NOVA IMS Information Management School

# MGI

Master's Degree Program in
**Information Management**

# A Method to Evaluate and Select an Enterprise Architecture Tool

João Carlos Chuva Seiça

Master Thesis

presented as a partial requirement for obtaining a master’s degree in information management

**NOVA Information Management School**
**Instituto Superior de Estatística e Gestão de Informação**
Universidade Nova de Lisboa

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**A Method to Evaluate and Select an Enterprise Architecture Tool**

by

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Master Thesis presented as a partial requirement for obtaining the master’s degree in information management, with a specialisation in Information Systems and Technologies Management

## Supervised by

Vitor Santos, PhD, NOVA Information Management School

May, 2024

# STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Lisboa, May 2024

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# ABSTRACT

Enterprise architecture tools are widely used in business. However, selecting an enterprise architecture tool is a complex and time-consuming process. This study aimed to develop a highly customisable model that allows organisations to effectively evaluate and choose an enterprise architecture tool tailored to their unique requirements. The text discusses the evaluation criteria for analysing enterprise architecture tools: functionality, ease of maintenance, usability, reliability, supplier capabilities, cost-benefit analysis, stakeholder views and characteristics related to results and presents a structured approach using the Analytical Hierarchy Process to decide. The demonstration of the proposed method was carried out through an exploratory case study, and the evaluation was proven through a questionnaire in which experts in information technology systems and procurement specialists participated to provide evidence that the proposed artefacts can determine their effectiveness in facilitating informed decision-making about the adoption of enterprise architecture tools within organisations. The study's findings can also illuminate prevailing trends and challenges in the enterprise architecture tool landscape and highlight pain points organisations face when choosing such tools, potentially leading to industry-wide improvements.



# KEYWORDS

Enterprise Architecture; Systematic Literature Review; Decision-Making Methodologies

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# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **ADM** | Architecture Development Method |
| **AHP** | Analytical Hierarchy Process |
| **BPMS** | Business Process Management Suite |
| **C4ISR** | Command, Control, Computers, Communications, Intelligence, Surveillance, and Reconnaissance |
| **CMDB** | Configuration Management Database |
| **DISA** | Defense Information Systems Agency |
| **DoDAF** | Department of Defense Architecture Framework |
| **DSR** | Design Science Research |
| **EA** | Enterprise Architecture |
| **EAP** | Enterprise Architecture Planning |
| **FEA** | Federal Enterprise Architecture |
| **GAO** | Government Accountability Office |
| **IEC** | International Electrotechnical Commission |
| **IEEE** | Institute of Electrical and Electronics Engineers |
| **IoT** | Internet of Things |
| **ISO** | International Organization for Standardization |
| **MADM** | Multiple Attribute Decision Making |
| **MCDM** | Multi-Criteria Decision Making |
| **MODM** | Multiple Objective Decision Making |
| **NIST** | National Institute of Standards and Technology |
| **PPM** | Project Portfolio Management |
| **QA** | Quality Assessment |
| **SLR** | Systematic Literature Review |
| **SOA** | Service-Oriented Architecture |
| **TAFIM** | Technical Architecture Framework for Information Management |

# 1. INTRODUCTION

Enterprise Architecture (EA) is crucial in modern organisational strategy, guiding the complexities of today's business landscapes.

EA is based on fundamental principles outlined in ISO/IEC/IEEE Standard 42010 and encompasses a holistic understanding of an organisation, its components, and the principles guiding its evolution. With market demands and technological advancements constantly evolving, EA plays an increasingly pivotal role in ensuring strategic alignment and operational efficiency.

This chapter defines EA and its core components and examines the drivers propelling its adoption, including internal imperatives and external pressures such as regulatory mandates and market competition. It emphasises the importance of managing EA effectively to enhance agility, innovation, and competitive advantage.

Finally, this chapter outlines the thesis's themes and objectives. It provides a roadmap for the subsequent chapters, exploring EA's strategic importance and role in driving organisational success in the digital age.

## 1.1. Background

Per the ISO/IEC/IEEE Standard 42010 (2022), *architecture* is "fundamental concepts or properties of an entity in its *environment* and governing principles for the realization and evolution of this entity and its related life cycle processes" (p. 2).

Another essential definition from the ISO/IEC/IEEE Standard 42010 (2022) identifies a *stakeholder* as a "role, position, individual, organisation, or classes thereof, having an interest, right, share, or claim, in an *entity of interest*" (p. 4).

While most stakeholders of a given system might not be interested in the architecture itself, they are certainly interested in how it affects their concerns. On the other hand, an architect should be aware of these concerns and be able to communicate the architecture clearly and understandably to all stakeholders involved, who may come from entirely different backgrounds, as presented in Figure 1.1. The architect must discuss these concerns with the stakeholders to ensure everyone is on the same page (van der Raadt et al., 2008).

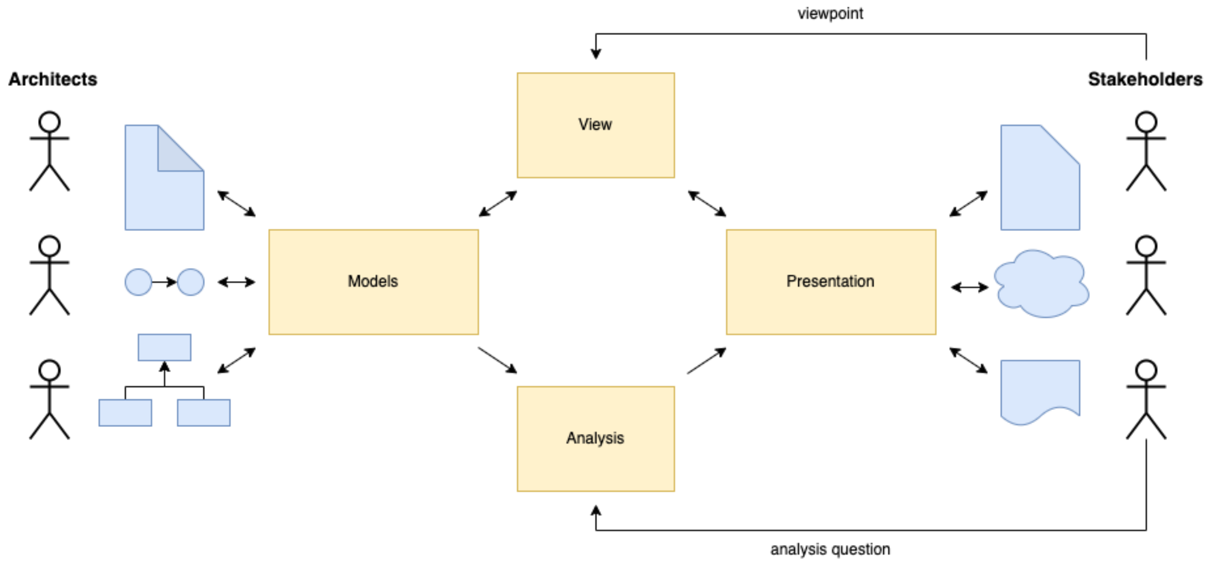


Figure 1.1 - Adapted from communicating about architecture (Lankhorst, 2017)

Although the intricacies of a system's architecture may only captivate the attention of some stakeholders, they are undoubtedly concerned with its impact on their specific needs (van der Raadt et al., 2008). An architect must, therefore, be able to comprehend these needs and communicate the architecture concisely and comprehensibly to all stakeholders despite their varying backgrounds. The architect must engage in dialogue with stakeholders to ensure a shared understanding of the system's impact (TOGAF, 2022).

In line with the previous definition of architecture and stakeholder according to Harrell and Sage (2010), the concept of EA was initially introduced by Zachman (1982), which is in line with the previous definition of architecture and stakeholder. However, this appears to have been an accidental occurrence since the term was only defined once and was not used in subsequent publications that referred to it as Information Systems Architecture (Fong & Goldfine, 1989; Sowa & Zachman, 1992).

Since then, EA has been defined and described in different ways, with the idea of using architecture to understand and design various aspects of enterprises. This has led to the development of several frameworks and resulted in multiple definitions of EA that vary in scope and purpose.

Rigdon (1989) consistently used the term EA to describe the NIST EA model but needed a clear definition of its meaning. Richardson et al. (1990) formally defined EA, which described applying the PRISM framework in a large oil organisation. In their MIS Quarterly article, they defined EA as an architecture that "defines and interrelates data, hardware, software, and communications resources, as well as the supporting organization required to maintain the overall physical structure required by the architecture" (Richardson et al., 1990, p. 386).

Kappelman et al. (2008) pointed out that:

> The "enterprise" portion of EA is understood by some as a synonym to "enterprise systems", yet others as equivalent to "business" or "organisation". (…) Even less uniform is the understanding of the meaning of "architecture". The most common understanding of the term is a collection of artifacts (models, descriptions, etc.) that define the standards of how the enterprise should function or provide an as-is model of the enterprise (p. 7).

Similarly, Tamm et al. (2011) define EA as the "definition and representation of a high-level view of an enterprise 's business processes and IT systems, their interrelationships, and the extent to which these processes and systems are shared by different parts of the enterprise" (p. 142).

As described by Saint-Louis et al. (2017), the definitions for EA diverge significantly, already hinting at differences in quality issues. However, "Today, EA is considered for many organizations as an important discipline and practice because it helps them face ongoing and disruptive change" (Saint-Louis et al., 2017, p. 41) by attempting to align IT and business strategy.

For Lankhorst (2017), EA is a foundational framework that encapsulates a business's core components, technological infrastructure, and evolution over time. This framework's beauty lies in its ability to safeguard the organisation's essential elements while allowing for a high degree of flexibility and adaptability in addressing specific challenges. Without a solid EA, achieving business success can be an uphill battle.

*Drivers for Enterprise Architecture*

In her introduction to drivers for EA, Lankhorst (2017) refers to them as a comprehensive understanding of the structure, workflows, technological capabilities, product offering, and the intricate web of relationships that connect the organisation to its environment, which is crucial for any business. In addition, external influences from customers, suppliers, business partners and regulators must also be considered. As an organisation expands and becomes more complex, sound architectural practises become even more essential.

Similarly, Iacob et al. (2014) write, "Drivers represent internal or external factors, which influence the plans and aims of an enterprise. Assessments of these drivers are needed to decide whether existing intentions need to be adjusted or not" (p. 1062-1063).

In this context, in the following paragraphs, we will briefly highlight the key internal and external drivers presented in Figure 1.2 that determine the structure of an enterprise architecture.

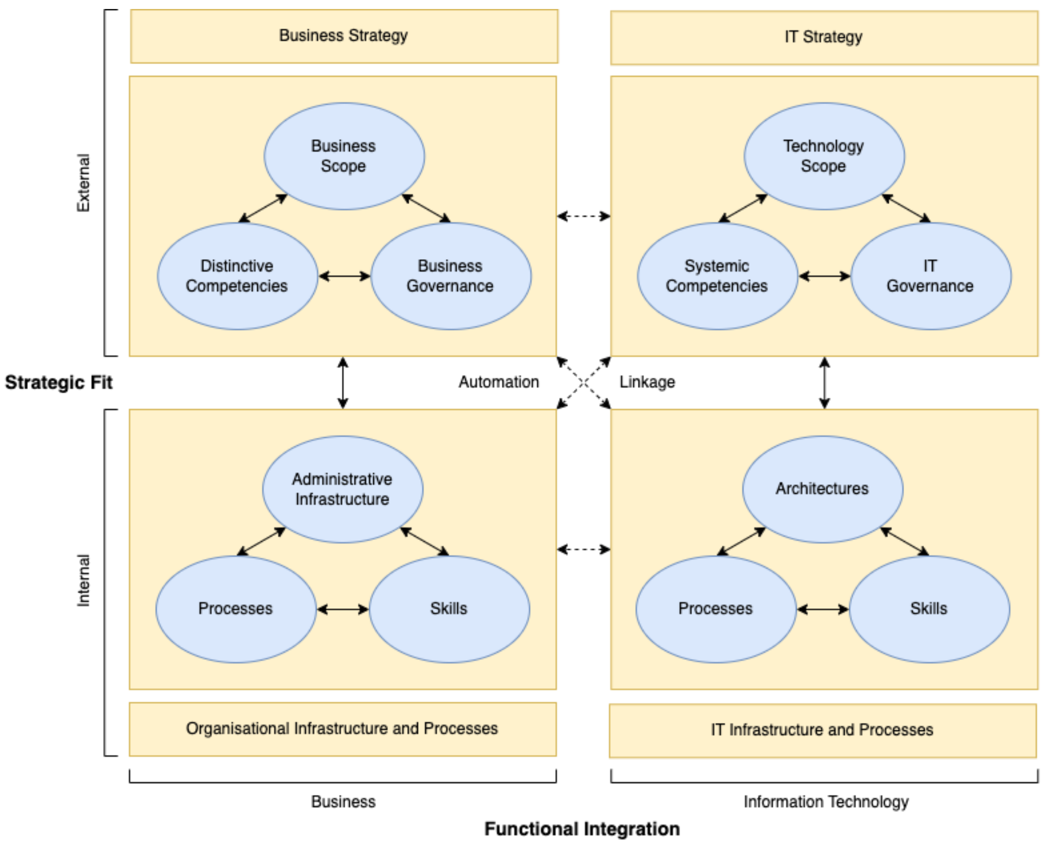


Figure 1.2 - Adapted from the strategic alignment model (Henderson & Venkatraman, 1993)

*Internal Drivers*

Achieving optimal organisational effectiveness requires a seamless alignment between business and IT components. This requires strategic coordination among all parts rather than solely optimising individual components. The interrelationships between these components are paramount, and it is essential to prioritise them over the minutiae of specific technical requirements.

*External Drivers*

Organisations are under increasing pressure to implement architectural practices because of external factors, such as regulatory requirements. For instance, the Clinger-Cohen Act (1996) mandates that US government agencies establish an integrated IT architecture, while the Basel framework (2023) compels banking institutions to manage their financial risks effectively. The Sarbanes-Oxley Act (2002) also encourages sound corporate governance practices. Meeting these regulatory requirements necessitates a robust architectural strategy.

## 1.2. Context and motivation

EA has evolved as a discipline for managing information systems and business elements within complex organisations since the late 1980s (Lapalme et al., 2016; Zachman, 1987). Today, various practices and frameworks are available to help organisations manage their existing architectures and transition from a current state to a future one. EA constantly evolves and is shaped by social progress, technological advances, and learning outcomes (Romero & Vernadat, 2016).

In today's fast-paced business environment, organisations continuously adjust to new challenges and change how they work. As a result, managing the entire business structure, applications, data, and technology has become complex (Brée & Karger, 2022). Organisations must remain agile and adaptable to overcome new challenges.

To achieve this, many organisations increasingly recognise the value of EA (Tamm et al., 2022) and invest heavily in it, shifting from Traditional Enterprise Architecture, limited by business constraints, and emphasising frameworks, tools, and technology to Digital Architecture. Digital Architecture integrates the latest digital capabilities, such as social media, Service-Oriented Architecture (SOA), big data analytics, Omni-channels, cloud computing, virtualisation, and the Internet of Things (IoT). This approach enables businesses to keep up with emerging technology and global business practices.

This shift in focus towards effectively managing EA within organisational contexts leads to new architectural building blocks and integrations that have significant potential to influence EA management practices (Gampfer et al., 2018).

## 1.3. Research gap

A vast amount of literature exists that delves into the evaluation and selection of software packages. This literature offers specific guidelines for assessing various software packages. However, it does not provide a universally accepted standard set of criteria that can be applied to evaluate any software package. The interpretation of each criterion varies among evaluators, and the terminology employed to describe a criterion also differs from author to author, leading to confusion (Jadhav & Sonar, 2011).

Additionally, some literature focuses solely on the functional and quality aspects of software packages and overlooks other critical factors, such as vendor information, cost and benefits, technical requirements (hardware and software), opinions, and output-related features of the software package (Jadhav & Sonar, 2011).

Similarly, several articles (Gartner, 2022; Jadhav & Sonar, 2011; Lankhorst, 2017; Sascha et al., 2014; Schekkerman, 2011) explore the features of an optimal enterprise architecture tool and provide an overview of available options. However, these studies also suggest that functional criteria cannot be generalised, and there needs to be more literature concerning the functional criteria related to the capabilities of enterprise architecture tools.

Therefore, further research is necessary to establish a practical approach for assessing and selecting enterprise architecture tools to fill this research gap.

### 1.4. RESEARCH QUESTION AND OBJECTIVES

This master thesis aims to answer two research questions to address the identified gap.

Research Question 1:

| What are the functional criteria to consider when comparing Enterprise Architecture Tools? |
|---|

Our main objective for this first research question was to create a comprehensive and well-organised list of functional criteria for systematically comparing different enterprise architecture tools. To achieve this, we conducted a systematic literature review using Kitchenham et al. (2009) guidelines involving three main phases (design, conducting, and reporting).

Research Question 2:

| Is the suggested assessment method reliable for selecting an Enterprise Architecture Tool? |
|---|

Question two, a pivotal part of this research, focused on assessing the reliability of the suggested assessment method for evaluating and selecting an enterprise architecture tool. This was done through an exploratory case study (Yin & Campbell, 2018) and a questionnaire with a panel of Information Technology Systems and Procurement Specialists experts. This research aimed to provide evidence that the purposed artefacts can determine their effectiveness in facilitating informed decision-making regarding adopting enterprise architecture tools within organisations, a topic of utmost relevance and necessity in the field.

### 1.5. RESULTS, CONTRIBUTIONS AND STUDY RELEVANCE

This research presents a unique and customisable method to help organisations evaluate and select an enterprise architecture tool that aligns with their needs. By following a systematic approach based on established criteria, organisations can make informed decisions that support their strategic goals.

Additionally, this study offers tangible benefits to organisations looking to evaluate their current and potential tools. Organisations can use the study's insights to identify trends and challenges in the enterprise architecture landscape by improving decision-making capabilities, potentially leading to industry-wide improvements.

In summary, the "A Method to Evaluate and Select an Enterprise Architecture Tool" study is relevant and essential for organisations seeking to embark on or optimise their enterprise architecture initiatives. In today's fast-paced and competitive business environment, making informed decisions about enterprise architecture tools is crucial for success. This structured approach provides a powerful tool that empowers organisations to choose tools that align with their specific needs, resulting in increased efficiency, effectiveness, cost savings, and improved competitiveness. Additionally, it helps mitigate risks and ensures future scalability and compliance, offering critical insights into a vital component of contemporary business strategy and technology adoption. It presents a comprehensive roadmap for selecting the appropriate enterprise architecture tool, enabling businesses to achieve their objectives and maintain a competitive edge.

## 1.6. DISSERTATION STRUCTURE

This dissertation thoroughly analyses enterprise architecture frameworks and tools using the design science research methodology. Chapters Two and Three delve into the history of EA frameworks and our methodology while exploring decision-making processes and multi-criteria methods. In Chapter Four, we offer a comprehensive strategy with detailed step-by-step guidance for implementation. Chapter Five showcases the practical application of our proposed method in an organisation, highlighting its ability to support informed decision-making. Finally, Chapter Six concludes our study with limitations, contributions, and suggestions for future research. Our research offers valuable insights into enterprise architecture frameworks and tools, and we hope it provides practical solutions for practitioners and researchers in this field.

# 2. LITERATURE REVIEW

In this chapter, we aim to delve into the fundamental concepts and background information that underpin our research, which is essential for achieving the proposed solution. Our analysis encompasses all the findings obtained throughout the research process, and this work aligns precisely with the scope and objectives of this dissertation. Consequently, the following analysis covers all the works contributing to developing the solution.

The chapter is divided into several parts to ensure clarity, each accounting for the essential elements that must be considered. Section 2.1 provides an overview of historical enterprise architecture frameworks, forming a solid foundation for our study. In section 2.2, we conduct a rigorous literature review to explore the functional criteria to consider when comparing enterprise architecture tools, a crucial aspect of our first research question. Finally, section 2.3 delves into an intriguing literature review focusing on the decision-making process, particularly multicriteria methods that robustly support it. Specifically, we examine the Analytical Hierarchy Process (AHP), which we use to answer our second research question.

## 2.1. EA FRAMEWORKS OVERVIEW: HISTORY AND EVOLUTION

Back in 1986, the PRISM research service of Index Systems and Hammer and Company introduced the concept of an EA framework (PRISM, 1986). The aim was to develop ideal ways of describing the architecture of distributed systems. This innovative framework, backed by a group of organisations, including IBM, became the first modern EA Framework (Harrell & Sage, 2010). Although similar ideas had been proposed earlier (Wardle, 1984), the PRISM EA framework was the first to be published. It organises an architectural description into sixteen categories grouped into four domains (organisation, application, data, and infrastructure) and four types (inventory, principles, models, and standards). PRISM EA framework is shown in Figure 2.1.

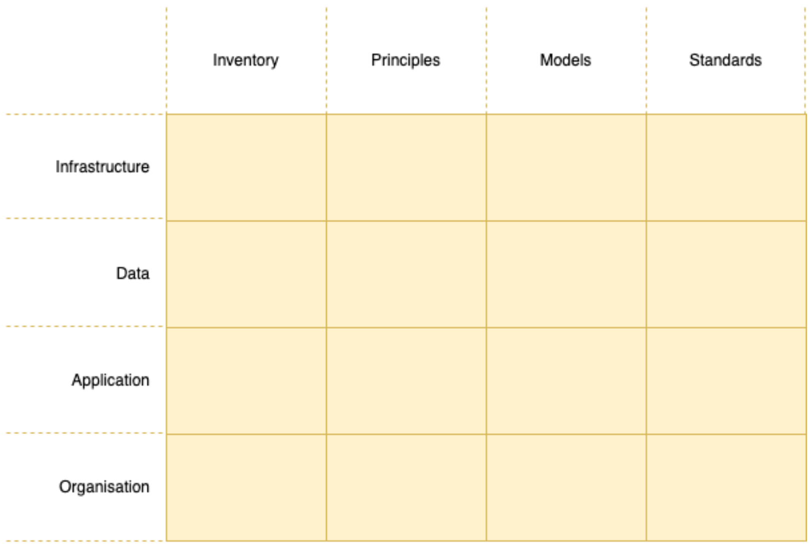


Figure 2.1 - Adapted from PRISM enterprise architecture framework (PRISM, 1986)

In 1987, IBM's marketing specialist, John Zachman, introduced a comparable framework in the IBM Systems Journal (Zachman, 1987), which underwent internal review. The Zachman Framework organises an architectural description into fifteen categories according to five perspectives (planner, owner, designer, builder, and subcontractor) and three interrogatives (what, how, and where). The framework for Information Systems Architecture is shown in Figure 2.2.

| | Data (What) | Function (How) | Network (Where) |
|---|---|---|---|
| Scope (Planner) | List of things important to the business | List of processes the business performs | List of locations in which the business operates |
| Enterprise Model (Owner) | e.g., Entity/Relationship diagram | e.g., Process flow diagram | e.g., Logistic network |
| System Model (Designer) | e.g., Data model | e.g., Data flow diagram | e.g., Distributed systems architecture |
| Technology Model (Builder) | e.g., Data design | e.g., Structure chart | e.g., System architecture |
| Components (Subcontractor) | e.g., Data definition description | e.g., Program | e.g., Network architecture |
| Functioning System | Data | Function | Communications |

Figure 2.2 - Adapted from the information systems architecture (Zachman, 1987)

Furthermore 1989, the National Institute of Standards and Technology (NIST) released the first official guidance on EA (Rigdon, 1989). The NIST EA model organises an architectural description into five different architecture levels (business unit, information, information system, data, and delivery system). The NIST EA model is shown in Figure 2.3.

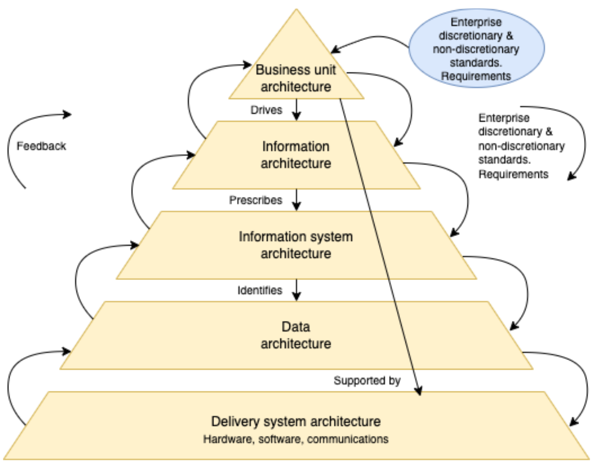


Figure 2.3 - Adapted from the NIST enterprise architecture model (Rigdon, 1989)

However, in 1992, the IBM Systems Journal published an extended version of the Zachman Framework (Sowa & Zachman, 1992), which categorises an architectural description into thirty categories based on five perspectives (planner, owner, designer, builder, and subcontractor) and six interrogatives (what, how, where, who, when, and why).

The Extended Framework for Information Systems Architecture is shown in Figure 2.4.

| | Data (What) | Function (How) | Network (Where) | People (Who) | Time (When) | Motivation (Why) |
|---|---|---|---|---|---|---|
| Scope (Planner) | List of things important to the business | List of processes the business performs | List of locations in which the business operates | List of organisations/agents important to the business | List of events significant to the business | List of business goals/strategy |
| Enterprise Model (Owner) | e.g., Entity/Relationship diagram | e.g., Process flow diagram | e.g., Logistic network | e.g., Organisation chart | e.g., Master schedule | e.g., Business plan |
| System Model (Designer) | e.g., Data model | e.g., Data flow diagram | e.g., Distributed systems architecture | e.g., Human interface architecture | e.g., Processing structure | e.g., Knowledge architecture |
| Technology Model (Builder) | e.g., Data design | e.g., Structure chart | e.g., System architecture | e.g., Human/technology interface | e.g., Control structure | e.g., Knowledge design |
| Components (Subcontractor) | e.g., Data definition description | e.g., Program | e.g., Network architecture | e.g., Security architecture | e.g., Timing definition | e.g., Knowledge definition |
| Functioning System | Data | Function | Communications | Organisation | Communications | Communications |

Figure 2.4 - Adapted from an extended information systems architecture (Sowa & Zachman, 1992)

Spewak and Hill (1992) proposed the Enterprise Architecture Planning (EAP) methodology, building upon IBM's Business Systems Planning. It involves five steps to practice EA effectively:

1. Understand and document the current state of an organisation.
2. Develop the desired future state of an organisation.
3. Analyse the gaps between current and future states.
4. Prepare the implementation plan.
5. Implement the plan.

While Spewak and Hill (1992) claimed that EAP creates the top two layers of John Zachman's Framework, it is essential to note that the framework is only mentioned for marketing purposes. EAP's deliverables are structured around four architecture domains that do not map to the three columns of the Zachman Framework. Additionally, they do not distinguish between the top two rows of the framework. EAP methodology has been the foundation for many modern EA methodologies despite these limitations.

The EAP methodology is shown in Figure 2.5.

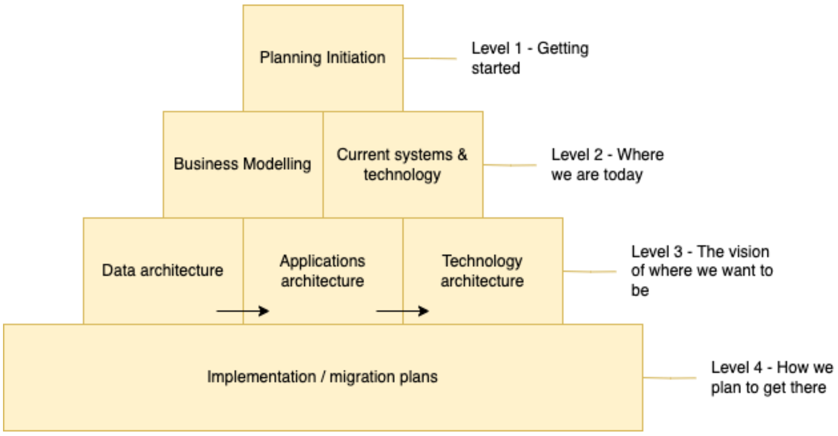


Figure 2.5 - Adapted from EAP methodology (Spewak & Hill, 1992)

In 1992, Spewak and Hill collaborated with the Government Accountability Office (GAO) to introduce an architecture development methodology for federal agencies (GAO, 1992). The GAO methodology, identified in Figure 2.6, encompasses eight steps to establish an enterprise architecture.

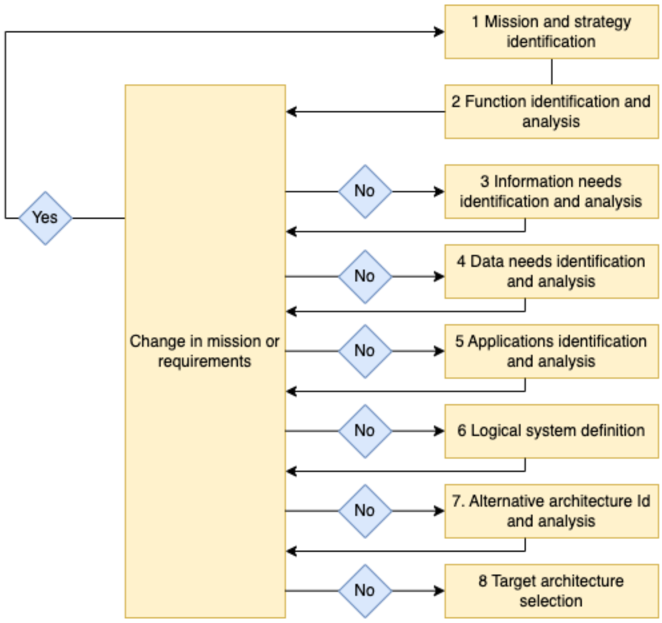


Figure 2.6 - Adapted from strategic information systems planning framework (GAO, 1992)

Best practices from prominent private and public organisations were later incorporated to enhance the methodology. In 1994, the Defense Information Systems Agency (DISA) introduced the Technical Architecture Framework for Information Management (TAFIM) (TAFIM, 1996) to expedite information system delivery, reduce costs, and promote integration and flexibility. TAFIM follows a seven-step iterative process that suggests defining four EA domains (work organisation, information, applications, and technology).

Figure 2.7 shows that the Department of Defense was among the first federal agencies to embrace EA and TAFIM.

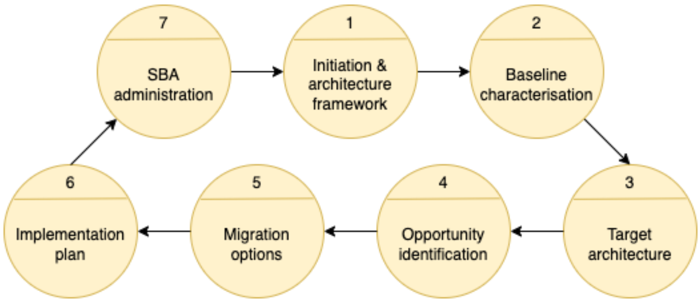


Figure 2.7 - Adapted from TAFIM methodology (TAFIM, 1996)

In 1996, Congress enacted the Clinger-Cohen Act, which mandated that all federal government departments establish consistent architectures compatible with the NIST EA model. This legislation aimed to enhance the use of information systems. In response, the Federal CIO Council initiated the Federal Enterprise Architecture (FEA) program in 1999, which included the publication of the corresponding FEA Framework (FEA, 2012; FEAF, 2013).

The FEA framework recommends that the business, data, applications, and technology architectures be described separately and outlines the same procedures as EAP for practising EA. While the FEA framework is said to be based on the Zachman Framework, it is used merely as a symbol and has no significant impact (FEAF, 2013).

In 1996, the Clinger-Cohen Act facilitated the switch from TAFIM to the Command, Control, Computers, Communications, Intelligence, Surveillance, and Reconnaissance (C4ISR) framework (C4ISR, 1997), which was then retired in 2000. Subsequently, in 2003, the Department of Defense Architecture Framework (DoDAF) replaced C4ISR (DoDAF, 2015; Schekkerman, 2003).

After TAFIM had been replaced, its materials were explicitly given to The Open Group, providing a basis for creating the TOGAF standard initiated in 1995 (TOGAF, 2022).

Unsurprisingly, the TOGAF standard also recommends describing the typical four domains in EA (business, data, applications, and technology) and recommends the Architecture Development Method (ADM) with one preliminary phase and eight cyclic phases, including describing current and future states, analysing gaps, preparing transition plans, and implementing them (TOGAF, 2022).

The TOGAF ADM is shown in Figure 2.8.

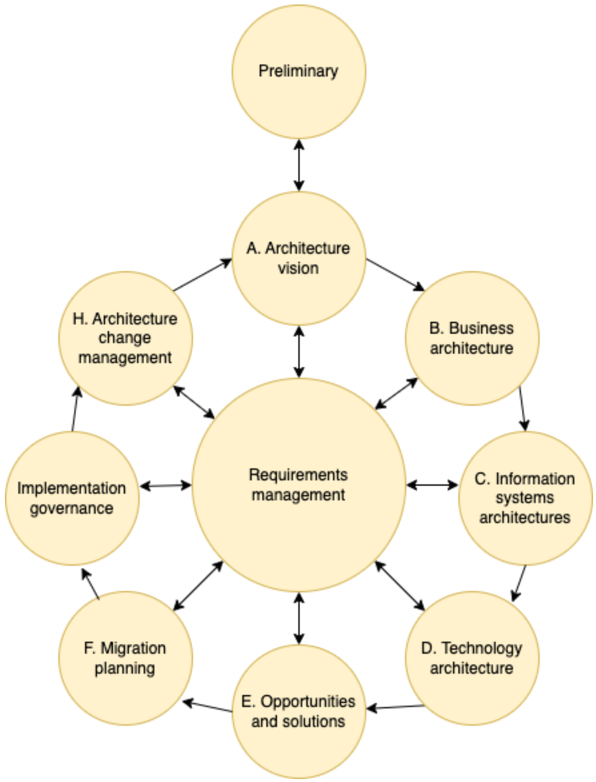


Figure 2.8 - Adapted from the TOGAF architecture development method (TOGAF, 2022)

TOGAF embodies the modern understanding of EA frameworks and is even considered a de facto industry standard in EA practice by some authors (Dietz & Hoogervorst, 2011; Lankhorst et al., 2010; Sobczak, 2013).

## 2.2. Systematic literature review in functional criteria to consider when comparing Enterprise Architecture Tools

The research method chosen for this study was a Systematic Literature Review (SLR). The guidelines developed by Kitchenham et al. (2009) have been utilised to conduct the study.

According to Kitchenham et al. (2009), the SLR process consists of three consecutive stages - planning, execution, and result analysis - along with a packaging stage that runs throughout the entire process to store the results of the previous stages. Therefore, there are two checkpoints to assess the accuracy of the SLR process.

Figure 2.9 illustrates all the activities in each phase, which will be elaborated in detail in the following subsections.

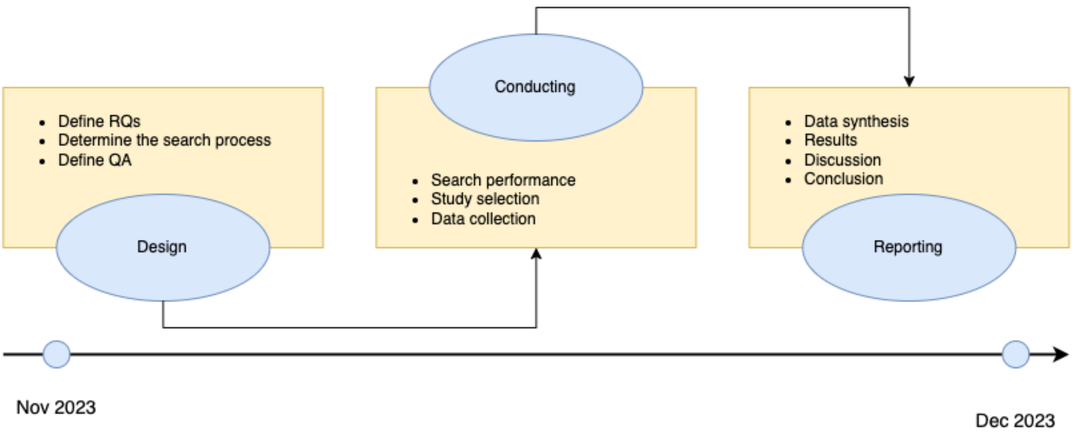


Figure 2.9 - Adapted from research activities (Kitchenham et al., 2009)

### 2.2.1. Design

This subsection describes the foundation of this review by defining the research question, determining the search process, and defining the quality assessment.

*Define research question*

Our research is focused on conducting a comprehensive and in-depth analysis of functional criteria to select an enterprise architecture tool. We aim to identify the various functional criteria for their effectiveness and efficiency. We will also consider the current challenges that are associated with the use of these tools. Our study will be based on a rigorous SLR approach, enabling us to gather data and insights from multiple sources, including academic journals, conference proceedings, and industry reports. Through this research, we hope to provide valuable insights into the use of enterprise architecture tools and contribute towards enhancing the field of Enterprise Architecture.

| What are the functional criteria to consider when comparing Enterprise Architecture Tools? |
| --- |

*Determine the search process*

This SLR searches scientific databases and industry reports instead of books, assuming that significant research is found in papers and reports. The selected sources for the search are:

Table 2.1 - Search databases

| Source | URL |
|---|---|
| ACM Digital Library | https://dl.acm.org |
| IEEE Xplore | https://ieeexplore.ieee.org/Xplore/home.jsp |
| Science Direct | https://www.sciencedirect.com |
| Scopus | https://www.scopus.com |

Our database selection was based on including full texts from the most significant journals and conference proceedings relating to the implementation of enterprise architecture tools. After an initial search of these databases, we performed further scans and reference analyses to ensure all crucial studies and a representative collection of studies were included. Additionally, we will cross-reference our research results with a core set of studies on implementing enterprise architecture tools to ensure the comprehensiveness and reliability of our findings.

The following search keywords were used to find relevant studies in the article title, keywords, and abstract:

Table 2.2 - Search query

| Sources | Search query |
|---|---|
| ACM Digital Library | Title:("enterprise architecture") AND AllField:(tool OR software) AND AllField:(selection criteria) |
| IEEE Xplore | ("Document Title":"enterprise architecture") AND ("All Metadata":tool OR "All Metadata":software) AND ("All Metadata":selection criteria) |
| Science Direct | "enterprise architecture" AND (tool OR software) AND "selection criteria" |
| Scopus | "enterprise architecture" AND (tool OR software) AND "selection criteria" |
| Other Sources | "enterprise architecture" AND (tool OR software) AND "selection criteria" |

*Define quality assessment*

After identifying several primary studies that meet our inclusion and exclusion criteria, we can proceed to evaluate their quality. As outlined in the guidelines for SLR by Kitchenham et al. (2009), we utilise three defined Quality Assessment (QA) questions to assess each research proposal and make a quantitative comparison. This process enables us to determine the overall quality of the studies and make informed decisions based on our findings.

| |
|---|
| The scoring procedure used was Yes (Y) = 1, Partially (P) = 0.5 or No (N) = 0. |

These are the quality assessment questions that have been established for the SLR:

Table 2.3 - Clarity of criteria

| **Clarity of criteria** | |
|---|---|
| Yes | The document clearly defines the criteria for evaluating enterprise architecture tools. |
| Partially | The document only mentions a few criteria for evaluating enterprise architecture tools. |
| No | The document does not describe or mention any criteria for evaluating enterprise architecture tools. |

Table 2.4 - Explanation of the research process

| **Explanation of the research process** | |
|---|---|
| Yes | The document provides a clear explanation of the research process. |
| Partially | The document mentions the process but does not explain it. |
| No | The document needs to explain the research process. |

Table 2.5 - Documentation of work limitations

| **Documentation of work limitations** | |
|---|---|
| Yes | The document clearly explains the limitations of the criteria for evaluating enterprise architecture tools. |
| Partially | The document mentions the limitations but does not explain them. |
| No | The document does not mention any limitations. |

These questions can help us check the proposals' biases and external and internal validation.

### 2.2.2. Conducting

This subsection outlines the protocol for conducting the SLR. Upon completing the primary studies, a specialised extraction form is used to gather the essential data to address the defined research question.

*Search performance: Inclusion and exclusion criteria*

Our research solely focuses on papers providing comprehensive criteria to consider when comparing enterprise architecture tools. Duplicate reports of the same study are not considered, and only the most comprehensive version is included. This SLR highlights the factors relevant to enterprise architecture tools. For a better understanding, please refer to Table 2.6, which displays the inclusion and exclusion criteria used in this research.

Table 2.6 - Inclusion and exclusion criteria

| Inclusion criteria | Exclusion criteria |
|---|---|
| Studies including conferences proceedings, journal papers and industry reports. | Studies not in English. |
| Studies between the years 2000-2023. | Duplicated studies by title. |
| Studies that focus on enterprise architecture tools and/or software. | Studies that are not related to the research questions. |

*Study selection*

Once we have gathered primary studies that may be relevant, it is crucial to assess their relevance. To do so, we review the selected primary studies. Furthermore, we randomly re-evaluate the chosen studies following the initial screening to ensure that our inclusion and exclusion decisions remain consistent. As a result, our selection of studies is carried out through the following meticulous processes:

- Search in databases to identify relevant studies using the search keywords.
- Exclude studies based on the exclusion criteria.
- Exclude irrelevant studies based on analysis of their titles and abstracts.
- Evaluation of the selected studies based on reading the full text.
- Obtain primary studies.

*Data collection*

Gathering information from various studies is a critical step in the research process, known as data extraction. A standardised data extraction form is used for all primary studies to ensure a thorough analysis. Table 2.7 illustrates the specific data extraction form implemented for this purpose.

Table 2.7 - Data collection

| # | Extracted Data | Description | Type |
|---|---|---|---|
| 1 | Identity of study | Unique identity for the study. | General |
| 2 | Bibliographic references | Authors, year of publication, title, and source of publication. | General |
| 3 | Type of study | Book, journal paper, conference paper, workshop paper, white paper. | General |
| 4 | Research method used for data collection | Included technique for the design of the study, e.g., case study, survey, experiment, interview to obtain data, observation. | General |
| 5 | The criteria which are considerer | Description of the criteria that are considered on comparing enterprise architecture tools. | RQ1 |
| 6 | Finding/Contribution | Indicating finding and contribution of study. | General |

### 2.2.3. Reporting

This subsection answers the first research question based on selected primary studies. Furthermore, a comprehensive examination of the data obtained from the primary studies culminates in a general discussion that is also included in this section.

*Data Synthesis*

Table 2.8 shows the number of papers found for each source based on the keywords searched in the selected database. The second column reveals the results of the initial paper screening for each source, and the "Candidate" column shows the number of papers selected after eliminating exclusion criteria. The "Selected" column indicates the number of documents from each source selected after the inclusion process.

Table 2.8 - Studies retrieved through search engines

| Source | Paper found | Candidate | Selected |
|---|---|---|---|
| ACM Digital Library | 52 | 4 | 0 |
| IEEE Xplore | 5 | 2 | 0 |
| Science Direct | 85 | 4 | 0 |
| Scopus | 6 | 1 | 0 |
| Other Sources | 3 | 3 | 2 |
| **Total** | **151** | **14** | **2** |

The search process was done in November 2023.

The significant gap between the studies found and candidate studies is due to duplicates, short, irrelevant, or inappropriate papers. Figure 2.10 shows the number of studies after each stage of the process.

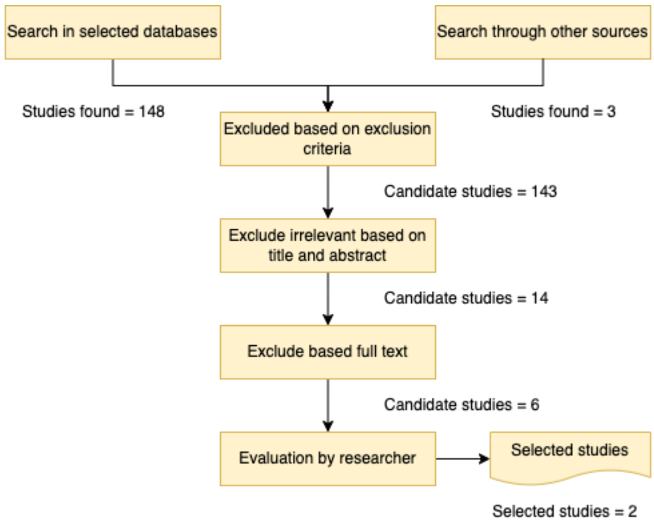


Figure 2.10 - Adapted from finding studies (Moher et al., 2009)

Four of the candidate papers were rejected. One was relevant to our objective, but it needed to be demonstrated which functional criteria they used to evaluate the enterprise architecture tools. The other three papers were rejected because of their short descriptions and the need to provide more information about their findings.

Table 2.9 shows the number of citations for the selected papers. The "Cited" columns are obtained from Google Scholar.

Table 2.9 - Selected papers citations

| Study | Cited |
| --- | --- |
| (Schekkerman, 2011) | 92 |
| (Gartner, 2022) | 11 |

One of the two studies was published after 2020, so it is expected to have a low citation number. The second study has high citation rates, with over fifty other sources citing it.

*Quality assessment*

We began our SLR by identifying primary studies, which were then evaluated using a set of quality assessment questions outlined in the section defining quality assessment.

In Table 2.10, scores are assigned to each study for each question, with the "% total score" row representing the percentage of points obtained by all selected studies. The last row, "% by max QA" shows the percentage of points collected by the values assigned for a given quality assessment question over the points collected if every selected study got the highest score.

All primary studies scored at least two and a half on the highest possible score of three, representing 63% and 75% of the maximum possible score, respectively. Our findings indicate that the first and third questions are distributed over 36% of the total score, while question two represents 27%. Overall, the quality of the research presented by the proposals evaluated is good since they all obtained a minimum quality score of 75%.

Table 2.10 - Quality assessment of papers chosen

| Study | QA1 | QA2 | QA3 | Total score | % by max # |
|---|---|---|---|---|---|
| (Gartner, 2022) | Y | P | Y | 2,5 | 63% |
| (Schekkerman, 2011) | Y | Y | Y | 3 | 75% |
| Total | 2 | 1,5 | 2 | 5,5 | |
| % total score | 36% | 27% | 36% | 100% | |
| **% by max QA** | **100%** | **75%** | **100%** | | |

*Findings*

We identify thirteen functional criteria for evaluating enterprise architecture tools presented in Table 2.11.

Table 2.11 - Functional criteria to consider when comparing Enterprise Architecture Tools

| # | Criteria | Criteria meaning | Studies |
|---|---|---|---|
| C1 | Repository | The enterprise architecture tools leverage a robust data repository to store and categorise various objects, models, and artefacts. The repository plays a crucial role in defining the scalability and functionality of the tool and can either be a commercial relational database management system or a proprietary repository system.<br>The repository facilitates seamless data management features like model versioning, roll-back, and access control by enabling collaboration among concurrent users and combining models. | (Gartner, 2022; Schekkerman, 2011) |
| C2 | Modelling | Business strategies, objectives, goals, constraints, capabilities, personas, customer journeys, activities, processes, value streams, policies, decision models, metrics, applications, technologies, roadmaps, projects, and programs are structured and related. | (Gartner, 2022; Schekkerman, 2011) |
| C3 | Analysis | Recognising, evaluating, ranking, and monitoring shortcomings, obstacles, prospects, and hazards within an organisation's range of abilities, investments, procedures, ventures, systems, and technologies is essential. Enterprise architecture software assists in building models and offers assistance for examining and managing them. Analytical aid is associated with specific modelling methods, such as Flow Analysis for process/workflow modelling. Sophisticated analytical support allows the model to be closely examined or subjected to specific techniques. Manipulation functions alter how models are depicted, displaying particular categories of entities or merging distinct models. | (Gartner, 2022; Schekkerman, 2011) |
| C4 | Presentation | Information can be displayed through dashboards, heat maps, models and scenarios, which can help colleagues assess the impact of decisions and proposed solutions. | (Gartner, 2022) |
| C5 | Usability | Ease-of-use features and functions enable support for various users, including enterprise architects, analysts, business users, technology architects, strategy analysts, and operations researchers. | (Gartner, 2022) |
| C6 | Configuration Management | Setup and administration features are implemented to support the security of the Enterprise architecture tool. Different classes of users are set up with their respective access rights and feature alignment. Furthermore, access to information stored in the repository is controlled. | (Gartner, 2022) |

(continued)

Table 2.11 - (continued) Functional criteria to consider when comparing Enterprise Architecture Tools

| # | Criteria | Criteria meaning | Studies |
|---|---|---|---|
| C7 | Extensibility and Customization | Expanding the metamodel of an Enterprise architecture tool is achievable by introducing new modelling concepts and relationship types, creating custom graphical representations, and enforcing domain-specific rules. This allows tailoring the enterprise architecture tool to suit an organization's unique needs. Customization can be achieved by adding or modifying existing modelling approaches. The underlying metamodels of the tool can be altered or supplemented to accommodate new modelling approaches. Moreover, the tools functionality and behaviour can be tailored through a programming interface or by adding external components. Integration with other software products can be achieved either directly or through middleware. Data can be imported and exported using standard formats like text files or HTML. | (Gartner, 2022; Schekkerman, 2011) |
| C8 | Publication | Enables easy access to the data in the Enterprise architecture tool, capturing feedback on content and score elements in repository views across the organization and beyond. | (Gartner, 2022) |
| C9 | Frameworks | The repository structure and relationships among artefacts support different architectural methods and vertical industry models. This includes selecting EA frameworks and identifying overlaps and gaps. | (Gartner, 2022; Schekkerman, 2011) |
| C10 | Integration | The enterprise architecture tool can be a hub to unite different standard tools in the enterprise technology ecosystem. It can expose and import data to and from products such as product management, configuration management database (CMDB), Project Portfolio Management (PPM), business process management suite (BPMS), and process mining. | (Gartner, 2022) |
| C11 | Model Development Interface | The model development interface is a crucial component of enterprise architecture development tools. It is used to design, build, maintain, and manipulate models that constitute the architecture. The interface must be intelligently structured, with limited screen space, and be logical and consistent to use and navigate. It should follow the graphical user interface conventions and guidelines for its host operating system. | (Schekkerman, 2011) |
| C12 | Automation | For EA practitioners, there are automated tools available that can significantly simplify their work by providing process and policy automation functions. These tools can speed up the development of EA by automating repetitive tasks and generating architecture models from stored data or data manipulation functions. EA practitioners can create macros or scripts that combine functions to save time and achieve consistent and reliable outcomes. In summary, automated tools can empower EA practitioners to deliver value quickly and efficiently, equipped with the latest information. | (Gartner, 2022; Schekkerman, 2011) |
| C13 | Innovation management | Mechanisms that facilitate the creation and tracking of innovation and change initiatives, including support for creativity, trendspotting, colleague engagement, PPM links, and benefits realization. | (Gartner, 2022) |

*Discussion*

Despite the scarce studies on this topic, our analysis of existing data puts forth a cohesive, functional criteria list that offers valuable guidance and support for organisations navigating the intricate landscape of enterprise architecture tool selection.

In this subsection, we delve into the findings derived from our research question, focusing on pivotal insights from primary studies that elucidate the functional criteria for comparing enterprise architecture tools. All the studies under analysis converge on identifying foundational functional criteria as integral considerations in evaluating enterprise architecture tools. These critical criteria include Repository, Modelling, Analysis, Extensibility and Customization, Frameworks, and Automation.

Gartner (2022) enriches this spectrum by introducing additional critical functional elements. These encompass Presentation, Usability, Configuration Management, Publication, Integration, and Innovation Management. This augmentation provides a more comprehensive framework for assessing and selecting enterprise architecture tools.

Similarly, Schekkerman (2011) contributes to the discourse by highlighting the significance of functional criteria related to the Model Development Interface. Acknowledging this aspect adds depth to our understanding of the intricate criteria for selecting enterprise architecture tools.

*Conclusion*

Our research has identified thirteen functional criteria frequently employed in comparing and choosing enterprise architecture tools. These insights were instrumental in crafting a thorough approach to evaluate and select both present and future enterprise architecture tools, which we then put to the test. Our method was informed by the criteria we discovered in response to our initial research query, and we leveraged these functional criteria in an actual case study to gain deeper insight into their efficacy in enterprise architecture tool implementations. This bolstered our list of recommendations and opened new avenues for future exploration.

## 2.3. DECISION-MAKING

This section explores the literature surrounding decision-making. To ensure clarity, the section is broken down into three subsections. Firstly, subsection 2.3.1 will provide an in-depth decision-making process analysis, outlining the essential steps for successful completion. Subsection 2.3.2 will distinguish between various multi-criteria methods that assist with decision-making, all of which were extensively researched during the preparation of this dissertation. Finally, subsection 2.3.3 will furnish comprehensive information on the AHP.

### 2.3.1. Decision-making process

According to the Oxford Advanced Learner's Dictionary (Brown & Lynn, 1976), *decision-making* is "the process of deciding about something important, especially in a group of people or in an organization".

Decision-making is a process that is constantly present in all our lives. Everything we do, consciously or unconsciously, results from some decision. We gather information that helps us understand the world, develop a judgment, and reach conclusions. However, not all information collected helps develop this judgment; holding a large amount of information can be as harmful as holding very little information. To decide, it is necessary to know the problem, the needs, the purpose of the decision, the decision maker's criteria and sub-criteria, the interested parties, and what alternatives exist (T. Saaty, 2008).

Decision-making, nowadays, has become a mathematical science. This formalises the opinions we consider so that a decision is transparent in all its aspects. Decision-making must involve criteria and sub-criteria duly identified by a decision-maker used to classify the alternatives for a decision. It is necessary to create priorities not only for the other options to the criteria or sub-criteria but also for the criteria and the alternatives themselves (T. Saaty, 2008). With this, the author intends to show how complex decision-making can be.

According to Anderson et al. (2012), decision-making is generally associated with the first five steps of problem-solving. Therefore, the first step in decision-making is identifying and defining the problem. Decision-making ends with choosing an alternative, which is making the decision.

For Baker et al. (2001), the main priority when deciding is to establish who the decision-makers and the parties interested in the decision's results are.

Identifying these figures in advance reduces the possibility of mistakes throughout the decision-making process.

Baker et al. (2001) defend a decision-making sequence that allows for rational and appropriate problem-solving. Figure 2.11 shows the steps mentioned, and each is described below.

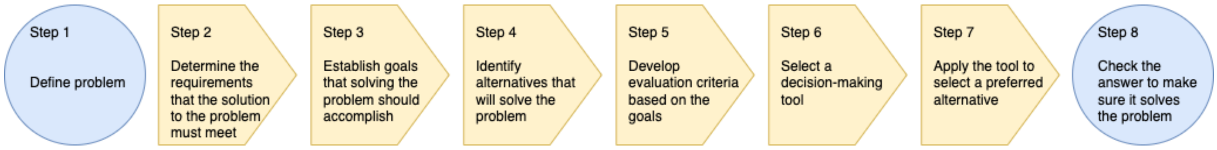


Figure 2.11 - Adapted from the general decision–making process (Baker et al., 2001)

*The first step is to define the problem*

The problem must be contained in a single sentence, concise and clear, that describes the initial conditions and the desired conditions.

*The second step is to determine the solution requirements*

Requirements are conditions that the solution to the problem must meet.

*The third step is to establish the desired objectives*

Objectives are the intentions and desired values found in solving the problem. While requirements are the minimum necessary for the solution to be correct, objectives must have additional positive points for the solution.

*The fourth step is to identify alternatives*

Alternatives must offer different approaches to change the initial condition to the desired condition. The other options must meet the requirements and objectives defined in the previous steps. When describing each alternative, we must show how it can solve the problem.

*The fifth step is to define the decision criteria*

Decision criteria must be defined based on the objectives set. They evaluate how much each alternative can achieve. Therefore, the requirements must be well-detailed so that the implications of each alternative are clear to decision-makers. Maintaining the number of criteria is essential. However, all objectives must generate at least one criterion; if an aim does not raise a criterion, it must be eliminated.

*The sixth step is to select a decision-making support tool*

The selection of the tool/method should be based on the complexity of the problem and the experience of those involved in the process. Generally, the more straightforward the technique, the better. In subsection 2.3.2, some of the existing methods are described.

*The seventh step is to apply the chosen tool*

Alternatives can be evaluated with quantitative, qualitative, or a combination of methods. The criteria must be considered and used to classify/order the other options. Sensitivity and uncertainty analyses can also be carried out to improve the quality of the process.

*The eighth step is to check the validity of the results*

After an alternative has been selected, the solution to the problem must be verified and validated to ensure that it effectively solves the identified problem. The final solution must meet the requirements and achieve the objectives.

According to Baker et al. (2001), the decision analysis techniques elucidated in publications are logical procedures that facilitate the application of critical thinking to information, data, and experiences. Such techniques prove valuable in making an informed decision between multiple alternatives.

### 2.3.2. Multicriteria methods to support decision-making

Decision-making becomes relatively simple when considering a problem with a single criterion. In this case, we only need to choose the alternative that carries the most significant weight. For instance, if a person's only criterion for buying a car is the price, he or she will choose the most economical car. However, when we evaluate alternatives with multiple criteria, many issues, such as criteria weights, dependencies, and conflicts, complicate the choice, and more sophisticated methods become necessary.

Decision support methods are rational and systematic processes that apply human critical thinking to information and concrete data to make a balanced decision, especially when the alternative solutions are not clear. These methods are based on several steps, including clarifying the problem's purpose, evaluating risks and benefits, and scoring criteria and alternatives. Scoring helps translate human language into mathematical language (Baker et al., 2001).

Decision support methods are adaptable to numerous situations, determined by the complexity of the problem, the client's needs, the team's experience, and the time and resources available. No one-size-fits-all method exists for all decisions (Baker et al., 2001).

Tzeng and Huang (2011) argue that to deal with problems in the decision-making process, the first step is to identify and understand the situation. Next, we must quantify and evaluate the existing attributes, criteria, and alternatives. The next step is to select an appropriate method to assess possible options.

According to Kahraman (2008), there are two primary approaches to dealing with Multiple Criteria Decision-making (MCDM) problems, as shown in Figure 2.12:

- Multiple Attribute Decision-Making (MADM) and,
- Multiple Objective Decision-Making (MODM).

MADM applies when choosing the best alternative and considers a limited number with discrete preference classifications.

As MODM, it is more suitable when the number of other options is significantly high, or even infinite, and continuous functions represent the variables.

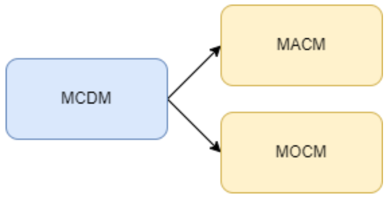


Figure 2.12 - Adapted from the approach to decision-making processes with multiple criteria (Kahraman, 2008)

MADM refers to deciding between available alternatives, characterised by multiple attributes that generally conflict. MADM methods are decision-making aids to evaluate competing alternatives defined by various attributes (Chang, 2005).

The MADM approach requires a choice between decision alternatives described by their attributes. Problems in this approach are considered to have a predetermined and limited number of decision alternatives. MADM approaches can be seen as alternative methods for combining information from a decision matrix from a given problem with additional information from the decision maker to determine a prioritisation, screening, or final selection between alternatives. The vast majority of MADM methods require this additional information from the decision maker to reach a final classification of other options (Kahraman, 2008).

The AHP is a widely recognised technique in MCDM. It has been extensively studied across multiple fields, with more than 1300 articles and 100 doctoral theses dedicated to its exploration (Subramanian & Ramanathan, 2012).

This approach is precious in considering the subjective perspectives of decision-makers, which is why it was exclusively selected for use in this dissertation.

Several methods can be applied within MADM. Several factors must be considered to choose the most appropriate method. Thus, Table 2.12 summarises these methods collected through a literature review, where the advantages and disadvantages of each one can be verified.

Table 2.12 - Adapted from the summary of MCDM methods (Velasquez & Hester, 2013)

| Method | Advantages | Disadvantages |
|---|---|---|
| **SAW** | Ability to compensate between criteria; intuitive for decision makers; the calculation is simple and does not require complex computer programs. | The estimates revealed do not always reflect the actual situation; the results obtained may not be logical. |
| **TOPSIS** | It has a simple process that is easy to use and program; the number of steps is constant regardless of the number of attributes. | Using Euclidean distances does not consider the correlation between attributes; it is challenging to prioritize and maintain consistency in the decision. |
| **ELECTRE** | It considers uncertainty and imprecision. | The process and outcome can be challenging to explain in layperson's terms. |

(continued)

Table 2.12 - (continued) Adapted from the summary of MCDM Methods (Velasquez & Hester, 2013)

| Method | Advantages | Disadvantages |
|---|---|---|
| **AHP** | Easy to use; hierarchy structure easily adjusts to various problems; does not require large amounts of data. | It can generate problems due to the interdependence between criteria and alternatives and lead to inconsistencies in the prioritization of criteria. |
| **MAUT** | Takes uncertainty into account; can incorporate preferences. | Requires a large amount of input data; preferences must be explicit. |
| **CBR** | It does not require too much information; requires little maintenance; may improve over time; can adapt to changes. | Sensitive to inconsistent data; requires many cases. |
| **DEA** | Able to deal with multiple inputs and outputs; efficiency can be analysed and quantified. | It does not consider inaccurate data and assumes that all inputs and outputs are precisely known. |
| **Fuzzy Set Theory** | Allows inaccurate inputs; considers insufficient information. | Difficult to develop; may require many simulations before being put into practice. |
| **SMART** | Simple; allows any prioritization technique; less effort on the part of decision-makers. | The procedure may not be convenient considering the problem framework. |
| **GP** | Able to deal with large-scale problems; can produce an infinite number of alternatives. | It needs to be combined with other MCDM methods to weight coefficients. |
| **PROMETHEE** | Easy to use; does not require the assumption that the criteria are proportional. | It does not provide a straightforward method by which to assign weights. |

### 2.3.3. Analytic Hierarchy Process

The AHP is a method that assists in making complex decisions. In addition to determining the best decision, this method helps to select and justify the chosen option. Professor Thomas Saaty from the University of Pennsylvania in the United States of America developed it in the 1970s. Since then, it has been extensively studied.

AHP was designed to solve complex multi-criteria decision problems. This method requires the decision maker to present judgments about the relative importance of each criterion and then specify a preference for each decision alternative using each criterion. The output of the AHP is a prioritised ranking of decision alternatives based on the general preferences expressed by the decision maker (Anderson et al., 2012).

Saaty and Vargas (2012) state that AHP is a fundamental approach to decision-making. It was designed to deal with rationality and intuition to select the best alternatives evaluated against various criteria. In this process, the decision maker makes superficial pairwise comparison judgments to develop general priorities for ranking alternatives. AHP allows for inconsistencies in judgments and provides a means to improve consistency.

Saaty (2008b) highlights that AHP is a theory of relative measurement with absolute scales of tangible and intangible criteria based on the judgment of specialised people. AHP translates a multidimensional problem into a one-dimensional problem. Decisions are determined by a single number for the best result or by a priority vector that allows the different possible results to be ordered.

Thus, AHP is a comprehensive and rational mathematical procedure for structuring a problem to quantify and transform perceptions, feelings, and value judgments, which may sometimes seem abstract, into finite, tangible and perceptible results. It is used globally in various decision-making situations in government, business, industry, healthcare, and education.

The following steps are necessary to develop this method, and they will be applied in the development of this dissertation.

*Develop a hierarchy*

The AHP is a problem-solving method that visually represents the problem. This includes the hierarchy's objective, criteria, and decision alternatives, as shown in Figures 2.13 and 2.14. The top level of the hierarchy represents the overall objective, while the second level consists of the essential criteria for achieving that objective. At the third level, each decision alternative is evaluated regarding its contribution to each criterion.

In the AHP, the decision maker assigns weights to each criterion based on its importance in achieving the overall objective. The decision maker then evaluates each decision alternative, indicating a preference for each based on how well it satisfies each criterion.

The AHP synthesises this information using a mathematical process, providing an overall priority ranking of decision alternatives (Anderson et al., 2012).

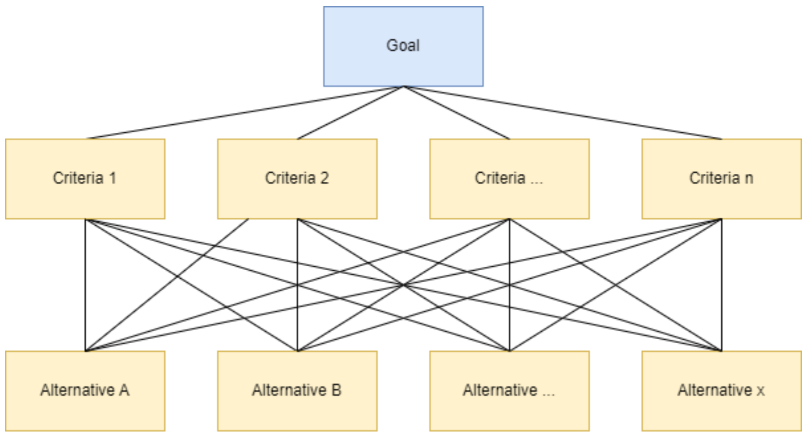


Figure 2.13 - Adapted from the simple hierarchy of a problem (Anderson et al., 2012)

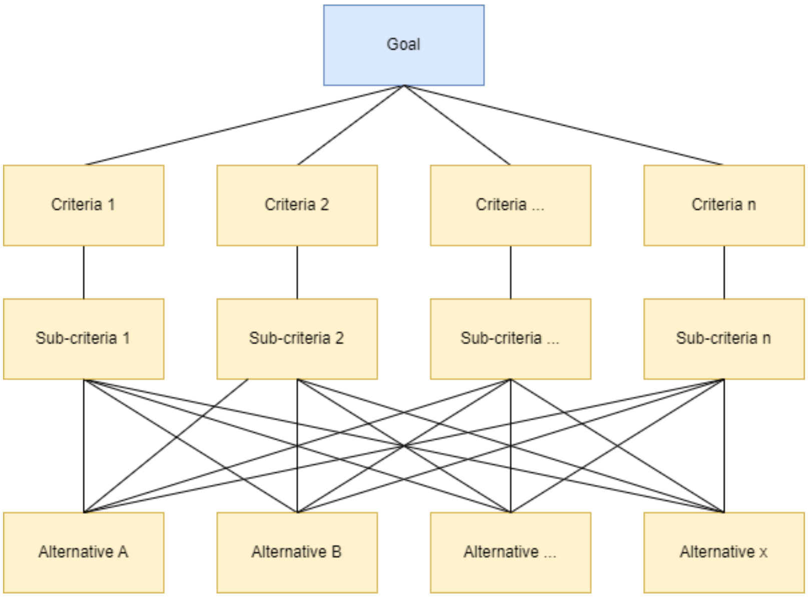


Figure 2.14 - Adapted from the complex hierarchy of a problem (Anderson et al., 2012)

When making decisions using the AHP, decision-makers create a hierarchy and systematically evaluate the various elements by comparing them in pairs. This evaluation can be based on either concrete data or the decision-maker's judgment of each component's relative importance. A key feature of AHP, as explained by Anderson et al. (2012), is that it incorporates human judgments into the decision-making process, not just numerical data. These judgments are then converted into numerical values, allowing for a consistent and rational comparison of all elements within the hierarchy. This unique characteristic of AHP enables decision-makers to assign a numerical weight or priority to each component, even when they may be distinct and challenging to compare using other decision-making methods.

*Pairwise Comparisons*

The AHP is a valuable decision-making method employing paired comparisons to establish criteria and decision alternative priorities.

Two criteria are compared through paired comparisons to determine the less dominant one and assign it a value on a scale of one to nine. This enables evaluating how often a criterion is more dominant than its pair, with the inverse value used to compare the less dominant criterion.

Saaty (2008) asserts that a scale of numbers is necessary for making comparisons and indicating the level of importance or dominance of one criterion over another. Rather than assigning two numbers and creating a ratio, a single number from the fundamental scale of one to nine represents this ratio, the closest integer approximation to the relationship.

Saaty and Vargas (2012) underscore the importance of the fundamental scale, displayed in Table 2.13, and its respective meanings. This is a crucial aspect of the AHP approach.

Table 2.13 - Adapted from the fundamental scale of absolute numbers (T. Saaty, 2008)

| Intensity of importance | Definition | Explanation |
|---|---|---|
| 1 | Equal importance | Two activities contribute equally to the objective. |
| 2 | Weak or slight | |
| 3 | Moderate importance | Experience and judgement slightly favour one activity over another. |
| 4 | Moderate plus | |
| 5 | Strong importance | Experience and judgement strongly favour one activity over another. |
| 6 | Strong plus | |
| 7 | Very strong or demonstrated importance | An activity is favoured very strongly over another; its dominance demonstrated in practice. |
| 8 | Very, very strong | |
| 9 | Extreme importance | The evidence favouring one activity over another is of the highest possible order of affirmation. |
| Reciprocals of above | If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i* | A reasonable assumption. |
| 1.1 - 1.9 | If the activities are very close | May be difficult to assign the best value but when compared with other contrasting activities the size of the small number would not be too noticeable, yet they can still indicate the relative importance of the activities. |

The fundamental scale shows the flexibility of AHP as it can accommodate the unique preferences of each decision-maker.

*Comparison matrix*

Paired comparisons must be translated into the comparison matrix; each numerical classification of the fundamental scale must be inserted in this matrix. The matrix comparison is just an organisation of paired comparisons, as shown in Table 2.14.

Table 2.14 - Adapted from pairwise comparison matrix (T. L. Saaty & Vargas, 2012)

| Criteria j / Criteria i | Criteria 1 | Criteria 2 | ... | Criteria n |
|---|---|---|---|---|
| Criteria 1 | 1 | $a_{12}$ | ... | $a_{1n}$ |
| Criteria 2 | $a_{21}=1/a_{12}$ | 1 | ... | $a_{2n}$ |
| ... | ... | ... | ... | ... |
| Criteria n | $a_{n1}=1/a_{1n}$ | $a_{n2}=1/a_{2n}$ | ... | 1 |

To establish the hierarchy, the matrix must first be populated with criteria and compared to determine their objectives. Sub-criteria must be compared against their corresponding criteria for a more intricate hierarchy until alternatives are reached. Comparing the other options involves evaluating them against their corresponding criterion or sub-criterion. At each stage, a matrix, like Table 2.14, is created.

The criteria are represented in rows (i) and columns (j), with $a_{ij}$ indicating the assigned importance value. The diagonal of the matrix is always filled with the value one, as each element is equally important to itself. It is important to note that inverse values are represented as $1/a_{ij}$.

*Synthesis process*

The AHP synthesis process is a helpful tool in determining the hierarchy's objective priority. This is achieved by normalising the comparison matrix to obtain a priority vector. To obtain this priority vector, we must follow these steps:

1. Begin by totalling the values of each column of each comparison matrix, as exemplified in Table 2.15.

Table 2.15 - Adapted from the total of each column (T. L. Saaty & Vargas, 2012)

| Criteria j / Criteria i | Criteria 1 | Criteria 2 | ... | Criteria n |
|---|---|---|---|---|
| Criteria 1 | 1 | $a_{12}$ | ... | $a_{1n}$ |
| Criteria 2 | $a_{21}$ | 1 | ... | $a_{2n}$ |
| ... | ... | ... | ... | ... |
| Criteria n | $a_{n1}$ | $a_{n2}$ | ... | 1 |
| ∑ | ∑ criteria 1 | ∑ criteria 2 | ... | ∑ criteria n |

2. Divide each element of the comparison matrix by its sum; the resulting matrix is called the normalised comparison matrix, as shown in Table 2.16.

Table 2.16 - Adapted from the comparison matrix after normalisation (T. L. Saaty & Vargas, 2012)

| Criteria i \ Criteria j | Criteria 1 | Criteria 2 | ... | Criteria n |
|---|---|---|---|---|
| Criteria 1 | 1/∑ criteria 1 | $a_{12}$/∑ criteria 2 | ... | $a_{1n}$/∑ criteria n |
| Criteria 2 | $a_{21}$/∑ criteria 1 | 1/∑ criteria 2 | ... | $a_{2n}$/∑ criteria n |
| ... | ... | ... | ... | ... |
| Criteria n | $a_{n1}$/∑ criteria 1 | $a_{n2}$/∑ criteria 2 | ... | 1/∑ criteria n |

3. Calculate the average of the elements in each row of the normalised comparison matrix; these averages provide the priorities for the criteria, as shown in Table 2.17.

Table 2.17 - Adapted from the calculation of eigenvector (T. L. Saaty & Vargas, 2012)

| Criteria i \ Criteria j | Criteria 1 | Criteria 2 | ... | Criteria n | Priority |
|---|---|---|---|---|---|
| Criteria 1 | 1/∑ criteria 1 | $a_{12}$/∑ criteria 2 | ... | $a_{1n}$/∑ criteria n | ∑ criteria 1/n |
| Criteria 2 | $a_{21}$/∑ criteria 1 | 1/∑ criteria 2 | ... | $a_{2n}$/∑ criteria n | ∑ criteria 2/n |
| ... | ... | ... | ... | ... | ... |
| Criteria n | $a_{n1}$/∑ criteria 1 | $a_{n2}$/∑ criteria 2 | ... | 1/∑ criteria n | ∑ criteria n/n |

Thus, the priority vector is obtained, and the synthesis process is completed. Considering the defined hierarchy, the synthesis process must be applied to all existing comparison matrices in the problem.

*Consistency*

It is crucial to validate the classifications made by the decision maker in the AHP as they are subjective. With multiple comparisons between criteria, achieving perfect consistency can be challenging, leading to some degree of inconsistency. To tackle this issue, a method to measure the degree of inconsistency has been developed, known as the Consistency Ratio (CR). Equation (1) shows the calculation involved.

$$CR = \frac{CI}{RI} \qquad (1)$$

The denominator Random Consistency Index (RI) is the consistency index of a randomly generated comparison matrix. The RI value depends on the number of elements (n) to be compared and is given by the values in Table 2.18.

Table 2.18 - Adapted from the random consistency index (T. L. Saaty & Vargas, 2012)

| **n** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RI** | 0,00 | 0,00 | 0,52 | 0,89 | 1,11 | 1,25 | 1,35 | 1,4 | 1,45 | 1,49 | 1,52 | 1,54 | 1,56 | 1,58 | 1,59 |

The numerator Consistency Index (CI) is calculated using Equation (2):

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad (2)$$

To determine the $\lambda_{max}$, which represents the mean of the weighted sum vector values, we can utilise the following steps:

1. Begin by multiplying the priority vector by the respective weights of the comparison matrix. Then, sum up the matrix values to obtain the vector of weighted sums.
   This calculation can be represented by the Equation (3):

$$\sum Criteria_{1/n} * \begin{bmatrix} 1 \\ a_{21} \\ \dots \\ a_{n1} \end{bmatrix} + \sum Criteria_{2/n} * \begin{bmatrix} a_{12} \\ 1 \\ \dots \\ a_{n2} \end{bmatrix} + \dots + \sum Criteria_{n/n} * \begin{bmatrix} a_{1n} \\ a_{2n} \\ \dots \\ 1 \end{bmatrix} \qquad (3)$$

2. Proceed to divide the weighted sum vector's elements by the priority vector's elements (i.e., by the weight of each criterion).

3. Then, compute the average of the previously obtained values (represented by $\lambda_{max}$).

If the CR value is less than 10%, then the weights assigned by the decision maker are consistent. However, if the value is higher, it indicates that the weights assigned are inconsistent and unacceptable. Consequently, the decision maker must review the weights assigned to the pairs of elements before proceeding with the analysis.

*Priority ranking*

At this stage, we have acquired personalised priorities that indicate the favoured option for every criterion. However, it is crucial to determine the global or ultimate priority for each alternative. This priority considers the preference for the options regarding each criterion, bearing in mind that each criterion carries a different weight.

To compute the global priority, we compare the priority vector of every alternative with each criterion or sub-criterion, depending on whether the hierarchy is complex. The priority vector of each criterion is also considered. Table 2.19 displays the vectors required to calculate the global/final priority.

Table 2.19 - Adapted from the summary of priority vectors (T. L. Saaty & Vargas, 2012)

| | Criteria 1 | Criteria 2 | ... | Criteria n |
|---|---|---|---|---|
| Criteria priority vector | $c_1$ | $c_2$ | ... | $c_n$ |
| Priority vector of alternative A | $a_1$ | $a_2$ | ... | $n_a$ |
| Priority vector of alternative B | $b_1$ | $b_2$ | ... | $b_n$ |
| ... | ... | ... | ... | ... |
| Priority vector of alternative X | $x_1$ | $x_2$ | ... | $x_n$ |

Through synthesis, we have determined the relative importance of the options (a and b) and factors (x and c). Following the guidance outlined in Table 2.20, we have multiplied each option's priority by each factor's priority. This computation generates a unique priority score for each combination of options and factors. We combine all the individual scores to arrive at the ultimate priority score.

Table 2.20 - Adapted from the global priority calculation (T. L. Saaty & Vargas, 2012)

| | Criteria 1 | Criteria 2 | ... | Criteria n | Global Priority |
|---|---|---|---|---|---|
| Alternative A | $a_1 * c_1$ | $a_2 * c_2$ | ... | $a_n * c_n$ | $a_1 * c_1 + a_2 * c_2 + \ldots + a_n * c_n$ |
| Alternative B | $b_1 * c_1$ | $b_2 * c_2$ | ... | $b_n * c_n$ | $b_1 * c_1 + b_2 * c_2 + \ldots + b_n * c_n$ |
| ... | ... | ... | ... | ... | ... |
| Alternative X | $x_1 * c_1$ | $x_2 * c_2$ | ... | $x_n * c_n$ | $x_1 * c_1 + x_2 * c_2 + \ldots + x_n * c_n$ |

The AHP priorities are arranged in descending order, indicating that the alternative with the highest priority is the optimal decision. Notably, the disparity between AHP priorities demonstrates the proportionality of the best alternatives.

*Sensitivity Analysis*

The importance assigned to various criteria plays a significant role in shaping overall priorities. To assess the impact of altering criteria weights on the outcome, a "what-if" analysis is conducted. This process, known as sensitivity analysis, represents the final stage in the AHP methodology. Sensitivity analysis is a crucial component of examining the robustness of the initial decision and identifying the criteria that influenced the original results. It is imperative to conduct a sensitivity analysis before reaching a final decision (Mu & Pereyra-Rojas, 2016).

# 3. METHODOLOGY

This chapter delves into diverse philosophical paradigms and identifies the most fitting one for our research. We present an in-depth analysis of the design science research methodology, detailing each method and technique utilised throughout the research process. Our thorough exploration of design science research methodology seeks to provide a comprehensive comprehension of this research approach.

## 3.1. A BRIEF REVIEW OF RESEARCH METHODOLOGIES

Different research methodologies exist. Natural sciences use quantitative methods to investigate phenomena systematically (Myers, 1997). Numerical techniques like Mathematical Modelling, Laboratory Experiments, and Surveys collect numerical data or information from Tests, Measurements, or Checklists on pre-defined scales (Creswell, 2013).

Social and cultural phenomena require different methodologies, such as qualitative techniques, developed in the social sciences by Galliers and Land (1987). These methods include case studies, ethnography, ground theory, and Design Science Research (DSR), used in research projects. Data collection techniques include participant observation, interviews, and document or text analysis (Myers, 1997).

Qualitative research is exploratory and valuable when the investigator is unaware of the critical variables to be studied, as in the case of a new problem. To address the limitations of quantitative and qualitative techniques, researchers can combine methods and triangulate the data by combining various information-gathering techniques into a single research study (Creswell, 2013).

## 3.2. DESIGN SCIENCE RESEARCH METHODOLOGY

According to March and Smith (1995), Natural Science is descriptive and explanatory. It tries to understand reality and is concerned with explaining the "how" and "why" of that reality.

In contrast, Design Science "attempts to create things that serve human purposes" (March & Smith, 1995, p. 253) and aims to develop innovative artefacts that solve real-life problems (Simon & Laird, 2019).

March and Smith (1995) also note that Design Science provides recipes and creates artefacts that incorporate those recipes.

For this reason, "design science is inherently a problem-solving process" (Hevner et al., 2004, p. 82).

Gregor and Hevner also refer to these two ways of "consuming and producing knowledge" (2013, p. 343) in the DSR process and give each of them a designation:

- Descriptive knowledge: Knowledge produced in Natural Sciences (the "how" and "why").
- Perspective knowledge: knowledge produced in Design Science (the "understanding things that serve humans").

This view is supported by Hevner and Chatterjee (2010), for whom an "artefact" is something artificial built by humans; in contrast, "natural" is something that happens in nature (Gregor & Jones, 2007; Simon & Laird, 2019).

Design Science scientists, rather than defining theories - like Natural Sciences scientists - create "models, methods and implementations that are innovative and valuable" (March & Smith, 1995, p. 254).

According to March and Smith (1995) and Hevner (2007), a research project using DSR produces artefacts that can be either constructs, models, methods, or an instance of one of the three. An instance operationalises one of these three possible artefacts and "demonstrate the feasibility and effectiveness of the models and methods they contain" (March & Smith, 1995, p. 258).

*knowledge contribution*

When embarking on DSR projects, assessing their potential impact on the broader field of knowledge is imperative.

In 2013, Gregor and Hevner introduced a framework in their study that outlines the criteria for identifying and defining such projects based on their knowledge contribution, as depicted in Figure 3.1.

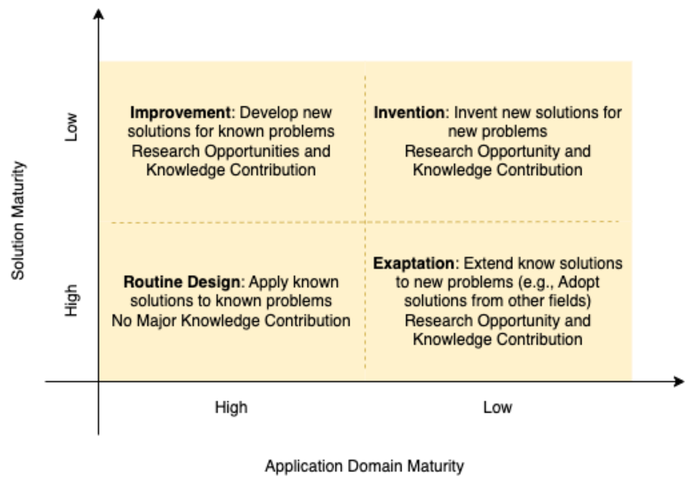


Figure 3.1 - Adapted from the DSR knowledge contribution framework (Gregor & Hevner, 2013)

A project's evaluation depends on the maturity of the problem and solution. The authors define a graph with the problem's decreasing maturity on the x-axis and the solution's decreasing maturity on the y-axis.

There are four quadrants:

- High maturity quadrant on both measures: This is about applying known solutions to known problems. The authors call this quadrant "Routine Design". This quadrant does not contribute to the knowledge base or present any research opportunity, as existing knowledge applies to routine situations.

- Quadrant of high maturity in knowledge of the problem and low maturity in solution knowledge: This is about developing new solutions to old problems. The authors call this quadrant the "Improvement" quadrant. This quadrant presents a research opportunity and brings possible contributions to the knowledge base.

- Quadrant of low maturity in knowledge of the problem and high maturity in solution knowledge: This involves extending known solutions to new problems. The authors call this quadrant the "Exaptation" quadrant. This quadrant presents a research opportunity and brings possible contributions to the knowledge base.

- The low maturity quadrant in both measures: Involves inventing new solutions to new problems. The authors call this quadrant the "Inventions" quadrant. This quadrant presents a research opportunity and brings contributions to the knowledge base. It is a quadrant where there is an actual beginning from scratch. However, inventions are rare, and inventors are even rarer.

We position our investigation in the "Improvement" quadrant since we aim to contribute to the definition of a Method, one of the three types of artefacts defined by March and Smith (1995) and Hevner (2007) as results of a DSR process, for the development of "A Method to Evaluate and Selecting an Enterprise Architecture Tool".

Hevner (2007) notes that the DSR process has three cycles (relevance cycle, design cycle, and rigour cycle) and functions within three spaces (environment, design science research and knowledge base), presented in Figure 3.2.

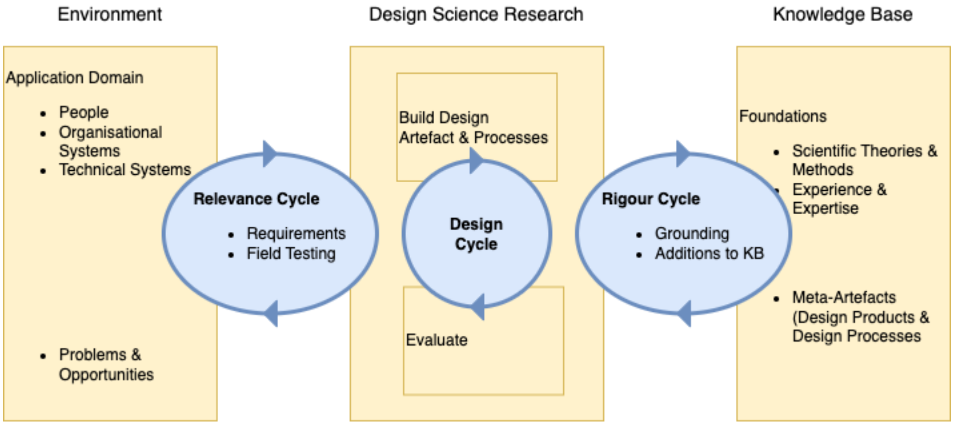


Figure 3.2 - Adapted from design science research cycles (Hevner, 2007)

The following is a detailed description of the activities of the three cycles and how they function in the designated spaces:

- Relevance Cycle activities: The methodology used for assessing an artefact depends on its type, and there are two possible ways to do so: objectivist or subjectivist. The former relies on quantifiable metrics and analysis methods, assuming the artefact can be measured. Conversely, the latter is based on assumptions and observations that may differ from one observer to another.
  This approach may yield diverse opinions, enrich conclusions, and bring new perspectives to the research project. As measuring intangible artefacts is challenging, this method allows for qualitative analysis.

- Design Cycle activities: During the design cycle, crucial development activities for the artefact occur within the DSR Space. This space comprises distinct micro-cycles that construct and evaluate the artefact, and these cycles interact.
  The DSR process undergoes multiple iterations before contributing to the Relevance and Rigor cycles. Gregor and Jones (2007) cite Simon and Laird (2019), who explain the concept of evolving artefacts where feedback loops promote flexibility and adaptability.
  The primary artefact development activities occur in the design cycle, and evaluation micro-cycles provide feedback to construction micro-cycles.

- The Rigour Cycle activities: Involve selecting knowledge from scientific theories and engineering methods for the knowledge base, while the relevance cycle activities focus on acquiring environmental requirements. The knowledge base space generates new artefacts through the rigour cycle activities and establishes the state-of-the-art in the DSR's application domain. Ultimately, the constructed artefact is assessed in the context of the application.

These activities, the rigour cycle and relevance cycle, are not just isolated steps but are essential for identifying the knowledge bases required to construct artefacts in the Design Cycle. This cycle, which also encompasses the "theorisation" and "justification" activities as mentioned by March and Smith (1995), forms a logical and coherent framework within the DSR process.
To achieve this, the researcher must develop the theories implicitly contained in the DSR process. This process will contribute new theories to the Knowledge Base Space.

These three cycles function within three Spaces:

- Environment: This "context that not only provides the requirements for the research (e.g., the opportunity/problem to be addressed) as inputs but also defines acceptance criteria for the ultimate evaluation of the research results" (Hevner, 2007, p.89).
  Only the Relevance Cycle operates in this space.

- Design Science Research: This is the space where the researcher builds and evaluates the artefact. "That artifacts must be rigorously and thoroughly tested in laboratory and experimental situations before releasing the artifact into field testing along the relevance cycle" (Hevner, 2007, p. 91).
  All three cycles intervene in this space, but the Design Cycle is restricted.

- Knowledge Base: This knowledge base provides the working foundations of the research project, including theories that explain or support the phenomena and add rigour to the project.
  Only the Rigor Cycle operates in this space.

The research project contributes to the growth of the number of theories in the knowledge base by extending existing theories or adding new ones, providing new artefacts, and sharing the experience gained.

Hevner et al. (2004) propose other DSR methodology approaches for guiding and conducting research in the Information Systems area. In this methodology, the outcome is "a purposeful IT artifact created to address an important organizational problem. It must be described effectively, enabling its implementation and application in an appropriate domain" (p. 82).

Peffers et al. (2007) identified six steps critical for effectively solving research problems, as shown in Figure 3.3, and elaborated on in Table 3.1.

The proposed methodology can follow a more complex process to be considered. As Peffers et al. (2007) state, "there is no expectation that researchers would always proceed in sequential order from activity 1 through activity 6. In reality, they may start at almost any step and move outward" (p. 56).

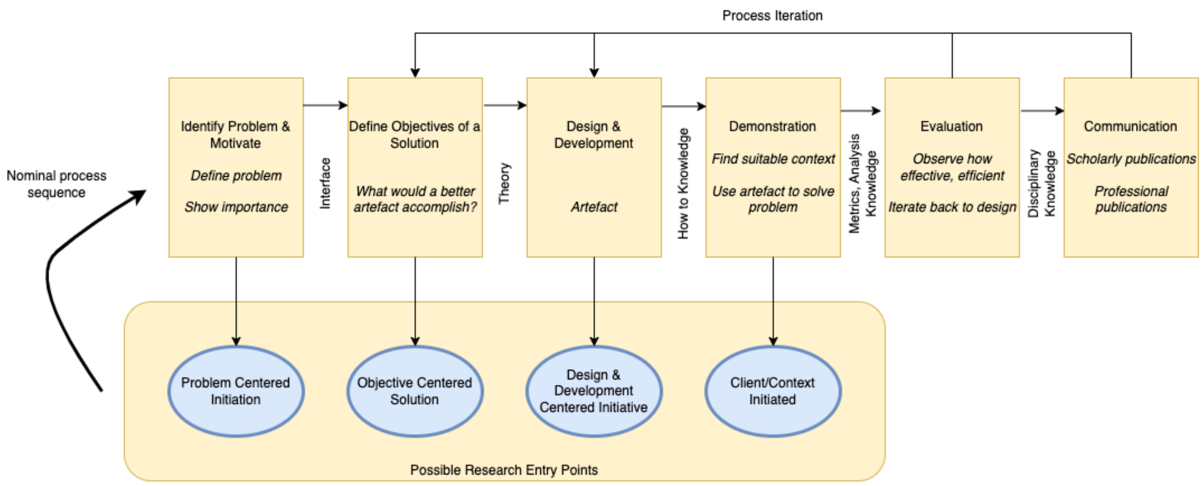


Figure 3.3 - Adapted from the DSR methodology process model (Peffers et al., 2007)

Table 3.1 - Adapted from the six DSR methodology steps (Peffers et al., 2007)

| Step | Objective | Description |
|---|---|---|
| Step 1 | Problem identification and motivation | Defining the specific research problem and justifying the value of a solution. |
| Step 2 | Defining the objectives or a solution | Inferring the objectives of a solution from the problem definition and knowledge of what is possible. |
| Step 3 | Design and Development | The creation of the artefact and such as constructs models, methods, or instantiations. Peffers et al. (2007) suggest an artefact can be any object in which a research contribution is embedded in the design. |
| Step 4 | Demonstration | The use of the artefact to solve one or more instances of the problem. This involves its use in experimentation, simulation, case study, proof, or other appropriate activity. |
| Step 5 | Evaluation | Measuring how well the artefact supports a solution to the problem. The objectives of the solution are compared to the observed results after implementation of the artefact. |
| Step 6 | Communication | Communicating the problem and its importance, the artefact its utility and novelty, the rigor of its design and its effectiveness, to researchers and other relevant audiences such as practicing professionals. This is done through scholarly research publications. |

## 3.3. Research strategy

Our research employed the DSR methodology approach outlined by Peffers et al. (2007), presented in Figure 3.3. This tried-and-true methodology has effectively tackled complex issues in academic and business environments. By adhering to this approach, we conducted our research meticulously and comprehensively, guaranteeing precision and accuracy in our findings and ensuring that our proposed solution is appropriate for the issue at hand. These activities included:

*Problem identification and motivation*

A well-developed enterprise architecture is valuable for businesses seeking a comprehensive understanding of their processes, systems, and assets. It enables them to exercise better control mechanisms and align IT strategies with overall business objectives, ultimately contributing to their organisation's success through improved efficiency and optimal performance.

By having a holistic view of business operations, organisations can identify redundancies, streamline processes, and allocate resources optimally. The structured approach of enterprise architecture enhances decision-making, risk management, and overall governance, providing better control over operations and assets.

If businesses fail to prioritise enterprise architecture in their management system, they may face challenges that lead to inefficiencies and suboptimal performance. It is crucial to prioritise enterprise architecture in business management to ensure better control over operations and assets, leading to improved efficiency and alignment with strategic goals.

Choosing the exemplary enterprise architecture tool is a critical decision that significantly impacts an organisation's ability to manage and optimise its IT infrastructure. Addressing these challenges thoughtfully during the selection process can help organisations choose an enterprise architecture tool that aligns with their needs and contributes to their business's success.

*Defining the objectives or a solution*

The proposed solution seeks to provide organisations with a versatile method that simplifies choosing the optimal enterprise architecture tool that meets their unique requirements, minimising the time and energy invested in this often-cumbersome task.

By meeting these objectives, organisations can successfully navigate the complexities of selecting an enterprise architecture tool, ensuring that it supports their strategic goals and effectively manages their IT landscape.

*Design and Development*

To develop the optimal product, we have created a comprehensive method that helps us choose the most suitable enterprise architecture tool. Our method considers a range of criteria, including evaluating decision-making methodologies and emphasising the use of the Analytic Hierarchy Process methodology.

The AHP methodology is a widely accepted approach for complex decision-making. This methodology enables us to make informed decisions by breaking down complex problems into smaller, more manageable parts. It helps us identify the most important criteria for our product development and evaluate each criterion based on its level of importance.

*Demonstration*

The proposed method was successfully demonstrated through an exploratory case study analysis. The case study involved one organisation interested in implementing an enterprise architecture tool solution. The developed artefact proved highly effective in a real-world scenario, highlighting its potential for successful implementation across various organisations.

*Evaluation*

March and Smith (1995) define evaluation as "the process of determining how well the artifact performs" (p. 254). DSR design artefacts "are assessed against criteria of value or utility – does it work?" (March & Smith, 1995, p. 253). An essential purpose of DSR evaluation is to determine whether or how well the developed evaluation achieves its purpose.

As part of our project, we carefully considered the most effective approach to evaluating the artefact's performance, reliability, usability, and usefulness. Ultimately, conducting questionnaires with a diverse panel of individuals with expertise in information technology systems and procurement specialists provided comprehensive insights. Analysing the questionnaires, we gathered valuable feedback and recommendations that helped shape the artefact's development and optimise its functionality.

*Communication*

The dissertation's release will share the proposed method with those interested in evaluating and selecting an enterprise architecture tool. This form of communication may have some limitations in constructing and implementing the artefact and suggest areas for future research in this field. However, with the submission of this master thesis, this critical step has been completed.

# 4. A METHOD TO EVALUATE AND SELECT AN ENTERPRISE ARCHITECTURE TOOL

In this chapter, we undertake a voyage that centres around accomplishing the primary goal of our research: determining the most efficient approach for assessing and choosing an enterprise architecture tool. Our suggested method is not merely a typical framework but an open and flexible approach that provides versatility and adaptability. It acts as a custom solution tailored to meet the requirements of each organisation, capable of evolving as their specific context dynamically changes. Our method offers a structured applicability approach, ensuring that the process for selecting an enterprise architecture tool remains consistent with the organisation's evolving objectives and needs.

## 4.1. A METHOD FOR SELECTION OF ENTERPRISE ARCHITECTURE TOOLS

When choosing an enterprise architecture tool, decision-makers typically follow steps to guide their selection process. While this methodology is not meant to be rigid, it serves as a helpful guideline that can be tailored to meet the unique needs of any organisation.

The selection process involves seven steps, as shown in Figure 4.1, to identify and evaluate suitable enterprise architecture tools.


Figure 4.1 - Selection for Enterprise Architecture Tool

*The first step is the definition of the team for the evaluation and selection*

A diverse evaluation and selection team representing various parts of the organisation is crucial. It is recommended that the team consist of the following key roles:

- An executive sponsor who can ensure that all decisions have the backing of senior management.
- Representatives from various stakeholder groups who can offer input on specific requirements.
- Technical specialists in IT and procurement who can advise on any technical and financial aspects, such as customising the enterprise architecture tool and the estimated timeline for completion.

- An independent consultant who is knowledgeable about evaluation and selection processes and can anticipate and address potential issues before they escalate.
- A spokesperson who has the authority to speak on behalf of the team and make commitments with vendors.

*The second step is the requirement definition*

It is the most crucial step in which functional and non-functional requirements of enterprise architecture tools are identified. The requirements must be accurate, complete, and detailed to select the most appropriate enterprise architecture tool.

*The third step involves a preliminary investigation of the availability of the Enterprise Architecture Tool*

This step includes a high-level investigation of significant functionalities and features supported by the enterprise architecture tools. Web-based resources, including vendor's websites, professional association catalogues, and other third-party reports, can be helpful in this phase. The output of this phase is a list of available enterprise architecture tools that might be candidates for evaluation.

*The fourth step is the shortlisting of Enterprise Architecture Tools*

In this step, candidate enterprise architecture tools identified in the second phase that do not provide essential functionalities and features or do not work with existing hardware, operating systems, data management software, or networks are eliminated. Criteria related to vendor or price of the enterprise architecture tools can also be used to eliminate some candidate enterprise architecture tools. The output of this phase is a list of candidate enterprise architecture tools to be considered for detailed evaluation.

*The fifth step involves establishing evaluation criteria*

In this step, we develop the standards by which the enterprise architecture tools will be evaluated. These standards are systematically organised into a hierarchical tree structure. The outcome of this phase is a collection of criteria presented in a hierarchical tree structure.

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In the next section, we offer a potential standardised list of criteria for assessing enterprise architecture tools.

However, it is essential to emphasise that while these are the recommended benchmarks, the method allows for utilising alternative criteria, empowering organisations to tailor the approach and making the proposed method timeless and adaptable to specific contexts.

---

*The sixth step is the evaluation of Enterprise Architecture Tools*

In this step, we use the AHP presented in subsection 2.3.3, where the metrics are defined, and weights are assigned to each essential attribute in the criteria hierarchy. For each enterprise architecture tool considered for detailed evaluation, ratings are done against each crucial criterion in the hierarchy. The aggregate score is then calculated for each enterprise architecture tool.

*Finally, the seventh step is the selection of the Enterprise architecture tool*

In this step, the available alternatives are ranked in descending order of the score, and the best enterprise architecture tool is selected. Price/performance trade-offs can be considered to identify the best value of the enterprise architecture tool. After choosing the best alternative, the next step is to negotiate and sign a contract with a vendor of the enterprise architecture tool selected by specifying the software price, number of licenses, payment terms and conditions, functional specification, repair and maintenance responsibilities, the timetable for delivery, and options to terminate the agreement.

## 4.2. Criteria for evaluation of Enterprise Architecture Tools

This section presents a comprehensive list of evaluation criteria for analysing any enterprise architecture tool. Each criterion is accompanied by a clear definition to evaluate potential enterprise architecture tool candidates. These criteria are organised into seven distinct categories, as shown in Figure 4.2.

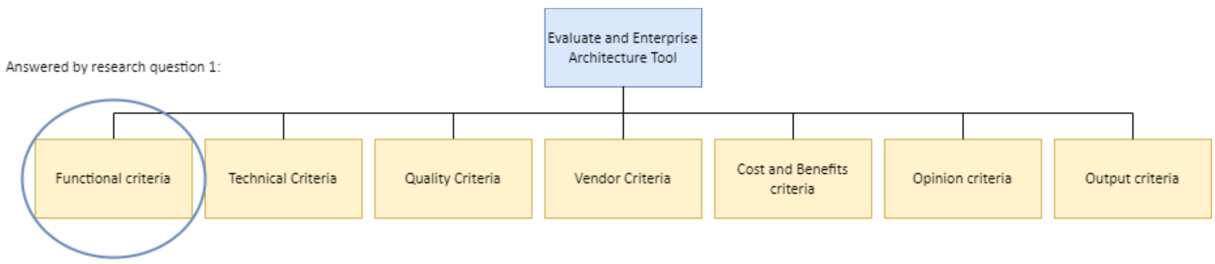


Figure 4.2 - Adapted from Software evaluation criteria (Jadhav & Sonar, 2011)

*Functional criteria*

The answer to the first research question determined the functional capabilities of the enterprise architecture tools (see Functional Criteria).

*Technical criteria*

Table 4.1 presents an in-depth description of the measurable attributes associated with the technical requirements of the enterprise architecture tools. These technical requirements include hardware and software specifications crucial for the software's proper functioning. By referring to this table, you can better understand the specific criteria that must be met to ensure that the enterprise architecture tools are operating optimally.

Table 4.1 - Adapted from the technical criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| Communication protocol | Communication protocol | Communication protocols supported by the package (TCP/IP, UDP, NETBUI, HTTP, FTP, SOAP, etc.). |
| External storage | External storage | External storage capacity required |
| Network technology | Network technology | Network technology supported by the package (LAN, WAN, MAN). |
| Primary storage | Primary storage | Primary storage capacity required. |

*Quality criteria*

We use quality criteria based on the ISO/IEC 25002 (2024) model to evaluate the quality of enterprise architecture tools. Our customised model enables us to assess and select any enterprise architecture tool effectively. The ISO/IEC quality model identifies six major quality characteristics: functionality, portability, maintainability, usability, reliability, and efficiency.

Functionality measures the enterprise architecture tools' ability to meet the organisation's specific needs, and we have created a separate category to account for the varying functional criteria across tools.

Portability assesses the enterprise architecture tools' ability to transfer between different environments.

At the same time, maintainability evaluates the enterprise architecture tools' ability to undergo modifications, including corrections, improvements, or adaptations to meet changing functional requirements and specifications.

Usability measures the enterprise architecture tool's ease of learning and operation under specific conditions, while reliability evaluates the software's ability to run consistently without crashing.

Efficiency measures the performance of enterprise architecture tools relative to the resources used under certain conditions.

Additionally, customizability accounts for the ability of the enterprise architecture tools to be customised according to the user's needs.

Quality criteria are divided into sub-criteria to provide a comprehensive evaluation, as outlined in Table 4.2.

Table 4.2 - Adapted from the quality criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| Portability | Middleware standards | Breadth of the middleware standards supported by the software package (CORBA, DCOM, RMI, ODBC, JDBC, OLE DB). |
| | DBMS standards | Breadth of the DBMS systems supported by the software package (MS-Access, MS-SQL, MS-Excel, Oracle, DB2, Informix, Sybase, MySQL, Ingrace). |
| | Communication standards | Inter-organizational data exchange standards supported by the software package (EDI, XML). |
| | OS compatibility | Package compatibility with the operating systems. |
| | Hardware compatibility | Package compatibility with the hardware. |
| Customisability | Vertical solution | Number of customized versions of the software package. |
| | Customizable fields | Ability to personalize layout of the software package. |
| | Customizable reports | Ability to personalize layout of the report produced by the software package. |
| | Interface type | Interface type of the software package. |
| | Programming languages | Ability to personalize modules of the software package by programming languages. |
| Maintainability | Modules | Average size of the independent code modules. |
| | Number of independently installable modules | Level of independence among the modules by indicating whether groups of modules or sub-modules need to be simultaneously installed even if only subset of them is required. |
| | Number of workstations | Maximum number of simultaneous users that can be supported by the software package. |
| | Maximum number of distribution tiers | Ability to split the software package into separate application tiers that can be distributed onto different servers. |
| | Number of modules that can be installed on separate servers | Ability to distribute modules on different servers. |
| | Scalability | Ability to support an increasing number of users and higher load of transaction. |
| Usability | User interface | Ease with which user can use interface of the software package. |
| | Learning curve | Ease with which user can learn and operate the package. |
| | User types | Ability of the software package to support beginners, intermediate, advanced users or a combination of user types. |
| | Data visualization | Capability of the software package to present data effectively. |
| | Error reporting | Error reporting and messaging ability of the software package. |

(continued)

Table 4.2 - (continued) Adapted from the quality criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| | Domain variety | Capability of the software package to be used in different industries to solve different kinds of business problems. |
| Reliability | Robustness | Capability of the software package to run consistently without crashing. |
| | Backup and recovery | Capability of the software package to support backup and recovery feature. |
| Efficiency | Time behaviour | Capability of the software package to produce results in reasonable amount of time relative to data size. |
| Security | Auditing | Products logging and auditing capabilities. |
| | Password | Package support for password. |
| | Data security | Level of support for data security. |
| | Individual and group access rights | Package support for managing and enforcing access rights. |
| | Field level security | Package support for security at the field level. |
| | Data/document encryption | Package support for data/document encryption. |

*Vendor criteria*

Table 4.3 provides a detailed breakdown of the vendor criteria used to evaluate the capabilities of enterprise architecture tools. This breakdown is further divided into sub-criteria, which allows for a more granular and comprehensive analysis of the capabilities of the enterprise architecture tools. By utilising these vendor criteria, organisations can make more informed decisions when selecting an enterprise architecture tool that best fits their needs and requirements.

Table 4.3 - Adapted from the vendor criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| Training and documentation criteria | Tutorial | Availability of tutorial to learn how to use the software package. |
| | Troubleshooting guide | Availability of troubleshooting guide. |
| | Training | Vendor support for training courses to learn the software package. |
| | User manual | Availability of user manual with indexes, with important information and the main commands. |
| Maintenance and up-gradation | Consultation | Availability of technical support and consultancy by the vendor. |

(continued)

Table 4.3 - (continued) Adapted from the vendor criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| | Communication | Communication with the vendor. |
| | Demo | Availability of on-site demo and free-trial version. |
| | Response time | Level of service rendered by the vendor. |
| | Business skills | Business skills of the vendor. |
| Vendor reputation | Vendor popularity | Popularity of vendor in the market. |
| | Product history | Popularity of vendor product in the market. |
| | Length of experience | Experience of vendor about development of the software package. |
| | Number of installations | Number of installations of the software package. |
| | Number of references | Number of references of the existing customers. |
| | Past business experience | Past business experience with the vendor if any. |

*Cost and benefits criteria*

When assessing the enterprise architecture tool, specific criteria are considered to evaluate its cost- and benefit-related characteristics. Table 4.4 provides a comprehensive list of the measurable attributes to assess these criteria. Examining these attributes makes it possible to determine enterprise architecture tools' cost-effectiveness and potential benefits to end users.

Table 4.4 - Adapted from the cost and benefits criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| License cost | License cost | License cost of the software package. |
| Hardware and software cost | Hardware and software cost | Cost of an additional hardware and software required to run the software. |
| Installation and implementation cost | Installation and implementation cost | Installation and implementation cost of the software package. |
| Maintenance cost | Maintenance cost | Maintenance cost of the software package. |
| Training cost | Training cost | Training cost of the software package. |
| Upgrading cost | Upgrading cost | Upgrading cost of the software package. |
| Direct benefits | Direct benefits | Direct benefits of the software package. |
| Indirect benefits | Indirect benefits | Indirect benefits of the software package. |

*Opinion criteria*

In Table 4.5, we described the quantifiable characteristics of the criteria that relate to the viewpoints of multiple stakeholders regarding the enterprise architecture tools.

Table 4.5 - Adapted from the opinion criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| End users | End users | Opinion of end users about the software package. |
| External consultants | External consultants | Opinion of external consultants about the software package. |
| In-house experts | In-house experts | Opinion of in-house experts about the software package. |
| Magazines | Magazines | Opinion about the software package given in the magazines. |
| Outside personal acquaintances | Outside personal acquaintances | Opinion of outside personnel about the software package. |
| Product leaflets | Product leaflets | Opinion about the software package in product leaflets. |
| Subordinates | Subordinates | Opinion of subordinates about the software package. |
| Vendor and sales representatives | Vendor and sales representatives | Opinion of vendor and sales representatives about the software package. |

*Output criteria*

Table 4.6 describes the measurable attributes of the output-related characteristics of the enterprise architecture tool.

Table 4.6 - Ad(Jadhav & Sonar, 2011)criteria (Jadhav & Sonar, 2011)

| Sub-criteria | Basic criteria | Criteria meaning |
|---|---|---|
| Printer | Printer | Package support for printer output. |
| File | File | Package support for file output. |
| Other software | Other software | Package support for output to other software. |

# 5. RESULTS AND DISCUSSION

In this chapter, we present the results of an extensive case study that aims to explain and evaluate the proposed method comprehensively.

## 5.1. CASE STUDY

A detailed case study was conducted in a large organisation to evaluate the feasibility and effectiveness of the proposed method for evaluating and selecting an enterprise architecture tool and identify potential opportunities for improvement.

Initially, a characterisation of the organisation where this case study was carried out is presented to contextualise it.

The next step was to perform a usability test to verify the proposed method's functionality, efficiency, effectiveness, and convenience. For that, we conducted semi-structured interviews with three experts (one Enterprise Architect, one Solution Architect, and one Procurement Specialist) with knowledge/experience of evaluation and selection of tools during February 2024 so that they could test the proposed method and provide us with proper feedback on its usability.

The interviews were conducted in person and were split into two distinct phases.

- In the training phase, individuals identified as experts were trained on how the proposed method works.

  Typically, this phase took approximately 15-20 minutes.

- In the testing phase, identified experts were tasked with selecting only the necessary criteria when evaluating enterprise architecture tools. Additionally, they were asked to specify the user needs of the enterprise architecture tool using the selected criteria. As part of this testing phase, they were also asked to verify the method's results (which included ranking possible enterprise architecture tools) by adjusting the user requirements and the importance of the evaluation criteria.

Finally, the results analysis is presented.

*Characterisation of the organisation*

With a legacy spanning over four decades, Energias has established itself as a significant player in the energy sector. The company has a robust global presence across four continents. It operates across Portugal's energy value chain, employing around seven thousand individuals. Its footprint in the Iberian Peninsula is equally significant.

As one of the largest national investors in Portugal, Energias heavily invests in innovation and development, making it one of the largest Portuguese industrial groups and the world's largest renewable energy producer. Energias has integrated humanisation, innovation, and sustainability values into its culture and prioritises commitment to its stakeholders by maintaining an open and transparent dialogue with those involved in the business.

Energias activity is founded on fundamental pillars such as teamwork and individual development, entrepreneurship, results orientation, continuous innovation and improvement, and human and environmental safety. The organisation's primary mission is to create value, a commitment that underpins all its operations. Energias operates on ethics and transparency, instilling confidence in its stakeholders.

*Characterisation of the experts*

Enterprise Architect

The individual in question is a highly experienced and passionate architect who has successfully led the end-to-end enterprise architecture function at Nokia Digital Office. Her exceptional leadership skills have enabled the organisation to adopt more modern and efficient IT architecture practices, particularly in Application Integration Architecture Delivery. As Principal Architect, she was responsible for overseeing the governance of the domain and solution architects' community across the Digital Office, working closely with other Nokia stakeholders and business groups.

Her impressive career spans several years, including a significant tenure at a major energy group in Portugal. During this time, she led an Operational Architecture team and spearheaded the Solution Architects group, the Integration Center of Excellence, and the SAP Center of Excellence. This experience allowed her to develop invaluable skills in managing critical business operations and driving digital transformation initiatives through modernisation and innovation.

She has worked with major software companies like SAP and Oracle, a Portuguese consultancy company, Siemens Networks, and a Portuguese electronics company throughout her professional journey. This diverse experience has equipped her with a broad range of skills in architecture, including expertise in central application software stacks like SAP, Outsystems, Salesforce, and Oracle; cloud deployments in Azure, Google Cloud Platform, and SAP Cloud Platform; business intelligence and data architecture solutions; digital architecture patterns using composable architecture patterns enabled by API management solutions; and a deep understanding of security and privacy controls that address GDPR requirements.

Her educational qualifications are a testament to her commitment to continuous learning and professional excellence. She holds a master's in business management and an Executive MBA from INDEG-ISCTE, where she was recognised as the year's best student. Additionally, she has an Engineering Degree in Electrotechnical and Computer Engineering.

Solution Architect

With over fifteen years of experience as a technical consultant, he has established a reputation for fully integrated solutions that use the latest technology. His proficiency in IT infrastructure and SAP software solutions is complemented by his comprehensive understanding of multiple operating systems, databases, and virtualisation platforms.

He has effectively overseen various end-to-end implementation and support projects throughout his career. He can navigate the entire IT landscape, from the initial planning and design phases to deploying, configuring, maintaining, troubleshooting, and migrating information systems. His expertise encompasses both on-premises infrastructures and cloud-based solutions, rendering him an asset to any organisation.

Procurement Expert

This accomplished professional boasts more than 17 years of hands-on experience in procurement, spanning many industries, such as automotive, aviation, plastic packaging, trading, and healthcare. With an MBA and a degree in Mechanical Engineering, he has further honed his skills by completing several prestigious programs, including the Negotiation Dynamics seminar at INSEAD and the Negotiation and Strategy program at Católica Lisbon School. His areas of expertise include procurement, purchasing, negotiation, business strategy, management, team leadership, contract management, supplier management, supply chain management, and logistics.

*Applicability of the proposed method*

Once the case context was established and the process was explained to the interviewees, we proceeded with the proposed method. This method entailed meticulously executing each step, such as data collection, analysis, and interpretation, all of which are expounded upon in chapter four.

In this case study, the experts established an evaluation criteria hierarchy, illustrated in Figure 5.1, that aligned with the alternatives listed in Table 5.1 to assess each vendor's proposal for enterprise architecture tools.

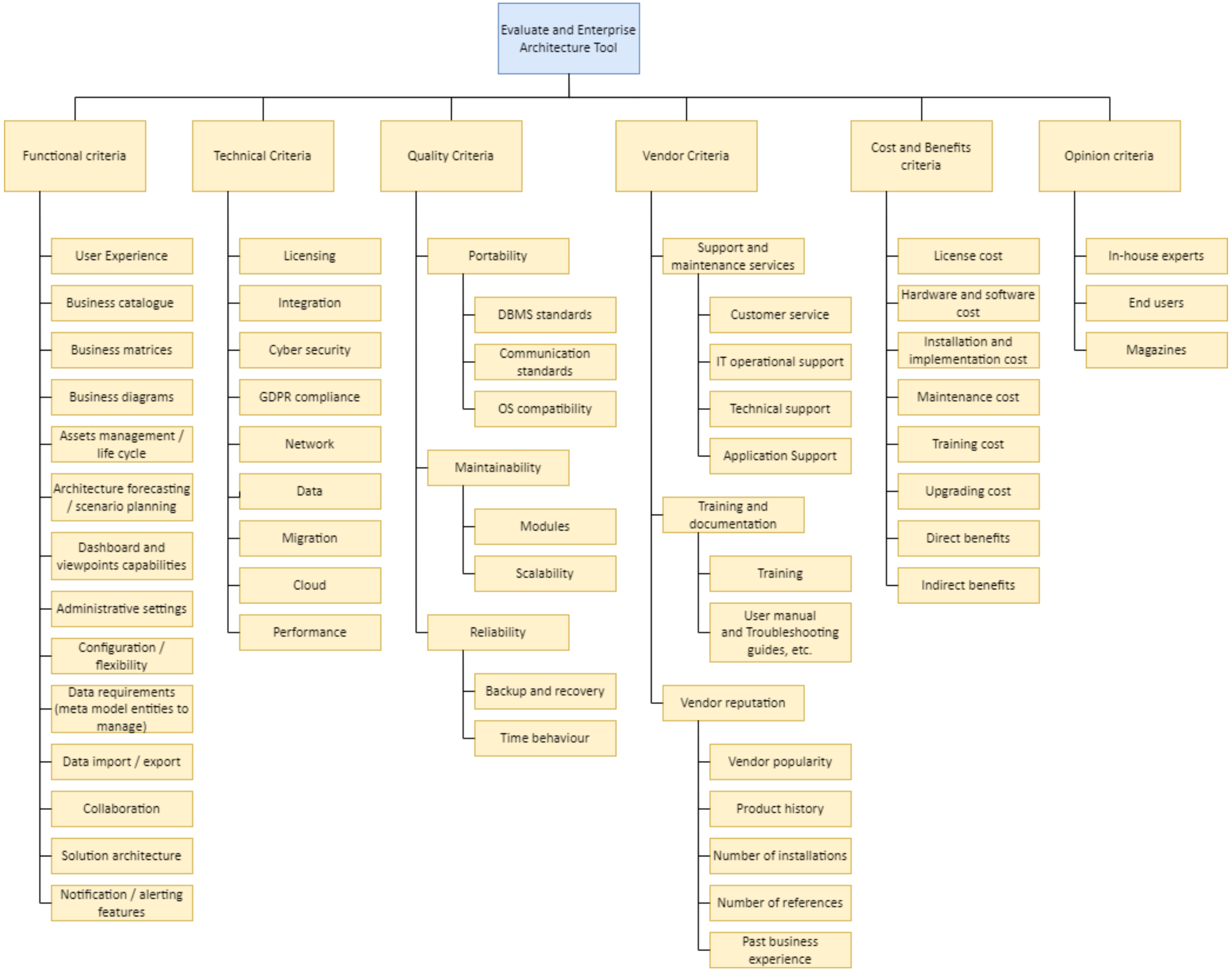


Figure 5.1 - Case study evaluation criteria

Table 5.1 - Enterprise Architecture Tools (alternatives)

| # | Name | Company | URL |
|---|---|---|---|
| 1 | ABACUS | Avolution | https://www.avolutionsoftware.com/abacus/ |
| 2 | ADOIT | BOC Group | https://www.boc-group.com/en/adoit/ |
| 3 | Ardoq | Ardoq | https://www.ardoq.com/ |
| 4 | iServer | Orbus Software | https://www.orbussoftware.com/solutions/enterprise-architecture |
| 5 | LeanIX | LeanIX | https://www.leanix.net/en/enterprise-architecture |

After thoroughly examining and analysing all the data in Table 5.2, we have arrived at a clear and well-informed decision regarding the ideal enterprise architecture tool proposal to meet Energias' specific needs and requirements.

Figure 5.2 reveals that LeanIX (33.10%) offers the most suitable solution of the five proposals submitted by various vendors.

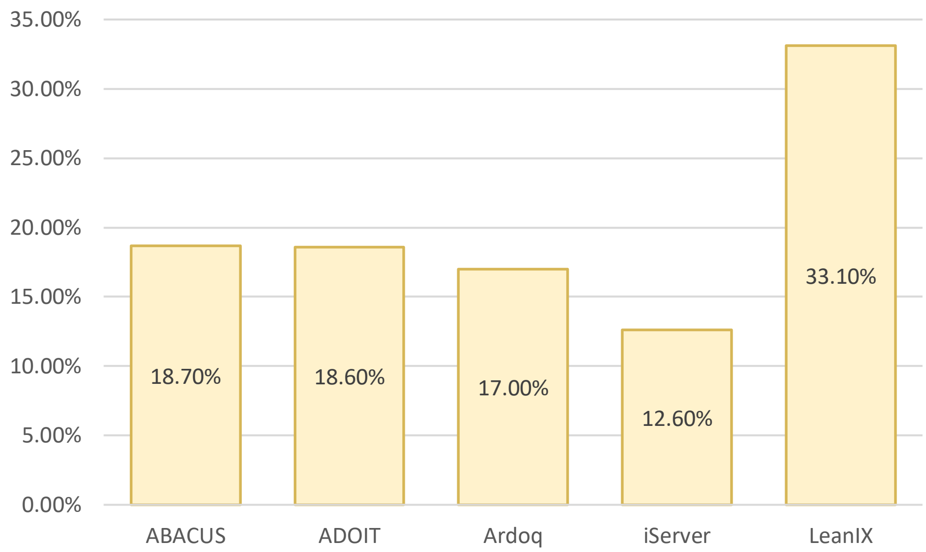


Figure 5.2 - Consolidated result

Table 5.2 - Final decision-making matrix with all criteria evaluated throughout the selection process

| Goal | Main Criteria | Sub-criteria (Level 3) | Sub-criteria (Level 4) | % | ABACUS | ADOIT | Ardoq | iServer | LeanIX |
|---|---|---|---|---|---|---|---|---|---|
| Evaluate and Enterprise Architecture Tool | Functional criteria 0.274 | | User Experience 0.120 | 3.3% | 0.102 | 0.176 | 0.066 | 0.110 | 0.546 |
| | | | Business catalogue 0.132 | 3.6% | 0.273 | 0.137 | 0.073 | 0.069 | 0.449 |
| | | | Business matrices 0.110 | 3.0% | 0.149 | 0.257 | 0.135 | 0.075 | 0.385 |
| | | | Business diagrams 0.117 | 3.2% | 0.257 | 0.143 | 0.079 | 0.079 | 0.443 |
| | | | Assets management / life cycle 0.021 | 0.6% | 0.085 | 0.219 | 0.085 | 0.085 | 0.526 |
| | | | Architecture forecasting / scenario planning 0.026 | 0.7% | 0.181 | 0.112 | 0.101 | 0.054 | 0.552 |
| | | | Dashboard and viewpoints capabilities 0.085 | 2.3% | 0.099 | 0.247 | 0.140 | 0.071 | 0.442 |
| | | | Administrative settings 0.033 | 0.9% | 0.131 | 0.137 | 0.095 | 0.095 | 0.541 |
| | | | Configuration / flexibility 0.054 | 1.5% | 0.170 | 0.124 | 0.126 | 0.088 | 0.492 |
| | | | Data requirements (meta model entities to man 0.048 | 1.3% | 0.385 | 0.203 | 0.108 | 0.102 | 0.203 |
| | | | Data import / export 0.051 | 1.4% | 0.059 | 0.141 | 0.199 | 0.093 | 0.508 |
| | | | Collaboration 0.087 | 2.4% | 0.074 | 0.121 | 0.376 | 0.215 | 0.215 |
| | | | Solution architecture 0.089 | 2.4% | 0.181 | 0.197 | 0.100 | 0.071 | 0.451 |

(Continued)

Table 5.2 - (Continued) Final decision-making matrix with all criteria evaluated throughout the selection process

| Goal | Main Criteria | Sub-criteria (Level 3) | Sub-criteria (Level 4) | % | ABACUS | ADOIT | Ardoq | iServer | LeanIX |
|---|---|---|---|---|---|---|---|---|---|
| | | | Notification / alerting features 0.027 | 0.7% | 0.222 | 0.141 | 0.136 | 0.091 | 0.409 |
| | Technical Criteria 0.311 | | Licensing 0.018 | 0.5% | 0.239 | 0.135 | 0.096 | 0.158 | 0.373 |
| | | | Integration 0.022 | 0.7% | 0.208 | 0.264 | 0.144 | 0.090 | 0.293 |
| | | | Cyber security 0.209 | 6.5% | 0.190 | 0.153 | 0.107 | 0.159 | 0.391 |
| | | | GDPR compliance 0.392 | 12.2% | 0.100 | 0.197 | 0.401 | 0.092 | 0.210 |
| | | | Network 0.089 | 2.8% | 0.211 | 0.202 | 0.143 | 0.083 | 0.361 |
| | | | Data 0.068 | 2.1% | 0.044 | 0.104 | 0.232 | 0.232 | 0.389 |
| | | | Migration 0.050 | 1.6% | 0.231 | 0.111 | 0.085 | 0.169 | 0.405 |
| | | | Cloud 0.059 | 1.8% | 0.230 | 0.192 | 0.122 | 0.077 | 0.379 |
| | | | Performance 0.093 | 2.9% | 0.216 | 0.285 | 0.082 | 0.120 | 0.297 |
| | Quality Criteria 0.235 | Portability 0.143 | DBMS standards 0.413 | 1.4% | 0.194 | 0.124 | 0.143 | 0.137 | 0.402 |
| | | | Communication standards 0.327 | 1.1% | 0.257 | 0.151 | 0.172 | 0.167 | 0.254 |
| | | | OS compatibility 0.260 | 0.9% | 0.166 | 0.125 | 0.220 | 0.163 | 0.326 |
| | | Maintainability 0.429 | Modules 0.250 | 2.5% | 0.210 | 0.188 | 0.115 | 0.144 | 0.343 |
| | | | Scalability 0.750 | 7.5% | 0.135 | 0.222 | 0.107 | 0.133 | 0.403 |

(Continued)

Table 5.2 - (Continued) Final decision-making matrix with all criteria evaluated throughout the selection process

| Goal | Main Criteria | Sub-criteria (Level 3) | Sub-criteria (Level 4) | % | ABACUS | ADOIT | Ardoq | iServer | LeanIX |
|---|---|---|---|---|---|---|---|---|---|
| | | Reliability 0.429 | Backup and recovery 0.833 | 8.4% | 0.286 | 0.186 | 0.129 | 0.101 | 0.297 |
| | | | Time behaviour 0.167 | 1.7% | 0.178 | 0.101 | 0.118 | 0.201 | 0.402 |
| | Vendor Criteria 0.090 | Support and maintenance services 0.743 | Customer service 0.110 | 0.7% | 0.312 | 0.141 | 0.155 | 0.141 | 0.251 |
| | | | IT operational support 0.223 | 1.5% | 0.223 | 0.152 | 0.200 | 0.232 | 0.193 |
| | | | Technical support 0.418 | 2.8% | 0.259 | 0.225 | 0.196 | 0.171 | 0.149 |
| | | | Application Support 0.250 | 1.7% | 0.232 | 0.219 | 0.197 | 0.132 | 0.219 |
| | | Training and documentation 0.194 | Training 0.333 | 0.6% | 0.196 | 0.225 | 0.149 | 0.171 | 0.259 |
| | | | User manual and Troubleshooting guides 0.667 | 1.2% | 0.226 | 0.226 | 0.182 | 0.174 | 0.192 |
| | | Vendor reputation 0.063 | Vendor popularity 0.075 | 0.0% | 0.328 | 0.124 | 0.188 | 0.143 | 0.216 |
| | | | Product history 0.182 | 0.1% | 0.354 | 0.268 | 0.088 | 0.202 | 0.088 |
| | | | Number of installations 0.270 | 0.2% | 0.250 | 0.250 | 0.125 | 0.250 | 0.125 |
| | | | Number of references 0.194 | 0.1% | 0.143 | 0.143 | 0.221 | 0.165 | 0.329 |
| | | | Past business experience 0.278 | 0.2% | 0.253 | 0.225 | 0.160 | 0.170 | 0.192 |
| | Cost and Benefits criteria 0.061 | | License cost 0.131 | 0.8% | 0.253 | 0.149 | 0.231 | 0.199 | 0.168 |
| | | | Hardware and software cost 0.156 | 1.0% | 0.196 | 0.171 | 0.149 | 0.225 | 0.259 |

(Continued)

Table 5.2 - (Continued) Final decision-making matrix with all criteria evaluated throughout the selection process

| Goal | Main Criteria | Sub-criteria (Level 3) | Sub-criteria (Level 4) | % | ABACUS | ADOIT | Ardoq | iServer | LeanIX |
|---|---|---|---|---|---|---|---|---|---|
| | | | Installation and implementation cost 0.205 | 1.3% | 0.266 | 0.252 | 0.186 | 0.205 | 0.091 |
| | | | Maintenance cost 0.181 | 1.1% | 0.257 | 0.306 | 0.147 | 0.199 | 0.091 |
| | | | Training cost 0.052 | 0.3% | 0.175 | 0.165 | 0.296 | 0.199 | 0.165 |
| | | | Upgrading cost 0.095 | 0.6% | 0.259 | 0.196 | 0.225 | 0.149 | 0.171 |
| | | | Direct benefits 0.095 | 0.6% | 0.243 | 0.276 | 0.175 | 0.188 | 0.117 |
| | | | Indirect benefits 0.085 | 0.5% | 0.259 | 0.195 | 0.221 | 0.129 | 0.195 |
| | Opinion criteria 0.029 | | End users 0.238 | 0.7% | 0.174 | 0.219 | 0.132 | 0.139 | 0.336 |
| | | | In-house experts 0.625 | 1.8% | 0.144 | 0.190 | 0.158 | 0.159 | 0.349 |
| | | | Magazines 0.137 | 0.4% | 0.372 | 0.128 | 0.128 | 0.161 | 0.211 |
| | | | | **1.0** | **18.7%** | **18.6%** | **17.0%** | **12.6%** | **33.1%** |

## 5.2. EVALUATION AND DISCUSSION

During the evaluation phase, the previously identified experts evaluated the performance of the proposed method by completing a usability questionnaire.

The questionnaire contained ten questions, shown in Table 5.3.

Table 5.3 - Questionnaire questions

| # | Statement |
|---|---|
| 1 | This method effectively helped me in selecting criteria for evaluation of the enterprise architecture tools |
| 2 | Evaluation criteria used in this method are enough to evaluate and rank the candidate enterprise architecture tools |
| 3 | This method has used proper hierarchy of the evaluation criteria |
| 4 | This method effectively helped me to specify user needs of the enterprise architecture tools |
| 5 | I can effectively complete task of evaluation and selection of the enterprise architecture tools using this method |
| 6 | I can efficiently complete task of evaluation and selection of the enterprise architecture tools using this method |
| 7 | Results, i.e. ranking of the candidate enterprise architecture tools, produced by the system in the form of case matching is easy to understand |
| 8 | Results produced by the method effectively helped me in determining the fit between enterprise architecture tool and user needs |
| 9 | This method has all the functions and capabilities I expected it to have |
| 10 | Overall, I am satisfied with this method |

The experts answered each question using a five-point scale (Likert, 1932), shown in Table 5.4, where one is "Highly Unacceptable" and five is "Highly Acceptable".

Table 5.4 - Adapted from the technique for the measurement of attitudes (Likert, 1932)

| Scale | Interpretation |
|---|---|
| 5 | Highly Acceptable |
| 4 | Acceptable |
| 3 | Uncertain |
| 2 | Unacceptable |
| 1 | Highly Unacceptable |

Table 5.5 shows the experts' average rating for the questionnaire statement, which expresses the experts' evaluation of the proposed method’s performance. Experts found that the method effectively helped them in:

- Selecting criteria for evaluation of the enterprise architecture tools.
- Using a proper hierarchy of the evaluation criteria.
- Effectively complete the task of evaluation and selection of the enterprise architecture tools.

Table 5.5 - Results of the evaluation

| # | Enterprise Architect | Solution Architect | Procurement Specialist | Average rating |
|---|---|---|---|---|
| 1 | Highly Acceptable | Highly Acceptable | Acceptable | 4.67 |
| 2 | Acceptable | Acceptable | Acceptable | 4.00 |
| 3 | Highly Acceptable | Acceptable | Highly Acceptable | 4.67 |
| 4 | Acceptable | Acceptable | Acceptable | 4.00 |
| 5 | Acceptable | Highly Acceptable | Highly Acceptable | 4.67 |
| 6 | Uncertain | Uncertain | Uncertain | 3.00 |
| 7 | Acceptable | Acceptable | Uncertain | 3.67 |
| 8 | Highly Acceptable | Acceptable | Acceptable | 4.33 |
| 9 | Acceptable | Acceptable | Uncertain | 3.67 |
| 10 | Acceptable | Acceptable | Acceptable | 4.00 |

Experts also found that this method assists decision-makers in determining the best fit between enterprise architecture tools and user needs.

# 6. CONCLUSIONS

In this dissertation's final chapter, we reflect on synthesising the developed work, limitations, and future work that have emerged from our research. By doing so, we comprehensively understand whether the specified objectives were met. Based on the feedback received during the evaluation stage, we can confidently state that the proposed artefact has successfully fulfilled the initial objectives. It provides a precise sequence of phases to be followed when selecting the most suitable enterprise architecture tool system to meet the organisation's needs.

## 6.1. SYNTHESIS OF THE DEVELOPED WORK

The present dissertation offers a thorough evaluation and selection process for enterprise architecture tools. It highlights the growing recognition and investment in enterprise architecture, including the shift from traditional to digital architecture.

Developing a highly customisable model to effectively evaluate and select enterprise architecture tools tailored to specific organisational requirements is emphasised. Informed decision-making that aligns with strategic goals is crucial, and the text offers valuable insights into prevailing trends and challenges in the enterprise architecture tools landscape.

The text stresses the importance of a practical approach to the evaluation criteria for analysing enterprise architecture tools: functionality, maintainability, usability, reliability, vendor capabilities, cost-benefit analysis, stakeholder viewpoints, and output-related characteristics and presents a structured approach utilising the analytic hierarchy process for decision-making proposing a methodological method for evaluating and selecting enterprise architecture tools.

It concludes with a detailed case study validating the proposed method and assessing its usability through expert feedback.

The research goals have been accomplished, and the resulting approach is extensive. It offers a clear pathway for organisations to evaluate, select, and implement enterprise architecture tools. This approach improves operational efficiency, promotes alignment with strategic objectives, and enhances competitiveness in the rapidly evolving business landscape, guaranteeing a thorough and impactful implementation of enterprise architecture tools.

## 6.2. LIMITATIONS

Certain limitations must be considered when choosing an enterprise architecture tool. One of the main limitations of this study was the validation of the proposed method.

However, even with the ever-evolving landscape of enterprise architecture tools, the proposed method was designed to be technologically agnostic, ensuring its relevance over time.

While the proposed approach is comprehensive, it was only tested in one real-world scenario; a case study validated the method and feedback from area experts, and a more diverse group of participants, including professionals from different organisations and sizes, would have provided universal validation, allowing for more comprehensive input and validation.

Therefore, more case studies are needed to complement the information regarding the functional criteria to apply when evaluating enterprise architecture tools. Addressing these limitations is crucial to enhancing the robustness and applicability of the proposed approach, allowing organisations to make well-informed decisions about their enterprise architecture tool investments.

## 6.3. FUTURE WORK

Upon reflection on the limitations highlighted in the study, it becomes evident that while the proposed method for selecting enterprise architecture tools was designed to be both technologically agnostic and comprehensive, some areas still require further attention. The primary limitation is the method's validation, primarily based on a single real-world scenario.

To enhance the approach's robustness and applicability, it is recommended that the validation process be expanded to include a more diverse range of participants and organisational contexts. Incorporating feedback from professionals across different industries and organisational sizes would capture a broader spectrum of perspectives and challenges, thus ensuring its relevance across various contexts.

Furthermore, conducting additional case studies would provide valuable insights into how the proposed criteria apply in different scenarios and offer practical examples of how organisations evaluate and implement enterprise architecture tools. These case studies could provide valuable lessons and best practices for future adopters, further refining the selection process.

Addressing these limitations is crucial to ensuring the proposed approach remains relevant and effective in helping organisations make well-informed decisions about their enterprise architecture tool investments. Organisations can confidently navigate the ever-evolving landscape of enterprise architecture tools by continually refining and validating the method.

# BIBLIOGRAPHICAL REFERENCES

Anderson, D. R., Sweeney, D. J., Williams, T. A., & Camm, J. D. (2012). *An introduction to management science: quantitative approaches to decision making*. Cengage Learning.

Baker, D., Bridges, D., Hunter, R., Johnson, G., Krupa, J., Murphy, J., & Sorenson, K. (2001). *Guidebook to decision-making methods* (Vol. 45). Westinghouse Savannah River Company Aiken, SC, USA.

Basel Committee on Banking Supervision. (2023). *The Basel Framework*. https://www.bis.org/basel_framework/index.htm

Brée, T., & Karger, E. (2022). Challenges in Enterprise Architecture Management: Overview and Future Research. *Journal of Governance and Regulation*, *11*(2 Special), 355–367. https://doi.org/10.22495/jgrv11i2siart15

Brown, L. A., & Lynn, R. W. (1976). Oxford Advanced Leamer's Dictionary of Current English, Third edition. A S Homby, with the assistance of A P Cowie and J Windsor Lewis Oxford University Press, 1974. xxvii, 1056 pp. *RELC Journal*, *7*(1), 77–79. https://doi.org/10.1177/003368827600700111

C4ISR. (1997). *C4ISR Architecture Framework*. https://www.csee.umbc.edu/courses/undergraduate/CMSC445/Fall06/fw.pdf

Chang, J. O. (2005). *A generalized decision model for naval weapon procurement: Multi-attribute decision making*. University of South Florida. https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=3818&context=etd

*Clinger-Cohen Act*. (1996). https://www.fismacenter.com/Clinger%20Cohen.pdf

Creswell, J. W. (2013). *Research Design (International Student Edition): Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications. https://books.google.pt/books?id=YDFvlwEACAAJ

Dietz, J. L. G., & Hoogervorst, J. A. P. (2011). A critical investigation of TOGAF - Based on the enterprise engineering theory and practice. In *Lecture Notes in Business Information Processing: Vol. 79 LNBIP*. https://doi.org/10.1007/978-3-642-21058-7_6

DoDAF. (2015). *The DoD Architecture Framework, Volume 1: Overview and Concepts, Version 2.02*. https://dodcio.defense.gov/Portals/0/Documents/DODAF2/DoDAF%20v2.02%20Chg%201%20Vol%20I%20Final%202015-01-19.pdf

FEA. (2012). *The Common Approach to Federal Enterprise Architecture*. https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/egov_docs/common_approach_to_federal_ea.pdf

FEAF. (2013). *Federal Enterprise Architecture Framework*. https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/egov_docs/fea_v2.pdf

Fong, E., & Goldfine, A. (1989). *Information Management Directions: The Integration Challenge*. Special Publication (NIST SP), National Institute of Standards and Technology, Gaithersburg, MD. https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=900419

Galliers, R. D., & Land, F. F. (1987). Viewpoint: Choosing Appropriate Information Systems Research Methodologies. *Communications of the ACM*, *30*(11), 901–902. https://doi.org/10.1145/32206.315753

Gampfer, F., Jürgens, A., Müller, M., & Buchkremer, R. (2018). Past, current and future trends in enterprise architecture—A view beyond the horizon. *Computers in Industry*, *100*, 70–84. https://doi.org/10.1016/j.compind.2018.03.006

GAO. (1992). *Strategic Information Planning: Framework for Designing and Developing System Architectures*. https://www.gao.gov/assets/imtec-92-51.pdf

Gartner. (2022). *Magic Quadrant for Enterprise Architecture Tools*. https://www.gartner.com/en/documents/4947731

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly: Management Information Systems*, *37*(2), 337–355. https://doi.org/10.25300/MISQ/2013/37.2.01

Gregor, S., & Jones, D. (2007). The anatomy of a design theory. *Journal of the Association for Information Systems*, *8*(5), 312–335. https://doi.org/10.17705/1jais.00129

Harrell, J. M., & Sage, A. P. (2010). Enterprise architecture and the ways of wickedness. *Information Knowledge Systems Management*, *9*(3/4), 197–209. https://doi.org/10.3233/iks-2010-0166

Henderson, J. C., & Venkatraman, N. (1993). Strategic alignment: leveraging information technology for transforming organizations. *IBM Systems Journal*, *32*(1), 4–16. https://doi.org/10.1147/sj.382.0472

Hevner, A., & Chatterjee, S. (2010). Design Science Research in Information Systems. In A. Hevner & S. Chatterjee (Eds.), *Design Research in Information Systems: Theory and Practice* (pp. 9–22). Springer US. https://doi.org/10.1007/978-1-4419-5653-8_2

Hevner, A. R. (2007). A Three Cycle View of Design Science Research. *Scandinavian Journal of Information Systems*, *19*(2), 87–92. https://aisel.aisnet.org/sjis/vol19/iss2/4

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly: Management Information Systems*, *28*(1), 75–105. https://doi.org/10.2307/25148625

Iacob, M. E., Meertens, L. O., Jonkers, H., Quartel, D. A. C., Nieuwenhuis, L. J. M., & van Sinderen, M. J. (2014). From enterprise architecture to business models and back. *Software and Systems Modeling*, *13*(3), 1059–1083. https://doi.org/10.1007/s10270-012-0304-6

IEEE/ISO/IEC International Standard for Software, systems and enterprise--Architecture description. (2022). *ISO/IEC/IEEE 42010:2022(E)*, 1–74. https://doi.org/10.1109/IEEESTD.2022.9938446

ISO/IEC 25002 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality model overview and usage. (2024). *ISO/IEC 25002:2024(En)*. https://www.iso.org/obp/ui/en/#iso:std:iso-iec:25002:ed-1:v1:en

Jadhav, A. S., & Sonar, R. M. (2011). Framework for evaluation and selection of the software packages: A hybrid knowledge based system approach. *Journal of Systems and Software*, *84*(8), 1394–1407. https://doi.org/10.1016/j.jss.2011.03.034

Kahraman, C. (2008). *Fuzzy multi-criteria decision making: theory and applications with recent developments* (Vol. 16). Springer Science & Business Media. https://doi.org/https://doi.org/10.1007/978-0-387-76813-7

Kappelman, L., McGinnis, T., Pettite, A., & Sidorova, A. (2008). *Enterprise Architecture: Charting the Territory for Academic Research* (Vol. 162). http://aisel.aisnet.org/amcis2008/162

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering - A systematic literature review. *Information and Software Technology*, *51*(1), 7–15. https://doi.org/10.1016/j.infsof.2008.09.009

Lankhorst, M. M. (2017). Enterprise architecture at work: Modelling, communication and analysis, fourth edition. In *Enterprise Engineering Series*. https://doi.org/https://doi.org/10.1007/978-3-642-29651-2

Lankhorst, M. M., Quartel, D. A. C., & Steen, M. W. A. (2010). Architecture-based IT portfolio valuation. In *Lecture Notes in Business Information Processing: Vol. 69 LNBIP*. https://doi.org/10.1007/978-3-642-16770-6_4

Lapalme, J., Gerber, A., Van Der Merwe, A., Zachman, J., Vries, M. D., & Hinkelmann, K. (2016). Exploring the future of enterprise architecture: A Zachman perspective. *Computers in Industry*, *79*, 103–113. https://doi.org/10.1016/j.compind.2015.06.010

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems*, *15*(4), 251–266. https://doi.org/10.1016/0167-9236(94)00041-2

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Journal of Clinical Epidemiology*, *62*(10), 1006–1012. https://doi.org/10.1016/j.jclinepi.2009.06.005

Mu, E., & Pereyra-Rojas, M. (2016). *Practical decision making: an introduction to the Analytic Hierarchy Process (AHP) using super decisions V2*. Springer. https://doi.org/https://doi.org/10.1007/978-3-319-33861-3

Myers, M. D. (1997). Qualitative research in information systems. *MIS Quarterly: Management Information Systems*, *21*(2), 241–242. https://doi.org/10.2307/249422

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

PRISM. (1986). *Dispersion and Interconnection: Approaches to Distributed Systems Architecture*. http://www.iso-architecture.org/42010/docs/PRISM-1986-Jun.pdf

Richardson, G. L., Jackson, B. M., & Dickson, G. W. (1990). A Principles-Based Enterprise Architecture: Lessons from Texaco and Star Enterprise. *MIS Quarterly*, *14*(4), 385–403. https://doi.org/10.2307/249787

Rigdon, W. B. (1989). Architectures and Standards, in Information Management Directions. *Information Management Directions: The Integration Challenge (NIST Special Publication 500-167)*, 135–150. https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication500-167.pdf

Romero, D., & Vernadat, F. (2016). Enterprise information systems state of the art: Past, present and future trends. *Computers in Industry*, *79*, 3–13. https://doi.org/10.1016/j.compind.2016.03.001

Saaty, T. (2008). Decision making with the Analytic Hierarchy Process. *Int. J. Services Sciences Int. J. Services Sciences*, *1*, 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Saaty, T. L. (2008). Relative measurement and its generalization in decision making why pairwise comparisons are central in mathematics for the measurement of intangible factors the analytic hierarchy/network process. *Revista de La Real Academia de Ciencias Exactas, Fisicas y Naturales - Serie A: Matematicas*, *102*(2), 251–318. https://doi.org/10.1007/BF03191825

Saaty, T. L., & Vargas, L. G. (2012). *Models, methods, concepts & applications of the analytic hierarchy process* (Vol. 175). Springer Science & Business Media. https://doi.org/https://doi.org/10.1007/978-1-4614-3597-6

Saint-Louis, P., Morency, M. C., & Lapalme, J. (2017). Defining enterprise architecture: A systematic literature review. *Proceedings - IEEE International Enterprise Distributed Object Computing Workshop, EDOCW*, *2017-Octob*, 41–49. https://doi.org/10.1109/EDOCW.2017.16

Sascha, R., Marin, Z., & Florian, M. (2014). *Enterprise Architecture Visualization Tool Survey 2014*. epubli GmbH, Berlin, www.epubli.de. https://wwwmatthes.in.tum.de/file/q4tajx4tmyzm/sebis-Public-Website/Research/Enterprise-Architecture-Management/EAVTS2014-Enterprise-Architecture-Visualization-Tool-Survey/EAVTS-2014-Final-Report/EAVTS2014.pdf

Schekkerman, J. (2003). *How to Survive in the Jungle of Enterprise Architecture Framework: Creating or Choosing an Enterprise Architecture Framework*. Trafford.

Schekkerman, J. (2011). *Enterprise Architecture Tool Selection Guide*. https://www.academia.edu/6549603/Enterprise_Architecture_Tool_Selection_Guide

Simon, H. A., & Laird, J. E. (2019). *The Sciences of the Artificial, reissue of the third edition with a new introduction by John Laird*. MIT Press. https://books.google.pt/books?id=yYSkDwAAQBAJ

Sobczak, A. (2013). Methods of the Assessment of Enterprise Architecture Practice Maturity in an Organization. In A. Kobyliński & A. Sobczak (Eds.), *Perspectives in Business Informatics Research* (pp. 104–111). Springer Berlin Heidelberg. https://doi.org/https://doi.org/10.1007/978-3-642-40823-6_9

Sowa, J. F., & Zachman, J. A. (1992). Extending and formalizing the framework for information systems architecture. *IBM Systems Journal*, *31*(3), 590–616. https://doi.org/10.1147/sj.313.0590

SOX. (2002). Sarbanes-oxley act. *Washington DC*. https://www.congress.gov/bill/107th-congress/house-bill/3763/text

Spewak, S. H., & Hill, S. C. (1992). *Enterprise Architecture Planning: Developing a Blueprint for Data, Applications and Technology*.

Subramanian, N., & Ramanathan, R. (2012). A review of applications of Analytic Hierarchy Process in operations management. *International Journal of Production Economics*, *138*(2), 215–241. https://doi.org/https://doi.org/10.1016/j.ijpe.2012.03.036

TAFIM. (1996). *Department of Defense Technical Architecture Framework for Information Management, Volume 1: Overview*. https://apps.dtic.mil/sti/pdfs/ADA321110.pdf

Tamm, T., Seddon, P. B., & Shanks, G. (2022). How enterprise architecture leads to organisational benefits. *International Journal of Information Management*, *67*. https://doi.org/10.1016/j.ijinfomgt.2022.102554

Tamm, T., Seddon, P. B., Shanks, G., & Reynolds, P. (2011). How does enterprise architecture add value to organisations? *Communications of the Association for Information Systems*, *28*(1), 141–168. https://doi.org/10.17705/1cais.02810

TOGAF. (2022). *TOGAF® Standard*. https://www.opengroup.org/togaf-standard-10th-edition-downloads

Tzeng, G.-H., & Huang, J.-J. (2011). *Multiple attribute decision making: methods and applications*. CRC press. https://doi.org/https://doi.org/10.1201/b11032

van der Raadt, B., Schouten, S., & van Vliet, H. (2008). Stakeholder Perception of Enterprise Architecture. In R. Morrison, D. Balasubramaniam, & K. Falkner (Eds.), *Software Architecture* (pp. 19–34). Springer Berlin Heidelberg. https://doi.org/https://doi.org/10.1007/978-3-540-88030-1_4

Velasquez, M., & Hester, P. (2013). An analysis of multi-criteria decision making methods. *International Journal of Operations Research*, *10*, 56–66.

Wardle, C. (1984). *The evolution of information systems architecture*. https://aisel.aisnet.org/icis1984/4

Yin, R. K., & Campbell, D. T. (Donald T. (2018). *Case study research and applications : design and methods* (Sixth edition.). SAGE Publications, Inc.

Zachman, J. A. (1982). Business Systems Planning and Business Information Control Study: A comparison. *IBM Systems Journal*, *21*(1), 31–53. https://doi.org/10.1147/sj.211.0031

Zachman, J. A. (1987). A framework for information systems architecture. *IBM Systems Journal*, *38*(2/3), 454. https://doi.org/10.1147/sj.382.0454

# APPENDIX

This section presents a detailed and all-inclusive summary of the data gathered in our case study.

## CRITERIA PRIORITY EVALUATION MATRIXES

### *Evaluate and Enterprise Architecture Tool*

Consistency Ratio CR: 4.2%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Functional criteria | 27.4% | 2 |
| 2 | Technical Criteria | 31.1% | 1 |
| 3 | Quality Criteria | 23.5% | 3 |
| 4 | Vendor Criteria | 9.0% | 4 |
| 5 | Cost and Benefits criteria | 6.1% | 5 |
| 6 | Opinion criteria | 2.9% | 6 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 1.00 | 4.00 | 5.00 | 8.00 |
| 2 | 1.00 | 1 | 2.00 | 4.00 | 5.00 | 8.00 |
| 3 | 1.00 | 0.50 | 1 | 4.00 | 4.00 | 7.00 |
| 4 | 0.25 | 0.25 | 0.25 | 1 | 3.00 | 3.00 |
| 5 | 0.20 | 0.20 | 0.25 | 0.33 | 1 | 4.00 |
| 6 | 0.13 | 0.13 | 0.14 | 0.33 | 0.25 | 1 |

### *Functional criteria*

Consistency Ratio CR: 8.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | User Experience | 12.0% | 2 |
| 2 | Business catalogue | 13.2% | 1 |
| 3 | Business matrices | 11.0% | 4 |
| 4 | Business diagrams | 11.7% | 3 |
| 5 | Assets management / life cycle | 2.1% | 14 |
| 6 | Architecture forecasting / scenario planning | 2.6% | 13 |
| 7 | Dashboard and viewpoints capabilities | 8.5% | 7 |
| 8 | Administrative settings | 3.3% | 11 |
| 9 | Configuration / flexibility | 5.4% | 8 |
| 10 | Data requirements | 4.8% | 10 |
| 11 | Data import / export | 5.1% | 9 |
| 12 | Collaboration | 8.7% | 6 |
| 13 | Solution architecture | 8.9% | 5 |
| 14 | Notification / alerting | 2.7% | 12 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 1.00 | 1.00 | 2.00 | 3.00 | 3.00 | 5.00 | 2.00 | 4.00 | 4.00 | 1.00 | 2.00 | 4.00 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 3.00 | 3.00 | 3.00 | 2.00 | 3.00 | 4.00 | 3.00 | 2.00 | 3.00 | 3.00 |
| 3 | 1.00 | 1.00 | 1 | 2.00 | 2.00 | 2.00 | 3.00 | 2.00 | 2.00 | 3.00 | 2.00 | 2.00 | 1.00 | 4.00 |
| 4 | 1.00 | 0.50 | 0.50 | 1 | 4.00 | 4.00 | 2.00 | 2.00 | 2.00 | 3.00 | 4.00 | 2.00 | 3.00 | 6.00 |
| 5 | 0.50 | 0.33 | 0.50 | 0.25 | 1 | 0.50 | 0.20 | 0.25 | 0.25 | 0.20 | 0.25 | 0.20 | 0.20 | 0.25 |
| 6 | 0.33 | 0.33 | 0.50 | 0.25 | 2.00 | 1 | 0.33 | 0.50 | 0.25 | 0.33 | 0.25 | 0.20 | 0.20 | 2.00 |
| 7 | 0.33 | 0.33 | 0.33 | 0.50 | 5.00 | 3.00 | 1 | 3.00 | 2.00 | 2.00 | 3.00 | 2.00 | 2.00 | 3.00 |
| 8 | 0.20 | 0.50 | 0.50 | 0.50 | 4.00 | 2.00 | 0.33 | 1 | 0.33 | 0.33 | 0.50 | 0.25 | 0.33 | 0.50 |
| 9 | 0.50 | 0.33 | 0.50 | 0.50 | 4.00 | 4.00 | 0.50 | 3.00 | 1 | 2.00 | 1.00 | 0.33 | 0.25 | 2.00 |
| 10 | 0.25 | 0.25 | 0.33 | 0.33 | 5.00 | 3.00 | 0.50 | 3.00 | 0.50 | 1 | 1.00 | 0.50 | 0.50 | 3.00 |
| 11 | 0.25 | 0.33 | 0.50 | 0.25 | 4.00 | 4.00 | 0.33 | 2.00 | 1.00 | 1.00 | 1 | 0.50 | 0.33 | 5.00 |
| 12 | 1.00 | 0.50 | 0.50 | 0.50 | 5.00 | 5.00 | 0.50 | 4.00 | 3.00 | 2.00 | 2.00 | 1 | 1.00 | 5.00 |
| 13 | 0.50 | 0.33 | 1.00 | 0.33 | 5.00 | 5.00 | 0.50 | 3.00 | 4.00 | 2.00 | 3.00 | 1.00 | 1 | 5.00 |
| 14 | 0.25 | 0.33 | 0.25 | 0.17 | 4.00 | 0.50 | 0.33 | 2.00 | 0.50 | 0.33 | 0.20 | 0.20 | 0.20 | 1 |

### *Technical Criteria*

Consistency Ratio CR: 7.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Licensing | 1.8% | 9 |
| 2 | Integration | 2.2% | 8 |
| 3 | Cyber security | 20.9% | 2 |
| 4 | GDPR compliance | 39.2% | 1 |
| 5 | Network | 8.9% | 4 |
| 6 | Data | 6.8% | 5 |
| 7 | Migration | 5.0% | 7 |
| 8 | Cloud | 5.9% | 6 |
| 9 | Performance | 9.3% | 3 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.50 | 0.11 | 0.11 | 0.20 | 0.20 | 0.33 | 0.25 | 0.17 |
| 2 | 2.00 | 1 | 0.20 | 0.13 | 0.20 | 0.14 | 0.20 | 0.20 | 0.17 |
| 3 | 9.00 | 5.00 | 1 | 1.00 | 2.00 | 3.00 | 4.00 | 4.00 | 4.00 |
| 4 | 9.00 | 8.00 | 1.00 | 1 | 8.00 | 8.00 | 9.00 | 8.00 | 8.00 |
| 5 | 5.00 | 5.00 | 0.50 | 0.13 | 1 | 2.00 | 3.00 | 1.00 | 1.00 |
| 6 | 5.00 | 7.00 | 0.33 | 0.13 | 0.50 | 1 | 1.00 | 1.00 | 1.00 |
| 7 | 3.00 | 5.00 | 0.25 | 0.11 | 0.33 | 1.00 | 1 | 1.00 | 0.33 |
| 8 | 4.00 | 5.00 | 0.25 | 0.13 | 1.00 | 1.00 | 1.00 | 1 | 0.33 |
| 9 | 6.00 | 6.00 | 0.25 | 0.13 | 1.00 | 1.00 | 3.00 | 3.00 | 1 |

### *Quality Criteria*

Consistency Ratio CR: 0.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Portability | 14.3% | 3 |
| 2 | Maintainability | 42.9% | 1 |
| 3 | Reliability | 42.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 1 | 0.33 | 0.33 |
| 2 | 3.00 | 1 | 1.00 |
| 3 | 3.00 | 1.00 | 1 |

### *Portability*

Consistency Ratio CR: 5.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | DBMS | 41.3% | 1 |
| 2 | Communication | 32.7% | 2 |
| 3 | OS | 26.0% | 3 |

Consolidated Decision Matrix

| | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 |
| 2 | 1.00 | 1 | 1.00 |
| 3 | 0.50 | 1.00 | 1 |

### *Maintainability*

Consistency Ratio CR: 0.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Modules | 25.0% | 2 |
| 2 | Scalability | 75.0% | 1 |

Consolidated Decision Matrix

| | 1 | 2 |
|---|---|---|
| 1 | 1 | 0.33 |
| 2 | 3.00 | 1 |

### *Reliability*

Consistency Ratio CR: 0.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Backup | 83.3% | 1 |
| 2 | Time | 16.7% | 2 |

Consolidated Decision Matrix

| | 1 | 2 |
|---|---|---|
| 1 | 1 | 5.00 |
| 2 | 0.20 | 1 |

### *Vendor Criteria*

Consistency Ratio CR: 7.4%

Consolidated Priorities

| | Criteria | Priority |
|---|---|---|
| 1 | Support and maintenance services | 74.3% |
| 2 | Training and documentation | 19.4% |
| 3 | Vendor reputation | 6.3% |

Consolidated Decision Matrix

| | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 1 | 5.00 | 9.00 |
| 2 | 0.20 | 1 | 4.00 |
| 3 | 0.11 | 0.25 | 1 |

### *Support and maintenance services*

Consistency Ratio CR: 1.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Customer service | 11.0% | 4 |
| 2 | IT operational | 22.3% | 3 |
| 3 | Technical support | 41.8% | 1 |
| 4 | Application | 25.0% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1 | 0.50 | 0.33 | 0.33 |
| 2 | 2.00 | 1 | 0.50 | 1.00 |
| 3 | 3.00 | 2.00 | 1 | 2.00 |
| 4 | 3.00 | 1.00 | 0.50 | 1 |

## *Training and documentation*

Consistency Ratio CR: 0.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Training | 33.3% | 2 |
| 2 | User manual | 66.7% | 1 |

Consolidated Decision Matrix

| | 1 | 2 |
|---|---|---|
| 1 | 1 | 0.50 |
| 2 | 2.00 | 1 |

## *Vendor reputation*

Consistency Ratio CR: 4.8%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | Vendor | 7.5% | 5 |
| 2 | Product | 18.2% | 4 |
| 3 | Number of | 27.0% | 2 |
| 4 | Number of | 19.4% | 3 |
| 5 | Past | 27.8% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.25 | 0.25 | 0.33 | 0.50 |
| 2 | 4.00 | 1 | 0.50 | 1.00 | 0.50 |
| 3 | 4.00 | 2.00 | 1 | 1.00 | 1.00 |
| 4 | 3.00 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 2.00 | 2.00 | 1.00 | 2.00 | 1 |

## *Cost and Benefits criteria*

Consistency Ratio CR: 5.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | License cost | 13.1% | 4 |
| 2 | Hardware and | 15.6% | 3 |
| 3 | Installation and | 20.5% | 1 |
| 4 | Maintenance | 18.1% | 2 |
| 5 | Training cost | 5.2% | 8 |
| 6 | Upgrading cost | 9.5% | 5 |
| 7 | Direct benefits | 9.5% | 6 |
| 8 | Indirect | 8.5% | 7 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.0 | 1.0 | 0.5 | 3.0 | 2.0 | 1.0 | 1.0 |
| 2 | 1.0 | 1 | 1.0 | 1.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| 3 | 1.0 | 1.0 | 1 | 2.0 | 3.0 | 2.0 | 3.0 | 3.0 |
| 4 | 2.0 | 1.0 | 0.5 | 1 | 2.0 | 2.0 | 3.0 | 3.0 |
| 5 | 0.3 | 0.5 | 0.3 | 0.5 | 1 | 0.5 | 0.3 | 0.3 |
| 6 | 0.5 | 0.5 | 0.5 | 0.5 | 2.0 | 1 | 2.0 | 1.0 |
| 7 | 1.0 | 0.5 | 0.3 | 0.3 | 3.0 | 0.5 | 1 | 2.0 |
| 8 | 1.0 | 0.5 | 0.3 | 0.3 | 3.0 | 1.0 | 0.5 | 1 |

## *Opinion criteria*

Consistency Ratio CR: 1.9%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | End users | 23.8% | 2 |
| 2 | In-house | 62.5% | 1 |
| 3 | Magazines | 13.7% | 3 |

Consolidated Decision Matrix

| | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 1 | 0.33 | 2.00 |
| 2 | 3.00 | 1 | 4.00 |
| 3 | 0.50 | 0.25 | 1 |

## ALTERNATIVES EVALUATION MATRIXES

### *User Experience*

Consistency Ratio CR: 3.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 10.2% | 4 |
| 2 | ADOIT | 17.6% | 2 |
| 3 | Ardoq | 6.6% | 5 |
| 4 | iServer | 11.0% | 3 |
| 5 | LeanIX | 54.6% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.50 | 2.00 | 1.00 | 0.17 |
| 2 | 2.00 | 1 | 3.00 | 2.00 | 0.20 |
| 3 | 0.50 | 0.33 | 1 | 0.50 | 0.20 |
| 4 | 1.00 | 0.50 | 2.00 | 1 | 0.25 |
| 5 | 6.00 | 5.00 | 5.00 | 4.00 | 1 |

### *Business catalogue*

Consistency Ratio CR: 3.5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 27.3% | 2 |
| 2 | ADOIT | 13.7% | 3 |
| 3 | Ardoq | 7.3% | 4 |
| 4 | iServer | 6.9% | 5 |
| 5 | LeanIX | 44.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 5.00 | 5.00 | 0.33 |
| 2 | 0.50 | 1 | 2.00 | 2.00 | 0.33 |
| 3 | 0.20 | 0.50 | 1 | 1.00 | 0.25 |
| 4 | 0.20 | 0.50 | 1.00 | 1 | 0.20 |
| 5 | 3.00 | 3.00 | 4.00 | 5.00 | 1 |

### *Business matrices*

Consistency Ratio CR: 2.9%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 14.9% | 3 |
| 2 | ADOIT | 25.7% | 2 |
| 3 | Ardoq | 13.5% | 4 |
| 4 | iServer | 7.5% | 5 |
| 5 | LeanIX | 38.5% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.50 | 1.00 | 3.00 | 0.33 |
| 2 | 2.00 | 1 | 2.00 | 4.00 | 0.50 |
| 3 | 1.00 | 0.50 | 1 | 2.00 | 0.33 |
| 4 | 0.33 | 0.25 | 0.50 | 1 | 0.33 |
| 5 | 3.00 | 2.00 | 3.00 | 3.00 | 1 |

### *Business diagrams*

Consistency Ratio CR: 3.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.7% | 2 |
| 2 | ADOIT | 14.3% | 3 |
| 3 | Ardoq | 7.9% | 4 |
| 4 | iServer | 7.9% | 4 |
| 5 | LeanIX | 44.3% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 4.00 | 4.00 | 0.33 |
| 2 | 0.50 | 1 | 2.00 | 2.00 | 0.33 |
| 3 | 0.25 | 0.50 | 1 | 1.00 | 0.25 |
| 4 | 0.25 | 0.50 | 1.00 | 1 | 0.25 |
| 5 | 3.00 | 3.00 | 4.00 | 4.00 | 1 |

### *Assets management / life cycle*

Consistency Ratio CR: 2.1%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 8.5% | 3 |
| 2 | ADOIT | 21.9% | 2 |
| 3 | Ardoq | 8.5% | 3 |
| 4 | iServer | 8.5% | 3 |
| 5 | LeanIX | 52.6% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.33 | 1.00 | 1.00 | 0.20 |
| 2 | 3.00 | 1 | 3.00 | 3.00 | 0.25 |
| 3 | 1.00 | 0.33 | 1 | 1.00 | 0.20 |
| 4 | 1.00 | 0.33 | 1.00 | 1 | 0.20 |
| 5 | 5.00 | 4.00 | 5.00 | 5.00 | 1 |

### *Architecture forecasting*

Consistency Ratio CR: 3.5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 18.1% | 2 |
| 2 | ADOIT | 11.2% | 3 |
| 3 | Ardoq | 10.1% | 4 |
| 4 | iServer | 5.4% | 5 |
| 5 | LeanIX | 55.2% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 2.00 | 4.00 | 0.20 |
| 2 | 0.50 | 1 | 1.00 | 3.00 | 0.20 |
| 3 | 0.50 | 1.00 | 1 | 2.00 | 0.20 |
| 4 | 0.25 | 0.33 | 0.50 | 1 | 0.17 |
| 5 | 5.00 | 5.00 | 5.00 | 6.00 | 1 |

### *Dashboard and viewpoints capabilities*

Consistency Ratio CR: 2.0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 9.9% | 4 |
| 2 | ADOIT | 24.7% | 2 |
| 3 | Ardoq | 14.0% | 3 |
| 4 | iServer | 7.1% | 5 |
| 5 | LeanIX | 44.2% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.33 | 0.50 | 2.00 | 0.25 |
| 2 | 3.00 | 1 | 2.00 | 3.00 | 0.50 |
| 3 | 2.00 | 0.50 | 1 | 2.00 | 0.25 |
| 4 | 0.50 | 0.33 | 0.50 | 1 | 0.20 |
| 5 | 4.00 | 2.00 | 4.00 | 5.00 | 1 |

### *Administrative settings*

Consistency Ratio CR: 5.2%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 13.1% | 3 |
| 2 | ADOIT | 13.7% | 2 |
| 3 | Ardoq | 9.5% | 4 |
| 4 | iServer | 9.5% | 4 |
| 5 | LeanIX | 54.1% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 1.00 | 0.17 |
| 2 | 0.50 | 1 | 2.00 | 2.00 | 0.25 |
| 3 | 1.00 | 0.50 | 1 | 1.00 | 0.20 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 0.20 |
| 5 | 6.00 | 4.00 | 5.00 | 5.00 | 1 |

### *Configuration / flexibility*

Consistency Ratio CR: 4.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 17.0% | 2 |
| 2 | ADOIT | 12.4% | 4 |
| 3 | Ardoq | 12.6% | 3 |
| 4 | iServer | 8.8% | 5 |
| 5 | LeanIX | 49.2% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 2.00 | 0.33 |
| 2 | 0.50 | 1 | 2.00 | 1.00 | 0.20 |
| 3 | 1.00 | 0.50 | 1 | 2.00 | 0.25 |
| 4 | 0.50 | 1.00 | 0.50 | 1 | 0.20 |
| 5 | 3.00 | 5.00 | 4.00 | 5.00 | 1 |

### *Data requirements*

Consistency Ratio CR: 0.2%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 38.5% | 1 |
| 2 | ADOIT | 20.3% | 2 |
| 3 | Ardoq | 10.8% | 4 |
| 4 | iServer | 10.2% | 5 |
| 5 | LeanIX | 20.3% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 3.00 | 4.00 | 2.00 |
| 2 | 0.50 | 1 | 2.00 | 2.00 | 1.00 |
| 3 | 0.33 | 0.50 | 1 | 1.00 | 0.50 |
| 4 | 0.25 | 0.50 | 1.00 | 1 | 0.50 |
| 5 | 0.50 | 1.00 | 2.00 | 2.00 | 1 |

### *Data import / export*

Consistency Ratio CR: 3.9%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 5.9% | 5 |
| 2 | ADOIT | 14.1% | 3 |
| 3 | Ardoq | 19.9% | 2 |
| 4 | iServer | 9.3% | 4 |
| 5 | LeanIX | 50.8% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.33 | 0.25 | 0.50 | 0.20 |
| 2 | 3.00 | 1 | 0.50 | 2.00 | 0.25 |
| 3 | 4.00 | 2.00 | 1 | 2.00 | 0.25 |
| 4 | 2.00 | 0.50 | 0.50 | 1 | 0.20 |
| 5 | 5.00 | 4.00 | 4.00 | 5.00 | 1 |

### *Collaboration*

Consistency Ratio CR: 0.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 7.4% | 5 |
| 2 | ADOIT | 12.1% | 4 |
| 3 | Ardoq | 37.6% | 1 |
| 4 | iServer | 21.5% | 2 |
| 5 | LeanIX | 21.5% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.50 | 0.25 | 0.33 | 0.33 |
| 2 | 2.00 | 1 | 0.33 | 0.50 | 0.50 |
| 3 | 4.00 | 3.00 | 1 | 2.00 | 2.00 |
| 4 | 3.00 | 2.00 | 0.50 | 1 | 1.00 |
| 5 | 3.00 | 2.00 | 0.50 | 1.00 | 1 |

### *Solution architecture*

Consistency Ratio CR: 3.4%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 18.1% | 3 |
| 2 | ADOIT | 19.7% | 2 |
| 3 | Ardoq | 10.0% | 4 |
| 4 | iServer | 7.1% | 5 |
| 5 | LeanIX | 45.1% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 3.00 | 2.00 | 0.25 |
| 2 | 1.00 | 1 | 2.00 | 3.00 | 0.50 |
| 3 | 0.33 | 0.50 | 1 | 2.00 | 0.25 |
| 4 | 0.50 | 0.33 | 0.50 | 1 | 0.20 |
| 5 | 4.00 | 2.00 | 4.00 | 5.00 | 1 |

### *Notification / alerting features*

Consistency Ratio CR: 7.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 22.2% | 2 |
| 2 | ADOIT | 14.1% | 3 |
| 3 | Ardoq | 13.6% | 4 |
| 4 | iServer | 9.1% | 5 |
| 5 | LeanIX | 40.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 2.00 | 3.00 | 0.33 |
| 2 | 0.50 | 1 | 2.00 | 1.00 | 0.33 |
| 3 | 0.50 | 0.50 | 1 | 3.00 | 0.33 |
| 4 | 0.33 | 1.00 | 0.33 | 1 | 0.33 |
| 5 | 3.00 | 3.00 | 3.00 | 3.00 | 1 |

### *Licensing*

Consistency Ratio CR: 7.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 23.9% | 2 |
| 2 | ADOIT | 13.5% | 4 |
| 3 | Ardoq | 9.6% | 5 |
| 4 | iServer | 15.8% | 3 |
| 5 | LeanIX | 37.3% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 3.00 | 3.00 | 1.00 | 0.50 |
| 2 | 0.33 | 1 | 1.00 | 2.00 | 0.25 |
| 3 | 0.33 | 1.00 | 1 | 0.50 | 0.33 |
| 4 | 1.00 | 0.50 | 2.00 | 1 | 0.50 |
| 5 | 2.00 | 4.00 | 3.00 | 2.00 | 1 |

### *Integration*

Consistency Ratio CR: 5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 20.8% | 3 |
| 2 | ADOIT | 26.4% | 2 |
| 3 | Ardoq | 14.4% | 4 |
| 4 | iServer | 9.0% | 5 |
| 5 | LeanIX | 29.3% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 2.00 | 0.50 |
| 2 | 1.00 | 1 | 3.00 | 2.00 | 1.00 |
| 3 | 0.50 | 0.33 | 1 | 3.00 | 0.50 |
| 4 | 0.50 | 0.50 | 0.33 | 1 | 0.33 |
| 5 | 2.00 | 1.00 | 2.00 | 3.00 | 1 |

### *Cyber security*

Consistency Ratio CR: 5.8%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 19.0% | 2 |
| 2 | ADOIT | 15.3% | 4 |
| 3 | Ardoq | 10.7% | 5 |
| 4 | iServer | 15.9% | 3 |
| 5 | LeanIX | 39.1% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 2.00 | 1.00 | 0.33 |
| 2 | 0.50 | 1 | 1.00 | 2.00 | 0.33 |
| 3 | 0.50 | 1.00 | 1 | 0.50 | 0.33 |
| 4 | 1.00 | 0.50 | 2.00 | 1 | 0.50 |
| 5 | 3.00 | 3.00 | 3.00 | 2.00 | 1 |

### *GDPR compliance*

Consistency Ratio CR: 4.5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 10.0% | 4 |
| 2 | ADOIT | 19.7% | 3 |
| 3 | Ardoq | 40.1% | 1 |
| 4 | iServer | 9.2% | 5 |
| 5 | LeanIX | 21.0% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.33 | 0.25 | 2.00 | 0.33 |
| 2 | 3.00 | 1 | 0.33 | 2.00 | 1.00 |
| 3 | 4.00 | 3.00 | 1 | 3.00 | 2.00 |
| 4 | 0.50 | 0.50 | 0.33 | 1 | 0.50 |
| 5 | 3.00 | 1.00 | 0.50 | 2.00 | 1 |

### *Network*

Consistency Ratio CR: 8%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 21.1% | 2 |
| 2 | ADOIT | 20.2% | 3 |
| 3 | Ardoq | 14.3% | 4 |
| 4 | iServer | 8.3% | 5 |
| 5 | LeanIX | 36.1% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 3.00 | 0.33 |
| 2 | 0.50 | 1 | 3.00 | 2.00 | 0.50 |
| 3 | 1.00 | 0.33 | 1 | 2.00 | 0.50 |
| 4 | 0.33 | 0.50 | 0.50 | 1 | 0.33 |
| 5 | 3.00 | 2.00 | 2.00 | 3.00 | 1 |

### *Data*

Consistency Ratio CR: 3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 4.4% | 5 |
| 2 | ADOIT | 10.4% | 4 |
| 3 | Ardoq | 23.2% | 2 |
| 4 | iServer | 23.2% | 2 |
| 5 | LeanIX | 38.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 0.25 | 0.20 | 0.20 | 0.17 |
| 2 | 4.00 | 1 | 0.33 | 0.33 | 0.25 |
| 3 | 5.00 | 3.00 | 1 | 1.00 | 0.50 |
| 4 | 5.00 | 3.00 | 1.00 | 1 | 0.50 |
| 5 | 6.00 | 4.00 | 2.00 | 2.00 | 1 |

### *Migration*

Consistency Ratio CR: 4.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 23.1% | 2 |
| 2 | ADOIT | 11.1% | 4 |
| 3 | Ardoq | 8.5% | 5 |
| 4 | iServer | 16.9% | 3 |
| 5 | LeanIX | 40.5% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 3.00 | 2.00 | 2.00 | 0.33 |
| 2 | 0.33 | 1 | 2.00 | 0.50 | 0.33 |
| 3 | 0.50 | 0.50 | 1 | 0.50 | 0.25 |
| 4 | 0.50 | 2.00 | 2.00 | 1 | 0.50 |
| 5 | 3.00 | 3.00 | 4.00 | 2.00 | 1 |

### *Cloud*

Consistency Ratio CR: 6.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 23.0% | 2 |
| 2 | ADOIT | 19.2% | 3 |
| 3 | Ardoq | 12.2% | 4 |
| 4 | iServer | 7.7% | 5 |
| 5 | LeanIX | 37.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 2.00 | 3.00 | 0.33 |
| 2 | 0.50 | 1 | 3.00 | 2.00 | 0.50 |
| 3 | 0.50 | 0.33 | 1 | 2.00 | 0.50 |
| 4 | 0.33 | 0.50 | 0.50 | 1 | 0.25 |
| 5 | 3.00 | 2.00 | 2.00 | 4.00 | 1 |

### *Performance*

Consistency Ratio CR: 5.8%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 21.6% | 3 |
| 2 | ADOIT | 28.5% | 2 |
| 3 | Ardoq | 8.2% | 5 |
| 4 | iServer | 12.0% | 4 |
| 5 | LeanIX | 29.7% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 3.00 | 2.00 | 0.50 |
| 2 | 1.00 | 1 | 2.00 | 2.00 | 2.00 |
| 3 | 0.33 | 0.50 | 1 | 0.50 | 0.25 |
| 4 | 0.50 | 0.50 | 2.00 | 1 | 0.33 |
| 5 | 2.00 | 0.50 | 4.00 | 3.00 | 1 |

### *DBMS standards*

Consistency Ratio CR: 2.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 19.4% | 2 |
| 2 | ADOIT | 12.4% | 5 |
| 3 | Ardoq | 14.3% | 3 |
| 4 | iServer | 13.7% | 4 |
| 5 | LeanIX | 40.2% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 2.00 | 0.33 |
| 2 | 0.50 | 1 | 1.00 | 1.00 | 0.33 |
| 3 | 1.00 | 1.00 | 1 | 1.00 | 0.33 |
| 4 | 0.50 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 3.00 | 3.00 | 3.00 | 2.00 | 1 |

### *Communication standards*

Consistency Ratio CR: 4.8%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.7% | 1 |
| 2 | ADOIT | 15.1% | 5 |
| 3 | Ardoq | 17.2% | 3 |
| 4 | iServer | 16.7% | 4 |
| 5 | LeanIX | 25.4% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 2.00 | 1.00 |
| 2 | 1.00 | 1 | 0.50 | 1.00 | 0.50 |
| 3 | 0.50 | 2.00 | 1 | 1.00 | 0.50 |
| 4 | 0.50 | 1.00 | 1.00 | 1 | 1.00 |
| 5 | 1.00 | 2.00 | 2.00 | 1.00 | 1 |

### *OS compatibility*

Consistency Ratio CR: 3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 16.6% | 3 |
| 2 | ADOIT | 12.5% | 5 |
| 3 | Ardoq | 22.0% | 2 |
| 4 | iServer | 16.3% | 4 |
| 5 | LeanIX | 32.6% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 0.50 | 1.00 | 0.50 |
| 2 | 0.50 | 1 | 0.50 | 1.00 | 0.50 |
| 3 | 2.00 | 2.00 | 1 | 1.00 | 0.50 |
| 4 | 1.00 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 2.00 | 2.00 | 2.00 | 2.00 | 1 |

### *Modules*

Consistency Ratio CR: 3.8%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 21.0% | 2 |
| 2 | ADOIT | 18.8% | 3 |
| 3 | Ardoq | 11.5% | 5 |
| 4 | iServer | 14.4% | 4 |
| 5 | LeanIX | 34.3% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 2.00 | 0.50 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 0.50 |
| 3 | 0.50 | 1.00 | 1 | 0.50 | 0.33 |
| 4 | 0.50 | 0.50 | 2.00 | 1 | 0.50 |
| 5 | 2.00 | 2.00 | 3.00 | 2.00 | 1 |

### *Scalability*

Consistency Ratio CR: 3.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 13.5% | 3 |
| 2 | ADOIT | 22.2% | 2 |
| 3 | Ardoq | 10.7% | 5 |
| 4 | iServer | 13.3% | 4 |
| 5 | LeanIX | 40.3% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 1.00 | 1.00 | 0.25 |
| 2 | 1.00 | 1 | 3.00 | 2.00 | 0.50 |
| 3 | 1.00 | 0.33 | 1 | 1.00 | 0.25 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 0.50 |
| 5 | 4.00 | 2.00 | 4.00 | 2.00 | 1 |

### *Backup and recovery*

Consistency Ratio CR: 2.5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 28.6% | 2 |
| 2 | ADOIT | 18.6% | 3 |
| 3 | Ardoq | 12.9% | 4 |
| 4 | iServer | 10.1% | 5 |
| 5 | LeanIX | 29.7% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 3.00 | 3.00 | 1.00 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 0.50 |
| 3 | 0.33 | 1.00 | 1 | 1.00 | 0.50 |
| 4 | 0.33 | 0.50 | 1.00 | 1 | 0.33 |
| 5 | 1.00 | 2.00 | 2.00 | 3.00 | 1 |

### *Time behaviour*

Consistency Ratio CR: 1.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 17.8% | 3 |
| 2 | ADOIT | 10.1% | 5 |
| 3 | Ardoq | 11.8% | 4 |
| 4 | iServer | 20.1% | 2 |
| 5 | LeanIX | 40.2% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 1.00 | 0.50 |
| 2 | 0.50 | 1 | 1.00 | 0.50 | 0.25 |
| 3 | 1.00 | 1.00 | 1 | 0.50 | 0.25 |
| 4 | 1.00 | 2.00 | 2.00 | 1 | 0.50 |
| 5 | 2.00 | 4.00 | 4.00 | 2.00 | 1 |

### *Customer service*

Consistency Ratio CR: 2.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 31.2% | 1 |
| 2 | ADOIT | 14.1% | 4 |
| 3 | Ardoq | 15.5% | 3 |
| 4 | iServer | 14.1% | 4 |
| 5 | LeanIX | 25.1% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 3.00 | 2.00 | 1.00 |
| 2 | 0.50 | 1 | 1.00 | 1.00 | 0.50 |
| 3 | 0.33 | 1.00 | 1 | 1.00 | 1.00 |
| 4 | 0.50 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 1.00 | 2.00 | 1.00 | 2.00 | 1 |

### *IT operational support*

Consistency Ratio CR: 3.9%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 22.3% | 2 |
| 2 | ADOIT | 15.2% | 5 |
| 3 | Ardoq | 20.0% | 3 |
| 4 | iServer | 23.2% | 1 |
| 5 | LeanIX | 19.3% | 4 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 1.00 | 1.00 |
| 2 | 0.50 | 1 | 0.50 | 1.00 | 1.00 |
| 3 | 1.00 | 2.00 | 1 | 0.50 | 1.00 |
| 4 | 1.00 | 1.00 | 2.00 | 1 | 1.00 |
| 5 | 1.00 | 1.00 | 1.00 | 1.00 | 1 |

### *Technical support*

Consistency Ratio CR: 4.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.9% | 1 |
| 2 | ADOIT | 22.5% | 2 |
| 3 | Ardoq | 19.6% | 3 |
| 4 | iServer | 17.1% | 4 |
| 5 | LeanIX | 14.9% | 5 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 2.00 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 0.50 | 1.00 | 1 | 1.00 | 2.00 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 1.00 |
| 5 | 0.50 | 1.00 | 0.50 | 1.00 | 1 |

### *Application Support*

Consistency Ratio CR: 3.5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 23.2% | 1 |
| 2 | ADOIT | 21.9% | 2 |
| 3 | Ardoq | 19.7% | 4 |
| 4 | iServer | 13.2% | 5 |
| 5 | LeanIX | 21.9% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 1.00 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 0.50 | 1.00 | 1 | 2.00 | 1.00 |
| 4 | 1.00 | 0.50 | 0.50 | 1 | 0.50 |
| 5 | 1.00 | 1.00 | 1.00 | 2.00 | 1 |

### *Training*

Consistency Ratio CR: 4.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 19.6% | 3 |
| 2 | ADOIT | 22.5% | 2 |
| 3 | Ardoq | 14.9% | 5 |
| 4 | iServer | 17.1% | 4 |
| 5 | LeanIX | 25.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 0.50 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 0.50 | 1.00 | 1 | 1.00 | 0.50 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 1.00 |
| 5 | 2.00 | 1.00 | 2.00 | 1.00 | 1 |

### *User manual and Troubleshooting guides*

Consistency Ratio CR: 4.9%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 22.6% | 1 |
| 2 | ADOIT | 22.6% | 1 |
| 3 | Ardoq | 18.2% | 4 |
| 4 | iServer | 17.4% | 5 |
| 5 | LeanIX | 19.2% | 3 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 1.00 |
| 2 | 1.00 | 1 | 2.00 | 1.00 | 1.00 |
| 3 | 0.50 | 0.50 | 1 | 2.00 | 1.00 |
| 4 | 1.00 | 1.00 | 0.50 | 1 | 1.00 |
| 5 | 1.00 | 1.00 | 1.00 | 1.00 | 1 |

### *Vendor popularity*

Consistency Ratio CR: 2.1%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 32.8% | 1 |
| 2 | ADOIT | 12.4% | 5 |
| 3 | Ardoq | 18.8% | 3 |
| 4 | iServer | 14.3% | 4 |
| 5 | LeanIX | 21.6% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 2.00 | 2.00 | 2.00 |
| 2 | 0.50 | 1 | 0.50 | 1.00 | 0.50 |
| 3 | 0.50 | 2.00 | 1 | 1.00 | 1.00 |
| 4 | 0.50 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 0.50 | 2.00 | 1.00 | 2.00 | 1 |

### *Product history*

Consistency Ratio CR: 3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 35.4% | 1 |
| 2 | ADOIT | 26.8% | 2 |
| 3 | Ardoq | 8.8% | 4 |
| 4 | iServer | 20.2% | 3 |
| 5 | LeanIX | 8.8% | 5 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 3.00 | 2.00 | 3.00 |
| 2 | 0.50 | 1 | 3.00 | 2.00 | 3.00 |
| 3 | 0.33 | 0.33 | 1 | 0.33 | 1.00 |
| 4 | 0.50 | 0.50 | 3.00 | 1 | 3.00 |
| 5 | 0.33 | 0.33 | 1.00 | 0.33 | 1 |

*Number of installations*

Consistency Ratio CR: 0%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.0% | 1 |
| 2 | ADOIT | 25.0% | 1 |
| 3 | Ardoq | 12.5% | 4 |
| 4 | iServer | 25.0% | 1 |
| 5 | LeanIX | 12.5% | 4 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 2.00 |
| 2 | 1.00 | 1 | 2.00 | 1.00 | 2.00 |
| 3 | 0.50 | 0.50 | 1 | 0.50 | 1.00 |
| 4 | 1.00 | 1.00 | 2.00 | 1 | 2.00 |
| 5 | 0.50 | 0.50 | 1.00 | 0.50 | 1 |

*Number of references*

Consistency Ratio CR: 1.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 14.3% | 4 |
| 2 | ADOIT | 14.3% | 4 |
| 3 | Ardoq | 22.1% | 2 |
| 4 | iServer | 16.5% | 3 |
| 5 | LeanIX | 32.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 0.50 | 1.00 | 0.50 |
| 2 | 1.00 | 1 | 0.50 | 1.00 | 0.50 |
| 3 | 2.00 | 2.00 | 1 | 1.00 | 0.50 |
| 4 | 1.00 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 2.00 | 2.00 | 2.00 | 2.00 | 1 |

*Past business experience*

Consistency Ratio CR: 4.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.3% | 1 |
| 2 | ADOIT | 22.5% | 2 |
| 3 | Ardoq | 16.0% | 5 |
| 4 | iServer | 17.0% | 4 |
| 5 | LeanIX | 19.2% | 3 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 3.00 | 1.00 | 1.00 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 0.33 | 1.00 | 1 | 1.00 | 1.00 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 1.00 |
| 5 | 1.00 | 1.00 | 1.00 | 1.00 | 1 |

*License cost*

Consistency Ratio CR: 4.4%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.3% | 1 |
| 2 | ADOIT | 14.9% | 5 |
| 3 | Ardoq | 23.1% | 2 |
| 4 | iServer | 19.9% | 3 |
| 5 | LeanIX | 16.8% | 4 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 1.00 | 2.00 |
| 2 | 0.50 | 1 | 1.00 | 0.50 | 1.00 |
| 3 | 1.00 | 1.00 | 1 | 2.00 | 1.00 |
| 4 | 1.00 | 2.00 | 0.50 | 1 | 1.00 |
| 5 | 0.50 | 1.00 | 1.00 | 1.00 | 1 |

### *Hardware and software cost*

Consistency Ratio CR: 4.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 19.6% | 3 |
| 2 | ADOIT | 17.1% | 4 |
| 3 | Ardoq | 14.9% | 5 |
| 4 | iServer | 22.5% | 2 |
| 5 | LeanIX | 25.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 0.50 |
| 2 | 1.00 | 1 | 1.00 | 0.50 | 1.00 |
| 3 | 0.50 | 1.00 | 1 | 1.00 | 0.50 |
| 4 | 1.00 | 2.00 | 1.00 | 1 | 1.00 |
| 5 | 2.00 | 1.00 | 2.00 | 1.00 | 1 |

### *Installation and implementation cost*

Consistency Ratio CR: 3.2%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 26.6% | 1 |
| 2 | ADOIT | 25.2% | 2 |
| 3 | Ardoq | 18.6% | 4 |
| 4 | iServer | 20.5% | 3 |
| 5 | LeanIX | 9.1% | 5 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 3.00 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 2.00 |
| 3 | 0.50 | 1.00 | 1 | 1.00 | 2.00 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 3.00 |
| 5 | 0.33 | 0.50 | 0.50 | 0.33 | 1 |

### *Maintenance cost*

Consistency Ratio CR: 3.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.7% | 2 |
| 2 | ADOIT | 30.6% | 1 |
| 3 | Ardoq | 14.7% | 4 |
| 4 | iServer | 19.9% | 3 |
| 5 | LeanIX | 9.1% | 5 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 3.00 |
| 2 | 1.00 | 1 | 3.00 | 2.00 | 2.00 |
| 3 | 0.50 | 0.33 | 1 | 1.00 | 2.00 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 3.00 |
| 5 | 0.33 | 0.50 | 0.50 | 0.33 | 1 |

### *Training cost*

Consistency Ratio CR: 3.5%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 17.5% | 3 |
| 2 | ADOIT | 16.5% | 4 |
| 3 | Ardoq | 29.6% | 1 |
| 4 | iServer | 19.9% | 2 |
| 5 | LeanIX | 16.5% | 4 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 1.00 | 0.50 | 1.00 |
| 2 | 1.00 | 1 | 0.50 | 1.00 | 1.00 |
| 3 | 1.00 | 2.00 | 1 | 2.00 | 2.00 |
| 4 | 2.00 | 1.00 | 0.50 | 1 | 1.00 |
| 5 | 1.00 | 1.00 | 0.50 | 1.00 | 1 |

### *Upgrading cost*

Consistency Ratio CR: 4.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.9% | 1 |
| 2 | ADOIT | 19.6% | 3 |
| 3 | Ardoq | 22.5% | 2 |
| 4 | iServer | 14.9% | 5 |
| 5 | LeanIX | 17.1% | 4 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 2.00 | 1.00 |
| 2 | 0.50 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 1.00 | 1.00 | 1 | 1.00 | 2.00 |
| 4 | 0.50 | 0.50 | 1.00 | 1 | 1.00 |
| 5 | 1.00 | 1.00 | 0.50 | 1.00 | 1 |

### *Direct benefits*

Consistency Ratio CR: 6.9%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 24.3% | 2 |
| 2 | ADOIT | 27.6% | 1 |
| 3 | Ardoq | 17.5% | 4 |
| 4 | iServer | 18.8% | 3 |
| 5 | LeanIX | 11.7% | 5 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 2.00 |
| 2 | 1.00 | 1 | 3.00 | 1.00 | 2.00 |
| 3 | 0.50 | 0.33 | 1 | 1.00 | 3.00 |
| 4 | 1.00 | 1.00 | 1.00 | 1 | 1.00 |
| 5 | 0.50 | 0.50 | 0.33 | 1.00 | 1 |

### *Indirect benefits*

Consistency Ratio CR: 2.6%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 25.9% | 1 |
| 2 | ADOIT | 19.5% | 3 |
| 3 | Ardoq | 22.1% | 2 |
| 4 | iServer | 12.9% | 5 |
| 5 | LeanIX | 19.5% | 4 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2.00 | 1.00 | 2.00 | 1.00 |
| 2 | 0.50 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 1.00 | 1.00 | 1 | 2.00 | 1.00 |
| 4 | 0.50 | 0.50 | 0.50 | 1 | 1.00 |
| 5 | 1.00 | 1.00 | 1.00 | 1.00 | 1 |

### *End users*

Consistency Ratio CR: 4.7%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 17.4% | 3 |
| 2 | ADOIT | 21.9% | 2 |
| 3 | Ardoq | 13.2% | 5 |
| 4 | iServer | 13.9% | 4 |
| 5 | LeanIX | 33.6% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 2.00 | 1.00 | 0.33 |
| 2 | 1.00 | 1 | 1.00 | 2.00 | 1.00 |
| 3 | 0.50 | 1.00 | 1 | 1.00 | 0.33 |
| 4 | 1.00 | 0.50 | 1.00 | 1 | 0.50 |
| 5 | 3.00 | 1.00 | 3.00 | 2.00 | 1 |

## *In-house experts*

Consistency Ratio CR: 4%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 14.4% | 5 |
| 2 | ADOIT | 19.0% | 2 |
| 3 | Ardoq | 15.8% | 4 |
| 4 | iServer | 15.9% | 3 |
| 5 | LeanIX | 34.9% | 1 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 1.00 | 0.50 | 1.00 | 0.50 |
| 2 | 1.00 | 1 | 2.00 | 1.00 | 0.50 |
| 3 | 2.00 | 0.50 | 1 | 1.00 | 0.33 |
| 4 | 1.00 | 1.00 | 1.00 | 1 | 0.50 |
| 5 | 2.00 | 2.00 | 3.00 | 2.00 | 1 |

## *Magazines*

Consistency Ratio CR: 1.3%

Consolidated Priorities

| | Criteria | Priority | Rank |
|---|---|---|---|
| 1 | ABACUS | 37.2% | 1 |
| 2 | ADOIT | 12.8% | 4 |
| 3 | Ardoq | 12.8% | 4 |
| 4 | iServer | 16.1% | 3 |
| 5 | LeanIX | 21.1% | 2 |

Consolidated Decision Matrix

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 3.00 | 3.00 | 2.00 | 2.00 |
| 2 | 0.33 | 1 | 1.00 | 1.00 | 0.50 |
| 3 | 0.33 | 1.00 | 1 | 1.00 | 0.50 |
| 4 | 0.50 | 1.00 | 1.00 | 1 | 1.00 |
| 5 | 0.50 | 2.00 | 2.00 | 1.00 | 1 |

NOVA Information Management School

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