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Contribution of Multimethodology to Human Factors in Air Navigation Systems

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CONTRIBUTION OF MULTIMETHODOLOGY TO HUMAN FACTORS IN AIR NAVIGATION SYSTEMS

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This article presents a general view of a post-graduation study developed from 2011 to 2014 into some civil Air Navigation contexts of a brazilian public organization, to promote System and Rational Thinking, and Metagovernance, aiming at structuring, understanding and monitoring problems prone to variability, dynamics and unpredictability, to contribute to minimum risks management and opportunities of changes in real work. The study was developed to support TRM (Team Resources Management) behavior abilities, introduced as a Program since 2009, and adopted: a qualitative and collective method; Multimethodology as a predictive methodology, in which Conceptual Map was the central instrument, based on Soft Operational Research (OR) principles; and complexity paradoxes, in which Metacognition and Selfdeception was the central one. Multimethodology assumed interdisciplinary iterations, interactions and integrations among professionals of different operational activities and organizational levels, applied in four yearly cycles.

In Brazil, Air Navigation and Aviation activities are prescribed by the military Aeronautic Command (COMAER), both for aeronautical accidents and incidents´ safety and investigation areas, civil and military, as follows: Air Navigation ones by the Air Space Control Department (DECEA); and Aviation ones by the Aeronautical Accidents and Incidents´ Investigation and Safety Center (CENIPA). Besides, Civil Aviation activities for civil aeronautical accidents and incidents´ safety and investigation areas are prescribed by the civil National Civil Aviation Authority (ANAC), which is the extinct military Civil Aviation Department (DAC). COMAER (DECEA and CENIPA) and ANAC are brazilian authorities, respectively: aeronautical and civil aviation ones. Both have specific complementary and, sometimes, conflicting standards, in fulfillment to the International Civil Aviation Organization (ICAO) standards, of which Brazil is a member.

Civil Air Navigation activities are developed either by military segments or civil services providers, duly homologated by DECEA, as follows: four military Integrated Air Space Defense and Control Centers (CINDACTA), located at Brazil´s Capitol (Brasília), Manaus (Amazonas), Recife (Pernambuco) and Curitiba (Paraná); one military Regional Protection Flight Service (SRPV), located at São Paulo (São Paulo); some military units (Destacamentos), located all over Brazil; some civil Air Traffic Control and Aeronautical Telecommunications Permitted Stations (EPTA), spread out all over Brazil. These military segments and civil services providers are components of: the Brazilian Air Space Control System (SISCEAB), which DECEA is its central institution; and the Accidents´ Investigation and Safety System (SIPAER), which CENIPA is its central institution.

The brazilian authorities standards take as reference: the Brazilian Aeronautical Code (CBA) (BRASIL, 1986), which has been up-dated for the last years; and the ICAO standards. ICAO´s Safety Management Manual (CANADA, 2013) standard of 2006, up-dated in 2011 and 2013, is fulfilled by all countries´ members to increase, continually, safety in the world, with recommendations for the implementation of: a National Safety Program (PNSO) by the Aviation and Air Navigation authorities; and Safety Systems (SGSO) by each of the services providers, based on PNSO. The Brazilian Operational Safety Program for Civil Aviation (PSO-BR) (BRASIL, 2009) is our PNSO, which is divided in two Specific Operational Safety Programs (PSOE), for the brazilian authorities with the main guidelines to the Civil Aviation and Air Navigation services providers to develop their own SGSO: PSOE-COMAER (DECEA and CENIPA) (BRASIL, 2010); and PSOE-ANAC (BRASIL, 2009a).

Human Factors (CANADA, 1989; BRASIL, 2012) have been responsible to a high contribution in aeronautical accidents and incidents´ occurrences, resulting in the following trainings´ standards: Crew Resource Management - CRM (CANADA, 1989a) for Civil Aviation activities, since 1972; and Team Resource Management - TRM (CANADA, 2008 and 2008a) for Air Navigation activities, since 2002. In Brazil: CRM standards were created in 2003 and up-dated in 2005 by DAC, adopted by ANAC (BRAZIL, 2005); and in 2005, by DECEA (BRAZIL, 2005a), adopted for Civil Air Navigation activities.

CRM and TRM have the common purpose to improve behavior team abilities (CABRAL, 2006): communication assertiveness; situational awareness; stress and health management; team dynamics and leadership; decision process. CRM (CANADA, 1989a) and TRM present two main focus: Error Management - EM; Threat and Error Management - TEM (CANADA, 1989 and 1989a; BRAZIL, 2005 and 2005a). CRM and TRM embodies, mainly, two modalities - conceptual and

practice, which the last one is applied in simulator environments, based on the following standards in Brazil: Line Oriented Flight Training (LOFT) for Civil Aviation activities (BRAZIL, 2005; CANADA, 1989 and 1989a); and practice in simulator environments for Civil Air Navigation activities, still being standardized.

This study is about the implementation of a methodology to deal with complexity (ESTELLITA LINS, 2010 and 2011) in complex systems (ESTELLITA LINS, 2010), to support going parallel, ahead and beyond: TRM (BRAZIL, 2005a and 2012b; CANADA, 2008); and NOSS (BRAZIL, 2012a; CANADA, 2008a).

THEORETICAL REFERENCES

The study was based on the following fundamental concepts, which will be commented in this article:

Complexity Paradoxes (ESTELLITA LINS, 2011) – Group of collective paradigms to increase the understanding of complex systems´ (ESTELLITA LINS, 2010) variability (CANADA, 2002; HOLLNAGEL, 2007), as follows:

Internal (personal subject) X External (common object to all) – In simple systems, the object of analysis gets either into a natural and phenomenal environment, or an artificial and laboratorial isolation submitted to control and manipulation by independent methods, without the need of observers (internal); in complex systems, the object of analysis gets into a permeable and systemic isolation submitted to multi-phenomenal factors, as membranes of each organizational whole, representing individuals´ location in different sets (external).

Processes preservation X Transcendence opened to changes – Simple systems enable to manage behaviors from the functional decomposition of their components in situated actions to preserve their processes; complex systems have self-organizational, emergent and non-analytical properties, accessible and identified, characterizing continuous variations and evolutions to enable transcendence opened to changes.

Isolated parts X Interdependent whole – Simple systems have a functional consistence where functions are restricted to one or a few areas of knowledge, and causal relations among their parts are controlled; complex systems have a multifunctional ambiguity, in which different systems´ components can be grouped as another system and focused by other systems´ components, in different areas of knowledge.

Located information X Distributed systemic information – In simple systems, information nature, power representation and decision making are centralized into production and science, commonly relegated to politic points of view; in complex systems, information is distributed and associated to "hologram" metaphor, in which each part represents an integrated view of the whole, with different degrees of precision, incorporated in constructivism.

Subject indivisibility X Subject multiplicity – Simple systems are characterized by neutrality, professed by an absolute and arbitrary disjunction between the observer and the observed object, requiring a dissociation (dynamics´ suppression) of other inadequate perceptions of the object (indivisibility) ; complex systems (social and productive) require engagement and constant observation of reality, under different points of view, in different, similar, conflicting and complementary activities (multiplicity).

Metacognition (FLAVELL, 1976) X Selfdeception (RUMSFELD, 2012 APUD WAGNER, MURPHY & KORNE, 2012) – According to the Mind Theory (PREMACK & WOODRUFF, 1978), followed by the Theory of Theory (GOPNIK & WELLMAN, 1994 APUD LANGDON, 2005), human mind represents others and ourselves in terms of mental states, therefore real world representation results from individual to social transformations and are associated to human behavior. In simple systems, people, apparently, get to preserve more Metacognition, because of the following processes: propositional, experimental, performing and epistemological dimensions of knowledge, interfering in perception; alternatives to deal with consciousness levels and metacognition; elements analysis to build references and thoroughfares from subjective to inter-subjective attributes; characterization and measurement of subjective attributes as relevant to decision processes (MINGERS, 2006). In complex systems, people tend to give preference to selfdeception and look for the acceptance of other groups not to go against the *status-quo*, and, without perceiving, reinforce certain wrongdoings instead of promoting continuous changes on processes to increase integrity and balance in the whole system. In this case, metacognition needs to be increased with cooperative learning about changes, to allow transcendence from individual to systemic paradigm in all system´s parts.

Unification X Diversification and integration – Simple systems present few differenced characteristics of uniform pattern and routine processes, not requiring much efforts for human cognition to deal with permanent stimulus. Complex systems

present diversification characteristics, requiring creativity, resilience, conflicts management, anticipation and agreement capacity to achieve balance and integration of the differences among components in complex environments.

Systemic Thinking (ACKOFF, 2005; GHARAJEDAGHI, 2011) and Rational Thinking (SENGE, 2008) – This concerns a collective way of thinking about qualitative problems, solutions and possibilities of changes, promoting "iterative loopings" or "iterations", characterized by multiple cycles, and continuous interactions (GHARAJEDAGHI, 2011).

Multimethodology (MINGERS, 2006) and Conceptual Map (ESTELLITA LINS, 2010) – Based on Soft Operational Research (OR) principles (ESTELLITA LINS, 2010; ARÊAS, 2009), it involves a group of instruments used to increase Metacognition (FLAVELL, 1976) about various aspects (material, social, organizational and individual) of real world, considering that only one methodology is very limited to embody complexity (ESTELLITA LINS, 2010 and 2011).

Metagovernance (JESSOP, 2002) – Governance assumes dependent relations in which a centralized and localized power of an upper isolated part of a system regulates what other lower parts have in common. Metagovernance (JESSOP, 2002) assumes interdependent relations with non-hierarchical and spanned coordination in all organization levels, intensifying positive criticism by different perspectives ("requisite variety") for effectiveness of: economic controls; collective purposes; and associated values.

CONTEXT, PARTICIPANTS AND PURPOSE

This article complements another presented at ISAP / 2013 (CABRAL, 2013) of a post-doctoral study (CANADA, 1989; BRAZIL, 2012) developed in five civil EPTA of a public organization of indirect administration, ruled by the Labors Laws´ Consolidation (CLT), homologated by DECEA, as civil Air Navigation service providers. These EPTA are, as well, SISCEAB, SIPAER and SGSO components, in fulfillment to PSOE-COMAER (DECEA and CENIPA) (BRASIL, 2010) and in complement to TRM (BRASIL, 2005a and 2012b). Taking advantage of the need to implement the Psychological Monitoring Program, limited to Air Traffic Controllers - ATC (PTA), the study expanded this focus to the participation of Meteorology Professionals (PMET), Meteorologists (MEG), Aeronautical Information Service´s Professionals (PNA-TIA), Aeronautical Telecommunication Service´s Professionals (PNA-OEA) (BRASIL, 2010b), Airport Safety Professionals (PSA), and leaderships (managers, coordinators and supervisors), embodying the following activities: Air Traffic Control and Monitoring, Meteorology; Aeronautical Information Service and Aeronautical Telecommunication Service (BRASIL, 2010a).

The main purpose of the study was to promote Systemic Thinking (ACKOFF, 2005; GHARAJEDAGHI, 2011), Rational Thinking (SENGE, 2008) and Metagovernance (JESSOP, 2002) towards a collective reflection of operational reality, under different actors´ point of view, in order to structure, analyze and monitor, appropriately, problems focused to common goals in safety operation of the civil Air Navigation EPTA studied. Debate was emphasized to allow, continuously, balance in the complexity paradoxes (ESTELLITA LINS, 2011) mentioned, in complement to: TRM concepts (BRAZIL, 2005a and 2012b; CANADA, 2008); TRM practice in simulator; and NOSS (BRAZIL, 2012a; CANADA, 2008a). This proposition was not limited to quantify and solve organizational problems´ impacts on civil Air Navigation operations, but mainly to enhance a collective and qualitative understanding of emerging threats for adequate risk management, prioritizing Human Factors.

METHOD, METHODOLOGY PHASES AND INSTRUMENTS

This study adopted a qualitative and collective method, and Multimethodology (MINGERS, 2006) as a predictive safety methodology (CANADA, 2013), which did not follow a prescribed approach, but developed its own instruments, applied gradually and cyclical in complex civil Air Navigation contexts (EPTA), to: structure problems; enable perspectives of changes and improvements; complement to TRM (BRAZIL, 2005a and 2012b; CANADA, 2008) and NOSS (BRAZIL, 2012a; CANADA, 2008a); and look for balance in the complexity paradoxes (ESTELLITA LINS, 2011), of which Metacognition (FLAVELL, 1976) and Selfdeception (RUMSFELD, 2012 APUD WAGNER, MURPHY & KORNE, 2012) is the central one.

Multimethodology (MINGERS, 2006) used some instruments, distributed in four yearly cycles, to allow up-dating and structuring problems in real work (VIDAL & MÁSCULO, 2011), by iterative "loopings" and interactions (GHARAJEDAGHI, 2011), with active participation, positive criticism and explicit communication, looking for balance in the complexity paradoxes (ESTELLITA LINS, 2011). The instruments used (Table 1) were: Brainstorm; Simbolization and Simulation; Speeches; Feedback to Leaders; Debates; Group Dynamics; Conceptual Maps (ESTELLITA LINS, 2010) as the central one; and Reports.

Table 1:
Study Phases and Related Instruments of Multimethodology (MINGERS, 2006)

QUALITATIVE AND COLLECTIVE METHOD IN SOFT OPERATIONAL RESEARCH (OR)			
PHASES	**INSTRUMENTS OF PREDICTIVE MULTIMETHODOLOGY IN SAFETY**		
1st. PHASE - Problems´ Awareness, Representation and Consolidation	**2011**		
Awareness	1st. Group Dynamics: "Alphabet"		
	1st. Speech: "Problems´ Definition, Monitoring and Resolution"		
Representation	*Group Exercises*		
	Brainstorm Registration	Simbolization and Simulation Registration	1st. Oral Presentation
Consolidation	*Post-visit*		
	1st. Conceptual Map	1st. Report	Debriefing to Leaders
2nd. PHASE - 1st. Up-date of Problems´ Awareness, Representation and Consolidation	**2012**		
Awareness	2nd. Speech: "Psychology under Human Factors and Ergonomics Focus in Air Navigation Context"		
Representation	*Group Exercises*		
	1st. Debate	2nd. Oral Presentation	
Consolidation	*Post-visit*		
	2nd. Conceptual Map	2nd. Report	

QUALITATIVE AND COLLECTIVE METHOD IN SOFT OPERATIONAL RESEARCH (OR)		
PHASES	**INSTRUMENTS OF PREDICTIVE MULTIMETHODOLOGY IN SAFETY**	
3rd. PHASE - 2nd. Up-date of Problems´ Awareness, Representation and Consolidation	**2013**	
Awareness	2nd. Group Dynamics: "Without Thinking too Much"	
	3rd. Speech: "Problems Monitoring to Find Collective Solutions"	
Representation	*Group Exercises*	
	2nd. Debate	3rd. Oral Presentation
Consolidation	*Post-visit*	
	3rd. Conceptual Map	3rd. Report
4th. PHASE - 3rd. Up-date of Problems´ Awareness, Representation and Consolidation	**2014**	
Awareness	3rd. Group Dynamics: "Your Activity"	
	4th. Speech: "Cognitive Restructuring"	
Representation	*Group Exercises*	
	3rd. Debate	4th. Oral Presentation
Consolidation	*Post-visit*	
	4th. Conceptual Map	4th. Report

ANALYSIS AND CONCLUSION SUMMARY

Based on the complexity paradoxes (ESTELLITA LINS, 2011), here will be presented a general analysis of the study:

Internal (Personal Subject) X External (Common Object to All) – There is a trend to individual and personal interests and benefits, reinforcing the isolation of systems´ parts, as an obstacle to achieve common goals of the whole system´s planning and operation, for instance: medical orders optimizing work absence as a compensation of continuous hard shift working ; training, workload distribution and vacations planning based on personal criteria by some managers. This points out to internal and subjetc criteria in place of external and systemic ones, contributing to a negative organizational climate and poor communication.

Processes of Preservation X Transcendence Opened to Changes – There is a Quality Program to certificate EPTA after periodic audits, which non-compliances are corrected by pressure, due to the need of attempting prescribed procedures and quantitative references, distant to operational difficulties. Multimethodology (MINGERS, 2006) came up with a qualitative and collective method to evidence emergent problems in real work (VIDAL & MÁSCULO, 2011), although there is a disproportional slowness of upper organizational levels (Governance) to respond to their demands. Some examples involve inappropriate physical and cognitive operational conditions in terms of equipment, material and personnel in all kinds of air traffic plan, control and management. This emphasizes a trend to processes´ preservation, proper of public organizations, in place of structures, functions and processes´ transcendence to provide changes, solutions and improvements.

Isolated Parts X Interdependent Whole – Initially, in the first phases of the study, participants of different activities or of the same activities but different working groups, showed unfamiliarity among themselves, tending to add value to its own context. As well, there were some operators physically located nearby others, but working in different activities, who had never talked to each other. So, different positions´ relationships and diverse activities´ routines used to be addressed separately, as isolated parts of the same systems (SIPAER and SISCEAB), in spite of considering common safety goals. Besides, the rapport among EPTA´s operators and leaderships with actors of Aeronautical Authority (CENIPA and DECEA) presented hierarchical and non-systemic characteristics, based on poor communication and interaction. This kind of attitude was less issued in TRM (BRASIL, 2005a and 2012b) than in Multimethodology (MINGERS, 2006) because Conceptual Map (ESTELLITA LINS, 2010) showed contribution to promote Systemic and Rational Thinking (ACKOFF, 2005; GHARAJEDAGHI, 2011; SENGE, 2008), although not enough to advance from military values of dependence to Metagovernance (JESSOP, 2002), based on interdependence.

Located Information X Distributed Systemic Information – Multimethodology (MINGERS, 2006) with emphasis on Conceptual Map (ESTELLITA LINS, 2010), in complement to TRM (BRASIL, 2005a and 2012b), helped to distribute systemic information, although there is still a centralized bureaucratic culture involving located information, linear and dependent interactions, and emphasis on parts more than on the whole system. This contributes to emphasize loss of self-confidence, motivation, confidence on the organization, development of a fragile commitment from top to bottom organizational levels, in place of focusing to effective integration on relationships involving common structures, functions and processes. Some examples are: privatization of airports; Human Factors´ abilities devaluation; deficit of operators and hard shifts working; linear and confuse communication; organizational pressures to attend prescribed standards trading-off deep problems on operational reality.

Subject Indivisibility X Subject Multiplicity – There is a trend to passive and complacent behavior to accept organizational pressures and bureaucratic prescriptions, not taking chances to develop subject multiplicity in order to face possible changes focused to systemic and common goals. To change this paradigm, in complement to TRM (BRAZIL, 2005a and 2012b; CANADA, 2008) prerogatives, the study´s iterations and interactions reinforced cooperation, assertiveness in communication, team dynamics and flexible parameters related to system´s latent failures and individual´s active errors, in place of culpable and competitive parameters. Promoting subject multiplicity still remains a challenge to be reached continuously.

Metacognition (FLAVELL, 1976) **X Selfdeception (RUMSFELD, 2012 APUD WAGNER, MURPHY & KORNE, 2012)** – This complexity paradox (ESTELLITA LINS, 2011) involves the others and was permanently debated in the study in order to: optimize individual and group perception of different human needs and points´ of view; understand operational reality from a systemic dimension of structures, functions and processes; and increase metacognition in place of selfdeception.

Unification X Diversification and Integration – Gradually, the study led to interactions among different parts in terms of different operations, activities and positions, which enabled to exchange knowledge and experience, ideas and propositions, aiming at diversification on collective learning. Integration was observed in lower intensity, once it requires a continuous maturity up-grade in all organizational levels, based on Metagovernance (JESSOP, 2002), which wasn´t implemented, as desired.

Multimethodology (MINGERS, 2006) as a predictive methodology, with emphasis on Conceptual Map (ESTELLITA LINS, 2010), based on a collective and qualitative method, seemed to succeed on achieving the main purpose of the study: to promote Systemic Thinking (ACKOFF, 2005; GHARAJEDAGHI, 2011) and Rational Thinking (SENGE, 2008) towards a collective reflection of operational reality focused to common safety goals, enabling to structure and monitor problems. Balance in complexity paradoxes (ESTELLITA LINS, 2011) is a continuous process needed according to each context to stimulate which Metacognition (FLAVELL, 1976). Metagovernance (JESSOP, 2002) still needs future studies. Detailed description of this study may be found in its doctoral thesis and related papers.

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