

EMPOWERING DECISION SUPPORT WITH SIMULATION TECHNOLOGY – SCENARIO NAVIGATOR

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ABSTRACT

The commercial simulation environments that are available today focus primarily on the development of simulation models. They are designed for a single user. They provide animation during the simulation run and in most cases they provide outcomes of the simulation run in reports. Our experience in developing computer based simulation models with different commercial and non-commercial simulation software packages and found that these packages do not offer sufficient support in: performing experiments with large complex models, performing experiments with multiple users, managing experiment data and results, analyzing the experiment results and comparing them. The items that are summarized above are a necessity to bring simulation technology to a wider use. Simulation technology could be very well used as an operational decision support tool. In order to meet this demand we have developed Scenario Navigator, a client-server based application that allows multiple users to create, populate, run, analyze and compare experiments.

1 INTRODUCTION

Shannon (1975) defines simulation as “*the process of designing a model of a concrete system and conducting experiments with this model in order to understand the behaviour of a concrete system and/or to evaluate various strategies for the operation of the system.*” (p2). The objective in a simulation study is to understand a system and its behavior by performing experiments. The process of performing these experiments require that all stakeholders can define possible alternatives for evaluation, so they can understand the effects of their suggestions.

The understanding of a system and possible alternatives also requires that the team that is working in the simulation study, i.e. model developers, model analysts, data providers and problem owners can introduce new possible solutions and analyze the outcome of the simulation runs together (van Meel, 1994).

Hillen (1993) describes that performing experiments in a simulation study consists of three steps:

- a) Define experiment conditions
- b) Execute simulation run
- c) Register results

These three steps are performed just as long until the problem owners are satisfied and have gathered sufficient insight in the possible solutions. According to Robinson (1999) the simulation study duration or the budget are limited and thus the insight should be provided before the time or budget has been exceeded.

The commercial simulation environments have been working over the past 10 years on improving the support for all three activities. They help model developers by entering data easier via user interfaces to modules, links with Excel sheets or model developers can make customized VBA interfaces. The speed of simulation execution has been mainly improved by faster more powerful computers. The registration of results is improved by standardized reports, writing data to databases and export to Excel sheets.

Taylor et al (2001) describe the use of a tool called GroupSim to generate ideas and suggestions as part of a group session to identify new experiments. GroupSim stops at the moment that the experiments are defined and GroupSim does not offer features to the stakeholders for analyzing the outcome. Furthermore, the preparation of a simulation model to run the simulation experiment and to combine the performance indicators is a time consuming process. During this process the stakeholders can easily define new simulation experiments. As a result the stakeholders are all waiting during the meeting for the first simulation experiment to finish.

The main time consumer of performing experiments with already defined scenarios is entering the parameters in a model and evaluating the outcomes. There are several possibilities which are statistical solid approaches to minimize the number of experiments to perform (Kleijnen, 1977) or result in automatic optimization and providing

the best fitted result (Krug, 2001). The strength of these processes is in situations where a mathematical equation can be defined to judge what the best performance is of a system. Unfortunately in situations with several stakeholders involved there is not one best solution, but there are a range of possibilities with all advantages and disadvantages. The approaches as described by Kleijnen (1977) and Krug (2001) are thus not suited as a generic solution for support to stakeholders in the simulation experimentation process.

Scenario Navigator allows multiple users to perform experiments, to create experiments, add, edit and delete data in an experiment, run experiments, analyze the results of the experiment and compare experiments in an easy way. Scenario Navigator enables simulation novices to run experiments with one or more simulation models. This paper describes the Scenario Navigator software solution. Section 2 describes available tools and practices. The concept of Scenario Navigator is described in section 3 Section 4 describes the main functionality of Scenario Navigator and section 5 concludes this paper.

2 AVAILABLE TOOLS AND PRACTICES

In order to manage the issues set out in the introduction of this paper, simulation consultants use a range of available tools and apply different practices that we will set out in this section.

2.1 Custom Interfaces on simulation models

The development of custom interfaces to a simulation model is often a time consuming effort and require a lot of development time of the model builder. These interfaces are often customized for a simulation model and are developed over and over again. Only the simulation experts who are regularly developing simulation models in the same domain can benefit from previously developed interfaces and will be able to work with minor adjustments. The advantage of these custom interfaces is that advanced reports can be made with custom graphs of different variables in the simulation model. Nevertheless, our experience is that these interfaces are fixed with one simulation model and these interfaces do not offer the ability to evaluate performance indicators of different scenarios.

2.2 Spreadsheet interfaces

The spreadsheet is often used to analyze results of a simulation run. Most commercial simulation engines provide a link to MS Excel. The results of the simulation model can be written to a spreadsheet and from the spreadsheet the analysis of the results can be done. However, these spreadsheets do not allow for analysis of multiple experi-

ments and have size limitations when exporting large amounts of data of a run into the spreadsheet.

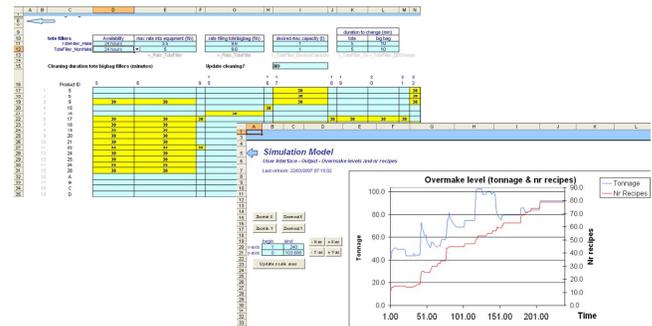


Figure 1: Dedicated spreadsheet interface for data entry

2.3 Experimenting functionality in simulation engines

The simulation environment Arena offers an instrument that is specifically developed for defining a range of simulation experiments and compare performance indicators of these experiments. This tool is called Process Analyzer (Kelton et al, 2007) and also enables to schedule simulation experiments using different simulation models. The ability to use different simulation models is required to enable simulation experiments that are more than just a parameter setting, for example a complete new production line or a new control mechanism to allocate jobs to a set of resources. **Figure 2** shows Process Analyzer of Arena including 15 different scenarios that are ready to be executed. The grey column at the right of **Figure 2** will contain the values that are returned from the simulation environment once the simulation runs for these scenarios are performed. In Process Analyzer only quantitative performance indicators can be observed, in this case average waiting time. Process Analyzer does not show graphs of change values over time, no confidence intervals and no nice representation for a lot of performance indicators.

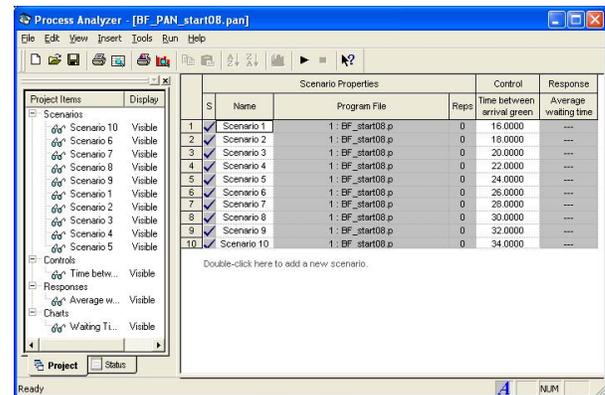


Figure 2: Process analyzer of Arena

Another custom tool is provided by Automod and named AutoStat (Banks, 2000). AutoStat is a tool that provides data analysis like confidence intervals and required warm-up period for a simulation run. Unfortunately, this custom tool can not provide analysis of several experiments. All mathematical power is organized for one experiment and thus does not support multiple experiments like common is performed in a simulation study.

2.4 Optimizing tools

Optimization technology in combination with simulation is available for support to identify the optimum in a system by changing single parameter settings. Optimization tools like OptQuest (April et al, 2004) or Issop (Krug, 2001) provide different optimization algorithms to find the optimum configuration of a set of parameters. The optimization instrument feeds the simulation with a parameter setting, the simulation runs and returns one number (the objective function). **Figure 3** shows the value of an object value, the best identified set of parameters and the current evaluation for one simulation model after over 35 experiments. Disadvantage of optimization is that an objective function needs to be defined. A single objective function can not always defined. For example, a higher utilization versus a lower cost is hard to express in an objective function.

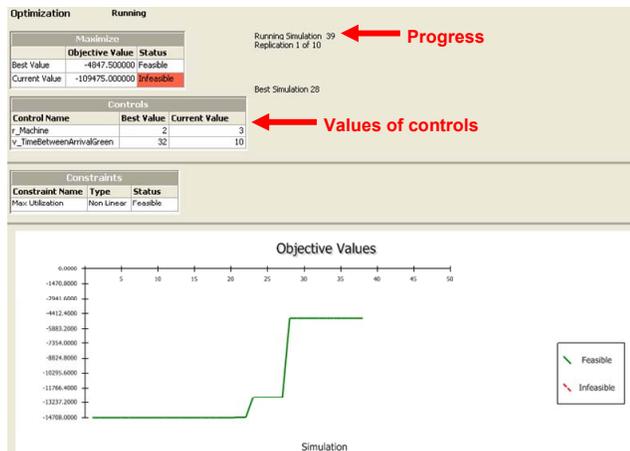


Figure 3: Results of optimization: best and current run

3 SCENARIO NAVIGATOR CONCEPT

We encountered the limitations of the existing tools and practices numerous times whilst delivering decision support solutions at our customers. Therefore, we have designed and developed Scenario Navigator. Scenario Navigator is a software platform that can turn any model, into a decision support system, ready to be used by model builders (for model validation), but also by analysts and decision makers to support the decision making process.

Scenario Navigator brings the power of simulation models to the desktop of managers, independent of the engine that is used for modeling.

The database of Scenario Navigator contains data of all experiments that can be accessed by any user and can trigger simulations. **Figure 4** shows the interaction of data input for experiments and simulation models into Scenario Navigator. Within the database a range of scenarios are then triggered to be performed using one or more simulation models in one or more simulation environments. The outcome of the simulation models is stored in the Scenario Navigator database and allows the user to view different reports, either a report of an individual scenario, or a report of multiple experiments.

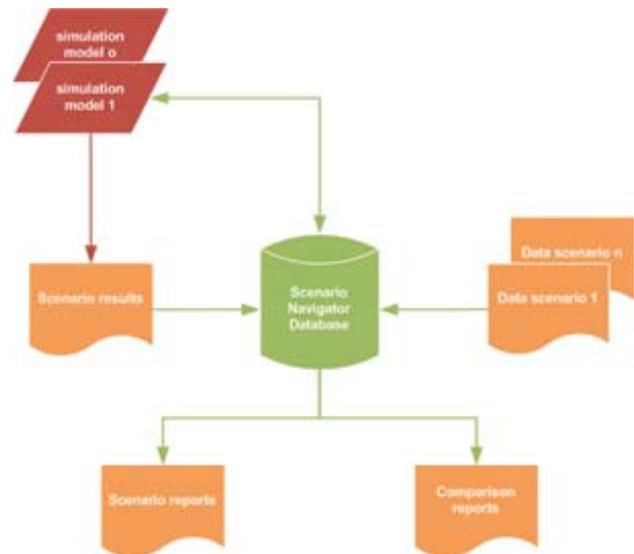


Figure 4: Interaction Scenario Navigator

In **Figure 4** at the left are four reports shown of a scenario and at the right hand side three reports with different topics, i.e. utilization, wait time and queue length. These reports are simple examples, but can be customized and contain different sets of scenarios and performance indicators.

Figure 5 is the process of working with Scenario Navigator. A model developer creates a simulation model according to normal processes (Banks, 1999). This simulation model is added to the Scenario Navigator database and the problem owner (or any stakeholder in the simulation study) can add, edit or delete data for experiments. The experiments are added into the Scenario Navigator database, whereby the user can copy already defined experiments (to re-use the already entered data) or adjust already defined experiments. The activities of adding, editing and deleting data is tracked in the scenario history, to enable users to return to a previous state.

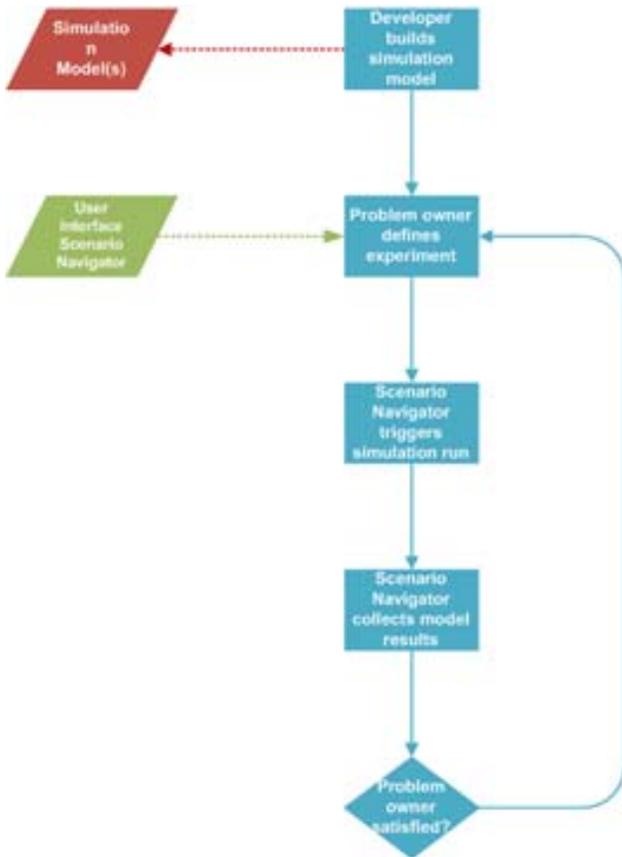


Figure 5: Process of performing simulation experiments with Scenario Navigator

The next step is to perform the simulation experiments. The users of Scenario Navigator can identify a list of simulation runs to be performed. Scenario Navigator will trigger the simulation application to perform the experiments. The performance indicators of the simulation experiment are automatically imported and stored in the Scenario Navigator database. The collection of performance indicators enable stakeholders to view results in custom reports at any time.

The reports enable the stakeholders to evaluate whether they now gathered sufficient insight in the system thanks to the simulation study. If they do not have sufficient insight yet, then they will define some additional experiments and perform them. Once they have collected sufficient insight, they will stop the simulation study and act according to their findings.

The parameters and performance indicators of scenarios are kept in the database. If in a later stage additional scenarios are required or a report needs to be adjusted slightly, then this can be performed easily, without performing the simulation experiments again.

The Scenario Navigator application is designed for multiple users. A database server will be connected to the network and all computers connected to this computer can

define new scenarios or view the results, given the correct user rights. **Figure 6** provides an example of computers connects to enter input and to view output, all to the same Scenario Navigator database within a simulation study.

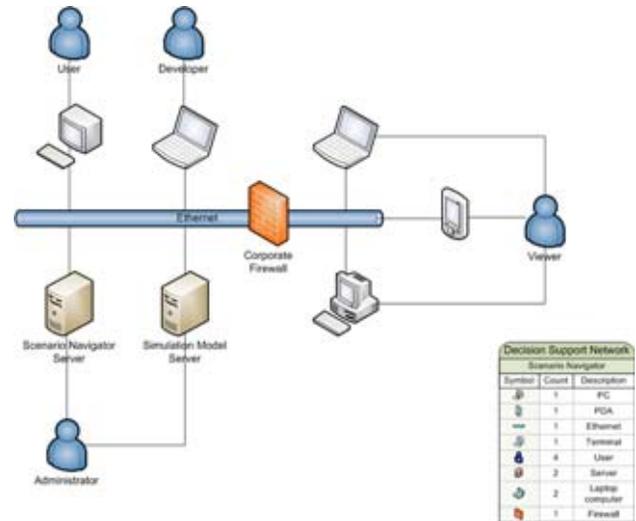


Figure 6: Network users, Scenario Navigator and simulation environment

4 SCENARIO NAVIGATOR FUNCTIONALITY

This section describes the Scenario Navigator functionality and different screenshots of the software are included. The functionality is set out in different sub-sections that describe experimenting, data management, dashboards, analyzing results, the management of multiple users, the configuration and custom extensions of Scenario Navigator.

4.1 Experimentation

In Scenario Navigator new experiments can be created from a base case or created without any data. The process of defining a scenario starts with the definition of the scenario parameters name, model, start date and time, run length, warm-up period and the number of replications as shown in **Figure 7**.

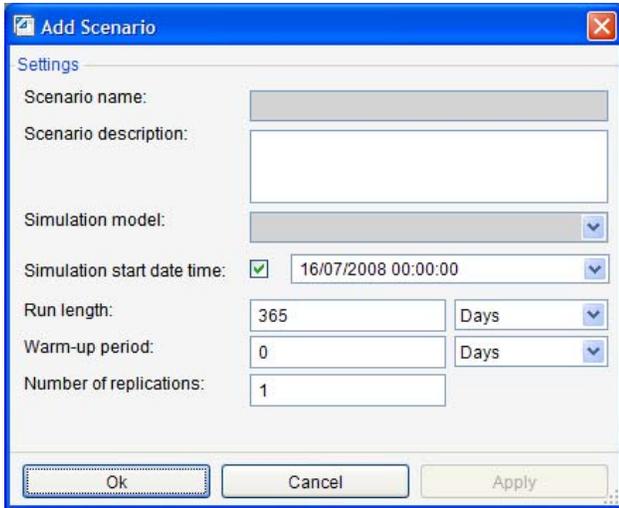


Figure 7: Creating experiments

Scenario data can be added, edited and deleted in the different data tables that the model developer has configured in Scenario Navigator. This results in an experiment that is ready to run. The scenarios that are set up can be added to the scenario run queue which will execute the experiments subsequently.

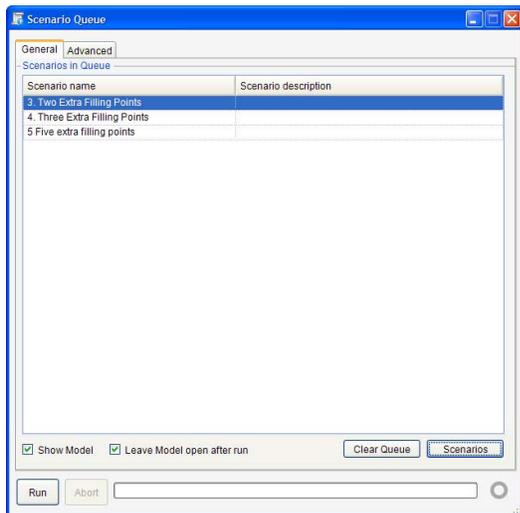


Figure 8: Running multiple experiments subsequently

Any stakeholder can view the latest changes in any scenario by referencing the scenario history tables to get a better insight into the differences between scenarios. (see Figure 9)

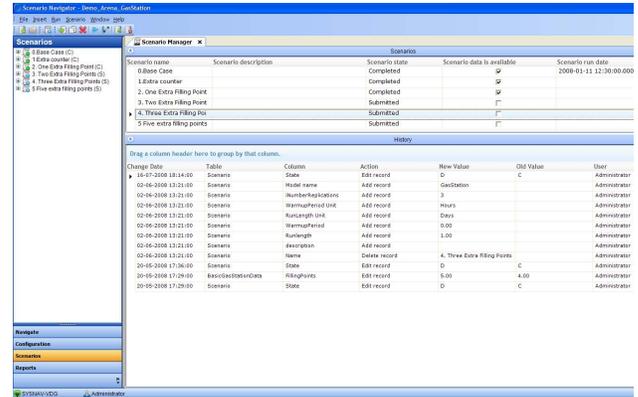


Figure 9: Manage the experiments

4.2 Data Management

Scenario Navigator manages the input data for the simulation model and stores them in the database with the results of the scenario when the scenario has been run.

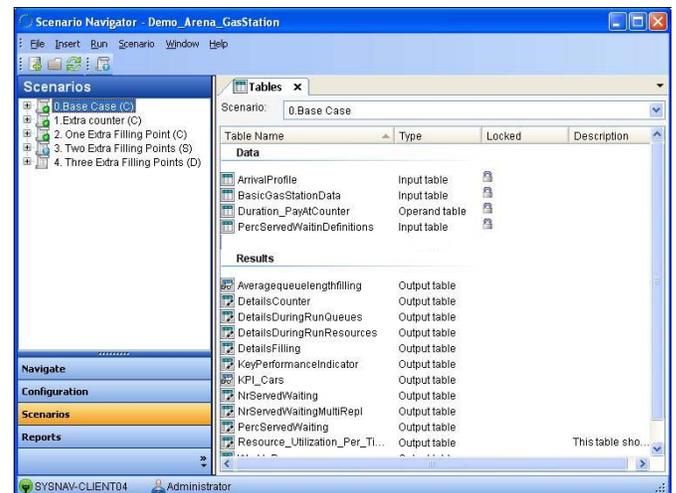


Figure 10: Data and result tables

Each scenario contains the full data structure that has been configured by the model developer. When the scenario is in design mode the user can edit the data and when the scenario is in completed state the user can view the result tables for the scenario.

4.3 Dashboards

Scenario Navigator can be configured to have different dashboards that allow different users to easily create experiments and analyze results.

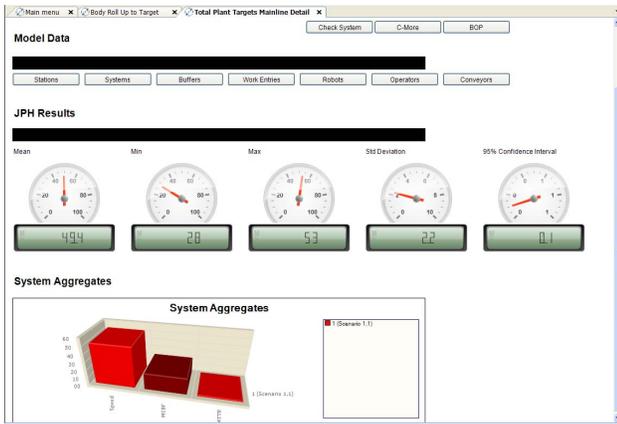


Figure 11: Dashboards for easy solution navigation

A dashboard contains data of a selected scenario and by switching the scenario the stake holders can compare the results.

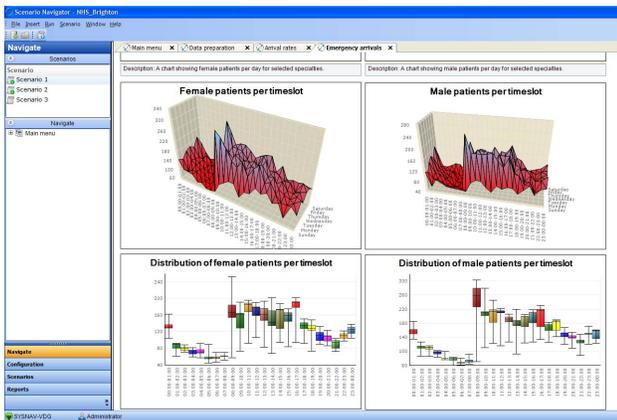
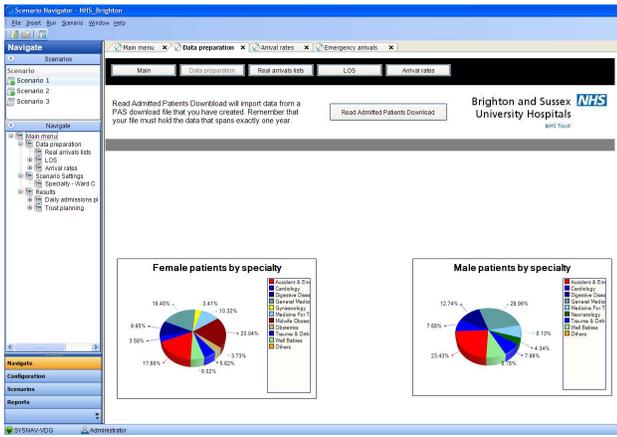


Figure 12: Create customized user friendly dashboard for performing experiments

4.4 Analyzing results

Scenario Navigator has multiple tools to analyze the results and compare different scenarios.

Scenario Navigator has different chart types that can be configured to show scenario results as shown in Figure 13.

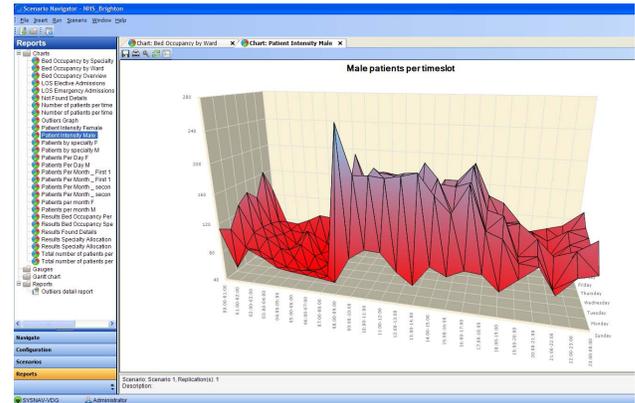


Figure 13: Heatmap chart in Scenario Navigator

The charts in Scenario Navigator can also show the results of different scenarios in the same chart by simply selecting the scenarios to compare see Figure 14.

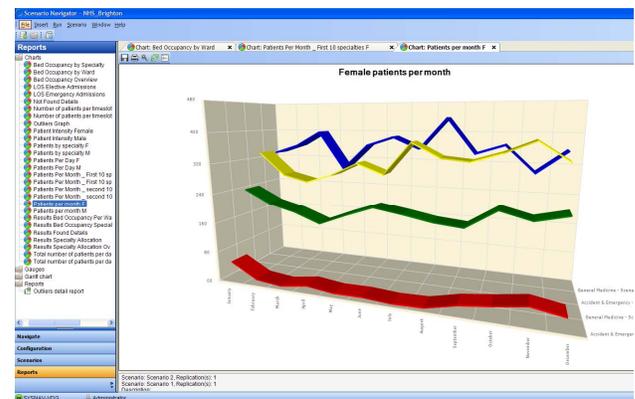


Figure 14: Comparing results

Scenario Navigator also provides the user with reports that can show results of a scenario or of multiple scenarios in the same reports. Figure 15 shows a report with multiple scenarios that can be compared.

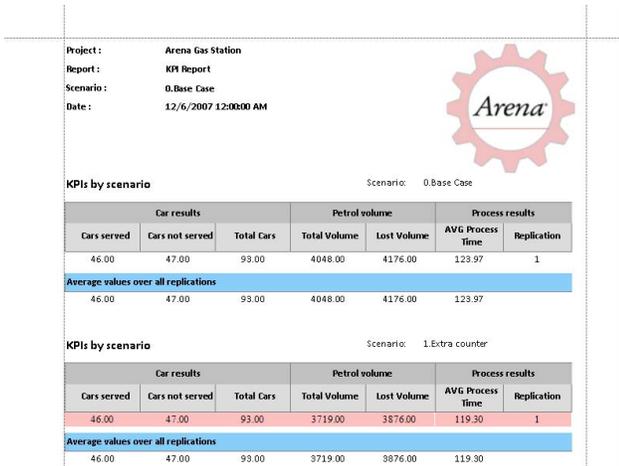


Figure 15: Comparing experiments in customizable reports

The reports in Scenario Navigator can be shared and exported to different formats.

4.5 Manage multiple users

User management is one of the key features of Scenario Navigator. Users have a user role, which provides the user with certain user rights. A user can be added to a project in order to allow the user to access the project.

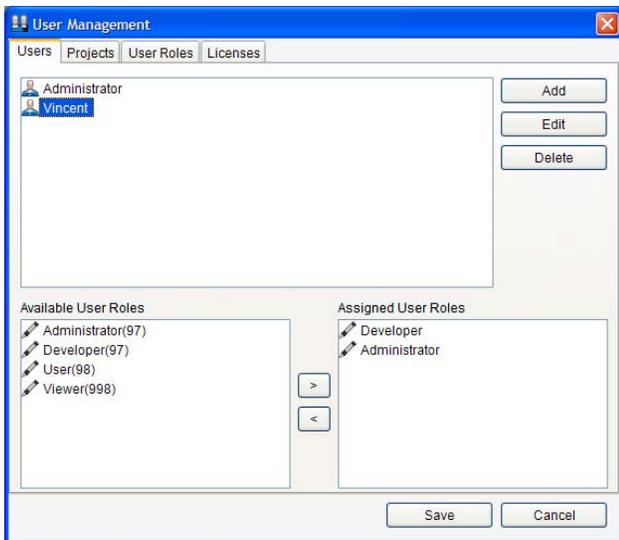


Figure 16: Manager users, roles and project access

4.6 Configuration

Scenario Navigator is a highly configurable tool. Items that need to be configured in Scenario Navigator are the data structure, models, dashboards, graphs, gauges and reports.

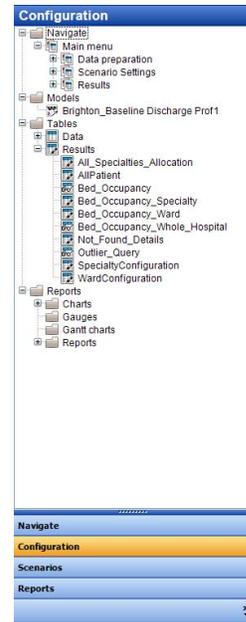


Figure 17: Configure project structure

The data structure in Scenario Navigator is configured with data tables, result tables and queries. There are different table types for different types of connections with the simulation model.

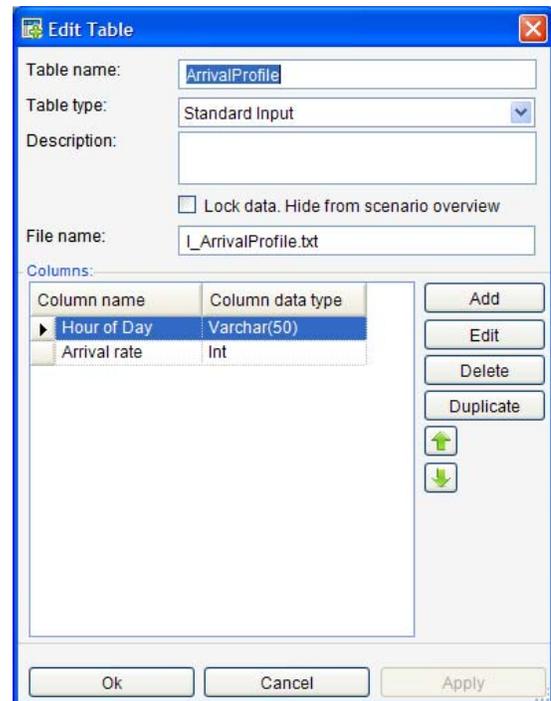


Figure 18: Configuring the data structure

Scenario Navigator requires at least one simulation model in order to be able to run scenarios. The simulation envi-

ronments that are currently supported are Arena, Enterprise Dynamics, ExtendSim and Simul8.

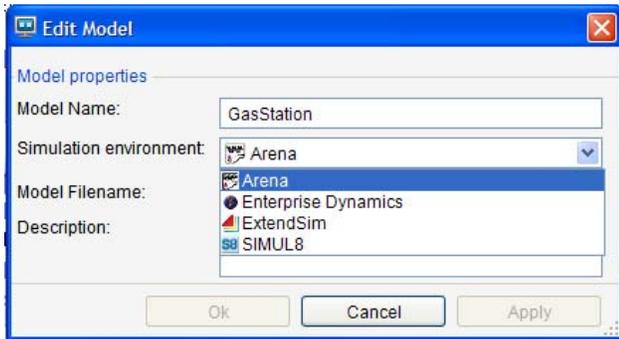


Figure 19: Configuring models

Charts and gauges can be configured with wizards that allow the developer to attach data tables and queries to the charts and gauges. There are many different chart types available.

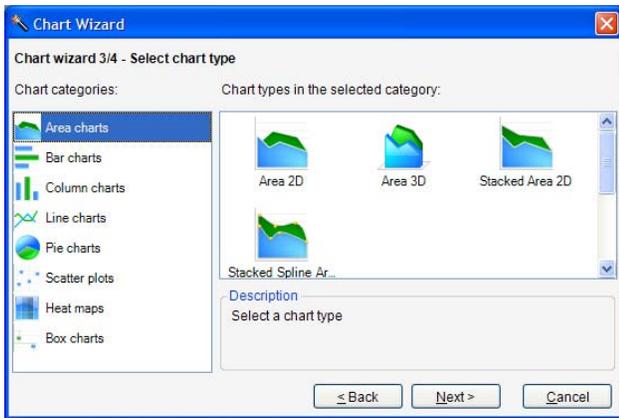


Figure 20: Chart wizard

Dashboards in Scenario Navigator can be configured with data tables, graphs navigation buttons and gauges.

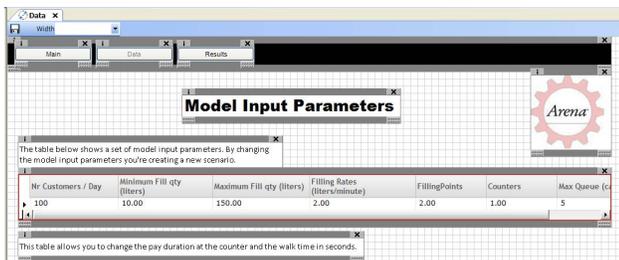


Figure 21: Configuring dashboards

4.7 Domain/customer extensions

Scenario Navigator can be customized for particular domains or extended with specific functionality. The generic

Scenario Navigator application is currently implemented in one of the worlds' largest food manufacturers. This is done by using the software in combination with the generic extensions concept. A complete dedicated data structure in combination with engine library and customized reports is added to the software. This allows the end users to generate a complete model of an existing or new plant, and analyze its performance in detail.

The Scenario Navigator application is also used in decision support in hospitals together with the dedicated simulation library called Hospital Navigator (Hay et al, 2006). This is currently in use by several NHS hospitals in the United Kingdom. This enables hospitals to use the application for regular evaluation of allocation of beds and achieve a higher utilization of their beds without denying patients service.

Optquest, by Opttek, is available as extension, allowing complete and customized simulation optimization within Scenario Navigator projects.

5 CONCLUSION

Developing the ideas behind this decision support framework for simulation, Scenario Navigator, has been a continuous process of many years. In those years we have been involved in practicing simulation in a wide variety of industries. The lessons learned in these projects, the encountered limitations in software and the customers needs have directed us in our development work thus far. Our motivation for developing this framework comes primarily from our objective to bring the power of simulation models to the desktop of problem owners. The development of the Scenario Navigator software has been a process of 3 years, resulting in the operational use of simulation with several corporate organizations that base their weekly planning on the outcome of the simulation.

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