

An AHP-Based Artifact for Prioritizing Software Technical Debt Items: A Design Science Research Study

Um Artefato Baseado em AHP para Priorização de Itens de Dívida Técnica de Software: Um Estudo de Design Science Research

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ABSTRACT

When a delivered system deviates from its expected requirements, Technical Debt (TD) may arise. TD extends beyond purely technical issues; the literature identifies fifteen distinct types, including requirements, documentation, and testing debt. Furthermore, TD can be incurred at any stage of the software development lifecycle. The lack of structured management for TD items often results in complex and costly system maintenance for organizations. This study aims to present the development and application of a prioritization

matrix for software TD items using the Analytic Hierarchy Process (AHP) method. Adopting a Design Science Research (DSR) approach, this research develops an artifact designed as a practical solution to address the challenges organizations face in prioritizing TD items. The proposed matrix was validated through a case study in a multinational company within the vehicle monitoring and tracking sector. The results demonstrate that the matrix successfully established a prioritized list of TD items based on consistent

judgments provided by the decision-maker. This study contributes to technical debt management by proposing and evaluating a structured

Keywords: Technical Debt, Software Engineering, Prioritization, Decision Making

RESUMO

*Quando um sistema entregue se desvia de seus requisitos esperados, pode surgir a Dívida Técnica (DT). A DT vai além de questões puramente técnicas; a literatura identifica quinze tipos distintos, incluindo dívidas relacionadas a requisitos, documentação e testes. Além disso, a DT pode ocorrer em qualquer etapa do ciclo de vida de desenvolvimento de software. A ausência de uma gestão estruturada para os itens de DT frequentemente resulta em uma manutenção de sistemas complexa e custosa para as organizações. Este estudo tem como objetivo apresentar o desenvolvimento e a aplicação de uma matriz de priorização para itens de DT em software, utilizando o método *Analytic Hierarchy Process* (AHP). Por meio de uma abordagem de *Design Science Research* (DSR),*

Palavras-chave: Dívida Técnica, Engenharia de Software, Priorização, Tomada de Decisão

AHP-based artifact that supports the prioritization of technical debt items using literature-based decision criteria and consistent managerial judgments.

esta pesquisa desenvolve um artefato concebido como uma solução prática para enfrentar os desafios que as organizações encontram ao priorizar itens de DT. A matriz proposta foi validada por meio de um estudo de caso em uma empresa multinacional do setor de monitoramento e rastreamento veicular. Os resultados demonstram que a matriz estabeleceu, com sucesso, uma lista priorizada de itens de DT, com base em julgamentos consistentes fornecidos pelo tomador de decisão. Este estudo contribui para a gestão da dívida técnica ao propor e avaliar um artefato estruturado, fundamentado no método AHP, que apoia a priorização de itens de dívida técnica utilizando critérios de decisão baseados na literatura e julgamentos gerenciais consistentes.

1. INTRODUCTION

The concept of technical debt (TD) was contextualized by Ward Cunningham (1992) as an analogy to financial debt, referring to short-term development shortcuts that compromise long-term system architecture and maintenance. Furthermore, TD encompasses multiple dimensions; Rios et al. (2018) identified fifteen types of technical debt, ranging from design and architecture to documentation and infrastructure. When managed consciously, TD can serve as a strategic business trade-off; however, unmanaged debt increases system complexity and maintenance costs over time (De Lima et al., 2022).

Knowing which TD items to prioritize for repayment remains a critical challenge for organizations (Da Silva et al., 2022). Prioritization is essential to optimize resource allocation, balancing immediate technical needs against long-term business goals (Alfayez et al., 2020). Project managers frequently struggle to evaluate competing technical debt items, making TD prioritization a core component of project risk management (Codabux & Williams, 2016).

Because TD prioritization involves evaluating trade-offs across conflicting technical and business parameters, Multi-Criteria Decision Analysis (MCDA) offers a suitable framework for structuring this process. Among MCDA techniques, the Analytic Hierarchy Process (AHP) (Saaty, 1988) enables decision-makers to structure complex problems, weigh criteria through pairwise comparisons, and generate a consistent ranking of alternatives. Applied to TD management, AHP provides a structured mechanism to minimize subjective bias while synthesizing expert judgment into actionable prioritization (Seaman et al., 2012).

This study sought to answer the following research question: How can software technical debt items be prioritized using a multi-criteria decision-making method? Although the literature recognizes the difficulty of Technical Debt (TD) prioritization, there is still a lack of artifacts applicable to real organizational environments. This gap is highlighted by the absence of solutions that combine explicit criteria, consistent judgment, and an operational final ranking.

To address this gap, the general objective of this study is to develop and evaluate a practical artifact for prioritizing software TD items based on the AHP method. Specifically, this research aims to conceptualize the decision model, implement the prioritization artifact, demonstrate its application in a real corporate environment, and evaluate its operational utility for software management decision-making.

2. THEORETICAL FRAMEWORK

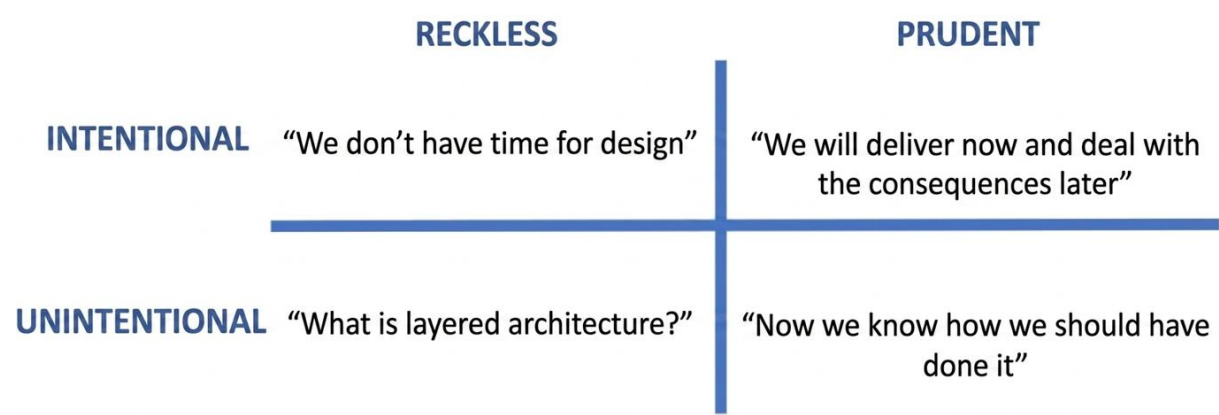
For more than three decades, since the concept of TD was introduced by Ward Cunningham (1992), several authors have been researching the topic of TD.

2.1. Software Technical Debt

In 2008, McConnell described that TD can be classified as intentional and unintentional. Intentional TD is generated consciously. Unintentional TD occurs when TD is conceived accidentally and unconsciously.

Fowler (2009) enhanced McConnell's (2008) initial concept with two additional classifications: Prudent and Imprudent TD. Thus, the TD quadrant was formed: Conscious, Unconscious, Prudent, and Imprudent, as illustrated in Figure 1.

Figure 1 - TD Quadrant



Note: Adapted from Technical Debt Quadrant, by M. Fowler, 2009 (<https://martinfowler.com/bliki/TechnicalDebtQuadrant.html>).

2.2. Types of Technical Debt

In 2018, Rios, De Mendonça Neto, and Spínola conducted a tertiary study evaluating thirteen secondary studies dated from 2012 to March 2018. They identified

fifteen types of TD: design (violations of good object-oriented design principles) and architecture (non-uniform architectural policies and patterns), test (lack of tests/insufficient testing), documentation (lack of documentation/outdated documentation), code (highly complex/poorly written code), defect (postponed software bug fixes), infrastructure (outdated components of the software development environment), requirements (partially or unsatisfactorily implemented), people (delays in hiring), build (the build process may involve code that does not add value to the customer/manual build), process (manual processes that could be automated), test automation (lack of automated tests), usability (inadequate usability decisions), service (inappropriate selection and replacement of web services leading to incompatibility between service capabilities and application requirements), and versioning (issues in source code version control).

2.3. Prioritization of Technical Debt Items

According to Lenarduzzi et al. (2021), there is no unified approach to how the prioritization process of TD items should be performed, nor is there a consensus on which aspects to consider when conducting the prioritization process of these items. Due to limited resources for dealing with TD, prioritizing repayment decisions regarding TD items is fundamental (Codabux & Williams, 2016). The study of TD, and specifically its prioritization, is a relatively new research topic (Alfayez et al., 2020).

The prioritization process is used to define the ordering and/or scheduling of software refactoring initiatives (Lenarduzzi et al., 2019). Seaman et al. (2012) addressed the use of the Analytic Hierarchy Process (AHP) method for managing TD items. As the authors' study points out, it was demonstrated that the AHP method provides a simple method for structuring a problem. The authors indicate that when applying AHP to the TD management problem, the decision alternatives would be the various identified TD criteria existing in the system, and the process outcome would be a priority ranking of these TD items, indicating which ones should be paid first.

2.4. Decision Criteria in Technical Debt Item Management

In 2016, Ribeiro et al. conducted a systematic study on the criteria used to decide on software TD repayment. Fourteen decision-making criteria were identified: TD Severity, Existence of an Alternative Solution, Age of the TD item in the system, TD Location, Visibility, Analysis of when the refactored part will be used, TD Impact on the Customer, TD Impact on the Project, Scope of Tests, Cost-Benefit, Effort for fix implementation, Project Nature, System lifespan, and Need for system or feature evolution. Still in 2016, Ribeiro and Spínola conducted a survey to evaluate and characterize the pertinence and relevance of the decision criteria for managing TD items identified in the systematic study previously conducted by Ribeiro et al. (2016). This evaluation was carried out with thirty-three participants from academia and industry.

The authors indicate that only nine criteria were considered pertinent and relevant to support decision-making regarding the repayment of TD items. The four most pertinent criteria listed are: TD Impact on the Customer, Visibility, TD Severity, and TD Impact on the Project (Effort Category). A criterion is pertinent when it is important to support decision-making on the repayment of a TD item. On the other hand, the relevance of a criterion indicates how important it is at the moment of deciding on the repayment of a debt item (Ribeiro & Spínola, 2016).

2.5. Multi-Criteria Decision-Making and the AHP Method.

Multi-criteria methods are techniques that support decision-making, helping to solve problems that involve multiple, often conflicting objectives, with multiple possible actions, uncertainties, various stages, and several individuals affected by the decision (Brioso & Musetti, 2015). The distinguishing factor between multi-criteria decision-making methods and other approaches is their ability to address multiple aspects and evaluate actions based on a diverse set of criteria (Ensslin et al., 2001). According to Vargas (1990), the AHP method is a tool that has found application across a wide range of problem areas, spanning from simple to complex decisions.

AHP decision applications are carried out in two phases: hierarchical design and evaluation. Designing hierarchies requires experience and knowledge of the problem domain. A group of decision-makers can work together to reach a consensus

on the hierarchy design, as well as on the judgments and their evaluation (Vargas, 1990). AHP is an easy-to-use and flexible multi-criteria decision-making method. Among the advantages of using AHP for decision-making is the opportunity to consider the varying importance of criteria and, consequently, assign different weights so that certain criteria dominate the decision (Emrouznejad & Marra, 2017).

In general, the criteria that matter across all different levels of decision-making are common and recurring; for instance, customer satisfaction, technological advancement, and profit appear in all aspects (Saaty, 2013). The AHP approach involves constructing a hierarchy of criteria, assigning weights and scales to these criteria, and finally conducting a series of pairwise comparisons between alternatives against the various criteria (Lenarduzzi et al., 2021).

3. METHOD

This study adopts a Design Science Research (DSR) approach to develop and evaluate an artifact for Technical Debt (TD) prioritization. Following the recommendation of distinguishing the methodological framework from the domain knowledge acquisition, this section is structured into two main parts: the overarching research design based on DSR and the systematic literature search executed to ground the decision criteria.

Research Design (Design Science Research)

To address the practical challenge of technical debt management and produce a rigorous scientific artifact, this study follows the Design Science Research methodology proposed by Peffers et al. (2007). DSR is particularly suited for software engineering research because it focuses on creating and evaluating innovative artifacts designed to solve identified organizational problems.

The execution of this research is structured around the six core activities of DSR:

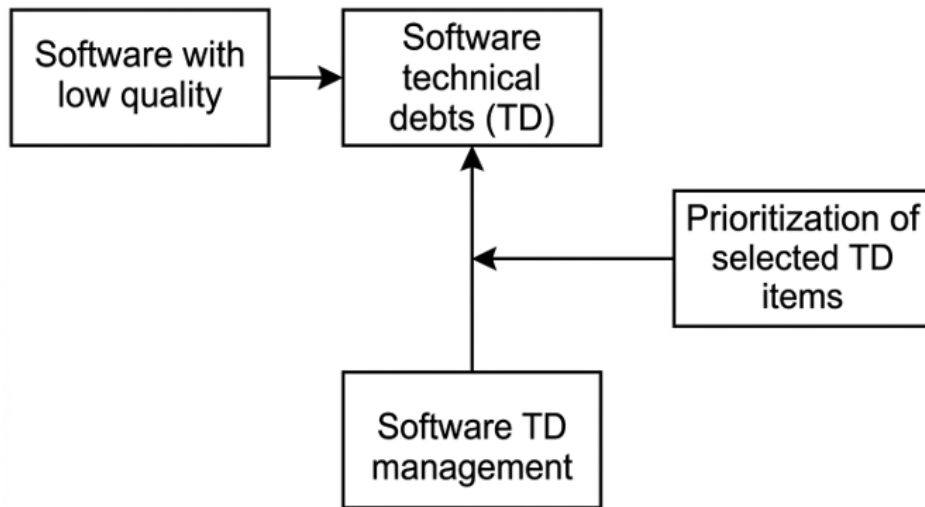
1. **Problem Identification and Motivation:** Defining the organizational difficulty of prioritizing technical debt items without relying on purely

subjective judgments, which frequently leads to suboptimal refactoring strategies.

2. **Definition of Solution Objectives:** Establishing the requirements for a multi-criteria decision-making model grounded in the Analytic Hierarchy Process (AHP). This process structures expert judgments through the AHP method and verifies their consistency, reducing arbitrariness in the prioritization process.
3. **Design and Development:** Constructing the conceptual framework, the decision hierarchy, and the instantiation artifact (a structured spreadsheet-based prioritization matrix).
4. **Demonstration:** Applying the developed artifact in a real-world industrial context within a multinational vehicle tracking and monitoring enterprise.
5. **Evaluation:** Assessing the artifact's utility, consistency, and operational feasibility through a structured interview and questionnaire with a domain practitioner (Tech Lead).
6. **Communication:** Disseminating the research process and empirical findings through academic publication.

To apply the AHP method within the Design and Development stage, it is necessary to identify the alternatives and criteria that will be used for evaluation. With these data, the pairwise comparison matrix can be constructed. Figure 2 illustrates the conceptual construct diagram of this study, in which low software quality leads to TD, and the prioritization of TD items constitutes an essential part of software technical debt management, ultimately resulting in software quality improvement.

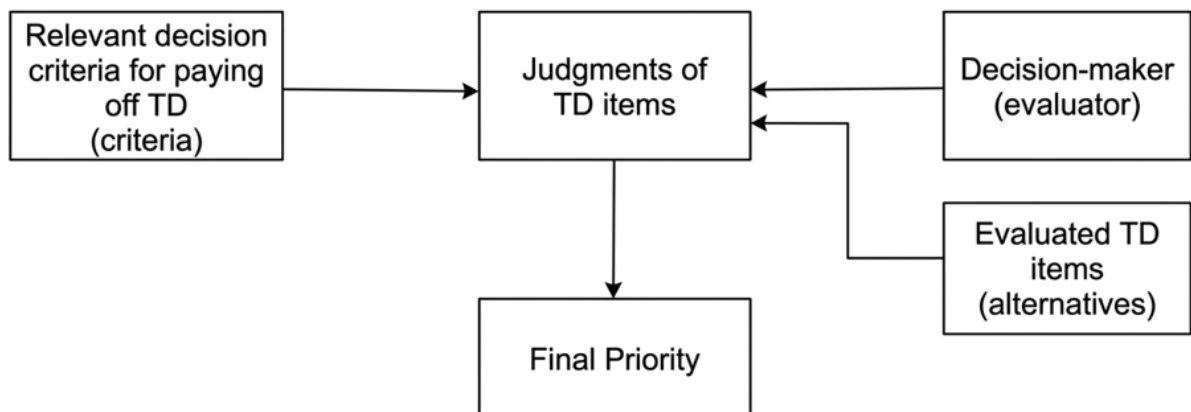
Figure 2 - Conceptual Diagram - Construct



Note: Created by the authors (2024)

To detail the operational relationships within the decision model, Figure 3 represents the conceptual model reflecting the interaction between the core variables of this research: the decision criteria for paying off TD items, the decision-maker, the judgment process, and the evaluated TD items, ultimately yielding the prioritized output.

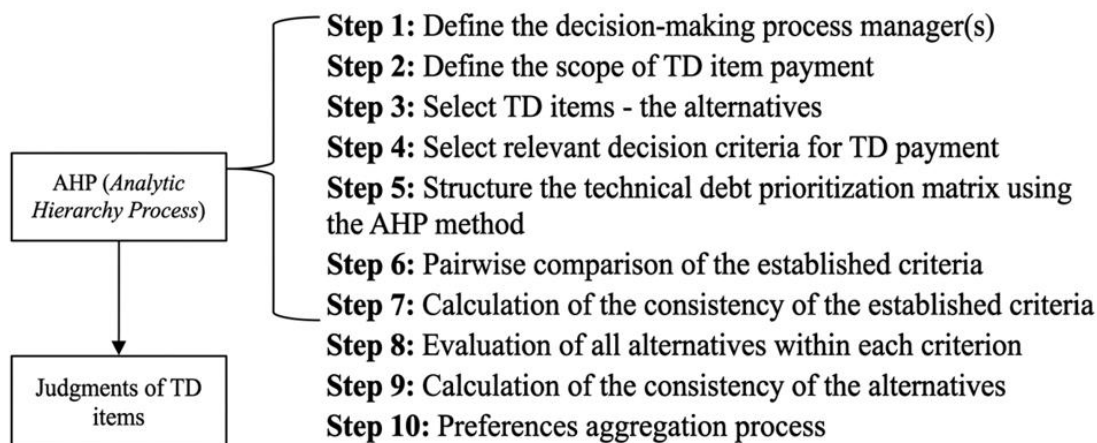
Figure 3 - Conceptual Diagram -TD item prioritization model



Note: Created by the authors (2024)

To operationalize the proposed framework within an industrial environment, the application procedure was structured into a ten-step sequence. Figure 4 presents the methodological element of this research, listing ten steps for the demonstration and application of the matrix within the organizational context.

Figure 4 - Conceptual Diagram - Method



Note: Created by the authors (2024)

3.1. Literature Search and Criteria Selection

To ensure that the criteria embedded within the AHP model reflect established software engineering knowledge rather than arbitrary choices, a structured literature search was conducted.

Search Strategy and Execution

The search was executed across two major academic databases: Scopus and Web of Science (WoS). The search string targeted studies at the intersection of technical debt management, prioritization, and multi-criteria decision methods: ("Technical Debt" OR "Software Debt") AND ("Prioritization" OR "Priority") AND ("AHP" OR "Analytic Hierarchy Process" OR "Multi-criteria"). The search was limited to title, abstract, and keywords, restricted to peer-reviewed journal articles and conference papers published in English.

Screening and Selection Criteria

The initial database queries yielded a total pool of 44 articles, distributed as follows:

- Scopus: 24 articles
- Web of Science: 20 articles

The 44 resulting articles were imported into Microsoft Excel (2016 version) for systematic deduplication and screening. The selection followed a structured filtering pipeline:

Identification: A combined total of 44 publications were retrieved from the initial database searches (24 from Scopus and 20 from Web of Science).

Deduplication and Screening (Inclusion/Exclusion Criteria):

Duplicate records were removed using Microsoft Excel, and the unique papers were screened against predefined criteria:

- **Inclusion Criteria:** Primary or secondary studies focusing on software technical debt management; Studies proposing, evaluating, or surveying criteria used to prioritize technical debt repayment.
- **Exclusion Criteria:** Studies focusing exclusively on non-software technical debt; Extended abstracts, posters, panel summaries, or keynotes; Papers where full-text access was unavailable.

Final Synthesis:

Following full-text review to substantiate the theoretical framework of this research, 24 articles were selected for final analysis and criteria extraction.

Derivation of AHP Criteria

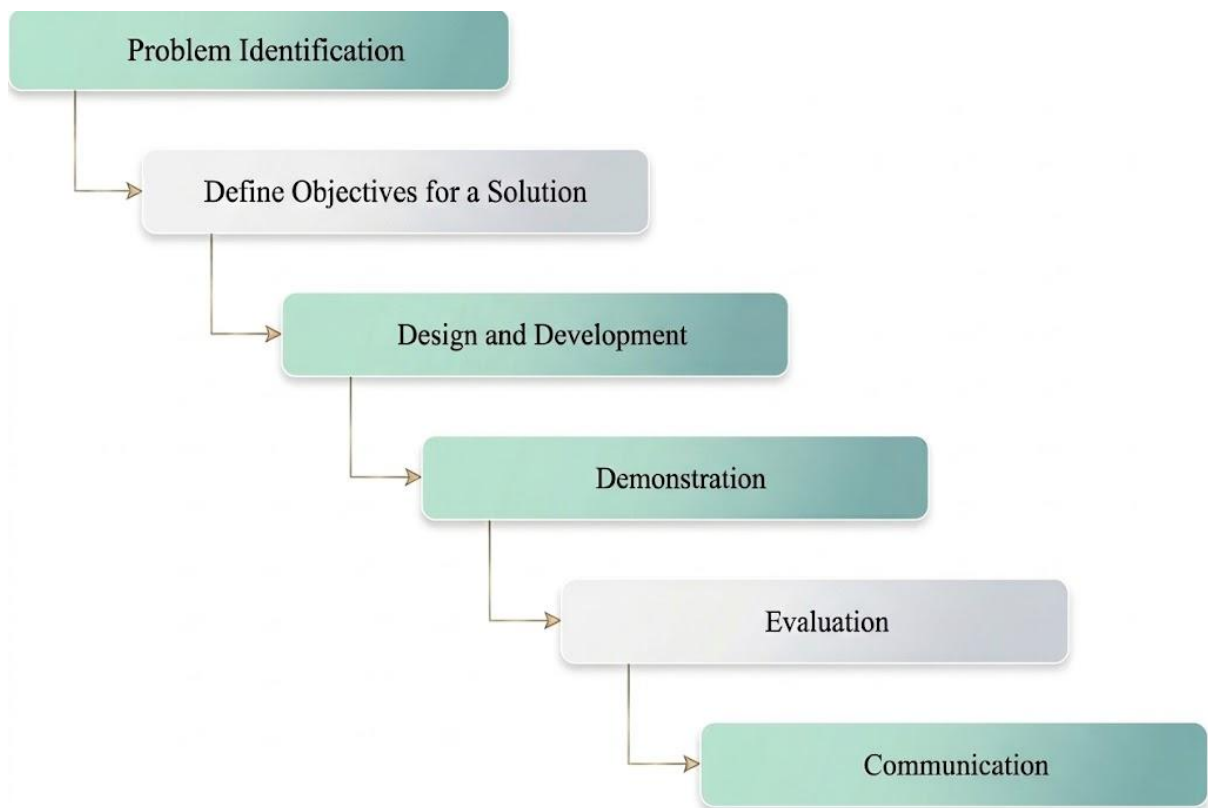
The 24 selected articles were systematically analyzed to map the most recurrent, impactful, and operationally viable decision criteria for software refactoring. Rather than incorporating an excessive number of criteria—which would exponentially increase the cognitive burden of AHP pairwise comparisons—the literature synthesis revealed four dominant dimensions frequently validated in industry contexts (e.g., Ribeiro & Spínola, 2016):

- **TD Impact on Customer:** Measures the extent to which the technical debt directly affects end-user experience, system usability, or service availability.
- **Visibility:** Evaluates whether the debt item is visible to business stakeholders or hidden within internal code/architectural structures.
- **TD Impact on Project:** Assesses the internal friction caused by the debt on ongoing development velocity, maintainability, and delivery schedules.
- **TD Severity:** Quantifies the technical urgency, risk of defect propagation, or potential failure magnitude if the debt remains unpaid.

These four synthesized criteria directly established the criteria layer of the AHP decision hierarchy implemented in the DSR artifact.

The method used in this research is Design Science Research (DSR). This research method is recommended when the research objective is to design and develop artifacts and prescriptive solutions, whether in a real-world environment or otherwise (Dresch et al. 2015). The DSR research method proposed by Peffers et al. (2007) consists of six stages: Problem Identification, Definition of Expected Objectives, Design and Development, Demonstration, Evaluation, and, finally, Communication. These stages are described in Figure 5.

Figure 5-Stages of the Design Science Research method



Note: Adapted from "A Design Science Research Methodology for Information Systems Research," by K. Peffers et al., 2007, *Journal of Management Information Systems*, 24(3).

In this research, during the problem identification phase, it was possible to observe the challenge that organizations face in prioritizing software TD and the lack of tools for this purpose. There are obstacles in the prioritization of technical debt, such as the lack of automated methods that encompass various types of technical debt within software (Pina et al., 2021).

To analyze the volume of publications in the scientific literature related to software TD prioritization, a search was conducted in the Scopus and Web of Science databases, in accordance with the criteria outlined in Table 1. The search string used was: "Technical Debt" AND ("Prioritization" OR "Prioritizing" OR "Prioritize" OR "Prioritisation" OR "Priorities" OR "Priority"). The search fields targeted were Title, Abstract, and Keywords, with no time period restrictions applied to the search.

Table 1- Search Criteria for TD Prioritization

Attributes	Criteria
Search string	"Technical Debt" AND ("Prioritization" OR "Prioritizing" OR "Prioritize" OR "Prioritisation" OR "Priorities" OR "Priority")
Search fields	Title, Abstract, and Keywords
Time period	All years
Publication type	Article

Note: Created by the authors (2023)

As a result of the search, the total number of articles listed below was found:

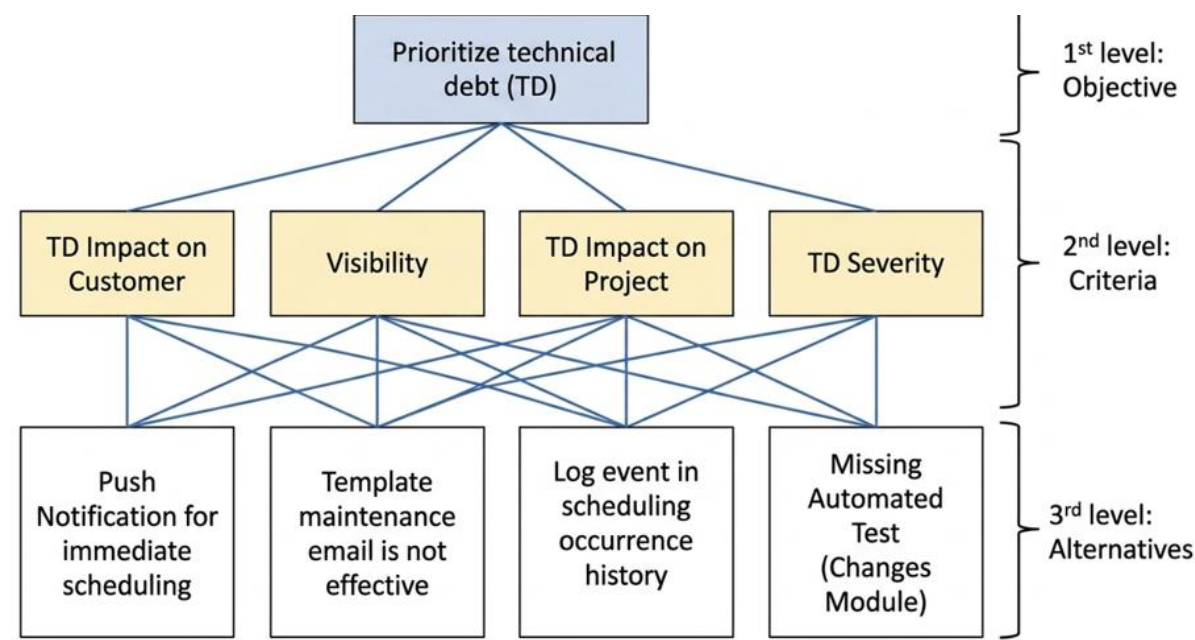
- **Scopus:** 24
- **Web of Science:** 20

A screening of the forty-four articles resulting from both scientific databases was performed using Microsoft Excel (2016 version) to remove duplicates. This resulted in a total of twenty-four articles. These were read in their entirety to provide the foundation for the theoretical framework of this research.

4. RESULTS AND DISCUSSION

This chapter presents the empirical implementation and evaluation of the developed software Technical Debt (TD) prioritization artifact. Grounded in the Analytic Hierarchy Process (AHP), the artifact was operationalized and demonstrated in a real industrial context to assess its practical utility and consistency in supporting decision-making. In figure 6 is showed Overview of the AHP matrix: objective, criteria hierarchy and alternatives.

Figure 6- Overview of the AHP matrix: objective, criteria hierarchy and alternatives



Note: Created by the authors (2024)

4.1. Artifact Architecture and Operational Model

The proposed artifact operationalizes the AHP method within an accessible spreadsheet format (Microsoft Excel) to prioritize TD items based on multi-criteria trade-offs. The conceptual model establishes a structured relationship between four core entities: the decision-maker, the candidate TD items (alternatives), the decision criteria, and the mathematical preference aggregation process.

To balance analytical rigor with industrial usability, the artifact incorporates four criteria validated in software engineering literature (Ribeiro & Spínola, 2016): TD Impact on Customer, Visibility, TD Impact on Project, and TD Severity. The model guides the evaluator through pairwise comparisons at both the criteria level and the alternative level under each specific criterion. Table 2 details the selected criteria, their literature rationale, and their operational interpretation within the present study.

Table 2- Synthesis of AHP Decision Criteria Derived from Literature

Criteria	Literature Rationale	Interpretation in the Present Study
TD Impact on Customer	Relevant criterion for TD repayment decision	Measures perceived impact on the user/customer
Visibility	Relevant criterion for decision-making	Measures how noticeably the issue affects the organization/user
TD Impact on Project	Relates TD to effort, timeline, or delivery	Measures impact on the project/roadmap
TD Severity	Indicates technical or operational severity	Measures the criticality of the TD item

Note: Created by the authors (2024)

4.2. Empirical Demonstration

The artifact was demonstrated in a multinational vehicle tracking and monitoring enterprise operating across seven countries. The chosen decision-maker was the Tech Lead of an active software development squad. The scope of evaluation encompassed four candidate TD items distributed across three core production systems.

The empirical demonstration proceeded through the following analytical steps:

- **Criteria Evaluation and Consistency Adjustment:** The decision-maker conducted pairwise comparisons among the four criteria. In the initial iteration, the mathematical aggregation yielded a Consistency Ratio of 28% ($CR = 28\%$). Because this exceeded Saaty's standard 10% threshold ($CR \leq 10\%$), the judgments were identified as logically inconsistent. Through a guided re-evaluation, the Tech Lead refined the pairwise trade-offs, successfully reducing the consistency ratio to 8.4% ($CR = 8.4\%$) and validating the logical coherence of the criteria weights.
- **Alternative Evaluation under Criteria:** The four candidate TD items were evaluated pairwise against each individual criterion. All four resulting sub-matrices met the required consistency thresholds: TD Impact on Customer ($CR = 6.0\%$), Visibility ($CR = 8.0\%$), TD Impact on Project ($CR = 9.0\%$), and TD Severity ($CR = 4.0\%$).

- **Preference Aggregation and Ranking:** Multiplying the criteria priority vector by the alternatives' relative weight matrices produced the consolidated priority ranking for the backlog items.

4.3. Post-Demonstration Evaluation

Following the demonstration, a structured evaluation interview was conducted with the Tech Lead using a combined questionnaire (Likert scale and qualitative open feedback) in Table 3.

Table 3-Evaluation interview summary with the decision-maker

Evaluation Dimension	Indicator Metric	/	Decision-Maker Response
Operational Effort	Manual Effort	Filling	Medium
Decision Clarity	Result Understanding		High
Process Adoption	Recommendation Likelihood		Yes / Positive
Qualitative Assessment	Key Strength		Provides objective mathematical backing to defend refactoring priorities to business stakeholders.
Qualitative Assessment	Primary Limitation		Manual entry in spreadsheets can become tedious if scaled to larger backlogs.

Note: Created by the authors (2024)

The evaluator emphasized that the artifact successfully replaces intuitive "gut-feeling" decisions with a defensible prioritization rationale, though automated integration with issue trackers was highlighted as a key requirement for wider organizational adoption.

The artifact evaluation was essentially exploratory in nature, focusing on the perception of the participating decision-maker to provide an initial proof-of-concept validation within a real operational environment. Although the evaluation was limited

to a single decision-maker, the results indicate initial evidence of utility, understandability, and organizational relevance of the proposed artifact.

However, it is recognized as a limitation that the findings reflect the individual perspective of a single Tech Lead, which prevents direct generalization of the results to other organizational cultures, domain contexts, or team structures. To address this limitation and strengthen empirical validity, future research must expand this evaluation to involve multiple decision-makers, diverse development squads, and direct benchmark comparisons with alternative technical debt prioritization methods.

4.4. Critical Discussion of Findings

The empirical results provide valuable insights into the practical applicability, decision support capability, and cognitive dynamics of multi-criteria decision models for technical debt management within software engineering governance.

Strategic Alignment and Managerial Implications

The final preference aggregation yielded a highly differentiated priority distribution among the evaluated technical debt items: Push Notification for immediate scheduling (Immediate Scheduling project) received the primary priority share (61%), followed by Missing Automated Test – Changes Module from Contract Management (23%), Email maintenance template is not effective from Predictive (11%), and Missing to record fact in the history of the occurrence occurrence, also from Predictive (5%).

A deeper analysis of this hierarchy reveals critical managerial implications:

- **Rationale Behind the Top Priority (61%):** The item "Push Notification for immediate scheduling" dominated the backlog ranking due to its dual alignment with customer satisfaction and operational visibility. In live operational systems, failure or delay in real-time notifications directly impairs end-user experience and triggers operational escalations, making its repayment a business imperative rather than a purely technical chore.
- **Dominant Criteria Driving the Decision:** The criteria weighting revealed that TD Impact on Customer and Visibility exerted the strongest influence on the overall prioritization matrix. Consequently, technical items directly affecting

user-facing operations absorbed the majority of the allocation weight, overriding items focused solely on internal traceability or secondary logging.

- **Trade-off Analysis Across Criteria:** The AHP hierarchy exposed essential trade-offs among the four evaluated dimensions:
 - Customer Impact vs. Project Impact: The absence of automated testing (Missing Automated Test at 23%), despite representing a severe technical risk to long-term project maintainability, ranked second to an item with immediate, direct customer-facing impact.
 - Severity vs. Visibility: Communication and usability flaws (such as the ineffective email template at 11%) took precedence over missing historical event logging (5%), as external visibility influenced the decision-maker more heavily than internal event logging.
- **Roadmap Decision Support and Resource Allocation:** Rather than attempting to address all backlog items simultaneously, the 61% vs. 5% disparity provides actionable guidance for resource allocation. Engineering managers can justify concentrating development effort on the top two items (representing 84% of total priority value), while consciously deferring lower-priority items without risking system stability.
- **Mitigation of Informal and Subjective Decision-Making:** In software management, technical refactoring is frequently relegated to informal negotiations or "gut-feeling" decisions, often leading to friction between Tech Leads and Product Managers. The proposed AHP artifact bridges this gap not by eliminating subjectivity, but by structuring expert judgments through a rigorous pairwise comparison process and verifying their mathematical consistency. The model provides defensible evidence to justify refactoring investments to non-technical business stakeholders, shifting technical debt management from a tactical burden to a strategic information systems governance practice.

Cognitive Dynamics and Operational Usability

- **Mitigation of Unconscious Bias:** The initial 28% inconsistency ratio illustrates a common phenomenon in software management: technical leaders

often hold conflicting implicit priorities when assessing risks. Without a structured framework, these conflicting assumptions remain undetected, leading to arbitrary refactoring choices. The forced consistency check in AHP served as a cognitive calibration tool, prompting the Tech Lead to explicitly articulate trade-offs and arrive at a robust decision (successfully reaching an acceptable 8.4 % inconsistency ratio).

- **Organizational Timing and Usability:** While the Tech Lead reported a "medium" filling effort for four items, scaling pairwise comparisons manually to dozens of backlog items introduces exponential cognitive fatigue. Consequently, the optimal operational window for this matrix is at the Strategic Planning and Roadmap Definition level (quarterly or bi-annually), rather than during fast-paced, short-term Sprint Planning.
- **Scalability via Hierarchical Sub-grouping:** To prevent comparison fatigue in larger backlogs, the mathematical framework must be adapted. Rather than conducting flat pairwise comparisons across all items, future implementations should group debt items into intermediate hierarchical categories (e.g., by architectural layer or business domain), thereby maintaining matrix orders below five items per evaluation block.

5. FINAL CONSIDERATIONS

This study demonstrated the design, application, and post-demonstration evaluation of a software Technical Debt (TD) prioritization matrix artifact using the Analytic Hierarchy Process (AHP) within a multinational vehicle tracking enterprise. Grounded in Design Science Research (DSR), the primary motivation was to address the organizational challenge of prioritizing technical debt through structured decision frameworks, shifting technical debt management from informal negotiations toward strategic information systems governance.

By applying the artifact, four decision criteria derived from a systematic review of the literature were utilized to evaluate four specific TD items across three real-world software systems. The application confirmed that the AHP framework successfully provided a transparent, priority-weighted ranking driven by explicit criteria trade-offs,

particularly highlighting the dominance of customer impact and operational visibility. The artifact evaluation conducted with the participating domain practitioner (Tech Lead) corroborated the initial utility, understandability, and organizational relevance of the artifact. Notably, the optimal operational window for applying the matrix was identified as Strategic Planning and Roadmap Definition, rather than short-term sprint planning. To enhance usability and scale the artifact for larger backlogs, the decision-maker recommended future automation and integration with backlog management tools.

Methodologically, this work demonstrates that the AHP method aids in formalizing the decision-making process not by providing purely objective truth or eliminating human perception, but by structuring expert judgments, quantifying trade-offs, and verifying their mathematical consistency.

Despite these positive insights, the findings must be interpreted within the inherent limitations of this study. As a design science contribution, this research represents an exploratory proof-of-concept validation limited to a single decision-maker, a single development squad, and four prioritized items within a single organizational context. Consequently, these findings cannot be directly generalized to other organizational cultures, domain contexts, or team structures.

To build upon this initial baseline and strengthen empirical validity, future research should:

- Extend the evaluation to involve multiple decision-makers using consensus-building multi-criteria models (Group AHP);
- Validate the artifact across diverse development squads, heterogeneous business domains, and larger technical debt backlogs structured through hierarchical sub-grouping;
- Perform direct benchmark comparisons between the proposed AHP artifact and alternative technical debt prioritization methods;
- Automate the spreadsheet artifact into an integrated decision-support tool to minimize cognitive fatigue during pairwise comparisons.

Ultimately, embedded as an iterative practice within organizational governance, the proposed AHP artifact offers a defensible, mathematically consistent

mechanism to bridge the gap between engineering leads and business stakeholders, enhancing the overall quality of technical debt governance.

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