SELECTION OF THE SIMULATION SOFTWARE FOR THE MANAGEMENT OF THE OPERATIONS AT AN INTERNATIONAL AIRPORT

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Abstract

A new airport in Ciudad Real, Spain, is looking for tools that will help with the management of resources. Operations in this airport will start in late 2007 or early 2008. The selection of the software applications to be used is crucial to the success of the development of the real-time tool that will be implemented for daily operations. The selection process requires a study of the capabilities in the commercial and general-purpose simulation and visualization tools available. Three alternatives have come out of an initial screening process: Witness to simulate and MsExcel as the interface, Arena with Excel, and Visual Basic to simulate and to show Gantt charts and JAVA to visualize the airport in real time. A model that reflects the operations that take place at a parking position has been developed in each of these three platforms to better assess their possibilities. It has been necessary to define the individual criteria, and relative weights of different capabilities, that will help with the ranking of the alternatives: user related (ease of use and decision making capabilities) and developer related (connectivity, maintenance and cost). Analytical Hierarchy Process has been used to quantitatively select the Specific tool that includes a simulation model developed with VisualBasic on the spreadsheet and a graphical visualization screen developed in JAVA, which will allow in the future to automatically update the data.

Keywords: Discrete-Event, Software Selection, AHP.

Presenting Author's biography

Javier Otamendi. Received the B.S. and M.S. degrees in Industrial Engineering at Oklahoma State University, where he developed his interests in Simulation and Total Quality Management. Back in his home country of Spain, he received a B.S. in Business Administration and a Ph.D. in Industrial Engineering. He is currently a simulation and statistics consultant and university professor at the Rey Juan Carlos University in Madrid. He collaborates with Autolog Group at Univ. Castilla - La Mancha, http://autolog.uclm.es. (franciscojavier.otamendi@urjc.es)

1 Introduction

Spain is suffering important changes in the air service industries. Several new private airports are being built all over the country to attract low cost companies for vacation flights (Castellón), to relief part of the traffic in the main airports (Girona, close to Barcelona) or to be used for freight.

Ciudad Real is a city located 200 kilometres south of Madrid and its airport is being built to cover all the previous three voids. The aim is to start operations at the end of 2007. For that reason, the management of the company is starting to develop tools that will help in the daily operations with the aim of optimally allocating resources.

The first objective of the research is the graphical definition and representation of the operations that are going to be carried at the parking positions: embarking and disembarking of passengers and crew, and all of the associated activities.

The second objective, which will be studied in detail after the first one is completed, is the staffing and the dynamic scheduling of resources. Within one software application, the manager should be able to establish shifts of personnel and levels of material resources for the upcoming periods (either years or weeks) as well as dynamically assign, in real time, the available resources to the different parking positions when the airport is under normal conditions of operation.

The selection of the tool to be used is crucial to the success of the project. This tool is to be composed of two different parts: the model and scheduling algorithm and the visual user interface. The two parts are going to be treated separately in the selection process, although their link is going to be also a critical variable.

This paper begins by presenting an overview of the most commonly used simulation tools for airport logistics and continues by describing, in more detail, the specific situation of the airport at Ciudad Real. The paper deals then with the specification of the criteria that will be used in the selection process.

To the common ones (cost and development time), other ones like friendliness (or ease of use), connectivity (or use and interrelation of standard software) or adequacy to the decision process (to address the necessities of the problem in hand) are included.

The software selection step calls, on one hand, for the inclusion in the decision team not only of the management or the simulation and modelling specialists; but also of the final user of the application. On the other hand, and thinking in terms of the whole project, it also calls for the use of a unique platform to address the two objectives of the project.

In most of the cases, the clients want that the input of data be performed in spreadsheets that they already handle and that the results appear in the same spreadsheets in different formats. For this reason, it is most important that the selected software is picked among those that allow for the input and output of information via spreadsheets. Moreover, the client is neither interested in the knowledge of the software or the simulation code, nor in having to learn a new application. It would be interesting that the simulation software could be controlled from the same spreadsheet.

The second part of this paper deals with the enumeration of the possible software alternatives and their evaluation according to the stated criteria. Both commercial simulation software, like WITNESS or ARENA, and programming tools, like Visual Basic or C++, are explored to develop the algorithms. The graphical user interface might be developed either with the commercial simulation software or with any other animation tool like Java APPLETS. The development of a small application is carried out in each of the alternatives to facilitate the evaluation process.

The tool that fulfils the majority of the previous requirements is simulation on spreadsheets. Among its fortes, one can mention: the low cost, the quickness in the development, being one of the tools most used by the majority of the personnel in the companies, and being based on standard software – which facilitates the interchange of information with other applications. Spreadsheets also offer graphical possibilities for visualizing the results with different types of diagrams and graphics.

Some other advantages of the spreadsheets include the great variety of mathematical, statistical, financial and date/time functions that have been built-in, the ease of interconnection to databases and the capacity of automation that they offer through the use of its own programming language, Visual Basic for Applications in the case of MsExcel.

However, when the algorithms to be implemented or the data structures to be handled are very complex, the spreadsheets do not turn out to be sufficient. To implement more complex logics, it is possible to resort to programming in Visual Basic inside the spreadsheet. The second option is to use object oriented environments as JAVA or .NET to create an application that encapsulates the spreadsheets, but allows adding other functionalities like algorithms, complex structures or graphical visualization.

The option to use commercial simulation software also exists, with the majority of them already allowing for the interchange of information with the spreadsheets. It has to be remembered that the simulation software must be hidden to the user who just wants to interact with the spreadsheet. One of the points to analyze is how different simulation software

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packages react to spreadsheet calls. The main problem in small or medium applications of simulation is the added cost.

2 Desirable simulation software characteristics

Simulation has been one of the most important modelling techniques in the management of resources field, in general, and in the airport area, in particular, over the last couple of decades [1]. A new airport like the one in Ciudad Real is looking for tools that will help with the management of resources when the operations start in late 2007 or early 2008.

In this section, a survey of simulation tools is performed so that both: a complete list of software tools and desirable characteristics; are available.

2.1 Commercial software

A complete survey of simulation software is performed biannually by Swain and published by OR/MS Today [2]. 48 products are listed in the operations research and management science field. Each commercial software is described in terms of typical application and market orientation, system requirements, model building, animation, support/training, pricing and vendor information, and major new features.

A second source of data is provided by the consulting firm lead by Dr. Averill Law [3], which proposes a training course in which several simulation software are evaluated using 19 different characteristics.

2.2 Screening of software alternatives

Out of the available software tools, two options appear as the main routes to be evaluated: using commercial software and add functionality with the spreadsheet or developing an ad-hoc model with general-purpose software, focusing on the user interface from the very beginning.

The first route is to develop the tool using any of the discrete-event technologies that are commercially available but facilitating the interface with the user. The main two problems that this type of software presents are the interface and the visualization of the execution of the model. The main driver of these tools is being able to represent complex logic and not the visualization. For that reason, the current trend in the market is to develop the interface in spreadsheets or databases, which shows a button to execute the simulation and presents the main results in an environment which is familiar to the user. The simulation is performed in the background without any interaction or visualization.

Witness and Arena are considered for further analysis mainly because are the tools that the members of the research and development team are familiar with but also because an interface may be built in MsExcel, which is the most popular software tool among the managers of the airport. The future users clearly show a desire to use spreadsheets as the interface, so they are not really worried about the software that lies underneath performing the calculations.

The second route looks at developing the software from scratch using a general-purpose language, as VisualBasic, JAVA or C++. The main driver in this case is to think about the visualization from the start, and develop the model and program its logic, which is not too complex, to fulfil the interface needs.

In this case, it looks like the appropriate alternative is to develop the logic of the model in Visual Basic, including a first graphical representation in MsExcel, showing the commonly used 2-D Gantt charts. Then a more visual screen is to be developed in JAVA.

So three alternatives are selected for further development: Witness with an MsExcel interface, Arena with an MsExcel interface, and a spreadsheet simulation with a JAVA interface.

2.3 Proposed criteria

To compare the alternatives, a multicriteria decision model is to be set using a subset of the characteristics included in the literature [2, 3]. To reduce the set of final criteria even more, a further grouping has been made, so the total number of desirable characteristics is set to five.

The first one is the COST. It includes both the product/software cost and the development of the model.

The maintenance costs as well as the tasks to update and improve the application are grouped under UPDATE. Characteristics like hierarchical modelling or object-oriented philosophy are taken into account under this more general criterion.

The third one, EASE, aggregates all the characteristics concerning with user friendliness and ease of use by the operators in a daily basis.

CONNECT includes the connectivity issues with external software, like spreadsheets, databases, visualization applications or even on-line control software.

Finally, animation capabilities, output analysis, adequacy to the decision system and policies, …, they are all included under the last criterion, called DECISION.

3 Software development

Once both the criteria and the alternatives have been set and specified, it is the proper time, prior to taking the final decision, to develop trial versions of each of the proposed management decision platforms so that the selection has a deeper foundation.

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3.1 The system

The system under study includes all the operations that will be carried at the airplane parking positions at the airport. The loading of passengers includes the escorting of the passengers from the gate to the stairs of the airplane, while the unloading includes the walk from the airplane to the arriving lounge. The resources that are available are operators that escort either passengers or crew and the stairs to enter or exit the aircraft.

3.2 Witness

Modelling in Witness is performed in three steps. First, the objects are and drawn out of a standard library. Then, each object is particularized, including name, graphical appearance and personal characteristics (capacity, process times…). Finally, the logic of movement is included. The appearance in 2D for this model is shown in Fig. 1.

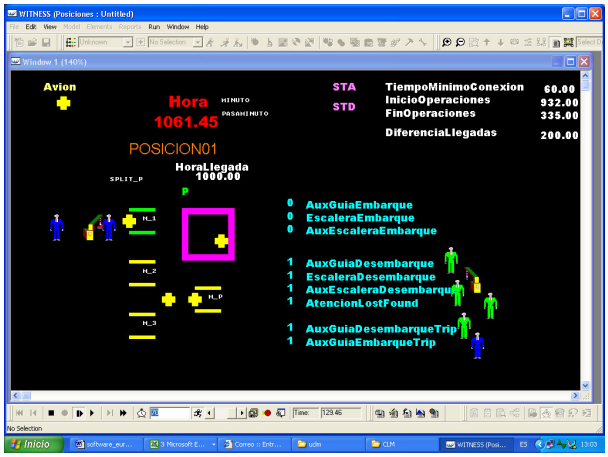

Fig. 1 Interface in Witness

Although easy to develop and maintain, the interface in 2D is usually not appealing. The software has the possibility to develop a 3D interface, but it is usually too costly and time consuming to develop it.

The MsExcel interface allows to interchange input or output data easily and to execute the simulation. It is appropriate for experimentation purposes and so is to develop a required by-product at the airport: the Gantt chart (Fig. 2).

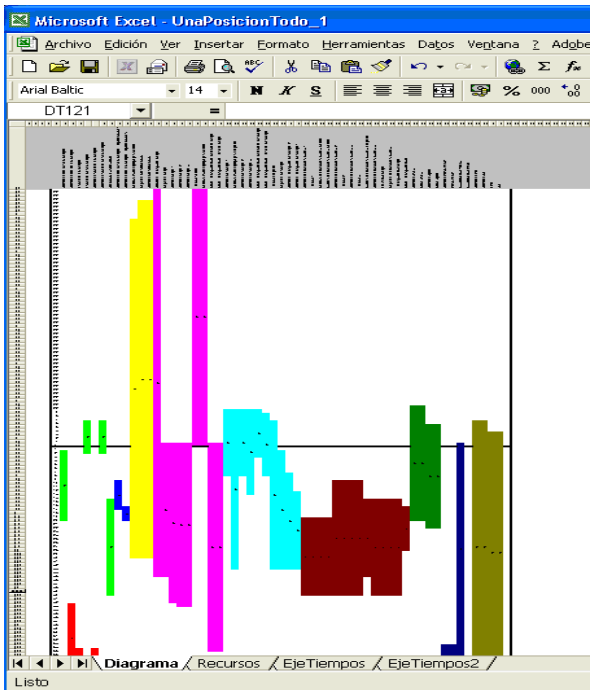

Fig. 2 Interface in MsExcel

3.3 Arena

The model in Arena also creates the MsExcel Gantt chart, although its logic and visualization capabilities are somewhat different than in Witness (Fig. 3).

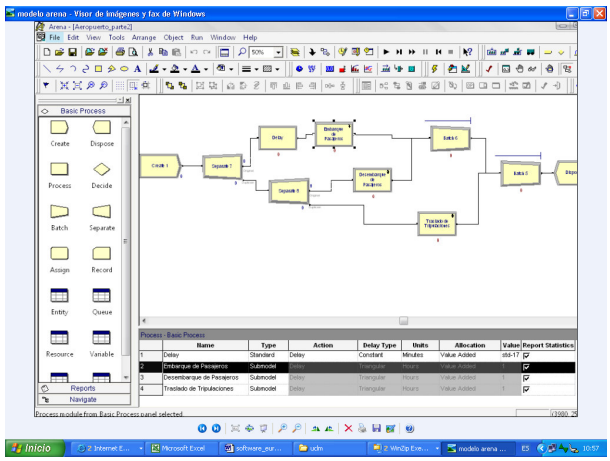

Fig. 3 Interface in Arena

The block structure makes the modelling somewhat easier than in Witness, although, it is necessary to develop a parallel visualization model to improve the presentation.

3.4 Specific tool

Fig. 4 shows the visualization interface that has been developed in JAVA. In the right panel, the plane changes colours to differentiate between the moments in which the plane is present or not. The resources that are busy surround the plane. The left panel shows the resources that are available and idle. There exists the

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possibility to use it in a video mode, rewinding or fast-forwarding the execution.

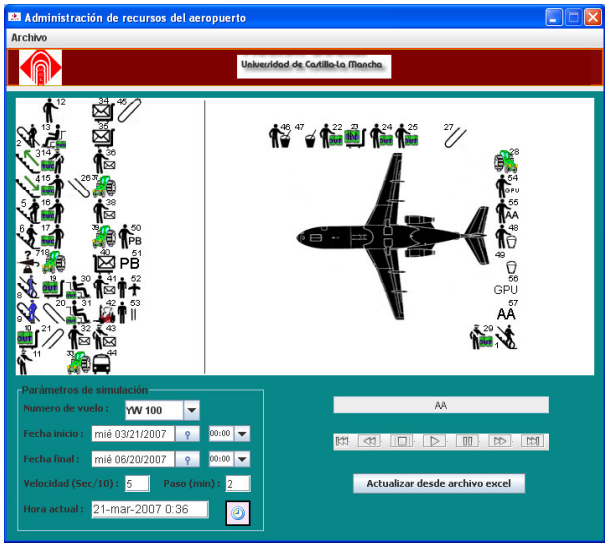

Fig. 4 Interface in JAVA

4 Software comparison

Although, qualitatively, the fortes of each of the alternatives have already been mentioned, a quantitative study using available discrete optimization techniques is to be performed.

One of these techniques is Analytical Hierarchy Process (AHP), which is a decision making technique developed by Thomas Saaty [4]. He claimed AHP allows for the rational evaluation of pros and cons concerning different alternative solutions to a multi-goal problem.

AHP is based on a series of pairwise comparisons between alternatives for each of the criteria individually, with a posterior aggregation step based on the subjective weighing of the criteria.

4.1 Pairwise comparisons

The first step in AHP is to provide a subjective evaluation of the alternatives per criterion. The particular way of assigning ways using this technique is to make all the two-way comparisons and assign a value to each pair. Fig 5 shows the resulting matrix for the criterion "Cost". Witness-Specific has been assigned a value of 1 (or a tie) since the expensive Witness has barely no development cost compared to the high development cost of the free JAVA. Arena is cheaper than Witness with approximately the same development cost, so the pair Arena-Witness has been assigned a value, below 1, of 0.70, and so has the pair Arena-Specific. For the pairs mentioned in the reverse order, the technique calls for the assignment of the inverse value.

COST	ALTERNATIVES			
ALT.	WITNESS	ARENA	SPECIFIC	
WITNESS	1.000	1.429	1.000	3.429
ARENA	0.700	1.000	1.429	3.129
SPECIFIC	1.000	0.700	1.000	2.700
	2.700	3.129	3.429	

Fig. 5 Evaluation of criterion "Cost"

With respect to the criterion "Update", the matrix is shown in Fig 6. Due to its hierarchical structure and its debugging capabilities, Witness seems superior to Arena. Specific tools do not perform well because of their lack of generality.

UPDATE	ALTERNATIVES			
ALT.	WITNESS	ARENA	SPECIFIC	
WITNESS	1.000	1.250	1.667	3.917
ARENA	0.800	1.000	1.111	2.911
SPECIFIC	0.600	0.900	1.000	2.500
	2.400	3.150	3.778	

Fig. 6 Evaluation of criterion "Update"

However, under the very important ease of use and friendliness criteria, Specific performs much better than the flow-oriented commercial software. Arena has a relatively better value than Witness due to its visualization characteristics. Fig. 7 summarizes the diagnosis.

EASE	ALTERNATIVES			
ALT.	WITNESS	ARENA	SPECIFIC	
WITNESS	1.000	0.833	0.333	2.167
ARENA	1.200	1.000	0.400	2.600
SPECIFIC	3.000	2.500	1.000	6.500
	5.200	4.333	1.733	

Fig. 7 Evaluation of criterion "Ease"

The Connectivity criterion also calls for the use of the Specific tool. A JAVA-based platform allows for easier connections between model logic and model visualization than commercially available software. The experience of the research group makes Arena a little better than Witness, specifically with visualization tools. Fig. 8 depicts the matrix for this criterion.

CONEC	ALTERNATIVES			
ALT.	WITNESS	ARENA	SPECIFIC	
WITNESS	1.000	0.909	0.667	2.576
ARENA	1.100	1.000	0.667	2.767
SPECIFIC	1.500	1.500	1.000	4.000
	3.600	3.409	2.333	

Fig. 8 Evaluation of criterion "Connectivity"

For the last criterion, "Decision" (Fig. 9), which reflects the very important use of the tool for decision making purposes, it is necessary to remember that what was clearly defined by the management of the future facilities was the output information that the tool must have, so the total match could only be achieved using the Specific tool.

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DECISION	ALTERNATIVES			
ALT.	WITNESS	ARENA	SPECIFIC	
WITNESS	1.000	1.000	0.500	2.500
ARENA	1.000	1.000	0.500	2.500
SPECIFIC	2.000	2.000	1.000	5.000
	4.000	4.000	2.000	

Fig. 9 Evaluation of criterion "Decision"

4.2 Final selection

Once each criterion has been individually analyzed, it is the time to aggregate the values into a one common value that will help select the proper tool. The procedure needs subjective weights that account for the relative importance of the different criteria. From the user point of view, the two important ones are "Ease of use" and "Decision support", so they are given a value of 4 and 3, respectively (Fig. 10). The other three criteria come from the designer's side, ranking them, in order, "Connectivity", "Update" and "Cost".

	ALTERNATIVES			
CRITERIA	WITNESS	ARENA	SPECIFIC	WEIGHTS
COST	0.373	0.332	0.295	1.00
DECISION SUPPORT	0.250	0.250	0.500	3.00
EASE OF USE	0.192	0.231	0.577	4.00
CONECTIVITY	0.277	0.295	0.428	3.00
UPDATE	0.418	0.315	0.267	2.00
	3.559	3.519	5.922	13.00

Fig. 10 Final Aggregation

The Specific tool, due to its customer-oriented philosophy, obtains the higher aggregated weighted value. Even more, its problem, its high development and maintenance costs, is eradicated due to the regional support [5] The development time, longer than with commercial software, is also not a problem since the R&D project started 18 months in advance and the final tool has 6 more months to complete its development.

5 Conclusions

A quantitative analysis has been performed to select the proper management tool to be used for the daily assignment of resources at the parking position and the posterior online control in an airport.

The clearness of mind of the managers of the facilities, both at the strategic or decision levels and at the tactical decisions users, drove the selection process very smoothly.

Analytic Hierarchy Process has been used to quantitatively select the proposed ad-hoc tool due to its superior client orientation. With the user and the application in mind, the model will be developed in MsExcel, as well as part of the front end (Gantt charts). The user interface with enhanced visualization performance will be developed in JAVA.

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