SIMULATION OF BUSINESS PROCESSES FOR THE EVALUATION OF CADASTRAL OPERATIONS

Theo BOULOUCOS[*], **Georgia DAVANELOU**[**], **Mostafa RADWAN**[*]
[*]International Institute for Aerospace Survey and Earth Sciencies (ITC)
Enschede, The Netherlands
bouloucos@itc.nl
radwan@itc.nl
[**] Thessaloniki, Greece
davaneloujuli@technologist.com

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ABSTRACT

Geographic Information Organizations (GIOs) have used until recently traditional methods for producing and selling their products and services. Many of these organizations are now facing challenges, due to, new government policies, to changes in the market demands for custom products, and to the advancements in technology.
Business Process Reengineering (BPR) is a technique that can help an organization adjust to changing performance requirements. BPR identifies the deficiencies, the bottlenecks, and the deadlocks of an organization' s existing processes and allow organizations to model their workflow and to determine the impact that process modification will have on their overall production.
Due to the high risk of failure, the effect of the redesigned processes on the organization's performance must be evaluated, before they can be implemented. Simulation can evaluate and support the selection of the optimal business processes and help an organization to manage change.

The paper is focuses on the evaluation of design alternatives (scenarios) of the field surveys program, known as Home Office – Field Office program that is one of the six main elements of the Dutch Kadaster' s (DK) BPR project, named IT 2000. The system under simulation was identified to be a discrete event dynamic non-terminating system and was modeled as queuing system.
The performance measure of interest for the experiment was identified as the average response time for the addressing of cadastral survey cases.
The survey cases were classified in urban, rural and concentrated cases. Urban and rural cases concern the survey of parcels in urban and rural areas respectively. Concentrated cases concern the survey of a large number of parcels in the same area because of a project e.g. the development of a new urban area.
The varying parameters of the system were chosen to be the interarrival intervals of the survey cases, and the processing time of each activity.
Through our experiments became clear that simulation could successfully be applied for the evaluation of cadastral business processes at the operational level.

1 INTRODUCTION

Many countries are in the process of creating or modernizing their cadaster information systems. It could be very beneficial to the Cadastrer Organizations of these countries to take advantage of the experience of cadaster information systems successfully established elsewhere, but, naturally, systems have to be carefully adapted to the conditions of the indivitual country and local circumstances. It is, however, the impression that the advantages could be substantial either in strategic decision making in connection with the planning and development of cadaster information systems or in the operational level for the establishment of subsystems.
The Dutch Kadaster (DK) is an example of a Cadastral Organization that has successfully automated its operations and is running efficiently. In 1994, the organization was forced by law to become autonomous and almost completely economically self-financing. This change brought new challenges to the organization; it had to become service-oriented. For this attempt, BPR techniques were essential, so that the organization would be able to provide products that are more flexible and services. The Dutch Kadaster started its own redesign project in 1996, named IT 2000, a component of which is the Home Office-Field Office (HOFO) program.

The objective of the HOFO program is to optimize the Cadastre' s surveying activities. It will be achieved by making use of the current technology to complete field surveys for cadastral updating. The Home Office-Field Office is a laptop computer with essential software that provides total office functionality for field surveying. It includes on-line processing of field survey data into a finished product. This type of software solutions have been developed and utilized by land surveyors since quite a while. In the case of the Dutch Kadaster, though, it must be integrated with the Workflow Management System (WFMS) that will be implemented in the organization. Experience gained over the years allowed the Dutch Kadaster to carefully design various scenarios for the processes relating to the HOFO, however they still need to be tested before implementation.
The processes of HOFO could be used as an example for the design and co-ordination of the surveying activities of other Cadastral Organizations. The adaptation and adoption of proven ideas and experiences of the DK will be very beneficial to other countries.

2 THE HOME OFFICE-FIELD OFFICE PROGRAME

Surveying is part of the cadastre's everyday activities. Revision activities of cadastral and large scale topographic maps, control surveys, boundary set out for any purpose and photogrammetric field completion are cadastral surveying activities (manual of the technical activities of the Cadastral Agency of the Netherlands (HTW)).
The HOFO objective is to reduce time and money needed for the surveying activities; Its motto is "re-surveying should be avoided". The definition of Home Office and Field Office is as follows

Field Office: Equipment of the employee in the terrain includes:

- A total station
- A pen computer
- A vehicle
- A mobile telephone

Home Office: Equipment of the employee at home includes:

- An Integrated Services Digital Network (ISDN) connection
- A pen computer

The realization of the Field Office program will be done in two phases:

- Phase I: Quality control in the field
- Phase II: Full cartographic and geodetic functionality in the field

It is important to check the quality of the data while in field. This is the goal of Phase I. It will be made possible by connecting the Field Office computer to the *Electronic Frond Door*, the main connection to the cadastral Network, and by exchanging files with the source data bases, integrated cadastral information in the future. Errors are located by following a two step procedure: at first, the measurements are processed by use of least square adjustment and then they are checked against the source data. A report containing the measurements and the quality control is the output of the process. In this way, all errors are expected to be detected and repaired in the field.

The processes included in cadastral surveys are listed below:

- The work preparation involves the coding of the survey cases, which cadastral parcels are to be surveyed. The survey cases are flagged on a topographic map, to indicate the status of each case.
- The work allocation involves the selection of a routing plan, the mailing of invitations to landowners, the selection of the relevant cadastral and topographic information and the request of archived documents (Electronic Frond Door).
- The boundary identification involves the identification of new parcel boundaries in the field by land owners
- The surveying involves the actual survey of the parcel. The collected data are the reconstruction data, which are input in a project file, with the reference data as background.
- The coordinate calculation involves the least square adjustment of the collected data.
- The cartographic editing involves the adding of semantic data to the project file. Eventually, the semantic data are related to the existing data.
- The cadastral application involves the formation of the new parcel in the data base (parcel generation). If a parcel is split, the new parcel numbers are allocated and associated with the old parcel. If parcels are merged, the new parcel

number is allocated and associated with the old parcels. Finally, the administrative data are linked with the new parcel(s).

- The area calculation involves the calculation of the area of the parcel according to the collected data. The calculated are is later checked against the area referred in the deed.
- The cadastral update involves the final update of the cadastral database with the new data.

2.1 Design alternatives

In total five design alternatives were developed, as different set ups to allow primarily the reduction in personnel costs. Although the main processes are the same for all the scenarios, their difference lies on three elements: location, crew composition and work preparation. For each element a certain number of options is predetermined. Each design alternative is composed of the combination of an alternative from each element.

There are six alternatives for the location option:

1) All preparations are done in the office , the measurements are done in the field
2) Work preparations and cadastral applications are done in the office, the rest of the work is done in the Field Office
3) Work preparation in the office, cadastral application in the Home Office, the rest of the work is done in the Field Office
4) Work preparation and cadastral application in the Home Office, the rest of the work is done in the Field Office
5) Work preparation in the Home Office, the rest of the work is done in the Field Office
6) All work is done in the Field Office

The crew composition element has three options:

1) A Land surveyor – cartographer with an assistant
2) Two Land surveyors – cartographers
3) One Land surveyor – cartographer

Work preparation has three options:

1) By a Land surveyors – cartographers without being supported by a Workflow management System (WFMS)
2) By a specialised officer, without being supported by a WFMS
3) Work preparation fully automated through a WFMS

The combinations of options per design alternative are shown in Table.1. They range from the current situation (design alternative one) to the most automated (design alternative five).

Design alternatives	1	2	3	4	5
Location	1	2	4	5	6
Crew composition	1	3	1	2	3
Work preparation	1	2	1	2	3

Table.1 The composition of HOFO's design alternatives

3 THE SIMULATION

A simulation project was carried out to evaluate two of the HOFO's design alternatives, design alternative one and five, The comparison between these two design alternatives was thought to be more meaningful, because they represent the two extremes. Design alternative one represents the current situation in the DK, whereas design alternative five the most automated situation. The main difference between the two scenarios is that Scenario5 reduced the processing time of some tasks.

The project wants to investigate the impact of the HOFO concept to the performance, in particular to the average response time, of the cadastral surveys in the DK, which quantifies the average time taken from the submission of a cadastral survey request until it is fully processed.

3.1 Project planning

The system under simulation was identified to be a discrete event dynamic non-terminating system. Non-terminating, because during the system's inactive period, when the Cadastral Office is closed, survey cases remain inside and wait to be processed. The system was modeled as an M/G/4 queuing system (M: exponential distribution, G: general distribution, 4: the number of servers).
The performance measure of interest for the experiment was identified as the average response time for the addressing of cadastral survey cases. The survey cases were classified in: urban, rural and concentrated cases. Urban and rural cases concern the survey of parcels in urban and rural areas respectively. Concentrated cases concern the survey of a large number of parcels in the same area because of a project e.g. the development of a new urban area.
The varying parameters of the system were chosen to be:

- The interarrival intervals of the survey cases
- The processing time of each activity

The fixed parameters of the system was chosen to be:

- The number of surveyors remains the same throughout the simulation time. Sickness, absence or any other reason of failure of the crew was not modelled.

A discrete event simulator, SiMPLE++ (Simulation in Production, Logistics and Engineering) developed by AESOP, was chosen for the implementation and experimentation of the model.
SiMPLE++ enables interactive object oriented modeling, simulation and animation of discrete systems, by way of a graphic user interface and a basic object library. It makes possible the use of both standard and empirical statistical distributions. In addition, the collection of simulation outputs and of statistics (like average duration of a pause or blockage for an object etc.) can be automatically done by SiMPLE++.

3.2 Data acquisition and analysis

Sample data were collected from the HOFO report [Kadaster 1997], and were used as input values. The available data represented the average processing time of each activity, without any description of variation, statistical analysis was not able to be performed on the sample data. Consequently, an empirical approach was followed for the selection of the probability distributions of the stochastic parameters.
The interarrival intervals for the survey requests were set to follow the exponential distribution. There was no data about the interarrival intervals of the survey requests, so an appropriate investigation for the selection of a distribution could not be made, the exponential distribution was chosen as the most commonly used distribution for the modeling of arrivals.
The processing time for each activity was set to follow the uniform distribution. Only the average processing time for each activity was given, randomness was introduced by setting the upper and lower boundaries of the uniform distribution to ±10% of the average processing time.

4 EXPERIMENTATION

4.1 Production runs

The production runs were executed using SiMPLE++ 5.00 simulator running on Windows NT platform with 64 MB RAM.
The common random number (CRN) streams approach was applied for both design alternatives. The warm up period was determined through pilot runs of design alternative1 and plots of the average response time per cadastral case type. The plots indicated that the system has reached a steady state after approximately 699 cadastral cases have been fulfilled (Figure. 4-1)

4.2 Output analysis

The statistical analysis for simulation outputs is usually conducted using statistical tests. In our case, since the (CRN) was used for the comparison of both design alternatives, the simulation outputs were investigated whether are normally distributed (normality assumption). To investigate the normality assumption, the summary statistics of the outputs were calculated and their frequency histograms were plotted. The frequency histograms were used as a graphical method for comparing the distributions of the results with the normal distribution. The histograms suggested that the simulation outputs are not normally distributed.

The Wilcoxon signed ranks test was applied to test the null hypothesis, which states that the average response time outputs for the two design alternatives are the same, against the alternative hypothesis which states that there is a deference between the two design alternatives. The Wilcoxon signed ranks test was executed using SPSS 8.00 for Windows. The null hypothesis was rejected. This means that there is a difference between the two design alternatives (alternative hypothesis).

The summary statistics (Figure 4-2) clearly indicates that scenario 5 reduces response time for all types of survey cases. The reduction was for urban cases approximately 65%, for urban cases 57% and for concentrated 45% to the equivalent response time of scenario 1. (In the figure 4-2, from top; rural, urban concentrated cases scenario 1, followed by rural, urban concentrated cases scenario 5)

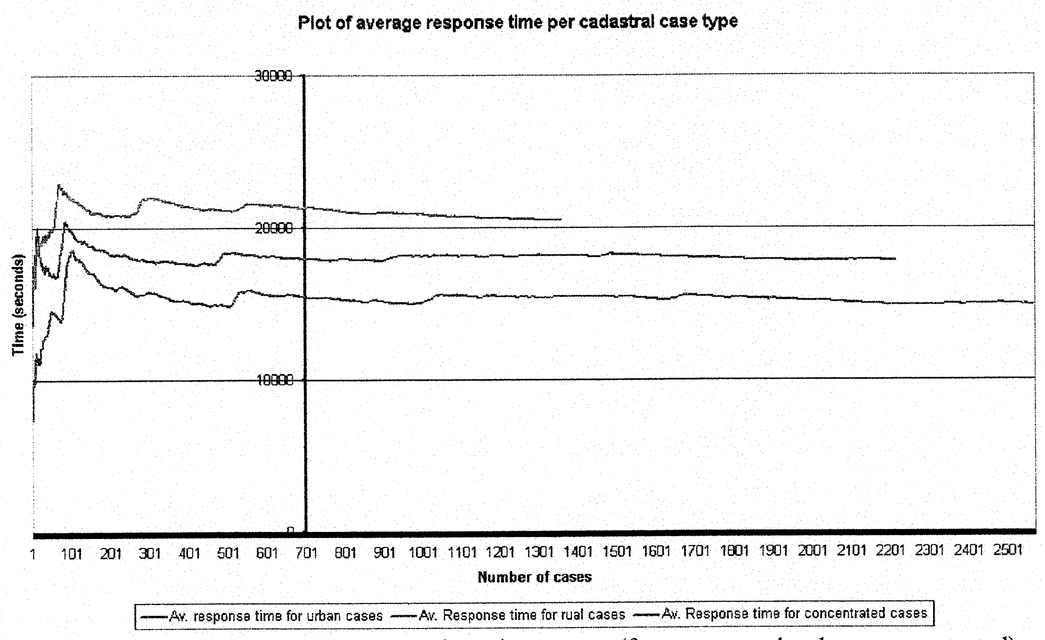

Figure 4-1: Average response time per cadastral case type (from top; rural, urban, concentrated)

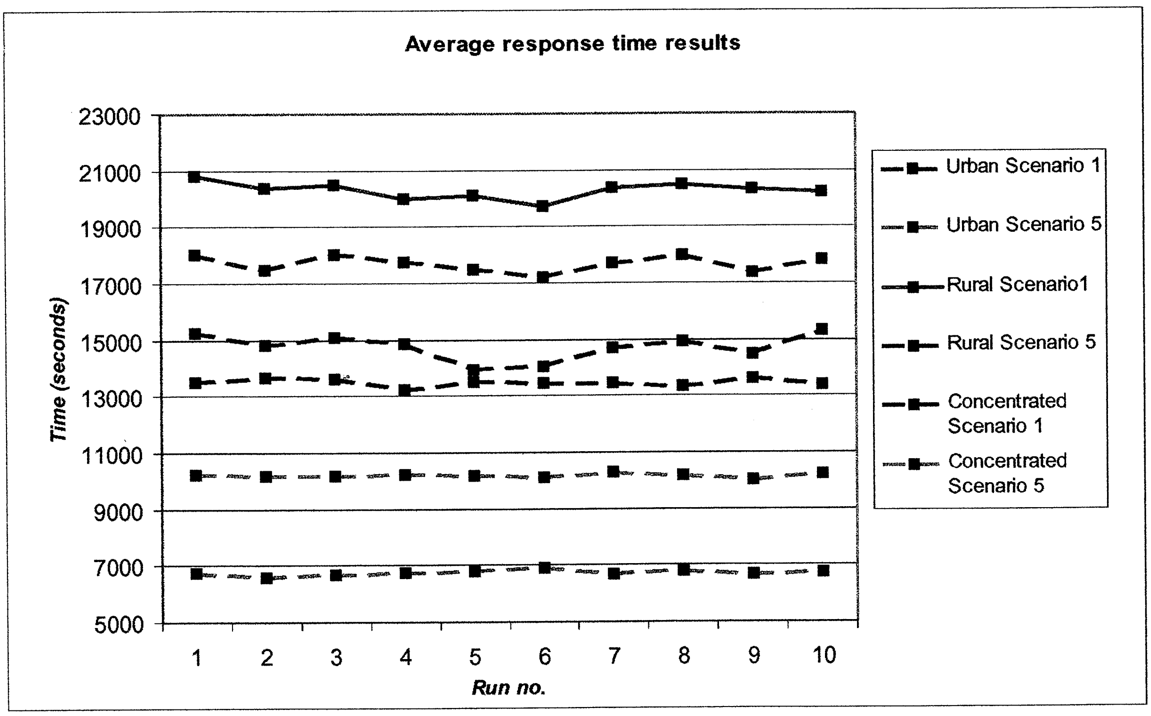

Figure 4-2: The simulation results of average response time

5 CONCLUSIONS

From this simulation study a number of conclusions can be drawn:
Simulation can be applied successfully for the evaluation of cadastral business processes at the operational level. The simulation example does not give us enough information to conclude on the use of simulation at the strategic and tactical levels.
SiMPLE++ is a flexible simulator that allows the easy and fast modeling of many different types of systems. Yet modeling in simulation has also statistical aspects, which must be considered. Sufficient knowledge of statistics is a key factor for obtaining reliable results.
One of the drawbacks of the designed model was that the available data were not possible to be statistically analyzed, The variation of input parameters can have major effects on the outputs. The evaluation, therefor, is an approximation of the model's actual behavior. The difficulty of obtaining appropriate data should be considered before starting a simulation study.
Outputs produced by simulation can be considered as samples that need to be analyzed using appropriate statistical techniques. Statistical tests can be used for the quantitative analysis of simulation outputs.
In many cases, the choice between design alternatives is not merely based on their performance, but on their financial requirements as well. The integration of simulation and cost evaluation techniques could be very meaningful for the decision making.
A study should be carried out to investigate the appropriate statistical tests that can be applied for the evaluation of more than two design alternatives.

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