DATA IDENTIFICATION AND COLLECTION METHODOLOGY IN A SIMULATION PROJECT: AN ACTION RESEARCH

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ABSTRACT

There seems to be a paucity in the research into the collection of data for use in simulation. This is rather unfortunate since data quality and availability are two of the most challenging issues in many simulation projects. In this paper, we are interested to know how practitioners identify and collect data for simulation projects. An action research was conducted at the ORH Ltd, a management consultancy company to evaluate their data collection guidelines using a real project conducted for a UK Ambulance Service to recommend new staffing levels to deal with increasing calls and to incorporate the installation of a new operating system. We discuss the issues surrounding the identification and collection of data which can be divided into data-related and process-related issues. We propose an improvement to the data identification and collection methodology to reduce the number of cycles in the data collection process.

Keywords: Data identification, Data collection, Simulation, Ambulance service, Call centre

1 INTRODUCTION

In the modern business world, there is high demand for the ability to create and deliver effective and useable simulation models to aid business decisions in uncertain environments. Amongst simulation experts many factors have been noted to affect the ability to develop and deploy useful models within an appropriate timescale and within budget. However, it is accepted that one of the serious limitations to achieve the above objective is inefficient data collection (Perera and Liyanage, 2000) with up to 40% of project time being required on data gathering and validation (Trybula, 1994). This may have an impact on the model design. A case in point includes the situation where a modeller quickly designs a relatively complex model with limited data (or even without any data) and then collects the required data. This dramatically increases the possibility of having to alter the original design due to assumptions and limitations built into the model being significantly affected by the quality and availability of the required data. On the other hand, a modeller could also be trapped into thinking that all data have to be collected first before a model can be built. This increases the potential to collect more data than needed, hence, significantly wasting scarce resources (time, money, and personnel) on a simulation project. Therefore, a good data collection methodology and its place within the overall simulation modelling methodology are important.

There has been an increase in the number of researchers that address the designing of simulation conceptual models. However, there seems to be a paucity in the research into the actual collection of data for use in simulation. The objective of our research is to understand more about the issues surrounding the identification and collection of data for simulation. We define the data identification in simulation modelling as a process that highlights the required data sets and their desired properties such as accuracy, sample period and format to allow the simulation model achieves the modeling objectives. Data collection is therefore defined as a process to obtain the identified data sets that meet the desired properties whether from a client directly or through direct collection. In this
paper, we report our findings on how the identification and collection of data is undertaken for simulation projects conducted by a management consultancy firm, the Operational Research in Health Ltd (ORH Ltd). The research data was collected by carrying out an action research to apply the data collection methodology adopted by ORH Ltd in a real simulation project. The rest of this paper is organised as follows. We present the overview of research in data collection methodology in simulation projects in Section 2. This is followed by the detailed explanation and analysis of the findings from the action research in Section 3. Finally, we end our paper with the conclusion.

2 LITERATURE ON SIMULATION DATA COLLECTION METHODOLOGY

Skoogh and Johansson (2008) note the lack of structured data collection methodologies in simulation. The main simulation textbooks discuss data collection very briefly and almost always as a sub-section rather than devoting a considerable space for deeper discussion. Pidd (2004) only commented on data collection issues and methodologies as a side topic. Bank et al. (2005) and Law (2007) devoted two pages or less with only Banks et al. using a specific section to comment on data identification and collection. Robinson (2004) dedicated six pages on data requirements and collection. Based on the requirement, data in simulation modelling are grouped into three types: contextual data to understand the problem situation, data for model realisation and data for model validation. Based on the availability, the data is grouped into three categories: available data, data sets that are unavailable but can be collected, and data that is not available and cannot be collected. Apart from Robinson (2004), the lack of inclusion within key simulation textbooks is in line with Skoogh and Johansson’s comment on the lack of research into the data collection methodology in simulation. This is rather unfortunate since data quality and availability have been mentioned as two of the challenging issues in many simulation projects. For example, Onggo et al. (2010) and Gunal et al. (2008), documented simulation projects in the European Commission and UK police forces, respectively, where data quality had been issues for project delivery.

Research into data collection methodology in simulation has been dominated by automatic data collection, mainly in manufacturing. Lehtonen and Seppala (1997) looked at data gathering methodologies in a logistics simulation project, however only briefly commenting on the collection and focusing on the analysis of data. Perera and Liyange (2000) carried out work into a methodology for data identification and collection in manufacturing systems, proposing several specific solutions to the industry using IDEF based methodologies. Robertson and Perera (2002) discussed the use of an automated data collection process for simulation by integrating the data collection system with Enterprise Resource Planning (ERP) software.

There has been research into a more generic data collection methodology with Bengtsson et al. (2009) investigating the input data management within discrete event simulation (DES) projects. Skoogh and Johansson (2008) proposed a detailed generic methodology for input data management during the early stages of a DES project life cycle. They produced a detailed process map to describe the steps taken throughout the collection and validation of data for use in simulation.

3 DATA COLLECTION IN PRACTICE: A PERSONAL EXPERIENCE

Given the lack of guidelines from the research literature, we are interested to know how simulation practitioners identify and collect data for simulation projects. One of the methods we use to achieve this is through action research, where one of the authors (Hill) conducted a full data collection life cycle for a real world project using ORH Ltd’s data collection guidelines. The project was conducted for a UK Ambulance Service (Client Y). Hill worked as an intern at ORH Ltd as part of his degree at Lancaster University, where he undertook the roles of analyst and modeller on the project mentioned above whilst being overseen by a senior consultant. The project was titled ‘Assessing Call-Taker Levels’ and involved recommending new staffing levels for ambulance control rooms to deal with increasing calls and to incorporate the installation of a new operating system (NHS Pathways) that had the effect of increasing call durations.
3.1 Methodology

The data collection activities were recorded during data collection stages and the actions taken to obtain aspired data through an ‘action research cycle’ structure. Action research is an approach to research that aims both at taking action and creating knowledge or theory about that action (Coughlan and Coghlan 2002) through the use of a plan-act-reflect iteration (Lewin 2005). Reason and Bradbury (2001) describe action research as: “... a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in pursuit of practical solutions to issue of pressing concern to people, and more generally the flourishing of individual persons and their communities” (Reason and Bradbury 2001, p. 4). Further to this definition it is also important to address the iterative process of plan-act-reflect which is at the heart of action research. Susman and Evered (1978) have expressed this cycle in a 5-stage process as described below:

1. Diagnosis: identifying the nature of the problem situation, including all interrelated factors and developing a working theory about the situation.
2. Planning: specifying actions that should alleviate the situation.
3. Intervention: taking action in the agreed area of application in line with the plan.
4. Evaluation: establishing whether the theoretical effects of the action were realized, and whether they did indeed relieve the problem(s).
5. Reflection: deciding what has been achieved in terms of both practical outcomes and new knowledge, and whether a new action research cycle is required.

The first and second stages can be grouped under the ‘plan’ whilst the following two steps come under the ‘act’ process. From the above definitions and descriptions, it is clear how action research matches the purpose and rationale of this research, with the iterative cycle being able to capture issues surrounding the identification and collection of data for the simulation project using ORH Ltd’s data collection guidelines.

As the researcher is actively involved in the carrying out of action research and creation of actions to solve pressing issues, their position and relation to the organisation and people involved needs to be addressed. Herr and Anderson (2005, pp. 31-42) proposed a 6 point continuum of positionality as shown below:

1. Insider – A researcher studies either alone or in a group within their own practice or practice settings. Examples include autobiography and narrative research as well as self study.
2. Insider in collaboration with other insiders – A group of insiders within the setting will research together within a study group with the aim of achieving a greater impact than seen in position 1.
3. Insider(s) in collaboration with outsider(s) – This is a situation where insiders invite or contract outsiders into their organisation to collaborate on research. The level of outsider involvement can vary from consultation on methodology to outsiders being included in the research project.
4. Reciprocal collaboration – Similar to position 3, outsiders work with insiders, however under this positionality power is equally displaced amongst all members. This form of working relationship is usually formed over a prolonged time period.
5. Outsider(s) in collaboration with insider(s) – Under this circumstance, an outsider will initiate a research project with insiders acting in a participating role rather than actively carrying out research.
6. Outsider – This extremity of the scale represents the traditional research methodology of quantitative or qualitative research where a research is merely an investigation into an organisation.

The continuum shows how a researcher is able to adopt many positions whilst carrying out action research and although all positions allow successful research, it is important for the researcher to identify their position in the project ensuring the validity of research. In our case, Hill worked as an intern at ORH Ltd as part of his degree requirement; hence he is not classified as a insider within the organisation due to his temporary role within the company. Also, the role which Hill plays in the
organisation is not one of significance when decisions are being made or organisational change is being proposed which pushes him away from the insider scale of the continuum. Throughout the research, Hill collaborated with the employees of ORH Ltd, which places the role taken during the project at position 5 on the scale. This role, allowed Hill to act in an observatory role while still being involved in the project, to create the personal experience of a project.

A journal was maintained noting the steps carried out, clearly defining the plan-act-reflect cycle at all stages. The journal captured when one made a choice and the consequences of such choices, which follows action research’s characteristic of using autobiographical data (Herr and Anderson 2005, p. 77).

3.2 Discussion
This section explains the result from the action research and presents our analysis.

3.2.1 Results
Based on our observation, we produced a flow chart that shows the data identification and collection process used by ORH Ltd for its simulation projects (see Figure 1). Typically, ORH Ltd will submit a data specification form, outlining the format, the required fields for all data sets, and the sample period. Shortly after sending a request, the client will comment on the availability of data within their organisation which influences the approach taken to collect and use representative data. Note that we differentiate between collecting the available data from client (i.e., get data from client) and collecting the unavailable or partially available data (i.e., collect) data. The process described in Figure 1 is triggered whenever there is a need for data during a simulation project. When the data identification and collection process ends, ORH Ltd will present the findings to the client. If the client agrees with the findings then the data will be used. Otherwise, they will discuss options to resolve the data issues. Figure 1 also shows that, depending on the availability status of the required data, there are three main process pathways.

First, if the specified data is fully available and meet the requirements given in the data specification form, ORH Ltd will progress to collect the said data and carry out investigative analysis which is then presented to the client for data validity checks. An example of this was found during the collection of planned and actual call taker numbers for each hour of the day across the week. The client could readily provide the said data for two of its control rooms. However, as evident from the journal entry shown in appendix A, further analysis showed that there was an increase in call taker hours throughout the final few months of the samples. The project team re-analysed the data and checked its validity with the client. They explained to the client how this might affect the simulation result. As a result, with the client’s agreement, the sample size was cut to ensure representative data was being used by removing the outliers.

The second possibility is when data is available but only meets part of the requirements. In this case, ORH Ltd will assess whether the data can still be used in modelling (although this may lead to altering the model design or adding more assumptions). If not, ORH Ltd will use a tradeoff between the amount of time required to collect the data and the overall benefit of having the data available to use in modelling. An example of this was found when trying to collect call taker hours for one of the three control rooms (see Appendix A). As extreme levels of time and effort would have to be spent manually collecting and then processing the data both on the client side and ORH Ltd’s role, it was decided with the client to collect a smaller sample of less granular data. This approach ensured the project was not delayed and sufficient data had been collected to continue modeling with small assumptions in place.

Finally, if the requested data is not available, ORH Ltd take a different approach. Discussions are held with the client, to investigate if any alternative data is available to collect. If so, the iterative cycle described above is then started until the client is happy with the findings. However, if no alternative data can be found, two options are available: use assumptions or adapt the modeling approach to deal with less granular data. An example of the use of assumptions was found during the
collection of outgoing call duration. Because the outgoing call data for the requested sample period was unavailable, with the client’s agreement, data from the previous year was used for outgoing calls (see Appendix B). In this situation, ORH Ltd used past project experience to aid the development of assumptions that could be used to make the data suitable for modeling. An example of the use of less granular data was found when data was collected for new call durations under the NHS Pathways system (see Appendix C). ORH Ltd requested raw call data to estimate the distribution of inter-arrival rates for incoming calls. It was found that the data was not available. However, less granular data, i.e., number of calls in 15 minute blocks by call category, was available. It was decided that using the less granular data was more desirable than collecting extra data, due to tight time constraints and report deadlines. It should be noted that if data sources are unavailable or assumptions are used, fewer parameters are available for analysis, optimisation and sensitivity modelling, hence reducing the possible impact of the project. In the project, through not being able to obtain a call taker unavailability factor within Client Y’s operations, a possible optimization parameter was lost due to the factor being used for model validation as a result of poor confidence in the supplied data.

![Flowchart of ORH Ltd’s data identification and collection process](image)

**Figure 1** ORH Ltd’s data identification and collection process

### 3.2.2 Analysis

We can divide the issues surrounding the identification and collection of data found during the project into data-related and process-related issues. The data-related issue refers to the availability, structure and quality of data. The data availability status is consistent with the three categories mentioned in Robinson (2004). The structure of data can be an issue where the data is available on a format that
cannot be readily used for analysis using computers. This includes mental data (tacit knowledge), qualitative data, quantitative data in hard-copy, and raw electronic data that is spread across various systems or must be processed before it can be used. Finally, the quality of the data refers to its validity, completeness and correctness of the level of detail.

Based on the findings from the action research, we can conclude that ORH Ltd has a very flexible and robust methodology allowing for all situations faced during the project. However, we believe the number of cycles during the data collection process could be reduced by introducing a preliminary investigation on how data has been collected and stored. In our example, in cases where the staffing data was not available for one of the control rooms or where multiple internal sources had to be combined to produce the call taker hours, had ORH Ltd been aware of the issue prior to submission of a data request, alternative actions could have been taken for the collection of data. The first example shows us that we cannot assume that data is available just because we think the client must have it for its operation. The second example teaches us that the process of combining data from multiple sources can take more time than anticipated and can affect the total amount of time spent in the data collection stage. Not only were delays in project progression a consequence, the validity and confidence in data could be reduced as a result of losing validation data in the process of combining data sources. A preliminary investigation should be able to detect the data availability issue at the expense of adding one more step to the process. However, given that the delay between the submission of the data specification form and the reply from the client usually takes longer than the added time needed for the preliminary investigation, this approach may reduce the amount of time needed for the data collection stage in a simulation project.

Sargent (2005) stated “there is not much to ensure that the data is correct”. This project and through our interactions with ORH Ltd has taught us that data validity could be improved by building excellent client interactions and developing enough knowledge on a specific domain knowledge. From the experiences gained from the project and from the one year internship at ORH Ltd, we have specifically observed that although a lengthy process at the time, ORH Ltd through excellent client interaction and their extensive industry knowledge of Emergency Services, managed to ensure the data was as correct as feasibly possible. For example, when collecting incoming call data across the control rooms, ORH Ltd from their industry expertise, used data available for ambulance incidents to cross check that levels of incoming calls to control rooms were of a realistic proportion, using past projects as benchmarks. We believe having the knowhow and experience of using ‘benchmarking’ style analysis can aid to develop confidence in data sets and offer alternative data sources.

4 CONCLUSION

From the analysis and results above, it can be said a methodology is in place at ORH Ltd during the collection of specified data and is one of a logical and robust manner. Their methodology allows the data collection stage to work around the specific clients’ needs and varying data availability levels. Even with the use of client discussions, expert knowledge and iterative cycles to ensure all data is collected and accurate, more emphasis needs to be placed in the earlier stages. The methodology used, skips a key step i.e., the identification of available data sources prior to requesting data. This probably explains many of the problems experienced in the project. Based on the experienced gained from working on the project, we believe that, with preliminary investigation to identify available data sources prior to requesting data being included in the initial phases, more realistic and achievable data could be requested and could reduce time spent in the data collection stage. Further work will be required to validate the additional step due to the lack of testing within a simulation project.

Despite being an important practical issue, the lack of research in the area of data identification and collection in simulation indicates the existence of a gap between research and practice in this area. This calls for closer collaboration between researchers and practitioners to tackle the issues surrounding the identification and collection of data in simulation projects. Robinson (2002) identified the importance of the availability and accuracy of data within his 19 dimensions of simulation project quality presenting the relationship of, poor quality of data leads to a poor model and ultimately an
unsuccessful simulation project. This reinforces the importance of having an effective methods for the identification and collection of data.

A JOURNAL ENTRY: CALL TAKERS DATA

Plan – Planned and actual call taker numbers are to be requested and required for each hour of the day across the week.

Act – A request was sent to the three pilot control rooms, asking for both planned and actual call taker deployments. All control rooms provided a planned roster for the sample period (July-October). Control rooms 2 and 3 were able to provide actual call takers for every hour of the sample period, which was then converted into average call takers at each hour of the week. However, control room 1 was not able to provide the said data in an effective manner. On analysing the data sent through from each control room, there were big discrepancies between actual and planned call taker levels in control rooms 2 and 3. This prompted more thorough analysis, which showed a step change in call taker hours in August through October. The case for control rooms 2 and 3 matches the situation in the guidelines where more data should be requested or client discussions held. Hence, it was agreed that further discussions about the operations of control rooms 2 and 3 during the sample period would need to take place. Taking control room 1, the guidelines say that we need to weigh collection effort and the usefulness of the data. It was agreed with the client, to select a random 6 weeks across the sample to use as the actual call taker numbers during the sample.

Reflect – The data collection methodology works well as an idea of data availability was captured with available data being collected and initial analysis completed. The random 6 weeks of data used for control room 1 to produce staffing levels is consistent with the guidelines in reaching a compromise between worth and effort. This approach also aids ORH Ltd in obtaining data when the project’s data availability is a possible detrimental factor on the project’s success. For, control rooms 2 and 3, the methodology allows ORH Ltd to gain an in-depth understanding of the data and avoid the situation of data being discounted in early stages due to poor validity issues. This cycle shows that assuming that staffing data is readily available in a call centre may not be correct, and how the use of client involvement is crucial to understanding data. As not all the required data has been collected and concerns raised, a further cycle is required to complete a data set for call taker hours in all three control rooms.

Plan – Due to the step change, questions need to be raised with the client into why this happened and hopefully prompting the client to collect data from each control into control practices for each month of the sample. From discussions regarding the unavailable data from control room 1, a request was sent for 6 random weeks within the sample period for call taker hours.

Act – The client investigated control room practices across the sample, noticing that control room 1 had implemented an initiative to increase call answer pick up performance through maximising bums on seats starting in August. At the same time it was discovered, a new operating system was implemented in control room 1, which required control room 2 and 3 staff to help in the switch over. A random 6 week sample was sent through and analysed to show more realistic differences between planned and actual call taker hours in control room 2 and 3. After discovering this, the chosen sample period was no longer considered to be an accurate reflection of business processes and operations across the three controls. Therefore with agreement from the client, control room 2 and 3’s sample period would be cut to April to July for all model parameters. At this stage, both ORH Ltd and the client agreed that a suitable sample had been analysed that represented an accurate picture of current call taker hours.

Reflect – By implementing a further iteration, ORH Ltd was able to complete a data set for call taker hours and be confident in having valid and credible data for use in simulating call takers in the model. Without this further step, concerns would have to be raised in the ability of ORH Ltd to accurately model the three control rooms.
B JOURNAL ENTRY: OUTGOING CALL DATA

**Plan** – In order to collect all data relating to the call takers activities whilst on the phone, outgoing call data was required for the same sample period as incoming call data.

**Act** – A data request was sent for a record of outgoing calls made by call takers for April to October for each control room. Very quickly, the client relayed that it was apparent that no data could be provided from all control rooms for outgoing calls due to system technicalities. This placed the situation in the third option of guidelines “If no data is available”. With the preferred data set being unavailable, ORH Ltd decided to ask ‘What data is available?’.

**Reflect** – Although the above approach follows the guidelines, if ORH Ltd had investigated the systems in place at client Y, it would have been noticed that no recordings of outgoing calls are present. This would have removed this step and reduced the duration of the data collection phase.

**Plan** – Instead of requesting exact data, ORH Ltd requested any data that was available relating to outgoing calls at the three control rooms.

**Act** – Another data request was sent to the client, asking for any available data regarding outgoing call numbers or patterns. Client Y was then able provide the number, and time spent on outgoing calls made from each control room for the period 1/1/2009 – 31/12/2009 inclusive. From analysis of the available data it was agreed by both the client and ORH Ltd that a ratio of outgoing to incoming calls from a 2009 sample would be representative of operations in 2010. However, later in the project, it was questioned what data had been given when ORH Ltd asked ‘What data is available?’, prompting the use of a further cycle to understand the data provided.

**Reflect** – In the above cycle, although ORH Ltd followed the process map set in Figure 1, problems were encountered when submitting a vague data request through the question “What data is available?”. By taking this approach ORH Ltd gave control to Client Y and subsequently resulted in ORH Ltd believing the data was showing something different than its actual content. Due to the concerns, further steps of analysis need to be taken for both the firm and client to be confident in the data set provided. However, analysis on a User ID level required further data prompting the start of a new data set collection cycle.

**Plan** – ORH Ltd is to request user ID data and analyse the data at this level, which would show the role of users making outgoing calls.

**Act** – From each control room, ORH Ltd requested and were provided with ID skill levels and roles occupied during the sample period. By using the provided roles, it was discovered that a mixture of roles were included in the data. However, roles other than Emergency Medical Dispatchers, were responsible for very small proportion of outgoing calls. Between ORH Ltd and the client, it was agreed to move forward with modelling due to the proportion of outgoing calls made by other roles being insignificant to the model.

**Reflect** – Through ORH Ltd using once again the iterative cycle of relaying results and allowing the client to see the whole picture as seen in Figure 1, it has allowed detailed analysis to be completed and a high understanding of data to be reached. Although there was a problem with caller roles, the approach has produced a result of higher confidence in data, despite a small avoidable delay.

C JOURNAL ENTRY: INCOMING CALL DATA

**Plan** – The main input for the model is a incoming call rate for each control centre, and is ideally required in the form of raw call data to allow a relevant distribution to be created. A request was designed for all three control centres for call by call data for the sample period.

**Act** – The data request was sent to the main point of contact (Mr.I). However soon after sending the request, it became apparent that a call by call database was not available for any of the three control rooms. Mr. I informed ORH Ltd that a ’15 minute chunk’ database was available, which grouped calls in to 15 minute blocks by call category. The database contained: total talk time, average call length, average post call processing and average call length including post call processing. ORH Ltd, again followed the guidelines for partial data availability, by opting to discuss possible assumptions with the client due to the initial plan of creating call demand and duration distributions, which known distributions would be fitted against not being possible.
Reflect – ORH Ltd followed the guidelines well, in sending a detailed request with the relevant sample period. By opting to accept the data available and move to considering assumptions, was aligned with the process shown in Figure 1. This step, caused a further iteration to be completed due to the complete data set not being completed and client discussions being involved.

Plan - Through discussions with the client, it was hoped to weigh up possible assumptions to allow the project to move on.

Act – In discussions, ORH Ltd and Client Y, decided that due to no call by call data being available, it would be assumed that incoming call inter-arrival rates follow an exponential distribution with an analysed mean parameter. The client was happy to follow this plan, as past projects completed by ORH Ltd had shown inter-arrival rates following an exponential curve. The same assumption was made for call durations, which had been seen to follow a normal distribution with an analysed mean and standard deviation. Analysis was carried out on the call logging data received to form a current service profile for each control room. Analysis for each control showed differing parameters across each control as expected. At this stage the client and ORH Ltd were happy with the data received and assumptions used due to limitations in the client’s data availability

Reflect – ORH Ltd followed the guidelines successfully and effectively used their expertise in the industry to aid the project and remove the risk of further delays. This approach is more desirable in a professional setting than changing the modelling method due to tight time constraints and report deadlines. As confidence was reached in the data set, no further iterations were necessary.

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REFERENCES


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