

# Co-Designing Service Systems for Public Robotics: A Design Science Approach to Business Model Innovation

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## Abstract

*Public service robotics involves deploying robotic systems in socially sensitive, institutionally complex environments. While adoption is growing, structured, context-sensitive methods for designing viable business models remain lacking. This paper introduces a design artifact developed through Design Science Research and enriched by Service Science. It consists of a modular toolbox, including a phased process model and role-specific tool guides, supporting competence centers and innovation networks in co-creating service-oriented business models. The artifact was iteratively refined through co-creative cycles across three centers. Results show how it fosters stakeholder alignment, methodological accessibility, and systemic integration. The study contributes to operationalizing service system design and offers guidance for business model innovation in public robotics.*

**Keywords:** Public Service Robotics, Service Systems Design, Design Science Research, Co-Creation

## 1. Introduction

In recent years, public spaces have increasingly served as testing grounds for robotic innovation, especially in domains like libraries and urban infrastructure (Friedrich et al., 2025; Rönnau et al., 2024). One EU-funded assistive robotics pilot, for instance, has reported notable improvements in social support, resilience, and quality of life among older adults with dementia, underscoring the potential of such systems to enhance public care services (D’Onofrio et al., 2019). Yet despite progress in artificial intelligence (AI), mobility, and human-robot interaction, sustainable, context-sensitive business

models for public deployment remain scarce. Many initiatives fail to progress beyond pilot stages or align with public sector constraints (Wirtz et al., 2018). Public robotics, unlike industrial applications, must navigate institutional complexity, a diverse set of stakeholders, ethical scrutiny, and non-monetary value creation (Mahr et al., 2021). This calls not only for technical robustness, but for new design approaches that organise collaboration and support co-creation across organisational and disciplinary boundaries (Mahr et al., 2024; Maule et al., 2024).

A core challenge lies in designing service systems, sociotechnical configurations of people, technologies, and institutions, that align robotic capabilities with public service logics, regulation, and citizen expectations. Many robotics projects suffer from fragmentation, unclear responsibilities, and lack of structured guidance for co-developing viable service and business models (Han et al., 2024; Reeler, 2020). While design science research (DSR) and Service Science offer relevant foundations, their integration in public robotics remains rare (Maule et al., 2024). DSR emphasizes artifact development but often neglects the systemic dynamics of multi-actor environments (Tuunanen et al., 2024). Service Science offers rich concepts, like value co-creation and resource integration, but tends to be too abstract for practical application (Sangiorgi et al., 2015). In public robotics, this disconnect is critical: solutions must function within complex sociotechnical environments shaped by collaboration, public accountability, and shifting stakeholder roles. Yet domain-specific artifacts that operationalize Service Science within a DSR framework, particularly for business model innovation (BMI), are still missing (Gupta & Göhlich, 2024). To address this gap, the paper proposes a

structured, service-oriented design methodology that enables stakeholders to co-develop business models for robotic applications in complex sociotechnical systems. Rather than focusing on isolated prototypes, such an approach must support systemic integration, clarify roles, and foster iterative, co-creative learning (Gupta & Göhlich, 2024; Morelli et al., 2008). This study responds to the practical need for methods that can navigate this complexity and enable sustainable innovation in public robotics. Accordingly, the paper investigates the following research question:

*How can a domain-specific design artifact support service system co-creation for business model development in public robotics?*

This study sits at the intersection of method development and domain innovation. It reports on a multi-phase DSR project conducted with three robotics-focused competence centers in Germany. Its core contribution is a domain-specific artifact comprising a modular toolbox, including a phased process model and role-specific tool guides. Designed to support collaborative business model development, the artifact enables contextual adaptation and systemic co-creation in public robotics. Methodologically, it integrates the rigor of DSR with the systemic perspective of Service Science, demonstrating how artifacts can be embedded in service systems and how abstract principles can be translated into actionable tools. Through application-oriented use cases, the paper shows the artifact's relevance and impact in real-world contexts. In doing so, it advances BMI in public services by supporting co-creation, stakeholder alignment, and systemic integration.

The remainder of this paper is structured as follows: Section 2 lays out the theoretical foundations. Section 3 details the research methodology and empirical context. The following section introduces the design artifact and presents its demonstration. The final section concludes with implications and avenues for future research.

## **2. Theoretical Background**

### **2.1. Service Systems and Collaborative Service Networks**

In Service Science, service systems are defined as dynamic configurations of people, technologies, and organizations that co-create value through interaction (Spohrer et al., 2008). They are inherently sociotechnical, combining material infrastructures (e.g., robotic platforms) with social relations among providers, users, and regulators. Value arises through interaction among actors with complementary roles, rather than unilateral delivery (Lusch & Vargo, 2014;

S. L. Vargo & Lusch, 2004). In public service design, recent work identifies resource integration, joint value propositions, and collaborative sense-making as core mechanisms of value co-creation (Trischler et al., 2019). In public robotics, service systems often span institutional and disciplinary boundaries (Dobrovestnova et al., 2025). The competence centers in this study exemplify collaborative networks that enable joint innovation through shared agendas, pooled resources, and iterative feedback.

These networks co-create value through shared agendas, joint resource use, and iterative feedback. Their heterogeneity, in roles and value logics, requires active orchestration and expectation alignment. Effective service design must also account for institutional constraints such as legal norms, public funding, and citizen participation (Prodi et al., 2022). Beyond coordination, normative concerns, like inclusion, accessibility, and fairness, are essential for public legitimacy and equitable access. Service system design operates across micro-level interactions (e.g., robot–user), meso-level structures (e.g., municipal ecosystems), and macro-level governance (e.g., policy) (Maglio et al., 2009). Addressing these layers requires approaches that reflect systemic patterns, actor constellations, and stakeholder–technology interactions.

### **2.2. Business Models in the Context of Service Robotics**

Business models define how organizations create, deliver, and capture value (Osterwalder et al., 2005). In public robotics, this involves balancing technological potential with institutional constraints and diverse public goals. Unlike commercial contexts focused on profit, public initiatives aim for inclusion, education, or efficiency. These goals introduce challenges such as equitable access, stakeholder diversity, and alignment with societal values (Mahr et al., 2024).

BMI offers a response to these challenges. It refers to the deliberate redesign of how organizations create, deliver, and capture value. In dynamic or uncertain domains like public robotics, BMI moves beyond static templates by promoting exploration, adaptation, and participatory experimentation. It addresses fragmentation, institutional constraints, and non-commercial value logics through stakeholder-centered design. This study builds on that foundation by applying BMI principles through a co-creative, domain-specific artifact (Foss & Saebi, 2015).

High upfront costs, regulatory ambiguity, and diverse stakeholder interests increase the complexity

of public robotics (Willems et al., 2022). To support stakeholder-centric design and iterative prototyping, standard tools must be adapted. Recent studies advocate moving beyond static canvases toward scenario-based and sociotechnical approaches, design methods that integrate technical, institutional, and ethical dimensions (Wirtz & Lovelock, 2016).

A notable example is Human-Robo Journey Mapping, which extends Customer Journey techniques to capture robot-specific interactions. In public robotics, value is often intangible or non-financial (PAICE, 2021). Business models must therefore account for societal outcomes and align with the incentives of users, policymakers, and developers (Fobbe & Hilletofth, 2021).

### **2.3. Integrating DSR and Service Science**

Designing effective solutions in public robotics requires both methodological rigor and systemic sensitivity. DSR provides a structured approach for iterative artifact development and evaluation (Hevner et al., 2004; Peffers et al., 2007), but often overlooks the complexities of multi-actor systems (Tuunanen et al., 2024). Conversely, Service Science offers conceptual depth for understanding value co-creation and institutional dynamics (Maglio et al., 2010; S. Vargo & Lusch, 2016), yet struggles with operationalization in practice. Their integration addresses these complementary limitations and forms the conceptual foundation for this research.

This study builds on the premise that combining DSR and Service Science enables more context-sensitive and robust design outcomes. While DSR provides a structured methodology for iterative problem-solving and formative evaluation (Peffers et al., 2007; Sonnenberg & vom Brocke, 2012), it often overlooks the institutional complexity and actor diversity found in public robotics. Integrating Service Science, specifically its concepts of value co-creation, actor constellations, and institutional context (Maglio et al., 2010; S. Vargo & Lusch, 2016), allowed us to embed stakeholder logics and systemic constraints directly into the artifact's design logic. This combination resulted in an artifact that balances methodological rigor with systemic fit, aligned with the realities of public service environments.

## **3. Research Methodology**

### **3.1. General Approach**

This study adopted a DSR approach (Peffers et al., 2007), complemented by Service Science to

address the sociotechnical complexity of public service robotics. The objective is to develop a domain-specific artifact that enables stakeholders to co-create service systems and business models in complex institutional environments. DSR guided the iterative structure of the study, framing relevance cycles, design iterations, and embedded evaluations (Sonnenberg & vom Brocke, 2012), while Service Science offered a systemic lens to account for collaborative value creation, actor constellations, and institutional dynamics (Maglio et al., 2009).

The project followed a cyclical design process with multiple iterations (Sonnenberg & vom Brocke, 2012), as outlined in table 1. Six DSR stages structured the overall approach, each linked to context-sensitive activities such as goal framing workshops, co-design walkthroughs, and field demonstrations across the three competence centers. This structure enabled ongoing stakeholder engagement, contextual grounding, and cross-case learning. To synthesize inputs across the design cycles, a qualitative content analysis was conducted following Mayring's methodology (Mayring, 2019), allowing feedback to be clustered into evolving category schemes and translated into design implications.

### **3.2. Research Context**

This study was conducted within the Transferzentrum Roboter im Alltag (RimA), a federally funded initiative (2021–2025) aimed at enabling the integration of service robotics into everyday public service environments. The project brought together three regionally anchored competence centers, RuhrBots, ZEN MRI, and rokit, each addressing a distinct dimension of public service robotics. RuhrBots focused on municipal application contexts, ZEN MRI explored interaction with vulnerable populations in real-world urban environments, and rokit examined legal and organisational frameworks for safe deployment. This deliberate diversity allowed the project to combine practical relevance with conceptual breadth, avoiding a single-case logic and instead building a transferable and comprehensive design foundation.

From a methodological standpoint, the competence centers served as embedded design environments that allowed the research team to ground the artifact in real-world stakeholder constellations, organisational constraints, and infrastructural realities. Rather than treating the centers as passive case sites, they were conceptualized as sociotechnical service systems, each with distinct institutional dynamics, actor networks,

DSR Stage	Activity	Events	Participants
Identify Problem	Co-creation workshops to identify stakeholder challenges, roles and barriers, method check and bilateral meeting	3	35
Objectives of a solution	Derivation of design objectives based on validated problem clusters	-	-
Evaluation Iteration 1	Scenario-based tool walkthroughs with structured feedback	4	14
Design & Development	Iterative co-design of toolbox, process model, and role guides	2	12
Demonstration	Use-case testing in three centers (e.g., library robotics)	5	30
Evaluation Iteration 2	Reflection workshops with final tool adjustments	3	10

**Table 1. Empirical Data Collection and Analysis Activities along the DSR Stages**

and service innovation goals (Maglio et al., 2009). Their involvement was not only instrumental for the identification of design challenges, but also for evaluating the artifact's flexibility and applicability across diverse public sector contexts.

### 3.3. Problem Identification and Solution Objectives

This study began by identifying key challenges in designing service-oriented robotics for public settings. Three co-creation workshops were conducted with approximately 35 participants from academia, municipalities, robotics development, and ethics. These workshops focused on obstacles to innovation, tool usability, and cross-role collaboration. Based on structured protocols and notes, qualitative content analysis was applied following Mayring's approach (Mayring, 2019). Insights were clustered into three core categories: (1) *role ambiguity*, (2) *methodological barriers*, such as lack of familiarity with tools like Design Thinking or the Business Model Canvas, and (3) *systemic process fragmentation*.

These analytical categories guided the formulation of shared design objectives. In follow-up sessions, researchers and stakeholders translated recurring concerns into actionable goals: clarifying roles, lowering access barriers to methods, and supporting adaptation to public service contexts. Framed as boundary objects, these objectives bridged empirical input and design rationale. They formed the foundation for deriving concrete design requirements (DRs) in line with established theorizing principles in IS research (Jones & Gregor, 2007). Section 4.1 outlines these DRs and links them to the identified challenges.

To validate and refine the DRs, four scenario-based walkthroughs were conducted with 14 participants. These walkthroughs tested usability, contextual fit, and perceived value. Feedback was again analyzed using Mayring's method and used to iteratively adjust the

requirements. In doing so, the DRs were not only grounded in observed challenges, but also evaluated for practical alignment before entering the design phase.

### 3.4. Design, Construct and Evaluation

Building on the previously identified DRs, the artifact was iteratively constructed, applied, and evaluated across multiple real-world contexts. The process involved three successive DSR phases, Design and Development, Demonstration, and Evaluation Iteration 2, each embedded in stakeholder engagement and design-oriented analysis. The goal was to refine the artifact's usability, contextual relevance, and conceptual coherence.

The Design & Development phase focused on translating validated requirements into tangible artifact components. Over the course of two co-design events involving twelve testers, the research team developed and refined a modular system comprising a Toolbox of business modeling tools, a Phased Process Model, and a set of role-specific Tool Guides. All sessions were documented using structured templates and feedback logs. Inputs were analyzed along functional dimensions such as tool purpose, user alignment, and interaction structure. This analysis enabled modular improvements, including adjustments to tool prompts, layout, and onboarding instructions. The refined artifact was then demonstrated in applied settings across the RuhrBots, ZEN MRI, and rokit centers. Five demonstration events included scenario-based walkthroughs, collaborative modeling exercises, and application tests involving around 30 participants. The artifact was used to address situated challenges in municipal libraries, healthcare environments, and robotics testbeds. These sessions revealed recurring tensions between public mandates and economic feasibility, which were documented and linked back to earlier DRs.

The final evaluation cycle engaged ten participants across three reflection workshops to assess the overall

quality and adaptability of the artifact. Feedback was analyzed using a category-guided synthesis approach, based on four refinement dimensions: technical fit, stakeholder alignment, usability, and institutional compatibility. While these categories helped capture practical suggestions for improvement, the goal was not to derive new requirements but to synthesize and validate design principles (DPs). These DPs were conceptually abstracted from the previously established DRs and clustered according to shared design rationales and systemic challenges observed throughout the project. This final synthesis step ensured theoretical generalizability while maintaining empirical grounding.

## 4. Results

### 4.1. Identified Challenges and Design Requirements

Based on the analysis presented in Section 3.3, this section outlines six DRs derived from co-creative workshops with the competence centers. These requirements emerged from recurring patterns identified through qualitative content analysis and reflect challenges related to role ambiguity, systemic barriers, and stakeholder needs. Most issues were not technological, but socio-organisational, highlighting the complexity of designing robotic services in public-sector settings.

A central challenge concerned internal collaboration. The competence centers, bringing together researchers, developers, and municipal actors, struggled to define responsibilities and understand systemic roles. This lack of clarity hindered coordination and visibility, prompting the need for tools to clarify responsibilities (DR1). Methodological familiarity also varied: while some participants knew design frameworks, others, especially from technical or ethical backgrounds, lacked confidence in using tools like the Business Model Canvas or Design Thinking. This asymmetry limited mutual understanding and participation, leading to the need for low-threshold, role-specific guidance (DR2).

Another frequent issue was the absence of a shared process logic. Without common structure, innovation remained fragmented and reactive. Participants emphasized the need for a clear phase model to coordinate contributions and align efforts (DR3). Abstract frameworks also proved insufficient in reflecting real-world constraints. To address this, the design needed to remain flexible and scenario-specific (DR4).

Across all centers, participants stressed the importance of embedding ethical, legal, and institutional

considerations early on, elements often absent from standard innovation tools. This led to the requirement for regulatory prompts, ethical checklists, and public-sector-specific examples (DR5). Finally, the novelty and complexity of the domain demanded mechanisms for structured reflection and iterative refinement. These insights were translated into a requirement for built-in feedback loops (DR6). The requirements are summarized in Table 2 and form the foundation for the design and evaluation.

### 4.2. Artifact Description

The central artifact developed in this study is a modular, web-based toolbox designed to support co-creative business model development in public service robotics. As illustrated in figure 1, the RimA toolbox integrates two core components: a set of role-specific Tool Guides and the Phased Process Model. Together, they form a cohesive system that addresses methodological, organisational, and domain-specific challenges encountered by the competence centers and their stakeholders. These components were iteratively developed and evaluated in real-world settings, as described in Section 3.4, and directly respond to validated DRs such as clarifying responsibilities, lowering methodological barriers, and enabling structured innovation.

The Tool Guides serve as the artifact's primary interface and are tailored to distinct stakeholder roles, such as municipal decision-makers, robotics developers, or researchers. Each guide includes an introduction, clear usage goals, step-by-step instructions, tool adaptations, and real-world examples. To ensure contextual fit, the guides also incorporate domain-specific resources such as regulatory prompts, ethical checklists, and funding templates. They are designed for accessibility and flexibility, offering both high-level overviews and in-depth guidance, including editable formats for direct application. Complementing the Tool Guides, the Phased Process Model structures innovation into five iterative stages: Analysis, Conceptualization, Validation, Implementation, and Optimization. For each phase, the model suggests appropriate tools, defines target outcomes, and identifies decision points. This structure balances orientation and adaptability, allowing teams to maintain a clear trajectory while responding to institutional constraints and project dynamics. The model also reflects Service Science concepts such as actor constellations, systemic value co-creation, and resource integration.

Taken together, the toolbox functions as a flexible coordination and learning infrastructure. Rather

#	Title	Design Requirement
DR1	Support stakeholder role clarification	<i>The artifact should include templates and tools (e.g., stakeholder maps, role description canvases) that assist project participants in clarifying their own roles and those of others, fostering systemic awareness and responsibility across service systems.</i>
DR2	Ensure accessibility for diverse expertise levels	<i>The artifact should accommodate varying degrees of methodological familiarity by offering low-barrier entry points, including simplified tools, visual walkthroughs, and role-specific instructions.</i>
DR3	Provide a structured, phase-based process model	<i>The artifact should present an overarching innovation process structured in phases (e.g., exploration, development, validation), and should link these to appropriate tools and coordination mechanisms.</i>
DR4	Include adaptable and applied tool components	<i>The artifact should comprise practice-oriented, modular tools that can be customized to the needs of specific stakeholder groups and application contexts.</i>
DR5	Integrate domain-specific knowledge on public robotics	<i>The artifact should embed context-sensitive templates, prompts, and examples that reflect institutional, legal, ethical, and infrastructural constraints specific to robotics in public environments.</i>
DR6	Embed mechanisms for feedback and iteration	<i>The artifact should incorporate feedback loops, reflection templates, and revision mechanisms to enable iterative learning and stakeholder-driven adaptation throughout the innovation process.</i>

**Table 2. Design Requirements**

than enforcing a rigid linear process, it supports experimentation, collaborative learning, and structured progress, enabling innovation that is both rigorous and practical across diverse public-sector environments.

### 4.3. Design Principles

The artifact's development was guided by DRs, which were later synthesized into six overarching DPs (Gregor et al., 2020). These generalize the artifact's problem-solution logic and provide prescriptive guidance for similar contexts. Each principle integrates stakeholder insights and combines concepts from Service Science and DSR to address the sociotechnical complexity of BMI in public robotics. The synthesis followed two iterative evaluation cycles and applied Gregor and Hevner's mid-range design theory framework, translating validated DRs into actionable, context-sensitive principles.

**DP1:** *Enable service system alignment through structured role clarification* In multi-stakeholder environments, unclear roles and fragmented responsibilities often impede innovation. This was evident in early workshops, where competence centers struggled to coordinate across technical, strategic, and administrative domains. To address this, the artifact draws on Service Science concepts of role transparency and structured interaction, offering stakeholder mapping templates and role clarification tools. These support systemic awareness, define contributions, and foster

accountability and alignment.

**DP2:** *Ensure inclusive access to tools and methods for heterogeneous stakeholders* Competence centers involve stakeholders with diverse methodological backgrounds. Several participants lacked experience with frameworks like Design Thinking or the Business Model Canvas, resulting in asymmetries in participation and confidence. This principle emphasizes the need for low-threshold access: simplified, visual, and role-specific guidance. Example-based templates and guided walkthroughs foster meaningful engagement across experience levels, promoting epistemic inclusivity, key to sustainable, participatory innovation.

**DP3:** *Guide innovation through a modular, phase-based process model* Without a shared process logic, innovation efforts risk fragmentation and loss of momentum. Stakeholders reported difficulties transitioning between phases, resulting in overlapping or uncoordinated activities. To address this, the artifact embeds a modular process model with distinct stages, exploration, development, validation, each linked to tools and decision points. This structure supports planning, reflection, and alignment with the temporal logic of service system transformation.

**DP4:** *Design for real-world applicability and methodological adaptability* Generic frameworks often fail to capture the operational realities of public robotics. Stakeholders emphasized the need for tools that move beyond abstraction and offer hands-on applicability. This principle therefore introduces

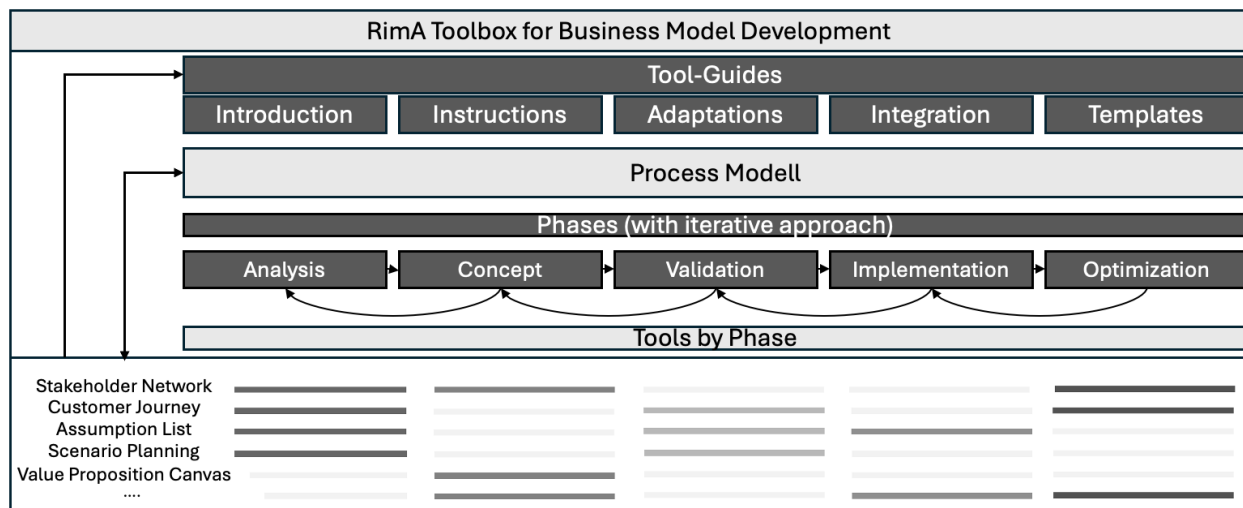


Figure 1. Artifact Visualization: RimA Toolbox for Business Model Development

modular components for use in workshops, planning, and prototyping, supported by annotated examples, adaptable templates, and stepwise guides. These tools permit local customization while preserving methodological integrity, balancing rigor with contextual responsiveness.

**DP5: Embed contextual knowledge specific to public robotics** Service robotics in public environments entails distinct legal, ethical, and infrastructural constraints. Unlike commercial deployments, public applications require transparency, citizen trust, and institutional accountability. This principle mandates embedding such constraints into the artifact's design. Accordingly, it includes prompts for ethical reflection, templates for articulating public value, and checklists aligned with relevant regulations, enabling solutions that are functional, and socially legitimate and policy-compliant.

**DP6: Foster iterative learning and stakeholder-driven adaptation** Innovation in complex service systems is rarely linear. As projects progress, assumptions shift, constraints emerge, and stakeholder needs evolve. Drawing on the formative evaluation pattern by Sonnenberg and vom Brocke (2012), this principle emphasizes iterative reflection and redesign. Features such as feedback loops, evaluation templates, and structured prompts support continuous learning. The artifact enables co-design and the co-evolution of service systems over time.

Together, these six principles form a coherent design theory for service system innovation in public robotics. They offer normative yet adaptable guidance for artifact development, grounded in stakeholder needs and systemic challenges. Importantly, they operationalize Service Science concepts, such as

co-creation, value networks, and system dynamics, into actionable structures for collaborative process design. Within the toolbox, these principles are embodied in the role-specific Tool Guides and the Phased Process Model, ensuring their practical relevance and applicability. Table 3 summarizes the principles.

#### 4.4. Demonstration: Use Case RuhrBots

To demonstrate the applicability and practical value of the artifact, real-world use cases were conducted in collaboration with the three participating competence centers. This section focuses on one representative case from the RuhrBots center: the development of a robotic book recommendation service for municipal libraries. While the artifact was also applied in the ZEN MRI and rokit centers, informing refinements and enabling cross-case validation, this example offers a tangible view of how the toolbox supported concept development, stakeholder collaboration, and iterative business model design.

The envisioned service involved an interactive robot (e.g., Pepper or Temi) assisting library visitors in selecting books. Following user authentication via a personalized robot ID card, the robot greets users, asks about their genre preferences, and presents three tailored recommendations on a screen, complete with spoken summaries and shelf locations. Users can request read-aloud samples, such as blurbs or short passages, before completing the interaction. The scenario was shaped through focus groups and citizen interviews in the Ruhr area and was designed for various user groups, with particular attention to interaction quality and inclusivity.

In practice, the toolbox supported this development by guiding tool selection and structuring co-creation workshops. Stakeholder maps and system role visualizations clarified responsibilities among librarians, municipal IT departments, and developers. The Human-Robo Journey tool enabled teams to capture key user interaction points, including emotional, spatial, and ethical aspects, while templates like the Value Proposition Matrix and Business Model Canvas helped explore alternative value configurations and delivery modes. These range from community-based, non-profit models to commercial matchmaking platforms.

Workshops with the competence centers facilitated the articulation of value propositions and economic rationales, supported by structured guides and domain-specific adaptations. Through scenario testing and feedback loops, key trade-offs emerged, for example, between public service mandates and economic sustainability, or between user inclusivity and technical feasibility. The artifact helped to make these tensions explicit and actionable.

Ultimately, the use case led to a set of validated service models, a prototype for a B2B coordination platform, and a brand concept developed with user input. The artifact served not just as a collection of tools, but as a practical framework that helped the RuhrBots team turn a broad innovation idea into a testable service concept, aligned with stakeholder needs and anchored in real-world conditions.

#### 4.5. Reflection on Iterative Improvement

The modular toolbox was iteratively developed through cycles of stakeholder feedback, adaptation, and structured reflection, following the logic of formative evaluation (Sonnenberg & vom Brocke, 2012). Each cycle contributed to a deeper understanding of service system dynamics, stakeholder needs, and contextual

constraints. Feedback was collected through workshop observations, reflection protocols, and verbal input during walkthroughs and evaluation sessions. These insights informed several key refinements.

One major adjustment addressed the perceived abstraction of early toolbox versions. While methodologically sound, they were often difficult to apply for non-expert users. In response, tool guides and templates were redesigned with intuitive visuals, real-world examples, and phased instructions, improving accessibility and contextual fit, especially in line with DPs 2 and 4. Later iterations revealed a need for greater flexibility in the phased process model. Optional loops and reflection points were introduced to accommodate non-linear progression while maintaining overall orientation. These enhancements better aligned the artifact with the dynamic and iterative nature of innovation in public-sector environments.

These refinements were not merely reactive. The co-design process evolved into a reflexive practice, allowing the toolbox to adapt alongside growing clarity around goals, roles, and system constraints. Each iteration thus became a micro-level transformation of the broader service system. The final evaluation cycle used category-guided synthesis to assess the artifact along four refinement dimensions: technical fit, stakeholder alignment, usability, and institutional compatibility. These insights informed immediate improvements and supported long-term capability building within the competence centers (Wetter-Edman & Malmberg, 2016). By embedding reflection and learning mechanisms, the artifact helped foster methodological awareness and stakeholder ownership throughout the design process.

## 5. Discussion & Conclusion

This study aimed to develop a structured, co-creative artifact for business model development in public service robotics. Grounded in DSR and Service Science, the approach addresses the socio-organisational complexity of multi-stakeholder innovation. The following section reflects on its theoretical contributions, practical relevance, and key limitations.

This study demonstrates how service systems in complex domains can benefit from artifact-driven design. Drawing on Service Science, it operationalizes value co-creation not only via stakeholder engagement, but through concrete design logic that enables alignment, coordination, and iterative learning (Maglio et al., 2009; S. L. Vargo & Lusch, 2004). Core elements, roles, interactions, and resource

Design Principle	DR
DP1: Role Clarity and Systemic Positioning	DR1, DR5
DP2: Inclusive Method Accessibility	DR2, DR4
DP3: Structured Innovation Process	DR3
DP4: Applied and Transferable Tooling	DR4, DR6
DP5: Context Sensitivity for Public Robotics	DR5
DP6: Embedded Iterative Learning and Co-Creation	DR6

Table 3. Design Principles

configurations, are translated into tools that help distributed actors collaborate effectively. The artifact, comprising the Phased Process Model and role-specific Tool Guides, functions as a boundary object that supports systemic innovation across institutional contexts. Its development was grounded in iterative evaluation cycles and structured content analysis, ensuring traceability from stakeholder feedback to design implications.

Practically, the artifact offers a flexible toolset for competence centers and public initiatives. Its modular structure, role-specific guides, and low-threshold formats help diverse teams navigate complex stakeholder landscapes. By surfacing tensions, such as value trade-offs or ethical dilemmas, it enhances both methodological and strategic capabilities. In the library robotics use case, tensions around institutional control, inclusive access, and data governance emerged during stakeholder alignment, illustrating how the artifact mediates conflicting priorities. The design logic links tool selection, stakeholder roles, and process phases to balance competing needs such as standardization vs. contextual flexibility or innovation speed vs. accountability. Involving multiple competence centers, rather than a single case, revealed cross-cutting challenges and strengthened the artifact's transferability.

Beyond structural alignment, public service innovation increasingly requires attention to normative concerns. While the artifact includes accessible formats, institutional adaptability, and stakeholder guidance, it does not yet draw on explicit ethical or inclusive design frameworks. These elements are embedded in practice, but remain conceptually underdeveloped. The artifact was also shaped by the conditions of a German transfer program, which may limit generalizability to other institutional or cultural contexts. End-users and citizens were not deeply involved, leaving experiential perspectives underrepresented. While the evaluation followed a formative pattern and applied category-guided analysis, it did not assess long-term effectiveness. Future work should examine how the artifact can be embedded in operational settings and how fairness, participation, and transparency can be systematically addressed.

In conclusion, this study presents a design artifact that enables co-creative business model development in public robotics. By combining methodological rigor with service system logic, it offers actionable tools to navigate sociotechnical complexity. The approach contributes to existing business model research by grounding co-creation in artifact design and linking it to systemic principles of service innovation.

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