Proceedings of the 2002 Winter Simulation Conference
E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, eds.

AN EVALUATION AND SELECTION METHODOLOGY FOR DISCRETE-EVENT SIMULATION SOFTWARE

Tamrat W. Tewoldeberhan
Alexander Verbraeck
Edwin Valentin

Systems Engineering Department
Faculty of Technology, Policy and Management
Delft University of Technology
Jaffalaan 5
Delft, 2628BX , THE NETHERLANDS

Gilles Bardonnet

Accenture
Avenue George V 55
75379 Paris Cedex 08, FRANCE

ABSTRACT

For large international companies with their own simulation team it is often hard to select new discrete event simulation software. Often, preferences and application areas between countries differ, and simulation software already in use influences the outcome of the selection process. Available selection methods do not suffice in such cases. Therefore, a two-phase evaluation and selection methodology is proposed. Phase one quickly reduces the long-list to a short-list of packages. Phase two matches the requirements of the company with the features of the simulation package in detail. Different methods are used for a detailed evaluation of each package. Simulation software vendors participate in both phases.

The approach was tested for the Accenture world-wide simulation team. After the study, we can conclude that the methodology was effective in terms of quality and efficient in terms of time. It can easily be applied for other large organizations with a team of simulation specialists.

1 INTRODUCTION

Currently the market offers a variety of discrete-event simulation software packages. Some are less expensive than others. Some are generic and can be used in a wide variety of application areas while others are more specific. Some have powerful features for modeling while others provide only basic features. Modeling approaches and strategies are different for different packages. There are many properties that make each discrete-event simulation package different. All discrete-event simulation packages have their particular strengths and weaknesses. This makes the selection and purchase of a simulation package difficult. Buying the appropriate discrete-event simulation package is important and can save a lot of money.

Accenture is the one of the world's leading management and technology services organizations. Accenture has a large team of simulation experts, who operate on a world wide basis in many types of projects for a wide range of customers. Currently, the Accenture simulation team uses two different simulation packages (Arena and ProModel), but they want to standardize on one package. The team applies simulation techniques to many different problem domains. The main ones are helping clients in defining strategies, designing processes, analyzing performance and extracting customer's experience. For the team, having one generic discrete-event package instead of several packages increases model reusability, staff interchangeability and reduces model development time, training costs and purchasing costs. The outcome of the research is the basis for a decision which discrete-event simulation package Accenture will use for the next three years.

This paper is structured as follows. First, we describe the background of the project, introducing the state of the field and presenting selection methods available from the scientific community. Second, the methodology that was used here is described. Third, results obtained by following the methodology are covered. Fourth, results are discussed. Finally, conclusion and issues for further research are presented.

2 BACKGROUND

Evaluation of discrete-event simulation packages is not new. Many researchers have carried out surveys on available packages for different purposes. However, there is only a limited number of papers that describe methods to perform an evaluation of discrete-event simulation packages. Hlupic (1997) developed a software tool (SimSelect) that selects a simulation software given the required features. Nikoukaran, Hlupic, and Paul (1999)

created a framework of criteria to be considered when evaluating discrete-event simulation software. Other researchers such as Banks (1991) and Pidd (1992) already showed a similar framework in earlier literature.

The need for having an efficient selection method for discrete-event simulation packages is increasing as the simulation application domain broadens (Shannon 1992) and as the number and type of discrete-event simulation packages increases (OR/MS Today 1999). Companies and institutions that use simulation do some research for their own use, and they use different methodologies and approaches. However, projects and published results on how to effectively conduct evaluation and selection process of discrete-event simulation software are limited.

On of the most elaborate frameworks is described in Nikoukaran, Hlupic, and Paul (1999). This framework is structured, and pays attention to a rich set of criteria on which simulation packages can be compared. It is, however, difficult to base a decision for a large multinational company on these criteria, as it is only a comparison, without weighing and without a method to determine the relative weights, and the weight differences between parts of the simulation team.

3 METHODOLOGY

To evaluate simulation packages, and to select the best one for a large company, is a time consuming task unless an efficient methodology is used. Usually, choosing from a list of alternatives requires detailed knowledge of the selection criteria, and on the score of the alternatives on these selection criteria. If there are many alternatives and if the criteria list is long, the evaluation becomes a challenging task. To accomplish this task efficiently, a two-phase evaluation and selection methodology is proposed, which will be explained below. The methodology was designed to be fast and as objective as possible. Of course it should respond to the specific needs of the simulation team that wants to acquire a new simulation tool.

In the first phase, simulation packages are selected based on the existence of the most important features and criteria. In the second phase, detailed evaluation and analysis are done for packages that satisfy the requirements of the first phase.

During the two phases, numerous interactions take place between the simulation team, management team, selection team and simulation package vendors. The selection team is defined here as the analysts who are responsible for carrying out the research and making the final recommendations for selection. They can be employees of the company or external consultants. The interactions between the actors are indicated in Figure 1. The vendors have only a limited interaction with company management (price) and the simulation team (demos), and most of their interaction with the selection team.

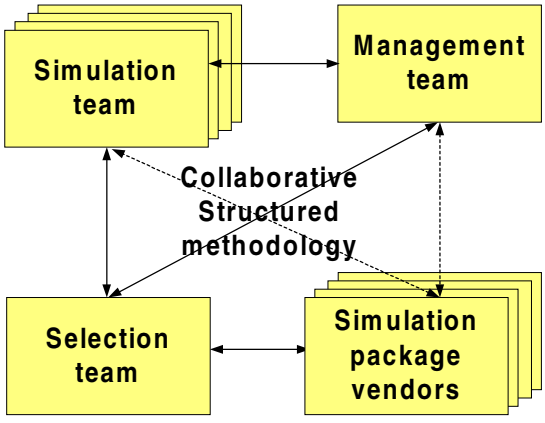

Figure 1: Interactions during the Selection Process

3.1 Phase One: Feature Check

In phase one, a list of required features is created, and a wide list of discrete-event simulation software packages are checked for availability of these required features. To accomplish this 'feature-check' phase, the following steps are taken: vision and requirement identification, criteria extraction, criteria weighing, characteristics of discrete-event simulation software identification, and screening and ranking the simulation software. Those packages that satisfy the first phase are transferred to the second phase. The detailed methodology of phase one is as follows.

3.1.1 Vision and Requirement Identification

Identifying the overall vision of the simulation team for the near future is necessary for identifying the functional requirement for the simulation packages. The vision covers items like: current and near future application area of discrete-event simulation, type of product/service, types of customers, business process or work routine, business objective and similar aspects. A questionnaire is one of the main methods to be used to extract the necessary information from the team. In other cases where the selection is carried out internally within a company, other methods such as workshops or a brainstorming session may be used (see Figure 2). The exact purpose of the questionnaire is to get the following items: future goal and plan of the simulation team regarding discrete-event simulation studies, main fields on simulation in which the team is involved, current use of discrete event simulation package in the team as well as near future use, features the team experts need from a simulation package, constraints the team expert have in the current simulation packages they use, and a criteria list for evaluation of packages with a ranking. In addition, interviews and library research can be used. Results that are found to be inconsistent during the analysis are discussed again with the team. The criteria list, then, is categorized using the Nikoukaran, Hlupic, and Paul (1999) framework.

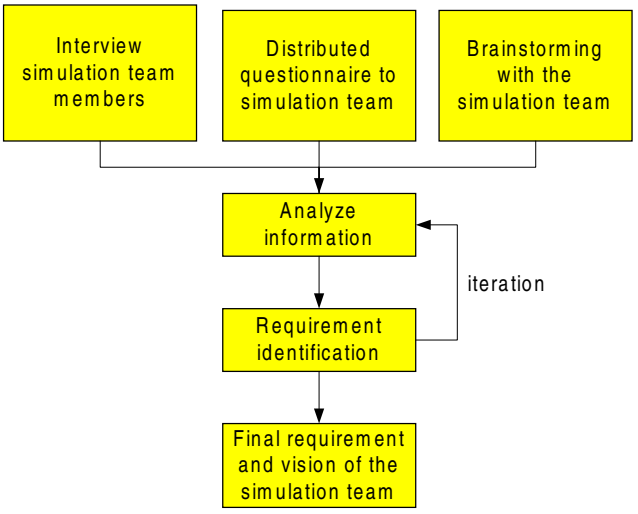

Figure 2: Vision and Requirement Identification

3.1.2 Criteria Extraction

Based on the vision identified and additional sources, criteria are extracted by the selection team, in close cooperation with the simulation team. The additional sources for input are external experts on simulation, the company's clients, internal project findings and reports, and literature. Criteria are extracted from the vision by asking questions such as: "*What are the main features of a simulation package that make it applicable to a wide range of problems?*", "*What functionalities are often used during an engagement*?", "*How does the team address a client's problem?*", "*How does the team use the simulation packages?*", and "*What are the main objectives of the simulation projects carried out?*".

For the additional inputs, literature, research projects and clients are consulted. From literature and research projects, the importance of certain criteria for particular application areas can be extracted and discussed with the simulation team and management. The reason behind using this methodology is that different features of simulation packages are required for different application areas. For example, optimization might be considered very important for supply chain management whereas external connectivity might be considered to be more important for real time simulation.

The initial list of criteria is discussed with the simulation team for additional feedback and consistency.

3.1.3 Criteria Weighing

After the extraction of the criteria, weights based on the level of importance are given to each criterion. In addition, to increase the efficiency of the selection, hard (criteria that must be satisfied by any means) and soft criteria are identified. To cope with the various locations of the simulation team members – even when the simulation team is based in one location, the team members will be external with clients on various projects – questionnaires are used to weigh the criteria. The result is then analyzed and presented to the team for additional feedback. E-mail is ideal to update the team with the latest progress.

For giving weights to the criteria, each member input from the simulation team is considered. Weighing is done by first defining the scale. A five level scale is defined using scales 1 to 5. Five indicates very important and one indicates least important. After weight definition, members of the team give their personal weight to each of the criteria. For each criterion, the average weight is then calculated from the weights obtained from the members. Afterwards, standard deviations and averages are analyzed and compared with the raw data. The results of the analysis and additional input gathered from other sources (e.g., literatures, clients) are then presented to the team members. Finally results are discussed to decide if they need to be adjusted. Modification of the weights is then done based on the feedback of the team.

In addition to assigning weights to the criteria, identification of hard and soft criteria is also made. Hard criteria are obtained from the weights. Those criteria that are very important (close to 5) are considered to be hard criteria. In this way, hard and soft criteria are separated. The hard criteria obtained are then discussed with the group so as to be sure there is nothing to be added or removed. The team should be well aware that a simulation package that does not satisfy just one of the exit criteria immediately leaves the race.

3.1.4 Characteristics Identification of Discrete-Event Simulation Software

For the evaluation processes, discrete-event simulation packages available in the market are collected. The sources of information used are conference proceedings, research papers, vendor websites, input from the simulation team, and simulation practitioners.

Since the focus is on discrete-event simulation packages, packages that are used specifically for continuous simulation and Monte Carlo simulations are not considered. However, packages that have discrete-event simulation capability as well as other capability are considered as possible candidates.

After the final list of discrete-event simulation packages is prepared, the characteristics of the packages are identified. Different ways can be used to extract the characteristics. One of the ways is consulting the vendors, experimenting with the demo version of the packages, referring to research papers that describe the experiences with simulation packages, and consulting simulation experts (outside and inside the company).

In most of the cases, however, vendors can best be consulted using questionnaires. The questionnaire is prepared to address general issues and specific questions regarding the packages. The general questions addresses issues such as modeling approach, simulation software class, simulation type, and application area.

Specific questions about the features of the packages, supplied by the vendors, are categorized based on a framework. The criteria categories are:

- *Model development*: questions that are related to model development and modeling approach. This includes features like model building tools, reusability of libraries, coding aspects, conditional routings, queuing policies, and other related aspects
- *Input modes*: This includes input modes such as interactive mode, batch mode, from external files (spreadsheets, database, text files, etc.) and random variate generation.
- *Testing and efficiency*: The questions in this category include debugging features and error control.
- *Execution*: The questions in this category covers features such as multiple replications, automatic batch run, warm up period, and reset capability.
- *Animation*: The questions in this category cover animation development features, animation running features, display features, and icon development.
- *Output*: The questions in this category include features used for displaying outputs either in terms of numbers or business graphics. It also includes capability to communicate with external packages.
- *User*: The questions in this category include cost, compatibility of packages with different operating systems and hardware.

The questionnaire should be designed to gather as much data as possible. Since the data obtained from vendors can be incorrect, validation of the data is done by using the other methods listed above i.e., experimenting with the package, reading research papers, consulting simulation experts, and checking vendors website. For the experimentation, demo and full versions of the packages are used. Experiments are done by building a small model and trying to address each criterion (and feature) in the criteria list, by checking most of the commands available, reading help files about the features of the package, running and debugging small models and demo models, and viewing and experimenting with already existing demo models provided by the vendor or by other users.

Another method used for extracting the characteristics of the packages is library research. Different research papers, conference proceedings and vendor websites are used.

3.1.5 Screening and Ranking of Simulation Software

Once the characteristics of the packages are identified, screening and ranking is performed. Screening is done by using the hard criteria that are obtained in the previous steps. The packages that don't satisfy one or more of the hard criteria are removed from the potential list. Those that satisfy all the hard criteria are kept for further ranking. Testing is done by checking whether the packages satisfy the requirement set by each criterion.

After the packages are filtered (by using the hard criteria), further ranking is done on the remaining packages (using soft criteria) to select a maximum of 10 best packages. The number 10 was chosen to restrain the solution domain, yet being representative. For ranking, the following procedure is used.

- Define score: if a package satisfies a particular criterion, it scores 1 otherwise 0.
- Give score to each package for all the criteria using 1 and 0.
- By following a simple Multi Criteria Decision Making (MCDM) method called Simple Multi-Attribute Rating Technique (SMART), criteria weights were multiplied by the scores of each package for all the criteria.
- The sum of the product of weight and score for each package is compared.
- The first 10 packages that have the highest scores are selected for further investigation

Two points need to be mentioned here. First of all, the ranking is done by only checking whether a package contains a particular feature or not. It is not based on the quality of a feature. The quality of each feature is checked in the next phase of the analysis. Second, the aim of the ranking is only to filter the best 10 packages in the list. This, however, doesn't necessarily mean that the one on the top of the list is going to be the best of the overall evaluation process. The best package for the company is known once the quality of each feature is tested for all the remaining packages in the second phase of research.

3.2 Phase Two: Quality Check

In phase two, discrete-event simulation packages are evaluated for their quality. To accomplish this quality-check phase, the following steps are taken: Criteria selection, criteria weighing, designing a case study, conduct experiments, gather additional information, ranking of software, sensitivity analysis. The detailed methodology of phase two is described hereafter.

3.2.1 Criteria Selection

To evaluate the packages quality wise, some criteria have to be selected. The criteria address features that are important to analyze the quality of the package, considering the use that the simulation team plans to make of the simulation package. Features that need to be evaluated are selected by brainstorming with team members, selection team judgments and information already available from the first phase of the project.

3.2.2 Criteria Weighing

The criteria obtained are weighed by following the procedure mentioned in section 3.1.3.

3.2.3 Designing Case Study

The purpose of the case study is to help evaluate the features of interest by carrying out a small simulation study using each of the packages that remained after the first phase. The case study is prepared in such a way that it addresses most of the criteria in the list of the first step of phase 2. It does not require a specific modeling approach – as we do not want to introduce a bias to a certain modeling approach. The case study should be small but fairly complicated, and it should represent a typical problem that is representative for the type of simulation study carried out by the simulation team.

The case study can best be constructed from scratch; when taking a previous project as case study, there can easily be a bias towards the currently used simulation package – in positive or negative sense depending on the success of the project. After choosing a typical case, it needs to be extended to address the criteria that need to be evaluated. The case study evolves by using feedback from the team members and, if necessary, outside experts. As the case study is on paper, it is again easy to involve the simulation team members in the selection process because the case description can be distributed using e-mail.

3.2.4 Conduct Experiment

Experiment on the packages is done by modeling the case study. The modeling steps are as follows:

- *Conceptualization*: conceptual model design based on the package's modeling approach. This can be difficult, because the package may ask for a different modeling approach than what the selection team is used to.
- *Specification*: actual model construction. All experiments with the different simulation packages should use the same data sets and distribution functions as input, so the results in the output are truly comparable. It is important to keep a logbook for immediately writing down the experiences with the simulation packages.
- *Execution*: running the model and creating output to analyze further. Run-time and animation speed can, for instance, be analyzed here if these are part of the quality criteria.
- *Output*: Analyzing the output provided. If the quality criteria include specific aspects of output types or post-processing of the output, it can be done in this step.
- *Scenario management*: analyze different scenarios if needed.

For the experiments, vendors should be involved. Vendor participation is important because they can show the most efficient way of modeling the case using their packages. Furthermore, their level of cooperation in the project is one way of investigating the support level of the vendor. The vendors can be given three options for participation:

- Vendor's work on the case study is transparent to other vendors (vice versa) and they know with whom they are competing.
- Vendor's work is not transparent to other vendors and they only know with whom they are competing.
- Vendors only work on the case study and vendors don't know with whom they are competing.

Consensus should be reached among the vendors on the way of working. The experiment is conducted based on their cooperation strategy.

3.2.5 Gather Additional Information

In addition to conducting experiment, additional information has to be collected to enrich the evaluation quality. The additional information collected is mainly considering the limits of the packages, and advantages and disadvantages of the packages. The additional information is collected from articles and research papers, and simulation experts who have used the packages. A very good source of input here can be a user group of the simulation package.

3.2.6 Ranking of Software

By using the output of the experiments and the additional information collected from various sources, a score for all the packages can be given. The following method is used:

- Define a scale for scoring: in this case, a 4 level scale is defined. Scaling is done using scale 0 to 3. 3 indicates "Good", 2 indicates "Sufficient", 1 in-

dicates "Insufficient", and 0 indicates "Feature doesn't exist".

- For all the packages, assign scores for each criterion based on the defined scale. The selection team, which has followed all efforts for working out the case study in detail, does the scoring.
- The detailed scores for all the criteria is averaged based on the criteria categories.
- Again, by following the Multi Criteria Decision Making (MCDM) method SMART (Simple Multi-Attribute Rating Technique), criteria weights are multiplied by the scores of each package for all the criteria.
- The sum of the product of weight and score for each package is compared.

The result of the ranking is then given to the team members to get feedback. After this ranking, the packages receiving the highest score can be considered better than the ones scoring lower, as the comparison has been based on the (perceived) quality of the simulation package in a representative case study.

3.2.7 Sensitivity Analysis

After ranking is done and the best package is known, sensitivity analysis has to be done in order to assess the robustness of the result. A sensitivity analysis is performed because both scores and criteria weights are often subjectively generated in Multi Criteria Decision Making (MCDM). The following approach is used for sensitivity analysis

1. Changing weights of criteria: Criteria weights are changed and how much the decision is sensitive to the change is observed. Changes made are
   a. Make all criteria weights equal
   b. Change each criteria weights to minimum one at a time
   c. Change each criteria weights to maximum one at a time
2. Limiting criteria: The first few important criteria were considered. The following considerations are made
   a. The first important criterion
   b. The first two important criteria are considered
   c. The first three important criteria are considered and so on.
3. Changing scores of alternative packages: Make some reasonable changes to scores of the different alternatives and observe the impact it would have on the recommended decision.

4 PRACTICAL APPLICATION OF THE METHODOLOGY

The methodology has been applied in practice for selecting a new discrete event simulation package for Accenture's world-wide simulation team. Following the methodology explained above, a detailed vision of the team was extracted in the first phase. The vision includes the team's strategy, work environment, type of clients, type of project, and team expertise. The criteria were generated with the weights, and categorized with the Nikoukaran, Hlupic, and Paul (1999) framework criteria framework. Based on the weights, the hard criteria are in boldface in the tables.

Table 1: Model Development and Input category Criteria

Criteria	Weight
Graphical model building	**5**
Merging models	4
Conditional routing	4
Statistical distribution	**5**
Queuing policies	4
Reuse of user defined modules	3
Built-in functions	3
Link to other languages	3
Coding tools and utilities	3
Input from text files	**5**
Input from database	4
Input from spreadsheets	**5**
Automatic data collection	3
Batch input mode	3
Interactive input mode	**5**
Random number generators	**5**
Program generator	3

The obtained model development criteria in Table 1 reflect the vision of the team. Since the team is involved in different application areas of simulation, flexibility and easy of use in modeling are very important. Therefore, the high score for "Graphical model building" reflects this vision. In addition, due to the different application areas, the precision and numbers involved vary from project to project, making the "random number generator" criterion important. "Input from external files" criteria scores very high reflecting the vision of the team.

Table 2: Vendor Category Criteria

Criteria	Weight
Documentation	4
Maintenance support	**5**
Pedigree	3
Pre-purchase facility	2

In Table 2 it can be seen that maintenance support and documentation is very important because time is a very im-

portant issue. Efficient and fast support is highly required in a work environment where deadlines are numerous. In addition, detailed and good documentation is very necessary.

Table 3: Execution Category Criteria

Criteria	Weight
Multiple runs	**5**
Automatic batch runs	3
Reset capability	4
Start in non-empty state	3
Interaction with user (in running mode)	2
Warm up period	**5**
Ability to calculate appropriate warm-up period and replications	3
Speed control	**5**
Self executable versions	3

The "Multiple runs" criterion in Table 3, which indicates repeating simulation runs many times, scores very high compared to others because of variance reduction test performance. For the team the "speed control" criterion is important because the speed of the simulation can vary from as fast as possible for getting numerical results to a slow speed for demonstrating results to clients. The "Warm up period" criterion is also important for Accenture because some of the systems the group deals with are non-terminating systems.

Table 4: Animation Category Criteria

Criteria	Weight
Integration of animation	3
Library of icons	3
Screen layout	3
Concurrent animation mode	3
Animation on/off feature	**5**
3D animation	1
Animation development feature	3

In the animation criteria of Table 4, the "3D animation" criterion is not important for the team because the group mainly carries out business process simulation as opposed to manufacturing where it could be more important. "Animation on/off" is important just because turning the animation off can increase the simulation speed.

Table 5: Testing and Efficiency Category Criteria

Criteria	Weight
Error checker	**5**
Interacting debugger	**5**
Multitasking	2
Display features	3
Tracing	3
Breakpoints	4
Running backwards	1
Limits	2

In Table 5, "Error checker" and "Interactive debugger" criteria score high because most of the projects managed by the group are complex and large. Without a good debugger, it is considered difficult to fine-tune the model.

Table 6: Output Category Criteria

Criteria	Weight
Standard report generation	4
Report customization	**5**
Integration with statistical packages	3
Integration with other simulation packages	3
Feature for exporting data to database	3
Feature for exporting data to spreadsheets	**5**
Feature for exporting data to text files or word processors	**5**
Optimization	3
Output analysis feature	4
Business graphics	4

For the output criteria in Table 6, "Customization", "Export to spreadsheets" and "Export to word processors" are considered important because the output features are common tools for displaying results to clients.

Table 7:User Category Criteria

Criteria	Weight
Cost	2
Connectivity with internet	2
Package interoperability	2
Package link to different animation packages	2
Package has open source code	1
Package application area	**5**
Flow oriented modeling approach	4
High level architecture	2
Capability for continuous simulation	2
Simulation strategy	3

For the user criteria in Table 7, "Package application area" criterion scored high for the reason that the package has to be generic enough to be applied in different domains.

For the phase 1 evaluation, more than 50 packages were considered. A few software vendors were not able to participate in the project. By using the hard criteria from tables 1 to 7, the packages were screened. Those packages that didn't satisfy all the hard criteria were eliminated. Packages that satisfied all the hard criteria in alphabetical order were Arena 5.0 (Rockwell Software), AutoMod 9.1 (Brooks Automation), Enterprise Dynamics 3.1(Enterprise Dynamics), Extend 5.0 (Imagine That Inc.), ProModel 2001 (Promodel Corporation), Quest (DELMIA Corporation), Simul8 6.0 (Simul8 Corporation), and Witness 2000 (Lanner Group, Inc.).

Furthermore, these packages were ranked based on detailed feature they offer, i.e., availability of features. The

result indicates that the score for all eight packages is close and the distinction between them is not significant. Without even doing sensitivity analysis, it can be seen that by just using these results, it can't be concluded that one excels or one is the best. Additional analysis needed to be conducted on the quality of each feature to investigate how good the packages were. This was done in the next phase of the project.

In the second phase, the quality of the eight discrete-event simulation software selected in phase one, were evaluated in detail. The quality of the packages regarding the following issue was tested.

- Vendor: includes vendor pedigree, maintenance support, and documentation
- Model development and input: includes model building and coding aspect, batch processing, library of reusable modules, conditional routing, statistical distributions, queue policy, input modes, automatic documentation, batch input modes, random number generator, and standard commands
- Execution: includes multiple run, automatic batch run, reset capability, start in non-empty state, interaction with user, and unit conversions
- Animation: includes icon and animation development, screen layout, and animation running
- Testing and efficiency: includes validation and verification tools, display features, tracing, step functions, breakpoints, model size, and model speed
- Output: includes report, integration with external packages, and business graphics
- User: required experience and cost of package
- Experimental design

Based on these criteria, a case study that considered most of the criteria was created. Out of the eight package vendors, five of them participated in the evaluation. Three others were not able to participate for several reasons. All vendors chose the same participation level i.e., their work on the case study is transparent to other vendors in the list and they know with whom they are competing. After the evaluation, a document was prepared for each of the packages and sent for additional feedback to the respective vendors so that a clear image of the packages could be produced. Vendors were not given evaluation details of the packages of other vendors. Based on all this material a detailed analysis of each package was produced. After the analysis, total ranking of the packages was made.

5 DISCUSSION

The result indicates that the package chosen is a package that best fits Accenture simulation team's needs. Sensitivity analysis indicates that the result is fairly stable to changes made on the weights of the criteria, scores for the alternatives, and limiting the criteria considered. The criteria considered were just mirrors to the vision and need of the team. Some of the most important needs were:

- Complexity of problems: Most projects the team deals with are complex. This point implies the use of tools that can help to model correctly.
- Time: Time is very important for the team. The work environment of the team encompasses strong deadlines.
- Simplicity of package: Simplicity is important because it decreases the time it takes to model.
- Different precision required for different applications: Quality of random number generators is important because of the different precision used in different simulation application areas.
- Client interaction: Ease of use and good ergonomics are important features for end users.

The criteria list generated was found out to be similar (slightly different) to the criteria list mentioned by researchers such as Nikoukaran, Hlupic, and Paul (1999) and Banks (1991). However, the weighing of the criteria depends on the application area. Hence it is not possible to compare the weights of the criteria with weights found for other organizations.

Even though the package that scored the highest was found out to be the best for Accenture simulation team, some other packages considered are also highly competitive. The five packages considered in the second phase were able to construct the case study under investigation with different level of quality.

6 CONCLUSION

The result was found to be stable for reasonable changes in the scores and weights. However, there are two limitations of the project. First of all, the project didn't thoroughly test two criteria: Optimization and Random number generators. Conducting tests on optimization and random number generator is a specific task that would require many theoretical tests, algorithm checks and statistical tests. Conducting such kind of tests could take months. Since conducting such an extensive test was beyond the scope of the project, recommendations from simulation experts and research papers were used. For random number generators, for instance, recommendations from experts such as Law and Kelton (2000) were used. Secondly, two discrete-event simulation packages, were out during of the evaluation process because the vendors were not willing to participate in the evaluation processes and not because of capability. Since it was not possible to do objective evaluation without

the involvement of vendors, these packages were not considered in the evaluation.

On the whole, the evaluation and selection methodology used was found out to be efficient and objective. Since the main concept behind the methodology is to be objective and effective, the result found is reliable. In addition, the methodology used is so generic that it can be applied in different application domains.

ACKNOWLEDGMENTS

The authors would like to thank software vendors who participated in the evaluation processes especially Simul8 Corporation, Imagine That Inc., Enterprise Dynamics Corp., ProModel Corporation and Rockwell Software.

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AUTHOR BIOGRAPHIES

TAMRAT WOLDU TEWOLDEBERHAN is a researcher in the Systems Engineering Group of the Faculty of Technology, Policy and Management of Delft University of Technology. He participates in the BETADE research program on developing new concepts for designing and using building blocks in software engineering, simulation, and organizational modeling. Contact information: <tamratt@tbm.tudelft.nl> <www.tbm.tudelft.nl/webstaf/tamratt>

ALEXANDER VERBRAECK is an associate professor in the Systems Engineering Group of the Faculty of Technology, Policy and Management of Delft University of Technology, and a part-time full professor in supply chain management at the R.H. Smith School of Business of the University of Maryland. He is a specialist in discrete event simulation for real-time control of complex transportation systems and for modeling business systems. His current research focus is on development of generic libraries of object oriented simulation building blocks in C++ and Java. Contact information: <a.verbraeck@tbm.tudelft.nl> <www.tbm.tudelft.nl/webstaf/alexandv>

EDWIN 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. Contact information: <edwinv@tbm.tudelft.nl> <www.tbm.tudelft.nl/webstaf/edwinv>

GILLES BARDONNET is an associate partner of Accenture, and part of the Accenture CRM / Customer Interaction line of business and is based in the Paris Office. He is currently leading the modeling and simulation practice for Accenture in EMEIA and is considered as a thought leader in this area. Gilles Bardonnet is an engineering graduate from Ecole Centrale de Lyon (France) and has a Master degree in Flexible Manufacturing Systems and Robotics from Loughborough University (UK). In addition to his consulting experience, Gilles has been a regular speaker for Accenture Process Excellence Core Competency Group and has conducted several seminars in Europe and in the USA. Contact information: <gilles.bardonnet@accenture.com>