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BOMI View Types: A Design Science Research Study

Bachelor of Science Thesis in Software Engineering and Management

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This paper presents a collection of BOMI view types that address the specific needs of the identified stakeholders and their concerns. The produced artifact was evaluated in cooperation with two BOMI method designers and several practitioners from four different companies involved in an ongoing research project.

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***Abstract* — Large-scale systems engineering companies often have many teams working in distinct ways, whether it be agile, waterfall, or a method falling somewhere in between. Challenges appear when one team's way of working differs from those around them, leading the overall organization to struggle with inter-team coordination. BOMI (*Boundary Objects and Methodological Islands*) concepts have been identified as a potential solution to this problem. However, prior work has found that practitioners often struggle with the vast amount of information displayed within the resulting BOMI models. This design science research study has attempted to reduce the BOMI models' complexity by implementing a collection of four specialized BOMI view types: the *overview* view type, *methodological island (MI)* view type, *boundary object (BO)* view type, and *governance* view type, each targeted towards a specific group of stakeholders and their concerns. This collection of BOMI view types has been evaluated as beneficial to practitioners, implying that there are potential advantages to implementing specialized BOMI views as expressed in previous work. However, this study merely examines the thoughts and opinions of a small group of practitioners and BOMI method designers. Therefore, future work should aim to expand on this topic further by investigating a larger population to verify and improve the presented artifact, possibly identifying additional stakeholders and implementing supplementary view types.**

Keywords* — *boundary objects, methodological islands, views

I. Introduction

Large-scale systems engineering companies consist of many teams that work in unison towards the creation of a singular product [1]. However, these teams often function using very distinct methods, tailoring their approaches to suit the assigned task. These groups – termed *methodological islands* (MIs) – are often surrounded by other organizational parts not using the same methods [1]. For example, in a large telecommunications company, there may be hundreds of teams that use a variation of agile and waterfall practices. These teams are not only dependent on each other, but also on outside suppliers who themselves may function using differing methods [1]. This way of working creates pockets of MIs and introduces a challenge for the overarching organizations that must now deal with the difficulty of systematic coordination between different groups [2]. Not only are these challenges found within a local setting, but many companies are now spread across the globe and must consider the added difficulties of knowledge sharing across distance and organizational cultures [3]. To address these issues, artifacts such as documents, models, and code are often shared between teams in an attempt to create a mutual understanding when referring to concepts with different terminologies [2]. These artifacts have been coined *boundary objects* (BOs) [4]. By striving to understand the interaction between MIs and BOs, effective management of information and inter-team coordination within an organization can be improved.

The study of BOs and MIs has led to the creation of a metamodel as shown in Fig. 1. This metamodel provides a structured view to knowledge management within an organization's infrastructure [1]. Centred around a specific BO, users can study, identify, and better understand current issues related to coordination [1].

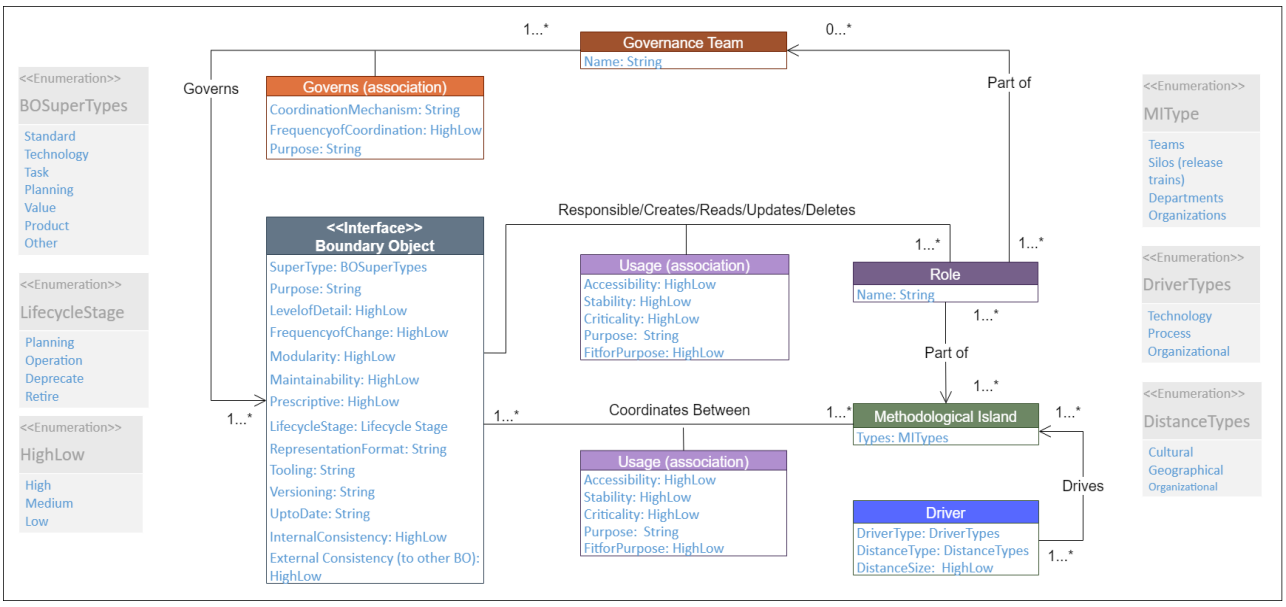

Fig. 1. BOMI Metamodel [3].

Although the creation of BOMI models is a step towards enhancing knowledge management and inter-team coordination, prior work has identified a number of issues surrounding the model, especially when it comes to complexity [4]. BOMI practitioners have expressed concerns about the model displaying large amounts of information, potentially causing difficulties in usability and understanding [4]. Horkoff et al., through a series of workshops with a limited number of companies, have identified visualization and views as a possible solution to this problem [4].

The implementation of specialized BOMI view types would allow practitioners to emphasize specific aspects of the central BOMI model [5], increasing usability while decreasing complexity. Moving forward, it is important to note the differences between a view and a view type. A *view type* "defines rules according to which views of the respective type are created" [5]. On the other hand, a *view* is an instance of a view type, with "the actual set of objects and their relations displayed using certain representation and layout" [5].

The process of view type creation itself presents another challenge: the identification of specific model aspects that are worth displaying. To address this issue, one must first identify what information is deemed relevant and to whom. Thus, specific stakeholders and their concerns must be recognized before a particular view can be implemented.

The concept of views and abstraction in general has been widely explored. Within project management, there have been studies examining how process model views are used, and the steps involved in establishing which view best suits the current purpose at hand [6].

A study by Polyvyanyy, Smirnov, and Weske explores how business process models often overflow with information, identifying several steps that can be implemented to create the same model at different levels of abstraction [7]. The authors believe that abstraction to create varying views can enhance both understanding and usability of the model [7].

According to previous literature, personalized views are believed to greatly benefit practitioners [4, 7]. By extracting the required information and hiding aspects that are deemed irrelevant to the use case, complexity is reduced. However, no implementation of role-specific views has been enacted for BOMI. Therefore, the aim of this study is to identify a set of BOMI stakeholders, recognize their concerns, and implement a collection of specialized view types that meet those concerns, as well as reduces complexity.

Within this paper, a design science process of two cycles, involving three phases each (investigation, solution, and evaluation), was conducted. The first cycle was focused on understanding the problem and involved collecting data via interviews and surveys. Three method designers were interviewed during the investigation phase, with two being consulted in the evaluation phase. Regarding the surveys, four industry practitioners from three different companies contributed to the investigation phase, while four practitioners from two different companies participated in the evaluation phase.

The second cycle of this study focused on improving the artifact by reflecting on the data gathered from cycle 1's evaluation phase and making the appropriate changes. To evaluate the updated version of the view type collection, a short discussion was held during a workshop with four practitioners from three different companies.

The remainder of this paper is structured as follows: Section II describes the related work, Section III details the research methodology employed, Section IV presents the results, Section V discusses the implications of the results together with the threats to validity, and Section VI concludes the paper.

II. Related Work

Work related to the topic of creating specialized BOMI view types generally falls into the following categories, each examined in further detail below:

Knowledge Management. By investigating the varying ways in which knowledge is shared within an organization, the work surrounding BOMI displays similarities to studies involving knowledge management [8]. However, previous work such as that done by Mariel et al. have focused on representing implicit knowledge related to creation, sharing, representation, and retrieval via an all-encompassing strategy [8]. Rather than identifying a universal approach related to knowledge management targeted for use by managers in particular, this study aims to recognize several stakeholders in varying positions that would benefit from using BOMI and creating view types to meet their needs.

BOMI visualization and views. As BOMI is a rather new concept, there are a limited number of resources examining this topic, or more specifically, the topic of BOMI views. Previous papers have worked with automotive companies to examine BOs and their role in Agile practices and systems engineering [10, 11]. By drawing distinctions between the artifacts shared amongst different actors within a company (BOs) and those used within a team, these studies have produced a set of guidelines to help those in the automotive domain manage their artifacts [11].

With regards to the BOMI language and BOMI modeling specifically, there are only a small subset of papers that examine this topic. One of these papers details the initial creation and thoughts surrounding BOMI, together with why it is are important [1], another focuses on the implementation of the BOMI metamodel itself [2], with the final paper briefly touching on the topic of views as a possible solution to the model's current challenge of complexity [3].

Fig. 1 shows a metamodel for Boundary Objects and Methodological Islands (BOMI) using a UML class diagram [4]. The BOMI metamodel gives an overview of the specific BO being studied, as well as the different types of relationships or associations surrounding the BO, including the Roles that interact with it, the MIs that coordinate around it, and the Drivers that have led to certain MIs [4].

Horkoff et al. discuss the subject of visualization and views, providing several potential actions that could be enacted, such as collapsing Roles or hiding attributes, in order to create these views [3]. In fact, their paper also mentions how a company attending one of the BOMI workshops created a simplified BOMI model for discussion [3]. Although no concrete rules were used in the creation of the improvised view, the fact that some practitioners chose to innately

implement a view at all provides good incentive for investigating the matter further.

View-Based Modeling. The advantages of view-based modeling have been covered in detail and thus provide a clear motivation as to why BOMI could benefit from implementing specialized views. Although more focused on tooling, Goldschmidt, Becker, and Burger also discuss the positives associated with having different views on a central model [5]. They outline several definitions, terminology, and classifications for view-based modeling [5], concepts which can be used to implement specialized view types more easily. Aside from this, several papers also examine the benefit of views on other types of models, such as those related to project management or businesses [6, 7]. This literature can be used to encourage the creation of specialized view types, supporting the purpose of this study, while providing examples of what specialized view types might look like, although in different domains.

Model Abstraction. The specific steps that one can take to extract a specialized view from a central model has also been covered in previous literature. Polyvyanyy, Smirnov, and Weske explore how business process models can be abstracted to create simplified view types, providing a manual abstraction technique that allows for the generalization of process models [7]. This technique outlines a set of questions that should be considered when trying to abstract a use case [7] and has been helpful when considering the research questions for this study.

Eshuis and Grefen propose a two-step approach to constructing customized process view types, first by collecting activities that the stakeholders wish to hide, then concealing or omitting this information [12].

Caetano, Pereira, and Sousa present a tool that helps to create business process model view types based on six communication questions: what, where, when, why, who, and how [13].

An advanced approach for implementing personalized view types is also introduced by Bobrik, Reichert, and Bauer, though this process focuses more on the use of tooling to create parameterizable view operations and thus, more easily compose a view type based on the pre-selected information within the tool [14].

Aside from the previously mentioned methods, Armando and Ordorica's abstraction process, which aims to limit/reduce the amount of information or features present in a model [15] is also relevant to the topic of view type creation. Two techniques were of particular interest, that of aggregation and elimination. These processes were also mentioned by Tsagkani and Tsalgatidou, who describe *aggregation* as retaining and simplifying certain pieces of information, whereas *elimination* (alternatively referred to as *omission*) targets elements not providing valuable information and removes them completely [16].

These methods, along with numerous others, may not be directly related to BOMI, however, the approaches associated with view and view type creation (such as model abstraction) can be examined and used to help with the implementation of a BOMI view type collection.

Overall, previous work surrounding BOMI, views, and view types, along with model abstraction techniques currently exist, although none examine the creation of specialized BOMI view types explicitly, thus revealing a knowledge gap. The existence of this previous literature, however, can be used to both motivate and guide this study.

III. Research Methodology

This section outlines the research method used for conducting the study, together with the data collection and analysis process.

A. Research questions

The purpose of this study is to identify specific BOMI stakeholders, recognize their concerns, and implement a collection of specialized view types that both meet stakeholder needs and reduces complexity. This aim is broken down into the following research questions (RQs):

RQ1: *Who are the main BOMI stakeholders?* To create specialized view types, the main users must first be identified.

- **RQ1.1:** *What are these stakeholders' main concerns?* To ensure that the new view types meet stakeholder needs, specific use cases must be recognized.
- **RQ1.2:** *What aspects of BOMI are needed or not needed to address these concerns?* The current metamodel should be reflected upon to help determine which aspects are essential to the stakeholder and thus, should be implemented in the specialized view types.

RQ2: *How can certain BOMI elements and relationships be used in view types to meet stakeholders' concerns?* To create a potential solution, the information obtained from exploring the problem is applied to the creation of personalized view types. The view types should address specified stakeholders' use cases.

RQ3: *To what extent do practitioners find these view types helpful for the usability of BOMI (i.e., ease of use when reading BOMI models)?* To evaluate and improve the artifact, stakeholders provide feedback on its usability.

In answering the above research questions, a collection of BOMI view types is created to enhance usability for a number of specific stakeholders.

B. Research methodology used

The research method of design science was chosen to facilitate this study as it is motivated by the desire to identify opportunities and problems within an environment and introduce new, innovative artifacts [17]. This process aligns with the goal of creating a collection of specialized view types to enhance BOMI usability and reduce complexity. Other research methods such as case studies and action research were also considered. However, case studies focus on contextual conditions that do not involve the introduction of an artifact [18], while action research places very little emphasis on the artifact itself, focusing more on the processes

Table I: Details of participating companies [4].

Company A	Develops telecommunications products. Separate organizational units exist for sales, product management, and other purposes.
Company B	Develops mechanical products, both for consumer markets and for industrial development and manufacturing. The systems are decomposed into several elements, which is also reflected in the organizational structure.
Company C	Is an automotive Original Equipment Manufacturer (OEM). Traditionally, the company has been structured according to vehicle parts (e.g., powertrain, chassis, ...), but has undergone restructuring into agile teams.
Company D	Develops high-tech solutions for vehicular systems. Software development teams are largely independent of hardware development.
Company E	Develops hardware and software products for consumers and industries. Follows a test-driven, scaled agile methodology.

[17]. Thus, design science was seen to be the most appropriate research method for this study.

Following the design science research framework and guidelines proposed by Hevner et al. [17], two research cycles were conducted in collaboration with a number of companies (shown in Table I) through a software centre project. These company contacts hold various technical coordination roles within their respective organizations, providing a decent variety of stakeholder backgrounds and experiences. The information attained via these organizations shall remain anonymous, though many participants have worked with BOMI in the past or engaged in previous workshops.

Fig. 2 presents the two-cycle process that was used in this research study. Each cycle consists of three phases: *investigation*, *solution*, and *evaluation*.

The first cycle was focused on understanding the problem, more specifically, who practitioners believed to be the main stakeholders (i.e., users) of BOMI, what their greatest concerns (i.e., use cases) are, and what aspects of the current model meets these concerns. Alongside this, an artifact was created and evaluated.

The second cycle centred around improving the artifact. The data gathered from the evaluation phase of cycle 1 was used to learn more about the problem, improve the current artifact, and evaluate the improvements to determine whether complexity had been reduced.

1) Data collection

a) Cycle 1

The first cycle of the study was aimed at exploring the problem domain to obtain a better understanding of the main stakeholders and their concerns, together with what they valued most within the current BOMI metamodel. An initial artifact was created from the knowledge gathered, and an evaluation of the artifact carried out in the final phase.

Investigation. The investigation phase focused on **learning more about the problem, in this case, which** stakeholders are believed to benefit most from BOMI, what their main use cases might be, and how the current BOMI model addresses these concerns. This was done using both interviews and surveys.

Interview Design: Three method designers (i.e., those involved in the creation and refinement of the BOMI

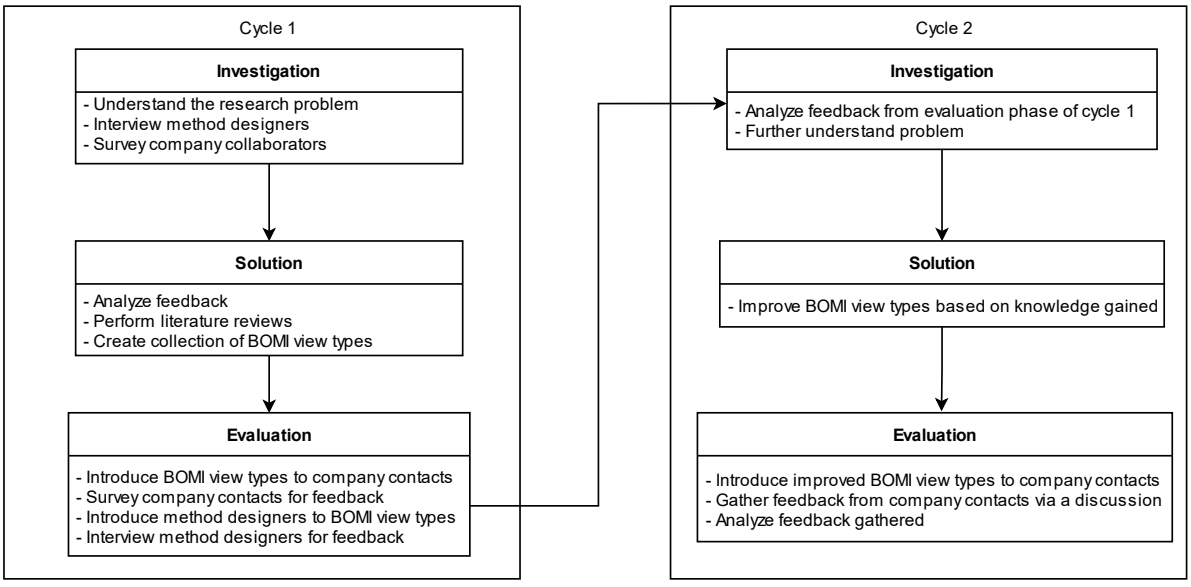

Fig. 2. Two cycle design science research.

metamodel, but not in the examination or supervision of this study) were consulted via Zoom interviews. As shown in Appendix A, the interviews were semi-structured in nature, with a series of open-ended questions. The queries focused on identifying who the most important stakeholders of BOMI might be, what their concerns or use cases are, and the most/least important elements of the BOMI metamodel when addressing those concerns (RQ1, RQ1.1, RQ1.2). The interviews were time boxed to be a maximum of 15 minutes to reduce fatigue.

Survey Design: Four company contacts were consulted via a survey, with all four providing responses. This survey was completed through a short online questionnaire, found in Appendix B, presented following a BOMI workshop run by several individuals knowledgeable about BOMI. The survey consisted of a demographic question and several open-ended questions. The queries were aimed at acquiring the opinions of practitioners with regards to who they believed would benefit most from using BOMI, what the stakeholders' concerns or use cases might be, and any thoughts on the current model's ability to meet those concerns (RQ1, RQ1.1, RQ1.2). The survey was kept as short as possible to prevent weariness, as participants were in the process of engaging in a two-hour workshop.

Solution. This phase of cycle 1 involved constructing an artifact, in this case, a collection of specialized BOMI view types (RQ2), which was then evaluated in the following stage.

Evaluation. The evaluation phase centred around assessing the artifact by gathering the opinions of stakeholders on the newly created collection of BOMI view types (RQ3). The artifact was evaluated in three ways. Similar to the investigation phase, a survey was conducted with company contacts and BOMI experts were interviewed. Both were shown the artifact and asked to provide feedback.

Interview Design: Two method designers were introduced to the newly created artifact via Zoom interviews. As shown in Appendix C, the interviews were semi-structured in nature, with a series of open-ended questions focused on how the BOMI view types could be improved. The purpose of these interviews was to gather method designers' opinions on whether the artifact met stakeholders' concerns and if further improvements could be made to enhance usability. The interviews were time boxed to be a maximum of 15 minutes to reduce fatigue.

Survey Design: After introducing the new artifact within a BOMI workshop, company participants completed a survey provided in the form of a short, online questionnaire as shown in Appendix D. The survey consisted of a demographic question and several open-ended questions. The aim of the survey was to evaluate whether the respondents believed this new collection of view types adequately addressed the specified stakeholders' concerns (established during the investigation phase), and if any other adjustments could be made to enhance usability/decrease complexity. The questions were again kept to a minimum as the survey was conducted within a two-hour workshop.

b) Cycle 2

The second cycle involved improving the existing view types based on feedback obtained during cycle 1 and was implemented through the three phases of investigation, solution, and evaluation.

Investigation. There was no gathering of new data during this phase. Instead, the results of cycle 1's evaluation phase (survey and interview results) were analyzed in order to better understand the problem, revealing more about how well each view type met the designated stakeholder's concerns, as well as how each view type could be further improved.

Solution. Based on knowledge obtained during the previous phase, the current version of the artifact was improved upon using feedback provided by company practitioners and BOMI method designers (RQ2).

Evaluation. The final phase of cycle 2 involved an assessment, this time of the improved artifact (RQ3). The evaluation was done through a short discussion held during a workshop. Company practitioners provided verbal feedback on the updated BOMI view types while the researcher took detailed notes for later analysis.

Discussion Design: The improved artifact was introduced during a workshop, with four company practitioners engaging in a short five-minute discussion. This discussion involved open-ended questions located in Appendix E. The purpose of this dialogue was to determine whether the revised collection of BOMI view types adequately addressed the specified stakeholders' concerns (established during cycle 1), and if any future changes could be made to enhance usability.

2) Data analysis

Interviews: The data collected from cycle 1's investigation and evaluation phase were recorded and manually transcribed for future reference. As the information was qualitative in nature, the method of thematic analysis as per Runeson and Höst [17] was implemented, with the researcher identifying important patterns via mixed coding, grouping them into specific themes.

Surveys: The data collected via surveys of both cycles was qualitative and quantitative in nature. The qualitative data was analyzed in a similar manner to that attained from the interviews, whereas the quantitative data was examined via descriptive analysis. This allowed the researcher to identify patterns related to thoughts on usability and complexity. Some of these patterns and codes were then checked by supervisors to ensure correct implementation of the analytical process. The data was then expressed in the form of graphs displaying overall participant responses.

Discussion: Similar to the process used in analyzing the surveys and interviews, detailed notes taken during the discussion were summarized and analyzed using thematic analysis. Specific codes were realized to identify patterns of thought related to the updated view types and suggestions were noted for future studies.

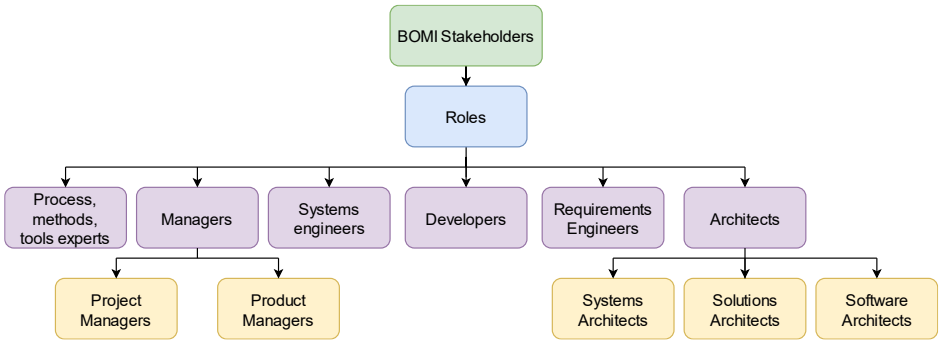

Fig. 3. Codes associated with RQ1.

All data gathered and analyzed during this study was recorded into codebooks, organized by cycle and phase, with Appendix F displaying cycle 1's investigation codebook, Appendix G showing cycle 2's investigation codebook, and Appendix H exhibiting cycle 2's evaluation codebook. Code hierarchies were also created for each RQ of the study.

IV. Results

This section provides the results obtained from the research process discussed in Section III, exhibited through code hierarchies and graphs when appropriate.

A. *RQ1: Who are the main BOMI stakeholders?*

Fig. 3 provides an overview of codes associated with BOMI stakeholders. The central code of roles branches downwards into subcodes such as managers, development teams, and systems engineers.

Interview Results: With regards to stakeholders, one BOMI method designer stated that "managers or product owners or maybe even members of agile teams" would be interested in working with BOMI. All other interviewees agreed, as managers and developers/development teams were the roles identified unanimously as potentially benefiting from the use of BOMI. Fig. 4 also shows that 1 participant believed "one important user or stakeholder of BOMI are these process, methods, tool experts," though no other interviewee mentioned this role. Similarly, the roles of requirements engineers, and more broadly, "BO owners," only garnered the support of 1 individual each, out of the 3 total participants.

Survey Results: The results of the surveys demographic question shows that participants totaled: 1 researcher, 1 product owner, 1 requirements engineer, and 1 lead systems engineer.

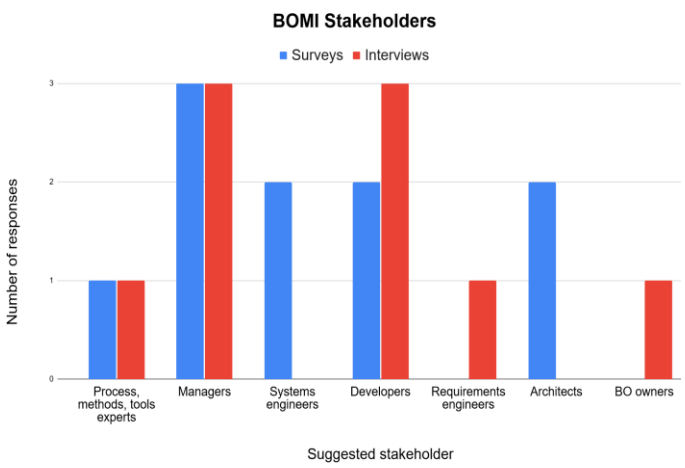

Fig. 4. Overview of identified BOMI stakeholders.

Several potential BOMI stakeholders were identified, including developers, systems engineers, and managers. As seen in Fig. 4, managers and developers/development teams were both mentioned by 3 of the 4 participants. Systems engineers and architects followed with at least 2 out of 4 participants believing they would benefit from using BOMI.

B. *RQ1.1: What are these stakeholders' main concerns?*

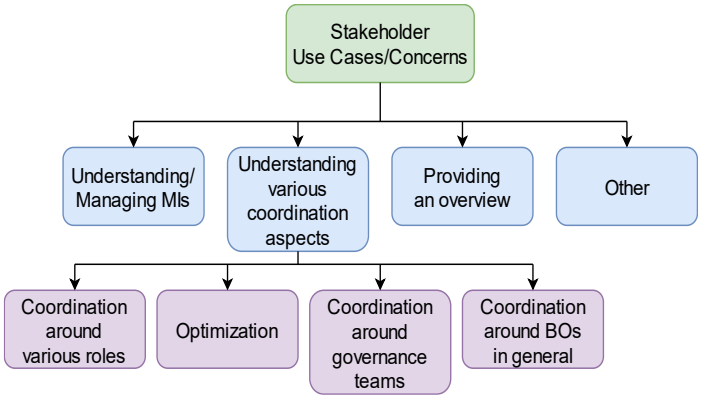

Fig. 5. Codes associated with RQ1.1.

Fig. 5 shows codes related to stakeholder concerns, with the 4 main subcodes of *understanding MIs*, *understanding coordination*, *providing an overview*, and *other* being realized. The larger code related to coordination has also been further broken down into subcodes.

Interview Results: With regards to stakeholder concerns, Fig. 6 shows 3 out of 3 participants agreeing that issues related to coordination could be addressed using BOMI. One interviewee believed BOMI models could be useful when making changes to an artifact (BO), stating that "if you wanted to change something, you would be interested in seeing which other teams are using this object so that you know how this change is going to affect them." Aside from coordination issues, managing MIs was deemed equally as important, especially for managers who would want to "see what drives this methodological island and see if they can find a way for these teams to work better together." Lastly, the use case of providing an overview, such as "trying to get a big picture of the organization," was mentioned by 2 of the 3 interviewees.

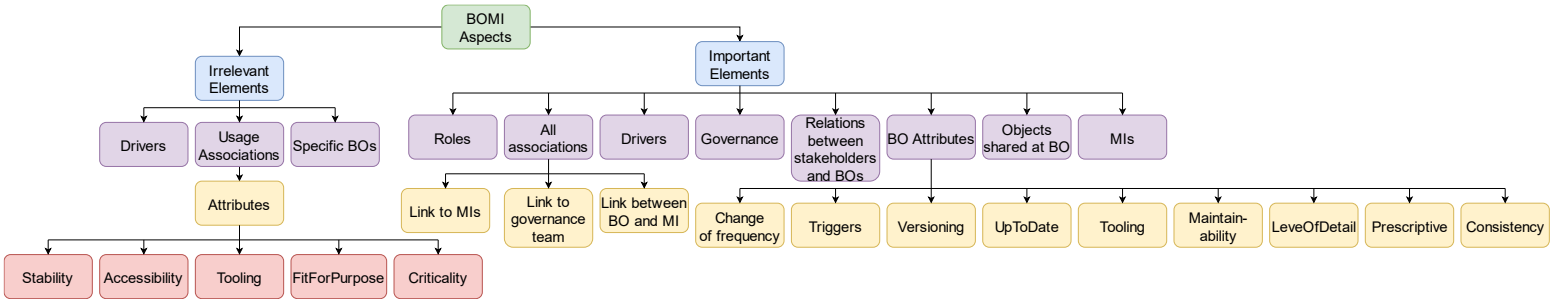

Fig. 7. Codes associated with RQ1.2.

Survey Results: When it comes to stakeholder concerns, Fig. 6 shows that 3 of the 4 participants believed issues related to coordination such as knowing how to "plan info and knowledge flows," as well as being able to "see what is important and where to focus," are essential. This use case, however, is quite large and encompasses subcases such as coordination around Governance Teams, Roles, and BOs in general, as well as optimization. With 2 of the 4 participants in agreement, the ability to provide an overview, along with managing MIs, were the second most mentioned use cases. Aside from this, the other category contains one individual's thoughts on BOMI being used as a pedagogical tool, and another simply stating "metamodels."

C. *RQ1.2: What aspects of BOMI are needed or not needed to address these concerns?*

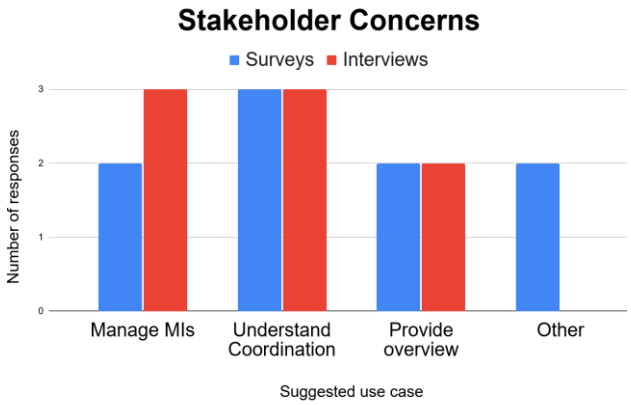

Fig. 6. Overview of stakeholder concerns.

Fig. 7 details the codes addressing the current BOMI metamodel aspects deemed most and least important.

Interview Results: When it comes to the most important elements of the current BOMI metamodel, 1 participant stated that "boundary objects are very important," summing up the thoughts of all participants. Equally as vital were the Governance Team and Role elements, as all interviewees believed many use cases would be "connected to Governance Teams" and stakeholders may "want to be able to talk to specific Roles." As shown in Fig. 8, the element of MIs and Drivers on the other hand, did not have unanimous support, only with 2 of the 3 participants believing that it would be important to "look at the methodological islands themselves" together with "what drives them." The other category pertains to elements mentioned by only 1 interviewee each, these include specific BO attributes, links between MIs and links to Governance Teams.

With regards to irrelevant BOMI elements, when focusing on coordination, 2 of the 3 participants believed Drivers to be least important. Others felt that the Usage associations and some of it's attributes, such as FitForPurpose, Stability, Criticality, Accessibility, or Tooling were irrelevant when specifically studying MIs and Drivers.

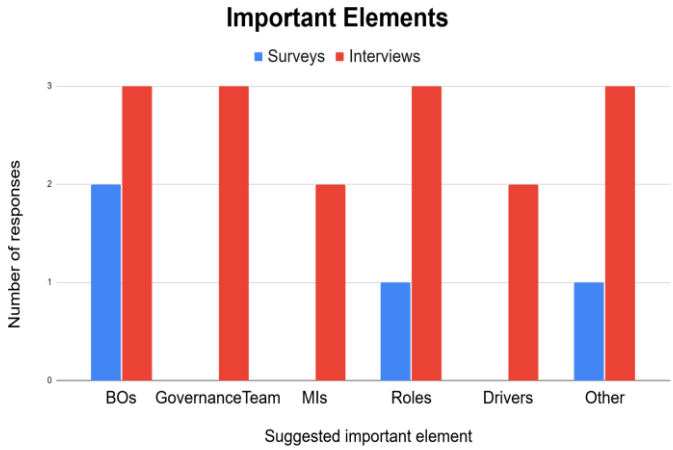

Fig. 8. Overview of important elements.

Survey Results: When asked to identify key BOMI aspects, only 2 of the 4 survey participants responded, both agreeing that BOs were important, one stating that "BOs and Roles they interact with" are crucial. The other participant believed that the Governs associations and certain BO attributes such as Triggers and Change Frequency would be important to meeting stakeholder concerns.

None of the survey participants provided elements they believed to be of least importance.

Finally, Fig. 9 combines elements of the previous code hierarchies. This resulted in a display of stakeholders, concerns, and elements that led to the initial proposal of view types. The concern of *understanding/managing MIs* was thought to benefit from the removal of the governance elements and Usage association attributes, while hiding all attributes was thought to reduce complexity when dealing with the concern of *providing an overview*. In order to address the large use case of *understanding various coordination aspects*, suggestions were made to remove MIs, Drivers, and Usage associations.

These initial proposals helped generate ideas on various aspects that could be abstracted to create a set of potential BOMI view types. These view types are further discussed in the following subsection.

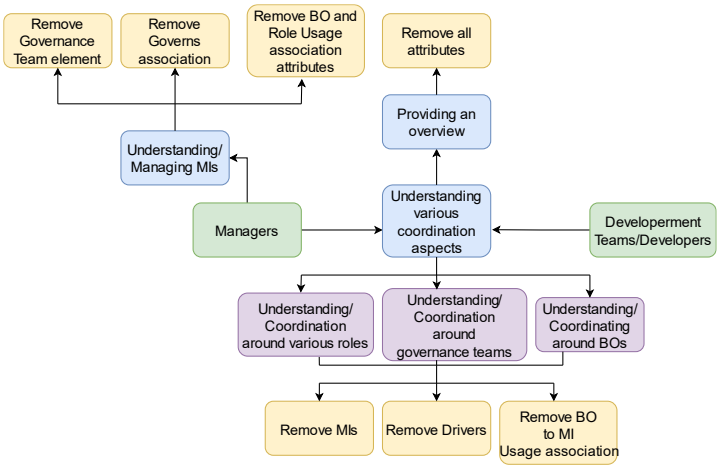

Fig. 9. Codes associated with RQ2.

D. RQ2: How can certain BOMI elements and relationships be used in view types to meet stakeholders' concerns?

An intermediate version of the artifact exists, created during the solution phase of cycle 1 and is found in Appendix I. Cycle 2's solution phase also involved a number of view type alternatives, these are found in Appendix J.

The initial version of the artifact consisted of 3 BOMI view types, all of which were the result of data gathered and analyzed from the surveys, interviews, and discussion mentioned previously. The view types focused on addressing the main stakeholder concerns of providing a big picture understanding of organization around a BO (the overview view type), identifying MIs and what drives them (the MI view type), and understanding coordination around a BO (the BO view type).

Based on the feedback from cycle 1's evaluation phase, several changes were implemented to all view types of the final artifact. First, the Usage association colour was changed to a dark purple to promote easier text visibility. An attribute titled *Frequency* was also added to all Usage associations, denoting how often the specified responsibility/CRUD action is performed. Changes that were made to each of the specific view types are detailed in the following paragraphs.

Only one change was implemented from the intermediate to the final version of the overview view type, with that being the removal of UML stereotypes.

The MI view type changed a great deal, as it initially contained all BOMI elements save for Governance Teams and Governs associations, with the final version seeing the removal of both the BO and its Usage attributes, leaving only the Roles, MIs, and Drivers.

The BO view type initially only hid MIs and Drivers. However, in addition to the previously mentioned elements, the final version saw the removal of all BOs except the one being studied, along with all governance information.

The details of each view type found within the final artifact is elaborated on in the following subsection.

1) Final Artifact

The final version of the developed artifact is a collection of four BOMI view types: the *overview view type* (derived from the concern of providing a big picture understanding of organization around the BO), *methodological island (MI) view type* (derived from the concern of understanding MIs and what drives them), *boundary object (BO) view type* (derived from the concern of being able to identify the Roles that interact with the BO and what their responsibilities are), *and governance view type* (derived from the remaining important aspect of BOMI, governance).

The *overview view type*, as shown in Fig. 10, focuses on providing stakeholders with a less detailed perspective of information surrounding the BO. This is accomplished by stripping away all attributes and enumerations of every element within the model, along with the UML stereotypes. As an example, Fig. 11 shows a full BOMI model created by company A. For comparison, Fig. 12 shows its corresponding overview view. The latter arguable allows users to more easily understand the different associations related to the BO of Test Cases, without having to face a potentially overwhelming number of attributes. A second full BOMI model, found in Appendix K, was created by company E, and involves the BO of a generic Feature. This model is made simpler in Appendix L, with the application of the overview view type. The removal of detailed information results in less distraction, which could benefit those being introduced to BOMI for the first time.

The final *MI view type*, as shown via a metamodel in Fig. 13, focuses on managing and understanding MIs. This view type strips away aspects related to governance and instead focuses on Roles, MIs, and Drivers. As seen in the MI view of Fig. 14, all Usage associations and BOs, including the main BO of Test Cases, have been removed completely. A second example of an MI view is found in Appendix M and can be compared with its original counterpart in Appendix K to further understand the simplification.

Fig. 15 shows the metamodel of a *BO view type* with all governance aspects, MIs, Drivers, and minor BOs removed. Fig. 16, a BO view of the model involving Test Cases (Fig. 11), has all the previously mentioned elements stripped way. This allows users to identify more easily who interacts with the BO and in what way. A second example of the BO view type can be seen in Appendix N, where the view has been derived from a full BOMI model (found in Appendix K) involving a generic Feature as the BO.

Lastly, Fig. 17 shows the metamodel of the *governance view type*, revealing the absence of all MIs and Drivers, with only the BOs, Roles, Usage associations, and information related to aspects of governance remaining. It should be noted that the Usage associations' attributes have now been hidden to provide further simplification. Derived from the full BOMI model in Fig. 11, its governance view in Fig. 18 allows users to identify not only those who interact with the BO, but also those who are involved in its governance. A second example of the governance view type is found in Appendix O, this one extracted from the previously mentioned model involving a generic Feature BO, which resides in Appendix K.

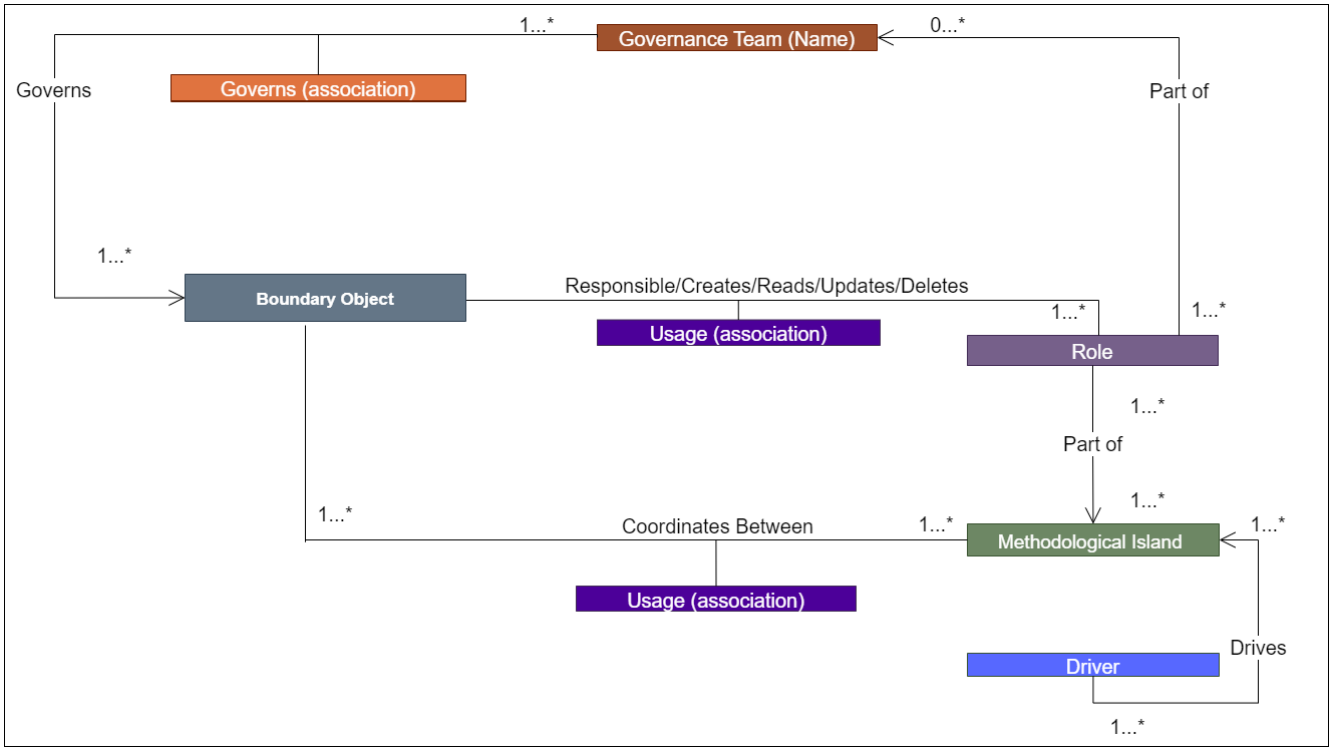

Fig. 10. Metamodel of final overview view type providing a big picture look at organization around the BO. This view type does not display any attributes, enumerations, or UML stereotypes.

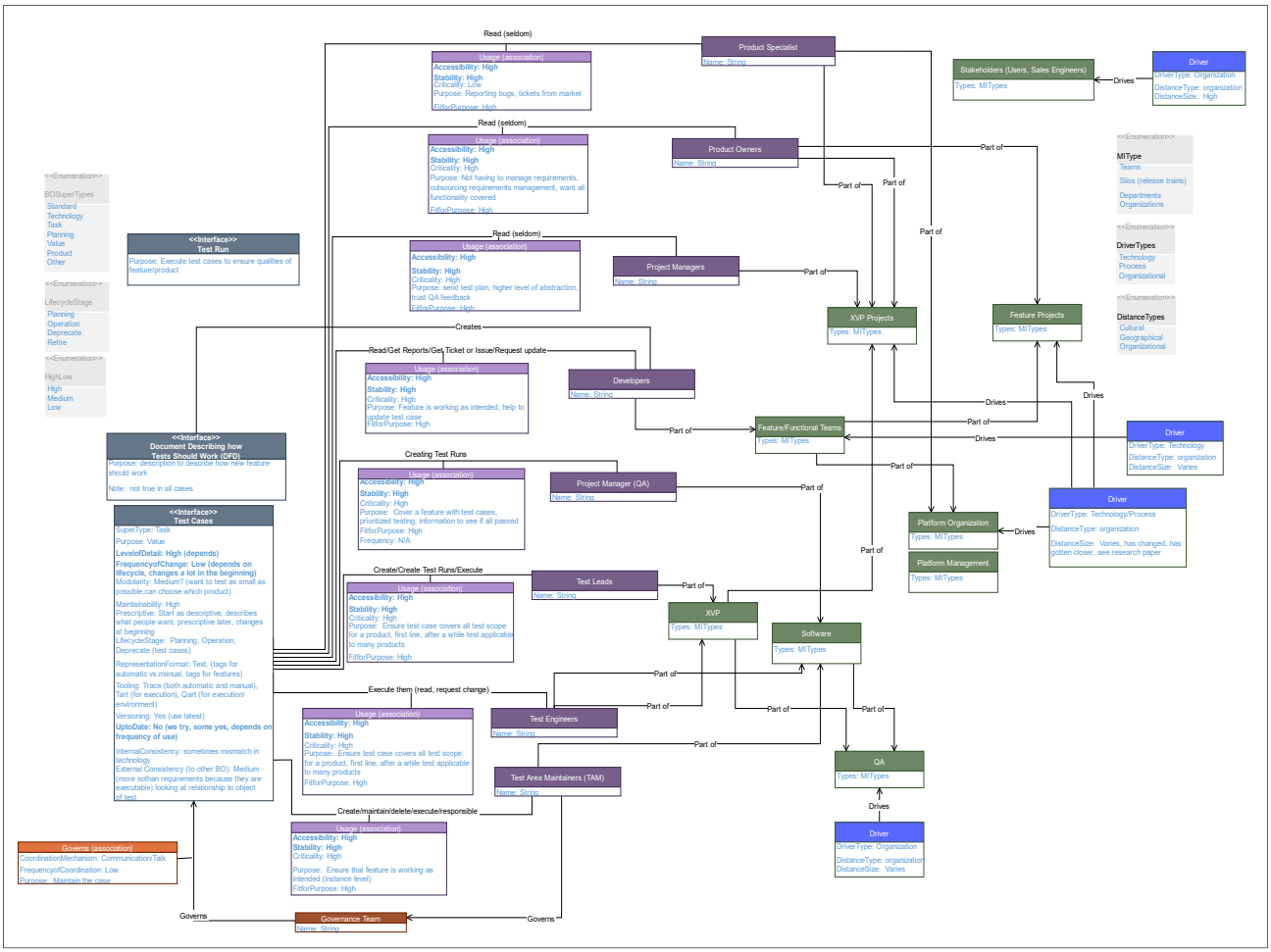

Fig. 11. Instance model of BOMI setup for Test Cases from Company A.

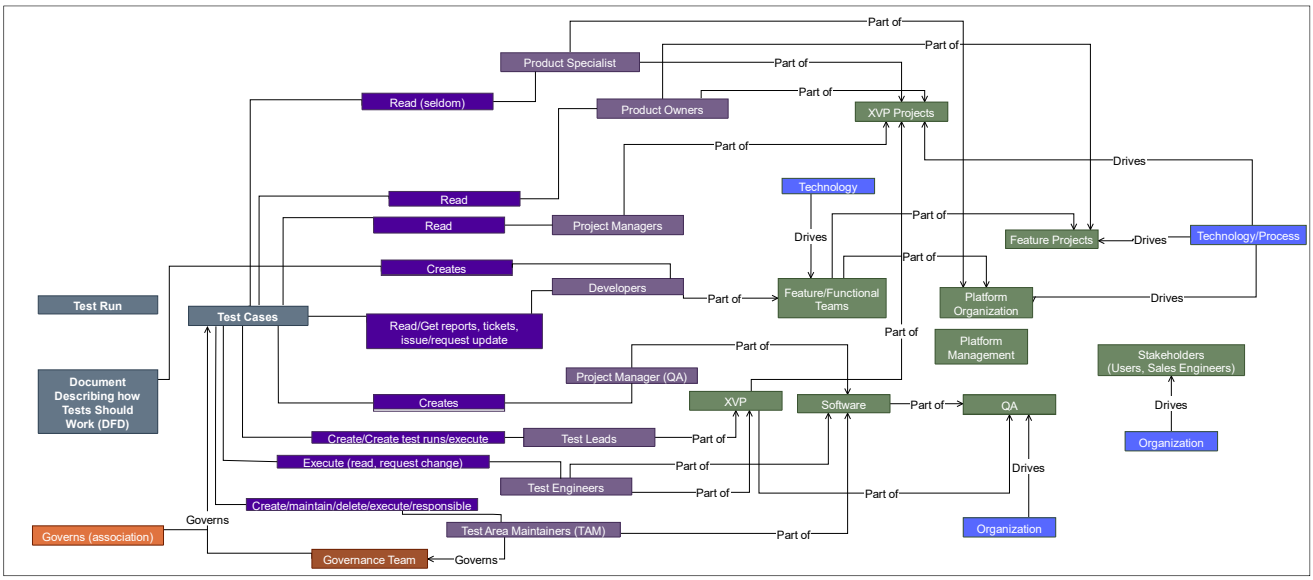

Fig. 12. Instance model of final overview view type setup for Test Cases from Company A.

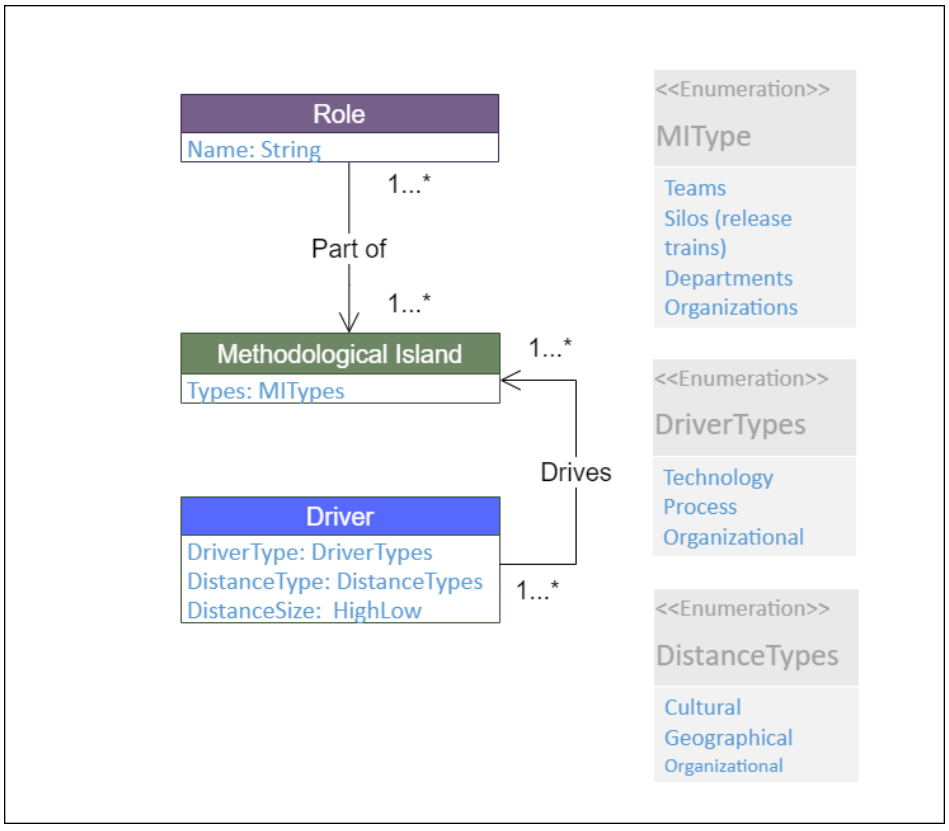

Fig. 13. Metamodel of final Methodological Island (MI) view type focused on MIs and Drivers. This view type does not display any governance, BO, or Usage association elements.

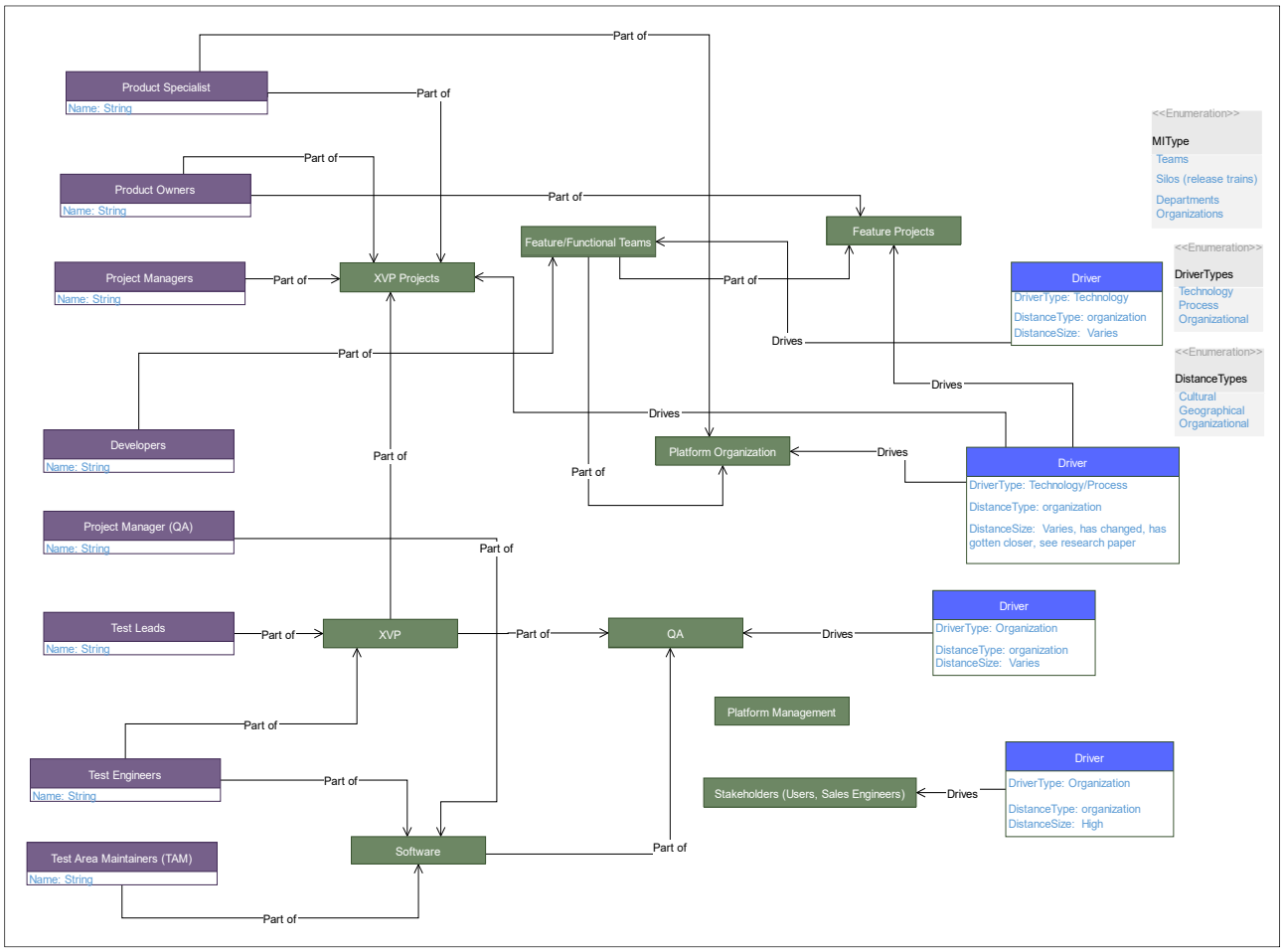

Fig. 14. Instance model of final MI view type setup for Test Cases from Company A.

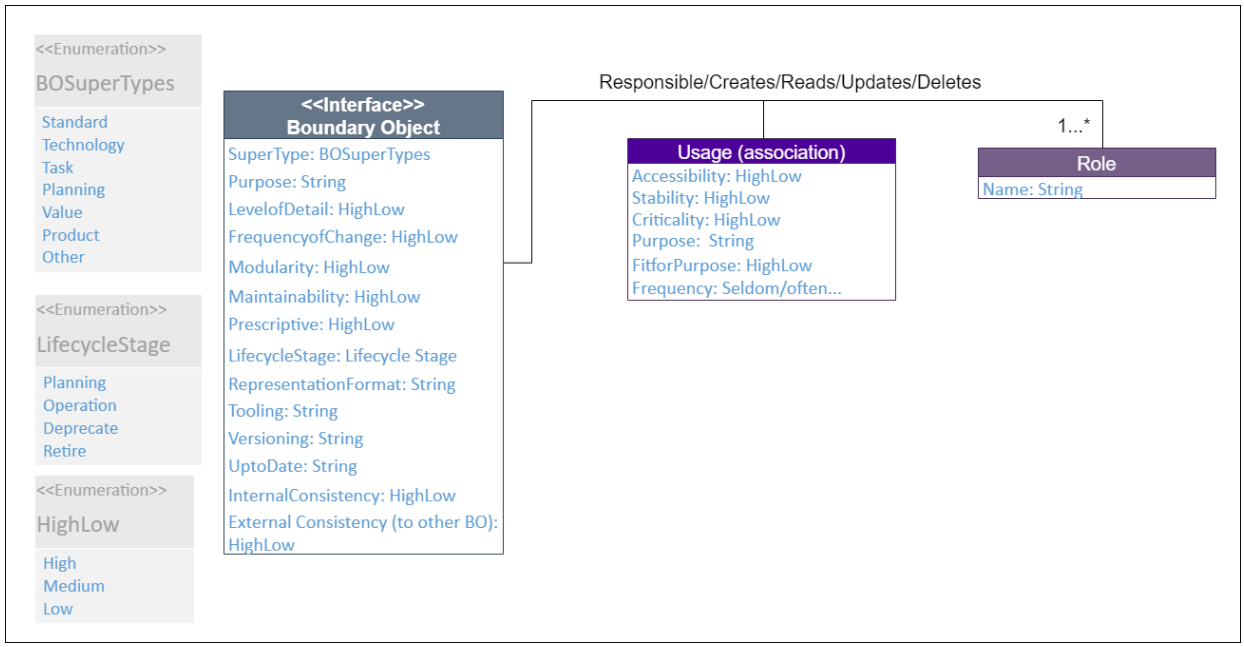

Fig. 15. Metamodel of final Boundary Object (BO) view type focused on the roles and responsibilities linked to the BO. This view type only features one BO and does not display the MIs, Drivers, or any information related to governance.

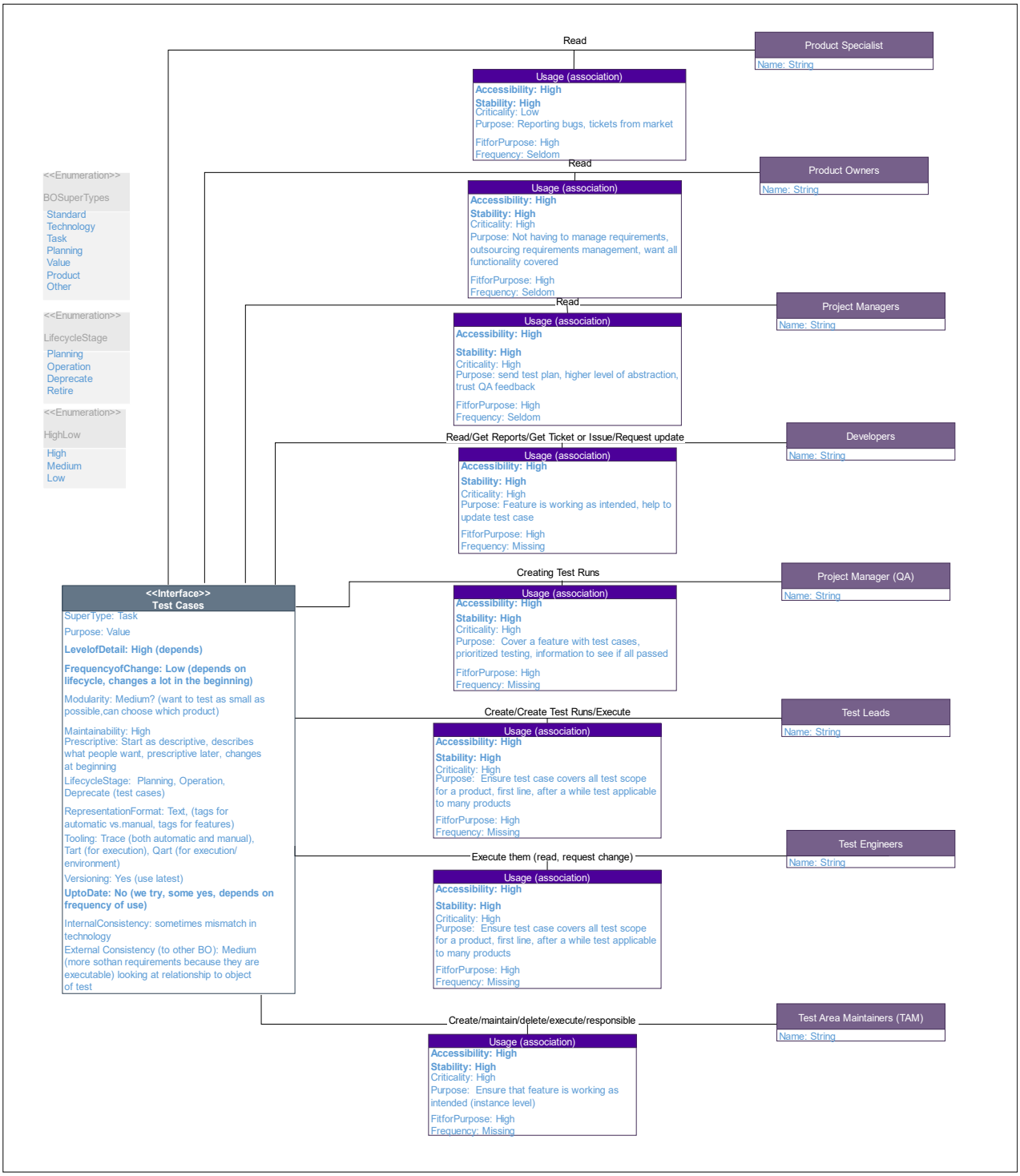

Fig. 16. Instance model of final BO view type setup for Test Cases from Company A.

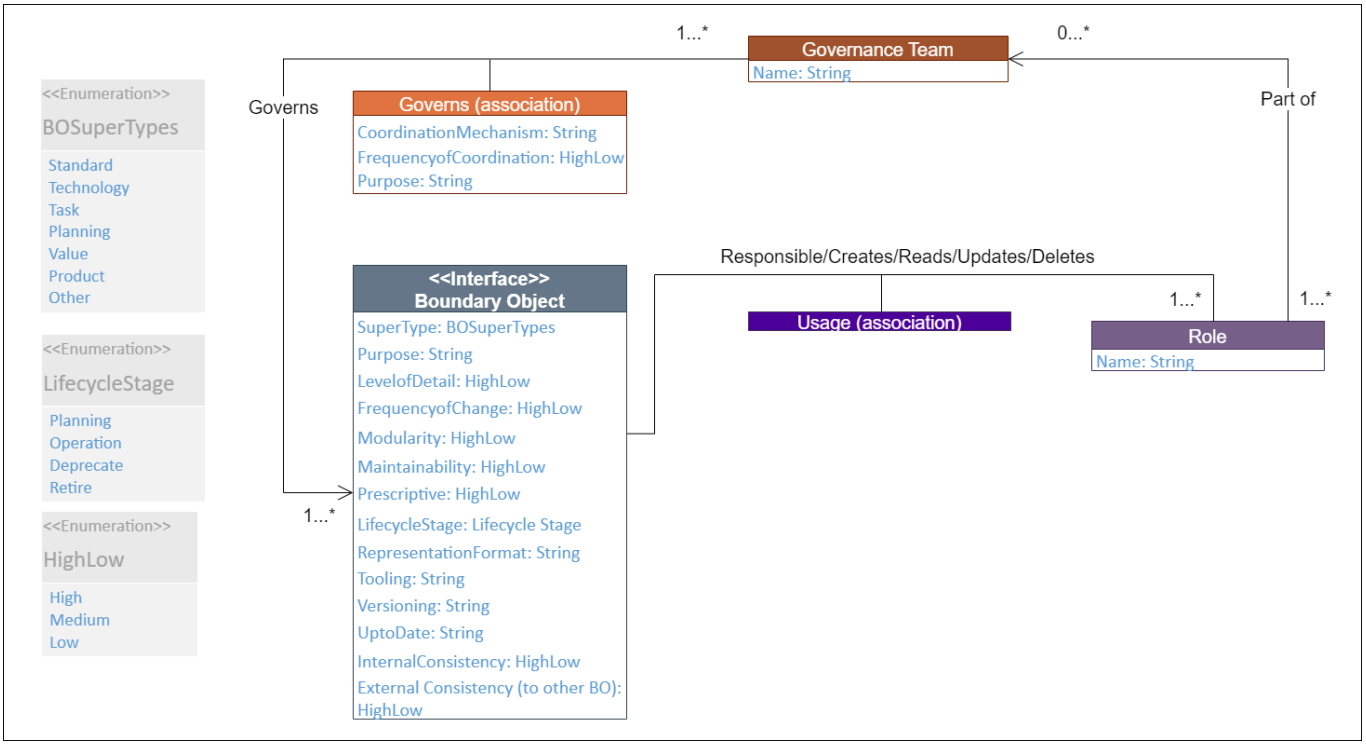

Fig. 17. Metamodel of final governance view type focused on the governance aspect of the BO. This view type does not display the MIs, Drivers, or Usage association attributes.

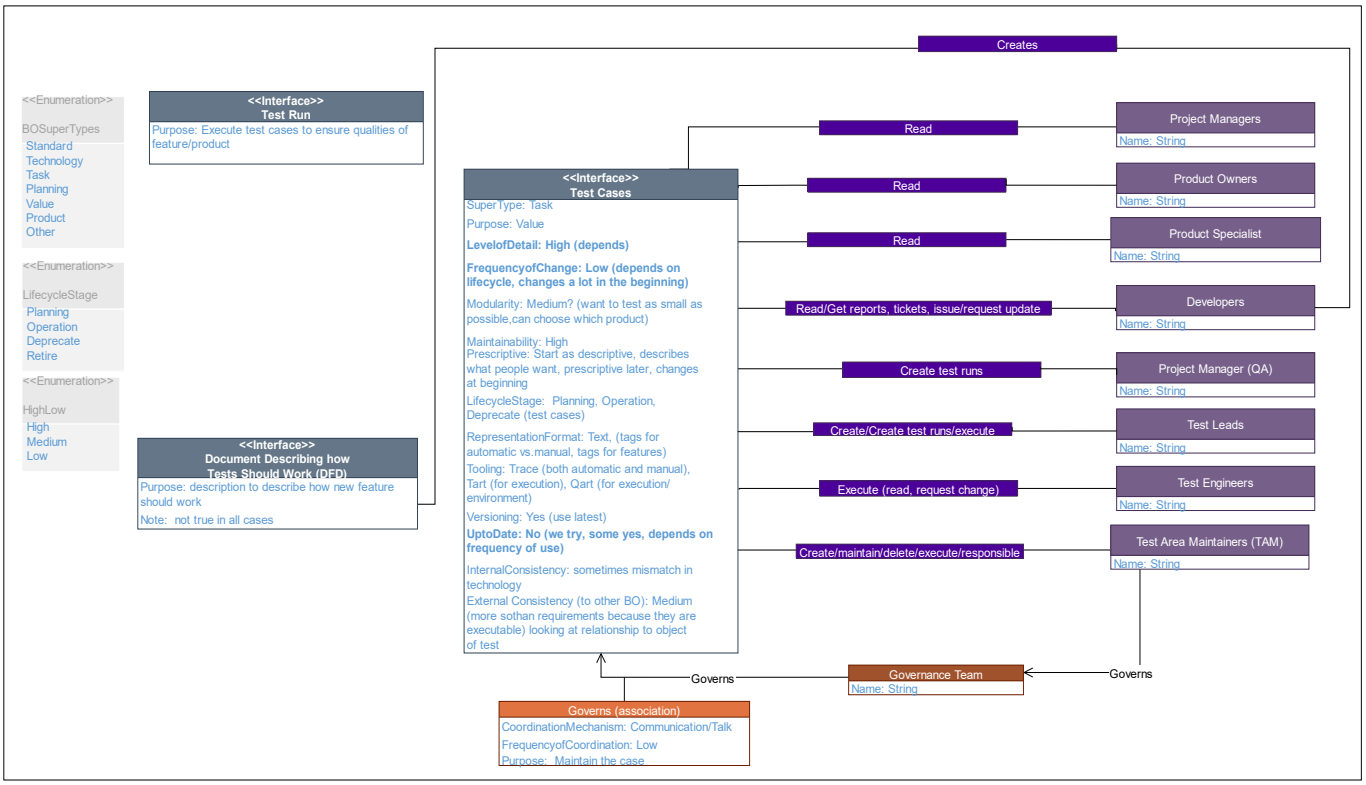

Fig.18. Instance model of final governance view type setup for Test Cases from Company A.

E. *RQ3: To what extent do practitioners find these view types helpful for the usability of BOMI?*

1) Initial Evaluation

The initial evaluation was done through a series of interviews with two BOMI method designers and surveys with four practitioners from companies A and B.

Fig. 19 details the codes addressing whether practitioners found the newly created view types helpful for the usability of BOMI. Upon evaluating the newly created artifact, practitioners were also asked to provide additional suggestions on how the view types could be further improved to meet both stakeholder needs, but also increase usability.

Interview Results: In general, readability was an issue that one interviewee felt could be improved upon. This participant believed that the Usage associations became more difficult to read when the attributes were removed, stating that it could be a "colour thing," and it might help if the colour were, "darker, maybe?" Another participant believed that the frequency of use for associations could be added as an attribute of the Usage association class rather than being displayed on the line.

When it came to the overview view type, 2 out of 2 interviewees expressed positive opinions, believing that it was "much simpler" and "easier to look at" in comparison to the original BOMI model.

With regards to the *MI* view type, one interviewee felt it was "a bit better," however, both participants struggled to see a big difference to the original model. One individual expressed confusion, wondering, "why was there a need to include the BO," when the concern is centred around understanding what drives the MIs and how others are using them. This participant suggested removing the BO completely, as it seemed irrelevant to the stated concern. However, the other participant disagreed, believing the presence of the BO beneficial. Instead, this individual suggested the implementation of an interactive tool that would allow for MIs to be selected and their related BOs hidden/displayed as desired.

The BO view type in general was seen as beneficial, with an interviewee simply stating, "I like this view." The participant believed that it was "easy to process" and "simple to understand." When asked if anything could be improved upon, one individual responded with, "nothing comes to mind." However, the second participant felt that the view could be "more filtered," and suggested a new view type that focuses on analyzing the individual BO with respect to "who creates, reads, and uses" the artifact.

Aside from this, there were also suggestions on tool implementations such as a zoom function and the ability to "open up" the model, showing certain indicators of bad smells or possible problems in the BOMI configuration. One interviewee also believed moving away from UML and exploring visualizations such as "bubbles or circles" when organizing elements could be beneficial.

Survey Results: The results of the surveys demographic question shows that participants totaled: 1 researcher, 1 systems architect, 1 requirements engineer, and 1 lead systems engineer.

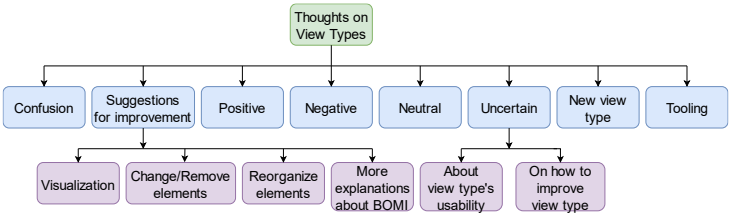

Fig. 19. Codes associated with RQ3 from initial evaluation.

As shown in Fig. 20, 3 out of the 4 participants felt that the overview view type provided increased usability, with 2 believing it does so slightly, while another felt it was much better than the original model. One participant believed this view type to be a stark improvement as it "shows the dependencies but removes a lot of detailed information." However, it must be noted that one individual felt the overview view type was no different than the original model. When it came to improving this view type, one participant suggested the removal of UML stereotypes "such as <<interface>>," as well as "reducing the number of intersections or elements." Other suggestions involved reorganizing the elements of the specific view by "aligning the boxes" or "removing some of the crossing lines" to "improve readability."

With regards to the MI view type, there were split results. When compared to the original model, one participant's response of "feels pretty equivalent to me," summarizes the general feeling around this view type. As shown in Fig. 20, 2 of the 4 participants felt there was no difference to the original model, with the remaining 2 believing it was only slightly better. One participant believed it would be best to "show less details," while another thought that the "long attribute lists" were "likely not so helpful." Instead, it was suggested that highlighting "the critical attributes" for each particular case would enhance usability.

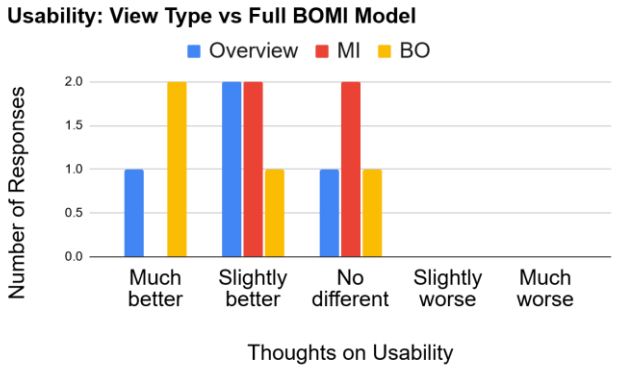

Fig. 20. Survey participants' thoughts on usability of specific view types vs. BOMI model example without views during initial evaluation.

Fig. 20 shows that 3 of the 4 survey participants felt the BO view helped improve usability, with 2 claiming it was much better, 1 slightly better, and the remaining participant seeing no difference at all. Most responses to this view type were positive, with many claiming it to be "really good." One individual provided a more detailed response, explaining that, "trying to communicate both the roles involved in a certain BO and also the roles' relation to the islands in the same picture has always made these graphs seem messy to me," believing the BO view type helps to address this issue. However, one participant did feel that this view type still made

it “hard to evaluate the impact of the changes,” and that there were “limited changes/diffferences between the various views.” The BO view type received suggestions for improvement such as the removal of “any attributes that are not critical” and that “someone actually need[s] to maintain the boundary object.”

It must be noted that one participant was unsure of both the BOMI model and its view types, stating that “BOMI models in general needs some help to understand.” More clarity on BOMI’s elements such as providing “clear link explanations other than part-of, drives” or displaying “color codes/legends,” was thought to be beneficial. When creating a model or view, starting out “VERY simple” and then slowly adding elements was also thought to be a step that could help with understanding and usability. The suggestion of starting “simple and building up the complexity gradually” was provided as a general solution to helping users understand BOMI. These findings are discussed further in section V.

2) Final Evaluation

After improving the BOMI view types (i.e., hiding and aggregating specific elements/attributes as detailed in subsection D of the Results) based on the initial evaluation, a short discussion was held during workshop with several company contacts who provided their thoughts on the updated artifact.

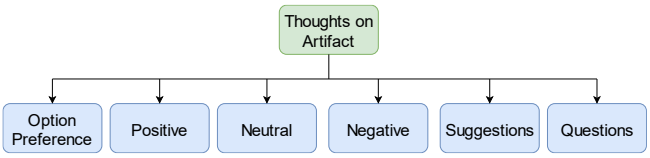

Fig. 21. Codes associated with RQ3 from final evaluation.

Fig. 21 details the codes addressing whether practitioners found the updated view types helpful for the usability of BOMI. Upon evaluating the updated artifact, practitioners were also asked to provide their preferences when examining view types with alternatives.

Discussion Results: There were a total of 4 practitioners who participated in the final evaluation, 2 from company A, 1 from company B, and 1 from company C. Of the 4 participants, 3 provided generally positive feedback on the updated artifact. One participant “really like[d]” the BOMI view types, favouring “less information in text,” and preferring to “understand the conceptual aspects” before going in and exploring deeper. A fellow participant agreed, believing it was beneficial to “focus on one type of information at a time,” stating simply that the view types worked “very well for me.” However, 1 of the 4 participants felt they did not have much input, believing it was difficult to judge the view types as there was “too much detail,” which made following along a challenge. This individual also preferred having more information available in the model, stating that they understood it to be a “hard balance.”

When examining the preferences between view types with alternatives (MI and governance), only one participant responded, stating “I think the alternative to the right is preferred for both.” The response of “the alternative to the right,” refers to option 2 of both the MI and governance view types. The reasoning provided was that there was “less text”, which is the respondent’s “personal preference.”

A number of individuals also provided ideas related to tooling. One participant believed it could be useful to have templates or boiler plates that would take in text and automatically create a BOMI model or vice versa. Another participant believed it would be helpful to have a legend (i.e. green boxes are MIs).

V. Discussion

This section discusses the results presented in Section IV and compares those results to that of previous studies in order to understand how different views can reduce complexity and enhance usability.

A. RQ1

The answer to the question *who are the main BOMI stakeholders?* was uncovered during cycle 1’s investigation phase of the research study.

Those in lead type positions such as managers, were identified as important BOMI stakeholders. The identification of managers as an important BOMI stakeholder corroborates that of previous studies [4]. This finding is understandable considering those in higher level positions are believed to be responsible for managing and optimizing ways of working and coordination, a focal point of BOMI and its concepts.

Several potential BOMI stakeholders, such as those of developers, process, methods, and tools experts, systems or requirements engineers, and architects were identified, all of which were not specifically mentioned in previous studies. As these individuals are likely to work closely with the BO (depending on what it is) in one way or another, it is understandable why these positions may be interested in working with a BOMI model.

B. RQ1.1

A number of use cases were realized when addressing the question of *what is this stakeholder’s main concern?*

Use cases involving the coordination around a BO, managing MIs, and providing a big picture understanding were found to be the main concerns of the identified stakeholders.

With complexity being a potentially hindering factor to the use of BOMI models, a simplified overview, stripping away the more detailed aspects of the model is practical. Alongside this, the two main aspects of BOMI are its Boundary Objects and Methodological Islands, thus, the creation of view types that emphasize those specific features is also reasonable. With one major aspect of BOMI models left unexamined – how a BO is governed – the creation of the governance view type addresses this use case.

Previous literature on BOMI has not yet targeted specific stakeholder concerns, therefore, comparison in this area is rather challenging. However, the process of identifying stakeholders and creating specialized views based on their needs has been examined in detail within the domain of business process models, resulting in the conclusion that this approach is both useful and beneficial [6, 7].

As views are typically used to address issues related to the understanding of a model, the use cases provided by the

majority of individuals were related to the reading of BOMI models. However, aspects of BOMI model creation were also brought up by a number of participants and will be addressed further in subsection E.

C. RQ1.2

The answer to *what aspects of BOMI are needed or not needed to address these concerns?* resulted in the suggestion of removing irrelevant aspects of the model depending on the use case.

The central BOMI model was believed to be too complicated, displaying a variety of information related to multiple use cases [4]. Thus, the suggestion of removing certain elements was almost unanimous, though which elements should be removed varied.

Associations, Drivers, and specific attributes were often brought up as candidates for removal. However, depending on the use case, certain elements believed to be important in one scenario were deemed unimportant in another. For example, when examining the use case involving coordination of Roles and Governance Teams around the BO, Drivers were thought to be irrelevant. Yet, when trying to manage or understand the MIs, Drivers were believed to be vital. This finding is reasonable, as different concerns would likely focus on different aspects of the model.

While these mixed results were used as a reference when creating the artifact, it is the established uses cases/concerns that played the biggest factor in the BOMI view types construction.

D. RQ2

The collection of BOMI view types was created when answering the question of: *how can certain BOMI elements and relationships be used in views to meet stakeholder concerns?*

Based on the previously identified stakeholders and their concerns, four view types were created, each focused on a specific use case: the *overview view type, the methodological island (MI) view type, the boundary object (BO) view type,* and *the governance view type.*

Attributes and elements deemed unnecessary to meeting the specified concerns were aggregated or eliminated completely. With the absence of irrelevant elements, practitioners are able to focus on the identified use cases without the distraction of unrelated details.

The process of hiding attributes for the purpose of simplification is one that is supported by previous work [15, 16]. Horkoff et al. observed a collaborating company create their own condensed view of a BOMI model with reduced BOs, hidden attributes, and simplified terms for the relationships [4]. However, it must be noted that, unlike the view types of this study, no use cases were identified, nor were there concrete rules applied to the improvised model.

E. RQ3

The results of cycle 2's investigation and evaluation phase were used to answer the question, *to what extent do practitioners find these view types helpful for the usability of BOMI?*

Based on the findings, the majority of practitioners and BOMI method designers found the collection of BOMI view types beneficial to usability. The individual view types allowed for specific use cases to be identified and the removal of irrelevant aspects helped to simplify and declutter the model.

Although previous work has suggested a potential benefit to creating simplified BOMI views [4], prior to this study, no research has examined this topic in detail. Nonetheless, the results of this paper are promising, positively corroborating previous conjectures.

From this study, the implementation of distinct view types that address specific stakeholder concerns seem to enhance BOMI's usability, simplifying the complex model while giving a clear direction to its use. However, there were concerns about BOMI modeling and the difficulties of both creation and understanding. There was a desire for more explicit information to be present, alongside more thorough, slow, step by step explanations of how to produce a basic BOMI model before creating large, complicated ones. This should be noted and kept in mind when presenting BOMI and its models or views, especially to those who are new to the concepts.

It should be noted that although the purpose of this study was to ease the reading of BOMI models by creating a collection of view types, some of the participant's feedback was instead focused on the aspect of BOMI model creation. This is an issue that could have been avoided by stating more explicitly to participants that the evaluation of the artifact should be based on ease of reading/understanding rather than on its construction.

F. Future Work

Aside from the topic of view types, many participants provided an array of potential ideas that could be explored in the future.

Tooling. Multiple individuals felt the implementation of a BOMI specific tool would be of great benefit. A function that allows for zooming in and out or hiding/revealing details only when needed was mentioned multiple times. The ability to identify potential issues with BOMI instances (bad smells) and to display a warning was also believed to be advantageous. In addition, there were suggestions of implementing a text to model function, where users could write sentences detailing the interaction of elements, resulting in the model being generated automatically.

Visualization. The idea of forgoing UML to instead create a BOMI specific language was thought beneficial by one individual. Suggestions included using unique shapes and colours, as well as implementing specific rules on where within the model certain elements must be placed. Others proposed displaying more explanatory elements, such as that of a legend, to aid in deciphering the different coloured boxes.

G. Threats to Validity

This section examines the potential weaknesses of this study.

Construct threats. As the domain of BOMI is rather new and unexplored, it is possible that the concepts of BOs and MIs could be easily misunderstood. To counteract this issue,

there was an attempt to provide clear and concise definitions during workshops. Since all the collaborating companies have been involved with BOMI in the past, participants were also more likely to have a solid understanding of the concepts.

The data collection method of surveys also introduced a possible threat. As both surveys were completed through online questionnaires rather than in person, it is possible that participants could misinterpret the questions. However, as these surveys were completed as part of a workshop, BOMI experts were present to answer any questions that may have arisen.

Internal threats. As the researcher is still a BOMI novice and has little experience in survey creation, conducting interviews, or leading workshop discussions, it is possible that their inexperience may have had an influence on the participants perception of the artifact presented. To counteract this issue, those knowledgeable in BOMI reviewed interview, survey, and discussion questions beforehand, assisting during workshops when needed.

External threats. The scope of this study is rather narrow, consisting of merely a few BOMI method designers and individuals from the companies involved in the research project. Although this sample provides valuable insights into stakeholders' concerns, it is possible that companies of varying sizes, specializations, and BOMI experience could provide differing results.

Reliability. Due to the study involving a large amount of qualitative data and having merely one researcher, the coding of data could face potential validity issues. However, there was an attempt to minimize this threat by having two academic supervisors examine certain parts of the coded work to ensure that it had been done correctly.

VI. Conclusion

Through a series of interviews, surveys, and discussions with BOMI method designers and company practitioners, this design science research study presents a collection of four BOMI view types: the *overview view type*, *Methodological Island (MI) view type*, *Boundary Object (BO) view type*, and *governance view type*, each focused on a specific set of stakeholders and their concerns.

This collection of view types garnered an overall positive reaction and was found to be quite beneficial, with most practitioners and method designers believing the view types helped reduce complexity, making the BOMI model easier to understand. However, it should be noted that suggestions were made on how to approach BOMI model creation, urging a slower and simpler, step by step process.

Although an initial collection of BOMI view types has been created, this study was limited with regards to both time and scope. Therefore, multiple areas can be explored further in future studies. Additional stakeholders could be identified, their concerns recognized, and supplemental view types added. Aside from this, it would be beneficial to replicate this study with extra resources, researchers, and iterations in order to verify the findings. Future work could also include other topics not covered in this study such as tooling and visualization.

Acknowledgments

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APPENDIX A

INTERVIEW GUIDE USED DURING CYCLE 1 (INVESTIGATION PHASE)

The related research questions (RQs) have been provided in parenthesis following each interview question.

1. Who do you believe to be the main users/stakeholders that would benefit from using BOMI? **(RQ1)**
2. What are these users' main concerns/use cases? **(RQ1.1)**
3. Which elements of the current metamodel are most important for the roles and goals identified above? **(RQ1.2, RQ2)**
4. What elements are least important? **(RQ1.2, RQ2)**

APPENDIX B

QUESTIONNAIRE FOR CYCLE 1 (INVESTIGATION PHASE)

The related research questions (RQs) have been provided in parenthesis following each survey question. Those labeled with "D" are related to demographics.

The purpose of this research project is to create a collection of BOMI view types that addresses identified stakeholder concerns.

This phase involves completing an online survey that will take approximately 5 minutes. The survey questions will investigate possible BOMI stakeholders, their concerns, and the current aspects of the BOMI metamodel deemed vital to meeting these concerns.

Your responses will be confidential, with all data being stored in a password protected electronic format, and the results being used for scholarly purposes only.

1. What is your role within the company? **(D)**
2. What positions/roles do you think would benefit most from creating or studying a BOMI model? **(RQ1)**
3. With regards to the roles/positions identified in question 2, what goals could these individuals achieve by using BOMI? What concerns or use cases could be met? **(RQ1.2, RQ2)**
4. Which elements of the current metamodel are most important for the roles and goals identified above? What elements are least important? **(RQ1.2, RQ2)**

APPENDIX C

INTERVIEW GUIDE USED DURING CYCLE 1 (EVALUATION PHASE)

The related research questions (RQs) have been provided in parenthesis following each interview question.

Questions for each view type:

1. What do you think about this view? (RQ3)
2. Do you think that the view type meets the stakeholder's concerns? Why or why not? (RQ3)
3. Do you think there are any aspects of the model that could be improved upon (added/removed) in order to further meet stakeholder needs? (RQ2)

General questions after showing all view types:

1. Are these views you expected, or did you expect to see different?
2. Do you have any additional thoughts when it comes to any of these view types?

APPENDIX D

QUESTIONNAIRE FOR CYCLE 1 (EVALUATION PHASE)

The related research questions (RQs) have been provided in parenthesis following each survey question. Those labeled with "D" are related to demographics.

The purpose of this research project is to create a collection of BOMI view types that addresses identified stakeholder concerns.

This phase involves completing an online survey that will take approximately 5-10 minutes. The survey questions aim to evaluate the extent to which practitioners find these view types helpful for the usability of BOMI.

BOMI Metamodel

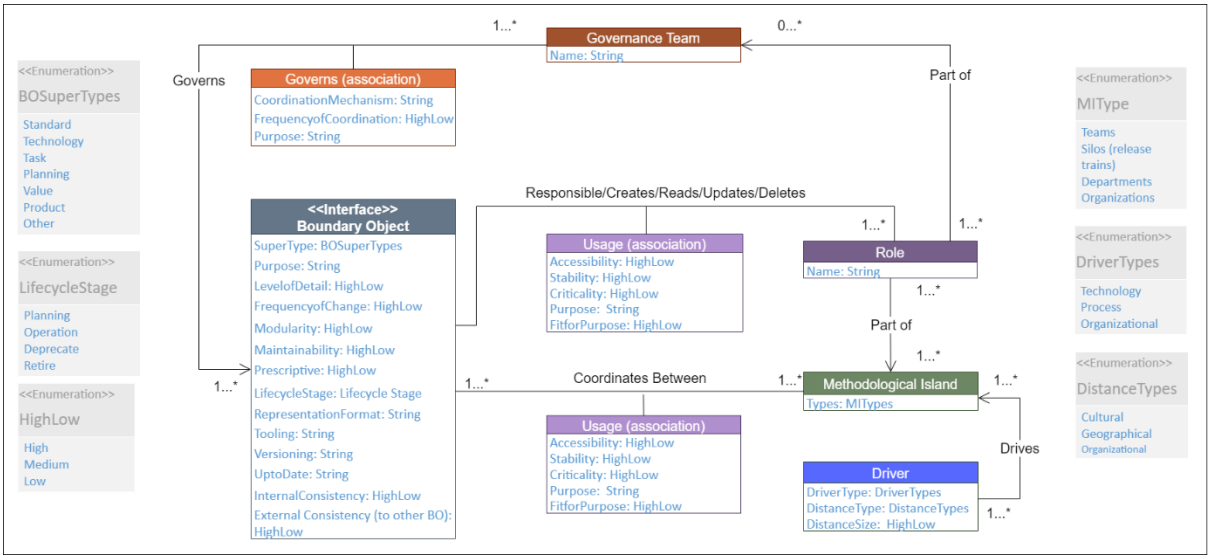


Fig. D.1. BOMI metamodel shown in questionnaire of cycle 1's evaluation phase.

The previous stage of this study involved engaging in surveys and interviews with both BOMI experts and industry practitioners who helped to identify certain BOMI stakeholders, their concerns and specific elements of the BOMI model deemed vital.

Based on the results of this previous stage, three BOMI view types have been created, each tailored

to meet the needs of specific stakeholders and their set of concerns:

1. Overview View Type
2. Methodological Island View Type
3. Boundary Object View Type

Below are a set of questions and models, all of which help to evaluate the view types mentioned above.

1. What is your role within the company? **(D)**

Example BOMI model

This BOMI model will be used to display each view type.

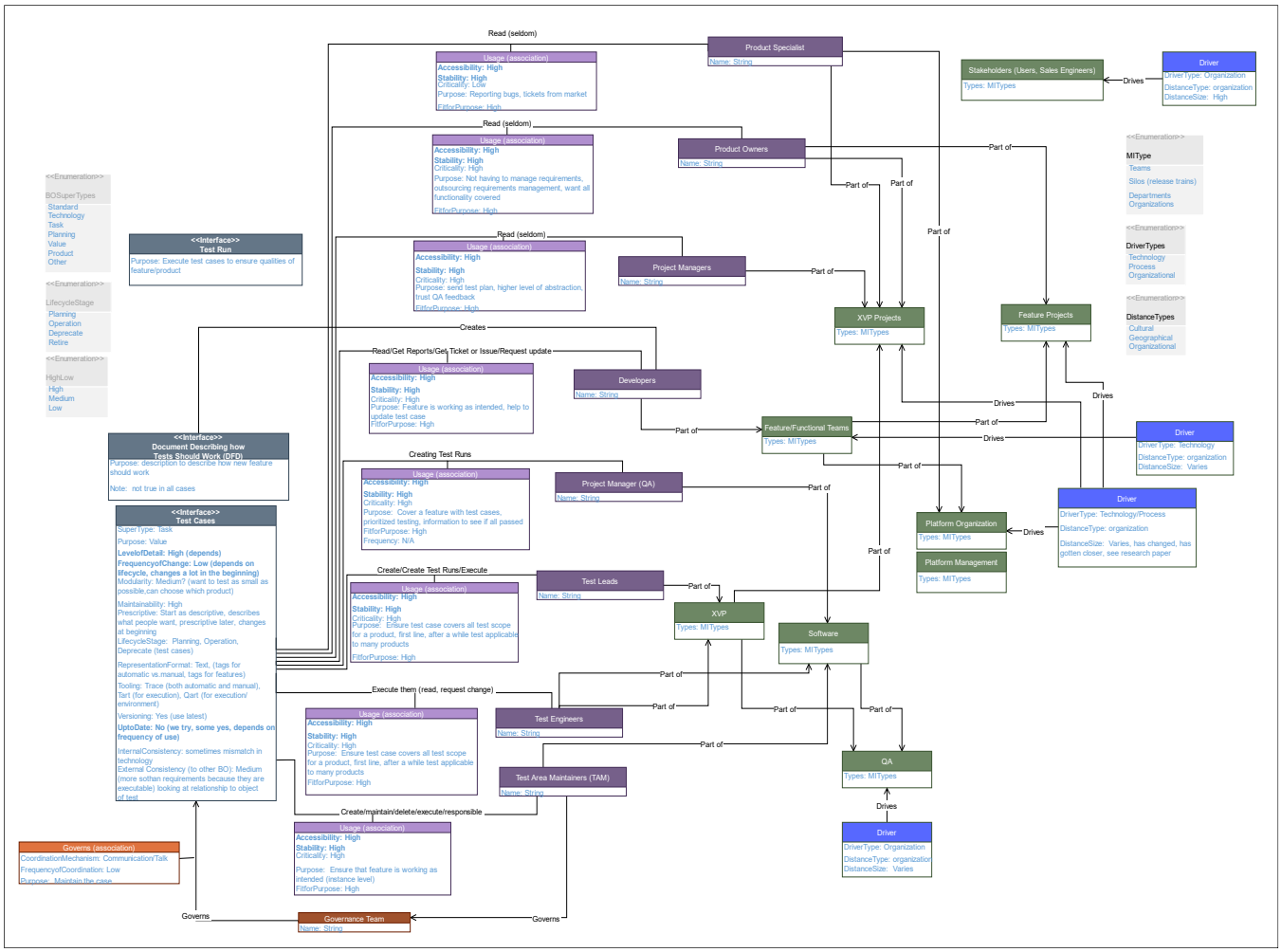


Fig. D.2. Example BOMI model shown in questionnaire of cycle 1's evaluation phase.

A. Overview View Type in example

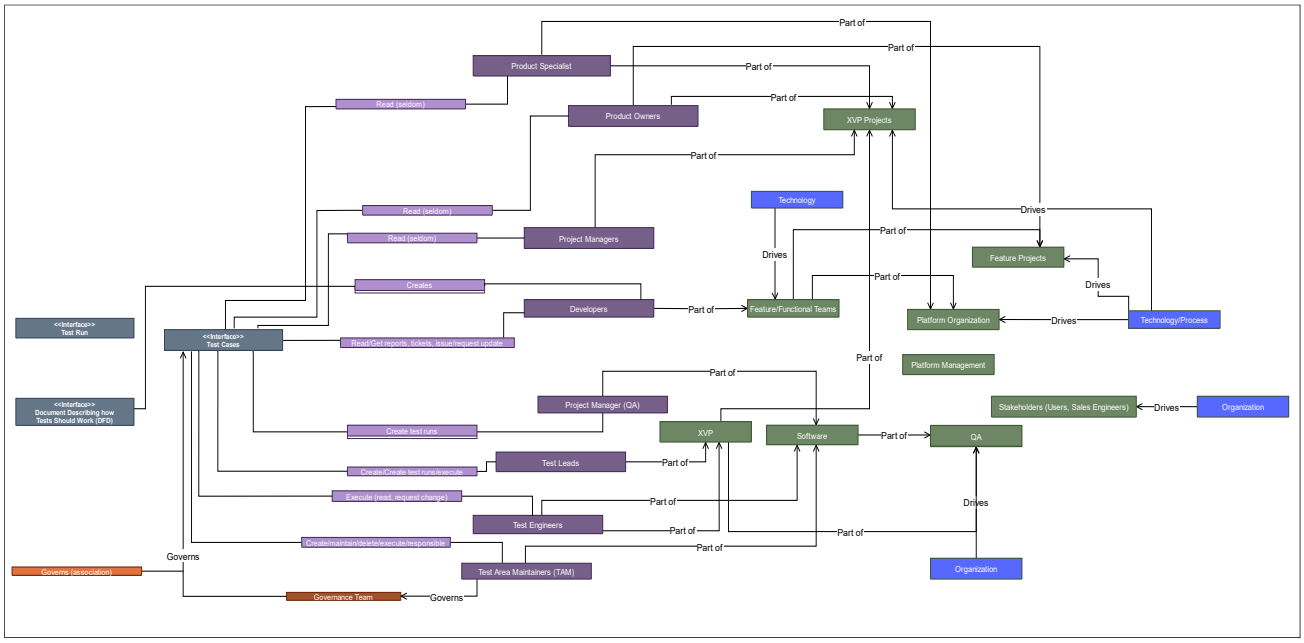


Fig. D.3. Overview view type in an example shown during cycle 1's evaluation phase questionnaire.

Shown above is the **Overview View Type**.
It has been identified as important to all users interested in the boundary object (BO) being studied. This view type displays only the elements, with all attributes removed. The purpose of this view type is to *simplify the model*, giving a *big picture of organization around the BO*.

1. In comparison to the original BOMI model, to what extent do you find this view type helpful for the usability of BOMI? **(RQ3)**

    a) Much worse than original model
    b) Slightly worse than original model
    c) No different than original model
    d) Slightly better than original model
    e) Much better than original model
    f) Much better than original model

2. Do you believe the view type adequately meets the identified stakeholder's concerns? Why or why not? **(RQ3)**

3. What aspects of the model could be improved upon (added/removed) to further meet stakeholder needs while reducing complexity? **(RQ2?)**

B. ***Methodological Island (MI) View Type in example***

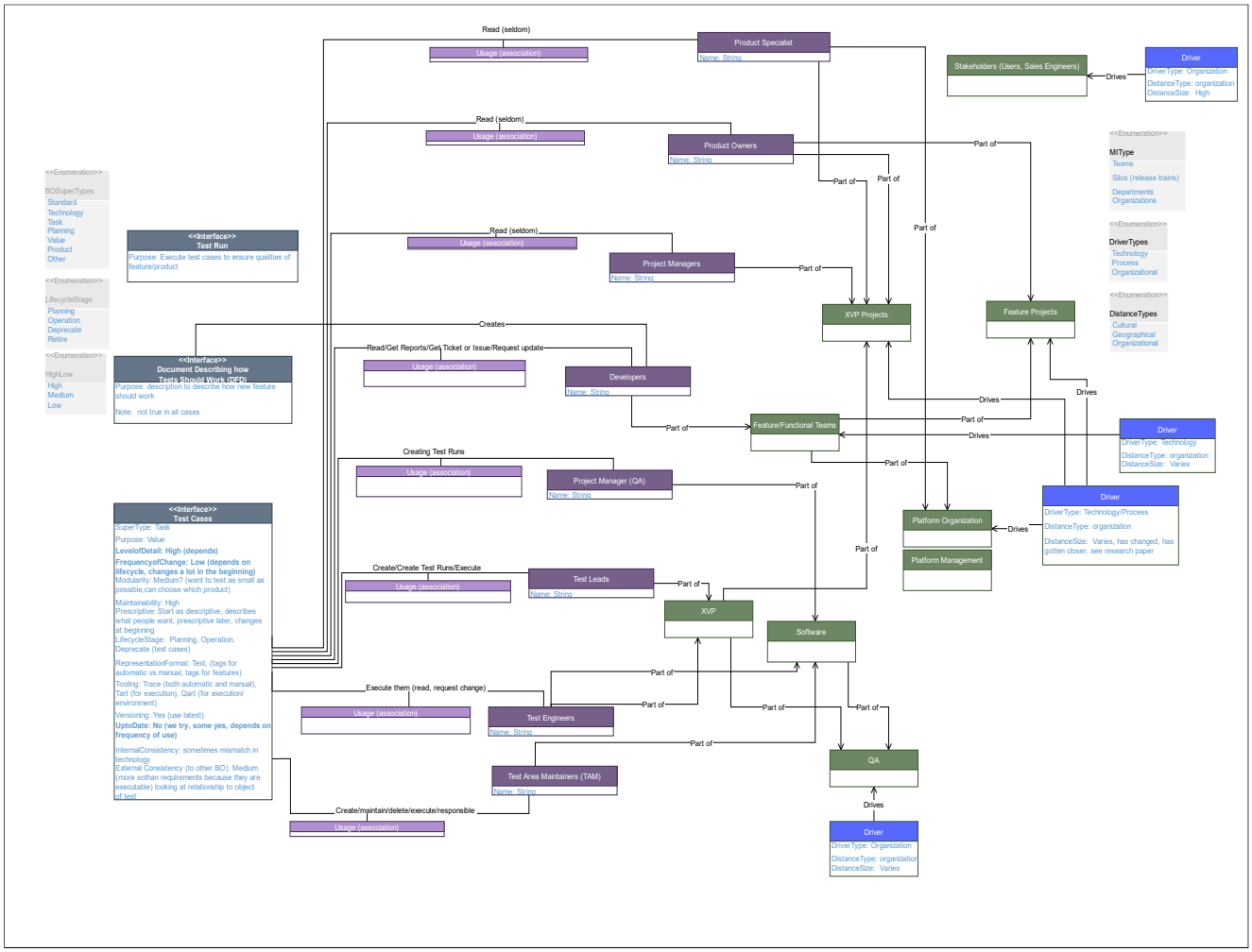


Fig. D.4. MI view type in an example shown during cycle 1's evaluation phase questionnaire.

Shown above is the **Methodological Island (MI) View Type.**
It has been identified as being important to *managers* in particular. This view type displays only the elements and attributes related to the BO, methodological islands (MIs), Drivers, and their associations. The purpose of this view type is to allow managers to *easily understand what drives the MIs* as well as *how others are using them*.

1. In comparison to the original BOMI model, to what extent do you find this view type helpful for the usability of BOMI? **(RQ3)**

    a) Much worse than original model
    b) Slightly worse than original model
    c) No different than original model
    d) Slightly better than original model
    e) Much better than original model

2. Do you believe the view type adequately meets the identified stakeholder's concerns? Why or why not?

(RQ3)

3. What aspects of the view type could be improved upon (added/removed) to further meet stakeholder needs? **(RQ2?)**

*C. **Boundary Object view type in example***

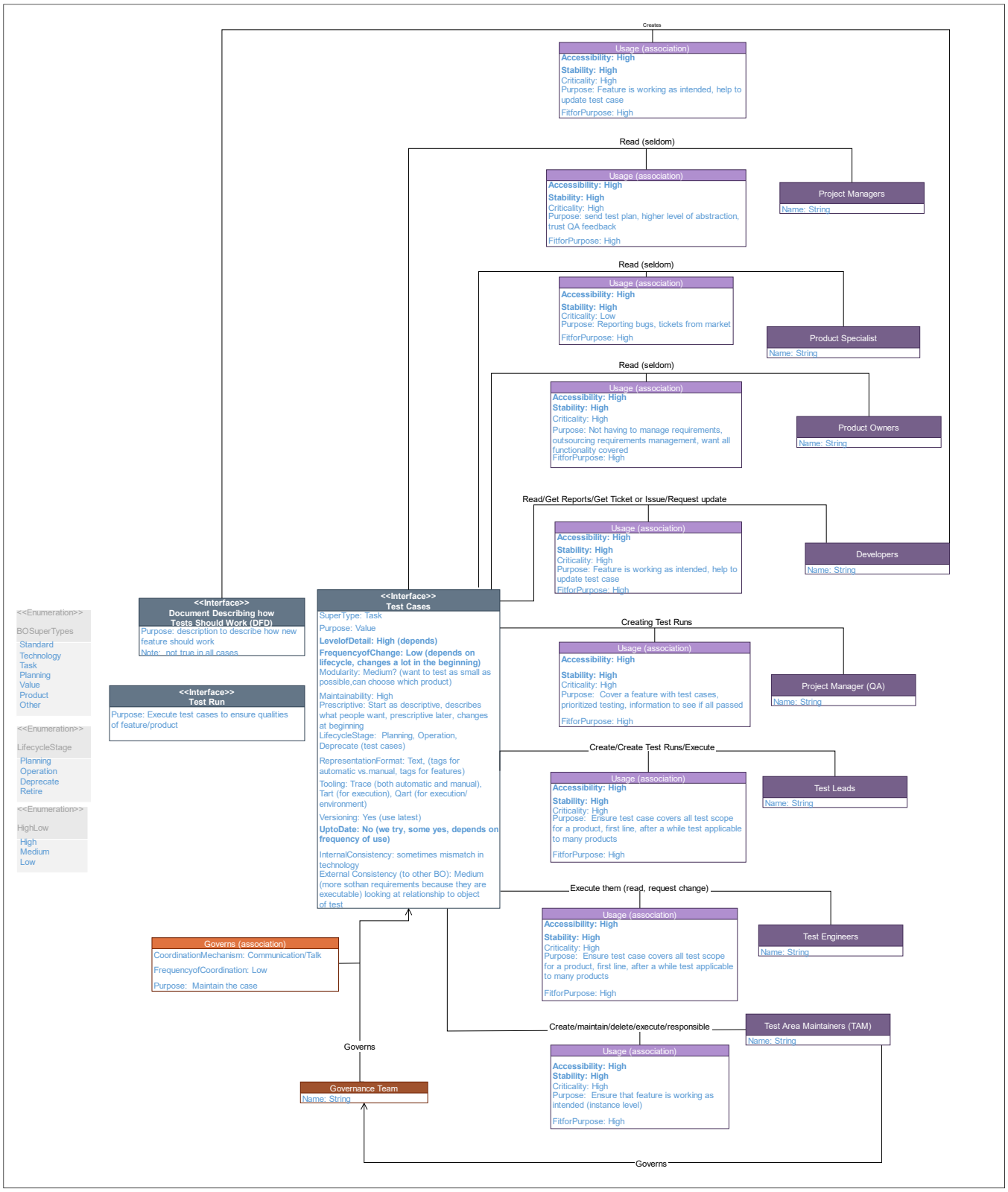


Fig. D.5. BO view type in an example shown during cycle 1's evaluation phase questionnaire.

Shown above is the **Boundary Object (BO) View Type.**

It has been identified as important to all *users interested in the boundary object* (BO) being studied. This view type displays only the elements, with all attributes removed. The purpose of this view type is to *provide a simple summary* of how information is coordinated around a chosen BO.

1. In comparison to the original BOMI model, to what extent do you find this view type helpful for the usability of BOMI? **(RQ3)**

    a) Much worse than original model
    b) Slightly worse than original model
    c) No different than original model
    d) Slightly better than original model
    e) Much better than original model

2. Do you believe the view type adequately meets the identified stakeholder's concerns? Why or why not? **(RQ3)**

3. What aspects of the view type could be improved upon (added/removed) to further meet stakeholder needs? **(RQ2?)**

APPENDIX E

CYCLE 2 DISCUSSION GUIDE (EVALUATION PHASE)

1. What are your overall thoughts on the view types? **(RQ.3)**
2. For the MI and governance view types, which options do you prefer? **(RQ.3)**

APPENDIX F

CYCLE 1 CODEBOOK (INVESTIGATION PHASE)

Code	Subcodes	Definition	Quotes
Roles	Managers	A specific stakeholder who would benefit from creating or studying a BOMI model	P7 – "I think that if you're at the managerial level, so for example if you have to manage a software development team or so, then you would benefit a lot from looking at the BOMI model…"
	Developers/Development teams		P2 – "Developers as consumers of information and practical alignment."
	Process, methods, tools experts		P5 – "…one important user or stakeholder of BOMI are these process, methods, tools experts, or sometimes architects…"
	Architects		P7 – "Yes. And the owners, so either you can have a requirement engineer, if it's something like a requirement…"
	Requirements engineers		P2 – "System Eng as drivers of system level consistency and integration."
	Systems engineers		
Use cases	Understanding aspects of Coordination	Concerns that could be addressed via studying or creating a BOMI model	P5 – "I think are interested in to see how can these boundary objects be governed, how they can be useful to the organization, how can they be up to date and managed with good processes and tools."
	Understanding/Managing MIs		P7 – "…what drives the different methodological islands and see if maybe there is something they can do there to begin with."
	Providing Overview		P5 – "…try to get the big picture of the organization, of different development teams and how they work with coordination issues."
	Other		P4 – "Metamodels."
Important elements	BOs and/or their attributes	Aspects of the BOMI metamodel deemed important to meeting stakeholder concerns	P1 – "Relations between stakeholders and BOs, governance, information about change frequency, triggers..."
	MIs		P6 – "I would look at the methodological islands of which the role is part of that islands."
	Governance		

			P3 – "…the list of boundary objects and which roles interact with them is the most important."
Irrelevant elements	Drivers Certain BO attributes Usage association and/or their attributes	Aspects of the BOMI metamodel deemed less important to meeting stakeholder concerns	P5 – "If I have a role that is interested in boundary objects as the main interface, then it might not be as relevant why there are certain Drivers that bring methodological islands further away from each other." P5 – "Or in some situations, if you are more interested in the roles that are part of different islands and want to model it from that perspective, maybe it doesn't matter so much what stability, criticality, accessibility, these different roles have or what tooling is used because then you're more interested in the coordination aspects." P6 – "Those ones [usage associations] are not important." P7 – "So if there's one thing I would remove and this would be totally from the perspective of I don't remember what it was for, FitForPurpose, cause I'm trying to figure out if it's high or low, what kind of decision can I make with this specific usage, right?"
Perspectives		Certain outlooks with which a user can look at BOMI	P5 – "…some might have more this boundary object perspective, some have more the traceability perspective of how diff boundary objects would be connected to each other." P6 – "There are so many perspectives if I look at BOMI. You can have… Is it a product perspective or something like that?"
Function		Suggested tooling functions	P3 – "Another way to bring down the complexity could perhaps be to add functionality to filter the model based on a certain boundary object at a time, so instead of showing all the boundary objects in one view…"
Confusion		Needed clarification about study or question posed	P7 – "So maybe my question would be to you what kind of visualizations are you thinking about? You thinking of visualizing the specific instances of the different BOMI models?" P6 – "So, I'm seeing here in this metamodel, I'm seeing the role is part of the MI and also part of governance team. And governing the BO. So, when you ask me what is the least important aspect here that I would maybe perhaps remove? I looked at that line in particular. I was wondering what can I

			remove here? What is the instance of this question?"
Positivity		Showed positive attitude towards study	P7 – "I think it does, I was just thinking what were you thinking of visualizing, but then if it's use case wise, I think that's good." P6 – "I am really really happy! I helped create this thing, but I like the idea that you're carrying it forward and it's actually getting to be meaningful a little bit more for me as well."

APPENDIX G

CYCLE 2 CODEBOOK (INVESTIGATION PHASE)

Code	Subcodes	Definition	Quotes
Positive		Positive thoughts or feelings about view types	P1 – "Slightly better than original model." P3 – "Much better. Everything is connected to a central object, but those objects are (mostly) not connected to each other, so the graph is much easier to read." P5 – "I like this view. I think it's simpler." P6 – "I think it's good that the methodological islands are not visible here and that the focus is more on different Roles and their usage of boundary objects."
Negative		Negative thoughts or feelings about view types	P4 – "Hard to evaluate the impact of the changes. To me limited changes / differences between the various views."
Neutral		Neutral thoughts or feelings about view type, belief that view types are no different that original model	P3 – "Feels pretty equivalent to the original model to me." P4 – "No different than original model." P6 – "From looking at it, it looks like it has a large overlap with the overview view type."
Uncertain	Uncertain of how to improve view types	Feelings or thoughts of uncertainty about view types, unsure of what could be improved in current view types	P1 – "No new ideas…" P5 – "So actually, I don't have any suggestions for more views."
	Uncertain of feelings about view types		P2 – "Intuitively it looks great, but it is hard to access if it is misleading in any way…" P5 – "Ah yes, I see. So, I think you see my struggle, right? With the previous one, there was a big difference between the two models, then you can clearly see that it made everything simpler. With this one. I guess, I dunno, maybe if I had a use case or if I was interested in a particular MI…"

Suggestions	Change/Removal of elements	Suggestions on how to improve view types or understanding of BOMI in general	P1 – "Show less detail." P2 – "You probably do not need the UML types, such as <<interface>> - would be better to see directly what is the boundary object. Perhaps reducing the number of intersections or elements?"
	More explanation about BOMI		P5 – "It becomes a bit harder when I come from product specialist and then read and then seldom and then test classes, so I'm not sure if this is rather just because we only removed the attributes, but we didn't do anything with the line. Probably because we want to keep the semantics – right? But it's a bit – or maybe it's just a colour thing, it needs to be a bit more… Darker, maybe?"
	Reorganize elements		P3 – "Aligning the boxes would improve the readability, I think. Also or alternatively, removing some of the crossing lines if possible, since they feel visually noisy."
	Visualization		P4 – "The BOMI model in general needs some help to understand." P2 – "Ability to interactively zoom into details would probably also be good here." P6 – "I think, and maybe that is out of scope for your current project but looking at other ways of visualizing boundary objects and BOMI models would be useful."
New View Type		Ideas for possible new view types	P6 – "That maybe you would want to have a process view for individual boundary objects as well. So, for test cases, maybe you would want to see what the overall process is of their creation, and the roles, associations that people reading it and people using it for different purposes and what the steps would be for this."
Tooling feature		Ideas for future tooling features	P5 – "You open the model and then you have some kind of a yellow or a warning mark or something based on certain indicators, like if you could have some kind of logic behind the different attributes then be able to mark something on top of the model that would alert whoever is looking at it of some smells or something like that. I think that would be very interesting." P6 – "Maybe checkboxes at the top and you can say what is it that I'm interested in, is it just the purpose? Or how it is accessed or how it is maintained? And then different things could be highlighted or brought

			together in a consolidated view so that not everything is being displayed at once and overwhelming the users of this model.”
Confusion		Questions about study or model that required clarification	P5 – “Is there a reason why the test run interface is disconnect and not connected to anything?” P6 – “Okay so the things that are missing are just the attributes and the enumerations? Otherwise, it’s exactly the same?”

APPENDIX H

CYCLE 2 CODEBOOK (EVALUATION PHASE)

Code	Definition	Excerpt from notes
Positive	Positive thoughts or feelings about view types	P1 - "… good, I prefer less information in text." P2 – "I agree with P1." P4 – "Very well done, the views with just subsets of information, it works very well for me."
Negative	Negative thoughts or feelings about view types	P3 – "It was hard to follow."
Neutral	Neutral thoughts or feelings about view type, no input, or suggestions	P3 – "Not too much input."
Suggestions	Ideas for future features	P2 – "Team A needs to coordinate with Team B… Can I make sentences through the models?" (Future tooling direction with text to model and model to text feature). P2 – "Legends would be nice for the colour schematics."
Questions	Questions about study or model that required clarification	P1 – "Are Roles based on SAFe framework roles?"
Option Preference	Expressing a preference for either option 1 or option 2 of the MI or governance view type alternatives	P1 – "I think the alternative to the right is preferred for both."

APPENDIX I

RESULTS OF CYCLE 1 SOLUTION PHASE

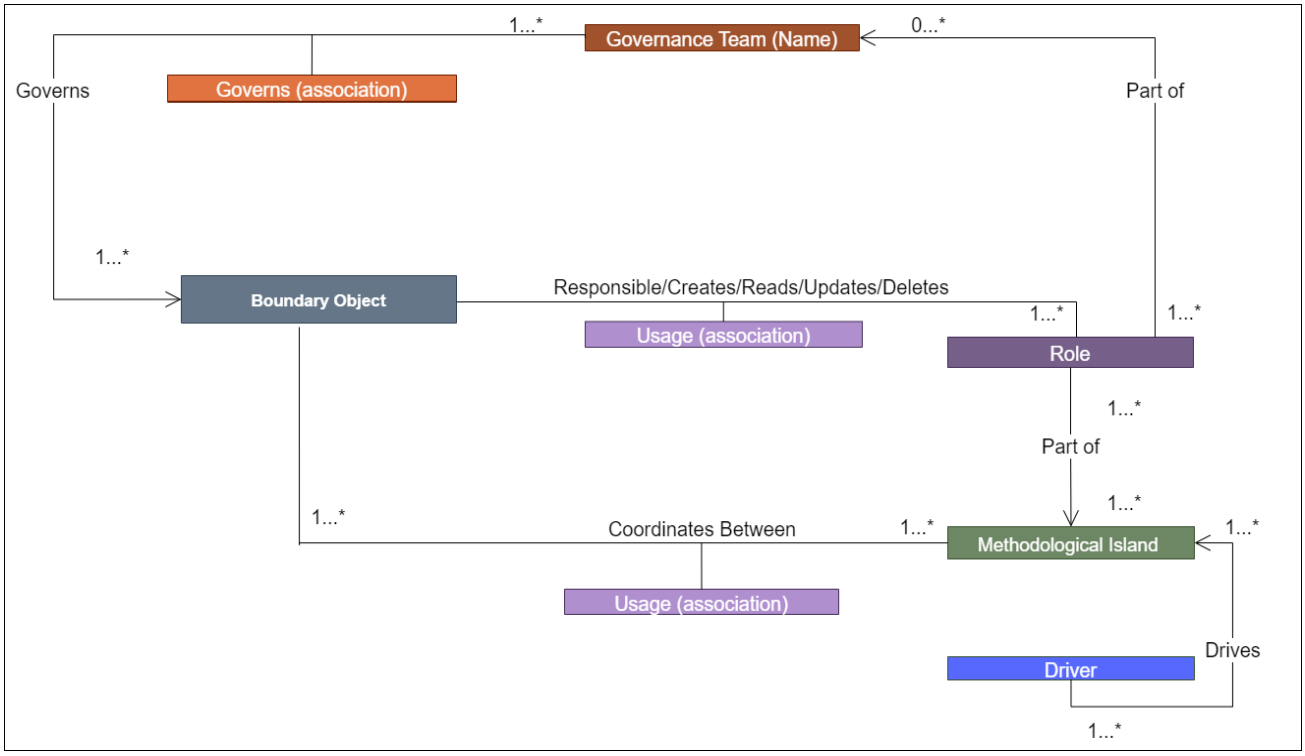


Fig. I.1. Metamodel of overview view type (cycle 1). This view type focuses on providing stakeholders with a simple summary of elements surrounding the BO. This is accomplished by stripping away the enumerations and all attributes of every element within the model, including that of the boundary object.

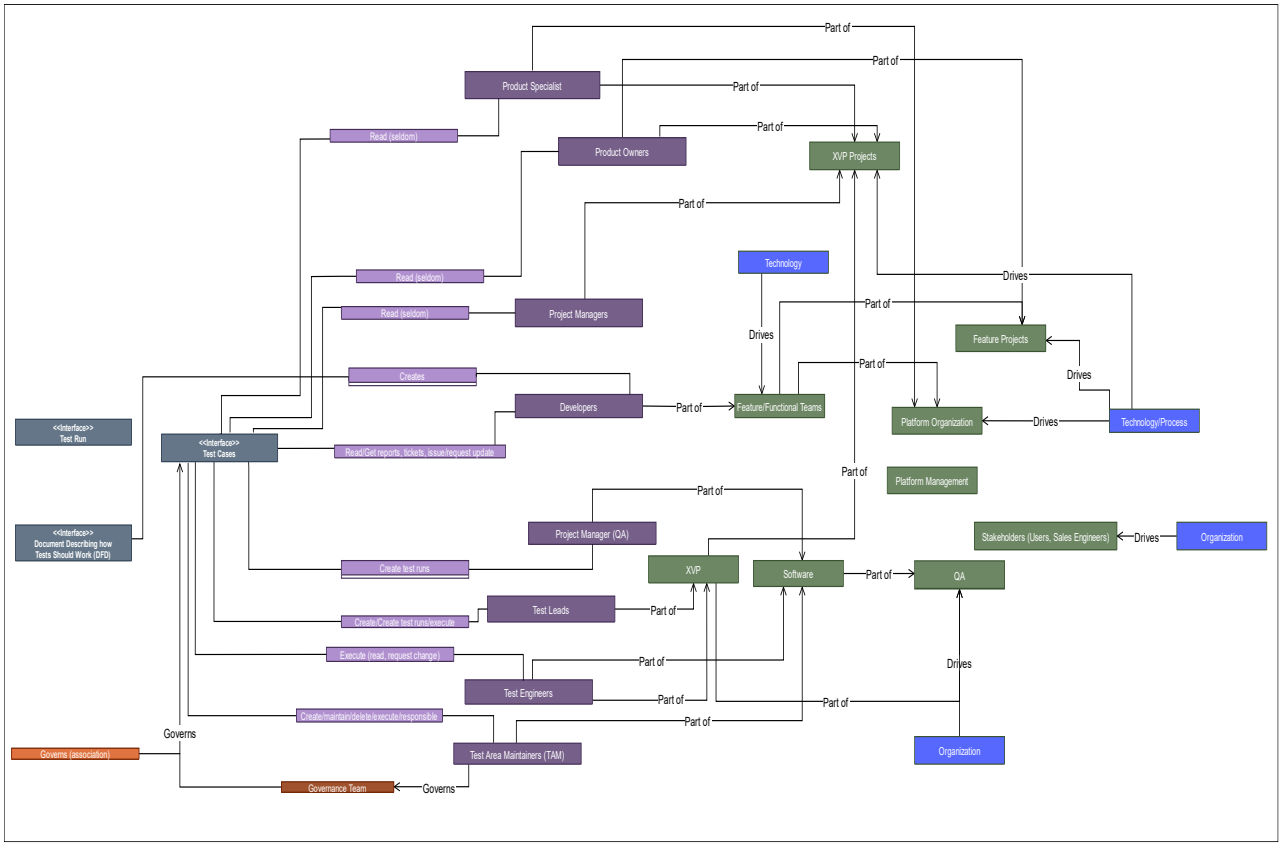


Fig. I.2. Instance model of cycle 1's overview view type derived from Fig. 11. This figure provides an example view involving the BO of Test Cases, which disregards the detailed information previously provided via the attributes and enumerations.

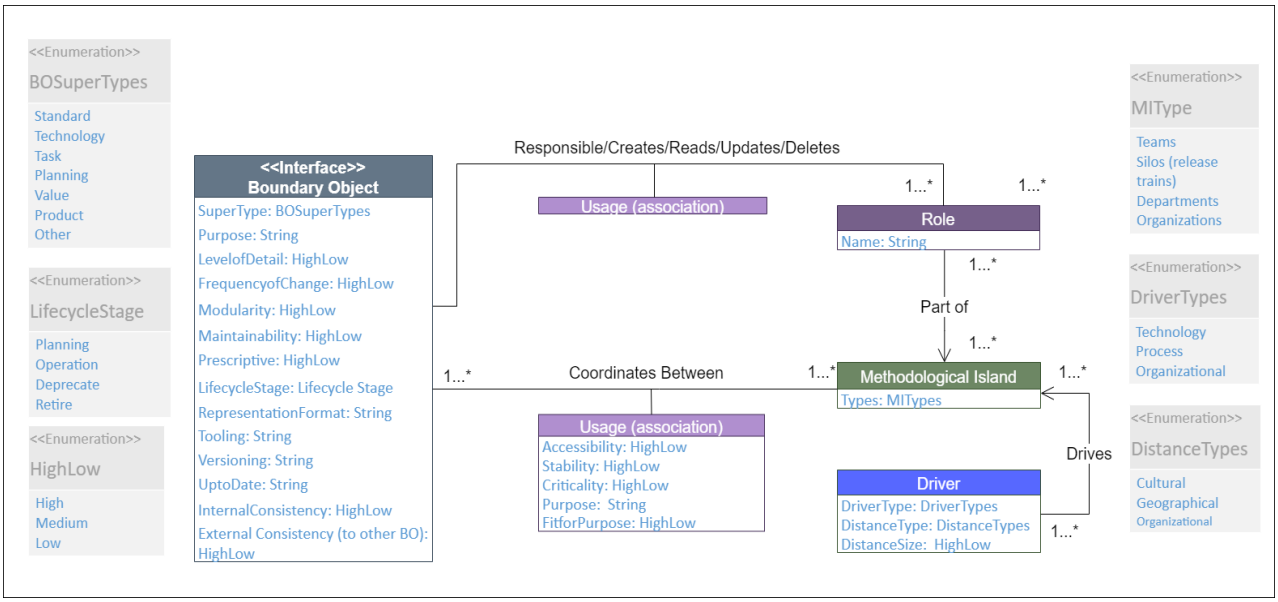


Fig. I.3. Metamodel of MI view type (cycle 1). This view type focuses primarily on understanding and managing MIs, it allows users – most likely managers – to focus on understanding what drives MIs and how others are using these MIs. To implement this view, the Governs association, Governance Team, and Usage association attributes (not directly linked to MIs) were removed, as they were deemed irrelevant when focusing on MIs and Drivers.

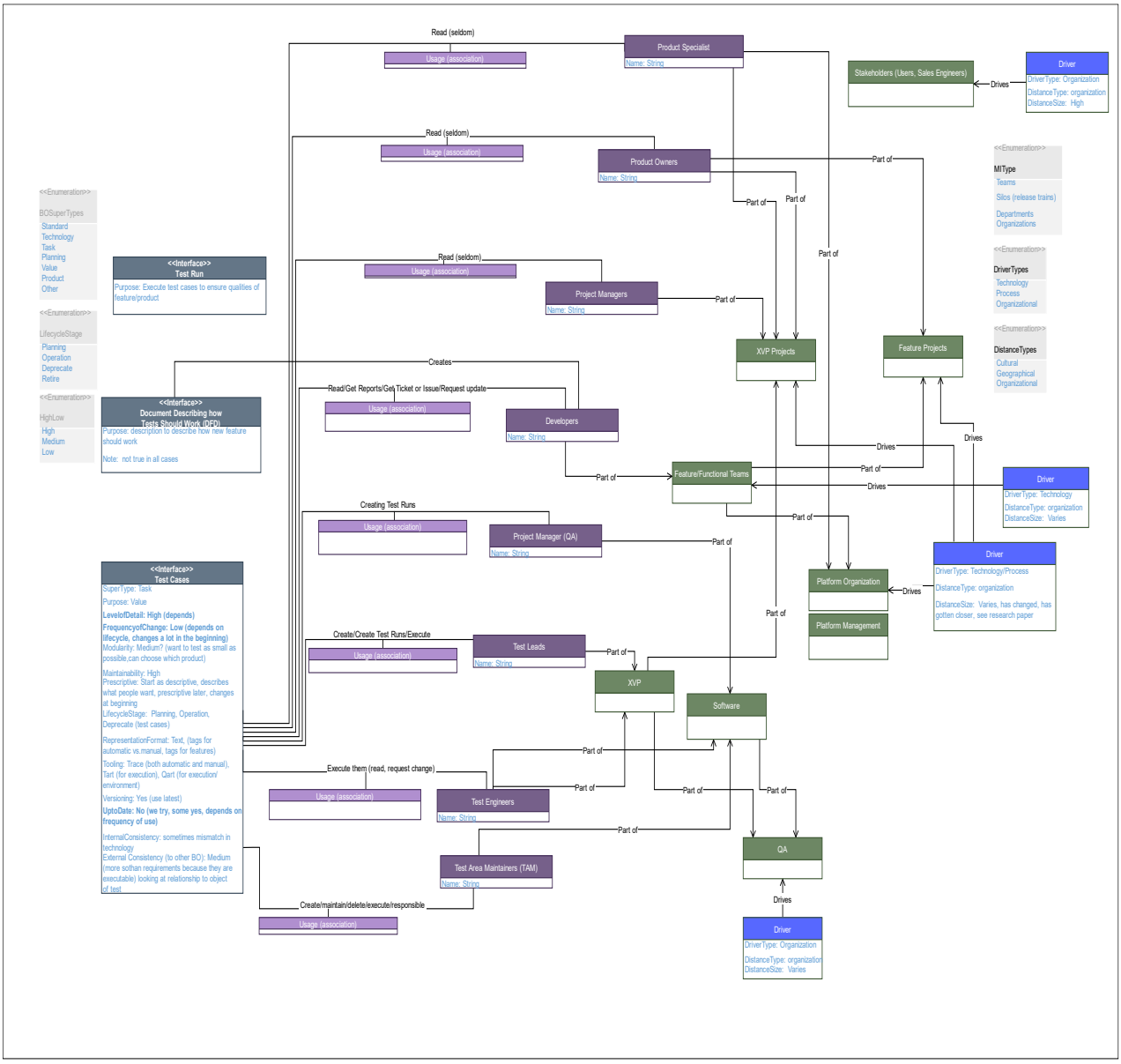


Fig. I.4. Instance model of cycle 1's MI view type derived from Fig. 11. With the absence of governance information and detailed Usage attributes, users could potentially examine the MIs and their Drivers with greater ease.

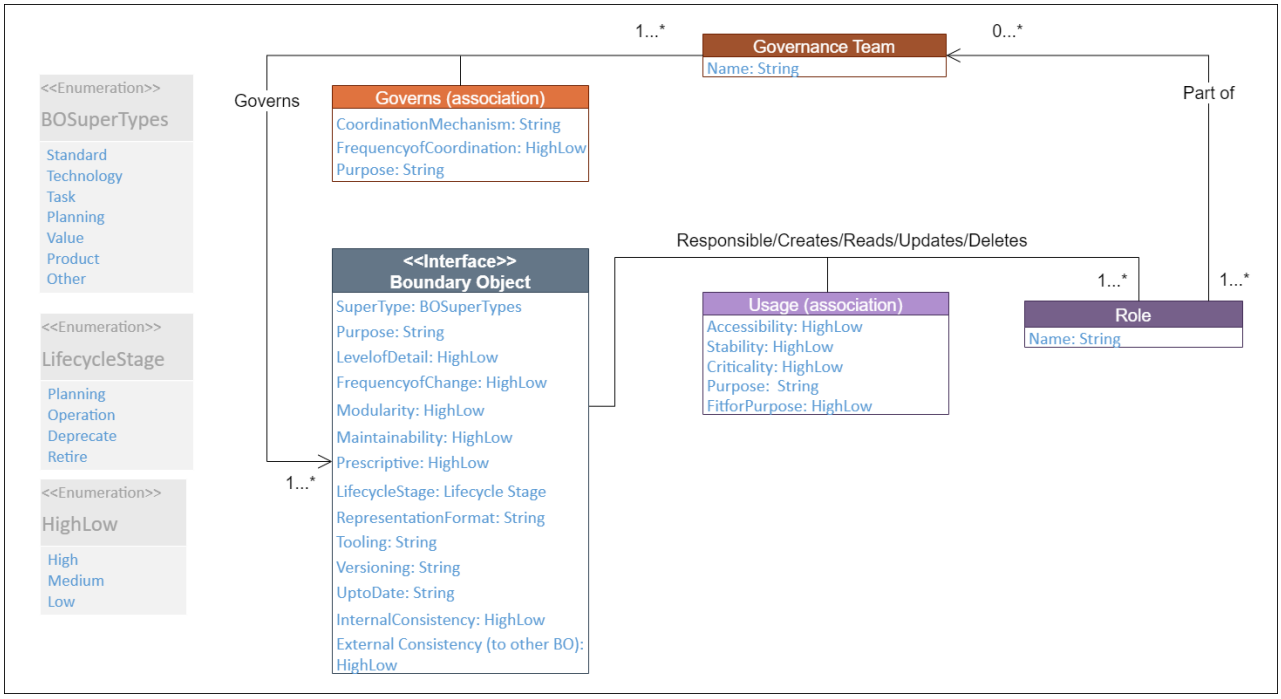


Fig. I.5. Metamodel of BO view type (cycle 1). This view type focuses on the BO, with the main stakeholders being either developers, managers, or anyone who is involved with the boundary object. Both MIs and Drivers are absent from this view type.

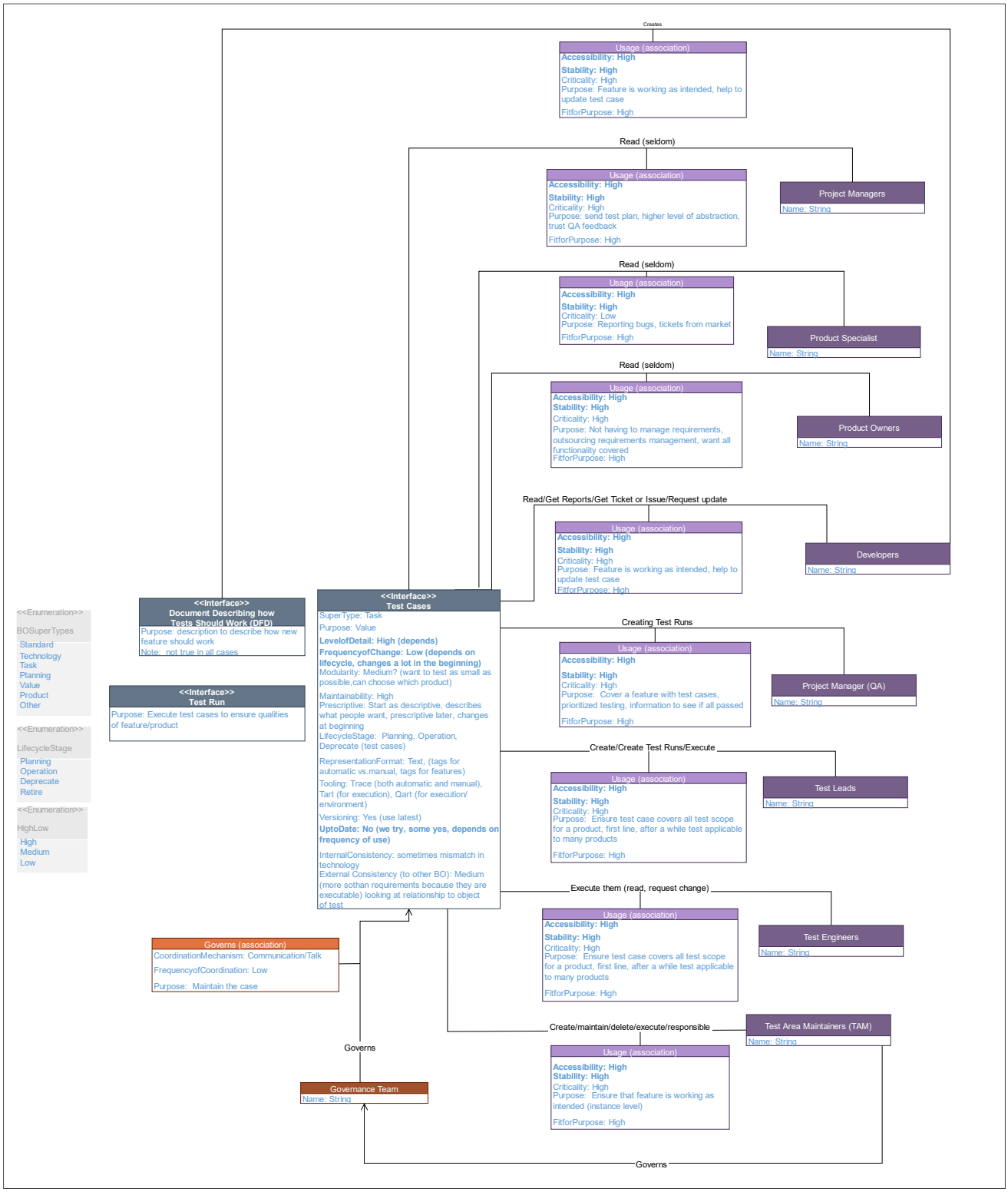


Fig. I.6. Instance model of cycle 1's BO view type derived from Fig. 11. It shows the MIs and Drivers completely removed to place focus on the BO of Test Cases and all the aspects directly associated with it.

APPENDIX J

RESULTS OF CYCLE 2 SOLUTION PHASE

The instantiated example views have been rearranged to decrease the overlapping lines and enhance readability.

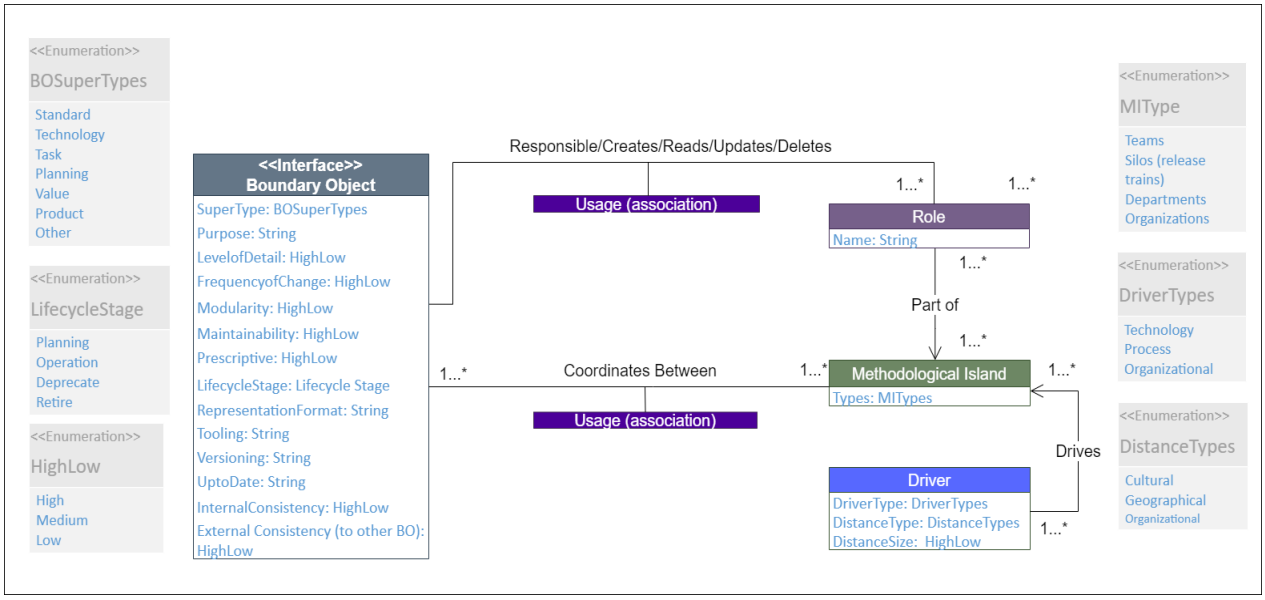


Fig. J.1. Metamodel of MI view type option 1 (cycle 2). Here, the BO and its elements remain displayed, while the Usage attributes are hidden, and all information related to governance is completely absent.

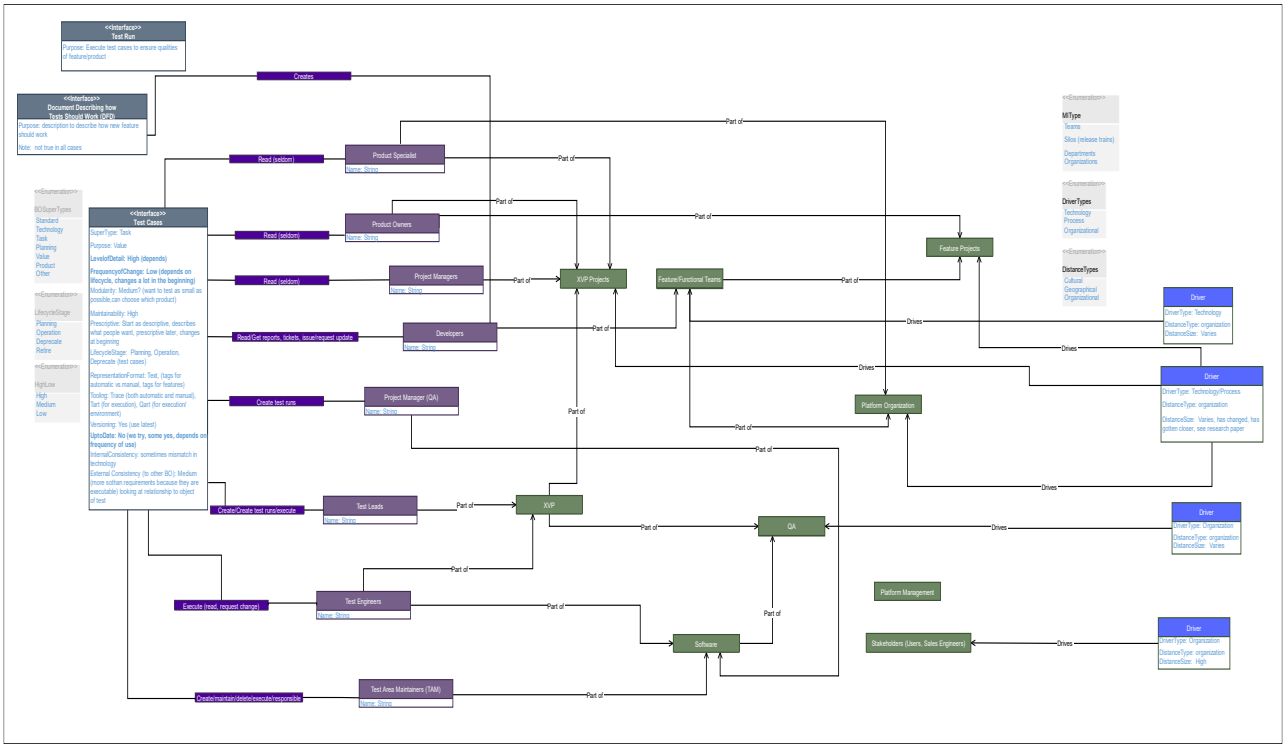


Fig. J.2. Instance model of cycle 2's MI view type option 1 derived from Fig. 11. It shows the BOs remaining present, with the Usage associations' attributes and all governance information removed.

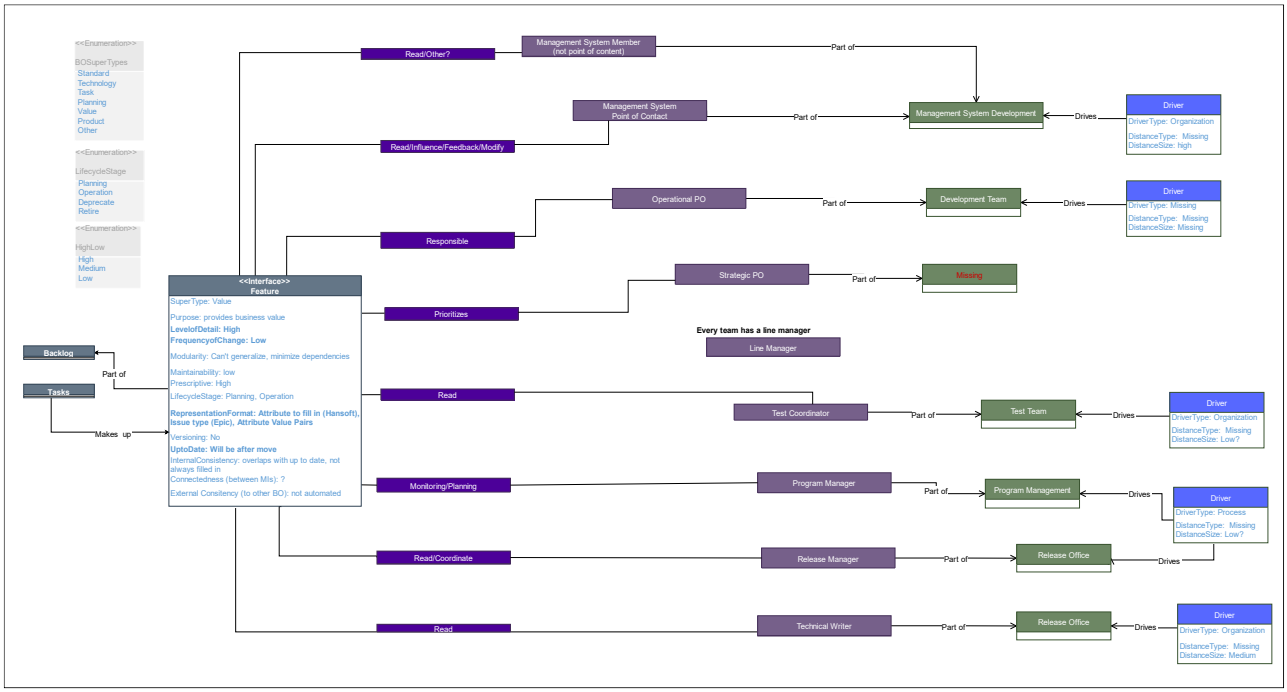


Fig. J.3. Instance model of cycle 2's MI view type option 1 derived from the full BOMI model found in Appendix K.

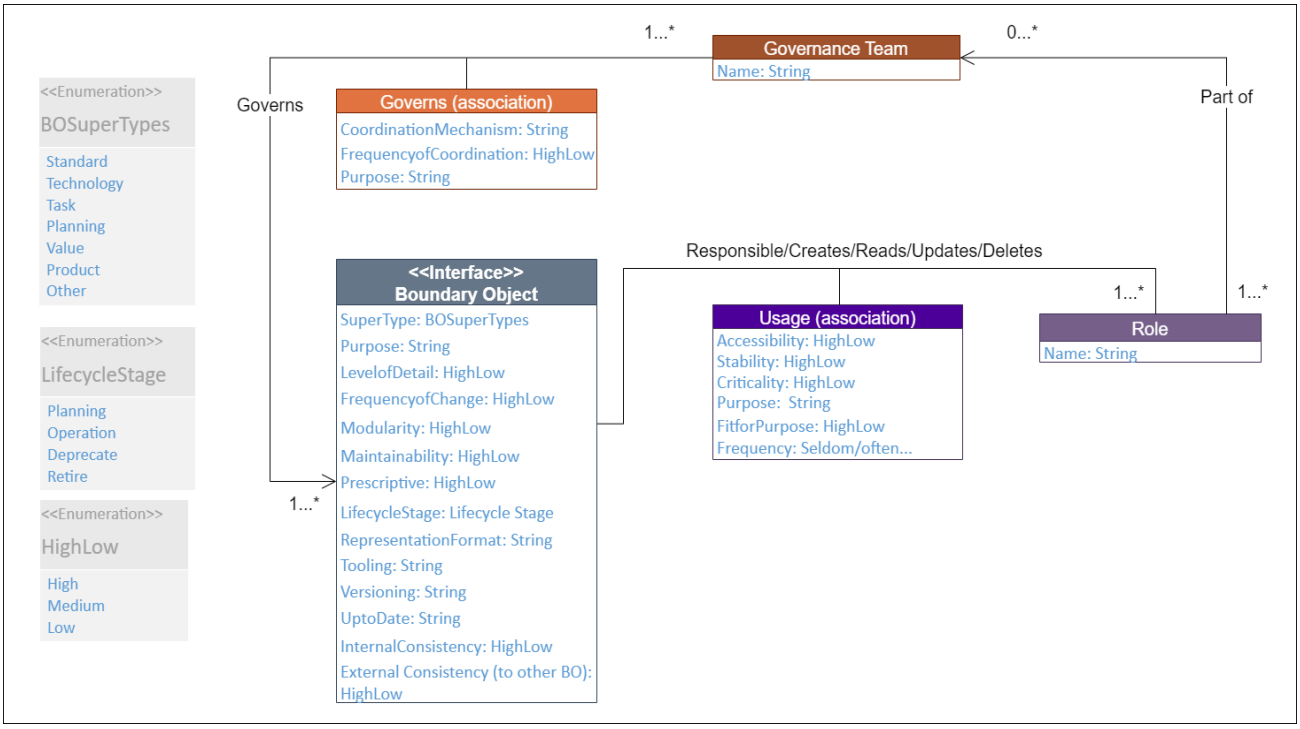


Fig. J.4. Metamodel of governance view type option 1 (cycle 2). This view type focuses on how the BO is governed and removes all MIs and Drivers.

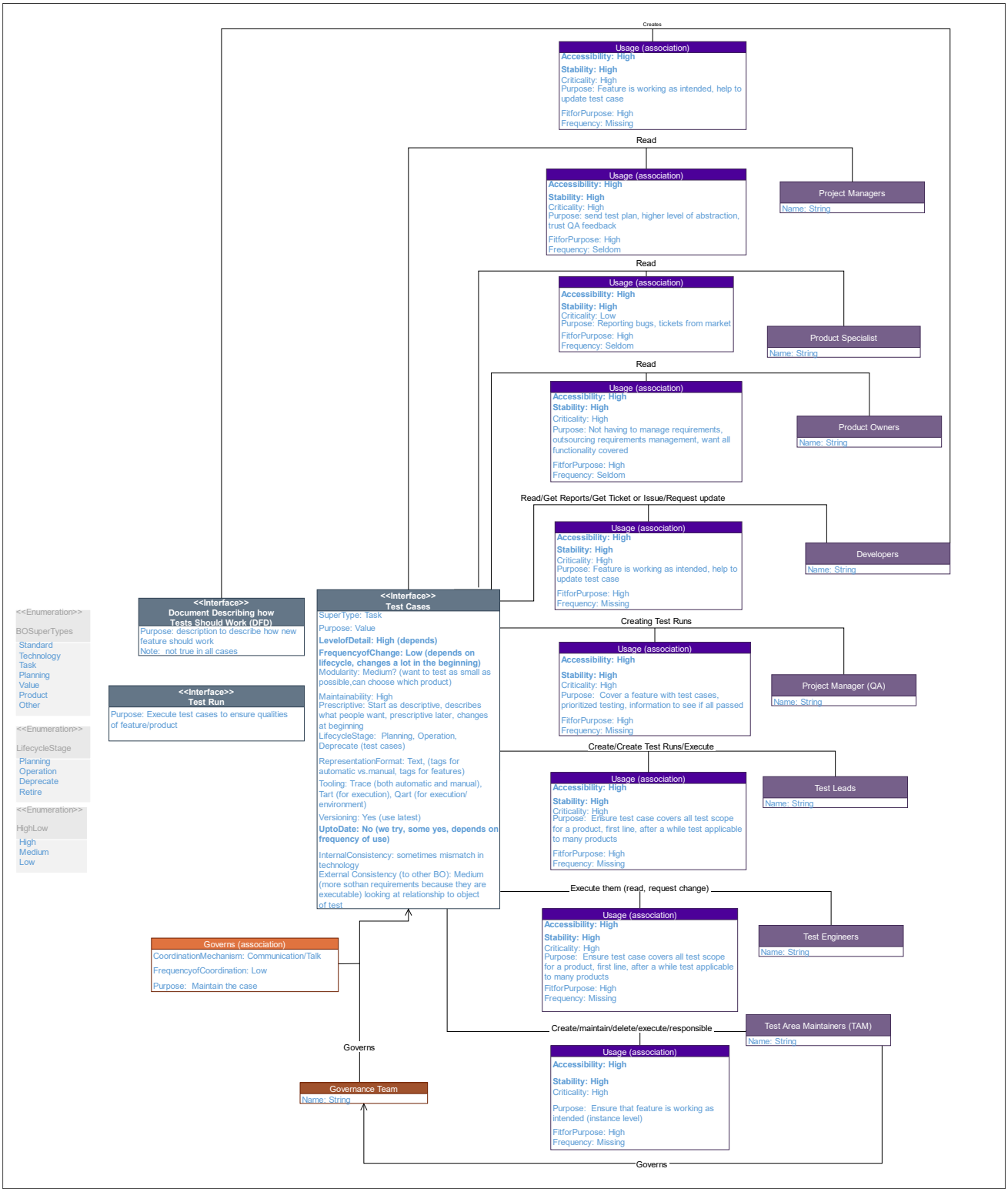


Fig. J.5. Instance model of cycle 2′s governance view type option 1 derived from Fig. 11. It displays the BO of Test Cases, its Usage associations and attributes, Roles, Governs associations, and Governance Teams.

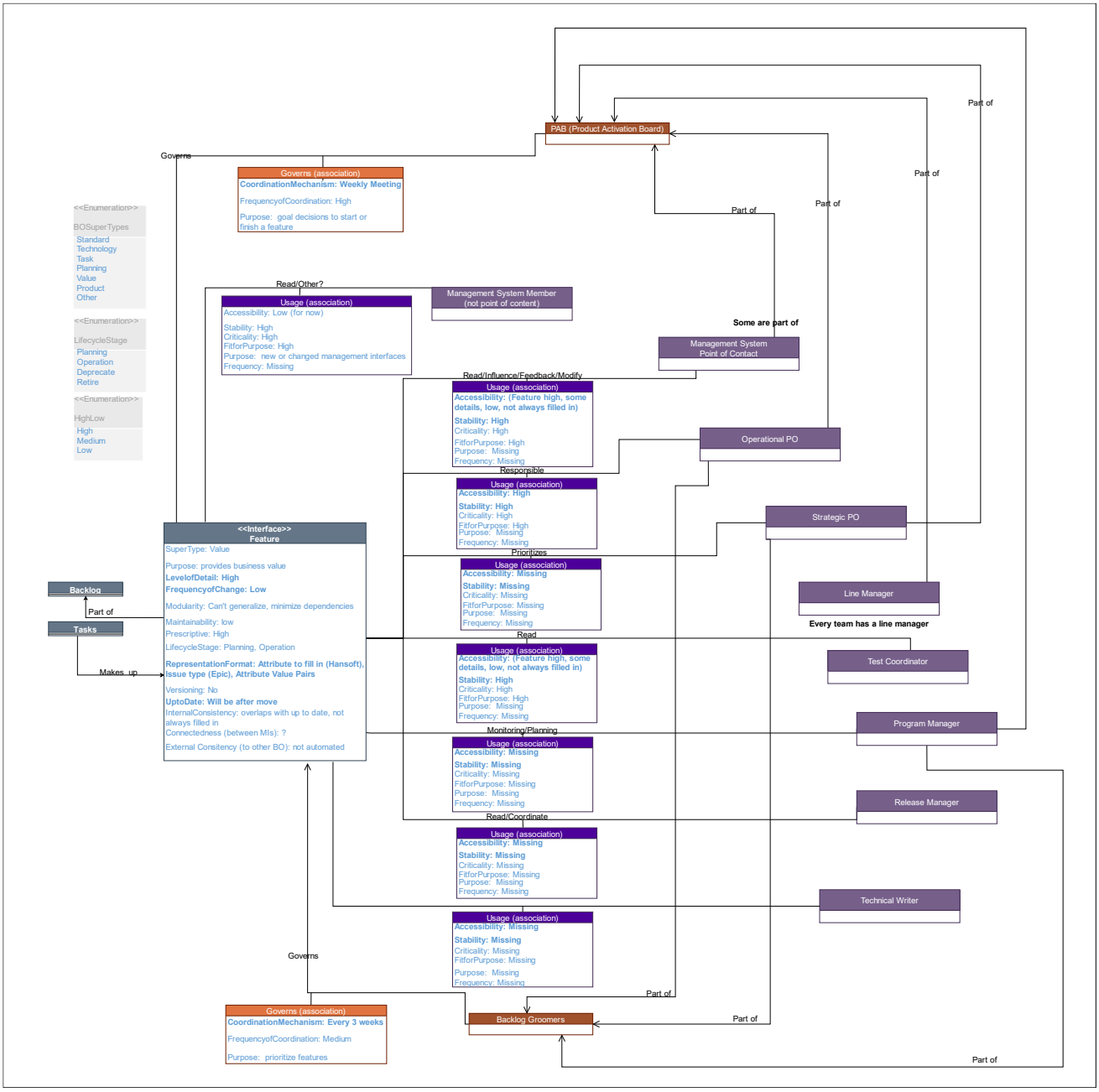
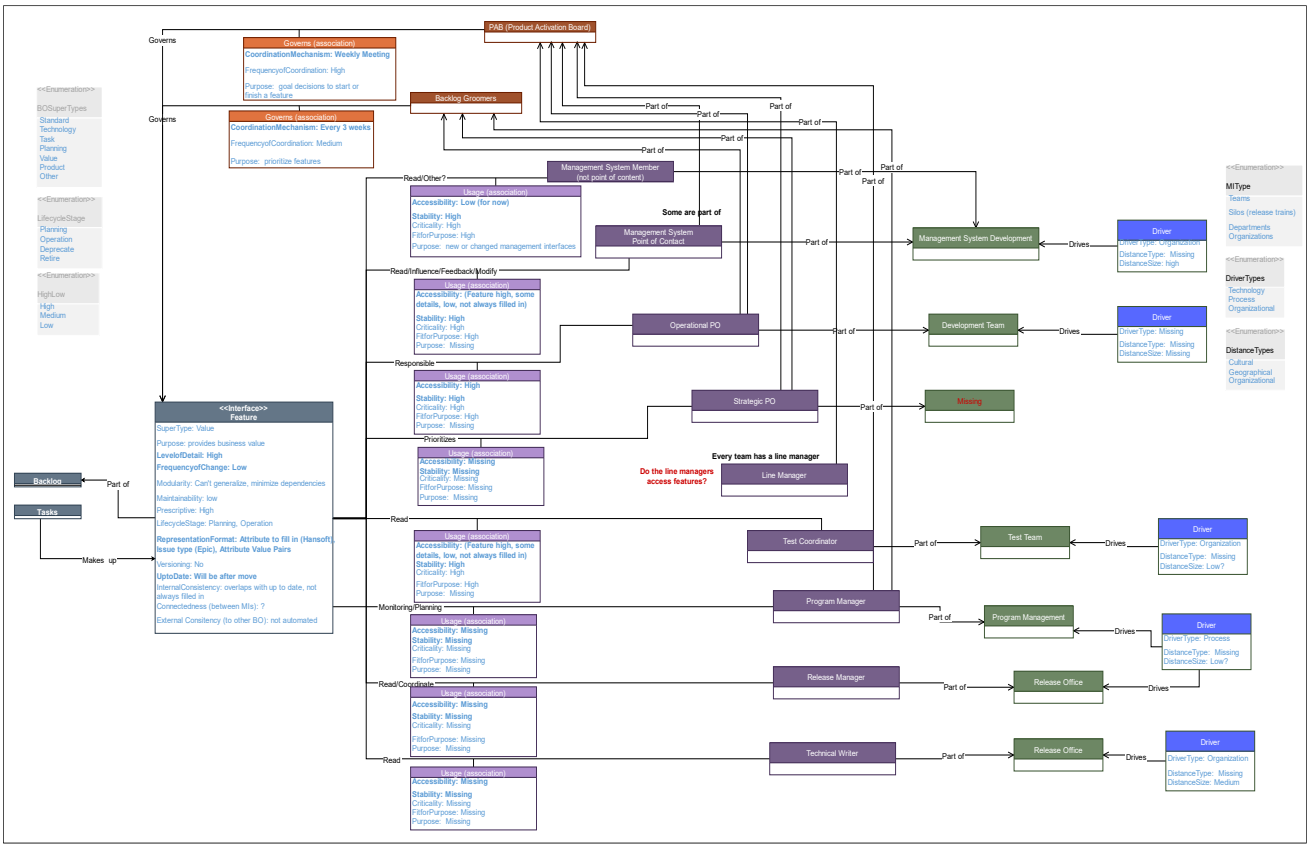


Fig. J.6. Instance model of cycle 2's governance view type option 1 derived from the full BOMI model found in Appendix K.

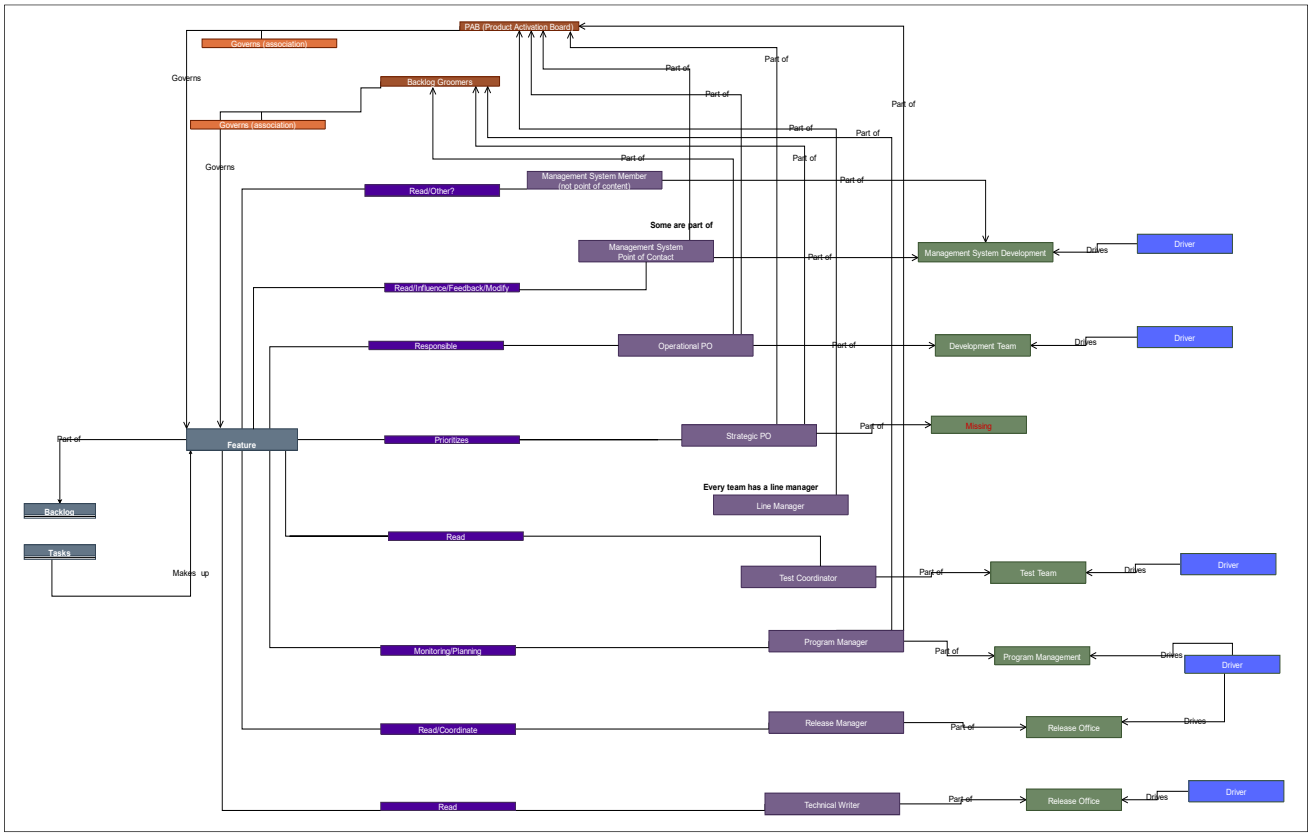
APPENDIX K

INSTANCE MODEL OF BOMI SETUP FOR A GENERIC FEATURE FROM COMPANY E



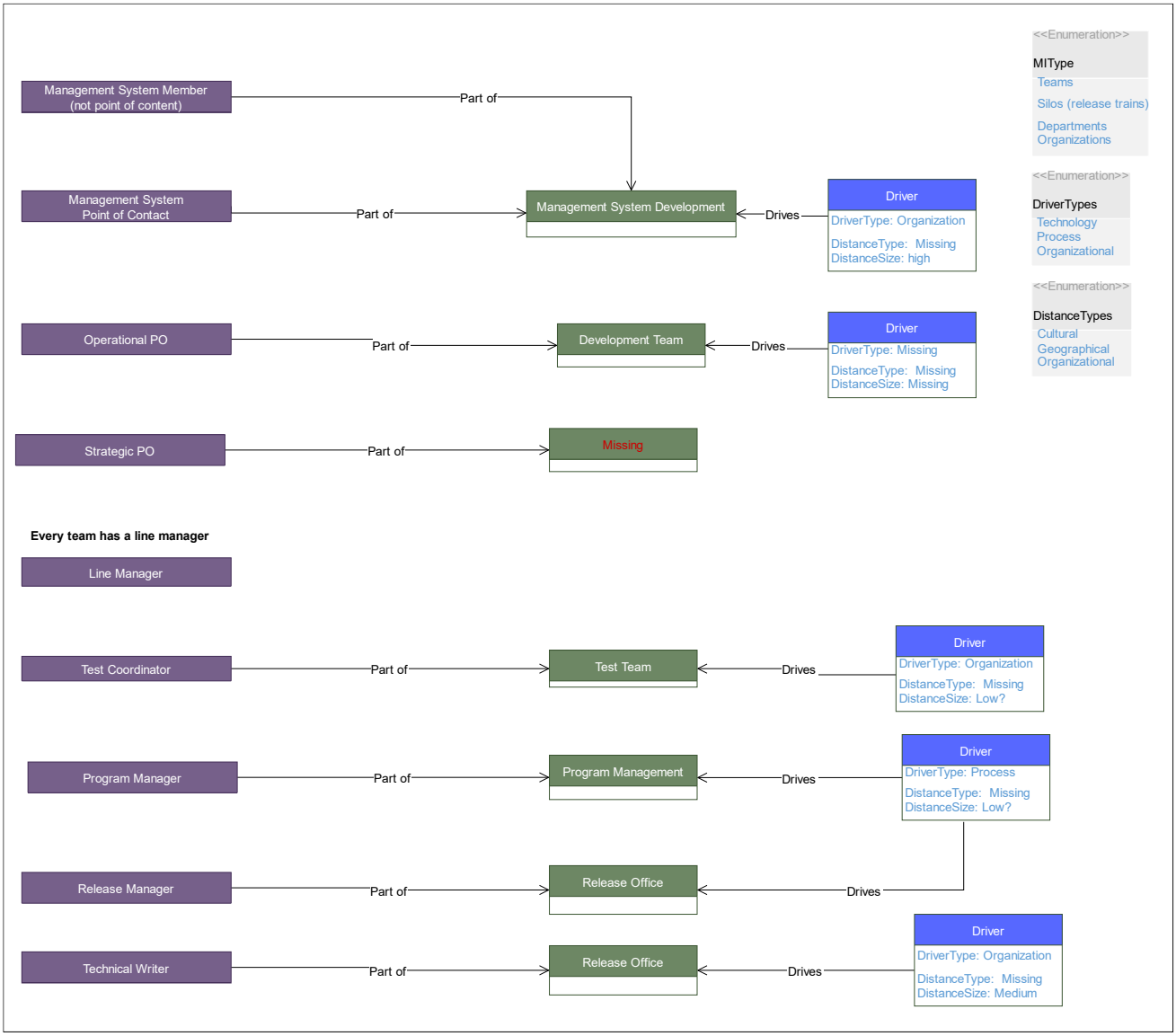
APPENDIX L

INSTANCE MODEL OF FINAL OVERVIEW VIEW TYPE SETUP FOR A GENERIC FEATURE FROM COMPANY E



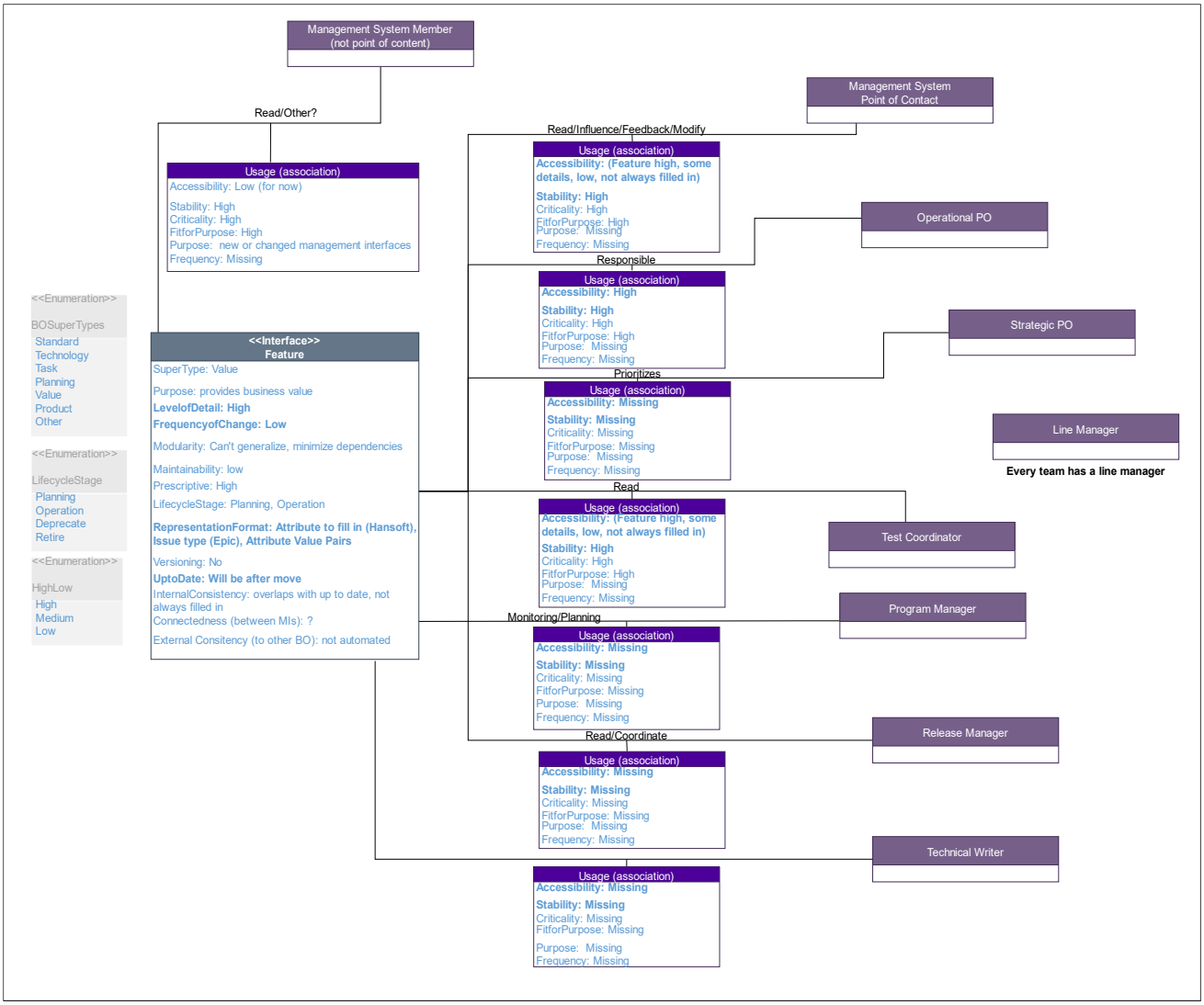
APPENDIX M

INSTANCE MODEL OF FINAL MI VIEW TYPE SETUP FOR GENERIC FEATURE FROM COMPANY E



APPENDIX N

INSTANCE MODEL OF FINAL BO VIEW TYPE SETUP FOR GENERIC FEATURE FROM COMPANY E



APPENDIX O

INSTANCE MODEL OF FINAL GOVERNANCE VIEW TYPE SETUP FOR GENERIC FEATURE FROM COMPANY E