Developing the Modeling Recommendation Matrix: Model-Assisted Communication at Volvo Aero.

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Abstract. Volvo Aero Norway (VAN) is a manufacturing company specializing in the production of high precision aerospace components for both commercial and military jet engines. VAN has, as a high-end production company, a highly diverse set of stakeholders in their employees, customers and suppliers. It is therefore a definite need for VAN to have personnel that can communicate efficiently between stakeholders to be able to complete projects and optimize production in order to sustain their competitive position.

Using systems modeling is a known technique to aid communication, raise understanding and create debate surrounding any given system of interest. By measuring the value, in regards to the aforementioned effects of modeling, of the work being performed at VAN we can discuss the usefulness of modeling-based communication. We will examine the connection between a stakeholder's distance to a given system and the optimal level of modeling detail and novelty.

In this paper, we will discuss model effectiveness based on balancing impact factors based on stakeholder's system proximity. We will classify and evaluate models in a 2D-Matrix and present recorded trends at VAN.

Introduction

Volvo Aero Norway is a manufacturing company specializing in the production of high precision aerospace components for both commercial and military jet engines. Typical components are drive shafts, guide vanes and turbine-, compressor-, and exhaust-cases. The manufacturing processes used are milling, turning, welding, brazing, de-burring, electrical erosion, grinding, heat treatment, and control/inspection.

The primary author of this paper is employed in the Technology-R&D department of Volvo Aero Norway (VAN), working with a wide range of stakeholders. This entails dealing with shop floor operators, engineers, economists, and management in addition to customers, suppliers, and supporting organizations/institutions. This paper describes connections between a stakeholder's system proximity and to the impact factors system novelty and level of detail. Proximity is the organizational distance between the recipient stakeholder and the first level stakeholder. The organizational distance is expressed in the number of hops in the organization diagram. A second level stakeholder would for instance be the immediate superior/subordinate or a colleague from a different field of expertise, relative to the first level stakeholder.

Systems engineers typically have a role where they do not need the deepest domain knowledge nor do they solve the most challenging technical problem. Rather they can function as the translating link between stakeholders. It is therefore a systems engineer's strongest commodity to be able to communicate the correct information to stakeholders. In this regard, models can be used to aid communication by for instance enhancing detail, simplifying problems, showing consequences, or raising understanding. To ensure model effectiveness it is important to create the model with stakeholder system proximity in mind. Stakeholder system proximity is a way to capture the human factor in the research. D.D.Woods (Woods 1984) states that the effectiveness of visualization depends on perception, cognition, and the users' specific tasks and goals.

Engebakken (Engebakken 2010) discusses the impact factors present in model-aided communication at VAN. Among the impact factors found were, for instance, Close to reality, Multi-view, Details and Dynamic models, which can be classified as "level of detail". The paper also points to "instant recognition" as an impact factor. The present paper focuses on the various aspects of lack of instant recognition, which is a common consequence of model novelty.

We applied multiple modeling techniques in several different projects ranging from design and improvement projects to financial and investment projects. The most extensive modeling efforts took place in two projects involving high focus on funding and finance. One is a project to get board consensus and funding to initiate a large R&D project set to automate a part of the guide vane production fully. The other project is aimed at development and implementation of a bonus system between VAN and their maintenance company Kongsberg Tero Tech (KTT). The remaining projects mostly deal with improvements and quality issues in the brazing and welding operations.

The models used are predominantly visualization models to raise understanding, and to organize and focus work effort. Among the models created are 3D/2D visualizations, physical block architectures, information flow, graphs, and charts.

Approach

The primary author, often in collaboration with other model builders, made the models discussed in this paper. This collaboration is referred to as the model generator. The models were created on demand from various stakeholders to support communication. Figure 1 illustrates how the modeling process has been applied to conduct research for this paper. The process starts with an issue/need that requires some kind of model assistance. After defining the setting where the model is to be used, the model maker can choose between the model types: Stand-alone, Working, or Lightning. We balance the use of the impact factors novelty and level of detail, chosen from (Engebakken 2010), based on the stakeholder system proximity. We further decomposed the stakeholder proximity in hierarchical proximity and "field" proximity, see Figure1. The stakeholder level increases for each organizational step it is removed from the first level stakeholder. We have used VANs organization map to define the steps, where different departments manage different fields of expertise and the organizational levels relate to the hierarchy. After applying the model we analyzed how it worked with regard to our impact factors, and then recorded the data in an experience 2D-matrix that will act as practical guidelines for the builders in the model generator. The benefit of classifying models in such a fashion is that the classifications can act as guidance for model makers inside and outside VAN.

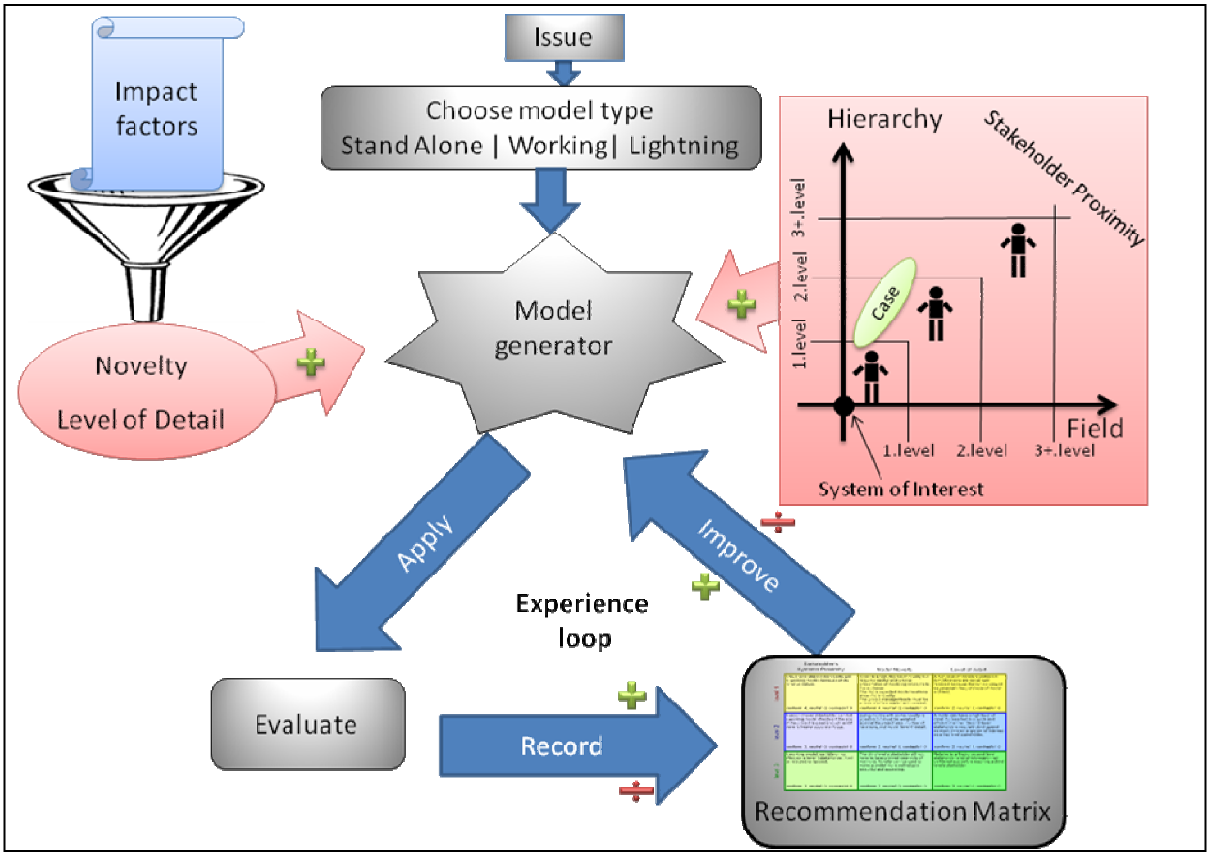


Figure 1 Research Approach

The recommendation matrix has a vertical axis showing the stakeholder level, where level 1 is organizationally close. The horizontal axis is used for the impact factors. The cells of the matrix contain the recommendations for that specific stakeholder level and impact factor. This matrix is filled for three types of models. The stakeholder feedback on 15 evaluated models is shown at the bottom of the cells.

Modeling cases

The objective of this research is to assess the feasibility of creating a standard of guidelines to support modeling for different stakeholders that will work for different types of models in different projects. For this purpose, we must categorize the models according to function rather than content. This has led to the three categories; Working models, Stand-alone models and Lightning models. All models can be classified into one of these categories based on how the model is being used. This paper presents an assortment of the models created and evaluated in this research.

Working models are used in an iterative fashion by both the model generator and the stakeholder recipient group. A premise for a working model is that it is used more than once and that it evolves by being modified and improved after sessions of interaction with the stakeholders. Once a model stops changing, it becomes a stand-alone model.

Models M2 and M4 in Figure 2 and 3 are active working models. Active entails a high degree of recipient interaction and considerable changes in the model. M2 is used in a project to design a bonus system between VAN and their maintenance company KTT. The reason for making M2 is to show the logical reasoning behind the Key Performance Indicators (KPIs) we have chosen as a basis for the bonus system. The construction of the model begins by defining the needs and expectations of VAN with respect to the implementation of a system. By using the selected KPIs, and by drawing colored lines to indicate how they impacted VAN needs, we could validate our choices and detect errors and redundancies. M4 in Figure 3 is a basic physical architecture of a point welding cell. This model is created for an improvement project to discover faults in the welding process. The idea is to discuss how the interfaces between the main components may be at fault. The point welding cell is heavily enclosed and located in a noisy factory environment where it can be very difficult to communicate. The model makes it possible to withdraw to an office and discuss details without losing the visual perspective.

M1, M3 and M5 are informative working models used in an ongoing effort to reduce process time on one of VAN's key products. Compared to M2 and M4 these models can be considered passive working models because they only undergo minor changes between sessions. They are not stand-alone since they are used repeatedly in regular sessions. The data presented intends to provoke discussion to uncover underlying causes for the unsatisfactory process duration.

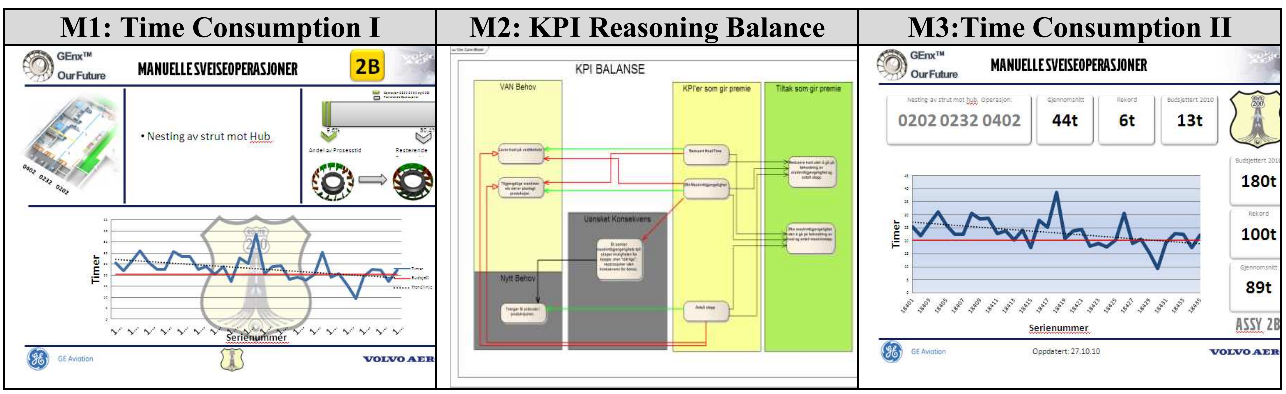


Figure 2 Working models I

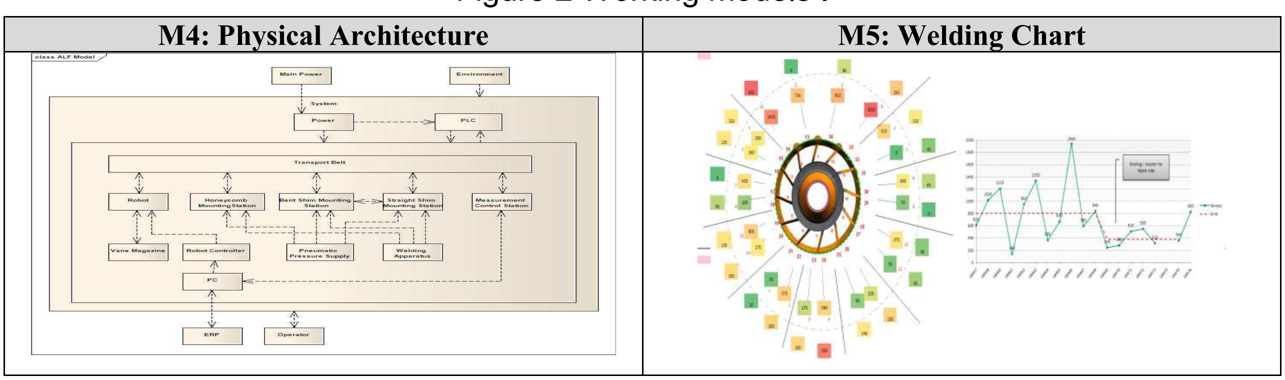


Figure 3 Working Models II

A stand-alone model, as the name implies, must be able to deliver its message alone without any type of additional explanation or discussion. A typical example of a stand-alone model is a poster or flyer. M6 and M7 in Figure 4 are physical representations of a production cell designed to conduct part marking. The models were used in a user manual for new robot programmers. A 3D model is developed to reduce text in the manual that is tedious to read and perhaps at bit too open for interpretation.

M8 in Figure 5 was originally constructed as a couple of posters placed at certain machines in the factory to give the operators a simple understanding of how the machine they worked on was connected in terms of data flow. These posters were the ones in the left box in M8. The rest of M8 was made by SINTEF, a research partner of VAN, who used the original poster to make a model of a new concept that they wanted to pitch to management.

M9 was made to support a discussion about a production cell's ability to produce a certain volume of parts. The model itself shows a part trace through the production process entailing machines used, operation time, transportation, and redundancy alternatives.

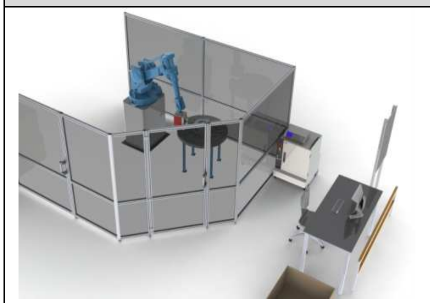
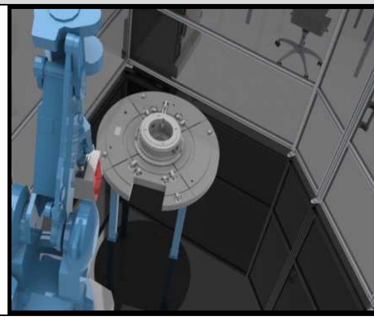
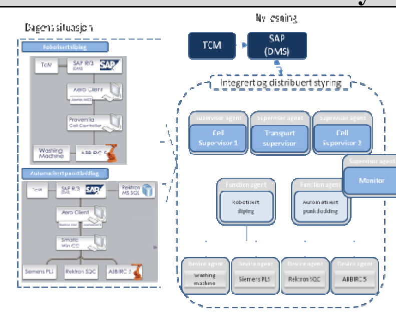
M6: 3D-Robot I	M7: 3D Robot II	M8: Data Flow Hierarchy
		

Figure 4 Stand-alone models I

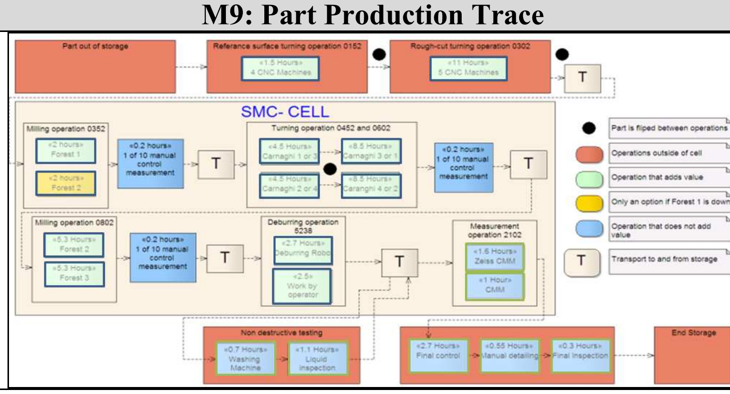
M9: Part Production Trace


Figure 5 Stand-alone models II

Lightning models are used when having a short window of opportunity to convey a message. An example is a Power Point presentation where we may use from 1-4 minutes per model. In contrast to the stand-alone models the lightning model can be accompanied by a verbal explanation and/or clarifying discussions.

M10 and M11 in Figure 6 are from a project pitch to obtain funding for a R&D project to automate a part of the guide vane production fully. This includes tying together EDM, grinding, deburring and milling operations. Automation on this scale has never been conducted at VAN before because of the complexity of the machining and the strict requirements regarding measurement and traceability in the aerospace industry. M10 is a 2D Auto CAD drawing of the factory with a simple concept sketch of a potential new cell. This was created to show what part of the process would be included in the cell and what scale of rebuilding it would entail. M11 relates to the same project to show how this automation project is connected to other projects and business/research partners.

Models M12:M15 in Figure 6 are made for the bonus project previously mentioned when introducing M2. M12 is a simplified version of M2. Rather than being a working model M12 is a way of presenting the results of using M2 to a different level of stakeholder. M13 and M14 are visual representations of the proposed method of calculating the bonus. M15 shows how the KPI "Machine availability" is calculated. Instead of explaining what it entails in text, we create an imagined timeline for an arbitrary machine in the factory. The idea is to use storytelling in model form.

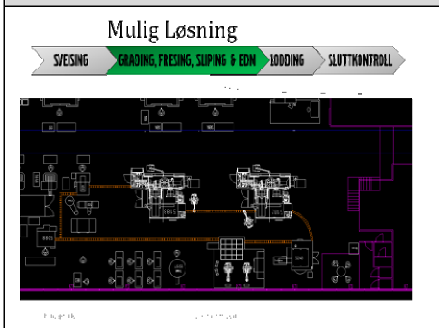
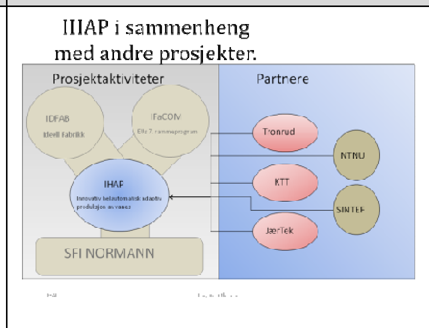
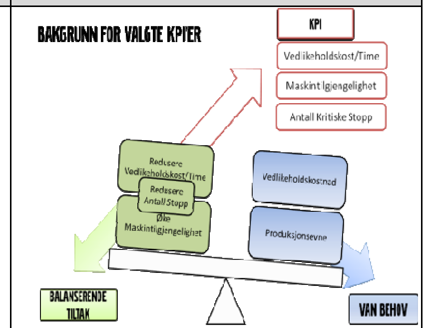
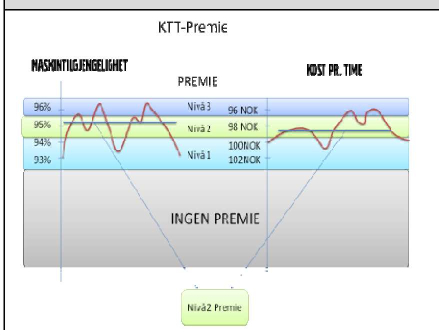
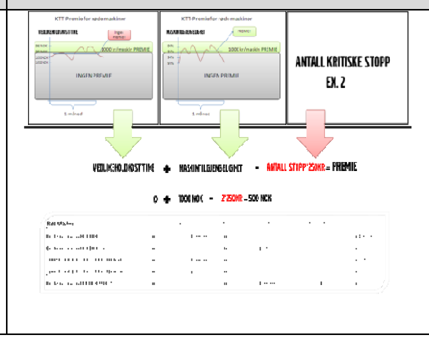
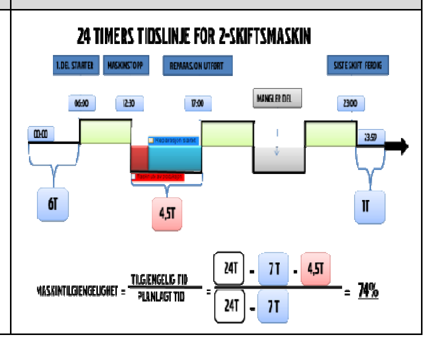
M10: 2D Lay-out	M11:Project Affiliations	M12:KPI Reasoning
		
M13:Bonus Model I	**M14:Bonus Model II**	**M15: KPI Timeline**
		

Figure 6 Lightning models

Findings

The findings in this paper are the experiences gathered from applying the 15 models in the case studies. After each segment we present the recommendation matrix where we have summarized the experiences of 40 models created by the model generator. Below each statement are three numbers to symbolize how many of the models analyzed confirm, are neutral to or contradicts the statement. The sum of these numbers is the amount of models applied that relates to the statement.

Applying the working models. M1, M3 and, M5 are all working models designed to solve the problem concerning too long operation time in a manufacturing process. The incentive to create the model came from engineering staff, a second-level stakeholder relative to the system of interest. The second-level stakeholder rejected M1 immediately because of the model's overextended use of visual imagery. The stakeholder had stated a need to show identifying operational information. The model generator met this need by showing 3D-CAD drawings of the process and its factory location. The visual information in the model was not new to the engineering staff and only led to focus being shifted away from the process data. To satisfy the stakeholders we had to reduce the model novelty by replacing the visual imagery with operation identification numbers and key process operation-time information as displayed in M3. Simultaneously, the M1 model showed to be fit for third level stakeholder when picked up by middle management using it as a lightning model. Attempts to apply M3 to the first level stakeholders were met with apathy and non-interest. After conducting stakeholder interviews it became apparent that using a model only to emphasize to a group that their results are poor does not inspire to improve. By directing the focus on what the problems are and where the problems occur, a more positive response was obtained. Therefore, in the creation of M5 the focus on time use was de-emphasized and replaced a detailed overview of the amount of errors and their location on the part. This in turn required the development of a more detailed model. After the model was applied a welding task force was created to continue the improvement work.

M2 in Figure 2 is a typical meta model used in a creative thought process. The model was expected to be perceived as novel and unfamiliar, considering that the receiving stakeholders had never been introduced to a similar model type before. The model was intended for use with first level stakeholders in the bonus project group comprised of engineers and managers. The model was immediately met with skepticism because the stakeholders expressed that they did not comprehend the model. After the presenter was given the chance to explain the model and its rationale the model seemed to be understood but its practical value in the project was questioned. As the project progressed, discussions arose pertaining details explained in the model. Even though the model presenter could successfully use the model to resolve the issues raised there was still hesitance among some of the stakeholders to continue application of the model. The model generator estimated the model to have 2 or 3 iterations with the group. Apparently, the model generator had put too much novelty into the model compared with how long it would take to understand. A higher number of estimated iterations allows for a longer learning period for the audience.

First- and second-level stakeholders used M4 in Figure 3 in weekly meetings to define the project status. The project group was divided into several smaller groups that worked on individual parts of the machine. Guided by the model the group could systematically move through the machine to identify possible causes for poor point-welding quality. The general opinion was that the model worked well to organize discussions in the weekly meetings where a top-level brainstorming was conducted. However, neither of the groups involved found the model useful when working on their assigned part of the machine.

	Stakeholder's Systems Proximity	Model Novelty	Level of detail
level 1	A level one stakeholder reacts well to working models because of its iterative nature. *conform: 4, neutral: 0, contradict: 0*	Open to a high degree of novelty but requires careful and precise presentation of modeling concepts to the audience. The more expected model iterations allow more novelty. The project manager/leader must be onboard before applying the model. *conform: 4, neutral: 0, contradict: 0*	A high level of details is preferred. Simplifications are not as well received because the can be viewed as personal interpretations of model architect. *conform: 2, neutral: 2, contradict: 0*
level 2	A second level stakeholder can find a working model effective if the size of the project is great enough and if there is heavy corporate focus. *conform: 3, neutral: 0, contradict: 0*	Using models with some novelty is possible but must be weighed against the project size, number of iterations, and model level of detail. *conform: 2, neutral: 1, contradict: 0*	A model can have a high level of detail if presented in a quick and efficient manner. Second level stakeholders regularly don't spend as much time on a system of interest as a first level stakeholder. *conform: 2, neutral: 1, contradict: 0*
level 3	A working model has little or no effect on a level 3 stakeholder. It will be rejected or ignored. *conform: 2, neutral: 0, contradict: 0*	The third level stakeholder will not have to be explained new tools of methods. Novelty can be used to make a model more esthetically beautiful and appealing. *conform: 2, neutral: 0, contradict: 0*	Relative to a first or second level stakeholder a lot of information will be filtered out before reaching a third level stakeholder *conform: 2, neutral: 0, contradict: 0*

Table 1 Model Matrix I: Working models. A working model is a model that is repetitively used and iterates after stakeholder feedback

Table 1 contains the working models section of the recommendation matrix. A total of 9 working models have been assessed, four to first level stakeholder, three to second level, and two models to third level stakeholders. None of the models applied contradict the findings recorded in the matrix though some are neutral to them. This can happened if external circumstances stop the model from being used properly.

Applying the stand-alone models. Acquiring feedback to assess the effectiveness of a stand-alone model is a far greater challenge than for a working- or lightning model. This is due to the absence of the instantaneous response, which in most cases is the most honest feedback.

M6 and M7 from figure 4 were made after complaints by the users of a robot programming manual. The original manual was a text manual attempting to describe the process of introducing new products to a robotized marking machine. It was perceived as unnecessary long and tedious to describe the system set-up and programming procedure. By shortening the text and using 3D visualizations, we have introduced the sufficient information via a model with low novelty and correspondingly low threshold for comprehension. After revising the manual the time to program each new part was reduced by 50%.

The model illustrating the data-flow hierarchy in a robot cell can be observed in M8 presented in Figure 5. Although the first-level stakeholders (in this case the machine operators) gave positive feedback on the posters, their interest faded after a few weeks. The information in the models was not very detailed and after seeing the posters daily, they soon knew everything on them. The purpose of the posters had not been clearly defined. Perhaps the posters should have been updated to increase knowledge to the first level stakeholders. Instead, the posters remained as they were because of their positive effect on visiting businesses. When the third-level stakeholders visit the factory they can stop at the machine and receive useful insight that would otherwise be difficult to obtain.

The intended recipients for M9 were a group of second-level stakeholders in the engineering production crew for a particular VAN product. The idea was to use it as a working model to aid discussions about production flow and machine utilization. The stakeholders responded that the model was esthetically pleasing but they preferred to continue using an operation list from SAP because the additional production information, displayed in the model, was perceived as redundant. Coincidentally, a new employee that worked in another division in the company stumbled upon the model. Being a third-level stakeholder the model entailed just the right amount of information and the visual aid for his needs.

	Stakeholder's Systems Proximity	Model Novelty	Level of detail
level 1	A typical stand-alone model for a first level stakeholder is some sort of documentation or procedure that can be used when necessary. They don't find posters interesting over time if they remain static. *conform: 4, neutral: 0, contradict: 0*	Novelty is often positive if it can simplify large amounts of information. The time aspect for use of the model is long, and opens for time to learn and understand new modeling methods and techniques. *conform: 3, neutral: 1, contradict: 0*	This is a perfect format to include a high level of detail if necessary. Typically entails the type of information that is difficult to remember but manageable to understand. *conform: 4, neutral: 0, contradict: 0*
level 2	The least likely of the stakeholders to use a poster/documentation. *conform: 2, neutral: 1, contradict: 0*	Keep it simple and concise. Far less open to novelty than the first level. *conform: 3, neutral: 0, contradict: 0*	One can use a fair amount of detail if the novelty is low. The stakeholder will normally not spend much time on the model. *conform: 2, neutral: 1, contradict: 0*
level 3	The perfect stakeholder for a poster. They will in most cases only have one viewing of normally 1-10 minutes *conform: 3, neutral: 0, contradict: 0*	The novelty must be balanced with the level of detail. It is preferred to use intuitive means in the model. Test the models before applying on a typical stakeholder. *conform: 3, neutral: 0, contradict: 0*	Must be balanced with the novelty but a general rule is; less is more. *conform: 3, neutral: 0, contradict: 0*

Table 2 Model Matrix II. Stand-Alone Models. A stand-alone model is a model that can be presented without any explanation ex. a poster. It should contain just the right amount of information to help the stakeholder.

In Table 2 we view the stand-alone models recommendation matrix. We recorded a total of 10 experiences that are included in this table. Like the working model matrix we have no real contradicting observations. This has much to do with the amount of models assessed and that the claims in the matrix are not especially bombastic.

Applying the lightning models. The lightning model is probably the easiest to evaluate because of the immediacy of the feedback. We experienced that, at VAN, a presenter will be told if the model is difficult to understand or if any information or logic is wrong, if given the opportunity.

Both M10 and M11 in Figure 6 are from the proposed automation projects previously mentioned. These lightning models were designed for presentation for third-level board members. When making the presentation the model generator was fortunate enough to get directions from one of VANs most experienced managers, who had worked his way up from being an operator, and knew what would work in a board presentation. By analyzing his feedback, we could transfer it to the chosen impact factors. When creating M10 the generator was a bit hesitant to use a 2D-CAD drawing because of the level of detail it seems to entail. The feedback, however, indicated that the novelty of a CAD drawing was greater to the model generator, giving a sense of greater level of detail, than to the board members who were comfortable using the tool. The level of detail actually proved to be too low for the second level stakeholders in middle management who got hung up on semantic details pertaining some simplifications. M11 was at first created with input from second-level stakeholders to show the connection between the project and affected projects and stakeholders. The original model had overlapping circles and descriptive arrows to show the exact relationship between- and magnitude of the projects and partners involved. This time the feedback was to simplify. Nobody on the board had any interest of knowing these details, only a short presentation of the parties and projects involved. The presentation led to board approval of the continuous concept development.

M12 in Figure 6 is the lightning version of the working model M2. Since M2 originally were perceived to have too high degree of novelty we simplified the model drastically for a second-level presentation. The presenter could spend, because of the simple model, some time explaining the reasoning behind the KPI choices illustrated by the model. Although M12 was much better received than M2 we could not have made M12 without the work done by using M2, verifying M2’s usefulness.

M13 to M15 in Figure 6 were used in a status meeting with both first- and second-level stakeholders. Models in M13 and M14 described two different methods of calculating the bonus. The graphs are used to visualize how the differences in performance would alter the bonus instead of just presenting the equation. The background for the calculation methods was weeks of discussions of possible implications. By simplifying the model we were able to put a lot of information in a simple model. In this case, it was evident that creating a model with low level of detail does not always imply shorter creation time as indicated by Engebakken (Engebakken 2010). Attempting to describe the reasoning behind the KPI “machine accessibility” without a model as basic as M15 is extremely difficult. The level of detail needs to be low in the model. Confusion about the KPI terminology complicated matters. When presenting this storytelling model with the support of a two-minute guide through the 24 hours presented, the stakeholder recipients expressed satisfaction with the model. The discussion following the presentation contributed to verify the effectiveness of the models since there was no confusion about our method of calculations, but rather an interest in which method would be best. Also by detecting a minor error in the model, a second-level stakeholder demonstrated that she fully understood the logic of the model. After the presentation, the KPIs were officially agreed upon and one of the calculation models was chosen.

All the modeling cases presented in Figure 6 had first level collaboration in the creation for other stakeholders. It was during this process where most of the discussions were held and decisions made. The iterative fashion in which these models are made is similar to the process with working models.

	Stakeholder's Systems Proximity	Model Novelty	Level of detail
level 1	Using lightning model is often accepted to a limited degree. Often contributes to the creation process. Gives less room for 2-way communication. *conform: 3, neutral: 2, contradict: 0*	Novelty can be used as long as one keeps the time constraint in mind. Test models before presentations. *conform: 4, neutral: 1, contradict: 0*	A low level of detail I preferred. Tends to like shorter presentations *conform: 4, neutral: 0, contradict: 1*
level 2	Lightning model is often a good format to use to convey quick information. *conform: 4, neutral: 2, contradict: 1*	Novelty can be used as long as one keeps the time constraint in mind. Test models before presentations. *conform: 4, neutral: 2, contradict: 1*	Often depends on the presenter's ability to communicate. The model must match the presenter's style. *conform: 4, neutral: 2, contradict: 1*
level 3	Is highly suited for lightning models. *conform: 8, neutral: 1, contradict: 0*	Some novelty can be used but be alert to what is novel to your audience. *conform: 8, neutral: 1, contradict: 0*	Might like a bit less information than second level in each model. Is often open to more models in a presentation. *conform: 6, neutral: 1, contradict: 2*

Table 3 Model Matrix III: Lightning models. The lightning model is a model that is to be presented, and understood, in about 1-4 minutes. This model does not need to stand alone.

The recommendation matrix for the Lighting models can be viewed in Table 3. We have applied a total of 15 models with the majority for the third level stakeholders. In contrast to the other matrixes we now have some contradicting observations. This is probably due to the amount of models being larger. When reaching a certain level of models assessed it would be reasonable to have some models that contradict the statement to show that you statement is not too generic. Too many contradictions would on the other hand imply that your statement is wrong.

Feedback

It can be complicated to measure the value of Modeling, as a Systems Engineering technique. Honour states that understanding the value of SE requires quantifying that value and that such a theory of necessity includes a statistical representation of human nature of the developers, a representation frequently viewed with skepticism (Honour). There will always be a level of personal interpretation of the model builder. The best kind of feedback is the one that is given without request because it is not tainted by the question asked and the recipient's first impression is still vivid. Validation that the model has addressed the initial need for the model is also important. Preparing a couple of revealing questions has proved very useful at times. Sometimes one may get a false impression that recipients understand the model until the right question is asked.

Reflection and future work

Muller states that models only get value when they are actively used (Muller, 2009). This has become evident after applying the recommendation matrix to our modeling work. The use of a 2D matrix forces the model builder to actively acquire feedback that in turn uncovers their weakness or strength. Muller's statement applies equally to the model builder as to the audience.

We have written this paper under the assumption that uncovering a set of trends for building models will reduce iterations and reduce model creation time. Now that these trends have been discovered it would be prudent to further study if our assumptions are correct. It would also be interesting to study if the classifications in the recommendation matrix apply equally well outside of VAN and if the same modeling trends are present.

We have conducted the first attempt at creating a recommendation matrix with model classification and harvested indications of positive results. However, the classifications and definitions applied are in need of future studies in order to be solidified and validated.

Conclusion

The aim of this paper was to research the feasibility of guidelines organized in a recommendation matrix. By using a two dimensional matrix we can offer model builders guidelines that support differences in impact-factor on stakeholder system proximity. The research method applied has uncovered clear distinctions between nine elements in a recommendation matrix.

The models that have been made and applied as part of the study support harvested trends per class of models. The main criterion for confirmation of a trend is the observed stakeholder satisfaction of the relevant models.

Using models to aid communication has, for different reasons, resulted in increasing project progress and thereby giving value to VAN. Models probably will be made and updated more often if the time to make them can be reduced. Reducing modeling time is attractive for companies using models.

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References

Engebakken, E., Muller G., Pennotti, M., *Supporting the System Architect: Model Assisted Communication,* Systems Research Forum, Vol. 4, No.2, 2010, p173-188.

D.D. Woods, "Visual Momentum: A Concept to Improve the Cognitive Coupling of Person and Computer," Int'l J. Man-Machine Studies, vol. 21, pp. 229-244, 1984.

Honour. Eric C., Understanding the Value Of Systems Engineering. Honourcode,Inc. Pensacola FL,USA, 2001

Gerrit Muller, Course Module Modeling and Analysis: Analysis and Using Models, November 29, Kongsberg: Buskerud University College, 2010