

Developing an ontological model to support an asset management system

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Abstract

Physical *assets* hold an integral role both in society and for stakeholders, necessitating effective management systems like the ISO 55000 standards introduced by the ISO. Despite the increased focus on implementing and sustaining these systems, they do not offer explicit guidance on design or implementation within an organisation. Empirical data and business case studies validate the benefits of employing the Design and Engineering Methodology for Organisations (DEMO) in organisational contexts. Thus, a DEMO-based asset management system, designed in line with ISO 55001 requirements, could potentially offer a viable solution for standard implementation within organisations. The DEMO model not only aids in the inception of an asset management system but also serves as a communication model within the asset management organisation. Further, the VISI system, regarded as the de-facto open standard in the Architecture, Engineering, and Construction (AEC) sectors for communicating contractual agreements, is rooted in DEMO. This makes VISI appear suitable as a communication mechanism for the ISO 55001 standard.

Keywords

DEMO, enterprise engineering, ISO 55000, asset management, asset management system, VISI, construction, AEC,

1. Introduction

This scientific paper reports on the additional value of DEMO in the implementation of an Asset Management System (AMS). Physical assets have an indispensable role in our society and for stakeholders. Assets like roads and bridges, utilities such as electricity, gas, water, buildings, and machinery must perform safely, cost-effectively and add in some way value. In addition, these assets represent a significant financial value for their owners and typically have a lifetime of several decades, so effective asset management is essential. ISO [1] defines asset management as a “Coordinated activity of an organisation to realise value from assets” and the constituted value of asset management depends on organisational objectives, the nature and purpose of the organisation, and the needs and expectations of its stakeholders.

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Asset management is concerned with “balancing costs, opportunities, and risks against the desired performance of assets to achieve the organisational objectives” [1]. Currently, two significant aspects amplify the need for asset management [2] in the Netherlands. First, many Dutch assets were built after 1945 and are approaching the end of their expected functional lives and require more intensive maintenance and modernisation. Secondly, asset managers increasingly face changes in the asset context, e.g. stakeholder needs such as higher electricity demand or heavier vehicles. Facing these challenges, it is essential to conduct asset management to add value towards stakeholders.

Organisations have become more focused on implementing and maintaining management systems to ensure that organisations meet stakeholder expectations and needs and improve organisational performance [3]. For example, the International Organisation for Standardisation (ISO) developed several management systems (Asset, quality, environment, information security, etc.) to improve organisational performance on the particular aspect.

However, the ISO 55000 series does not present enough information to design and implement the system. The ISO has provided the ISO 55000 standards, a management system for asset management which is adopted worldwide by a broad scale of organisations. The foundation of the ISO 55000 standards is asset management based on internationally acknowledged and approved practical experience and methods [4, 5] and apply to any industry and asset type [6]. ISO 55001 is part of the ISO 55000 standards and specifies the requirements for asset management systems within the context of an organisation. Many researchers have investigated the impact of management system standards of ISO 9001 (quality management system) or ISO 14001 (environmental management system) on organisational performance. However, only a few studies have been performed on the impact of ISO 55001 on organisational performance like the broad study on the organisational performance before and after ISO 55001 certification [4] where Alsyouf concluded that adopting ISO 55001 by organisations would result in better performance of their assets, but the implementation process is vital. The implementation process is about adopting the management system into daily practice in the organisation, and thereafter consistently maintaining it [7]. Therefore, instead of solely pursuing certifications, organisations should focus on the implementation process of a management system [8] to benefit from (asset) management system standards.

The publication of ISO 55000 standards mention the need for organisations to have an effective asset management system. However, it does not provide details regarding how such a system should be designed or implemented within an organisation. Furthermore, organisations often strive to improve their existing asset system because they do not have a structured methodology to design and implement an asset management system from scratch [9]. However, the lack of a prescription on how the organisation should fulfil these requirements makes them struggle with implementing an asset management system [10]. In ISO 55000 standards, ISO 55002:2018 provides guidance for implementing an asset management system. However, because ISO 55002 only guides some of the shortcomings in understanding the implementation of asset management systems based on ISO 55001 [9], it is not exhaustive or detailed in describing methodologies and practices, therefore, it is hard for organisations to apply the given guidance [6]. Concluding, ISO 55002 does not give organisations enough guidance to design and implement an AMS for an organisation.

1.1. Existing asset management models based on ISO 55001

An AMS [1] defines business processes and information for employees to apply asset management within an organisation [11, 12]. Therefore, organisations need an AM model that captures the business and information aspects. Researchers proposed multiple asset management models in the literature to help organisations design, implement, and maintain an asset management system. However, a recent study [5] about existing asset management models from the last ten years showed that only two models [5, 13] interpreted the ISO 55001 requirements as a guideline and expressed the business processes of ISO 55001 but did not capture the information employees use for asset management. Employees need to be able to locate the description of the roles they have, as well as the information they need for the execution of their tasks in the model. For example, BPMN and UML do not grasp the business or information perspective at the same time; therefore, we choose to use the ontological method Design and Engineering Methodology for Organisations (DEMO), which can capture ISO's necessary business and information perspectives.

The DEMO [14] is a method for systematically developing an ontology model. The ontological models of DEMO capture the business and information aspects [14]. Empirical evidence and business cases show the applicability of DEMO [14, 15, 16]. Furthermore, a case study about developing and implementing a management system showed that organisations benefit from applying DEMO [17]. Therefore, we assume that an asset management system could be modelled with DEMO based on ISO 55001 requirements. Thereby it might help organisations in the ease of implementation and maintenance of an AMS based on ISO.

We started this paper with the introduction, which contains the state of the research problem and addresses the research question and its relevance. In Section 2 the applied methods are discussed. Then, we present the used notions in Section 3, followed by the early artefact in Section 4. The results of the explorative focus group are in Section 5. The possible application of the findings are touched upon in Section 6. Finally, this research ends with the conclusion, limitations, discussion, and recommendations in Section 7.

2. Method

ISO 55001 is a worldwide adopted and accepted norm for asset management systems for asset management, but organisations experience difficulty implementing and maintaining an asset management system. A few AMS based on ISO 55001 in the literature exist to support implementing and maintaining. However, none of those models are ontological models that capture the business processes and information into a model specified by ISO 55001. We have the asset AMS based on ISO 55001 as an independent variable, support implementation and maintenance of an asset management system as a dependent variable, and DEMO as the moderator, shown in Fig. 1. We hypothesise that the ontological model based on DEMO positively supports implementing and maintaining an AMS based on ISO 55001.

We hypothesise that an ontological model base on DEMO positively supports implementing and maintaining an AMS based on ISO 55001, as shown in Fig. 1. Following the conceptual research model, we state the following research question: *How could an ontological model based on DEMO support implementing and maintaining an AMS based on ISO 55001?*

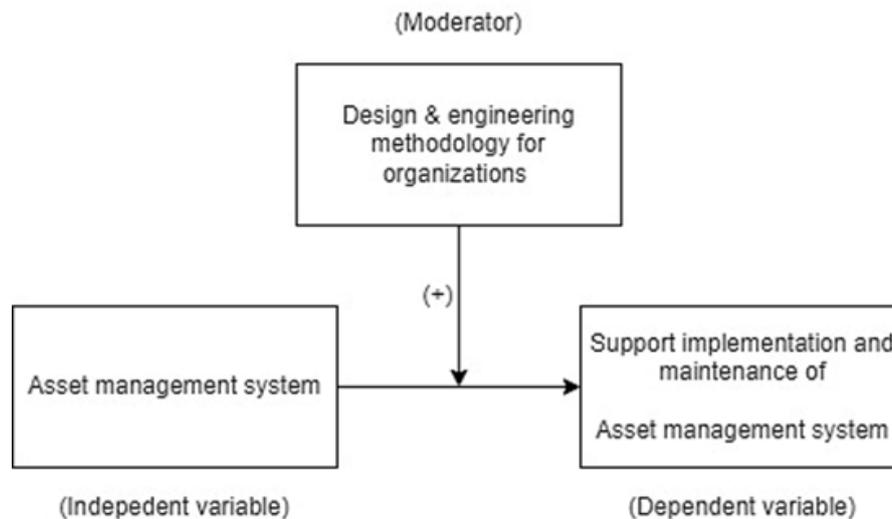


Figure 1: Conceptual research model

The selected method for answering the research question is Design Science Research (DSR) [18]. DSR is the scientific study and creation of artefacts as they are developed and used by the environment to solve practical problems. We try to develop an ontological model for an AMS based on ISO 55001.

To support our DSR, a methodological framework is used [19]. This model consists of the following elements: explicate the problem, define requirements, design and develop the artefact, demonstrate the artefact, and evaluate the artefact. We focus on one or two activities and discuss others lightly [19]. As the research objective is to develop an ontological model for an AMS based on ISO 55001, a development and evaluation focus DSR is evident [19]. Feedback for improvement of the artefact's design [20, 18, 21] is an essential component of DSR. We apply two strategies and methods for the iteration of the artefact, being the early design cycles [22] with document analysis and then later cycles of design refinement with an Exploratory Focus Group (EFG).

We have conducted the literature study based on a list of the most relevant available literature and research in asset management systems, models, and frameworks. We assessed literature that focused on asset management systems, models, or frameworks available for free, published in a respected journal, e.g. peer-reviewed, in English or Dutch based on the search terms ISO 55001, Asset management system and DEMO. We made four exceptions to the exclusion criteria of being freely available by purchasing the book or norm.

1. ISO 55000:2014 Asset management – Overview, principles, and terminology [1].
2. ISO 55001:2014 Asset management – Management Systems – Requirements [23].
3. ISO 55002:2018 Guidelines for the application of ISO 55000 [24].
4. Enterprise Ontology [14].

This research uses a specific document analysis method, **Performa, Informa, and Forma** (PIF) analysis which is part of the Organisation Essence Revealing (OER) method of the DEMO methodology [14]. Using this, we analysed the content of ISO 55001, chapter four, "Context of the organisation", and chapter five, "Leadership"[23]. If clarification was needed, we consulted the ISO 55000 standard, ISO 55002 standard, field experts, or the members of the ISO committee.

For the explorative focus group EFG we used the question “Could the ontological model support an organisation with the implementation and maintenance process of ISO 55001, and how?” and “Is ISO 55001 well interpreted into an organisational cooperation model?”. Therefore, we invited participants from areas of expertise: ISO 55000 experts and DEMO. The ISO 55000 experts are members of the ISO 55000 standards committee, and DEMO experts are DEMO certified or lecturers. It is essential to identify the moderator of the EFG [22]. An experienced independent moderator is invited whom understand the technical nature of this research to avoid bias. The researcher participated in the focus group as an observer, took notes, and provided an explanation if needed. As pre-read, we provided the EFG with pre-read material a week ahead. Then, at the start of the EFG, the researcher briefly explained DEMO. The question sequence consisted of the following three elements: 1. Open questions. 2. Statements. 3. Developed artefact. The three elements consisted of the following aspects: feedback, discussion and evaluation. We collected data in the first two elements on whether an ontological model could help organisations implement and maintain an asset management system based on ISO 55001. Then, in part three, we evaluated the developed artefact with the C4E criteria [14] and ease of implementation and maintenance for whether it could support an organisation. The artefact is evaluated by showing the participants the PIF analyses and the factual translation into the artefact for transparency done by the researcher. For the validation, we use the 5-point Likert agreement scale for scoring statements (2) and artefacts (3).

3. Notions

3.1. The ISO 55000 standards

The ISO 55000 standards are a set of international standards for asset management and asset management systems, including the three relevant parts *ISO 55000:2014 Asset management – Overview, principles, and terminology*, Providing an overview of asset management and the standard terms and definitions. *ISO 55001:2014 Asset management – Management Systems – Requirements*, Providing the requirements for an integrated, effective management system for asset management. *ISO 55002:2018 Guidelines for the application of ISO 55000*, Providing a guidance for the implementation of such a management system. These ISO 55000 standards are part of the High-Level Structure (HLS) family, which encompass all management system standards like e.g. ISO 9001 (quality), ISO 14001 (environmental), and ISO 27001 (information security). Being part of the HLS means the terminology, chapter structure, elements, and core requirements are identical.

An “asset” is defined as an “Item, thing or entity that has potential or actual value to an organisation”. Because the ISO 55000 standards are part of the HLS family, we use the definition of “management” in the ISO 9000 standards where “management” is defined as “Coordinated activities to direct and control an organisation” [25]. The definition for “asset management” is [1] “Coordinated activity of an organisation to realise value from assets”. A “management system” is defined [1] as “Set of interrelated or interacting elements of an organisation to establish policies and objectives and processes to achieve those objectives”. Now, the ISO 55000 standard combines the definitions “asset” and “management system”, and the definition for “asset management system” is [1] “Management system for asset management whose function is

to establish the asset management policy and asset management objectives”. The organisation uses an AMS to direct, coordinate and control asset management activities.

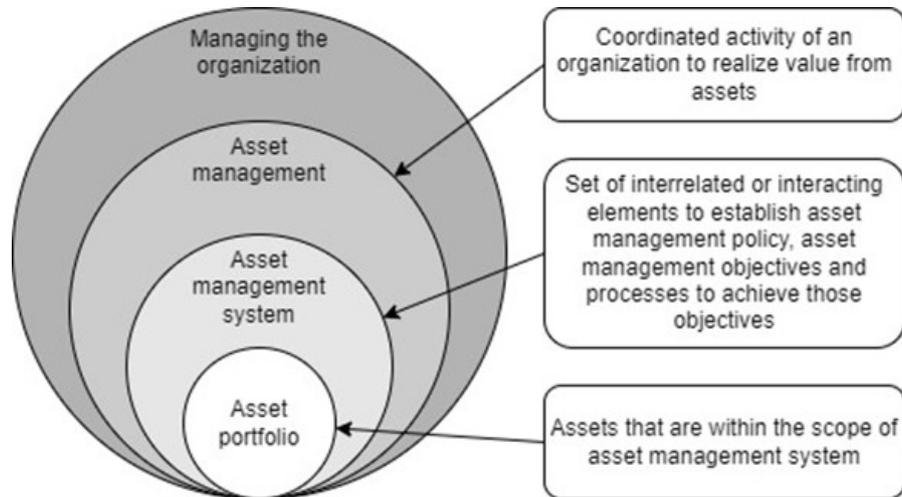


Figure 2: Asset management in the organisation [1]

To develop an AMS for asset management, we should know the relationship between asset management and AMS. According to ISO 55000 standards, an AMS is a subset of asset management [1]. Fig. 2 displays that the asset management system lies within the concept of asset management. Therefore, not every asset management activity can or should be implemented or captured in an AMS. For instance, the aspects of motivation, culture, and leadership considerably influence the achievements of asset management objects but may be managed outside the AMS by the organisation.

3.2. Design and Engineering Methodology for Organisations (DEMO)

The following sections describe the systematic approach of the DEMO for developing an ontological model for an AMS based on ISO 55001 in this research. We defined an asset management system with the following note: The elements of the system include the organisation structure, such as roles, responsibilities, planning, and operation. In this chapter will discuss how DEMO captures and expresses roles, responsibilities, and information in an ontological model. The DEMO methodology has a theoretical foundation (way of thinking) based on seven theories of which we mainly use the theory around the construction model [14]).

This (PSI) theory is about the operational perspective of an organisation seen as a social system where subjects are actors who mutually engage into commitments. The theory is the foundation of Enterprise Ontology (EO) and DEMO [26] and deals with roles, responsibilities, interactions, and information. It concerns the operational essence of the organisation [14], where it addresses the atomic building blocks, i.e. coordination and production acts and facts, and separates this communication between subjects into coordination and production worlds. Additionally it describes the communication interaction patterns, e.g. Transaction Kind (TK),

and productions, e.g. Product Kind (PK), between subjects in an organisation context as initiator and executor actor roles.

DEMO visualises the ontological model in four aspect models, each with a different perspective, i.e. Cooperation Model (CM), Process Model (PM), Fact Model (FM), and Action Model (AM). The cooperation model (CM) is about the coordination between its Actor Roles (ARs) and captures the coordination structures between them. The CM shows the combination of the (Multi) Transactions Kinds ((M)TKs), Product Kinds (PKs), and (Composite) Actor roles ((C)ARs) and their interaction structure. This paragraph discusses diagrams, tables, representations, and interaction structures used.

The goal of the method part of DEMO, OER, is to seek and find the essence of an organisation and is also called the Performa, Informa, and Forma (PIF) analysis. The method guides the analyser to transform a documental description into an ontological model in four steps. The first step aims to remove irrelevant details and abstract completely from realisation and implementation and reveals the transactions and actors. In the second step, the relevant TKs, PKs, and executing ARs can be found based on the distinguishing PIF results. The distinguishing concepts are visualised with colors, e.g. performa in red, informa in green, and forma in blue. In the third step, the essential models can be composed after identifying TKs and ARs, all the relevant TKs, PKs, and executing ARs. Here we can develop the CM aspect model and the Transaction Production Table (TPT). The last step of the OER method is done by the organisation in the form of validating the aspect models.

This research aims to develop an ontological DEMO model for an AMS based on ISO 55001 requirements. An AMS mainly concerns roles, responsibilities, and information. Translating this into DEMO terms, roles and responsibilities can be placed into the coordination world and information into the production world. Therefore, this research's logical first aspect model is the CM.

4. Early artefact

For the PIF analysis, we analysed the content of ISO 55001 chapter four, "Context of the organisation", and chapter five, "Leadership" [23]. During the analysis, we noticed that some of the revealed TKs contain time elements such as: periodically reviewed, updated, and continual improvement. We produced the TPT (Table 1) based on the results of the PIF analyses.

Multi Transaction Kind (MTK) are not part of a TPT [27]. Therefore, Table 2 shows the eleven MTKs we found during the PIF analyses including source chapters of the MTKs. While we first produced the TPT based on only chapter four, the researcher found no TK, only eight MTKs, which means chapter four only reveals the context of an AMS. However, TKs are necessary to develop an ontological AMS. Therefore, we added chapter five of ISO 55001 to the scope of the research, where we found eight TKs, PK and AR, and three other MTKs.

Based on the TPT, we modelled the Organisation Construction Diagram (OCD) (Fig. 3). During the modelling of the OCD, we noticed that TK04 "AM risk establishing" and TK05 "AM plan establishing" are not linked to the other revealed (multi) transaction kinds. As we only analysed two of the seven chapters of ISO 55001, we presume that the TK04 and TK05 might be used when analysing the remaining five chapters of ISO 55001. Therefore, we left

Table 1

Transaction Product Table of ISO 55001

Transaction kind		Product kind		Executor role	
TK01	Strategic AM plan establishing	PK01	[Strategic AM plan] is established	AR01	Strategic AM plan establisher
TK02	AM policy establishing	PK02	[AM policy] is established	AR02	AM policy establisher
TK03	AM objectives establishing	PK03	[AM objective] is established	AR03	AM objective establisher
TK04	AM risk establishing	PK04	[AM risk] is established	AR04	AM risk establisher
TK05	AM plan establishing	PK05	[AM plan] is established	AR05	AM plan establisher
TK06	Strategic AM controlling	PK06	Strategic AM controlling for [period] is done	AR06	Strategic AM controller
TK07	AM policy controlling	PK07	AM policy controlling for [period] is done	AR07	AM policy controller
TK08	AM objective controlling	PK08	AM objective controlling for [period] is done	AR08	AM objective controller

Table 2

The multi transaction kinds

Multi transaction kind		Chapter of ISO 55001
MTK01	Asset management system scope facts	4
MTK02	Management system facts	4
MTK03	Financial information facts	4
MTK04	Stakeholder facts	4
MTK05	External and internal issues facts	4
MTK06	Criteria asset management decision facts	4
MTK07	Organizational objective facts	4
MTK08	Asset portfolio facts	4
MTK09	Organizational policy facts	5
MTK10	Organizational plan facts	5
MTK11	Organization risks facts	5

TK04 and TK05 out of the OCD. We noticed that based on ISO 55001, MTK02, MTK03, MTK04, MTK05, and MTK06, are related to MTK01. However, in the DEMO specification language [27] is no link defined between MTK. Therefore, we added the proposed “contained in” [26] to the model. We modelled the “contained in” into an OCD to create a single overview for the focus group participants. On one hand, this design decision might affect the conciseness and comprehensiveness of the OCD during the focus group. On the other hand, this might help the (non) DEMO participants to determine whether the researcher correctly translated the ISO 55001 chapters into the OCD. While modelling the OCD, we made another design

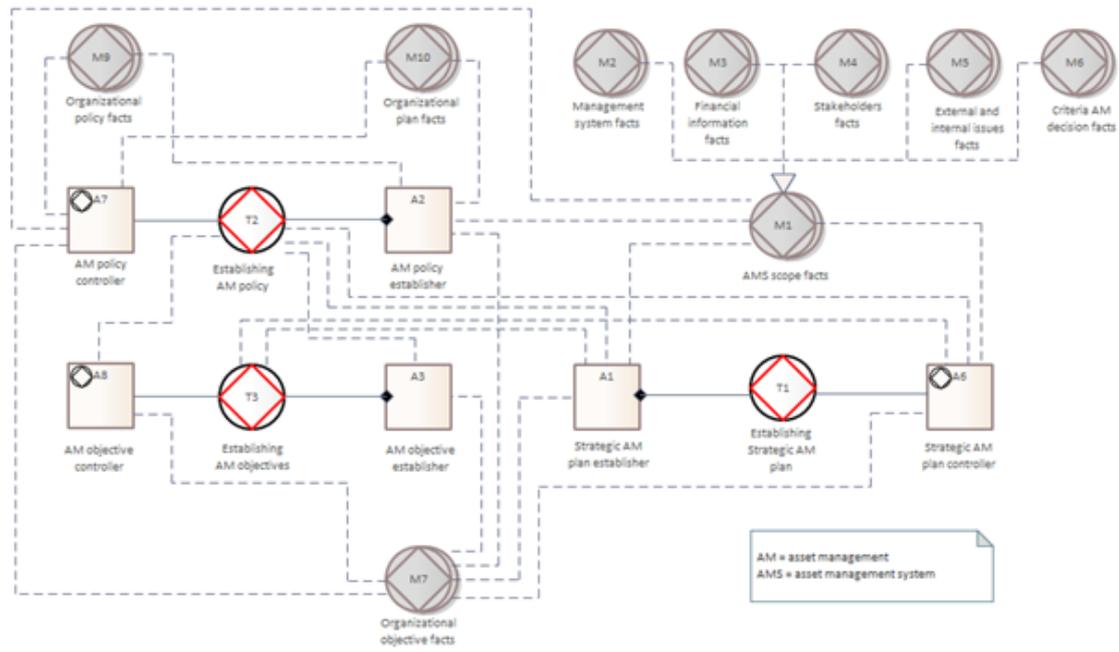


Figure 3: The developed early artefact

decision according to results of earlier conducted focus groups with non-DEMO participants [26]. We modelled the information link explicitly in the OCD. Explicitly modelling means that the link between AR and TK does not “overlap”, but each relationship has an individual link. Not overlapping the information links might give less conciseness and comprehensiveness of the OCD during the focus group. However, it might improve and increase readability for the non-DEMO participants of the EFG. Also, this could increase the evaluability of the conducted translation of ISO 55001 requirements into an OCD.

5. Explorative focus group

In the explorative focus group, the participant answers the following open question: “What can an ontological model offer for implementing ISO 55001 standards?” Every participant had the opportunity to submit multiple answers. After submitting the answers, the moderators display all the participants’ answers, and there is an opportunity for everyone to clarify their or ask for clarification on other participants’ answers. After that, the moderator clusters the given answers in agreement with the participants. Based on the average rating, variability, and abstains on the open question, the participants tend to agree that an ontological model could help organisations to focus on “what” should be implemented and/or maintained for an AMS instead of “how”. For example, it provides an overview of necessary asset management roles which should be assigned within the organisation. Therefore, an ontological model provides a structure for

organisations to implement and/or maintain an AMS. To a lesser degree, an ontological model could help organisations start a generic but adaptable supporting software system. Then again, ISO experts experience an ontological DEMO model as complex, impractical, and challenging to communicate with stakeholders, which suggests that an ontological model can not be used in its original form. Based on the open question round, the ISO and DEMO experts agree that an ontological DEMO model could offer multiple benefits when implementing ISO 55001. The benefits vary from focusing on “what”, to an overview of asset management roles, structure, and reference model.

We drafted and asked the focus group participants to rate the statements with the opportunity for feedback. Based on the three statements, we explored whether the participants agreed that a good implementation process, certification of ISO 55001, or ontological model would enhance an organisation’s asset management performance. The results show high variability for scores of every item, indicating that the focus group participants tend to disagree with each other. As feedback, two participants suggest bringing more nuance into the statements as they tend to be multi-interpretable. Therefore, it is hard to draw conclusions.

We split the evaluation of the artefact into two parts where the first part discusses the four *C₄E* criteria [14] and the second part the ease of implementation and maintenance criteria. The participants scored the (detailed) artefact on seven criteria and had the opportunity to leave feedback on every score. The translation of the ISO requirements into the artefact is shown during the evaluation for transparency. We found fluctuating average ratings and variability in the participants’ feedback and captured the following elements. First, the information links are explicitly modelled instead of overlaid in the OCD, which resulted in some participants’ (detailed) artefacts scoring lower on conciseness, coherence, essence, and comprehensive criteria. The *contained in* link in the third and fourth evaluation rounds influenced some participants’ scoring on conciseness, coherence, essence, and comprehensive criteria. Considering the feedback and suggestions given by the ISO and DEMO experts, they seem to agree that the translation of requirements of ISO 55001 chapters four and five towards the artefact is proper.

The DEMO experts disagree on whether the given artefact could ease the implementation. A participant stated that the detailed artefact would be more accessible to implement than the overall artefact, but the whole could give more structure. Another participant gave feedback that the artefact supports only the roles, which was not the information he needed. Based on the results, the artefact could partly support DEMO experts in the ease of implementation. The ISO experts could not see the ease of implementation due to the abstract nature of the artefact and the lack of context and content. Results suggest that translating an ontological DEMO model towards an implementation is more complex, but maintaining the implementation afterwards is easier.

The (detail) artefact evaluation provided the following insights:

- The artefact might be an aspect that could positively affect the implementation process.
- The effect on the ease of maintenance could not be determined.
- The ISO and DEMO expert seems to agree on translating ISO 55001 requirements into the artefact.

6. Conclusion and discussion

We combined the literature study, document analyses, and explorative focus groups to answer the research questions. From the insights gathered via the focus group, we conjecture that an ontological model, premised on the Design and Engineering Methodology for Organisations (DEMO), could facilitate the implementation and maintenance of an ISO 55001-based asset management system (AMS) in several ways:

1. It emphasises the ‘what’ to implement rather than the ‘how’.
2. It caters to an organisation’s informational requirements and asset management roles.
3. It provides a structural framework for an organisation.
4. The model can serve as a reference point.

However, while the findings suggest that the artefact could effectively assist organisations in implementing and maintaining an ISO 55001-based AMS, it requires further refinements to unlock this potential fully. Lastly, we concluded that an ontological DEMO model (coordination) of an AMS guided by ISO 55001 chapters four and five could be modelled, and we suspect chapters six to ten also could translate into a similar artefact. In the performed focus group, the participants seem to agree that the translation of requirements of ISO 55001 chapters four and five into the artefact is correct. We also find that an OCD might not be the most suitable DEMO aspect model for an organisation to implement and maintain such a management system due to its abstract nature.

This research is subject to limitations. We gathered data from ISO 55001 documents and performed content analysis to develop an early artefact. An issue concerning the use of documents for data collection is assessing their credibility [19]. Though ISO 55001 is the most used management system for asset management, and many experts worldwide support the norm, the document may contain inaccuracies, biases, and errors.

The early artefact is evaluated by gathering data from an explorative focus group. After the focus group, the researcher interprets the data. A drawback of a focus group, in general, is the dependency on the researcher’s interpretation and analyses. Strong participants’ opinions in the focus group could influence the other participants during the focus group sessions and drive the discussion in a particular direction [19]. In the conducted focus group, an experienced moderator led the focus group for a fruitful discussion and interaction between participants to minimise this chance.

The artefact is developed based on two of the possible seven chapters of ISO 55001 which we presume can also translate into a similar artefact. As ISO 55000 standards are a generic norm, an organisation should establish its organisation specifics itself, as the norm does not provide these. Therefore, the developed artefact does not grasp organisational or asset-specific details.

The invited ISO experts expressed challenges in assessing the artefact, indicating potential areas for improvement in our approach. One potential solution could involve dedicating more time to explaining DEMO during the focus group. While this may encroach on the valuable artefact evaluation time, given the recommended maximum focus group duration of two hours, it could enhance the participants’ understanding of DEMO. Alternatively, despite already providing extensive pre-reading material, a half-day boot camp could further enhance the ISO experts’ familiarity with DEMO.

Moreover, we might consider revising our selection criteria for ISO experts, focusing not solely on membership of the ISO 55001 committee but also on those employed by ISO 55001-certified organisations. Such individuals, including senior management or staff on the work floor, could possess a more practical understanding of ISO 55001 implementation, facilitating better interpretation of the artefact and DEMO. Perhaps, employees of organisations who certify ISO 55001 could be part of the EFG to provide valuable insights.

Our assessment was limited to the ease of implementation and maintenance of the coordination model at the organisation's construction level (refer to Figure 8). However, it might be more insightful to explore the process, action, or fact model, given their operational proximity and recognisably to non-DEMO participants.

Considering the ISO experts' feedback regarding the artefact's lack of practical application, alternative research methods, such as case studies, could be deployed. This would allow the ISO experts to evaluate the artefact within a specific context, possibly improving their understanding and assessment of its implementation and maintenance.

This paper represents an initial step towards creating an ontological DEMO model for an ISO 55001-based asset management system. Future research could expand the artefact to include chapters six to ten of the ISO 55001, and possibly incorporate other DEMO aspect models to address ease of implementation and maintenance.

Additionally, future research could explore the applicability of the other three DEMO aspect models for evaluating an organisation's ease of implementation and maintenance.

The research shows that the requirements of the ISO 55001 standard can be translated into the CM. We presume that ISO standards such as ISO 9001, 27001, 14401, etc. could be developed into a DEMO model as they are part of the high level structure family of ISO.

As conjectured, DEMO supports the introduction of an AMS, and we have a base to model the communication within an asset management organisation or with contracted service providers that implement the AMS. When we use DEMO modelling and focus on communication in a process, we can do future research on using the 'Creating conditions(V) for Introduction of Standards for Ict in construction (VISI) systematic for implementing the artefact. VISI is the de-facto open standard in the Architecture, Engineering, and Construction (AEC) (in the Netherlands) for communicating contractual agreements between Organisations and audit trails. VISI is captured into ISO 29481 *Building information models – Information delivery manual* and is a proven systematic and, therefore, on the governmental list of standards of "Use, or explain" and has been used for around 25 years now. As VISI captures "how" the communication between parties should be done, it is feasible to apply VISI for the communication and audit trails of an AMS.

Yet unpublished research confirms the transformation of any DEMO model on PSD level into a VISI model that is executable. Using VISI as communication means for the ISO 55001 standard appears to be feasible the results of this research. Though not tested in this research, transforming the DEMO model of the ISO 55001 to a VISI model could result in a usable operational model.

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