PAPER COGNITIVE WORK ANALYSIS TO UNDERSTAND TRAINING OPERATIONS IN BRAZILIAN ARMY AVIATION SIMULATORS

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ABSTRACT

This study explores the application of Cognitive Work Analysis (CWA) in the Flight Training Device (FTD) from the Simulation Division of the Army Aviation Instruction Center (CIAvEx). Cognitive Work Analysis is a methodology used to design and analyze complex sociotechnical systems, as well as to facilitate the communication between the teams involved in the system processes. It was considered as a proposal to verify the performance of Flight Training Device (FTD) simulators system used in military aviation, which offers configurations and displays of the Eurocopter AS-350, *Esquilo* aircraft, applying the four phases of CWA, mainly considering the risks of accidents during the training in real aircraft. The first phase, Work Domain Analysis, generated the abstraction hierarchy; the second phase, Work Task Analysis led to the control task analysis, the decision ladder and the contextual activity; the third phase, created the Strategies Analysis; and finally, the fourth phase was the Social Organization and Cooperation Analysis (SOCA). As a result of this process, it was verified the effectiveness of the method through tools that aim to analyze the behavior of workers, and also to understand the limitations and improvements in the project in a systemic view, regarding the interaction between the human factors and the technology presented without losses related to the safety of flight training.

Keywords: Cognitive Work Analysis, Army Aviation, Training.

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1. INTRODUCTION

Cognitive work analysis (CWA) is a framework for analysis, projection and evaluation of complex sociotechnical systems. The methodology is valued for its conceptual basis in empirical observations of human reasoning patterns in complex systems.

In complex sociotechnical systems the main goal is to design and develop a system that can be learned in a reasonable time and, also could also be easily understandable in order to identify and diagnose errors and abnormalities. The complex sociotechnical systems in aviation involve numerous human and non-human interactions, operating in dynamic, ambiguous, and critical domains for safety.

The complexity incorporated into these systems presents significant challenges for process modeling and analysis. Unlike the construction of an ordinary product, which is usually designed with the user in mind (JENKINS *et al.*, 2009).

In normal products, designers are guided by how users interact with the products and after these analyses they manage the product development. In this way, the user participates in the process of building and drawing the project, offering opinions and feedback about errors, performance data and subjective data, directing afterwards to product design and development.

However, in complex sociotechnical systems, this approach would certainly have limitations, because it is necessary to consider the project in its entirety. Not just the disconnected parts, which would likely occur when consulting the system users, who may have an incomplete understanding or misconceptions about the restrictions, offering an opinion that cannot be considered and influencing the existing functions about the system (JENKINS *et al.*, 2009).

Thus, traditional reductionist modeling techniques, with sequential task analysis, can rarely be extended beyond stable and repeatable systems. Thus, it is necessary to use a technique that can deal with the inherent complexity and versatility. In this sense, focusing on restrictions, which shape the way work is done in each domain, is one way of doing it.

In terms of the representation of the context, some methods and structures, such as CWA, Cognitive Task Analysis (*ConTA*) and Macro Ergonomic Analysis are evident in representing the task, the work domain analysis, individuals, and the organization, presenting a structure and/or a framework with steps that cover different types of analysis (WATERSON et al., 2015).

By focusing on the analysis of restrictions proposed by CWA, it is verified an independent event approach to work analysis, making possible to identify the information or knowledge about what and how workers need to deal with a wide variety of situations, including new or unexpected events.

Thus, in projects with complex sociotechnical systems, CWA provides a formative perspective, considering the restrictions of the actors' behavior instead of the details of these behaviors (Rasmussen, 1986; Rasmussen et al., 1994; Vicente, 1999 in NAIKAR, 2016).

Naikar and Lintern (2000) affirm that the CWA method, besides focusing on the human cognitive system, also addresses physical and social restrictions, unlike other forms of work analysis. In this sense, the CWA meets the premises of an analysis that aims to assist in the perception of the project, highlighting possible restrictions and possibilities for improvement.

Therefore, instead of describing the existing behavior, CWA offers a formative approach with focus on the possible behavior, besides the description of the system, which is independent of any actor, differently from the normative approaches, which focus on the existing activity, which is more likely to be individualistic and envisioned in only a small part of the whole system.

A difference between the normative approaches and the CWA, brought by Jenkins et al (2019), is that the normative ones are more prescriptive and focus on the final product or solution, whereas the CWA aims to describe the initial behavioral conditions to support the system on its adaptation.

It is defined that the normative approaches are more applicable to linearity and bureaucratic systems, while CWA is more applicable to analyze nonlinear support systems and emerging behaviors. Paraphrasing the authors:

> "…CWA offers a formative approach by focusing on possible behavior. CWA also starts by focusing on system description that is independent of any actor; conversely, normative approaches, by focusing on existing activity, are more likely to be more individualistic. Normative approaches are also likely to be far more prescriptive focusing on the final product or solution, whereas, CWA aims to describe the initial conditions for behavior to support the system in adaptation. This makes normative approaches more applicable for linearity and bureaucratic systems, whereas, CWA is much better equipped to analyses non-linear systems supporting emergent behavior" (JENKINS *et al.*, 2009, p.11).

Therefore, the objective of the present study was the application of CWA in order to analyze and understand the phases of this method and their applications serving as a subsidy to verify the performance of the FTD system used in military aviation, lined to the safety of fight training.

This work will be structured in 04 (four) sections, the first consisting in the Introduction; the second is about a Literature Review on the methodology used; the third section will present the Application of the Method employed; and finally, section 4, with Conclusions.

2. DESCRIPTION

2.1 Literature Revision

A notable characteristic of the CWA is represented by the study of human-machine systems with focus on the actors involved and existing behaviors related to the system restrictions.

The mentality impregnated in the CWA arises from the recognition that complex sociotechnical systems, open or closed, are exposed to unexpected events, having domains that can be classified as "perverse problems" or serious, which are not fully understood because they have imprecise limits, involve many pieces and has restrictions without evident or clear solutions. From a user-centered perspective, these "perverse problems" present a significant challenge in the development of projects (RITTEL and WEBBER, 1973).

Thus, the conceptual origins of the approach focus on studies for solving human problems in complex systems, while the applications of the methodology are focused on human factors and engineering, making it possible to examine the relevance of perceptions about human reasoning (NAIKAR, 2016).

The method was originally developed at the Riso National Laboratory by Jens Rasmussen and his colleagues (RASMUSSEN, 1986), in Denmark, in the 1970s, to meet the demand of the nuclear power industry, regarding the electronics department's need of identifying a design for adaptation, which projected new situations from the study of industrial accidents (JENKINS et al., 2009).

According to Naikar (2016), the challenge faced by the group was how to increase the security of nuclear plant operations in hardware systems, which already worked with extremely high reliability, leading them to develop the CWA.

In this matter, several empirical studies have been conducted with the intention of establishing a solid basis for designing safer man-machine systems.

Rasmussen and Jensen (1973) had investigated how professionals solve complex failures in electronic equipment available on the market. The authors have found that workers' rationality have different levels of abstraction while carrying out their work, leading to spontaneously changes of their view of the system; that workers ratiocinate at different levels of decomposition; workers tend to adopt models of the system over a space of rationality; and the space of reasoning is event independent. Therefore, regardless of whether workers adopt similar or diverse problem-solving paths, in the same or in different situations, all these trajectories can be mapped or explained by this reasoning space (NAIKAR, 2016).

CWA can be applied in closed systems, whose operations are more predictable, and open systems, in which the performance of the task is subject to influences and contexts not always predictable.

The method proposes that workers involved in the work system can adapt effectively to new and variable working conditions if they are aware of the limits of acceptable performance, which are defined by the objectives, requirements, and resources of the work system. In this matter, workers must achieve goals and requirements of the work system through the available resources.

Within the fundamental constraints of the system, workers have degrees of freedom or possibilities to decide about definitions of what, when and how they should perform, being able to adopt different sequences of tasks or behavioral trajectories to meet the objectives and requirements of the system with the available resources.

Therefore, as long as they are aware of the objectives, requirements and resources of the work system, workers can select and even create patterns or behavior trajectories while remaining within the limits of acceptable performance of a work system (RASMUSSEN *et al.*, 1994).

Composed of five stages, the method tries to identify the high-level analysis of the system structure (Abstraction Hierarchy), the comparison between functions and different work situations (Contextual Activity Model, Decision ladder), the analysis of usual tasks and strategies in emergency situations, the analysis of workload between agents, and the analysis of the decisions imposed on agents (skill, rule or knowledge).

Work Domain Analysis (WDA) refers to the first phase of the method, which examines the restrictions imposed on workers by the physical, social, and cultural environment. The most common analysis tool, at this stage, is the Abstraction Hierarchy.

Then, the ConTA analyzes the restrictions related to the activities necessary for the proper operation of the system. Decision ladders are used to illustrate how information will be processed by the actors involved in the system.

The third phase refers to Strategies Analysis (SA), which examines the restrictions of cognitive changes in behavior. In this step, a map is used to represent the information flow of the analysis.

The fourth phase consists of Social Organization and Cooperation Analysis (SODA). At this stage, the constraints arising from the ways which work can be organized in the system are analyzed, resulting in a diagram of the possibilities of work organization.

Finally, the Worker Competencies Analysis (WCA), which refers to the final phase of the CWA, analyzes the restrictions based on the correspondence between human cognitive abilities and limitations. The skills, rules and knowledge taxonomy are used to analyze training and information support requirements at this level (SHIVE AND DISCHINGER, 2019).

Rasmussen produced several publications on the CWA, highlighting the articles of journals on the skills, rules, and taxonomy of knowledge (RASMUSSEN, 1983) and the space of decomposition of abstraction (RASMUSSEN, 1985).

The CWA has two main motivations, one related to the publications of Rasmussen (1986), Rasmussen *et al*. (1994), and another to the studies of Vicente (1999). Naikar *et al* (2005) who elaborated the table below to demonstrate a comparison between the indicative terms of each stage described by the authors Vicente (1999) and Rasmussen *et al.* (1994) on table 1.

Table 1. The phases of the CWA.

Vicente (1999)	**Rasmussen *et al.* (1994)**	**Types of Limits or Restrictions**
Work Domain Analysis.	Work Domain Analysis.	Objectives, values and priorities, functions and physical resources.
Control Task Analysis.	Activity Analysis in terms of work domain and decision making.	Work situations, work functions and control tasks.
Strategy Analysis.	Activity Analysis related to Mental Strategies.	Strategies for executing the activity.
Social Organization and Cooperation Analysis.	Cooperation Analysis in the Organization.	Work distribution, including work allocation to individuals; individuals' organization in teams; and communication requirements.
Worker Competencies Analysis.	Commercial System Analysis.	Perceptual and cognitive abilities of workers cooperate.

VICENTE (1999) and RASMUSSEN *et al.* (1994)

Each phase offers tools to analyze the workers behavior in the system, to understand the limitations and restrictions of the work, as well as to realize the potentialities and possible improvements of the whole system. The results of each analysis phase guides and feeds the next phase, permitting the execution of the following one and the production of the work results (JENKINS *et al.*, 2009).

According to Jenkins *et al.*, (2009) the CWA was developed for a series of purposes such as: system modeling, system design, analysis of training needs, evaluation and design of the training program, information requirements specification, evaluation of proposals, team design, development of human performance measures and design of error management strategy.

It is also pointed out by the authors that the applications of the method occurred in a variety of complex domains such as air traffic control, automotive, aviation, healthcare, hydropower, nuclear, naval energy, manufacturing, military command, and petrochemical, rail, and transportation control road (JENKINS *et al.*, 2009).

CWA method was applied in a study, whose objective was to explore the coordination of human automation during the manual steering of the Space Launch System, NASA's new heavy-duty vehicle, designed to be a highly automated system (SHIVE AND DISCHINGER, 2019).

The authors' study (SHIVE AND DISCHINGER, 2019) about the application of the first stage of method, WDA, was limited to analyze the physical, environmental, and cultural environment where the work was performed. The other phases of the method, on the other hand, were focused on the activities of workers, strategies, social organizations, competences, skills, rules, knowledge, which brought restrictions on the behavior of those involved.

The application of WDA during the flight in the SLS, facilitated the systemic and global perception of the project and contributed to the emergence of a common language among the participants, demonstrating that the assumptions and the fundamentals which were used for design choices regarding the analysis of complex systems were similar, enabling the design of new interfaces (SHIVE AND DISCHINGER, 2019).

In addition, Shive and Dischinger (2019) have identified that the method can be a useful tool for promoting communication between the various groups involved in projects, from the most varied and different technical areas, such as managers, coordinators, engineers, technicians, administrators, and others.

Thus, the application of the method resulted in potential benefits, evidenced by the interaction and collaboration between NASA centers during the design, implementation, and support of the systems (SHIVE AND DISCHINGER, 2019).

Therefore, the Flight Training Device (FTD) simulators, used in the Brazilian Army Aviation, were developed with the objective of providing a high fidelity and flexibility to train crews, especially in high-risk situations. The system also intends to elevate the real operation safety levels through the training of cabin procedures and through the mission practice before the actual execution. The application of CWA could assist in the analysis of restrictions and at last, minimize the risks of the real operation.

The training in FDT simulators requires a methodology that incorporates information about the restrictions of human behavior considering their tools, such as aircraft controls, decision making, situational awareness and the projection of the image on the screen, which can cause physical fatigue.

It is important to consider solutions to human problems in complex systems, that is why the development of the CWA was possible and it became relevant to the development of military training.

2.2 Method Application

The present study occurred in the Simulation Division of the Army Aviation Instruction Center, in the city of Taubaté. The Simulation Division had six flight simulators, five FTDs, and one full flight simulator, all with the configurations and displays related to the aircraft AS-350, *Esquilo*, from Eurocopter.

In Brazil, flight simulators need to be certified by the National Civil Aviation Agency (ANAC) and their hours can be counted as flight hours for pilots. This process is called qualification of Flight Simulation Training Devices (FSTD) and aims to classify the simulators in three categories according to their performance and realism: PCATD (Personal Computer Aviation Training Device); ATD (Aviation Training Device) and FSTD (Flight Simulation Training Device).

The FTD was designed with the objective of being a flight simulator with a high fidelity and flexible environment, to allow the training of pilots in several conditions, including instrumental conditions and wearing night vision goggles. It also allows an initial familiarization with controls and instrument panels, ensuring a high learning gain for the entire crew.

The FTD cabin was a replica of the A-350 cabin, containing seats, flight controls and instrument panel, being all objects identical to the real aircraft.

For the application of the method and data collection, semi-structured interviews were realized with the Sub-Commander, who manages the base; the Technician, who is an assistant in the Computer-Assisted Teaching Section (SEAC) and supports the navigation and control activities of the simulators, and a Pilot, who commands and pilots the aircraft. It happened in the Army Aviation Instruction Center, on October 26th, 2020.

During the semi-structured interviews, the following sequence was performed: presentation of the method, signature of the consent form, explanation and recording of the interviews.

The semi-structured interviews had the following script:

1. Functional Purposes

Goals:

• What is the purpose of this work system? It was designed for what? What should it achieve?

• What are the highest-level objectives of this work system (services offered)?

• What are the values of people who work with this system (example, job security, efficiency)?

External restrictions:

• What are the restrictions imposed by the environment on the work system?

• What laws and regulations are imposed and applied to this work system?

2. ***Values and Priority Measures***

• What criteria can be used to judge whether the work system is achieving its objectives?

• What are the priorities of the work system? How are priorities assigned to the various roles in the work system (for example, decision is up to a teacher responsibility)?

• What criteria can be used to allocate resources (for example, materials, energy, information, people, money) to the functions related to the purpose? What resources are allocated to the various functions of the work system? How are resources allocated to the various functions of the work system?

3. Purpose-related Functions

• What are the roles of individuals, teams and departments in the work system?

• What functions coordinate the use of physical resources in the work system?

4. Object-related processes

• In which processes are the physical objects used in the work system?

• What are the functional capabilities and limitations of physical objects in the work system?

5. Physical Objects

• What physical objects or physical resources are needed to enable the processes and functions of the work system?

Based on the information collected, the first draft of the abstraction hierarchy was created. After that, the application of the method was completed using the CWA software.

3. RESULTS AND DISCUSSION

3.1 *Work Domain Analysis* - WDA

The main objective of the WDA is to model the constraints related to the intentional and physical context in which workers operate. The intentional context imposes restrictions on workers by specifying the purposes that the work system must fulfill, the values and priorities that the work system must satisfy and the functions that the work system must perform.

The physical context imposes restrictions on workers, specifying the physical objects that are available in the work system and the functional capabilities and limitations of the physical objects (NAIKAR et al, 2005).

The combined intentional and physical work context defines the fundamental problem of workers' space, specifying the purposes, values and priorities, and functions that must be achieved by a work system with a given set of physical resources.

Within the restrictions imposed by the context of intentional and physical work, however, workers have many options or possibilities for action in the field of work.

The most embracing reports about WDA, to this date, are provided by Rasmussen *et al.* (1994) and Vicente (1999). A summary of the data acquired in this analysis is shown in the table 2 below:

Table 2. Summary of the data.

Structure of Work Domain Analysis (WDA)		
Layers	**Description**	**Keywords**
1. Functional Purposes	The proposal of the work system and external restrictions of the operation	Reasons, goals, objectives, intentions, mission, ambitions, plans, services, products, roles, aspirations, desires, motives, values, beliefs, points of view, justification, philosophy, policies, norms, conventions, attitudes, customs, ethics, morals, principles.

2. Values and Priority Measures	The work criteria used in the system to measure progress towards the functional proposal.	References, tests, evaluations, calculations, evaluations, estimates, judgments, scales, criteria, budgets, schedules, results, goals, values, limits.
3. Purpose-related Functions	The general functions of the work system which are necessary to achieve the functional proposals.	Roles, responsibilities, purposes, tasks, jobs, duties, occupations, positions, activities, operations.
4. Object-related Processes	The functional capacities and physical limitations of objects in the work system that allow the functions related to the proposals.	Processes, functions, purposes, utility, uses, applications, functionality, characteristics, capabilities, limitations, physical, mechanical, electrical and chemical processes.
5. Physical Objects	The physical objects in the work system that provide the processes related to the object. .	Artificial and natural objects: tools, equipment, devices, appliances, machines, instruments, accessories, appliances, implements, technology, supplies, kit, equipment, buildings, facilities, infrastructure, assets, resources, personnel, terrain, meteorological characteristics.

(JENKINS *et al.*, 2009).

Next, the first stage of a CWA is conducted, an analysis of the work domain on Flight Training Device (FTD) simulators, used in the Brazilian Army Aviation. The result of applying Work Domain Analysis is shown on table 3.

It is also presented in Annex I due the figure size.

Table 3. Work Domain Analysis

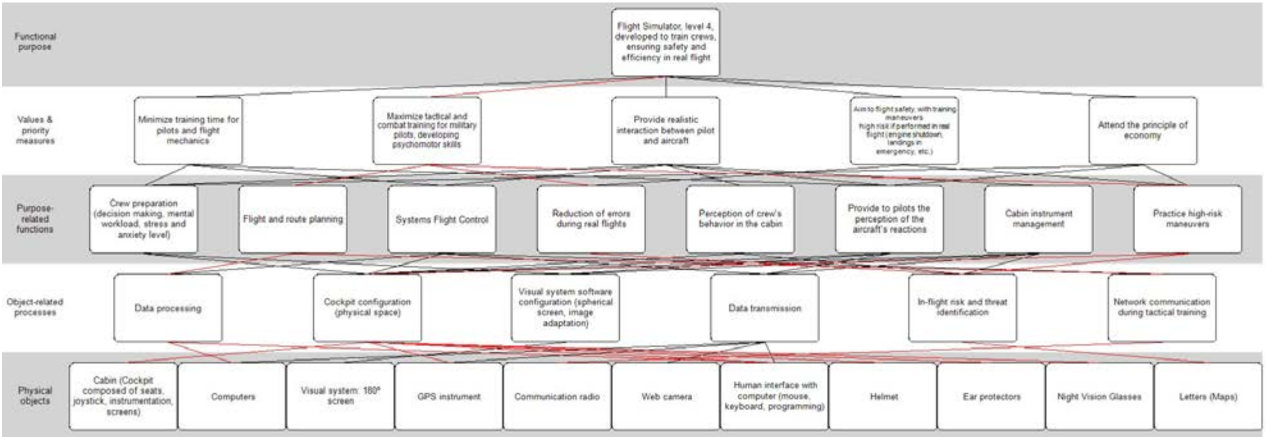


Table 3 shows the five stages of WDA and the links between the data acquired in the interviews are reinforced below:

Functional Purpose: Flight Simulator, level 4, developed to train the crew, ensuring safety and efficiency in real flight.

Values and Priority Measures: Minimize the training time for pilots and flight mechanics; Maximize tactical and combat training for military pilots through the development of psychomotor skills; Provide realistic interaction between the pilot and aircraft; Comply with the principle of economy.

Purpose-related Functions: Crew preparation (decision making, mental workload, stress and anxiety level); Flight and route planning; Control of flight systems; Reduction of the occurrence of errors on real flights; Perception of the crew's behavior in the cabin; Provide pilots with the perception of the aircraft's reactions; Management of the cabin instruments; Practice high-risk maneuvers.

Object-related Processes: Data processing; Cockpit configuration (physical space); Configuration of the Visual System software (spherical screen, image adaptation); Data transmission; Identification of risks and threats during the flight; Network communication during tactical training.

Physical Objects: Cabin (Cockpit composed of seats, joystick, instrumentation, screens); Computers; Visual system: 180º screen; GPS instrument; Communication radio; Web camera;

Human interface with computer (mouse, keyboard, programming); Helmet; Ear protectors; Night Vision Glasses; Letters (Maps).

Posteriorly, on table 4, the same stage is presented in another mode or format, the Hierarchy of Abstraction, which is divided into abstraction and decomposition, in relation of the totality of the system, the subsystems and the components.

Table 4. Hierarchy of Abstraction .

Decomposition / Abstraction	**Total System**	**Subsystem**	**Component**
Functional purpose	Flight Simulator, level 4, developed to train crews, ensuring safety and efficiency in real flight		
Values & priority measures	Attend the principle of economy Minimize training time for pilots and flight m Maximize tactical and combat training for military pilots. Provide realistic interaction between pil Aim to flight safety, with training maneuvers high risk if perf		
Purpose-related functions	Perception of crew's behavior in the cabin Provide to pilots the perception of the aircraft's reactions Cabin instrument management Practice high-risk maneuvers	Crew preparation (decision making, mental workload, stress and anxiety l Flight and route planning Systems Flight Control Reduction of errors during real flights	
Object-related processes	Network communication during tactical training	Data processing Data transmission In-flight risk and threat identification	Cockpit configuration (physical space) Visual system software configuration (spherical screen, image adaptation)
Physical objects	Cabin (Cockpit composed of seats, joystick, instrumentation, sc Visual system: 180° screen Helmet	Computers Communication radio Night Vision Glasses	GPS instrument Human interface with computer (Ear protectors Letters (Maps) Web camera

3.2 Control Task Analysis – ConTA

The second stage of the CWA, Work Task Analysis, also known as Control Task Analysis (Vicente, 1999), is based on the assumption that tasks are performed, problems are solved, and decisions are made through transformations between cognitive states induced by cognitive processes, demonstrating the recurrent activities that occur simultaneously in the complex system.

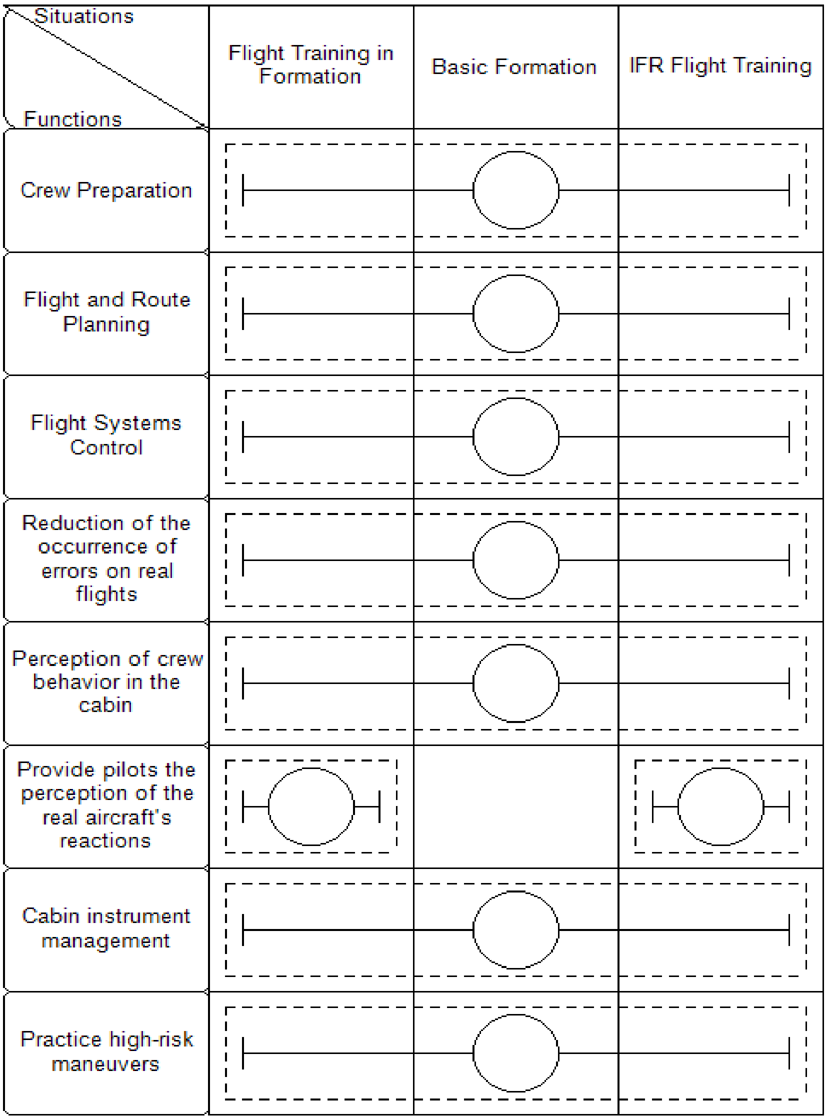
According to Lintern (2011), the cognitive state is a condition of being, for example, the state of being alert, the state of being aware of the situation, the state of being right or uncertain, the state of knowing something, as a cognitive process is an activity, for example, the process of searching for an information or a planning process.

The analysis of the work task identifies the cognitive states and the cognitive processes used within a work task by mapping the task trajectories provided by specialists in the subject on a decision ladder (LINTERN, 2011).

As a result, work tasks can be described in terms of cognitive states established during the task execution and during the cognitive processes used to perform transitions between states. The usual product of work task analysis is a set of decision ladders.

As shown in Table 5, it is divided into two parts, the horizontal axis as situation and the vertical axis as function. Roles are taken from the purpose-related function at the third level of the work domain analysis.

Table 5. Control Task Analysis

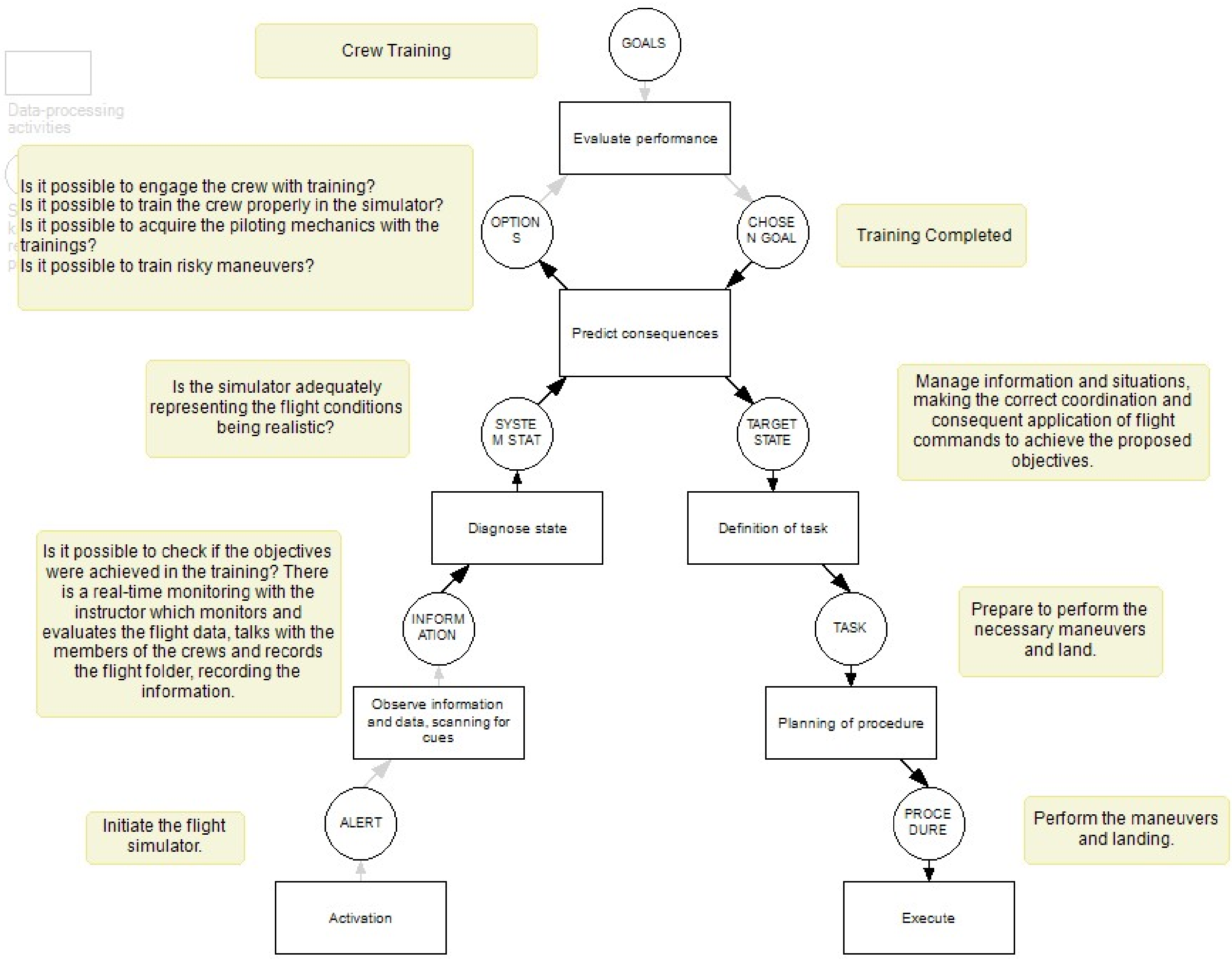


In the task control table, the analysis shows the relationship between situation and function. The meaning of the symbols is: dashes mean the relationship between situation and function "may be relevant", circles mean "generally relevant" and the blank box means that the relationship between situation and function is "impossible".

For example, in the first row, there are three situations that can happen: flight training in formation, basic training and IFR flight training. In the three situations, the relationship with the functions will be observed. The significance of the results demonstrates what may happen in the first, second and third situations, indicated by dashes and dots. In the first case, for example, it means that the Crew Preparation is relevant in the three training modalities. On the other hand, providing pilots with the perception of the aircraft's reactions is impossible to occur in pilot training.

Afterwards, the Contextual Activity of the Control Task Analysis, developed through the Decision Ladder, is presented. In this study, the Basic Training was chosen for the elaboration of the Decision Ladder, indicating the activities arising from this training, as shown on table 6.

Table 6. *Decision Ladder*



The Decision Ladder was developed by Rasmussen (1974) through the observation that experienced users trusted the behavior based on rules to perform tasks.

Rasmussen (1974) affirms that the sequence of steps between an initial suggestion and a final manipulation of the system can be identified as the steps that a novice must necessarily take to perform a subtask.

The Decision Ladder, product of the analysis from the work tasks, provides a model for mapping the set of generic subtasks involved in decision making, which are the cognitive states (represented as ellipses) and cognitive processes (represented as arrows).

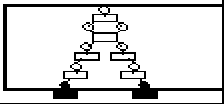
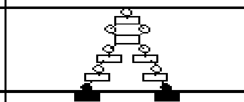
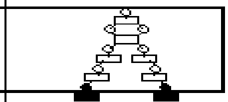
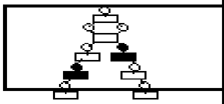
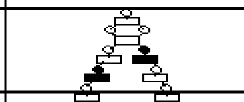
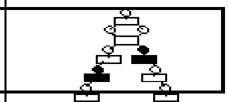
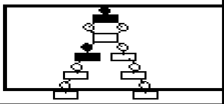
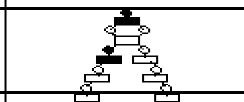
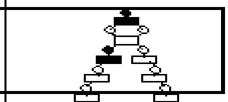
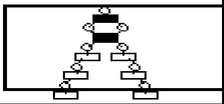
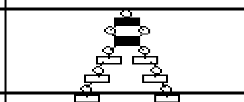
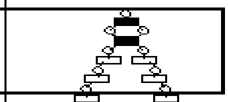
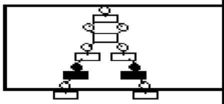
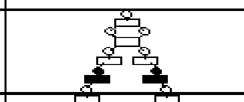
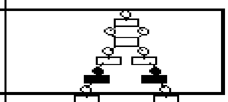
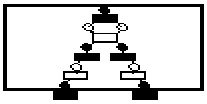
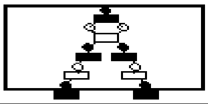
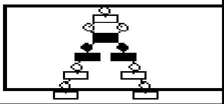
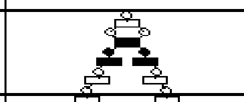
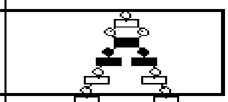
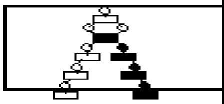
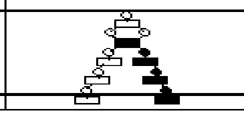
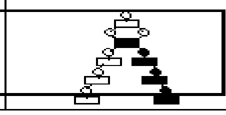
A work narrative can be mapped on the decision ladder to represent observed decision paths and to identify different decision processes (Rasmussen, et al, 1994, p 66).

The decision ladder has three main stages: assessing the situation on the left leg, analyzing options at the top and planning on the right leg.

The decision ladder accommodates rational and heuristic decision processes. A rational decision process will follow the perimeter of the decision ladder from the bottom left node to the bottom right node, while a heuristic decision process can start and end anywhere on the ladder and can transition through the ladder.

The processes can be explicit or implicit. An explicit process is accessible to conscious awareness, while an implicit one is not. In table 7, the explicit processes are represented by solid figures, while the implicit process is represented by a transparent figure.

Table 7. Contextual Activity

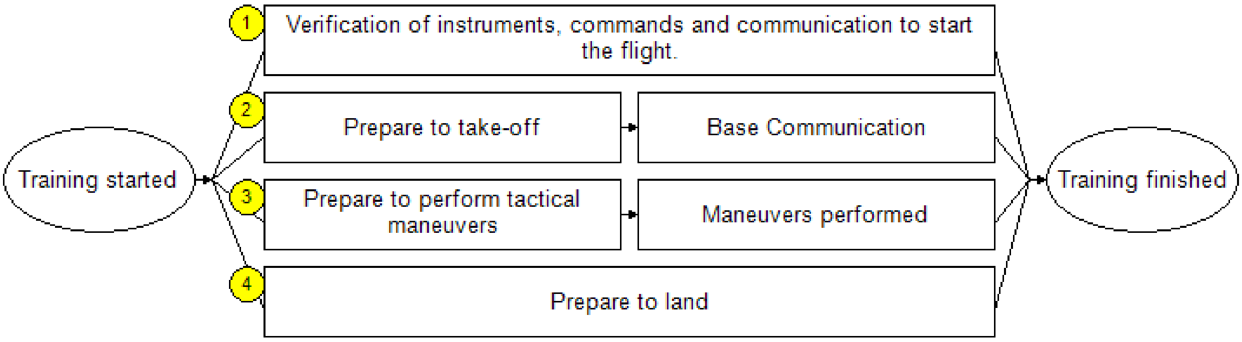
Situations / Functions	Flight Training in Formation	Basic Formation	IFR Flight Training
Crew Preparation			
Flight and Route Planning			
Flight Systems Control			
Reduction of the occurrence of errors on real flights			
Perception of crew behavior in the cabin			
Provide pilots the perception of the real aircraft's reactions			
Cabin instrument management			
Practice high-risk maneuvers			

3.3 Strategies Analysis

Strategy Analysis is the third stage of cognitive work analysis. The purpose of this step is to discover how things can be done in several stages. There may be a few different steps that can be performed at the same destination.

In this case, two different goals related to the check-in system and connected to the network were chosen. Thus, the objective of the strategy analysis was to identify the stages of training, as shown on table 8.

Table 8. *Strategies Analysis*



In this matter, the process starts in "Training Started" and ends in "Training Finished". Between the beginning and the end of the process, the following phases occur: the first step is to verify if all instruments, commands and communication, are ready and able to start the flight. The longest stages are the preparation for takeoff, which requires contact with the control tower, cabin coordination and checking of instruments; and the preparation for performing tactical maneuvers, which requires checking the aircraft limits, detailed briefing with the crew and cabin coordination before and during executions. And finally, the last step is to land the aircraft.

3.4 Social Organization and Cooperation Analysis - SOCA

This step showed the human factors involved in each situation and function of the system. Sometimes, there was more than one team in each situation and role. In the submitted case, there were four soldiers who were interpreted in four different colors, as can be seen on table 8.

In this study there were indications about the roles of the Commander, the Pilot, the Instructor and the Technician. Each individual had one responsibility, for example, the Commander is the Officer who manages the Military Base, being responsible for the management. The Technician is responsible for supporting and controlling the equipment of the simulators making the training possible to take place as expected. The Instructors accompany the training and the Pilots flight, as shown on table 8 and 9.

Table 8. Social Organization and Cooperation Analysis – SOCA

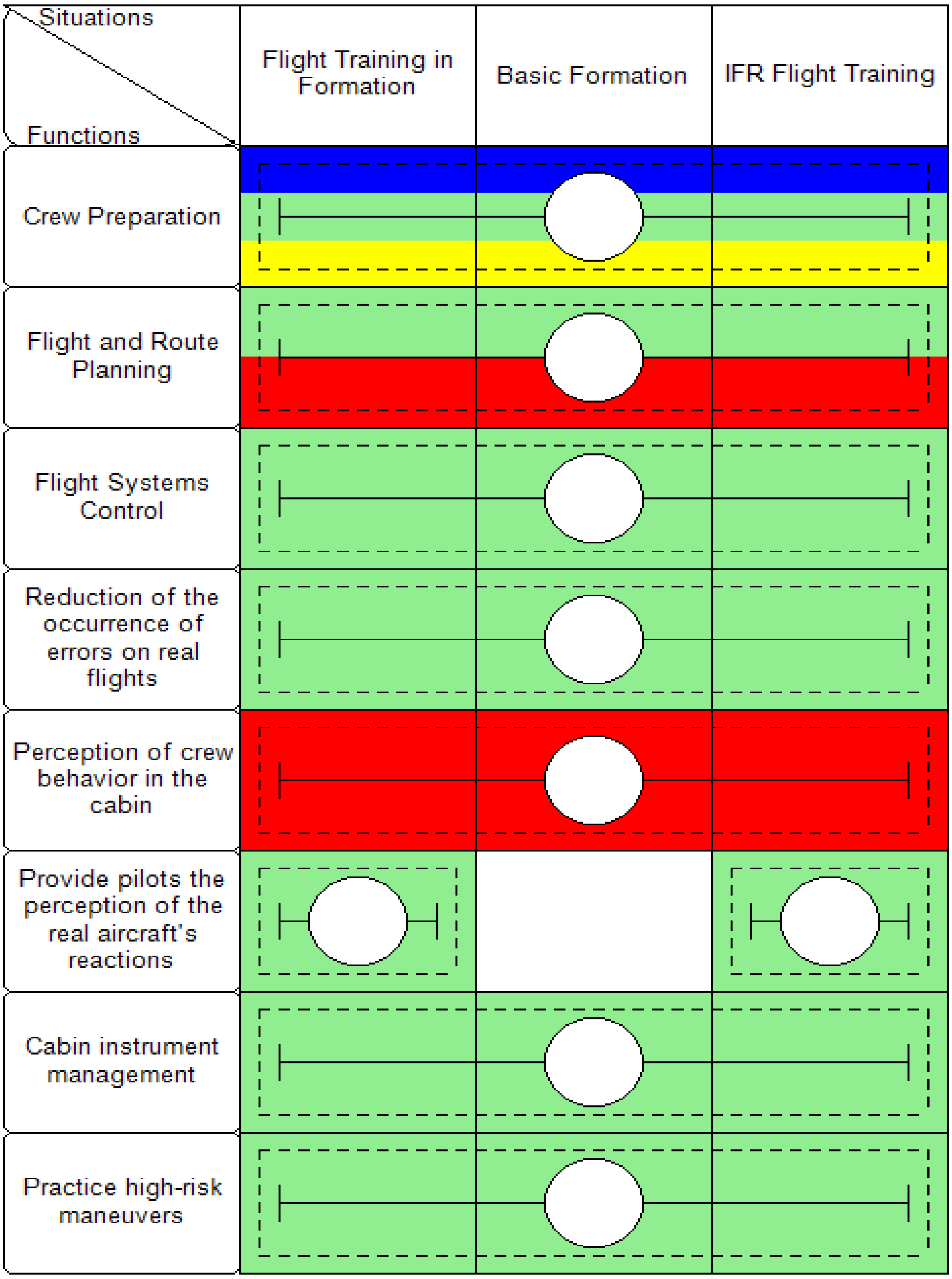


Table 9. Legend about the team and colors represented in SOCA analysis.

4. CONCLUSION

The purpose of the present study was the application of part of the Cognitive Work Analysis methodology in order to serve as a subsidy to verify the performance of the FTD system used in military aviation, identifying and reinforcing the need for training.

This article demonstrated that the CWA provides a compelling basis for designing interfaces that can promote high levels of performance by addressing human factors and engineering concerns in the military.

In addition, it promoted a systemic analysis of the existing process, highlighting the relevance of the interaction between human factor and machine, related to the use of existing technologies to benefit the training of militaries and corroborating with principles of economy and flight safety in aviation.

It should be noted that, despite all technological developments, and the quality of the simulators used, there is a significant difference between the simulated flights and actual flights, especially regarding the aircraft's reactions, weather conditions and the feeling of safety while practicing flight in a simulator.

I was found that the system is useful and minimize the risk of accidents during the real fight once the pilots get more confidence with the instruments and practicing before they manage the real aircraft, reinforcing the importance of the role of each member involved in the used of FTD to provide the training as well the competences of the simulator.

Furthermore, this work does not exhaust the proposed objective, becoming essential to the sequence of studies with sample expansion and application to the last phase of the CWA. New studies on CWA applications should be proposed in different areas, improving the concern with complex systems as a result of the interaction between human factors and engineering.

About the analyses related to risk of mental workload, the CWA methodology contributed to showing the importance of the training in simulators offering the sense of safety on board, the safety of training risk movements and getting to know the equipment before the real fight, which contributes to the pilots' confidence. Finally, the interaction between the human factor and the technology presented did not represent risk of mental workload by using the FTD.

In the future, it is planned to complete the CWA phases, which will allow the information processing activities, cognitive strategies, interpersonal communication requirements and crew training requirements to be considered necessary to support the actions of the simulators.

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