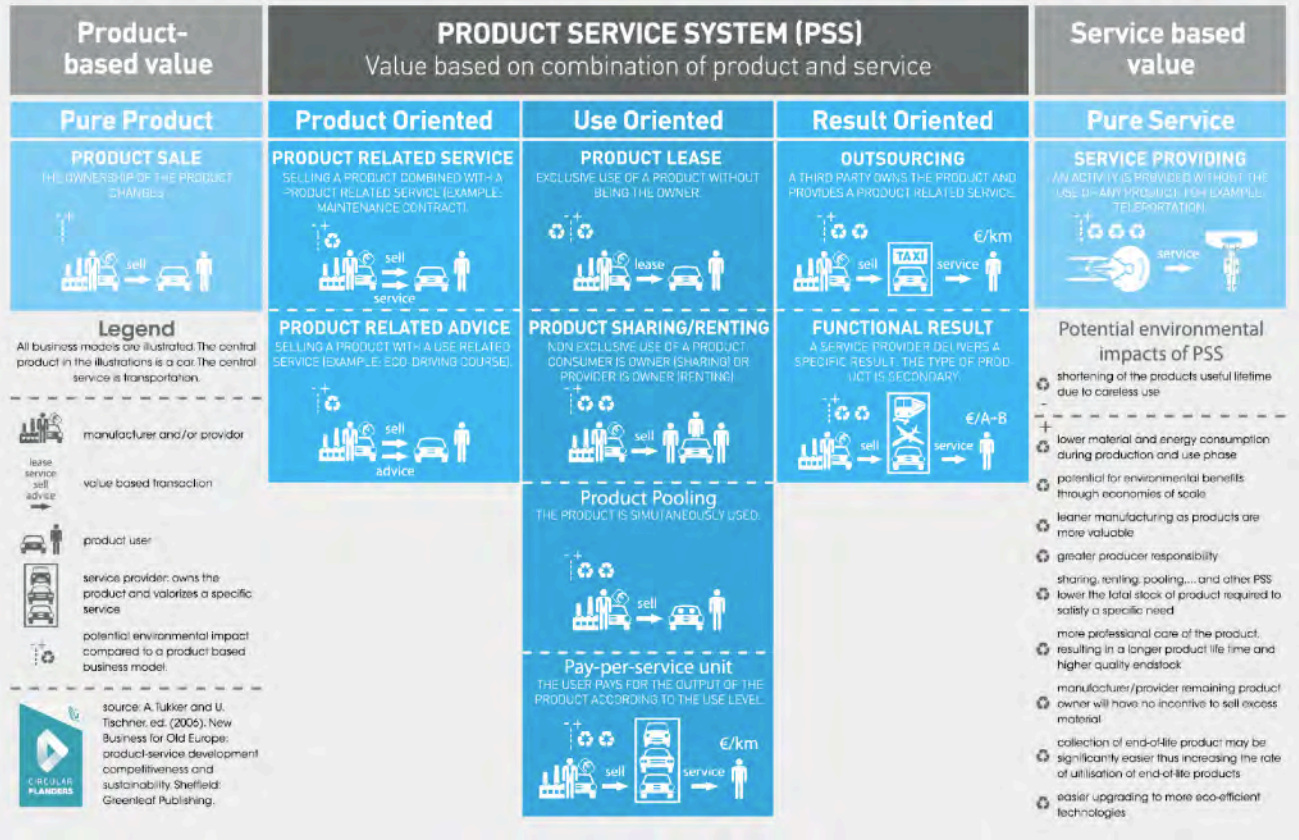
Service oriented model

Future customized solutions

Photo download from the official home page of each brand. Volkswagen/Nio/ Apollo Go, 2024

Product-Service System

A mix of *tangible products and intangible services is* ***designed and combined*** *so that they are jointly capable of fulfilling final* ***customer needs****. (Tukker and Tischner 2006)*

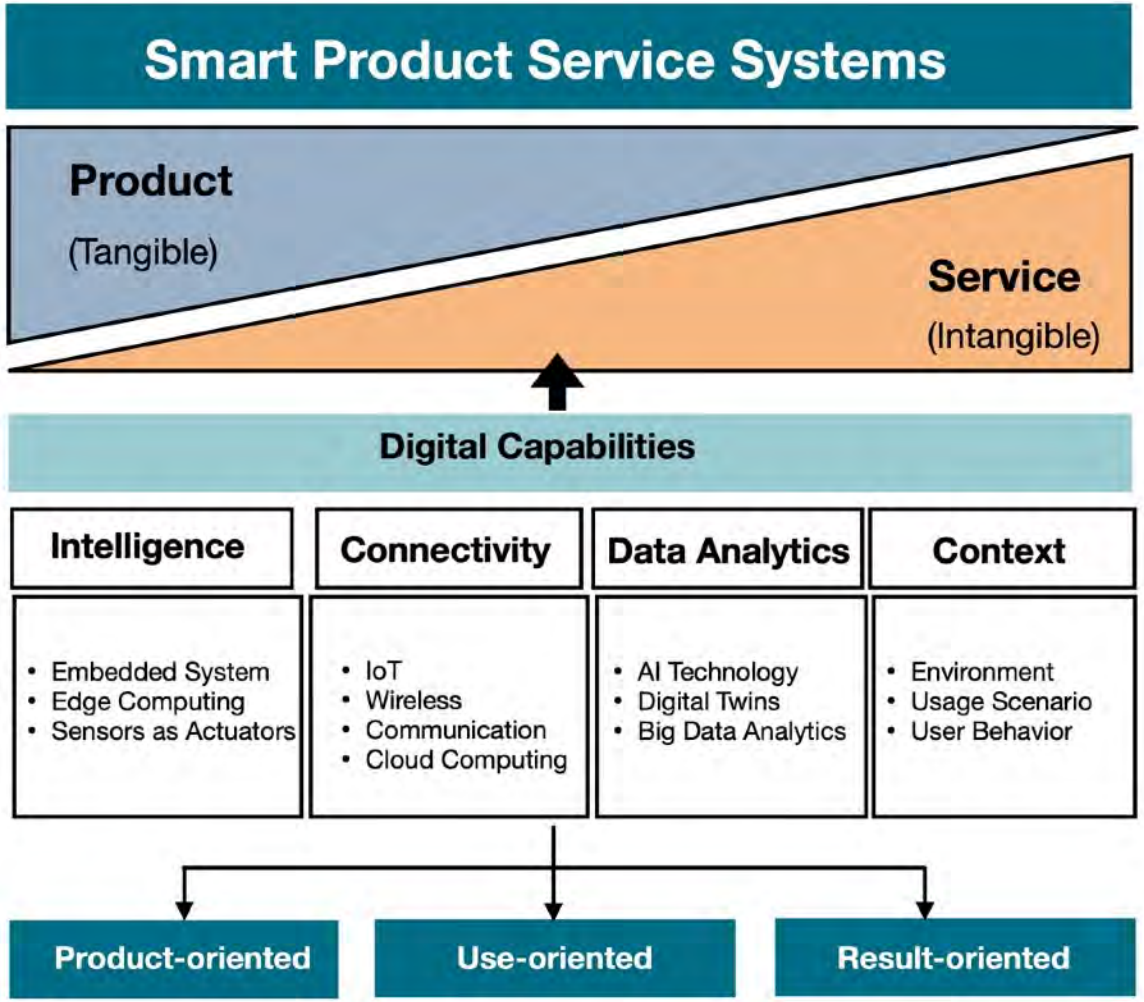


Tukker, A. and Tischner, U. (Eds.). (2006), *New Business for Old Europe: Product-Service Development, Competitiveness and Sustainability*, Greenleaf, Sheffield.

Smart Product-Service System

Smart PSS defined as a fusion of smart products and smart services into ***a cohesive offering****. (Valencia and Mugge, 2015)*

Digital capabilities *are a key distinction between traditional PSS and smart PSS.*



Valencia, A., & Mugge, R., Schoormans, J.P., & Schifferstein, H.N. (2015). The Design of Smart Product-Service Systems (PSSs): An Exploration of Design Characteristics. International Journal of Design. 9. 13-28.

Photo from thesis work, 2024

Challenges in transitioning to smart PSS

Sustainability in product development process

Adaptability in rapidly changing markets

Time / Cost Efficiency in Design and Development

Collaboration across disciplines

Decision-making capabilities from diverse stakeholders

Photo taken by author from his research work environment

Challenges in early-phase smart PSS design

Integration of Smart Product & Digital Service **in design process**

Numerous smart PSS configurations for generating design concepts

Forecasting the performance of **Future Customer Scenarios &Value?**

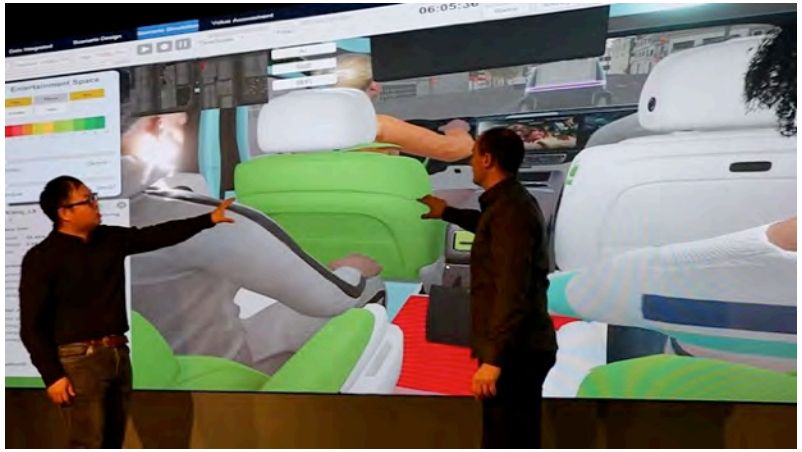
Photo taken by Li Auto. https://www.lixiang.com/

Challenges in smart PSS design approach

Exploring **a new design approach** that can facilitate the practicality of **emerging technologies** in designing the future solution.

Unknow

Realized



Aim & research questions

Research Aim/ Objectives

...to study the motivation to support the global manufacturing companies in transforming digital servitization through ***proposing innovative design approach*** *for designing smart PSS.*

Research questions

RQ1:

How to explore an innovative design approach in the early stages of smart PSS design (in the context of global manufacturing companies)?

RQ2:

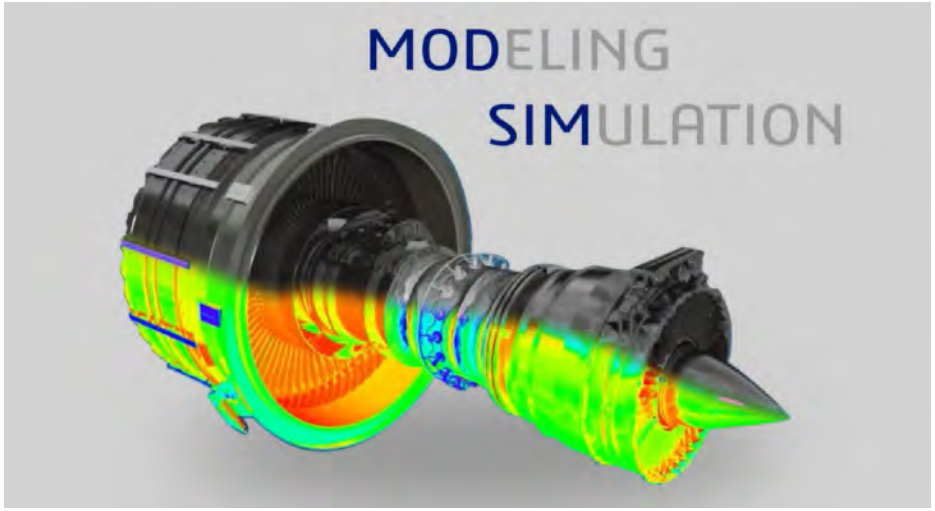
How can Digital Twins support the early stages of smart PSS design (in the context of global manufacturing companies)?

Knowledge Domains

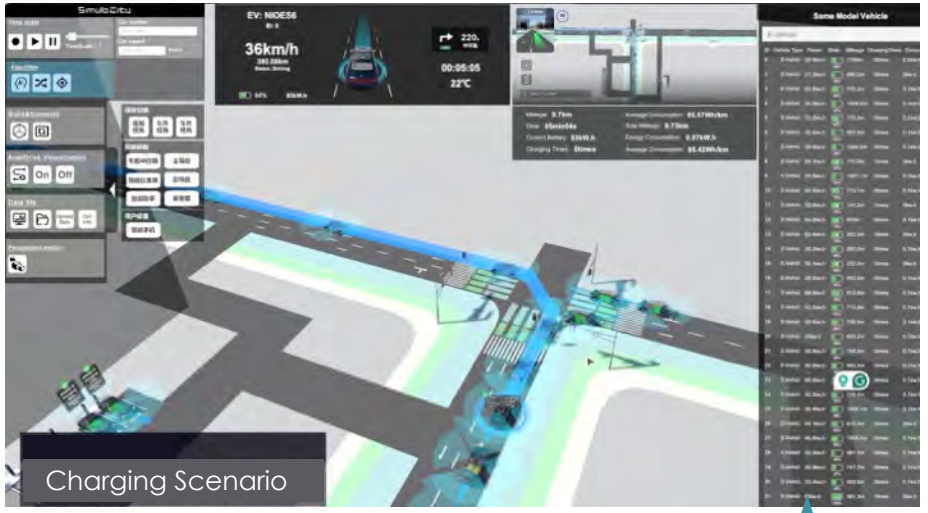
Simulation

*Simulation provides a **virtual environment** to model, test, and validate product performance before physical prototypes are created (Ulrich and Eppinger, 2015).*

The complexity of Smart PSS design requires advanced simulation techniques can manage uncertainty and variability inherent in service interactions (Bertoni and Bertoni, 2022).



Product Simulation



Service Scenario Simulation

Ulrich, K. And Eppinger, S. (2015). Product design and development. McGraw-Hill Higher Education.

Bertoni, M., & Bertoni, A. (2022). Designing solutions with the product-service systems Digital Twins: What is now and what is next? Computers in Industry, 138, 103629. https://doi.org/10.1016/j.compind.2022.103629

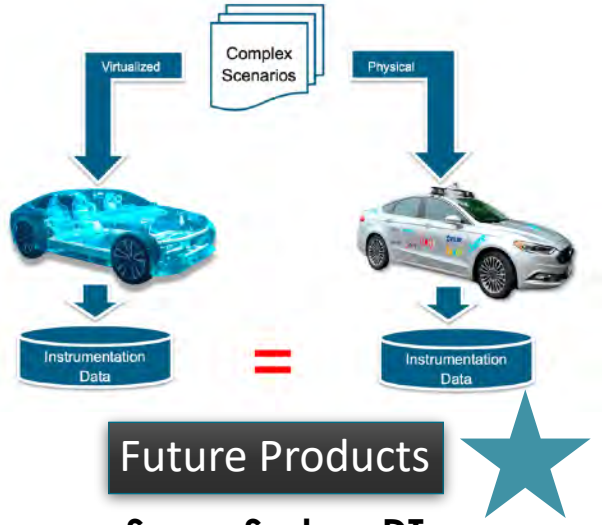
Photo from Google, the second capture from NIO case, 2024

Digital Twins

"A digital twin is a set of virtual information constructs that mimics the structure, context, and behavior of a natural, engineered, or social system (or **system-of-systems**), is dynamically updated with data from its physical twin, has a **predictive capability**, and **informs decisions that realize value** (NASEM, 2023).

Similar Product DT

Mock-up prototype DT



Super-System DT

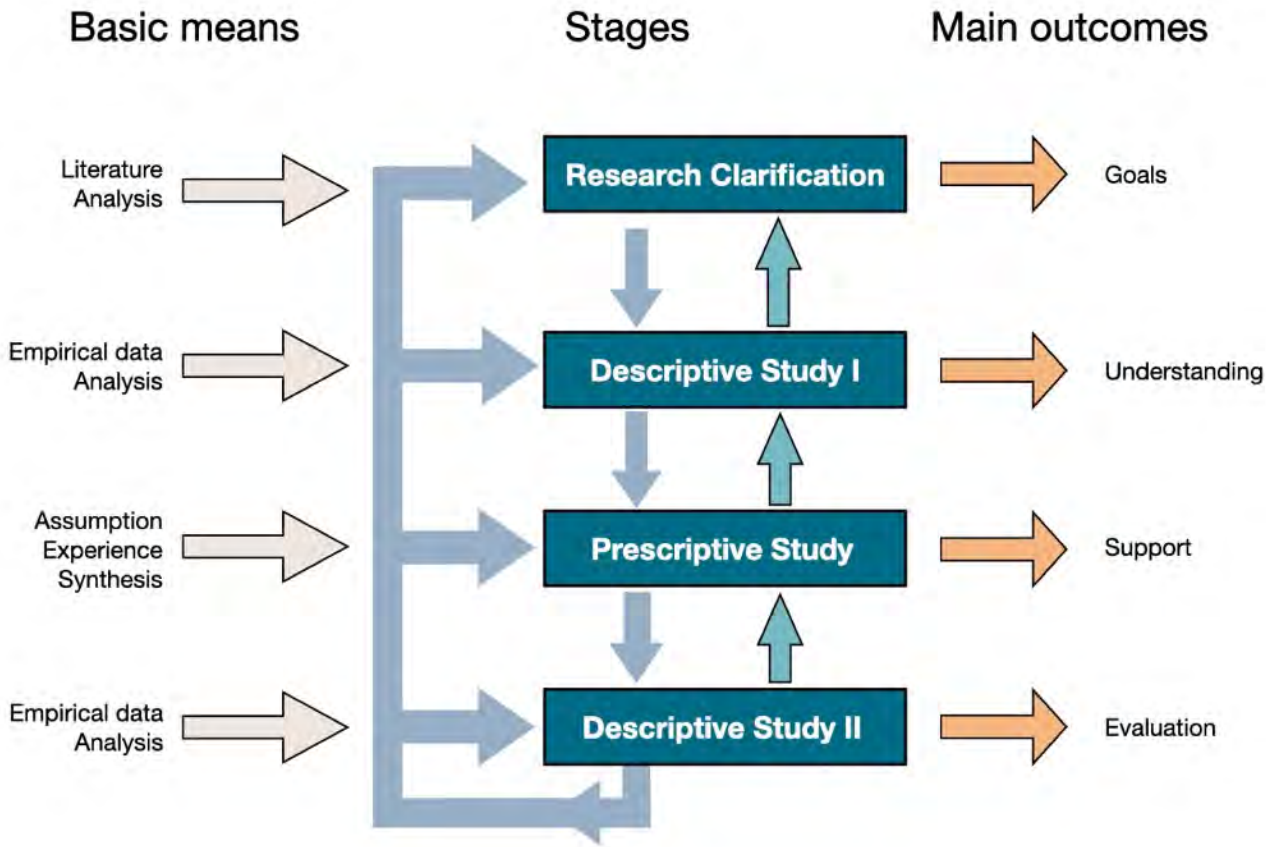
Photo from Google, the second capture from ID case, 2024

National Academies of Sciences, Engineering, and Medicine. *Foundational Research Gaps and Future Directions for Digital Twins* (The National Academies Press, 2023); https://doi.org/10.17226/26894

Haynes, P., & Yang, S. (2023). Supersystem Digital Twins-driven framework for new product conceptual design, Advanced Engineering Informatics, Volume 58, 2023, 102149, ISSN 1474-0346, https://doi.org/10.1016/j.aei.2023.102149.

Research Approach

Design Research Methodology



Paper A

Paper B

Paper C

Paper D

Paper E

Blessing, L.T.M. and Chakrabarti, A. (2009), DRM, a Design Research Methodology, Springer London, London. https://doi.org/10.1007/978-84882-587-1

Case companies

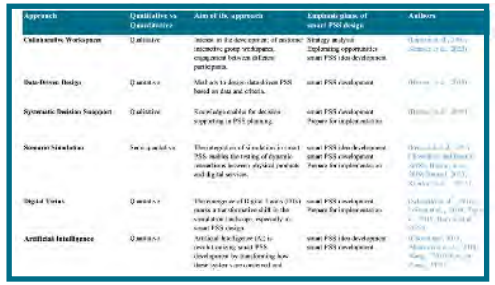
	Case company name	Industry type	PSS type	Specific product and service in case	Customer type	Collaborative departments	Paper
2020-2021	SAIC-Maxus	Automotive manufacturing	Product-oriented	Customer customization platform	B2C&B2B	Product planning Marketing R&D center	Paper A
2020-2024	Volkswagen	Automotive manufacturing	Product-oriented	Smart Electric Vehicles (SEVs)	B2C	Product planning Marketing	Paper B/C/D
2023-2024	King Long Bus	Bus manufacturing	Result-oriented	Smart Electric Tour Bus	B2B	Design center R&D center	Paper E

[1]www.saic.com
[2]www.volkswagen.com
[3]www.king-long.com/

Photo download from the official home page of each brand. Maxus, ID, King Long 2024

Data Collection

1. Literature review



2. Interviews

3. Participant observation

4. Internal company documents

Data Collection Method

5.Collaborative workshop

6.Design experiments

7.Questionnaires

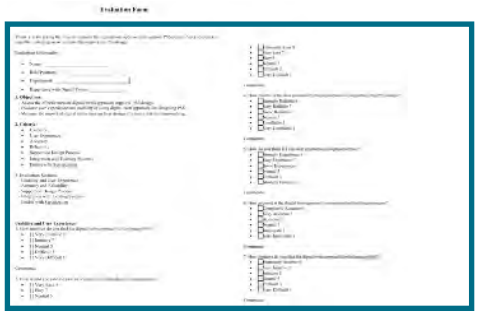


Photo taken by author from his research work environment

Data Analysis

"Both technically sound and practically viable in real-world scenarios"

Support Evaluation

1. Simulation software

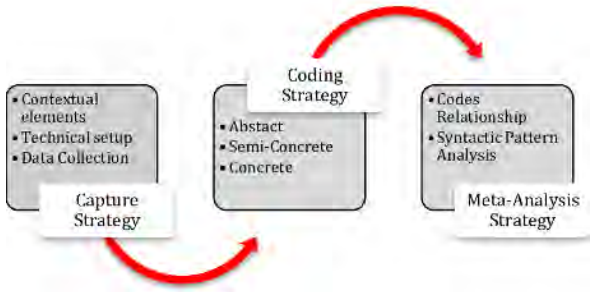
2. Experimental prototyping

3. Design experiments

Interviewee No.1	Interviewee No.2	Interviewee No.3	Interviewee No.4	Interviewee No.5
Meihua Lin	Xinyun Wu	Xibo Pan	Hongyi Qiu	Haoqiang Wang
CMF Engineer	Senior Engineer	Interior designer	3D modeling designer	Design director

Application Evaluation

1. Protocol analysis



2. Value visualization

3. Prototype Testing

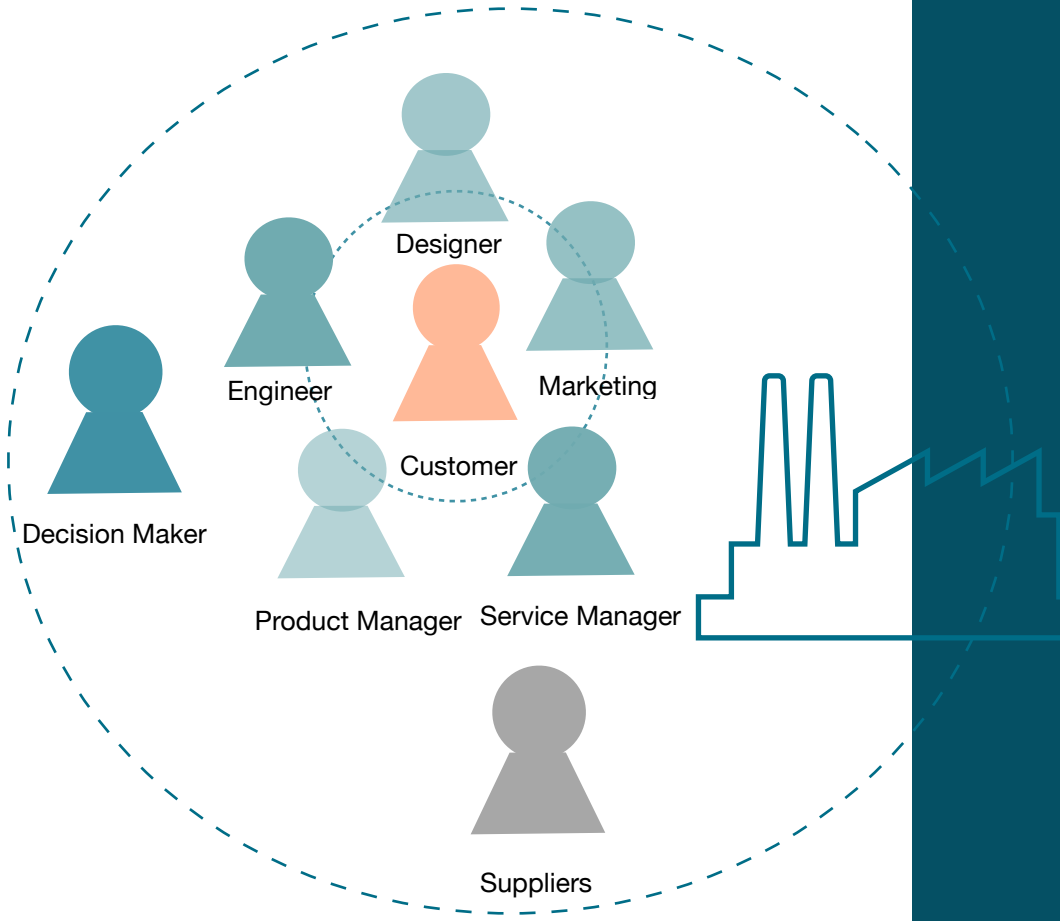
Photo taken by author from his research work environment

Results

1. Future Innovation Framework for supporting smart PSS design

Result: Future Innovation Framework (FIF)

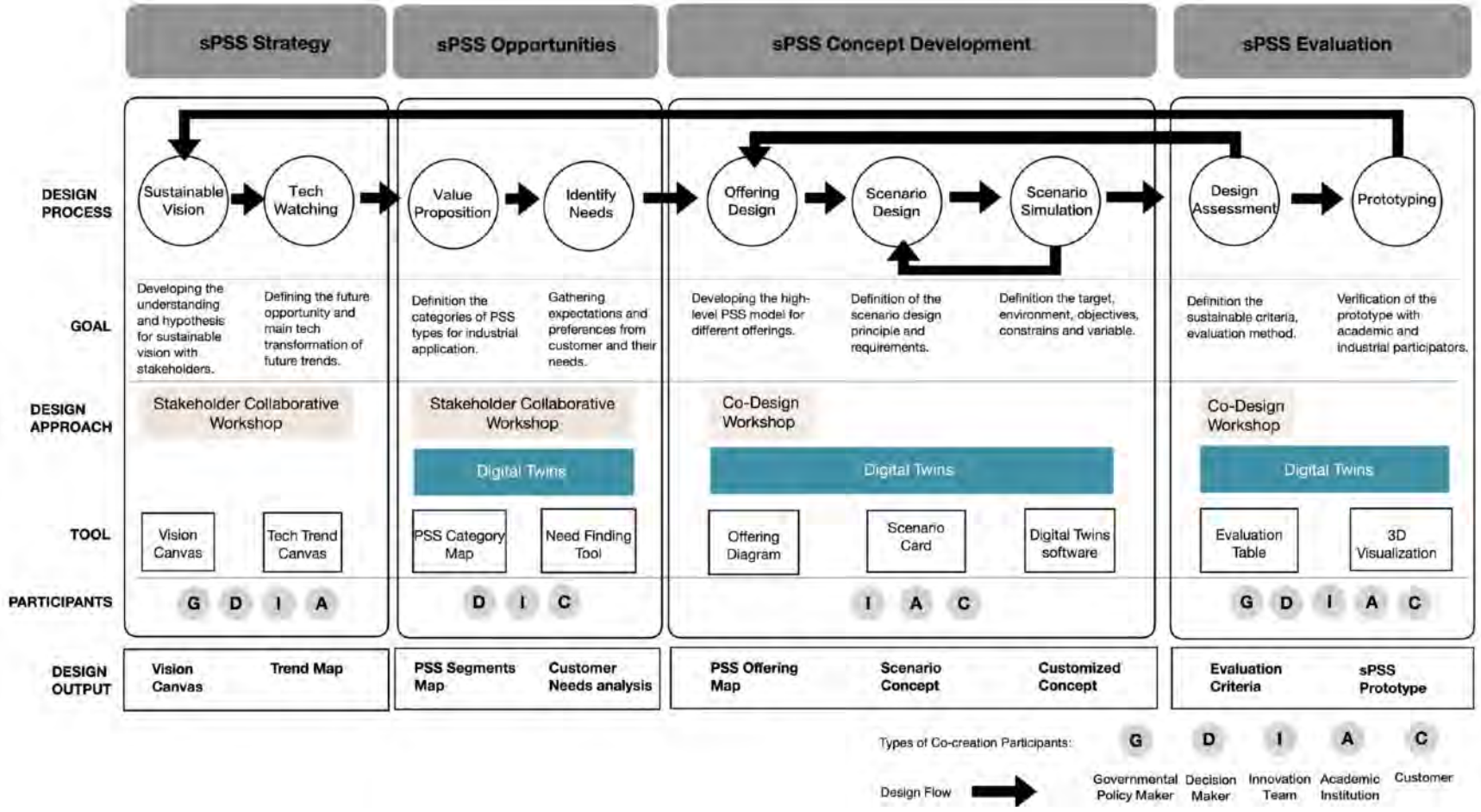
- FUTURE VISION
- INNOVATION PROCESS
- PRODUCT DEVELOPMENT
- PSS DESIGN PROCESS
- DESIGN APPROACH
- TOOLS



Yan, Z., Larsson, T., Larsson, A. (2024). "Future Innovation Framework (FIF) for Value Co-Creation of Smart Product-Service System Design in a Global Manufacturing Company." International Journal of Product Development, Vol.28, No.5, pp.1-29. https://doi.org/10.1504/IJPD.2024.10067828

Result: Future Innovation Framework (FIF)

FIF is a strategic innovation approach that facilitates **value co-creation** and addresses sustainability and digital transformation challenges in smart product-service system (PSS) design.



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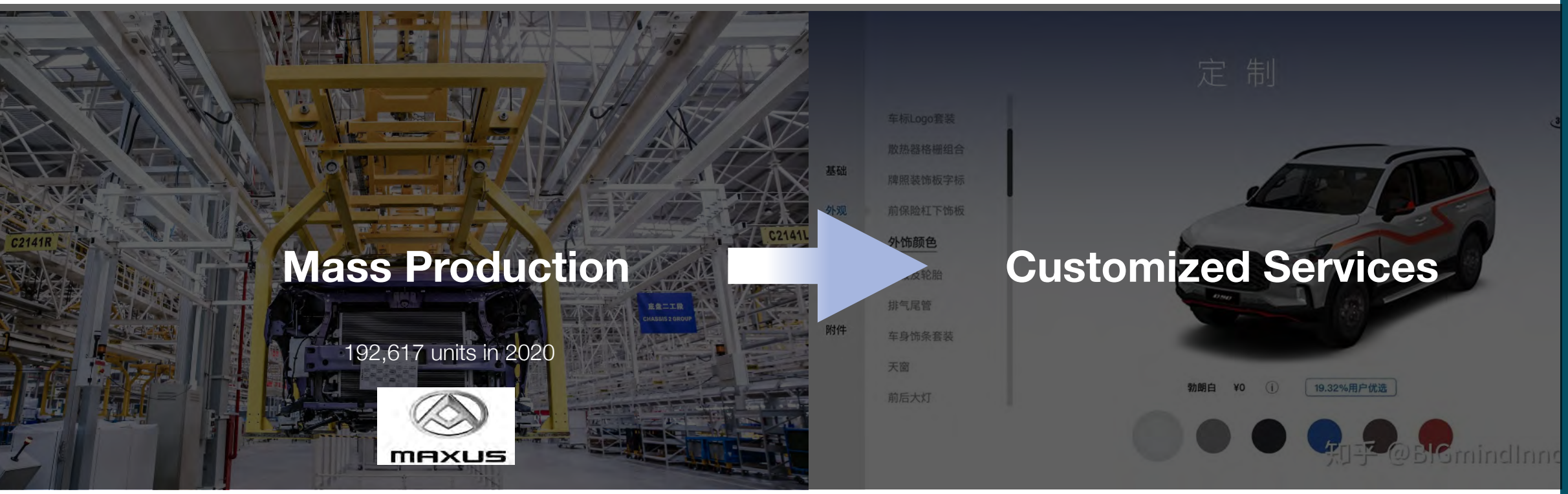
Result: FIF enabling the Value co-creation of PSS design



Founded in 2011, SAIC Maxus, a Chinese auto manufacturer, began exploring the **C2B (Customer-to-Business) model**, shifting from standardized mass production to **mass-customized services**.

Ref: Photo by author. https://en.saicmaxus.com/index.shtml

Paper A. Yan, Z., Larsson, T. and Larsson, A. (2022). "PSS Value Transformation: From Mass-Manufactured Vehicles to Provision of Mass-Customized Services – A Case Study of Designing and Prototyping Customized Digital Services for SAIC Motor in China." Proceedings of DESIGN 2022, pp. 1179 - 1188. DOI: 10.1017/pds.2022.120

Result: FIF enabling the Value co-creation of PSS design

PSS Strategy | **PSS Opportunities** | **PSS Concept Development** | **PSS Evaluation**

DESIGN PROCESS

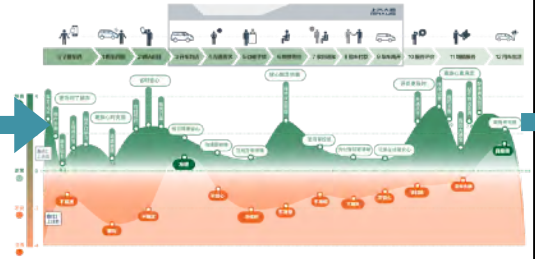
Sustainable Vision → PSS Strategy → Value Proposition → Identify Needs → Offering Design → Scenario Design → Scenario Simulation → Design Assessment → Prototyping

DESIGN APPROACH

PSS Strategy	PSS Opportunities	PSS Concept Development	PSS Evaluation
Stakeholder Collaborative Workshop	Stakeholder Collaborative Workshop	Co-design Workshop + Digital Twins	Co-design Workshop + Digital Twins

TOOL

PSS Introduction



Value-driven Needfinding

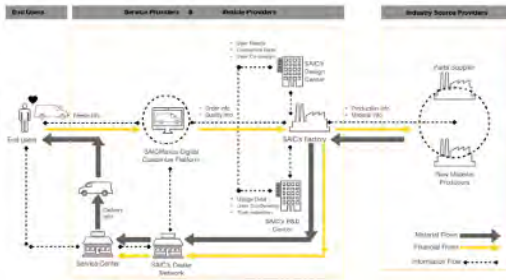
Full scenario

Digital Service Offering

Value assessment

DESIGN OUTPUT

C2B Strategy



New PSS system

Prototyping

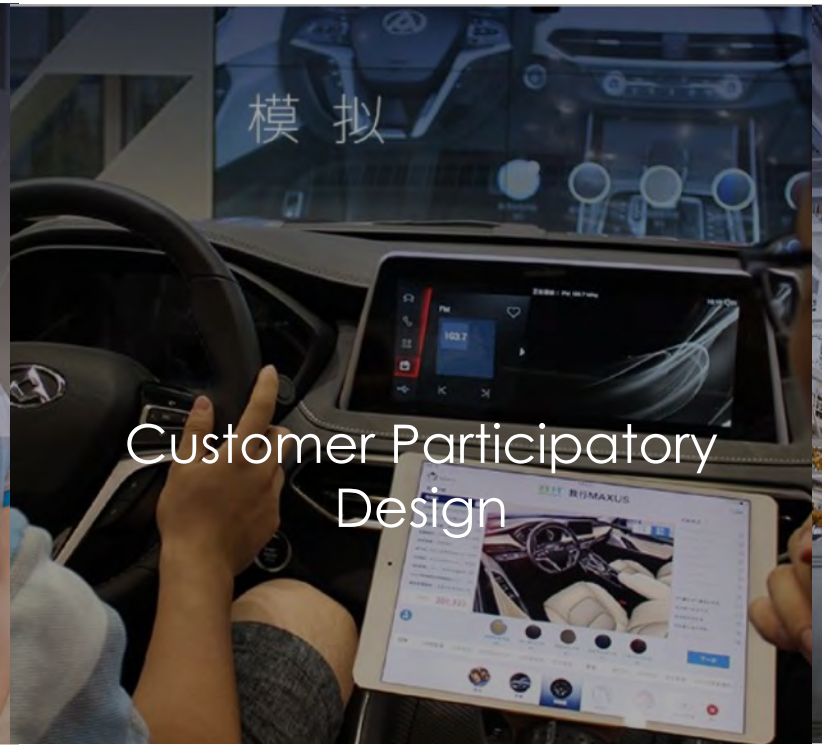
Scenario Simulation

1:1 Prototype

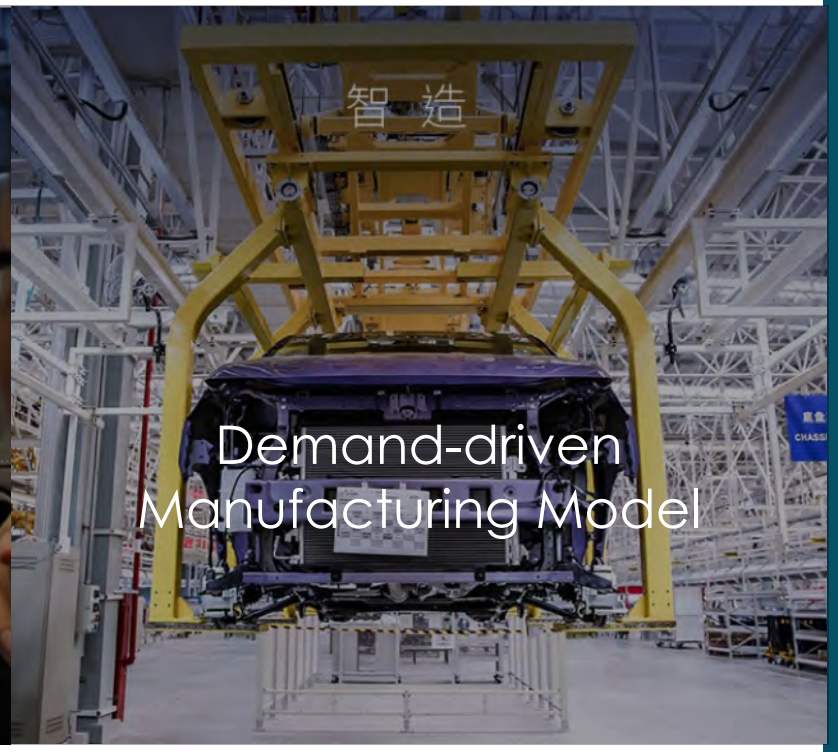
Photo taken by author from his research work environment

Result: FIF enabling the Value co-creation of PSS design

Experiential prototype on
1:1 scale site



Customized digital platform
in real application

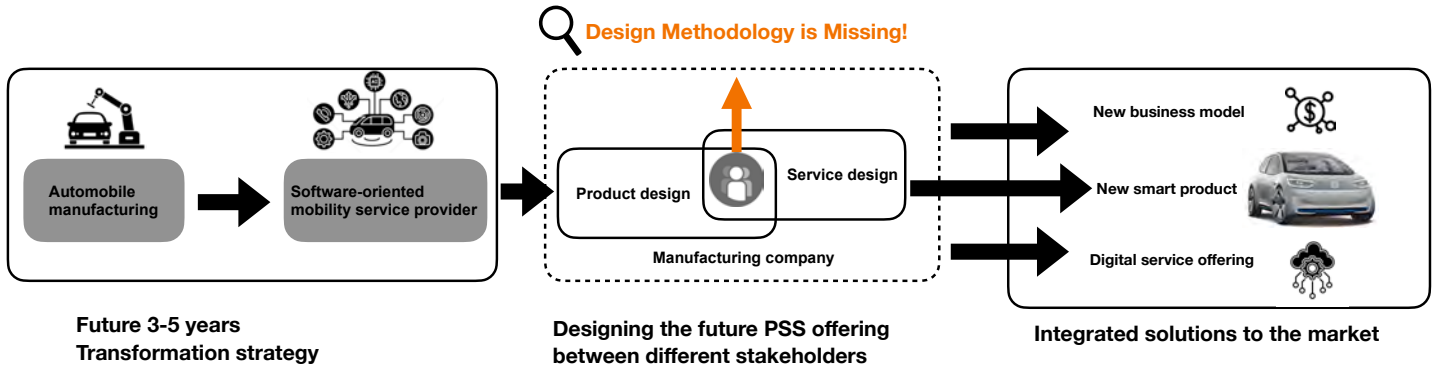


Proposed customized data
transmitted to the smart factory 4.0

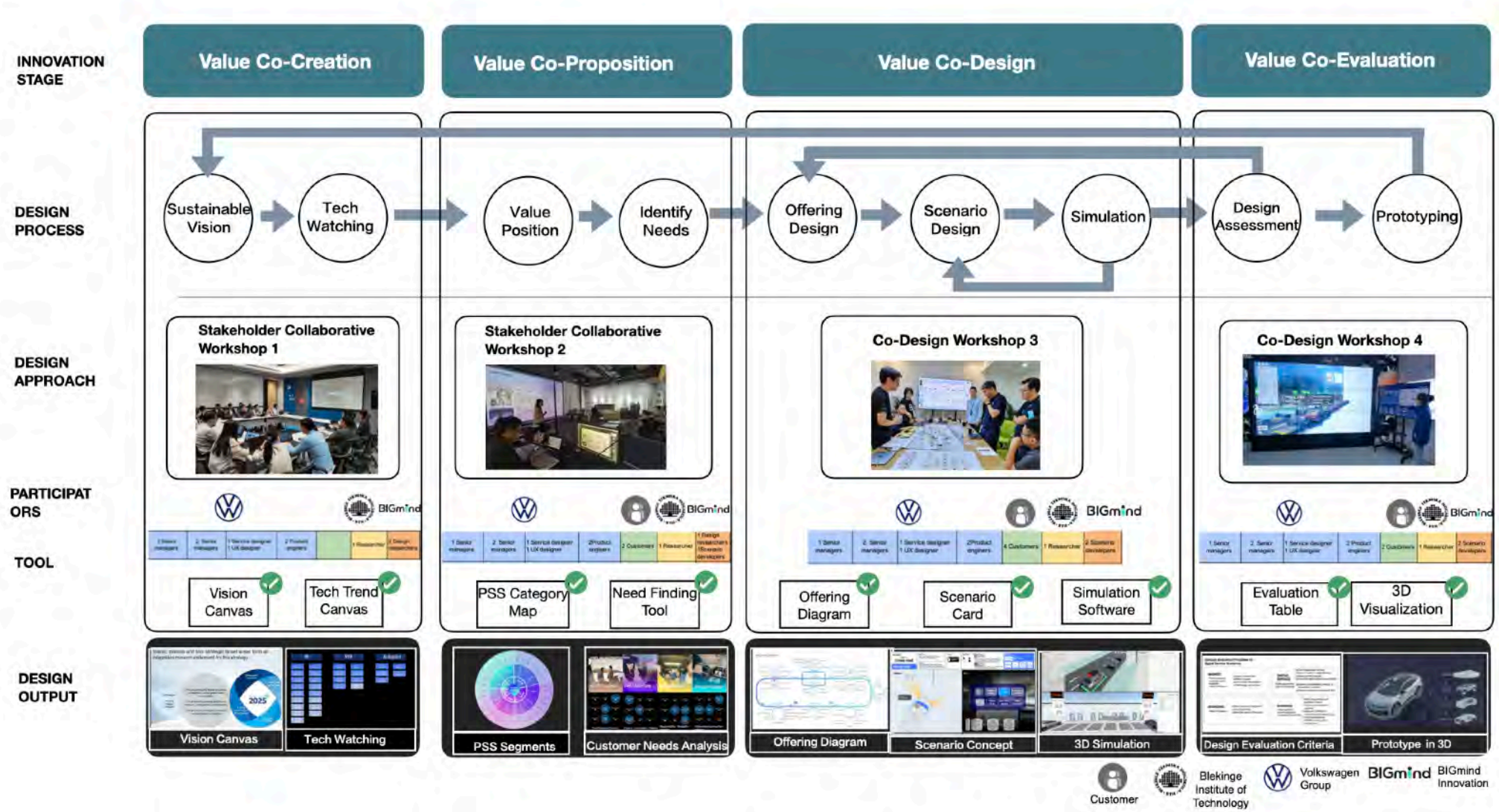
Photo by author

Paper A. Yan, Z., Larsson, T. and Larsson, A. (2022). "PSS Value Transformation: From Mass-Manufactured Vehicles to Provision of Mass-Customized Services – A Case Study of Designing and Prototyping Customized Digital Services for SAIC Motor in China." Proceedings of DESIGN 2022, pp. 1179 - 1188. DOI: 10.1017/pds.2022.120

Result: FIF enabling the Value co-creation of PSS design



Result: FIF enabling the Value co-creation of PSS design



Yan, Z., Larsson, T., Larsson, A. (2024). "Future Innovation Framework (FIF) for Value Co-Creation of Smart Product-Service System Design in a Global Manufacturing Company." International Journal of Product Development, Vol.28, No.5, pp.1-29. https://doi.org/10.1504/IJPD.2024.10067828

Future Innovation Framework (FIF)

Key Takeaways:

- The Future Innovation Framework (FIF) emerged as a comprehensive and adaptable framework that facilitates **value co-creation and innovation** in smart PSS design.

- The integration of digitalized design approaches within FIF supports the development of smart PSS solutions that **align with emerging market and technological trends, ensuring that manufacturing companies remain competitive in the digital era.**

2. Digital Twins Approach for smart PSS design

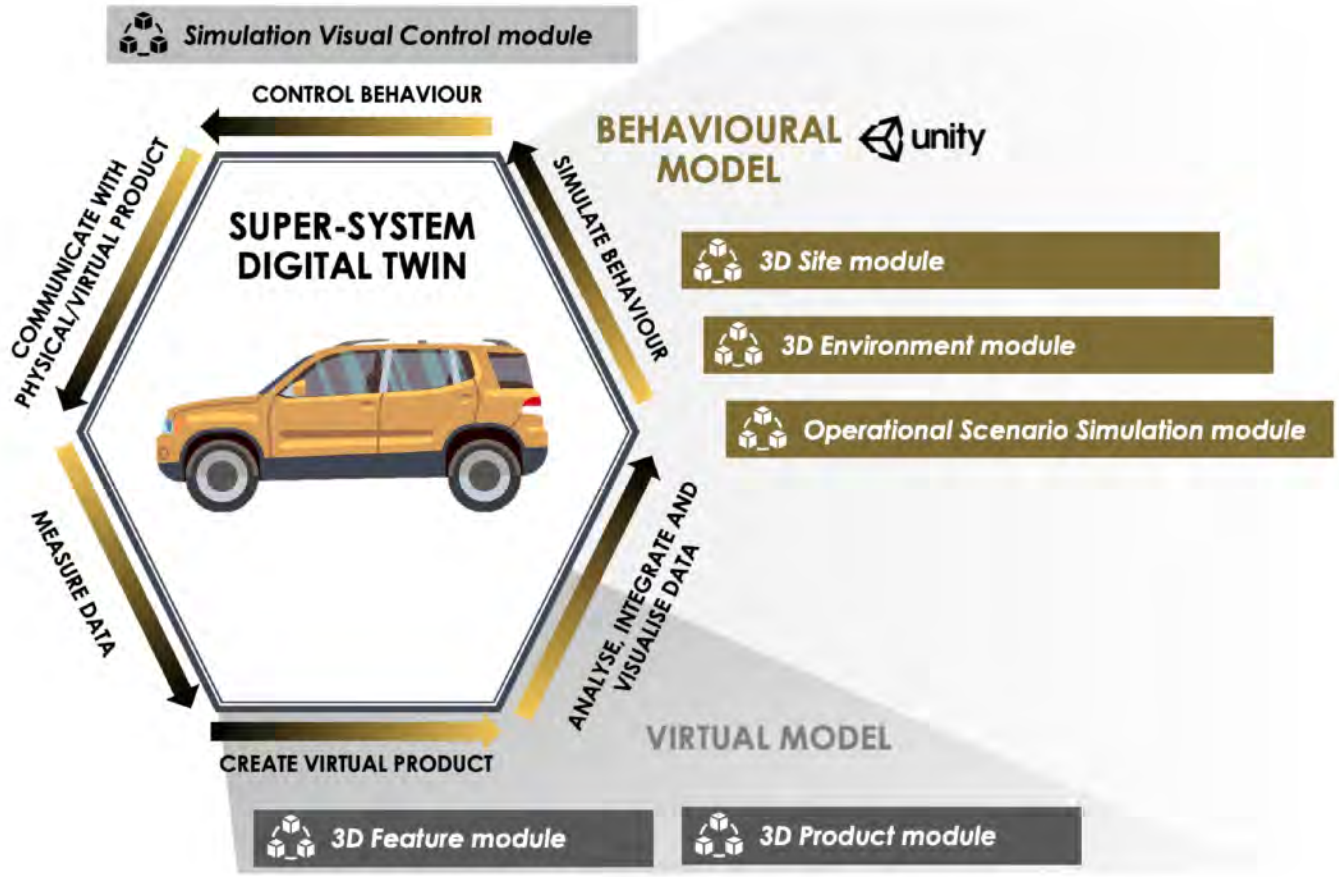
Super-System Digital Twins (SSDT)

A generic simulation environment tuned for smart PSS applications through data-driven immersive experiences.

Designer collects **environmental data**, which can then be used to establish **product requirements**.

Designers can gain a deeper understanding of the product context by integrating **user interaction data with environmental data**

Enhancing logical reasoning about **customer behaviors** and **decision-making processes**



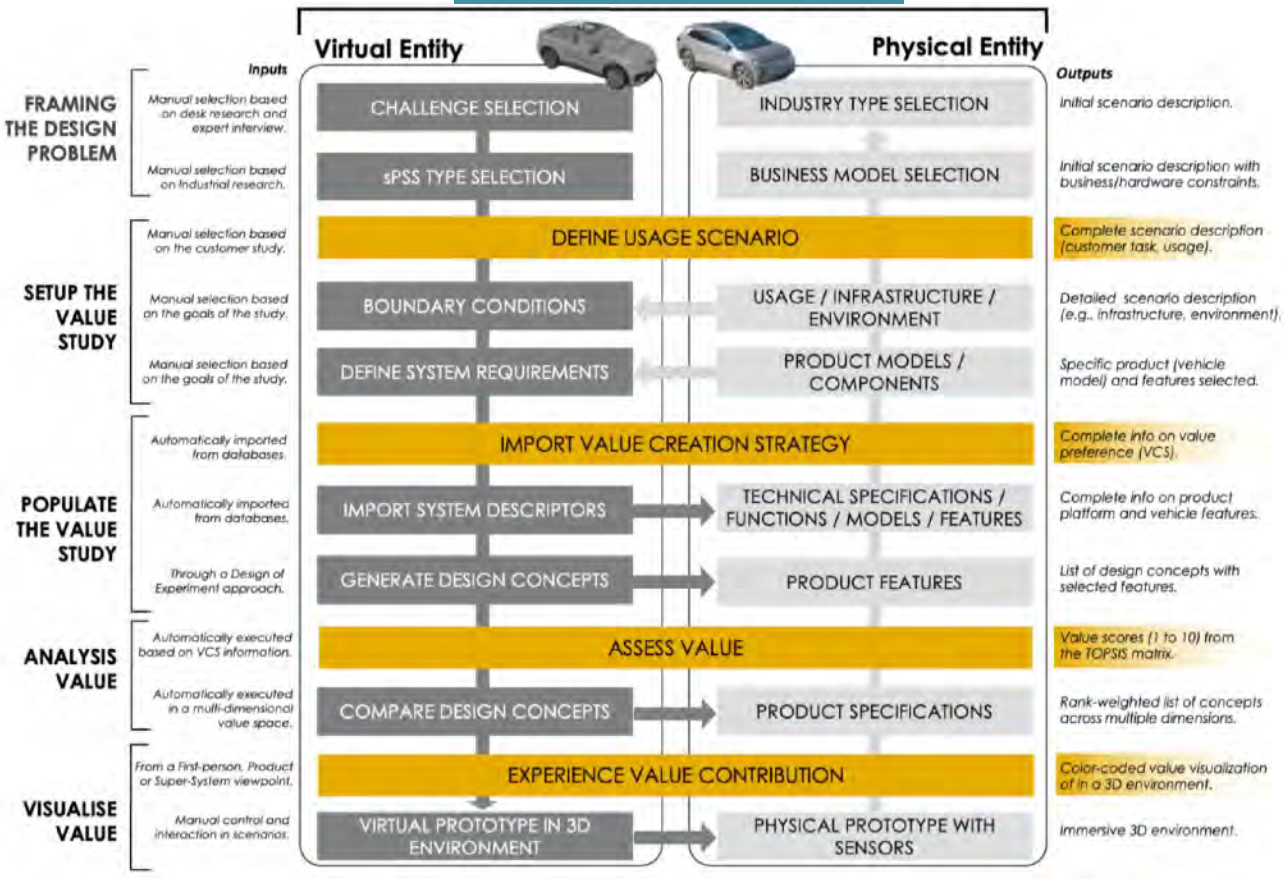
Paper C. **Yan, Z.,** Bertoni, M., Bertoni, A., Larsson, T., and Larsson, A. (2024). "Leveraging Digital Twins for Value-Driven Design in Smart Product-Service Systems: The Super-System Digital Twin Framework and SEV Case Study" (Submitted for Publication)

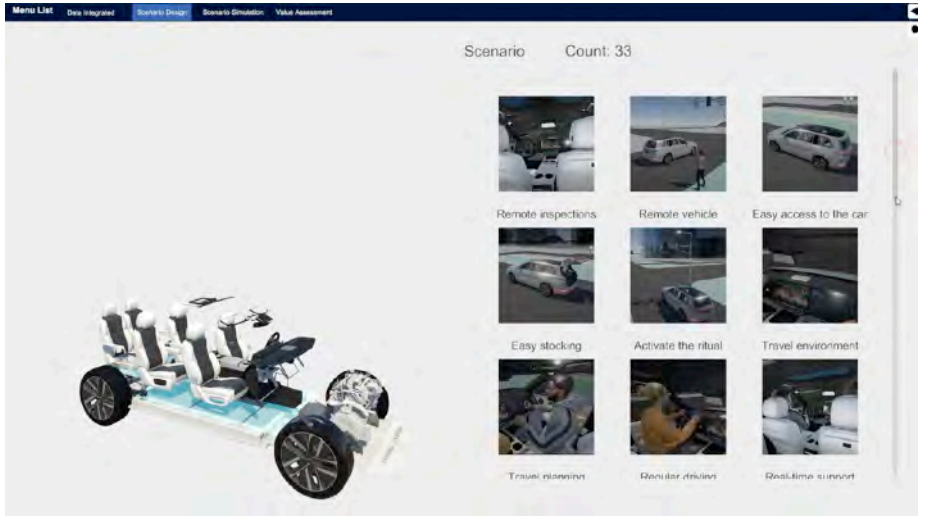
The SSDT approach-supported smart PSS design process

The SSDT approach is the integration of the Value-Driven Design (VDD) method that leverages digital twin technology to enhance design exploration in the early stages of smart PSS design.

Value-Driven Design

SSDT approach

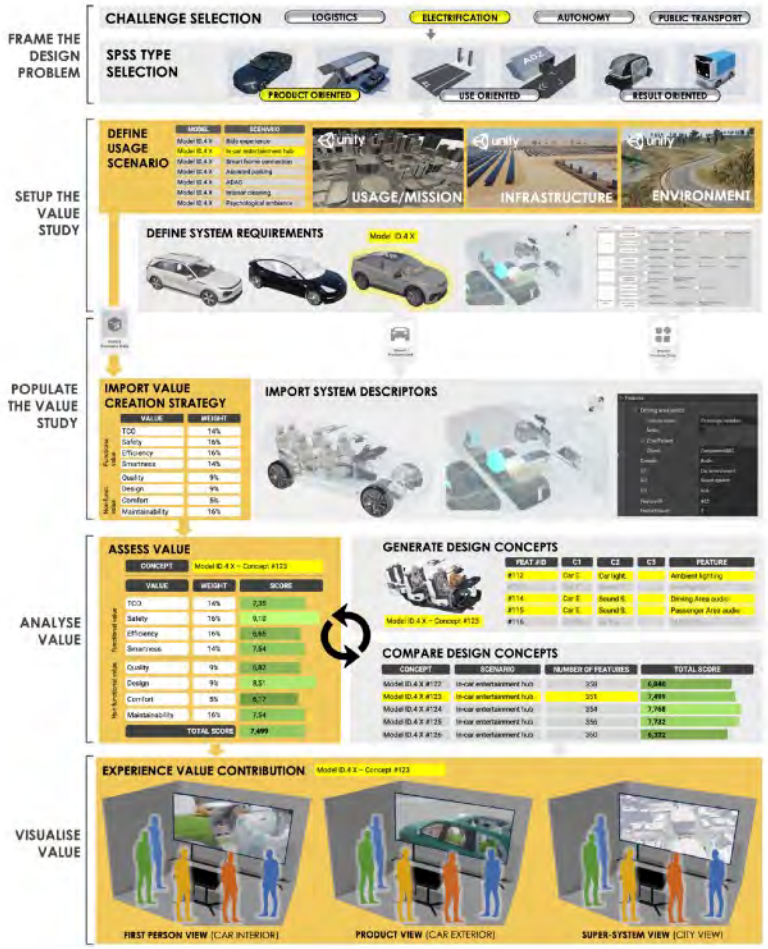




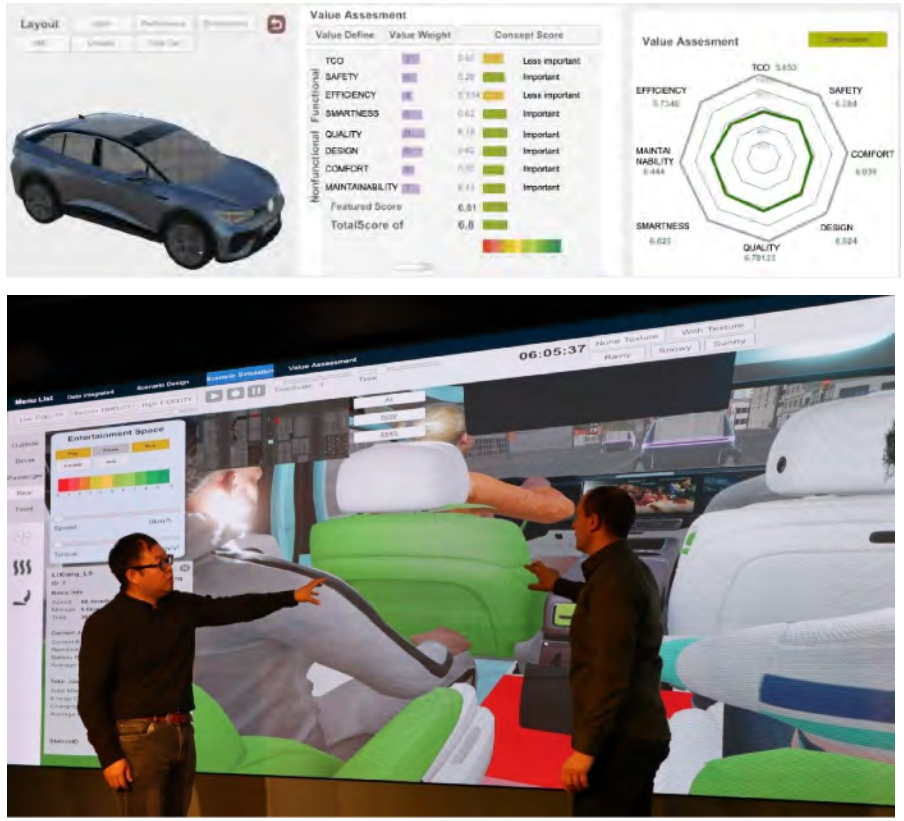
Digital Twins Approach - SimuloCITY Simulation Platform develop by author and BIGSimulo.Ltd

The SSDT approach-supported smart PSS design process

SSDT approach



Value-Driven Design



SPSS design

Paper C. **Yan, Z.,** Bertoni, M., Bertoni, A., Larsson, T., and Larsson, A. (2024). "Leveraging Digital Twins for Value-Driven Design in Smart Product-Service Systems: The Super-System Digital Twin Framework and SEV Case Study" (Submitted for Publication)

Result: The SSDT approach-supported prototyping a Tour E-bus Concept for Tourism Industry

Smart E-bus Design

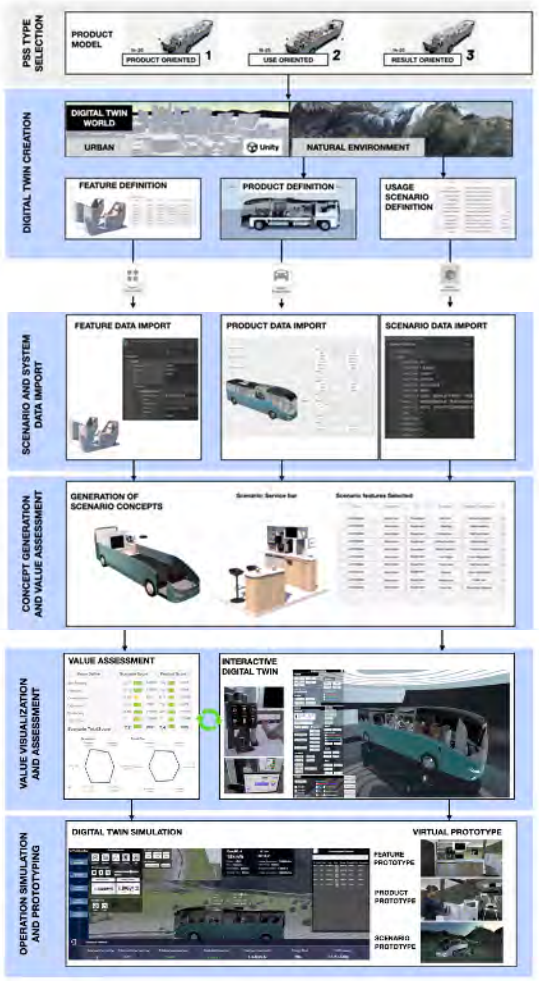
Tourism + Mobility Customization Service

SEB Intelligent Full Electric Tour Bus Is a Brand New Innovative Product Born Under the Background of Electrification and Intelligentization of the Tourism Industry. It Is a Customized Solution for the Tourism Industry To Meet the Needs of Regional Tourism, an Experience Design for the Diverse Needs of Tourists, and a Customized Service for Future Tourism Scenarios.
The Product Is Built Based on SPSS Intelligent Product Service System Design Concepts, Designed To Integrate Tourism Solutions and Customer Service Systems on the All-Electric Product Platform, Only for the New Era of Tourism Groups and Platforms To Provide Tourism Travel Solutions and New Business Models.

BIGmind X KING LONG X 西藏旅游股份有限公司 TIBET TOURISM CO.,LTD.

Result: The SSDT approach-supported prototyping a Tour E-bus Concept for Tourism Industry

SSDT approach



Digital Twins Approach - SimuloCITY Simulation Platform develop by author and BIGSimulo.Ltd

Paper E. **Yan, Z.**, Larsson, T. (2024). "Exploration of the Digital Twins for Prototyping the Product-Service System Design in a Bus Manufacturing Company". In: Marcus, A., Rosenzweig, E., Soares, M.M. (eds) Design, User Experience, and Usability. HCII 2024. Lecture Notes in Computer Science, vol 14716. Springer, Cham. https://doi.org/10.1007/978-3-031-61362-3_28

Result: The SSDT approach-supported prototyping a Tour E-bus Concept for Tourism Industry

Verification of Service Operation

January 2024 in Shanghai, China

Validation of Service Application

April 2024 in Tibet, China

The testing results are not included in this thesis.

Digital Twins Approach - SimuloCITY Simulation Platform develop by author and BIGSimulo.Ltd

Photo taken by author from his research work environment

2023 April

June

July

August

September

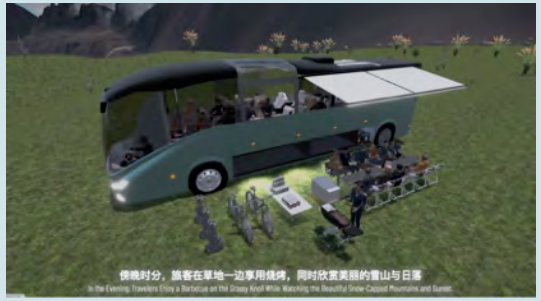
Research Introduction

Market Research

PSS Design

Digital Twins Developmentt

SSDT Simulation



April

2024 Jaunary

November

October

July-October

Product Testing

Service Simulation

Production

Product Launch

Prototyping V1

May

June

July

August

September

Service Operation Testing

Digital Twin updating

Research Validation

Research Published

Hanover IAA

Photo taken by author from his research work environment

Conclusions

Contribution to theory

Proposed **Future Innovation Framework (FIF)** integrates traditional PSS design methodologies with advanced digital approach, emphasizes value co-creation and cross-functional collaboration.

Proposed **Super-System Digital Twins (SSDT) approach for smart PSS design,** to integrate physical systems and digital models. This approach improves decision-making by allowing real-time simulation and analysis of design alternatives.

Proposed **Systematic Approach to Innovation,** the research combined the principles of digital transformation and sustainability with traditional automotive design, enabling a shift toward service-oriented business models.

Contribution to industry

Efficiency in early phase of design and product development, reducing the time and cost associated with physical prototyping by enabling virtual simulations.

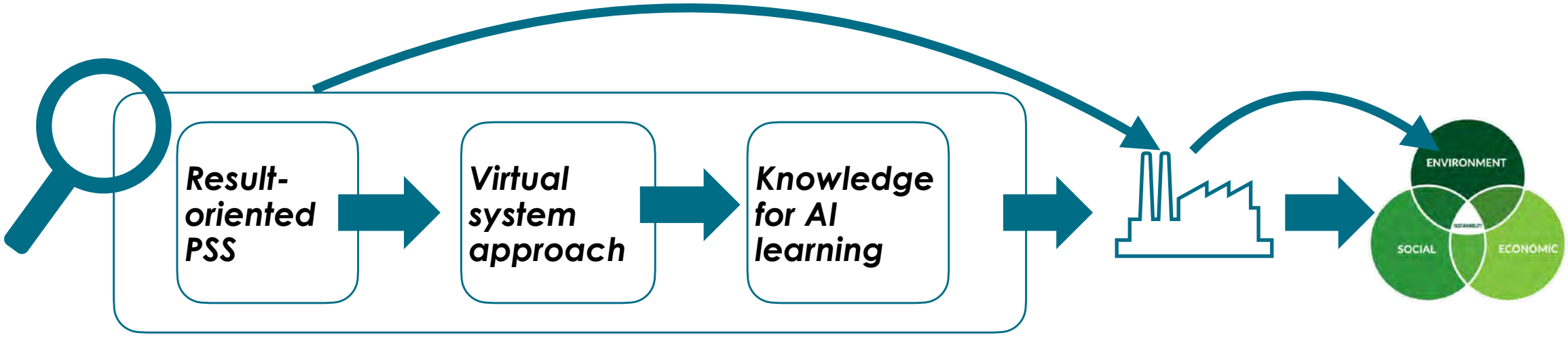
Adaptability to Market Changes, ensuring automotive products remained competitive in rapidly changing markets.

Collaboration Across Disciplines, promoting effective communication among innovation team through integrated digital platforms.

Sustainability in Automotive Design, avoiding overconsumption caused by excessive features added configurations and service operation from lifecycle analysis.

Future work – Prescriptive Study

A special emphasis will be placed on expanding the SSDT's capabilities to support real-time data integration and dynamic decision-making in more industry, further bridging the gap between theoretical frameworks and industrial application.

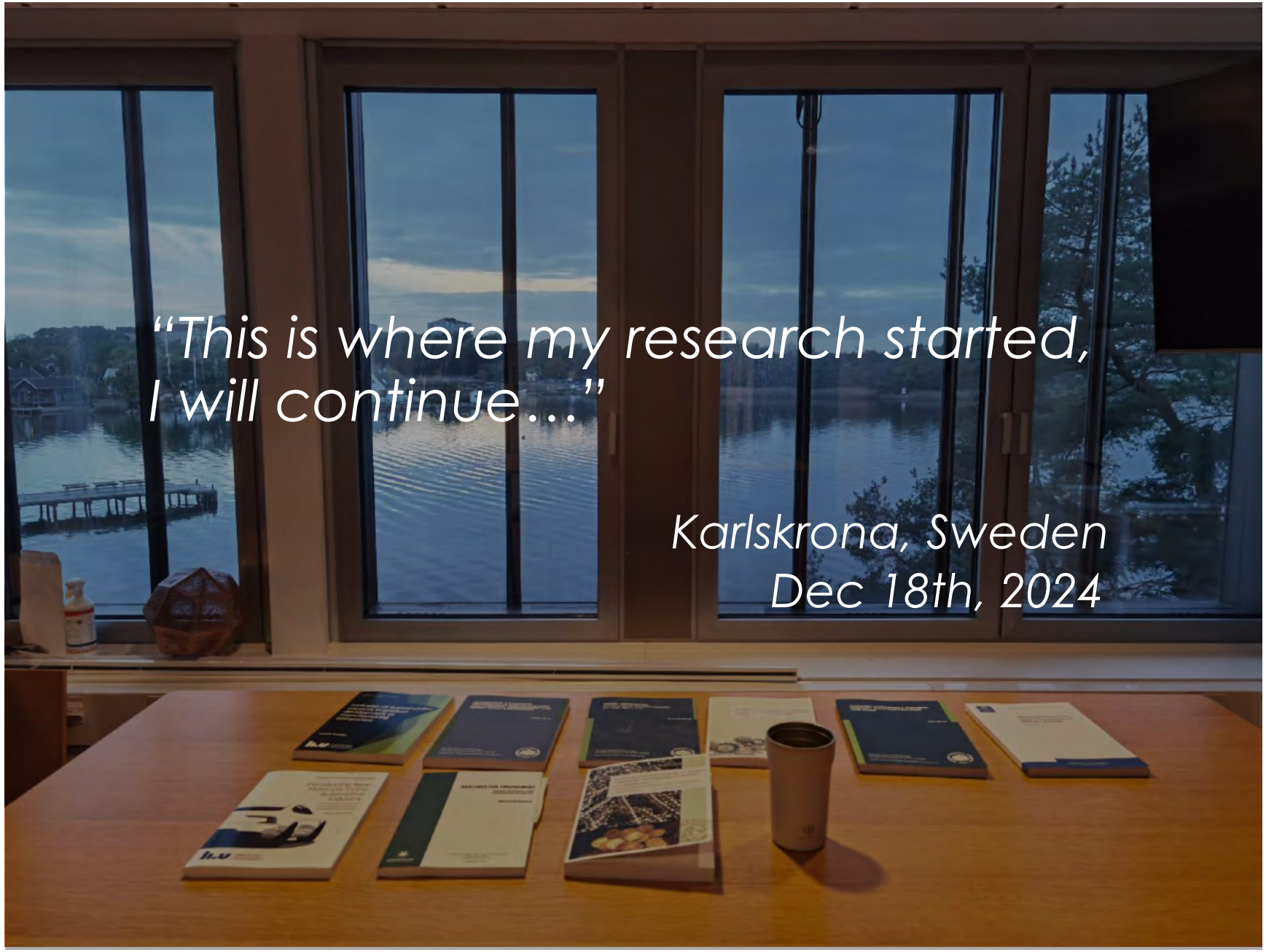


“Research is a spiritual practice and a long journey undertaken alongside **with family**."

2019, April in Karlskrona

THANK YOU!

2024, Dec in Shanghai


"This is where my research started,
I will continue…"
Karlskrona, Sweden
Dec 18th, 2024

Thank you !

Department of
Mechanical Engineering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