Evaluation of A3AO in Cyber-physical product development projects

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Abstract

Modern cyber-physical systems are becoming increasingly complex, involving tighter integration of mechanical, electrical, and software components. As a result, there is a growing need for improved communication, traceability, and effectiveness in early-stage development. This research explores the value of the A3AO approach, a diagram-based systems architecting approach that integrates physical, functional, and quantitative views to support the transition from requirements to engineering. We have conducted the research within the Design and Systems Architecture (DSA) department in Tomra Systems ASA. This department aims to enhance early-phase understanding and cross-disciplinary collaboration among project managers, testers, and engineers. Through case studies in two cyber-physical product development projects, we applied the A3AO method and evaluated the results based on project data and feedback. The findings indicate that the approach can enhance the effectiveness of multidisciplinary teams in the early phases and their understanding of the system. The case studies found that applying the A3AO approach in the development projects can save the company up to 285 hours per project.

Keywords

Systems architecture, A3AO, A3 architecture overview.

Introduction

Background

Tomra Systems ASA is a global, multi-sector company specializing in sensor- based technology, primarily focused on recycling, resource recovery, and resource extraction. Tomra Systems operates in over 100 countries and employs more than 5,000 people worldwide (Tomra, 13.05.2025). The divisions of Tomra Systems include Collection, Food, and Recycling. The company began with reverse vending machines in 1972. Our research is conducted in Tomra Collection, which manages the reverse vending machines. The reverse vending machine market is expanding, with an increase in competitors and their innovations. To maintain its position as the market leader, Tomra Collection must continue to innovate.

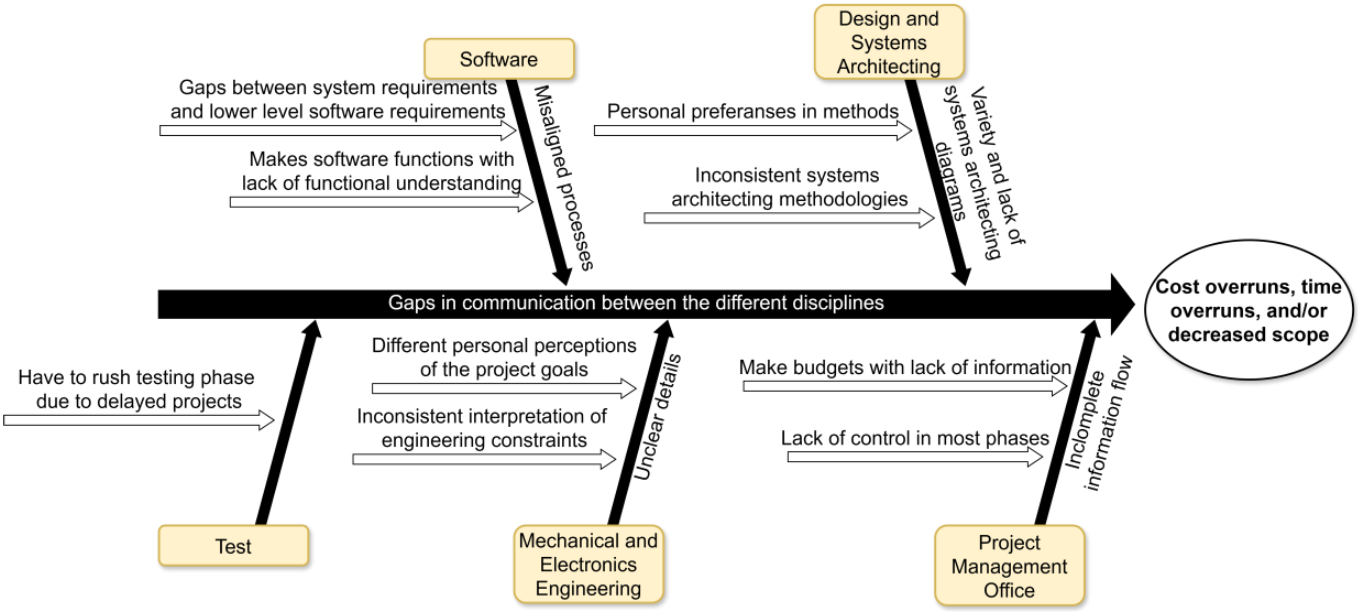

Figure 1 Root problem

To boost the effectiveness and efficiency of projects, Tomra Collection introduced systems engineering in 2018 by establishing a DSA department. The purpose of the initiative was to enhance traceability, communication, and delivery within projects and the organization. A key element in the new approach was to invest more time at the beginning of projects to understand the problems to be solved before commencing development. Honour (2010) has shown that this approach reduces unpleasant surprises later in projects. Given the organization's limited systems engineering experience, they initially prioritized systems requirements, road mapping, and some architectural methods.

Focus areas for improvement in DSA

A previous study conducted in Tomra Collection found that project waste due to requirements amounted to € 83 500 per project (Tomra, 2019). Since then, the focus areas for improvement within DSA have been how to write, maintain, store, and review requirements. These improvements have been significant for Tomra, but they have also led to an understanding of the need for a focus on systems architecture to link requirements to development.

The problem

Tomra Collection continues to have projects that exceed time and cost constraints, or that require scope reductions to deliver within time and cost.

Figure 1 shows most of the disciplines involved in Tomra's cyber-physical product development projects and their pain points. Based on these observations, the researchers have defined the scope of this research as follows: "Minimize the gap between system requirements and system development, ensuring that the design aligns with the desired system performance".

A3 Architecture Overview (A3AO)

In the research, we have evaluated how A3 Architecture Overviews (A3AO) can support the Tomra Collection need for minimizing the gap between system requirements and development. A3AO is a systems architecture approach developed by Borches (2010). A3AO combines different views on one sheet of A3 to solve a problem. It is recognized for enhancing communication among different disciplines. The A3AO originally consisted of two sides, one for text and one for visualizations, but this research uses only the visualization side.

Research questions

In our research, we seek to reduce the gap between system requirements and development while ensuring the design aligns with the desired system performance by answering the following Research Questions (RQs):

Main RQ: How can the A3AO approach support and improve the systems architecture process, and how efficient is it in practice?

RQ1: What are the challenges associated with the current systems architecture approach?

RQ2: How does the A3AO approach address these challenges, and what improvements does it introduce?

RQ3: How do internal stakeholders perceive the usefulness and practical benefits of the A3AO approach?

RQ4: What are the cost implications of implementing the A3AO approach?

RQ5: What are the key success factors for completing an A3AO efficiently, and what potential pitfalls may reduce its efficiency?

Literature

Background

Systems have become increasingly complex over the last few decades (Honour, 2010). Contributing factors for this are faster product development, increased product performance expectancy, reduced budgets for development, more rapid product optimization, and increased expectancy of electronics and software implementation (Borches, 2010). This is one of the main reasons behind the growing need for systems engineering. There are multiple definitions of systems engineering, but one holistic one is: *"Systems Engineering (SE) is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on holistically and concurrently understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying, validating, and evolving solutions while considering the complete problem, from system concept exploration through system disposal."* (Hutchison & Hoffman, 2024)

Systems engineering emphasizes a holistic perspective, integrating various viewpoints to ensure optimal performance for stakeholders; this objective is accomplished through systems thinking. Figure 2 shows that spending more time on system design with a systems thinking approach in a project will save both time and costs while also resulting in an overall lower risk. Systems thinking encompasses a range of diverse aspects, including architecture. The architecture illustrates the structure, components, and interconnections of the system (Sols, 2019). Systems architecture is the system engineering capability with the highest correlation to project success (Honour, 2010). This means that having a systematic architectural approach to follow is important for deriving greater value from systems engineering.

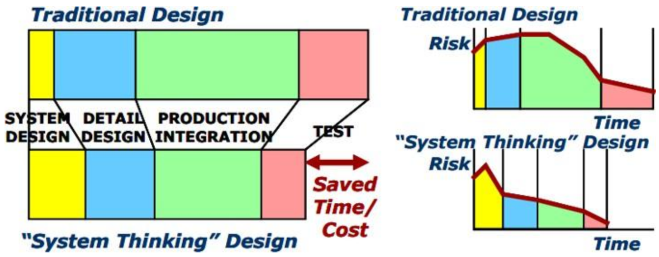

Figure 2 Value of SE, intuitive value, and risk reduction (Honour, 2010)

A3 architecture overview

Borches (2010) first introduced A3AO in his doctoral thesis, inspired by Toyota's A3 for problem-solving. The basic concept involves presenting the systems architecture on a single A3 sheet (420x594mm) to support effective architectural communication. One side features text, while the other displays visualizations.

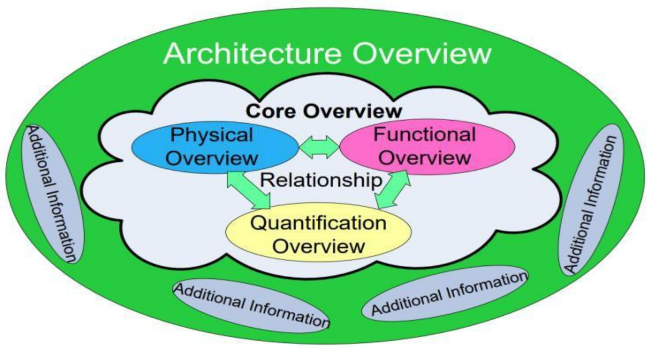

Figure 3 A3AO elements (Borches & Bonnema, 2010)

According to Zachman (1987) systems architecture is most effective when using multiple architectural views, which the A3AO provides. Borches and Bonnema (2010) show in Figure 3 the A3AO elements comprise three different architectural views: physical, functional, and quantification.

Research consistently shows that A3AO enhances overall project understanding due to its many

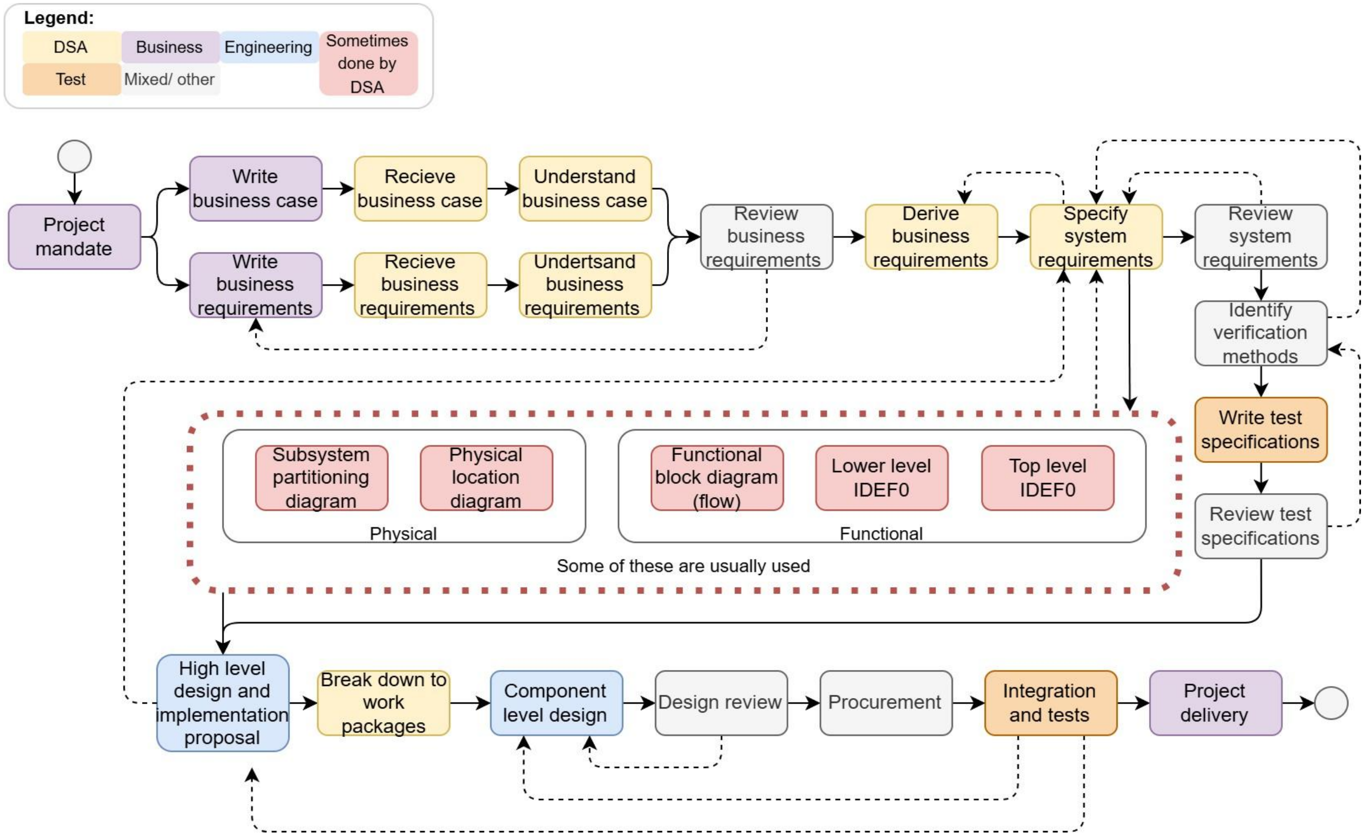

Figure 4 System lifecycle in projects in TC

visualizations combined in one sheet (Haugland & Engen, 2021; Hidle & Kjørstad, 2024; Johanssen & Zhao, 2019; Pesselse et al., 2019). Frequently noted factors include knowledge dissemination through A3AO (Boge & Falk, 2019; Løndal & Falk, 2018) and the improved communication it facilitates among all stakeholders involved in the project (Viken & Muller, 2018; Frønvold et al., 2017).

The TOMRA Approach

There are numerous systems engineering methods. Tomra has chosen a variant of the Vee model (Mooz & Forsberg, 1991). The original Vee model is an evolutionary sequential system life-cycle model (Marbach & Katz, 2024). Tomra have adopted the Vee model to fit within their organization. Figure 4 shows a high-level systems overview of how Tomra Collection implements cyber-physical projects. The systems engineering management approach guide in Tomra Collection (Tomra, 2024) provides insight into standards, processes, and toolsets the projects should use. This guide focuses on business cases, business requirements, system requirements, subsystem requirements, implementation, and different levels of integration and testing.

There is a lack of a standardized approach for conducting systems architecture in the company. As shown in Figure 4, systems architecting activities are part of the company process, as they use different functional and physical views. However, currently the company has no standard method to create, manage, utilize, and store the systems architecture artifact.

Research Approach

According to Muller (2012), research in systems engineering is challenging to support; therefore, it is optimally conducted using the industry-as-laboratory approach. This study uses industry-as-laboratory and action research. Potts (1993) discussed the industry-as-laboratory approach, which utilizes real system-development projects as case studies to produce and demonstrate research results. Action research is an approach that focuses on participation, and the researcher is also active in the research (Checkland & Holwell, 1998). The approach in this research aims to address some of the challenges Tomra Collection faces by introducing the A3AO approach through

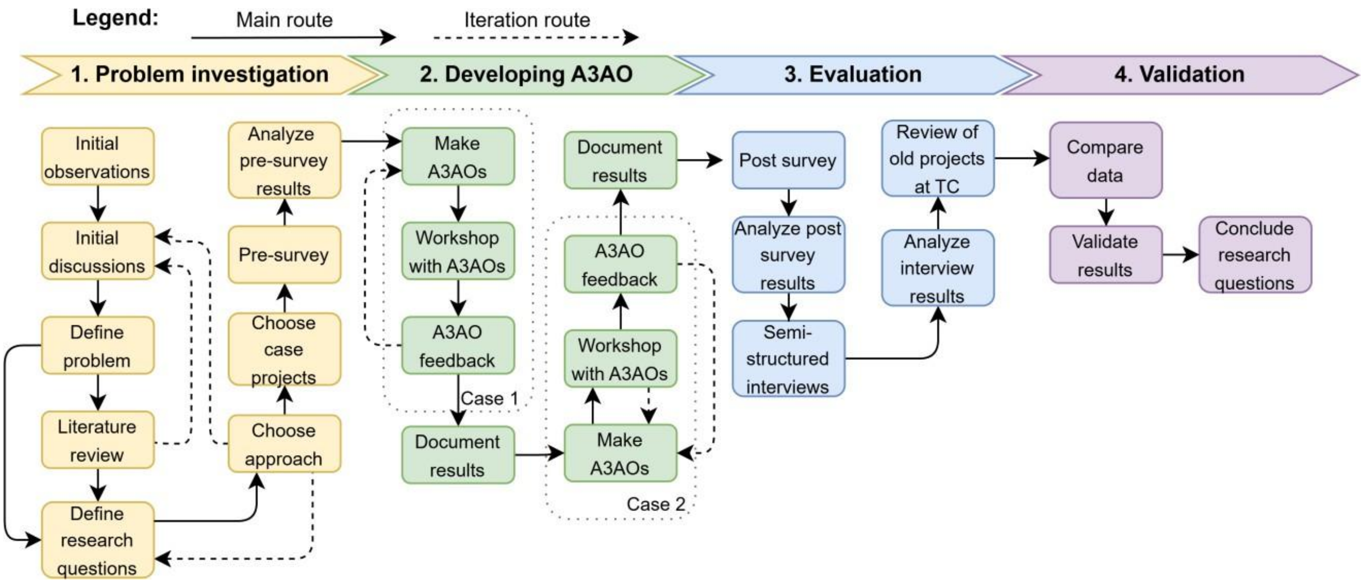

Figure 5 Research design

two separate cyber-physical product development projects that serve as case studies.

Research design

This study follows the four steps outlined in the research design presented in Figure 5. These steps include Problem Investigation, Developing A3AO, evaluation, and validation.

1. Problem investigation

The goal of the first phase was to identify a problem within TC and find an approach as a potential solution. The researchers began with open interviews and discussions around the office to pinpoint a common issue. After defining the problem, we conducted a literature review to establish the research questions and chose the approach to be applied. Following, we selected the projects to be used as case studies. Finally, the problem investigation phase concluded with a baseline survey to better understand the situation at Tomra Collection before proceeding with the research.

2. Developing A3AO

In the second phase, we focused on testing the A3AO approach in Tomra Collection on two ongoing projects in the company. The main researcher actively contributed to the projects and collaborated with systems architects to set up the A3AO and some of its content. The main researcher attended workshops and meetings where the A3AOs were the focus to gather feedback on overall concerns, benefits, and improvements to the A3AO setup. This feedback was used to revise the A3AO with DSA department. To log all data from A3AO development, workshops, and other feedback, we used a data logbook.

3. Evaluation

To evaluate the approach, we conducted post-surveys and semi-structured interviews with resources in the DSA department and other internal stakeholders in Tomra Collection.

4. Validation

To validate the research findings, the researcher compared all the data with one another and later with the literature.

Data Collection

Participation

The research consisted of two surveys and two interviews. We conducted the pre-survey at the beginning of the research, while we conducted the post-survey towards the end. The interviews were with the project participants from DSA department, while each survey included 20 participants across disciplines, as shown in Table 1.

Pre-survey

We utilized the pre-survey to gather baseline information regarding the current situation at

Discipline	Pre	Post	Interview
Systems Engineer	2	2	2
Project Manager	1	1	-
Mechanical Engineer	7	7	-
Software Engineer	3	3	-
Test developer	1	1	-
Project purchaser	2	2	-
Designer	2	2	-
Other	2	2	-
Total	**20**	**20**	**2**

Table 1 Research attendance

Tomra Collection. In the survey, we asked about the amount of time participants typically spend resolving ambiguities in system requirements and regarding challenges introduced by the current architectural approach. The reported challenges were categorized into pain points and the consequences of those pain points.

Post survey

The post-survey was divided into two parts; one part was the data to calculate cost estimates in solving ambiguities in system requirements after introducing the A3AO. The other part utilized a Likert scale to gather responses on how the A3AO helped mitigate pain points and consequences, as well as an overall assessment of the A3AO in TC.

The Likert scale is a method that makes it easy for the participants, as it does not force specific responses and is ideal for a single topic (Likert, 2025). To analyze the survey data, we used a Net Promoter Score (NPS). NPS is a tool that measures and indicates stakeholders' overall perception of a given topic (NPS, 2021). The NPS is calculated as the “$\%Promoters - \%Detractors$, considering strongly agree as promoters and neutral, disagree, and strongly disagree as detractors.

Figure 6 NPS levels (Raileanu, 2025)

Promoters (“strongly agree” on the Likert scale) are loyal enthusiasts; they will continue to support in the future. Passives (“agree” on the Likert scale) are satisfied with the current status but may change their mind later. Detractors (neutral, disagree, and strongly disagree with the Likert scale) are un- happy and could damage the reputation (NPS, 2021). Figure 6 shows what the different levels of NPS mean.

Semi-structured interviews

When the A3AOs were created and utilized in workshops, we conducted semi-structured interviews with the two participants from DSA department individually. These interviews primarily focused on the time spent developing the A3AO, the factors contributing to its success, and any potential pitfalls. The data included reported success factors and pitfalls, alongside their importance, which was rated from 1 to 10, with 10 indicating high significance. This data was subsequently combined and organized.

Review of old cyber-physical projects at Tomra Collection

The researcher gathered data from the past 20 cyber-physical product development projects in Tomra Collection to confirm the validity of the pre-survey data about project consequences.

Limitations

The research has identified three main limitations: only two projects tested A3AO; more projects would help obtain more valuable and accurate data. The number of participants, including DSA and stakeholders, is limited; a broader participant group would facilitate the collection of more data for better comparison. Sufficient time is needed to conduct more in-depth research and to broaden the scope to include additional aspects of how A3AO is developed, as well as the types and sizes of workshops that are best for reviewing it. Lastly, surveys and interviews measure participants' opinions and beliefs.

Pain Baseline

This section addresses the findings from both methods used to set a baseline for the study.

Pre-survey

At the initial stage of the research, we conducted a pre-survey to collect data on the pain points and consequences of the current systems architecture approach. The data was later combined and structured. Table 2 and Table 3 show all the pain points and consequences reported thrice or more.

Current pain points	Times reported
Lack of clarity in system requirements	16
Communication issues between disciplines	14
Poor traceability between requirements and design	10

Table 2 Pre-survey results: Current pain points

Consequences of the current pain points	Times reported
Time overrun	16
Cost overrun	14
Change requests (scope reduction)	10
Rushed conclusions	6

Table 3 Pre-survey results: Consequences from current pain points

The most frequently reported category in Table 2 includes statements referring to ambiguous or insufficiently defined system requirements. Similarly, the most frequently reported category in Table 3 comprises responses describing schedule delays caused by rework, late clarification of requirements, and extended decision-making processes.

In addition, we asked the participants about how much time they normally spend resolving ambiguities surrounding system requirements. From the survey, we found that the average time was approximately 40 hours per participant, which corresponds to 600 hours in total.

Review of old cyber-physical projects at TC

The researchers reviewed all the cyber-physical projects TC has undertaken in the past five years. The result was that only 14 out of 20 projects met their time and cost budgets as well as the scope of performance.

A3AO Development

In the next phase of the research, we researched how A3AO could support Tomra Collection to reduce the pain points found in the pre-survey.

We developed a A3AO for two different ongoing projects in the company. In both cases we carried out two separate workshops addressing the issue the A3AO was focusing on. In addition, we had individual feedback sessions with interested stakeholders. The A3AO development was done in iterations, and the following sub-sections describes the final A3AOs. Both of the final A3AOs are divided into three levels, and each level includes two to three of the views: "Functional", "Physical", and "Quantifications

The A3AO aims to minimize the gap between system requirements and development while ensuring that the design aligns with the desired system performance. The research also considers how the A3AO could be integrated in the existing workflows. Figure 7 demonstrates the intended workflow when utilizing the A3AO approach. As shown in the figure, the A3AOs incorporate views already created in the existing process, while the A3AO format provides these views with a structured framework. Additionally, a change is introduced in the review, as systems architecture should now be used in design reviews during the development phase.

Case 1

Case 1 considers a new single-feed reversed vending machine, focusing on a new power-saving mode. The A3AO aims to show how the machine enters and exits power-saving mode. This project was already in the development phase under this case study. The final A3AO is shown in Figure 8. The A3AO encouraged some discussion during the

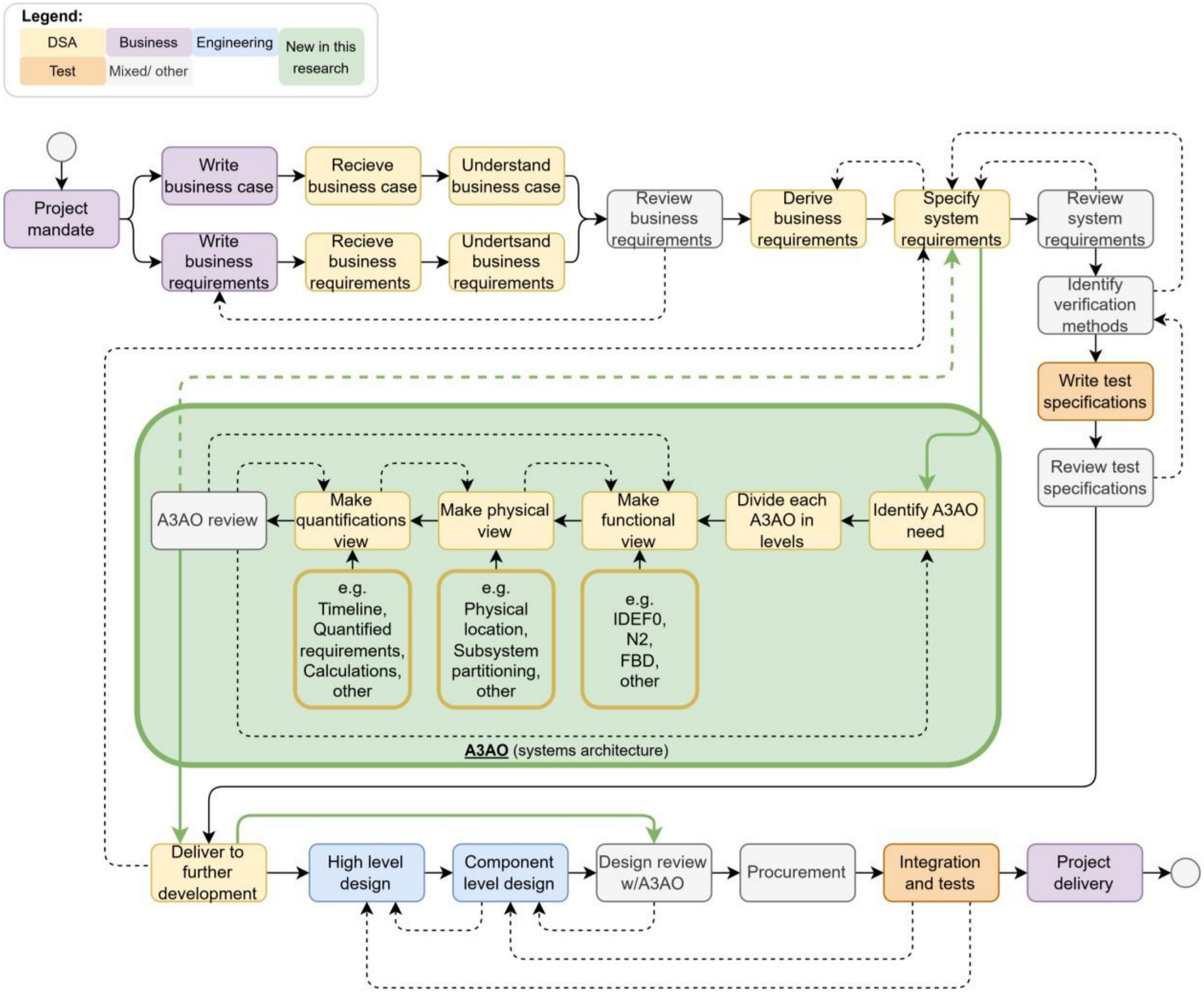

Figure 7 System lifecycle in TC in this study

workshops, primarily regarding the level of detail included. This might have been different if the project had been in an earlier phase when the first A3AO was developed.

Top level

The first level is the machine overview, focusing on the proximity card, which enables power save mode. The functional view presents a state diagram illustrating that the power-save mode has direct interface states. The physical view shows the electrical subsystems in the machine that are relevant to the proximity sensor, providing context. The quantification view details how to enter and exit the power-save mode. This also shows that the power-save mode is controlled separately from the other states.

Middle level

The next level focuses on the proximity card's interfaces. Here, the physical view provides all the connection types and electronic components. The quantification view shows the sensor data, including field of view, detection range, and more.

Bottom level

The lowest level in this A3AO focuses on the PCB itself. The physical and quantitative views are combined to show the PCB design, including important numbers. For the functional view, a sequence diagram illustrates the sequence of steps required for the proximity card to communicate with both the GUI and the main computer (brain).

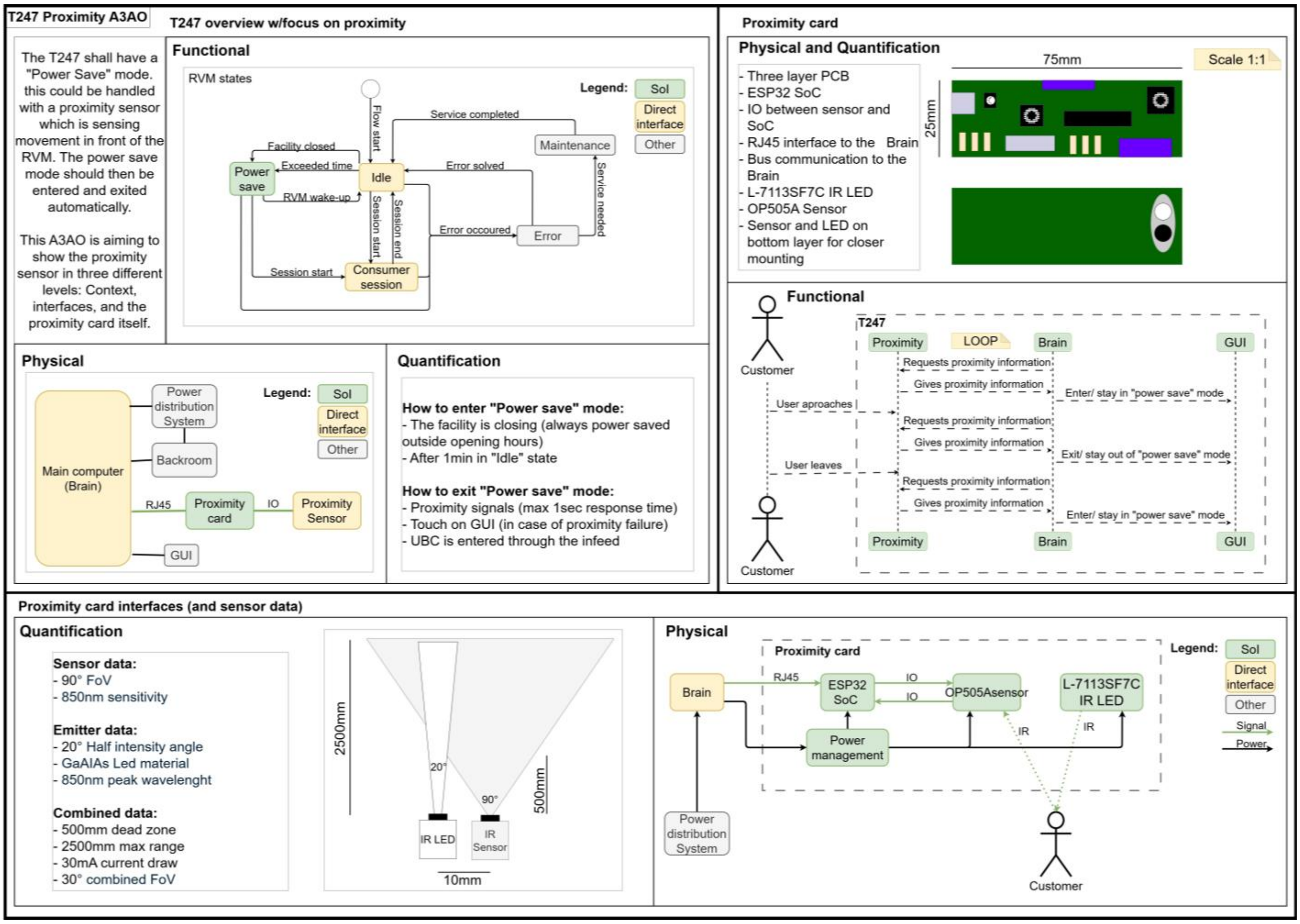

Figure 8 Case 1 final A3AO (anonymized data)

Case 2

The project for case 2 involved a multi-feed reverse vending machine designed to handle glass. During this study, the project was in the architecture phase. This new R7 glass machine will be based on the existing R6 machine, which is a multi-feed reverse vending machine, but it does not minimize glass breakage. The A3AO primarily focuses on the changes from the R6 to the new machine under development. In this A3AO, all views at the same level are much more closely connected, fostering a better understanding of the message at that level. As this project was in its early phase, the A3AO stimulated significant discussion among the team members working on the project.

Top level

The first level focuses on changes that all the new R7 glass machines will have, whether in a glass market or not. The physical view shows the GUI and a glass warning sticker indicating that these components will be new or altered. The functional view shows how the time-of-flight sensor in the infeed should lower its sensitivity to avoid detecting the warning label and glass residue. The quantification view provides information about the alterations the machine needs for the glass markets.

Middle level

The next level provides instructions on how to enter and exit glass mode, the state the machine enters when it detects glass bottles. The physical view illustrates the components needed to determine whether the used beverage container is glass. The quantification includes the requirements for classifying the objects as glass. Meanwhile, the functional view displays a block diagram showing all the machine's main functions up to the glass mode decision.

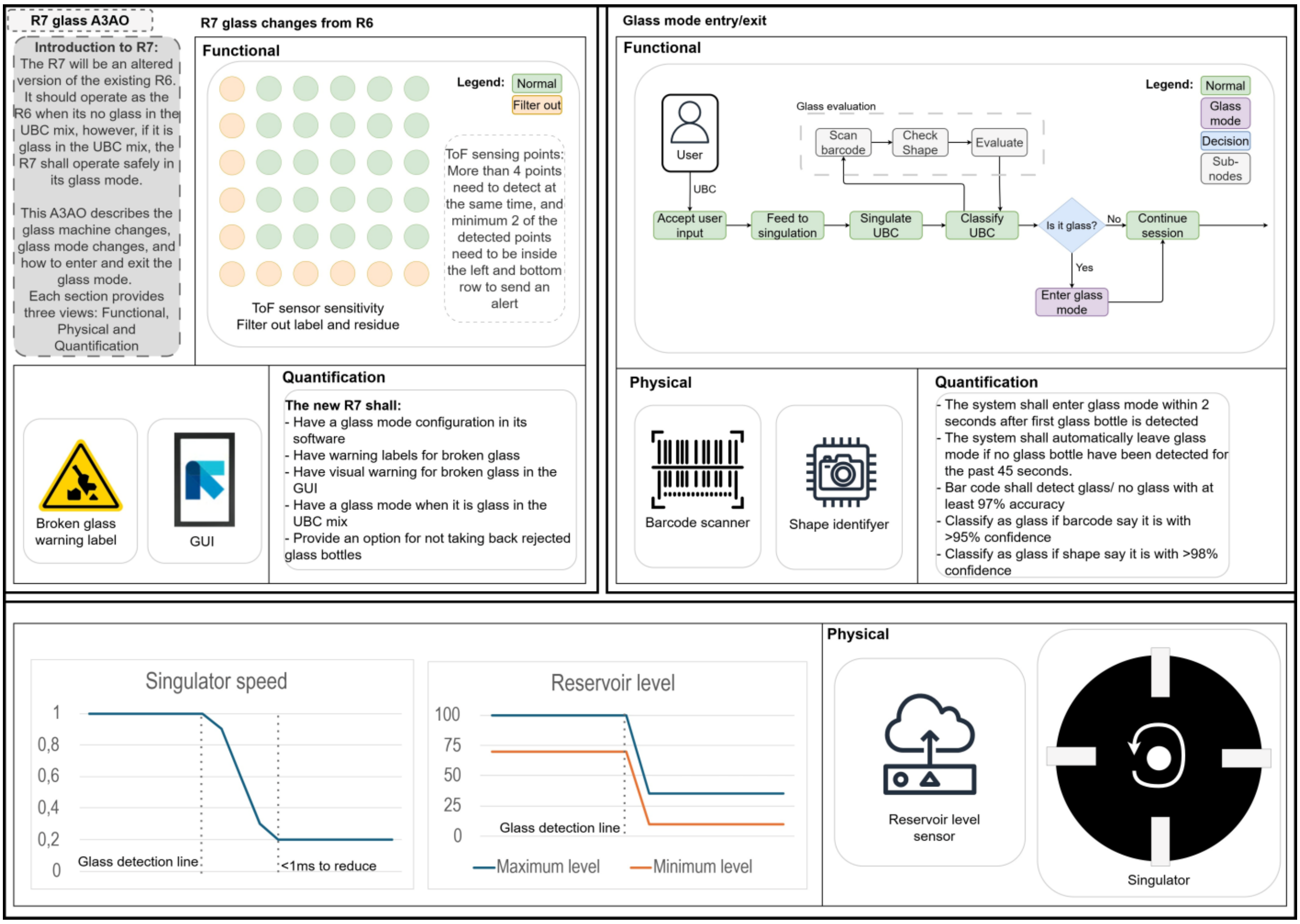

Figure 9 Case 2 final A3AO (anonymized data)

Bottom level

The lowest level in this A3AO shows the glass mode changes and the affected parts. The functional and quantification views are combined here to show that the singulator speed and reservoir level will be lowered when a glass bottle is detected. The physical view demonstrates that the singulator slows down, and the reservoir sensor needs to adjust its desired level to determine whether to fill it further.

A3AO Evaluation

Post survey

The researchers used a post survey to determine the extent to which participants believed the A3AO would affect the pain points and consequences identified in the pre-survey. Figure 10 shows the Likert scale data and the calculated NPS for each challenge.

As shown in Figure 10, five of the seven challenges received a positive NPS. The top ones were “Rushed conclusions”, “Change request (scope reduction)”, and “Lack of clarity in system requirements”. All of these received scores considered “great”, according to Raileanu (2025). Two of the challenges received a negative NPS, those were: “Cost overrun” and “Poor traceability between requirements and design”.

In the survey, we also collected data to evaluate the stakeholders’ satisfaction with the A3AO approach. The participants were asked to evaluate the following statement: “I feel that A3AO is worth using for TC in future projects.” Figure 11 shows the answers and the NPS score. As shown in the figure, most participants agree or strongly agree with this statement, giving a Net Promoter Score of 25%, which is considered a good score.

Finally, we collected data on how much time participants anticipated spending using A3AO to resolve ambiguities around system requirements. The average time to answer was 21 hours, compared to the 40 hours without A3AO.

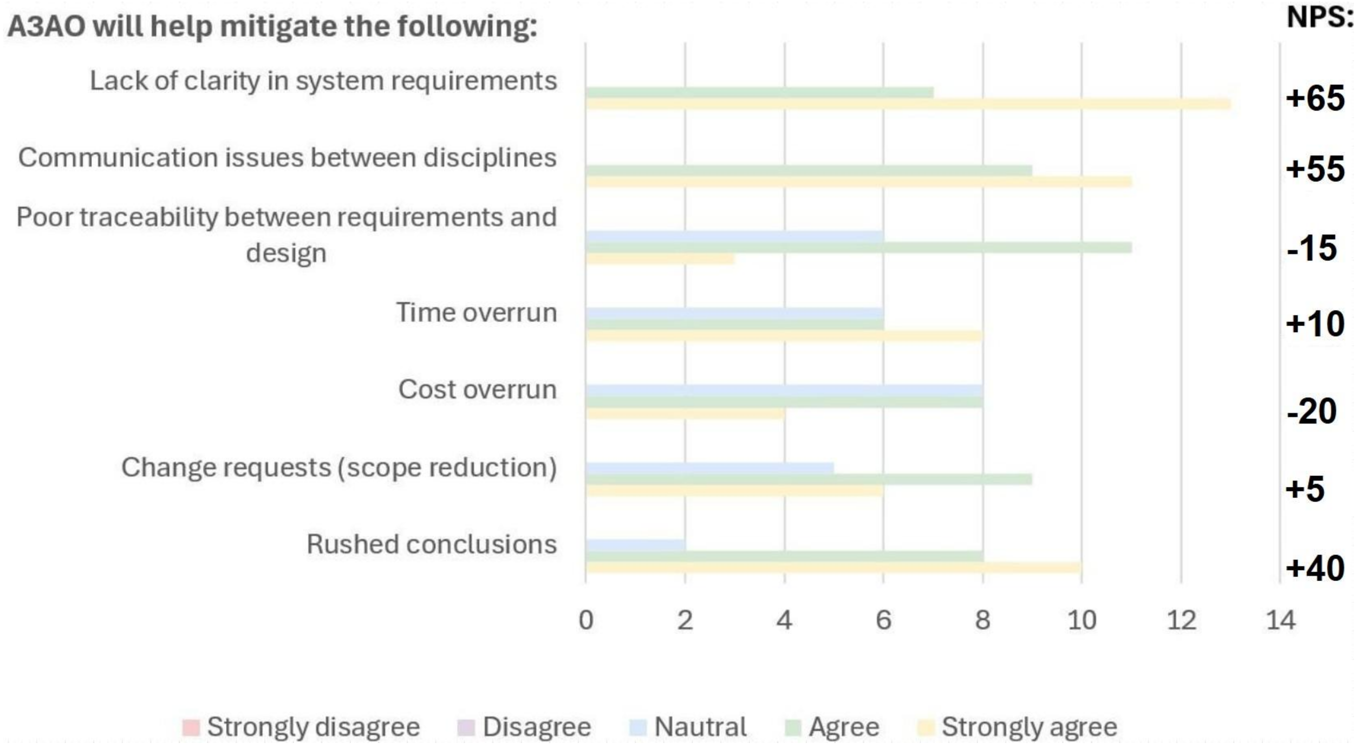

Figure 10 Post survey results: Improvements to challenges (NPS)

Semi-structured interviews

The researchers completed semi-structured interviews with both systems architects who participated in the research. Both of them have multiple years of experience as systems architects. Table 4 and Table 5 show the success factors and pitfalls reported, including the average reported importance.

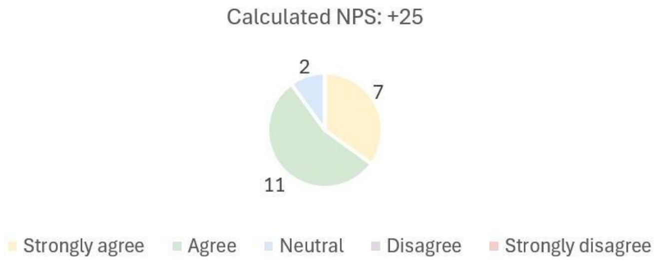

Figure 11 Post survey results: Overall satisfaction with A3AO (NPS)

Success factors	Average importance
A valuable way to store and use the A3AOs	10
Not too much effort is needed to make the A3AOs	9
Structured and well-defined template for the A3AOs	7.5
All the main users like the format	7
Regular reviews and revisions	6
A clear level of detail is required in each step in the A3AOs	6

Table 4 Interview results: Success factors

Pitfalls	Average importance
There is no structure to store or use the A3AOs	10
The A3AOs are complicated and time-consuming to make	9
The main users will not use them	8
The systems architects do not know how to fill out the A3AOs	7
No defined review or revisions	6.5

Table 5 Interview results: Pitfalls

The researchers also collected data on the time required to make the A3AO. The first participant said: *"The A3AO does require similar time to the usual approach; if there is a difference, the A3AO saves time because of the framework it provides."* The other participant answered: *"I feel that the time difference used to make the A3AO versus the old approach is neglectable."*

Overall benefits and concerns

During the case studies, the first author observed various benefits and concerns expressed by the stakeholders during the workshops. The main benefits include:

- It is nice to gather all these diagrams in one place; it provides an easier overview.
- The A3AO provides discussion earlier than usual, which makes changes easier and cheaper.
- The A3AO was divided in a way that makes it easy to understand which part of the problem the different diagrams provide information about.

Similarly, we observed the following concerns regarding the A3AOs:

- What do the different terms "functional", "physical", and "quantification" refer to, and what kinds of diagrams might they include?
- Where should the A3AO be kept, and how can we organize revisions systematically?

Discussion

The modern cyber-physical systems are becoming increasingly complex, and following there is an increasing need for improved communication, traceability, and effectiveness in the early-stage development. To cope with this, industry actors need to develop, communicate, and document the systems architecture, to ensure a proper understanding of the system. In this research, we have evaluated the use of A3AO as a systems architecture approach in cyber-physical system development projects. Through surveys, interviews, and case studies, we have explored the use of A3AO in Tomra Collection, with the aim of answering the following main research question: How can the A3AO approach support and improve the systems architecture process, and how efficient is it in practice? This is answered in the following subquestion.

RQ1: Current challenges

The current architecture approach at Tomra Collection has some challenges. Through a survey in the company, we found the main pain points with the current process to be "Lack of clarity in system requirements", "Communication issues between disciplines", and "Poor traceability between requirements and design". These pains also have some consequences; the main ones were: "Time overrun", "Cost overrun", and "Change requests (scope reduction)". In a review of the last 20 cyber-physical product development projects, we found that 30% of the projects experienced at least one of the consequences by the end of the project, showing the magnitude of the challenge the company is facing.

RQ2: Improvements to challenges

In the research, we developed two A3AOs in ongoing projects in Tomra Collection to support the systems architecture. After testing it in the projects, we conducted a survey of project participants to evaluate how the A3AO addresses the challenges. From the survey, we found that the participants found the A3AO mitigates most of the challenges identified in the pre-survey. In particular, the participants found the A3AO to be most supportive in mitigating rushed conclusions, communication issues between disciplines, and lack of clarity in system requirements. The pain points that were least supported by using the A3AO were found to be the cost overrun and the poor traceability between the requirement and the design. This coincides with the findings of other implementing A3AO to support systems architecture, showing that A3AO aids the communication across disciplines and clarifying the system of interest (Boge & Falk, 2019; Frønvold et al., 2017; Haugland & Engen, 2021; Hilde & Kjørstad, 2024; Løndal & Falk, 2018). Clear communication and understanding of the system boundary, support the project in getting a common understanding of the system requirements and scope, reducing the risk of change requests. In the workshops, we observe that the visual format of the A3AO supports the discussion, which mitigates the risk of making rushed conclusions.

Before the research, we expected that the A3AO would assist with tracing requirements to design, as this is a key factor in systems architecture. However, the survey showed that this was not the case in Tomra Collection. A drawback with the A3AO is how they should be maintained and linked to other system artifacts (van der Merwe & Muller, 2014), and this can be part of the reason why the participants found the A3AO to be less supportive for the challenge of traceability.

RQ3: Stakeholder satisfaction

In the survey, we also considered the participants' overall satisfaction with the A3AO approach by asking whether it is worth using in future projects at the company. The survey showed that this question was given a total Net Promoter Score of +25, which is considered "good" according to the satisfaction scale. In the past, the main researcher has observed that Tomra Collection is generally interested in new and improved approaches for projects, consistently seeking better methods. Therefore, it was expected that the stakeholders would be positive about further exploring the A3AO. Another aspect that might have affected the satisfaction is that almost all the diagram types were known to most stakeholders. The A3AO provides structure to the diagrams that support their needs, without the extra effort of creating new views and diagrams.

RQ4: Cost implications

To evaluate the efforts needed to implement A3AO in Tomra Collection projects, we conducted interviews with the system architects of the project we studied. We found that both considered the extra time to make the A3AO negligible, and also that it could provide future improvements to cost by providing a framework. This again relates to the reuse of existing diagrams, not introducing the need for additional views, only providing structure to the existing work. The research also shows a potential for cost reduction in the time spent on resolving ambiguities in system requirements. In the surveys, we asked about the time spent on resolving such ambiguities before and after implementing the A3AO. From the results we found, the participants, on average, reported that they would spend 19 fewer hours by using the A3AO, which would give a significant cost reduction for each project.

RQ5: Success factors and pitfalls

During the semi-structured interviews, the success factors the participants answered as most important were "A valuable way to store and use the A3AOs" and "Not too much effort is needed to make the A3AOs". This corresponds with the researchers' observations during the implementation. Another observation is that the introduction section of the A3AO is important to ensure that all workshop participants share the same understanding of why the A3AO is as it is.

The pitfalls the participants answered as most important were "There is no structure to store or use the A3AOs", "The A3AOs are complicated and time-consuming to make", and "The main user will not use them". These are strongly related to the success factors and correspond with the researchers' observations during the implementation. Another observation is that not all diagram types are intuitive to all participants.

Conclusion

This research aimed to assess the A3AO approach at Tomra Collection, emphasizing support and improvements to the architectural process and its efficiency. The researcher identified several pain points related to systems engineering in Tomra Collection. The primary pain points were "Lack of clarity in system requirements" and "Communication issues between disciplines". Meanwhile, the primary consequences of these pains were "Time overruns" and "Cost overruns". The stakeholders assessed whether A3AO could address the pain points and their consequences. The response was positive, indicating that A3AO will be beneficial in most areas.

The stakeholders rated their satisfaction after using the A3AO. The feedback varied significantly, resulting in a total NPS of +25, which is considered "good" and is close to "great". A3AOs can reduce the time required to resolve ambiguities in system requirements by 285 hours per project. The most critical success factors for the semi-structured interview participants were "A valuable way to store and use the A3AOs" and "Not too much effort is needed to make the A3AOs." The most critical pitfalls were "There is no structure to store or use the A3AOs", "The A3AOs are complicated and time-consuming to make," and "The main user will not use them".

The results of this research indicate that the A3AO approach could be beneficial in TC. Stakeholders have expressed satisfaction with this initiative; however, some are also concerned about the storage, revisions, and general handling of the A3AOs.

The results from RQ5 outline the success factors and pitfalls to consider when implementing A3AO as a systems architecture approach. This research advises companies interested in A3AO implementation to carefully evaluate all factors, facilitating a smoother path to success with the approach.

Recommendations for Future Research

The researcher identified success factors and pitfalls during this research, including the storage and handling of the A3AOs and which template to use. Unfortunately, this aspect was outside the scope of the research. Therefore, the researcher recommends further research focusing on the storage and handling of A3AOs and the various setups to better understand the full value of the A3AO approach.

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