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Ergonomic work analysis of airbus pilots job in Brazil

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Abstract. This article is the result of a case study of ergonomic work analysis carried out in a Brazilian airline company, focused on the safety of the activity of Airbus pilots from the company's national lines. The study was divided in three parts, each one with different approach. First step is how critical situations such as accidents and incidents are dealt with during flight. Then it comes to discuss about adversities found in the working place, the airbus cockpit, and the development of risk map. Last but not least, the study focused in how the irregular working journey compromises the biological clock of the pilots end may cause social issues.

Keywords: Pilots fight, Civil Aviation, Flight safety, Ergonomic work analysis

1. Introduction

The Brazilian civil aviation industry has experienced rapid growth in recent years, with 50% increase in the number of takeoffs and landings at domestic airports between 2003 and 2010 and expected to grow by 10% until the end of this year, compared to the previous.

Not accompanied by commensurate investment in airport infrastructure and training new workers, however, the aviation boom could have serious consequences to the health of "workers of the air" due to work overload, which can also affect flight safety.

The current rate of air accidents in Brazil-1.1 fatal accidents per million regular flights - is still high compared to world average of 0.5. Reducing this number has been identified since 2009 as a target in the Annual Report of the Flight Safety ANAC (National Civil Aviation Agency), which set a goal for the country achieve one of the five lower accident rates in the world.

In this context, the present study consists of a thorough analysis of the activities performed by airline pilots - more specifically, Airbuses - in the company, highlighting the health risk factors present in the aeronaut's project office and working conditions in order to allow the establishment of parameters to adapt the work to the psycho-physiological characteristics of professional, seeking the best compromise between comfort, safety and efficient performance, as set out in Regulatory Standard No. 17.

1.1. Methodology

Being the pilots' activity essentially cognitive, the choice was made for the methodology suggested by Beth Crandall, Robert R. Hoffman and Gary Klein in the book "Working Minds," a practical guide to cognitive task analysis, and as the main tool for obtaining practical data, interview previously structured addressing all issues relevant to the activity, followed by a systematic observation in a complementary and inextricable way. Added to these there are still the

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analysis of the flight manuals which formalize the activities provided to the commanders and co-pilots and consultations to what there is of most current in the composition of the state of the art in the areas of civil aviation, occupational medicine and ergonomics.

Finally, the study is based on the Brazilian law which deals with work in general - the applicable regulations, especially the NR4, NR5, NR9 and NR17 - and on a more particular way, under the law in 7183 / 84, known as "the Law of Aeronaut."

It is worth clarifying that the direct observation of the professional behavior in the performance of his duties would not be feasible for reasons of safety. The pre-flight procedures require full concentration of the pilots - a factor that could be compromised by the presence of others in the cabin. During the flight there are no accommodations for observers in the cabin, besides the loss to the concentration of pilots that could result from this observation, if it were held directly. The solution to circumvent this difficulty was to request the pilots for videos that allow authors to observe them performing their roles.

The tool, although it fits well with the situation, restricts, to a considerable extent, the time of observation, as well as limits the observable situations. For example, the production of videos of an emergency situation, in general, is not viable given that in these situations, both pilots must be fully dedicated to solving the situation. Adding tasks at this time could compromise flight safety. The randomness of the observation time is also greatly compromised since the pilots themselves are responsible for initiating them and finishing them turning on and off the camera.

Using the tools already specified, the production of labor is given in a dynamic way, seeking the maximum iteration between authors and professionals involved, based on a feedback system through internal advisors - two co-pilot and a commander - who received the reports from intermediaries authors throughout the study process and interviews for validation, making the same corrections when necessary.

1.2. Brief analysis of the state of arte

Published studies in recent years reveals a intrinsic relationship between pilots' fatigue and safety in aviation. In fact, the relative frequency of the occurrence of human errors is greater when the professional is fatigued. According to researchers conducted by the Department of Psychobiology of UNIFESP (Federal University of São Paulo), based on statistical analysis of information from the black boxes of aircraft which suffered accidents the risk of accidents increases significantly after the ninth hour of work, doubles after the twelfth hour and triples after the fourteenth. We can attribute this increase, to the highest incidence of errors due to the professional's fatigue along with the increase in the number of hours of uninterrupted work, once that, according to the Registration Office of Aircraft Accidents, the leading cause of aviation which suffered accidents is related to human error - attributed as a factor generator of 67.57% of the 17,369 fatal accidents recorded in the entire history of aviation, where 121,870 people died and 93,624 were injured.

Table 1
Air Accidents recorded in the entire history of aviation - Causes assigned

CAUSES ATTRIBUTED TO AIR ACCIDENTS RECORDED	Relative frequency of occurrence (percentage data)
HUMAM ERROR	67,57%
FALHA TÉCNICA	20,72%
TECHNICAL FAILURE	5,95%
BAD WEATHER	3,25%
OTHER CAUSES	2,51%

The table presents a summary of the relative frequency of the causes of aircraft accidents considering the universe of all recorded accidents in aviation history throughout the world - including since conventional jet to aircrafts between commercial flights and military cargo or passengers aircraft . The same office has records that rays have shot down 15 planes, mostly small, another 20 were shot down by storms, while strong turbulence were the cause of 73 fatal accidents . Since none of these factors was responsible for the downfall of an Airbus, we can consider this type of aircraft secure enough in relation to environmental and technical factors being the minimization of human error, the main way to maximize security, reducing the occurrence of these aircraft fatal accidents.

Another important result from the same survey by Unifesp relates to errors of the pilots on night work. According to studies by Professor Marco Tulio de Mello, late night flights on consecutive or inter-

rupted days at dawn with no suitable place to rest causes successive increase in the risk of accidents caused by human error - 6% on the second night, 17% and 36% in the third on Wednesday, in the first.

Fatigue is also identified as the main cause of the occurrence of human error, the Flight Safety Foundation, compromising the memory, especially short-term and cognitive process. In an article published, the foundation asserts that pilots' fatigued may fail to perceive or perform operational routine actions wrongly, as disregard basic checklist items.

Being clear the intrinsic relationship of cause and consequence between the pilots' fatigue and the occurrence of human errors - regarded historically the main cause attributed to almost 70% of all accidents already registered the history of aviation - it is clear that increasing the aviation security, mitigating the rate of aircraft accidents, depends on the implementation of an efficient system of risk and fatigue management. However, reality proves to be somewhat distant from this ideal scenario.

Research conducted by a job website CarrerCast, released by the April magazine, says "airplane pilot" is at the top of the list of most stressful professions. Symptoms of stress not only bring harm to the health of the aviator - by encouraging the development of diseases such as gastritis, skin diseases and high blood pressure - but also the safety of the flight - because it impairs memory and good sleep hygiene, physical exhaustion and difficulty in interpersonal relationships.

Based on this information, it is easy to notice the cause-effect relationship between development and implementation of an efficient program of risk to fatigue and minimizing the risk of aircraft accidents.

2. Inventory of risk factors to the aeronaut's health

An effective management and fatigue risk control program fatigue should begin to identify the stressors that cause this type of disorder among the aeronaut.

Extending this universe, the research seeks to identify the main risk factors to the aeronaut’s health in general and posteriorly, look among all the factors listed, those who present relationship to fatigue and flight safety.

According to WHO definition, "Health is related to the complete physical well-being, mental and social conditions." In this sense, can be considered risk factors to the health of all those aeronauts which consequences bring harm to the well being of the same in all three fields.

Aviation professionals are constantly subjected, due to the function performed by them, the three main types of risks: risks of accidents / incidents, adverse conditions imposed by the workplace and the activities and consequences of irregular working hours.

The daily contact with the risk of a fatal accident added to the responsibility to lead the lives of hundreds of people in the sky result in high levels of common stress common among airline pilots.

Since the workplace associated with intrinsic characteristics of the activity involves a number of risks in the field of physical ergonomics (as shown in Table 2)

The working hours are related, primarily to ergonomic hazards in the cognitive field. Irregular and alternating shifts - the shift associated to different time zones and - difficult to regulate circadian rhythm, causing symptoms - including fatigue, irritability, depression and poor concentration - that laughter can interfere in the ability of the pilot judgment and compromising flight safety.

The days of poor planning can lead to the intensification inherent risks to physical activity - since its consequences are presented in a manner proportional to the time of exposure to the risk factor.

Last but not least, the distance from family - reduced to eight days off per month - and constant irregularity associated with alterations in the scales of flight results in reduced life quality of the pilot regarding the personal, social aspects favoring the development of mental disorders such as stress, depression and phobias. Today, the airline industry is the seventh branch of activities with the highest number of absences due to these disorders.

The disorganization of life's normal rhythm the irregular sleep and nutrition and the difficulty in reconciling the days off with the social and family life can be identified as causes of some common health problems among pilots, such as depression, stress and high blood pressure besides contributing to the increase of fatigue.

Table 2
Physical Risks - Consequences to the Aeronaut's Health

Physical Risks / Physical Ergonomics	Consequences to the aeronaut's Health
Noise	Hearing loss - total or partial
vibration	Chronic Fatigue Syndrome
acceleration	affects the labyrinthine system and its balance
hypobaric	Development of High Altitude Hypoxia, a disease characterized by increased heart and respiratory rates and blood pressure due to prolonged exposure to hypobaric environments
Constant atmospheric pressure variation	damage to the cardiovascular, respiratory and neuropsychiatric systems -, temperature oscilations-
Static Electricity	Increased fatigue due to receive loads of energy due to low humidity and friction
Lighting / direct exposure to solar radiation	It can cause vision problems such as cataracts on the Aviator, and the increased incidence of skin cancer
Prolonged sitting posture	Concentration of the pressure exerted by the body in the spine, causing back pain, difficulty in blood circulation in the legs, causing circulatory problems.

2.1. Composition of the working hours

Besides the flight time - the beginning of the taxi to the cut of engines - and the procedures pre-and post-flight, conducted in the aircraft and at the airport, the pilots' working hours are also composed of a number of other activities on land. First, to protect the airline in case of any lack of pilots to compose the crew for a flight - either by the changing in the planning of flights, either by the absence of the pilot who was originally supposed to compose such crew - the company has a number of reserve pilots at the airport. This period is specified in the monthly scale received by the airman - with day, time, and which airport he/she should remain available to the company - and is also fully counted as working time for legal purposes.

The company also has, for the purpose of repairing unforeseen problems, a number of pilots under notice. In this case, the professional do not need to be at the airport and can take care of his/hers personal activities, provided that, if requested by the company, can be present at the base - in this case, the Guarulhos airport - an hour after receiving the call.

The period in which the airman will remain on standby is also specified in the received monthly scale, however, only a third of the hour is computed according to the law of the aeronaut, for the composition of the working hours of the pilot. This is due to the fact that the legislature understood that, in this case, the professional is free to be at home or engage in activities other than those pertaining to work. However, the short time between the call from the company and the presentation of the pilot at the base, forces him/her to stay in Sao Paulo, which is not the official residence of the family for much of the company's pilots.

It is still counted as hours of work the time of simulator training and travel time as extra crew. This occurs if the pilot is scaled to take a flight started in another city, other than its base or the city where he finished his last flight, and need to move from one city to another on a regular airline flight to compose a crew.

The working hours of the airman are regulated by the Law 7.183/84, which establishes the maximum hours of work, in Articles 20 to 24, and flight hours, in Article 30.

Regarding the days off, the law establishes a minimum of 8 days off per month, being mandatory,

among these, at least a social day off, that is, consisting of two consecutive days, including one Saturday or Sunday.

The daily working hours are limited by FAA regulations establishing the limits of consecutive hours of flight - varying between 10 and 11 hours for simple crews, according to a table, depending on whether the work is predominantly day or night - and ensures the local airman suitable place for rest, at least 12 hours in case of journeys interrupted by the dawn.

In relation to night work, however, there is no regulation, despite the statistical knowledge about the increased risk of accidents on consecutive nights of flight.

Research conducted in 2008 by a group of co-principals and students of Civil Aviation College of Anhembi Morumbi, under the guidance of Commander Roger Paulo Licata, made a comparison between the level of consciousness of a person in two situations: sleepy and drunk . The study revealed that after 15 hours awake, the pilot will have the same reflection of someone with 0.065% blood alcohol level, affecting reaction time in an emergency situation. It is worth mentioning that the Brazilian Aeronautical Regulation 91 prohibits the crew to fly with the concentration of alcohol in the bloodstream equal to or exceeding 0.045%.

The survey results provide an explanation for the higher incidence of errors made by commanders and co-drivers in the period between midnight and six o'clock in the morning. This time causes major physical and psychic damages to the pilots, interfering in the decision-making.

However, in the absence of specific rules, flights on consecutive nights and early mornings are quite common. As is also the breach of regulations of limit of flight hours, with practice, condemned by the law of double and triple shifts of work. For example, when, on arriving at contractual base after a flight, the pilot is driven to remain at the airport reserve, featuring double shift. The journey is triple if this pilot, in reservation, is driven to another flight.

The collection of the FAA, during the year 2010, with fines for different offenses, exceeded R$ 17.4 million, with proceedings against six companies. A spokesperson for the FAA, responsible for conducting such review, recognizes that this is still inaccurate and needs to be intensified, but defends himself by saying that Brazil is a very big country, while the agency, established in 2005, is still small in terms of personnel and resources.

The results from the crossing of information from the survey of risk factors with the historical records of removal of pilots for health reasons are presented in table 3.

Table 3

Main Pathologies	Possible Causes – Risk factors:
Backaches	Pressures caused by prolonged sitting posture. Muscle contraction cause by emotional disturbs such as stress
Circulatory Problems	Difficulty in blood circulation caused by prolonged sitting posture
High Blood Pressure	Prolongued exposure to hypobaric environments Stress resulting from living with the risk inherent to the profession, the high burden of responsibility, the irregular working hours and the constant changes in the scales
Insomnia	Changes in circadian rhythm due to the constant shifts between times and zones and the irregularity of working hours, causing sleep disorders
Otitis and Sinusitis	

3. Leading causes of fatigue among airmen

3.1. Self-inflicted overload

Fatigue may be aggravated by certain practices of the pilot, such as smoking, consumption of alcohol and drugs, use of medicinal drugs without medical supervision and poor diet.
In this regard, an important element of a risk management program is effective for fatigue awareness among professionals about the "management of health."

3.2. Physical factors

The exposure to physical risk factors inherent to the work environment contributes to increased pilot fatigue. They are: vibration, noise and static electricity.
Given the impossibility of eliminating these stressors elements, the best solution would be to minimize continued exposure through changes in the parameters established for planning scales.

3.3. Cognitive factors

From the point of view of cognitive activity, three factors can be pointed out as a cause of stress: the daily contact with the risk of a fatal accident, the high burden of responsibility associated to the activity and the need to remain alert and focused throughout the flight .

3.4. Factors related to work schedules

As detailed in Section 2, the high degree of concentration and attention demanded by an activity where errors can not be admitted is confronted with fatigue and weariness due to irregular work schedules and alternated shifts.
Once again, the solution to this demand lies in the establishment of new parameters for the planning of the flight stops in order to consider the psychophysiological characteristics of the professionals involved.

4. Proposals for readjustment

Improving the quality of life of the airman, as well as maximizing flight safety, is directly related to the adequacy of planning scales and flight hours of work, taking into consideration human psychophysiological factors that reduces the pilot's exposure to adverse conditions inherent to this activity performed by the pilot and, in parallel, reduces fatigue and stress that favor both the development of some diseases and the occurrence of accidents.

Thus, the proposed realignment of the working conditions of pilots in the Airbus company studied which is presented here are based on changes in the scales flight planning system and in the implementation of an efficient fatigue risk management, which foundations are reduction of night work and the preservation of a good sleep hygiene.

4.1. Fatigue avoidance scheduling tool

To quantify the effects of changes in the relationship between work and rest in the performance of the pilot, U.S. Air Force in 2000-2001 created a software called FAST (Fatigue Avoidance Scheduling Tool) that allows the planners and developers flight scales view, through a graphical format, the efficacy of cognitive performance as a function of time. The display also shows the ideal period of interruption of work to sleep, when the efficiency reaches the lower limit of 90%.
The tool is available now for sale in the market and its use is indicated to minimize the risk of fatigue among commercial airline pilots aiming to increasing flight safety.

4.2. Aerobic training / good alimentary habits

According to the research of specialist in Work Physiology, Ph.D. in Aerospace Science UNIFEM (University of the Air Force) Luciene Tell Kube, published in the journal Sipaer, airmen face the fatigue processes better when they are physically well conditioned, and is recommended the development of aerobic training programs.
Also in order to improve fitness and health of airmen, guidance on how to maintain a good diet and encouraging regular physical activity, through lectures, for example, are of significant utility.

4.3. Psychoemotional monitoring

Until recently, human performance was seen as a function of physical conditions and the training received. Today, it has a broader vision, which also considers aspects of the psychic and emotional dynamism of the pilot. It is known that they influence cognitive functions such as memory, attention and guidance and should be constantly evaluated by the department of preventive medicine, due to its strong influence on the final performance of the professional in performing an activity.

4.4. Incentives for training of new professionals

It is estimated today, in Brazil, an approximated number of sixty thousand pilots in different skills, throughout the national territory. Despite the apparently large number of professionals in the field, the time is right to those interested in this career.

With the Brazilian aviation market heated and indicating that it continues soaring in coming years - especially with the holding of the Olympics in 2016 and the FIFA World Cup in 2014 - the demand for airline pilots grows unevenly to the training of new professionals.

Given that the main impediment to the formation of new pilots lies on the high cost of this process, companies could encourage young people interested in this career through a financing program from the course to the formation of the professional, who would pay for this benefit after receiving his/her pilot certificate. The proposal is a program with similar functionality to the FIES (Student Financing Program) of the Federal Government, through which students can study for a higher level in their chosen career at a private university starting to pay for the course only after the expiration of a period of grace counted from the graduation.

5. Findings and results

Exhausting working hours - resulting from a scale plan that does not consider the human psychophysiological aspects in the planning stage - resulting in prolonged exposure of pilots to risk factors intrinsic to the activity performed, bringing the same health hazards as well as the fatigue of these professionals , affecting the degree of attention and concentration and judgment in critical situations, favoring human error and, consequently, the occurrence of incidents and accidents.

Thus, the strategy for minimizing the rate of aircraft accidents must be based on the revision of the parameters for planning of flight scales, prioritizing, based on recent studies, the reduction of night work and limit consecutive hours of flight and respect the rest period required between flights.

The pilots' awareness of attitudes which can also minimize risk and avoid fatigue development of sleep disorders is also important. The company can develop a program to encourage the management of their health, based on lectures on eating habits and regular physical activity associated with the monitoring of the health of the professional, the department of preventive medicine, since his/her admission to his/her termination.

References

[1] B. Crandall, Gary Klein and Robert R. Hoffman; “Working minds: A Practitioner’s Guide to Cognitive Task Analysis, Bradford Books

[2] D.F. Pilkey, Happy conservation laws, in: Neural Stresses, J. Frost, ed., Controlled Press, Georgia, 1995, pp. 332–391.

[3] E. Wilson, Active vibration analysis of thin-walled beams, Ph.D. Dissertation, University of Virginia, 1991.