Loss of Control on the Ground - An Analysis by SERA Software*

Perda de Controle no Solo - Uma Análise pelo Programa SERA

Simone Figueira SOBREDA[1]

Paulo Afonso de Oliveira SOVIERO[2]

ABSTRACT: *Due to increasingly reliable aircraft technology, equipment and material failures have become rare. Today, aircraft accident causes are primarily attributed to the human link in the system. The ability to investigate, classify and detect the human factors that cause incidents and accidents is thus vital to prevent their recurrence and for designing the logic to help prevent their propagation. The goal of this work is to analyze an accident which took place in Brazil, which included at least one human factor as a probable cause, and with the respective investigation already concluded by the authority. For this purpose the SERA software is used as a tool to investigate, analyze, classify and to prevent recurrences.*

KEYWORDS*: Human Error, SERA, Classification System, Flight 3054.*

RESUMO: *Com o constante aumento da confiabilidade da tecnologia aeronáutica, as falhas que ocorrem devido a equipamentos ou materiais são cada vez mais raras e as principais causas de acidentes são atribuíveis, hoje em dia, ao ser humano. Assim, a habilidade para investigar, classificar e detectar os fatores humanos, que se encontram na origem de acidentes e incidentes, passa a ter importância central no esforço de se evitar recorrências ou ainda no estabelecimento de defesas, de modo a impedir que os "erros humanos" se repitam ou se propaguem. O objetivo deste trabalho foi analisar um acidente ocorrido no Brasil, onde houvesse pelo menos um fator humano como uma das hipóteses prováveis para o acidente, e, cuja investigação já tivesse sido concluída pelo órgão investigador. Foi escolhido o programa SERA (Systematic Error and Risk Analysis), uma ferramenta que é utilizada para investigação, análise e classificação de erros humanos em acidentes aeronáuticos e, portanto, tornando possível a prevenção das recorrências destes erros.*

PALAVRAS-CHAVE: *Erro humano, SERA, Sistema de Classificação, Voo 3054.*

1 Introduction

With the invention evolution and increase reliability of aircraft, humans have played a progressively more important causal role in aviation accidents; as a result researchers are always looking for systems to analyze human error.

According to Reason (2008) errors are not random and they take recurrent and predictable forms.

*Based on the presented paper in SSV2012, Simpósio de Segurança de Voo – 2012. (São José dos Campos – SP)

[1] Systems Analyst. Masters in Aviation Safety and Continuing Airworthiness by Instituto Tecnológico de Aeronáutica – ITA. simone@ita.br

[2] Professor at Instituto Tecnológico de Aeronáutica - ITA. soviero@ita.br

Obviously the ability to investigate, classify and track human factors as causes of accident and incidents is central to prevent their recurrence or for putting in place traps to stop these “human errors” from propagating. (Hendy, 2003)

Understanding why this pattern of behaviour emerged is the key to explain the human factor issues associated with the occurrence. Based on an Organizational Approach and a Reason’s Latent Failures Model, a new tool has been proposed. Originally created to help Canadians forces investigators and with the purpose to populate the Human Factors Analysis and Classification System (HFACS) came out Systematic Error and Risk Analysis (SERA), a tool for accident and risk investigation, analysis and classification. This tool analyses the active failures and the pre-conditions related to these failures.

In this work the tool is used to analyse and classify an accident that occurred with the Flight 3054, in Brazil. Through software’s analysis and based on the final report it is possible to observe what (the active failures) happened to this flight and it is possible to see why (the pre-condition) these failures occurred, and finally how this accident could be avoided. According to SERA there are two active failures and several pre-conditions linked to these failures, they appear in all levels of Reason’s Latent Failures Model, showing us that for an accident to occur several organizations sectors have an influence, directly or indirectly. SERA linked each active failure with a set of most likely pre-conditions, however it was possible to extract others ones from the reading of the final report, in order to try to bring out the maximum possible of pre-conditions, and all of them found were cited in the investigation authority final report (CENIPA 2009). In this case study several pre-conditions had been dormant for many years and despite some signals, those involved in trying to avoid an accident did not realized the hazard.

Warning:

The analysis achieved in this work has only the purpose to serve as a single case study for an academic work. This analysis does not replace, does not counterclaim and does not complement the official final report. Above all it should not be used for any other purpose than to serve as an academic application example. The authors did not have access to other data related to the accident that was not entirely published by the authority, Aeronautical Accident Investigation and Prevention Center (CENIPA) through a final report. (CENIPA, 2009)

2 SERA (Systematic Error and Risk Analysis)

Keith C. Hendy, in 2002, developed a tool named SERA (Systematic Error and Risk Analysis) helping Canadians Forces accident investigators in analyzing systematic errors and risks in regards to the human factors issues associated with the occurrences. This tool was originally built to help populating the system used by these forces, the HFACS.

In addition, because SERA has its own human factors taxonomy, it can be used independently of HFACS. SERA can contribute both as an investigation tool and as an accident classification system.

SERA is a software written in a programming language known as JAVA and is available to be used in Windows or Macintosh platforms. This tool is able to provide, by a structured process, the emergence of both active failures as well as the pre-conditions that lead to these failures and then to an accident. According to Hendy (2003), to identify these points SERA is based on a solid theoretical framework provided by the Information Processing (IP) and Perceptual Control Theory (PCT) models.

The unsafe acts and the dormant pathogens of a system are expressed by four levels in SERA and they are based on Reason' Latent Failures Model (Reason, 1990). In SERA these four levels are classified as Active Failures, Pre-conditions, Command, Control and Supervision failures and the last level Organization Influences.

According to Hendy (2003) with the hierarchical breakdown of these four levels it is possible to link each active failure with a set of most likely pre-conditions. As the immediate pre-conditions are as remote as the representations of the "Whys" the active failure has been occurred. These observed pre-conditions define either directly or indirectly the condition of the personnel, the task and the working environment. Then, with the knowledge of this data it is possible to prevent recurrence and thus making necessary changes within organizations. The four levels of SERA are based on Reason's Latent Failures Model (Reason, 1990).

To start an analysis, firstly it is necessary to the investigator identifying the unsafe act or condition, a departure from safe operation, e.g., "What" happened to the operators that allowed that this accident or incident has arisen.

Then SERA guides the investigator to analyse a particular behaviour evaluating the attitude that triggered the accident, this guidance is made from three questions about the operator or crew as regards to his *goal*, his *action* and his *perception*. These three questions start a series of decision ladders and with the answers it is possible to then delineate the causal chain from an unsafe act to the active points of failure. Then this process finishes with twelve basic types of active failures in the human information processing system.

The response to most of these questions is simply "*yes*" or "*no*". While the requirements of human factors investigations are rarely trivial, this structured plain language process greatly eases the need for the investigator to have extensive human factors training or knowledge. (Hendy, 2003)

This decision ladder complete process can be seen in Figure 1.

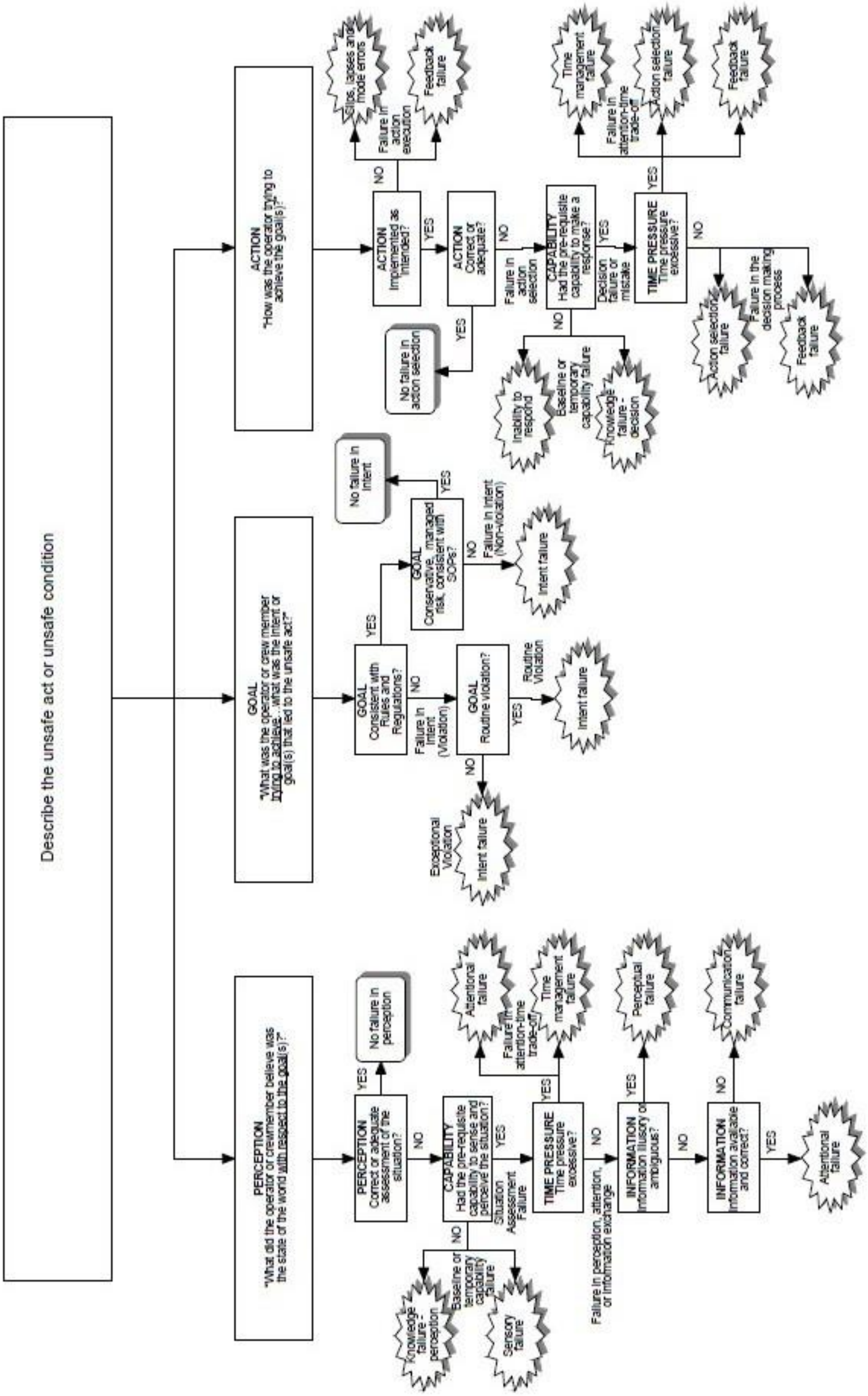

Figure 1 – Sera´s Decision Ladders (Hendy, 2003)

SERA software provides a large amount of pre-conditions taxonomies. These emerge conforming the investigation occurs. The definitions of each pre-condition are given by the software, this description can not be the same for different active failures and the investigator can observe them during the process of populating SERA.

In all steps, for each pre-condition the analyst has a space to write “additional remarks”, and this will generate a report which will help the investigators writing the final report. In addition SERA provide always an equivalent HFACS category to active failures and pre-condition, so SERA can be used as a front-end for data entry into HFACS.

3 Aviation Case Study Using SERA

To illustrate how SERA can be used as an investigative as well as analytical tool, an air crash analysis using the SERA software will be present. This analysis intends to classify the possible active failures as well as the pre-conditions to these human errors that triggered the accident. These preconditions are the so-called underlying causes described by Reason (1990).

A Brazilian air crash was chosen as an example to this case study. This accident occurred in July 17, 2007 with the aircraft PR-MBK, an Airbus A-320. The final report represents the official findings, analyses, conclusions and CENIPA’s recommendations. It should be noted that this study has the primary intention to look at the final report by way of a tool useful to identify both, the active failure and the preconditions that led to the human error involving aircraft accidents.

The investigation agency indicates two possibilities to the accident one of them human and another one a mechanical failure. For this paper, one hypothesis, human error, will be shown, because this is the object of the present study.

General Description of the Accident

On July 17 2007, Tuesday, at 17:19 local time, the Airbus aircraft, model A-320, registration PR-MBK, operating as flight 3054, departed from Salgado Filho International Airport in Porto Alegre city, Rio Grande do Sul State, destined to Congonhas International Airport in São Paulo city, São Paulo State.

The aircraft was carrying 187 people onboard, consisting of six active crewmembers and 181 passengers, including two infants and five extra crew members.

The weather prevailing along the route and at the destination was adverse, and the crew had to make a few deviations. However, until the moment of the landing, the flight was operating within the expected routine.

The aircraft was operating with the number two engine reverser de-activated, in accordance with the Minimum Equipment List (MEL).

According to information provided to the control tower by the crew that had landed earlier, the active runway at Congonhas, the 35L, was wet and slippery.

During the landing, according to final report, at 18:54 local time, the crew noticed that there was no change in the positioning of ground spoilers, devices that allow a more efficient braking. Thus, the aircraft was not slowing down as expected. It made a detour to the left, overran the left edge of the runway near the departure end, crossed over the Washington Luís Avenue, and collided with a building and with a fuel service station. The building that had suffered the collision was a cargo express service belonging to the aircraft operator.

All the people onboard perished. The accident also caused twelve fatalities on the ground among the people that were in the building. The aircraft was completely destroyed as a result of the impact and of the raging fire, which lasted for several hours. The accident caused severe damage to the convenience shop area of the service station and to some vehicles that were parked there. The building sustained structural damages that determined its demolition. (CENIPA, 2009)

The Tragedy Foretold

Two others accidents occurred due to improper positioning of the trust levers A-320 aircraft before this accident one in Bacolod, Philippines (1998) and another in Taipei, Taiwan (2004). In both cases, the pilots were operating an A-320 with the reverser of one of the engines deactivated. The pilots failed to comply with the procedure provided by the manufacturer for landing with inoperative thrust reverser, having left the throttle for which the engine thrust reverser was disabled in CLIMB position (CL). At that time, neither aircraft had a device to alert the crew about any inadvertent positioning of the thrust levers in case the positioning of the levers were in conflict with the conditions for landing.

According to this procedure, the pilot should reduce both thrust levers to IDLE position (without traction) during the flare, at about ten feet and, after touching down, he should activate only the available reverser, keeping the thrust lever of the other engine at IDLE position. Such procedure, although more efficient from a braking perspective, ended up allowing the crew to commit errors.

This situation which had not been foreseen by the manufacturer during the certification caused the Airbus to take two corrective actions to avoid conflicting situations such as those of the landing. One of the changes was an alert system for the Flight Warning Computer (FWC), by means of the H2F3 standard, which triggers a specific alarm with a message in the Electronic Centralized Aircraft Monitoring (ECAM), alerting the pilots that a lever would be at a position above IDLE during the landing. Another modification was an operational change requiring both thrust levers to be moved to IDLE during the flare and, after the touch-down, the setting of both thrust levers in the REV position, however this procedure required the crew to add 55 meters in the calculations of the runway length required for landing. These new operational changes suggested by Airbus were in effect in January 16, 2007. However the authorities responsible for the continuing airworthiness of the A-320 had not emitted an Airworthiness Directive (DA) concerning implementation of the H2F3 routine.

In the specific case of the PR-MBK, the FWC did not have the H2F3 standard installed.

Accident Analysis According to SERA Software

The analysis starts with the identification of the unsafe act. In accordance to the final report this accident befell because the landing occurred with the number 1 engine thrust lever at the IDLE position and the other one in the CLIMB position during the flare. After touch-down the number 1 engine thrust lever was put in REVERSE position while the other was maintained in CLIMB position. The thrust levers' correct position, according to Airbus procedure, should be IDLE and IDLE position and, afterwards, they should be put in REV and IDLE position for aircraft safe landing. So the unsafe act that directly leads the accident can be considered as "*incorrect procedures for landing the aircraft with inoperative thrust reverser*".

From this the analysis will be made in four levels like SERA´s model as viewed in Figures 2 and 3. This structure encloses on the first layer the Active Failures, on the second layer the SERA framework classifies the Pre-conditions directly linked to the operator's unsafe acts or conditions. On the third layer are Command, Control and Supervision failures. Finally, on the last layer are the Organizational Influences.

First of all the Active Failures will be classified based on CENIPA´S final report analysis.

In terms of design, during the operation of the aircraft, whenever the RETARD auto call-out stops, it means that the two thrust levers are at the IDLE position. For the pilots, this routine is repeated tens of times every week.

Even during the simulator training, the cessation of the RETARD auto call-out means that the two levers are at the IDLE position.

As this phenomenon occurs in all landing operations, it is admissible that such exposure ends up conditioning the pilots to understand that the cessation of the RETARD auto call-out means that both levers are at IDLE.

Consequently, and on account of this conditioning, it is possible to presume that the cancellation of the RETARD auto call-out when a thrust lever is at REV and the other is at CL would induce the pilots into believing, mistakenly, that both levers are at IDLE.

This wrong perception, in turn, would draw the attention of the pilots to other systems or inputs, making it hard to manage the cockpit, and leading to the making of incorrect decisions exactly at a critical moment for the flight safety (CENIPA, 2009).

Then, through this analyses and according to SERA software it is possible to conclude that there was an *Action Execution Failure* classified by SERA software as a *Slip Active Failure* – It occurs when the intended behaviour is 'captured' by a similar well-practised behaviour. These are failures in skill-based behaviour. Slips may occur when: the intended action involves a slight departure from the routine; some characteristics of the stimulus of the action sequence are related to the inappropriate but more frequent action; the action is relatively automated (skill-based behaviour) and is therefore not closely monitored (feedback). (Hendy, 2003)

Yet, looking closely at the final report it is possible to have more data to analyze. As stated by the investigation center, it is possible to identify the lack of the expected deceleration after the touchdown that might have been initially attributed to the runway conditions by the pilots. And then, without a correct understanding of the aircraft behaviour, they may have been made to believe that the aircraft was aquaplaning (CENIPA, 2009). At no moment of the management of that emergency situation was there any indication that either pilot had understood what was going on in relation to the aircraft and its systems. In the case of the accident, the pilots did not know how the system was operating to prevent the aircraft from landing. The instrument panel showed the non-deflection of the ground spoilers, but there was no other indication, and the system did not present any further information that could be of help for the pilots to understand what was really happening, or that even showed that the lack of deflection was linked to the positioning of the thrust levers (CENIPA, 2009).

Based on these facts and continuing the analysis it is still possible to identify another failure, a *Perception Failure* due to a communication machine and human, so SERA classifies this failure as a *Communication Active Failure* - A failure in communication or information exchange between *Machine (Display) and Human*. The operator did not receive relevant information, or was passed incorrect information. This is a breakdown in the information link between human and machine or display. (Hendy, 2003)

Until now "what" happened to the accident that occurred has been analyzed, that is, the active failures. From this point the other three layers will be analyzed, the pre-conditions, latent factors both immediate and remote, that made these Slip and Communication Active Failures more likely and then it is possible to classify "why" this accident took place. These three layers are so defined by Hendy (2003):

Pre-conditions - these are factors that are directly and immediately connected to the unsafe act or condition related to Condition of Personal, Working Conditions and Condition of the Task.

Command, Control and Supervision failures - these are defined in terms of forming strategic goals, the communication of those goals, and the provision of error correcting feedback. The Command, Control and Supervisory process is the conduit whereby the organizational layer affects the immediate pre-conditions.

Organizational Influences - these are remote factors that establish the purpose of the activities to be performed, control the resources, define the climate within which the activities are to be performed, set constraints that bound behavior though procedures, rules and regulations, and provide oversight.

After these three categories descriptions now is the moment to analyze what happened to the crew to commit the *Slip Active Failure*.

In relation to Pre-conditions for Unsafe Acts**,** category of *Condition of Personal*, the following sections of the final report can be observed:

The SIC's (Second-in-Command) experience as a co-pilot was limited to the Right Seat Certification training. (CENIPA, 2009) and there was a perception among the crew interviewed that the training through the years and on account of the high demand resulting from the company's growth was being abbreviated (CENIPA, 2009). These facts can be considered an instance of *training*. Many mode errors can be traced to an incomplete understanding (mental model) of system function (Hendy, 2003).

In view of all the operation scenario – the 55 meters added on account of the reverser procedure, the 2.4 extra tons of fuel on account of the tankering, the crowded aircraft, the pressure to proceed to Congonhas, the PIC's (Pilot-in-Command) physiological condition (headache), a SIC with little experience in the A-320 and in its autothrust system, the wet and slippery runway, the occurrences of the preceding days (97/119), all resulting in a influence to condition of personnel classified in SERA as *psychological*, where psychological states, attitudes, traits, and processing biases shape the goals we set, the way we interpret or perceive information, and the actions we form (Hendy, 2003).

The crew consisted of two captains, with the senior of the two sitting on the left seat during the entire journey and acting as the PIC during the landings and the short experience of the SIC in that seat may have contributed to the lack of perception of a possible slip or deviation in the execution of the procedure prescribed in the Master Minimum Equipment List (MMEL) and in the Standard Operating Procedures (SOP) (CENIPA, 2009). Within SERA framework are best considered *social* pre-condition: Factors that determine the effectiveness of how groups and teams interact (Hendy, 2003).

At a certain moment, during the approach, the PIC reported having a mild headache. It is possible that this trouble may have influenced his cognitive and psychomotor capabilities during the final moments of the flight, when the unpredictability of the situation demanded a higher effectiveness of performance (CENIPA, 2009). This occurrence is classified as *physiological*, physiological states that are associated with impaired performance. (Hendy, 2003)

Regarding to Pre-conditions for Unsafe Acts, an example of *Working Conditions* category, can be observed:

The FWC of the PR-MBK did not have the H2F3 standard, an improvement offered by the manufacturer by means of a service bulletin (CENIPA, 2009). In this case, the classification *equipment* that had the potential to contribute to this accident. Poor equipment design can set the scene for the propagation of these errors (Hendy, 2003).

Referring to *Command, Control and Supervision* category, the following instances can be given:

There was mention of an internal pressure to prevent the diversion to alternate airports, on account of the operational inconvenience of reallocating the passengers of connecting flights, in addition to the costs of fuel and the consequences to the company's image before the passengers. This kind of pressure was not formal but was perceived by the crews when in contact with the company during the flight, in search of guidance and coordination of the actions during bad weather situations (CENIPA, 2009). It is an example of failure in *communication of intent*: The objectives of the task and lines of responsibility were not clearly communicated by managers or supervisors (Hendy, 2003).

The communications between the Safety and the crews were transmitted by means of the corporate e-mail, without any control tool to confirm that the messages transmitted were effectively read, thus leaving out an important communication element: feedback. The change in the operational procedure with a pinned thrust reverser prescribed in the MEL, which had occurred in January 2007, had not been informed to the pilots by the company. One would only become aware of the procedure when flying an aircraft in that condition, and the crewmember had to refer to the MEL (CENIPA, 2009). In different parts of the final report it is possible identify breakdown in feedback from the company. It was classified in SERA as *monitoring and supervision*: Monitoring or supervisory activities are missing, delayed or were otherwise inadequate to provide error-correcting feedback ensuring successful task or mission completion (Hendy, 2003).

In the last layer, the *Organisational Influences* is possible observing the following sentences:

There were two accidents in similar conditions to the accident involving the flight 3054, that is, landing with inoperative thrust reverser for aircraft A-320, the very manufacturer recognized this importance by developing an improvement for the FWC, by means of the H2F3 standard, which triggers a specific alarm with a message in the ECAM, alerting the pilots that a lever would be at a position above IDLE during the landing and this aircraft did not have this improvement (CENIPA, 2009). There are two different classifications lumped in this category by these acts: one of then is *organisational process and practices* and another one is ***oversight*.** According to Hendy (2003) organisational process and practices procedures can assist in preventing failures due to memory limitations and oversight. It becomes a pre-condition when it was know that there were a high number of these types of incidents, and no corrective action was taken.

The authorities responsible for the continuing airworthiness of the A-320 considered that the non-implementation of this modification would not affect the safety of the operation, and no Airworthiness Directive (DA) was issued concerning its implementation. The issuance of a DA would render it mandatory and would oblige the manufacturer to install it on all A-320s in operation (CENIPA, 2009, p. 83). In this case it is possible to observe a lack in *rules and regulations* according with Hendy (2003) rules and regulations may be imposed by an external body, set the constraints and establish the legal requirements within which the operational mission has to be accomplished.

The investigation identified the perception that there was a pressure on the part of the management against diversions, on account of the inconvenience that could arise for the passengers and for the company itself (CENIPA, 2009). Yet it is another example specifically classified as *organizational climate*. Organizational climate refers to organization variables that shape worker attitudes and make certain behaviours more likely to emerge (Hendy, 2003).

There was a internal pressure to prevent the diversion to alternate airports, on account of the operational inconvenience of reallocating the passengers of connecting flights, in addition to the costs of fuel and the consequences to the company's image before the passengers. It is a *monetary* influence - monetary issues refer to the management of non-human resources, primarily monetary resources. At the same time, a transition of equipment was in progress within the company, which began to concentrate on the Airbus line, and stopped operating the Fokker 100. Thus, the demand for A-320 pilots (captains and co-pilots), which was already high, got even higher (CENIPA, 2009). This is an example of *human* issues - the term 'human' refers to operators, staff, support and maintenance personnel. The Operator was charged with the decision to implement or not the H2F3 standard improvement bearing reasonable costs. It is an *equipment* issue. Equipment refers to issues related to equipment design, including the purchasing of equipment that is suitable for the role and failures to correct known design flaws. *Monetary, human* and *equipment* are examples of *provision of resources* pre-conditions. This refers to the management, allocation, and maintenance of organizational resources and makes part of organisational influences category in SERA framework (Hendy, 2003).

The active failure slip and pre-conditions that has been emerged to the active failure in this accident are expressed in Figure 2.

Software SERA provide the pre-conditions that are more tightly linked with each point of each active failure, in this work they are flagged with green. Nevertheless others were found inside final report and for this work they are flagged with yellow.

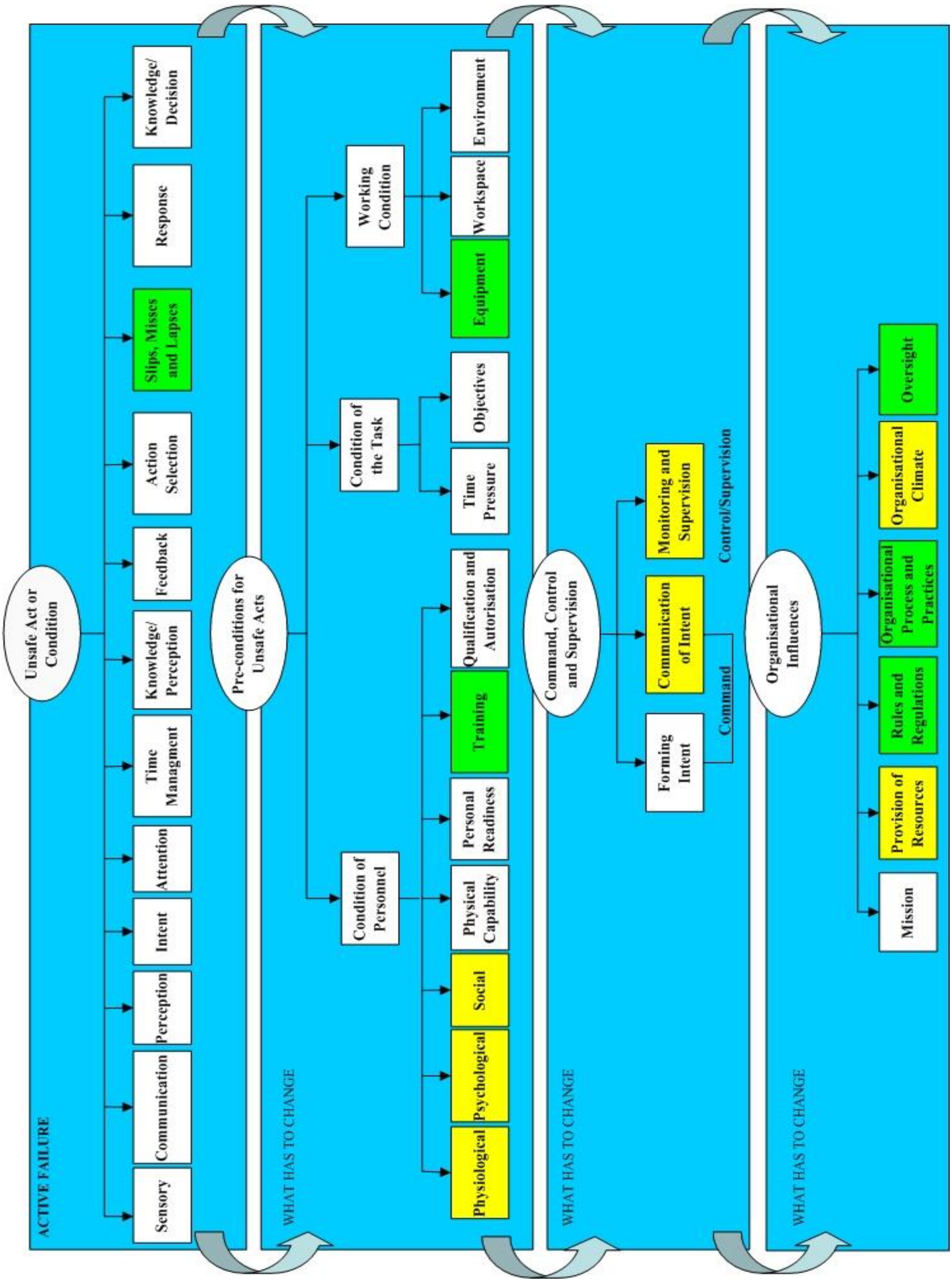

Figure 2 – Active Failure *Slip* and Pre-conditions Arising from the SERA Analysis of the Flight 3054 Accident (Sobreda, 2011)

Continuing with the analysis the next step is to bring the "whys" the Active Failure *Communication* has occurred.

For the category of *Condition of Personal* in Pre-conditions for Unsafe Acts, the following examples of the final report can be observed:

Although perceiving that the ground spoilers had not deflected, the pilots were not able to associate the non-deflection with the positioning of the thrust levers.

In addition, there is a high probability that the pilots were led to believe that the lack of the expected deceleration after landing was a result of the conditions of operation with a wet runway, the influence of which, from a psychological aspect perspective in the field of individual variables, was perceived along the investigation. (CENIPA, 2009) As can be observed this is an instance of *psychological* pre-condition - Human team members may have incorrect perceptions of a situation, or may retrieve the wrong information from memory. (Hendy, 2003)

Relatively to the psychosocial aspects, the crew was composed of two senior captains, and the one working as the co-pilot had only little experience in the equipment, since he had only taken the training program.

It was also observed that there was no division of the tasks during the emergency situation, contributing to a scenario that was different from the one that could be expected: the PIC acting as a leader and the co-pilot as an assistant. The scenario observed denotes that there were two leaderships on board.

According to the information obtained, if a situation occurs which someone has not been trained for, it is hard for a captain to get rid of the role to which he has been conditioned. The captain is the leader and this is a component of the group culture. (CENIPA, 2009) This is considered a *social* pre-condition. According with Hendy (2003) certain factors will influence the willingness of team members to communicate freely and openly.

At a certain moment, during the approach, the PIC reported having a mild headache. (CENIPA, 2009) This occurrence is classified as *physiological*, physiological states that are associated with impaired performance. (Hendy, 2003)

At a certain moment, during the approach, the PIC reported having a mild headache. It is possible that this trouble may have influenced his cognitive and psychomotor capabilities during the final moments of the flight, when the unpredictability of the situation demanded a higher effectiveness of performance (CENIPA, 2009). This occurrence is classified as *physical capability* as seen in this instance, a headache can be a factor that determine the capability (physical not cognitive) to sense information and implement the intended action or behavior (Hendy, 2003).

Analyzing the category of *Working Conditions* to this accident the follows instances can be found:

It was observed that the RETARD auto call-out sounds even if the thrust levers are already at IDLE, when the airplane crosses the height of 10 feet on the approach for a landing. On the other hand, it was observed that the RETARD auto call-out is deactivated when one thrust lever is positioned in REV and the other in CL. (CENIPA, 2009)

It was verified that, for an A-320 airplane proceeding to land, it is possible to place one of the thrust levers at the REV position and the other at CL, and no alerting device will advise the pilots in an efficient way. This situation may put the aircraft in a critical condition and, depending on the time it takes the crew to identify this configuration, and on the runway parameters, a catastrophic situation may occur.

In the specific case of this accident, even with the aircraft on the ground (Weight on Wheels - WOW), with the number 1 engine thrust lever at the REV position, with the ground spoilers armed, with the autobrake selected, and with application of maximum braking pressure on the pedals, the power control system gave priority to the information that one of the levers was at CL, and this lever did not have any safety devices regarding a possible inadvertent setting. (CENIPA, 2009) These clearly denote that a pre-condition *equipment* had influenced to this accident, for Hendy (2003) it happens when a human-machine communication can be degraded by inadequate displays of information (lacking necessary cues) or displays that provide incorrect information.

In this accident there can be found some failures in *Command, Control and Supervision* category as seen below:

The inobservance of the peculiarities present in its board of pilots, with a certain disproportion between the number of captains and the number of co-pilots, as well as some individual characteristics present in some crewmembers, added to the lack of monitoring of their operational performance since they joined the company, resulted in the composition of crews with an inappropriate profile for certain flights, as was the case with the flight 3054. (CENIPA, 2009) This is an instance of *monitoring and supervision* where it is possible inadequacies in team working, equipment or environment have not been reported and follow up action been initiated (Hendy, 2003).

There was mention of an internal pressure to prevent the diversion to alternate airports, on account of the operational inconvenience of reallocating the passengers of connecting flights, in addition to the costs of fuel and the consequences to the company's image before the passengers. This kind of pressure was not formal but was perceived by the crews when in contact with the company during the flight, in search of guidance and coordination of the actions during bad weather situations. (CENIPA, 2009) It also could be classified as a *communication of intent* pre-condition, in this case, the objectives of the task and lines of responsibility were not clearly communicated by managers or supervisors.

Of this accident several fails categorized by *Organizational Influences* can be recognized as the follows examples show:

The very manufacturer recognized this importance by developing an improvement

for the FWC, by means of the H2F3 standard, which triggers a specific alarm with a message in the ECAM, alerting the pilots that a lever would be at a position above IDLE during the landing.

However, the authorities responsible for the continuing airworthiness of the A-320 considered that the non-implementation of this modification would not affect the safety of the operation, and no Airworthiness Directive (DA) was issued concerning its implementation. The issuance of a DA would render it mandatory and would oblige the manufacturer to install it on all A-320s in operation.

Thus, the H2F3 standard represented only an improvement offered by the manufacturer through a service bulletin to all the A-320 operators. It was up to each one of them to decide either for its implementation, handling the respective costs, or not.

In the specific case of the PR-MBK, the FWC did not have the H2F3 standard installed (CENIPA, 2009). It can be considered an *organizational process* pre-condition, where the investigator has to look for a fail in process for handing reports of hazardous or unsatisfactory team working, equipment and environments (Hendy, 2003).

The way the policy of the company relative to a diversion to an alternate airport was seen by the crews, contributed to inhibit any thought of proceeding to another aerodrome, even with the anxiety regarding the conditions of Congonhas. (CENIPA, 2009) These kinds of policies can contribute to a pre-condition classified as *organizational climate*, that is, conditions that effect safe operations duly investigated and corrected (Hendy, 2003).

The operations sector of the company, in turn, did not manage to harmonize, in a proactive fashion, the different levels of professional qualification for the composition of the crews. So, it was allowed for the crew to be composed of pilots. It was observed that the crews were worried with the interferences on the operational processes and on each pilot’s individual decisions, a fact that created an unfavorable climate in relation to safety. There was mention of an internal pressure to prevent the diversion to alternate airports. This kind of pressure was not formal but was perceived by the crews when in contact with the company during the flight, in search of guidance and coordination of the actions during bad weather situations. (CENIPA, 2009) These are some examples of failures in *oversight* where systemic problems in team working, equipment or environment were known and corrective actions weren’t taken (Hendy, 2003).

There was a internal pressure to prevent the diversion to alternate airports, on account of the operational inconvenience of reallocating the passengers of connecting flights, in addition to the costs of fuel and the consequences to the company’s image before the passengers. It is a *monetary* influence - monetary issues refer to the management of non-human resources, primarily monetary resources. At the same time, a transition of equipment was in progress within the company, which began to concentrate on the Airbus line, and stopped operating the Fokker 100. Thus, the demand for A-320 pilots (captains and co-pilots), which was already high, got even higher (CENIPA, 2009). This is an example of *human* issues - the term ‘human’ refers to operators, staff, support and maintenance personnel. Operator was charged with the decision to implement or not the H2F3 standard improvement bearing reasonable costs. It is an *equipment* issue. Equipment refers to issues related to equipment design, including the purchasing of equipment that is suitable for the role and failures to correct known design flaws. *Monetary, human* and *equipment* are examples of *provision of resources* pre-conditions. This refers to the management, allocation, and maintenance of organizational resources and makes part of organisational influences category in SERA framework (Hendy, 2003).

The regulatory organization, although having already considered the availability of the reversers as a requirement for the operation in Congonhas, at least since April 2006, such a requirement was only formalized as a norm in May 2008. The opportune regulation of this requisite would have prevented the aircraft from operating in Congonhas with a wet runway condition (CENIPA, 2009). It is observed here an example of *rules and regulations*. Rules and Regulations have a special place within an organization's processes. Rules and Regulations, which may be imposed by an external body, set the constraints and establish the legal requirements within which the operational mission has to be accomplished (Hendy, 2003).

The active failures communication and pre-conditions that has been emerged to the active failure in this accident are expressed in Figure 3.

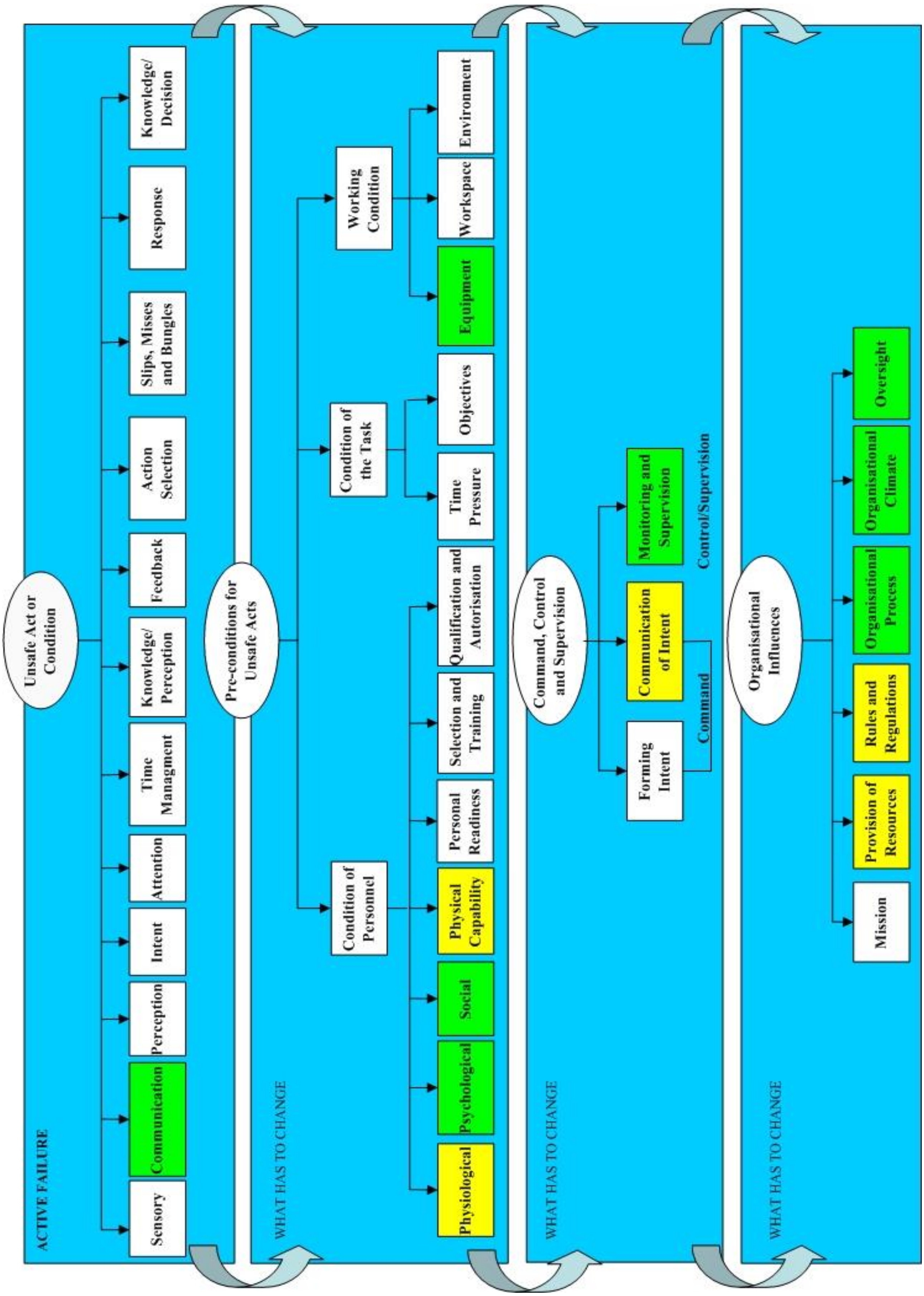

Figure 3 – Active Failure *Communication* and Pre-conditions Arising from the SERA Analysis of the Flight 3054 Accident (Sobreda, 2011)

4 Conclusion

The SERA tool structured process, simple and easy to analyze and investigate systematic errors, made clear, to the studied accident, two active failures and several pre-conditions linked to these failures. One of these failures is totally clear, a man-machine communication failure. It came out as attentive reading the final report as SERA application. It can be observed if that crew had, inside the cockpit, an alert about any inadvertent positioning of the thrust levers, this inadequacy could be corrected in time to avoid the accident. The other failure, the slip action failure, whether it was by using the old procedure for landing with inoperative thrust reverser, that has been forgotten by the correct position of the lever, this failure can never be proven, because, it is impossible to be sure of what really happened in the final moments of that crew. It can be stated that it will never be possible to know the real reasons, human or material, which led the thrust reverser in question remain in CLIMB position. Although the mechanical failure is probably too little, that crew is no longer present to come to the aid of looking for pursuit which led to that action execution failure.

In addition several dormant conditions and deviances were observed revealing a systemic breakdown in several levels of the aviation environment. Starting from manufacturer, authorities, airport infrastructure and various layers of the operator, untill to reach the last level of this chain, the crew.

Human Factor is not an exact science and can be interpreted differently by various observers. Differences in the analysis may arise during investigations, depending on the analyst and the political and economic conditions that involve an accident. In this respect, the SERA direct questions allow the occurrence investigation evaluation process, the most impersonal as possible. From structured classifications it is possible to predict, within the aviation system, and more specifically, within the organizations, the major failures, whether of operators, managerial or organizational, thereby making possible to create barriers to protect against these failures.

Through this analysis it is possible then to put barriers where is necessary and, obviously, it is the main goal of an accident or incident investigation, by means of these barriers avoiding recurrences and propagation, helping in preventing new ocurrences.

References

REASON, J., **Human error**. Cambridge: Cambridge University Press, 1990. 302 p.

REASON, J., **The human contribution.** Gower House: Ashgate, 2008. 310p.

CENIPA (Aeronautical Accident Investigation and Prevention Center), **FINAL REPORT, A-67/CENIPA/2009**. Brasília, DF, 2009.

HENDY, K.C., **A tool for human factors accident investigation, classification and risk management.** Toronto, Canada: DRDC, 2003. (TR 2002-057).

SOBREDA, S.F., **SERA - Uma Ferramenta para análise e classificação do erro humano em acidentes e incidentes aeronáuticos**. Dissertação (Mestrado Profissional) - ITA - São José dos Campos, SP, 2011.