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Anomalies and contradictions in an airport construction project: a historical analysis based on Cultural-Historical Activity Theory

Anomalias e contradições do processo de construção de um aeroporto: uma análise histórica baseada na Teoria da Atividade Histórico-Cultural

Anomalías y contradicciones en el proceso de construcción de un aeropuerto: un análisis histórico, basado en la Teoría de la Actividad Histórico-Cultural

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Abstract

Large construction projects involve the functioning of a complex activity system (AS) in network format. Anomalies such as accidents, delays, reworks, etc., can be explained by contradictions that emerge historically in the system. The aim of this study was to analyze the history of an airport construction project to understand the current contradictions and anomalies in the AS and how they emerged. A case study was conducted for this purpose, combining Collective Work Analysis, interviews, observations, and analysis of documents that provided the basis for sessions in the Change Laboratory, where a participant timeline was elaborated with the principal events during the construction project. Based on the timeline, a historical analysis of the airport's AS revealed critical historical events and contradictions that explained the anomalies that occurred during the project. The analysis showed that the airport had been planned for construction with politically determined deadlines that were insufficient and inconsistent with the project's complexity. The choice of the contract modality, which assigned responsibility to a joint venture for all of the project's phases, was another critical historical event, because it allowed launching the construction before a definitive executive project had been drafted. There were also different cultures in companies working together for the first time in the context of a project with time pressures and outsourcing of activities without the necessary coordination. Identifying these contradictions and their historical origins proved essential for understanding the current situation and efforts to prevent similar situations in the future.

Construction Industry; Occupational Health; History

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Introduction

The organizational analysis of event has received growing attention in the study of accidents and disasters, since it focuses on the investigation of transversal, vertical, and historical aspects in the organization, among other factors. The transversal aspects involve interactions between different entities that comprise a system's socio-technical functioning, whether belonging to the same company or to other, contracted-out companies. The vertical aspects refer to the interactions and modes of cooperation established between the operators, management body, and control rules. And the organization's historical aspects are phenomena involving a breakdown in the organization's safety that were not perceived in real time, but which prove relevant during the accident's subsequent analysis [1].

Exploring such dimensions, together with the analysis of the nature of the relations between the stakeholders and the strategies they use to achieve their object of work [2], should favor an understanding of the relevant processes and tendencies that resulted in unwanted events, like accidents and other anomalies [3].

Historical reconstitution is one of the tools in organizational analysis of event and facilitates the identification of the first signs of breakdown in the organization that contributed to the deterioration of a system's safety, for example insufficient action by oversight agencies, decisions made under excessive work pressure, and lack or inefficacy of analysis and learning from previous accidents and critical events, which Llory & Montmayeul [4] refer to as retour d'expérience (feedback or post-deployment analysis). Despite valuing the exploration of the historical roots of accidents, organizational analysis of event does not present a clear methodology for how to explore the systemic and historical origins of accidents and other anomalies, leaving the choice up to the investigator [1].

Therefore, Cultural-Historical Activity Theory (CHAT), on which the current study is based, makes an important contribution to understanding human productive activity and the historical origins of systemic disturbances. The use of this approach in the field of prevention is still incipient, with only a few studies in complex systems [5,6].

According to CHAT, productive actions by the human collective are mediated by cultural artifacts and object-orientedness [7], conceptualized as the activity's meaning, motive, and purpose [8]. In a dialectical relationship, the mediators provide (or fail to provide) to individuals the means to develop new forms of actions in order to achieve their objectives, thereby forming an activity system (AS) [9] (Figure 1). The AS consists of the following elements: subject (production collective), object (specific to each AS), instruments (technical and conceptual artifacts), community (clientele, social partners, regulatory bodies), division of labor (who does what, i.e., the hierarchy), and rules (technical standards, internal rules, contracts, etc.) [10].

Understanding the human collective's productive actions should consider the system as a dialectical unit of analysis rather than as an isolated study of the mediators per se [7,11]. Historical analysis allows identifying contradictions within or between these system mediators, which are the basis for organizational development and learning by stakeholders to dominate and overcome the problem situation [12].

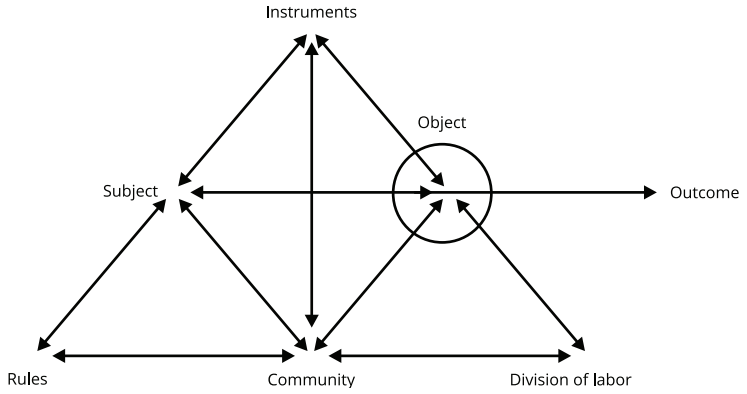
The AS develops over long periods of time, resulting in changes and innovations in the object, also accompanied by conflicts, disturbances, and anomalies generated by contradictions, understood as structural tensions, historically accumulated within the AS and/or between activity systems. Thus, the contradictions can only be understood on the basis of a dialectical logic and by means of an evaluation of occurrences in the historical development of the AS [7,13]. When an occurrence results in radical transformations of a structure in some elements of the AS, it is called a critical historical event [14], because its emergence implies significant changes in the system's total structure, representing an innovation over the course of history. In this approach, both success (expected results) and unexpected results are understood as manifestations of the balance or imbalance within the AS.

Visible and unwanted manifestations such as accidents, incidents, reworks, occupational diseases, workforce turnover, losses of quality, and others are understood as anomalies and disturbances in the AS, typically organizational phenomenon originating in contradictions that developed over the course of history [4].

In Brazil, studies to prevent unwanted events like work accidents sometimes fail to consider the network of determinant factors or the contradictions historically situated at the origin of such

Figure 1

Activity system.



Source: Engeström [10].

disturbances [15]. Thus, failure to identify these aspects represents a missed learning opportunity, fundamental for preventing new events and increasing the systems' reliability [4].

In recent years, the Brazilian civil construction industry, through the Growth Acceleration Program (PAC, in Portuguese), received Federal Government incentives for large-scale infrastructure construction works [16] such as stadiums, airports, and urban mobility facilities for international events like the 2014 FIFA World Cup and the 2016 Summer Olympic Games. However, these projects were accompanied by disturbances and anomalies like work-related accidents and deaths. The construction works for the 2014 FIFA World Cup alone in Brazil led to eight deaths [17].

Labor in civil construction in Brazil generally entails precarious conditions like low pay, high turnover, predominantly low workforce schooling and skills, high informality, serial outsourcing, labor recruitment by self-styled recruiters (called *gatos* or "cats" in Portuguese), intensification of pay-for-work-productivity, excessive use of overtime, and high work-related accident and occupational disease rates [18,19]. The combination of these factors can contribute to work accidents in the construction industry [20], which in the last decades has shown the highest rates of fatal and non-fatal work accidents and years of life lost, which are considered serious public health problems [21] and represent a burgeoning cost for employers, workers, and society [22].

Considering the disturbances and anomalies in the civil construction industry in recent decades and the boom in large-scale infrastructure works resulting from the PAC, we contend that an in-depth analysis of the history of an airport construction project with incentives from the Federal program will contribute to an understanding of the historical origins of accidents and other disturbances in the industry, and thus fostering collaboration between internal and government stakeholders to prevent such events in future situations.

The study's objectives are thus: (1) to identify the principal anomalies and disturbances during the construction of an airport and (2) to formulate hypotheses as to historical contradictions that would explain such problems.

The study's main hypothesis is that understanding the historical contradictions that generate disturbances and anomalies can help professionals to expand their understanding of the problems, contributing to the development of more effective and long-term preventive actions.

The study is innovative in that it proposes a historical analysis based on CHAT as a tool for surveillance and prevention of work-related accidents and injuries.

Research setting: an airport construction project as a network of activities

During construction of the airport, several serious accidents occurred in a short space of time. Following these accidents, the Office of the Public Prosecutor for Labor Affairs (MPT) contacted the School of Public Health at the University of São Paulo (FSP/USP) to assist with the analysis (and prevention of new accidents) through an agreement for technical and scientific cooperation between the two institutions [23], thus providing the field for developing this PhD research.

The bidding process for the airport project included a clause by which the winning company would be in charge of both its administration and renovation works and infrastructure improvements. The construction work was divided into six phases, and the results analyzed here refer specifically to phase 1-B, during which a "joint venture" (*junta construtora*) was hired by the concessionaire and became the company in charge of this phase of the construction.

The concessionaire or winning company consisted of three different companies, and the joint venture consisted of two different companies, both of which were subsidiaries of the concessionaire's two largest shareholding companies (Figure 2). In the attempt to harmonize and mitigate the negative effects of the different existing corporate cultures, the companies participating in the joint venture created the standard operating procedures (SOPs – rules) that defined the various companies' visions, duties, benefits, and roles in the undertaking.

The joint venture hired a large number of workers and approximately 100 outsourced companies at one stage in the project. As of March 2014, it had a peak average workforce of some 8,500 workers, of which 5,200 were employed directly by the joint venture and 3,500 by outsourced companies.

In this context of large dimensions and great complexity, the joint venture was considered a subject of the AS (Figure 1) and the airport construction was its object. The subject interacted with a community consisting of the concessionaire, suppliers, shareholders, public regulatory bodies like the MPT, the Ministry of Labor and Employment (MTE), the Reference Center for Workers' Health, and the National Civil Aviation Authority (ANAC).

The joint venture was mandated to comply with such rules as labor laws, safety and technical standards, SOPs, bidding standards, and the contract with the concessionaire, which defined such tools as deadlines, schedules, and penalties for delays.

The division of labor in April 2014 consisted of outsourced companies and the joint venture's own departments, as follows: Health, Safety, Environment and Social Responsibility, Engineering, Production, Procurement, Quality, Planning and Costs, Contract Administration, Administration, and Finances.

Methodology

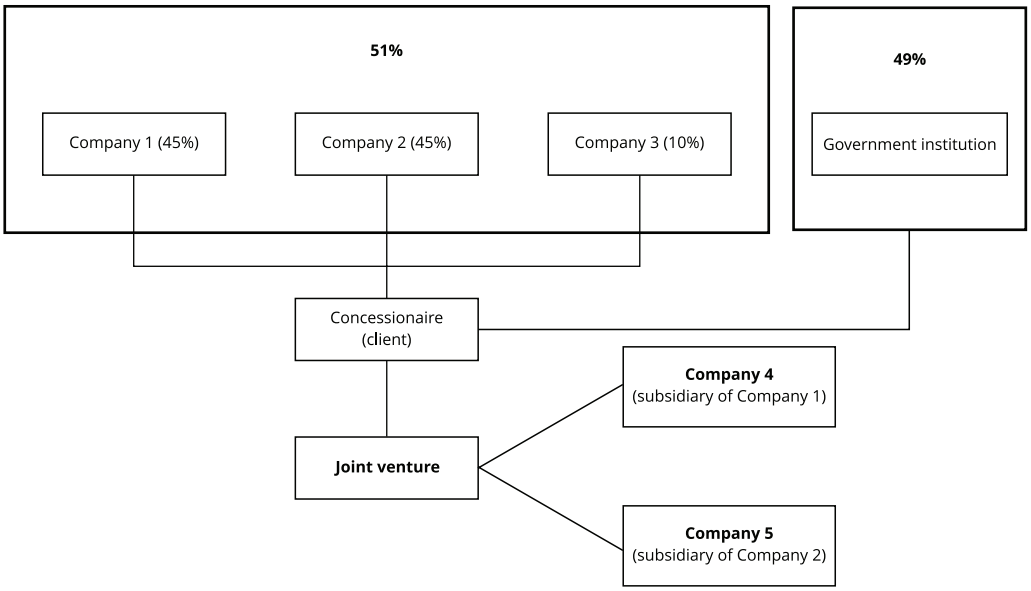
This was a case study with a qualitative approach. During the ethnographic phase, data and information were gathered through observations of the activities, analysis of 92 documents, and 132 persons interviewed through 103 collective or individual interviews, totaling approximately 378 hours of field work in nine months. We interviewed workers from the joint venture at different hierarchical levels and from different departments, as well as workers from the outsourced companies.

Two sessions of collective work analysis (CWA), with participation by 29 workers assigned to steel beam assembly, a job in which one of the serious accidents had occurred, totaling approximately four hours. CWA is a method based on activity ergonomics approach, which consisted of a voluntary meeting with a group of workers, led by the question "What do you do on your job?", to be explored exhaustively in the session [24]. The ethnographic data and information obtained from the CWA were used subsequently as mirror data in the formative intervention sessions through the Change Laboratory (CL) [25].

The CL is a collaborative and formative intervention methodology developed in Finland since the 1990s. It is based on CHAT developed by Vygotsky and followers. The methodology's main guidelines and stages are: an AS (Figure 1), object-oriented and used as a unit of analysis; the intervention's point of departure is the existence of a demand to resolve the activity's disturbances and anomalies; after the ethnographic data collection, the researchers, in cooperation with the internal stakeholders, organize 8 to 12 sequentially planned sessions in the CL [9].

Figure 2

Shareholding composition of the joint venture.



Over the course of the CL sessions in the airport, following the concepts of double stimulation, were offered to participants "mirror data", which reflect problems in the current practice, obtained from the ethnographic research and CWA, constituting a first stimulus. As a second stimulus, were offered to participants conceptual tools and models aimed at sparking questions and confronting different voices in the group, in the search for a systemic understanding to provide the basis for starting the phase of developing solutions. In the double stimulation, the participants ran through an expansive learning cycle, fostering both learning and agency in the participants [9,12].

The expansive cycle also searched for an understanding of the historical origins of the problems that had been identified [9]. Participants collectively built a timeline, which allowed chronologically organizing the visualization of the historical events and their respective dates. Timeline construction and analysis is a tool that contributes to the historical analysis, assists the subjects in understanding the logic of its development and gradual expansion of the object [26], in addition to identification of the critical historical events and contradictions within the AS [13].

The collected data were analyzed according to the selected theoretical approach. Some historical events identified in the timeline were selected and categorized as critical historical events, considering the content of the debates in the CL sessions and the collective and individual interviews. Contradictions were identified on the basis of the weight and ranking assigned by participants to the structural tensions within and/or between elements of the AS.

Six weekly CL sessions were held, lasting two to three hours each, or a total of 15 hours, with an average of 11 workers per session.

All the CWA and CL sessions were recorded and transcribed, but not all the interviewees agreed to the recording. The quotes were edited to improve the reader's understanding.

For ethical reasons, people interviewed in the ethnographic phase had their names redacted and were only identified according to the department in which they worked. Individuals that participated in the CL sessions were identified with the letter "I" (interventionist) or "P" (participant) and a number.

The study was approved by the Institutional Review Board of the FSP/USP, case review CAAE 11886113.5.0000.5421.

Historical analysis of the airport construction project

Analysis of the historical timeline identified 47 historical events, seven of which were considered critical, as depicted in Figure 3.

The history of the airport project began in 2007, long before the actual physical construction work, when the Brazilian Federal Government, on the wave of other construction works under the PAC, announced its intention to expand the airport. Nearly five years later, in November 2011, the government launched the call for bids for the concession.

The tender's result was announced in February 2012 and was challenged by losing contenders in the Federal courts. The verdict (final ruling) was issued in April 2012, setting a 22-month deadline (rule) for the conclusion of phase 1-B, which become a key determinant in the work's organization. Participants voiced that this time frame would only have been sufficient for the elaboration of the executive project (instrument), and that four to five years would have been needed to actually design and build the airport (object): "*In two years, or two and a half* [in the elaboration] *of the project, you execute it in* [another] *year and a half or two years*" (P12).

During the CL sessions, participants reported that no airports had been built in Brazil since the mid-1970s, explaining the lack of government (community) expertise in the bidding process, which led to a large lag between the public announcement of the airport expansion and the call for bids. According to the participants, the airport construction project was politically motivated, with an eye on the FIFA World Cup and Brazil's 2014 Presidential elections, which determined the construction timetable without considering the time actually needed and the undertaking's complexity.

The bidding process was considered a critical historical event (Figure 3 – E_1), since it defined the construction's entire structure and dynamic, introducing an important change in the concession's rules, no longer considering the construction project's realistic timetable and imposing an impracticable deadline, which significantly influenced the decisions and triggered actions in different phases of the work.

The construction work never had real deadlines, but a series of "eventlines" as the CL participants referred to them in a pun on the words "events" and "deadline". According to the group, the airport construction was oriented by a series of inaugural events (contractual milestones, FIFA World Cup, and the 2014 Presidential elections) that set priorities, deadlines, and the work pace. On the first official deadline for delivery of the finished construction, in May 2014, there were five "contractual milestones" to be met, and non-compliance with them entailed rider fines, the impact of which increased the overall project's financial cost.

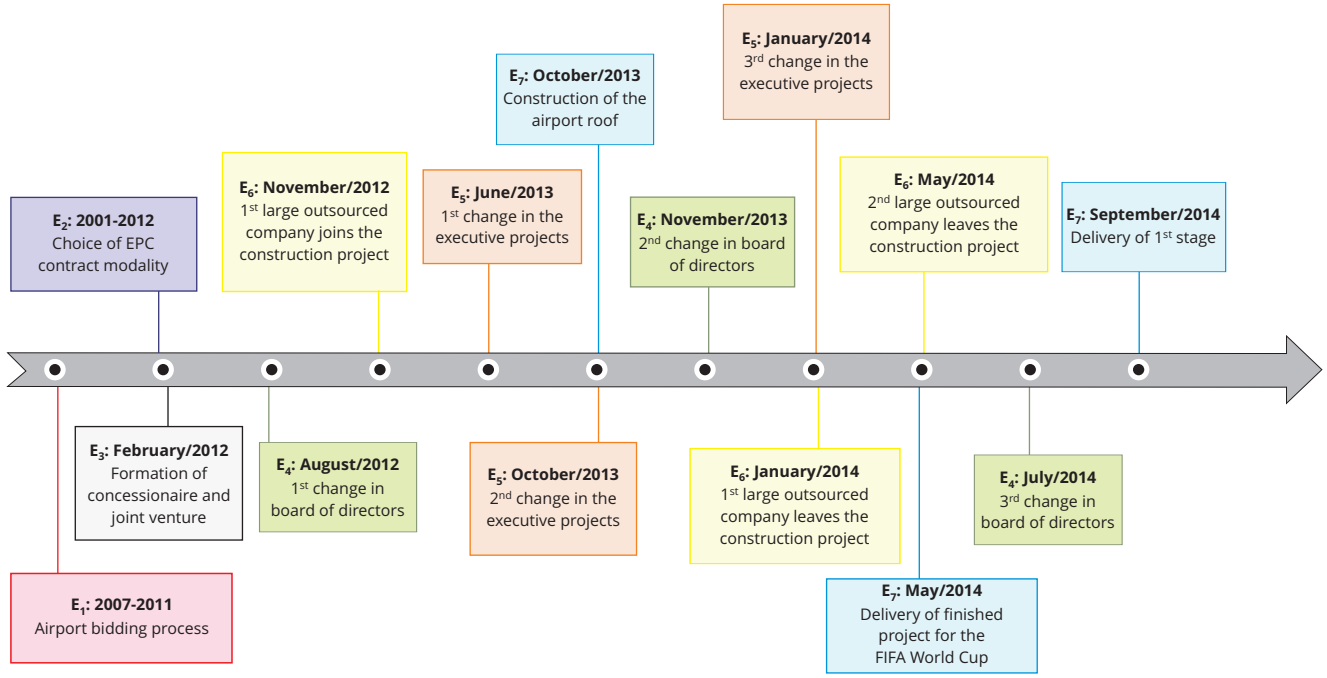
For example, in May 2014, workers were shifted from the domestic embarkation and disembarkation pier to the international embarkation and disembarkation pier, due to the impending FIFA World Cup and to avoid contractual fines. This meant simultaneous construction works that jeopardized the project's safety. Due to this juxtaposition of activities, the MTE (community) shut the work down. The delivery dates for these contractual milestones (rules) were considered critical historical events (Figure 3 – E_7), since they altered the division of labor, with a juxtaposition of tasks, besides delays in the supply of materials (instruments), thus requiring new planning.

Another critical historical event was the choice of the contract modality between the concessionaire and the joint venture (rule) for the execution of phase 1-B (Figure 3 – E_2). There are different contract modalities, e.g., design-bid-build (DBB) and Engineering, Procurement, and Construction (EPC) turnkey. In the DBB modality, the contractor prepares and hires the project, but receives and analyzes proposals by companies to execute the construction, choosing one of them through a tender. In the EPC turnkey modality, the contractor delegates to the construction company or joint venture the complete responsibility for the undertaking, i.e., for the project design, construction, assembly, operationalization, and delivery of the finished product [27].

For phase 1-B, the concessionaire hired a joint venture under the EPC modality, which can be considered a form of outsourcing, transferring to the contracted-out company the design and man-

Figure 3

Critical historical events in the airport construction.



agement of the executive project, supply of materials, and construction, while committing itself to deliver the new airport in full operating conditions.

With private capital investment in infrastructure works, the EPC modality grew significantly in the 1990s [27] and became the object of civil construction activity in Brazil by merging the activities of project elaboration and construction and assembly. However, this expansion of the object of construction assumes the existence of companies with the expertise and skills to meet these new demands, which did not occur in practice. As discussed below, the participating companies had expertise in physical construction, but not in the projects area.

The formation of the airport's managing concessionaire and joint venture was also considered a critical historical event (Figure 3 – E_3), since it resulted in a new subject in the construction activity: a joint corporate structure in which the concessionaire and joint venture are formed by the combination of different companies, with different histories, cultures, rules, standard operating procedures, etc. (Figure 2).

Culture is defined here as a set of conceptual artifacts that mediates human behavior in relation to a context, situation, or activity [28]. Safety culture is defined as a set of factors and practices that are developed and repeated and that operate to achieve production objectives for the safe functioning of the operation or process, thereby decreasing the work risks [1,2].

As voiced by one of the participants, the harmonization and consolidation of these different cultures takes time: "*...you can't develop a culture overnight, but you can do away with it overnight.* (...) *Today, a safety culture in large companies takes more than five years* [referring to the time taken for consolidation of a culture]" (Safety Department).

To further aggravate these difficulties, the joint venture had four new directors in just two years. Each change in the board of directors led to changes in the organizational structure, triggering

changes in departments and the management body, in a ripple effect. During the reformulation of the organizational structure (division of labor), some activities came to a standstill, waiting for the decision on new procedures, and this was considered a critical historical event (Figure 3 – E_4).

Changes in the elaboration of the executive projects were also considered another critical historical event (Figure 3 – E_5), since the basic project, which was supposed to orient the executive project (instruments), lacked the details required during the bidding process (rule). Meanwhile, the executive project was elaborated by a foreign company and displayed inconsistences with the Brazilian reality, thus requiring adaptation, which in turn imposed a heavier workload on the joint venture project team (division of labor). All this aggravated the difficulties in the definition of the executive project and reworks during the actual construction. The deliveries for the executive project occurred over the course of the construction work, finished in December 2014, very close to its conclusion.

Given the lack of expertise in the projects area and the time pressures in the construction's timetable, the joint venture (subject) outsourced the project's elaboration to a project design consortium (division of labor) and managed multiple projects; as a result, the activities were carried out asynchronously and at breakneck speed, leading to multiple delays, reworks, improvisation, and project changes and adjustments, placing the structural safety in jeopardy.

The situation was aggravated by the management strategy centered on outsourcing of construction activities, with a significant change in the division of labor, which involved more workers in outsourced companies. These companies were hired hastily, without the expertise or time needed to execute key construction tasks, thus another critical historical event (Figure 3 – E_6).

A network of activity systems in crisis

The historical analysis of the airport construction detected manifestations of contradictions between different elements of the AS, evidencing a crisis in this network of activities (Figure 4). Letters A through G in the Figure represent these structural tensions.

One of the main contradictions in this AS involved the concession's contractual rules, defined by the government, limiting the timetable for the execution of such a complex object, which required more detailed planning and execution, leading to heavy time constraints in the airport construction. These rules established an impracticable timetable in light of the object's complexity (Figure 4 – A).

According to participants, the government's deadline was influenced by the FIFA World Cup "eventline" and altered the work activities. Another important contradiction was between the unstructured timetable (instrument) and juxtaposition of activities (division of labor) (Figure 4 – C).

The formation of the joint venture was also influenced by the time pressures in this AS. The time available for the airport construction was insufficient for the SOP to be truly grasped by the subjects, revealing the existence of contradictions between the joint venture's internal operational rules and various elements of the AS (object, tools, and division of labor) (Figure 4 – A-D-E). The joint venture was assembled from different companies, with diverse cultures, tools, and rules, interacting for the first time in the airport construction, in an unfavorable context of time pressures and lack of management tools capable of facilitating communication and coordination and creating the collaboration required by the object's complexity.

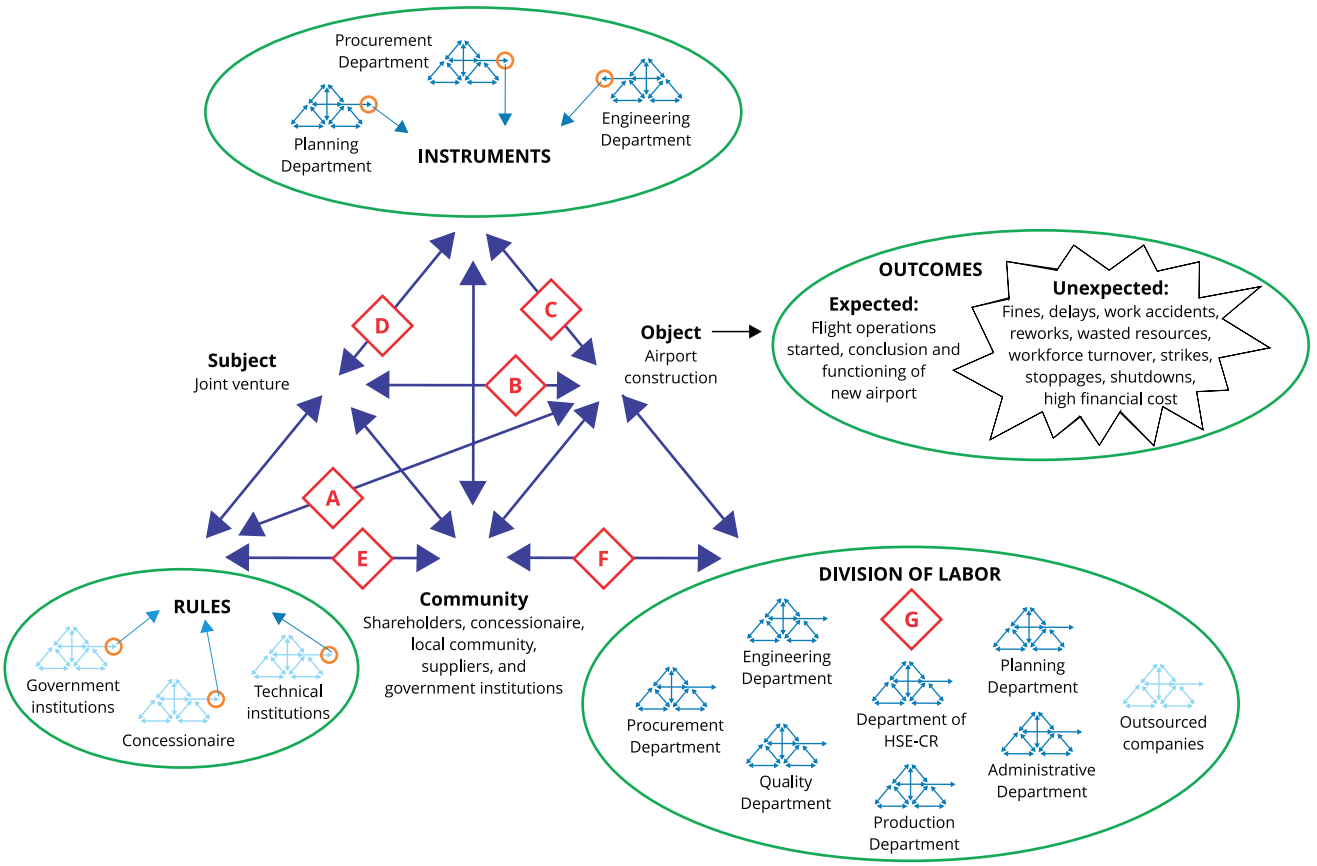
The series of changes in the board of directors (division of labor) also influenced the time available for the airport construction. Reorganization of the division of labor required more time for workers to adapt to and assimilate the new structure, generating contradictions within the division of labor (Figure 4 – G) and delays in the activities.

"*If the board of directors changes, the management is always going to change: new boss, new management, sometimes the guy that was there gets kind of lost*" (P12).

The choice of the contract modality between the concessionaire and the joint venture aggravated these contradictions, with the emergence of a new object. The joint venture (subject) and the other large contracted-out companies lacked the expertise to deal with this modality, i.e., a contradiction between the subject and the object (Figure 4 – B). As one of the participants explained, there was a lack of internal competencies for the project's management, which proved to be a growing element of dissatisfaction [27].

Figure 4

Contradictions in the airport activity system.



A: contradiction: rules x object; B: contradiction: subject x object; C: contradiction: instruments x division of labor; D: contradiction: rules x instruments; E: contradiction: rules x division of labor; F: contradiction: community x division of labor; G: between elements in the division of labor.

"A project [engineering] *company is not born overnight* (...) *Engineering is a job that requires this kind of interaction, otherwise it doesn't work* (...) *With the switch* [to EPC] *there was a violent break in the paradigm. And the large contractors* (...) *which had only been involved in construction and assembly, overnight* (...) *they became 'EPCist'.* (...) *Today, if you* [want] *to get a large company for a project in Brazil the size of an EPC, there aren't any..."* (Engineering Department).

The lack of expertise in drafting projects contributed to the various changes in the executive projects. Under pressure from the deadlines, the airport construction began with an unfinished executive project, although the latter was considered an essential tool for the construction, thus revealing a contradiction between the instrument and the rules (Figure 4 – D).

"The entire PTB [passenger terminal building] *was built without a structural project"* (P07).

Brazil was experiencing a construction boom at the time, and the available workers and companies (community) were not always the most highly qualified, thus revealing a contradiction between the community and the division of labor (Figure 4 – F).

In addition, the outsourced companies had their own safety cultures and worked on their own. In other words, there was no coordination or communication between these companies and the other

departments in the joint venture, displaying a contradiction between the elements in the division of labor (Figure 4 – G).

"*We work with the outsourced company and then abandon it. That's the truth* (...) *Some* [companies] *charge, but it's not just about charging. It's about giving them assistance. It's about giving them directions. It's saying: 'You've got this, that, and the other job to do.' But no, we throw the outsourced company* [into the work] *and don't give them any directions. There's no network*" (P04).

This quote shows a significant difference in the quality of management follow-up between the company's own workers and the outsourced workforce. For the company's own workers there's systematic control, orientation, and assistance in execution of the activities. For the outsourced workers, it's the opposite, with no follow-up, no supervision, (the worker is left to his own devices), i.e., the joint venture deliberately shirks any responsibilities for this outsourced workforce. The conclusion in the quote is that this company attitude leads to the lack of a workforce network and thus fragmentation in the work collective.

Due to this fragmentation or lack of network in the division of labor, the contradiction between the different elements also generated a contradiction between certain tools in the AS and the division of labor (Figure 4 – C). For example, the activities planning (instrument of the planning department) was not always in sync with the production department (division of labor), and thus there were constant shortages of materials (instruments) on some work fronts.

The contradictions between the different elements in the AS produced unexpected results such as fines, delays, work accidents, rework, wasted resources, workforce turnover, strikes, stoppages, and shutdowns. These results were considered anomalies and disturbances of the AS. Still, even with these contradictions, the AS managed to produce the expected results, i.e., the conclusion of Phase 1-B, with the startup of flight operations and the new airport fully functional.

Table 1 summarizes the critical historical events and elements that led to contradictions within the system.

Discussion

This empirical case study adopted a network of activity systems as the unit of analysis and representation of airport construction. Its description allowed understanding the relations between the different elements in the activity systems involved in this network, as well as their evolution over time. The theoretical concepts combined with the participatory process allowed building collective knowledge and synergy between the participants and researchers and thus the identification and classification of critical and non-critical historical events.

The narrative and data analysis revealed the dialectical relationship between the micro and macro dimensions, which is consistent with the theory of systemic levels of human activity proposed by Leontiev [29]. According to this theory, human activity can be divided into three levels: activity, action, and operation. Activity relates to a community's social motive within the AS (macro), action relates to the specific objectives performed by an individual or group (micro), and the operation involves actions that have become automatic procedures by repetition and practice (micro). There is a dialectical relationship between these levels, such that actions by individuals constitute and shape the joint activity, and the joint activity constitutes and shapes the actions by individuals [29].

The group's identification of this dialectical relationship between the micro and macro levels in the case description led participants to understand the links and relations in the determination between the different elements in the activity system, which together with the historical analysis allowed understanding the origins of the main contradictions, which in turn explained the anomalies faced during the construction.

The airport construction activity system was in a crisis with different manifestations of contradictions between their elements. The contradictions appeared years before the airport's actual construction, in a long and drawn-out bidding process further aggravated by the choice of the EPC contract modality. The critical historical events introduced changes in the system and gave rise to the main contradictions: (1) the concession rule that set an impracticable deadline vis-à-vis the airport's complexity and (2) adoption of the EPC contract modality, which led to a new object, the result of the

Table 1

Relationship between critical historical events, their impacts, and resulting contradictions.

Critical historical events *	Elements that changed in the activity system	Contradictions **
Bidding process (E_1)	Rules	A – Insufficient time in concession contract (rules) x Complex object
Choice of EPC contract modality (E_2)	Object	B – Joint venture's limited competencies in projects area (subject) x New object (fusion of activities in construction, assembly, and projects)
Formation of concessionaire and joint venture (E_3)	Subject and rules	A – Internal operational rules not internalized by subject x Complex object D - Internal operational rules not internalized by subject x Flaws in management tools (instruments) E - Internal operational rules not internalized by subject x Flaws in communication and coordination between departments in the joint venture (division of labor)
Changes in board of directors (E_4)	Division of labor	G – Between elements in the division of labor (new structure in division of labor x Reduced time for adaptation)
Changes in executive projects (E_5)	Instruments	D - Subject with limited expertise in projects (rules) x Unfinished executive project (instruments)
Outsourcing (E_6)	Division of labor	F – Construction boom (community) x Shortage of skilled labor (division of labor) G - Between elements in the division of labor (outsourced companies' own culture x Flaws in coordination and communication with other departments in the joint venture)
Contractual milestones (E_7)	Division of labor	C – Unstructured timetable (instruments) x Juxtaposition of activities (division of labor)

EPC: Engineering, Procurement and Construction.

* Codes E_1 through E7 represent the critical historical events in Figure 3;

** Letters A through G represent the contradictions identified in Figure 4.

merger of the activities in project elaboration management, construction, and assembly, versus the joint venture without the requisite expertise.

The adoption of the EPC model was based on international experience in which the contracted ("EPCcist") company has major expertise in the project's field, contrary to what happened in the airport construction analyzed here, in which the concessionaire handed a "blank check" to a joint venture with no command of this field, thus posing an obstacle to the undertaking's smooth operations. In a vicious circle, the critical historical events generated delays, reworks, shutdowns, and accidents that impacted the timetable, repeatedly reducing the time available for the project's conclusion. Attempts at solutions simply by changing the management team further aggravated the time pressures and difficulties in coordination.

The time pressures and lack of expertise in the elaboration of projects were permeated and defined by other contradictions, for example insufficient time to consolidate the joint venture's own culture and difficulties in coordination and communication between its different departments and the third-party companies.

These systemic contradictions as a whole resulted in anomalies and unwanted results for the construction, as mentioned above, taking a heavy financial toll on the project and resulting in more (and more serious) work accidents (there were not even more accidents thanks to the teamwork and dedication of professionals in controlling and adjusting for the impacts of the contradictions).

Final remarks

This study was based on CHAT and CL and was innovative in the field of workers' health, creating a collaborative environment between researchers and participants, who gradually took the agency in all stages of the process. This expansion was obtained with conceptual tools acting in the development of the situational diagnosis and visualization of solutions to future situations. A command of these tools helps participants understand the organizational aspects that are generally invisible to the eyes of health and labor professionals. Despite efforts by the National Network for Workers' Healthcare, what still prevails in this field are the traditional disciplines focused on risk factors that contribute little to a broader view of the work's process and organization [30,31].

Finally, this expanded analysis is important for more effective prevention of disturbances and anomalies like work accidents in an activity system. CHAT in the areas of workers' health and work safety thus proved innovative, both for understanding the phenomena and as a powerful tool for surveillance and prevention of work-related accidents and diseases.

Given the magnitude and complexity of the airport construction project (the object of this unique in-depth qualitative study), we believe that the findings in the narrative can be generalized to other construction works or activities, thereby contributing to organizational learning. The study showed the potential for application in hazardous work situations in order to induce changes and improvements in work, providing a basis for public policies targeting large-scale construction projects that are often subject to time pressures and other political and economic constraints.

Contributors

M. G. R. Lopes, R. A. G. Vilela and M. A. P. Querol participated in all stages of the article's elaboration.

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Resumo

A construção de grandes obras pressupõe o funcionamento de um sistema de atividade (SA) complexo em forma de rede. As anomalias como acidentes, atrasos, retrabalho etc., podem ser explicadas pela existência de contradições que surgem historicamente neste sistema. O objetivo deste estudo foi analisar a história da construção de um aeroporto para entender quais são, e como surgiram, as contradições atuais e anomalias desse SA. Para isso, foi realizado estudo de caso, combinando a Análise Coletiva do Trabalho, entrevistas, observações e análise de documentos que embasaram as sessões do Laboratório de Mudanças, nas quais elaborou-se, de modo participativo, uma linha do tempo sobre os principais eventos ocorridos na obra. Com base na linha do tempo, foi realizada uma análise histórica do SA do aeroporto, evidenciando os eventos históricos críticos e as contradições que explicavam as anomalias que aconteceram na obra. A análise mostrou que o aeroporto foi planejado para ser construído em um tempo determinado politicamente, insuficiente e incompatível com a sua complexidade. A escolha da modalidade de contrato, que definiu a junta construtiva como a responsável por todas as fases da obra, foi outro evento histórico crítico porque permitiu iniciar a obra sem um projeto executivo definitivo. Além disso, havia diferentes culturas de empresas trabalhando juntas pela primeira vez em um contexto de trabalho com pressão temporal e terceirização de atividades sem a coordenação necessária. Identificar essas contradições e suas origens históricas mostrou-se essencial na compreensão da situação atual e na busca da prevenção de situações semelhantes no futuro.

Indústria da Construção; Saúde do Trabalhador; História

Resumen

La construcción de grandes obras presupone el funcionamiento de un sistema de actividad complejo en forma de red. Las anomalías como accidentes, atrasos, trabajos repetidos etc. se pueden explicar por la existencia de contradicciones que surgen históricamente en este sistema. El objetivo de este estudio fue analizar la historia de la construcción de un aeropuerto para entender cuáles son, y cómo surgieron, las contradicciones actuales y anomalías en este sistema de actividad. Para tal efecto, se realizó un estudio de caso, combinando el Análisis Colectivo de Trabajo, entrevistas, observaciones y análisis de documentos en las que se basaron las sesiones del Laboratorio de Cambios, con las que se elaboró, de manera participativa, una línea del tiempo sobre los principales hitos ocurridos en la obra. Basándose en la línea del tiempo, se realizó un análisis histórico del sistema de actividad del aeropuerto, evidenciando los hitos históricos críticos y las contradicciones que explicaban las anomalías que se produjeron en la obra. El análisis expuso que el aeropuerto se planeó para que fuera construido en un tiempo determinado políticamente, insuficiente e incompatible con su complejidad. La elección de la modalidad de contrato, que fue definido por la junta constructiva como el responsable de todas las fases de la obra, fue otro hito histórico crítico, porque permitió iniciar la obra sin un proyecto ejecutivo definitivo. Además, existían diferentes culturas de empresa trabajando juntas por primera vez en un contexto de trabajo con presión temporal y tercerización de actividades sin la coordinación necesaria. Identificar estas contradicciones y sus orígenes históricos fue esencial para la comprensión de la situación actual y la búsqueda de mecanismos de prevención de situaciones semejantes en el futuro.

Industria de la Construcción; Salud Laboral; Historia

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