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A training method directed towards real-time operators: key steps and main tools to the Brazilian Power System

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Abstract: Real-time operators act on phenomena characterized by uncertainty, incomplete information, time pressure, unexpected events, and security threat. This is the case of hospitals, fire brigades, air traffic control, nuclear power plants, and power system operation. These activities require rapid decisions and demand a greater focus on the development of behavioral competencies in specific training programs. This article aims to describe how to develop a method of training programs for real time operators. Bibliographical research, documentary and field research in pioneering international experiences and in Brazil, in companies of power system operation, constituted the methodology. The steps and tools of the method were presented and analyzed with the focus in the context of the Brazilian Power System. The main result consists of a method that integrates six stages, highlighting the identification of infrastructure problems, operation activity, and competency analysis to be developed according to the organizational context. The simulation was considered the main tool, coupled in an observatory based on replay. Experts from the National Operator of the Brazilian Power System evaluated the method as satisfactory (81%) and scored it between 8 and 9 (75%). It is suggested to structure trainings transparently, practical assessments and stimulate real learning.

Keywords: Training Programs; Competencies; Human Resources Management.

Método de capacitação para operadores de tempo real: passos e ferramentas principais para o Sistema Elétrico Brasileiro

Resumo: Operadores de tempo real atuam em fenômenos caracterizados por incerteza, informações incompletas, pressão de tempo, eventos inesperados e ameaça à segurança. Este é o caso de hospitais, brigadas de incêndio, controle

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aéreo, usinas nucleares e operação de sistemas de potência. Estas atividades exigem decisões rápias e demandam maior enfoque no desenvolvimento de competências comportamentais em programas específicos de capacitação. Este artigo visa descrever como elaborar um método para programas de capacitação de operadores de tempo real. Pesquisa bibliográfica, documental e investigação de campo em experiências pioneiras internacionais e no Brasil, em companhias de operação de energia elétrica, constituíram a metodologia. Os passos e as ferramentas do método foram apresentados e analisados com enfoque no contexto do setor elétrico brasileiro. O resultado principal consiste em um método que integra seis etapas com destaque para identificação de problemas de infraestrutura, da atividade de operação e análise de competências a desenvolver segundo o contexto organizacional. A simulação foi considerada a principal ferramenta, acoplada em um observatório baseado no *replay*. Especialistas do Operador Nacional do Sistema Elétrico Brasileiro avaliaram o método como satisfatório (81%) e atribuiram nota entre 8 e 9 (75%). Sugere-se estruturar capacitações com transparência, avaliações práticas e estimular o aprendizado real.

Palavras-chave: Programas de Treinamento; Competências; Gestão de Pessoas.

1 Introduction

Real-time operations are maneuvers characterized by uncertainty, incomplete information, time pressure, interference from unexpected events and security threat (ANDERSON, 1986; NUUTINEN, 2005; VITÓRIO; MASCULO; MELO, 2012; VIGNOCHI et al., 2015). These phenomena require that professionals take rapid and effective decisions to act quickly. This is the case of the emergencies and urgencies common in hospitals, fire brigades, marine, air traffic, chemical industry, nuclear plants, and power system operation (SEMINARA; PARSONS, 1982; SMITH; BOSE; BURTON, 1985; PAGE; SMITH, 1998; GLEMMESTAD; SKODESTAD; GNUDERSEN, 1999; CHAUVIN; CLOSTERMANN; HOC, 2009; SCHARAAGEN et al.., 2010; CUKALEVSKI et al., 2012).

Training programs are necessary to educate and maintain actualized the real-time operators (DONG; LI, 20011; CUKALEVSKI et al., 2012; GOULDING et al., 2012). Researchers agree about the role of training to test competences in real-time operations (NUUTINEN, 2005; LOVEDAY et al., 2013). However, the necessity of integrating technical knowledge and behavioral competencies is not clear in traditional studies (VIGNOCHI et al., 2015).

Concerns about training for real-time operators is not new in the scientific literature (ANDERSON, 1986; SMITH; BOSE; BURTON, 1985; KEZUNOVIC et al., 2004; SCHARAAGEN et al., 2010). There is a knowledge organized as manuals based on steps according to the Systematic Approach to Training – SAT (U.S. DEPARTMENT OF ENERGY TRAINING, 1994; DICK; CAREY; CAREY, 2004). This is a traditional tool applicable in areas such as public safety, marine, fire brigades, nuclear plants, and power systems.

A real-time frame to address operational problems and the conditions to make decisions are crucial factors for action-learning (MARQUARDT et al., 2011). These findings are useful for planning training and solve operating problems.

The discussion about the nature of skills to solve operational problems is another weakness in current researches (KEZUNOVIC et al., 2004; SCHARAAGEN et al., 2010). It does not consider the neurobiological findings that decision-making occurs first in the limbic system, the brain center of emotions (OCHSNER; GROSS, 2005; LIEBERMAN, 2007). This means that effective decisions require a favorable emotional state.

Therefore, despite the consensus about the link between emotions, anxiety, stress, and development of behavioral skills, the traditional methods can be delayed in relation to real training needs. Thus, encourage an understanding of cognitive change of emotions is necessary for activities under time pressure and hazard, such as power system operation.

Simulation is the main tool to promote a training experience close to real situations (KEZUNOVIC et al., 2004). It occurs in live, virtual or constructive modalities, depending on the intensity of personal involvement, the complexity of the equipment, control systems, and technology. Thus, the use of this engineering training tool confirms that emergent technologies need to be included in research and training.

Energy transactions are dependent on operating systems and technology. Application of expert systems allows for the optimization of the process executed by operators (IEEE STANDARDS ASSOCIATION, 2013).

The technical level of knowledge may facilitate the power system operation. However, the development of specific skills and attitudes can provide psychological states and behaviors appropriate to operation task (HOCKEY; SAUER; WASTELL, 2007). This is necessary to provide safe, economical, and continuous energy.

However, technics for the acquisition of technical knowledge (classes, lectures, seminars, for example) tend to be dissociated from the analysis of behaviors occurring in simulation or during real-time operation (ALBUYEH, 2010; DONG; LI, 20011). Also do not care much studies suitable to the combination of simulation and the use of tools for training skills, attitudes and psychological states favorable to a safe, economical and effective operation (ALBUYEH, 2010; LOVEDAY et al., 2013).

Consequently, traditional methods for training programs have a gap to develop behavioral competencies such as skills and attitudes. In this study, we suppose that the engineering training processes can assist in building a sequence of activities involving different kinds of competences. Development of skills and abilities to look forward and solve operational problems in a specific organizational context can be achieved through a sequential training method.

This paper aims to describe how to develop a method to training programs for real-time operators. Power system operation is the subject area. Interactions within control systems operators are considered determining effective acts to take decisions. Involvement in emergencies, urgencies, and the risk to integrity, the physical and psychological safety of workers or populations mediated by high-technology systems requires the acquisition of skills and appropriate behaviors for effective operation.

This study is a result of four years of research in the subject area (2012-2016). The investigation involves bibliographic, applied and descriptive research. It is a predominantly qualitative study, but it contains an analysis of quantitative perception data.

The proposed method can contribute to improving training programs for real-time operators in general. It was organized like an engineering process in planning initial and continuous training programs to real-time operators. We suppose that this processual approach provides a rational, systematic, and sequential group of steps and tools to accomplish learning objectives. It favors an objective training approach to improve the decision making under uncertain and risk conditions. Specifically, it may attend the demand for effective actions in the context of the power systems operation teams, because it was evaluated by power system experts.

2 Training Methods in Real-Time Operations

Knowledge identification and skills development are necessary to perform job tasks. This is related to appropriate attitudes, i.e. competences lined up with a professional activity (U.S. DEPARTMENT OF LABOUR, 2012). The training promotes learning technical knowledge and skills for a defined purpose like a systematic and organized long-term process. In the learning development context, training programs are developed through methods to improve the effectiveness of the actions of specialists on the organizational results (U.S. DEPARTMENT OF LABOUR, 2012).

Real-time operations require decision-making during events, often unexpected or without complete information on their probability of occurrence (ANDERSON, 1986; NUUTINEN, 2005; VITÓRIO; MASCULO; MELO, 2012). The effectiveness of the actions taken by teams of real-time operations depends on their ability to solve complex problems and control critical events in a given time interval (ANDERSON, 1986). Urgency, emergency and other situations that require safety, economy and high quality of provision are the reality of these operations. They are connected with professional activities involved in air traffic control, marine traffic control, and ground traffic control; fire brigades, medical surgery, chemical industry, nuclear industry and power systems operation (SEMINARA; PARSONS, 1982; SMITH; BOSE; BURTON, 1985; PAGE; SMITH, 1998; GLEMMESTAD; SKODESTAD; GNUDERSEN, 1999; CHAUVIN; CLOSTERMANN; HOC, 2009; SCHARAAGEN et al., 2010, CUKALEVSKI et al., 2012).

A know how to handle high-tech information systems, execute instructions and comply with safety standards are necessary skills in activities of this nature. The influence of time pressure, the need for disaster recovery and critical incidents can become professionals susceptible to anxiety levels not recommended to decide rapidly and act effectively (KIRPATRICK, 2009). This can lead to human errors causing the removal of operational actions due to stress (HOCKEY; SAUER; WASTELL, 2007).

In the scientific literature on the topic may be found an extensive list of specific competencies needed to be able to perform real-time operations (NUUTINEN, 2005; CUKALEVSKI et al., 2012; LOVEDAY et al., 2013; VIGNOCHI et al., 2015). Technical competencies, such as formal knowledge and cognitive capacity to solve problems (memory, attention, and diagnostic capacity, for example) are the most emphasized by traditional training methods (U.S. DEPARTMENT OF ENERGY TRAINING, 1994).

Behavioral competencies are emphasized in the manuals, requirements, standards and academic publications about training methods for real-time operators. (NUUTINEN, 2005; CUKALEVSKI et al., 2012; LOVEDAY et al., 2013). However, the psychological, skills and abilities are considered as a group of generic competencies to be developed through additional and specific workshops (CUKALEVSKI et al., 2012). The cited behavioral skills (KEZUNOVIC et al., 2004; NUUTINEN, 2005; LOVEDAY et al., 2013) for the effective fulfillment of real-time operations are

- Using methods for troubleshooting,
- Ability to anticipate and seek ways to set goals,
- Ability to communicate thoughts verbally and in writing.
- Ability to understand the needs of the team objectives,

- Ability to question and evaluate the cost and benefits of initiatives,
- Negotiation capacity,
- Ability to handle unexpected situations,
- Control the reactions on the pressure and
- Ability to integrate and conduct changes in accordance with the procedures.

There is no doubt about the necessity of both, technical and behavioral competencies to effective performance in real-time operations. However, the observation of behavior to evaluate and develop generic competences has not been sufficiently linked and formalized to contribute to explanations in the planning of training (U.S. DEPARTMENT OF ENERGY TRAINING, 1994; KEZUNOVIC et al., 2004; LOVEDAY et al., 2013; VIGNOCHI; LEZANA; SILVA, 2014; PHILLIPS; PHILLIPS, 2016).

Practical use of System Approach to Training – SAT (U.S. DEPARTMENT OF ENERGY TRAINING, 1994) is evidence of a lack of integration between methods and tools for training real-time operators. It is used as a basic guide to identify training needs that do not take into account the typical problems of the area and the organizational context. It is focused on teaching organization of training (U.S. DEPARTMENT OF ENERGY TRAINING, 1994; VIGNOCHI; LEZANA; SILVA, 2014; PHILLIPS; PHILLIPS, 2016).

Job Task Analysis - JTA is a tool used to identify skills (ALBUYEH, 2010). It evolves the analysis of a matrix of knowledge, skills and attitudes. Nevertheless, JTA does not show which are the techniques to be used to obtain reliable information about the competencies mapped (U. S. DEPARTMENT OF LABOUR, 2012).

The simulation is the traditional tool utilized in real-time operations (KEZUNOVIC et al., 2004; GOULDING et al, 2012). It variates with the level of involvement of the people, equipment, and information technology in the actions of professionals.

There is a handle of behavioral technics on professional education i.e. workshops, group activities, technical trips, theatric technics like roleplay and transactional analysis (VAN BUREN; ERSKINE, 2002; ALBUYEH, 2010; VIGNOCHI; LEZANA; SILVA, 2014). None of these technics is adequate to protocols and teams of specialists accomplished to evaluate, intervene and promote the development of behavioral competencies based on mental states desired to achieve with the effectiveness of real-time operations (ALBUYEH, 2010).

At least, nor about articulation within technical knowledge and behavior during the training is mentioned with special focus in current researches (VAN BUREN; ERSKINE, 2002; ALBUYEH, 2010; VIGNOCHI; LEZANA; SILVA, 2014).

To achieve the objective of this study in the first place, it was necessary to understand the assumptions. Second, we need to show how to develop steps and propose tools for training programs for real-time operations. Third, we need to expose the engineering process training method to advance in the study of the subject. Finally, the reader can access a discussion of the key steps, the main tools of the method.

The methodological procedures are explained in the next section. In the sequential section, are described the key steps and the main tools of a method to training programs for real-time operators. The steps and tools will be described according to the reality of power systems operation. The specific area was selected because of its high complexity in people involved with security threats, economy and high-quality supply added to the evolvement of high technology. In addition, the specific area comprehends virtual appearance with routines, urgencies, and emergencies comprehending real-time transactions on power systems and correlated areas like nuclear power plants, fire brigades, and traffic control.

3 Methodological Procedures

This study is eminently qualitative, and descriptive (BRADLEY, 1993; DENZIN; LINKOLN, 2011). It explains how to develop a method to training programs for real-time operators, and delineates the proposed method.

The data were collected during four years (2012-2016). Bibliographic and secondary data support the elaboration of interviews, observations and an evaluation questionnaire, as well as the elaboration of the proposed method.

Secondary data of experiences in planning training programs for real-time operations, especially in the energy sector also inspired this research (CUKALEVSKI et al., 2012; PJM, 2014; ECRE, 2014).

It was conducted a group interview with three expert instructors in operation and training for power systems during a four-hour visit in the National Spanish System Operator - REE. The field investigation in the pioneer Spanish experience was important to establish an international overview of the applied and comparative perspectives of this study. A local company, two regional companies and an office of the Brazilian National Operating Company (ONS) provided data through semi-structured interviews with nine operating managers.

Five simulation-training sections were observed in the South department office of ONS. It was important to establish the contextual perspective of the method in contrast to the main international roles and experiences.

The content of the international and national experiences was analyzed in relation to the theory (BARDIN, 2011). Emphasis was placed on the interpretation of the individuals surveyed, according to the context of the company and the conception of organizational reality (MIGUEL et al., 2012). These steps allowed us to understand how to develop the method, and define the respective elements

The literature has suggested a framework for analyzing operator training programs offered by electric power companies around the world, and establish the proposed method. The dimensions and items of the analysis structure are:

a) Network infrastructure and technology

b) Characteristics of training programs

c) Compliance of training processes with international standards

A group of professionals of the Brazilian National System Operator Company - ONS, evaluated the proposed method by means of a perception questionnaire issued in Google Forms. The ONS is the top organization that is at the top of the control of the Brazilian Power System operation. There is no information about initiatives to evaluate a proposed method with experienced professionals on the management of the subject area.

The evaluation process will be resumed in the results section to accomplish the descriptive perspective of bibliographical, secondary, and field data collected over time. The evaluation by 16 experts on power system operation confirms the theoretical assumptions that sustain the proposed method, its steps, and the main tools.[5]

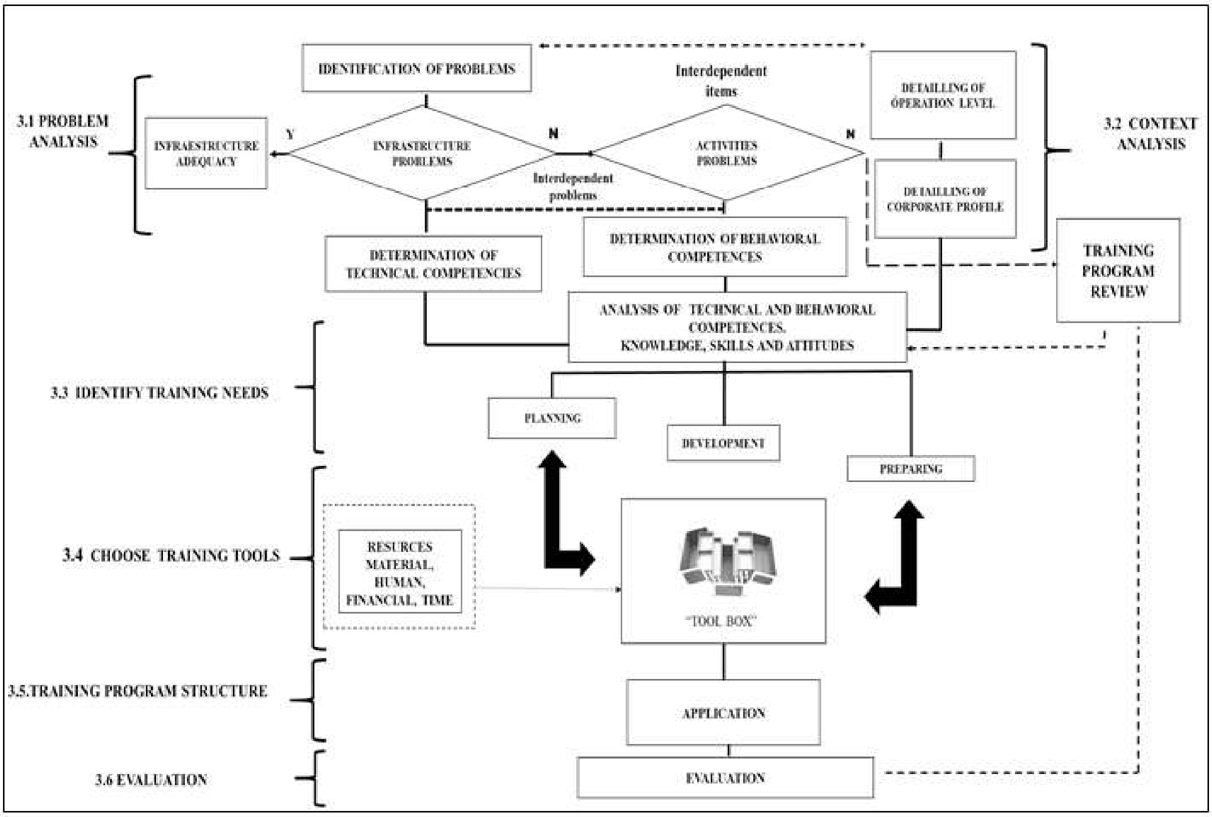
4 The Method

The proposed method is a rational and systematic group of steps to accomplish learning objectives. It is a sequential process organized to develop training programs and apply them through adequate tools according to the needs of real-time operators to accomplish the effect of your actions. The contextual method involves a suggestion for identification and training of technical and behavioral competencies.

In Brazil, there is no consensus on a patronization of training programs for power system operators (CUKALEVSKI et al., 2012). A necessary adjustment point justifies the applied perspective of this research. Nevertheless, it would not be scientifically described if it had not been carried out a robust bibliographical, documentary and field research.

The following subsections describe the method, i.e. the engineering processes developed in planning initial and continuous training programs to real-time operators. Six methodological steps are detailed upstate the following titles (3.1) Problem Analysis, (3.2) Context Analysis, (3.3) Identify Training Needs (3.4) Choose Training Tools (3.5) Training Program Structure, and (3.6) Evaluation. Figure 1 exposes the complete proposed method.

Figure 1: The proposed method



Source: The authors.

5 The complete details of the methodological procedures, as well as the instruments of data collection and analysis, can be found in Vignochi (2016).

4.1 Problem Analysis

A lack of autonomy in operational control and the isolation of northern Brazil are examples of structural problems of a national power system CUKALEVSKI et al., 2012. Hierarchical complexity added to a network structure of continental dimensions - more than 100,000 Km - and the isolation of the Amazon region may hinder operation tasks in the Brazilian Power System (CUKALEVSKI et al., 2012). Energy demand may increase with economic growth.

In the case of developed countries, as in the example of Spain, infrastructure problems are overcome by a high technology system and tight integration with neighboring countries (ROTHWELL; GÓMEZ, 2003; CANCELO; ESPASA; GRAFE, 2008). The Iberian country has suffered a drop in energy consumption in the 2008 crisis. However, the stable consumption is typical of developed countries (ROTHWELL; GÓMEZ, 2003; CANCELO; ESPASA; GRAFE, 2008).

These data show contextual differences as this type of problem, except for limitations of the simulation technology that occur independently of country context (CUKALEVSKI et al., 2012). In general, international standard SCADA systems and recognized suppliers are used.

According to the literature and the experiences analyzed in this study, the following problems related to the infrastructure are

- Fluctuations in demand that may require different training needs and distribution of human resources in work shifts;
- Lack of resources - assessing the need for adequate network infrastructure, technology, and equipment;
- Decision structure, whose complexity may require adaptation of professional profile and technical documentation;
- Sophisticated infrastructure demanding advanced computer technology systems and user-friendly interfaces for beginners or experienced operators, and
- Limitations of simulation technologies: the need for a broad knowledge base for decision-making, lack of concomitant inclusion of routine activities, urgencies, and emergencies.

During the preparation of the training, it is necessary to check if there are any issues falling within the infrastructure checklist.

If the answer is yes, should suit the infrastructure before moving to the investigation of work problems in the operating area. It is also necessary to prepare the operators to consider failure or delay in adjusting the system infrastructure to supply energy. The solution given requires adequate physical network infrastructure. The infrastructure can influence the existing technical expertise.

After solving the problems of infrastructure, the problems relating to operational activities must be evaluated. Some problems related to the activities of operation teams that may require training are listed below.

- Lack of unification of selection processes;

- Lack of a standardized initial training process throughout the countries, based on international standards, technical and behavioral skills;
- Operators Responsibilities - active role in the diagnosis and control systems; scenario analysis; fast decisions; execution safety instructions, maintenance, and system economy;
- Intensive work;
- High levels of stress;
- High demand for concentration;
- Obsolescence of experienced operator's skills, and
- Emergency conditions.

If there are no problems related to the current operational activities, may be a lag in previous training. Then, the review of the previous program is required.

Problems related to operational activities can determine the existing behavioral competencies. The identification of these problems does not preclude an analysis of concurrent infrastructures problems. Problems may be technical and behavioral.

Context and problems should be analyzed simultaneously because they are interrelated. The complexity of the operation and the corporate profile may have interdependent items related to the problems.

4.2 Context Analysis

The context of the training refers to detailing the operation complexity level of the power corporation. Profile determines the specificity of the operating area, functions, tasks and other territorial and spatial boundaries by training activities.

The operation level is helpful to take into account the real-time procedures and the operational interactions to perform maneuvers. The flow of communication and authorization request for decision-making in control centers and substations is also taken into account in the analysis of the context.

To set a profile of a corporation and identify the working conditions in power companies, it is necessary to characterize the following items.

- Organization Chart - it is useful to know the internal hierarchy of the company and to predict the effects of training in relations between bosses and subordinates when planning the program;
- Number of operators - know the number of operators per shift allows the scaling of the time;
- Employment status - be aware of the workload allows to know the scope of activities to be developed in groups or individually;
- Professional profile of operators - helps in the mapping of knowledge about the existing powers to act in the operation;
- Roles and tasks of operators - helps in understanding the level of knowledge and skills required within the organizational scope of training to be planned and developed;

- Information flow - instructions delimit the formal flow of information internally in the organization and thus to other levels of operational hierarchy to which the training must meet in order to be implemented effectively.

4.3 Identify Training Needs

This step involves analysis of competences, plan, develop and prepare the training program.

The analysis stage involves the assessment of knowledge, skills, and attitudes that form the individual and collective skills. The technique to be applied at this stage is Job Analysis and the tool is the JTA matrix.

Requirements for implementation of JA must be compatible with the requirements of other training processes existing in the organization. Documents containing training requirements, objectives, professional performance indicators, reports, previous feedbacks, and others can simplify this process. A set by documents as usual, in both selection procedures as for certification of operators.

Evaluation of skills through psychological testing is a widespread step. Measurement of knowledge and skills usually have high costs if applied with the rigors of validity and reliability (CUKALEVSKI et al., 2012). To achieve the validity is necessary to comply with the testing the practical by performing the task and verbal performance by description, and questioning the candidate through an adequate language.

For reliability, it should obtain the same results in different contexts by different evaluators.

Tasks based on data criteria for each element may be selected. The analysis of training needs determines the tools needed to develop technical and behavioral skills.

Analysis of competences is crucial in the method. It promotes the identification of gaps between existing and needed competencies and skills to perform real-time operation tasks. This will result in a set of competencies to be developed through planned training.

SAT supports the following steps. In this research, the traditional SAT contributes like a simple systematic tool to plan, to develop and prepare a training program.

In the planning phase, the objectives are established. In this phase is communicated how the training will be performed, how learning will be verified and how the training program will be evaluated.

Development means that the planning is placed in order of application and the material is prepared. This material should include the development plan, objectives and choose resources adequate to a training program.

Preparation consists of the establishment of activities to be performed by instructors and support staff, the application of analysis, design, development, and use of teaching materials and training techniques. It includes terminating the material and choice of resources, sequencing techniques, the choice of instructors and the schedule for implementation of the program.

4.4 Choose Training Tools

This item details the process of choice of training tools for a training program according to previous needs assessment. Noteworthy are the criteria for the choice of techniques for each situation diagnosed and a "toolbox" of techniques to specific training. This step may occur in a parallel, dynamic and intermittent manner and with the development phase.

Techniques must be chosen according to the kind of problem and needs that required preparation of a training program into an organizational context.

Are important analyses of what is necessary to learn, that is, what skills should be developed. Check the sensory needs of learners is another criterion to be considered in the selection of techniques. It should be considered if there are available means of communication and expertise about techniques to be applied. The sequencing, i.e., determining the logical order in which the training will be conducted should be consistently provided according to the needs and the actual activities of trainees. You must first teach the simple, progressing from general to specific. Practices can be transferred like analogies with the work environment. Appropriate tools should be selected in the "toolbox".

Availability of material resources and physical space for conducting the training are determining factors for choose techniques. Financial resources for planning time available, instructors qualified and any possibilities of investments in the development of new tools are also variables to consider during choose of training technics.

4.5 Training Program Structure

The training program is a result of the identification of problems that require training, context analysis and needs assessment. This section describes how to implement a training program.

A training program needs to support an active and exploratory approach. It must be formatted to encourage trainees to develop mental models and use risk strategies to test the feasibility of alternatives. Therefore, the presence of error and its correction are favorable to learning. The application is the delivery of training in an effective and efficient manner.

4.6 Evaluation

Evaluation is the last step of the method, but the evaluators can observe the consistency of the training process since the development phase. It helps to identify if what is being done is consistent with the original purpose. A formal evaluation should be done upon training completion. The effectiveness of a training program can be assessed per verification of improvement in staff and organization performance.

Questionnaires and interviews to participants are traditional protocols to be used. Results should be analyzed and interpreted to promote feedback evaluating the performance of trainees. Planning and execution teams can receive a feedforward about work objectives conduction.

At this stage, the evaluators and the planning team can identify necessary revisions. Documents and reports are records to guide the redesign of training.

Training can be reviewed in situations that there is no need to involve new problems of infrastructure or new situations related to operating activities. This means to resume the process from the steps of analysis of competences, check remaining gaps and review the planning. In these cases, the analysis of competences results from the evaluation of trainees and is concomitant to new planning based on feedforward of previous training.

We suggest the following resources evaluate the training program.

- Questioners and interviews,
- Results analysis,
- Program certification according to international standards.
- We suggest the following criteria to evaluate trainees.
- Application of theoretical and practical tests, and
- Certification in accordance with international operating standards.

5 Results and Discussion

The main result of this paper is the "Method to training programs for real-time operators". It was designed to accomplish the aim of describing a process and answer the question "How to do it". Results of the evaluation process with experts in Brazilian Power System operation will be exposed. A discussion highlighting the key steps is performed. Afterward is presented a discussion about the main tools. A behavioral observatory is proposed to advance in the debate and presents an objective solution to the main question of this paper. Finally, the suggestions of the experts are highlighted.

5.1 Evaluation by experts

Quantitative techniques are used to confirm the data surveyed in qualitative research (BRADLEY, 1993). Validation through the perception of experts was an alternative procedure for making the proposed method applicable to the employment context of real-time operation teams of the Brazilian Power System.

Engineers and technicians of the National System Operator performed the evaluation. These professionals perform control on top of the system and have access to an overview of the operating environment. The minimum time of evaluators experience is greater than the minimum period for certification by the authorities represented by the following inequality: 5years experience > 3 years first certification.

In added al experts have professional qualifications in line with operating activity and are active professionals. Thus, raters are qualified for assigning the degree of importance of the items in the steps of the method.

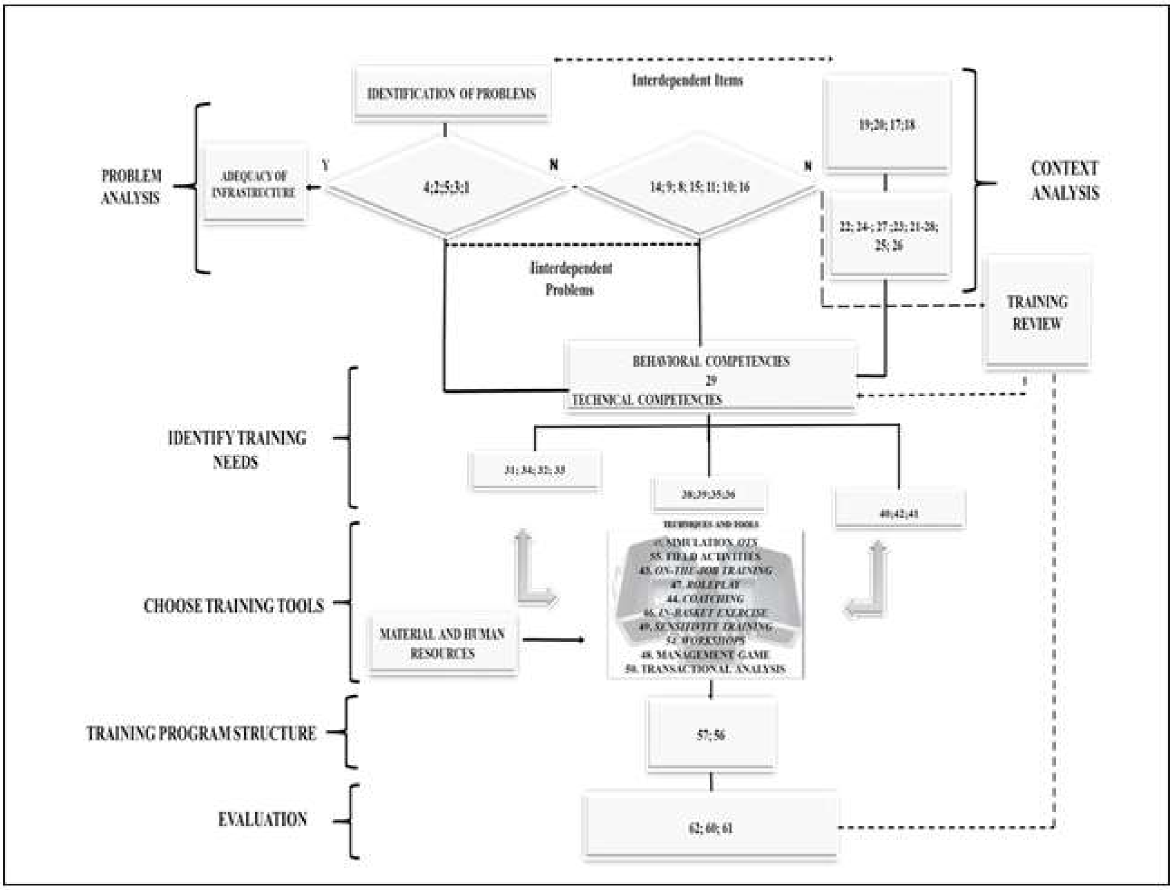
An initial protocol was submitted to verification of an expert in power system operation. It was necessary to adjust the language and structure of questioner trough a pretest with a group of six operating professionals.

Evaluation protocol consists of 57 statements related to the six steps of the method and its attributes. The application of a Likert scale (5 levels) revealed the intensity of importance for each attribute. It also contains a section for comments and suggestions. The questioner was sent randomly to all regional and national operations centers of the main Brazilian operating company.

Data were collected from 16 respondents. Research credibility was achieved due to professional qualification. Forty-four percent are technical professionals and 36% are graduated in engineering or related areas.

The criterion for the evaluation of each item of the method was the minimum percentage of 80% of importance attributed to each item of the method by the specialists. The steps and tools were selected according to the highest degree in the sum of the perception of the item as important (grade 3) and very important (grade 4). After the data analysis, the main steps and tools of the method were obtained. Figure 3 summarizes the main components of the method, and Figure 4 names the items numbered in Figure 3 in order of importance.

Figure 2: The more important items of the method



Source: The authors.

Figure 3: The more important items of the method

INFRAESTRUCTURE PROBLEMS
4 = ADEQUATING THE NUMBER OF WORKERS
2= ADEQUATING THE TECHINCAL PROTOCOLS
5= ADEQUATING THE AVAIBLE SIMULATORS TO EMERGENCIES
3= ADAPT THE PROFILE OF WORKERS TO OPERATION
1= ADAPT THE EQUIPMENT, AND THE TECHNOLOGICAL NETWORK

ACTIVITIES PROBLEMS
14 = HIGH CONCENTRATION REQUIREMENT
9 = MAKE DECISIONS QUIKLY
8= ANALYZE SCENARIOS
15= UPDATING THE SKILLS OF THE EXPERIENCED OPERATORS
10= STANDARD TRAINING
16= WORK UNDER EMERGENCY CONDITIONS

HIERARCHICAL LEVEL
19= LOCAL COMPANY
20= INSTALLATION COMPANY
17= NATIONAL OPERATOR
18= REGIONAL COMPANY

POWER COMPANY PROFILE
22= NUMBER OF OPERATORS PER SHIFT.
24= PROFESSIONAL PROFILE OF OPERATORS
27= OPERATING INSTRUCTIONS
23=WORK REGIME
21= KNOW THE ORGANIZATIONAL CHART
28= INFORMATION FLOW
25= ROLE OF OPERATORS
26= TASKS OF OPERATORS

ANALYSIS OF THE COMPETENCIES
29= JOB TASK ANALYSIS

PLANNING
31= DEFINING THE OBJECTIVES OF TRAINING
34 = CREATE TRAINING EVALUATION PLAN
32= DEFINE THE LEARNING DEVICES (TOOLS) AND WHO WILL LEAD THE TRAINING
33=CREATE WORKERS EVALUATION PLAN

DEVELOPMENT
38= DEVELOP SUPPORT MATERIAL
39= DEVELOP MEANS OF COMMUNICATION OF KNOWLEDGE
35= DEVELOP THE SCHEDULE
36= DEVELOP THE TRAINING PLAN

PREPARATION
40= DEFINE ACTIVITIES TO BE PERFORMED BY INSTRUCTORS
42= PREPARE THE PHYSICAL SPACES AND AGENDA
41= FINALIZE THE MATERIAL AND THE CHOICE OF RESOURCES, THE SEQUENCING OF TECHNIQUES AND THE CHOICE OF INSTRUCTORS

APLICATION
57= SEQUENCING OF THE TRAINING PROGRAM
56= APPLICATION BASED ON EXPERIMENTATION

EVALUATION
62= CERTIFICATION ACCORDING TO THE INTERNATIONAL STANDARDS
60= USE OF PRACTICAL TESTS
61= FEEDBACK

Source: The authors.

In the next sub-items, the figures (3 and 4) are explained.

5.2 Key steps

The proposed method is organized in a new way because emphasizes the importance of analysis of problems to determine gaps of competences to develop and meet the requirements of the operation. At the same time, the analysis of operational context is a novelty in relation to other approaches cited in this paper.

Noteworthy, the steps involving links between infrastructure troubleshooting and operating activities. These steps are important in determining technical knowledge and establish the dominance or the interrelationship with behavioral competencies, i.e. skills and attitudes.

Context analysis is a crucial factor to consider in order reaching the competences to be developed in a training program. This dynamic domain of the method emphasizes the importance of interpretive perspective, as a source of global understanding of training needs. This is a peculiar dynamics prepare real-time maneuvers through training programs developed according to the analysis of evidence in documents and records with special emphasis on facts and observations.

The interdependence within cognitive and behavioral competencies is underpinned. The assumption is that the knowledge base needed to make decisions depends on behaviors that express ability to act correctly under time pressure and hazard.

The following stages summarize a typical guideline for design and program registration. They relate to planning, development, and preparation of a training program. They involve part of training needs identification and are dependent on the resources available to the choice of training techniques.

A structured program should take into account the sort of learning, from the simplest to the most complex.

It must also observe action-learning perspective. It contains the possibility of error and fixes it.

Evaluation flows according to cognitive, technical and behavioral perspectives. An effective evaluation can be achieved through a combination of theoretical and practical tests. Trainee's answers are important to performance analysis in contrast to its opinion about planning and application. It contributes to review current training program and facilitate its actualization.

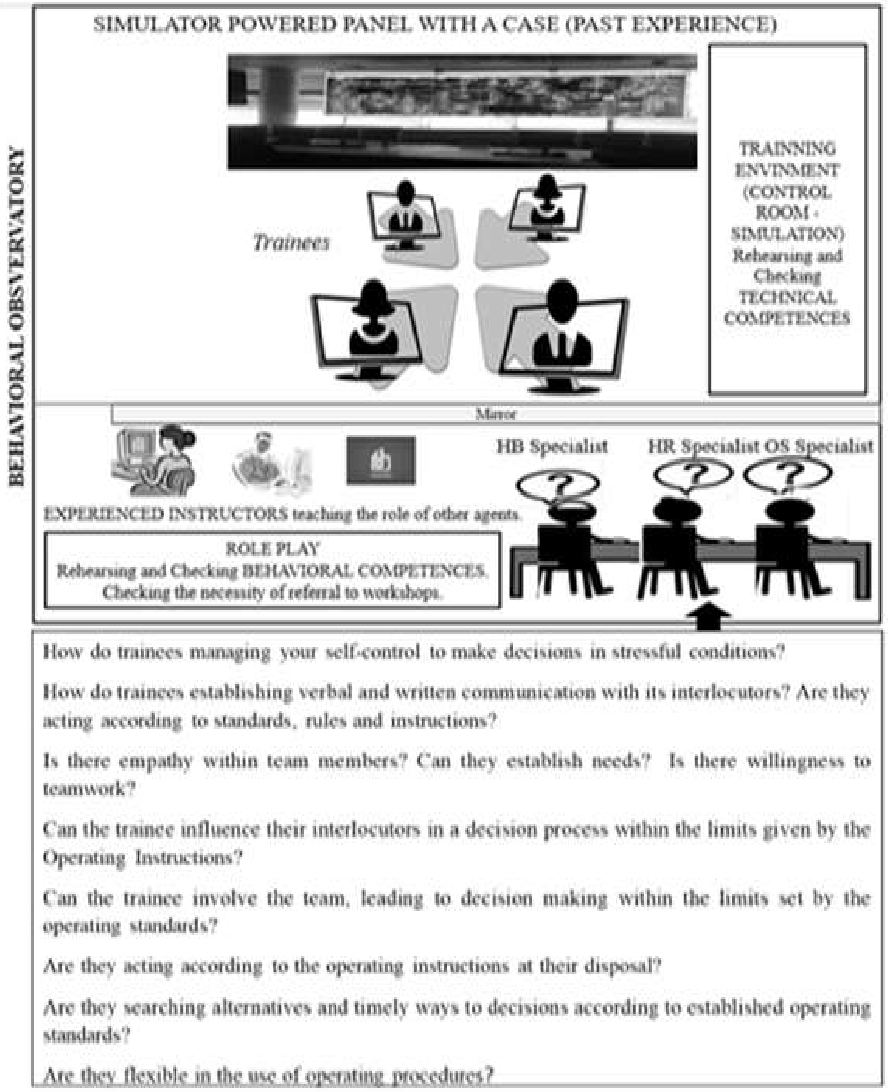
5.3 Main Tools

The main tools are simulations, field visits, on-the-job training, roleplay, coaching, in-basket exercise, sensitivity training, workshops, management game, and Transactional Analysis.

The resulting proposal of this study may shed light on how to integrate technical and behavioral training needs in a single device. There is no evidence from studies that propose a systematic follow up with technical professionals, human resources specialists, and behavioral specialists.

Figure 5 shows a Behavioral Observatory environment. Roleplay is integrated with the simulation. Other tools such as case studies and technics like observation are used for integrated development of technical, cognitive, emotional, psychological and behavioral competencies.

Figure 4: The Behavioral Observatory



Source: The authors.

In an observational environment, experiments with past events can be entered into a simulator. The review errors-based decisions can contribute to the learning process facilitating error correction. During roleplay, experienced instructors act out the role of interlocutors, fulfilling roles to assess psychological states, emotions and behaviors suitable or not suitable for operational tasks. A protocol with issues relating to compliance with operating tasks is used for intervening experts to modify and evaluate attitudes of operators and results of a roleplay.

Appropriate behaviors are reinforced and new capacity to cope with pressure situations can be acquired or discovered through analysis and specific troubleshooting. They should be aligned with rules, operating instructions, safety, efficiency and economy for power system operation. Hence, the observation protocol consists of evaluative questions that interrelate behavioral competencies to operating standards.

5.4 Suggestions

5.4.1 Regarding training programs elaboration

It was suggested, *"training programs should be structured programs with clarity and transparency"*. We argue that the development of skills based on the validated method coupled with the participation of experts (operation professionals, human behavior specialists, human resources professionals, engineers, and others) can favor development and implementation of new training programs.

5.4.2 Regarding evaluation of trainees

"Evaluations always practical considering the routine work, for example, simulation". Confirms that the evaluators prefer training activities that combine concepts and actions. Another aspect to consider regard to this suggestion is the disclosure about the understanding of how articulate professional expertise during the execution of operation maneuvers.

"Choose trained evaluators." Knowing the proposed method and establishing conditions for its certification according to international standards can be criteria for achieving this suggestion. The participation of expert instructors in Electricity, power systems operation, Human Resources professionals and Human Behavior experts can contribute to this suggestion. This can be a profile suitable for internal and external evaluators.

"The assessment is secondary since what matters is to run the experience as close to reality. Focus on evaluation can lead to distortions in the process and greater difficulties for trainees. "It is according to action-learning principle and learning by error correction. The competences to avoid failures in coping moments at the work really should not be subjugated to the evaluation process. The interference of pressure to a positive evaluation linked to certification of trainees can interfere negatively with the training process. More investigations are necessary to verify the veracity of this hypothesis.

6 Final Remarks

Real-time operations are characterized by uncertainty, incomplete information, time pressure, unexpected events, and security threat. Emergencies and urgencies demand rapid actions and effective decisions. This is the case of hospital emergencies, fire brigades, marine, air traffic control, nuclear plants control, and power system operation.

The articulation through practical experiences and theoretical propositions to develop behavioral competencies within technical knowledge has a lack of investigation. The same occurs in the scope of programs. This paper aims to describe how to develop a method of training programs for real-time operators.

The main result of this paper is a method to develop training programs for real-time operators evaluated by specialists. It was designed to accomplish the aim of describing a process and answer the question "How to do it". The method comprises six steps, Problem Analysis, Context Analysis, Identify Training Needs, Choose Training Techniques, Training Program Structure, and Evaluation. The steps contain the respective contextual items validated according to the degree of importance attributed by experts in power system operation (Figure 3).

It involves the named steps and training tools appropriate to the troubleshooting of problems of network infrastructure and technology, typical problems of operation, the international requirements and required competencies. The focus on behavioral competencies and their integrated development with the technical operation skills is the main innovation proposed. It involves findings in scientific literature supporting the assumption that capacity for actions and effective decisions consists of exercising flexibility in attitudes, negotiation skills, communication, group activity, trust, among others.

The proposed solution to address the training needs in the real-time operation is to articulate modern simulation capabilities at a Behavioral Observatory. It promotes de roleplay exercise to review behaviors, create new solutions to past cases and, the capability to combine adequate behaviors or mental states to new situations. Therefore, this is the main combination of training tools acknowledged in the study.

The results of this study cover four years of bibliographic research and field investigation. The pioneer experience in the Spanish power system developed by Red Electrica de España trough Escuela Corporativa de Red Eléctrica de España was a starting point for proposing the method.

The analysis of experiences in the Brazilian electricity sector completed the investigation. In addition, this allowed verifying the suitability of an internationally recognized experience in relation to the Brazilian context. Therefore, the results are only suitable for the investigated experiences.

The main empirical contribution of this research is the method validated by system operators and real-time engineers considered satisfactory to about 81% and score 8-9 attributed by 75% of experts (scale, 0-100%). This result confirms the process designed to propose a method to training programs for real-time operations in the Brazilian Power System operating environment.

Institutional governance of training programs is a crucial question to establish a transparent training program. We underline that a structured method needs involvement with standards, security, guard sensitive information, technical responsibility, and the physical, cognitive, emotional, psychological and mental health of workers. Moreover, engagement with international standards for operator training and certification is required.

Therefore, the top management of the operating company must define the departments responsible for design, implementation, financial management, human resources and inter-program relationship.

A commitment of the management, support of research and development institutions, universities, training companies, and other governmental or non-governmental institutions is critical to the success of the proposal formalized in this search.

The research methodology may be limited by the qualitative approach (subjectivity of the observers, the interviewees, and the perception of the evaluators). The proposed method is limited by the predominance of theoretical and field research in power system operation companies.

Quantitative research and application to the method in real-time operation companies can be put into practice on future. In order to increase the contribution to real-time operations, it is necessary to test the method in related areas. It may be a focus in addition to other comparative studies on the topic.

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