

Stakeholder-Oriented Model Formatting

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Abstract: It is crucial to orient enterprise architecture models towards their stakeholders' needs. In this paper, we assess formatting geared towards such stakeholder orientation. To this end, we collect requirements from existing research on information presentation, derive guidelines from these requirements, apply these guidelines to an exemplary set of initial models, and experimentally evaluate the added value for stakeholders. We conclude that appropriate application of formatting guidelines in modeling can indeed significantly improve the ease of information gathering. However, neglecting some requirements in favor of others can result in deterioration instead of the expected improvement. At the same time, additional factors should be considered when striving to meet stakeholder needs, such as the use of appropriate references – like enterprise architecture frameworks. Altogether, we furnish a universally applicable, concrete and measurable approach for orienting models towards their stakeholders that promotes ease of information gathering and inclusion through accessibility.

1 MOTIVATION

Models constitute an important form of communication in enterprise architecture (EA), especially in complex contexts (Lankhorst, 2017; Hillmann et al., 2021; Hillmann et al., 2024). In the following, we primarily employ the term model to refer to such EA models. However, our findings generalize to similar models outside the EA domain to a large extent. Models allow for communicating multidimensional concepts in a structured and – provided their stakeholders possess sufficient *Model Literacy* – easily understandable way (Larkin and Simon, 1987). This *Model Literacy* can be defined based on definitions of literacy in general as well as *Information* and *Data Literacy* in particular. Literacy commonly denotes the ability to read and understand written texts to the extent that the reader can employ the information contained in the text for their own purposes (Lechner et al., 2021). More generally, it is defined as understanding of some domain to an extent that enables communication in its context (Perin, 2019). According to this general definition, the aforementioned literacy regarding written texts should be designated more precisely – e.g., as *Print Literacy*. This *Print Literacy* is essential for fully participating in modern society (Lechner et al.,

2021). Consequently, *Information Literacy* denotes the ability to gather and categorize information such that one can actively participate in an educated society (Teixeira and Karim, 2023; Klidas and Hanegan, 2022). In contrast, *Data Literacy* denotes the ability to manage data by means of collection, interpretation, analysis, evaluation and utilization, such that the results can be employed in different contexts. For EA contexts, we define *Model Literacy* as the ability to extract, understand, and further employ the information contained in models to an extent that enables participation in corresponding communication processes at a level that corresponds to the individual stakeholder's role. We identify *Information* and *Data Literacy* as key prerequisites for *Model Literacy*.

As models are no end in themselves, but rather a means for their stakeholders to communicate, it is crucial to create them in a way that meets these stakeholders' needs (Lankhorst, 2017; Hillmann et al., 2025). Hence, stakeholder-orientation is paramount in modeling (Lucke and Lechner, 2011; Pankowska, 2015; Kurnia et al., 2021). One key objective of such a design is to promote ease of information gathering from models. Thereby, *Model Literacy* requirements placed on stakeholders can be softened. In this paper, we assess the need for stakeholder-oriented formatting – i.e., both graphical representation and content formulation, including architectural styling as recom-

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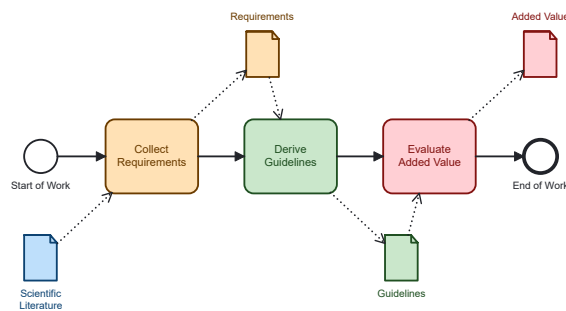


Figure 1: Applied Design Science Research Process.

mended by *The Open Group Architecture Framework (TOGAF)* – in order to meet this objective (Architecture Forum, 2022). To this end, we address the following research questions:

1. What are the requirements for stakeholder-oriented formatting of models?
2. How can these requirements be translated into formatting guidelines?
3. What value does applying these guidelines to models add for stakeholders?

The process of answering these questions is simplistically illustrated in Figure 1. Accordingly, the remainder of this paper is structured as follows: Firstly, we investigate existing research on information presentation in order to collect requirements. Secondly, we derive formatting guidelines from these requirements. Thirdly, we apply these guidelines to an exemplary set of initial models and thereby obtain a set of resulting models – one per initial model. Fourthly, we experimentally evaluate these initial and resulting models in order to ascertain the added value of stakeholder-oriented formatting. Finally, we summarize our key findings, discuss limitations, and suggest future work.

2 REQUIREMENT COLLECTION

In this section, we address stakeholder-oriented model formatting requirements. To this end, we firstly discuss existing research on information presentation in general and model formatting in particular. Secondly, we derive requirements from this research.

2.1 Existing Research

Investigating publications on (model) formatting, we distinguish three source types: Firstly, generalized sources provide a summary of abstract criteria for designing models. Secondly, focussed sources investigate singular modeling contexts, modeling aspects or model types. Finally, related sources do not directly

address model formatting, but topics related to an extent that allows for applying the findings.

The *Principles of Modeling*, *Conceptual Modeling Quality Framework*, *Semiotic Quality Framework*, and *Guidelines of Modeling* exemplify generalized sources (Pidd, 1999; Nelson et al., 2011; Krogstie, 2012; Schütte, 2013). While they establish criteria to be considered, they do not provide concrete requirements or even guidelines for modeling efforts (Lindland et al., 1994). Hence, they are suitable for understanding context and abstract objectives but insufficient for achieving improvement.

There are numerous focussed sources. While many of them provide in-depth insights into specific aspects of modeling, they do not provide a comprehensive overview of the topic. E.g., Sánchez-González et al. investigate the quality of business process models while Zimoch et al. examine their comprehension (Sánchez-González et al., 2012; Zimoch et al., 2018). Others exhaustively address very specific modeling contexts without generalizing their insights. E.g., the *Quality Requirements for Online Services and Portals in Public Administration (Service Standard)* limit themselves to the domain of German governmental IT applications (NIA, 2025). Hence, focussed sources are only suitable for understanding and improving limited sections of the topic.

Publications addressing concerns regarding the accessibility of ICT products serve as an example of related sources (Wentz and Lazar, 2016; Skjerve et al., 2016; Yesilada and Harper, 2019). Among these, the *Web Content Accessibility Guidelines (WCAG)* are of such wide acceptance that their version 2.2 is currently undergoing the process to become a standard of the *International Organization for Standardization (ISO)* (W3C, 2024). Moreover, a previous version 2.0 of the *WCAG* has already been recognized in the same way. The *WCAG 2.2* provide a comprehensive set of guidelines for achieving and assuring web accessibility. While many of these guidelines – like providing text alternatives for non-text content – do not apply to models, others are quite important. Hence, we need to identify applicable guidelines when we discuss accessibility concerns in Subsection 2.2. As the *WCAG 2.2* are primarily intended for web content, we also need to adapt them to the context of models where necessary.

2.2 Extracted Requirements

The research presented in Subsection 2.1 justifies the following requirements for stakeholder-oriented formatting of models:

1. **Selection of Modeling Languages:** Although no

modeling language is the best choice for every situation, one might be better suited for a particular context than others (Figl, 2017; Vermeulen, 2018; Zimoch et al., 2018). E.g., when modeling systems, the *Systems Modeling Language* might be a better choice than the *Unified Modeling Language (UML)* as its distinction between different types of blocks allows for easier identification of a represented entity's type compared to *UML's* generic classes (SysML Team, 2019; UML Team, 2017). Hence, the to-be-adhered-to modeling languages should be selected in advance – i.e., before the actual modeling begins – based on the modeling intent and the stakeholders' needs.

2. **Building upon References:** References – like *TOGAF*, *Unified Architecture Framework*, *NATO Architecture Framework (NAF)*, *Federated Mission Networking (FMN)*, *IT4IT*, or the *Service Standard* – offer guidance on model structure and contents (Architecture Forum, 2022; UAF Team, 2022b; UAF Team, 2022a; ACT, 2020; CPWG, 2024; IT4IT Forum, 2022; NIA, 2025; Zenz et al., 2025). Thus, models can be created in a way that conforms to widely recognized quality criteria – like the *ISO/IEC 250xx* series – and is familiar to stakeholders (JTC 1/SC7, 2014; JTC 1/SC7, 2024; JTC 1/SC7, 2023; Heiland et al., 2021; Heiland et al., 2023). E.g., basic technical terms – like Incident – are employed consistently. Thereby, *Model Literacy* requirements placed on stakeholders are softened.

Hence, appropriate references should be chosen in advance and adhered to during modeling.

3. **Limitation of Elements and Relations Visible in Parallel:** Additional cognitive load hinders the ability to solve problems – e.g., to gain information from a source (Sweller, 1988; Chandler and Sweller, 1991). A common strategy to mitigate this hindrance is to reduce extraneous cognitive load – i.e., not to adapt the information itself but the way it is presented (Sweller, 1994; Bannert, 2002). A key aspect of this is to avoid information overload by reducing the amount of information that needs to be processed simultaneously (Kear and Heap, 2007; Chen et al., 2011). For gathering information from models, the amount of information that must be processed in parallel mainly depends on the number of elements and relations presented in parallel. Usually, this is the number of elements and relations visible in a view.

Hence, excessive view sizes should be avoided by limiting the number of visible elements and relations per view – i.e., no more than 20 (optimal) to 40 (acceptable) elements should be shown

within a single view (Sánchez-González et al., 2012; Recker, 2013; Zimoch et al., 2017; Hillmann et al., 2022). For relations, not only the total number, but also the average number per element should be limited – i.e., no more than two (optimal) to three (acceptable) in- and outgoing relations should be shown per element within a single view (Sánchez-González et al., 2010; Reijers and Mendling, 2011; Recker, 2013; Sánchez-González et al., 2012; Hillmann et al., 2022). However, there are specific scenarios in which such limits should be exceeded – e.g., it might make sense to present every requirement related to some objective in a single view, even if this leads to a higher number of visible elements or relations than generally recommended. Moreover, more precise limits should be specified in a case-by-case assessment where the individual stakeholder demands, consequent modeling intent, overall context, and employed modeling language should be considered.

4. **Layout of Elements and Relations:** For placing view contents, horizontal layouts are preferable over vertical ones and left-to-right ones are preferable over right-to-left ones (Silver, 2011; Lübke et al., 2021; Figl and Strembeck, 2015). Such layouts correspond to the common way of reading in Western cultures. Accordingly, we assume that right-to-left layouts would be preferable for cultures where the main language is read from right to left – e.g., Arabic or Hebrew.

Hence, view contents should be laid out matching the stakeholders' cultural background. Again, specific circumstances of particular cases need to be considered – e.g., tree layouts are suitable for hierarchical structures. Furthermore, symmetric layouts can highlight interrelationships between model contents by emphasizing the unity of respective contents (Sun and Wong, 2005).

5. **Grouping of Elements:** By utilizing border boxes and similar techniques, elements belonging to the same group can be highlighted as such (Petrusel and Mendling, 2013; Ware, 2021). Hence, such techniques should be employed when applicable. Resulting groups should be limited to a maximum of nine elements (Miller, 1956; Sun and Wong, 2005). Once more, specific circumstances of particular cases should be considered – e.g., when employing swimlanes to differentiate actors in *Business Process Model and Notation (BPMN)* diagrams, all tasks performed by a particular actor should be positioned in the corresponding swimlane (BPMN Team, 2013).

6. **Employment of Colors:** Highlighting interrela-

Table 1: Relevant WCAG 2.2 Success Criteria for Models.

Number	Name	Emerging Requirements
1.3.1	Info and Relationships	Determinability
1.4.1	Use of Color	Distinction by Color
1.4.3	Contrast (Minimum)	Contrast Ratio
1.4.6	Contrast (Enhanced)	Contrast Ratio
1.4.8	Visual Presentation	Text Formatting
1.4.10	Reflow	Scrolling
1.4.11	Non-Text Contrast	Contrast Ratio
1.4.12	Text Spacing	Text Formatting
2.4.2	Page Titled	Naming
2.4.4	Link Purpose (In Context)	Naming
		Determinability
2.4.6	Headings and Labels	Naming
2.4.8	Location	Consistency
2.4.9	Link Purpose (Link Only)	Naming
2.4.10	Section Headings	Naming
2.5.5	Target Size (Enhanced)	Pointer Target Size
2.5.8	Target Size (Minimum)	Pointer Target Size
3.1.1	Language of Page	Wording
		Determinability
3.1.2	Language of Parts	Wording
		Determinability
3.1.3	Unusual Words	Wording
3.1.4	Abbreviations	Wording
3.2.3	Consistent Navigation	Consistency
3.2.4	Consistent Identification	Consistency
4.1.2	Name, Role, Value	Determinability

tionships between elements with color can improve the ease of information gathering from models (Petrusel and Mendling, 2013; Ware, 2021). Appropriate coloration can indicate both patterns within a single view and parallels across multiple views. However, employing more than six different colors can turn the positive effect into a negative one (Miller, 1956; Koning et al., 2002). Hence, a limited color set should be chosen based on each modeling effort's specific circumstances and adhered to during modeling. As with layouts, stakeholders' cultural background should be considered (Kummer et al., 2016). Also, some reference choices indicate appropriate colors – e.g., *NAF* color-codes different subjects of concern (ACT, 2020). The *IT4IT* model demonstrates this by matching its elements' colors to the *ArchiMate Full Framework* layers they belong to (IT4IT Forum, 2022; ArchiMate Forum, 2019).

7. Consideration of Accessibility Concerns: Investigating the *WCAG 2.2*, we identify the success criteria in Table 1 as each being partially or in total either directly applicable to or adaptable for models (W3C, 2024). Through aggregation, the following accessibility requirements emerge:

- (a) **Distinction by Color:** Color should not be the sole means of distinction – e.g., between different types of elements – unless other means

have been exhausted. However, it can freely be utilized to complement existing means of distinction – e.g., by form or annotation.

- (b) **Contrast Ratio:** The contrast ratio between text and background colors should be at least 7:1. The contrast ratio between other fore- and background colors should be at least 3:1.
- (c) **Text Formatting:** Text blocks should be limited to 80 characters per line and left-aligned. All texts should have a line height of at least 1.5 times the font size and spacings of at least 0.12 times the font size for letters, 0.16 times the font size for words, single-space-and-a-half for lines and the maximum of 2 times the font size and 1.5 times the line spacing for paragraphs.
- (d) **Wording:** A single language should be used for all text within a model. Unusual words and words with multiple meanings should be avoided, but technical terms should be employed when they promote understanding (Koschmider et al., 2015). The preceding criteria do not apply to texts that are citations. Identification of abbreviations' long forms and technical terms' meanings should be enabled.
- (e) **Naming:** All model contents – e.g., elements, relations, views, and packages – should be named in a way that indicates their purpose (Miller, 1956; Mendling and Strembeck, 2008; Moody and van Hillegersberg, 2009). To this end, names should be (a) meaningful and descriptive, (b) unambiguous, (c) unique within the model, and (d) consistent across the model (see Consistency). E.g., for relations, combining a verb and an object is a good practice (Mendling et al., 2010). In case of navigation cells and other linkages, names should match the target. For naming elements, we suggest preferring singular forms over plural ones.
- (f) **Pointer Target Size:** The size of pointer targets – e.g., navigation cells – should be no smaller than 44 by 44 pixels. This does not apply to pointer targets that are not intended to be clicked on in read-only model interactions – e.g., relation representations like lines, arrows, and labels. For responsive contexts, we propose replacing 44 with two times the font size.
- (g) **Scrolling:** Model contents should be positioned in such a way that no scrolling (optimal) or only one-dimensional scrolling (acceptable) is required to observe everything contained within a view. Exceptions can be made in cases where conveying the full meaning necessitates two-dimensional scrolling.

- (h) **Consistency:** Forms of navigation – e.g., package structure trees and navigation cells – should be provided consistently. Forms of identification – e.g., modeling languages, technical terms and abbreviations, font specifications and configurations, element and relation forms and sizes, colors and symbols as well as layouts – should be utilized consistently (Koning et al., 2002; Moody, 2009; Ware, 2021).
- (i) **Determinability:** All elements and relations should be programmatically determinable. Besides their names and other properties, this also applies to their roles. In particular, types, stereotypes, and similar categorizers should be chosen consistently to reflect these roles.

Meeting these requirements not only enables accessibility, but also promotes ease of information gathering. E.g., using consistent names and colors aids in identifying elements and relations, which promotes understanding their purpose. Moreover, the WCAG 2.2 in their totality can be applied to HTML reports generated from models.

3 CONCEPTUALIZATION

In this section, we obtain SMART guidelines to promote stakeholder-oriented model formatting (Doran, 1981). To this end, we examine the requirements from Subsection 2.2 to identify respective concrete calls to action (CTAs) and their interdependencies. To avoid conflicts, we determine additional CTAs. Afterwards, we aggregate each set of similar CTAs coming from different requirements into a single action item. Considering both their interdependencies and the points in the modeling process at which they should be addressed at the latest, we arrange these action items into an order suitable for the modeling process. Finally, we assemble the action items previously addressed in a more isolated manner into a comprehensive set of guidelines forming a single process.

The CTAs assigned to each requirement from Subsection 2.2 are listed in Table 2, with *fs* denoting the font size and *ls* denoting the line spacing. To avoid conflicts when satisfying them, additional CTAs need to be considered and are consequently also listed.

Aggregation, ordering, and assembly lead to four guidelines for stakeholder-oriented formatting of models. Under consideration of interdependence and timing, they form the process illustrated in Figure 2. Entering the *Preparation Phase*, analyze the circumstances of the modeling effort (circumstantial analysis). To this end, answer the following questions considering the respective aspects:

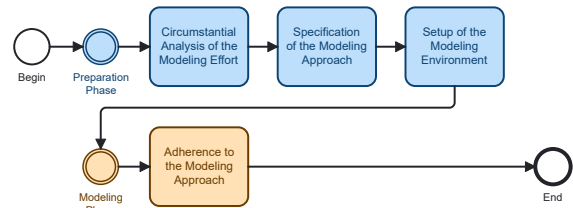


Figure 2: Formatting Guidelines as a Process.

1. Who are the stakeholders?
 - Cultural & professional backgrounds
 - Fulfilled Roles
 - Concerns & needs
 - Possessed degree of *Model Literacy*
2. What is the modeling intent?
 - Objective
 - Intended use & scope of resulting models
 - Desired levels of abstraction & detail
3. What stipulations need to be complied with?
 - Regulatory & legal stipulations
 - Organizational & project-specific stipulations
 - Additional stipulations
4. What references are suitable?
 - General considerability
 - Differences among versions
 - Appropriateness for circumstances
 - Compatibility with other options
5. What modeling languages are suitable?
 - General considerability
 - Differences among versions
 - Appropriateness for circumstances
 - Compatibility with other options
6. What modeling tools are suitable?
 - General considerability
 - Differences among versions
 - Appropriateness for circumstances
 - Compatibility with other options

Readdress previously answered questions whenever new insights are gained. For instance, selected references may lead to new stipulations – e.g., *FMN* might uncover interoperability constraints (CPWG, 2024). Afterwards, developing a conceptual baseline – like the one shown in Figure 3 – can promote consistency throughout the following steps and align their results (Hillmann and Karcher, 2023; Zenz et al., 2023). Remaining in the *Preparation Phase*, specify the modeling approach based on the circumstantial analysis (specification). To this end, consider the following aspects (Architecture Forum, 2022):

Table 2: Assignment of Calls to Action to Requirements and their Conflicts.

General Information Gathering	
Req.	Calls to Action
1	Consider modeling intent and stakeholders' needs Select modeling languages; adhere to them consistently
2	Consider modeling intent, applicable stipulations, and compatibility of references Choose references; adhere to them consistently
3	Consider ways to split views , possible splitting points, and edge cases Limit elements per view (e.g., 20 / 40) and relations per view & element (e.g., Ø3) Evaluate whether and where to split views from case to case; remain consistent Split views according to results of corresponding evaluations (e.g., on limits)
4	Consider view generation intent & foci and cultural & professional contexts Lay out views taking symmetry into account from case to case; remain consistent
5	Identify taxonomies and other group structures Limit number of elements per group (e.g., 9) from case to case; remain consistent Determine appropriate highlighting techniques; employ them consistently
6	Consider relevant circumstances like chosen references and cultural context Choose set of colors limiting the colors per view to 6 ; adhere to them consistently
Accessibility	
Req.	Calls to Action
7a	Consider additional means of distinction – like annotations – besides coloration Employ additional means of distinction whenever coloration is already employed
7b	Choose fore- and background colors with a contrast ratio of $\geq 7:1$ for texts and $\geq 3:1$ for other contents
7c	Format text blocks left-aligned with ≤ 80 characters per line Choose line height of $\geq 1.5 \cdot fs$ Choose line, letter, word and paragraph spacings of ≥ 1.5 , $\geq 0.12 \cdot fs$, $\geq 0.16 \cdot fs$, and $\geq \max(2 \cdot fs, 1.5 \cdot ls)$, respectively
7d	Choose single language for all text; adhere to it consistently Avoid unusual words and ones with multiple meanings Maintain glossary of technical terms and abbreviations ; employ them accordingly Exempt citations
7e	Choose names that convey the purpose of the corresponding model contents Keep naming meaningful, descriptive, unambiguous, unique, and consistent Name elements in singular and relations with combinations of a verb & an object
7f	Size pointer targets to $\geq 44 \times 44$ ($\geq 2 \cdot fs \times 2 \cdot fs$ for responsive contexts) pixels Exempt pointer targets that are not to be clicked in read-only model interactions
7g	Consider need for scrolling from case to case; remain consistent Format views such that scrolling is avoided or at least limited to 1 dimension Exempt cases in which conveying full meaning requires 2-dimensional scrolling
7h	Provide consistent forms of navigation Built upon references consistently Employ modeling languages consistently Utilize technical terms, abbreviations and symbols consistently Set font sizes, other font configurations, and colors consistently Present elements and relations in consistent forms and sizes
7i	Assign appropriate types and stereotypes to all model contents Consider possible inhibitors of programmatic determinability Avoid inhibitors of programmatic determinability
Collision Avoidance	
Conflict	Call to Action
1-2	Align modeling language selection with reference choice
3-5-6	Decide between view splitting, content grouping, & coloration from case to case
2-7e	Derive package structure from reference choice & model contents if applicable

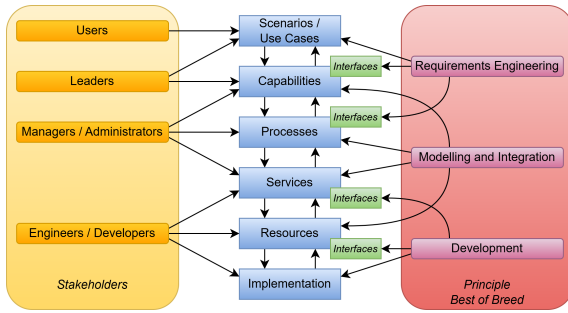


Figure 3: Conceptual Baseline for Holistic Modeling.

1. Employed modeling tools
2. Chosen references & selected modeling languages
3. Mainly employed natural language
4. Instantiated element, relation & view types with:
 - Particular references & modeling language
 - Naming & wording conventions
 - Limitation of elements & relations shown
 - Layout: shaping, sizing, placement, ...
 - Marking: coloration, annotation, grouping, ...
5. Corresponding formats with:
 - Shape, sizes, & colors for all contents
 - Font, line height, & spacings for texts
 - Alignment & line character limit for text blocks
6. Exemptions

In doing so, consider the requirements from Subsection 2.2 as well as possible scenarios and how to react to them – e.g., above what number of elements and how particularly a split should be performed. Here, established model splicing techniques should be considered (Weiser, 1984; Zhao, 2002). Combine all these considerations into a well-structured modeling approach (Ascher et al., 2022; Zenz et al., 2023). Exiting the *Preparation Phase*, set up the modeling environment based on both the circumstantial analysis and the specification (setup). To this end, follow these steps (Hillmann et al., 2022; Zenz et al., 2023):

1. Configure modeling tools regarding:
 - References & modeling languages
 - Layout tools & default formats
2. Create a model repository.
3. Create a package structure.
4. Add technical term & abbreviation glossaries.

Finally entering the *Modeling Phase*, adhere to the specified modeling approach throughout the whole modeling process (modeling). Especially in case-by-case decisions regarding layout, view splitting, and content grouping, ensure that the specification

is not violated. Whenever there is a previously unconsidered situation, update the circumstantial analysis, specification, and setup before modeling accordingly. Furthermore, maintain the package structure and glossaries of technical terms & abbreviations.

4 APPLICATION TO MODELS

In this section, we apply the guidelines from Section 3 to an exemplary set of initial models (IMs). Thereby, we obtain corresponding resulting models (RMs).

There are numerous examples for both well-designed models and ones in need of improvement (Keller et al., 1992; Aldea et al., 2015; Pöhn and Hillmann, 2021; IT4IT Forum, 2022; Jonkers et al., 2023; CPWG, 2024). Inspired by the latter, we construct IM1, IM2, IM3, and IM4 as presented in Figure 4. IM1 neither employs any colors nor meets the layout requirements from Subsection 2.2. While IM2 does employ colors, they are poorly chosen in terms of contrast and versatility. Moreover, it also does not meet the layout requirements from Subsection 2.2. IM3 and IM4 both similarly lack quality.

As the IMs are mockups, we assume that the circumstantial analysis and setup can be repeated or skipped for obtaining the RMs, but the specification needs to be adapted in terms of graphical representation. Hence, we look at corresponding requirements from Subsection 2.2. For IM1 and IM2, we consider 4 and 6 as well as 7a, 7b, 7g, and 7h. For IM3 and IM4, we also consider 3 and 5. All other requirements either do not apply to or are already met by the IMs. By modeling accordingly, we obtain RM1 for IM1, RM2 for IM2, RM3 for IM3, and RM4 for IM4 as presented in Figure 4. Although some RMs intuitively seem more straightforward than corresponding IMs, quantifying possible information gathering improvements necessitates further examination.

5 INITIAL RESULTS

In this section, we evaluate the guidelines from Section 3 in a preliminary experiment obtaining an initial indication of the added value for stakeholders. To this end, we compare the ease of information gathering between IMs and RMs from Section 4 in an eye tracking experiment. Consequently, the evaluation is limited to graphical representation aspects.

For conducting the experiment, 16 Western EA stakeholders – 13 men and three women aging from 26 to 56 – are recruited as respondents. None of

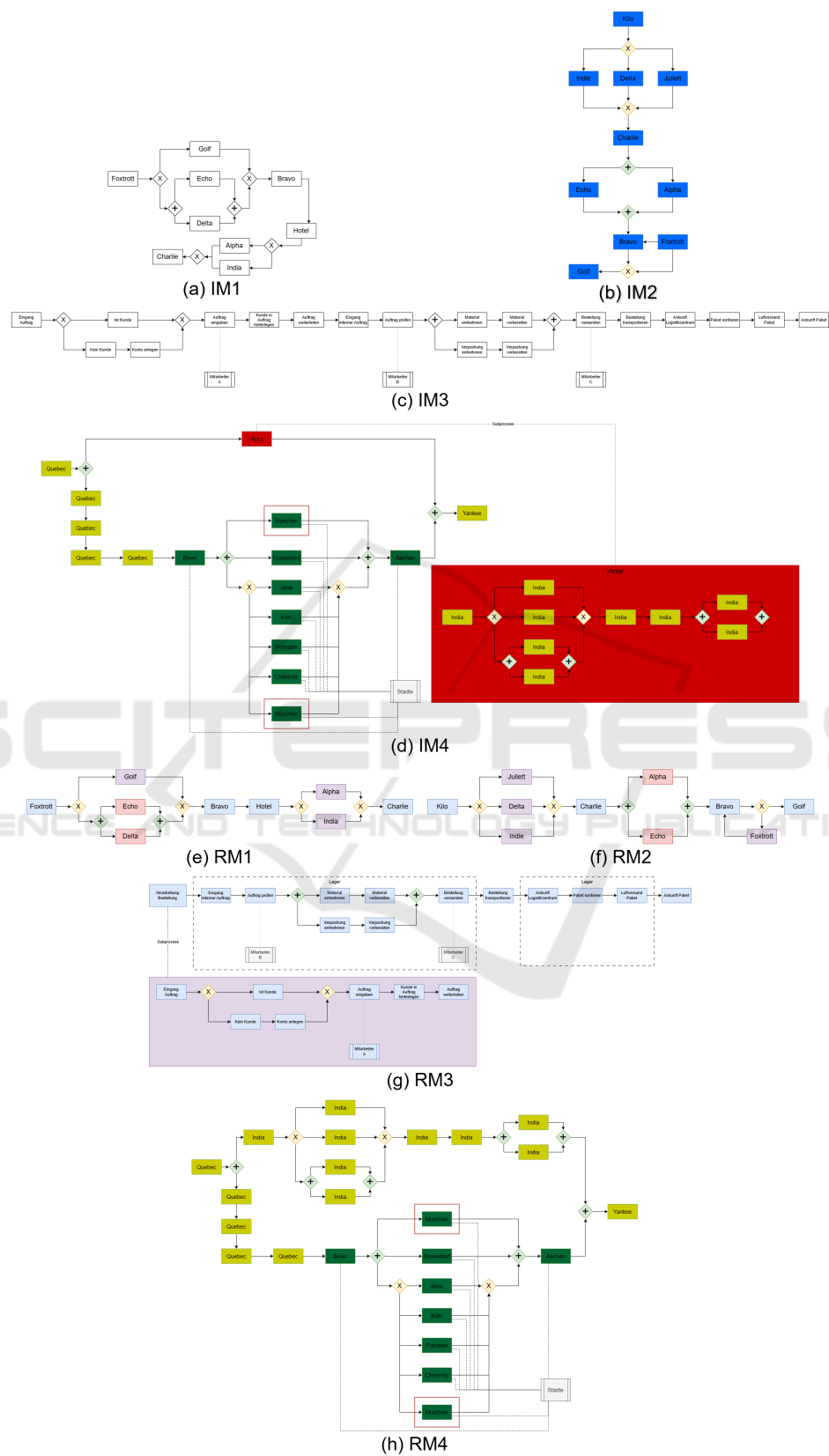


Figure 4: Initial and Resulting Models.

Table 3: Questions for the Experiment.

Model Pair	Questions
IM1 vs. RM1	1: Is there an element Juliett?
	2: How many elements are visited at the maximum?
	3: Can Alpha be visited after Golf?
	4: Does Bravo always follow after Echo?
IM2 vs. RM2	5: Is there an element Lima?
	6: Is Foxtrott always visited?
	7: Does any element appear twice?
	8: Are Kilo, Charlie, and Bravo always visited?
IM3 vs. RM3	9: Which employee sends the order out?
	10: How is the package finally transported?
	11: Are new customers' packages delivered differently?
	12: What happens before an order is examined?
IM4 vs. RM4	13: Which element appears twice?
	14: How many plus connectors are there?
	15: Can only one of Alpha and Delta be visited?
	16: Does Aachen follow after Bonn?

them suffer from any known uncorrected visual impairments. According to self-assessment of their individual modeling experience on a scale from 1 to 7, there are four beginners (2 / 3), nine experts (5 / 6), and three masters (7). Neither no (1) nor intermediate (4) modeling experience are represented. Based on their self-assessment, the respondents are split into two eight-person groups, G1 and G2, of roughly equal modeling experience. G1 is presented with IM1, RM2, IM3, and RM4 while G2 is presented with RM1, IM2, RM3, and IM4. Thereby, each group is presented with two IMs and two RMs, with each pair of IM and corresponding RM being divided between the two groups. Each respondent is asked the twelve questions shown in Table 3. During answering, we measure fixations with eye tracking and record both correctness & needed time (Zagermann et al., 2016).

These data points are aggregated into three sets of results per model. Firstly, we calculate the change in average required fixations per question from IM to RM. Secondly, we sum up the correct answers over all respondents. Thirdly, we determine the median time needed to answer each question. For each model pair, these measurements are compared in Table 4.

According to measured fixations, IM1, RM2, IM3, and RM4 cause less mental strain for respondents compared to their counterparts. For IM1 vs. RM1, this difference is small and the time difference

Table 4: Measurements from the Experiment.

Model Pair	Fixations	Correctness	Time (seconds)	Verdict
IM1 vs. RM1	2.89 more	20 vs. 26 of 32	9.04 vs. 8.97	+
IM2 vs. RM2	4.95 less	30 vs. 31 of 32	12.99 vs. 8.91	+
IM3 vs. RM3	6.99 more	31 vs. 27 of 32	12.79 vs. 18.27	-
IM4 vs. RM4	10.69 less	26 vs. 26 of 32	21.39 vs. 14.37	+

is negligible. However, the correctness is significantly higher for RM1. Overall, RM1 is a slight improvement. For IM2 vs. RM2, the fixation difference is significant. More so, significantly less time is needed for RM2. However, the correctness is only slightly higher for RM2. Overall, RM2 is a significant improvement. For IM3 vs. RM3, the fixation difference is significant. More so, significantly more time is needed and the correctness is significantly lower for RM3. Overall, RM3 is a significant deterioration. For IM4 vs. RM4, the fixation difference is significant. More so, significantly less time is needed for RM4. However, the correctness is equal for both models. Overall, RM4 is a significant improvement. Deteriorations and improvements are also reflected in heat maps as exemplified for questions 12 and 13 in Figure 5. Here, a higher concentration is shown for IM3 and RM4 compared to RM3 and IM4, respectively.

Choosing $\alpha = 0.05$, we conduct Mann-Whitney U, K-S, F, and Student's t tests. For G1 vs. G2, modeling experience differs insignificantly ($p \approx 0.91$). For IMs vs. RMs, correctness is normally distributed ($D \approx 0.23$) with equal variance ($F_{max} \approx 1.52$) and differs insignificantly ($p \approx 0.84$). Unlike for IM1 vs. RM1 ($p \approx 0.86$), time differs significantly for IM2 vs. RM2 ($p \approx 0.01$, $r = 0.33$), IM3 vs. RM3 ($p \approx 0.03$, $r = 0.28$), and IM4 vs. RM4 ($p \approx 0.00$, $r = 0.37$).

Altogether, the initial results indicate that applying our guidelines as demonstrated in Section 4 lead to improvements in ease of information gathering if applied correctly. Although a significant deterioration occurs for RM3 compared to IM3, this can be explained by two mistakes. Firstly, contrast ratios are not considered for relations which negatively impacts readability. Secondly, an unnecessary subprocess is added to the model which negatively impacts understandability. Hence, the guidelines are not followed completely and correctly and RM3 does not constitute an improvement over IM3, in the first place.

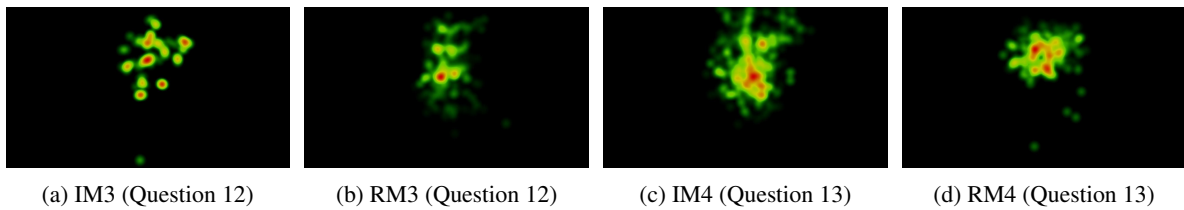


Figure 5: Exemplary Eye Tracking Heat Maps.

6 CONCLUSION

In this paper, we collected numerous publications on requirements for stakeholder-oriented model formatting and found that they address not only the graphical representation but also prerequisites – like building upon references – and other formatting concerns – like wording and naming. Besides general information gathering, we also considered accessibility. Based on these requirements, we determined a comprehensive set of calls to action and aggregated them into four guidelines whose interdependencies and timings allow for forming them into a single process. Afterwards, we constructed an exemplary set of initial models and applied the guidelines to them, whereby we obtained a set of resulting models, to instantiate our approach. Finally, we conducted an eye tracking experiment to determine the added value for stakeholders of following the guidelines and thereby meeting the requirements. We found that the guidelines can lead to significant improvements in ease of information gathering – more so for more complex models. However, care is needed when applying the guidelines as neglecting some requirements in favor of others can lead to deteriorations.

All things considered, we furnished a comprehensive approach for stakeholder-oriented formatting of models taking the form of an easily followed process that promotes ease of information gathering and inclusion through accessibility. To support executing the process, Table 2 can be consulted as a checklist. However, considering the requirements from Subsection 2.2 in their entirety is essential for avoiding deteriorations and obtaining high-quality models.

We are currently working on a more extensive validation of the graphical representation requirements. In particular, we are investigating their impact on ease of information gathering both individually using correspondingly constructed models and collectively using real-world models. In doing so, we strive to prioritize requirements, derive guidelines for handling conflicting requirements, and, based on these findings, automate our process regarding graphical representation to enable modelers to focus on substantive aspects. Besides that, future research could explore inclusivity considerations. On the one hand, the impact on ease of information gathering for stakeholders with non-Western cultural backgrounds could be examined. Here, different non-Western cultural backgrounds should be considered. On the other hand, the impact on inclusion for impaired stakeholders could be explored. In this context, the focus should lie on different visual impairments, but other impairment types should also be considered.

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