# Simulation Software in Manufacturing Environments: a Users' Survey

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The increased use of simulation in the manufacturing environment has resulted in more available software tools. This paper presents the results of a survey of simulation specialists, both from industry and universities across Europe, on the use of simulation software. The main purpose of this survey was to discover how satisfied users are with simulation software, and how such software can be further improved.

*Keywords:* manufacturing systems, simulation software, survey

## 1. Introduction

Simulation has been increasingly used as a tool to facilitate the design and operation of manufacturing systems (HOLLOCKS, 1989), (HLUPIĆ and PAUL, 1991), (KOCHHAR and MA, 1989), (SINGHAL et al, 1987). The main reason for this is increasing competition in industry, which has resulted in an even greater importance attached to the automating of manufacturing systems in order to improve productivity and reduce operating costs. Due to the complexity, dynamics and stochastic behaviour of these systems, simulation seems to be the adequate method for modelling and analysing advanced manufacturing systems.

The growing popularity of simulation has resulted in a growth in the number of simulation languages and simulators in the software market. This paper presents the results of a survey on the use of simulation software. The survey of a number of simulation specialists in industry and universities across Europe, was carried out to discover whether users are satisfied with the simulation software they use, and how this software can be further improved.

Following a brief review of simulation software and survey research in the area of simulation software analysis, the survey that was conducted is described. Results obtained are presented and analyzed. Conclusions outline the main findings of this research.

## 2. Simulation software and user's surveys

In this research, simulation software is classified in two groups. The first group includes simulation languages, whilst the second group refers to simulation packages which embrace different types of simulation software such as data driven generic simulators and program generators.

When a model is developed using a simulation language, the simulation analyst has to write a program using the modelling constructs of the language. This approach provides flexibility, but it is costly and time consuming. Some of the most popular simulation languages are SIMAN, SLAM II, SIMSCRIPT II.5, GPSS/H, SIMULA, PCModel and ECSL.

On the other hand, a simulation package allows the modelling of the problem with little or no programming. When this approach is used, the modelling time can be notably reduced, but only if the system under consideration fits the domain of the package. Examples of some packages that are data driven generic simulators, and that are widely used in manufacturing environments, include WITNESS, SIMFACTORY II.5, XCELL+, ProModelPC and AutoMod II. Some examples of program generators include CAPS, which produces code written in the ESCL language, and VS7 which generates Pascal code.

Several summaries of users' surveys can be found in simulation literature. A dated survey carried out by Kleine (1970 and 1971), examined users' views of eleven discrete simulation languages. The results of this survey showed that it was difficult to interpret the results, mainly because there were a limited number of respondents who were proficient in more than one language. In addition, the expertise of some respondents was difficult to specify.

CHRISTY and WATSON (1980) used a survey of nonacademic users to explore issues such as the functional areas that use simulation, the method of selecting simulation software, the popularity of various software tool for simulation applications etc. This analysis revealed that, of the total applications of simulation, 59% are in the area of manufacturing systems. For simulation software, the results showed that generally there is a reluctance to implement and learn new programming languages for simulation applications.

VAN BREEDAM et al (1990) conducted a survey in order to evaluate several simulation software tools. They distributed a questionnaire to experienced users of simulation, who were asked to rate a sample of simulation packages on the various criteria. On the basis of the received answers, they classified the software evaluated into clusters according to the main software features.

KIRKPATRICK and BELL (1989) used a survey approach to investigate the issues related to visual interactive simulation in industry. These issues include the types of problems being addressed, reasons for using visual interactive modelling, and the ways in which this type of modelling affects problem solving. The results revealed that although some of the participants are aware of the significant set-up costs, and the demands associated with learning new software and a new methodology, most participants agreed that visual interactive modelling provides enhanced interaction with decision makers, more useful and easier-to-understand models, and better decisions.

## 3. A survey

### *Purpose of the survey*

The main purpose of the survey was to investigate users' requirements of simulation software, and especially of software used for manufacturing simulation, and their opinions about ways of improving current simulation software tools to better satisfy their needs.

The questionnaire distributed to the participants in the survey consists of nine questions dealing with the type of simulation software used (1), the specification of particular packages used (WITNESS, SIMFACTORY II.5, SIMAN/CINEMA, ProModelPC, XCELL+, INSTRATA or other) (2), the purpose of using simulation (3), general opinions about each software item used (4) and the types of systems being modelled (5). Other questions include an estimation of how successful the simulation studies carried out were from the point of view of the software used (6). In particular, users had to appraise whether substantial approximations had to be made due to limitations of the software, or whether all desirable features of the systems under consideration could be modelled. The participants were also asked to list the main weaknesses and limitations of the software used (7), as well as the most important positive software features (8). Finally, they were asked to specify the most important features that should be included in existing simulation packages, and that are to the best of their knowledge not yet provided (9). The majority of the questions regarding opinions about the software, and possible ways of its improving it (questions 4,6,7,8 and 9), were open-ended. It is believed that this approach avoids the possibility of putting suggestions into the minds of the participants, and hence gives better and unprejudiced responses.

### *Survey sample*

The survey sample includes a number of regular simulation users both in educational institutions and industry around Europe. A number of academics from universities across Great Britain participated in the survey as well as academics from other countries such as The Netherlands, Germany and Denmark.

Participants from industry include simulation users from a variety of industrial companies. Most of these companies are involved in automobile manufacturing, aircraft manufacturing and manufacturing of audio equipment.

The survey sample was not selected by any formal statistical method. The participants, were known to be, or were believed to be, regular users of simulation, and hence were selected deliberately for this reason. It was intended to obtain a sample of users experienced mainly in the use of simulators (referred to as simulation packages in the questionnaire) rather then languages. The response rate was a moderate 30% out of 120 distributed questionnaires. In addition, the ratio of responses from universities and from industry was about 70% and 30% respectively, although an approximately equal number of questionnaires was distributed to each group of users. Not only was the response significantly higher from users from universities, on average each response from a university provided more information then a response from a user in industry. All these facts might raise questions concerning the statistical significance of the obtained results. However, this is the fate of surveys of this type, and it is believed that the deliberate selection of the survey participants, all of whom have experience in simulation, in fact enhances the importance and usefulness of the results.

## 4. Responses from users at universities

Regarding the type of software used, 51.7% of users at universities use only simulation packages (including simulators), 44.8% use both simulation packages and languages, and 3.5% use only simulation languages. Analysis of the specification of simulation software tools used reveals that more than half (51.7%) of the users use only one software tool, but the other half use more than one software tool, up to six different software packages. Table 1 summarizes results obtained regarding the number of simulation packages used.

Regarding the simulation purpose, 20.7% of participants use simulation only for modelling real systems, 10.3% use simulation only for education, whilst the majority of 69% use simulation both for modelling real systems and education.

Common elements from the responses concerning general opinions about the software are summarized in table 2, together with the percentage of users that have specified a certain software feature.

*Table 1.* Results obtained regarding the number of simulation packages used at universities.

| Number of simulation packages used | Percentage of users (%) |
|---|---|
| 1 | 51.7 |
| 2 | 13.8 |
| 3 | 6.9 |
| 4 | 17.2 |
| 5 | 3.5 |
| 6 | 6.9 |
| | 100 |

*Table 2.* A summary of users' general opinions about the software (universities)

| Software features | Percentage of users (%) |
|---|---|
| – Too limited for complex problems | 24.1 |
| – Easy to use | 20.7 |
| – Good graphics | 17.2 |
| – Easy to learn<br>– Biased to manufacturing problems | 13.8 |
| – Slow<br>– User friendly<br>– Poor statistical support | 10.3 |
| – Inadequate experimentation facilities<br>– Difficult to validate models | 6.9 |

Concerning the systems being modelled, 31% of users model only manufacturing systems, 44.9% are involved in modelling both manufacturing and other types of system, whilst 24.1% model only other types of systems.

When being asked about the success of modelling, 27.6% of participants declared that they have been able to model desirable features of the systems being modelled, 37% have managed to model most of the features, whilst 34.5% had problems in modelling due to software limitations and inflexibility.

Table 3 summarizes responses concerning the main limitations and weaknesses of the software, whilst table 4 summarizes responses regarding the most important positive features of the software used.

*Table 3.* A summary of users' opinions about the main limitations of the software (universities).

| Software features | Percentage of users (%) |
|---|---|
| – Restricted flexibility | 31 |
| – Validation difficulties | 17.2 |
| – Slow<br>– Lack of facility for output analysis | 13.8 |
| – Difficult to use<br>– Difficult to learn<br>– Lack of facility for experimental design<br>– Poor statistics | 10.3 |
| – Lack of database linkages<br>– Limits to the size of models | 6.9 |
| – Expensive | 3.4 |

*Table 4.* A summary of users' opinions about the most important positive features of the software (universities).

| Software features | Percentage of users (%) |
|---|---|
| – Graphics (animation) | 34.5 |
| – Ease of use | 20.7 |
| - Ease of learning<br>- Automatic report generation | 13.8 |
| – User support<br>– User interface | 10.3 |
| – Flexibility<br>– Documentation<br>– Good statistical analysis<br>– Speed of modelling | 6.9 |
| – Interface with other software<br>– Support for UNIX platforms<br>– Incorporated cost analysis<br>– Easy check of 'what-if' questions<br>– Cheap | 3.4 |

Finally, a summary of the features that users would like incorporated in simulation software that could improve the software they use is presented in Table 5.

*Table 5.* A summary of users' opinions about the features that should be included in simulation software (universities).

| Software features | Percentage of users (%) |
|---|---|
| – Better software compatibility | 24.1 |
| Link to databases | 17.2 |
| Link to spreadsheets | 10.3 |
| Link to CAD software | 3.4 |
| Link to statistical packages | |
| Link to MRP scheduling software | |
| – Facility for output analysis | 17.2 |
| – More flexibility<br>– Help in experimental design | 13.8 |
| – Better and more intelligent on line-help<br>– Better experimentation facilities<br>– Support of standard programming concepts | 10.3 |
| – Elimination of memory limitations<br>– Better documentation<br>– Easy model editing | 6.9 |
| – Ability to create run-time applications<br>– Automatic save<br>– More prompt to save<br>– Hierarchical model building<br>– Low cost of software<br>– Easy design of on-line reports<br>– Availability on standard hardware and software systems | 3.4 |

## 5. Responses from users in industry

Considering the type of software used, 72.7% of users in industry use only simulation packages (and simulators), 18.2% use both simulation packages and languages, and 9.1% use only simulation languages. Examination of the number of simulation software tools used shows that all users use only one software tool (100%).

Considering the simulation purpose, 90.9% of participants use simulation only for modelling real systems, whilst 9.1% use simulation both for modelling real systems and education, and none of them use simulation only for education.

Analysis of the responses concerning general opinions about the software used is summarized in table 6, together with the percentage of users that have specified a certain software feature.

*Table 6.* A summary of users' general opinions about the software (industry).

| Software features | Percentage of users (%) |
|---|---|
| – Generally very good<br>– Interactive<br>– Graphics<br>– Slow to run<br>– Easy to use but only when applied to standard systems | 72.7 |
| – Reasonably easy to learn<br>– Difficult to use for non standard systems<br>– Biased to manufacturing problems | 18.2 |
| – Quick<br>– Easy to use<br>– Lack of good support for fluid processing | 9.1 |

Regarding the systems being modelled, 45.5% of users model only manufacturing systems, 36.4% model both manufacturing and other types of system, whilst 18.1% of users are involved in modelling only other types of systems.

Concerning the success of modelling, 27.3% of participants report that they have been able to model desirable features of the systems, 54.5% have managed to model the majority of the features, whilst 18.2% had problems in modelling because of software limitations and inflexibility.

Tables 7 and 8 summarize the responses concerning the main limitations and weaknesses of the software used, and the responses concerning the most important positive features of the software used, respectively.

*Table 7.* A summary of users' opinions about the main limitations of the software (industry).

| Software features | Percentage of users (%) |
|---|---|
| – Limited flexibility for non standard systems | 36.4 |
| – Too slow<br>– Manufacturing bias and terminology problem | 27.3 |
| – Inadequate graphics<br>– Expensive<br>– Lack of a support for fluid processing<br>– Lack of support for object oriented concepts<br>– Big models are not understandable | 9.1 |

*Table 8.* A summary of users' opinions about the most important positive features of the software (industry).

| Software features | Percentage of users (%) |
|---|---|
| – Graphics | 36.4 |
| – Ease of use<br>– Interactivity | 27.3 |
| – Speed to build models<br>– Being menu driven | 9.1 |

Table 9 presents a summary of the features that users would like incorporated in the simulation software, and which to their knowledge does not yet exist in the software they use.

*Table 9.* A summary of users' opinions about the features that should be included in simulation software (industry).

| Software features | Percentage of users (%) |
|---|---|
| – Dedicated systems to more specific applications<br>– Higher execution speed | 18.1 |
| – CAD links<br>– Improved editing facilities<br>– Removal of unnecessary constraints<br>– Enhancement of fluid processing facilities<br>– Automatic generation of entity cycle diagrams | 9.1 |

## 6. Summary of findings

The results of the survey show that there are both similarities and differences in the response obtained from the two different groups of users. Concerning the type of software being used, users that use only simulation languages are in a minority for both groups. The percentage of users that use both simulation packages (simulators) and languages is quite even for university users. The explanation for this might be that almost half (48.3%) of these users use more than one simulation software tool (some of them are even using six different simulation packages and languages), combining education, research and real life projects. In addition, probably most of these software tools were obtained with an educational discount.

On the other hand, users in industry are much more oriented to using packages. It is believed that the main reasons for this are a deliberate sampling of users of simulators, and the fact that all the users from industry (100%) who participated in the survey use only one software tool for simulation. In addition, industrial companies usually have to pay the full price of the package.

Regarding the simulation purpose, it is interesting to note that the majority of users at universities (69%) use simulation both for education and modelling real systems, which indicates that many of the academic participants in the survey are involved in both research and work on real life projects. Those that are involved only in modelling real systems are probably those doing only research and not teaching. On the other hand, the percentage of academics that are involved only in education (at least concerning simulation) is relatively low (10.3%), which supports the point concerning the diversity of activities performed in an academic environment.

As expected, a vast majority of users in industry use simulation for modelling real systems, a small proportion of them are involved both in modelling real systems and education, and none of them are involved only in education.

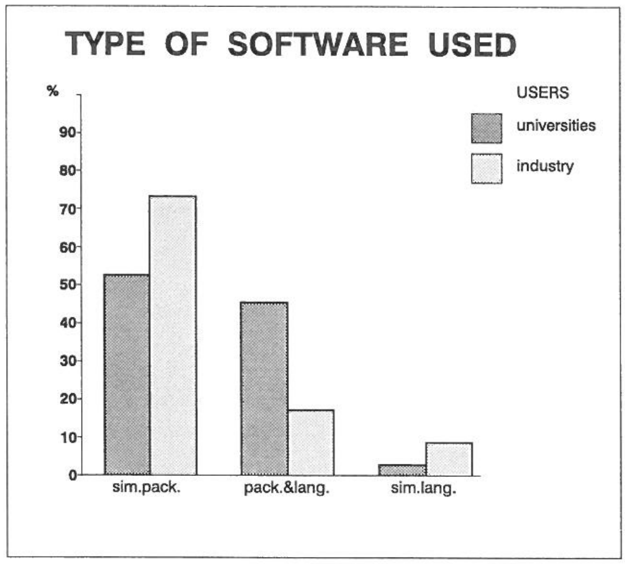


*Fig. 1.* Comparison of the type of software used by survey participants

Figure 1 shows a comparison of responses obtained for different groups of users regarding the type of software used, whilst figure 2 shows results obtained regarding the simulation.

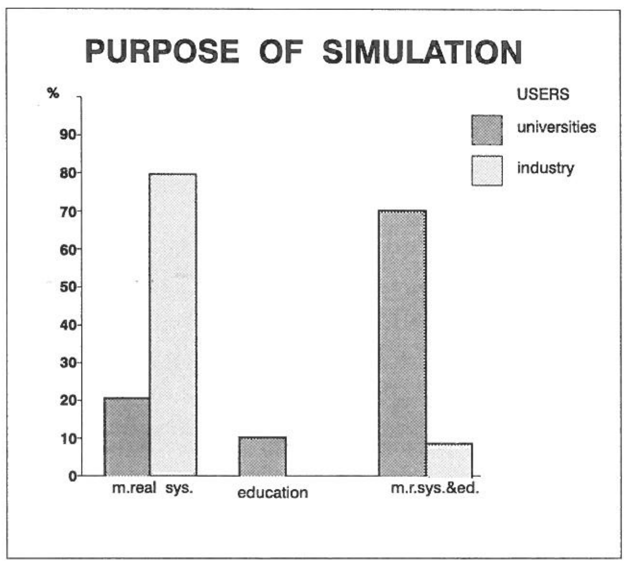


*Fig. 2.* Comparison of the purpose of simulation performed by survey participants

Analysis of the open-ended questions regarding general opinions about the software used, (positive, negative and desirable software features) reveals that users in universities have listed the features that could be expected from users in industry. Many of these features actually correspond to those listed by users in industrial companies. The main reason for this may be the involvement of the majority of academics in modelling real systems in addition to teaching.

Concerning general opinions about the software used, the main objection is that this software is too limited for complex (academics) and non-standard problems (users in industry). The majority of users in industry generally have positive opinions about the software they use, favouring the interactivity and graphical features of simulation software, but are not satisfied with the running speed. Ease of use is more approved by users at universities, whilst both groups agree that the software they are using is biased towards manufacturing problems.

Analysis of the main weaknesses listed exposes the main limitation for both groups of users as the limited flexibility of the software being used. Academic users are more aware of validation difficulties, a lack of facilities for output analysis and experimental design, whilst both groups agreed that the software is too slow. None of the users in industry considers the price of the software to be a problem, and similarly only a small percentage of users in education consider simulation software to be expensive.

Regarding the most important positive features of the software being used, it is notable that a majority of participants in both groups have specified graphics as the most beneficial software feature. The second best features for both groups is ease of use. Academics are aware of ease of learning, automatic report generation and good user interfaces. On the other hand, not too many of them consider flexibility, statistical facilities, documentation, modelling speed or software compatibility to be of either of good quality or a distinctive advantages of the software they use. Modelling speed is also listed by very few users in industry.

Finally, the examination of the features that users would like to be incorporated in simulation software shows that better software compatibility is the most important for the majority of academics. Within this feature, a linkage to databases appears to be the most needed, and then follows a linkage to spreadsheet software and then a linkage to other types of software. Further important features specified by this group of users include a facility for output analysis, more flexibility and experimental design. Some of these users have requested features such as an improvement to documentation and easier model editing, whilst not many of them have demanded features such as the ability to create run-time applications, automatic save, hierarchical model building or lower costs of the software. Users in industry want an improvement in the execution speed and more systems dedicated to specific applications. Some of them require features such as CAD links, improved editing facilities, or removal of unnecessary constraints.

## 7. Conclusions

A general analysis of all the results obtained shows that simulation software currently being used by all participants in this survey is predominantly easy to use, visual, interactive, but too limited for complex and non-standard problems, too slow and biased to manufacturing problems. In addition, there is a variety of features that users have requested that refer to better software compatibility, more flexibility and more systems dedicated to specific applications (which is actually contradictory), a provision of facilities for output analysis and experimental design, and better modelling assistance (eg. easier editing and better on-line help).

These results indicate that users prefer using simulation packages, and especially data driven simulators, instead of doing bespoke programming. However, the majority of them would like these packages to be more flexible and improved, with additional features that would make modelling easier and faster.

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