*Proceedings of the 2006 Winter Simulation Conference*
*L. F. Perrone, F. P. Wieland, J. Liu, B. G. Lawson, D. M. Nicol, and R. M. Fujimoto, eds.*

# ALLOCATING FIELD SERVICE TEAMS WITH SIMULATION IN ENERGY/UTILITIES ENVIRONMENT

Luiz Augusto G. Franzese
Marcelo Moretti Fioroni

Paragon Tecnologia
R. Clodomiro Amazonas, 1435 – 5th
São Paulo, SP, 04537-012, BRAZIL

Luis Eduardo Pinheiro
João Batista Eustáchio Soares

Elektro Eletricidade e Servicos S.A.
R. Ary Antenor de Souza, 321
Campinas, SP, 13053-024, BRAZIL

## ABSTRACT

Field Service Teams (FSTs) allocation problems are usually addressed with Linear Programming models. But when certain models can be very complex, especially if allocation rules are dynamic, pooled resources can be used and variation is effective. In order to better analyze FSTs allocation problems for Utilities segment, simulation was used to power CAPSIM, which has been validated and used by ELEKTRO S.A., one of the largest Energy Distributors in Brazil. This paper addresses problem conceptualization, model design and calibration, as well as results and future steps.

## 1 INTRODUCTION

More and more companies in general look for ways to guarantee your collaborators' safety, optimize your operational efficiency, improve the quality of employee's life, improve the quality of the service rendered the customers and to satisfy the shareholders with a suitable remuneration with the risk of investment.

In this context, tools that help to reach these goals are welcome. And energy supplier companies are under an even more critical situation, because the today's energy-driven world requires a high level of reliability. Energy supply interruptions must be restored in lower times.

That is a difficult objective to achieve, because of the big size of an energy supply network. The exposure of that structure to the bad weather just worsens the problem, and the solution is to keep many maintenance teams near the more problematic areas, or at key-points to reach any part of the network as quick as possible.

Finding the best key points and team sizes is the only way to provide high service level. This should be just another problem to be solved with a linear programming approach, but when the system has many different behaviors and process times vary, the best approach is discrete-event simulation.

These are the reasons why an important energy distributor in Brazil, Elektro Eletricidade e Serviços S.A., chose to use discrete-event simulation to plan team capacity for each location from its coverage area. The study was later used to build a simulation tool that provides great flexibility to evaluate new scenarios, under a user-friendly interface.

The tool presented here is in use by Elektro since 2005, and help to plan the technical team's allocation on every weather situation and year season. Later on this work, the parameters results and case study will be presented.

## 2 LITERATURE REVIEW

There are many examples of studies for team planning using discrete-event simulation or this approach mixed to others, like queuing systems, as presented by Dijk (2002), with case studies on BPR at an office, callcenter and even a railroad, but not an energy supply case.

Lin et al. (2002) presents a study for field service using simulation, which has many similarities with this one. The main difference is the problem described does not allocate personnel on different places, which is a key aspect of the energy supplier problem.

A very similar study is presented by Tommelein (1999), where the location of temporary facility sites for construction workers and its capacity is analyzed with simulation, considering the travel time to the construction places. This has many elements in common, like the definition of capacity and location, but in addition, the energy field service has the weather factor, that changes many variables on the system behavior.

The study presented by Boyer & Arnason (2002) applies simulation with a network of queues to analyze the staff sizing problem for switching telephone maintenance and repair. It is very similar with the problem presented here, but the "failure curve" of equipments is very different from the demand curve for the energy field service system. On the last one, the weather factor have great importance, despite the fact of the failure curve for equipments is part of the problem too. The same could be said about the study of

Cowdale (2003), about firefighting staff, and Koch & Weigl (2003), about ambulance service.

Guttkuhn et al. (2003) presents a similar study for train crew assignment and movement on a railroad network. As the present study, this was turned into a tool for later use.

## 3 MODEL APPROACH

Modeling approach was inspired by Xerox Field Service Simulation Tool (Watson, Chawda, McCathy, Drevna, and Sadowski 1998), and consisted in development of a model that could mimic in detail:

- Dynamic occurrence of different types of events, geographically based within region limits, that would require service team;
- Selection between own teams and outsourced Field Service Teams (FST);
- Dynamic rules of team dispatch, considering crew skills, service priorities, service level regulation and geographic region;
- Service teams schedules;
- Details of duration and execution of repair, considering that some events may need different teams to initiate and to end a job.

Simulation model was implemented using powerful Arena 10.0, with data analysis performed with Minitab. Even tough a tool like Optquest could have been used with simulation model, no optimization routine was implemented, with special attention to expert's analysis of technical, commercial and even policy restrictions that cannot be easily modeled as restrictions.

## 4 CASE STUDY: ELEKTRO

Elektro S.A., a subsidiary of Prisma Energy, is one the largest energy distributors in Brazil, providing energy and services to 1,800,000 customers, covering 228 cities in São Paulo State/Brazil, in a wide and not consecutive geographic area, as seen in all colored areas of figure 1.


Figure 1: Coverage Area of the State of São Paulo

Service Level performance is audited and regulated per National Energy Agency (ANEEL Agência Nacional de Energia Elétrica), that establishes performance levels for call-center and field service metrics, that is a consistent aid to push corporations to invest to offer exception services, but may have a counterpart of cost increase.

So ELEKTRO identified opportunity of using simulation to better evaluate field service infrastructure, and help decide quantity and location of service bases for FSTs, based on seasonality.

### 4.1 Geographic Coverage

Coverage is divided in five different zones (or regional services), that operated independent from each other, due to geographical location. FSTs are ranked according to hierarchy described in figure 2:

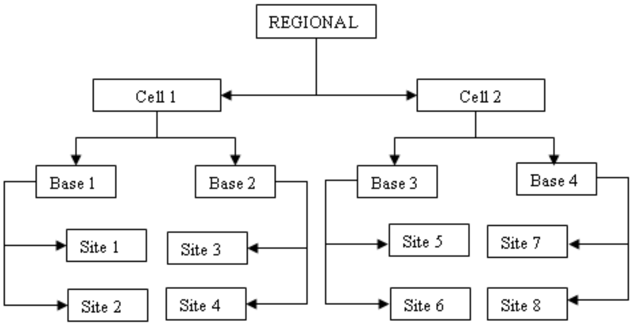



Figure 2: Regional Structure Diagram

- SITES (Customer sites): Cities where customers are located, and where service requests are generated.
- BOP (Base of Operations) : Location of FSTs.
- CELLS (Service Network Cell): Location with better infrastructure and additional FSTs that may offer additional coverage to a BOP inside its CELL or even to another CELL.
- REGIONAL: Administrative headquarters.

### 4.2 Service Types

Customer requests for services and repairs can be generated automatically (due to network detection) or through a dedicated callcenter, generating dispatch orders, that register date and hour and request generation, for performance measure.

Among dozens of services classification, aggregation into two macro categories was necessary: technical requests and commercial requests, each with different subtypes. These categories had different priorities, duration and FSTs requirements.

### 4.3 Events Forecast

Event seasonality is clearly affected by rain season, so it was treated into two different patterns, humid and dry season.

In order to reproduce random requests generations, from different sub-types in different cities, according to proper season, data was gathered from three years of operations, allowing analysis with Minitab support.

So event generation was randomly chosen according to Poison distribution, with a breakdown hierarchy from Season, Service Type, Sub-type and finally location.

### 4.4 Events Duration

Event duration is described by a stochastic distribution of service execution times plus transportation times of FSTs, from closest BOP to event location, and can also be affected by seasonality.

Duration also depends upon service sub-type as well as FSTs skills, since different FSTs may be assigned to execute repairs.

### 4.5 Crew Types

Several crew types are available, with different skills for executing services requests. Detailed operational rules were considered, since multi-skill teams may be available, with different event priorities and also different cost.

And to add more complexity, certain requests include one FST to initiate and another FST to conclude service.

Different teams from other locations can also be allocated, upon a higher service request waiting time. This mobility may be allowed or not.

Graphical Simulation modeling was really valuable to represent all rules related, in an understandable flowchart.

Work Schedules and extra hours are also an important variable considered.

## 5 TOOL DESIGN: CAPSIM

Tool development could follow different approaches: template-oriented or simulator-based design.

A template based solution may offer a very good modeling solution for a series of similar process or industries (i.e., a toolset to model field service systems), while a simulator represents a generic or customized model, that allow only with few or even no changes in model logic, being data-driven and specialized in a certain application. Simulator driven design was used for CAPSIM.

### 5.1 Simulator Design

Simulation tool developed was named CAPSIM (Capacity Simulator), and substituted regular spreadsheets that were used before. With simulation it is possible to better analyze scenarios like:

- Different Service Times and variation effect
- Crisis or peak situations
- Hourly, daily or even event analysis
- Estimate gains and losses
- Dispatch rules
- Base locations
- Base aggregations

Tool design was initiated from its database and data structure, rather than process flow approach. This led into a robust user interface/reporting tool instead of using a standard spreadsheet interface, and usage of a relational database is connected to a professional user interface developed with Ms Visual Studio, as well as to ARENA 10.0, as seen in figure 3.

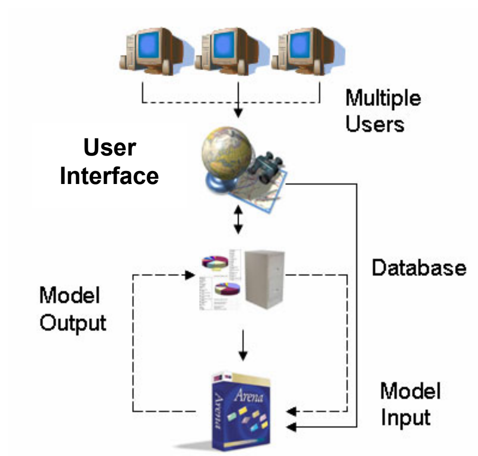



Figure 3: CAPSIM Tool Structure Diagram

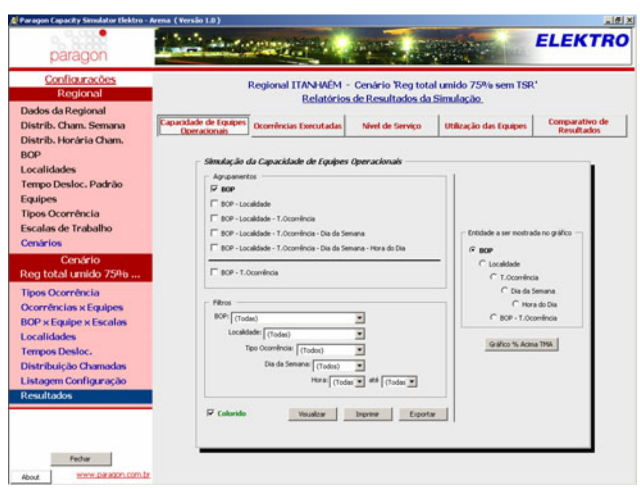



Figure 4: CAPSIM User Interface

User interface, showed in figure 4, was planned to be ease to use, as well as flexible enough to allow user to create, generate and compare multiple scenarios.

### 5.2 Data Input

Data structure allowed separation of scenario data from calibration data, helping maintain and update tool.

Due to its relational design, it is possible to create multiple scenarios from different combination of possible events forecasts, crew scenarios, dispatch rules etc.

### 5.3 Animation

Simulator allows calculation with animation mode or batch mode, with different computing speed. Animation is consistently used initially for model validation and scenario demonstration purposes, as shown in figure 5, representing Itanhaém region (one of five different regions).

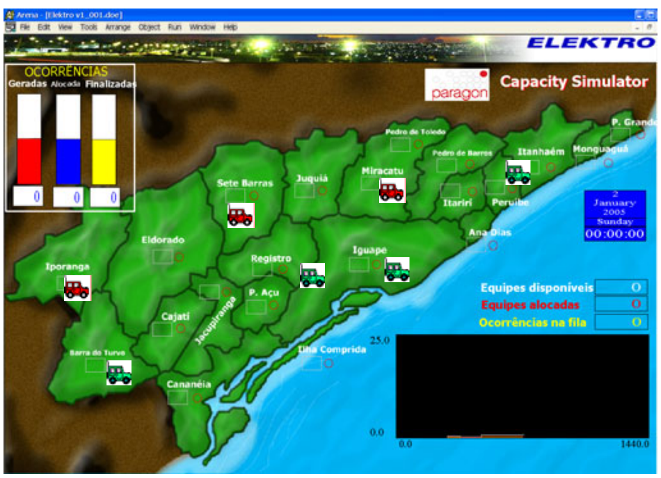



Figure 5: CAPSIM Animation

### 5.4 Validation

Model was validated with a very high confidence level against real data of year 2004, using existing logistics infrastructure and rules, for Itanhaém region. This region is highly impacted by seasonality factors on its coast in summertime (tourist flow).

Metrics like number of different events served (per day, per city) using existing crew was used to reach model accuracy superior than 95%.

Even tough it was not relevant, small cities that represent a very small portion of events did produce a considerable distortion in its individual results, due to sample size.

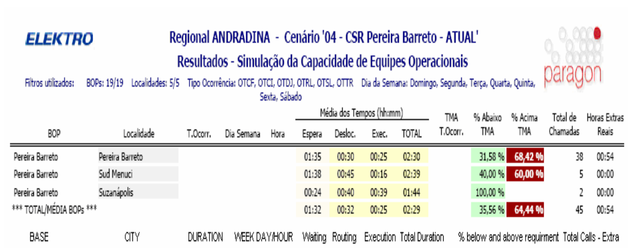
### 5.5 Reports

A special reporting function and capability was implemented, since scenario analysis are complex due extensive variables range.

Most typical reports, that can be presented graphically, include information of detailed performance metrics, allowing quantitative and qualitative comparison of multiple scenarios.

Results can be aggregate into different time patterns, and a detailed log recording routine was implemented, allowing analyzing each execution individually.

Service times obtained from validation scenario of Andradina city is shown on figure 6 :



ELEKTRO — Regional ANDRADINA - Cenário '04 - CSR Pereira Barreto - ATUAL'

Resultados - Simulação da Capacidade de Equipes Operacionais

Filtros utilizados: BOPs: 19/19 Localidades: 5/5 Tipo Ocorrência: OTCF, OTCI, OTDJ, OTRL, OTSL, OTTR Dia da Semana: Domingo, Segunda, Terça, Quarta, Quinta, Sexta, Sábado

| | | | | | Média dos Tempos (hh:mm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOP | Localidade | T.Ocorr. | Dia Semana | Hora | Espera | Desloc. | Exec. | TOTAL | TMA T.Ocorr. | % Abaixo TMA | % Acima TMA | Total de Chamadas | Horas Extras Reais |
| Pereira Barreto | Pereira Barreto | | | | 01:35 | 00:30 | 00:25 | 02:30 | | 31,58 % | 68,42 % | 38 | 00:54 |
| Pereira Barreto | Sud Menuci | | | | 01:38 | 00:45 | 00:16 | 02:39 | | 40,00 % | 60,00 % | 5 | 00:00 |
| Pereira Barreto | Suzanápolis | | | | 00:24 | 00:40 | 00:39 | 01:44 | | 100,00 % | | 2 | 00:00 |
| *** TOTAL/MÉDIA BOPs *** | | | | | 01:32 | 00:32 | 00:25 | 02:29 | | 35,56 % | 64,44 % | 45 | 00:54 |
| BASE | CITY | DURATION | WEEK DAY/HOUR | | Waiting | Routing | Execution | Total Duration | | % below and above requirment | | Total Calls - | Extra |

Figure 6: Partial Report for Service Level Performance

Among main results categories obtained per scenarios, and that can be grouped geographically or per sub-type:

- Quantitative: requests generated, served and queued;
- Service Level: waiting times, execution times;
- FSTs utilization: average time idle, busy, extra hours.

Even tough minimum service level performance is already defined, FSTs occupation is a key factor in this equation.

Before using simulation, FST occupation was discussed in an empirical form, since spreadsheet tools could not properly relate occupation to queuing.

Simulation of scenarios with 70% until 75% occupation level show that service level is not affected, but higher occupation heavily impact in waiting times, what is now considered as a guideline in studies.

Another important metric reported is extra hours usage that can help fine tunes schedules and operation costs. Extra hours can also affect next day operation, since FSTs may suffer from fatigue, was not desirable.

### 5.6 Deployment

CAPSIM was designed to be deployed within organization, to aid tactical analysis developed by engineers, with reduced simulation skills requirements.

## 6 CONCLUSIONS AND NEXT STEPS

Simulation proved to be a valuable resource for Logistics Analysis on Field Service Structure, helping identify changes like Service Base relocation, Crew level adjustments (higher and lower in some cities), potential gain in service level, and extra hours reduction.

Simulator currently can test schedules but cannot generate them based on necessity. So a future step may include usage of optimization to aid schedule generation, since Brazilian labor law has several restraints and allow multiple combinations.

## ACKNOWLEDGMENTS

The authors thank the personnel at different areas of ELEKTRO S.A. for their confidence and collaboration.

## REFERENCES

Dijk, N. M. 2002. The Pool or not to Pool ? “The Benefits of Combining Queuing and Simulation.”. In *Proceedings of the 2002 Winter Simulation Conference*. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Lin, Y., H. Hsu, and R. Rajamani. 2002. A Simulation Model for Field Service With Condition-Based Maintenance. In *Proceedings of the 2002 Winter Simulation Conference*. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Tommelein, I. D. 1999. Travel-Time Simulation to Locate and Staff Temporary Facilities Under Change Construction Demand. In *Proceedings of the 1999 Winter Simulation Conference*. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Boyer, G., and A. N. Arnason. 2002. Application of the Simulation and Mean Value Analysis to a Repair Facility Model for Finding Optimal Staffing Levels. In *Proceedings of the 2002 Winter Simulation Conference*. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Cowdale, A. C. 2003. Simulation Modeling in Support of Emergency Firefighting in Norfolk. In *Proceedings of the 2003 Winter Simulation Conference*, USA.

Koch, O., and H. Weigl. 2003. Modeling Ambulance Service of the Austria Red Cross. In *Proceedings of the 2003 Winter Simulation Conference*. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Guttkuhn, R., T. Dawson, U. Trutschel, J. Walker, M. Moroz. 2003. A Discrete Event Simulation for the Crew Assignment Process in North American Freight Railroads. In *Proceedings of the 2003 Winter Simulation Conference*. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Watson, E. F, Chawda, Prabhulal P, McCathy, Brad, Drevna, Michael J, Sadowski, P. Randy. 1998. A simulation metamodel for response-time planning. *Decision Sciences*, Winter.

## AUTHOR BIOGRAPHIES

**LUIZ AUGUSTO G. FRANZESE** is a simulation consultant with a Production Engineering and MSc. in Logistics background, who has completed almost 150 successful projects with simulation. Founded PARAGON Tecnologia in 1992, it is the pioneer and leading consulting company in simulation in South America, which has trained more than 1,200 professionals in simulation. His e-mail is <paragon@paragon.com.br>.

**MARCELO MORETTI FIORONI** is a simulation consultant with Electrical Engineering degree, MSc. in Manufacturing and under Logistics PhD program. Has participated in almost 150 successful projects with simulation. Co-founder of PARAGON Tecnologia in 1992, the pioneer and leading consulting company in simulation in South America. Teaches OR and Simulation at FISP. Has trained more than 1,200 professionals in simulation. His e-mail is <marcelo@paragon.com.br>.

**JOÃO BATISTA EUSTÁCHIO SOARES** is Operations Engineer at ELEKTRO, with Electrical Engineering degree. Developed several simulation studies to increase operation performance metrics. His e-mail is <joao.soares@elektro.com.br>.

**LUIS EDUARDO DE OLIVEIRA PINHEIRO** is Operations Manager at ELEKTRO, with Electrical Engineering and MBA degrees. Has extensive experience in operations management and simulation enthusiast. His e-mail is <luis.pinheiro@elektro.com.br>.