ACCELARATING JOINT DESIGN: SIMULATION BUILDING BLOCKS AND PROCESS SUPPORT

EDWIN C.VALENTIN, JACO H. APPELMAN and
MARIELLE DEN HENGST-BRUGGELING

Delft University of Technology, the Netherlands
faculty of Technology, Policy and Management
{edwinv ; jacoa ; mariellb}@tbm.tudelft.nl

Abstract: Simulation is often seen as a powerful, but time consuming research instrument. We think that by employing simulation building blocks it is possible to use simulation in joint design meetings. We reflect on field experiments where this approach was tested and discuss how these findings inform the design of the joint design meeting. We aim to offer the first contours of an approach that could deliver a jointly designed simulation model in one day.

Keywords: Collaboration, meeting activities, process design, simulation, joint design, building blocks, collaborative engineering.

1 INTRODUCTION

Strategic decisions that involve the use of technology cannot be undertaken without taking into account their impact on relevant stakeholders. Collaboration is therefore an important activity during the development of new policies or preparation and execution of technically complex projects. This communication intensive process tends to consume a lot of time because it usually has to provide solutions for a mix of interrelated strategic or technically complex problems that impinge on different disciplines [Ackermann & Eden, 1996; Vennix, 1996]. A solution often used to shorten decision-making processes is by employing Group Decision Support [Vreede, 1995]. However, the actual act of decision-making is not the most intricate part in the process, evaluation of different alternatives or convergence towards one best or most shared solution is much more difficult. A popular research instrument that can support these meeting activities is simulation because it provides insight in the behaviour of a system and visualizes outcomes. Actors involved in the decision-making process can qualify and quantify the different solutions.

However, the modelling of a system is a cognitively complex task in which the time needed to deliver a specified output cannot be accurately predicted and tend to consume a lot of time [Keller et al, 1991]. It is not uncommon for a simulation study to take over a year, which is often too long for decision makers. In previous research we found that simulation building blocks can reduce the time of a simulation study and still provide the support required by decision makers [Verbraeck et al, 2002]. Support is improved because decision makers better understand the simulation models and much more alternatives can be evaluated in a shorter time-frame, thanks to the fact that model adjustment is significantly easier.

An interesting new research field is the combination of the design of collaborative meetings and simulation because it could amplify the advantages simulation delivers. We expect that simulation studies will be concluded much faster and we aim to reduce the lead-time of simulation studies from months to at most a couple of meetings. The way we hope to do that is:

1. through a reduction of the cognitive load involved in constructing a model by using simulation building blocks;
2. and by structuring and designing GSS-supported meeting processes explicitly.

Formulated in this way we built on earlier research in the research-tradition labelled Collaborative Business Engineering [Maghnouji et.al., 2001]. We describe in this paper a background on simulation and building blocks (section 2). Then we introduce the concepts of meeting activities and ThinkLets(section 3). We elaborate on our experiences with two experiments that meant to speed up joint design of models (section 4). In section 5 we provide an overview of our observations and we describe the sequences of meeting activities that should be performed during different phases of model construction. We conclude in section 6 with the main lessons learned concerning joint design processes that use simulation blocks and offer suggestions for further research.

Proceedings 17th European Simulation Multiconference
(c) SCS Europe BVBA, 2003   ISBN 3-936150-25-7

2 BACKGROUND ON SIMULATION, BUILDING BLOCKS AND JOINT DESIGN

Joint design or collaborative engineering can be used amongst others, to develop solutions for problems in multi-organizational settings. Different actors with different opinions want to make sure their points of view are represented in the design and ensure that the selected solution satisfies stakeholders they represent. As a result even simple convergent problems are affected by politic and social contexts, which leads to messy problems. [Ackermann and Eden 2001, Appelman 2002, Vennix, 1996]. In such circumstances it is of utmost importance that all stakeholders involved have a common frame of reference, a shared group memory. Modelling is a way to condense information to such an extent that all participants can make sense of the impacts that the modelled system might have.

Visualization of the potential impacts of choices or policies through building blocks contributes to more speedy but robust decision-making. [Verbraeck et al, 2002]. Note that visualization is broadly defined, the use of charts, graphs or other means that condense information is also implied. Visualization is thus not only cartoon-like animation of trucks going from A to B. The visual is the dominant sense that allows us to grasp and formulate, in retrospect, knowledge that can be generalized and objectified. Something that is much harder for other senses like hearing and taste [Urry, 2001]. We hypothesize that visualization of outcomes or behaviour of a system boosts the alignment of perceptions. All participants SEE the same information and, they do not have to develop their own individual mental pictures as much as they would have if they would have listened to an oral explanation. Cognitive distance between group members be more easily achieved when visualization of the process and outcomes is possible. [Nooteboom, 2001] Perfect alignment of perceptions would mean that every member had the exact same image of all the objects and outcomes involved. Alignment therefore ensures that the participants involved in a process of collaboration come to more robust models in a shorter time-frame. Alignment of perceptions also contributes to the creation of consensus that supports decision-making and implementation. The more visualization and joint design practices contribute to a shared focus the more likely it will be that the project will also be successful in the implementation phase.

We conclude that there seems to be a great potential for collaborative simulation but, in practice, it is used sparingly. Keller et al [1991] propose that the following reasons mainly account for this fact:

- that the simulation experts do not understand the decision makers, and thus deliver simulation models that do not provide the right answers and;
- that the simulation process takes too much time, and thus provides the desired support after the ideal moment of decision making.

Simulation building blocks support the rapid construction of simulation models because visualization ensures a high recognizability of the concepts for all stakeholders involved [Valentin and Verbraeck, 2002]. Building blocks hide the complexity of the underlying code and the complex functional behaviour and they provide an easy to understand user-interface including visualization. At the same time, visualization could improve the quality of decision-making because all actors share the same set of visualized system building blocks and these enable cognitive distance to be bridged.

Building blocks are in first instance a technical feature, used for the execution of current simulation studies but we think that this concept constitutes a key innovation for joint simulation in the future [Pater and Teunisse, 1997; Valentin and Verbraeck, 2002]. Whether it concerns a new container port, the expansion of an airport, the organizational structure of local governments or the closing of a factory, in each of these cases different actors with different learning-curves, opinions and ideas talk and discuss a visualized lay-out that is the same for every actor involved.

Zeigler et al [2000] reflect on the different modes of collaboration necessary at different stages of model building. They base themselves on the concept of DEVS, which provides chunks of re-usable simulation models similar to simulation building blocks. The DEVS-approach incorporates all stages of a model-building trajectory [Banks, 1999]. Each stage consists of a number of phases. To each phase, within a stage, a collaboration mode is assigned and a drawn-out process is implied. Zeigler et al do not, however, devote much text on what the different collaboration modes entail in terms of cognitive (group-) activities that have to be performed. This "simple" version of collaboration and simulation is visualized in figure 1.

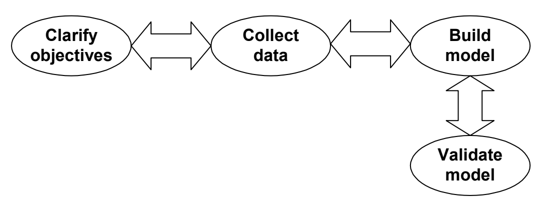

Figure 1: Phases in Model Construction (adopted from Zeigler et al, 2000)

They do not expand on what happens in the different phases and do not explain what the different actors should do during the joint design process. We intend to remedy this situation by formulating a process design based on meeting activities and simulation building blocks. For the sake of the argument, brevity and clarity we assume that all activities take place in one conventional meeting.

In collaborative settings the validation of the model will directly lead to suggestions for adjustments to the model, which means a new model. Although the arrows in the "simple' model represent the iterative character of collaborative processes it is not visualized clearly enough and it does not show at any point in the process the modeling exercise could be abandoned.

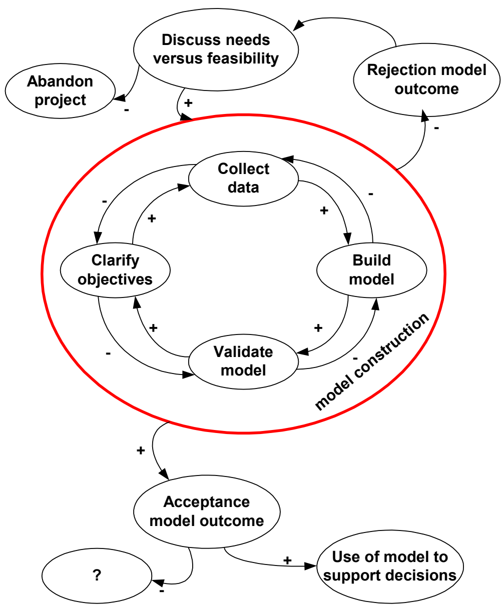

Figure 2: Dynamic Model of Model Construction

Figure 1 displays only a small part of a more complex problem solving project. In figure 2 we contextualize the generic core-model, we show the relation of the 4 phases within the whole project. The actors involved have the power to stop the cycle at any moment and accept or reject whatever outcomes have been reached thus far. The process facilitator should constantly be aware of the possibility that such a contingency occurs. One of his main tasks is to ensure that people stay committed and participate as long as is needed.

3 PROCESS STRUCTURING USING MEETING ACTIVITIES

We argued that Zeigler's work provided a good foundation to model/describe meetings but that it could be ameliorated by the provision of more detail on what needs to be done during the different phases. In order to be able to do this in section 5 we introduce here the concept of meeting activity and ThinkLet.

At an abstract level the following 5 meeting activities can describe any meeting: Diverging, Converging, Organizing, Evaluating and BuildingConsensus. Divergence is popularly known as brainstorming and denotes going from a few or no concepts to a larger number. Convergence works the other way around, here we reduce the amount of concepts, ideas, etc. Organizing serves to structure in information in such a way that the participants and the constituencies they represent recognize their input and to ensure that all the participants share the same group memory. Put differently it is a move to a better understanding of the relationships between concepts or categories. Evaluate involves specifying criteria to value concepts. It is a move to achieve more understanding concerning the values a group attaches to concepts. Building Consensus is the last activity and it denotes the process of getting more agreement among stakeholders wit the outcomes of the meeting. (although it can also be an objective of a meeting in itself). Building Consensus inevitably entails a degree of negotiation and could be considered a 'cross-over' phase or an activity that connects collaboration with negotiation. Since negotiation is a separate field of research we do not go into these activities involved.

In addition to the meeting activities researchers at TU-Delft and Arizona University have formulated a smaller unit of analysis, that represent processes and (the settings) of technologies used in meeting activities. In short, structures the design of GSS-supported meetings, this unit has coined a ThinkLet and is defined as: "the smallest unit of intellectual capital required to create one repeatable, predictable pattern of thinking among people working toward a goal." [Briggs and de Vreede 2001: p.1] ThinkLets have as an additional benefit that they focus on the process of thinking and reasoning a group must go through in order to achieve a goal. Which was one of the elements we found lacking in the description of Zeigler and we need such insights to integrate joint design of simulation models with building blocks and meeting design. In other words, we aim to integrate the processes of thinking and reasoning that are part of simulation and modelling exercises with processes of reasoning and thinking that are commonplace in (electronically supported) meetings. A ThinkLet is build up of 3 parts:

- the script,
- the tool and,
- configuration of the tool.

The script explains how the ThinkLet should be introduced to the group by the facilitator or chairman as part of the meeting activity. The script contains instructions/explanations about the tool, and the activity to be performed. A tool is defined as a description of the version of the software and hardware used to create a pattern of thinking. The configuration details the specifics of how the hard- and software are configured to create a particular pattern of interaction. We disregard the hardware requirement in this paper that is necessary for research purposes because otherwise verification of results cannot be undertaken. Here we do not compare GSS-research outcomes, so the need is not there.

ThinkLets are categorized according to the kind of meeting activity they support but there are many variations to a theme. One can for instance, diverge in multiple ways. We will return to this observation in section 5.

Now that we have introduced the concepts of ThinkLets and meeting activities we continue, in section 4, with two experiments that elucidate the intricacies and barriers that groups of users experience when using simulation blocks. We draw lessons from these cases that, at a later stage, might lead to 'recipes' or 'prescriptions' of sequences of ThinkLets for joint design meetings. In section 5 we limit ourselves to a formulation of process guidelines that would support successful joint design meetings. We will do so, after we have described the activities to be undertaken in each phase of model construction.

4 OUR OWN EXPERIENCES WITH JOINT DESIGN AND SIMULATION

As argued before, process improvements occur in joint design meetings when simulation building blocks, that visualize output or represent it graphically, are used to develop simulation models. Improvements in efficiency (time-compression) and effectivity (more robust models) are anticipated. In this section we sketch our first experiences and conclusions on joint design based on one field (airport-security) and a laboratory (container-terminal design) experiments. The first experiment we researched the phases of model building and validation in the last and more controlled experiment we made the participants go through all 4 phase involved in model construction.

4.1 Security at Amsterdam Airport Schiphol

The European Committee requires that everyone in the lounges of international airports is screened for security reasons. This means that airports have to integrate security with passport control. The effectuation of this requirement involved participation of four important stakeholders at the Amsterdam Airport Schiphol:

- Securop, the security company of the airport;
- KMAR, the Royal Dutch Police the organization that checks passports;
- The passengers' representatives;
- Schiphol passenger management.

These four different stakeholders entertained different ideas and preferred different solutions. For example, Securop liked to provide a large number of staff; the passengers do not want to wait and Schiphol Management does not want to pay.

In three joint design meetings the actors were brought together to discuss different alternatives using simulation. The design options were the number of passport checks and security X-ray machines, the sequence (first passport check followed by security check or other way around) and the planning and allocation of personnel over different locations at the airport. Detailed descriptions of the simulation building blocks used in these experiments can be found in Verbraeck and Valentin [2002].

During the sessions, designs were configured and transformed to simulation models. Transformation took a few minutes, but the run of the simulation and the evaluation of the outcome was a cumbersome task. The process facilitator needed to keep the participants occupied with anecdotes, but participants responded that this was misuse of their valuable time. They were able to quickly specify what they wanted because of the ease of use of the building blocks and expected that the results could be displayed almost instantly. However, the transformation slowed down because the level of detail inside the simulation models resulted in a lot of data that complicated analysis. The level of detail also affected the ability to rapidly adjust the model and affected speed of the simulation runs. The main effect of slow transformation was that participants became dissatisfied with process and therewith with outcomes.

4.2 Design of container terminals

A management game served as a pre-text for a laboratory experiment. Ten different kinds of (simulated) actors (like municipality, bank, logistics company, environmentalists and residents) were part of the experiment. All actors were obliged to jointly design a container terminal. The management game showed how participants should interact and specified how many different performance indicators were needed to design a container terminal from hundreds of design options. Like in any multi-actor system, each actor had a different set of priorities and desired outcomes for different performance indicators. For example, residents did not want the container terminal to make a lot of noise, a bank wants a stable financial plan and an operator expects a healthy profit margin.

Most of the performance indicators of a container terminal could only be evaluated with a simulation model. We developed a set of simulation building blocks that represented the behaviour of a container terminal. We simplified the design process by the provision of a link to the drawing environment VISIO and outcomes of the simulation model were produced in the form of an Excel sheet.

The participants (70 students of our full-time education program) filled a questionnaire after the game. Main conclusions from the survey are that the support tool consisting of VISIO-drawings, a pre-defined database, easy to understand Arena models and representation of outcomes in Excel, helped them with:

- Understanding each other's roles and preferences (94%)
- Evaluating the performance of the designed container terminal (85%)
- Speeding up the design process (81%)
- Making container terminal designs of high quality (68%)

More detailed information concerning the outcomes of the survey can be found in Bockstael-Blok et al [2003].

We tentatively conclude that the use of simulation in this management-game was a success, however, observations by experts on collaboration made some other things clear as well. For example, the participants could and did easily hide some input parameters, which made their results look much better then they actually were. The participants also limited themselves to a discussion of topics defined by the support tool. They did not produce alternative solutions like: noise-shields, deepening the canal or replacing the marina because these topics did not have corresponding input parameters in the support tool.

5 THE INTEGRATION OF PROCESS SUPPORT AND SIMULATION BUILDING BLOCKS

We combine the lessons from sections 3 and 4 and formulate a number of suggestions on how to model the process of GSS supported meetings using simulation building blocks. By linking the domains of group systems support and simulation it is possible to deliver better simulation models in a shorter time span.

5.1 Pre-meeting

A meeting can only be effective when it is thoroughly prepared. A meeting that aims to design in the context of a multi-actor environment should even be better prepared because of the need to satisfy diverging or opposing interests and to cope with complexity that is a result of the need to accommodate interests or to integrate different technologies to produce a solution. Another reason for the rejection of model outcomes surfaced from the experiment. This became especially clear in the airport field experiment. The delays that occurred between the input given by the participants and the time needed to produce visualized results did not match their expectations. The net result was dissatisfaction with both process and outcomes. The outcomes the validated models delivered were not trusted. The outcomes were rejected and a discussion on the need and feasibility of a new round of joint design meetings ensued. It was decided that the model construction phase would be outsourced so decision makers would only have to bother themselves with selection of the 'right' model.

It is therefore important to try to mitigate goal-divergence, manage expectations, accommodate interests and to avoid delays between input delivered by the participants and output generated by the model/GSS. Ideally, the 'object-clarification' phase and data-collection phases are completed before the meeting. Practically it would mean that:

- A set of simulation building blocks has been developed or bought that fit the design questions of the actors involved.
- The time needed to transform input into visualized output is tested and improved if deemed necessary. Put differently, a number of simulation models should be developed beforehand.
- An initial simulation model, ideally drawn from information provided by the organizations and their representatives that will participate in the design meeting(-s), has been developed.

Zeigler et al comment on this phase: "… consider that it is very hard to get people to agree on common objectives in building a model. Perhaps, the only way to do that is to bring them together in one room and try to hammer out agreement through seemingly-endless discussions. Several meetings of this sort might be required."(Zeigler et al, 2001:534) However, we said that we would aim to reduce the cycle of model construction to one meeting. Which is what we will do in the next subsections.

5.2 Meeting activities to support the model construction cycle

5.2.1 Phase 1: Clarify objectives

The meeting should start with explanations by the facilitator or problem-owner(-s). It should be made clear why the meeting is held, why the group of persons is brought together, why simulation will be used and what the possible outcomes of the different simulation runs will be. This exercise is important because it is a mean to manage the expectations of the group and we have seen that unmanaged expectations concerning the time needed to produce results in the Schiphol case led to rejection of the model and its outcomes. The facilitator should make sure the process is of interest to all participants. They will feel more committed when they perceive the advantages of participating.

When the meeting is supported by a GSS, participants will start to diverge, brainstorm. They produce a list of objectives that then needs to be organized to allow for an evaluation. The evaluation will deliver a ranking and reduce the number of objectives as far as possible. Through evaluation the group converges toward the most important objectives. Then a new divergence activity starts where participants can comment on the remaining objectives. This activity ensures that the participants align their individual perceptions they bridge cognitive distance in this phase. The last step is the building of consensus. This can be a lengthy process but if these meeting activities are converted to a design with ThinkLets we estimate that this phase can be done in 2 to 3 hours. Provided that all decision makers are present and not one of them has an agenda of frustrating the meeting. Secondly, divergence can also be done in a 'relay-form'. This opens up the possibility to let decision makers define objectives, that are then checked by technical experts concerning the feasibility of the objectives. Once closure has been reached on an objective a facilitator can instruct the GSS to forward this objective to domain experts that in their turn provide the data needed. So, you get cycles within cycles, within cycles and this explains why you can really speed up the model construction phase. Small groups are simultaneously working on different phases but always follow the right order that lead to the construction of a model. When done in such a way it becomes possible to construct a model in one meeting.

Reality is however never so clear-cut as we would like to have it. We do not deem it likely that everybody will start to do 'one-day modelling meetings'. We therefore continue to comment on how meeting activities can best be supported during the different phases.

5.2.2 Phase 2: Data collection

Data collection can be a synchronous non-distributed group activity, but it is unlikely because it would mean that a facilitator would be able to predict, before the phase of the clarification of objectives has commenced, what data need to be gathered and which actors can deliver that particular data. It is perhaps much wiser to do this a-synchronous and let simulation expert evaluate the data for usability. However, if done in a meeting the emphasis in this phase should be on divergence and organization activities. As much data as possible should be elicited from the participants and be stored in a group memory to prepare for the next phases.

5.2.3 Phase 3 and 4: Build model and validation

We combine phase 3 and 4 to emphasize the iteration involved in these phases. During these phases a technical simulation model builder should be available for support. Simulation building blocks support the easy and rapid construction of models. Different models and/or different outcomes can be produced. As a result the model building and validation phases will be characterized by convergence and evaluation meeting activities. Within the small group different designs can be generated and evaluated using the simulation model. The order of input in the simulation model determines the order in which topics are discussed. When a simulation model is ready, the simulation model can be executed, followed by an evaluation of the performance indicators. If the outcomes are not satisfactory the simulation model can be adjusted and re-executed. This process continues until the actors in the group can converge to an agreement. The time it takes to build consensus can vary enormously and is influenced by a host of variables that cannot be influenced during a meeting. Consistent with the cases we assume that the goal of the meeting is to produce a model of which the input parameters can be changed. The process of consensus building that should eventually lead to select one best solution or model is not considered.

Taking a number of constraints into account we do think it will be practically possible to design and construct a model jointly in one day. But only if the political activity surrounding the project is low, otherwise people will not feel free to divulge all the information needed to design and construct a model.[Appelman et al, 2002]

6 CONCLUSIONS AND FURTHER RESEARCH

In this paper we describe the possibilities to support the design and use of simulation building blocks to enable joint design. We identified the need for a methodology that supports participatory design processes and the evaluation processes of the designs using simulation. Visual representation makes learning easier and speeds up different meeting activities that need to be performed in a sequence to come to a model everybody can agree to. Our own experiences with joint design were illustrated with two different case-descriptions of experiments with joint design in two different domains.

The most important lesson we learned was to keep expectations of the participants realistic and invest much preparation time in the phases 1 and 2. Investment is not just the development of the right simulation building blocks, execution of test-sessions it is also an investment in the enthusiasm of the participating actors. The experiment with container terminals clearly showed that it speeds up phases 3 and 4 because participants had clear instructions, had to adhere to their role and were provided with the right simulation building blocks. We learned from the Schiphol experiment that time between input and visualization should be as short as possible.

6.1 Further Research

In the beginning of this paper we explained that we aim to develop a first methodology for joint design using simulation. The second case of the container terminal gave us very motivating results, but we know we still have to do a lot of things in the research of joint design. Firstly, we aim to replicate the experiments in order to optimise the design of the process and the simultaneous use of different GSS's. Secondly, we think two other areas of research could offer knowledge to better support joint design. On the one hand it would be interesting to know the extent to which it is possible to perform meeting actitivities such as joint design in a distributed setting. On the other hand research that delivers commonly performed sequences of meeting activities can inform the design of meeting processes supported by a GSS.

REFERENCES

Ackermann, F. and C.Eden "Contrasting Single User and Networked Group Decision Support Systems for Strategy Making," *Group Decision and Negotiation*, volume 10, issue 1, p47-66. 2001

Ackermann, F. and C.Eden "Contrasting GDSSs and GSSs in the Context of Strategic Change; Implications for Facilitation," *Journal of Decision Systems*, volume 6, issue 3, p221-250. 1996

Appelman, J.; Rouwette, E.; Qureshi, S. "The Dynamics of Negotiation in a Global InterOrganizational Network: Findings from the Air Transport and Travel Industry," *Group Decision and Negotiation*, volume 11, issue 1, p145-163. 2002

Appelman, J. "Acceptance and transition Of Group Support Systems in Interorganizational Networks.", *Proceedings of the Group Decision and Negotiation Conference Perth, Elsevier.* 2002

Banks, J. "Introduction to simulation", In: P.A. Farrington, H.B. Nembhard, D.T. Sturrock and G.W. Evans (Eds.) *Proceedings of the 1999 Winter Simulation Conference*, p7-13, 1999

Briggs, R.O.; G.J.de Vreede; J.F.Nunamaker; D.Tobey. "ThinkLets: Achieving Predictable, Repeatable Patterns of Group Interaction with Group Support Systems (GSS)" In: R.H. Sprague and J.Nunamaker (Eds). *Proceedings of 34th Annual Hawaii International Conference on System Sciences* (CD-ROM) , 10 pages, 2001

Bockstael-Blok,W.; I.S.Mayer, E.C.Valentin "Supporting the design of an inland container terminal through visualization and gaming-simulation" In: R.H. Sprague and J.Nunamaker (Eds). *Proceedings of 36th Annual Hawaii International Conference on System Sciences* (CD-ROM), 10 pages, 2003

Keller, L. ; C.Harrell ; J.Leavy. "The three reasons why simulation fails". In: *Industrial Engineering,* Volume 23, Issue 4, p27-31, 1991

Maghnouji, R.; G.J. de Vreede; A. Verbraeck; H.G. Sol; "Collaborative Simulation Modeling". In: R. Sprague, J.F. Nunamaker (Eds.) *Proceedings of the 34th annual Hawaii International Conference on System Sciences* (cd-rom). p. 1-10. 2001

Nooteboom, B., Learning and innovation in organizations and economies, Oxford University Press, 2001.

Pater, A.J.G.and M.Teunisse "The Use of a Template-Based Methodology in the Simulation of a New Cargo Track from Rotterdam Harbor to Germany" In: S.Andradottir, K.J.Healy, D.H.Withers and B.L.Nelson (eds.)*Proceedings of the 1997 Winter Simulation Conference*, San Diego, 1997

Valentin, E.C.; A. Verbraeck. "Simulation using building blocks " In: F.J.Barros, N.Giambiasi (Eds.) *Proceedings conference on AI, Simulation and Planning*, p65-71, 2002

Vennix, J.A.M. *Group model-building: facilitating teamlearning using system dynamics.* Chichester: John Wiley. 1996

Verbraeck A.; Y. Saanen; Z. Stojanovic; B. Shishkov; A. Meijer; E. Valentin; K.van der Meer. *Chapter 2:What are building blocks?*. IN: Verbraeck and Dahanayake (eds.) *Building blocks for Effective Telematics Application Development and Evaluation,* TU Delft press, 2002

Vreede, G.J.de. *Facilitating Organizational Change,* Dissertation TU Delft, 1995

Vreede, G.J. de and A. Verbraeck. "Animating Organizational Processes - Insight Eases Change". In: *Simulation Practice and Theory* 4 Elsevier Science B.V., Amsterdam. pp. 245-263. 1996.

Urry J., *'Mobile Cultures'* (draft), Department of Sociology, Lancaster University, http: //www.comp.lancs.ac.uk/sociology/soc030ju.html

Zeigler B.P.; H. Praehofer, T.G. Kim. *Theory of Modeling and Simulation : Integrating Discrete Event and Continuous Complex Dynamic Systems*. Academic Press, 2000.

AUTHOR BIOGRAPHIES

EDWIN C. VALENTIN is a researcher in the Systems Engineering Group of the Faculty of Technology, Policy and Management of Delft University of Technology. His specialty is the development of domain-dependent generic discrete-event simulation libraries. Edwin participates in the BETADE research program on developing new concepts for designing and using building blocks in software engineering, simulation, and organizational modeling. His web addresses is www.tbm.tudelft.nl/webstaf/edwinv.

JACO H. APPELMAN is a senior researcher in the Systems Engineering Group of the Faculty of Technology, Policy and Management of Delft University of Technology. His specialty is design and support group decision making processes. Appelman has facilitated many group meetings in both public and private environments. His research focuses at the design of group processes to support (distributed) decision making.

MARIELLE DEN HENGST is a senior researcher in the Systems Engineering Group of the Faculty of Technology, Policy and Management of Delft University of Technology. She is a specialist in supporting methodologies for decision making processes. Using a way of thinking of models and group processes she is developing a methodology called Collaborative Business Engineering. Den Hengst has been actively involved in this field with projects for the Port of Rotterdam, the policesquads Amsterdam/Amstelland and the supply chain of Methanol.